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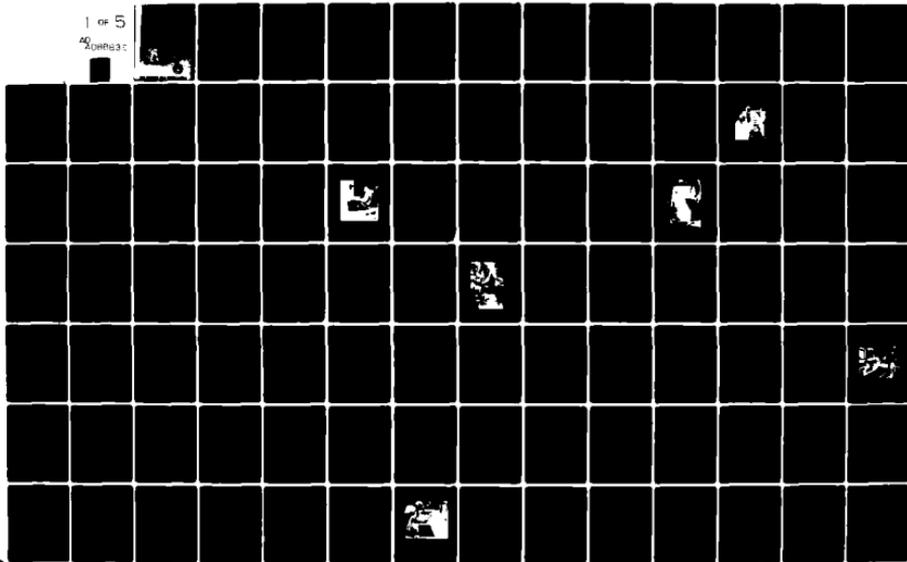
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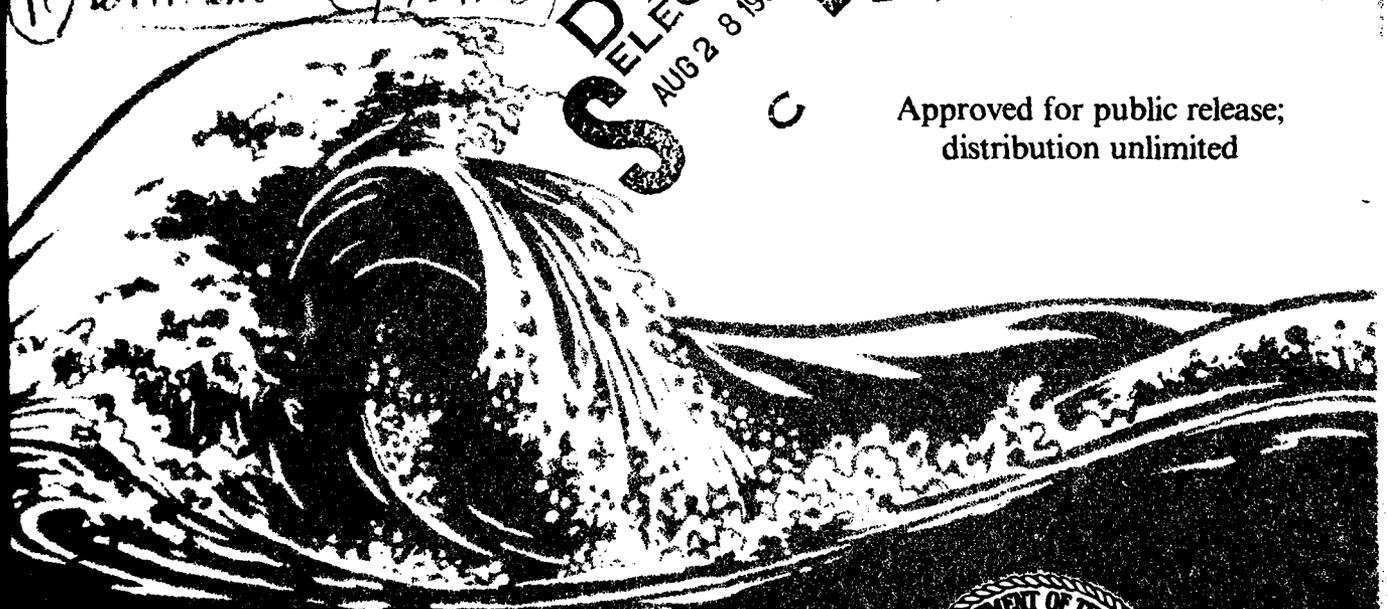
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NAVAL POSTGRADUATE SCHOOL  
Monterey, California

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Superintendent

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This report was prepared by:

  
William M. Tolles  
Dean of Research

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## A SUMMARY OF RESEARCH ACTIVITIES

### INTRODUCTION AND BACKGROUND

Research activity at the Naval Postgraduate School (NPS) performed during fiscal year 1979 is abstracted in this summary volume. These results are due to the efforts of principal investigators (faculty members at NPS) with, in most cases, student contributions through activity leading to a thesis in pursuit of an advanced degree.

The importance of research at NPS is recognized in the mission statement:

"...to encourage a program of research in order to sustain academic excellence."

Research performed at an educational institution such as NPS provides not only the benefits of original investigations inherent in all research activities but, in addition, it contributes to the knowledge base and vitality of the educational activities at the institution. Sponsor benefits include augmentation of research efforts with student activity, and exposure of students to areas of current concern.

The Naval Postgraduate School provides a unique interface between academic institutions and the Navy. As such, the research projects undertaken are, in general, more clearly related to Navy and DOD interests. A substantially larger fraction of the R&D effort at NPS is in the 6.2 category than would be found in most universities. This is a result of student interests as well as faculty interest created by the environment at NPS.

The level of research performed during the academic year at NPS has risen almost linearly over the past 20 years to the current level of effort. Prior to this period there was minimal activity. Such growth represents a maturation of the graduate educational process at NPS, and a provision of professional activities clearly contributing to the quality of the faculty and the educational process.

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## DEPARTMENT OF COMPUTER SCIENCE

The Research Program of the Computer Science Department supports and is supported by the NPS Computer Laboratories and the NPS Computer Center. An expanding research effort includes work in: hardware and software performance measurement methods and applications; optimization theory and applications; compiler and operating system design, implementation and optimization; coding and information theory; microcomputer structures, software, and systems design; signal processing; computer graphics; design of real time systems; digital filters; and artificial intelligence.

The research program has permitted the development of a number of functional laboratories which support further research as well as instruction. These include a microelectronics laboratory where microprocessors and single board computers are interfaced with a variety of equipment to become imbedded computers and a microcomputer laboratory which includes a number of microcomputer development systems as well as a multi-user development system.

### INTERACTIVE GRAPHICS

The principal effort in the Graphics area has been the design and implementation of software interfaces and language extension for the support of interactive graphics. This work provided the necessary foundation for the mechanization of certain anti-submarine warfare programs on a storage tube display by G. A. Rahe.

### CODING AND INFORMATION THEORY

R. W. Hamming is responsible for many fundamental results in coding and information theory. He is continuing this research. During 1979 he published a book on this subject.

### MICROCOMPUTERS

The work of U. R. Kodres has made this department a recognized center of expertise which has contributed to Navy-wide efforts to formulate standards for microcomputers. U. R. Kodres continues to explore the application of the interconnected networks of microcomputers. A multi-terminal microcomputer development system has been acquired to provide continuing support work in microcomputer languages and operating systems.

## LARGE SCALE OPTIMIZATION

G. Bradley and G. Brown are doing research on the solution of large scale networks, linear programs and integer programs. The research has been applied to major DOD projects including material distribution, personnel assignment and ammunition production.

## SIGNAL PROCESSING

The research area of G. A. Rahe continues to be concerned with anti-submarine warfare and computer graphics.

## PERFORMANCE MEASUREMENT AND SOFTWARE RELIABILITY

N. F. Schneidewind has done research on the development and application of performance measurement techniques including the analysis of multiprogrammed computer performance; the relationship between program structure and error detection; and the development of stochastic models for software error prediction.

## COMPUTER SECURITY

R. R. Schell is exploring the vulnerabilities in the internal security controls of current and projected computer systems. The effectiveness of vulnerability countermeasures, including the security kernel technology, is being addressed.

## OPERATING SYSTEMS

U. R. Kodres and R. R. Schell have continued research on operating system structures for effective use of multi-microcomputers in combat systems. Experimental configurations with the Intel 8086 and the Zilog Z8000 are being evaluated.



**Dr. Tibor Horwath, Director of Navy Technology, NAVMAT,  
Inspects NPS Image Processing Facilities with Professor George Rahe.**

Title: Large Scale Optimization

Investigators: Gordon H. Bradley, Professor of Computer Science, Gerald G. Brown, Associate Professor of Operations Research and Computer Science

Sponsor: Office of Naval Research

Objective: Continued development of theory and algorithms for solution of large scale optimization models.

Summary: The research program has continued on several fronts. Large models exhibiting network structure have been solved with almost one million variables. Large scale linear and mixed integer optimization models are being studied with newly developed automated preoptimization analysis routines, and solved with a prototype test-bed optimization system. Results indicate for a wide range of benchmarks that the preprocessing of large models is invaluable both from managerial and mathematical viewpoints. The optimization system has been compared side-by-side with all major competitors and shown to be at least ten times more efficient for large linear models, and much more so for mixed integer models. Using decomposition, problems have been solved with several million variables.

Publications: G. G. Brown, A Geoffrion and G. Bradley, "Seasonal Production Planning with Limited Shared Tooling at the Key Operation," to appear in Management Science.

G. G. Brown and G. Graves, "Optimal, Real-Time Dispatch of Petroleum Trucks," to appear in Management Science.

G. G. Brown and D. Thomen, "Automatic Prior Factorization of Generalized Upper Bounds in Large Scale Optimization Models," to appear in Management Science.

G. H. Bradley, G. G. Brown and G. W. Graves, "Design and Implementation of Large Scale Primal Transshipment Algorithms," in Management Science, 24, 1 (1977), p. 1.

G. G. Brown and H. C. Rutenmiller, "Means and Variances of Stochastic Vector Products with Applications to Random Linear Models," Management Science, 24, 2 (1977), p. 210.

G. Bradley, "Survey of Deterministic Networks," AIIE Transactions, 7, 3 (1975), p. 222.

Theses Directed:

D. Thomen, "Automatic Prior Factorization of Generalized Upper Bounds in Large Scale Optimization Models," MS/OR, September 1979.

C. Mavrikas, "Optimal Five-Year Planning Using Mixed Integer, Linear Programming-- Three Models Implemented for Naval Air Test Center, MS/OR, March 1979.

R. Buffum, "Naval Air Test Center Workforce Planning Model," MS/MSMT, September 1978.

C. E. Sibre, "A Quadratic Assignment/Linear Programming Approach to Ship Scheduling for the U.S. Coast Guard," MS/OR, June 1977.

P. I. Galatas, "ATHENA" MS/OR and CS, March 1979.

**Title:** Exploration of Performance Prediction Techniques for Advanced Computer Architectures

**Investigator:** Lyle A. Cox, Jr., Assistant Professor of Computer Science

**Sponsor:** Naval Postgraduate School Research Foundation

**Objective:** Establish a testbed facility and continue development of top-down computer system design and evaluation techniques.

**Summary:** This research effort has resulted in the establishment of a 16 bit microprocessor development system within the Computer Science Department's Microprocessor Laboratory. This system is dedicated in the analysis and simulation of complex, advanced computer systems. Of particular interest are systems capable of significant concurrency or parallelism. Such units constructed to date have not lived up to their promise, being expensive and difficult to program. In order to understand how such systems respond and to be able to economically explore alternative designs, design description languages and processors have been implemented. These systems allow the designer/user to describe his hardware and software systems and then predict reliably the performance of such a hypothetical system. Results indicate that the petri-net concurrent control system techniques being developed are capable of providing efficient, accurate and easily used computing system models.

**Publications:** Lyle A. Cox, Jr., "Performance Prediction from a Computer Hardware Description," Proc. Fifth International Symposium on Computer Hardware Description Languages, October 1977.

**Theses Directed:** D. M. Stowers, "An Analysis of the SEAFIRE Gunfire Control System," (in progress)

R. Hartell, "Predicting Performance of Distributed Processing/Communications Systems," (in progress)

**Title:** A Microprocessor Based Secure Archival Storage System

**Investigators:** Lyle A. Cox, Jr., Assistant Professor of Computer Science and Roger R. Schell, LTCOL, USAF, Assistant Professor of Computer Science

**Sponsor:** NPS Foundation Research Program

**Objective:** Specify, design and implement a certifiably secure archival storage system based on microprocessor technology. Such a system can serve as the "hub" of a secure network of computers sharing data and programs.

**Summary:** Security has been a continuing problem in developing and operating all types of computers, especially distributed networks of computers. Since these systems have the potential of allowing a wide audience of users to access sensitive data, they must be designed with caution. A technique for such system design, the "kernel technique," has been shown to be capable of providing the necessary security. Until recently, this technique could be implemented efficiently only on large computers. Recent advances in large scale integration microprocessors and "Winchester" disk storage system have made it possible to implement a secure archival system on a mini/micro scale. This scale is required for development of reliable distributed processing systems such as the "automated office" and the Navy's "SNAP II" systems. Specifications, basic and advanced designs for this system have been completed and the project is entering early stages of implementation.

**Theses Directed:** E. J. Parks, "Operating System for Secure Multi-level Data Storage and Retrieval," in-progress.

D. L. Smith, "Method to Evaluate Microcomputers for Non-Tactical Shipboard Use," Master Thesis, September 1979.

A. R. Coleman, "Security Kernel Design for a Microprocessor-Based, Multilevel, Archival Storage System," Master's Thesis, September, 1979.

**Title:** Operating Systems Structures for Distributed Multi-Microcomputer Systems

**Investigators:** Uno R. Kodres, Associate Professor of Computer Science, Roger R. Schell, Assistant Professor of Computer Science

**Sponsor:** Office of Naval Research

**Objective:** The purpose of the study is to: identify operating systems structures which will more effectively support combat systems applications using commercially available architectures; provide architectural guidelines for hardware design to support the required operating systems capabilities and efficiencies; and to identify the hardware and operating system features which enhance the implementation of secure systems composed of multi-microcomputers.

**Summary:** An emulation system which is able to model a typical real time combat system on a multi-microcomputer architecture (Intel 8080/20) was implemented. An architectural enhancement of the Intel 8086 based system was designed and constructed to increase the multiply performance 4-8 times. The design of a family of real-time operating systems for a secure multi-microprocessor system was completed. Implementation of both an Intel 8086/12 and Zilog 8000 based systems is continued. The architectural features which enhance the implementation of a security kernel have been identified.

**Publications:** H. Amir and U. R. Kodres, "The Intel 8086 Arithmetic Performance Enhanced by the TRW Multiplier," Proceedings of Mini- and Microcomputers, International Society for Mini- and Microcomputers (accepted for publication).

R. Schell, "Architectural Implications of Secure Operating Systems," Proceedings of Mini- and Microcomputers, International Society for Mini- and Microcomputers (accepted for publication).

Theses Directed:

Luis A. Guillen, "A Tactical System Emulator for a Distributed Microcomputer Architecture," Masters Thesis, June 1979.

J. S. O'Connell and L. D. Richardson, "Distributed Secure Design for a Multi-Microprocessor Operating System," June 1979.



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Research-Computer Science Laboratory

Title: A Decision Support System Model for Technology Transfer

Investigator: Ronald J. Roland, Instructor of Computer Science

Sponsor: NPS Foundation Research Program

Objective: To develop a conceptual model of the DSS design process; select and adapt, or create, appropriate software to mechanize the model; develop a knowledge base to describe the interactiveness of various organization variables and managerial decision-making needs.

Summary: Technology transfer is the process by which technology originating at one institutional setting is adapted for use in another. A major impediment to the implementation of new technologies to assist with managerial decision-making problems, is a lack of communication between the technology and management communities. Development of a tool designed to bridge the technology transfer gap is the goal of this research. The result will be a prototype software package which may be used on an interactive computer terminal by a manager for assistance in designing a decision support system (DSS).

Publication: Ronald J. Roland, "A Decision Support System Model for Technology Transfer," November, 1979. NPS52-002 (in preparation).

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**Title:** Computer Security Vulnerability Evaluation

**Investigator:** Roger R. Schell, Assistant Professor of Computer Science

**Sponsor:** Central Intelligence Agency

**Objective:** Develop an improved understanding of the security risks resulting from the vulnerabilities of internal security controls of current and anticipated computers.

**Summary:** Computers are increasingly used to process sensitive and classified information; therefore, there is an increasing need to assess the attendant security risks. Previous projects have examined the weaknesses of the internal security controls of the contemporary computers, and a few current efforts, such as the government-sponsored Kernelized Secure Operation System (KSOS), are addressing such vulnerabilities. The project summarized here will evaluate the potential impact on system security of the vulnerabilities evident in the existing products of major manufacturers. In particular, the project will assess the risks that result from practical techniques to exploit these vulnerabilities in order to gain unauthorized access to computerized information. The project will also address the security value of various vulnerability countermeasures; the effectiveness of the security kernel technology and KSOS in particular will be specifically considered in this evaluation.

**Publications:** R. R. Schell, "Computer Security: The Achilles' Heel of the Electronic Air Force?", Air University Review, January-February 1979, Vol. XXX, No. 2, p 16-33.

L. A. Cox and R. R. Schell, "Understanding Computer Related Crime," Crime Prevention Review, 6, 4 (July 1979), p. 1.

## DEPARTMENT OF MATHEMATICS

The major areas of research in the Mathematics Department are Numerical Analysis, Optimization and Applied Statistics. A brief summary of the activities in each field is given and then some of the miscellaneous research activities.

### NUMERICAL ANALYSIS

F. D. Faulkner has been analyzing the Fourier coefficients in weather prediction for NEPRF. The errors in prediction are analyzed as a time series; testing with data from FNOC indicates a significant improvement associated mainly with the long waves. R. H. Franke has been investigating scattered data interpolation schemes and has completed a report comparing 29 collocation methods for fitting a function of two variables. He and T. Jayachandran are investigating the Foutz Goodness-of-Fit Test. He is also investigating methods for ship hull definition for NAVSEA. A. L. Schoenstadt has been working on numerical methods in differential equations. He has been studying the effects in the solutions due to different schemes for discretizing the differential equations used in weather prediction, particularly those associated with geostrophic adjustment.

### OPTIMIZATION

I. B. Russak is investigating the convergence properties of algorithms for determining a minimum of functions in both unconstrained and constrained cases. G. Owen is continuing his work on game theory; in particular, the information of coalitions.

### APPLIED STATISTICS

T. Jayachandran, with D. R. Barr and H. J. Larson, Operations Research, has been developing statistical tests to monitor the tri-service spectrometric oil analysis, to study the wear condition of aircraft engines by examining lubricating oil samples. They are establishing upper bounds in the contamination levels before an overhaul is recommended. Jayachandran and M. G. Sovereign, Operations Research, are developing a formal model to describe the relationship between the aerospace industry and the DoD in the weapons-system acquisition process, to be used in revising the DoD's procurement and acquisition policies. Jayachandran and Schoenstadt has also completed a statistical analysis on the occurrence and extent of asbestos material in walls, ceilings, etc. from

about 1,500 Navy buildings from all over CONUS. Jayachandran is working on the development of prediction intervals, i.e., intervals in which a future observation is expected to lie with a specific probability; it is assumed that the observations are from a first order auto regressive process. He and Franke are studying the properties of a new goodness-of-fit test due to Foutz, comparing it with existing tests. P.C.C. Wang is continuing research in threat forecasting technology and in automation technologies applied recently to predicting Soviet ECM intentions and capabilities. This research sponsored variously by ONR, NISC, OMEW, will be a key part of the vulnerability assessment required for the Defense Systems Acquisition Review Council and the Army Systems Acquisition Review Council.

#### MISCELLANEOUS

G. E. Latta has rather extensive results in the solution of singular integral equations arising in various applications in physics and engineering. A. L. Schoenstadt has just finished work using simulation to measure the relative efficacy of different methods predicting reliability in series systems. He and S. Parry, Operations Research, are incorporating communications and electronic warfare modeling into the STAR combat system that Parry is developing. M. D. Weir is continuing developing instructional materials, particularly for programmable calculators. D. H. Trahan has continued work in complex variables on regions of convergence for generalized Lambert series. H. B. Marks is working on a model and analysis of changes in strategic balance due to industrial hardening and civil defense buildup. E. J. Stewart is working on properties of idempotent matrices.



Computer Graphics used to Display a Numerical Analysis  
and Computer Solution of Scientific Problems is Researched

Title: A Use of Time Series in Improving Weather Forecasting

Investigator: Frank D. Faulkner, Professor of Mathematics

Sponsor: Navy Environmental Prediction Research Facility (NEPRF)

Objective: To analyze the errors in predicting the Fourier coefficients of a variable such as the 500-mb surface for trends, to improve prediction.

Summary: The time series of errors in the 500-mb surface from FNOC records have been analyzed, and fitted with various types of linear difference equations. Based on these corrections are predicted. A standard NEPRF skill score, based on the errors in the important part of the northern hemisphere indicates an improvement (decrease) of about ten percent, based on limited testing. Corrections are effected mainly for the long waves.

Further testing with more data and with other meteorological variables indicates similar results.

Initial plans have been made to include the routine in the new global model.

Publication: Frank D. Faulker, Craig Comstock, and Robert R. Fossum, "A Use of Time Series in Improving Weather Forecasting," NAVENV PREDRSCHAFAC, CR 79-07.

Another report is in progress.

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Title: Comparison of Methods for Approximation of Surfaces by Interpolation at Scattered Data Points

Investigator: Richard Franke, Associate Professor of Mathematics

Sponsor: NPS Foundation Research Program

Objective: The objective is a critical comparison of proposed methods for fitting surfaces to scattered data by interpolation.

Summary: A total of 29 programs for scattered data interpolation were written or obtained from their authors. These were compared on a number of sets of data, consisting of both test surfaces and data for which the underlying surface is unknown. Tables of accuracy, timing, sensitivity to parameters and other aspects were generated. Plots of surfaces were obtained for visual purposes.

Publications: "A Critical Comparison of Some Methods for Interpolation of Scattered Data," NPS-53-79-003.

"Smooth Interpolation of Large Sets of Scattered Data," (with Gregory M. Nielson) NPS-53-79-005, (To appear in International Journal for Numerical Methodology in Engineering.)

A manuscript, summarizing the results of the project and pointing towards NPS-53-79-003, is in preparation and will be submitted for publication.

Title: Surface Definition Improvement

Investigator: Richard Franke, Associate Professor of Mathematics

Sponsor: Naval Sea Systems Command, Washington, D.C.

Objective: To determine the desired characteristic of the surface definition scheme necessary to adequately define the hull for both the present and future computer aided surface definition method.

Summary: A survey of the literature was undertaken, together with consultations with persons presently involved in hull definition and related areas. Based on this a report recommending the use of parametric B-splines for representation of the hull, and acquisition of suitable computer and graphics equipment to implement the design process was forwarded to NAVSEA.

Publications: "Recommendations for Ship Hull Surface Representation," NPS 53-80-001, 1980.

Title: Occupational Safety Assessment

Investigator: Professor T. Jayachandran, Associate  
Professor of Mathematics

Sponsor: Office of Naval Research

Objective: To provide statistical analysis support to the Naval Analysis Programs to assess the impact of OSHA on Navy Programs. The primary task is to develop a statistical sampling plan to efficiently locate asbestiform in Naval installations.

Summary: Participated in several planning meetings at the Naval Civil Engineering Laboratory, Port Hueneme, CA to develop requirements, stratified sampling plans with building usage codes as strata and geographical location as substrata. The sampling plan is to identify ten percent of all Navy buildings (about 40,000) that would be representative of the total in estimating efficiently the amount of asbestiform in Naval installations.

Also participated in two workshops to assess the impact of OSHA on the Navy and determining a prioritized list of critical issues.

Publications: A report on the results of the asbestos survey has been submitted to the Naval Civil Engineering Laboratory, Port Hueneme, CA.

Title: Technical Assistance in Asbestos Monitoring

Investigators: Toke Jayachandran, Arthur L. Schoenstadt, Richard Franke and I. Bert Russak, Associate Professors of Mathematics

Sponsor: Naval Civil Engineering Laboratory, Port Hueneme, CA

Objective: The Naval Civil Engineering Laboratory has been tasked by OP45 and NAVFAC to conduct a survey of all Navy buildings to estimate the extent and the amount of damage of friable asbestos material in ceilings and walls. NPS is to assist NCEL in the preparation of a training manual for the surveyors, construction of a questionnaire to collect data and the statistical analysis of the resulting data.

Summary: NPS helped in the preparation of the survey training manual and the survey form. Most of the data has been received and put on a computer tape. Analysis procedures have been developed and most of the data analysis has been completed.

Publications: A report on the results of the asbestos survey has been submitted to the Naval Civil Engineering Laboratory, Port Hueneme, CA.

Title: Convergence of the Conjugate Gram Schmidt Method

Investigator: I. Bert Russak, Associate Professor of Mathematics

Sponsor: NPS Foundation Research Program

Objective: The conjugate Gram Schmidt method is a powerful tool for solving unconstrained optimization problems and understanding its convergence characteristics is necessary for its successful application to actual problems.

The objective of this work is to determine the convergence characteristics of the conjugate Gram Schmidt method in the non-quadratic case when using numerical derivatives.

Summary: A version of the Conjugate Gram Schmidt method which requires only function evaluations was considered. In this version, function evaluations replaced the computation of analytic derivatives, thus greatly reducing computer time. It was shown that N-step superlinear convergence to a minimum is possible when applying this version to non-quadratic functions.

Publications: Russak, I. B., "Convergence of the Conjugate Gram Schmidt Method," accepted for publication in the Journal of Optimization Theory and Applications.

Title: Workshop on Applied Mathematics

Investigators: Arthur L. Schoenstadt, Associate Professor of Mathematics and Craig Comstock, Professor of Mathematics

Sponsor: Office of Naval Research and NPS Foundation Research Program

Objective: Numerous observers of current mathematics have perceived an "information gap" between what is often labeled "applied mathematics" and the mathematics actually used in applications in industry and government laboratories. The objective of this workshop was to provide a forum, building on the theme of linear systems, to help narrow this gap.

Summary: The workshop was held at the Naval Postgraduate School, 20 - 24 February, 1979, and consisted of three sessions of invited papers, as well as contributed paper sessions. In each of the invited paper sessions, two outstanding workers, one an applied mathematician and the other an engineer, started by speaking jointly on a common topic of interest in the area of linear systems. The engineer presented his problems, techniques, constraints, difficulties and trends, while the mathematician presented recent developments which have proven useful or seem to show promise. These presentations were followed by an in-depth discussion between the presenters and members of the audience. Approximately 80 engineers and mathematicians attended and, in addition to the six invited presentations, approximately 20 contributed papers were presented.

Publications: Proceedings in preparation.

## DEPARTMENT OF ADMINISTRATIVE SCIENCES

The Administrative Sciences Department is the Naval Postgraduate School's organizational unit responsible for academic programs designed to educate officers and DOD civilians in a variety of functional management specialties. As such, it is a large, multi-disciplinary department with diverse research projects oriented to support management tasks within the Navy and the Department of Defense. For ease of exposition the research program may be divided into the following six (sometimes overlapping) areas of research concentration: Systems Acquisition Management, Organizational Sciences, Health Care Delivery Systems Management, Financial/Resource Management, Information Systems and Technology Transfer. The past year's focus of the specific research projects in these areas is summarized in the following paragraphs.

### SYSTEMS ACQUISITION RESEARCH

C. R. Jones continued his research into the behavior of defense contractors and the peculiarities of this industry structure for defense contracting. D. C. Boger began an examination of aerospace industry profitability in an attempt to determine the extent and nature of profitability differences between aerospace and other industries. D. N. Burt completed his research into the impact of Foreign Military Sales on NATO system selection. A. C. Crosby developed case studies in the military procurement area. M. B. Kline continued his research in systems engineering and the systems acquisition process areas. He also examined the application of the lognormal distribution to corrective maintenance repair times and on the OPUS VII simulation model for spare parts processing. P. Ein-Dor studied computer software conversion costs and is currently in modeling to predict such conversion costs.

### ORGANIZATIONAL SCIENCES

J. D. Senger continued his exploration of the relationship between personality test scores, academic performance and the career success of Naval officers. He also completed a text on human behavior in organizations. R. Elster began two research projects: the first involves the design and evaluation of a "counter-attrition" experiment at a Naval Training Center; the second will provide information concerning the military service performance of General Educational Development certificate holders. C. K. Eoyang, in conjunction with P. Butler, R. McGongial and R. T. Harris, continued his research in the Human Resources Management area. The overall goal is the application of Behavioral Sciences technologies to

improve organizational effectiveness and to increase productivity through extensive field investigation and contract. M. R. Louis continued her research into the dynamics of career transitions, developing a theoretical framework describing individuals coping processes during such transitions and evaluating alternative organizational practices to facilitate the transition. R. A. Weitzman analyzed and applied various methods for predicting retention rates, including aggregation of enlisted ratings, according to tasks performed and Bayesian estimation applicable to officer's subspecialties. In addition Professor Weitzman continued his research into development of predictive techniques useful in manpower/personnel research. Specifically he investigated the derivation and use of true-score estimation of cell frequencies and Bayesian estimation of criterion performance in pattern analysis, as well as the estimation of race or sex bias in ability or achievement tests. N. R. Lyons continued his research into the impact of changes in computer technology on the auditing of accounting systems and initiated an investigation of basic human information processing behavior. J. K. Arima, in conjunction with P. M. Carrick and colleagues in the Department of Operations Research, continued the research program in Officer Manpower and Personnel Planning, the object of which is to develop a dynamic, interactive computer model to assist in such planning, and in the evaluation of related policy.

#### HEALTH CARE DELIVERY SYSTEMS AND MANAGEMENT

D. R. Whipple, in conjunction with R. T. Harris, G. Thomas and K. Kocher continued the multi-year effort to develop an algorithm to estimate the appropriate mix of physician and nonphysician providers required to staff clinics in military hospitals. In addition, Professors Whipple, Thomas and Kocher continued their investigation into the feasibility of a non-workload-based efficiency measure for use in the military hospital's budgetary process. Professor Whipple also continued his research into the operational meaning of "Health Care as a Right" and the implications for structuring a National Health Insurance program.

#### FINANCIAL/RESOURCE MANAGEMENT RESEARCH

S. S. Liao completed a study which models the "cost variance investigation" decision and began an experimental study into the effects of expected pay-off on such a decision. J. M. Fremgen and Professor Liao collaborated in a study of common cost allocation practices for the National Association of Accountants. K. J. Euske continued to expand his research on the behavioral effects generated by the budgetary process.

R. G. Nickerson developed case studies for use in the policy analysis and resource allocation areas. R. A. Bobulinski continued his work relating organizational management principles to practical comptrollership functions. E. A. Fincke revised the textbook for the Navy Financial Management course and W. H. Skierkowski developed a text for Marine Corps Financial Management personnel. D. C. Boger continued his research into the nature of private and social costs experienced in inland water and rail transportation. In addition the work cited by Professor Boger and by Professor Jones under System Acquisition Research and that by Professor Whipple under Health Systems, are also a part of this research area. R. D. Little continued his research on the human capital investment decision. He completed a project on human capital returns to the self-employed, investigated the elements of the "bridging gap" hypothesis as it applies to veterans, and began work on the socio-economic characteristics of the All Volunteer Force.

#### INFORMATION SYSTEMS

A.W. McMasters continued his investigation of possible internal criteria which the Naval Electronics System Command could use to determine the timely transfer of inventory control to the Ship's Part's Control Center of the Naval Supply Systems Command. He also began development of a local delivery system for the Oakland Naval Supply Center. S. J. O'Hare continued his research into the development of large functionally integrated information systems, focusing on the conversion and installation phases. N. F. Schneidewind continued his investigation in the areas of software engineering and management, specifically studying methods to improve system and software specification processes so that the resulting software can be more easily maintained, with specific application to the TRIDENT program.

#### TECHNOLOGY TRANSFER MANAGEMENT RESEARCH

J. W. Creighton continued his research on the technology transfer process. The focus of his analysis on the human interaction with emphasis on the utilization of the process and concepts of technology transfer by managers, whose understanding and relationship to individuals in the organization can highly influence the transfer of technology from source to user and is considered to be one of the prime responsibilities of a successful manager. He expanded his research to treat the need for acquiring skills for innovating in the development of executive capabilities. Other emphasis is on the acceleration of the rate by which results of research are utilized, and the resultant benefits for the national economy.



Students Participating in Management Seminar — Administrative Sciences Department

**Title:** Economic Aspects of the Regulated Inland Waterway Freight Transportation Industry

**Investigator:** Dan C. Boger, Assistant Professor of Administrative Science

**Sponsor:** Alfred P. Sloan Foundation, through grant 78-4-1 to the Department of Economics, University of California, Berkeley and by the Navigation Analysis Center, Water Resources Support Center, Institute of Water Resources of the U.S. Army Corps of Engineers through Contract DACN 73-78-D-0051.

**Objective:** To obtain estimates of inland water freight carrier costs and the costs of providing inland water rights-of-way in order to compare these costs with similar costs for rail freight carriers.

**Summary:** Inland water freight transportation methods of operational, industry structure and regulations are examined. Linear specifications of carrier-incurred and provider-incurred costs as functions of output measures are specified and estimated. The carrier cost relationship yields measures of economies of density and economies of length of haul. The provider cost relationship yields a measure of economies of density. Measures of total social costs of inland water transport are compared to similar costs for rail transport and inland water costs are found to be approximately one-half the level of Rail costs.

**Publications:** Dan C. Boger, "Economic Aspects of the Regulated Inland Water Freight Transportation Industry," Working Paper SL-7906, Department of Economics, University of California, Berkeley.

**Title:** Utilization of RDT&E Investments by the Naval Facilities Engineering Command

**Investigators:** J. W. Creighton, Professor of Administrative Science

**Sponsor:** Naval Facilities Engineering Command

**Objective:** This has been a continuing project for several years. The objective of the overall project has always been to help the NAVFAC 03 environment provide products to potential users in a form that is usable and available. The FY 79 primary effort included several areas of study which included an attitude survey of CEL technical and management personnel, an attitude survey of field personnel, and a questionnaire administered by personal interviews to assess attitudes of NAVFAC and EFD personnel assigned as Program Managers and Project Leaders. A sample from recent years was requested to determine the perception of user influence on final R&D effort undertaken at the Civil Engineering Laboratory.

**Summary:** During March, April, May and June of 1979, a series of interviews were conducted with a sampling of people from the Civil Engineering Laboratory, Public Works Centers, the Engineering Field Division at San Bruno, and civil engineering personnel from Bechtel Corporation and Fluor Corporation. A few questions were asked to determine the general response that might be expected if a questionnaire were to be submitted to laboratory or field personnel. People in the laboratory were interviewed in a conversational mode. Discussion was about the role of the scientist in the laboratory, work environment and morale, and future career potential for young scientists and engineers. Those interviewed felt that the individual who wished to stay in straight science and engineering work had the opportunity to do so although they considered that those moving into project management and contracting represented a certain amount of threat. They believed that the mission of the laboratory supported a move in

this direction and that the increased activity in contracting and project management was an indication of the strength of the laboratory. Previous studies had exposed deficiencies in the documentation and distribution systems then in use and modifications have resulted to bridge some gaps in understanding the movement of knowledge. A network has been developed to clarify the elements contributing of R&D products of the laboratory.

Publications: Buckles, T. A., An Effective Technology Transfer Process. Technical Note No. CSUS/NPS Jo78091.

Buckles, T. A., Utilization of Exploratory Development. Technical Report No. CSUS/NPS Jo78101.

George, P. A. and J. A. Jolly, Productivity and Investigation of the Issues. Technical Report No. Jo78121. This publication treats technological lag as one of the elements contributing to national slow-down in productivity.

Buckles, T. A., J. A. Jolly, and J. W. Creighton, Exploratory Development Research Effectiveness, A Second Evaluation. Technical Report No. CUSU/NPS Jo78092. This was the second effort to explore the transition of projects from the Civil Engineering Laboratory into use or into further research after completion.

Rohrer, T., T. A. Buckles, J. A. Jolly, and J. W. Creighton, Technology Transfer and Research Utilization Methodology Studies: Exchanges of Navy Sponsored Effort. Technical Report No. CSUS/NPS Cf79051. This is a report resulting from the November 1978 meeting in Washington, D.C. in which the spider chart relating the various activities undertaken was utilized to review the extent of prior work conducted under the technology transfer investment project.

Sullivan, T. F., Organizational and Managerial Mechanisms to Encourage Innovation. Technical Report No. NPS 54Cf79093.

Corbett, J. T. Maintenance Surcharge for Range Use at the Pacific Missile Test Center.  
NPS THESIS.

The Journal of Technology Transfer. Vol. 3, No. 1, Fall 1978. Edited by J. A. Jolly and J. W. Creighton, featured two articles in the issue: "Dimensions of Innovation," by Pelz, Munson, and Jenstrom, and "Adapting to the Foreign Technology Challenge," by Sherman Gee. Six other articles concerning the varied aspects of technology transfer were presented in this issue.

Title: Update the Civilian Logistics Scenario

Investigators: J. W. Creighton & R.R. Jackson, Jr.

Sponsor: Chief of Naval Material

Objective: Develop a set of management science and material logistics assumptions to evaluate the results of the Boeing Phase I, II, and III reports. Review Phase I, II, and III reports. Determine alternative courses of action available to the CNM and the Naval Postgraduate School. Provide recommendations as to the future role of the Naval Postgraduate School in the Boeing study.

Summary: The study is intended to be used by the Naval Material Command (MAT-04B) in support of the objective relative to Workforce Analysis of the Department of the Navy Civilian Logistics Career Program. Three phases have been completed to date:

Phase I - Research, obtain, and review reference materials relative to the current workforce and logistics environment of the DON Civilian Logistics Career Program. Define the Scenario, its purpose and content. Develop a Scenario format for recording findings, implications, and recommended actions. Submit final report to include the Definition of Scenario and formats.

Phase II - Analyze and develop a compendium/symposium of facts and trends which reflect the environment within each Logistics Discipline operates today and will operate in the future. The specific disciplines to be considered are: Integrated Logistics Support Management, Supply Support Management, Quality and Reliability Assurance, and Personnel and Training.

Phase III - Analyze the projections of Phase II to develop and determine findings. Determine and list the conclusions upon which to base decisions concerning the DON Civilian Logistics Career Program. Develop and list recommendations. Submit interim and final

reports consisting of the Findings, Conclusions, and Recommendations.

Administrative study and review of the conclusions provided by the report findings has been completed. The statistics presented were obtained from one source only. The data presented in the scenarios is qualitative and additional data is necessary to conduct a job analysis. Recommendations have been made to sponsoring agency for refinements to Phases IV & V in the analysis to determine the potential projections for the major elements which may impact the current and future work environment.

Publication: In preparation.

Title: Evaluation of a Counterattrition Program at  
RTC Great Lakes

Investigator: R. S. Elster, Professor of Administrative  
Science

Sponsor: OP-01H, Chief of Chaplains

Objective: Investigate the impact of an experimental  
program intended to lower first-term enlisted  
attrition from the Navy.

Summary: Under CNO direction, an experimental counter-  
attrition program has been initiated at RTC  
Great Lakes. Experimental and control groups  
have been formed through random assignment of  
recruits. The performance of these indi-  
viduals are being tracked using the Defense  
Manpower Data Center cohort file. The track-  
ing will continue for four more years. The  
tracking and associated statistical analysis  
will allow the Navy to determine the effec-  
tiveness of the experimental counterattrition  
program.

Publications: First report will be completed in the summer  
of 1980.

Thesis  
Directed: S. Hawkins, thesis underway; is gathering  
data for an initial comparison of the attri-  
tion from the experimental and control  
groups.

Title: Relationships Among Educational Credentials and Military Performance of Enlisted Personnel

Investigator: R. S. Elster, Professor of Administrative Science

Sponsor: National Institute of Education

Objective: Determine the relationship between performance in the service and the types of pre-service educational experiences of enlisted personnel.

Summary: Large data bases from DOD, Job Corps and state educational information systems are being manipulated. Service cohort files are being merged with files containing pre-service educational information. The results will assist the Services in their pre-enlistment recruitment and selection processes, and provide program effectiveness information to the Job Corps and participating states.

Publications: Forthcoming in the summer and fall of 1980.

Thesis  
Directed: G. Carrier, thesis is underway; is investigating the use of a nonparametric prediction technique using several of the projects data bases.

Title: Women in the Navy

Investigator: R. S. Elster, Professor of Administrative Science

Sponsor: Navy Personnel Research and Development Center, San Diego, California

Objective: Identify manpower, personnel and training issues and R&D requirements associated with changing numbers and roles of women in the Navy.

Summary: Ten guest lecturers addressed inter-service groups of officer students at NPS. In a give-and-take atmosphere, issues were identified. The sessions were tape recorded and typed transcripts prepared. An edited version of these transcripts, along with an introduction and summary, has been prepared.

Publications: An NPRDC technical report should be forthcoming in spring or summer of 1980.

Theses  
Directed:

P. K. Carreon, "Psychological, Social and Attitudinal Variables Associated with Infantry Combat and Their Relation to Women," Master's Thesis, June, 1979.

R. C. Hansell, "Officer Promotion Opportunity Within the Navy Unrestricted Line: 1973-1979", Master's Thesis, June, 1979.

V. S. Matthews and S. S. Almendinges, "An Examination of Unrestricted Line Women Officers' Career Patterns and Related Issues," Master's Thesis, June, 1979.

T. Printy, "A Consideration of Factors Contributing to Strength Difference in Men and Women," Master's Thesis, June, 1979.

Title: Human Resources and Management System: Research and Support Project

Investigators: Carson K. Eoyang, Associate Professor of Management and Reuben T. Harris, Associate Professor of Management

Sponsor: Naval Military Personnel Center

Objective: To provide continuing research, analysis, training, and consultation support to the U.S. Navy's Human Research Management Support System (HRMSS) at both field and staff levels.

Summary: Numerous activities were conducted under this project in support of the above objective. In response to a request for assistance in developing a plan for revitalizing the HRMSS, a "report" was written which detailed a series of suggested actions which might be undertaken to achieve such a goal. Two long-term demonstration projects were undertaken with the goal of improving the capability of HRMC's and documenting the strategy and outcome of those efforts. The two project sites are HRMC-San Diego and HRMC-Pearl Harbor. Also, NPS faculty have delivered training activities at HRMC's and HRMD's at Pearl Harbor, San Diego, Alameda, Norfolk, Charleston, Washington, D.C. and NPS. NPS faculty planned and managed the Military HRM Symposium held at NPS (November 1979) and produced the published Proceedings of that conference. Finally, NPS faculty have served as a primary vehicle for knowledge and information developed and available in the non-military areas to be transferred to Navy policy and operational units. As a result of this role, NPS faculty continue to operate in a consultant role to NMPC-6 and have been awarded continuing support for FY 80.

Publications and Reports:

R. T. Harris and C. K. Eoyang "Suggestions for and Reports: Action Aimed at Revitalizing the U.S. Navy's HRMSS," unpublished report submitted to NMPC-6, October 1978.

R. T. Harris (ed.), Proceedings 1979: Military Human Resource Management Symposium, March 1979.

R. T. Harris and C. K. Eoyang, "Helping the Helpers: Dynamics and Consequences of Improvement Efforts in Navy Human Resource Management Centers" (article in preparation - expected completion date is 1 January 1980).

Title: An Analysis of the Relationship of Performance to Perceived Control over Budget Measures Used for Evaluation Purposes

Investigator: Kenneth J. Euske, Assistant Professor of Accounting

Sponsor: NPS Foundation Research Program

Objective: To investigate the relationship of performance as measured by the operating budget and the perceived ability of the manager to control the budget measures used for performance evaluation.

Summary: The field research project investigated the relationship of performance as measured by the operating budget and the perceived ability of the manager to control the budget measures used for performance evaluation. The data were analyzed using a linear model. The results indicate a relationship between performance as measured by the operating budget and the perceived ability of the manager to control the budget measures used for performance evaluation. However, the moderating variables of sex of the manager, leadership style of the manager's supervisor and differences between the firms participating in the study demonstrated the strongest relationships with performance as measured by the operating budget.

Publications: Euske, K. J., Jackson, D. W., Jr. and Reif, W. E., "Exploring the Performance and Satisfaction of Bank Managers." Journal of Bank Research, in press.

Title: Allocation of Indirect Costs

Investigators: James M. Fremgen, Professor of Accounting,  
and Shu S. Liao, Associate Professor of  
Accounting

Objective: To determine actual industrial practices with  
regard to allocations of indirect costs for  
various purposes. To study how and why  
industrial firms allocate indirect costs for  
performance evaluation, pricing, decision  
making and financial reporting purposes; to  
determine the cause of differences, if any,  
in allocation practices.

Summary: This project is currently in process; it is  
expected to be completed early in 1980. To  
date, the literature review has been com-  
pleted and the survey questionnaire has been  
designed.

**Title:** Aerospace Industry - DOD Relationship

**Investigators:** Carl R. Jones, Professor of Administrative Sciences, Michael G. Sovereign, Associate Professor of Operations Research.

**Sponsor:** Office of Naval Research

**Objective:** The objective of this research is the furtherance of the Navy's understanding of the nature of the DOD-private contractor relationship with special emphasis on the aerospace industry. The ultimate goal is to construct a formal model of this relationship which would provide a benchmark for objective public policy analysis.

**Summary:** A statistical analysis of the financial data on major aerospace companies and their DOD business has been completed. A draft of a technical report on the results is under preparation.

**Publications:** A technical report incorporating the results of the analyses and a descriptive model of the existing DOD-aerospace industry relationship will be issued.

Title: Computer System Conversion: Estimating Costs and Regulatory Effects

Investigators: C. R. Jones, Chairman, Department of Administrative Sciences and P. Ein-Dor, Adjunct Professor of Information Systems

Sponsor: NPS Foundation Research Program

Objective: To study the complete cost of transporting software systems from one hardware system to another, to investigate the regulatory effects of current acquisition rules when software conversion is involved and to suggest modifications to procedures which might increase agency efficiency without reducing competition.

Summary: Data on computer system conversion costs were obtained from material made available by NAVDAC and GAO. These data permitted formulation of a model for predicting software conversion costs based on the nature and size of programs to be converted. This model is now being used to study the cost of procedures which induce conversions by mandating competitive acquisitions. Alternatives are being examined to determine whether changes in acquisition procedures may permit a reduction in the outlays on conversions without detracting from the advantages of competitive acquisition.

Publications: Two reports are currently in preparation, one on the cost estimation model for software conversions and the other on the conversion-related aspects of acquisition procedures.

**Title:** Application of the Lognormal Distribution to Corrective Maintenance Downtimes

**Investigators:** Melvin B. Kline, Professor of Administrative Science and LCDR Ronny Almog, Israel Navy

**Sponsor:** NPS Research Foundation Program

**Objective:** The objectives of the research were to verify that the lognormal distribution is a suitable descriptor for corrective maintenance repair times; to estimate the percentage error caused in assuming an exponential distribution for availability and maintainability calculations when, in fact, the distribution is lognormal; to test the lognormal and exponential distributions against mechanical and other nonelectronic systems, since the current data base is primarily on electronic systems; to test these distributions for systems and equipments in which new technologies in microcircuitry and computation are used to increase reliability and decrease diagnostic time; and to determine expected ranges of the principal distribution parameters for different classes of equipment.

**Summary:** From the data analysis conducted in this research, it was concluded that the lognormal distribution is a good descriptor of the distribution of corrective maintenance repair time. Fifteen of the 19 cases from maintainability demonstrations of radically different designs tend to show that, with an acceptable level of significance, this assumption cannot be rejected. Similarly, the data analysis shows that the assumption of an exponential distribution should be rejected in 17 of the cases.

The percentage error in the MTTR, when assuming an exponential distribution instead of a lognormal distribution, as a matter of convenience, for calculating system availability has been found to be small. Other than the one case in which the exponential would not be rejected and the lognormal would, all cases have an error less than ten

percent and, thus, will not have any significant effect on availability.

We were unable to obtain maintainability demonstration data on mechanical systems or on systems using digital and microcircuit technology to a significant extent. It is hoped that future research will explore these types of systems and equipments.

Publications: M.B. Kline and R. Almog, "Application of the Lognormal Distribution to Corrective Maintenance Downtimes," Proceedings, NATO/AGARD Conference on Avionics Reliability, its Techniques and Related Disciplines, NATO/AGARD, Neuilly Sur Seine, France (1979), pp. 3.10-1 to 3.10-13.

Conference Presentation: M. B. Kline and R. Almog, "Application of the Lognormal Distribution to Corrective Maintenance Downtimes," NATO/AGARD Conference on Avionics Reliability, its Techniques and Related Disciplines, Ankara, Turkey, 9-13 April 1979.

Thesis Directed: R. Almog, "A Study of the Application of the Lognormal Distribution to Corrective Maintenance Repair Times," Master's Thesis, June 1979.

Title: Estimating Probabilities for Cost Variance Investigation Decisions: A Bayesian Approach

Investigator: Shu S. Liao, Associate Professor of Accounting

Sponsor: NPS Research Foundation Program

Objective: Develop method to utilize the Bayesian decision theory to arrive at a decision rule that will minimize the expected total cost from investigating cost deviations.

Summary: Some cost deviations represent random variation and, therefore, cannot be corrected. Others, however, may be caused by correctable factors and require investigative and corrective actions. This research develops a simple and easy-to-follow procedure for obtaining and updating reliable probability estimates from available cost reports, so that a decision rule can be developed to minimize total cost.

Publication: Shu S. Liao, "Contract Cost Overrun Audit Strategy: A Bayesian Approach," under review for publication in Naval Research Logistics Quarterly.

Title: The First Years Out Study--Career Transitions: Facilitating Recruit Adaptation

Investigator: M. R. Louis, Assistant Professor

Sponsor: The Research Board, The University of Illinois, Urbana-Champaign and the NPS Foundation Research Program

Objective: This study is a part of a continuing research program, the overall aims of which are to expand our understandings of the characteristics of career transitions, and cognitive and behavioral processes by which individuals cope with transitions, organizational practices which could facilitate transitions of individuals into unfamiliar organizational setting.

Summary: Thus far, the research program has resulted in the formulation of: a theoretical model of the cognitive processes by which individuals cope with transition experiences, a conceptual framework distinguishing among features of transition experiences, i.e., 'surprise', 'contrast', and 'change'; typology of career transition situations, to aid in analyzing particular transition situations and integrating research transition settings.

Future work will aim at empirically assessing and refining each of the above.

Publications: Career Transitions: Varieties and Commonalities. To appear in Entering Unfamiliar Organizational Settings. To appear in Administrative Science Quarterly.

Conference Presentations: A Framework of Redesigning Organizational Entry Practices. Presented at the ORSA/TIMS meetings, Los Angeles, California, November, 1978.



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**Students Discussing Model Simulation Project — Research  
for Administrative Sciences Department**

Title: Development of a Local Material Distribution Plan

Investigator: Alan W. McMasters, Associate Professor of Operations Research and Administrative Sciences

Sponsor: Naval Supply Center, Oakland

Objective: To develop a general material distribution plan for local area support by a large wholesale activity which can then be applied to the three Naval Supply Centers mentioned below.

Summary: The Navy is in the process of implementing a recommendation of the DOD Material Distribution System (DODMDS) Study that the management and administration of wholesale supply operation of the Naval Air Stations be merged with the Naval Supply Centers at Oakland, San Diego and Norfolk. Further, this action results in a direct support relationship between the NARF and NSC Oakland. NSC Oakland will then support three industrial activities in the Bay Area: NARF Alameda, NSY Mare Island, and PWC San Francisco. This consolidation provides opportunity to develop a new local material distribution plan which will greatly improve supply support to all Bay Area customers.

The procedure consists of the following four phases: Material Characteristics Sensitivity Analysis; Material Flow Analysis; Stock Positioning/Material Distribution Algorithm; and Production Support Inventories

During the past year the following progress was made:

From the demand history file at NSC Oakland 174 local customers have been identified and their geographic locations have been determined. During the year between Julian dates 7244 and 8243 these customers submitted 643,260 requisitions, 341,354 of these covering 83,670 National Stock Numbered items were shipped via the Bay Area Local Delivery

system (BALD). The number of local delivery requisitions, both daily and annual, have been determined for each customer (UIC) and have been further subdivided by COG and by priority class.

Investigations are also well underway to determine the existing modes of delivery and related costs from NSC to the two major industrial activities, NSY Mare Island and NARF Alameda, and from NAS Alameda to NARF Alameda.

A preliminary model was formulated which presents a trade-off between shipping costs and delay costs. In support of this model, an attempt was made to quantify the costs of material delays to NARF Alameda.

This next year, completion of phases one and two are expected. Additional alternatives will be investigated for phase four. A complete formulation of the model needed in phase three is expected as well as conduct of parametric analyses of the trade-offs between time standards and distribution costs for NSY, Mare Island, and NARF Alameda.

Theses  
Directed:

Angelopoulos, Gary J., "Impact of U.S. Naval Vessel Movements within the San Francisco Bay Area on Naval Supply Center Oakland's Transportation System." Master's Thesis, September, 1979.

Boyt, G. R., "A Decision Model and Data Collection Guide for Planning Change in Material Distribution Systems." Master's Thesis, December, 1978.

Grant, Charles W., "The Effect of Material Shortages on Production at the Naval Air Rework Facility, Alameda." Master's Thesis, September, 1979.

Hoffman, Lee D., "Operational Support Inventory for Naval Air Rework Facility, Alameda." Master's Thesis, September, 1979.

Nelson, N. B., III, "A Container Stuffing Algorithm for Rectangular Solid when Voids may be Required." Master's Thesis, September, 1979.

Title: Stock Migration from NAVELEX to SPCC

Investigator: Alan W. McMasters, Associate Professor of Operations Research and Administration Sciences

Sponsor: Naval Electronic Systems Command

Objective: This is a continuing research effort addressing the question of when inventory management of an item should be transferred from NAVELEX to SPCC.

Summary: In an attempt to identify parameters which would be useful in determining when an item could have its management logically transferred from NAVELEX to SPCC, the following steps have been taken over the past two years:

1. Determine the current way NAVELEX manages its repairables.
2. Determine the current way SPCC manages its repairables.
3. Compare inventory management techniques of NAVELEX and SPCC.
4. Determine the extent of current stock transfer activities between NAVELEX and SPCC.
5. Determine the role and influence of NAVMAT on stock migration.
6. Determine the current budget procedures covering the life-cycle of an electronic component.
7. Examine demand data to see if it suggests points in time for stock transfer.
8. Discuss problems of unstable electronic equipment with the engineers.
9. Determine ways to alleviate budget shortfalls for NAVELEX managed items.

The purpose in studying the budget problems was to attempt to eliminate their influence on stock migration deliberations. Steps 1 through 6 and 9 have been completed. Work continues on Steps 7 and 8. In this connection, a printout for each 2Z cog item showing ten years of demand history with demand categorized as planned, unplanned, and CASREPT was provided to NAVELEX for use in migration deliberations. Work this next year will attempt to compare installed populations to demand history to determine if failure rates can be computed. In addition, NAVELEX needs to have an orderly procedure developed in telling SPCC managers of 4G cog items when an item becomes obsolete. Existing NAVSUP and NAVELEX procedures will be studied to see what changes could be made which would result in such a procedure.

Theses  
Directed:

Gary D. Lynn, "Funding Considerations for Material Managed by the Naval Electronic Systems Command," Master's Thesis, June, 1979.

Title: Software Engineering, Software Maintainability

Investigator: N. F. Schneidewind

Sponsor: U.S. Navy, Trident, CCSMA, Newport, R.I. 02840

Objective: Identification of Software Engineering tools and methodologies which will improve software maintenance.

Summary: Unpublished report sent to sponsor which contained a review and critique of selected military software specifications and standards. Criteria for evaluating these standards were based on contemporary software specification, testing, documentation and maintenance techniques which are proposed in the literature, including those proposed by the Investigator.

Publications: N. F. Schneidewind, "Application of Program Graphs and Complexity Analysis to Software Development and Testing," IEEE Transactions on Reliability, August 1979, pp. 276-286.

N. F. Schneidewind and H-M. Hoffman, "An Experiment in Software Error Data Collection and Analysis," IEEE Transactions on Software Engineering, May 1979, pp. 276-286.

Conference Presentations: N. F. Schneidewind, "Software Metrics for Aiding Program Development and Debugging," AFIPS 1979 National Computer Conference Proceedings, pp. 989-994.

Theses Directed: Joe Harris, "Software Complexity and Costing," Master's Thesis, December 1979.

Fritz Petrie, "System and Software Specification Systems," Master's Thesis, (In progress).

Title: An Approach to Demand Theory Under Uncertainty

Investigator: George Thomas, Adjunct Professor of Administrative Sciences

Sponsor: NPS Foundation Research Program

Objective: Development of a theory to explain demand theory under uncertainty.

Summary: Recent articles have extended the traditional theory of the firm into a nondeterministic environment. Such extensions frequently involve the presence of a random variable in the demand function. The explicit incorporation of uncertainty into the model of the firm usually leads to a situation of demand-supply disequilibrium in the market place, e.g., expected excess demand is nonzero. The availability of the good becomes an important attribute in these markets. Such markets include public utilities, recreational parks, restaurants and airlines. This research: discusses the effect of such disequilibrium on consumer behavior; develops a more realistic model of consumer behavior under less than certain probability of delivery of the good; and applies the model to a market pricing problem.

Publication: Submission is in preparation.

**Title:** Aggregation of Enlisted Pay Grades and Service Ratings by Tasks Performed: Implications for Officer Subspecialty Aggregation

**Investigator:** Weitzman, R. A., Associate Professor of Administrative Science

**Sponsors:** Principal Deputy Assistant Secretary of the Navy (Manpower and Reserve Affairs) and Deputy Chief of Naval Operations (Manpower, Personnel, and Training)

**Objective:** To aggregate jobs within an organization by the application of multi-dimensional scaling and hierarchical cluster analysis to task-performance data

**Summary:** The analysis produced a two-dimensional map showing clusters of enlisted pay grades and service ratings for electronic technicians; assignment data obtained for officers will make possible a similar analysis for officer billets.

**Publications:** Weitzman, R. A., "Aggregation of enlisted pay grades and service ratings by tasks performed: Implications for officer subspecialty aggregation." Technical report NPS 54-78-008, Naval Postgraduate School, Monterey, California, December 1978 (23 pages).

**Conference Presentations:** Weitzman, R. A., "Use of multi-dimensional scanning and hierarchical cluster analysis to aggregate jobs within an organization." Paper presented at October 1979 ORSA/TIMS Joint National Meeting (Cited in ORSA/TIMS Bulletin, No. 8, October 15, and 17, 1979).

Title: Estimation of Continuation Fractions for Small Service-rating and Subspecialty Groups

Investigator: R. A. Weitzman, Associate Professor of Administrative Science

Sponsors: Principal Deputy Assistant Secretary of the Navy (Manpower, Personnel, and Training)

Objective: To develop a method for obtaining reliable estimates of continuation fractions for small specialized-work groups

Summary: A Bayesian estimation method was developed to estimate continuation fractions or other criterion proportions reliably for groups of any size defined by an organization chart.

Publications: A technical report and journal article describing and illustrating this research are currently under preparation.

Title: Officer Retention as a Function of Commission Source and First and Second Duty Assignments

Investigators: R. A. Weitzman, Associate Professor of Administrative Science and D. W. Robertson

Sponsor: Navy Personnel Research and Development Laboratory

Summary: Three retention estimation models were developed and applied to officer data to show continuation fractions for all three-element patterns of commission source and first and second duty assignments; the model assuming predictor-variable independence within retention groups proved best.

Publications: Weitzman, R. A., and Robertson, D. W. "Naval Officer Retention as a Function of Commission Source and First and Second Duty Assignments: An Evaluation of three Evaluation of Three Estimation Models." Technical Report NPS 54-79-006, Naval Postgraduate School, Monterey, California September 1979 (33 pages).

Title: Test Bias

Investigator: R. A. Weitzman, Associate Professor of Administrative Sciences

Sponsor: None

Objective: To develop methods for measuring test bias and constructing unbiased tests of aptitude and achievement.

Summary: Formulas were developed to measure test bias and assess the cost in validity reduction to be expected from the construction of unbiased tests.

Publications: Weitzman, R. A., "Bias-free Selection: Better cutting scores or better tests?" Journal of Educational Measurement (under review).

Conference Presentation: Weitzman, R. A. "Test Bias, Overprediction, and Validity." Psychological Bulletin (under review).

Wietzman, R. A., "Bias-Free Selection: Better cutting scores or better tests?" Technical report, NPS 54-78-006, Naval Postgraduate School, Monterey, California, November 1978 (27 pages).

Weitzman, R. A., "Test Bias and Overprediction." Technical Report NPS 54-79-005, Naval Postgraduate School, Monterey, California, July 1979 (28 pages).

Weitzman, R. A., "The Problem of Overprediction." Paper presented at June 1979 Annual Meeting of the Psychometric Society.

Title: The Test of  $H_0$  in Psychology

Investigator: R. A. Weitzman, Associate Professor of Administrative Science

Objective: To document the weaknesses of the traditional test of  $H_0$  in psychology and to develop new and stronger testing procedures

Summary: Numerous weaknesses due to the test of  $H_0$  in a study cited in the literature for its methodological excellence were pointed out and two new and stronger tests, one classical and one Bayesian, were developed and illustrated.

Publications: Weitzman, R. A., "The Test of  $H_0$  in Psychology." Psychological Bulletin (under review).

Weitzman, R. A., "The Test of  $H_0$  in Psychology. Technical Report NPS 54-79-015, Naval Postgraduate School, Monterey, California, November 1979 (33 pages).

Title: Cost Per Beneficiary as a Performance Measure

Investigators: David Whipple, Associate Professor of Economics and Systems Analysis; George Thomas, Adjunct Professor of Economics; Kathy Kocher, Adjunct Professor of Economics

Sponsor: None

Objective: To estimate the average yearly cost to deliver health care to a member of the Navy's eligible population by facility and/or region, adjusted for population and health care facility characteristics.

Summary: The military health services system (MHSS) has traditionally based planning and budgeting on its historical workload data. Such a basis has been criticized as: being unable to identify unmet needs; tending to promote continuance of past practice; being easy to manipulate; and, lacking of prescriptive qualities. In contrast, a system based on cost per beneficiary: focuses on meeting the population's needs; can promote efficiency by ranking facilities on the basis of adjusted relative cost per beneficiary; is less subject to perverse manipulation; and can be prescriptive. This study estimates the cost per beneficiary of the MHSS at the facility level. Cost and population estimates were gathered for each continental United States inpatient facility for FY '76. Both total and capitated costs were derived, where the latter were those dependent on the population. The current methodology for estimating population was described and analyzed. Cost, population estimates, and costs per beneficiary were aggregated to regional, service, and tri-service totals. Refinements based on further data analysis continue.

Publications: W. G. Brown and M. J. Roman, "Estimation of Average Cost Per Beneficiary in the Military Health Service System", Master's Thesis, March 1978.

Title: Naval Officer Career and Quality of Life Study

Investigators: David Whipple, Associate Professor of Administrative Sciences and C. B. Derr, Associate Professor of Management, University of Utah

Sponsor: Office of Naval Research

Objective: To derive policy implications for retention and productivity management of the Officer corps of career choice determinants and the quality of life.

Summary: This was the final year of a three-year study. The research was designed, data collected, and analysis begun in the first two years. The following reports have been prepared based on the analysis. The approach was that of the structured interview which elicited those elements which seem to contribute most significantly to career choice decisions by members of the Officer corps.

Publications: "Some Career Development Issues which Relate to Naval Officer Retention," C. Brooklyn Derr, Tech Report No. NPS 54-80-01, January, 1980.

"Junior Officer Retention: Another Perspective," C. Brooklyn Derr, Tech Report No. NPS 54-80-02, January, 1980.

"Career/Organizational Politics: A Model Applied to U.S. Naval Officers," C. Brooklyn Derr, Tech Report No. 54-79-014, October, 1979.

"More on Career Anchor Concepts: The Case of U.S. Naval Officers," C. Brooklyn Derr, Tech Report No. NPS 54-79-007, September, 1979.

"Career Switching and Career Strategies Among U.S. Naval Officers," C. Brooklyn Derr, Tech Report No. NPS 54-79-004, July, 1979.

"Marriage/Family Issues and Wife Styles  
Across Naval Officer Career Stages: Their  
Implications for Career Success," C. Brooklyn  
Derr, Tech Report No. NPS 54-79-003, July,  
1979.

Title: Navy Health Care Systems: Professional/Paraprofessional Personnel Mix Study

Investigators: David Whipple, Associate Professor of Economics and Systems Analysis; Reuben Harris, Associate Professor of Organizational Behavior and Management; George Thomas, Adjunct Professor of Economics; Kathy Kocher, Adjunct Professor of Economics; Larry Caviola, Assistant Professor of Operation's Research; William B. Giaugue, Associate Professor of Decision Sciences, Brigham Young University; and Richard Scheffler, Associate Professor of Economics, George Washington University.

Sponsor: Chief of Naval Operations, Office of Systems Analysis, For the Office of Assistant Secretary of the Navy (MRA&L)

Objective: Develop a methodology for use at the facility (hospital) level in determining the appropriate mix of physician and non-physician providers (NPP) to staff specified clinics.

Summary: The present utilization and cost problems of NPP's in the civilian and military health care sectors were identified and analyzed. The tasks underlying the present peacetime staffing requirement of the Navy's health care system were identified and analyzed and a draft methodology developed. Structured field contact will be undertaken to indicate areas in need of modification. The draft methodology will then be refined and expanded to include a complete implementation strategy, tailored to the Navy's particular needs. The project is scheduled for completion in June, 1980.

Publications: "Non-Physician Providers in the Military Health Care Delivery System", Bryan Colfack and David Whipple, Working Paper #1, April, 1979.

"Non-Physician Providers: A Review of Their Costs and Monetary Benefits", Bryan Colfack and David Whipple, Working Paper #2, April 1979.

"Non-Physician Providers: A Review of Their Utilization and Staffing," Bobby Gene Clark and David Whipple, Working Paper #3, September, 1979.

"An Analysis of Present Patterns of Non-Physician Provider (NPP) Usage in the Military Health Care System", William C. Giaque and David Whipple, Working Paper 4, October, 1979.

## DEPARTMENT OF OPERATIONS RESEARCH

Operations Research is a multi-disciplinary field, a fact which is reflected by the variety of areas covered by the sponsored research of the faculty. The topics can be grouped into broad areas of basic research in the techniques of operations research and its applications to military problems. The techniques are mathematical programming and stochastic modeling. The applications areas are combat models, manpower and personnel, resource allocation, and command, control and communication.

### MATHEMATICAL PROGRAMMING

Mathematical programming represents the major optimization tool of operations research and the Naval Postgraduate School contributes to the profession through its basic research in the area.

Joint research by Professor Gordon Bradley of Computer Science and Professor Gerald Brown of Operations Research, sponsored by the Office of Naval Research, has led to the further development of extremely fast mathematical programming codes which exploit the special structure of certain optimization problems. Professor Brown has completed work on several material distribution applications.

### STOCHASTIC MODELING/STATISTICS

The other major approach in Operations Research is probabilistic model-building and statistical analysis. Many faculty contribute to this area.

Professor Donald Gaver, under National Science Foundation, ONR and Defense Communications Agency funding, has continued development of several models using a diffusion approximation technique for communications systems, computer systems, and for systems involving maintenance and repair. Professor James Esary has continued his studies in reliability. Professor Harold Larson and Professor Donald Barr have continued analysis of spectrometric data from oil analysis under sponsorship of the DOD.

Professor Peter Lewis derived properties for new stochastic point processes and time series models. In addition new methods for stimulating a broad class of stochastic point processes have been discovered. This work was supported by ONR and the National Science Foundation and resulted in three

publications and twenty-two presentations this year. He also continues work in simulation analysis, particularly development of a revision to the LLRANDOM generator. Professor Patricia Jacobs has been funded by the National Science Foundation for work in related areas.

#### COMBAT MODELS

The application of operations research to the development and employment of weapons reflects both the origin of the profession and the special role of the Naval Postgraduate School in the field.

Professors Sam Parry, Jim Hartman and Ed Kelleher have developed a computer simulation model for tank-anti-tank warfare for the Training and Doctrine Command. This model is now being used for studies supporting current decisions. Professor James Taylor has continued his fundamental studies of warfare via Lanchester-type differential equations including six papers published on work supported by ONR and the Army Research Office. On this topic a monograph has been completed and published by the Military Applications Section of the Operations Research Society.

Professor Neagle Forrest has directed the Strategic Systems Project Office research program at the Naval Postgraduate School for several years. In addition, he has produced additional programmable calculator models for magnetic anomaly detection. In a similar area, Professor Rex Shudde has been developing routines for hand-held computers for use on board P-3 aircraft for the ASW Pacific Patrol Squadrons.

Professor Alan Washburn and Professor Bryce Tysver have done work for the Naval Torpedo Station in range studies. Professor Washburn also continued his studies of search and evaluation.

#### MANPOWER AND PERSONNEL

The major cost of the U.S. military is for personnel. Planning and analysis of the personnel system is, therefore, of considerable interest. Professor Kneale Marshall and Professor Paul Milch are developing an interactive model of the Naval officer system for policy analysis and manpower/personnel planning. This is a cooperative research project between the Operations Research and Administrative Sciences departments.

## RESOURCE ALLOCATION

Many of the tools of operations research are applicable to the question of how to allocate resources in the military.

Professor Michael Sovereign has participated with Professor Jones of the Administrative Sciences Department in the ONR supported study of the government-contractor relationship. Professor Sovereign also serves as a reviewer for a major Navy study of ship maintenance. He and Professor Hartman reviewed an Army combat and surveillance model.

## COMMAND, CONTROL AND COMMUNICATIONS

Command, control and communications (C<sup>3</sup>) problems are a uniquely difficult problem for military organizations. Research in this area supports the new C<sup>3</sup> curriculum at the Naval Postgraduate School. Professors Gary Poock and Russell Richards have participated in design of experiments for the ARPA-funded Advanced Architectural Test Bed (ACCAT) project. Professor Poock has begun experiments in voice input of data.



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**Students Collecting Data on Human Auditory Capabilities**

Title: HP-67 Program Development and Support

Investigators: Alvin F. Andrus, Associate Professor of Operations Research and Statistics Rex H. Shudde, Associate Professor of Operations Research

Sponsor: Office of Naval Research, Code 230 and COMPATWINGSPAC

Objective: Provide HP-67 program development and support to COMPATWINGSPAC for the Tactical Development and Evaluation Program for the P-3 aircraft. Specific programs for tactical application will be developed, tested, documented and provided to COMPATWINGSPAC for application and inclusion in the Fleet-mission library.

Summary: Research is still in progress and will be completed in April 1980. Current research involves developing methodology for converting LORAN-C navigation procedures to an HP-67 program. No significant accomplishments have been completed. Future work will continue on LORAN-C fixing and NATOPS cockpit/aircraft performance programs.

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Title: Effectiveness of Advertising and Promotions

Investigator: James K. Arima, Associate Professor of Operations Research and Behavioral Science

Sponsor: Navy Personnel Research and Development Laboratory

Objective: Develop methods and measures for evaluating the effectiveness of Navy advertising and promotions for recruiting

Summary: The project was concluded with the publication of a technical report.

**Title:** Identification and Assessment of Individual Differences in Cognitive Ability and Intelligence

**Investigators:** James K. Arima, Associate Professor of Operations Research and Behavioral Science

**Sponsor:** None

**Objective:** To achieve an understanding of individual intelligence and cognitive ability and to measure them in a culture-fair way with the ultimate objective of enlarging the pool of selectees for military service and providing better quality recruits.

**Summary:** A prototype performance test of learning ability using nonverbal materials had been given a trial at the Navy Recruit Training Center, San Diego. Results showed that the test was highly reliable and practical to administer. It was only modestly correlated with the AFQT (Armed Forces Qualification Test) score for white subjects, but not nonwhite. White and nonwhite scores on the prototype test appeared to disappear in a self-paced mode. Because of the promising results, a better physical packaging of the test was accomplished using a high-quality, commercial, portable teaching machine. Students at four high schools in Monterey County who had taken part in the DOD High School Testing Program were used as subjects in a trial of the improved test. This sample was unselected (as the recruit sample had been) and it also included women. Moreover, scores for each subject were obtainable for the entire Armed Services Vocational Aptitude Battery (ASVAB). The subjects could also be classified on a white-nonwhite dimension. Results suggested that the performance test was even easier to administer now and just as reliable. Comparison with the ASVAB indicated that the test was measuring to a large extent the same general intelligence factor that is a ubiquitous feature of the ASVAB. It appeared to be a better measure of that factor for nonwhite persons and those scoring low on the AFQT. Since the ASVAB is not

scored for general intelligence, these findings have important implications for current service selection procedures.

**Publications:** A NPS technical report is in process.

**Conference Presentations:** The project is scheduled for presentation at the Sixth Annual Meeting of the Military Testing Association, San Diego, California, in October 1979 and at the XXIInd International Congress of Psychology in Leipzig, GDR in July 1980.

Title: Research in Officer Manpower and Personnel Planning

Investigators: James K. Arima, Associated Professor of Operations Research and Behavioral Science; Paul M. Carrick, Associate Professor of Management; Ronald A. Weitzman, Associate Professor of Psychology; Michael G. Sovereign, Professor of Operations Research; Kneale T. Marshall, Professor of Operations Research; Paul R. Milch, Associate Professor of Operations Research and Statistics; Richard C. Grinold, Professor, Operations Research Center and Graduate School of Business, University of California, Berkeley; Robert E. Stanford, School of Business, Auburn University.

Sponsors: Principal Deputy Assistant Secretary of the Navy (Manpower and Reserve Affairs); Deputy Chief of Naval Operations (Manpower Personnel Training)

Objective: Develop a dynamic, interactive computer model of the Navy's officer corps that can be exercised for manpower/personnel planning and the evaluation of policy; conduct research and study efforts to support the modelling.

Summary: The main thrust of the program has been the development of a prototype, interactive flow model of the Navy's URL surface officer community. The model uses billets-at-sea as the requirement driving the system and "at sea" tour positions as the flow points through which individuals must pass as they age in the system. The flow and continuation rates through the system are, at present, obtained from an existing Navy personnel/manpower model. This prototype model has been implemented on a commercial time-sharing computer system that can be accessed by telephone line. Work has continued in refining and modelling the tour paths of the model. A prototype, transient model was in development during the summer to examine the relationship between sea and shore billets as an initial step in the process of including shore billets in the overall model. Other efforts have included an examination of

constraints in the U.S. Code with respect to the management of officers, application of an existing algorithm to cluster shore billets for management purposes, career paths for women URL officers, and an examination of factual flow rates through different paths. A survey to assess the perceptions of officers regarding the billets they are receiving and the procedures for determining their assignments was given a try-out preparatory to its implementation on a Navywide basis.

Theses  
Directed:

Jimmy W. Parker, A Study of Surface Warfare Junior Officer Retention, MS in Operations Research, September 1979.

Michael J. Panchura, Jr., U.S. Naval Officer Perceptions of Billet Assignments and the Placement/Assignment Process, MS in Management, June 1979.

George R. Parish, III, The Relation of Naval Officer Promotion to Commission Source and Billet History, MS in Management, June 1979.

Title: Statistical Procedures for the Joint Analysis Program

Investigators: Donald R. Barr, Professor of Operations Research, Toke Jayachandran, Associate Professor of Mathematics and Harold J. Larson, Professor of Operations Research

Sponsor: JOAP-TSC, NARF, Pensacola, FL

Objective: The joint oil analysis program is a tri-service standardized program to monitor the wear condition (of aircraft engines, etc.,) through the use of spectrometric oil analysis. The analysis measures the amount of wear metals in lubricating fluids and provides any indication of unusual wear. The accuracy of such an analysis is dependent on the daily spectrometer calibration routine; the oil standard used for calibration; and the quality of the electrodes used. In an earlier project, statistical techniques to ensure that the quality of the electrodes and standard samples meet minimum requirements and the calibration routines are followed accurately were developed. The objective of the project is to perform the appropriate modification of the procedures for automatic computer implementation.

Summary: The required computer codes have been developed, the input and output specifications were defined; the program has been debugged and the total package has been delivered to the sponsors.

Publications: A final report describing the research effort is under preparation.

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A SUMMARY OF THE NAVAL POSTGRADUATE SCHOOL RESEARCH PROGRAM. (U)

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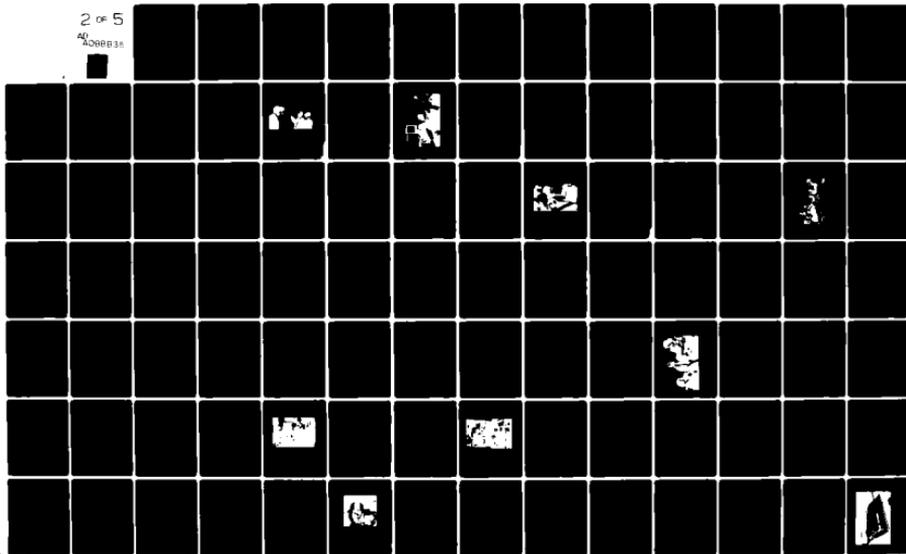
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**Title:** Statistical Analysis for the Joint Oil Analysis

**Investigators:** Donald R. Barr, Professor of Operations Research and Statistics  
Harold J. Larson, Professor of Operations Research and Statistics  
Toke Jayachandran, Associate Professor of Mathematics

**Sponsor:** Naval Air Rework Facility, Pensacola, FL

**Objective:** Continuation of development of statistical analysis procedures for the Joint Oil Analysis Program; implementation of a laboratory certification procedure.

**Summary:** A computer program in COBOL was developed for use at Kelly AFB, Texas, for use in the Tri-services oil analysis laboratory certification process.

**Publication:** Letter report to TSC, Pensacola, FL

**Conference Presentation:** Significance Level Interrelationships 10<sup>th</sup> International Biometrics Conference

**Thesis Directed:** D. Hatcher, "Accuracy and Repeatability Indices for Joint Oil Analysis Program Data," Master's Thesis, September, 1979.

**Title:** Statistical Analysis for the TPQ-27 Program

**Investigators:** Donald R. Barr, Professor of Operations Research and F. Russell Richards, Associate Professor of Operations Research

**Sponsor:** Naval Electronics Systems Command

**Objective:** To analyze data obtained from the PSVT test of the AN/TPQ-27 system so as to provide information concerning the performance of the system under varying drop conditions including speed, altitude, and bomb rack position. To determine the significance of these factors on system accuracy.

**Summary:** PSVT data were analyzed and the performance of the system was assessed. The contribution of major factors to bombing accuracy was ascertained.

**Publications:** D. R. Barr and F. R. Richards, "MK 82 Bomb Ejection Sensitivity Test Report," NPS Technical Report NPS55-79-02, February, 1979.

**Title:** Statistical Procedures for Certification of Spectrometric Laboratories in the Joint Oil Analysis Program

**Investigators:** Donald R. Barr, Professor of Operations Research and Statistics; Toke Jayachandran, Associate Professor of Mathematics; Harold J. Larson, Professor of Operations Research and Statistics

**Sponsor:** SA-ALC/MMETP, Kelly AFB, TX

**Objective:** Develop a program in COBOL to be installed on the Kelly AFB 360-65 computer to implement a previously derived certification program.

**Summary:** Program is completed and installed. We expect funding this year to examine failed engine data to suggest optimal sampling intervals and to provide detailed instructions for the implementation of any suggested techniques.

**Publications:** Paper under development on significance level interrelationships.

**Conference Presentation:** H. J. Larson, D. R. Barr, and T. Jayachandran, Significance Level Interrelationships, Conferencia Internacional de Biometria, Guaruja, SP, Brasil, 6-10 Agosto 1979.

**Theses Directed:** D. C. Hatcher, "Accuracy and Repeatability Indices for Joint Oil Analysis Program Data," MS in Operations Research, September 1979, with D. R. Barr.

Title: ASW Localization

Investigator: R. Neagle Forrest, Professor of Operations Research

Sponsor: Defense Nuclear Agency

Objective: To investigate the ASW localization effectiveness of nonacoustic sensors.

Summary: A localization model has been developed. The model can be used to determine numerical values for several measures of localization effectiveness, and this has been done for an airborne magnetic anomaly detection system.

Publications: R. N. Forrest, "The Localizaton Effectiveness of MAD," NPS Technical Report NPS55-79-026, November 1979.

**Title:** FBM Vulnerability and Effectiveness Studies

**Investigator:** R. Neagle Forrest, Professor of Operations Research and Alan R. Washburn, Associate Professor of Operations Research

**Sponsor:** Strategic Systems Project Office

**Objective:** To develop models for evaluating FBM vulnerability and effectiveness.

**Summary:** A model for assessing the localization information associated with submarine spoor and a model for estimating the detectability of submarine spoor have been developed.

**Publications:** R. N. Forrest, "Spoor Identification and Submarine Localization."  
R. N. Forrest, "A Submarine Spoor Detection Model."

**Title:** Research and Development on the Role of Information in Wargames

**Investigators:** Donald P. Gaver, Professor of Operations Research and John M. Wozencraft, Professor of Electrical Engineering

**Objective:** To study the impact of information on command and control decision making.

**Summary:** Analytical and numerical models were constructed to exhibit the influence of information on the progress of combat. The equations are a modification of Lanchester's.

Two manual wargames (Pegasus and First Battle) were carefully scrutinized with the objective of understanding what decisions need to be made when, and on the basis of what information, during the course of a land battle.

Preliminary research was undertaken aimed at devising a suitable objective function/measure of effectiveness for quantitative evaluation of the results of a wargame. This is essential in order that one be able to effectively analyze the impact of an ADP system on battle outcome.

**Publications:** Research report in progress.

**Conference Presentations:** D. P. Gaver, "Modeling the influence of information on the progress of combat," Joint MIT/ONR Conference on Command and Control, Naval Postgraduate School, August 1979.

J. M. Wozencraft, "Objective functions for wargames," Joint MIT/ONR Conference, Naval Postgraduate School, August 1979.

**Theses Directed:** D. Nicolosi, Jr., "A Framework for an Interactive, Computer-Supported, Battalion-Level War Game," MS in Command and Control, June 1979.

K. Tonguc, "Modeling the Effect of Information on Conflict Outcome," MS in Operations Research, September 1979.

Title: Models for Complex Systems

Investigator: Patricia A. Jacobs, Associate Professor of Operations Research

Sponsor: National Science Foundation, Engineering Division, Systems Analysis and Operations Research Program.

Objective: To study probabilistic models for complex systems arising in such areas as reliability, inventory, queueing, and time series.

Summary: This grant is a reissuance of a previous NSF grant from Stanford University to the Naval Postgraduate School. The research has progressed in several areas. The investigation of parametrically simple models for dependent sequences of random variables is being pursued. Situations represented by such models include the sequence of access path lengths in a data base system, the number of vehicles in moderately congested traffic crossing a fixed point on a road during consecutive time intervals of fixed length, and the sequence of daily maximum pollutant levels measured at a recording station. The use of dependent sequences of random variables as parts of larger models such as queueing models is being investigated. Models for structural loading are also being studied.

Publications: P. A. Jacobs, "A Cyclic Queueing Network with Dependent Exponential Service Times," Journal of Applied Probability, Vol. 15, 1978, pp. 573-589.

D. P. Gaver and P. A. Jacobs, "Non-homogeneously Paced Random Records and Associated Extremal Processes," Journal of Applied Probability, 15, 1978, pp. 552-559.

D. P. Gaver and P. A. Jacobs, "Storage Problems when Demand is All or Nothing," National Science Foundation, NPS55-79-07, March 1979.

P. A. Jacobs, "Heavy Traffic Results for Single Server Queues with Dependent (EARMA) Service and Interarrival Times," National Science Foundation, NPS55-79-09, April 1979.

Conference

Presentations:

D. P. Gaver, P. A. Jacobs, T. Vessey, "Storage Systems with All or Nothing Demand," ORSA/TIMS Joint National Meeting, Los Angeles, 13-15 November 1978.

P. A. Jacobs, "Queues with Interarrival and Service Times," ORSA/TIMS Joint National Meeting, Los Angeles, 13-15 November 1978.

P. A. Jacobs, "Random Load Processes," ORSA/TIMS Joint National Meeting, New Orleans, LA, 30 April - 2 May 1979.

P. A. Jacobs, "Discrete Time Series Generated by Mixtures," 24<sup>th</sup> International Meeting of the Inst. of Management Sciences, Honolulu, HI, 18-22 June 1979.

P. A. Jacobs, Random Loads, "Stochastic Processes and Their Applications - 9<sup>th</sup>," Evanston, IL, 6-10 August 1979.

Title: Enhancements to LLRANDCOM II Random Number Generation Package

Investigator: Peter A. W. Lewis, Professor of Statistics and Operations Research

Sponsor: NPS Foundation Research Program

Objective: To investigate the latest Gamma random number generators for inclusion in the LLRANDOM II package and to finish coding the package in such a way as to facilitate use of new multipliers without new programming effort.

Summary: The initial object of this work was to make available a fast and reliable package for generating common random variables such as normal, exponential, Cauchy, Gamma, Geometric and Poisson. The two-parameter Gamma family of random variables is particularly difficult to simulate efficiently and the new routines coded into LLRANDOM II were found to be less efficient than the routines in LLRANDOM I. Thus, a further investigation was undertaken and the enhanced LLRANDOM II package incorporates the newest and simplest Gamma variate generators, which we have shown to be a considerable improvement over previous generators.

The enhanced LLRANDOM II package also has the capability of producing arrays of sorted variates (uniform, exponential, Gamma, Cauchy, etc.) and a simple way of choosing from either the old multiplier (16807) from LLRANDOM I and new multiplier (397204094). The new multiplier significantly slows down the generation process, but generates random numbers which have better statistical properties than those generated with the old multiplier if the sequences are not shuffled.

Publications: Two manuals for LLRANDOM II are in the final stages of preparation.

Title: Stochastic Analysis (Part I)

Investigators: Peter A. W. Lewis, Professor of Statistics and Operations Research and Donald P. Gaver, Professor of Operations Research

Sponsor: Office of Naval Research

Objective: To develop models for the analysis of stochastic point processes and time series and to develop new statistical methodology for use in simulations which are required in mathematical statistics and in the analysis of stochastic systems.

Summary: Several models have been developed over the last few years for sequences of positive random variables, in particular those having exponential marginal distributions. These schemes have been considerably extended to a class of two-parameter NEAR (1) exponential autoregressive processes and another scheme for generating processes with mixed exponential marginals has been found. These processes will be helpful not only in modeling point processes, but also in modeling stochastic systems in general.

In simulation a method for generating non-homogeneous Poisson processes by thinning of a dominating Poisson process has been extended to the simulation of a broad class of conditional Poisson processes. These include doubly stochastic Poisson processes, self-exciting processes and renewal processes. Nonstationary cases are included.

Publications: P. A. W. Lewis, "Simple models for positive-valued and discrete-valued time series with ARMA correlation structure," Proceedings of Fifth International Symposium on Multivariate Analysis, North Holland: Amsterdam, 151-166, 1979.

P. A. W. Lewis and G. S. Shedler, "Simulation of nonhomogeneous Poisson processes with logquadratic rate function," J. Operations Research Society, 27, 5, 1026-1040, 1979.

P. A. W. Lewis and G. S. Shedler, "Simulation of nonhomogeneous Poisson processes by thinning," Naval Research Logistics Quarterly, 26, 3, 403-413, 1979.

A. J. Lawrance and P. A. W. Lewis, "The exponential autoregressive-moving average process EARMA (p,q.)," to appear in J. Roy. Stat. Soc., 1980.

D. P. Gaver and P. A. W. Lewis, "First order autoregressive Gamma sequences and point processes," to appear in Advances In Applied Probability, 1980.

Title: NPS Support for the R&D Function of the Development Center

Investigator: Glenn F. Lindsay, Associate Professor of Operations Research

Sponsor: U.S. Marine Corps Development Center

Objective: NPS Support for the Development Center.

Summary: A continuation of the program of general technical support for the Development Center together with specific activities aimed at increasing the use of operations research and modern R&D managerial techniques at the Development Center.

Title: Color Coding in Airborne Tactical Display Systems in the S-3A

Investigator: Douglas E. Neil, Assistant Professor of Operations Research

Sponsor: Naval Air Development Center

Objective: Determine what the possible advantages/disadvantages of color displays are in terms of application to airborne tactical display systems. In addition, identify gaps in the literature in terms of the system(s) of interest.

Summary: Research effort consisted of an examination of existing color display research in an attempt to determine current "state of the art" in color display design. Once accomplished, an examination of tactical weapon system displays was conducted to determine applicability of research to the specific problem area. Recommendations are made as to gaps and potential advantages/disadvantages of the incorporation of color in the S-3A.

Publications: D. E. Neil, "Application of Color in Tactical Display System Aboard the S-3A," NPS Technical Report. In progress.

Thesis Directed: H. C. Conner, "Application of Color in Airborne Tactical Displays."

**Title:** Development of a Mid-Resolution Combined Arms Combat Model and Analysis of Model Results

**Investigators:** Samuel H. Parry, Associate Professor of Operations Research and James K. Hartman, Associate Professor of Operations Research and Administrative Sciences

**Sponsor:** U.S. Army Training and Doctrine Command Fort Monroe, VA 23651

**Objective:** To develop a combined arms combat model to support the XM1 105/120 mm Stowed Load Study and to initiate development of extended models.

**Summary:** A significant requirement exists in the Army for a land combat model capable of representing combat at any hierarchical level required. Currently many models exist, but there is very little capability to use these models in tandem because of their independent development. This research project represents a continuing effort to develop a hierarchy of Combined Arms Combat Models. During the current research period, a battalion ground combat model was completed and approximately 300 production runs made in support of the XM 105/120 mm Stowed Load Study. Subsequent to those runs, the air/air defense module was completed and run as an integral part of the air/ground module. In addition, significant progress was made in the areas of target selection and dynamic route selection modules. An ammunition and fuel resupply module was developed, as well as a Communication/Electronic Warfare module. Research was initiated in the development of a second echelon network model external to the Simulation of Tactical Alternatives (STAR) Brigade Model. Finally, research has been conducted to directly represent various aspects of C<sup>3</sup> in both STAR and the Second Echelon Model. This project is continuing and an increased level of effort to continue development of those areas described above and to initiate new research into such areas as smoke, limited visibility, NBC Warfare, variable aggregation in STAR and manual interaction with the computer simulation through use of computer graphics.

**Conference**

**Presentations:**

S. H. Parry, E. P. Kelleher, W. S. Wallace, and E. G. Hagewood, "STAR: The Combat Model for Analysis of XM-1 Stowed Load Configurations," 17th Army Operations Research Symposium, Fort Lee, VA, November 1978.

S. H. Parry and J. R. Kelley, "Ammunition Transport Capability in Support of a Combat Unit," 17th Army Operations Research Symposium, Fort Lee, VA, November 1978.

S. H. Parry and E. P. Kelleher, "Simulation of the Tactical Employment of Field Artillery," 17th Army Operations Research Symposium, Fort Lee, VA, November 1978.

S. H. Parry and W. B. Meiers, "STAR: Simulation of Tactical Alternative Responses," 1978 Winter Simulation Conference, Miami Beach, FL, 4-6 December 1978.

S. H. Parry and W. Cladwell, "STAR: A Brigade Model for Land Combat Analysis," 1979 Summer Simulation Conference, Toronto, Canada, June 1979.

S. H. Parry and E. P. Kelleher, "STAR: A High Resolution Land Combat Simulation Model," Military Operations Research Symposium, West Point, NY.

**Publications:**

S. H. Parry and E. P. Kelleher, "Tactical Parameters and Input Requirements for the Ground Component of the STAR Combat Model," NPS55-79-023, October 1979.

**Theses**

**Directed:**

E. G. Hagewood and W. S. Wallace, "Simulation of Tactical Alternative Responses (STAR)," MS in Operations Research, December 1978.

G. S. Coker and D. R. Forinash, "System Analysis for the Interactive Simulation with Graphical Displays to Support Simulation of Tactical Alternative Responses (STAR)," MS in Computer Science, March 1979.

G. J. Broussard, "A Dynamic Study of Factors Impacting on the Tank Commander's Target Selection Process," MS in Operations Research, March 1979.

J. S. Kramer, "Simulation of Dynamic Tactical Route Selection with Application in the STAR Model," MS in Operations Research, March 1979.

G. Clifford and M. Nelson-Palmer, "C<sup>3</sup> Overlay to the STAR Combat Model," MS in C<sup>3</sup>, March 1979.

W. D. Meiers and W. C. Caldwell, "An Air-to-Ground and Ground-to-Air Combined Arms Combat Simulation (STAR-Air)," MS in Operations Research, September 1979.



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**Members of the STAR Research Team Selecting Defensive Positions**

Title: Experimentation Methodologies for the ACCAT and the NPS RSM

Investigator: Gary K. Poock, Professor of Operations Research and Man-Machine Systems

Sponsor: Naval Ocean Systems Center

Objective: To provide consultation and initial operating demos for the Advanced Command and Control Architectural Testbed (ACCAT) at NOSC and NPS.

Summary: Initial demonstrations have been developed and are currently operational in the NPS remote site module (RSM). These use the facilities of the NOSC testbed and the NPS RSM. There should be several demonstrations of production rule systems available for the RSM when it becomes operational in the fall of 1979.

Theses Directed: Mark Smith, "An Application of Rule Directed Interactive Transaction Agent for the Automated Technical Control of the Defense Communications System," MS in C<sup>3</sup>, June 1979.

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Professor Gary Pöock Talking to Computer Using Voice Recognition Equipment

Title: Asymptotic Efficiency of Point Estimators

Investigator: Robert R. Read, Professor of Operations Research, Probability and Statistics

Sponsor: None

Objectives: Development of Systematic methods to choose estimating equations and to characterize the multivariate efficiency of the resulting estimators.

Summary: This is a continuing project and has been reported over the last two years. The work on the negative binomial distribution has been submitted for publication. Some work on the Neyman Type A distribution is reported in LT Bishop's thesis.

Publications: R. R. Read, "General Characterizations," Journal of American Statistical Association, decision pending.

R. R. Read, "Estimation of Negative Binomial Parameters," Technometrics, decision pending.

Thesis Directed: H. R. Bishop, "The Use of the Empirical Probability Generating Function to Estimate the Neyman Type A Distribution Parameters," MS in Operations Research, September 1979.

Conference Presentation: R. R. Read, "Efficient Estimation of Negative Binomial Parameters," 166th Meeting of the Institute of Math Statistics, New Orleans, 9-11 April 1979.

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**Title:** Ranking and Selection Procedures

**Investigator:** Robert R. Read, Professor of Operations Research, Probability and Statistics

**Sponsor:** None

**Objectives:** Development and Comparison of ranking and selection procedures for data that consist of objects ranked by judges.

**Summary:** This project began with the methods developed to choose the recipient of the award for excellence in teaching. These methods are being compared with those used to rank the papers in Technometrics and select the recipients of the Wilcoxon and Yondan awards.

**Publications:** R. R. Read, "Data Analysis of the Teaching Award Ballots," NPS55-79-013, July 1979.

**Title:** COSAL Support Based on Operational Availability

**Investigators:** F. Russell Richards, Associate Professor of Operations and James D. Esary, Professor of Operations Research

**Sponsor:** Naval Supply Systems Command

**Objectives:** To explore the issues concerned with using equipment operational availability as a decision criterion for the determination of shipboard allowance lists.

**Summary:** The research has focused primarily on two areas. The first is the basic issue of alternative operational definitions of system availability. The second is the determination of the operational availability of a complex system as a function of the availabilities of its components when there are only finitely many spares for support of those components. Various operating scenarios have been considered.

**Presentations:** Results of the research will be presented at a special joint meeting of the Reliability/Maintainability and Logistics Working Groups at the 44th MORS meeting.

**Thesis:** Kil Ju Park, LT, Korean Navy, "Experimental Availability Tables for Finite Spares Backlogs," MS in Operations Research, March 1979.

**Title:** Aerospace Industry

**Investigators:** Michael G. Sovereign, Professor of Operations Research, Carl R. Jones, Professor of Administrative Sciences and Toke Jayachandran, Associate Professor of Mathematics

**Sponsor:** Office of Naval Research

**Objective:** Extend previous government-contractor behavior modeling to a data base to be developed on the aerospace industry.

**Summary:** Theoretical model development has progressed considerably with the two papers listed below. The empirical examination of the aerospace industry was slowed by nonavailability of personnel but a report is in progress.

**Publication:** John D. Finnerty, "A Two-State Model of the Weapons Procurement Process," to appear as NCAR publication.

**Conference Presentation:** C. R. Jones and K. C. Sontheimer, "Government as Customer and Regulator: The Bilateral Monopoly Case," Western Economics Association meeting, June 1979.

**Title:** Maintenance System Development

**Investigators:** Michael G. Sovereign, Professor of Operations Research and James D. Esary, Professor of Operations Research and Statistics

**Sponsor:** Naval Sea Systems Command, PMS-306

**Objective:** Provide an outside monitoring of the technical reports of the Maintenance System Development Program (MSDP).

**Summary:** This is a continuation of the review of the work done for PMS-306 by a number of contractors participating in the MSDP, a five-year, multi-million dollar effort to improve the maintenance of the Navy's surface ships. The investigator serves on the three technical panels monitoring the work.

**Publications:** More than ten reviews have been prepared for the project manager. A number of meetings of technical panels and contractors have also been attended. Some of the technical difficulties noted during the preparation of these reviews have influenced a presentation on the concept of operational availability to be given to a special joint meeting of the Reliability/Maintainability and Logistics Working Groups at the 44th MORS meeting.

Title: Navy Center for Acquisition Research

Investigator: Michael G. Sovereign, Professor of Operations Research

Sponsor: Office of Naval Research

Objective: Serve as a support organization to the Navy acquisition research element

Summary: In May 1978 the Charter of the ONR-NAVMAT Acquisition Research Council was approved by the Secretariat, which included the Navy Center for Acquisition Research at NPS as a support organization. The acting director participated in developing the Navy Acquisition Research Plan arrangements for a full-time staff which are now underway.

Publications: J. M. Fremgen and Shu S. Liao, Regulation of Naval Shipbuilding, Working Paper 79-1, January 1979, Forward by M. G. Sovereign.

Conference Presentations: M. G. Sovereign, "Improvements in Cost Estimating - The Decade of the '70's," 14th Annual DOD Cost Research Symposium, Washington, D.C., 28 September 1979.

D. V. Lamm, Presentation to San Francisco Chapter of National Contract Management Association on Acquisition Policy.

Title: Review of COMWTH II Model

Investigators: Michael G. Sovereign, Professor of Operations Research and James K. Hartman, Associate Professor of Operations Research and Administrative Sciences.

Sponsor: U.S. Army Mobility Equipment R&D Command Fort Belvoir, VA

Objective: Perform an evaluation of the COMWTH II model methodology for current and planned uses by MERADCOM.

Summary: COMWTH II is a simulation model of indirect fire including target acquisition, weapons assignment, and weapon lethality. It is used by MERADCOM for analyzing the contribution of camouflage to survival of U.S. high value targets in rear battle areas. The research concentrated on the COMWTH II methodology and its application to MERADCOM's camouflage program, as well as some proposed additional uses. Primary findings included: a streamlined version of the model methodology seems adequate for the camouflage design program; some weak areas in the methodology were identified which make its extension to more comprehensive scenarios dubious; and the model needs documentation and a systematic configuration and data base control system.

Publications: A letter report has been submitted.

Title: Optimization of Combat Dynamics

Investigator: James G. Taylor, Professor of Operations Research

Sponsor: U.S. Army Research Office, Mathematics Division

Objective: To extend the state of the art for the quantitative determination and analysis of optimal time-sequential combat strategies in scenarios of tactical interest. Consideration to be given to extension of evaluation methodologies, problem formulation, combat-modeling methodologies, and/or optimization theory as required by specific time-sequential tactical allocation problems. Also, methodology for the analysis of existing combat models to be developed for the quantitative analysis of strategy and tactics.

Summary: Progress was made in two broad areas: 1) obtaining insights into the dynamics of combat by studying relatively simple Lanchester-type force-on-force combat models; and 2) investigating optimal time-sequential tactical decisions with such simple models. Research emphasis, though, has been on the first topic, mainly because it is in some sense a prerequisite for the second (optimizing tactical decisions). Research efforts have focused on analyzing simplified versions of combat models currently used by the U.S. Army. In particular, recent work has investigated victory-prediction conditions that allow one to predict battle outcome (without having to explicitly compute battle trajectories) and to explicitly relate the initial force ratio and weapon-system-capability parameters to battle outcome. "Simple approximate" conditions that are sufficient (but not necessary) to predict battle outcome were developed for two different basic combat models (variable-coefficient Lanchester-type equations both for modern warfare and also for area fire) and for two different important battle-termination-mechanism models (fixed-force-level-breakpoint battles and also fixed-force-ratio-breakpoint battles).

These new results allow one to quickly and easily compute force ratios that guarantee victory under various different circumstances of tactical interest. Upper and lower bounds on the length of battle for these two basic combat models were also developed. Consideration has also been given to strategies for analyzing and explaining complex operational models in terms of simplified auxiliary models.

Publications:

J. G. Taylor and G. G. Brown, "Numerical Determination of the Parity-Condition Parameter for Lanchester-Type Equations of Modern Warfare," Computers & Operations Research, 5, 227-242, 1978.

J. G. Taylor, "Overview of a Lanchester-Type Aggregated-Force Model of Conventional Large-Scale Ground Combat," Proceedings of the 17th Annual U.S. Army Operations Research Symposium, Fort Lee, VA, 551-562, 1978.

J. G. Taylor, "Recent Developments in the Lanchester Theory of Combat," Proceedings of the 8th IFORS International Conference on Operational Research, K. B. Haley (Editor), North-Holland, Amsterdam, 773-806, 1979.

J. G. Taylor, "Attrition Modeling," Operations-Analytische Spiele fur die Verteidigung, R. K. Huber, K. Niemyer and H. W. Hofmann (Editors), Oldenbourg, Munchen, 139-189, 1979.

J. G. Taylor, "Optimal Commitment of Forces in Some Lanchester-Type Combat Models," Operations Research, 27, 96-114, 1979.

J. G. Taylor, "Prediction of Zero Points of Solutions to Lanchester-Type Differential Combat Equations for Modern Warfare," Siam Journal on Applied Mathematics, 36, 438-456, 1979.

J. G. Taylor, "Some Simple Victory-Prediction Conditions for Lanchester-Type Combat Between Two Homogeneous Forces with Supporting Fires," Naval Research Logistics Quarterly, 26, 365-375, 1979.

CONFERENCE

PRESENTATIONS:

J. G. Taylor, "Overview of a Lanchester-Type Aggregated-Forces Model of Conventional Large-Scale Ground Combat," 17th Annual U.S. Army Operations Research Symposium (AORS XVII), Fort Lee, VA, 8 November 1978.

J. G. Taylor, "A Lanchester-Type Aggregated-Force Model of Conventional Ground Combat," ORSA/TIMS Joint National Meeting, Los Angeles, CA, 13 November 1978.

J. G. Taylor, "Force-Annihilation Prediction Conditions for Lanchester-Type Equations of Modern Warfare," TIMS/ORSA Joint National Meeting, New Orleans, LA 30 April 1979.

Thesis

Directed:

J. Smoler, "An Operational Lanchester-Type Model of Small-Unit Land Combat," MS in Operations Research, September 1979.

Title: Quantitative Analysis of Air-War Strategies for Use in Air-Armaments Planning

Investigators: James G. Taylor, Professor of Operations Research and Reiner K. Huber, Professor of Applied Systems Science, Hochschule der Bundeswehr, Munchen

Sponsor: NPS Foundation Research Program

Objective: To develop quantitative methodology (including computational algorithms and computer programs) for determining optimal air-war allocation strategies in long-range planning situations. In this initial phase, to formulate the attendant operational models to support this general goal. Also, to improve the scientific bases for such operational models (development of a theory of combat).

Summary: The research program was pursued on several fronts. Feasible evaluation methodology was established by reviewing previously developed air-campaign models that internally allocate air-combat resources to missions (in particular, optimization models) and other relevant contemporary force-on-force combat models. Based on such a comprehensive review of the combat-modeling state of the art, an operational model, the Tactical Air War Analysis Game (TAWAG), was designed and steps initiated for its implementation as a computer program on a large-scale digital computer. Also, both investigators help organize and participated in a theory-of-combat workshop, in which the scientific underpinnings of such operational combat models were critically reviewed.

Publications: J. G. Taylor, "Attrition Modeling," Operations-Analytische Spiele fur die Verteidigung, R. K. Huber, K. Niemeyer and H. W. Hofmann (Editors), Oldenbourg, Munchen, pp 139-189, 1979.

J. G. Taylor, "Some Simple Victory-Prediction Conditions for Lanchester-Type Combat Between Two Homogeneous Forces with Supporting Fires," Naval Research Logistics Quarterly, 26, pp. 365-375, 1979.

R. K. Huber, L. J. Low and J. G. Taylor, "Some Thoughts on Developing a Theory of Combat," Technical Report NPS55-79-014, July, 1979.

R. K. Huber and J. C. Taylor, "On an Analytical Game to Assess Long-Range Air Armaments Policy Options (TAWAG)," in preparation.

Conference  
Presentation:

R. K. Huber, "Approximating a Theory of Combat," DNA/NPS Theory of Combat Workshop, Monterey, California, 10 July 1979.

J. G. Taylor, "A Review of Some Previous Attempts to Establish a Theory of Combat," DNA/NPS Theory of Combat Workshop, Monterey, California, 10 July 1979.

Thesis  
Directed:

C. C. Chon, "Methodology for Evaluation of Air Armaments Planning," Master's Thesis, March, 1979.

S. L. Shupack, "An Examination of the Conceptual Basis of the Attrition Processes in the Institute for Defense Analyses Ground-Air Model (IDAGAM)," Master's Thesis, March, 1979.

R. W. Szmczak, "Transferability of Combat Models: Limitations Imposed by Documentation Practices," Master's Thesis, September, 1979.

F. F. Von Fabek, "A Conceptualization of Fire Superiority for Greater Reality and Credibility of Combat Models," Master's Thesis, September, 1979.

Title: Instrumental Range Studies--Torpedo Path Estimation

Investigator: J. Bryce Tysver, Associate Professor :  
Operations Research

Sponsor: Naval Undersea Warfare Engineering Station,  
Keyport, Washington

Objective: Combine development of theory and algorithms  
to improve existing track smoothing program  
in use at NUWES.

Summary: The research program has continued on three  
sub-tasks with effort devoted primarily to  
the first. They are as follows:

The use of sequential differences to identify and locate outlier data points in data on torpedo and target data was explored. Tentative thresholds were selected for distinguishing outlier causing disturbances from noise and variations in actual torpedo and target paths. The methodology was applied to data from a torpedo path collected at NUWES and demonstrated its ability to detect outliers.

This effort was directed toward reduction in the computational requirements of track smoothing. The least-squares method of fitting polynomials to torpedo path data is amenable to simultaneous computation of the quality of fit (as indicated by the residual fitting errors) by polynomials of several orders. This facilitates the selection of the appropriate order of polynomial to fit any segment of the torpedo path. Reduction in computational requirements can also be achieved by use of general monitoring except for point or segments of the path of special interest. Combination of the above techniques can result in a reduction of computational requirements by a factor of ten or more. This sub-task has not been completed.

The geometry of the torpedo and its target (in particular, the miss distance) in the vicinity of intercept is of particular

interest. Methods for extracting this information from the data and presenting it needs exploration and development. This sub-task has received only slight consideration and requires further effort.

Publications: J. B. Tysver, "Use of Sequential Differences in Smoothing 3-D Data," NPS55-79-012PR.

Title: Validation of Formula for Probability of Detecting a Retiring Target

Investigator: Alan R. Washburn, Associate Professor of Operations Research

Sponsor: Department of the Navy

Objective: Validation of formula for probability of detecting a retiring target.

Summary: A searcher arrives at an old target position at time  $\tau$  after the target has been there, and searches at speed  $v$  and sweep width  $2R$  for a time  $t$ . In the meantime, the target maneuvers at speed  $U$  in an attempt to avoid detection. A formula for probability of detection based on the random search assumption can easily be derived. This research is an attempt to validate the formula by enlisting many pairs of officer-students to repeatedly play an electronic simulation of the game. Results so far indicate that the formula is slightly high; research is continuing.



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**Students Validating Theoretical Results Concerning Search for Moving Targets.  
Research Conducted by  
Associate Professor Alan Washburn, of the Operations Research Department.**

Title: Minimum Delay Routing of  $C^3$  Computer Networks  
Using Adaptive Distributed Algorithms

Investigator: Jin Y. Yen, Adjunct Professor of Operations  
Research

Sponsor: NPS Foundation Research Program

Objective: To develop adaptive distributed algorithms  
for minimizing delays in  $C^3$  computer net-  
works.

Summary: The purpose of this research project was to  
develop efficient adaptive distributed algo-  
rithms for minimizing delay in routing  $C^3$   
computer networks. The first stage of the  
project developed some adaptive distributed  
shortest path algorithms which were used as  
subroutines for solving minimum delay routing  
in  $C^3$  computer networks. The first stage of  
the project developed some adaptive distri-  
buted shortest path algorithms which were  
used as subroutines for solving minimum delay  
routing in  $C^3$  computer networks. Efficient  
adaptive shortest path algorithms were  
developed for this purpose. The advantage of  
these algorithms are that they are up to  $N$   
times more efficient than other available  
algorithms, where  $N$  is the number of nodes  
in the network.

Publications: Yen, Jin U., "A decentralized algorithm for  
finding the shortest paths in defense commun-  
ications networks," NPS55-79-015, July, 1979.

Yen, Jin Y., "Distributed shortest path  
algorithms for computer networks," NPS55-  
79-017, July 1979.

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## DEPARTMENT OF NATIONAL SECURITY AFFAIRS

The research program of the Department of National Security Affairs has continued along several main lines: (1) politico military analysis with a focus on particular geographic areas, (2) perceptions and perception management, (3) analysis of Soviet military exercises, (4) net assessment, (5) operational test and evaluation, and (6) maritime theater nuclear warfare.

### REGIONAL POLITICO MILITARY ANALYSIS

Work focused on Western Europe has continued to emphasize understanding the character and evolution of European Communist parties and their influence on the viability of the NATO Alliance. With regard to the Soviet Union, the primary emphasis has been on the role of the Soviet Union in the third world, with particular emphasis on the relationship between the Soviet Union and Cuba as it relates to Soviet use of Cuban proxies in the Horn of Africa and Angola.

In the Middle East, research has focused on the analysis of Arab political elites through the use of biographical data.

### PERCEPTIONS AND PERCEPTION MANAGEMENT

The Department has, for a number of years, engaged in original research on methods for measuring third-country perceptions of the U.S.-Soviet military balance and identifying the principal causes of change in those perceptions. Arising out of this work, we have deception in international relations, negotiations, and war. The Department is currently managing a substantial interdisciplinary research effort in this area which we expect to continue over the next few years.

### ANALYSIS OF SOVIET MILITARY EXERCISES

The Department continues to examine trends in Soviet military exercises and to develop techniques for relating exercises to each other. Soviet exercises play an important role, together with major procurement decisions and doctrinal writings in interpreting Soviet military strategy and intentions.

### NET ASSESSMENT

There are two main efforts in this area: continuing analysis of the Soviet-U.S. strategic balance and an analysis

of the military balance in southern Africa, which was completed during the year.

#### OPERATIONAL TEST AND EVALUATION

Based on prior research conducted at NPS on the effectiveness of aircraft against tanks in World War II, the Department has been engaged in a major program of test and evaluation of the A-10 aircraft against tanks and other FEBA targets.

#### MARITIME THEATER NUCLEAR WARFARE

The Department was involved in an extensive review of U.S. naval capabilities to operate effectively in a nuclear environment. This review included analyses of U.S. nuclear policy and the Navy's role in it; all-source intelligence on Soviet doctrine and capabilities for nuclear war at sea; battle group formations and nuclear ASW and AAW; ship and weapon system hardening; new offensive and defensive technologies for nuclear warfare at sea; and personnel education, training and readiness for nuclear war.



National Security Affairs Students Discussing Eastern Studies in Asian Seminar Room

Title: Bilingualism and Biculturalism in the Canadian Armed Forces

Principle: Lt Col David P. Burke, USAF, Assistant Professor of Political Science

Sponsor: None

Objective: To determine the effects of the policy of bilingualism and biculturalism on the Canadian Armed Forces.

Summary: This project is a study of some effects of the official languages and policies of the Canadian Armed Forces and the Canadian Government as a whole. The Armed Forces are often pointed out as the most successful case of the promotion of bilingualism and biculturalism in the Canadian federal government. The evidence indicates that this is accurate, but that some policies that have been introduced in the Forces, especially as regards promotion policy and the creation of French Language units, have not worked and cannot do so without major revisions in recruitment patterns and personnel structures. At the same time, the policies of the Department of National Defense and of the Commissioner for Official Languages have come into greater and greater conflict.

Publications: David P. Burke, "Bilingualism and Biculturalism in the Canadian Armed Forces," paper presented at the biennial meeting of the Association for Canadian Studies in the United States, September 1979.

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Title: Development of a Man-Manual Game of Nuclear Planning and Nuclear War as a Heuristic Teaching Device at the Advanced University Level

Investigator: Lt Col David P. Burke, USAF, Assistant Professor of Political Science

Sponsor: None

Objective: To produce a heuristic game as a teaching device in the field of nuclear strategy.

Summary: This project, conducted in connection with course NS 3280 - Nuclear Weapons and Foreign Policy, has produced a man-manual simulation of planning, procurement and use of strategic offensive and defensive forces over a nine year period of game time. The simulation includes a crisis that may result in a nuclear war. The purpose of the game is to provide students with a heuristic experience to complement and enrich more traditional studies of nuclear policymaking.

Publication: David P. Burke, "Player's Manual of Rules and Procedures for the Half-SAFE Game." NPS Technical Report, to be published in early 1980.

Title: Romanian Defense Policy and the Warsaw Pact Threat

Investigator: Lt Col David P. Burke, Assistant Professor of Political Science

Sponsor: None

Objective: To determine the nature of Romanian defense policy and its implications for NATO and the Warsaw Pact.

Summary: This project is based upon an analysis of Romanian Defense policy based mainly on Romanian sources. It indicates that, far from being a component of the Warsaw Pact threat to NATO, the defense efforts of Romania since the 1968 invasion of Czechoslovakia, like that of the NATO countries, have been directed to the deterrence of an attack by the Soviet Union and Romania's other allies. Though this has been clear at least since 1972, it has not affected the assumption of a monolithic Warsaw Pact responsive to Soviet orders that underlies most US and NATO planning.

Publications: David P. Burke, "Strategy and Mass Mobilization in Romania: A Warsaw Pact Country Faces the Warsaw Pact Threat," paper presented at the Southwest Regional Conference of the Inter-University Seminar on Armed Forces and Society," at The Air University Maxwell AFB, AL, June 1979.

David P. Burke, "Defense and Mass Mobilization in Romania: A Warsaw Pact Country Faces the Warsaw Pact Threat," Armed Forces and Society, forthcoming 1980.

David P. Burke, "Romanian Defense Policy: A Communist Maverick and the Soviet Threat," in Douglas Murray and Paul Viotti, eds., Comparative Defense Policy, 2nd ed. (Baltimore: The Johns Hopkins University Press, forthcoming 1980).

Title: The Politics of Canadian Armed Forces Unification

Investigator: Lt Col David P. Burke, USAF, Assistant Professor of Political Science

Sponsor: None.

Objective: To determine why and how Canada chose to unify its armed forces as an illustration of Canadian decision-making.

Summary: In 1968 the Canadian government abolished the country's Army, Navy and Air Force and in their place created a single military service, the Canadian Armed Forces. This project is a case study and analysis of that decision concluding with a description of the effects of unification in the years since 1968. The results will be reported in a book now being revised for publication by the University of Toronto Press. Final revision has been delayed until 1980 to take account of the work of the Canadian government's Task Force on the Review of the Unification of the Canadian Armed Forces.

Title: Soviet Deception in the Cuban Missile Crisis

Investigator: Lt Col David P. Burke, USAF, Assistant Professor of Political Science

Sponsor: None.

Objective: To determine the extent and nature of Soviet deception on the Cuban Missile Crisis.

Summary: One of the major elements of the Cuban Missile Crisis was the belief by President Kennedy that he and his government had been deliberately deceived by the Soviets, and that such deception, linked to an attempt radically to alter the balance of power could not be tolerated. This study, based in part on access to newly opened papers at the John F. Kennedy Memorial Library, is an analysis of the degree and kind of Soviet deception practiced in the Cuban Missile Crisis. It reveals that the Soviets certainly lied, but that their deception was primitive and uncoordinated in comparison to the efforts of the Western Allies in World War II, and was ultimately unsuccessful. Furthermore, the degree of deception turns in part on one's understanding of what the Soviets and the Americans meant by "offensive weapons," a point of some apparent dispute even among the Soviet governing elite.

Publication: The results will be included in a technical report of five case studies to be published as part of the NPS Soviet Deception Project in early 1980.

Title: The United States and Korea: Background for Policy

Investigator: Claude A. Buss, Professor of National Security Affairs

Sponsor: None

Objective: Shed further light on US-Korea policy formulation in the past and to define more sharply the possible alternatives for the future.

Summary: To describe the growth, development and problems of the Republic of Korea (ROK), stressing the social changes, economic development, and political evolution of the ROK. Special attention is given to the military threat, the problem of reunification and the effects of the assassination of President Park.

To discuss American policies and commitments regarding the ROK, pointing out the American role in the creation of the ROK; US responsibilities under the armistice and subsequent agreements; the political, military and economic commitments of the US to the ROK; and the conflicting perceptions of those commitments.

To analyze the changing strategic environment in East Asia, as affected by the growing strength and influence of the USSR, changing attitudes in Japan, and the new trends in the policies of the PRC. Special attention is given to the problem of credibility.

To consider what changes, if any, might be appropriate in US-ROK relations, recognizing that the paramount consideration for the US must be its global confrontation with the USSR and for the ROK must be for its survival in the face of the military threat from the north. Within these parameters, alternatives are examined for the solution of such issues as troop withdrawal, modernization of the ROK armed forces, economic cross-purposes, and human rights. If my study underscores any

single point, it is the importance of stability in Northeast Asia and the maintenance of peace while seeking a new equilibrium of forces in East Asia and the Western Pacific.

Conference

Presentations:

Conducted two seminars for the Naval Aviation Institute's middle level managers, one at Princeton and one at Berkeley. Each was a week-long affair, and included experts from NPS faculty (Professors Teti, Looney and Said) as well as from other institutions.

Theses

Directed:

An Analysis of Selected Treaties of Friendship and Cooperation of the Union of Soviet Socialist Republics," LT Michael Lennon, USN.

"Cambodia and Chinese Vietnamese Relations," LT Luanne Smith, USN.

"Political Impact of the Overseas Chinese in West Malaysia Since 1965, Capt. Ronald Toms, USA.

"Arms Transfer to The Korean Peninsula, 1945-1979: Impact and Implications, Capt. Richard P. Cassidy, USA.

"China's Pedagogical War. China and Vietnam," LCDR Henry Carde, USN, and Maj. Edward Ross, USA.

**Title:** Naval Net Assessment Conference

**Investigator:** D. C. Daniel, Associate Professor of National Security Affairs

**Sponsor:** Navy Net Assessment Office

**Objective:** Hold a conference at the Naval Postgraduate School to discuss current naval net assessment issues.

**Summary:** A two-and-one-half day conference was held at the Naval Postgraduate School in January 1979. It dealt with issues of both substance and method in net assessment. A great deal of discussion centered about a case study of U.S. capability to defend its sea lines of communications against a Soviet attack.

Title: Political, Economic and Social Change in the People's Republic of China, 1976-80

Investigator: R. R. Garside, Professor, National Security Affairs

Sponsor: Signed contracts for publication of book with McGraw-Hill in the U.S. and Andre Deutsch in the UK, and both provided royalties.

Objective: To identify and explain the more important political, economic and social changes which have occurred in the People's Republic of China in the period 1976-80, in the form of a book which would convey the significance of the changes to a non-specialist reader, and also have some value to specialists who have not had the opportunity to follow developments in China as closely as I have from 1976 to 1980.

Summary: My three-year posting to Peking, 1976-79, as the First Secretary in the British Embassy charged with analysis and reporting of Chinese domestic politics gave me an excellent opportunity to study in some depth the official and unofficial publications appearing in China at that time, observe Chinese leaders in meetings with foreign leaders, talk with young activists in the movement for democracy and human rights and observe conditions in Peking and other parts of China. During my stay at this school, I have been able to continue to monitor the Chinese press, through the FBIS daily reports and the reports of foreign correspondents in China.

Based on this research, I have written a book which is a blend of narrative and analysis.

I begin by showing the tensions in Chinese society breaking to the surface on the death of Premier Zhou Enlai. I describe the stark terms in which the official Chinese press presented the "struggle between the bourgeois line and the proletarian line" which, it claimed, was manifesting itself again at that time. Through a brief review of the post-1949 career of Chairman Mao Zedong, I trace the actual course of the left-right struggle

inside the Communist Party of China in the years 1949-76, and demonstrate that before the death of Zhou Enlai his chosen successor, Deng Xiaoping, had indeed been preparing to launch a program of rightist reforms which would sweep away much of the policy-structure and many of the power-holders of Mao's last decade of the policy-structure and many of the power-holders of Mao's last decade (1966-76).

I then proceed to show how badly needed such reforms were. I describe the torpor and repression of life in China in 1976; this prepares the reader for the anger which the ordinary citizens showed in the spring of 1976 when the left first denigrated the memory of Zhou then denounced his chosen successor as a "capitalist-roader."

I give an eyewitness account of the demonstrations which took place in Peking in early April 1976, peaceful at first, then violent. I explain their meaning as a demonstration of loyalty to the political legacy of Zhou and of defiance of Mao and those of his followers who were later to become known as the Gang of Four. I show how this manifestation of popular will, which occurred in many other cities also at the same time, prepared the way for the arrest of the Four as soon as Mao died in September 1976.

I then trace the victorious struggle of the pragmatic reformers led by Deng Xiaoping to achieve dominance in the Party. I show the interaction between their action in the political superstructure and the action of ordinary citizens at the grass roots of society. I compare and contrast this with earlier political movements in 20th century China.

I identify the key political issues on which Deng and the reformers fought those who sought to uphold the infallibility of Mao and deny anyone the right to re-examine his policies: the need for material incentives, the participation of foreign capital in the development of the economy, a degree of

elitism in education and science, the freedom for artists and writers to depict the dark side of life under socialism, the introduction of a contract system for agricultural production which gives more incentives to the family unit, increased decisionmaking powers for economic enterprises, closer alignment of foreign policy with the West and Japan, opening the country to western cultural influences, and greater freedom of expression for the ordinary citizen, etc.

I examine the political tension between the young, who want western-style democracy and individual liberties--and want them now--and the conservative officials of the older generations, who fear losing power if such radical changes are made, and fear that the "socialism" they fought for will be swept away.

I show the tactical retreat that Deng and his followers have made in the face of conservative opposition to democracy and the rule of law, and point out that the reformers have kept the rest of their program moving steadily ahead.

I end by posing the question: how long can the young be held in check to humor the older conservatives?

The balance of the evidence and arguments I present tend to support the proposition that the West and Japan have a good opportunity to establish a long-term relationship with a China that will, with their cooperation, become a very valuable counterweight to the expansion of Soviet power.

**Publications:**

My typescript has been scheduled for publication, jointly by my two publishers, in October. I am now awaiting the outcome of scrutiny by the Foreign and Commonwealth Office.

Title: Syllabary of Command and Control Communications in the New Korean Language.

Investigator: Jurika, Stephen & Rhee, Suh. Editor and Project Officer, Jurika, Stephen.

Sponsor: National Security Affairs

Objective: In three stages, computerize for immediate translation from Korean to English some eight thousand words and phrases used in Command and Control of N. Korean armed forces.

Summary: Submitted to NSA in January, 1980.

Publications: S. Jurika, "From Pearl Harbor to Vietnam: The Memoirs of Admiral Arthur W. Radford," Stanford; Hoover Institution Press. 491 pages; illustrations, notes, index, and bibliography. For sale nationally April, 1980.

S. Jurika, "Reminiscences, Volume I," Annapolis, MD; U.S. Naval Institute Press, 1979. 581 pages, index. Volume II currently being indexed.

#### Theses

Directed: Lee, Alice, "Koreans in Japan: Their Influence on Korean-Japanese Relations," Master of Arts, September, 1979.

Hazlett, James A., "National Security and U.S. Naval Ocean Policy," Master of Arts, September, 1979.

Needham, Robert B., "The Philosophy of Force in Foreign Policy: A Theory of the Just War," Master of Arts, May, 1979.

Hayes, Bradd C., "The Invisible Blockade and the Covert War: U.S. Relations with Chile, 1970-1973," Master of Arts, June, 1979.

Carde, Freeland H., "The Making of Chinese Foreign Policy; Actors and Processors," Master of Arts, September, 1979.

Pierce, LDCR Paul G., "Impact Analysis of Possible Philippine Base Closure on the Capabilities of U.S. Naval Forces to Counter Soviet Naval Actions in the Western Pacific and Indian Oceans," Master of Arts, September, 1979.

**Title:** Effect of Islamic Culture on the Acceptance and Use of Western Cultural Items

**Investigator:** Ralph H. Magnus and John W. Amos, II

**Sponsor:** Office of Net Assessment, Department of Defense

**Objective:** To assess how Islamic cultural, social and educational systems either impede or assist in the acquisition of Western technology and associated skills.

**Summary:** Sponsorship has been obtained for the first phase of the project. In this phase we develop a general model of acculturation, using anthropological models, applicable to the situation of an Islamic acceptor and a Western donor culture.

**Publications:** Interim report on first phase to be completed in March 1980. Research to continue in the Spring Quarter by Professor Amos. Completed report due September 30, 1980.

Title: International Organizations and the Persian Gulf

Investigator: Ralph H. Magnus, Assistant Professor

Sponsor: International Regional Studies, Inc., 7200 Burtonwood Drive, Alexandria, VA 22307

Objective: To discuss the participation of the states of the Persian Gulf region in international organizations and the impact of these organizations on the international relations of the area.

Summary: The organizations are considered in five categories: Universal Organizations, such as the League of Nations and the United Nations and their specialized agencies; regional political/security organizations; regional economic organizations; petroleum organizations; and religious organizations. The most striking conclusion of this study is that there is no regional organization dealing with the Persian Gulf itself. Attempts to create such an organization have been made, these are evaluated, and the obstacles to their implementation are discussed.

Publications: "International Organizations and the Persian Gulf," contribution of The Persian Gulf States, edited by C. E. Bosworth, R. M. Burrell, A. J. Cottrell, K. S. McLachlan and R. M. Savory. The Johns Hopkins University Press, June 1980.

Title: Societies and Social Change in the Persian Gulf

Investigator: Ralph H. Magnus, Assistant Professor

Sponsor: International Regional Studies, Inc., 7200 Burtonwood Drive, Alexandria, VA 22307

Objective: To survey the processes of social change in the Persian Gulf states, identifying indigenous and external factors, and assess the current condition of these societies with regard to modernization.

Summary: The states of the Persian Gulf region, through a series of historical events, succeeded in maintaining their traditional social structures intact to a much greater degree than in other Middle Eastern states. Since the great development of the oil industry, however, these states have been undergoing social change at a much more rapid pace. Traditionalism remains powerful, and the processes of change are being directed by traditional elites in most of these states.

Publications: "Societies and Social Change in the Persian Gulf," contribution to The Persian Gulf States, edited by C. E. Bosworth, R. M. Burrell, A. J. Cottrell, K. S. McLachlan and R. M. Savory, The Johns Hopkins University Press, June 1980.

**Title:** Maritime Theater Nuclear Warfare

**Investigator:** Patrick J. Parker, Professor of National Security Affairs

**Sponsor:** Defense Nuclear Agency

**Objective:** Provide the Chief of Naval Operations with a comprehensive review of the Navy's preparedness for nuclear warfare.

**Summary:** This project includes six endeavors as follows:

A review of national nuclear policy and recommendations for changes in the Navy's role within it.

An all-source analysis of the Soviet views of and capabilities for maritime theater nuclear warfare and a comparison with U.S. doctrine and capabilities.

An analysis of present and programmed U.S. doctrine, forces, weapon systems and readiness for nuclear war at sea and projection of power ashore.

A review of new nuclear weapon technology with recommendations for Navy application.

A review of Naval programs for ship and weapon system hardening with recommendations for application to Navy programs.

A review of Navy education and training for nuclear war with recommendations for change.

**Publications:** Draft Navy policy on theater nuclear warfare. Report of the Maritime Theater Nuclear Warfare working group.

Title: Military Deception: A Multidisciplinary Perspective

Investigator: P. J. Parker plus eleven associate investigators (D. C. Daniel, Katherin Herbig, William Reese, Paul Moose, Ronald Sherwin, Theodore Sarbin, Richards Heuer, Frank Teti, John Amos, Jiri Valenta and David Burke).

Sponsor: Central Intelligence Agency

Objective: To investigate the nature of military deception and factors conditioning its use; identify problems associated with multidisciplinary research and to make related recommendations.

Summary: A group of investigators representing diverse academic disciplines wrote individual point papers on the nature of military deception and factors conditioning its use. The papers provided the basis for regular meetings intended to share and sharpen each other's insights on the topic. The papers are now in final revision and will shortly be submitted to the sponsor. In addition, one investigator, a specialist in organizational development, observed the interactions of the group. He documented the difficulties which group members had in working together and evaluated the procedures implemented to overcome them.

Publications: In addition to the reports to be delivered to the sponsor, this research has resulted in two conference papers to date: D. C. Daniel and Katherin Herbig, "Deception in Military Affairs: Proposition for Historical Analysis." Paper presented 18 September 1979 at conference on the History of Intelligence, University of Lund in Lund, Sweden.

D. C. Daniel, "Interdisciplinary Research on Deception: The NPS Approach." Paper presented 6 December 1979 at the 44th Symposium of the Military Operations Research Society, Vandenburg Air Force Base, California.

Title: Data Analysis and National Security Policy Making

Investigator: Ronald G. Sherwin, Assistant Professor of National Security Affairs

Sponsor: Cybernetics Technology Office, Defense Advanced Research Projects Agency

Objective: The objectives were to provide a computerized data base for monitoring international political affairs and to refine a set of techniques which may aid in crisis forecasting and to support ad hoc analyses for decision-making.

Summary: This was the final year of a joint effort involving NPS and other agencies from the research and academic communities. The research effort culminated in a set of monitoring and forecasting techniques designed to aid real time information processing and decision-making. The techniques have been transformed into a set of computer routines which currently support policy formation in the arena of international politics.

Publications: The Management and Analysis of Arms Transfers Information (S), with Lois Van Beers and Edward J. Laurance, U.S. Naval Postgraduate School Technical Report No. 56-09-002, 1 October 1978, 310 pp.

"Arms Transfers and Military Capability," with Edward J. Laurance, International Studies Quarterly, 23, 1 (September 1979), 360-389.

Thesis Directed: Schindler, Ralph L, "Development and Evaluation of Cross-Impact Analysis as a Crisis Decision-Aid," June, 1979.

Title: GAU-8 Armor Lethality Testing at Nellis AFB

Investigator: Russel H. S. Stolfi, Associate Professor of National Security Affairs

Sponsor: Armaments Directorate, A-10 System Program Office, Wright Patterson AFB, Ohio

Objective: To evaluate the performance of existing production lots of GAU-8 ammunition when fired from the air under operational conditions.

Summary of Results: Ammunition toward end of firing passes in tests involving the first simulated Soviet tank company disintegrated. Ammunition was redesigned to overcome the forces induced by the high stress of combat simulated firings.

Ammunition proved capable of perforating the sides of T-62 tanks and similarly armored main battle tanks.

Publications: Nine Naval Postgraduate School Technical Reports have been published or are in process of publication to record the results of the tests, e.g., R.H.S. Stolfi, et al., A-10 GAU-8 Low Angle Firings Versus Individual Soviet Tanks (February-March 1978), Naval Postgraduate School Report, August 1979, 73 pages, and eight other similar reports.

Title: German Disruption of Soviet Command, Control, and Communication in the Opening Stages of Barbarossa

Investigator: Russel H.S. Stolfi, Associate Professor of National Security Affairs

Sponsor: OSD, Director of Net Assessment

Objective: To recover the actual targets attacked by the Germans in the early weeks of Barbarossa and to assess the success<sup>3</sup> of the German attacks in disrupting Soviet C<sup>3</sup> within the framework of the general offensive.

Summary: The researchers to date have conducted interviews of German participants in Barbarossa and visited the German military archive and military research institute as part of the research effort to uncover the targets attacked by the Germans in Barbarossa and the success of the attacks in disrupting the Soviets. Findings at present are still tentative and in the process of being sorted out.

Title: Threat Forecasts

Investigator: R.H.S. Stolfi and P.C.C. Wang, Associate Professor of National Security Affairs

Sponsor: U.S. Navy, Director of Net Assessment

Objective: To produce threat forecasts of Soviet (1) naval air-to-surface missiles, (2) surface-to-surface missiles, (3) torpedoes (emphasis on antiship), and (4) electronic warfare (emphasis on deception).

Summary: Professors Stolfi and Wang are working with several teams of students to support the objective of producing threat forecasts. Hardware being examined includes specifically antiship torpedoes, electronic warfare, and ASW aircraft.

**Title:** U.S. Air Force Armored Target Arrays

**Investigator:** Russel H.S. Stolfi, Associate Professor

**Sponsor:** Armaments Directorate, A-10 System Program Office, Wright Patterson AFB, Ohio

**Objective:** To conduct realistic firings of the A-10/GAU-8 weapon system against tactical arrays of actual main battle tanks in order to test effectively the quality of existing lots of 30mm armor-piercing ammunition.

**Summary:** The ammunition has been shown to be effective as a damage agent in an exceptionally broad spectrum of launch parameters, i.e., dive angles, attack azimuths, ranges of engagement, etc.

**Publications:** A total of nine Naval Postgraduate School Reports, which describe the results of the firings, have either been published or are in an advanced state of completion.

Title: U.S. Air Force Kinetic Energy Gun Munitions

Investigator: Russel H.S. Stolfi, Associate Professor

Sponsor: Armament Directorate, A-10 System Program Office

Objective: To prepare high fidelity tank targets for attack by the A-10/GAU-8 weapon system and to assess the damage to those targets.

Summary: The target tanks have been realistically configured with diesel fuel, ammunition, crew mannikins, and lubricating oil and, as such, have given realistic damage results. The targets substantiate a view that the 30mm AP ammunition used in the tests is particularly effective in causing mobility and catastrophic kills to modern main battle tanks similar to M-47, M-48, M-60, T-55 and T-62 NATO and Warsaw Pact vehicles.

Publications: A total of nine Naval Postgraduate School Reports, which describe the results of the firings, have either been published or are in an advanced state of completion.

**Title:** Communist Countries and Africa

**Investigator:** Jiri Valenta, Assistant Professor of National Security Affairs

**Sponsor:** NPS Foundation Research Program

**Objective:** To assemble papers and edit an anthology which would assess the military involvement of Communist countries in Africa, a subject previously discussed in Valenta's article "Soviet-Cuban Intervention in Angola, 1978," Studies in Comparative Communism, Spring-Summer 1978. To convene a three-day conference on Communist countries and Africa at the Naval Postgraduate School on July 26-28, 1979, for the presentation of invited papers by leading national and international experts on the subject.

**Summary:** The conference fulfilled the stated objectives by bringing together the leading experts in this field, who delivered papers, and NPS students who are currently working on theses in this area and who helped with the organization of the conference. The principal investigator served as organizer of the conference and will be co-editor of its proceedings. Valenta wrote and presented a paper at the conference and chaired most of the conference sessions.

**Publications:** Valenta, J. and Albright, D., "Communist Countries and Africa," (eds.) (Bloomington: Indiana University Press, forthcoming, 1980). Contract has been signed.) Valenta's chapter "Communist Countries and the Horn of Africa," will be included in the book.

**Conference Presentations:** "Communist Countries and the Horn of Africa," NPS conference on the Communist Countries and Africa.

**Theses Directed:** W. A. Nurthen, "Soviet Strategy in the Red Sea Basin," Master's Thesis, March 1980.

LCDR Shannan Butler, "East German Foreign Policy in Africa, Interaction within the Warsaw Pact," Master's Thesis, June, 1980.

Title: Eurocommunism, Eastern Europe and the USSR

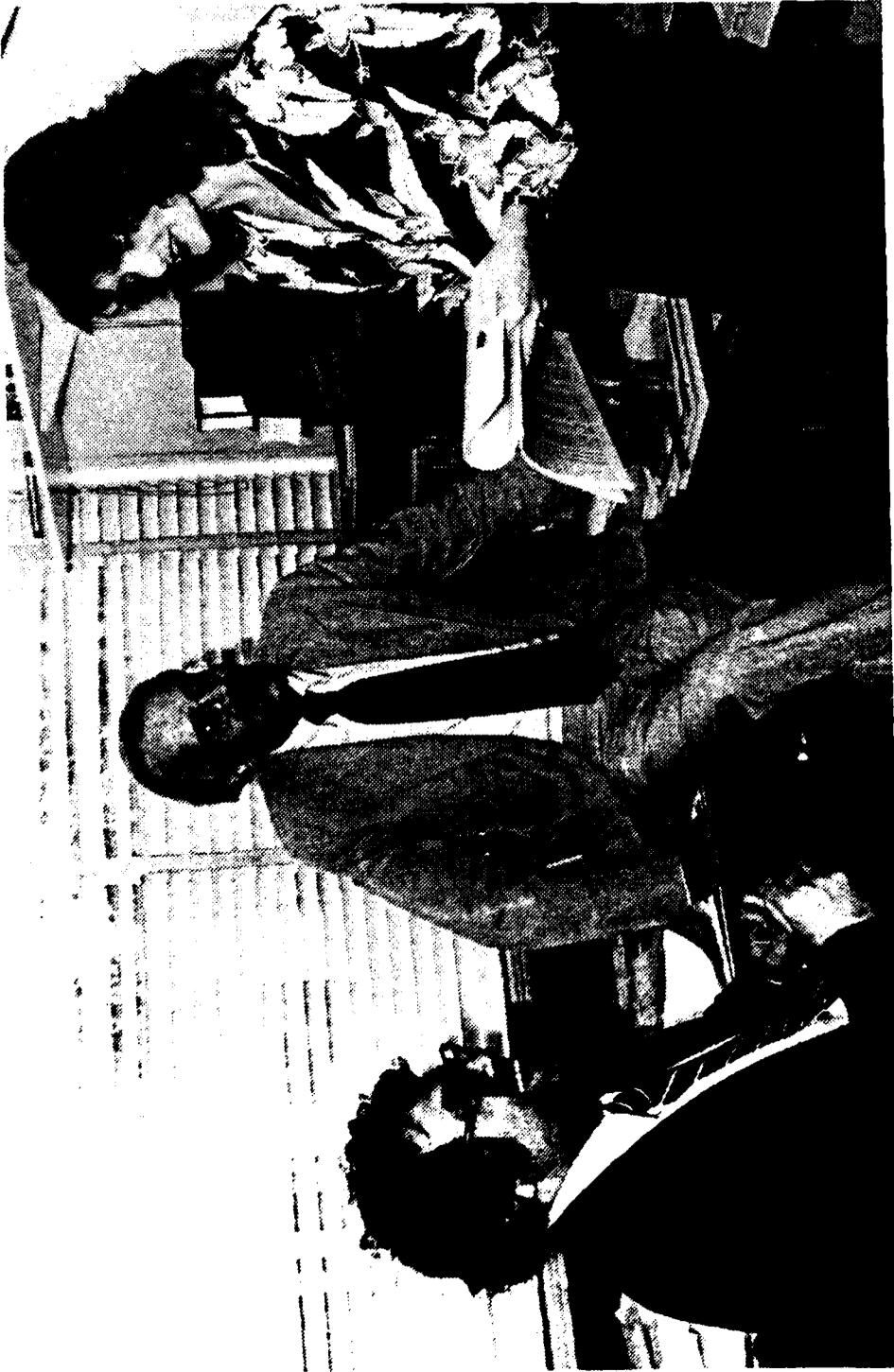
Investigators: Jiri Valenta, Assistant Professor of Political Science, and Lt Col David P. Burke, USAF, Assistant Professor of Political Science

Sponsor: None

Objective: To add to knowledge of the roots and significance of Eurocommunism.

Description: This project involved the conduct of the Naval Postgraduate School Conference on Eurocommunism, Eastern Europe and the USSR at NPS in August 1978 and the production of a book based upon papers presented at the conference and additional contributions commissioned after it. The development of the book extended into FY 1979 and FY 1980 with publication scheduled in the Summer of 1980.

Publication: Vernon Aspaturian, Jiri Valenta and David P. Burke, Eurocommunism between East and West (Bloomington, Ind.: Indiana University Press, forthcoming 1980).



Associate Professor Jiri Valenta, Dr. Walter Conner, (Foreign Service Institute, Department of State )  
and Research Assistant Mary Jett Hintze Discuss Soviet Intervention in Afghanistan.

Title: The USSR, Cuba and Africa

Investigator: Jiri Valenta

Sponsor: Foundation Research Program

Objective: To assess the Soviet and Cuban military intervention in Africa. This study is an outgrowth of an earlier research project on the Soviet-Cuban intervention in Angola which has been published in a scholarly journal and as part of an anthology.

Summary: The research for this paper relies extensively on Soviet, East European and African sources. The results indicate a new assertive pattern in Soviet and Cuban behavior characterized by military involvement in the Third World, in general, and in Africa in particular. The Soviet-Cuban intervention in Angola and Ethiopia came about as a trend. Other related factors were qualitative and quantitative improvement of Soviet sea-and air-lift capabilities, perfection of Soviet-Cuban military cooperation, Soviet strategic objectives in the Red Sea, accurate assessment of the U.S. response and pressures of Soviet domestic and bureaucratic politics. There is a remote likelihood that military intervention by the Soviets and Cubans (and lately the East Germans), if not countered, may be repeated in other strategically important areas of Africa: Namibia, South Rhodesia and elsewhere. This topic calls for further careful examination.

Publications: "Soviet-Cuban Intervention in Angola, 1975: Security Implications," U.S. Naval Institute Proceedings, April, 1980.

"Soviet-Cuban Intervention in Angola: Politics, Naval Power, Strategic Implications," S. Rosefielde (ed.), World Communism in Transition. (Boston: Martinus Nijhoff, May, 1980.)

Theses  
Directed: "East German Foreign Policy in Africa, Interaction within the Warsaw Pact," Shannan Butler, LCDR/USN, June, 1980.

Title: The USSR and the Somalian-Ethiopian Conflict

Investigator: Jiri Valenta, Assistant Professor and Coordinator of Soviet and East European Studies, Department of National Security Affairs

Sponsor: NPS Foundation Research Program

Objective: To assess the Soviet and Cuban military intervention in the Horn of Africa in 1977-1978. (This study is the outgrowth of an earlier research project on the Soviet-Cuban intervention in Angola, which has been published in a scholarly journal and as part of an anthology.)

Summary: The research for this paper, which relies extensively on Soviet, East European and African sources, was conducted with Captain Gary McGraw who is my student. The results indicate a new assertive pattern in Soviet and Cuban behavior characterized by military involvement in the Third World, in general, and in Africa in particular. The Soviet-Cuban intervention in Ethiopia came about as a result of this trend. Other related factors were qualitative and quantitative improvement of Soviet sea-and air-lift capabilities, perfection of Soviet-Cuban military cooperation, Soviet strategic objectives in the Red Sea, accurate assessment of the U.S. response and pressures of Soviet domestic and bureaucratic politics. There is a remote likelihood that military intervention by the Soviets and Cubans (and lately the East Germans), if not countered, may be repeated in other strategically important areas of Africa: Namibia, South Rhodesia and elsewhere. This topic calls for further careful examination by experts on the subject in the form of a conference.

Publication: "The Soviet-Cuban Military Intervention in the Horn of Africa," J. Valenta and G. McGraw in Communist Countries and Africa, Valenta, J. and Albright, D. (eds.) (Bloomington, Indiana University, 1980.)

## DEPARTMENT OF PHYSICS AND CHEMISTRY

During the year, members of the Department have been involved as principal investigators in nearly thirty research projects with funding totaling \$830,000 provided by seventeen different sponsoring agencies. Ninety percent of the Department's faculty participated in this research activity.

While the research spans quite a large number of areas, a common thread runs through the majority of the efforts. That thread might be called "interface phenomena"--the interface between man-made systems and their functioning in a nonmanipulable environment governed by complex physical laws. Partly because of this, our research effort is becoming increasingly interdisciplinary in its nature, involving colleagues from other departments and students from a number of different curricula. As described in the following, several new research areas have been introduced during the year, and some continuing research has taken new directions.

### NUCLEAR PHYSICS

The electron accelerator (LINAC). F. R. Buskirk, J. N. Dyer, R. Pitthan and students have completed a survey of the giant resonances in about ten representative nuclei from silicon to uranium. The electric dipole quadrupole and octopole modes were investigated in this basic survey of the hydrodynamic or collective modes of nuclear oscillation.

### RADIATION PHYSICS

The LINAC electronic beam is being investigated as a tool to produce novel sources of radiation. Transition radiation experiments give a narrow band, well collimated source of X-rays which is being developed by Melvin Piestrup and Adam Chu from Stanford, in collaboration with J. N. Dyer, J. R. Neighbours and F. R. Buskirk.

SESR or stimulated electromagnetic shock radiation is an effect predicted to occur when fast electrons are forced to oscillate transversely when passing through a medium. F. R. Buskirk, J. N. Dyer, J. R. Neighbours, with M. A. Piestrup and R. S. Spitzer from Stanford are investigating this effect as a source of visible and ultraviolet radiation, sponsored by ONR.

### GEOMAGNETIC PHENOMENA

O. Heinz and P. Moose in cooperation with E. C. Crittenden are continuing their work on ambient magnetic field fluctuations.

The objective of this project is to obtain improved long term data on and identification of sources of electromagnetic noise on the ocean floor. By using a combination of total field magnetometers and directional antennas, the frequency range from a few milliHertz to several Hertz is covered. During FY 79, a series of measurements were carried out on the floor of Monterey Bay in water depth ranging from 30 to 300 meters. An optically pumped Cs vapor magnetometer and associated electronic and recording equipment were deployed from the Research Vessel ACANIA in a self-contained instrumentation package. Fourteen hours of recordings of the total magnetic field on the sea floor were obtained for subsequent analysis.

#### LASER AND PLASMA PHYSICS

F. Schwirzke has continued his investigation of laser-produced plasmas with emphasis on the magnetic field generation at the steep shock-like front of the expanding plasma cloud. Also continued has been the laser induced surface analysis which is a cooperative effort with DOE supported fusion research at UCLA. Together with K. Woehler, a DNA funded program on X-ray emission from laser induced pinches continued. This research supports the DNA X-ray flux simulation efforts.

#### ATOMIC PHYSICS

Our Spectroscopic Data Center directed by R. Kelly continues its long-range program of providing definitive compilations of data. A compilation stored on magnetic tape of all lines for the first 18 elements for all stages of ionization has been completed and submitted for publication. Work on the compilation of all lines below 2,000 Å for the first 36 elements is in progress and a special compilation of 30,000 lines for the first 36 elements in the 2,000 - 3,000 Å region has been completed and published in support of NASA's space exploration and solar physics program.

#### SURFACE PHYSICS

D. E. Harrison, Jr., with support from the National Science Foundation and two collaborators from the Pennsylvania State University, has continued to investigate the ion impact analysis of clean and chemically reacted single crystal metal surfaces by classical trajectory computer simulation methods.

## ATMOSPHERIC PHYSICS

Research concerning the optical properties of the marine boundary layer with E. C. Crittenden, A. E. Cooper, E. A. Milne, G. W. Rodeback and R. L. Armstead and students participating, has continued in the area of measurement of extinction due to fog and aerosols, and has also returned again to applications of earlier work on the effects of the atmosphere on resolution of imaging systems. A system was developed and measurements made for the Army Missile Command at Redstone Arsenal, Huntsville, Alabama for evaluation of the effects of the atmosphere on performance of Army imaging and optical guidance systems during conditions of high density of dust and smoke. Work was also initiated with Pt. Mugu and China Lake for evaluation of the effects of atmospheric turbulence on the performance of airborne optical devices. That work and related work for White Sands Missile Range is expected to continue into fiscal 1980.

## ENVIRONMENTAL PHYSICS

Professor Schacher, with C. Fairall and K. Davidson, have continued their efforts on modeling the marine boundary layer with special emphasis on the coupling between the surface layer fluxes and dynamics of the full boundary layer. In this area current projects address:

- Effect of turbulence on optical propagation
- Optical extinction by aerosols
- Overwater transport and dispersion
- Boundary layer modeling

The second general area is air-sea interaction. They are looking in detail at wind cave coupling with special emphasis on hydrostatic stability effects. The specialized topics of interest are:

- Microwave backscatter from the sea surface
- Marine aerosol generation

AY 79 efforts have involved one cruise on Monterey Bay to investigate the effects of temperature-humidity fluctuations coupling an optical propagation, beginning evaluation of data for surface truth verification for the SEASAT-1 satellite, and evaluation of data for past cruises. The data evaluation led to results for boundary layer mixing rates, dynamics of the marine inversion, and preliminary results on aerosol generation.

## UNDERWATER ACOUSTICS

A. Coppens and J. V. Sanders and students have continued their theoretical and experimental investigation of the transmission of acoustic energy from an ocean of decreasing depth into a fast bottom and theory and experiment appear to converge. H. Dahl has pursued his development of Ray Tracing Algorithms for the accurate positioning of sound sources for the underwater acoustic range of the Naval Undersea Warfare Station. H. Medwin with his students investigated ocean parameters affecting sound propagation along several lines including near grazing scattering of sound from rough surfaces and acoustical shadowing by seamounts. J. V. Sanders studied the possibility of obtaining source levels of sources of unknown location in the presence of reverberation. O. B. Wilson, with colleagues from several other departments, has continued his work on long range problems for the Naval Undersea Warfare Engineering Station, Keyport, Washington. This included work on measuring and predicting acoustic properties of sediments on Keyport's weapons test ranges. Also, with students, work on transducers and underwater acoustic measurements was done.

In collaboration with Professor Sackman and several students, O. B. Wilson made measurements of the array gain of a vertical line array in the Santa Cruz Basin at the Santa Cruz Island Acoustic Range Facility (SCARF).

## ACOUSTICS

O. B. Wilson and students pursued the development of a 75kHz transducer which makes use of flexural waves on a flash mounted plate and which is to be used on acoustic tracking ranges.

H. Medwin conducted studies of the shadowing by finite noise barriers and infinite wedges and plates.

The investigation of noise characteristics of pneumatic hand tools begun last year by H. A. Dahl and J. V. Sanders has continued. This work, done in support of the Naval Rework Facility, seeks to establish techniques for measurement of and criteria of acceptability for noise power spectra emitted by hand tools used in aircraft rework.

## WEAPONS AND WEAPONS EFFECTS

Under this heading all Department efforts related to either physical weapons effects or analysis of whole weapon systems are collected. W. Reese has continued his support for

the Naval Intelligence community. Together with members from the NSA Department, he was involved in a comparative analysis of major Soviet Fleet exercises, and open literature technical forecast study and the development of a threat forecasting methodology.

R. A. Reinhardt and G. F. Kinney have continued their theoretical investigations of internal blast phenomena. Their thermodynamic calculations are directed toward determination of over-pressures resulting from explosions in confined spaces. The scope of these investigations has been enlarged by including the effects of a reactive metal component.

Professors Moose, Harrison and Woehler have begun a new effort which was funded by the Director of Net Assessment in OSD and is scheduled to be funded by DARPA in FY 80. The effort is directed at developing analytic models of whole C<sup>3</sup> systems using concepts from statistical thermodynamics.



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View of the 100 MeV Linear Accelerator (LINAC) - Inside the Shielding Tunnel

Title: Investigation of the Disintegration of Lithium by High Energy Electronics

Investigators: F. R. Buskirk, Professor of Physics, and J. N. Dyer, Professor of Physics

Objective: To measure the electro disintegration of lithium and resolve differences between our earlier experiments and those from other laboratories.

Summary: Inelastic electron scattering and experiments were carried out on  ${}^7\text{Li}$  within a range of momentum transfer squared of  $.2 < q^2 < .65$  ( $F^{-2}$ ). Inelastic cross sections and form factors were determined for the 4.55 MeV inelastic peak and the inelastic continuum caused by the disintegration of  ${}^7\text{Li}$  into an alpha particle and a triton above the threshold of 2.45 MeV. Results of these experiments are in general agreement with results achieved by Bishop and Bernheim, which were for a different range of momentum transfer. The continuum observed appears to be associated with the disintegration of  ${}^7\text{Li}$  into an alpha particle and a triton. Data presented herein should be further analyzed in an effort to draw conclusions in terms of various nuclear models and multipole transitions.

Thesis Directed: R. F. Ryan, "Inelastic Electron Scattering from  ${}^7\text{Li}$  in the Vicinity of the  $\alpha$ -Triton Threshold," Master's Thesis, March 1979.

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Title: Investigation of the LINAC Electron Beam as a Source of Coherent Electromagnetic Radiation

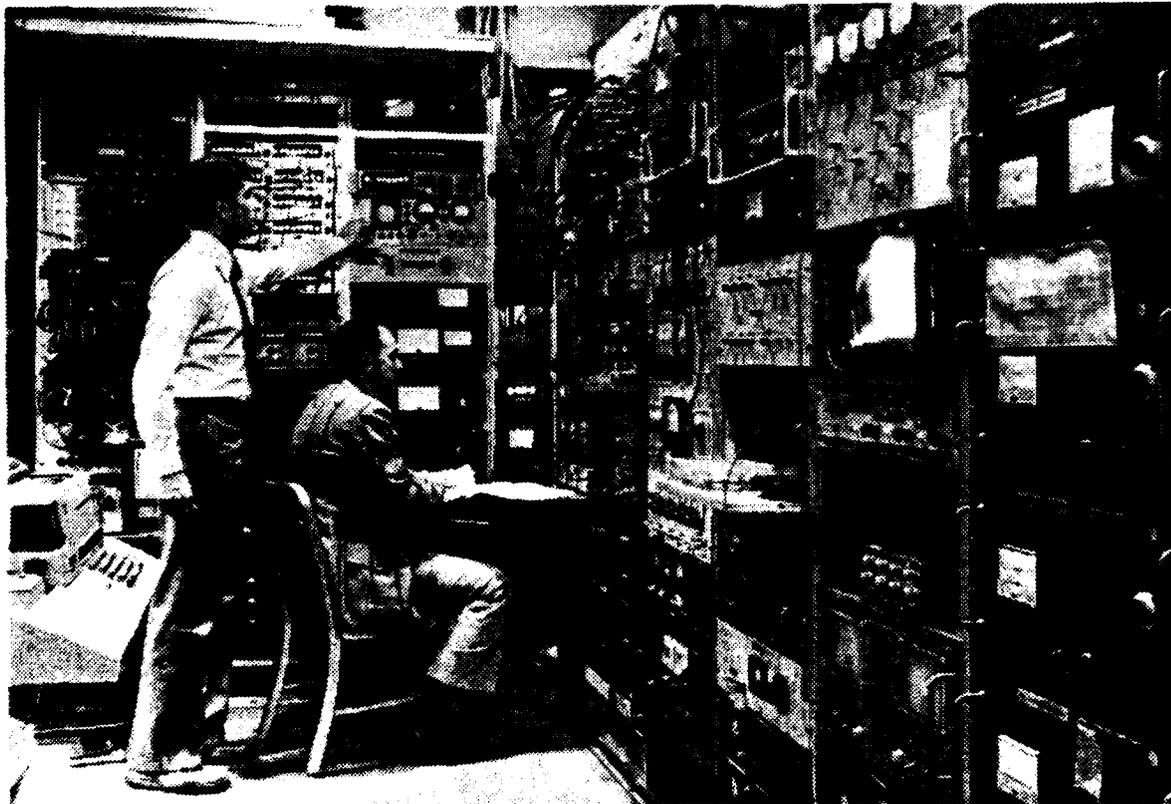
Investigator: F. R. Buskirk, Professor of Physics

Sponsor: NPS Foundation Research Program

Objective: Theoretical investigation of the LINAC as a tool for producing coherent electro-magnetic radiation to be followed by experiments.

Summary: The research has included a historical survey of scientific developments predating the free electron laser (FEL) concept and a general theory of operation of the FEL. The use of electromagnets to generate a static periodic magnetic field of alternating polarity (as a pump wave source) was investigated. Measurements of characteristics of the proposed electromagnet design were analyzed. The results from this initial research will be used in the investigations of electromagnetic shock radiation, which has been funded by the Office of Naval Research.

Thesis Directed: R. B. Ellis, "Stimulated Emission by Relativistic Electrons Traversing a Periodic Magnetic Field," Master's Thesis, June, 1979.



**Control Room for the 100 MeV Linear Electron Accelerator (LINAC)  
Beam is on and experiment is in-process.**

Title: Nuclear Giant Multipole Resonances by Inelastic Electron Scattering

Investigators: F. R. Buskirk, Professor of Physics, J. N. Dyer, Professor of Physics and R. Pitthan, Professor of Physics

Sponsor: Naval Postgraduate School Foundation

Objective: A survey of the collective modes of oscillation of nuclei, called giant resonances. These resonances have been observed in the energy range from 10 to 35 MeV in various medium and heavy nuclei.

Summary: Scattering experiments using the NPS LINAC included  $^{238}\text{U}$ ,  $^{140}\text{Ce}$ ,  $^{89}\text{Y}$ ,  $^{60}\text{Ni}$ ,  $^{58}\text{Ni}$  and  $^{28}\text{Si}$ , which combined with our previous studies of  $^{208}\text{Pb}$ ,  $^{197}\text{Au}$  and  $^{163}\text{Ho}$ , from a survey of the giant resonances in many nuclei. The energy resolution of about 0.4% to 0.5%, was usually sufficient for studying these broad resonances; the excitation energy range covered was from 4 to 40 or 50 MeV and showed giant resonances of energies from 6 to 33 MeV. The cerium experiment was especially productive. In addition to E2 ( $\Delta T=0$ ) at 10 MeV and E1 at 15.3 MeV, the isovector E2 appears at 25 MeV and 36 MeV in general agreement with the model of Bohr and Mottelson. For Uranium, both quadrupole resonances were observed, but were low in strength unless a transition radius larger than the ground state radius was assumed.

Publications: R. Pitthan, H. Hass, D. H. Meyer, F. R. Buskirk and J. N. Dyer, "E0, E1, E2, E3 and E4 giant resonances in the N=82 nucleus  $^{140}\text{Ce}$  between 4 and 48 MeV excitation energy with inelastic electron scattering," *Physical Review C* 19, p 1251 (1979).

R. Pitthan, F. R. Buskirk, J. N. Dyer, E. E. Hunter and G. Pozinsky, "Distribution of E2 strength in  $^{28}\text{Si}$  below 50 MeV excitation energy, *Physical Review C* 19, p. 299 (1979).

R. Pitthan, G. M. Bates, J. S. Beachy, B. B. Dally, D. H. Dubois, J. N. Dyer, S. J. Kowalick and F. R. Buskirk, "Comparison of

giant multipole resonances of multipolarity  
E1 to E4 in  $^{58}\text{Ni}(T=1)$  and  $^{60}\text{Ni}(T=2)$  with  
inelastic electron scattering," Physical  
Review C 20, (1979).

Title: Development of a System for Measurement of  $C_n^2$  by Means of MTF on Military Optical Ranges

Investigators: E. C. Crittenden, Jr., A. W. Cooper, E. A. Milne, G. W. Rodeback, S. H. Kalmbach and R. L. Armstead

Sponsor: U.S. Army, MIRADCOM, Huntsville, Alabama

Objective: To develop and deliver to the optical range at Huntsville, a system for measurement of  $C_n^2$  by means of MTF, suitable for use through smoke and haze.

Summary: Previous work by this group has led to a technique for measurement of the turbulence structure constant for optical index,  $C_n^2$ , along an optical path by measuring the optical resolution as expressed by means of the MTF. The method provides a nearly instantaneous readout of  $C_n^2$  by use of on-line computers and data sampling equipment. The system developed for MIRADCOM was adapted to utilize the computers available on their range at Huntsville. The optical hardware was also modified somewhat to fit their particular needs as required by the optical systems to be tested at Huntsville.

Publication: Manual for Operation of Equipment for Measurement of  $C_n^2$  from MTF. Supplied to MIRADCOM, Huntsville.

Title: Effects of Turbulence on Airborne Optical Projectors

Investigators: E. C. Crittenden, Jr., A. W. Cooper, E. A. Milne, G. W. Rodeback, S. H. Kalmbach, and R. L. Armstead

Sponsor: Pacific Missile Test Range Compass-Hammer Program

Objective: Measurement of  $C_n^2$  for optical turbulence effects on optical paths from rapidly moving aircraft to the ground.

Summary: Optical systems, such as in the Compass-Hammer program, are degraded by the effects of index fluctuation in the optical path from an aircraft to the ground. The turbulence structure constant for optical index,  $C_n^2$ , can be measured by means of measurement of the optical resolution in terms of MTF (Modulation transfer function). The NPS system for such measurements is being modified to permit rapid measurements using a pulsing laser source aboard an aircraft that is to fly over at low altitude.  $C_n^2$  will be measured with this system for ranges between 10 km and 2 km. Use of the pulsing laser source permits use of a widely diverged laser on the aircraft, thus eliminating the need for a tracking laser on the aircraft. The fast pulses, however, have required development of a new detection and tracking system. The pulses are stretched and directly digitized. The on-line computer carries out the required calculations in real time. As a by-product of the fast data reduction, the reduced data is used to provide the tracking of the telescope system. Preliminary tests are favorable, and full scale tests are in preparation, to occur in FY1980.

Publications: None to date (Verbal report presented on 6 September, 1979, at Pt. Mugu).

**Title:** Optical Transmission Measurements in Coastal Environments

**Investigators:** E. C. Crittenden, Jr., A. W. Cooper, E. A. Milne, G. W. Rodeback, S. H. Kalmbach, and R. L. Armstead

**Sponsor:** EOMET Program, Block funded through NOSC, San Diego, Juergen Richter, Block Funding Head

**Objective:** Development and application of techniques for obtaining precision transmission measurements of the atmosphere for long path lengths (10 km) for correlation with predictions based on measured aerosol particle size distribution spectra.

**Summary:** Predictions of atmospheric extinction of transmitted optical beams in the principal wavelength windows of the atmosphere, have been in disagreement with observed extinction values. This program is aimed at establishing the causes of this disagreement. Precision extinction results are needed for a variety of atmospheric conditions, for which the particle size distribution is known. A companion program (Schacher and Fairall) at the NPS is involved with obtaining the particle size distribution spectra during the same time intervals and for the same region as the optical paths during extinction measurements. The optical program reported here is concerned with the techniques of measuring the optical extinction. Black body source and laser transmitters were developed to provide measurements at three laser wavelengths and eleven black body source wavelengths as defined by filters. Preliminary measurements were made along an optical path from Pt. Pinos to Marina for a range of 13.3 km.

**Publications:** Final report in preparation.

Title: Evaluation of Noise Characteristics of Pneumatic Hand Tools

Investigators: Harvey A. Dahl, Assistant Professor of Physics; James V. Sanders, Associate Professor of Physics; Karlheinz E. Woehler, Professor of Physics

Sponsor: Naval Aviation Logistics Center (NAVAIREWORKFAC, San Diego, CA)

Objective: Continued determination of the absolute noise level and noise spectrum of certain pneumatic hand tools for comparison with newer tools and with health standards.

Summary: Measurements have been made of the sound pressure level distributions of the pneumatic grinder furnished us. These measurements serve as prototypes for the operation of the overall sound-power measuring system in obtaining noise-power data for additional pneumatic tools.

The noise measurements were made with the grinder suspended from a light frame placed on the wire mesh floor at the center of the large anechoic chamber in Spanagel Hall. Suspension by means of flexible cord minimized acoustic coupling to the floor of the chamber. Noise readings were taken in a grid of eight angular positions spaced uniformly over a sphere of nominal radius of 1.5 meters. The noise spectrum was analyzed both in one-third octave frequency bands and constant width 4 Hz or 100 Hz bands. The narrower bandwidths were used to obtain noise level data at the rotational frequency of the tool and at the harmonics of that frequency.

Results of the measurements show that the noise power in the audible frequency range emitted by the grinder is distributed essentially uniformly at the spherical grid of measurement points. A grid of eight measuring points is thus adequate to obtain accurate noise power data for sources of this size. Total noise power values obtained were in good agreement with values reported elsewhere for comparable noise sources.

Noise Measurements will be made on other types of pneumatic tools to verify the accuracy of the technique and to obtain noise power levels of interest to the sponsor.

Publications: Several unpublished reports have been made to the sponsor.

Title: Classical Trajectory Studies of Low Energy Ion Impact Mechanisms on Clean and Reacted Single Crystal Surfaces

Investigators: Don E. Harrison, Jr., Professor of Physics with B. J. Garrison and N. Winograd, Pennsylvania State University

Sponsors: National Science Foundation and NPS Foundation Research Program (collaborators have separate support)

Objectives: Continue study of the effects produced when ions bombard clean and chemically reacted single crystal metal surfaces to understand mechanisms and coordinate with experimental investigations.

Summary: Classical trajectory simulations have developed to the point that it is feasible to model the cascade produced by an ion impact event. The ability to follow each individual atom in the cascade leads naturally to pictorial interpretations of a single sputtering event. Statistical analysis of data produces numbers which can be directly compared to the experimental data. The model computations are done using single crystal targets oriented to expose the low index surfaces. Research effort this year has been devoted to the study of the ion energy dependence of the effects previously reported. The distribution of the number of atoms ejected for single ion (ASI) tells a great deal about the formation of multimers. Most of the ejected atoms (or 90 percent) come from the first target layer at all ion energies investigated (25 eV to 20.0 KeV). The second and third layer yields peak at approximately 10 KeV for the Cu/Ar system for both the (111) and (100) surfaces. preliminary studies of ion mass dependence were begun.

Publications: B. J. Garrison, Nicholas Einograd and Don E. Harrison, Jr., "Ejection of Molecular Clusters from Ion-Bombarded Surfaces," J. Vac. Sci. Technol., 16(2) 789-92 (1979).

N. Winograd, B. J. Garrison, T. Fleisch W. N. Deglass and D. E. Harrison, Jr., "Particle

Ejection from Ion-Bombarded Clean and Reacted Single Crystals," J. Vac. Sci. Technol. 16 (2) 629 (1979).

B. J. Garrison, N. Winograd and Don E. Harrison, Jr., "Atomic and Molecular Ejection from Ion-Bombarded Reacted Single-Crystal Surfaces. Oxygen on Copper (100)," Phs. Rev. B., 18, 6000-6010 (1978).

Conference  
Presentations:

Don E. Harrison, Jr., Barbara J. Garrison and Nicholas Winograd, "Atom Ejection Mechanisms and Models," Proceedings of the Second Int'l SIMS Conference, Palo Alto, California, August, 1979.

D. E. Harrison, Jr., "Atom Ejection Studies by Classical Trajectory Simulation," Proceedings of the Surface Physics Workshop, La Jolla, California, August, 1979.

Don E. Harrison, Jr., "The Influence of Cascade Interactions on Sputtering by Molecular Ions," Atomic Collisions in Sounds IX, Hamilton, Ontario, Canada, 1979.

**Title:** Geomagnetic Field Fluctuations on the Ocean Floor

**Investigators:** O. Heinz, P. Moose, Professor of Physics and Chemistry

**Sponsors:** ONR, Code 463 (Mr. John G. Heacock) Arms Control and Disarmament Agency, State Department (Mr. Roger Booth)

**Objective:** To obtain improved long-term data and interpretations on the electromagnetic noise on the ocean floor.

**Summary:** Using an optically pumped Cs vapor magnetometer and a novel recording scheme, we have measured the magnetic field intensity on the floor of Monterey Bay. Water depth ranged from 30 to 340 m and power spectral densities for fluctuation frequencies from 1 millihertz to 5 Hz have been obtained. Typical amplitudes range from  $10^{-3}$  nT at a few millihertz to a few times  $10^{-3}$  nT at 5 Hz. The magnetic power spectral density curves show a rapid decrease up to .1 Hz and are relatively flat above that frequency. Measurements of surface wave spectra were also carried out and compared to the geomagnetic spectra. The magnetic signature of surface gravity waves with periods of 10-12 seconds is observable to a depth of more than 200 meters.

**Conference Proceedings:** "Geomagnetic Fluctuations on the Floor of Monterey Bay: by P. Moose, J. Chaffee, and O. Heinz, in Proceedings of Workshop on Ocean Floor Electromagnetics held at NPS, Monterey, California, August 1979.

**Thesis Directed:** "Power Spectra of Geomagnetic Fluctuations between 0.4 and 40 Hz" by F. W. Clayton. (M.S. in Physics, June 1979).

Title: Investigation of Geomagnetic Fluctuations in the Sea

Investigators: O. Heinz, Professor of Physics, P. H. Moose, Adjunct Professor of Physics and Chemistry

Sponsor: Office of Naval Research - Code 463 (Dr. Robert Andrews)

Objective: To determine the nature, level, spectra and origins of ULF electromagnetic fields on the sea floor.

Summary: A Cs-vapor, optically pumped magnetometer has been packaged, along with power supplies and recording apparatus, in glass spheres for operation in the deep sea. Preliminary testing in Monterey Bay from April 79 through Oct 79 produced for frequencies from .005 to 3 Hz. Simultaneous collection with wave buoy measurements has indicated a good correlation with ocean surface waves to depths of 100 m. Magnetic field levels are close to those predicted by theory. An interesting 60 second period wave has been found which may relate to the "seventh wave" effect. Loop antennas have been designed and manufactured for deep sea operations. Initial testing will occur in November 1979.

Publications: P. H. Moose and E. J. Chaffee, "An instrument for Recording ULF-ELF Geomagnetic Fluctuations Measured by Optically Pumped Magnetometers," IEEE Transactions on GeoScience Electronics, to be published, January 1980.

Conference Presentations: P. H. Moose, E. J. Chaffee, and O. Heinz, "Measurement of Geomagnetic Fluctuations in Monterey Bay," Workshop on Sea Floor Electromagnetics, Naval Postgraduate School, August 1979.

Thesis Directed: L. C. Dearth, "Investigation of Electrode Materials for Low Frequency Electric Antennas in Sea Water," Master's Thesis, December 1978.

D. A. Saddler, "Data Acquisition System for Geomagnetic Waves," Master's Thesis, June 1979.



**Student Preparing Equipment for Geomagnetic Measurements on the Ocean Floor**

Title: Spectroscopic Data Center Compilation of Atomic Energy Levels

Investigator: Raymond L. Kelly, Professor of Physics

Sponsor: NPS Foundation Research Program

Objective: To produce a useful, comprehensive and semi-critical compilation of atomic energy levels, based on publications listing spectrum lines. The compilation is to be stored on magnetic tape, in order to be available to a large community of users and is to be updated regularly on a continuing basis.

Summary: The initial phase of the compilation has been completed for the first 19 elements, Hydrogen through Argon, for all stages of ionization. Such information makes possible classification of unidentified lines from plasma sources and in solar spectra, as well as the prediction of other lines (valuable in laser physics).

Publication: Ionization Potential of Fe XVII in the Neon Isoelectronic Sequence, Revised Value; by Raymond L. Kelly and Don E. Harrison, Jr., Atomic Data and Nuclear Data Tables 19, 301-303 (1977).

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Title: Spectroscopic Data Center Compilation of Near Ultraviolet Spectra

Investigator: Raymond L. Kelly, Professor of Physics and Chemistry

Sponsor: National Aeronautics and Space Administration, Dr. Albert Bogges, Code 683, Goddard Space Flight Center, Greenbelt, MD

Objective: To produce a critical compilation of long wavelength ultraviolet lines (wavelengths 2000-3000 Angstroms) in support of space exploration and solar physics, maintaining a current compilation on continuous basis. The work is based on publications in the open literature.

Summary: The initial compilation of 30,000 lines, from the first 36 elements, has been completed. It has been stored on magnetic tape and published as a NASA Special Publication. Work has started on adding the classifications to each line as an extension of the initial compilation. This continuing project will be completed in three years. Included in the final compilation will be (for each spectrum line) wavelength, intensity, classification, and energy level for both the upper and lower state in the transition.

Publications: Atomic Emission Lines in the Near Ultraviolet; Hydrogen Through Krypton: NASA Technical Memorandum 80268 (April 1979).

**Title:** Spectroscopic Data Center Compilation of Vacuum Ultraviolet Spectra

**Investigators:** Raymond L. Kelly, Professor of Physics and Chemistry

**Sponsor:** Department of Energy, Dr. Don Priester, Applied Plasma Physics Program, Office of Fusion Energy

**Objective:** Preparation of a critical compilation of atomic spectrum lines with wavelengths below 2000 Angstroms, for the first 36 elements. This is a continuing project.

**Summary:** Computer-based files are prepared containing the wavelength, intensity, and classification for all lines observed in solar or terrestrial sources. A complete file of atomic energy levels is maintained for calculation of wavelengths of predicted transitions. These wavelengths are critically compared with those reported in the literature and in unpublished communications. A new compilation has been completed for the first 18 elements and stored on magnetic tape, and submitted for publication. Completion of the final compilation is scheduled for 1981.

**Publication:** Ionization Potential of Fe XVII in the Neon Isoelectronic Sequence, Revised Value; by Raymond L. Kelly and Don E. Harrison, Jr., Atomic Data and Nuclear Data Tables 19, 301-303 (1977).

Title: Forward Scatter from a Randomly Rough Surface  
Investigator: H. Medwin, Professor of Physics and Chemistry  
Sponsor: NPS Foundation Research Program  
Objective: To calculate sound forward scattered at the sea surface.

Summary: The Biot-Tolstoy theory of diffraction by wedges is used as a building-block for the calculation of forward at a sea surface composed of contiguous wedges. The objective of the research is to study the effects of shadowing on rough surface forward scattering. To reach this objective a computer modelling technique that was developed in the FY77 research on forward scatter has been completed to isolate the contributions due to facet reflection and facet diffraction in long-crested surfaces and the results will be compared with available experiments.

To summarize, the aim of the proposed research is to reach a better understanding of rough surface forward scattering through the inclusion of shadowing and multiple scatter effects which have been shown to be necessary for both the direct and the inverse problem.

Publications: J. C. Novarini and H. Medwin, "Diffraction, reflection and interference during near-grazing and near-normal ocean surface back-scattering," J. Acoust. Soc. Am. 64, 269-268 (1978).

Title: Ocean Parameters Affecting Sound Propagation  
Investigator: H. Medwin, Professor of Physics  
Sponsor: Office of Naval Research Code 486

Summary: A new theory describing sound scatter from a low roughness rigid surface [I. Tolstoy, "The scattering of spherical pulses by slightly rough surfaces," J. Acoust. Soc. Am. 66, 1135-1144 (1979)] has predicted that at near-grazing incidence a boundary wave will be formed in the fluid above the surface, and that at sufficient ranges the amplitude of this scattered boundary wave will exceed that of the direct wave. A model experiment has been conducted using a point source and receiver embedded in a rough plane surface constructed of close-packed rigid hemispherical bosses and the prediction of the amplitude of the boundary wave has been fully confirmed. In addition, the experiment has revealed that the coherent scattered boundary wave, which at lowest frequencies or ranges leads the incident wave by  $90^\circ$ , becomes more nearly in phase with the incident spherical wave as frequency or range are increased, thereby further strengthening the signal at the rough surface relative to smooth surface propagation.

The impulse wave solution of point source radiation which is diffracted by an infinite rigid corner or wedge, [M.A. Biot and I. Tolstoy, J. Acoust. Soc. Am. 29, 281-391 (1957)], describes a closed form time-domain solution to an old problem that is generally studied in the frequency domain. The theory is tested by an experiment using models of wedges and plates in an anechoic chamber, and the source regions of diffraction are identified and compared with theoretical predictions. In addition, numerical Fourier transformation of the dominant part of the solution provides the transmission loss as a function of frequency without further assumptions or approximations.

Publications: "Near grazing scattering by slightly rough surfaces," J. Bailie and H. Medwin (Department of Physics and Chemistry, Naval Postgraduate School, Monterey, CA 93940) in J. Acoust. Soc. Am. 64, Suppl. 1, Fall 1978.

"Impulse wave diffraction by rigid wedges and plates," J. Bremhorst and J. Medwin (Department of Physics and Chemistry, Naval Postgraduate School, Monterey, CA 93940) J. Acoust. Soc. Am. 64, Suppl 1, Fall 1978.

"The scattered acoustic boundary wave generated by grazing incidence at a slightly rough rigid surface," H. Medwin, J. Bremhorst, B. J. Savage and I. Tolstoy (Physics and Chemistry Department, Naval Postgraduate School, Monterey, CA 93940) J. Acoust. Soc. Am. 66, 1131-1134 (1979).

Theses: J. Bailie, "Near grazing scattering by slightly rough surfaces," MS, September, 1978.

J. Bremhort, "Impulse wave diffraction by wedges and plates," MS, 1978.

**Title:** Topographical Effects in Underwater Sound Propagation

**Investigator:** H. Medwin, Professor of Physics

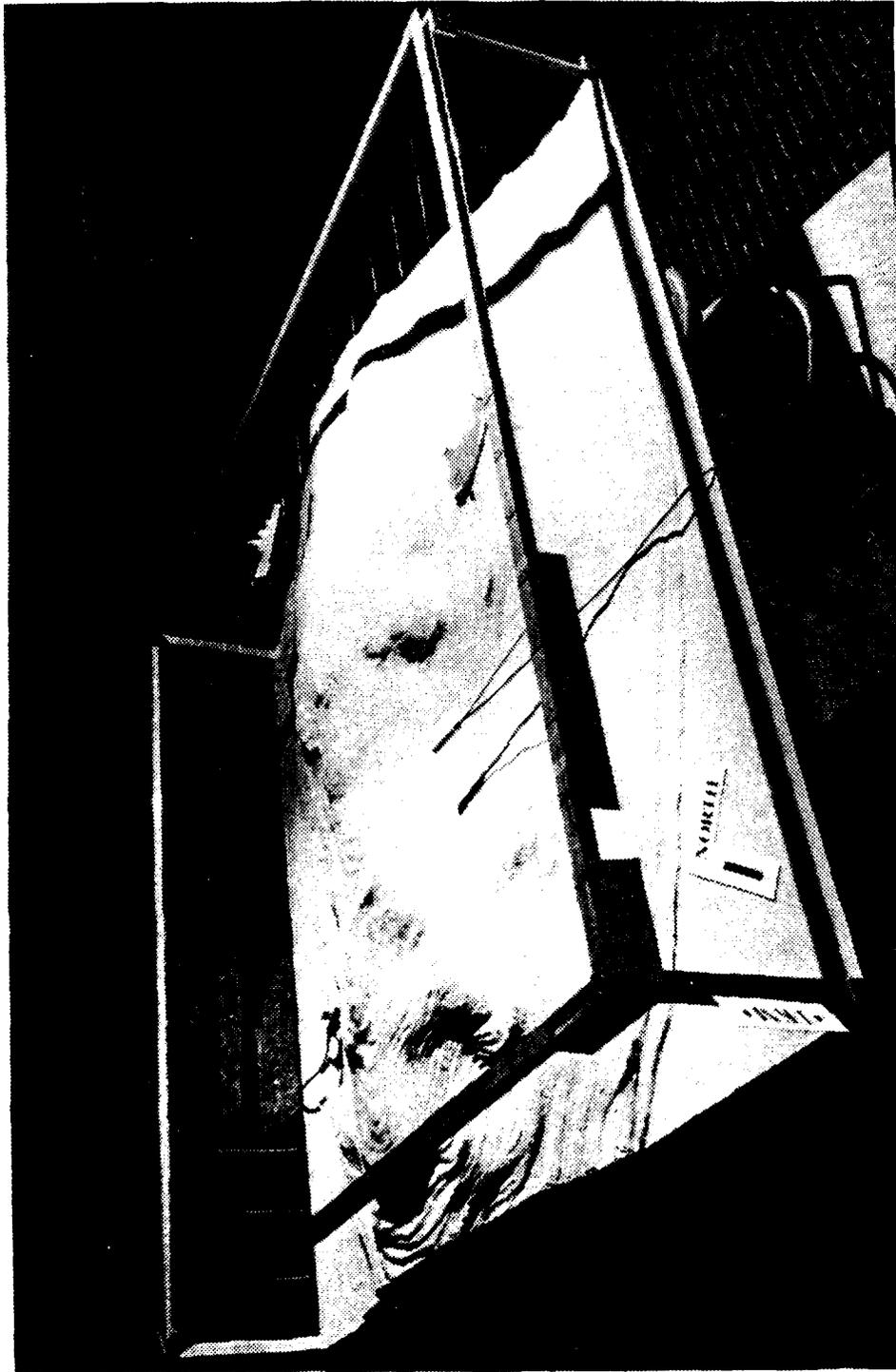
**Sponsor:** Manager, ASW Systems Project Office (ASW 13); NAVSEA; NAVELEX 320

**Objective:** To determine the influence of a seamount in long range propagation and detection of sound at sea.

**Summary:** Major topographical features such as seamounts can cause large propagation losses which are functions of sound frequency and the type of interruption of the sound path. A 2 x 2 x 0.2-m high model of Dickens Seamount has been constructed of wood and plaster to a scale of 1:7874 and the sound shadowing in air has been studied for various source/receiver locations and for five octaves of laboratory frequencies. A new universal concept, the farfield "diffraction strength," is defined. The diffraction strength obtained from laboratory measurements is used to predict the isovelocity, frequency-dependent loss at sea. This loss is added to predictions of ray refraction losses during propagation up to, and away from, the seamount. This sum agrees well with the total long-range ocean propagation loss measured beyond Dickens by G. R. Ebbeson, J. M. Thorleifson and R. G. Turner [J. Acoust. Soc. Am. 64, S76 (1978)]. The scale model is a relatively inexpensive device to aid in the prediction of shadowing losses at sea.

**Publications:** Shadowing by seamounts. H. Medwin and R. Spaulding (Physics and Chemistry Department, Naval Postgraduate School, Monterey, CA 93940) J. Acoust. Soc. Am. Suppl. 1, Vol. 66 Fall 1979.

**Theses:** R. P. Spaulding, Jr. "Physical Modeling of Sound Shadowing by Seamounts," MS, September, 1979.



Scale Model of Dickens SEAMOUNT used for Measuring Propagation Loss



Title: Cybernetic Models of Military C<sup>3</sup>I

Investigators: Paul H. Moose, Adjunct Professor of Physics,  
Don E. Harrison, Professor of Physics.

Sponsor: Office of Secretary of Defense, Net Assessment.

Objective: To develop analytical techniques to measure performance and stability of complex man-machine information systems.

Summary: Cybernetic models have been made of two quite different military situations. One model is of a naval warfare game called CRUISE. This problem illustrates an application of the theory to a system that has final or terminal states and shows how the principle of equifinality can be used to calculate force multiplier coefficients for C<sup>3</sup>I. The second problem examined is a hypothetical two-level surveillance system. This example can differentiate quantitatively between control policies and can measure effects of communication and decision making delays as well as sensor errors in a quite general way for systems in equilibrium. An initial effort to develop a thermodynamic mathematical analog of the cybernetic model of the surveillance system has shown promising results. Additional research in this direction is anticipated during FY 80.

Publications: P. H. Moose and D. E. Harrison, "An Analytical Model of Coordinated Effort with Application to the Problem of Surveillance C<sup>3</sup>", NPS Report No. NPS 61-79-008, May 1979.

P. H. Moose, D. E. Harrison, and K. E. Wgehler, "Cybernetic Model of Military C<sup>3</sup>I Systems", NPS Report NPS 61-79-010PR, August 1979.

Conference Presentations: Paul H. Moose, "Cybernetic Models of Military C<sup>3</sup>I Systems," ONR/MIT 1979 C<sup>3</sup> Workshop, Naval Postgraduate School, July 1979.

Thesis Directed: R. G. Lyman, "A Cybernetic Characterization of the Fleet Ocean Surveillance Information Facility at Rota, Spain," Master's Thesis, March 1979.

Title: Support of Non-Acoustic Analysis

Investigators: W. Reese, G. Sackman, J. Von Schwind,  
S. Tucker

Sponsor: Naval Intelligence Support Center

Objective: Provide review and evaluation of selected  
papers from the open Soviet literature.

Summary: Papers dealing with Ocean Hydrodynamics,  
Ocean Optics and Geomagnetic topics have been  
reviewed and individual memoranda prepared.  
A 71 page segment of a report dealing with  
Russian theoretical work on Internal Waves  
was completed and forwarded. Work will  
continue on a carry-over basis in FY 80.

**Title:** Internal Blast Computations

**Investigators:** R. A. Reinhardt, Professor Chemistry, G. R. Kinney, Distinguished Professor Emeritus, K. J. Graham, Research Chemist Naval Weapons Center, China Lake.

**Sponsor:** Naval Weapons Center, China Lake, CA

**Objective:** Continued research into the phenomena of confined explosions of conventional and reactive-metal-containing explosives.

**Summary:** Calculations have been completed for temperature, pressure and product composition resulting from internal explosions of mixtures of magnesium with various fuels and explosives under adiabatic conditions. A more general approach to treating the equilibrium, has been modelled. Trial computations on limited systems indicate that this method will be capable of giving satisfactory results.

**Publications:** R. A. Reinhardt, "Adiabatic Computation of Internal Blast From Magnesium-Cased Charges in Air," for Naval Weapons Center, China Lake, CA, NWC Technical Memorandum No.3820, April 1979.

**Conference Presentations:** R. A. Reinhardt and G. F. Kinney, "Internal Blast From Magnesium-Cased Charges," DEA-G-1060 Ballistic Research and Development Meeting, Naval Postgraduate School, Monterey, CA, 19-20 October, 1978.

**Title:** Nonlinear Acoustic Processes in Geometrically-Perturbed Rectangular Cavities

**Investigators:** James V. Sanders, Associate Professor of Physics; Alan B. Coppins, Associate Professor of Physics

**Sponsor:** Office of Naval Research

**Objectives:** To extend existing theoretical models for rectangular cavities to cavities with perturbed boundaries, and to compare the predictions of the model with experimental results.

**Summary:** A systematic experimental study of the unperturbed but degenerate cavity revealed that while the experimentally measured magnitudes and frequencies of the peaks of the nonlinear response curves were in excellent agreement with the theory, significant discrepancies existed between theory and experiment for frequencies well away from these peaks. It was suspected that this difficulty may result from excitation of certain degenerate normal modes by an interaction between the driving piston and the nonlinearly excited normal modes. The cavity was redesigned to place the piston to minimize this interaction. The results are now in excellent agreement with the predictions of the theory and the effects of geometrical perturbations on the nonlinear standing waves are now being studied.

**Publications:** Midyear Status Report; NC4 (61Sd)/rk 4 May 1979.

**Conference Presentations:** Experimental processes in the Finite-Amplitude Excitation of Weakly-Perturbed Rectangular Cavities, J. V. Sanders and E. Kuntsal, 96th Meeting of the Acoustical Society of America, Honolulu, HI 27 Nov-1 December 1978, J. Acoust. Soc. Am., Vol. 64, Suppl. No. 1, Fall 1978

**Theses Directed:** Kuntsal, Experimental Study of Finite-Amplitude Standing waves in Rectangular Cavities with Perturbed Boundaries, M.S. Thesis, December, 1978.

**Title:** Transmission of Acoustic Energy from a Fluid Wedge into a Fast Bottom

**Investigators:** James V. Sanders, Associate Professor of Physics and Alan B. Coppens, Associate Professor of Physics

**Sponsor:** Office of Naval Research

**Objective:** To develop the ability to predict the properties of sonic beam transmitted into a fast bottom underlying a wedge-shaped fluid layer.

**Summary:** Theoretical formulations of the sound field have been studied with the help of large, high-speed computers. The results have been analyzed for empirical relationships, and it appears that the analysis will prove successful. The computer generated solutions are in rather good agreement with experimental investigations.

**Theses Directed:** Kawamura and Ioannou, "Pressure on the Interface between a Converging Fluid Wedge and a Fast Fluid Bottom", M.S. Thesis, December 1978.

**Title:** Aerosol Spectrometer Intercomparison

**Investigators:** G. E. Schacher, Department of Physics and Chemistry K. L. Davidson, Meteorology Department

**Sponsor:** Naval Ocean Systems Center

**Objective:** Intercompare aerosol spectrometers and optical instruments to determine validity of spectrometer predicted optical extinction.

**Summary:** NPS conducted three principal studies including: intercomparison with other Navy EO/MET program instruments at San Nicolas Island; calibration at Max Planck Institute, FRG; analysis of all past NPS shipboard data to assess environmental affects on aerosol spectrometers. The validity limits of the NPS spectrometers have been clearly identified, in particular which ranges and bins yield poor quality data. Comparison with optical instruments show that spectrometer predictions are within the factor of two error which has been determined to be acceptable. Wind direction shows a strong influence on the results at high wind speeds.

**Publications:** G. E. Schacher, C. W. Fairall and K. L. Davidson, "Results of NPS Aerosol Measurements for San Nicolas Island Spectrometer Intercomparison," NPS 61-79-011PR

G. E. Schacher, K. L. Davidson, and C. W. Fairall, "Assessment of Aerosol Spectrometer Performance and Their Use to Predict Optical Extinction," NPS Report in preparation.

Title: Parameterization of Water Vapor Effects on the Refractive Index Structure Function Parameter,  $C_N^2$

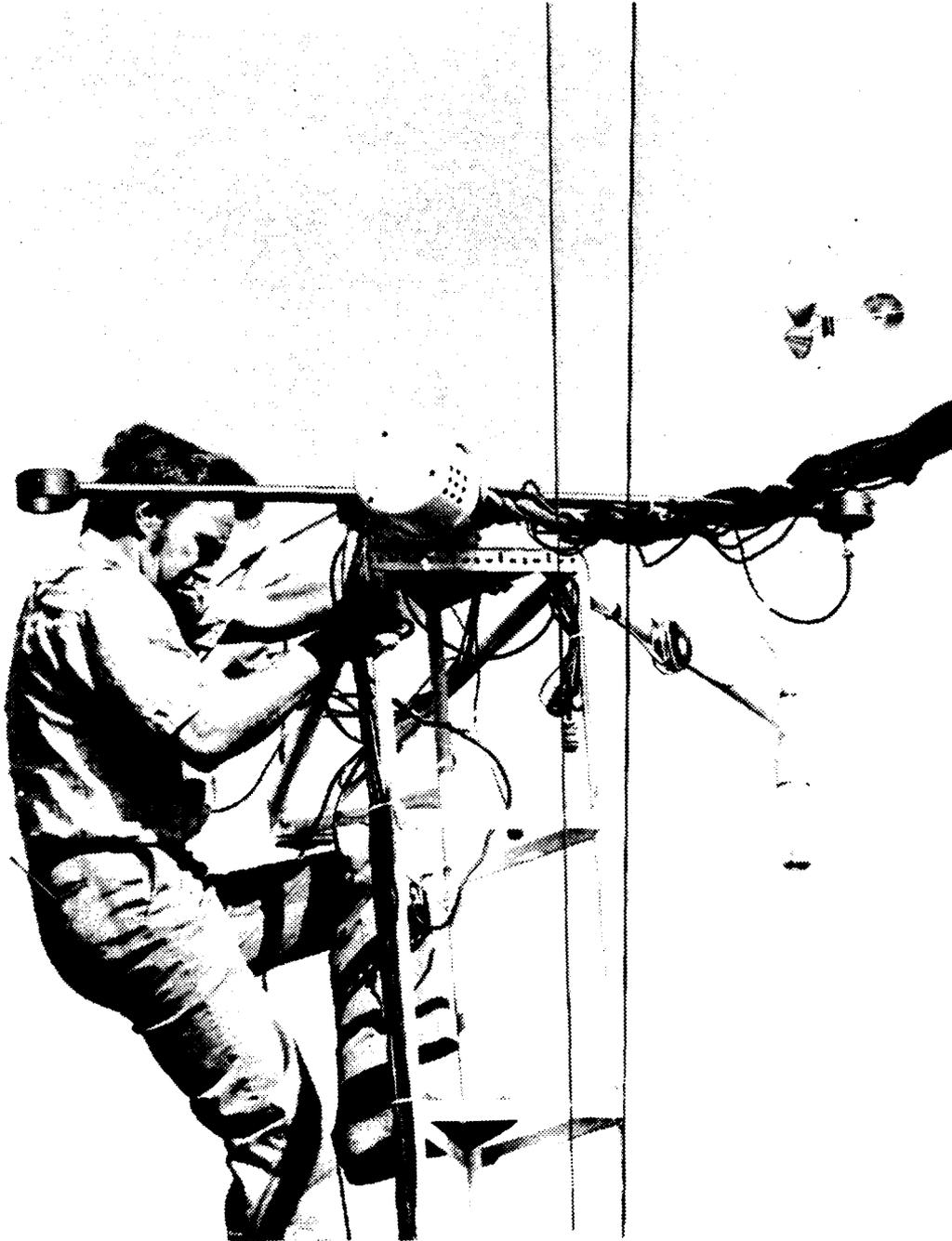
Investigators: Gordon E. Schacher, Associate Professor of Physics and Chemistry and Kenneth L. Davidson, Associate Professor of Meteorology

Sponsor: NPS Research Foundation Program

Objective: Determine the influence of humidity fluctuations on the optical structure function in the marine atmospheric surface layer.

Summary: Atmospheric turbulence measurements, including temperature and humidity fluctuations, were made from the R/V ACANIA, off the coast of California in June, 1979. The purpose of the experiment was to investigate the scaling properties of the humidity structure function parameter ( $C_q^2$ ) and temperature-humidity co-spectrum structure function parameter ( $C_{Tq}$ ) in the marine surface layer. The bulk parameterization method was used to obtain Monin-Obukhov Similarity (MOS) scaling parameters  $u_*$ ,  $T_*$ ,  $q_*$  and  $L$ . Assuming a neutral stability humidity drag coefficient  $C_{qn} = 1.3 \times 10^{-3}$ , the dimensionless humidity structure function parameter  $C_q^2 z^{2/3}/q_*^2$  was found to be 18% lower than the corresponding temperature function obtained by Wyngaard, et al., (1971). Furthermore, the measurements indicate that temperature-humidity fluctuations are highly coherent well into the inertial subrange. The results have direct application to turbulent scattering of waves propagating in the atmosphere (particularly microwaves) and methods of estimating air-sea surface fluxes.

Publications: C. W. Fairall, G. E. Schacher and K. L. Davidson, "Measurements of the Humidity Structure Function Parameters,  $C_{\rho 2}$  and  $C_{Tq}$  over the Ocean," Boundary Layer Meteorology, accepted for publication.



**Research Vessel ACANIA —  
Professor Gordon Schacher Checking Meteorological Probes on the Mast**

Title: SEASAT Satellite Surface Truth Verification

Investigators: G. W. Schacher, Department of Physics and Chemistry and K. L. Davidson, Meteorology Department

Sponsor: National Oceanic and Atmospheric Administration

Objective: Compare shipboard data obtained by the Naval Postgraduate School with SEASAT satellite determined wind speeds and sea surface temperatures for the purpose of satellite verification.

Summary: NPS data taken aboard the RV/ACANIA during the MABLES-WC experiment and aboard the RS/Challenger (GB) during the JASIN experiment has been reduced. The times of SEASAT satellite overflights have been determined. The satellite sensor modes at times of overflight have been used to select appropriate orbits for comparison to surface data. No satellite data has been obtained from the supplier (Jet Propulsion Laboratory) to enable the project to be completed. Presumably JPL will have geophysical data output ready early in 1980.

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Title: Vertical Mixing Rates in the Marine Boundary Layer

Investigators: G. E. Schacher, Department of Physics and Chemistry and K. L. Davidson, Meteorology Department

Sponsor: California Air Resources Board

Objective: Determine rates of vertical mixing over the ocean in California coastal waters for application to air pollution models.

Summary: Current air pollution models rely on estimates of vertical mixing rates based on overland measurements. NPS has conducted five cruises in California coastal waters that had sufficient equipment on board to enable mixing rates to be determined. The area from San Francisco to San Diego from near the shoreline to 100 miles at sea has been covered, with major emphasis placed on heavy population areas. The results for the various areas, times of day, etc., have been found to be consistent and fairly easily correlated with local conditions. These values can be used for improved parameterization of pollution models. A simplified calculation techniques based on shore line measurements has also been developed.

Publications: G. E. Schacher, K. L. Davidson, and C. W. Fairall, "Marine Atmospheric Boundary Layer Mixing Rates in California Coastal Waters," Proceedings of 2nd Annual Conference on Coastal Meteorology, December 1979.

Title: Laser Induced Acoustic Pulses in Water

Investigator: F. Schwirzke, Associate Professor of Physics and Chemistry

Sponsor: NPS Foundation Research Program

Objective: In this new project the generation of sound by laser pulses, the coupling efficiency and the sound spectrum were studied.

Summary: The interaction of Q-switched neodymium glass (1.06  $\mu\text{m}$ ) laser radiation with distilled water for the purpose of creating acoustic pulses was investigated. Average laser output was 80 MW. Two sound generation mechanisms were studied: thermo-elastic expansion and dielectric breakdown. The thermoelastic process was shown to produce a spherically expanding pressure wave with a fundamental frequency of 50 kHz. Maximum sound pressure levels of 65 dB (re 1  $\mu\text{bar}$ ) were observed with an energy coupling efficiency on the order of  $10^{-6}\%$ . The frequency of 200 kHz and produce sound pressure levels near 120 dB (re 1  $\mu\text{bar}$ ). The coupling efficiency was approximately 1%.

Additionally, Schlieren system shadowgraphs revealed the formation of a dense plasma bubble in the breakdown region. Peak pressures within the bubble were calculated to be as high as 450 k bars. Maximum shock velocities of  $8.5 \times 10^5$  cm/sec were measured from the shadowgraphs.

Theses Directed: D. A. Armstrong, "Laser Induced Acoustic  
Pulses in Water," Master's Thesis, December,  
1978.

J. H. Cocwitch, "Laser Induced Aconstic  
Pulses in water," Master's Thesis, Decenber  
1978.

**Title:** LISA, Laser Induced Surface Analysis

**Investigators:** Associate Professor F. Schwirzke, Department of Physics and Chemistry and R. J. Taylor, Department of Physics, University of California, Los Angeles

**Sponsor:** Research at UCLA supported by the Department of Energy

**Objective:** In this joint project a new laser probing technique has been developed to determine the concentration of loosely bound impurities present on the surface at any time during a tokamak discharge.

**Summary:** Impurities released by plasma-surface interactions play a major role in influencing the performance characteristics of many of today's magnetic fusion machines, especially tokamaks. Sputtering leads to an influx of high-Z impurities from the walls and limiter. Not all of the sputtered metal atoms, when being redeposited from the plasma onto the wall, will be recaptured on lattice sites where they are tightly bound to the crystal structure. Loosely bound metal atoms are probably contributing to the observed, higher than expected, high-Z impurity concentrations in tokamaks. Knowledge of the surface conditions during tokamak discharges is most important for a better understanding of processes related to plasma-surface interactions, discharge cleaning, and impurity transport.

Conventional surface analytic techniques like auger spectroscopy, low energy electron diffraction, secondary ion mass spectroscopy, etc., have been used to measure after many discharges the integrated accumulation of wall and limiter materials on clean test surfaces. These techniques are not applicable during the discharge and time resolved measurements are not possible.

Now a new laser probing technique has been developed to determine the concentration of loosely bound impurities present on the surface at any time during the tokamak

discharge. Surface spot heating by a laser pulse induces desorption of loosely bound species. Coincident spectroscopic measurements of the locally increased impurity radiation show the species and amount of impurities which were present on the surface. The first laser shot onto a new surface produces a large impurity influx into the plasma while consecutive laser shots produce much smaller signals. These results reveal the existence of loosely bound chromium and iron on tokamak surfaces.

Publications: L. Oren, F. Schwirzke, and R. J. Taylor, "Phenomenology of Metal Influx in Macrotor," Journal of Nuclear Materials, 76 and 77, 412-417 (1978).

L. Oren, F. Schwirzke, and R. J. Taylor, "Measurements of Wall Impurity Concentrations During Tokamak Discharges," published as a chapter in a book entitled Diagnostics for Fusion Experiments, E. Sidoni, and C. Wharton, Editors, Pergamon Press Ltd, Oxford, UK., pages 601-615 (1979).

Conference

Presentations: F. Schwirzke, and R. J. Taylor, "Observation of Radiative Continua from High Z Impurities in a Tokamak Plasma," Twentieth Annual Meeting, Division of Plasma Physics, American Physical Society, held at Colorado Springs, Colorado, October 30 - November 3, 1978. Bull. Am. Phys. Soc. 28, 802 (1978).

Theses Directed: Z. W. Hwang, "Laser Induced Evaporation from Stainless Steel Surfaces," December 1978.

**Title:** Time Development of Laser Produced Plasmas

**Investigators:** F. Schwirzke, Associate Professor of Physics and Chemistry

**Sponsor:** NPS Foundation Research Program

**Objective:** In this continuing project the interaction is investigated between intense laser pulses and targets. The dynamics of the laser produced plasma and self-generated magnetic fields are studied.

**Summary:** Further experimental evidence has been found that magnetic fields are generated in the steepened front of a fast moving plasma plume which is interacting with a background plasma. A laser produced plasma expands in z-direction normal to the target surface with a velocity of about  $10^7$  cm/sec. If the laser produced plasma flows into a photo-ionized background plasma of sufficient density, shock heating at the front will produce a temperature gradient in z-direction. Magnetic fields in azimuthal direction are then generated long after laser shut-off by the cross product of the radial density gradient and the electron temperature gradient in z-direction. The location of the peak magnetic field coincides with the steepest gradient in the shock front. Very basically spontaneous magnetic fields should be generated whenever a shock is produced by a plasma streamer.

**Conference Presentations:** F. Schwirzke and C. Y. Parlar, "Magnetic Field Generation in a Hydrogen Plasma by Laser-Produced Shock Waves," 1979 IEEE International Conference on Plasma Science, June 4-6, 1979, Montreal, Canada.

**Publication:** Conference - Record Abstracts, IEEE Catalog Number 79CH 1410-0 NPS, p. 127 (1979).

**Thesis Directed:** C. Parlar, "Self-Generated Magnetic Fields in Laser Produced Shock Waves," December, 1978.

**Title:** Acoustic Properties of Sediments

**Investigator:** O. B. Wilson, Jr., Professor of Physics and Chemistry

**Sponsor:** Naval Undersea Warfare Engineering Station

**Objective:** To obtain information about the sediments which can be used in the design and development of acoustic imaging devices which may be useful in locating and recovery of torpedoes which become buried in the sediments.

**Summary:** Estimates were made of sound absorption and sound speed characteristics of sediments at the Dabob Bay and Keyport Shallow Water ranges operated by the Naval Undersea Warfare Engineering Station using empirical models developed by Hamilton and mean grain size and porosity data measured in samples collected by the authors. Data reported by earlier investigators permit estimates to be made also for sediments at the Nanoose and Jervis Inlet ranges. Sound speeds were measured in a number of the gravity core samples. The most common surficial sediment is a soft, saturated silty-clay mud. For such sediments the sound absorption coefficient  $\alpha = 0.1 f$  where  $f$  is the sound frequency in kHz. It is concluded that sound absorption in these sediments, although not small, should not preclude the short range use of an acoustic imaging system operating at moderate frequencies. The possibility and the consequences of the existence of gassy sediments is discussed.

**Publications:** O. B. Wilson, Jr., and R. A. Helton, "Acoustic Properties of Sediments at Weapons Test Ranges of the Naval Under-Warfare Engineering Station, Keyport, Washington," NPS-61-79-005, June, 1979.

Title: Range Studies Program

Investigators: O. B. Wilson, Jr., Professor of Physics and Chemistry, and D. B. Hoisington, Professor of Electrical Engineering

Sponsor: Naval Undersea Warfare Engineering Station, Keyport, WA

Objective: To continue the study of the long-term requirements and plans of the Naval Undersea Warfare Engineering Station in areas of ship and underwater weapons testing, and, based on changing technology and changing operational needs of the Navy, recommend changes on upgrading or replacing equipment, modifications of procedures and development of new testing concepts.

Summary: Approximately eight faculty members from various disciplines and a number of officer-students participated in various task projects. Individual summaries are reported elsewhere in this document. A very brief summary of task activities follows:

Algorithms incorporating Kalman Filters for real-time acoustic tracking of vehicles on an underwater weapons test range were developed and plans made for their testing. Studies of current accuracy test procedures for sonars and underwater weapons fire control system were initiated with the objective of proposing possible improvements. Development work on small acoustic transmitters for range tracking was continued. Development was continued on a data acquisition system for performance monitoring of radio communications links. Work was begun which is preliminary to the development of an acoustic imaging system for use in recovery of buried torpedoes. Statistical methods were adapted to torpedo path estimation problems. Studies of the problem of using fiber-optic methods for data links were continued. A study of effects of implosion in a pressure test vessel was made. A study was begun of effects of multi-path interference in high frequency underwater acoustic measurements.

Publications: O. B. Wilson, Jr., "Annual Summary Report of  
Range Studies Program," NPS-61-80-001PR,  
October, 1979.

Title: X-Ray Emission from a Laser-Initiated Pinch

Investigators: K. E. Woehler, Professor of Physics and F. R. Schwirzke, Associate Professor of Physics

Sponsor: Defense Nuclear Agency

Objectives: The feasibility is studied to use a laser produced plasma as a preionized medium for a high power pulsed x-ray generator.

Summary: Intense x-ray emissions have been produced from the pinch of imploding wire arrays. The emitted radiation spectrum depends on the available generator power, the coupling of the energy into the plasma, the z-number of the wire material, the geometry, the mass and dynamics of the imploding wire array.

To produce x-spectra of desired characteristics z-values or z-value combinations of alloys and wire diameters may be required which are not readily available or cannot be fabricated.

Gas-puff experiments have been made successfully which widened the array of available materials, but are limited by the number of high-z atoms containing complexes which in gaseous state at temperatures which are compatible with these experiments.

In this investigation vapor puffs are released from solid surfaces by pulses of high intensity laser radiation.

This method has the advantage that almost any kind of material composition could be used as target. In addition there is a wide range of flexibility in the choice of the laser intensity and pulse length to vary mass and temperature of the ejected plasma in order to optimize the ejected plasma column for the main discharge. Laser induced evaporation of material from the surface of an aluminum target in a vacuum was studied. The experiment was conducted using a neodymium glass laser modified for normal pulse operation. The energy density was varied from  $8.5 \times 10^{23}$  J/cm<sup>2</sup> where no breakdown occurred to  $5 \times 10^3$

$J/\text{cm}^2$  where the threshold for breakdown was exceeded. The normal pulse duration was  $600\mu\text{s}$ . Analysis of the ejected material was achieved by using an ionization gauge placed in the path of the ejected material. Oscilloscope traces of the ionization gauge output show pulses of distinguishable signals for ions, and neutral particles ejected from the target surface. The signal sequence was dependent on the particle velocity. By measuring the time of flight from the surface to the collector, the first arriving neutral particle velocity was determined to be  $5.2 \times 10^4$  cm/s. There is good correlation between laser radiation, plasma radiation and ionization gauge fluctuations.

A theoretical study was aimed at producing a simple prediction model that allows to determine the amount of ejected mass from a flat surface as function of the material used, the laser energy density and the pulse duration. The model uses a one dimensional heat conduction model and an energy balance. Numerical results are given for the ejected mass  $m$  times the absorbed radiation flux  $F_0$  as function of  $F_0\sqrt{t}$  where  $t$  is the pulse length for a number of materials of interest as suitable x-ray sources.

**Theses**

Directed:

C. B. Johnson, "Induced Evaporation of Material from an Aluminum Surface by Normal Pulse Neodymium Laser," Master's Thesis, September, 1979.

G. L. Travers, "Laser Produced Material Surface Evaporation Model: Master's Thesis, December, 1979.

## DEPARTMENT OF ELECTRICAL ENGINEERING

The Electrical Engineering Research Program encompasses a variety of areas including: Electronic Warfare Systems; Electromagnetics, Antennas and Microwaves; Signal Processing; Communications; Range Studies; Digital Systems; Control Systems; Command, Control and Communication (C<sup>3</sup>); and Vapor Toxicity Level Studies. The projects in each of these areas generally involve one or more faculty members working with several thesis students. A summary of the projects follows:

### ELECTRONIC WARFARE SYSTEMS(EW)

A bearing estimator for small aperture sensor arrays is an ongoing project by Professor George Sackman. The objective is to improve bearing accuracy of passive sonars, direction finders and seismic arrays. The estimator algorithm has been simulated on a computer and experiments are planned to verify results of simulation.

The use of lasers for infrared (IR) missile jamming is a project on which Professor John Powers continues to work. A linear simulation of the seeker and control loop has been implemented and tested. Future work will incorporate nonlinearities in the model and simulation.

Professor Lonnie Wilson initiated work in the area of automated target classification. Objectives are to develop an automatic radar ship classification system using digital signal processing and pattern recognition techniques and to develop an emitter classifier using acousto-optical processing and pattern recognition techniques.

Professor John Bouldry continued his investigation of the performance of the TPS-59 radar in a jammed environment. The objective is to determine its usefulness against sophisticated enemy denial and deceptive jamming. The study will conclude with the present testing.

Work in three EW areas: 1) mission planning for the EA6-B jammer aircraft; 2) missile countermeasure techniques; and 3) scoring techniques for jamming effectiveness against noncommand guided missiles was continued by Professor Harold Titus. The EA6-B mission planning program is in use on three carriers. A program is presently being developed to process the post flight digital tape. Cooperative countermeasures (blinking jamming) were simulated against various missiles. Scan with compensation techniques are being investigated.

The investigation of task force information and timeliness requirements for tactical over-the-horizon missile launching is an ongoing project by Professor Stephen Jauregui, Jr. Additionally, studies have been made on the effect of DF and navigation error on targeting accuracy.

#### ELECTROMAGNETICS, ANTENNAS, AND MICROWAVES

Professor Jeffrey Knorr initiated a study of transmission media for millimeter wave integrated circuits. The goal of this work is to identify structures with desirable properties and through theoretical and experimental investigations to develop the data necessary to do millimeter wave integrated circuit design using these structures. This project is just beginning. Professor Frederick Tischer continued his studies of millimeter wave transmission media.

The following three projects: 1) beam scanning using dielectric inserts in frequency swept horn antennas for search radar; 2) unconventional loading of dipole antennas to improve radiation characteristics; and 3) microwave applications of polyconductor devices for receiver protection, low power density measurements and scanning antenna arrays were initiated by Professor Michael Hamid. In addition, Professor Hamid joined an ongoing project on millimeter wave printed circuit antennas.

Professors Michael Morgan and Kenneth Gray initiated a study of electromagnetic pulse (EMP) energy coupling into the SM-2 missile. The results of computer analyses will be used to aid in the planning of in-situ measurements.

Professors Morgan and Hamid also initiated a time-domain electromagnetic scattering research program. The goal of this effort is to investigate viable inverse scattering methods for advanced radar applications. A finite-element numerical method is being employed, and a new image-plane time-domain scattering range is being constructed.

Professors Paul Moose, Otto Heinz (Physics/Chemistry) and R. Neagle Forrest (ASW Group) continued work on magnetic background noise measurement and analysis. The goal of this project is to obtain data on ULF EM spectra and propagation in the ocean. Initial instrumentation (Cs-vapor magnetometer and recorders) has been developed and deployed to acquire data on the floor of Monterey Bay in the .005 to 10 Hz frequency band. Excellent correlation has been obtained with surface wave spectra from a local wave buoy. Future emphasis will be on

deploying deep-sea autonomous recording devices and establishing a permanent land based magnetic field site with real time data telemetry to NPS.

A project on transient response determination of electromagnetic wave propagation in plasma was initiated by Professor Gray. Professors Gray and Ohlson initiated a program to make shipboard Radio Frequency Interference measurements at millimeter wave frequencies in support of the Navy Advanced Satellite Program (NASP). Shipboard measurements on USS Coral Sea and USS Horne have been made and another series of shipboard measurements will begin in Spring 1980. Professor Gray is also beginning a SM-2 EMP vulnerability study.

Professor Sackman completed work on specifications for a system providing real-time processing and display of electromagnetic signals from on-board measurements. Tests of a proposed measurement suite were made using recorded data and results were reported to the sponsor.

Professor Jauregui completed a study of the electromagnetic compatibility of composite materials currently used in aircraft manufacture. Special probes for measurement have been developed and are being tested. The probe work was under the direction of Professor Orestes Baycura. Professor Jauregui also continued a project to investigate the horizontal-vertical polarization effects on HFDF small aperture antennas. The objective is to develop skywave discrimination techniques for small aperture HFDF.

#### SIGNAL PROCESSING

Professor Sackman continued a project on adaptive acoustic processing with applications to noise cancelling in torpedo sonars. An experimental noise canceller was constructed and tested in the anechoic chamber with promising results. In this same general area Professors Sackman and Bryan Wilson (Physics/Chemistry) continued their project of acoustic absorption measurements and acoustic imaging techniques in bottom sediments. The objective is to apply some of the recent developments in acoustic imaging technology and image data processing to locate object buried in bottom sediment. In another project, acoustic background noise measurements were used to determine the array gain of a vertical line aperture. The objective was to determine the effect of the directional noise field on array gain in various sea states.

Work on computer-aided acoustical imaging and techniques of optically excising various frequency components within an

RF signal was continued by Professor Powers. The data acquisition unit of the acoustical imager has been brought under microprocessor control and is essentially completed. The optical excision study has performed preliminary work on modeling and experimental verification of acousto-optical techniques for spectrum analysis of wideband signals.

Professor Sydney Parker continued his work in modeling of circuits and systems for the purpose of performance evaluation and fault detection. The current effort is to use "lattice parameters" rather than zero/pole parameters in models and to extend the theory to modeling of non-linear circuits and systems. Professor Parker also continued his studies of discrete signal processing and the filtering of radar signals. Involved are a self-adaptive digital filter and the development of simplified and efficient adaptive algorithms for recursive and nonrecursive digital filters.

Ongoing work by Professor Tien Tao concerns "Smart Sensor Signal Processing" of images from IR mosaic detector arrays which are processed for detection, tracking and recognition of moving targets in high altitude surveillance systems. The study is being extended to process IR images in missile systems for terminal homing.

Work on image processing for target detection/tracking and non-linear estimation techniques for passive acoustic tracking was continued by Professor Titus. A real time torpedo tracking program has been developed using Kalman filter techniques.

Professors Moose and Anthony Rockmore initiated a project to study techniques for optimization of spatial distribution of random acoustic arrays.

A program on computer simulation of the Bulldog/Bullseye wideband system in an effort to test proposed Bulldog improvements to the Bullseye HFDF system was furthered by Professors Jauregui and Knorr. Professor Jauregui also continued a project to investigate intermodulation products and proper ways to specify them in wideband HF multicouplers.

#### COMMUNICATIONS

The SATCOM Signal Analyzer program, under the direction of Professor John E. Ohlson, continues its productiveness. A prototype SATCOM Signal Analyzer is under construction and will be evaluated at NAVCOMMSTA, Stockton, California in the spring of 1980.

Professors Jauregui, Knorr and Glen Myers completed their work to determine the effectiveness of communications channels by measuring noise and interference and modeling propagation paths and antenna patterns.

#### RANGE STUDIES

A project concerning acoustic range facilities was continued by Professor Donald Stentz. The goal of the study is to determine specific acoustic measurements, range facilities, and fleet exercises to be made that will accurately characterize the condition and readiness of sonar and other acoustic systems. The result of the study is to provide productive thesis topics for NPS students.

Ongoing work by Professor Knorr concerns propagation loss for several line-of-sight radio paths in the Pacific Northwest. Both multipath and fading effects are considered.

Work on fiber optic communications for a shallow water communications link is an ongoing project by Professor Powers. The link is for possible use in the data collection network of the Shallow Water Torpedo Range under current design at Keyport. The work included engineering system design, filter cable identification and hermetic coupling techniques.

#### DIGITAL SYSTEMS

Work on applications of Very Large Scale Integration (VLSI) devices for implementation of signal processing algorithms continues under the direction of Professors Tao and Uno Kodres (Computer Science). Current emphasis is on development of a multiple micro-computer system for signal processing of IR images for surveillance and guidance applications.

Professors Mitchell Cotten, Rudolf Panholzer, Bernard Carey, and Uno Kodres initiated a project on VLSI utilization in combat systems (AEGIS). This project has as its goal the use of multi micro-computer networks for large-scale problems. Initial application is to radar signal processing and beam steering.

#### CONTROL SYSTEMS

Professors Alex Gerba and George Thaler continued their project on analysis and design of the control systems for the Captured Air Bubble type Surface Effect Ship. Development of models for Surface Effect Ships using both analytical and experimental methods was continued. Professor Thaler also

initiated projects on torpedo guidance and computer-aided design of control systems.

#### COMMAND, CONTROL & COMMUNICATION (C<sup>3</sup>)

An interdisciplinary research program aimed at better understanding command and control systems, and their evaluation, has begun under sponsorship by the Defense Advanced Research Projects Agency. As part of this program, Professor Moose is studying cybernetic models of C<sup>3</sup> systems, with emphasis on surveillance, and Professor John Wozencraft is investigating the problem of determining objective functions for describing the relative desirability of various battlefield configurations. Also participating on other facets of the program are faculty from the Operations Research and Physics and Chemistry departments.

#### VAPOR TOXICITY

Professor John Duffin completed a program to use infrared techniques to detect and record toxic vapor levels in various work areas of the Naval Air Rework Facility - North Island (NARF-NORIS).

Title: Alternative Seafarer Antennas

Investigator: O.M. Baycura, Associate Professor of Electrical Engineering

Sponsor: NPS Foundation Research Program

Objective: To reduce the physical size of the present Seatores antenna from 100 miles to approximately ten miles.

Summary: By using a magnetic antenna with high permeability ( $\sim 10^6$ ) and high dielectric constant ( $\sim 10$ ), the wave velocity can be reduced from the speed of light to 1/1000 the light speed. The speed reduction reduces the antenna to ten miles of length for one-quarter wave length radiator with high radiation resistance an efficiency.

Publications: O.J. Baycura, "Alternative Seafarer Concepts," NPS Report No. NPS 62-79-009PR, 1 January 1979.

**Title:** Investigation of Toxic (Known or Potential) Airborne Vapor Concentrations in Various Work Areas of the Naval Air Rework Facility, North Island

**Investigator:** J.H. Duffin, Professor of Electrical Engineering

**Sponsor:** Naval Air Logistics Facility (NALF), Patuxent River, MD Mr. Al Jones, via the Aircraft Environmental Support Office (AESO), North Island, CA, Code 64270, Mr. Robert Hammond.

**Objective:** To study hazardous gas concentrations in various work areas of the Naval Air Rework Facility, North Island to try to model the expected concentration versus productivity for a given work area.

**Summary:** Calibration work started during a research quarter at NPS and was continued during an intersessional quarter at North Island. The infrared instrument (Miran IA) was updated by installing new silver bromide cell windows and by installing a new detector/preamplifier.

The Miran IA was used in painting and chemical shops to study concentrations of various vapors. In the time available, it was not possible to arrive at what constitutes "productivity" in these areas and so no modelling was done. Monitoring of vapor concentrations in these areas was done.

**Publications:** Report No. NPS 62Dn78-010 December, 1978 "Use of Portable Infrared Airborne Vapor Concentration Detection Device for Calibration for the Monitoring of Materials in use at Various Work Areas of Naval Air Rework Facility at North Island, CA."

Title: Analysis and Design of Control Systems for the CAB Type Surface Effect Ship

Investigators: A. Gerba, Jr., G. J. Thaler, D. M. Layton

Objective: Continued development by experimental and analytical methods of models for the surface effect ships that can be used for design of control systems. Design and evaluation of control systems using these models.

Summary: The analytical work for FY 78/79 was directed towards the development of a simplified 2DOF, Pitch-Heave Model and development of a real-time, hybrid simulator for the proposed design of a 3000 ton surface effect ship. The first objective was successfully completed and the resulting model is reported by Barnes (see below). Work on the real-time simulator began with a familiarization and planning phase which was completed and reported in NPS 62-79-008. The next phase of development is nearing completion and will be reported in the thesis of Nelson to be completed in December 1979.

Publications: Gerba, A., "Development of a Real-Time Hybrid Computer Simulation for the 3-K-SES, 5 DOF, Data-Familiarization and Planning," NPS-62-79-008, June, 1979

Thesis: Barnes, Leslie W., "Development and Time Domain Validation of a Low-Order Constant Speed, Pitch-Heave Model for the XR-3 Surface Effect," Master of Science, March, 1979.



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**A Diagnostic Session on the "Bridge" of a Real-Time Hybrid Computer Simulator of a 3,000 Ton Surface Effect Ship Following a Manual Control Recovery from an Accidental Thruster Failure During a High Speed Run.  
From Left to Right: Professor Alex Gerba (Advisor), LT Lee Oliphant (Helmsman) and MAJ Tom Nelson (Simulator Designer)**

Title: Investigation of Transient EM Waves in Frequency-Dispersive Media by a Multiple-Scattering Method

Investigator: Kenneth G. Gray, Assistant Professor of Electrical Engineering

Sponsor: NPS Foundation Research Program

Objective: To develop a new method for solving transient electromagnetic problems.

Summary: This research involves a new method for finding the transient response of frequency-dispersive media to time-dependent electromagnetic waves. For the interesting cases of propagation through an absorbing region with an imposed longitudinal magnetic field, the transient response can be expressed directly in terms of the corresponding free-electron response; the free-electron response being an infinite sum of scatters. The method is verified for general ionization profiles and specific solutions are found for the cases of a uniform and exponentially increasing ionization profile. Future research on this topic should involve extension to arbitrary polarization of incident waves and regions that are spatially inhomogeneous in two dimensions.

Publications: "The Reflected Impulse Response of a Lorentz Medium" Proceedings of the IEEE, in press.

"A Convolution Method for Finding the Impulse Response of a Horizontally-Stratified Cold Plasma." Paper is in review status.

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Title: A Study of the Effect of the Click Jammers on U.S. Navy Radar Systems

Investigator: David B. Hoisington, Professor of Electronics

Sponsor: Naval Intelligence Support Center

Objective: Investigation of jamming environment in which Navy radars will have to operate in the 1980's, and the effects of this environment.

Summary: Previous efforts look at a one jammer versus one AN/SPS-48 radar. This year the investigation has been expanded to look at a scenario with a large number of jamming aircraft in a attack force which is launching a multiplicity of missiles at the U.S. task force. The ability of the AN/SPS-48 to supply range and elevation information on incoming missiles to fire-control radars for various geometrics is estimated.

Publications: A final report is in preparation

Thesis  
Directed: William G. Evans, "Effect of Soviet EW on 198X War-at-Sea Scenario (U)" Master's Thesis, June, 1979.

Title: Modulation Studies Continuation

Investigator: S. Jauregui, Associate Professor of  
Electrical Engineering

Sponsor: NAVELEX PME-117-24

Objective: To investigate certain aspects of a communications system with the emphasis this year being on noise and interference. A second objective was to model the Fishbone resistive receiving antenna.

Summary: Over a two-year period ten different U.S. sites were visited and measurements on noise and interference were made. This data has been analyzed, problems defined and in some cases solutions recommended. The Fishbone antenna has been modeled on the IBM 360 using the NEC program. A BDM report has been issued.

Publications: S. Jauregui, E. Cummins, W. Vincent, "Time and Frequency Domain Characteristics of Manmade Radio Noise Affecting HF Communications Sites," IEEE Transactions on Electromagnetic Compatibility, EMC-21, No. 3, August 1979 (pp. 182-189).

BDM report of 1 April, 1979. "HF Communications Antennas Modeling by," R. Adler

Thesis Reports: E.J. Cummins, "High Frequency Radio Interface," EE, March 1979.

**Title:** Operational HF Multicoupler Investigation

**Investigator:** S. Jauregui, Associate Professor of Electrical Engineering

**Sponsor:** COMNAVSECGRUCOMM G80

**Objective:** To determine adequacy of multicouplers currently used in HF CDAA sites.

**Summary:** Various multicouplers were measured in the field where both intermodulation products and parasitic oscillations were discovered. These multicouplers were measured in accordance with specifications and in some cases met the specs. New methods to specify and measure the specification were investigated.

**Publications:** S. Jauregui, E. Cummins, W. Vincent, Field Multicoupler Study for Intermodulation Products and Parasitic Oscillations", NPS 62-79-006PR, 11 July 1979.

**Thesis Reports:** E.J. Cummins, "High Frequency Radio Interference," EE, March 1979

Title: Requirements for Tactical OTH Missile Launching

Investigator: S. Jauregui, Associate Professor of Electrical Engineering

Sponsor: NSA R-93  
NAVELEX PME-107

Objective: To investigate various facets of surface launcher OTH missiles with emphasis on outboard and combat DF ships

Summary: Facets of DF accuracy, navigation, communications, inter task force support, and off task force sensors were investigated. A total of six theses were produced on the individual parts of the study.

Thesis

Directed:

P.A. McNulty, "Sensitivity Analysis of Navigational Error in Over the Horizon Targeting," MA in NSA, September 1979

D.M. Whitney, "An Evaluation on Non-Task Forces Sensors in Support of OTH-DCIT," MS in ST, March 1979

R.J. Heifner, "Horizon Extension for the Carrier Task Group," MS in ST, March 1979

E.R. Fennel, "A Plan for the Tactical Exploitation of National Capability (TENCAP)," MS in ODS, March 1979

K.E. Verbrugge, "Algorithm Investigations for Shipboard NFDF Improvements," EE, December 1978

J. Becker, "Special Intelligence Communications Support for Classic Outboard," MA in NSA, September 1979

**Title:** HULTEC Vulnerability Program Technical Design Review

**Investigator:** Kirk, D.E., Coordinator, G.L. Sackman, Investigator for Acoustic Module.

**Sponsor:** Naval Electronic Systems Command, Code 9523, Washington, D.C.

**Objective:** Evaluate computer simulation module for acoustic sensors.

**Summary:** Reviewed technical background and assumptions.

**Publications:** Unpublished report to sponsor.

Title: Communications System Studies

Investigator: Jeffrey B. Knorr, Associate Professor of Electrical Engineering

Sponsor: Naval Undersea Weapons Engineering Station, Keyport, Washington.

Objective: To determine the propagation loss for several line of sight radio paths in the Pacific Northwest, including the effects of multipath and fading.

Summary: Development of a Radiowave Propagation Data Acquisition System has been completed. Data will be acquired and analyzed during FY 1980.

Publications: J.B. Knorr, "Radiowave Propagation Data Acquisition System," technical report NPS 62-79-001, October 1979.

J.B. Knorr, "A Dual Channel Radiowave Propagation Data Acquisition and Transmission System," Technical Report NPS 62-79-01OPR, September 1979.

P. Ruputz, "Remote Acquisition of Atmospherically Propagated Radio Frequency Communication Channel Performance Data By Way of Dialup Telephone Networks", MS thesis, June 1979.

J. Cano, "The Statistics of Multipath Fading for An Overwater Path at VHF Applied to Communications Links at NUWES Keyport, Washington," MS thesis, June 1979.

Title: Radar Target Identification Via Time-Domain Scattering Signatures

Investigators: Michael A. Morgan, Assistant Professor of Electrical Engineering and Michael Hamid, Professor of Electrical Engineering

Sponsor: NPS Research Foundation Program

Objective: To initiate a comprehensive program in inverse scattering research via both experimental and analytical efforts. The long-range goal is to identify and develop enhanced target recognition and classification schemes for future radar systems.

Summary: This is a new project that is still in the start up phase. During the next year, our goal is to develop a new iterative inverse scattering method for radar target identification. A parallel effort will be the set up of a versatile time-domain scattering laboratory for use in both confirming and exercising the analytical approach, as well as in scale modeling radar returns from various targets of military significance. A practical demonstration of the method is our one-year benchmark objective.

Thesis  
Directed:

B.E. Welch, "Numerical Computation of Time-Domain Electromagnetic Scattering," (in progress) Master's Thesis, June, 1980.

Title: SATCOM Signal Analyzer

Investigator: John E. Ohlson, Professor of Electrical Engineering

Sponsor: NAVELEXSYSCOM

Objective: Design construct prototype system for monitoring of Navy UHF SATCOM signals

Summary: Following on previous years' work, a prototype SATCOM Signal Analyzer is being built. It uses multiple antennas for simultaneous satellite use. It has seven receivers for multi-channel monitoring. Fast Fourier Transform processing is used for spectrum analysis. Uplink assessment is made with a computer-control transmitter.

Theses Directed:

"Design of the Digital Control and Test Unit Subsystems for a Satellite Signal Analyzer", LT C. Musgrave, MSEE June 1979.

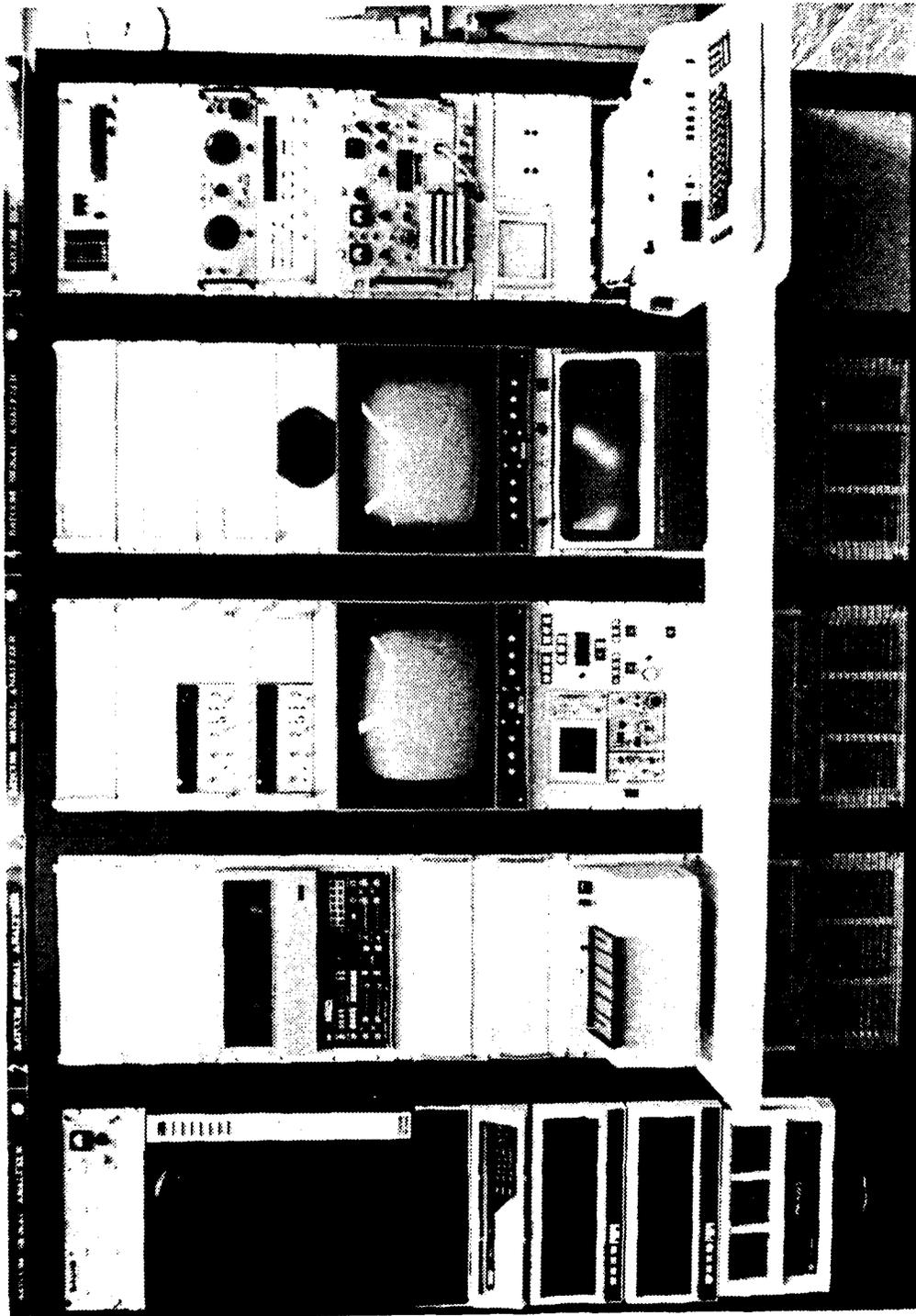
"Long Term Stability and Drift Measurements of GAPFILLER's Onboard Oscillator," LT J.M. Forgy, MSEE, March 1979.

"Spectrum Receiver and Signal Selection Unit Designs for the Naval Postgraduate School SATCOM Signal Analyzer," LT W.E. Davidson, MSEE, June 1979.

"Analog-to-Digital Signal Processing in a Prototype SATCOM Signal Analyzer," LT W.B. Zell, Jr., MSEE, March 1979.

"Frequency Receivers in the Satellite Communications Signal Analyzer," LT M.J. Rogers MSEE, September 1979.

"Orbital and Satellite Ephemeris Data Estimation," CAPT C.E. Boyer III (USMC), MSEE, December 1979.



Prototype SATCOM Signal Analyzer System  
Developed by Professor John E. Ohlson of Electrical Engineering Department

Title: Shipboard Microwave RFI

Investigators: John E. Ohlson, Professor of Electrical Engineering and Kenneth G. Gray, Assistant Professor of Electrical Engineering

Sponsor: NAVELEXSYSCOM  
PME 106-1  
M. Plunkett

Objective: Characterize Navy Shipboard Radio Frequency Interference (RFI) to satellite communications at microwave frequencies.

Summary: The Microwave frequencies above the UHF band are attractive for Navy satellite communications usage. This research program has developed instrumentation to characterize microwave RFI in the bands 7.25-7.75, 20.2-21.2 and 40.0 to 41.0 GHz. Several ships are being examined by use of this instrumentation. The primary interferers are shipboard radars so they are being examined closely.

Thesis  
Directed: M. Blume, "Shipboard RFI Measurements,"  
Master's Thesis, December 1979.

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Title: Reduced Order (Macroscopic) Characterization of Circuits and Systems

Investigator: Sydney R. Parker, Professor of Electrical Engineering

Sponsor: Office of Naval Research

Objective: This research is concerned with the investigation of techniques for the reduced order (macroscopic) modelling of linear and nonlinear circuits and systems for purposes of fault detection and performance analysis. The macroscopic model parameters are to be developed dynamically from a finite set of input/out measurements on the circuit/system and they are to be used within the concept of a "fault dictionary" or performance criteria index to evaluate the behavior of the system for failure detection or degraded mode operation. The techniques being developed are particularly significant in light of the rapidly developing technology in very large scale integrated circuit technology (VLSI) which can be expected to expand on line computational capabilities well beyond what is available today.

Summary: As a result of research this year, several very promising results have been obtained.

Early work demonstrated the relationship between the various general linear models, the unifying property of mixed autoregressive-moving average (ARMA) models, and the various parameter estimation techniques available for the macroscopic characterization of linear systems. A computer program was developed as a research tool in order to examine the effects of finite data lengths, correlation versus covariance analysis, undermodeling and overmodeling, and the case of additive measurement noise. The experimental results demonstrated the expected theoretical behavior and served as a base from which to extend the research into the more general field of nonlinear systems. Specifically, the following new results have been achieved:

As a result of linear model studies the coefficients of the denominator of a general zero-pole (ARMA) model have been related to the coefficients of the all pole (AR-auto-regressive) model, and the coefficients of the numerator of a general zero/pole model have been related to the all zero (MA-moving average) model coefficients. In each case the result is of the form:

$$P(\text{zero/pole}) = P(\text{all zero or all pole}) + (\text{Gain})(\text{Error})$$

where the gain terms in the two cases have been shown to be the transpose of each other. The error represents the discrepancy between the impulse response of the model and the actual impulse response. The gain factor weights these errors proportional to the impulse response and inversely proportional to the difference between the autocorrelation function of the system output and the estimate of the autocorrelation function of the system impulse response.

These results as well as a discussion of the concept of "equation" error versus "system" error were presented of an invited paper in a special session at the IEEE International Symposium on Circuits and Systems, July, 1979. The significance of the result lies not only in the insight it provides to the linear modeling problem, but more significantly, in the "Kalman Filter" like formulation of the equations. This formulation enables a full set of model parameters, ranging from the all pole through the mixed zero/pole to the all zero models, to be obtained readily from measured data. It is these parameters which can provide entry into a fault dictionary or other performance criteria to evaluate system behavior.

After studying the theoretical basis of several nonlinear models (Volterra, Hammerstein, and Bilinear) in light of the foregoing linear ARMA model studies, a new extended generalized model (EGM) has been postulated and tested. The model is based upon the equation error formulation and in

essence consists of discrete Volterra like series expansions for the input and output signals, respectively, and a discrete Bivariate expansion for cross coupling between of the forementioned linear and non-linear models. Of significance is the fact that minimizing a quadratic error criteria between the model and system outputs, based upon the equation error, leads to model parameter estimation procedures involving the solution of a set of linear equations. The coefficients of these equations are shown to involve high order auto and cross correlation functions of the input and output data. Previously developed computer programs have been expanded to effectively handle the EGM with second order nonlinearities. Extensive experimentation has been done with these programs to investigate the characteristics of the EGM, and confirm its effectiveness.

Publications:

"Recursive Solutions for Zero-Pole Modeling", S.R. Parker & F.A. Perry. Asilomar, November 1979. (to be published)

"An Autoregressive Discrete Nonlinear Model", S.R. Parker Int. Symp. on Circuits & Systems, April 1979. (to be published).

"A Lattice Structure for Zero-Pole Modeling", S.R. Parker & F.A. Perry. IEEE Int. Symp. on Circuits & Systems, April 1979. (to be published)

"Block Adaptive Filtering", S.R. Parker, S. Mitra, & Clark. IEEE Int. Symp. on Circuits & Systems, April 1979. (to be published).

"Adaptive Filters Using Simplified Gradient Estimations", Proceedings of the Workshop on Applications of Adaptive Control, Yale University, 1979, pp. 61-67.

"Reduced Order Modeling of Analog Circuits", S.R. Parker, presentation IEEE Conference on Circuits & Systems, Tokyo, July 1979.

Title: Signal Processing Studies

Investigator: Sydney R. Parker, Professor of Electrical Engineering

Sponsor: Naval Electronics Systems Command

Objective: This research is directed toward the development of new algorithms for the processing of discrete signals with applications to speech, images, and radar. The work is particularly significant in light of current developments in VLSI circuit technology which will increase the scope of signal processing possibilities that are feasible for military systems.

Summary: The wave digital filter approach to algorithm design essentially transforms an LC analog filter circuit into a digital filter algorithm using the bilinear z-transform and incident and reflected waves as signal parameters. This approach has been conjectured to lead to algorithms with minimum sensitivity with respect to multiplier coefficients and thus require the smallest number of decimal or binary places in the multipliers, as well as exhibiting minimum output noise due to finite precision arithmetic. This conjecture is based upon the direct transformation of circuit elements to wave digital filter parameters, so that the optimal sensitivity properties of LC filter circuits are preserved in the transformation. An in-depth analytical and experimental study of wave digital filter has just been completed. The results generally confirm the low sensitivity conjecture.

It has been stated in the literature and generally acknowledged, that limit cycles (coherent oscillations due to finite precision arithmetic) do not occur in wave digital filter algorithms. However, our studies have indicated that hidden limit cycles can exist internally as a parasitic type of oscillation, so that they are not detected in the output signals. A paper on these results has been presented and published.

The feasibility of using linear predictive coding of speech to change the overall frequency characteristics of the speech wave form while maintaining the perceived sounds and information content has been demonstrated. The processing technique consists of using linear predictive coding to determine z-plane pole locations of 25 m/sec segments of speech. The speech is then resynthesized by shifting the pole locations and changing the excitation pitch period. The use of this technique for speech modification and/or secure communications seems feasible. A thesis report is available and a paper is being prepared.

An extended Bode approach, namely the use of semi-infinite planes to approximate the log-magnitude versus log-frequency characteristics of two dimensional analog filters is under study. The technique works well with separable filters and the use of the double z-transform converts these transfer functions into stable quarter plane two dimensional digital filters for image processing. It has also been shown that the extended Bode planar approach can be applied to non-separable two dimensional transfer functions. However, the use of the double bilinear transform with these factors does not necessarily lead to stable two dimensional digital filters. A thesis has been written in this area.

Studies have continued on adaptive recursive and non-recursive digital filters. Our results include the investigation of different techniques (error sign, error magnitude, and others) for approximating gradients with comparisons being made on the basis of convergence time and residue. A particularly promising method for adaptive recursive digital filtering appears to be the use of random search techniques for the coefficients of the recursive section of the filter in cascade with a non-recursive (all zero) adaptive section for which the LMS algorithm, or one of the simpler implementations mentioned above, is used. It has also been shown that there is much to be gained in terms of convergence time and residue, if

advantage is taken of any constraints which can be imposed from a priori information on the digital filter parameters--particularly in the recursive section.

In the area of the digital processing of radar signals, two new techniques for separating two targets in the same radar resolution cell have been developed and tested by computer simulation. The first involves a modified Kalman filter approach to the problem, and the second introduces the concept of a probability filter. These results are available in a dissertation, and two papers on the subject are under preparation.

Publication:

"An In-depth Study of the Sensitivity of Wave Digital Filters", S.R. Parker & M. Sanaie-Fard. Asilomar, November, 1979.

"Hidden Limit Cycles and Error Bounds in Wave Digital Filters", S.R. Parker, & F. Perry, Proceedings of the IEEE Int. Symp. on Circuits & Systems, July 1979, pp. 372-377.

"Computer Modelling of Voice Signals for Adjustable Pitch and Formant Frequencies", S.R. Parker & G. Hall, Asilomar, November, 1979.

**Title:** Computer Aided Acoustical Imaging

**Investigator:** John P. Powers, Associate Professor of Electrical Engineering

**Sponsor:** National Science Foundation  
Division of Engineering  
Automation, Bioengineering and Sensing  
System Program

**Objective:** This project investigates the verification of the use of the computer to produce images from complex valued scalar diffraction patterns produced from reflected or transmitted ultrasound. A coherent detector is scanned through the diffraction pattern and the amplitude and phase are recorded. A computer performs the image formation and image processing.

**Summary:** Work continued on the data acquisition portion of the project. Improvements were made in the mechanical and electronic stability of the equipment. The data flow of the raster scan geometry was brought under the control of an 8748 microprocessor with a recording capability to use either a digital cassette recorder or a paper tape punch. The cassette reader was also interfaced to the PDP-11 computer that drives the graphical output devices. Design of the interactive software for data processing and image manipulation is proceeding currently. A faster scanning system design utilizing a linear receiving array, data control by a faster microprocessor, (the 8010) and electronic memory storage was completed.

**Publications:** J.P. Powers, J.R.Y. DeBlosis, R.T. O'Bryon and J.W. Patton, Acoustical Holography Volume 8, Chapter titled, "A Computer Aided Ultrasonic Imaging System" pp. 235-248, Plenum Press, New York, 1979.

**Conference Presentations:** J.P. Powers, J.R.Y. DeBlois and C. Culpepper, "Computer-Aided Acoustic Imaging System Using Backward Wave Propagation." Presented at the Fourth International Symposium on Ultrasonic Imaging and Tissue Characterization,"

National Bureau of Standards, Gaithersburg, MD, 18-20 June 1979.

J.P. Powers and G.L. Sackman organized and chaired a session on Acoustic Imaging (Medical, Underwater and Seismic) at WESCON, San Francisco, 18-20 September 1979.

**Theses**  
**Directed:**

MAJ Reid Carlock, "Analog and Digital Hardware Development for a Micro-processor Controlled Data Acquisition System for Acoustical Imaging," MSEE 1979.

LT Rod Colton, "A Microprocessor-based Digital Acquisition Controller for a Computer Aided Acoustic Imaging System," MSEE, 1979.

**Title:** Fiber Optics in Underwater Range Applications

**Investigator:** John P. Powers, Associate Professor of  
Electrical Engineering

**Sponsor:** Naval Underwater Warfare Engineering Station,  
Keyport, WA

**Objective:** This project is investigating the feasibility  
of using fiber optic communications in the  
underwater torpedo ranges.

**Summary:** Using the shallow water range design specifi-  
cations a prototype system has been designed,  
built and tested in the laboratory environ-  
ment. A simulated PSK signal was formed,  
detected and converted into digital format  
for transmission over the fiber. Candidate  
transmitter and receivers were evaluated and  
selected for underwater use. Design of a  
system to use with the current spaced fre-  
quency shift keying modulation format and  
range element spacing is ongoing.

**Theses  
Directed:** CAPT John R. McHenry, "Fiber Optic Design  
Application for a Shallow Water Torpedo  
Tracking Range", MSEE, March 1979.

**Title:** Jamming Parameter Study of Helicopter-borne Countermeasures

**Investigator:** John P. Powers, Associate Professor of Electrical Engineering

**Sponsor:** Naval Air Systems Command

**Objective:** This project is to develop a computer mode of various missile control systems that can be used in analyzing the interplay and trade-offs of the parameters of IR countermeasures. A degradation model of the demodulator and subsystems of specific missiles will be developed and investigated against various jammer forcing functions and jam-to-signal ratios.

**Summary:** A linear missile control model has been studied, implemented and tested on the computer. Efforts to include control nonlinearities into the model are continuing.

**Theses Directed:** LT C.E. Vance and J.P. Powers, "SA-7, MOD 1, Grail Missile Seeker System Simulation for Guidance Degradation Studies." Thesis Report NPS 62-79-001 MS in Systems Technology, September 1979.

**Title:** Techniques of Acousto-optical RF Signal Analysis

**Investigator:** John P. Powers, Associate Professor of Electrical Engineering

**Sponsor:** Naval Electronics Systems Command

**Objective:** This project investigates techniques of optically excising various frequency components within a wideband RF signal. The excision is performed in the transform domain of an acousto-optic signal processor. Our goal is to develop a first order model relating the laser beam, Bragg cell, excisor and detector parameters. This involves working in the time, frequency and space domains since they are all interrelated by this system. A simple experimental test bed is also being constructed.

**Summary:** Important device parameters have been identified and interrelationships have been worked out on the subsystem level. Models have been developed for the laser beam propagation through the system, interaction between the laser beam and the Bragg cell (including beam truncation effects) and interaction between the beam and the detector. Further work should include refinement of these models and exercising of the total system model. Preliminary theoretical filter response curves of the optical excisor have been obtained.

**Thesis Directed:** LT F. Weldon Regan and J.P. Powers, "Acousto-optic Spectrum Analysis and Narrowband Interference Excision in Wideband Signal Environments," Thesis Report NPS 63-79-011, Electrical Engineer Degree, September 1979.

Title: Support of Non-Acoustic Analysis

Investigator: Reese, W. Coordinator with G.L. Sackman,  
S. Tucker, J. Von Schwind, N. Forrest

Sponsor: Naval Intelligence Support Center

Objective: Evaluation of translated technical  
literature.

Summary: Papers related to magnetics and signal  
processing were reviewed to obtain a general  
idea of the status of signal processing in  
the USSR. Areas of interest included maximum  
entropy spectrum analysis, adaptive filters,  
array processing, and Fast Fourier Transform  
analysis.

Publications: Unpublished reports to sponsor were  
submitted.

Title: Sampled Analog Signal Processing

Investigator: T.F. Tao, Professor of Electrical Engineering

Sponsor: NPS Foundation Research Program

Objective: To develop theory, design procedure and applications of sampled analog recursive and nonrecursive filters using charge transfer devices. Also to investigate the limitations and sensitivities of sampled analog signal processing.

Summary: The investigation has concentrated in the area of nonrecursive filters for image processing applications, including the following: 1) The applications of sampled analog nonrecursive filters for image processing applications have been expanded to include both spatial and temporal filters designed by two optimization criteria for enhancing the target-to-clutter noise ratios including minimization of mean square error and maximization of target signal-to-clutter noise ratio. It was found that their design procedure and filter performance depends critically on the nature of targets of interest (unresolved point targets or resolved targets), background clutter (temporal and/or spatial correlation) and relative speed of target and frame time between successive frames of images; 2) The design and performance of both statistical spatial and/or temporal filters have been investigated by using several real-world infrared images and yielded good background clutter suppression results; 3) The design of experimental implementation of nonrecursive spatial/temporal filters using CTD Tapped Delay Line device controlled by a 16-bit microcomputer has been completed and partially fabricated; 4) Since the sample analog devices have relatively limited accuracy compared with digital processing devices, a sensitivity study was carried out to determine the deterioration of background clutter suppression performance of sampled analog nonrecursive filters of different degrees of accuracy beyond two significant decimal numbers. This magnitude of

accuracy required should be within the realm of possibility for sampled analog LSI devices. However, the accuracy requirements of other signal processing devices prior to the non-recursive filter stage, may be more demanding than typically offered by sampled analog CTD devices. This aspect is being investigated.

Publication:

T.F. Tao, D. Hilmers, B. Evenor and D. Bar-Yehoshua, "Focal Plane Processing Techniques for Background Clutter Suppression and Target Detection," Processings of the 1979 East Society of Photo-Optical Instrumentation Engineers, Volume 178, "Smart Sensors," pp. 2-12, 1979.

Theses

Directed:

D.C. Hilmers, "Spatial-Temporal Filters for Clutter Suppression and Target Detection of Real World Infrared Images," Engineer's Thesis, December 1978.

K.P. Easterday, "Electronic Implementation of Spatial Filter Using Microcomputer Controlled CID Camera and CTD Tapped Delay Line," Master's Thesis, March, 1979.

K. Celik, "Focal Plane Signal Processing for Clutter Suppression and Target Detection in Infrared Images," Engineer's Thesis, June, 1979.

M. Koray, "Focal Plane Processing Techniques to Suppress Infrared Background Clutter, Detection and Tracking of Very Dim Targets Buried in Clutter Noise," Engineer's Thesis, June, 1979.

Title: Real Time Focal Plane Array Processing Studies

Investigator: Tien F. Tao, Professor of Electrical Engineering

Sponsor: Naval Electronics Systems Command

Objective: To develop real-time focal plane array processing using charge transfer devices and microcomputer for background clutter suppression and target detection.

Summary: Progress made during the past year will be summarized separately for the theoretical algorithm development and the experimental implementation.

(1) Theoretical algorithm development: An end-to-end image processing program has been developed including the following steps: Statistical temporal and spatial filters for background clutter suppression; Adaptive thresholding; frame suppression technique to distinguish moving point targets from moving large objects; logic "OR" step to build composite images from several successive frames of filtered and thresholded images; three different linking or streaking algorithms to distinguish moving tracks from false alarms. This end-to-end image processing program has been tested using two real world infrared images both in the medium wavelength infrared spectral band. Using five frame statistical temporal filter followed by a statistical spatial filter of 3x3 pixels, background clutter suppression on the order of 6,000 to 10,000 using these two sets of infrared images have been demonstrated. Evaluation of the target detection performance has been made by imbedding simulated moving targets into the infrared images and expressed in terms of probability of detection versus probability of false alarms for different target intensities.

(2) Experimental implementation using microcomputer: This end-to-end image processing program has been implemented also on a 16 bit microcomputer (DEC LSI-11). In order to determine the trade-off between accuracy and

execution speed of the microcomputer implementation of the image processing program, computation results using single and double precision have been compared. It was found that the major computational loads are in the calculation of statistical characteristics of the image which are needed in the design of our statistical spatial and temporal filters for background clutter suppression. Target acquisition using either a 5 of 10 hits or a 6 of 10 hits algorithm takes approximately the same amount time of that of the design and performing of the temporal filter. For an image of 32x32 pixels, the total execution time of the end-to-end image processing program from the initial background clutter suppression to the target acquisition takes about 53 seconds on one 16 bit microcomputer with a basic clock rate of 1 Mbits/sec. This computation speed is far from real-time execution. However, it represents our first success in performing a relatively complex image processing program on one microcomputer. Improvement of execution speed by using array processor is being investigated. A project to develop a multiple microcomputer system to improve the execution speed has also been started.

Publication: T. F. Tao, D. Hilmers, B. Evenor and D. BarYehoshua, "Focal Plane Processing Techniques for Background Clutter Suppression and Target Detection", Proceeding Society of Photo-optical Engineers, Vol. 178, "Smart Sensors", pp. 2-12, 1979.

Theses Directed: D. C. Hilmers, "Spatial-Temporal Filter for Clutter Suppression and Target Detection of Real World Infrared Images," (Engineer Thesis), December 1978.

B. Even-or, "Statistical Nonrecursive Spatial-Temporal Focal Plane Processing for Background Clutter Suppression and Target Detection," (Ph.D. Thesis), March 1979.

K. Celik, "Focal Plane Signal Processing for Clutter Suppression and Target Detection in Infrared Images," (Engineer Thesis), June 1979.

A. M. Koray, "Focal Plane Processing Techniques to Suppress Infrared Background Clutter, Detection and Tracking of Very Dim Targets Buried in Clutter Noise", (Engineer Thesis), June 1979.

Title: Analysis and Design of Control Systems for the CAB type Surface Effect Ship

Investigators: George J. Thaler, Distinguished Professor of Electrical Engineering,  
Alex Gerba, Jr., Associate Professor of Electrical Engineering,  
D.M. Layton, Associate Professor of Aeronautics

Sponsor: Naval Sea Systems Command  
PMS-304  
Box 34401  
Bethesda, MD 20034

Objective: Continued development by experimental and analytical methods of models for the surface effect ships that can be used for design of control systems. Design and evaluation of control systems using these models.

Summary: The analytical work for FY 78/79 was directed to the objectives of: 1) development of a simplified 2DOF, Pitch-Heave Model, 2) development of a real-time, hybrid simulator for the proposed design of a 3,000 ton surface effect ship, and 3) design of an optimal maneuvering control for the 3K-SES.

The first objective was successfully completed and the resulting model is reported in the thesis by Barnes (see below). Work on the real-time simulator began with a familiarization and planning phase which was completed and reported in NPS 62-79-008. The next phase of development was the design and implementation of the real-time simulator using the hybrid computer of the NPS Computer Laboratory as reported by Nelson (see below). The third objective was achieved in parallel with the development of the real-time simulator and provided an automatic control that would operate in an optimal manner to maintain desired heading during an accidental thruster failure. The design was developed and described in the thesis by Manoussos.

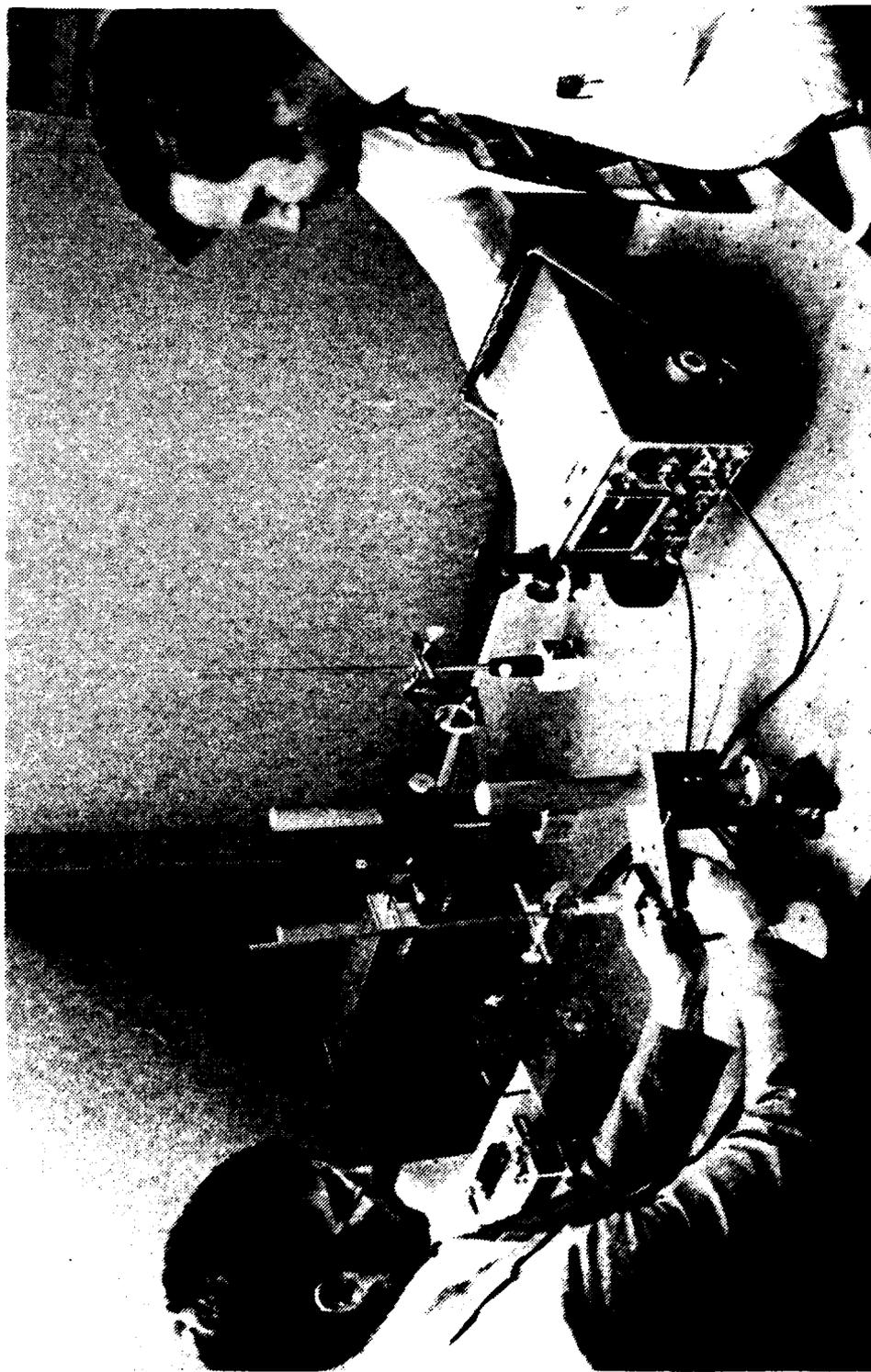
Publications:

G.J. Thaler and Alex Gerba, "Development of a Real-time Hybrid Computer Simulation of the 3K-SES, 5DOF, Data Based Program. Part I. Familiarization and Planning". NPS Technical Report, 1979. NPS 62-79-008.

Barnes, L. W., "Development and Time Domain Validation of a Low-Order, Constraint Speed, Pitch-Heave Model for the XR-3 Surface Effect Ship," MSSEE March 1979.

Nelson, T. S., "Real Time Simulation and Control 3000 Ton Surface Effect Ship," MSEE December 1979.

Manoussos, S. M., "Design of Optimal Maneuvering Control of the 3000 Tne Surface Effect Ship During Failure Modes," MSEE December 1979.



**Acousto-Optical RF Signal Analysis  
Experiment in the Laser Laboratory**

## DEPARTMENT OF METEOROLOGY

The research program in the Department of Meteorology continues in several areas: (A) Numerical weather and ocean modeling and prediction, (B) Analysis and dynamics of tropical weather systems, (C) The marine boundary layer, (D) Marine fog observation, analysis and prediction, (E) Polar studies and (F) Satellite remote sensing. Under each of these headings, a number of related investigations have been pursued by various faculty members.

### NUMERICAL MODELING AND PREDICTION

R. T. Williams is developing and testing numerical procedures for global and regional weather prediction. He is especially interested in the finite element method, and its application to the prediction of air flow near mountains. Professor Williams has also modified an existing model to determine better the changes which occur in frontal structure when a front moves over a surface where moisture and temperature properties are changing.

R. L. Elsberry and R. W. Garwood, Jr. (Oceanography) have used a one-dimensional mixed-layer ocean model to predict the upper oceanic thermal response to atmospheric forcing, and have successfully simulated the Mixed Layer Experiment. In a joint effort with R. L. Haney, the mixed-layer model has been coupled with a general circulation ocean model. This hybrid model is a first in oceanographic applications and may represent a breakthrough in the numerical simulation of upper ocean dynamics.

R. L. Haney has also used a large-scale ocean circulation model to investigate the dynamics of large-scale thermal anomalies observed in the North Pacific.

Other modeling efforts include a dynamical-statistical model for predicting the movement of tropical cyclones by R. L. Elsberry, a marine boundary layer model developed by K. L. Davidson and G. Schacher (Physics & Chemistry) for predicting marine fog, and the beginning of a comparison of several global initialization schemes by a Ph.D. candidate under the direction of Professors G. J. Haltiner and R. T. Williams.

### ANALYSIS AND DYNAMICS OF TROPICAL WEATHER SYSTEMS

C. P. Chang, R. L. Elsberry and R. T. Williams are investigating various aspects of the dynamics of tropical

weather systems, including development of hurricanes and typhoons by Elsberry, the dynamics and energetics of tropical synoptic and planetary scale waves by Chang and Williams, and the diagnostic analysis of winter and summer monsoon circulations by Chang.

C. P. Chang and K. M. Lau are using domain-averaged climatic numerical models to investigate the various mechanisms pertinent to the large-scale interaction between tropical atmosphere and oceans. Among the phenomena being studied are the Walker circulation, the Hadley circulation and the El Nino fluctuations.

#### MARINE BOUNDARY LAYER

Research in this area includes several interdisciplinary observational and theoretical projects involving Professor K. L. Davidson. Objectives of the individual projects are: to intercompare aerosol spectrometers and optical instruments for determining the validity of spectrometer predicted optical extinction, to determine the influence of humidity fluctuations on the optical structure function in the marine atmospheric surface layer, to relate the vertical distribution of sea-salt aerosol to surface layer parameters, and to determine rates of vertical mixing over the ocean in California coastal waters for application of air pollution models.

#### MARINE FOG OBSERVATION, ANALYSIS AND PREDICTION

K. L. Davidson is working on the development of a marine boundary layer model to predict marine fog. Aircraft measurements of surface layer parameters will be used for verification and further development of the model in the atmospheric mixed layer.

An interdisciplinary project involving R. J. Renard, W. van der Bijl and faculty members from the Department of Oceanography is concerned with the observation, climatology analysis and numerical/statistical prediction of fog over open ocean and coastal regimes, both on a regional and hemispheric scale.

#### POLAR WEATHER STUDIES

Currently R. J. Renard's research is concerned with the observational network commensurate with synoptic/mesoscale weather events over the Antarctic area. In addition to data from conventional and satellite sources, data from prototype

remote automatic weather stations and the Airborne Research Data-Handling System aboard an LC 130 R Aircraft have been analyzed for their contributions both to the scientific and operational weather endeavors in support of the U.S. mission in Antarctica.

#### SATELLITE REMOTE SENSING

NAVAIR Research Chair incumbent Henry E. Fleming completed research involving the derivation of sea-surface temperatures from high-resolution satellite infrared measurements on a mesoscale level. He also completed a study on obtaining vertical atmospheric temperature and constituent profiles from a combination of angle and frequency satellite measurements. His final research effort during FY 79 dealt with the problems of deriving optimal vertical wind shear estimates from the horizontal gradients of radiances measured by satellite.

**Title:** Dynamics of Tropical Waves and Monsoons

**Investigators:** Chih-Pei Chang, Associate Professor of Meteorology and R. T. Willaims, Professor of Meteorology

**Sponsor:** National Science Foundation

**Objectives:** To study the structure and dynamics of large-scale flow in the tropics and subtropics, including stationary and propagating waves and monsoons, in terms of their development, maintenance and interactions between them. This is a continuing project, the recent emphases include the winter component of the International Monsoon Experiment (MONEX) of 1978-79, and theoretical study of wave disturbances embedded in the varying basic flow of the monsoons.

**Summary:** The winter MONEX was carried out between 1 Dec 1978 -5 March Mar 1979. Operational and "quick-look" data from Phase 1 (1-31 Dec 79), including research aircraft, ship, satellite and station data are being collected and analyzed in order to produce a synoptic series to study the equatorial disturbances that either propagate into the South China Sea from Western Pacific or developed north of Borneo. This work is being carried out jointly with scientist at the Malaysian Meteorological Service and the University of Wisconsin. At the same time pre-MONEX data are used for pilot studies. The Dec 1974 study has been completed, which includes both the synoptic disturbance behavior in the South China Sea region and the planetary-scale flow patterns over the broad area of Pacific-Asia-Indian Ocean. Coherent variations of the local Hadley and Walker circulations and the jet streams in relation to the cold surges are suggested. Upper tropospheric waves during the summer monsoon are studied numerically using a nonlinear barotropic model with cyclic boundary conditions. Forcing is included which produces a zonally varying easterly jet with maximum speed over India. Waves develop in this mean flow and a statically steady state is reached in which

the waves move through the jet and change amplitude relation to the local conditions. In addition the original mean flow is modified by interaction with the waves.

Publications: "Possible influences of sea-surface temperature on the easterly waves over the equatorial Pacific", Papers in Meteorological Research, Vol. 2, #1, April 79, 1-13.

"Northeasterly cold surges and near-equatorial disturbances over the winter MONEX area during Dec 1974. Part I: Synoptic aspects", Monthly Weather Review, 107, July 79, 812-829

"Reply to coments on viscous internal gravity waves and low-frequency tropical oscillations", Journal of Atmospheric Sciences, 36, March 79, p. 547.

"Northeasterly cold surges and near-equatorial disturbances over the winter MONEX area during Dec 1974. Part II: Planetary scale aspects", Monthly Weather Review, (with K. M. W. Lau) Accepted.

Conference

Presentations: "Northeasterly cold surges and near-equatorial disturbances over the winter MONEX area during Dec 1974", 12 Tech. Conference on Hurricanes and Tropical Meteorology, AMS New Orleans, LA, 24-27 April 1979.

Thesis

Directed: "A synoptic study of Northeast Monsoon over the South China Sea and its vicinity during Dec 1974", John Reickson, M.S., Dec 1978.

"A study of interannual and intraannual tropical atmospheric circulations during Northern Hemisphere Summer", Earle L. McCormick, M.S., Dec 1978.

Title: Numerical Study of Tropical Large-Scale Ocean Atmosphere Coupling

Investigators: Chih-Pei Chang, Associate Professor of Meteorology and Ka Ming W. Lau, Professor of Meteorology

Sponsor: NPS Foundation Research Program

Summary: This research is aimed at studying the effects of interactions between the tropical atmosphere and ocean on the long-term variabilities of the coupled system. A large-scale air-sea coupled model has been developed to investigate specifically the climatic feedback mechanisms between the Hadley and Walker-type low-latitude circulations in relation to mixed-layer and advective processes in the ocean. Results indicate a negative feedback existing between the strength of the Hadley circulation and the ocean-mixed layer temperature, such that over the equatorial eastern Pacific, an anomalous increase in the trade winds is always opposed by the concomitant cooling of the sea-surface temperature due to upwelling below the seasonal thermocline. Further results indicate a positive feedback in the form of interactions between low-frequency atmospheric and oceanic Kelvin waves may exist in the equatorial coupled system.

Publications: Ka Ming W. Lau, 1979: A numerical study of tropical large-scale air-sea interactions, Journal of Atmospheric Sciences, 36, 1467-1489.

\_\_\_\_\_, 1979: Climate feedback mechanisms in the equatorial Pacific, The Garp Programme on Numerical Experimentation.

\_\_\_\_\_, 1979: Large-scale coupled oscillations in a simple equatorial ocean-atmosphere system, to appear in Ocean Modelling.

\_\_\_\_\_, 1979: Oscillations in a simple equatorial climate system. Part I: An Analytical study, submitted to Journal of Atmospheric Sciences.

\_\_\_\_\_, 1979: Oscillations in a simple equatorial climate system. Part II: A numerical study, submitted to Journal of Atmospheric Sciences.

Conference

Presentations:

Ka Ming W. Lau: A numerical study of tropical large-scale air-sea interaction, presented at Third Conference on Ocean-Atmosphere Interaction, Los Angeles, California, 30 January - 1 February 1980.

Title: Synoptic and Numerical Studies of East Asia Monsoon Trough

Investigators: Chih-Pei Chang, Associate Professor of Meteorology

Sponsor: Naval Air System Command

Objective: To study the structure and behavior of the East Asia monsoon trough during early summer.

Summary: The East Asia and early summer monsoon trough (Mei-Yu) is a major disturbance weather-producing system over East China Sea during May and June. Radiosonde and DMSP satellite data are used to carry out a composite study of the cross-sectional structures of the trough crossing three regions. The vorticity budget is also calculated which shows the relative importance of topography and cumulus convection. The trough over East China Sea reveals a mixed mid-latitude and tropical structure, being a transition between a mid-latitude baroclinic front over Japan and sub-tropical semi-barotropic convergence zone over southern China. Numerical modeling of the trough is being planned in light of these results.

Publications: "Structure and vorticity budget of early summer monsoon trough (Mei-Yu) over South-eastern China and Japan", (with George T. J. Chen), Monthly Weather Review, accepted.

Title: Temporal and Spatial Variations of Large-Scale Tropical Flows

Investigators: Chih-Pei Chang, Associate Professor of Meteorology

Sponsor: National Oceanic and Atmospheric Administration

Objective: To study the temporal and spatial variations of the planetary scale flows, and the interactions between the synoptic disturbances and the planetary scale flows, especially during the summer and winter monsoons.

Summary: DMSF and NOAA satellite data are used to study the synoptic disturbances in the equatorial South China Sea in Dec 1974. The same data and objectively analyzed gridpoint wind and temperature data at 200 mb are used to study the possible relationship between these disturbances and the planetary scale flows.

Publications: "Possible influences of sea-surface temperature on the easterly waves over the equatorial Pacific", Papers in Meteorological Research, 2, April 79, 1-13.

"Northeasterly cold surges and near equatorial disturbances over the winter MONEX area during Dec 1974: Art I: Synoptic aspects" Monthly Weather Review, 107, July 79, 812-829.

"Northeasterly cold surges and near-equatorial disturbances over the winter MONEX area during Dec 1974 Part II: Planetary scale aspects", Monthly Weather Review, accepted.

Conference Presentations: "Northeasterly cold surges and near-equatorial disturbances over the winter MONEX area during Dec 1974", 12th Technical Conference on Hurricanes and Tropical Meteorology, AMS, New Orleans, LA, 24-27 April 1979.

"A synoptic study of Northeast Monsoon over the South China Sea and its vicinity during Dec 1974", John E. Reickson, M.S., Dec 78.

"A study of interannual and intraannual tropical atmospheric circulations during Northern Hemisphere Summer", Earle L. McCormick, M.S., Dec 78.

Title: Development of Stability Dependent Surface Layer Aerosol Model

Investigator: K. L. Davidson

Sponsor: Naval Air Systems Command (Monitor, NEPRF)

Objective: Relating vertical distribution of sea-salt aerosol to surface layer parameters

Summary: This research effort consists of examinations of both aerosol balance models and surface layer turbulence models to establish a model for estimating concentrations of locally generated aerosols. The approach is based on the fact that the equilibrium aerosol distributions depend on local generation, relative humidity and transport. The role of transport has received the least attention in existing empirical models. Recent understandings have enabled reasonable estimates of stability influence transport from bulk meteorological surface layer parameters. The goal is to relate observed aerosol distributions to these bulk parameters. A paper describing the approach from balance considerations has been completed.

Publications: A. Goroch, S. Burk and K. Davidson, "Stability Effects on Aerosol Size and Height Distributions" to appear in Tellus, 1980.

K. Davidson, "Stability Influences on 1  $\mu$ m Aerosol Concentrations Observed in the North Atlantic", Technical Report, NPS 63-79-006, December 1979, 73 pp.

Title: Marine Boundary Layer Processes

Investigators: K. Davidson, Meteorology Department and  
G. Schacher, Professor of Physics and  
Chemistry

Sponsor: Naval Air Systems Command

Objective: Prediction of marine fog through the development effort and an experimental field program. The modeling effort is based on the empirical relation of entrainment at the top of the layer to the surface fluxes. The intention is to allow prediction of boundary layer evolution from measurements of surface meteorological parameters and daily radiosonde data. The model includes the effects of subsidence and cloud radiative cooling. The experimental program has historically focused on verification from shipboard measurements of the surface layer scaling laws used in the model. More recently, the field work has been expanded to aircraft measurements of mean and turbulent parameters for verification and further development of the model in the atmospheric mixed layer.

Publications: J. Jarrell, J. Ernst, G. Schacher and  
K. Davidson, "Wind Wave Coupling in SEASAT Surface Truth Interpretations", SEASAT Colloquim.

K. L. Davidson, G. E. Schacher, C. W. Fairall, and T. M. Houlihan, "Observations of Atmospheric Mixed-Layer Changes off the California Coast". Proceedings at 2nd Conference on Coastal Meteorology, December 1979.

K. L. Davidson and V. R. Noonkester, "Observations of the Marine Atmospheric Boundary Layer (CEWCOM-76)", Proceedings of 2nd Conference on Coastal Meteorology.

G. E. Schacher, K. L. Davidson, and C. W. Fairall, "Observation on Turbulent Kinetic Energy Dissipation Rates, Over the Ocean", Submitted to Boundary Layer Meteorology.

K. L. Davidson, T. M. Houlihan, C. W. Fairall and G. E. Schacher, "Observation of the Temperature Structure Function,  $C_T^2$ , over the Ocean", Boundary Layer Meteorology, 15 507 (1978).

C. W. Fairall, G. E. Schacher, K. L. Davidson and T. M. Houlihan, "Atmospheric Marine Boundary Layer Measurements in the Vicinity of San Nicolas Island During CEWCOM-78" Proceedings of 2nd Conference on Coastal Meteorology, December 1979.

C. W. Fairall, Ralph Markson, G. E. Schacher and K. L. Davidson, "An Aircraft Study of Turbulence Dissipation and Temperature Structure Function in the Unstable Marine Atmospheric Boundary Layer", Accepted by Boundary Layer Meteorology.



**Professor Kenneth L. Davidson and Doctor Christopher W. Fairall Discuss Atmospheric Turbulence Data from a Printout of a Recent Flight.**

Title: Modeling Upper Ocean Thermal Structure

Investigators: Russell L. Elsberry, Professor of Meteorology and Roland W. Garwood, Jr., Assistant Professor of Oceanography

Sponsor: Naval Ocean Research and Development Activity, Code 320, Dr. S. A. Piacsek

Objective: Application of one-dimensional oceanic boundary layer model for prediction of the upper ocean thermal structure.

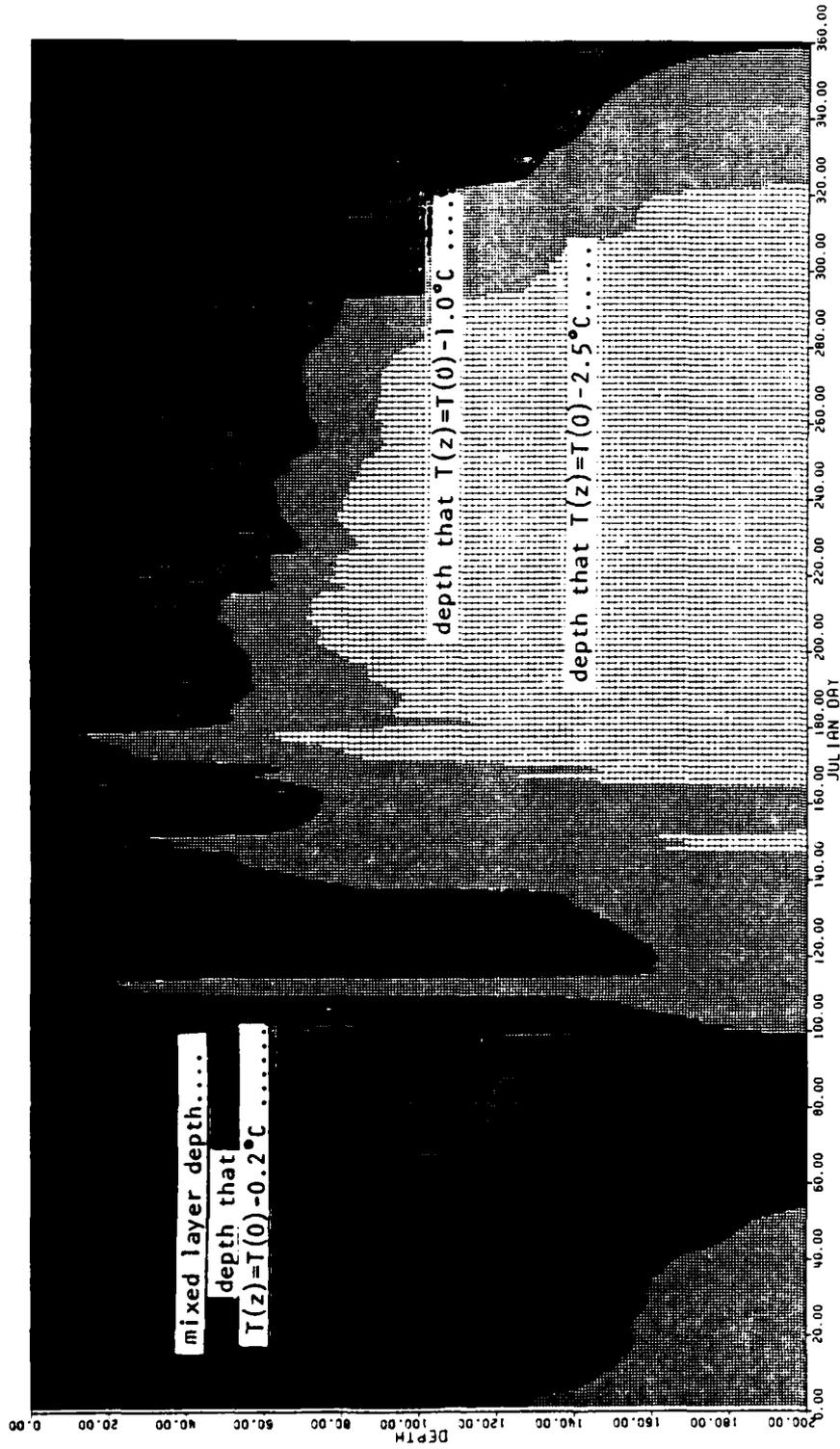
Summary: A software system (Gallacher, 1979) that extracts the time series of atmospheric forcing fields required to drive an ocean thermal structure model has been produced. The forcing fields derived from Fleet Numerical Weather Central analyses and predictions have been shown to be suitable for driving the model over most of the central north Pacific region. Significant east-west and north-south variations in ocean thermal structure during the autumn are predicted in response to the initial conditions and the variations in atmospheric forcing. We are presently testing the atmospheric forcing fields and ocean model predictions during the spring transition season.

Publications: R. L. Elsberry, P. C. Gallacher and R. W. Garwood, Jr., "One-dimensional model predictions of ocean temperature anomalies during fall, 1976," NPS 63-79-003, 30 pp.

P. C. Gallacher, "Preparation of ocean model forcing parameters from FNWC atmospheric analyses and model predictions," NPS 63-79-004.

Conference Presentations: R. L. Elsberry, P. C. Gallacher and R. W. Garwood, Jr., "One-dimensional model simulations of ocean temperature anomaly modifications during winter 1976-77. Presented at Fall AGU Meeting, abstract in Transactions American Geophysical Union, 59 (12), p. 1108.

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Model Simulation of Upper Ocean Temperature Structure Changes

**Title:** Ocean Thermal Response to Atmospheric Forcing

**Investigators:** Russell L. Elsberry, Professor of Meteorology; Ronald W. Garwood, Jr., Assistant Professor of Oceanography

**Sponsor:** Office of Naval Research, Code 480

**Objective:** To understand through numerical model simulations the role of atmospheric forcing in the dynamics of the upper layers of the ocean.

**Summary:** At the end of the first year of this two-year research project, progress has been made in a number of areas. Highlights include:  
A simulation of the Mixed Layer Experiment (MILE). The evaluation of the turbulent boundary layer at the MILE site (50W, 145W) was shown to be largely one dimensional and in response to the local history of surface meteorological conditions.  
The response of the upper ocean to hurricane forcing has been studied using a new coupled boundary layer/general circulation model developed by the investigators together with Dr. David Adamec and Dr. Robert Haney. This hybrid model is the first of a kind in oceanographic applications and may constitute a breakthrough on achieving realistic numerical simulation of upper ocean dynamics.  
This hybrid model is also presently used to study the response of ocean surface density fronts to prescribed atmospheric boundary conditions.

**Publications:** Adamec, D. R. L. Haney, R. L. Elsberry and R. W. Garwood, 1979: "A hybrid ocean model for coupling a circulation model with a turbulence closure boundary layer model," (in preparation).

Elsberry, R. L. and P. G. Black, 1979: "A review of hurricane-ocean interaction," (in preparation).

Garwood, R. W., 1979: "Air-sea interaction and the dynamics of the surface mixed layer," accepted for Rev. Geophys. Space Phys.

Garwood, R. W. and J. Y. Yun, 1979: "Bulk closure for the oceanic planetary boundary layer -- a realistic and numerically efficient model." Proc. Second Symp. Turb. Shear Flow.

Conference  
Presentations:

Adamec, D., R. L. Elsberry, R. W. Garwood and R. L. Haney, 1979: "Thermal and dynamic response of a model ocean with a mixed layer to hurricane forcing." Presented at XII Tech. Conf. on Hurricanes and Tropical Meteorol., New Orleans.

\_\_\_\_\_, 1978: "Developmental experiments to include vertical mixing processes in numerical model simulations of ocean anomalies." Presented at Annual Meeting of the AGU, San Francisco.

Garwood, R. W., 1978: "Evidence of planetary-scale dissipation in the summertime oceanic boundary layer." Presented at Annual Meeting of the AGU, San Francisco.

Paulus, R. and R. L. Elsberry, 1978: "Salinity effects in an oceanic mixed layer model." Presented at Annual Meeting of the AGU, San Francisco.

Title: Tropical Cyclone Studies  
Investigator: Russell L. Elsberry  
Sponsor: Naval Air Systems Command (AIR-370)  
Objective: Development of an operational numerical tropical cyclone prediction model for the North Pacific.

Summary: A cooperative effort to develop an operational numerical forecast model for tropical cyclones in the North Pacific was begun in 1975. Since that time a number of feasibility and data impact studies have been completed using numerical models developed at NPS and adapted by NEPRF and FNWC personnel. A review of the status of operational tropical cyclone models was prepared for the Technical Exchange Conference and was subsequently published in the proceedings and as a journal article. A review of nested grid models for atmospheric prediction was prepared for an American Society of Mechanical Engineers symposium and was subsequently published as part of a book. Hacunda (1978) demonstrated that the tropical cyclone models are sensitive to the intensity of the wind bogus and the initial relative humidity in the region of the typhoon. Frill (1979) developed a statistical regression technique for adjusting the Tropical Cyclone Model output to remove systematic errors. This technique appears to reduce 72-h track errors by at least 25 percent, and will be further tested with independent data in anticipation of operational application.

Publications: Elsberry, R. L., 1979: Applications of tropical cyclone models, Bulletin of the American Meteorological Society, V. 60, #7, 750-762.

Elsberry, R. L., 1979: Computational Techniques for Interface Problems, AMD-Vol. 30 (K. C. Park and D. K. Garthing) "Prediction of Atmospheric Flows on Nested Grids" American Society of Mechanical Engineers, 67-85.

Title: Numerical Models of Ocean Circulation and Climate Interaction--A Review

Investigator: Robert L. Haney, Associate Professor of Meteorology

Sponsor: NPS Research Foundation Program

Objective: To research and review the open literature and prepare a review article for inclusion in a United States Quadrennial Report to the International Union of Geodesy and Geophysics.

Summary: From a survey of the recent literature, it was found that considerable progress was made in modeling the ocean circulation and climate interactions during the last four years. In summary, the most significant advances include an increased understanding of the sensitivity of the atmosphere to large-scale anomalies of sea surface temperature in both middle and equatorial latitudes; the establishment of a new theory for the formation of El Nino involving equatorial Kelvin waves; the discovery, suggested by a comparison of fine-resolution model studies and ocean data, that mid-ocean eddies are driven by energy exported from regions of intense currents; and the discovery of a large oceanic seasonal heat transport from the summer hemisphere to the winter hemisphere and a possible explanation for it in terms of Ekman pumping suggested by numerical model simulations. Future progress is needed in understanding the role of mesoscale rings and eddies in maintaining the oceanic general circulation and the oceanic poleward heat flux; in developing methods of parameterizing their effects in ocean circulation models; in coupling realistic ocean mixed layer models to ocean circulation models dedicated to climate; and numerical simulations of the interannual variability of the coupled ocean atmosphere system should be made in more complete models and the role of the ocean in producing that variability determined.

Publications: Haney, R. L., "Numerical Models of Ocean  
Circulation and Climate Interaction," Rev.  
Geophys. Space Physics, 17, 7(1979),  
1494-1507.

Title: Numerical Studies of the Dynamics of Large-Scale Ocean Anomalies

Investigators: Robert L. Haney, Associate Professor of Meteorology

Sponsor: Office of Naval Research

Objective: To continually develop a numerical model of the North Pacific Ocean and to use the model to investigate the dynamics of large-scale thermal anomalies observed in the North Pacific Ocean.

Summary: During the period of this report, numerical simulations of large-scale anomalies have been extended to include anomalies in the surface heating and a simple parameterization of turbulent wind mixing. Results indicate the dominant effect of the wind relative to the heating in generating the large scale anomalies observed in the North Pacific Ocean during the winter of 1976-77. In a cooperative study, the Garwood mixed-layer model has been embedded into a two-dimensional version of the ocean circulation model and a paper which describes the embedding technique and shows several applications are in preparation.

Publications: Haney, R. L., W. S. Shiver and K. H. Hunt, "A Dynamical-Numerical Study of the Formation and Evolution of Large-Scale Ocean Anomalies," J. Phys. Oceanogr., 8, (1978) 952-969.

White, W. B. and R. L. Haney, "The Dynamics of Ocean Climate Variability," Oceanus, 21, 4(1978), p 33-39.

Haney, R. L., "Discussion of Process Parameterization and the Structure of Ocean General Circulation Models," Dyn. Atmos. Oceans, 3, 1(1979), p. 283-287.

Haney, R. L., "A Numerical Case Study of the Development of Large-Scale Thermal Anomalies in the Central North Pacific Ocean," J. Phys. Oceanogr. 10, 4(1980) in press.

Conference

Presentations:

Haney, R. L., "A Numerical Case Study of the Formation of Upper Ocean Thermal Anomalies During the Fall and Winter of 1976-77," Fall Meeting of the A.G.U.; San Francisco, Ca; Dec 4-8, 1978.

Adamec, D., R. L. Elsberry, R. W. Garwood, and R. L. Haney, "Thermal and Dynamic Response of a Model Ocean with a Mixed-Layer to Hurricane Forcing," A.M.S. Twelfth Technical Conference on Hurricanes and Tropical Meteorology; New Orleans, La; Apr 24-27, 1979.

Title: Applications of Model Output Statistics to Forecasting Operationally Important Air/Ocean Parameters

Investigators: R. J. Renard, Professor of Meteorology and W. van der Bijl, Associate Professor of Meteorology

Sponsor: NPS Foundation Research Program

Objective: Improvement of marine visibility forecasting (short-term. Prediction of cloud heights/amount and near-surface winds (long-term).

Summary: The study represents the initial development of a model output statistics scheme to specify the probability of each of several ranges of visibility over the open ocean, using stepwise multiple linear regression. The probabilities are further manipulated to yield categorical visibility estimates. Predictors are chosen from available Fleet Numerical Oceanography Center's output parameters, with sensible and evaporative heat fluxes, relative humidity, sea level pressure and meridional wind speed contributing most to explaining the variance of visibility prediction. The dependent tests, still in the diagnostic stage, are being carried out for the North Pacific Ocean summer season with verification scores indicating considerable promise for the scheme.

Thesis

Directed: LT W. T. Aldinger, "Experiments on Estimating Open Ocean Visibilities Using Model Output Statistics." Master's Thesis, December, 1979.

Title: Mesoscale Atmospheric Events--Antarctica

Investigator: Professor R. J. Renard, Department of Meteorology

Sponsor: Office of Polar Programs, National Science Foundation

Objectives: It is proposed to diagnose mesoscale atmospheric events and their relation to synoptic scale circulations during the Austral summer period over an area surrounding McMurdo, Antarctica, through the analysis of observation taken by weather satellites (visual and infrared), specially-configured aircraft, automatic weather stations and conventional means. The immediate goal is to identify the meso-synoptic scale processes relating to operationally significant weather in the McMurdo area, demonstrated thereby the unique combined use of the aforementioned data sources. Particular attention will be given to katabatic winds, pole-ward directed moisture intrusions and regionally-induced thermal/circulation patterns. The longer term goal is to model mesoscale systems associated with significant weather-producing synoptic-scale circulations over a permanent ice/snow covered region of variable elevation and to show the applicability of weather satellite observations, with or without a supporting net of closely spaced stations, to monitor such atmospheric events. Extensions of the mesoscale network to areas other than McMurdo and seasons other than summer is dependent on achieving the immediate goals of the proposals.

Summary: Work this past year was again concentrated on special Antarctic data sources - both processing and evaluating such sources and planning for a suitable base of such data to carry out the project objectives. A twelve-day period of pressure, wind, temperature and moisture observations recorded by the Airborne Research Data System aboard a Navy LC130R A/C, 12-23 Jan 1978, is being computer processed. This particular data set taken during radio echo sounding (RES) magnetometer flights, includes observation periods at

levels within a few thousand feet of the surface over heretofore unsampled remote interior areas of west and east Antarctica. RES A/C height data furnished by the Scott Polar Research Institute, England, allows an estimate of selective pressure-level heights above sea level for flight levels below 5000' above the surface. Flight-level atmospheric data are being analyzed for internal consistency and for their relation to conventional data and constant pressure analyses made available by the Naval Support Force Antarctica, McMurdo; Australian Analysis Centre, Melbourne; Fleet Numerical Oceanography Center, Monterey, CA; and the National Meteorological Center, Washington, D.C. An airborne experiment planned to sound meso-scale circulations near McMurdo by an LC130 A/C in January 1980 was unsuccessful. Effort was also expended in organizing the analysis of 1979 automatic weather stations (AWS II) data from Antarctica, and in obtaining pressure/temperature data from two fixed-location remote stations near McMurdo. Close liaison with the AWS II developers, Stanford University and the ARDS maintenance/management group, Applied Physics Lab, was maintained. A report on these activities is planned for early 1980.

Title: Global Modeling  
Investigator: R. T. Williams, Professor of Meteorology  
Sponsor: Naval Air Systems Command  
Objectives: To develop and test numerical procedures for global and regional prediction.

Summary: The proper modeling of air flow over a narrow, high mountain range is a major problem in numerical weather prediction. The numerical model developed by Hayes and Williams (1977) was used to determine the critical mountain height for a particular basic flow field. When this critical height is exceeded, the air flows around the mountain rather than over it. These studies have been extended to more general wind fields.

The finite element method has special promise for limited area forecasting since the size and configuration of the elements can be easily changed. However, it was shown that the most efficient FEM formulations either carry different fields at different nodal points or use a vorticity and divergence formulation. Some simple numerical experiments were carried out to illustrate the difference between methods.

A numerical integration method for the shallow water equations was developed that is more accurate than the usual leapfrog method, and that requires less computer time. The gravity wave terms in the equations are integrated with shorter time steps with the forward-backward method. The advection terms are integrated with a longer timestep using an implicit FEM formulation.

Publications: "Use of Galerkin Methods in Numerical Weather Prediction", NEPRF, FNWC, Tech. Report NPS63-78-006, December 1978, 53 pp.

A report is in preparation which will be entitled "Formulation of Efficient Finite Element Prediction Models".

Title: Response of Moving Atmospheric Front Changes in Environmental Conditions

Investigator: R. T. Williams, Professor of Meteorology

Sponsor: NPS Research Foundation Program

Objectives: The objective of the research is to determine the modifications in frontal structure, which occur when an atmospheric front moves over a surface whose temperature and moisture properties are changing.

Summary: This research is based on the primitive equation model which was developed by Cronelius, Glevy and Williams (1975) for a steady state frion with condensation. The finite difference scheme was changed to a spatially staggered form that was designed to reduce the numerical noise in the solution. A coordinate transformation was made that allowed the front to move to a fixed speed respect to the ground. The numerical solutions with condensation heating were much smoother than in the previous study. The coordinate transformation led to steady-state solutions in the moving coordinate system and the frontal structure was compared with non-moving cases. This research will be continued during FY 80 by applying the model to various conditions observed in the early summer monsoon trough over eastern Asia.

Publication: "Effects of Latent Heat of Condensation and Surface Propagation on Steady State Fronts," in preparation.

Title: Treatment of Mountains in Numerical Prediction Models

Investigators: R. T. Williams, Professor of Meteorology

Sponsor: Fleet Numerical Oceanography Center

Objective: To develop and test methods for properly treating mountains in numerical forecasting models.

Summary: Numerical experiments were carried out with flow over a long mountain range on a sector of the globe. The basic flow was stratified with zero vertical wind shear. For small mountain heights the character of the flow did not change as the height of the mountain was increased. However, when a critical height was reached the air began to flow around the mountain range and new disturbances formed. These experiments have been extended to cases with vertical wind shear in the basic flow.

Finite element models were examined from the point of view of developing better models for prediction of flow near mountains.

Publications: "Use of Galerkin Methods in Numerical Weather Prediction", NEPRF, FNWC, NPS Report 63-78-006, December 1978, 53 pp.

A report is in preparation which will be entitled "Formulation of Efficient Finite Element Prediction Models".

## DEPARTMENT OF AERONAUTICS

The research effort of the Aeronautics faculty covers a broad range of aeronautical engineering disciplines with special emphasis on Naval aviation problems.

### AIRCRAFT COMBAT SURVIVABILITY

Professor Ball has continued his research on the vulnerability of aircraft by determining experimentally and theoretically the failure mechanisms and carrying capacity of graphite-epoxy composite fuel tank walls. Also, he has conducted mission threat analyses of the P-3 and S-3 aircraft and he has prepared a summary document on the SA-7 missile.

### STABILIZATION OF GASEOUS DISCHARGES

Professor Biblarz is conducting studies to define practical aerodynamic means for stabilizing discharges of interest for electrical lasers and other applications. Tests were completed to determine the effects of low frequency turbulence on the discharge.

### ELECTRODE LOSS MECHANISMS IN MHD GENERATORS

Professors Biblarz and Ball are investigating the nature and extent of voltage drops in MHD generators and other high pressure plasma flows. In the vicinity of the electrodes, both the sheath and the boundary layer contribute to the voltage loss. Effects currently studied include ionization/recombination, rectangular domain, and electronic heating.

### MARKS' ELECTROTHERMODYNAMIC GENERATOR

Professors Biblarz and Gawain are conducting a theoretical research effort complementary to the Marks' Polarized Corporation test program in order to help interpret and document results of generator tests.

### LASER DOPPLER VELOCIMETRY INVESTIGATIONS

Professor Collins is measuring complex flow fields using laser Doppler velocimetry. He has completed one set of measurements downstream of a transonic compressor rotor and he is currently mapping steady and vane excited unsteady jet flow fields. The objective of the latter investigation is the study of turbulent mixing enhancement for possible use in thrust augmenting ejectors.

#### MISSILE CONTROL INVESTIGATIONS

Professor Collins is studying new missile control concepts and applications for the STM missile.

#### LASER BEAM PROPAGATION PROBLEMS

Professors Fuhs and Vanderplaats are determining the degradation of laser propagation due to turbulent shear layers.

#### NONDESTRUCTIVE TESTING

Professor Fuhs is exploring the feasibility of using speckle for nondestructive testing purposes. In a second project he is determining the suitability of holographic nondestructive testing as a means of locating weld flaws.

#### EXCIMER LASERS

Professor Fuhs is investigating the transient index of refraction in an e-beam pumped XeF excimer laser.

#### INFRARED DETECTOR FOR MISSILE SEEKERS

Professor Fuhs is performing feasibility studies related to future IR detection devices.

#### ICEBERG UTILIZATION FOR FRESH WATER PRODUCTION

Professors Fuhs and Stolfi have conducted a series of iceberg towing experiments for the purpose of determining the rate of regression of fresh-water ice subjected to turbulent flow of sea water.

#### WIND POWER OPTIMIZATION

Professors Fuhs and Vanderplaats have determined optimum hill shapes for several different constraints to augment the wind power.

#### COMBAT SYSTEMS AND SHIP ARRANGEMENTS

Professor Fuhs is attempting to determine a quantitative figure of merit for ship arrangements as related to combat systems.

#### PIPE FLOW STABILITY

Professor Gawain has reexamined the problem of pipe flow stability and has developed a new analysis which successfully accounts for the experimentally observed instabilities. Extensive calculations for various wave numbers are being made to explore the full implications of the theory.

#### SURFACE EFFECT SHIP TECHNOLOGY TESTCRAFT

Professor Layton has completed a systematic test program to determine the seal loads on the manned model testcraft XR-3 under varying conditions of loading, center of gravity, seal shape, seal position and turning performance.

#### AIRCRAFT FATIGUE STUDIES

Professor Lindsey is working on aircraft fatigue problems directed toward fleet fatigue life monitoring. He is developing methods of data reduction for the aircraft fatigue monitoring devices currently being prototyped using microprocessor technology.

#### HEAT TRANSFER IN OSCILLATING FLOW

Professor Miller is developing a measuring technique using platinum resistance thermometer-heaters to measure the heat transfer on cylinders in oscillatory flow.

#### SOLID FUEL RAMJETS

Professor Netzer is developing an interior ballistics model for the solid fuel ramjet and is conducting experiments to examine the three-dimensional flow characteristics and the fuel performance.

#### JET ENGINE TEST CELL EMISSION CHARACTERISTICS

Professor Netzer is determining the emission levels and air quality effects from Naval Air Station aircraft operations and test cells. This project involves the development of an air quality assessment model for U.S. Navy operations. The effects of test cell design and engine operating characteristics on pollutant concentrations in the exhaust stack are being determined experimentally and a computer model is being developed to predict the effects of engine operating conditions and turbojet test cell design on the flow field and engine exhaust distribution within the test cell, augmentor and exhaust stack.

#### SOLID PROPELLANT COMBUSTION

Professor Netzer is attempting to obtain high-resolution holograms of  $Al/Al_2O_3$  agglomerates within the propellant grain of a solid rocket motor.

#### VSTOL PROPULSION PROBLEMS

Professor Platzer is investigating a new concept to increase the secondary flow entrainment in thrust augmenting ejectors. Also, he is continuing the study of blade flutter in transonic compressors.

#### VSTOL AERODYNAMICS

Professors Schmidt and Bell are studying VSTOL jet reaction flow fields by direct measurement of the vorticity field.

#### TRANSONIC COMPRESSOR STUDIES

Professor Shreeve is conducting a program of measurements, using the transonic compressor test rig of the Naval Postgraduate School, to determine the flow phenomena occurring in transonic axial compressor bladings in order to appraise and improve analytical models for steady and non-steady effects. Instrumentation includes rakes and fixed probes at stage inlet and outlet, traversing probes, pneumatic static taps in case and hub walls, and measurements of torque and speed. Real time and steady-state data are acquired using a dedicated minicomputer system.

#### AXIAL COMPRESSOR FLOW FIELDS

Professors Shreeve and Adler developed techniques for deriving the velocity vector from a system of high-response impact pressure probes. Current work is devoted to detailed flow field measurements.

#### MULTI-STAGE COMPRESSOR STUDY

Professor Shreeve is conducting an investigation of the flow characteristics in a low speed three-stage compressors, with special emphasis on tip clearance effects. To this end a large three-stage axial compressor is being rebladed and instrumented in order to carry out a wide range of measurements.

Title: Aircraft Combat Survivability Studies

Investigator: Robert E. Ball, Professor of Aeronautics

Sponsor: Naval Air Systems Command

Objective: To provide technical support to Air-5184, Survivability Branch, Naval Air Systems Command. The following efforts contribute to the technology methodology base in several areas of survivability:

Determine experimentally and theoretically the failure mechanisms and carrying capacity of graphite-epoxy composite fuel tank walls attached to ribs and spars with metal fasteners and subjected to hydraulic ram loading.

Conduct a mission-threat analysis of the P-3 aircraft to determine the possibility of exposure of the P-3 to a hostile environment during its normal operations and develop a procedure for evaluating the investment cost of a crew and cost penalties associated with a crew loss.

Present a summary document on the SA-7 that includes the physical layout, the mode of operation, the effectiveness and the validity of current simulation computer programs for missile flyout.

Use the TAC ZINGER digital computer program to determine the relationship between the F/A-18 aircraft radar cross section and the miss distance of a radar guided surface to-air missile for a straight and level aircraft flight path over the launch zone of the missile, with and without electronic countermeasures.

Conduct a mission-threat analysis and a susceptibility assessment of the S-3 aircraft to determine the operational modes that expose the aircraft to a hostile environment and develop regression equations for predicting missile miss distance as a function of the important encounter and aircraft parameters.

AD-A088 835

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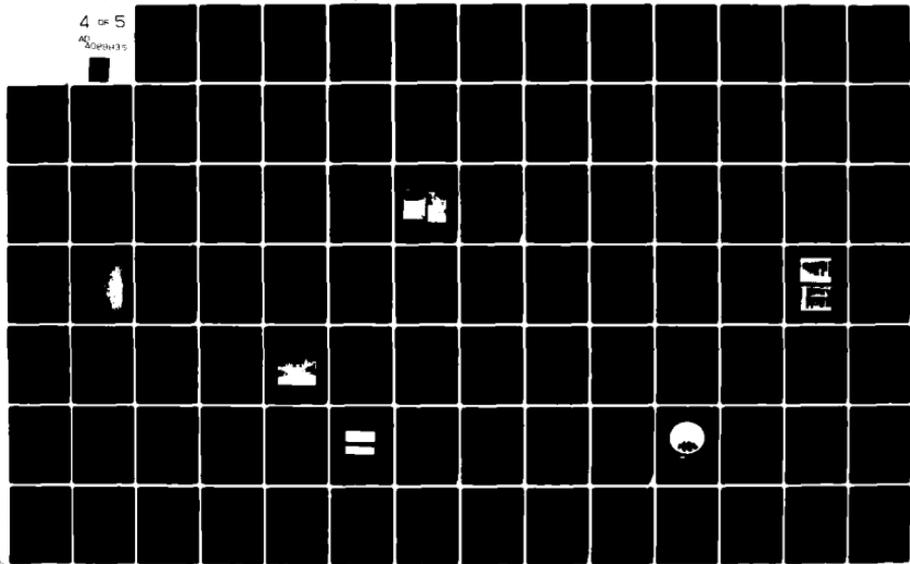
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Examine current aircraft to determine those features that reduce vulnerability and study historical combat data to determine effect of survivability on combat operations and effectiveness.

Summary:

This is the second year of this program. Two new devices for introducing an axial force and moment in metal and composite test specimens have been designed and built. Preliminary tests were conducted on metal specimens instrumented with strain gauges to evaluate the operation of the devices. This part of the program will be completed in the first quarter of AY 79-80.

This program was completed in the fourth quarter of AY 78-79. The mission-threat analysis was conducted and a procedure was proposed for evaluating the investment costs and the cost penalties associated with a crew loss. An example problem was given.

This program was completed in the fourth quarter of AY 78-79. Due to difficulties with the countermeasures subroutine the effect of the electronic countermeasure on miss distance could not be determined. A detailed examination of the F/A-18 radar cross-section was conducted.

This program started the fourth quarter of AY 78-79. Information on the operational modes of the S-3 aircraft on its various missions and on the radar cross-section was gathered. This program will be completed in the second quarter of AY 79-80.

This program started in the fourth quarter of AY 78-79. Survivability features on current and in production aircraft were identified and documented. This program will be completed in the second quarter of AY 79-80.

**Theses**

**Directed:**

"The Development and Evaluation of an Experimental Apparatus for the Investigation of Fastener Pull-Through Failure in Graphite-Epoxy Laminates," W. R. Hanley, MS, March 1979.

"P-3 Survivability and Crew Cost Considerations," F. F. Cazenave, MS, Sept. 1979.

"A Study of the SA-7 STRELLA and Analysis of its Effectiveness (U)," J. A. Bursch, MS, Sept. 1979.

"Radar Cross Section Effects on the Susceptibility of the F/A-18 to a Radar Guided SAM (U)," J. E. Beakley, MS, Sept. 1979.

**Title:** Aerodynamic Stabilization of Gaseous Discharges

**Investigators:** Oscar Biblarz, Associate Professor of Aeronautics, J. Stricker, Adjunct Research Professor of Aeronautics

**Sponsor:** NPS Foundation Research Program

**Objectives:** The main objective is to define practical aerodynamic means for stabilizing discharges of interest for electrical lasers and other applications. A particular objective was to test the effects of intense, low-frequency turbulence on the discharge and to consider a design for transient laser-discharge experiments. This is part of a continuing program.

**Summary:** Turbulence generated in the mixing region of the main flow with an auxiliary oscillating flow has been tested. The first oscillator-flow unit has been found somewhat lacking and a second one is under consideration. Also, a Ludwig tube design has been outlined for the eventual testing of laser mixtures.

**Publications:** Y. Khait and O. Biblarz, "Influence of Turbulence on a Diffuse Electrical Gas Discharge Under Moderate Pressures," JAP, 50, 4692 (1979).

J. Stricker, "Design Considerations of a Flow System for Transient Laser Discharge Experiments," NPS Report NPS67-79-008, (August 1979).

**Title:** Electrode Contributions in Moving Plasmas of Moderately High Density

**Investigators:** Oscar Biblarz and Associate Professor of Aeronautics and R. E. Ball, Professor of Aeronautics

**Sponsor:** Wright-Patterson Air Force Base  
Dr. A. Garscadden, AFAPL/POD, Bldg. 450

**Objectives:** Effects of the collisional sheath on current transport in plasma flow devices are being studied. This description is valid for laser discharges. Nonemitting electrodes are represented using a continuum approach. This is a new direction for a continuing project.

**Summary:** The original program has been modified considerably to include ionization/recombination, a rectangular domain, and electron heating terms. These modifications are expected to yield more realistic answers.

**Title:** Performance Analysis of a Type of Electrohydrodynamic Power Generator

**Investigators:** O. Biblarz, Associate Professor of Aeronautics and T. H. Gawin, Professor of Aeronautics

**Sponsor:** Department of Energy, Division of Advanced Energy Projects

**Objective:** To evaluate independently the performance possibilities of the type of EHD power now under development by the Marks Polarized Corporation and to devise improvements and alternatives.

**Summary:** Our analysis has been successful. It has revealed grave flaws in Marks' original scheme and has led to several proposed improvements and two patent disclosures.

**Publications:** T. H. Gawain and O. Biblarz, "Performance Analysis of a Type of Electrohydrodynamic Power Generator, NPS Report NPS67-79-006, (April 1979).  
O. Biblarz and T. H. Gawain, "Optimally Loaded Electrohydrodynamic Power Generator," NPS Report NPS67-79-011, (October 1979).

**Conference Presentations:** T. H. Gawain and O. Biblarz, "Performance Characteristics of a Type of Electrohydrodynamic Generator," 14 th Intersociety Energy Conversion Engineering Conference, Boston (August 1979), Proceedings of the 14th Intersociety Energy Conversion Engineering Conference, American Chemical Society (1979) Vol. II pp. 1962-67.

**Patent Applications:** T. H. Gawain and O. Biblarz, "Optimally Loaded Electrohydrodynamic Power Generator," and T. H. Gawain and O. Biblarz, "Multistage Electrohydrodynamic Power Generator."

**Title:** Study of Marks' Electrothermodynamic (ETD) Generator

**Investigators:** Oscar Biblarz, Associate Professor of Aeronautics and T. H. Gawain, Professor of Aeronautics

**Sponsor:** U.S. Department of Energy

**Objectives:** To conduct a theoretical effort complementary to the Marks' Polarized Corp. experimental program and to interpret and document test results obtained by Marks.

**Summary:** This study of the proposed ETD generator revealed that ejector and friction losses are relatively very large, and the resulting thermodynamic efficiency appears to be of marginal interest to DoE. The analysis will be refined to include compressibility and available data will be interpreted.

**Publications:** Gawain, T. H. and Biblarz, O., "Performance Analysis of a Type of Electrohydrodynamic Power Generator," NPS Report NPS 67-79-006 (April 1979) (Sec. II-3).

**Conference Presentations:** Gawain, T. H. and Biblarz, O., "Performance Characteristics of a Type of Electrohydrodynamic Generator," 14th IECEC, Boston (August 1979) (Sec. II-4).

**Patent Applications:** O. Biblarz and T. H. Gawain, "Optimally Loaded Electrohydrodynamic Power Generator," T. H. Gawain and O. Biblarz, "High Output EHD-Generator Concept."

Title: LDA Investigations

Investigator: Daniel J. Collins, Professor of Aeronautics

Sponsor: Naval Air Systems Command, Washington, D.C.

Objectives: Systematic application laser techniques to flow field measurements.

Summary: One set of measurements downstream of a transonic compressor rotor has been completed. Also, the flow characteristics of a vane-excited jet have been measured using laser Doppler anemometry. It was found that vane oscillation significantly enhanced the mixing and secondary flow entrainment. Further measurements are in progress to evaluate the potential of jet excitation for use in thrust augmenting ejectors.

Thesis  
Directed: N. Brownsberger, "Estimation of Sonobuoy position Relative to an Aircraft Using Extended Kalman Filters, Master's Thesis, September 1979.

Conference  
Presentation: "LDA Applied to Turbomachinery," J. H. Wayland Symposium, C. I. T., June 1979, J. H. Wayland Symposium Proceedings.

Title: Missile Investigations

Investigator: Daniel J. Collins, Professor of Aeronautics

Sponsor: Naval Weapons Center, China Lake, CA

Objectives: Simulation of missile flight (STM) and investigation of new concepts.

Summary: STM missile was investigated and some simple programs were developed for the 9835 computer.

Thesis  
Directed: T. A. Grote, "Guidance and Control of Tactical Missiles," Master's Thesis, December 1979.

**Title:** Aero-optics; Boundary Layer Control for Laser Beam Propagation

**Investigators:** Allen E. Fuhs Distinguished Professor of Aeronautics, , Dr. G. N. Vanderplaats, Mr. Gregory A. Blaisdell, and Ms. Susan E. Fuhs, California Institute of Technology

**Sponsor:** Code ALO, Air Force Weapons Laboratory, Kirtland Air Force Base, New Mexico, 87117

**Objective:** To determine the degradation of a laser propagation due to the turbulent boundary layer and turbulent shear layers; propagation wavelength is in a visible or near UV.

**Summary:** For lasers mounted on aircraft, the beam must traverse a turbulent boundary layer or a turbulent shear layer to exit from the aircraft. For long or medium IR, the effects are not serious. However, in the visible or near UV, the beam quality can be degraded seriously.

**Publications:** G. N. Vanderplaats, Allen E. Fuhs, and Mr. Gregory Blaisdell, "Optimized Laser Turrets for Minimum Phase Distortion," Aero-Optics Symposium sponsored by NASA Ames and the Air Force Weapons Laboratory, August 14-15, 1979. To be published in Progress Series in Aeronautics and Astronautics (AIAA).

Allen E. Fuhs and Susan E. Fuhs, "Optical Phase Distortion Due to Compressible Flow over Laser Turrets," Aero-Optics Symposium sponsored by NASA Ames and the Air Force Weapons Laboratory, August 14-15, 1979. To be published in Progress Series in Aeronautics and Astronautics (AIAA).

**Presentation:** The papers were presented by Allen E. Fuhs at the Aero-Optics Symposium sponsored by NASA Ames and the Air Force Weapons Laboratory, at NASA Ames, August 14-15, 1979.

**Theses Directed:** LCDR Paul M. Huber, "Holographic Nondestructive Test," Master's Thesis, March, 1978.

LT Phillip P. Hoffman, "Vibration Analysis and Nondestructive Testing Using Holographic Techniques," Master's Thesis, September, 1978.

LCDR John Michael Fahey, "Vibration Analysis and Nondestructive Testing Using Double-Exposure Holographic Techniques," Master's Thesis, June, 1979.

Title: Beam Quality in Excimer Lasers

Investigators: Dr. Allen E. Fuhs, Distinguished Professor of Aeronautics and Physics and Chemistry  
LT Lonnie Cole  
CAPT (USA) James Etchechury  
Mr. Gregory A. Blaisdell, California Institute of Technology

Sponsor: DARPA Strategic Technology Office

Objective: Investigate transient index of refraction in an e-beam pumped XeF excimer laser.

Summary: Each species in a XeF excimer laser contributes to the index of refraction. A computer program for excimer laser kinetics was obtained from NRL and is being modified to obtain populations. The index of refraction for excited neon has been calculated for 3s and 3p configurations.

Thesis Directed: Captain (USA) James Etchechury, "A Single Model for Calculating the Index of Refraction of Neon I and Neon\* (3s) in the Cavity of a Xenon Fluoride Laser," Master's Thesis, June 1979.

LT Lonnie Cole, "Computer Program for Kinetics and Populations in a XeF Laser," Master's Thesis, December, 1979.

Title: Combat Systems and Ship Arrangements

Investigators: Dr. Allen E. Fuhs, Distinguished Professor of  
Aeronautics and Physics and Chemistry  
LT William H. Parks  
LT John S. White  
LT James M. Terrell

Sponsor: NAVSEA

Objective: Determine a quantitative figure of merit for  
ship arrangements as related to combat  
system.

Summary: Many factors influence the arrangement of  
various components of a warship. Arrange-  
ments are currently evaluated on the basis of  
judgment by the ship designer. For computer  
aided design, a quantitative figure of merit  
for arrangements is needed which incorporates  
the interaction of many variables.

Theses  
Directed: LT William H. Parks, "Combat System and Ship  
Arrangements," MS in Engineering Science  
Thesis, December, 1980.

LT John S. White, "Combat System and Ship  
Arrangements," MS in Engineering Science  
Thesis, December, 1980.

LT James M. Terrell, "Combat System and Ship  
Arrangements," MS in Engineering Science  
Thesis, June, 1980.

Title: Land Contouring to Optimize Wind Power

Investigators: A. E. Fuhs, Distinguished Professor of Aeronautics, Physics & Chemistry, Susan E. Fuhs, California Institute of Technology, G. N. Vanderplaats, Naval Postgraduate School

Sponsor: Proposal submitted to the Department of Energy

Objective: Certain locations on a hill have higher local wind velocity than the freestream value. The augmentation of wind power depends on the shape of the hill. An optimum shape for the hill provides maximum wind power.

Summary: Optimum hill shapes were determined for several different constraints. Knowledge of the optimum shape is valuable for two reasons. First, the site selection is aided if the best contour is known; near optimum shape may occur naturally. Second, for a given site, the excavation and fill necessary to achieve optimum shape can be determined. Four cases were studied with wind power augmentation ranging from 156 to 311 percent.

Publication: S. E. Fuhs, G. N. Vanderplaats, and A. E. Fuhs, "Land Contouring to Optimize Wind Power," AIAA No. 78-279. Accepted for publication in the Journal of Energy.

Conference Presentation: Presented at AIAA 16th Aerospace Science Meeting, Huntsville, Alabama, January, 1978.

Title: MK 500 Maneuvering Reentry Body for Trident

Investigators: Allen E. Fuhs, Distinguished Professor of  
Aeronautics and Physics and Chemistry,  
LT Martin Warren Mellor

Sponsors: Strategic Systems Project Office

Objective: To determine best configuration to achieve  
operational requirements.

Thesis  
Directed: LT Martin Warren Mellor, "MK 500 Maneuvering  
Reentry Body for Trident," Master's Thesis,  
December 1980.

Title: Melting of Ice Subjected to Turbulent Flow of Sea Water

Principal Investigators: Allen E. Fuhs, Distinguished Professor of Aeronautics and Physics and Chemistry and Russel Stolfi, Associate Professor of National Security Affairs

Sponsor: NPS Foundation Research Program

Objective: To determine the rate of regression of fresh-water ice subjected to turbulent flow of sea water. Further, to develop an analytical model which allows prediction of the ice melting rate and heat transfer rates.

Summary: Large blocks of ice with dimensions 16x4x2 feet are frozen. The ice blocks are instrumented with thermocouples to measure gradients in the thermal boundary layer in the ice. The blocks are towed at speeds ranging from 0.7 to 1.2 knots. Weights are obtained before and after towing. Measurements are made of the dimensions of the ice block before and after towing.

Nine blocks of ice have been towed in Monterey Bay; two of the blocks were towed in tandem to verify the concept of a sacrificial iceberg for thermal protection. Nusselt numbers for heat transfer have been obtained. The regression rate has been correlated using the computer code of Dr. Owen Griffin. Ice ripples have been observed and measured. The observations of ripples correlate well with existing theories. Temperatures in the base flow region have been determined. A thermal boundary layer profile has been obtained. The heat transfer equations have been solved for the temperature profile within the ice. Agreements between theory and experiment is excellent.

Publications:

Allen E. Fuhs, Warren W. Denner, Matthew D. Kelleher, William Clifford, Reginald Erman, Russel Stolfi, Robert H. Bourke, and Peter C. C. Wang, "Self Propelled Iceberg." Paper published in ICEBERG UTILIZATION, Proceedings of the First International Conference held at Ames, Iowa, October 2-6, 1977, Edited by A. A. Husseiny, Pergamon Press, New York, pp. 356-378.

Russel Stolfi, Allen E. Fuhs, Peter Wang, Robert Bourke, Reginald Erman and William Clifford, "Ice Moving in Seawater." Paper published in ICEBERG UTILIZATION, Conference held at Ames, Iowa, October 2-6, 1977, Edited by A. A. Husseiny, Pergamon Press, New York, pp. 199-219.

Owen M. Griffin, "Heat, Mass and Momentum Transfer Effects on the Ablation of Icebergs in Seawater." Paper published in ICEBERG UTILIZATION, Proceedings of the First International Conference held at Ames, Iowa, October 2-6, 1977, Edited by A. A. Husseiny, Pergamon Press, New York, pp. 229-244.

W. Clifford, R. Erman, A. Fuhs, and R. Stolfi, "Measurement of Thermal Conduction Within a Large Fresh Water Ice Block Being Towed in Sea Water," COLD REGIONS SCIENCE AND TECHNOLOGY, Elsevier Publishing Co., Amsterdam (In press).

A. E. Fuhs, R. Stolfi, R. Erman, W. Clifford, W. Denner, P. Wang, R. Bourke, and O. Griffin, "Experiments Involving Melting of a Large Ice Block Towed in Sea Water," COLD REGIONS SCIENCE AND TECHNOLOGY, Elsevier Publishing Co., Amsterdam (In Press).

Allen E. Fuhs, "Experiments Involving Iceberg Melting and Towing," Paper for the Society of Naval Architects and Marine Engineers, Northern California Section, San Francisco, California, 46 pp.

Conference

Presentations:

Allen E. Fuhs, Warren W. Denner, Matthew Kelleher, William Clifford, Reginald Erman, Russel Stolfi, Robert Bourke, and Peter C. C. Wang, "Self Propelled Iceberg." Paper presented by Allen E. Fuhs at the First International Conference on Iceberg Utilization for Fresh Water Production, Weather Modification and Other Applications, Ames, Iowa, October 2-6, 1977.

Allen E. Fuhs, "Experiments Involving Iceberg Melting and Towing," Paper for The Society of Naval Architects and Marine Engineers, Northern California Section, San Francisco, California, by Dr. Allen E. Fuhs, 25 October 1979.

Thesis

Directed:

LCDR William Francis Clifford and LT Reginald Joseph Erman, "Experimental Determination of Melting Rates of Ice Moving in Seawater," Master's Thesis, March 1979.

Title: Self Filtering Infrared Detector for Missile Seekers

Investigators: LCDR Richard Fantauzzo, Allen E. Fuhs, Distinguished Professor of Aeronautics and Physics and Chemistry  
Dr. Richard B. Schooler, MSWC/WOL

Sponsor: Code ALO, AFWL, Kirtland AFB, NM, 87117

Objective: To determine if a new technology is feasible for future IR detection devices.

Summary: For a particular threat spectrum, design and fabricate a self-filtering IR detection device. The method is epitaxial film growth by vacuum deposition of composition-tuned lead chalcogenides to form a filter and detector layer on barium fluoride substrates. To utilize pure lead to create a Schottky Barrier across the P-N junction. Gold ohmic contacts complete the device. To test the devices and compare performance to commercial indium antimonide devices. This phase of the project is completed. Spectral response was measured and found to be as predicted. Quantum efficiency was less than predicted.

Thesis  
Directed:

LCDR Richard A. Fantauzzo, "Advanced Infrared Detector for Future Missile Systems," Master's Thesis, December 1978.

**Title:** A Basic Reformulation of the Pipe Flow Stability Program

**Investigator:** T. H. Gawain, Professor of Aeronautics

**Sponsor:** NPS Foundation Research Program

**Objective:** To reformulate the classical unsolved problem of the hydrodynamic stability of pipe flow in such a way as to obtain an analytical and numerical solution which finally accounts for the experimentally observed facts.

**Summary:** The present analysis has revealed that the boundary conditions at the axis of the pipe have a complexity which has hitherto been unsuspected. These complex boundary conditions have now been reformulated in a completely general and rigorous fashion, thus completing the analytical solution. Extensive numerical calculations still remain to be carried out. The results of these calculations should prove or disprove the new theory.

**Publications:** A technical report is in preparation which summarizes theoretical developments up to this time. Publications of technical papers will be held in abeyance until forthcoming numerical work reveals decisive results.

Title: Aircraft Fatigue Studies  
Investigator: G. H. Lindsey, Professor of Aeronautics  
Sponsor: Naval Air Systems Command  
Objective: To develop better methods of fatigue life prediction using data from in-flight fatigue monitors developed on this project.

Summary: Feasibility studies were conducted in the aero laboratories during 1975-1977 on a microprocessor device which was designed to serve as an in-flight data acquisition system. The studies included design and fabrication of prototype units as well as the development of software for the units. After laboratory tests and limited flight tests, the project was transitioned to NAVAIRSYSCOM. Currently, 100 improved and more advanced units have been ordered from electrodynamics Inc., for immediate installation on F-14's.

Since 1977, work has been directed toward development of more refined analytical methods which can be used to more accurately predict fatigue damage from the more precise data collected in-flight. This year, work will continue with using nominal stress and strain values, which will come from the monitor, to predict the size of the plastic zone, at the stress concentration site, stress and strain values within the plastic zone, and resulting residual stresses and strains left at the notch after unloading. Once the local stresses and strains are known with confidence, improved methods of calculating fatigue damage will be addressed.

Publications: G. H. Lindsey, "Microprocessors as Aircraft Fatigue Monitors," Proceedings of the 25th International Instrumentation Symposium of the Instrument Society of America, Part 1, p. 553, May 1979.

G. H. Lindsey, "Research on Fatigue of Aircraft Structures," Technical Report NPS67-78-004PR, August 1978.

G. H. Lindsey, "Progress Report on Aircraft Fatigue Studies," Technical Report NPS67-Li-77091, September 1977.

G. H. Lindsey, "Microprocessors as Aircraft Fatigue Monitors," Technical Report NPS67-Li-77041, April 1977.

**Theses**

**Directed:**

Gary L. Stuart, "An Investigation of Residual Stress Characterization of 7075-T6 Aluminum for Application in Fatigue Analysis," December 1978.

F. M. Blakely, Jr., "Design of Software Package for Incorporation of Random Load Testing and Data Processing on Materials Testing System Machine," June 1978.

L. D. Newsome, "Fatigue Crack Propagation Analysis of Aircraft Structures," March 1978.

J. C. Garske, "An Investigation of Methods for Determining Notch Root Stresses from Far Field Strains in Notched Flat Plates," September 1977.

R. A. Bentley, "An Investigation of the Recovery Processes in 7075-T651 Aluminum Responsible for Stress Decay During Dynamic Load Histories," March 1977.

S. J. Atkinson, "A Study of Spectrum Loading and Range - Pair Counting Method Effects in Cumulative Fatigue Damage," February 1977.

Title: Calibration of a New Ten Channel Linearized Hot-Wire Anemometer

Investigator: J. A. Miller, Associate Professor of Aeronautics

Sponsor: NPS Foundation Research Program

Objective: To complete and calibrate a ten channel hot-wire anemometer designed and constructed by Professor Miller.

Summary: The ten channel hot-wire anemometer, first described by Miller (1976), has been completed and calibrated. In addition, the improvements to the design suggested by Simpson, Heizer and Nasburg (1979) have been incorporated.

Title: Heat Transfer from a Cylinder Immersed in an Oscillating Free Stream Flow

Investigator: J. A. Miller, Associate Professor of Aeronautics

Sponsor: NPS Foundation Research Program

Objective: To calibrate the platinum resistance thermometer-heaters in a four-inch heat transfer model and obtain heat transfer data in steady flow to validate instrumentation.

Summary: Calibration of the 16 platinum resistance thermometer-heaters was carried out in an isothermal bath from 60°F to 180°F. Steady flow heat transfer measurements were made at four Reynolds numbers:  $1.76 \times 10^5$ ;  $2.4 \times 10^5$ ;  $3.5 \times 10^5$  and  $4.9 \times 10^5$ . Resultant data have been compared with the steady flow results of Seban (1960) and Achenbach (1975) showing excellent agreement. Preliminary oscillating flow runs have been made at oscillation frequencies of 21, 60 and 100 Hz indicating that an important separation effect is encountered between 21 and 60 Hz. During these latter runs, the model was inadvertently overheated and some delamination resulted. This has now been corrected employing specially formulated high temperature bonding materials.

Thesis  
Directed:

The work to-date has served as a special project (AE 3815) for LT D. A. Duval. It is expected that the remainder of the investigation will serve as a thesis project.

Title: Holographic Study of Solid Propellant Combustion

Investigator: David W. Netzer, Associate Professor of Aeronautics

Sponsor: NPS Foundation Research Program

Objective: To obtain high resolution holograms of Al/Al<sub>2</sub>O<sub>3</sub> agglomerates within the propellant grain of a two-dimensional solid rocket motor in order to assess the effects of propellant properties and operating environment on two-phase flow losses.

Summary: This program was initiated in September 1979. As of 30 November 1979, the following progress has been made. The two-dimensional slud motor has been designed and required material ordered; and an initial holographic set-up has been made and laser checkout/repair initiated.

**Title:** Interior Ballistics of Solid Fuel Ramjets

**Investigator:** David W. Netzer, Associate Professor of Aeronautics

**Sponsor:** Naval Weapons Center, Code 3246, F. Zarlingo

**Objective:** To develop an interior ballistics model for the solid fuel ramjet. This is a continuing project.

**Summary:** An adaptation of a primitive variable, two-dimensional, finite-difference computer program was accomplished in order to predict the reacting flow field in a solid fuel ramjet. Comparisons were made between the model predictions, experimental data, and predictions from an earlier stream function-vorticity model. It was found that the new model reasonably predicted the flow field and permitted calculations within the aft mixing chamber. Current efforts are directed at three-dimensional models and experimental evaluation of fuel performance.

**Publications:** C. A. Stevenson and D. W. Netzer, "A Primitive Variable Computer Model for Combustion Within Solid Fuel Ramjets," NPS Report NPS67-79-010, October 1979.

**Conference Presentations** "A Primitive Variable Computer Model for Combustion within Solid Fuel Ramjets", 16th JANNAF Combustion Meeting, September 10-14, 1979, Naval Postgraduate School.

**Thesis Directed:** C. A. Stevenson, "An Adaptation and Validation of a Primitive Variable Mathematical Model for Predicting the Flows in Turbojet Test Cells and Solid Fuel Ramjets." Aeronautical Engineer, June 1979.

F. D. Ameal, "Application of Powered High Lift Systems to STOL Aircraft Design," Master's Thesis, September, 1979.

Title: Turbojet Test Cell Aerodynamics and Emission Levels

Investigator: David W. Netzer, Associate Professor of Aeronautics

Sponsor: Naval Air Propulsion Center, Code PE71, A. Klarman

Objectives: Develop and experimentally validate a computer model which can be used to assess the effects of engine operating conditions and turbojet test cell design on the flow field and engine exhaust distribution within the test cell and augmentor tube.

Experimentally determine the effects of fuel additives and test cell design on emitted particulate levels.

Summary: A primitive variable, finite-difference, two-dimensional computer program was developed which is capable of predicting the flow field within turbojet test cells up to full engine throttle conditions. Model predictions were compared to experimental data from a subscale test cell and to predictions obtained with a stream function vorticity model. Current work is directed at model validation using data obtained in a full-scale test cell.

Subscale test cell modifications were completed and initial tests were conducted to measure the particulate size and concentration at both the engine and stack exhausts. Mie scattering techniques, transmissometers, and electron microscope examination of collected samples are being utilized. Current work is directed at determination of the effects of smoke suppressant fuel additives.

Publications: C. A. Stevenson and D. W. Netzer, "A Primitive Variable Mathematical Model for Predicting the Flows in Turbojet Test Cells", NPS Report NPS67-78-009, October 1979.

Thesis

Directed:

C. A. Stevenson, "An Adaptation and Validation of a Primitive Variable Mathematical Model for Predicting the Flows in Turbojet Test Cells and Solid Fuel Ramjets," Aeronautical Engineer, June 1979.

T. Darnell, "Particulate Emissions from Turbojet Test Cells" (current).

Title: Validation of Air Quality Assessment Model for Naval Air Operations

Investigator: David W. Netzer, Associate Professor of Aeronautics

Sponsor: Naval Air Propulsion Center

Objectives: To complete the development of AQAM for Naval Air Operations and Validate the Model with data obtained at NAS, Miramar, CA.

Summary: All required modifications to AQAM have been completed. 1978/79 operational data have been incorporated and special receptors located at the actual measurements sites. An initial data collection effort was performed at NAS Miramar by EPA/Northrop Services, NAPC, Pt. Mugu, and NPS personnel. Current efforts are directed at comparison of the model predictions with experimental data.

A neutrally stable atmospheric surface layer was simulated in a low speed wind tunnel. Jet dispersions were measured using thermocouples. Shorter jet penetration lengths and more rapid jet dispersions were observed than currently used in the AQAM program. Initial plume dimensions were found to vary significantly with jet orientation to the ambient wind direction and some plume rise was observed. Current efforts are directed at incorporation of these results into the AQAM program.

Publications: J. V. Brendmoen and D. W. Netzer, "Atmospheric Dispersion of High Velocity Jets," NPS Report NPS67-79-012, November 1979.

Conference Presentations: "AQAM for Naval Air Operations", Air Quality and Aviation: An International Conference, Reston, VA. October 16-18, 1979.

"Effects of Naval Air Operations on Ambient Air Quality", Reserve Forces Meteorology Workshop, Long Beach, CA., July 9-20, 1979.

Thesis

Directed:

Jack V. Brendmoen, "Measurements of Jet Dispersions Simulated in an Aeronautical Wind Tunnel", MSAE, November 1979.

T. S. Douglas, "AQAM Validation at NAS Miramar" (current).

Title: Investigation of VSTOL Propulsion Problems

Investigator: M. F. Platzer, Professor of Aeronautics

Sponsor: Naval Air Systems Command

Objective: To investigate flow phenomena in VSTOL propulsion systems and to perform feasibility studies of VSTOL propulsion concepts.

Summary: A new jet excitation mechanism has been identified which shows the potential of significantly increasing the secondary flow entrainment in thrust augmenting ejectors. Also, the analysis of unsteady supersonic cascade flows has been continued and a feasibility study of installing a transonic flutter rotor in the NPS Transonic Compressor Test Facility was begun. In addition, an assessment of a new type of jet engine has been performed.

Publications: M. F. Platzer, J. M. Simmons, K. Bremhorst, "Entrainment Characteristics of Unsteady Subsonic Jets", NASA Ames Research Center, Workshop on Thrust Augmenting Ejectors, June 28-29, 1978, NASA Conference Publication 2093, September 1978, pp. 311-324.

J. M. Simmons, J. C. S. Lai, M. F. Platzer, "Jet Excitation by an Oscillating Vane", University of Queensland Report No. 10/79, August 1979, 28 pgs.

J. A. Strada, W. R. Chadwick, M. F. Platzer, "Aeroelastic Stability Analysis of Supersonic Cascades", ASME Journal of Engineering for Power, Vol. 101, No. 4, October 1979, pp. 533-541.

Title: VSTOL Aerodynamics

Investigators: L. V. Schmidt and R. W. Bell, Professors of Aeronautics

Sponsor: Naval Air Systems Command

Objective: This new project attempts improving insight into VSTOL jet reaction flow field modeling in order to increase the predictive capability of VSTOL related flow phenomena such as suckdown, hot gas ingestion and entrainment, which impact design analysis and evaluation.

Summary: Vorticity apparently plays the major role in characterization of the jet trajectory in a crossflow, and hence of the jet interference effects relative to both the airframe and the ground in a VSTOL context. Experimental procedures are being developed to study the jet from direct measurements of vorticity, and to determine the effects on the jet of interfering with it or modifying it both by changing its velocity profile and by introducing swirl components into it.

Title: Axial Compressor Flow Fields

Investigators: Associate Professor Raymond P. Shreeve,  
Department of Aeronautics and Visiting Pro-  
fessor Dan Adler, Technion, Israel

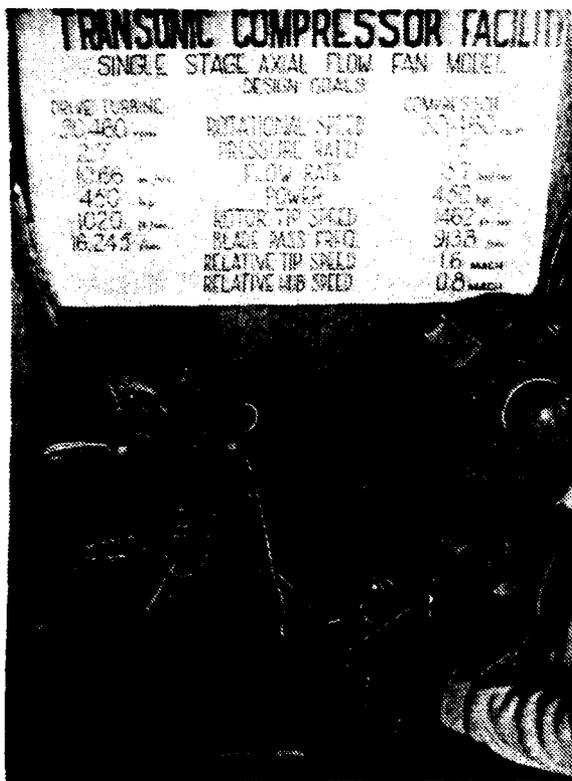
Sponsor: Office of Naval Research

Objective: To improve our understanding of flow fields  
in axial compressors and to obtain detailed  
measurements against which new computer codes  
can be verified.

Summary: The complete definition of the flow field  
leaving a high speed single stage axial rotor  
in a rotor-first arrangement is being  
attempted using a new measurement tech-  
nique. Two semi-conductor probes of simple  
geometry are used together with "synchronized  
sampling" to measure the periodic component  
of the velocity (vector) field. Comparison  
with two component LDV measurements of the  
same flow field is planned. To date, the  
distribution of flow yaw angle on the annulus  
centerline has been measured in the com-  
pressor using a single probe. Also, two  
techniques for deriving the velocity vector  
from the calibration of the two-probe system  
have been devised and reported. Compressor  
measurements with two probes are underway.

Publications: Shreeve, R. P., McGuire, A. G., and Hammer,  
J. A., "Calibration of Two Probe Synchronized  
Sampling Technique for Measuring Flows Behind  
Rotors," paper presented at IEEE Interna-  
tional Congress on Instrumentation in Aero-  
space Simulation Facilities, Monterey, CA,  
September 24-26, 1979. Proceedings, ICIAFSF  
'79 Record, IEEE Catalogue No. 79CH1500-8AES.

Adler, D., and Shreeve, R. P. "A General  
Procedure for Obtaining Velocity Vector from  
a System of High Response Impact Pressure  
Probes," Naval Postgraduate School Technical  
Report NPS67-79-007, July 1979.



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COMPRESSOR RESEARCH Turbopropulsion Laboratory

Title: Development of a Transonic Compressor Model

Investigator: Raymond P. Shreeve, Associate Professor of Aeronautics

Sponsor: Naval Air Systems Command

Objective: To develop a small transonic axial air compressor model and establish methods of measuring the performance and flow behavior in small machines.

Summary: Testing of a 450 HP transonic compressor model was held to 70% of design speed while needed measurement techniques were developed. A second generation combination temperature-pneumatic probe for interblade row surveys was designed and calibrated. Data acquisition software was written for a new minicomputer operating system to acquire stage performance, rotor blade element performance and wall pressure data in a program of compressor tests now in progress at higher speeds.

Publications: Larson, V. J., "Unsteady Effects on the Measurement of Total Pressure in Rotating Machines," Master's Thesis, September 1977.

Shreeve, R. P., "Probes and Measurement Techniques from Tests of a Small Transonic Axial Compressor," AIAA Paper No. 78-969, AIAA/SAE 14th Joint Propulsion Conference, Las Vegas, Nevada, July 25-27, 1978.

Geopfarth, R. N., "Development of a Device for the Incorporation of Multiple Scanivalves into a Computer-Controlled Data System," NPS67-79-002, March 1979.

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**Title:** Multi-Stage Compressor Study

**Investigator:** R. P. Shreeve, Associate Professor of Aeronautics, and Dipl. Ing. Hans Zebner, Aachen, West Germany

**Sponsor:** NPS Foundation Research Program

**Objective:** To reblade and instrument a large three-stage axial compressor to facilitate a wide range of compressor experiments, including the study of tip clearance effects.

**Summary:** A method of casting blading from epoxy resin was developed earlier in-house. Since the cast blades do not have to be machined, different blading designs can be built and evaluated inexpensively. New blading of moderate loading was designed and cast for three stages of a 36-inch O.D. compressor. The blades are 7.2 inches long and arranged in a straight annulus. A procedure to finish the blade tips and to set the individual blade angles to uniform accuracy was devised and the necessary jig was designed and built. A data acquisition system which uses a stand-alone Hewlett-Packard System 45 with a Scanivalve interface developed in-house, was procured. Installation of the blading is proceeding.

**Title:** Transonic Compressor Investigations

**Investigators:** Raymond P. Shreeve, Associate Professor of Aeronautics, and Visiting Professor Dan Adler, Technion, Israel, and Adjunct Assistant Professor S. Sharma

**Sponsor:** Naval Air Systems Command

**Objective:** To determine by measurement the behavior of the flow through transonic axial compressor bladings in order to appraise and improve predictive analytical models for steady and unsteady effects.

**Summary:** In earlier phases of this program, a single stage axial compressor and test rig were designed, built, installed and tested to transonic flow conditions. A variety of measurement techniques were then developed and applied to define the flow behavior in the compressor stage. "Synchronized Sampling" techniques were successfully applied to Kulite probes and wall-mounted transducers in order to define the flow field through the rotor. Major improvements have now been made to the minicomputer-data acquisition system to enable the rapid collection of all types of data as the compressor speed is progressively increased to its design value. An extended program of tests is now underway. Concurrently, the development of a cascade model of the relative flow at the rotor tip at a Mach number of 1.4 was continued. Preliminary calibration tests were run successfully. A comparison of cascade and compressor measures is planned. Modifications to the compressor test rig, which are necessary in order to operate a rotating cascade for experimental investigations of compressor blade flutter, were studied in detail.

**Publications:** Shreeve, R. P., Anderson, D. J., and Olson, J. A., "Velocity Vector Determination from Multiple-Sensor Probe Measurements," AIAA Journal, Vol. 15, No. 11, November 1977, pp: 1539-1540.

Winters, K. A., "Development of a Method for Measuring Velocity at the Exit of a Compressor Rotor Using Kulite Probes with Synchronized Sampling," Naval Postgraduate School Master's Thesis, March 1978.

Demo, W. J., "Cascade Wind Tunnel for Transonic Compressor Blading Studies," Naval Postgraduate School Master's Thesis, June 1978.

Shreeve, R. P., Dodge, F. J., Hawkins, W. R., and Larson, V. J., "Probe Measurements of Velocity and Losses from a Small Axial Transonic Rotor," AIAA Paper No. 78-1198, AIAA 11th Fluid and Plasma Dynamics Conference, Seattle, Washington, July 10-12, 1978.

Shreeve, R. P., Simmons, J. M., Winters, K. A., and West, J. C., "Determination of Transonic Compressor Flow Field by Synchronized Sampling of Stationary Fast Response Transducer," Symposium on Nonsteady Fluid Dynamics, ASME 1978 Winter Annual Meeting, San Francisco, CA, December 1978 (To be published in ASME Journal of Fluids Engineering).

Adler, D., "Status of Centrifugal Impeller Internal Aerodynamics: Experiments and Calculations," Naval Postgraduate School Technical Report NPS67-79-004.

Adler, D. and Shreeve, R. P., "A General Procedure for Obtaining Velocity Vector from a System of High Response Impact Pressure Probes," Naval Postgraduate School Technical Report NPS67-79-007, July 1979.

## DEPARTMENT OF OCEANOGRAPHY

The research program of the Department of Oceanography may be considered under four headings according to the facilities utilized and topics considered. These headings are: ship programs; coastal ocean studies; open ocean studies; and special studies.

### SHIP PROGRAMS

The investigators in this category make use of the Naval Postgraduate School research vessel ACANIA, a ship supported by the Oceanographer of the Navy; also, some investigators make use of other ships. J. B. Wickham and S. P. Tucker have continued an observational study of the California Countercurrent. It has two parts: a year's continuous monitoring of the core of the Countercurrent with an array of moored current meters and sensors of water mass properties; and a broader monthly sensing of the region of the Countercurrent with densely spaced continuous profiling of the water mass properties. The study region is one of relatively uncluttered sea floor topography on the continental slope and borderland south of Point Sur. The conventional oceanographic results are used to interpret satellite imagery, and vice versa. The sponsor is NASA.

E. C. Haderlie uses ACANIA to carry out a study of the biology of stone and wood boring organisms in the deeper waters of the Monterey Bay. His purpose is to determine the identity and the vertical and horizontal distribution of these borers as well as their growth rates, settlement times, and destructive effects. The sponsor is ONR, Code 480.

E. D. Traganza uses ACANIA off the coast of California in a study of chemical mesoscale associated with ocean fronts in the coastal upwelling region off Point Sur. Cruises are coordinated with satellite imagery obtained from the National Environmental Satellite Service at Redwood City. This study attempts to link physical, chemical, biological, and acoustic properties in this and similar regions. The sponsor is ONR, Code 480.

R. G. Paquette and R. H. Bourke make use of U.S. Coast Guard ice breakers to observe and analyze ocean thermal fine-structure near the ice margin in the Chukchi Sea. These studies have acoustical applications. The sponsor is the Arctic Submarine Laboratory, NOSC.

Physical factors affecting sound propagation in the ocean are being studied by E. B. Thornton. Spatial and temporal variability of upper ocean physical and acoustical variables have been measured. The sponsor has been the NPS Foundation.

R. G. Paquette and R. H. Bourke took the lead in procurement of a CTD (conductivity, temperature, depth) System for the Department. The sponsor is the NPS Foundation.

#### COASTAL OCEAN STUDIES

E. B. Thornton is studying the kinematics and energetics of breaking waves in the surf zone. His research is based on measurements of water particle motion within the surf zone. Measurements are being made at La Jolla and Santa Barbara as part of the National Nearshore Sediment Transport Study. NOAA/Sea Grant and ONR, Code 462 are the sponsors.

W. C. Thompson is completing a statistical investigation of wave-group properties of ocean waves. This study has applications to ship motions in ocean waves, wave damage of offshore structures and rubble-type breakwaters, and seiching in harbors. The project uses data from a Datawell wave buoy in relatively deep water off Monterey Bay. The problem of determining vertical datum planes in estuaries in the zone of transition where the water level reflects both the harmonic tidal regime of the open coast and the irregular river stage regime of the navigable river is also studied. These reference planes are used for both depth charting and for property boundary determination. NOAA/NOSS is the sponsor.

E. C. Haderlie uses concrete wharf pilings and other structures on the coast in investigating organisms responsible for deterioration of engineering materials placed in the sea and in determining the general biology and destructive effects of these organisms. NCEL is the sponsor.

D. F. Leipper and G. H. Jung of Oceanography and R. Renard of Meteorology are studying the formation of coastal marine fog. This project involves relationships between measurements from the R/V ACANIA and regularly obtained meteorological observations at shore stations. The project also undertakes analyses of data gathered at sea by other means such as through aircraft, satellites and commercial and weather ships. It now extends to open ocean investigations in the Gulf of Alaska. An extensive coordinated survey (CEWCOM '78) was conducted off Southern California in May 1978. NEPRF is the sponsor.

## OPEN OCEAN STUDIES

R. W. Garwood in conjunction with R. L. Elsberry and R. L. Haney of the Department of Meteorology is modeling upper ocean thermal structure. Their investigations of the response of the ocean surface turbulent boundary layer to atmospheric forcing have led to the development of models that can be used to compute upper ocean thermal structure changes if the atmospheric conditions are known. ONR, Code 480 is the sponsor. The success of these models under test conditions has led to an applied research program in which the models shall be used to aid in the analysis of the upper ocean thermal structure, especially in those regions of the ocean that lack frequent observations. NORDA, Code 320 is the sponsor. A spin-off of this research is an effort to couple an oceanic general circulation model to an oceanic boundary layer model.

R. H. Bourke, with Dr. C. E. Dorman of San Diego State University, has obtained new estimates of oceanic rainfall over the Pacific Ocean based on the correlation of rainfall amount with the present weather observation as recorded by ships at sea. Analysis of Atlantic Ocean data is in press. A comparison between evaporation and precipitation rates over the oceans will be conducted in the future.

R. W. Garwood is modeling the generation of surface buoyancy patches that may impact fisheries processes. NOAA/NMFS is the sponsor.

Ocean observations taken along latitude sections in the Atlantic Ocean during IGY have been used by G. H. Jung as the basis for new geostrophic calculations of mass, salt and heat transported in that ocean. Values of heat carried by these large scale circulations in the North Atlantic are being compared to values transported by various smaller scale phenomena there; South Atlantic Ocean computations are also completed as well as data for two South Pacific Ocean sections. One North Pacific section is being readied for computation. All ocean transports are being compared to associated climatic anomalies of the data period.

C. N. K. Mooers participates in FRONTS, a multi-institutional experiment to analyze the subtropical front of the North Pacific. His role is to analyze the atmospheric forcing, make use of the FNOC and NEPRF oceanographic surface and subsurface fields, and develop a diagnostic model for oceanic fronts. The sponsor is ONR, Code 480.

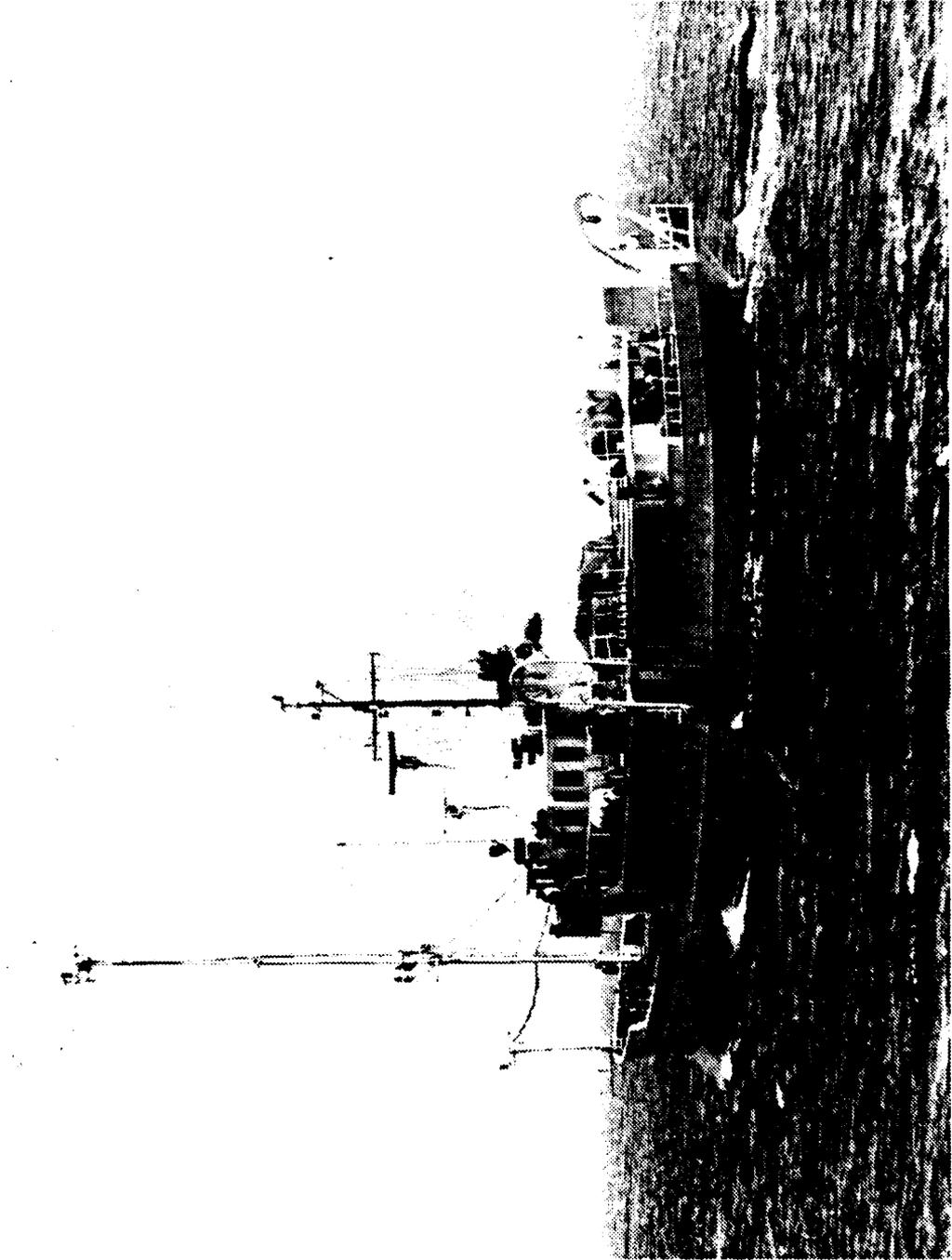
## SPECIAL STUDIES

Dr. W. Weeks, who occupied the ONR Chair in Arctic Marine Science, studied the crystallography of arctic ice and organized a workshop on problems of the Seasonal Sea-Ice Zone held at NPS, the proceedings of which are in press. ONR, Code 461 is the sponsor.

J. J. von Schwind has completed volume one of an introductory textbook in geophysical fluid dynamics for oceanographers, to be published in 1980 by Prentice Hall. Naval Ship Systems Center (NSSC) is the sponsor.

G. H. Jung, R. H. Bourke, and LCDR C. Dunlap study relations between atmospheric and oceanic variations and long range, low frequency sound propagation in the North Pacific Ocean. The Sponsor is, Commander, Oceanographic Systems Pacific (COSP).

S. P. Tucker is assessing Soviet work in optical oceanography. The sponsor is the Naval Intelligence Support Center (NISC).



Research Vessel ACANIA — Leaving Monterey Harbor on a Fog Related Experiment

Title: Buoyancy Patchiness in the Oceanic Planetary Boundary Layer and Implications for Fisheries

Investigators: Roland William Garwood, Jr., Assistant Professor of Oceanography

Sponsor: National Oceanic and Atmospheric Administration

Objective: To simulate the creation of buoyancy patchiness in the upper ocean that may impact biological productivity and fisheries potential.

Summary: In this new research project, turbulence closure models and techniques that have been developed under Navy-funded projects shall be applied to studies of the fisheries environment. The creation and destruction of vertical stratification in the upper ocean in response to the local weather conditions may have a great impact upon the chance of survival of anchovy larva and other species. Such modeling could enhance the predictability of the fishery resource and thus improve the management for this important component of the world food supply.

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Title: Biology of Stone and Wood Boring Animals in the Monterey Submarine Canyon and the Deeper Waters Off the Central California Coast.

Investigators: Eugene C. Haderlie, Distinguished Professor of Oceanography

Sponsor: Office of Naval Research, Code 480

Objective: To determine the distribution of stone and wood borers in the deeper waters of Monterey Bay and offshore, and to determine rates of destructicn of wood and various kinds of stone in the sea.

Summary: Dredging operations have been completed and a long paper accepted for publication in April 1980 covering this work. Work continues on the experimental part of the project with panels being exposed at various depths and periodically recovered for analysis. X-ray analysis of infested stone is proving fruitful in determining rates of growth of several species of stone borers.

Publications: Haderlie, E. C., 1979, "Range extension of Penitella fitchi Turner, 1955" (Bivalvia: Pholadidae), *Veliger* 22:85.

Haderlie, E. C., 1979, "Recent Bivalve Borers as Related to the Geology of Monterey Bay." Abstract in: Cordelleran Section, *Geol. Soc. America*, 11:81.

Haderlie, E. C., 1980. "Seastar Predation on Rock-boring Bivalves," *Veliger*, in press, to be published April 1980.

Haderlie, E. C., 1980, "Stone Boring Marine Bivalves from Monterey Bay." *Veliger*, in press, to be published April 1980.

Title: Detecting Damage by Marine Organisms to Waterfront Structures Using Sonic Techniques

Investigator: Eugene C. Haderlie, Distinguished Professor of Oceanography

Sponsor: Naval Civil Engineering Laboratory, Port Hueneme, CA

Objective: To attempt to determine if passive listening devices could be used to detect the presence of shipworms and gribbles in the wood employed in waterfront structures.

Summary: Experimental panels have been used to collect shipworms and gribbles (each in separate panels), then acoustic signatures of the activities of the boring animals have been recorded in the laboratory. Using this information as a guide, we have then placed sensitive microphones on wharf pilings and submerged sea walls and recorded the sounds coming from these structures. Because of extensive ambient noise created by barnacles, we have not as yet been able to positively identify wharf piles which are infested with borers.

Publications: Haderlie, E. C., Sounds Produced by Wood Boring Marine Animals and Attempts to Detect these Animals in Waterfront Structures Using Passive Sonic Techniques, NPS Technical Report, in press, to be dated September 1979.

**Title:** Oceanographic Studies in Support of COMOCEANSYSPAC (COSP)

**Investigators:** Glenn H. Jung, Professor of Oceanography; Robert H. Bourke, Associate Professor of Oceanography, LCDR Calvin Dunlap, Assistant Professor of Oceanography

**Sponsor:** Naval Ocean Systems Center, San Diego, CA; Naval Ocean Research and Development Activity, NSTL Station, MI

**Objective:** Continue with studies to evaluate the NOAA GOSSTCOMP product and to investigate long range acoustic propagation through frontal regions and eddies in the North Pacific Ocean.

**Summary:** Sea surface temperatures (SST) from the NOAA GOSSTCOMP product were compared with those from ship observations and from charts prepared by Fleet Numerical Weather Oceanography Center (FNOC) to establish the acceptability of the satellite-derived product. For the period 10-30 August 1977 in the eastern North Pacific Ocean, the NOAA GOSSTCOMP temperatures were 3.5 to 3.9°C warmer than the baseline values. Over-correction for atmospheric attenuation by water vapor or system noise is suggested as a possible reason for the bias. An assessment of various parameters was conducted to determine the anomalous performance of a hydrophone array in the eastern North Pacific Ocean. The analysis was conducted using the range-dependent Parabolic Equation model with varying bottom topography and climatological thermal structure. The results of this study were able to elucidate the temporal and spatial impact of these parameters on acoustic propagation.

**Publications:** Klein, F. C., in conjunction with Glenn H. Jung, "An Evaluation of the GOSSTCOMP Model in Determining Ocean Thermal Features with a Literature Summary of Remote Sensing of the Oceans (Northeast Pacific Ocean, August 1977)," NPS Technical Report NPS 68-79-005, Department of Oceanography, Naval Postgraduate School, Monterey, CA, 128 pp., June 1979.

Ammann, C. J., Jr., in conjunction with Glenn H. Jung and Robert H. Bourke, "Long-Range Low-Frequency Sound Propagation to a Fixed Array in the Northeast Pacific Ocean (U)," NPS Technical Report NPS 8-79-007; Department of Oceanography, Naval Postgraduate School, Monterey, CA, September 1979.

Theses  
Directed:

Klein, F. C., "An Evaluation of the GOSSTCOMP Model in Determining Ocean Thermal Features with a Literature Summary of Remote Sensing of the Oceans (Northeast Pacific Ocean, August 1977)," Master's Thesis, NPS Department of Oceanography (Glenn H. Jung, Advisor), June 1979.

Ammann, C. J., Jr., "Long-Range Low-Frequency Sound Propagation to a Fixed Array in the Northeast Pacific Ocean," Master's Thesis, NPC Department of Oceanography (Glenn H. Jung, Advisor), September 1979.

**Title:** Marine Fog Forecasting

**Investigators:** Dale F. Leipper, Professor of Oceanography;  
Robert J. Renard, Professor of Meteorology;  
and Glenn H. Jung, Professor of Oceanography

**Sponsor:** Naval Air Systems Command

**Objective:** To improve the analysis and forecasting of marine fog over the open ocean and coastal areas.

**Summary:** Observations of fog at sea will be obtained, analyzed, and statistically related to other parameters representing the state of the atmosphere and ocean. Weather satellite imagery will be used to identify marine fog. Programs for statistical diagnostic and prognostic specification of marine fog will be developed. Improvement of regional area fog forecasting will be sought using a marine fog sequential development model and forecasting indices. GOES West satellite data for July 1978 have been tested in the eastern North Pacific Ocean for their skill in specifying marine fog, using transient ship synoptic observations as ground truth verifications. Work continued on the linear regression approach to diagnose marine fog from FNOC model output parameters, fog-frequency climatology and persistence. A six-stage sequential development model of visibility and cloud cover, as related to eastern ocean coastal fog, was tested by daily hindcasts over a one-year period (1973) at Monterey, CA airport. A synoptic model is sought for sequential fog development over the open ocean. Calspan applied the Davoie model to predict deformation of atmospheric inversions, occurrence and location of condensation, and convergence in the marine boundary layer of the extreme eastern North Pacific Ocean off the West Coast of the United States.

**Publications:** Ousts, S. O. and R. J. Renard, "Refinement of a Statistical Diagnostic Model of Marine Fog Using FNOC Model Output Parameters," NPS Technical Report 63-79-002, Department of Meteorology, Naval Postgraduate School, Monterey, CA, 87 pp., June 1979.

**Theses**

**Directed:**

Quinn, P. F., "Further Development of a Statistical Model of Marine Fog Using FNWC Model Output Parameters," Master's Thesis, NPS Department of Meteorology (R. J. Renard, Advisor), September 1978.

McNab, O. F., "Analysis of Statistical Parameters Derived from Satellite Digital Data (July 1978, GOES-West) for Use in Diagnosing Marine Fog Areas," Master's Thesis, NPS Department of Meteorology (R. J. Renard, Advisor), March 1979.

Title: Chair in Arctic Marine Science

Investigators: Robert G. Paquette, Wilford F. Weeks (Occupant of Chair, FY 79)

Sponsor: Office of Naval Research, Code 462 (Arctic Programs Branch )

Objective: To provide a dynamic interactive mechanism between ONR and NPS through execution by the incumbent of the Chair of responsibilities: to conduct research in an area of particular interest to ONR and NPS; to engage in teaching to a limited extent; to generate faculty and student interest in and direct conduct of research germane to the interest of ONR and the goals of NPS in Arctic marine science.

Summary: Dr. Weeks, with the assistance of the principal investigator, organized the Workshop on the Seasonal Sea Ice Zone held at NPS on 26 February to 1 March 1979. Dr. Weeks has edited the proceedings, and arrangements have been made to publish them as a special issue of Cold Regions Research and Engineering. Dr. Weeks did a small amount of lecturing to students and faculty. He did some work in the application of the statistics of extremes to ice pressure ridges. He completed ten papers, of which three are published, and partially prepared five others.

Title: Studies of Finestructure in the Marginal Sea-Ice Zone

Investigators: Robert G. Paquette, Robert H. Bourke, W. R. Lohrmann, W. E. Small

Sponsor: Arctic Submarine Laboratory, Naval Ocean Systems Center, San Diego, Code 87.

Objective: Part of a continuing program of study of oceanographic and acoustic problems of submarine transit and weapons utilization in shallow, ice-covered arctic seas. The study is focused on temperature finestructure near the ice margins but has ramifications in descriptive and theoretical physical oceanography.

Summary: We have reduced, corrected, reported and archived salinity-temperature data taken in an August icebreaker cruise to the Chukchi Sea. We published an article summarizing five years of finestructure conditions in the Chukchi Sea and have made significant progress in understanding the nature and mechanisms of formation of oceanic fronts near the ice. We established the technique of deducting water flow from the ice melt - back pattern and have made significant contributions to techniques of correcting conductivity-temperature-depth recorders which are subject to salinity spiking.

Publications: Paquette, R. G. and R. H. Bourke, 1979: Temperature finestructure near the sea-ice margin of the Chukchi Sea. Journal of Geophysical Research.

Paquette, R. G., 1978: Cruise Report MIZPAC 78, USCGC GLACIER, 5 October 1978.

Paquette, R. G. and R. H. Bourke, 1979: The Oceanographic cruise of the USCGC GLACIER to the marginal sea-ice zone of the Chukchi Sea - MIZPAC 78, NPS-68-79-003.

Small, W. E. (with R. G. Paquette and R. H. Bourke): Finestructure, fronts and currents in the Pacific marginal sea-ice zone-MIZPAC 78. NPS-68-79-002.

Lohrmann, W. R. (with R. G. Paquette and R. H. Bourke): Winter and spring oceanographic conditions in and under the ice of the Bering Sea, NPS-68-79-001.

Paquette, R. G. and R. G. Bourke, 1979: Temperature finestructure near the sea-ice margin of the Chukchi Sea, NPS-68-79-004.

Conference

Presentation:

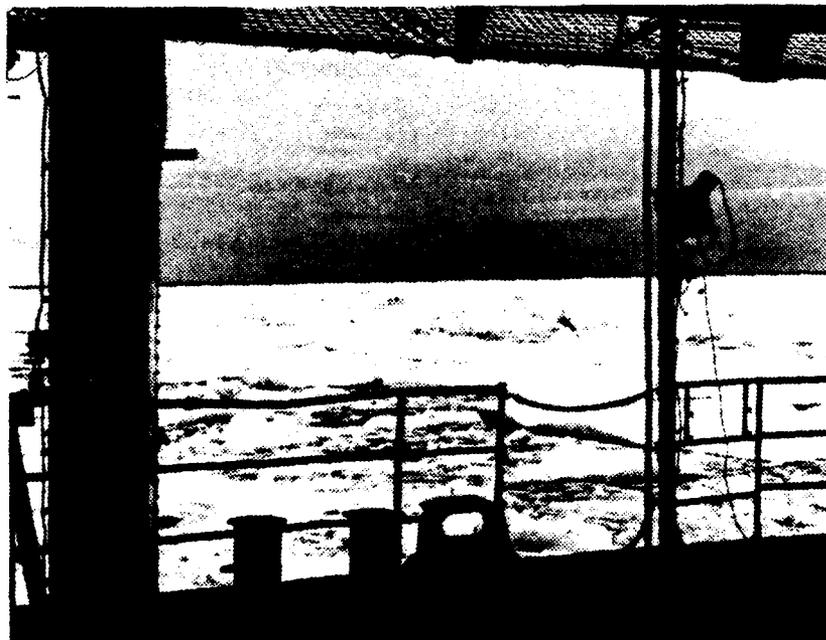
Paquette, R. G. and R. H. Bourke, San Francisco, December 1978, "Temperature fronts in the marginal sea-ice zone of the Chukchi Sea." Fall Annual Meeting of the American Geophysical Union, 1978.

Theses

Directed:

Lohrmann, Walter R., Winter and Spring Oceanographic Conditions in and Under the Ice of Bering Sea, M. S. Thesis, March 1979, Co-advisor with R. H. Bourke.

Small, Warren E., "Finestructure, Fronts, and Currents in the Pacific Marginal Sea-Ice Zone - MIZPAC 78," M.S. Thesis, June 1979, co-advisor with R. H. Bourke.



**Studies of Finestructure in the Marginal Sea-Ice Zone —  
Research headed by Professors Robert G. Paquette and Robert H. Bourke.**

Title: Precision of Tidal Datums in a Tidal River  
Investigator: Warren C. Thompson, Professor of Oceanography  
Sponsor: National Ocean Survey, NOAA

Objective: To determine the precision with which tidal datums may be computed by use of the method of comparison of simultaneous observations at water-level gaging stations located in the tidal portion of a river.

Summary: In the ocean/river transition zone, vertical reference plans are essential for depth charting and for the determination of water-front property boundaries. In this investigation, time-series water-level measurements available from a series of gaging stations in the transition zone of a navigable river (Sacramento River, CA) will be computed by the method of comparison of simultaneous observations with a reference gage located at the mouth of the river system (Golden Gate) in order to determine the elevation of equivalent 19-year datums. Record lengths of one-half to four fortnightly tidal cycles will be used. The variation of the equivalent 19-year datums will be determined in relation to record length and associated river level at each gaging station up the river. This study is an extension of a 1979 study, referenced below, to examine the properties of tidal datums in the ocean/river transition zone.

Publications: Zeile, F. C., in conjunction with W. C. Thompson, 1979; "Tidal and River Datums in the Sacramento River," NPS Thesis Technical Report No. NPS-68ZeTh78121, 91 pp., June 1979.

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Title: Relationship of Analog Waves to the Frequency Spectrum

Investigator: Warren C. Thompson, Professor of Oceanography

Sponsor: None

Objectives: To investigate the anatomy of the ocean wave frequency spectrum in relation to the individual waves composing the spectrum.

Summary: Selected ocean wave records obtained from a Datawell wave buoy installed in 60 meters depth on the open shelf off the California coast are being analyzed through the use of energy density histograms and by consideration of processes of amplitude modulation and phase modulation of the dominant carrier to determine the contribution of the individual waves in the record to the frequency spectrum. Particular attention is being given to the larger waves in the record which occur as wave groups. This study has applications to ship motions, wave damage to offshore structures and rubble breakwaters, and seiching in harbors. The study is an extension of the earlier studies referenced below.

Publications: Sedivy, D. G., in conjunction with W. C. Thompson, 1978; "Ocean Wave Group Analysis," NPS Thesis - Technical Report No. NPS-68SeTh78091, 90 pp., Sept 1978.

Title: Statistical Properties of Ocean Wave Groups

Investigator: Warren C. Thompson, Professor of Oceanography

Sponsor: None

Objectives: To investigate the statistical occurrence of wave group properties and their intergroup and group-to-record relationships.

Summary: Ocean wave records obtained from a Datawell wave buoy installed in 60 meters depth on the open shelf off the California coast are being analyzed to determine: the frequency of occurrence of the primary wave-group properties, i.e., group energy (relative to the record energy), average group period, and number of waves per group, the interrelationship of the primary group properties, and the relationship of the primary group properties and the properties of the wave record, i.e., significant wave height, spectral peak period, and wave steepness. Findings to-date indicate that as the average group period approaches to the spectral peak period of the record, all other wave-group properties assume a maximum value. This study has applications to ship motions, wave damage to offshore structures and rubble breakwaters, and seiching in harbors. The study is continued into FY 80.

Publications: Sedivy, D. G., in conjunction with W. C. Thompson, 1978; "Ocean Wave Group Analysis"; NPS Thesis-Technical Report No. NPS-68SeTh 78091, 90 pp., Sept 1978.

**Title:** Vertical Datum Planes in the Ocean/River Transition Zone

**Investigator:** Warren C. Thompson, Professor of Oceanography

**Sponsor:** National Ocean Survey, NOAA

**Objective:** To examine the properties of vertical datum planes in the transition zone of estuaries where the water level is composed of both periodic tidal oscillations and irregular river-stage variations.

**Summary:** In the ocean/river transition zone, vertical reference planes are essential for depth charting and for the determination of water-front property boundaries. In this investigation, time-series water-level measurements available for a selected gauging station in the transition zone of a navigable river (Sacramento gauge on the Sacramento River) will be separated into a tidal component and a river-stage component. Each component will be statistically analyzed for datum planes, and the relationships between the planes examined. Stability and continuity of reference planes through the transition zone will be of principal concern. This study will be extended in FY 1979 to determination of the precision of tidal planes at auxiliary tide stations in the lower Sacramento River computed by the method of comparison of simultaneous observations.

**Publications:** Zeile, F. C., in conjunction with W. C. Thompson, 1979; "Tidal and River Datums in the Sacramento River;" NPS Thesis-Technical Report No. NPS-68ZeTh78121, 91 pp., June 1979.

Title: Acoustic Variability Experiment

Investigators: E. B. Thornton, Associate Professor of Oceanography and T. P. Stanton, Adjunct Professor of Oceanography and W. W. Denner, Adjunct Professor of Oceanography

Sponsor: NPS Foundation Research Program

Objective: Investigation of the phase and amplitude modulation of sound propagating through the upper layers of the ocean.

Summary: A successful experiment was conducted 2 to 26 August 1979. Acoustic amplitude and phase fluctuations were measured across a 400 meter path. The sound source and hydrophones were mounted on the shelf adjacent to the Carmel Canyon at a depth of 35 meters. The depth of the Canyon at this location is approximately 180 meters. The experiment was designed to measure only the direct path of sound and not receive either the surface or bottom reflected sound. The acoustic source signal was a composite pulse consisting of a 0.5 millisecond 20 kHz pulse followed by 5 milliseconds of pseudo-random noise. The pseudo-random noise has acoustic energy in the band from 1 to 20 kHz.

The ocean temperature structure was measured both at the source and the receivers using horizontal and vertical thermistor arrays in order to determine the structure and correlation functions for the temperature microstructure. A two current meter array measured the current shear; thermistors were also mounted on the current meter packages to give long time series of the temperature. Analysis of the approximately 200 megabytes of data is in progress.

Publication: Denner, W. W., E. B. Thornton, T. P. Stanton, "Acoustic Variability and Air Sea Transfer," presented at MORS Conference, December 5, 1978, Naval War College, Newport, Rhode Island.

Thesis: Christensen, C., "Temperature Microstructure Profiles in Monterey Bay," Master's Thesis, December 1978.



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Transmitter Tower for the Carmel Bay Acoustic Range (AVEX August 1979)

Title: Field Measurements of Surf Zone Energetics  
Investigator: Edward B. Thornton, Associate Professor of Oceanography

Sponsor: NOAA through National Sea Grant Program

Objective: The forcing function for sediment transport processes as a function of incident wave and beach parameters are measured in the field and characterized. Specific measurements include waves, onshore and alongshore velocities both inside and outside the surf zone and winds and tides.

Summary: The forcing functions for sediment transport, the bed shear stress, turbulent or wave-induced velocities and mean currents, were measured at Torrey Pines Beach, California. The dynamics instrumentation included 22 electromagnetic current meters, ten wave staffs, nine pressure meters, three run-up meters and wind anemometer. Initial analysis of all data has been accomplished. Intercomparisons of local pressure, velocity, and sea surface elevation spectra for the wind wave-frequencies (0.05-0.3 Hz) were made using linear wave theory. Errors in both total variance and energy density in a particular frequency band are less than 20% both inside and outside the surf zone. Surface elevation spectra measured at 10 m depth were shoaled using linear wave theory. The total variance at stations between 10 m and 3 m depth are typically predicted with less than 20% error, although harmonic amplification and other nonlinear effects can lead to significant errors in the prediction at particular frequency bands.

Publications: Guza, R. T. and E. B. Thornton, "Longshore Current Variability," Proceedings of the 16th International Conference on Coastal Engineering, Sept. 1978.

Guza, R. T. and E. B. Thornton, "Local and Shoaled Comparisons of Sea Surface Elevations, Pressure and Velocities, accepted for publication in J. of Geophysical Research.

Title: Kinematics of Breaking Waves within the Surf Zone

Investigator: Edward B. Thornton, Associate Professor of Oceanography

Sponsor: Office of Naval Research, Code 461

Objective: Basic studies are being made on the kinematics of the breaking waves within the surf zone in the field. The specific objectives of the proposed research are to determine: breaking criterion as a function of depth, beach slope and wave frequency; and determine the transformation of waves across the surf zone due to energy conversion and dissipation in the breaking process.

Summary: Measurements have been made on both sandy beaches and coral reefs. The dynamics of wave transformation are similar and are shown to be highly nonlinear. Energy is transferred from the primary spectral wave frequency to higher and lower frequencies in the shoaling and subsequent breaking process. The energy transferred to higher frequencies results in secondary waves at harmonic frequencies and a cascade of energy in a saturation range above the harmonic region. Separation of wave-induced and turbulent kinetic energies shows that most of the kinetic energy is wave-induced even under breaking waves. Joint pdf's of heights and periods of breaking waves show high correlation ( $> 0.7$ ) and bimodality due to secondary waves.

Title: Satellite and Synoptic Studies of Bio-Chemical Fronts on the California Current

Investigator: Eugene D. Traganza, Associate Professor of Oceanography

Sponsor: Office of Naval Research, Code 480

Objective: Development of a synoptic model of the evolution and ecological significance of chemical and biological fronts in the ocean.

Summary: Satellite infrared and visible imagery are combined with automated bio-chemical analysis of surface waters to detect and understand chemical and biological fronts in the California Current. Long-range objectives are to calibrate satellite data so that quantitative inferences on mean nutrient fluxes and biomass distributions can be made and to develop a synoptic model of the evolution and ecological significance of chemical and biological fronts. Several sets of unique data suggest that chemical and biological fronts are characteristic components of evolving ecological systems. Some of these systems appear to develop in association with the recurrent formation of mesoscale cyclonic eddies detected in a region southwest of Point Sur, California.

Publications: E. D. Traganza, D. A. Nestor and A. K. McDonald, "Satellite Observations of a Nutrient Upwelling off the Coast of California," Journal of Geophysical Research (1979), publication pending.

Conference Presentation: E. D. Traganza, "Satellite Observations of a Nutrient Upwelling off the Coast of California," Marine Chemistry into the Eighties, University of Victoria, Victoria, B.C., Canada, May 31 to June 1 (1979).

Thesis Directed: D. A. Nestor, "A Study of the Relationship between Oceanic Chemical Mesoscale and Sea Surface Thermal Structure as Detected by Satellite Infrared Imagery," Master's Thesis, June 1979.

Title: Assessment of Soviet Work in Underwater Optics

Investigator: Stevens P. Tucker, Assistant Professor of Oceanography

Sponsor: Naval Intelligence Support Center

Objective: To create a comprehensive, self-consistent bibliography of Soviet literature related to underwater optics; to review recent Soviet work in underwater optics; and to assess Soviet effort in underwater optics with special regard to ASW applications.

Summary: A large initial bibliography has been created, and work is underway on the review paper.

**Title:** Dynamics of the Oceans

**Investigators:** J. J. von Schwind, Associate Professor of Oceanography

**Sponsor:** Naval Sea Systems Command

**Objective:** To prepare a detailed and systematic treatise covering the geophysical fluid dynamics of the oceans. When completed, this treatise will include fundamental and advanced topics and be so structured and written as to be particularly useful to technical persons whose work involves the ocean environment but who may have little or no formal education in theoretical physical oceanography.

**Summary:** The treatise in its entirety will consist of four major parts including: fundamentals of geophysical fluid dynamics; ocean circulation theories and models; elementary and advanced wave theories, internal waves, tides; and advanced topics in the fluid dynamics of the ocean.

At the present time, the subject matter to be covered is found only in a wide variety of sources, ranging from textbooks and technical journals to personal unpublished notes. To date the first two sections have been completed and constitute Volume 1 of the treatise. Volume 2 has been started, and the portions dealing with linear waves, standing waves, capillary waves, and an elementary treatment of internal waves has been completed.

**Publications:** Approximately 100 pages of the manuscript of Volume 2 have been forwarded to the Naval Sea Systems Command.

Title: Three Dimensional Structure and Behavior of Mesoscale Ocean Features Associated with Their Remotely Sensed Surface Signatures

Investigators: Jacob B. Wickham, Associate Professor of Oceanography; Stevens P. Tucker, Assistant Professor of Oceanography

Sponsor: National Aeronautical and Space Administration (NASA)

Objective: Construction of three-dimensional descriptions which show the evolution of mesoscale ocean features whose manifestations at the surface are shown by visual and infrared imagery obtained from satellite sensors. The description is to be based on data collected from an array of moored sensors of currents and watermass properties and vertical profilers operated from an oceanographic vessel

A further objective is to examine the dynamics of observed motions so that the behavior of a remotely sensed surface anomaly may be used to infer the character of the related subsurface disturbance and to foster prediction of the anomaly's evolution is fostered.

Summary: This is a continuation of a study of the currents over the seaward edge of the continental slope of Central California, including more than a year's recording of currents and temperatures in the California Countercurrent using moored meters. The principal findings thus far have been a mesoscale eddy of few months' duration, an impulsive variation in Countercurrent speed associated with a satellite sensed warm anomaly, and a westward progressing baroclinic wave of annual period (manifested in changes of thermocline depth).

## DEPARTMENT OF MECHANICAL ENGINEERING

The Department of Mechanical Engineering has a diversity of research interest and talent, as is evidenced by a variety of projects. These projects are categorized as follows: material science; heat transfer; structures; vibrations, and solids; and hydrodynamics and fluid mechanics.

### MATERIALS SCIENCE

The Naval Postgraduate School continues its strong commitment to research in Materials Science and Metallurgy. During 1979, Professor Jeff Perkins returned from his temporary assignment at the Office of Naval Research in London. He will now be directing his research efforts into microstructures and phase transformation in splat-quenched alloys. For this, he will be returning to England in FY 80 for a six-month sabbatical to study with Professor R. W. Cahn at the University of Sussex.

Professor Terry McNelley has continued his research in thermo-mechanical processing of high magnesium content aluminum magnesium alloys. Currently, studies are examining the influence of warm rolling on alloys containing eight percent Mg and ten percent Mg, and are also looking into the effects of other alloy additions. Effects of processing on microstructures include the development of fine dispersions of the inter-metallic  $Al_3Mg_2$  in the alloy along with grain refinement. Additional areas of research being pursued under the guidance of Professor McNelley include studies on the influence of prior thermo-mechanical processing on the hardening response of high-carbon bearing steels, such as AISI 52100. It has been found that prior warm rolling provides increased hardness during subsequent hardening of such steels and a finer, more homogeneous dispersion of the carbide phase.

Adjunct Professor Donald Boone, during his year at NPS, began efforts into hot corrosion of gas turbine materials. In particular, his studies have focused on the influence of platinum as a portion of a coating system with emphasis on its ability to enhance coating effectiveness.

Professor Kenneth D. Challenger, who recently joined the faculty after two years as a research associate at Stanford University, intends to continue his research on the effects of the environment in creep and fatigue fracture processes. His past research in this subject area has resulted in several publications and a design correlation for creep/fatigue/environment interaction in a low alloy steel used for steam

generator construction. In the coming year, he intends to establish a facility for high temperature environmental fatigue studies in order to continue this research at NPS.

#### HEAT TRANSFER

Heat transfer considerations in the design of engineering systems have taken on new importance with the need to design for energy efficiency. The department has continued to engage in a vigorous heat transfer research program.

Professor P. J. Marto has continued his investigation into improving the performance of main steam condensers. In conjunction with Professor R. H. Nunn, efforts have been made to modify an existing one-dimensional condenser analysis computer code to incorporate the effects of vapor velocity and condensate inundation. This code has been compared to experimental test data from a Navy condenser. Efforts are being made to couple this code to a numerical optimization code. A test facility for investigating condensation on plain and enhanced tubes has been built, and a variety of corrugated tubes have been tested to compare their heat transfer and pressure drop characteristics to a smooth tube. Tests during dropwise condensation on smooth tubes have also been performed. The data to-date show that heat transfer can be improved by as much as 100% for some of the enhanced tubes.

Professor Marto has also continued his investigation of the heat transfer performance of rotating wickless heat pipes. Recent work with Professor Salinas has concentrated on examining the performance of internally finned condenser sections and on comparing experimental results to an existing finite element analysis. A linear triangular finite element formulation has been used to solve the steady state two-dimensional conduction heat transfer equation in the condenser wall. Experimental work has been focusing on ways to enhance condenser heat transfer within these devices. A variety of internally finned condensers have been tested, using water, ethanol, and Freon 113 as working fluids.

Professor Kelleher is continuing to investigate the heat transfer and fluid mechanics of turbomachinery blades. At the present time, the use of liquid crystal thermography for NACA series 65 blades is being explored in the M.E. Department's laminar flow wind tunnel. When the technique has been verified, it will be used to study the flow and heat transfer on blading in the rectilinear cascade.

Professor Kelleher has continued his investigation of heat transfer in curved ducts. Experiments to determine streamwise heat transfer variation on the concave wall are being initiated. An experimental study of natural convection in thin horizontal liquid layers is also being conducted. Experiments are presently being conducted to determine the effect of fluid Prandtl number on the critical Rayleigh number.

Professor Salinas and LT Vatikiotis are investigating the problem of a composite plate with air flow over one surface and subject to internal combustion. This activity is being performed for the Naval Weapons Center in China Lake. In addition, Professor Salinas is working on two-phase heat transfer and diffusion problems.

#### STRUCTURES, VIBRATIONS, AND SOLIDS

Professor A. P. Boresi, of the University of Illinois, the 1979 occupant of the NAVSEA Research Chair, has studied the dynamics of elastic systems containing rigid limit stops, vibration dampers and other devices, with the intention of optimizing gun barrel restraints for maximum accuracy. He has continued work on dynamics of hyperboloidal shell cooling towers under earthquake excitation, and has developed computationally efficient finite element models for reinforced axisymmetric shells, and has studied the behavior of cylinder-cone structures having intermediate continuity at the shell junction.

Professor John E. Brock has completed a multi-year development of a set of sophisticated and versatile computer programs for determining critical loads which induce lateral buckling of beams. He has also completed studies on motion of a sphere on a rough inclined plane, elastically supported beam columns, and limit loads on plates.

Professor Gilles Cantin has spent a great deal of time familiarizing himself with the department's TEKTRONIX 4081 Computer System. Several students and faculty members have been introduced to the machine. A mesh generator has already been installed. A number of other projects have been started, all having to do with the solution of substantial problems on a minicomputer. A Finite Element System is currently being installed.

Professor R. E. Newton has continued to study applications of the finite element method to underwater shock problems. Efforts have been concentrated on the effects of

cavitation and the resulting nonlinear mathematical models. Two formulations have been shown to give good results in one-dimensional problems. The investigation is currently concentrated on the development of a code to handle two-dimensional problems of shock induced cavitation.

Professor D. Salinas has been active in the analytical investigation of a laminate composite plate subjected to severe thermal environment. The study utilizes computer programs for the thermo-mechanical response of the system.

#### HYDRODYNAMICS AND FLUID MECHANICS

The study of the motion of compressible and incompressible fluids is vital to the development of advanced technology for the Navy. A strong research program has been developed in support of Navy needs.

Professor Sarpkaya has been in charge of a number of basic and applied research programs. He continued his investigation into the basic understanding of the vortex breakdown phenomenon over delta wings with the sponsorship of the Naval Air Systems Command. He continued to work on the strumming of smooth and rough cables and on hydroelastic oscillations with the cooperation of the Naval Construction Battalion Center. Professor Sarpkaya also continued his work on time-dependent flows about bluff bodies. An extensive numerical and experimental study has been carried out on the determination of wave and current induced forces on cylinders. The results of this investigation have received international attention and were incorporated into the design codes of offshore structures. Related studies on the determination of wave forces on risers, submarine pipelines, hydroelastic oscillations in oscillating flows are currently in progress.

Professor Sarpkaya and his students continued to explore both theoretically and experimentally the forces acting on missiles at high angles of attack. For this purpose, a special vertical water tunnel has been constructed and the impulsively started flow about cylinders have been simulated. Another time-dependent flow dealing with the Loss-of-Coolant-Accident in nuclear reactors has received considerable theoretical attention and resulted in the determination of the time history of the resulting fluid forces on bodies immersed in the suppression pool. Professor Sarpkaya has initiated two additional projects. One of these concerns the exploration and design of a low-speed velocity sensor for use in hovering helicopters under adverse environmental conditions. The second project deals with the motion of submerged bodies in

fluids with density gradients. A special water channel is currently under construction for the study of this problem. The projects cited in the foregoing have been sponsored by the Naval Air Systems Command, Naval Construction Battalion Center, National Science Foundation, and the Defense Advanced Research Projects Agency.

Professor Pucci continued his theoretical and experimental investigation of the optimization of ship exhaust educators. Experiments have been carried out with hot and cold gas with extremely encouraging results. The purpose of exhaust gas stack educators for shipboard gas turbine propulsion plants. The program involves the design, construction, and testing of scale models, and the verification of analytical predictions.

Professor Nunn initiated an investigation on the ball-obtured spinning tubular projectile. The objective of this effort is to develop a comprehensive computer-based model for the prediction of the internal and external ballistic performance of ball-obtured spinning tubular projectiles. Professor Nunn also continued his investigations on the characteristics of jets in subsonic and supersonic cross flows. The most recent efforts is directed toward the modeling of pressure distributions on the adjacent boundaries. Professor Nunn is also a co-investigator with Professor Marto in a major Navy program to advance the technologies related to main propulsion surface condensers. Professor Nunn's main role in this program has been related to computer modeling and numerical optimization.

Title: Evaluation of the Mechanical Behavior of Materials and Coatings

Investigator: Donald H. Boone, Adjunct Research Professor of Mechanical Engineering

Sponsor: NPS Foundation Research Program

Objective: To evaluate the mechanical behavior of materials and coatings in aerospace type environments and conditions. A research program was established to evaluate the effects of processing and microstructure on the fatigue behavior of high strength AISI 52100 steel used in gas turbine bearings.

Summary: Suitable materials were obtained, processed and characterized prior to testing in a modified room temperature cantilever bend fatigue machine, modified under Foundation support. Results of a study of structural and processing effects showed significant improvements in low cycle fatigue and endurance limits. Results are documented in the thesis listed below. Additional material is being used in a continuing microstructural and fracture toughness evaluation program.

Thesis Directed: Chung, LCDR Ik Sik, ROK, "Fatigue Behavior of Ultra-High Carbon Steels," Master's Thesis, December, 1979.

Title: Investigation of the Flow in the Rectilinear Cascade using Hot Wire Anemometry and Liquid Crystal Thermography

Investigator: Matthew D. Kelleher, Associate Professor of Mechanical Engineering

Sponsor: NPS Foundation Research Program

Objective: Develop and implement experimental techniques for studying the fluid mechanics in the NPS rectilinear cascade. The techniques to be investigated are: hot wire anemometry to measure the velocity distribution and turbulence characteristics of the flow; and liquid crystal thermography for the visualization of surface characteristics of the flow over blading.

Summary: Using hot wire anemometry, a base line turbulence intensity level has been determined for the rectilinear cascade at the NPS Turbopropulsion Laboratory. The turbulence with straight inlet guide vanes has been compared to the turbulence without guide vanes. Results indicate a uniform though slightly greater turbulence level when using guide vanes. The use of liquid crystal thermography is being investigated as a technique for visualizing the flow over cascade test blades. Methods of applying the crystals and methods of resistance heating the blade surface have been investigated.

Publications: A research report is being prepared.

Thesis Directed: W. R. Miller, "Hot Wire Anemometer Investigation of Turbulence Levels and Development of Liquid Crystal Flow Visualization Techniques for the Rectilinear Cascade Test Facility," Master's Thesis, September, 1979.

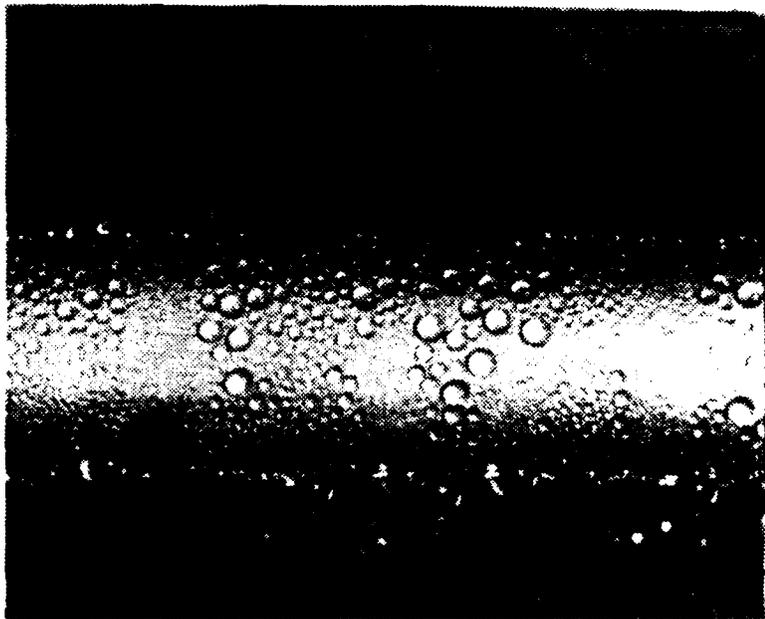
Title: The Effect of Promoter Thickness on Dropwise Condensation Heat Transfer

Investigator: P. J. Marto, Professor of Mechanical Engineering

Sponsor: Naval Sea Systems Command, Code 05R, Mr. Charles Miller

Objective: To study the effect of coating thickness on the heat transfer coefficient during dropwise condensation and determine if an optimum coating thickness exists where maximum heat transfer occurs.

Summary: Three hydrophobic coatings were tested during dropwise condensation of steam on copper, copper/nickel and titanium discs. The coatings were sputtered teflon, a fluoroepoxy film, and a commercially applied coating similar to teflon. The heat transfer coefficient with these coatings were only 56 percent higher than with film condensation. A chemically coated surface with n-octadecyl mercaptan in octanoic acid improved performance by as much as 500 percent. Heat transfer improved as coating thickness decreased. No optimum thickness was found, in part, due to suspected outgassing of the coatings themselves.



Photograph of Dropwise Condensation upon a Horizontal Condenser Tube

Title: Exploratory Design and Development of Compact Naval Condensers

Investigators: P. J. Marto, Professor Mechanical Engineering  
R. H. Nunn, Associate Professor of Mechanical Engineering

Sponsor: Naval Sea Systems Command, Code 05R, Mr. Charles Miller

Objective: To develop a comprehensive computer-based model for the analysis of compact Naval condensers that can be optimized according to specified objective functions and constraints (cost, volume, weight, etc.)

Summary: An intensive survey of condenser design models, and the condensation heat transfer literature has been complete including input from foreign sources. The ORCON1 one-dimensional computer code has been operated to test its ability to correctly predict the effects of non-condensable gases, tube geometry, enhancement, etc., on condenser performance. An improved version has been developed which includes vapor velocity effects. The need to develop a two-dimensional code has been identified and efforts have been made to begin development of this code. An experimental test condenser with interchangeable tubes, bundle geometries, air concentration, etc., has been considered, and tentative specifications have been determined. Heat transfer data have been gathered for a variety of tube shapes and diameters, including data for dropwise condensation.

Publications: Marto, P. J., Reilly, D. J., and Fenner, J. H. "An Experimental Comparison of Enhanced Heat Transfer Condenser Tubing," Advances in Enhanced Heat Transfer, Asme, 1979, pp. 1-9.

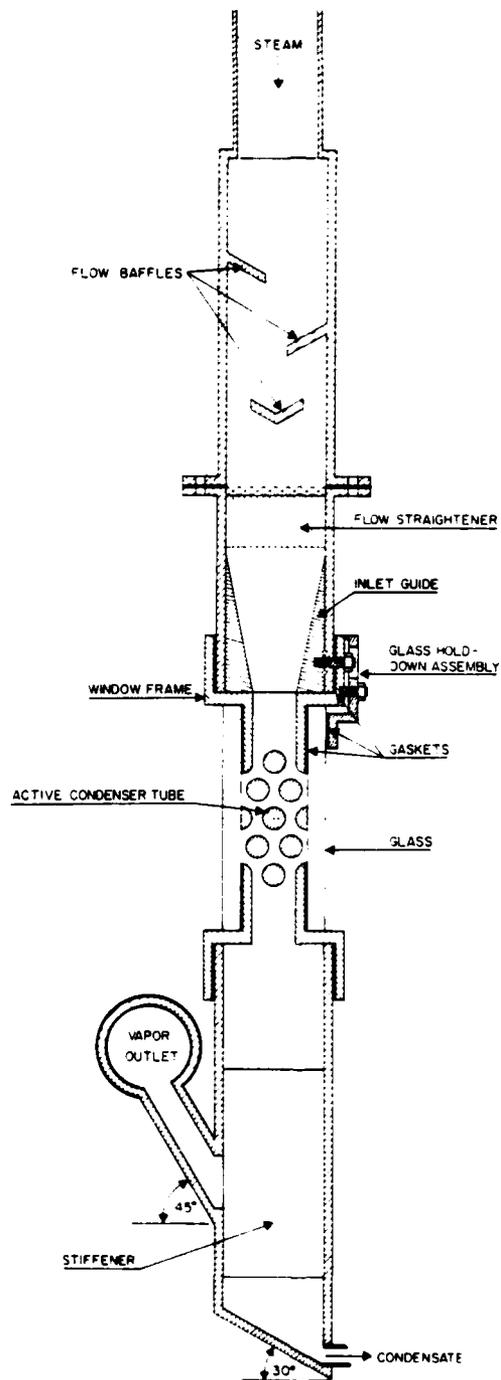
Manvel, J. T., and Marto, P. J., "An Experimental Study of Dropwise Condensation on Horizontal Condenser Tubes," NPS Report NPS69-79-004, June 1979.

Marto, P. J., and Nunn, R. H., "Exploratory Design and Development of Compact Naval Condensers, Interim Report #1," Naval Sea Systems Command, 1979.

**Theses**

**Directed:**

J. T. Manvel, "An Experimental Study of Dropwise Condensation on Horizontal Condenser Tubes", Master's thesis, June 1979.



**Cross-Section of Test Condenser  
Showing Active Tube in Dummy Tube Bundle**

Title: Finite Element Analysis of an Internally Finned Rotating Heat Pipe

Investigator: P. Marto, Professor of Mechanical Engineering  
D. Salinas, Associate Professor of Mechanical Engineering

Sponsor: None

Objective: Development of an analytical model for the design of internally finned rotating heat pipes.

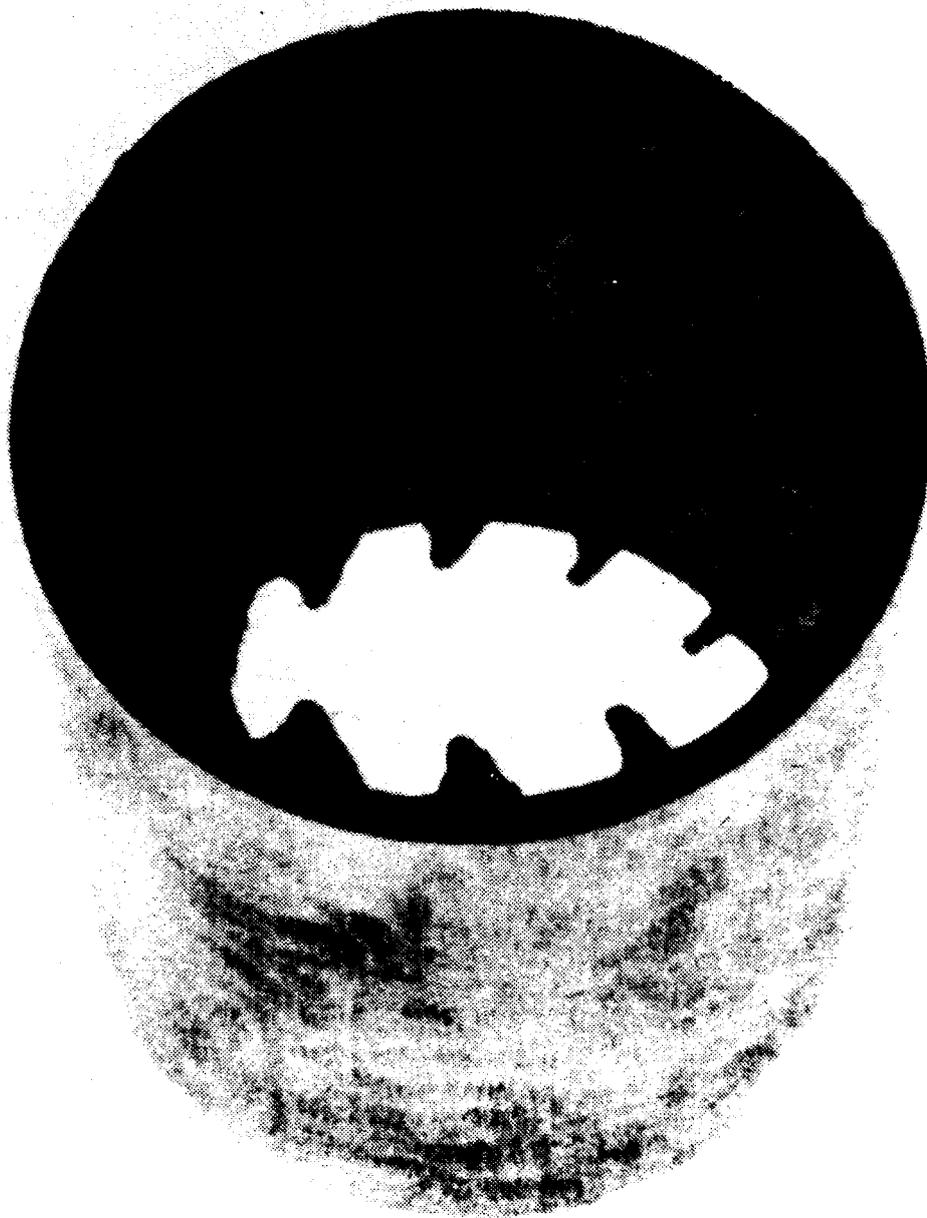
Summary: A mathematical model of a finned rotating heat pipe has been formulated, and developed into a finite element program. The formulation couples the condensation and conduction problems, leading to a nonlinear conjugate problem.

Publications: A paper is in preparation for submittance to NUMERICAL HEAT TRANSFER. (In addition to P. Marto and D. Salinas, Major I. S. Purnomo of the Indonesian Army is a joint author.)

Theses: LT R. D. Corley, "Heat Transfer Analysis of a Rotating Heat Pipe Containing Internal, Axial Fins," Master's Thesis, June 1976.

Major I. S. Purnomo, "The Enhancement of Heat Transfer in a Rotating Heat Pipe," Thesis for Engineers Degree in Mechanical Engineering, June 1978.

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**Photograph of a Section of the Internally Finned Condenser**

Title: Improving the Heat Transfer Performance of Rotating Heat Pipes

Investigator: P. J. Marto, Professor of Mechanical Engineering

Sponsor: None

Objective: The purpose of this study is to improve the heat transfer capability of rotating heat pipes by enhancing the condenser heat transfer characteristics.

Summary: A rotating heat pipe assembly was tested at rotational speeds of 700, 1400, and 2800 RPM with distilled water, ethyl alcohol and freon-113 as working fluids. Tests were made using a variety of copper condenser configurations during film condensation conditions. Measured heat transfer rates were plotted versus the temperature difference between the saturated vapor and the cooling water inlet. Several internally finned condensers improved performance by over 200 percent when compared to a smooth-walled cylinder. Performance of these configurations depends upon fin helix angle and fin height.

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Title: NAVSEA Research Chair

Investigator: P. J. Marto, Professor of Mechanical Engineering

Sponsor: Naval Sea Systems Command

Objective: To conduct research of interest to NAVSEA, to interact with students and faculty at NPS.

Summary: Professor Arthur P. Boresi, Professor of Theoretical and Applied Mechanics and Nuclear Engineering, University of Illinois interacted with a variety of faculty and students from several departments at the Postgraduate School including acting as a technical advisor on four M.S. theses. He attracted four outside experts as seminar speakers in the research area of applied mechanics and interacted with a variety of government laboratories such as the Naval Civil Engineering Laboratory, Defense Nuclear Agency, David Taylor Naval Ship Research and Development Center, and the Ballistics Research Lab at Aberdeen, Maryland.

His research work focused on the analysis of the transient response of a gun barrel subject to repeated firing. A finite element approach was used with a sidewise cubic approximation of the deformation in order to ensure continuity of deflections and slopes at the mesh points. A digital computer program based on the analysis was developed which may be used to determine the static deflection of the gun barrel. The effects of gun barrel tuning mass, eccentricities of the breech and of the recoil mechanism, stiffness and damping of the supports, and the prescribed motion of the foundation, are included.

Publications: A. P. Boresi, "Transient Response of a Gun System Under Repeated Firing," NPS Report NPS69-79-008, August 1979.

A. P. Boresi and David Salinas, "The Vibration of a Cantilever Tub that Slides Axially in a Rigid Frictionless Hole," NPS Report NPS69-79-009, September, 1979.

A. P. Boresi, "The Stresses in Mass Flow Bins Due to Wind and Granular Bulk Material, AMD-Vol. 31, Mechanics Applied to the Transport of Bulk Materials," ASME, 1979, pp. 113-125.

A. P. Boresi, "Boundary Conditions at a Cone-Cylinder Shell Junction," Journal of Applied Mechanics, Vol. 45, ASME, pp. 938-40.

Title: Ballistic Characteristics of Thermomechanically Processed Ultra-High Carbon Steels

Investigator: Terry R. McNelley, Associate Professor of Materials Science, Department of Mechanical Engineering

Sponsor: Ballistics Research Laboratory

Objective: Continued evaluation of thermomechanically processed AISI 52100 steels and laminates; processing and heat treating of selected ultra-high carbon steels for ballistic testing by BRL.

Summary: Research in the past year has further examined the terminal ballistic response of thermomechanically processed AISI 52100 steel and results indicate that such material, as processed, does possess a higher ballistic limit than comparable conventional steel armor materials. Further study on the terminal ballistic response of laminates, composed of this 52100 steel and low-carbon steel, exhibit still-better ballistic performance than monolithic plate. This improved performance is primarily due to the absence of adiabatic shear band formation in these materials when subject to ballistic impact. Studies on similar steels containing up to 1.5% carbon have indicated poorer performance in an as-rolled condition but excellent performance when heat treated to hardness HRC 65 or greater. This is attributed to the high hardness attainable and the fine martensitic microstructure produced.

Publication: T. R. McNelley, "Ballistic Limit Determination for Thermomechanically Processed Ultra-High Carbon Steels and Ultra-High Carbon Steel Laminates," NPS69-78-020, December 1978; also published as part of "Evaluation of the Armor Potential of Ultra-High Carbon Steel," Stanford Research Institute Final Report on Project No. FYU-7387, January 1979.

Presentation: T. R. McNelley, "Microstructural, Mechanical and Ballistic Characteristics of Thermomechanically Processed Ultra-High Carbon Steels," Invited Seminar, Ballistics Research Laboratory, U.S. Army Proving Grounds, Aberdeen, Maryland, October 13, 1979.

Title: Thermomechanical Processing of Aluminum-Magnesium Alloys Containing High Weight Percentages of Magnesium

Investigator: Terry R. McNelley, Associate Professor of Mechanical Engineering

Objective: Development of processing procedures for Aluminum-Magnesium Alloys containing 8 to 14 Weight Percent Magnesium and Characterization of the Mechanical Behavior of Such Materials

Summary: This research effort has now focused primarily on alloys containing 8 or 10 weight percent Mg; in part, the effort has addressed the precipitation and recrystallization behavior of these alloys during warm rolling to gain further insight into the physical metallurgy of this system. Efforts on mechanical characterization have continued as well; recent studies have focused on material warm rolled at temperatures as low as 200°C. An alloy of 10 weight percent Mg, also containing 0.5 weight percent Cr, was warm rolled at 200°C with a resultant ultimate tensile strength of 565 MPa (82 PSI) and with 11.5 percent elongation to fracture.

Thesis  
Directed:

R. A. Grandon, "High Strength Aluminum-Magnesium Alloys: Thermomechanical Processing Microstructure and Tensile Mechanical Properties," Master's Thesis, March 1979.

W. R. Speed, "The Influence of Thermomechanical Processing and Intermediate Annealing Treatments on the Mechanical Behavior of High Magnesium-Content Aluminum-Magnesium Alloys," expected completion December 1979.

R. R. Martin and J. W. Phillips, "Ballistic Performance, Shear Band Formation and Mechanical Behavior of Thermo-Mechanically Processed Ultra-High Carbon Steel," Master's Thesis, December 1978.

D. R. Hillier, "Evaluation of Superplastic Ultra-High Carbon Steel as Armor Plate for Critical Component Protection," Master's Thesis, June 1979.

Title: Finite Element Analysis of Cavitation

Investigator: R. E. Newton, Professor of Mechanical Engineering

Sponsor: Defense Nuclear Agency

Objective: To include cavitation effects of fluid/structure interaction by modifying the conventional finite element model of the fluid field. This is a continuing program.

Summary: A finite element code using a displacement potential as dependent variable has been developed for studying shock induced cavitation in plane regions. This program has been used together with a structural program developed in a thesis project to determine circumstances under which cavitation occurs. The ultimate objective is to find out whether cavitation increases the severity of shock loading on submerged structures.

Publications: Newton, R. E., "Effects of Cavitation on Underwater Shock Loading - Axisymmetric Geometry." Defense Nuclear Agency Report, NPS69-78-017PR, November 1978.

Newton, R. E., "Effects of Cavitation on Underwater Shock Loading - Plane Problem, Part I." Defense Nuclear Agency Report, NPS69-79-007PR, July 1979.

Newton, R. E., "A Finite Element Code for Shock Induced Cavitation." Conference on Computer Codes for Dynamic Structural Analysis, Fort Belvoir, VA. August 1979.

Thesis  
Directed: Waller, Jack T.: "Dynamic Structural Model of Submerged Ring," Master's Thesis, September 1979

**Title:** Ball-Obturator Spinning Tubular Projectile

**Investigator:** R. H. Nunn

**Sponsor:** Naval Weapons Center, China Lake

**Objective:** To develop a comprehensive computer-based model for the prediction of the internal and external ballistic performance of ball-obturator spinning tubular projectiles and, using this model, to develop project designs that are optimized with respect to specified objectives.

**Summary:** The investigation has focused upon the dynamical behavior of the ball-obturator within the projectile. A three-degree-of-freedom model (spinabout three axes) has been developed and a computer code has been written to solve the nonlinear coupled equations of motion. The central problem is the description of the torques applied to the ball by virtue of its rotation within the projectile. To this end, an experimental apparatus has been designed and built. The purposes of the experiments are to (1) develop insights as to the nature of the interaction between the ball and the spinning projectile and, (2) to validate the predictions of the analysis.

**Publications:** Progress report for quarter ending 31 March, 1980. Thesis of LT J. W. Bloomer, (to be dated June, 1980).

Title: Jet-Crossflow Interaction with Application to Ship Bow Thrusters

Investigator: R. H. Nunn

Sponsor: NAVSEA

Objective: To develop a comprehensive analytical model for the prediction of side forces and yaw moments resulting from the action of ship bow thrusters while stationary and underway.

Summary: Because of the complex canel interactive nature of jets in crossflows, modelling tests have not been successful in predicting the forces on ships due to the action of their bow thrusters. This investigation has led to the development of a preliminary analytical model, based largely upon V-STOL technology, to predict the pressure distributions upon ship hulls due to interaction of bow-thruster jets with crossing flows. The model replaces the jet with a series of vortex panels whose strengths depend upon the geometry and relative velocities of the problem. Jet blockage is also modelled and comparisons with the limited amount of available data indicated that the theoretical model is well founded.

Publications: Thesis of LCDR B. W Waterman, III. Mechanical Engineer, March, 1980.

Title: Carbon Dioxide Removal in Diving Systems

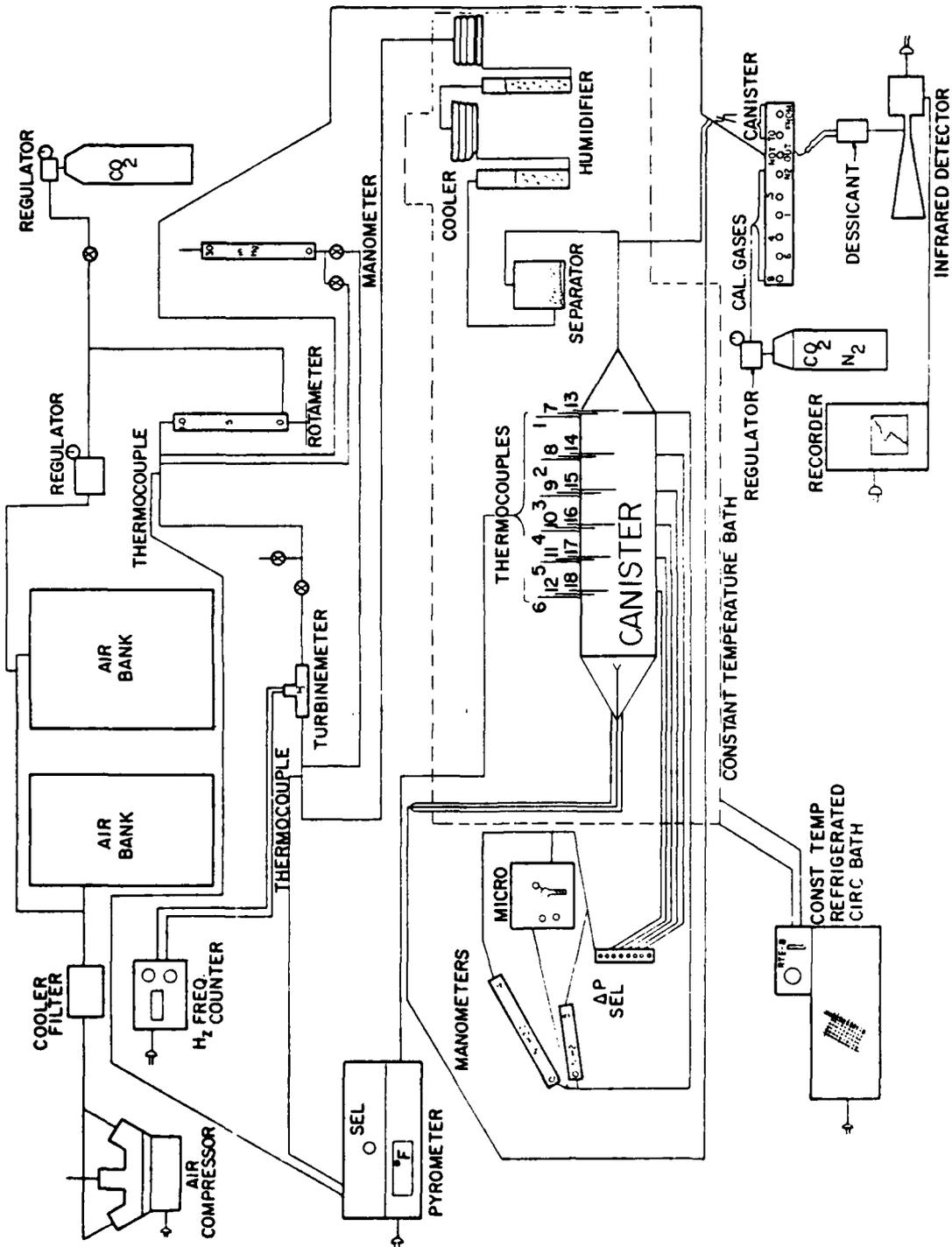
Investigator: Paul F. Pucci

Sponsor: Naval Coastal Systems Center

Objective: Determine the effect of flowrate and flow geometry on the effectiveness of carbon dioxide absorption by the commercially available absorbant, sodasorb, used in current Naval Systems.

Summary: In FY79, the design of the experimental system, the purchase of standard components and instrumentation of the fabrication of unique parts, and the assembly of the system was also performed. Initial tests were begun and will continue into FY80.

# EQUIPMENT SCHEMATIC



The Experimental Apparatus uses Inlet Gas Systems, Infrared Monitoring of Carbon Dioxide (Into and Out of the Canister). Control and Measurement of Temperatures, and Measurements of Inside Canister Gas Pressures

Title: Gas Turbine Exhaust Stack Eductor Systems

Investigator: Paul F. Pucci, Professor Mechanical Engineering

Sponsor: NAVSEASYSKOM, Code 0331G, Mr. C. L. Miller

Objective: To determine the performance of scale model of gas turbine exhaust gas stack eductor system, and to recommend criteria for the design of gas turbine exhaust stack eductor systems for naval ships.

Summary: Two eductor geometries, suggested by "cold flow" tests, incorporating diffuser rings and a cooling shroud were tested in the "hot flow" facility during FY79. These tests demonstrated that the geometries tested were capable of significant cooling of the external mixing stack walls in addition to providing adequate cooling air to mix with the gas turbine exhaust gas.

Publications: Results have been published as theses- previously referenced in this report.

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Title: Rankine Cycle Energy Recovery Systems

Investigator: Paul F. Pucci, Associate Professor of Mechanical Engineering

Sponsor: NAVSEASYSCOM

Objective: Provide technical support by assisting NAVSEA in the evaluation of proposals received for the recovery of waste heat from gas turbine engine exhaust by using a Rankine cycle system.

Summary: Proposals were evaluated and a written recommendation made at time of the selection board.

**Title:** Advanced Composites Response Program

**Investigators:** David Salinas, Principal Investigator, Associate Professor of Mechanical Engineering

**Sponsor:** Naval Weapons Center, China Lake

**Objective:** Development of an analytical model to predict the thermal and strength behavior of a composite in a fire environment. This is a continuation of previous research activity.

**Summary:** The analytical effort includes the formulation and development of mathematical models for the thermal problem and the strength problem. The former model includes conduction, convection, radiation, combustion and diffusion. The latter model includes the determination of temperature dependent properties for anisotropic composites, and the solution of the resulting boundary value equations.

**Publications:** Two NPS technical reports will be completed before November 30, 1979.

An abstract is being prepared for presentation at the ASME National Heat Conference to be held in Orlando, Florida, July 27-30, 1980. Abstract will be sent by November 30, 1979.

A paper is being prepared for publication in the ASME Journal of Heat Transfer.

**Thesis Directed:** LT C. Vatikiotas, "Transient Heat Transfer with Thermal Reaction in a Fibrous Composite," Engineers Degree in Mechanical Engineering, to be granted June 1980.

Title: Finite Element Analysis of Moving Boundary Problems

Investigators: D. Salinas, Associate Professor of Mechanical Engineering, and Aguirre-Ramirez, Professor of Computer Sciences, University of Louisville

Sponsor: None

Objective: The formulation and solution of a wide class of moving boundary problems.

Summary: Problems with moving boundaries occur in various engineering disciplines. The Stefan multiphase problem, the diffusion - consumption problem, and the problem of a beam sliding in and out of a support are examples of moving boundary problems. A general procedure for this class of nonlinear transient field problems has been developed, and has been successfully applied to the Stefan problem and the diffusion - consumption problem. The beam problem has been formulated, and present effort is underway for its solution.

Publications: Presentation at Conference for Advances in Computer Methods for Partial Differential Equations III held at Lehigh University, Bethlehem, PA., June 20-22, 1979.

Paper, Cubic Splines to the Diffusion Equation with Moving Boundary, submitted to MATHEMATICS AND COMPUTERS IN SIMULATION, September 1977. Decision pending.

A NPS Technical Note (with Professor A. P. Borelli, Professor of Engineering, University of Illinois) has been published, NPS69-79-009.

A paper on the Stefan problem (in conjunction with Professor Aguirre-Ramirez) is in preparation.

Title: Cable Strumming

Investigator: Turgut Sarpkaya, Distinguished Professor of Mechanical Engineering

Sponsor: Civil Engineering Laboratory, Naval Construction Battalion Center, Port Hueneme, Calif.

Objective: Continued development of analysis and experiments for the prediction of the characteristics of strumming.

Summary: The characteristics of strumming of smooth cables have been investigated and methods have been devised for the design of such cables subjected to the ocean environment. A series of extensive experiments have been performed with sand-roughened cylinders to determine the effect of surface roughness on strumming. The results have shown that roughness may become very important above certain roughness Reynolds numbers. A method has been devised to incorporate the effect of roughness into the analysis for the prediction of oscillation amplitude and driving force. A numerical analysis has been carried out through the use of the discrete vortex model and turbulent boundary layer assumption.

Publications: Sarpkaya, T. and Shoaff, R. L., "Numerical Modeling of Vortex-Induced Oscillations," in CIVIL ENGINEERING IN THE OCEANS IV, Vol. 1, September 1979, pp: 504-515, ASCE, New York, N. Y.

Sarpkaya, T., "Wave Loading in the Drag/Inertia Regime with Particular Reference to Groups of Cylinders," Proceedings of the Symposium on Mechanics of Wave Induced Forces on Cylinders, University of Bristol, 1979, pp: 245-372.

Sarpkaya, T., "Lateral Oscillations of Smooth and Rough Cylinders in Oscillating Flow," Proceedings of the Symposium on Mechanics of Wave-Induced Forces on Cylinders, University of Bristol, 1979, pp: 373-387.

Sarpkaya, T., "Fluid Forces on Oscillating  
Cylinders," Journal of the Waterway, Port,  
Coastal and Ocean Division, ASCE, Vol. 104,  
No. WW4, August 1978, pp: 275-290.

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A SUMMARY OF THE NAVAL POSTGRADUATE SCHOOL RESEARCH PROGRAM. (U)

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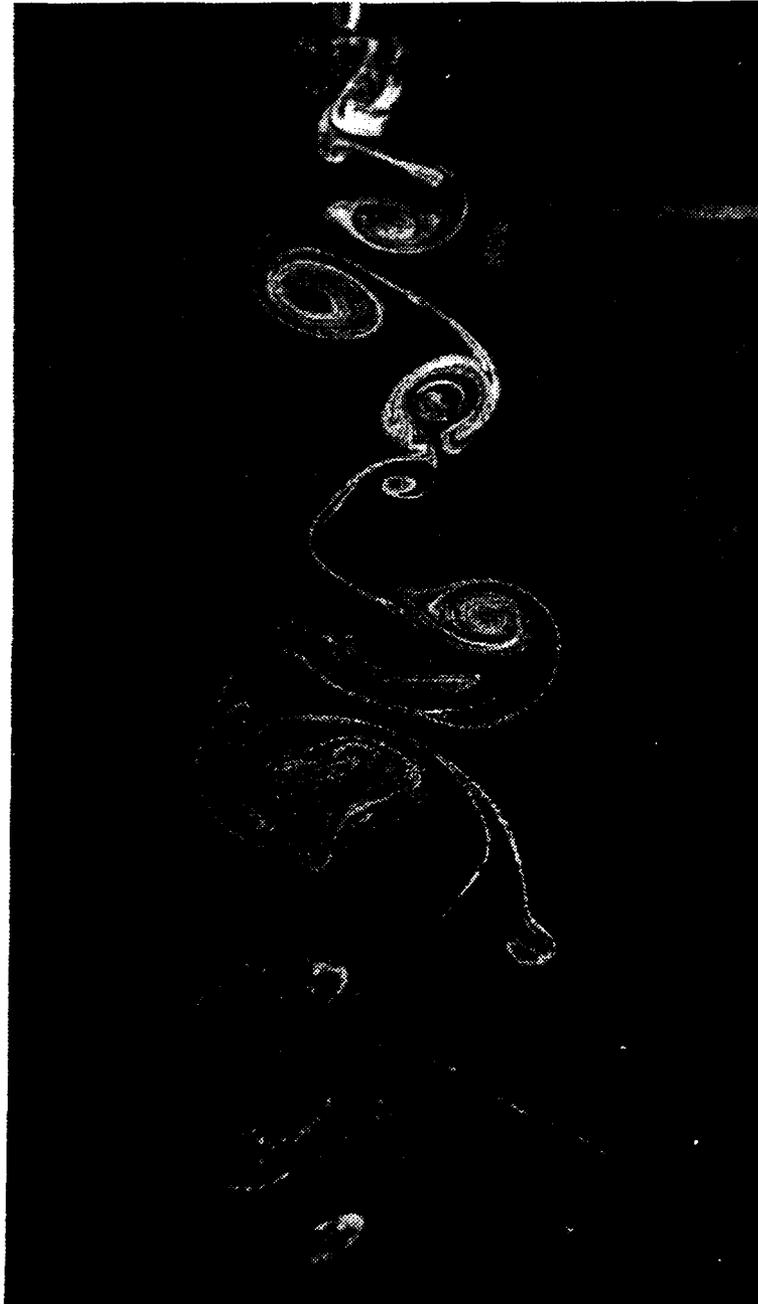
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**Vortex Shedding from a Strumming Cable**

Title: Flex-Valve and Fuel Control in Gas Turbines

Investigator: Turgut Sarpkaya, Distinguished Professor of Mechanical Engineering

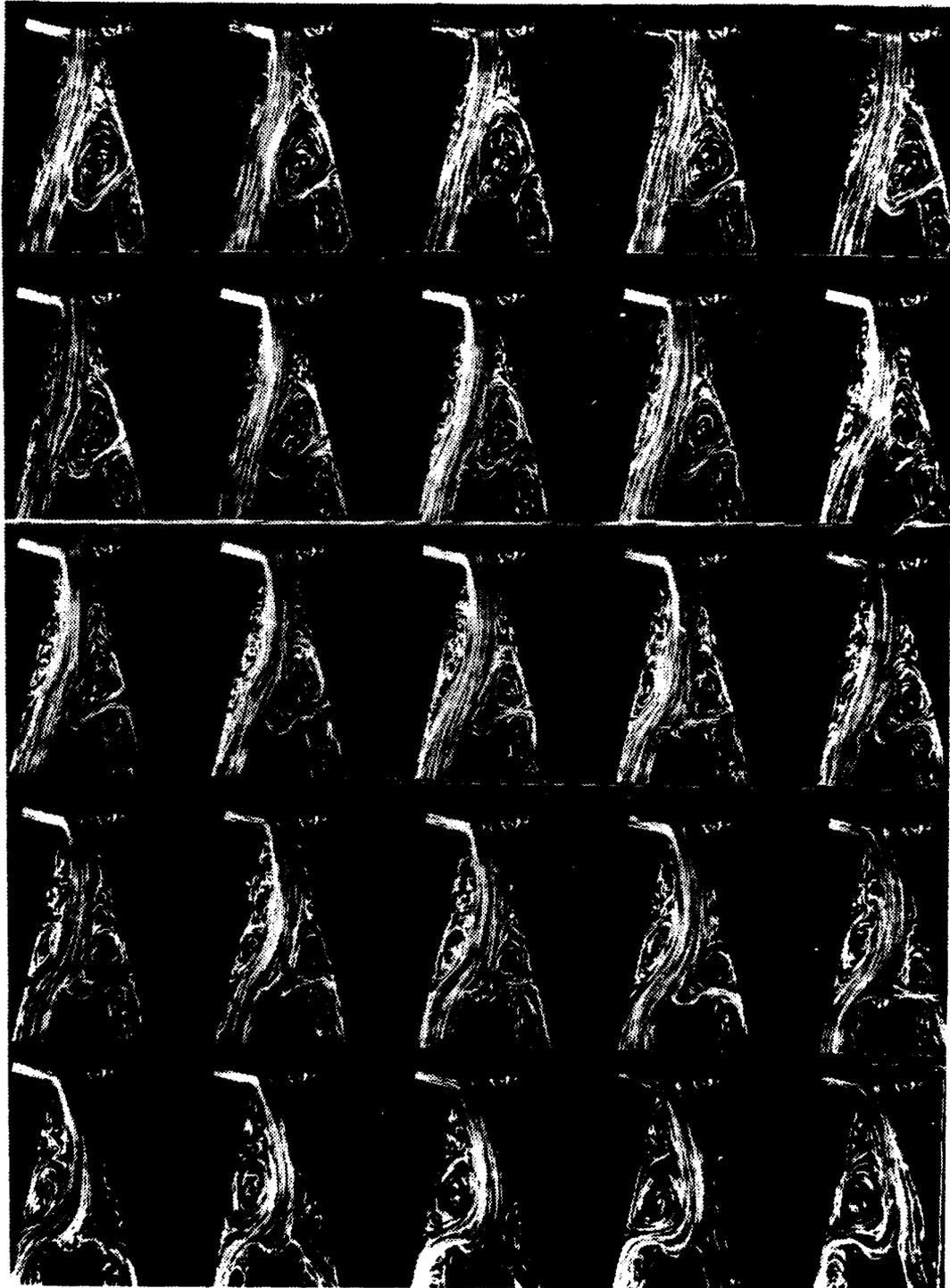
Sponsor: Naval Air Systems Command

Objective: To develop a no-moving part flow control valve for the regulations of fuel in gas turbines

Summary: A small scale model has been designed, constructed, and tested for various flow rates and system parameters. The results have been expressed in terms of the ratios of inlet and outlet pressures and flow rates. Furthermore, the maximum power efficiency has been determined. The results have shown that a flex valve can be effectively used to control fuel in gas turbines. An analysis has been carried out to predict and to optimize the performance of the valve. Additional work is needed to understand the dynamic response of the valve under operating conditions.

Thesis  
Directed: William K. Boyd, Jr., "Static Characteristics of a Flex-Valve," Master's Thesis, September 1979.

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Separated Flow in Fluidic Control Systems Switching Phenomenon

Title: Hydroelastic Oscillation of Cylinders in Harmonic Flow

Investigator: Turgut Sarpkaya, Distinguished Professor of Mechanical Engineering

Sponsor: National Science Foundation

Objective: Understanding of the fluid-mechanical phenomena leading to hydroelastic oscillations and the determination of the parameters controlling the oscillations.

Summary: The research program has continued on several fronts. Experiments have been performed with smooth and rough cylinders immersed in harmonically oscillating flow in a large U-shaped water tunnel. The results have been analyzed in terms of the governing parameters to determine the characteristics of synchronized oscillations. A numerical model based on the discrete vortex analysis has been developed and applied to steady and unsteady flows about cylinders. The model took into consideration the time-dependent boundary layer, rediscrretization of shear layers, and circulation dissipation. The predictions of the model compared extremely well with those obtained experimentally.

Publications: Sarpkaya, T., "Vortex-Induced Oscillations - A Selective Review," JOURNAL OF APPLIED MECHANICS, ASME, Vol. 46, No. 2, June 1979, pp: 241-258.

Sarpkaya, T., "Acceleration Forces on Finite Cylinders by an Oscillating Air Bubble," Transactions of the American Nuclear Society, Vol. 29, June 1979, pp: 429-430.

Sarpkaya, T. and Shoaff, R. L., "An Inviscid Model of Two-Dimensional Vortex Shedding for Transient and Asymptotically-Steady Separated Flow Over a Cylinder," Journal of the American Institute of Aeronautics and Astnautics, (will appear in the October 1979 issue)

Sarpkaya, T. and Shoaff, R. L., "Numerical Modeling of Vortex-Induced Oscillations," in CIVIL ENGINEERING IN THE OCEANS IV, Vol. 1, September 1979, pp: 504-515, ASCE, New York, N. Y.

Sarpkaya, T., "Hydroelastic Response of Cylinders in Harmonic Flow," ROYAL INSTITUTION OF NAVAL ARCHITECTS JOURNAL (to appear in March 1980).

Sarpkaya, T., "Fluid Forces on Oscillating Cylinders," JOURNAL OF THE WATERWAY, PORT, COASTAL AND OCEAN DIV., OF ASCE, Vol. 104, No. WW4, August 1978, pp: 275-290.

Sarpkaya, T., "Wave Impact Loads on Cylinders," SOCIETY OF PETROLEUM ENGINEERS JOURNAL, Vol. 15, February 1979, pp: 29-36.

Thesis  
Directed:

R. L. Shoaff, "Discrete Vortex Analysis of Separated Flow about a Stationary and Oscillating Cylinder," Ph.D. THESIS, December 1978.

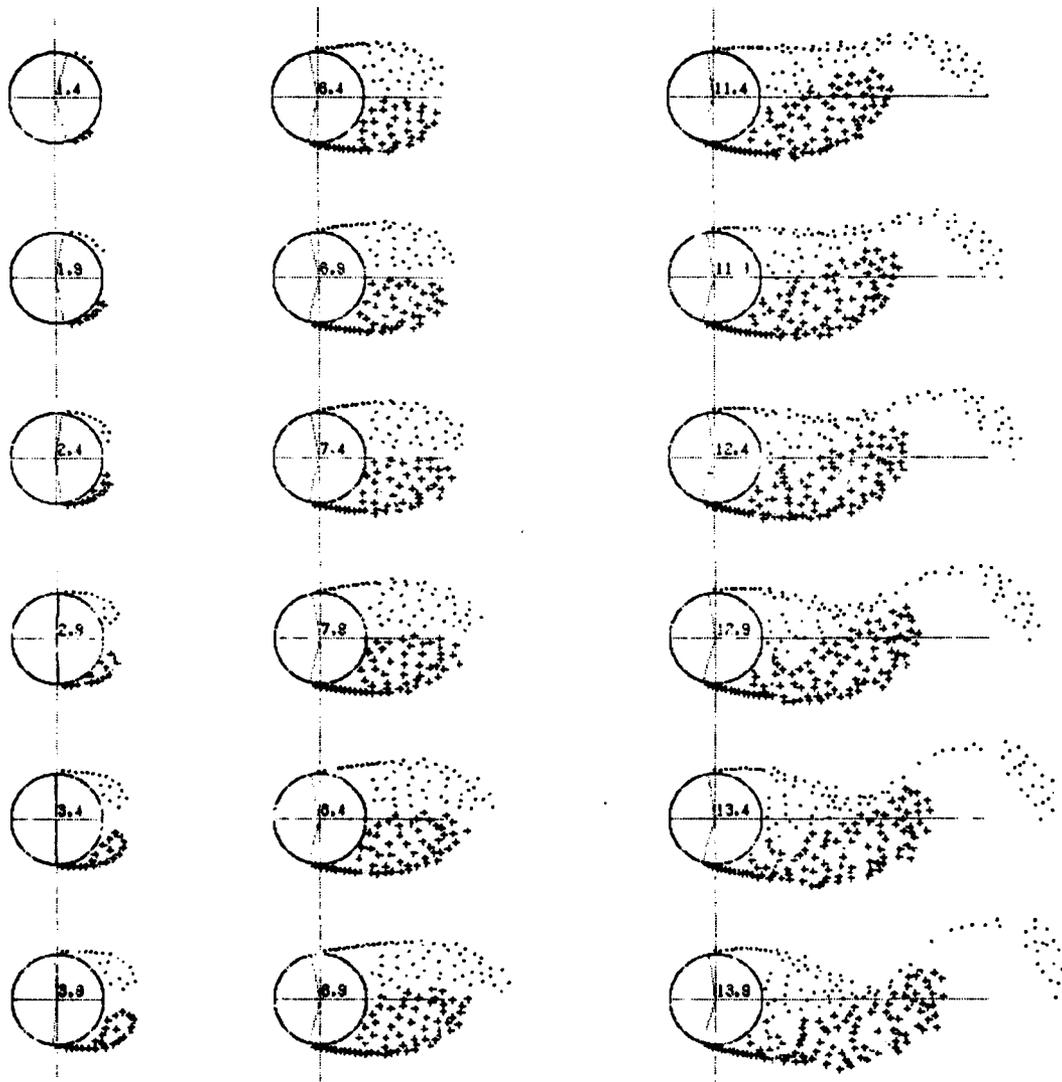
M. Cinar, "Oscillating Flow about Tube Bundles and Two-Cylinder Arrangements," MASTER'S AND ENGINEER'S THESIS, September 1979.

S. Ozkaynak, "Hydroelastic Oscillations of Smooth and Rough Cylinders in Harmonic Flow," MASTER'S AND ENGINEER'S THESIS, September 1979.

F. Rajabi, "Hydroelastic Oscillations of Smooth and Rough Cylinders in Harmonically Oscillating Flow," (Ph.D. Thesis) to be completed in December 1979.



**Vortex Breakdown in Swirling Flows and Above Delta-Wing Aircraft**



Vortex Shedding Analysis Through the use of Discrete-Vortex Model

Title: Missile System Reliability Program

Investigator: W. M. Woods, Dean of Educational Development

Sponsor: Strategic Systems Project Office, Washington, D.C.

Objective: Provide mathematical and reliability technical support on TRIDENT Program.

Summary: Several technical papers were written in response to specific assignments pertaining to detection of degradation of missile reliability and evaluation of Lockheed Missile and Space Company documents. A contractor reliability estimation procedure proposed for use in the TRIDENT Program was evaluated for accuracy via computer simulation. Gap switches data were analyzed, a missile motor data analysis procedure was reviewed, the statistical procedures in an Accuracy Improvement Program Manual were reviewed and the Reliability Performance Evaluation Manual was reviewed. Numerous trips were made to LMSC Sunnyvale, California to participate in meetings.

Thesis Directed: P. A. Craig, "Evaluation of a Proposed Modified Log-Gamma Confidence Bound Method for Fleet Missile System Reliability," Master's Thesis September 1979.

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