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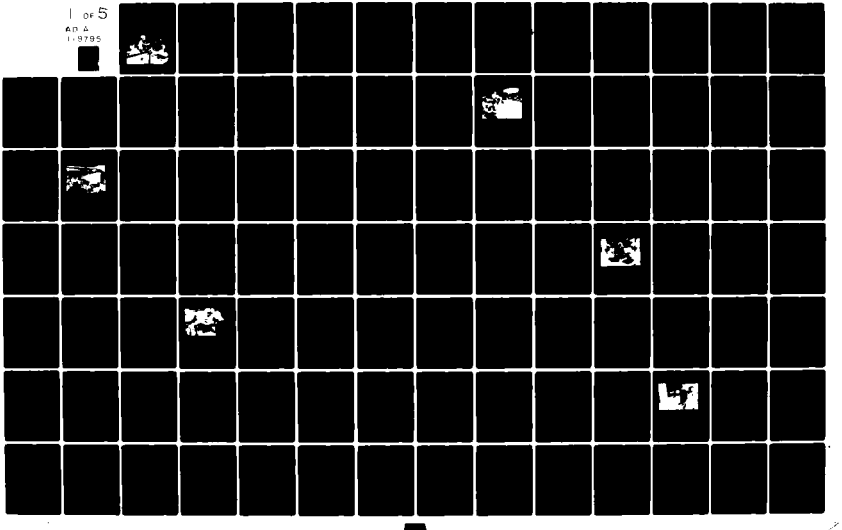

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# A SUMMARY OF THE NAVAL POSTGRADUATE SCHOOL RESEARCH PROGRAM

REPORT FOR THE PERIOD
1 OCT 1980 to 30 SEPT 1981

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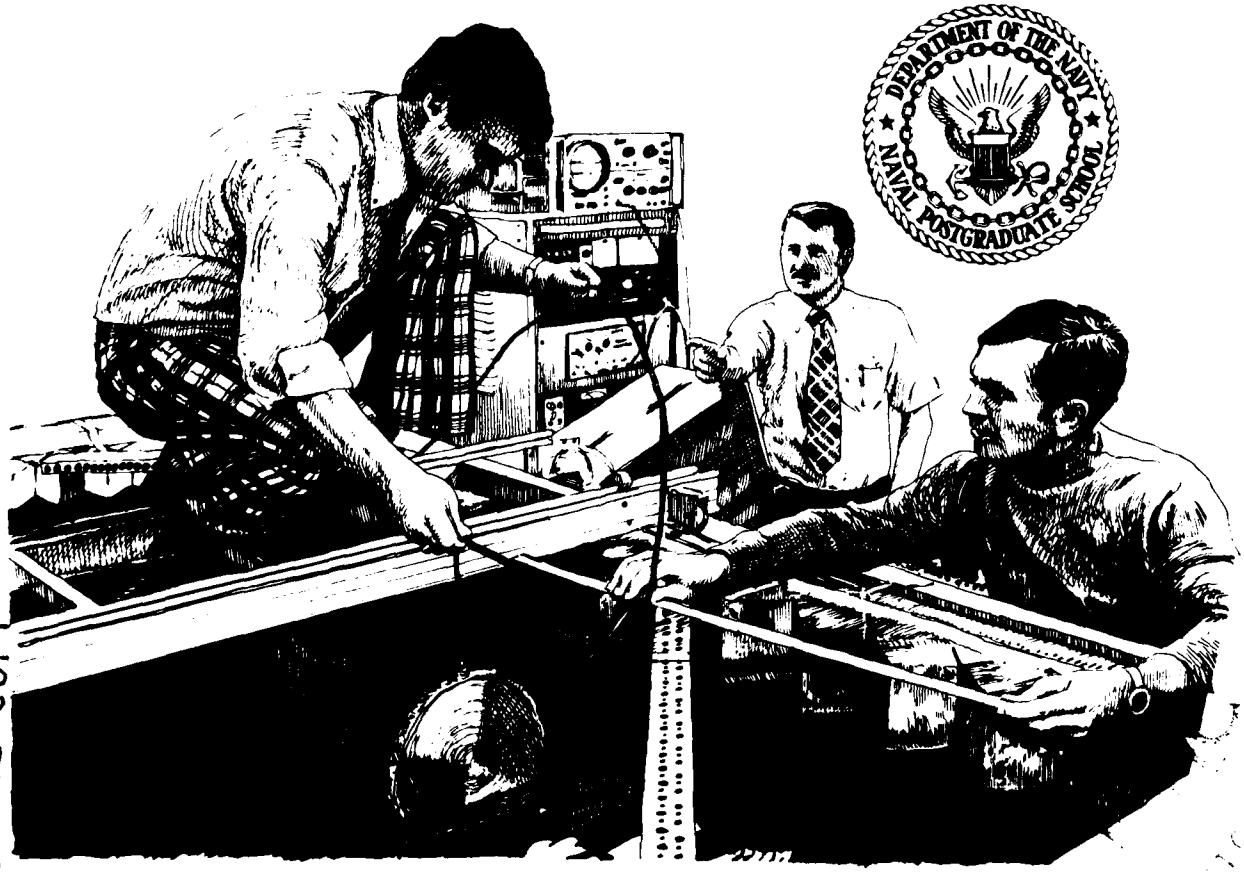




NAVAL POSTGRADUATE SCHOOL
MONTEREY, CALIFORNIA

NAVAL POSTGRADUATE SCHOOL
Monterey, California

Rear Admiral John J. Ekelund
Superintendent

David A. Schrady
Acting Provost

The work reported herein was supported by various sponsors as indicated by the summaries.



This report was prepared by:

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Acting Provost

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Summary Report

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report contains 224 summaries on research projects which were carried out under funding to the Naval Postgraduate School Research Program. This research was carried out in the areas of Computer Science, Mathematics, Administrative Sciences, Operations Research, National Security Affairs, Physics and Chemistry, Electrical Engineering, Meterology, Aeronautics, Oceanography and Mechanical Engineering. The Table of Contents identifies the areas of research.

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# A SUMMARY OF RESEARCH ACTIVITIES

## INTRODUCTION AND BACKGROUND

Research activities performed at the Naval Postgraduate School (NPS) during fiscal year 1981 are 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 addit.on, 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, clearly related to Navy and DOD interests. A substantially larger fraction of the R&D effort at NPS is in the exploratory development category than would be found in most universities. This is a result of student interests as well as faculty motivation created by the environment at NPS.

Support of NPS research activities has diversified to presently include more than seventy separate sponsoring agencies. The enclosed summaries indicate the level of activity and the diversity of efforts in support of both education and R&D.

NAVAL POSTGRADUATE SCHOOL
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General inquiries concerning faculty and student research at the Naval Postgraduate School should be addressed to:

Superintendent
Naval Postgraduate School
(Attn: Research Administration, Code 012A)
Monterey, California 93940

TABLE OF CONTENTS

# DEPARTMENT

# OF

# COMPUTER SCIENCE

## DEPARTMENT OF COMPUTER SCIENCE

The Research Program of the Computer Science Department consists of work in various aspects of computer science and the application of computers to Navy problems. The Department's research efforts have allowed the development of extensive research laboratories that feature microcomputers, minicomputers, computer graphic devices, and image and signal processing equipment.

### SOFTWARE DEVELOPMENT

B. J. MacLennan has continued the development of the theory and practical methodology for advanced software development. The research has involved the development and comparision of formal models of systems, the development of a method of determining the major structural components of programming languages, a demonstration of the use of relational calculus operators in very high level languages, and an investigation of tools to enhance the development and maintenance of software.

### AUTOMATIC DESIGN OF ALGORITHMS

D. R. Smith has continued his research on the automatic design of computer algorithms from user-supplied formal specifications. The work has included a formalism for representing problems, abstract control structures and correctness schemes, and the development of a new class of deductive mechanisms.

### OPERATING SYSTEMS FOR COMBAT SYSTEMS

U. R. Kodres and R. R. Schell have investigated hardware and operating systems software characteristics for effective use of multi-microcomputers in combat systems. The research has focused on operating systems structures that will support combat system applications, architectural guidelines for hardware design, and hardware and operating system features to enhance implementation of secure systems.

### DISTRIBUTED DATABASES

D. Z. Badal has continued his work on concurrency control mechanisms for distributed database systems. The research has focused on the study of concurrency overhead and mechanisms.

### LARGE-SCALE OPTIMIZATION

G. Bradley and G. Brown have continued their research on the solution of large scale optimization problems. The research has extended network optimization to include models with elastic and mixed integer features, constructed a microcomputer based system for optimization problems, and developed interactive model-building systems.

### MULTI-MICRO COMPUTER ARCHITECTURE

U. K. Kodres, M. L. Cotton and R. Panholzer have continued their study

of the use of very large scale integration technology in the SPY-1A radar control. The research involves hardware interface development using fiber-optics, implementation of skeletal weapons control systems interface and command and decision interface, and system's programming and performance analysis.

MAN-MACHINE SYSTEMS

G. A. Rahe has done research on the development of embedded tutorials to reduce equipment training costs. The research has focused on the development of a self-paced computer aided instructional learning tool for the Ramteck 9400 Color Graphics Display System.

TIME-SHARING ON THE NPS COMPUTER LABORATORY UNIX SYSTEM ALLOWS RESEARCH IN A VARIETY OF AREAS AT THE FOREFRONT OF COMPUTER SCIENCE.

Title: Concurrency Control in Distributed Database Systems

Investigator: D. Z. Badal, Assistant Professor of Computer Science

Sponsor: NPS Foundation Research Program

Objective: To analyze concurrency control mechanisms for distributed database systems.

Summary: This research divides concurrency control (CC) mechanisms into three classes. One class consists of blocking CC mechanisms and two classes contain nonblocking CC mechanisms. We define CC overhead and derive it for each class of CC mechanisms. Since CC overhead is dependent on CC mechanism only, it can be used as a metric for comparison of CC mechanisms and as a measure of CC load on DBMS resources. The research also described two new distributed CC mechanisms which are compared in terms of CC overhead with industry standard distributed 2 phase locking.

Publications: D. Z. Badal, "Concurrency Control Overhead or Closer Look at Blocking vs. Nonblocking Concurrency Control Mechanisms", Proceeding of the 5th Berkeley Conference on Distributed Data Management and Computer Networks, San Francisco, February 1981, pp. 85-105.

D. Z. Badal, "Concurrency Control Overhead or Closer Look at Blocking vs. Nonblocking Concurrency Control Mechanisms", NPS Technical Report, NPS52-81-005, June 1981.

Title: Emulation of a Multi-Microcomputer Architecture for the SPY-1A Control Computer

Investigators: Uno R. Kodres, Associate Professor of Computer Science; Mitchell L. Cotton, Associate Professor of Electrical Engineering, and Rudolph Panholzer, Professor of Electrical Engineering

Sponsor: Naval Sea Systems Command

Objective: To explore the use of VLSI (very large scale integration) technology in the application of SPY-1A radar control.

Summary: This continuing project is subdivided into: hardware interface development, software interface to system's components development, applications programs emulation, system's programming and performance analysis. A fiberoptic interface with raw data rates of up to 10 megabits per second has been purchased. The design of a ring interface is scheduled for completion by June '82 which connects distantly located computer complexes. A parallel interface between the developmental system and the multiprocessor system has been implemented and tested for high speed data transmission. The Intel 432/100 experimental system was installed to permit evaluation of this new 32 bit micro-mainframe processor as a system's component. Implementation of skeletal weapons control systems interface and the command and decision interface was completed in June '81. A single thread model of the 20 modules in the SPY-1A controller system is presently under construction and the first phase is scheduled for completion by Dec. '81. The executive system which operates the real time multiprocessor system was tested on two processors. A construction of a gate to this executive system is scheduled for completion Dec. '81.

Theses Directed: Gary D. Taul, "A Microprocessor I/O Simulator for the AEGIS AN-SPY/1A Controller." Master's Thesis, Dec. 1980.

Demonsthenis K. Rapantzikos, "Detailed Design and Implementation of the Kernel of a Real-Time Distributed Multiprocessor Operating System." Master's Thesis, March '81.

Michael B. Candalor, "Alteration of the CP/M-86 Operating System." Master's Thesis, June '81.

Title: Operating System Structures for Distributed Multi-Microcomputer Systems

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

Sponsor: Office of Naval Research

Objective: Identify hardware and operating system software characteristics for effective use of multi-microcomputers in combat systems.

Summary: The recent development of Very Large Scale Integrated (VLSI) general purpose computers will radically change the economics and design concepts of dedicated computational systems which can be built from concurrently operating multi-computer systems composed of commercially successful single board (in the future, single chip) computers. The purposes of this study: (1) identify operating system's structures that will more effectively support combat systems applications, (2) provide architectural guidelines for hardware design and support the required operating system capabilities and efficiencies and (3) to identify the hardware and operating system features which enhance the implementation of secure systems composed of multi-microcomputers.

The development of a family of multi-microcomputer executive systems has continued from designs which were completed a year ago to implementation. Recovery from a system malfunction caused by a processing element was designed and partially implemented. System initialization which dynamically determines the available resources was designed and implemented. The kernel of a real time multiprocessor operating system was tested on a single processor and dual processor systems. The CPM-86 operating system was adapted to the hardware environment which exists in our multi-microcomputer laboratories.

Theses Directed: Demonsthenis K. Rapantzikos, "Detailed Design and Implementation of the Kernel of a Real-Time Distributed Microprocessor Computer System. Master's Thesis, March 1981.

Richard L. Anderson, "Automatic Recovery in a Real-Time Distributed Multiple Microprocessor Computer System. Master's Thesis, Dec. 1980.

Lawrence J. Shirley, "Non-Discretionary Security Validation by Assignment. Master's Thesis, June '81.

Gary S. Baker, "Initialization Design for Dynamic Determination of Resources. Master's Thesis, June '81.

Michael B. Candalor, "Alteration of the CP/M-86 Operating System. Master's Thesis, June '81.

Title: Advanced Methods for Software Development

Investigator: Bruce J. MacLennan, Assistant Professor of Computer Science

Sponsor: NPS Foundation Research Program

Objective: Continued development of the theory and a practical methodology for advance software development.

Summary: Progress has been made on this project in four areas: theory, metrics, languages, and tools.
(1) Theory. This project has continued an investigation of the general properties of systems. Several formal models of systems have been developed and compared.
(2) Metrics. One of the most important properties of a system is its complexity. This project has developed a method of determining the major structural components of programming languages and other systems. This forms a basis for measuring the complexity of these systems. This project has also addressed the problem of the validation of complexity measures.
(3) Languages. This project has made progress in two aspects of very-high-level languages. First, it has shown that the operators of a relational calculus can be used for the high level manipulation of both data structures and program structures. Second, it has investigated the nature of objects and values in very-high-level functional and applicative programming languages. This has resulted in a clarification of the role each of these play, and guidelines for future language design.
(4) Tools. This project has investigated tools to enhance the development and maintenance of software. A tool that is proving very valuable is a syntax-directed editor. Since a separate syntax directed editor is required for each programming language, this project has developed and implemented a method for implementing these automatically.

Publications: B. J. MacLennan, "Values and Objects in Programming Languages", NPS Technical Report, NPS52-81-006, April 1981, also submitted for publication.

B. J. MacLennan, "Introduction to Relational Programming", NPS Technical Report, NPS52-81-008, June 1981.

Title: Application of Auto-Instruction to Undersea Surveillance

Investigator: George A. Rahe, Professor of Computer Science

Sponsor: Naval Electronics Systems Command

Objective: To demonstrate improved manpower utilization and system performance by application of the methods of artificial intelligence expert systems to undersea surveillance.

Summary: The objective of this research was to create an embedded tutorial for the Ramtek 9400 Color Graphics Display System. An embedded tutorial is a self-paced Computer Aided Instruction (CAI) learning technique which is implemented on the actual equipment the subjects are learning to use. This technique has tremendous potential in helping the Department of Defense meet its goal of increased manpower effectiveness. The Tutorial should eliminate the necessity for each user to possess and master large quantities of often confusing documentation. Goals of good CAI system design and man-machine interface, and the design techniques actually used to implement the embedded Tutorial are discussed. Evaluations by faculty, staff, and students were performed to identify areas of improvement. A User's Manual and Software Maintenance Manual were also written to accompany the embedded Tutorial.

Publication: J. Hayes, J. Sherrard, "Ramtek 9400 Users Manual," NPS Technical Report, Dec. 1981.

Thesis Directed: J. Hayes, J. Sherrard, "A Computer Aided Instruction Tutorial for the Ramtek 9400 Color Graphics Display System," Master's Thesis, December 1981.

THE NPS COMPUTER LABORATORY WAS ONE OF THE FIRST FACILITIES IN THE NATION TO COMBINE RESEARCH IN COMPUTER GRAPHICS AND SIGNAL PROCESSING.

| | |
|---|---|
| Title: | The Automatic Design of Algorithms |
| Investigator: | Douglas R. Smith, Assistant Professor of Computer Science |
| Sponsor: | NPS Foundation Research Program |
| Objective: | The automatic design of computer algorithms from a user-supplied formal specification of a problem. |
| Summary: | A new approach to automatic algorithm design has been developed. This research has involved several supporting sub-activities:<br>1) development of a formalism, called a problem reduction system for representing problems,<br>2) development of the abstract control structures and associated correctness schemes for the different algorithmic methods for solving problem reduction systems,<br>3) development of the theory of a new class of deductive mechanisms called *precondition generators*.<br>The algorithm design method has been used to derive 10 common divide and conquer algorithms by hand from their specifications. |
| Publication: | D. R. Smith, "A Design for an Automatic Programming System", Proceedings of the Seventh International Joint Conference on Artificial Intelligence, August 1981. |
| Conference Presentation: | D. R. Smith, "Problem Reduction Systems", Mathematics Department Seminar, NPS, January 1981. |
| Theses: | J. S. Lape, and C. W. Miller, "Condition Recognition for a Program Synthesizer", Master's Thesis, June 1981. |

# DEPARTMENT

# OF

# MATHEMATICS

## DEPARTMENT OF MATHEMATICS

The major areas of research activity in the Mathematics Department are: Numerical Analysis, Applied Statistics, Optimization and the development of a Microcomputer Laboratory. A brief summary of the activities in each area is given as well as a summary of some of the miscellaneous research activities.

### NUMERICAL ANALYSIS

R. H. Franke is continuing research in the area of surface approximation, especially in the case of scattered data points. A comparison of various methods has been accepted for publication by the Mathematics of Computation. An algorithm for the interpolation of scattered data will appear in Computers and Mathematics with Applications. Professor Franke and Professor T. Jayachandran are continuing research into the properties of the Foutz multivariate goodness-of-fit test. Professor Jayachandran's student R. Linhart is considering power properties of the test for fitting a multivariate normal distribution. M. D. Humphries has been working on numerical solutions of fixed point equations. He has a paper on choosing on a theoretical and experimental basis between algorithms. Some new more efficient methods were found. His paper "A Journal of Approximation Theory" will appear soon. He continues his study of acceleration of convergence of iterative algorithms, and a development of non-standard analysis. A. L. Schoenstadt continues to develop and test, with R. T. Williams, better procedures for global and regional weather prediction. Additionally, with C. P. Chang, they are considering numerical modelling of unique atmospheric phenomena. A talk on a filter coefficient methodology for analysis of numerical prediction models was presented.

### APPLIED STATISTICS

T. Jayachandran, together with H. J. Larson, is developing statistical procedures to analyze spectrometric measurements on oil samples from aircraft engines. His paper, "Methodology for Determining Sampling Intervals" appeared as an NPS report. The same individuals also worked on a statistical analysis of technician proficiency data on an Air Force nondestructive analysis program. They developed ranking for the individuals and laboratories involved.

### OPTIMIZATION

I. B. Russak continues work on constrained optimization problems. His paper "Convergence of the Conjugate Gram Schmidt Method" appeared in the Journal of Optimization Theory and its Application. His research for the Aerospace Corporation on a technical investigation of two major optimization computer programs also appeared as an NPS report. He also continues a study

of rates of convergence of non-linear optimization algorithms under weakened hypotheses.

MICROCOMPUTER LABORATORY

The microcomputer laboratory in the Mathematics Department provides an area for research for several faculty members. G. E. Latta continues to act as campus coordinator for the laboratory. M. D. Weir has been concentrating on course development as it relates to the Apple computer and microcomputer development generally. C. O. Wilde has been writing programs for course development especially in ODE's and in probability distributions.

MISCELLANEOUS

H. M. Fredricksen has been working on methods for using full length binary sequences for various spread spectrum applications. He spoke to the International Information Theory on this subject. His survey papers on generation of full length non-linear shift-register cycle algorithms will appear soon in SIAM Review. Work continues in this area. Additionally, he supported S. Jauregui in a signal recognition and analysis project and worked on algorithms for signal processing with L. A. Cox. L. D. Kovach continues work on his textbooks "Advanced Engineering Mathematics" publication eminent and "Boundary Value Problems" to appear soon - both with Addison-Wesley. D. H. Trahan has been considering paths in lattice diagrams. This work is joint with H. M. Fredericksen and a student, S. Slayton. He and Slayton are also collaborating on research on Venn diagrams. P. C. C. Wang is providing essential analytical components required to develop and operate an integrated system for production of long term projections of foreign ground force weapon systems. This research effort will be incorporated and implemented within the Army intelligence community to improve its projective capability. The investigator will evaluate and develop microcomputer applications tailored to a set of problems associated with the engineering data handling systems to be used in threat projections. M. D. Weir published a paper "Glottochronology: An Application of Calculus to Linguistics". His book, "Calculator Clout" and "Calculus by Calculator" have appeared or will appear soon from Prentice-Hall. C. O. Wilde has been writing, reviewing and editing instructional materials on the contraction mapping principle, error correcting codes, vector and vector field identities, dimensional analysis for UMAP and calculus of variations in Application in Mechanics.

| | |
|---|---|
| Title: | Literature Search |
| Investigator: | H. M. Fredricksen, Associate Professor |
| Sponsor: | National Security Agency |
| Objective: | To perform a literature search through documents provided by the sponsor to determine and discover items of interest to the sponsor. |
| Summary: | The literature search was performed on documents provided by the sponsor to determine certain interest items. Several criteria developed during the period of the search to improve the search techniques. |

| | |
|---|---|
| Title: | Using Full Sequences for Spread Spectrum Applications |
| Investigator: | H. M. Fredricksen, Associate Professor of Mathematics |
| Sponsor: | NPS Foundation Research Program |
| Objective: | To develop algorithms to generate sequences to be used in spread spectrum applications and to determine the efficacy of those sequences for the proposed use. |
| Summary: | The binary full length non-linear shift register sequences were considered as possible good sequences to be employed in a spread spectrum system. It was necessary to determine good and efficient algorithms to generate the sequences and then to determine for the sequences generated how well they could be used as sequences in the spreading applications. Several algorithms were detailed and some of the sequences generated were further analyzed as spreading sequences. Research continues in this area on an unfunded basis. |
| Publication: | H. M. Fredricksen, "A Survey of Full Length Non-Linear Shift Register Cycle Algorithms", SIAM Review, April 82 (forthcoming). |
| Conference Presentation: | H. M. Fredricksen, "Using Full Sequences for Spread Spectrum Applications", International Information Theory meeting, Santa Monica, California, February 9 - 12, 1981. |

| | |
|---|---|
| Title: | Numerical Solution of Fixed-Point Equations |
| Investigator: | Michael D. Humphries, Adjunct Professor of Mathematics |
| Sponsor: | NPS Foundation Research Program |
| Objective: | To study the behavior of certain numerical methods, to develop them into useful algorithms, to apply them to other kinds of fixed-point problems, and to obtain a theoretical analysis of their properties. |
| Summary: | Theoretical and experimental analyses were carried out to determine which algorithms were most appropriate. The choice of various parameters depends on the characteristics of the particular equation. New, more efficient algorithms were introduced as a result of this study. |
| Publication: | Michael D. Humphries, "Numerical Solution of Fixed-Point Equations, NPS Technical Report, (forthcoming). |

Title: Statistical Methods for the Joint Oil Analysis Program

Investigators: Toke Jayachandran, Associate Professor, Mathematics Department and Professor H. J. Larson, Operations Research Department.

Sponsor: Kelly Air Force Base

Objective: Develop statistical procedures to analyze the spectrometric measurements on oil samples from aircraft engines.

Summary: We developed statistical methodologies for:

a) determining if a spectrometer is properly calibrated by analyzing a set of synthesized oil samples;
b) determining formulas to convert measurements made on an Atomic Absorption spectrometer into an equivalent set of measurements from an Atomic Emission spectrometer;
c) the use of a moving regression approach for monitoring the wearmetal buildup rates in engine oil samples and to predict impending engine failures.

This is a continuing project and the sponsor has agreed to extend the project into FY 82.

Publications:

H. J. Larson, T. Jayachandran, "Methodology for Determining Sampling Intervals," NPS Technical Report, NPS53-81-001, November 1980.

H. J. Larson, T. Jayachandran, "Statistical Methods for the Joint Oil Analysis Program," NPS Technical Report, NPS55-82-002, January 1982.

Title: Convergence of Non-Linear Optimization Algorithms Under Weakened Hypotheses

Investigator: I. B. Russak, Associate Professor of Mathematics.

Sponsor: NPS Foundation Research Program

Objective: To establish a weakened set of hypotheses under which it can be guaranteed that certain types of non-linear optimization algorithms will converge. Also to determine what the convergence rates are.

Summary: Consider the general constrained optimization problem

minimize $f(X)$
subject to
$g_\alpha(X) \leq 0 \quad \alpha=1,\ldots,m' \qquad g_\alpha(X)=0 \quad \alpha=m'+1,\ldots,m$

where X is an N-dimensional vector. Real world applications of this problem occur very frequently in military applications, e.g. optimizing with respect to time to intercept, the parameters of a missile inteceptor system subject to constraints on its motion. Often however the restrictive conditions assumed in many convergence proofs of numerical algorithms for solving problems of this type are not true. It may therefore be incorrect to apply such algorithms in those cases. A weakened set of hypotheses which more accurately represents the real world situation is being developed and convergence rates under these modified conditions are being investigated.

Publication: I. B. Russak, "Convergence of Non-Linear Optimization on Algorithms Under Weakened Hypothesis," NPS Technical Report, (forthcoming).

| | |
|---|---|
| Title: | Technical Investigation of Two Major Optimization Computer Programs |
| Investigator: | I. B. Russak, Associate Professor of Mathematics |
| Sponsor: | The Aerospace Corporation |
| Objective: | To perform a brief investigation of two large scale optimization computer programs called GTS and Prose in order to determine their relative overall applicability to current aerospace projects. |
| Summary: | The investigation was completed. For reasons detailed in the report listed below, it was determined that GTS was the more suitable program. In addition a number of recommendations for improving GTS were made. |
| Publication: | I. B. Russak, "Technical Investigation of Two Major Optimization Computer Programs," NPS Technical Report, NPS-53-81-010, September 1981. |

| | |
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# DEPARTMENT

# OF

# ADMINISTRATIVE SCIENCES

## 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 (sometimes overlapping) areas of research concentration: Systems Acquisition; Information and Logistics Systems; Organizational Sciences; Financial/Resource Management; and Manpower, Personnel and Training. The past year's focus of the specific research projects in these areas is summarized in the following paragraphs.

### SYSTEMS ACQUISITION, INFORMATION AND LOGISTICS SYSTEMS

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 continued his examination of aerospace industry profitability in an attempt to determine the extent and nature of profitability differences between aerospace and other industries. In addition, Professor Boger continued his investigation of the relationship of internal firm organization and financial performance. Professors Boger and Jones, in conjunction with Professor K. Sontheimer of the University of Pittsburg, continued an examination of the incentive effects present in long-run contractual arrangements. M. B. Kline continued his research in systems engineering and the systems acquisition process areas, including analysis of maintainability, active repair time, and suitability of logistics provisioning, level of repair, and life support cost models for optimizing logistics resources. N. Lyons continued working on man-machine interface problems in the C3 area. N. F. Schneidewind continued his research in the areas of software engineering and management, specifically studying methods to improve system and software specification processes. He was also involved in designing computer-communications networks in support of Naval logistics programs. R. Weissinger-Baylon continued his research on the function of visual mental imagery in problem solving and decision making. A. W. McMasters developed failure rate estimates for items managed by the Naval Electronic Systems Command, to be used in determining when to transfer control of the inventories of these items to the Ships Parts Control Center. Professor McMasters is also working on the development of an improved local delivery system for Naval Supply Centers at Oakland and Norfolk. Finally, he is analyzing hotel steam flow rate data to determine the amount of steam needed by ships in port. J. W. Creighton continued his research on the technology transfer process, focusing on the human interaction with emphasis on the utilization of the process and concepts of technology transfer by managers.

## ORGANIZATIONAL SCIENCES

C. K. Eoyang, R. T. Harris, R. McGonigal and W. R. Bishop continued the long term research program in organization development. Their extensive field work underlies significant contributions to the revitalization of the Navy's program in Human Resource Management, which is the largest in the country. P. Bromiley continued his examination of regulatory priority setting by mid-level employees. M. R. Louis continued her research into the dynamics of career transitions, developing a framework for diagnosing transition situations and identifying common tasks to be accomplished by newcomers. R. Evered continued his research in both the Strategic Management area and the epistemology of social science research. D. Whipple and K. Kocher began an investigation of the existence of an interdisciplinary predictive theory of intra-firm behavior. J. D. Senger began investigating authoritarian attitudes among U. S. and allied military officers and is developing the "psychological multiplier" concept.

## FINANCIAL/RESOURCE MANAGEMENT

D. Whipple, in conjunction with R. T. Harris and K. Kocher, completed the multi-year effort to develop a method to estimate and implement the appropriate mix of physician and non-physician providers required to staff primary care clinics in military hospitals. K. J. Euske continued to expand his research on the behavioral effects generated by the budgetary process. R. A. Bobulinski continued his work relating organizational management principles to practical comptrollership functions, evaluating budget and accounting execution at DOD field activities, and studying ways to improve operational auditing in the public sector. J. M. Fremgen initiated a project to investigate actual and potential uses for depreciation data in the Federal government. P. Bromiley continued a study of the determinants of corporate capital investment. S. S. Liao studied the feasibility of using cost accounting and program accounting techniques to measure the performance of general government operations.

## MANPOWER/PERSONNEL/TRAINING RESEARCH

R. S. Elster, G. W. Thomas, and K. J. Euske developed and applied a methodology for development of an attrition severity-index using priorities, manpower requirements, loss rates, and replacement costs for U. S. Navy ratings. Professor Thomas conducted research on the econometric estimation of enlistment and reenlistment supply functions, estimation of earnings functions, and the socio-economic attributes of the AVF. Professors Elster and Thomas directed a study of the manpower requirements and availabilities for a 600 ship Navy in 1990. R. S. Elster completed his work on the evaluation of a Navy counter-attrition effort, as well as his analysis of the relationship of pre-service educational accomplishment to performance in the military. R. A. Weitzman continued development

and application of sequential aptitude testing for recruit selection and assignment. In addition Professor Weitzman continued his research into development of predictive techniques useful in manpower/personnel research.

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| Title: | Estimation and Prediction in Enlistment Supply Models |
| Investigator: | Dan C. Boger, Assistant Professor of Economics, Department of Administrative Sciences |
| Sponsor: | Naval Personnel Research and Development Center |
| Objective: | To provide alternative econometric techniques for pooling time series data with cross-section data within the context of enlistment supply models. |
| Summary: | A survey of the literature on pooling time series and cross section data within linear models was conducted. The models encountered were categorized according to assumptions made concerning the coefficients of the independent variable. The three major assumptions were, first, that all coefficients were constant over individuals and time periods, second, that slope coefficients were constant but intercept coefficients were varying and, third, that both slope and intercepts were varying over individuals and time. Additionally, in the second and third models the coefficients may be interpreted as either fixed or random. Comments concerning the appropriateness of the models' assumptions were included. |
| Publications: | Dan C. Boger, "A Survey of Pooling Time Series and Cross-Section Data," September 1981, Working Paper submitted to NPRDC. |

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| Title: | Measurement of Inflation for Military Systems |
| Investigators: | Dan C. Boger, Assistant Professor of Economics, Department of Administrative Sciences and Toke Jayachandran, Associate Professor of Mathematics |
| Sponsor: | Office of the Assistant Secretary of Defense |
| Objective: | To provide an assessment of the impact of inflation on the real purchasing capability of the Department of Defense. |
| Summary: | An analysis of alternative techniques for forecasting inflation rates was conducted. The alternative techniques all relied upon macroeconometric models but to different extents. The three alternative estimates were produced by OMB/OSD, CBO and DRI. Using various ways of measuring forecast error, it was determined that the OMB/OSD forecasts were consistently worse than either the CBO or DRI forecasts. The effect of this was to cause an even further increase in the amount of funds required for the continuance of the ongoing acquisition of systems. |
| Publication: | D. C. Boger, M. G. Sovereign, T. Jayachandran, "Measuring the Accuracy of Alternative Forecasts of Inflation", (forthcoming). |

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| Title: | Demand Disclosures and Conditions on Exclusion: An Experimental Investigation |
| Investigators: | Earl R. Brubaker, Adjunct Professor of Economics, Department of Administrative Sciences |
| Sponsor: | National Science Foundation |
| Objective: | To generate experimental evidence on human responses to decision situations characterized by theoretically interesting variation of conditions on exclusion. |
| Summary: | Random samples of subjects were invited to respond to: (1) a highest-rejected-bid auction, (2) a modified classical collective economic decision-situation, and (3) individual unconditional non-exclusion. The experimental design made feasible observation of decisions on a scale approximating actual collective economic decisions in contemporary developed economies. |
| Conference Presentations: | E. R. Brubaker, "Demand Disclosures and Conditions on Exclusion: An Experimental Investigation," Public Choice Society Meeting, San Antonio, Texas, 4-6 March 1982. |

Title: First-term Enlisted Attrition: Costs of Attrition and Severity of Attrition

Investigators: R. S. Elster, Professor of Management and Psychology, Department of Administrative Sciences, K. J. Euske, Assistant Professor of Accounting, Department of Administrative Sciences and G. Thomas, Adjunct Associate Professor of Management and Psychology, Department of Administrative Sciences

Sponsor: Naval Personnel Research and Development Center

Objective: The objectives of the proposed research were to develop:
- the costs to the Navy of replacing individuals attriting from the different ratings in the Navy
- A means for assessing the severity of first-term enlisted attrition from each of the Navy's ratings.

Summary: Replacement Cost Estimation: The cost analysis portion of this research was designed to develop estimates of the costs of replacing rated and non-rated personnel who attrite from the Navy. It was proposed that a cost model be developed that would include the effects of attrition at each stage of the personnel replacement and development process. Ultimately the model was to contain sufficient detail so that an estimate of the replacement cost for each of the approximately 94 ratings could be generated. The initial goal for the model was to have it provide the replacement cost for each of the occupational specialities and for selected critical ratings within each of the occupational specialities. The model was to include estimates of all of the various costs incurred in the personnel replacement and development process (e.g., recruiting costs, training costs, pay, cash supplements, and fringe benefits). The most current estimates of the various costs were to be used in the model. Initially the model was to use published estimates for each of the costs included. However, as the model is refined, it is planned to test the validity of each of the cost estimates.

Attrition Prediction: The attrition analyses in this research were designed to focus on predicting the first-term attrition of non-prior service male enlisted U.S. Navy Personnel. This research was to proceed in stages, with additional predictors being introduced at some of the stages.

Stage 1: Develop first-term survival curves for clusters of similar Navy ratings. (Each curve would show the percentage of personnel in a cohort surviving as a function of length of service.) Then develop a survival curve for each of the Navy's ratings, where sample size allows this to be done reliably. Generate the curves for AN, FN, and SN. Use the survival data to form an initial severity of attrition scale and to order the ratings and AN, FN, and SN on this scale. Begin conceptual work to determine if a more sophisticated severity of attrition scale should be formed. (Should, for example, an attrition severity index be influenced by the requirements for second-term and careerist enlisted personnel in Navy ratings?)

Stage 2: In this stage, a series of analyses were to be conducted that would examine the relationships of first-term attrition with: assignment patterns (e.g., sea - sea, sea - shore), ships' characteristics, commanding officer changes, and amount of sea duty. The results obtained in this stage could have implications beyond how the Navy conducts its recruiting and enlistment process.

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| Title: | Battle Assessment for $C^3$ |
| Investigators: | Carson K. Eoyang, Associate Professor of Organizational Behavior, Norman R. Lyons, Associate Professor of Information Science, and John M. Wozencraft, Professor and Chairman, Command, Control and Communications Academic Group |
| Sponsor: | Naval Electronic Systems Command |
| Objective: | The study investigates what attributes are desirable and useful in a computer supporte naval wargaming facility. Particular emphasis was placed on establishing the user interface procedures and on determining what level of detail is required in order to achieve appropriate levels of game verisimilitude. |
| Summary: | The research in this project is on-going. We have been able to implement a number of scenarios, make a few preliminary observations on the interfacing requirements for wargaming and gain experience in the use of the system. |

Title: Human Resource Management System: Research and Support Project

Investigators: Carson K. Eoyang, Associate Professor, Department of Administrative Sciences and Reuben T. Harris, Associate Professor, Department of Administrative Sciences

Sponsor: Naval Military Personnel Command

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: Since FY 79, 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 have been undertaken which the goal of improving the capability of HRMC's and documenting the strategy and outcomes 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, Mayport, London (UK), Rota (Spain), Subic Bay (Republic of the Philippines), 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. 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. Finally, NPS faculty designed and delivered annual two-week Advanced OD Course for HRMC OD Specialists since 1979.

COMMANDER DICK BISHOP, PROFESSOR REUBEN HARRIS AND PROFESSOR CARSON EOYANG DISCUSSING ORGANIZATIONAL DEVELOPMENT RESEARCH DATA.

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| Title: | The Development of Case Research Methods in the Organizational Sciences |
| Investigator: | Roger D. Evered, Associate Professor of Organizational Sciences, Department of Administrative Sciences |
| Sponsor: | NPS Foundation Research Program |
| Objective: | To explore ways for extracting generalizable knowledge and theories from in-depth case studies of particular situations. It is postulated that systematic procedures can be found as an alternative to the usual reductivistic way of testing for commonalities, which necessarily destroys the complexity of the real event. This is part of an ongoing study to overcome the limitations of positivism in the social sciences. |
| Summary: | A search has been made for studies that have examined the epistemology of the case method. Case epistemology has been contrasted with the nomothetic science method. Several possible case-based epistemologies are identified together with their advantages relative to normal nomothetic sciences. |
| Publications: | R. D. Evered, "Case: The Surface Effect Ship Program," Intercollegiate Case Clearing House, with teaching note, 1981. |
| Theses Directed: | D. Karnesky, "Case Writing for Military Organizations," Master's Thesis, March 1981. |

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| Title: | The Allocation of Corporate Indirect Costs |
| Investigators: | James M. Fremgen, Professor of Administrative Sciences and Shu S. Liao, Professor of Administrative Sciences |
| Sponsor: | National Association of Accountants |
| Objective: | To determine actual practices relating to the allocation of corporate indirect costs among primary profit centers and reasons therefore. |
| Summary: | The survey addressed allocation practices and objectives for four purposes: external financial reporting, internal performance evaluation, cost-based pricing, and decision analysis. Results indicated far more extensive allocations than the theoretical literature would suggest. Reasons for these allocations were primarily behavioral in nature, particularly with respect to the purposes of performance evaluation and decision analysis. |
| Publications: | James M. Fremgen and Shu S. Liao, The Allocation of Corporate Indirect Costs, New York: National Association of Accountants, 1981.<br><br>James M. Fremgen and Shu S. Liao, The Allocation of Corporate Indirect Costs, "Management Accounting" September 1981, pp. 66-67. |

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| Title: | Analysis of Corrective Maintenance Active Repair Time Data |
| Investigator: | M. B. Kline, Professor of Administrative Sciences |
| Sponsor: | NPS Foundation Research Program |
| Objective: | To continue analysis of active corrective maintenance repair time data from previous research to include non-electronic systems as well as more recent electronic systems which use advanced digital techniques such as digital diagnostics and built-in-test with respect to the suitability of the lognormal or exponential distributions as an estimator of repair times. |
| Summary: | Data on mechanical systems and components such as helicopters, nuclear energy generation equipment (pumps, cooling components, extractors) and more recent electronic systems has been collected and is currently being analyzed using various statistical data analysis methods. The previous research established that the lognormal distribution was a more suitable description for repair times than the exponential distribution for electronic items. |
| Publications: | M. B. Kline and R. Almog, "Suitability of the Lognormal Distribution to Corrective Maintenance Repair Times," Proceedings, Second International Conference on Reliability and Maintainability, Perros-Guirec, France, September 1980, pp 338-344. |
| Conference Presentations: | M. B. Kline and R. Almog, "Suitability of the Lognormal Distribution to Corrective Maintenace Repair Times," NATO/AGARD Conference, Ankara Turkey, April 1979.<br><br>M. B. Kline and R. Almog, "Suitability of the Lognormal Distribution to Corrective Maintenance Repair Times," Second Annual Conference on Reliability and Maintainability, France, September 1980. |
| Thesis Directed: | E. Camozu, "Analysis of Repair Time Data of Some Electronic and Mechanical Equipments," Master's Thesis, (forthcoming). |

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| **Title:** | Cost Accounting and Analysis in the Governmental Sector |
| **Investigator:** | Shu S. Liao, Associate Professor of Administrative Sciences |
| **Sponsor:** | NPS Foundation Research Program |
| **Objectives:** | To develop the framework for a cost accounting system for governmental organizations by integrating program budgeting, output measurement, and cost accounting techniques. |
| **Summary:** | Using municipal government organization as a model, this study developed methods of integrating policy setting, service, delivery, and performance evaluation in an accounting system. The primary purpose of such an accounting system is to generate useful information for governmental managers and policy makers. The accounting system also facilitates the preparation of an operating statement called for by the Financial Accounting Standards Board. |
| **Publications:** | Shu S. Liao, "Integrating Policysetting, Service Delivery, and Performance Evaluation in an Accounting System: A General Framework," under review for publication in *Public Administration Review*.<br><br>Shu S. Liao, "Nonbusiness Financial Reporting: An Operating Statement Approach," under review for publication in Journal of Accounting, Auditing and Finance. |
| **Conference Presentation:** | Shu S. Liao, "A Cost Accounting System for General Governmental Operations," Collected Abstracts of the American Accounting Association's Annual Meeting, August 6-8, 1981. |

Title: Career Transition Agenda: Identifying What is Accomplished in Adapting to a New Job

Investigator: Meryl R. Louis, Assistant Professor of Administrative Sciences

Sponsor: NPS Foundation Research Program

Objective: This study is part of a continuing research program and overall aims of which are to expand our understandings of career transitions. The current phase of the research was designed to identify fundamental tasks which newcomers accomplish in completing career transitions.

Summary: To date the research program has resulted in the formulation of: 1) a model of the cognitive processes by which individuals cope with transition experiences; 2) a conceptual framework distinguishing among features of transition experiences; 3) a typology of career transition situations; 4) an agenda of fundamental career transition tasks. In addition, a comparative analysis of alternative organizational practices for facilitating career transitions was conducted. Cultural aspects of organizational life relevant to newcomers have been described, as have more general aspects of culture in organizations.

Publications:

M. R. Louis, "Managing Career Transitions: A Missing Link in Career Development", Organizational Dynamics, Spring 1982.

M. R. Louis, "A Cultural Perspective on Organizations: The Need for and Consequences of Viewing Organizations as Culture-Bearing Milieus", Human Systems Management, Volume 2, pp 246-258, 1981.

M. R. Louis, "Organizations as Culture-Bearing Milieus", In Louis R. Pondy et al (Eds.) Organizational Symbolism, Scott-Foresman (forthcoming).

M. R. Louis, "MBA's in the Press", Wharton Magazine, pgs 12-18, Fall 1981.

M. R. Louis, "Alternative Perspectives in the Organizational Sciences: 'Inquiry from the Inside' and 'Inquiry from the Outside'", Academy of Management Review, 1981, 6, #3, 385-395.

Conference Presentations:

M. R. Louis,"'The Emperor Has No Clothes': The Effect of Newcomers on Work Group Culture", presented at the Western Academy of Management Meetings, April 1981, Monterey.

M. R. Louis, "Conversations on Organizational Culture", A symposium conducted at the Western Academy of Management Meetings, April 1981, Monterey.

M. R. Louis, "Managing Career Transitions: A Missing Link in Career Development", presented at the ORSA/TIMS Meetings, Colorado Springs, November 1980.

Thesis Directed:

Steven Froehlich, "The Sponsor Program: Facilitating Anticipatory Socialization for Personnel Being Transferred in the United States Coast Guard", Master's Thesis, December 1980.

ASSOCIATE PROFESSOR MERYL LOUIS AND SUZANNE WOOD, RESEARCH ASSOCIATE, REVIEW PROGRESS OF THEIR RESEARCH ON MBA'S AND ORGANIZATIONAL CULTURE.

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: This is a continuing research effort to develop a general material distribution plan for local area support by a large wholesale activity which can then be applied to the Naval Supply Centers at Oakland, San Diego, and Norfolk.

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 (NSC) at Oakland, San Diego and Norfolk. Further, this action results in a direct support relationship between the NSCs and the local Naval Air Rework Facilities (NARF). This consolidation provides opportunity to develop a new local material distribution plan which will greatly improve supply support to all local customers of a NSC.

The procedure consists of the following four phases:

1. Material Characteristics Sensitivity Analysis
2. Material Flow Analysis
3. Stock Positioning/Material Distribution Algorithm
4. Production Support Inventories

During the past year the following progress was made:

An analysis of local customer business for NSC San Diego for a base nine-month period prior to 1 October 1981. The demands for each customer have been analyzed and reported. In addition, the modes and partial schedules of local delivery activities have been documented.

Theoretical modelling of local direct delivery alternatives between an NSC and a local NARF was completed and parametric analyses were conducted. The modelling was extended then to include the

siting of inventories at a NARF instead of at the NSC.

A review was conducted of the current state of the art in vehicle scheduling algorithms and suggestions were made on how they might be used to facilitate the local delivery by an NSC.

Publications: A. W. McMasters, "Models for Siting Repair Parts Inventories in Support of a Naval Air Rework Facility", Research Report NPS 55-81-011, April 1981.

Theses Directed: T. R. Chambers, "The Multi-Customer Local Delivery Problem and the Siting of Repair Parts Inventories". Master's Thesis, September 1981

C. O. Clausen, "Vehicle Routing Algorithms for Local Delivery at Naval Supply Centers", Master's Thesis, March 1981.

M. E. Davidson, "A Parametric Analysis of Three Models for Direct Delivery by a Naval Supply Center to a Naval Air Rework Facility", Master's Thesis, March 1981.

J. M. Eller and R. T. Moore, "An Analysis of Material Distribution from Naval Supply Center San Diego to Local Customer", Master's Thesis, March 1981.

J. M. Robertson, "Pre-Consolidation Supply Demand Patterns of NARF North Island & Local Customers of the Naval Supply Center San Diego", Master's Thesis, September 1981.

Title: Steam Requirements for Ships in Port

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

Sponsor: Civil Engineering Laboratory

Objective: To statistically analyze the steam flow rate data being obtained by the Port Systems Project for hotel steam provided by port services to ships in port.

Summary: Daily curves of steam flow rates for several classes of ships have been screened to develope a "worst case" composite of observed actual flow rates over the period of days during which the data was obtained. Data values have been obtained for one such case and have been smoothed into an average diurnal curve. The fluctuations of the data around this smoothed curve have been analyzed and found to be normally distributed.

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| Title: | Stock Migration from NAVELEX to SPCC |
| Investigator: | Alan W. McMasters, Associate Professor of Operations Research and Administrative Sciences |
| Sponsor: | Naval Electronics 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: | Failure rate curves for all 2Z cog items were successfully developed this year and the computer printouts for these curves have been given to the appropriate supervisors. Discussions were also held with them to determine the extent of their knowledge about causes of high early failure rates. The causes were found to be different for communication equipment than for radar equipment.<br><br>A study was also made this year of the problems associated with reprocurement of electronic parts by SPCC for items transferred to their inventory management from NAVELEX. Issues such as obsolescence of superceded equipment and internal changes introduced by a new contractor were discussed and suggestions made for reducing the magnitude of their impacts. |
| Thesis Directed: | R. A. Hallums, "The Impact of Technological Change in Electronics Repairables on the Acquisition Process at Ships Parts Control Center Mechanicsburg," Master's Thesis, March 1981. |

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| Title: | Computer Performance Measurement, Evaluation and Modeling of the IBM VM/SP Operating System |
| Investigator: | N. F. Schneidewind, Professor of Computer Science, Administrative Sciences Department. |
| Sponsor: | Trident Command and Control Maintenance Agency, U. S. Navy |
| Objective: | Test a hypothesis concerning the appropriate model for relating performance, user workload characteristics and system workload characteristics. Test a second hypothesis regarding the hardware independence of the model for a given operating system. |
| Summary: | Data have been collected, analyzed and certain performance parameters have been identified as the best indicators of performance on the NPS IBM 3033 AP installation, operating under VM/SP. Additional data is to be collected from this installation and the CCSMA-IBM4341 installations in order to test the performance model hypotheses. |
| Thesis Directed: | Waldo Marmanillo, "Performance Anaysis of Computer Installation, Virtual Machine/370 CVM/370," Master's Thesis, December 1981. |

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| Title: | Computer Systems Performance Evaluation |
| Investigators: | N. F. Schneidewind, Professor of Computer Science, Department of Administrative Sciences and M. Kennedy, Adjunct Professor of Information Systems, Department of Administrative Sciences. |
| Sponsor: | Aviation Supply Center |
| Objective: | Improve the performance of computer systems management and operations at the Aviation Supply Office. |
| Summary: | Visits were made to ASO on several occasions for the purpose of collecting data and for conducting interviews with ASO personnel. Analyses were made of various computer operations and acquisition problems. |

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| Title: | Stock Point Logistics Integrated Communications Environment (SPLICE) Networking Study |
| Investigator: | N. F. Schneidewind, Professor of Computer Science, Administrative Sciences Department. |
| Sponsor: | Fleet Material Support Office |
| Objective: | Determine the requirements for the characteristics of a computer network to support SPLICE. |
| Summary: | The AUTODIN II system was studied and its protocols and connection mechanisms were evaluated in order to determine whether it is suitable for supporting SPLICE. As a result of this analysis a different type of interface was recommended. A Navy-provided AUTODIN II interface design was evaluated and modifications to this design were recommended. |
| Publications: | N. F. Schneidewind, "Stock Point Logistics Integrated Communications Environment", NPS Technical Report NPS-54-81-014, Oct 1981. |
| Theses Directed: | M. Cooper, "Evaluation of Data Base Management Systems for the Stock Point Integrated Logistics Communications Environment", Master's Thesis, December 1981. |
| | S. Nelson, "Commercial Communications Alternatives for SPLICE", Master's Thesis, December 1981. |

Title: Development for an Attrition Severity Index Using Priorities, Manpower Requirements, Loss Rates, and Replacement Costs for U.S. Navy Ratings

Investigators: George Thomas, Professor of Management and Psychology, Department of Administrative Sciences; Richard Elster, Professor of Management and Psychology, Department of Administrative Sciences and Kenneth Euske, Assistant Professor of Accounting, Administrative Sciences Department

Sponsor: Navy Personnel and Research Development Center

Objective: To provide a methodology for combining various attributes of attrition into a single index for measuring the severity of attrition in navy occupations.

Summary: This report describes the development of an index of the severity of attrition from Navy ratings. The data used in the formation of the index reflect attrition rates, replacement costs, and personnel requirements for Navy ratings. A variable reflecting judgements concerning the relative importance of priority of Navy ratings was also used in the attrition severity index.

First-term enlisted attrition, the separation from the Navy of first-term enlisted personnel prior to completion of their first enlistment, has been particularly recognized as a service personnel problem since the beginning of the All-Volunteer Force in 1973.

The impact of personnel attrition rates should be discerned in the context of the costs of replacing the individual who leaves the Navy (e.g., training and recruitment), the requirements for personnel in the skill area from which the loss of personnel occurs, the personnel loss rates in that skill area, and the importance of the rating to the Navy. The attrition severity index developed in this report integrates personnel loss, cost, priority, and personnel requirements information for Navy ratings. This index can be used by the Navy in initiatives to improve its process for assigning new enlistees to Navy ratings.

**Publications:**

P. Girffin, G. Thomas, K. Euske, and R. Elster, "Development for an Attrition Severity Index Using Priorities, Manpower Requirements, Loss Rates, and Replacement Costs for U.S. Navy Rating", forthcoming Technical Report, NPRDC, San Diego, CA.

P. Griffin, K. Euske, G. Thomas and R. Elster, "Replacement Cost of Navy Personnel as a Measure of the Cost of Attrition", submitted to Focus, September 1981.

**Thesis Directed:**

Patricia Griffin, "A First Term Attrition Severity Index for U.S. Navy Ratings", Master's Thesis, June 1981.

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| Title: | Enlistment Supply Models |
| Investigator: | George Thomas, Professor of Management and Psychology, Department of Administrative Sciences |
| Sponsor: | NPS Foundation Research Program |
| Objective: | To develop a supply model for high quality sailors. Then, to utilize the model to demonstrate a methodology for comparing alternative compensation policies for obtaining a required number of high quality sailors. |
| Summary: | This research resulted in a development of a supply model for high quality sailors, i.e., mental group categories I and II, high school graduates. The explanatory variables were relative military pay, unemployment, number of recruiters, and the size of the eligible pool. Research on the demand for high quality sailors yielded data both on past accessions of high quality sailors and current utilization of high quality sailors by navy occupations. The supply model was used to demonstrate a methodology for comparing alternative compensation policies for accessioning a required number of high quality sailors. |
| Publications: | G. Thomas and W. Van Doran, "The Supply of High Quality Sailors," NPS Technical Report, (forthcoming). |
| Thesis Directed: | W. Van Doran, "The Demand and Supply of High Quality Sailors," Master's Thesis, December 1981. |

**Title:** Sources and Uses of Information for Task Force and Fleet Commanders

**Investigators:** Roger Weissinger-Baylon, Associate Professor of Management Information Systems, Department of Administrative Sciences and Rear Admiral J. J. Ekelund, Advisor

**Sponsor:** Naval Electronic Systems Command, C3I Systems and Technology Directorate

**Objective:** To specify the information required for Tactical Flag Command Centers (TFCC) and Fleet Command Centers (FCC) by observing Flag Officer decision making during Fleet exercises (with an emphasis on carrier group operations).

This project has been renewed through Fiscal Year 1981-1982.

**Summary:** For TFCC and FCC, the complete specification of information requirements demands an understanding of tactical decision making processes. In particular, this must include decisions by the OTC (Overall Tactical Commander) and his staff. Otherwise, C3 specifications may impose the collection, storage, and transmission of data that is inessential or in highly undesirable form. Vital information, which should trigger key decisions, may be excluded from the system specifications or handled inexpeditiously by TFCC/FCC. Consequently, this project has observed decision making in a laboratory war game involving carrier group operations in an ASW context. The observational and analytical techniques that were developed will now be applied to study OTC decision making during actual carrier group operations. The research will develop testable, empirically based specifications of C3 information sources and uses; the resulting improvements to TFCC/FCC will provide a valuable force multiplier for vital weapon platforms and personnel.

ADM Worth Bagley (Vice CNO, Vet), ADM Alfred Whittle (CNM, Vet), and ADM Elmo Zumwatt (CNO, Vet) have visited the Naval Postgraduate School to contribute to this project. As a result of a meeting with General David Jones, Chairman of the Joint Chiefs of staff, the research forces will be extended to include joint exercises.

Publications:

Roger Weissinger-Baylon, "Analyzing Executive Decision Making Processes: *The Methodological Contribution of* Visual Mental Imagery Protocols" in Proceedings of the First International Conference on Information Systems, December 1980.

Roger Weissinger-Baylon, "Cognitive Analysis of Communication Errors: A New Implementation and Evaluation Approach for Decision Support," in Proceedings of the Conference on Decision Support Systems: DSS-81, June 1981.

Conference Presentation:

Roger Weissinger-Baylon, "Representation Issues in Decision Support for C3," Colorado Workshop on Representation, April 1981.

Thesis Directed:

T. B. Born, "Empirical Analysis of Systematic Communication Errors," Master's Thesis, September 1981.

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| Title: | Prediction of College Achievement from the Scholastic Aptitude Test and the High School Record |
| Investigator: | R. A. Weitzman, Professor of Administrative Sciences |
| Sponsor: | None |
| Objective: | To investigate and correct the low observed predictive validity of the SAT |
| Summary: | The study shows the SAT predictive validity to be low because of criterion scale multiplicity: A grade in one college does not represent the same achievement as the same grade in another. The study also derives a method for correcting validities for this problem and applies it to the SAT. |
| Conferences: | R. A. Weitzman, "The Predictive Validities of the Scholastic Aptitude Test and the High School Record," University of North Carolina, North Carolina, 27-29 May 1981. |

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| Title: | Sequential Testing for Selection: Tryout on Real Data |
| Investigator: | R. A. Weitzman, Associate Professor of Psychology |
| Sponsor: | NPS Foundation Research Program |
| Objective: | A previous study showed that sequential testing worked on Monte Carlo data--the observed matched the theoretical Type I and Type II selection errors. The current study extended the method to real data. |
| Summary: | The current study simulated sequential testing on real data consisting of the responses (correct or incorrect) of 960 Navy enlisted men to 70 items on the Electronic Technician Selection Test. The method successfully used these responses to predict with specified Type I and Type II selection errors performance on the final examination in the Basic Electricity and Electronics Class A School. |
| Publications: | R. A. Weitzman, "Sequential Testing for Selection," (submitted for publication to Applied Psychological Measurement). |
| | R. A. Weitzman, "Sequential Testing for Selection," NPS Technical Report, NPS54-80-013, December 1980. |

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| Title: | Use of Sequential Testing to Pre-screen Prospective Recruits for Military Service |
| Investigator: | R. A. Weitzman, Professor of Administrative Sciences |
| Sponsor: | Navy Personnel Research and Development Center |
| Objective: | Sequential testing for selection requires an applicant to respond to one item at a time until an acceptance or rejection decision occurs with pre-specified probabilities of error. The method depends on the existence of a bank of calibrated items. The purposes of this study are to calibrate every item in the bank developed by NPRDC to pre-screen recruits and to simulate the sequential-testing method on the data used for the item calibration. |
| Summary: | The bank to be calibrated consists of 200 items. For the method to work, the correlation between any pair of these items must be due to the correlation of each with the criterion to be predicted, in this case AFQT score. The correlation between many pairs of items appears to be due not only to their common correlation with AFQT but also to their correlation with at least one other variable, like electronic information. On tryouts so far, the method has thus failed to work. |

Title: An Investigation into the Existence of a General Theory of Intra Firm Behavior

Investigators: David Whipple, Associate Professor of Economics and Systems Analysis, Department of Administrative Sciences and Kathy Kocher, Adjunct Professor of Economics, Research Investigator, Department of Administrative Sciences

Sponsor: NPS Foundation Research Program

Objective: To begin the formalization of the differences and similarities in discipline-specific approaches to intra organizational efficiency-based problem solving in order to facilitate the development of more effective solution strategies.

Summary: Over the past few years there has been evidenced increasing concern over the applicability of traditional economic, management, and systems analysis theories to problems faced by specific individual firms, or production entities. This has led, in part, to the development of disciplines such as organizational behavior which have attempted to devise solution strategies based on the application of highly subjective techniques to the specific problem environment. While this may well alleviate or mitigate some of the specific problems encountered by that specific firm, it unfortunately does not (or at least, has not yet) lend itself to the formalization of a general theory of such intra firm behavior which would then be useful to analysts and policy-makers involved in decision making which may have significant (e.g., industry-wide) ramifications. This in turn has led to a general inability to predict and control such behavior and therefore, to the adoption of ineffective, or worse, counter productive, "macro" policies, and to the observation that, even if situations involve relatively homogeneous, or small numbers of, firms, policies flowing from rigorous and correct research and analysis do not often lead to the projected results after implementation. The general plan of attack here was to analyze representative pieces of three types of existing literature: traditional economics/theory of the firm, management/organizational behavior, and an institution-specific subset, to compare and contrast the major implications flowing from the first two in terms of the desire to motivate more

efficient behavior within typical organizations, and to develop testable hypotheses based on this juxtaposition.

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

Investigators: David Whipple, Associate Professor of Economics and Systems Analysis, Department of Administrative Sciences; Reuben Harris, Associate Professor of Organizational Behavior and Management, Department of Administrative Sciences and Kathy Kocher, Adjunct Professor of Ecnomics, Department of Administrative Sciences.

Sponsor: Chief of Naval Operations

Objective: Develop a method for use at the facility (hospital) level to determine 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 method developed. Structured field contact was undertaken to indicate areas in need of modification. The draft method was then refined and expanded to include a complete implementation strategy, tailored to the Navy's particular needs.

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

# DEPARTMENT

# OF

# OPERATIONS RESEARCH

## 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 communications.

### 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.

Continuing research by Professor Gerald Brown of Operations Research and Professor Gordon Bradley of Computer Science, sponsored by the Office of Naval Research, is leading to 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. This research program has resulted in the Naval Postgraduate School having one of the most powerful existing optimization laboratories.

### STOCHASTIC MODELING/STATISTICS

A second major area in Operations Research is probabilistic model-building and statistical analysis. Many faculty contribute to this area.

Professor Donald Gaver, under ONR and Naval Air Systems Command funding, continues development of several models using diffusion approximation techniques for communications systems, computer systems, systems involving maintenance and repair, and environmental prediction. 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.

Professors Patricia Jacobs and Peter Lewis continue to derive 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 has been supported by ONR and the National Science Foundation. Professor Lewis also continues work in simulation analysis, particularly development of a revision to the LLRANDOM generator.

### 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 Samuel Parry and James Hartman continue to develop a computer simulation model of air/land combat for the Training and Doctrine Command. Emphasis this year has been on target acquisition. 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. This work is 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. A text on Lanchester's Equations is completed with publication expected in 1982.

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 has investigated various tracking algorithms, and continued his research in search and evaluation.

Professor Bryce Tysver has done work for the Naval Torpedo Station in range studies, and Professor Glenn Lindsay continues to give general technical support to the United States Marine Corps Development Center.

MANPOWER AND PERSONNEL

The major cost of the U.S. military continues to be for personnel. Planning and analysis of the personnel system is, therefore, of considerable interest. Professor Paul Milch continues to develop interactive models of the Naval officer system for policy analysis and manpower/personnel planning. This is a cooperative research project between the Operations Research and Administrative Science departments.

COMMAND, CONTROL AND COMMUNICATIONS

Command, control and communications ($C^3$) problems are a uniquely difficult problem for military organizations. Research in this area supports the new $C^3$ curriculum at the Naval Postgraduate School. Professors Gary Poock and Russell Richards continue their research in design of experiments for the ARPA-funded Advanced Architectural Test Bed (ACCAT) project. Professor Poock continues to have great success in adapting available hardware to perform voice input of data to computers on the ARPANET.

LCDR RICHARD J. DAVISON, US COAST GUARD, AND PROFESSOR JAMES D. ESARY EXAMINE A MICROCOMPUTER DISPLAY OF A POISSON ARRIVAL PROCESS.

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| Title: | NPS Support of ACCAT Experiments |
| Investigators: | Donald R. Barr, Professor of Operations Research and Statistics<br>Gilbert T. Howard, Associate Professor of Operations Research |
| Sponsor: | Naval Ocean Systems Center |
| Objective: | To make preparations for use of the Naval Postgraduate School Remote Site Module (RSM) as a node in support of a Tactical Flag Communication Center experiment conducted at the Advanced Command and Control Architectual Testbed, located at the Naval Ocean Systems Center, San Diego. Also to coordinate activities at the RSM during the experiment and to report the results at the NPS node. |
| Summary: | Planning, conduct and review of results of a multi-node experiment conducted by NOSC, NPS and CINCPACFLT in October of 1980 were analyzed from the NPS point of view. Lessons learned and suggestions for future experiments were reported. |
| Publications: | D. R. Barr, G. T. Howard and E. F. Roland, "Naval Postgraduate School Participation in an ACCAT Multi-Node Experiment," Project Report, NPS55-81-018, September 1981. |
| Thesis Directed: | J. P. Ferranti, Jr., "Evaluation of the Artificial Intelligence Program Stammer 2 in the Tactical Situation Assessment Problem," Master's Thesis, September 1981. |

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| Title: | TEAM Evaluation |
| Investigators: | Donald R. Barr, Professor of Operations Research and Gilbert T. Howard, Associate Professor of Operations Research |
| Sponsor: | Naval Electronics Systems Command |
| Objective: | To evaluate the Teachable English Access data Manager (TEAM) software currently under development for NAVELEX. |
| Summary: | The TEAM software currently under development by Stanford Research International's (SRI) Artificial Intelligence Group is intended to allow English language access to databases. The software works interactively with the database administrator to establish the access to the particular database in question. After the initial session, a database user can access information from the database using English language queries.<br><br>The research evaluated the adequacy of the TEAM software conducting an experiment involving officer students in the $C^3$ curriculum at the Naval Postgraduate School. The version of TEAM tested was not complete and several deficiencies were noted, but overall TEAM appeared to be a good product with a real potential for applications in information retrieval from databases. |
| Publications: | D. R. Barr and G. T. Howard, "TEAM Evaluation," NPS Project Report, NPS55-81-024PR, October 1981. |

Title: Large-Scale Optimization

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

Sponsor: Office of Naval Research

Objective: Develop theory and algorithms for solution of large-scale optimization models.

Summary: The NPS research program in large-scale optimization has continued with significant progress in several areas. Network optimization has been extended to include new algorithms for elastic and mixed-integer models with fixed charges. A micro-computer based system has been completed with linear, nonlinear, and mixed integer algorithms, large-computer interfaces, and user friendly editors and operating system. Large-scale nonlinear and nonlinear mixed integer models have been solved in a new benchmark series evaluating the experimental optimization system XS. Interactive model-building systems have been developed and applied. The NPS research program has apparently assembled one of the most powerful optimization laboratories extant.

Publications:

G. Brown and W. Wright, "Automatic Identification of Embedded Special Structure in Large-Scale Optimization," in Computer Assisted Model Analysis and Simplification, H. Greenberg and J. Maybee, eds., Academic Press, 1980, pp. 61-90.

G. Brown and D. Thomen, "Automatic Identification of Generalized Upper Bounds in Large-Scale Optimization Models," Management Science, V. 26, No. 11, November 1980, pp. 1166-1184.

G. Brown and W. Wright, "Automatic Identification of Network Rows in Large-Scale Optimization Models," Technical Report NPS55-80-030, November 1980, 27 pp. (Also forthcoming in the open literature.)

G. Bradley, G. Brown and G. Graves, "Structural Redundancy in Large-Scale Optimization Models," Technical Report NPS55-80-029, November 1980, 44 pp. (Also forthcoming in the text: Redundancy in Mathematical Programming, edited by S. Zionts and S. Telgen, Academic Press.)

G. Brown and G. Graves, "Real-Time Dispatch of Petroleum Tank Trucks," Management Science, V. 27, No. 1, January 1981, pp. 19-32.

G. Brown, A. Geoffrion and G. Bradley, "Production and Sales Planning with Limited Shared Tooling at the Key Operation," Management Science, V. 27, No. 3, March 1981, pp. 247-259.

G. Brown and D. Thomen, "Automatic Identification of Generalized Upper Bounds in Large-Scale Optimization Models," appears in Large-Scale Linear Programming, G. Dantzig, M. Dempster and M. Kallio, eds., International Institute for Applied Systems Analysis, Laxenburg, Austria, 1981, pp. 747-780.

G. Brown and W. Wright, "Automatic Identification of Embedded Structure in Large-Scale Optimization Models," appears in Large-Scale Linear Programming, G. Dantzig, M. Dempster and M. Kallio, eds., International Institute for Applied Systems Analysis, Laxenburg, Austria, 1981, pp. 781-808.

G. Brown and R. McBride, "Efficient Solution of Generalized Network Problems," Technical Report, School of Business, University of Southern California, September 1981, 34 pages. (Also forthcoming in the open literature.)

G. Brown and R. McBride, "Extracting Embedded Generalized Network Problems from General LP Problems," Technical Report, School of Business, University of Southern California, September 1981, 11 pages. (Also forthcoming in the open literature.)

G. Brown, G. Graves and M. Honczarenko, "Large-Scale Facility and Equipment Location: An Application of Goal Programming in Multicommodity Decomposition," Technical Report, University of California, Los Angeles, September 1981, 24 pages. (Also forthcoming in the open literature.)

G. Brown, G. Bradley and G. Graves, "Review of Computational Aspects of the CRA/EPRI Coal Market Analysis System," Electric Power Research Institute Technical Report, May 1981.

G. Brown, G. Bradley and G. Graves, "Review of the Computational Aspects of the TBS Regulatory Analysis Financial Model," Electric Power Research Institute Technical Report, September 1981.

Conference Presentations:

G. Brown and D. Dean, "Experiments Using a Large-Scale Optimization System with Nonlinear and Integer Models," CORS/ORSA/TIMS International Conference, Toronto, 1-3 April 1981.

G. Brown and R. Duff, "Network Optimization with a Microcomputer: A Live Demonstration and Tutorial," CORS/ORSA/TIMS International Conference, Toronto, 1-3 April 1981.

G. Brown and D. Thomen, "Automatic Identification of Generalized Upper Bounds in Large-Scale Optimization Models," CORS/ORSA/TIMS International Conference, Toronto, 1-3 April 1981.

G. Brown, G. Graves and D. Dean, "Computational Experiments with Large-Scale Nonlinear Optimization," CORS/ORSA/TIMS International Conference, Toronto, 1-3 April 1981.

G. Brown, G. Graves and M. Honczarenko, "Large-Scale Facility and Equipment Location: An Application of Goal Programming in Multicommodity Decomposition," ORSA/TIMS, Houston, 18-21 October 1981.

Theses Directed:

D. Dean, "Computational Advances in Large-Scale Nonlinear Optimization," Master's Thesis, September 1981.

C. Burchinal, "IVONNE: An Interactive Network Model-Building System," Master's Thesis, September 1981.

R. Duff, "A Microcomputer-Based Network Optimization Package," Master's Thesis, September 1981.

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| Title: | Optimal Stock Positioning |
| Investigator: | Gerald G. Brown, Professor of Operations Research |
| Sponsor: | Defense Logistics Agency |
| Objective: | To develop, implement and apply large-scale optimization models and algorithms for solution of current strategic planning problems faced by the Defense Logistics Agency and associated with positioning of stocks, procurement and operations. |
| Summary: | Extensive consultation with DLA analysts was performed to direct data gathering and aggregation for modelling the procurement, inbound (first destination) freight costs, storage and handling, and outbound (second destination) freight costs. Several large-scale models were solved and the results analyzed with DLA personnel. |
| Presentations: | G. G. Brown, "Optimal Stock Positioning Models and DLA Operations Policy," MORS, Monterey, December 1981. |

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| Title: | A Target Motion Analysis Procedure |
| Investigator: | R. N. Forrest, Professor and ASW Academic Group Chairman |
| Sponsor: | NPS Foundation Research Program |
| Objective: | To investigate bearings-only target motion analysis procedure that can be implemented on a handheld computer. |
| Summary: | Two target motion analysis procedures that can be implemented on handheld computers have been investigated. The investigation indicated that one of these can be modified to a single leg procedure. |
| Publication: | R. N. Forrest, "Two Target Motion Analysis Procedures," NPS Technical Report, NPS-71-81-002, June 1981. |

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| Title: | Computational Statistical Tools for Weather Forecasting |
| Investigator: | Donald P. Gaver, Professor of Operations Research and Statistics |
| Sponser: | Naval Air Systems Command (through Naval Environmental Prediction Research Facility) |
| Objective: | Assess possible advantages in analysis and forecasting of weather conditions to be gained by utilization of modern methods of statistical data analysis. |
| Summary: | A study of Monterey Peninsula rainfall statistics, using exploratory data analysis was conducted; a simple probability model was developed. There appears to be some prognostic information in early season rainfall. Analysis of cloud-cover data at airfields was initiated. |
| Publications: | D. P. Gaver, P. A. Jacobs, "Analysis and Modeling of Monterey Area Rainfall," NPS Technical Report (forthcoming). |
| Thesis Directed: | D. Kirca, "A Statistical Analysis of Monthly Rainfall for the Monterey Peninsula in Central California," Master's Thesis, September 1981. |

Title: Stochastic Modeling and Data Analysis

Investigator: Donald P. Gaver, Professor of Operations Research and Statistics

Sponsor: Office of Naval Research

Objective: To develop, and show how to apply, statistical methods of data analysis and probability modeling to problems arising in the environment, to communications problems, computer systems including military $C^3$, and equipment reliability.

Summary: Studies were conducted, and models constructed, for communications systems that cooperatively service voice and data. A probability-theoretical analysis was conducted of the time to failure for a mechanical system suffering superpositions of random loads. Statistical analysis and modeling of ice thickness data was initiated in cooperation with P. A. Jacobs (OR, NPS) and Dr. D. Wadhams of Scott Polar Research, Cambridge, England.

Publications:

D. P. Gaver, P. A. Jacobs, "On Combinations of Random Loads," SIAM Journal of Applied Mathematics, 40 (1981), pp. 459-466.

D. P. Gaver, P. A. W. Lewis, "First-Order Auto-Regressive Gamma Sequences and Point Provesses," Advanced Applied Probability 12 (1980), pp. 722-745.

D. P. Gaver, P. A. Jacobs. "Storage Problems When Demand is 'All or Nothing'," Naval Research Logistics Quarterly 27 (1980), pp. 529-538.

J. Lehoczky, D. P. Gaver, "Diffusion Approximations for the Cooperative Service of Voice and Data Messages," Journal of Applied Probability 18 (1981), pp. 660-671.

D. P. Gaver, J. P. Lehoczky, "Channels that Cooperatively Service a Data Stream and Voice Messages," IEEE Trans. Communication Society (1981).

Conference Presentation:

D. P. Gaver and J. P. Lehoczky, "Performance Evaluation of Voice-Data Queueing Networks," Probability and Computer Science - The Interface, Boca Raton, Florida, January 1981.

Theses Directed:

B. Aba, "Investigation of Alternative Methods, Including Jackknifing, for Estimating Point Availability of a System," September 1981.

C. Janusch, "Statistical Analysis of Three High-Frequency Direction Finding Algorithms with Bearing Selection Based on Ionospheric Models," Master's Thesis, September 1981 (2nd reader).

Title: Probabilistic Models for Complex Systems

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

Sponsor: National Science Foundation

Objective: This grant is a continuation of previous grants awarded to develop stochastic models for complex systems.

Summary: Research during the past year continued in four areas: 1) One was to continue the development of discrete time series models whose correlation structure is that of an ARMA(p,q) process. 2) Another area was the study of birth-death processes with randomly varying coefficients. Numerical procedures were developed to evaluate expected first-passage times and limiting probabilities for some models in which the model parameters were themselves a Markov process. 3) A third area was to develop probabilistic models for the stress put on a structure by loads that vary randomly in time. Progress was made in understanding the robustness of the approximation that the time until the stress on a structure exceeds the strength of the structure has an exponential distribution. 4) A fourth area was the study of diffusion models for manpower systems.

Publications:

D. P. Gaver and P. A. Jacobs, "Storage Problems when Demand is 'All or Nothing'," Naval Research Logistics Quarterly, 4 (1980), 529-538.

D. P. Gaver and P. A. Jacobs, "On Combinations of Random Loads," SIAM Journal of Applied Mathematics, 40 (1981), 454-466.

Conference Presentations:

P. A. Jacobs, "An Explanatory Analysis of Oxidant Data," Joint Statistical Association and the Biometric Society, Detroit, August 1981.

P. A. Jacobs, D. P. Gaver and J. P. Lehoczky, "Diffusion Approximations to Manpower Models," ORSA/TIMS Joint National Meeting, Colorado Springs, November 1980.

Title: Collection System Performance Optimization Study

Investigators: Jeffrey B. Knorr, Associate Professor of Electrical Engineering
Donald D. Barr, Professor of Operations Research and Statistics

Sponsor: Office of Naval Research

Objective: To develop a systematic method for optimizing the performance of a collection system against specified target emitters. Supporting work on emitter antenna modeling and intercept probabilities is included.

Summary: When several sensors are concurrently scanning the same domain for signals, varying numbers of sensors may detect each signal. On some occasions, a signal may not be detected by any of the receivers. Using detection data collected from all the receivers over a period of scanning, it is possible to estimate the total number of signals that occurred in that period (including those that were not detected at all), as well as the detection probabilities for the individual receivers. Several estimators for these quantities were developed, in the contexts of several models concerning the signal generation process and the receiver behavior.

Publications: D. R. Barr, "Estimation of Sensor Detection Probabilities with Data from Concurrent Sensors," Technical Report NPS55-81-014, August 1981.

Thesis Directed: D. S. Hendrickx, "An Evaluation of Estimators for Receiver Detection Probabilities and Unknown Signal Population Size," Master's Thesis, September 1981.

M. Scagnelli, "Computer Modeling of Reflector Antenna Far Field Sidelobe Levels," Master's Thesis, December 1981.

Title: Statistical Methods for the Joint Oil Analysis

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

Sponsor: Kelly AFB

Objective: Develop useful statistical procedures for analysis of spectrometric oil analysis readings.

Summary: We developed:

(a) Tables for use in checking the daily standardization of Baird Atomic emission spectrometers.

(b) Tables useful for converting atomic absorption readings into atomic emission readings and vice versa.

(c) Moving regression methodology to monitor the contamination level of aircraft engines.

In addition to the foregoing, we met with the data base committee of the Joint Oil Analysis Program Coordinating Group, giving our suggestions for the structure of the data base and types of reports which could be useful. This work is expected to appear in a technical report to be issued within the next few months.

Publication: H. J. Larson, T. Jayachandran, "Methodology for Determining Sampling Intervals," NPS Technical Report, NPS53-81-001, November 1980.

Title: Stochastic Analysis and Simulation

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

Sponsor: Office of Naval Research

Objective: To develop simple, tractable models for the analysis of stochastic point processes and time series; to develop new statistical methodology for use in the simulations which are required in mathematical statistics and in the analysis of systems; to pursue data analysis and stochastic modelling for stochastic systems such as the Circadian sleep-wake process in mammals.

Summary: This ongoing project has two aspects, the development of statistical methods and stochastic models for time series, and the development of new simulation methodology.

A previously developed exponential time series model (EAR(1)) was extended to broader, two parameter structure called NEAR(1) (new exponential autoregressive process of order 1). This model in turn was extended to a process with mixed exponential marginal distributions which can be given a complete autoregressive-moving average structure. Problems with statistical estimation for these models led to formulation of a Gamma process which should have broad applicability. An investigation into the use of this model for modelling wind velocity data was initiated.

In simulation a long-standing problem of estimating quantiles in the dependent sequences which arise in systems simulations has been definitively solved. Both point and confidence interval estimates were obtained. Also a graphical and statistical methodology called regression adjusted graphics and estimation was applied to regenerative systems simulations. The result is a sequential procedure which fully exploits the regenerative structure and produces a stopping rule and a direct variance estimate for the regenerative point estimate. This technique is also being applied to other, non-regenerative simulations.

Publications:

P. A. W. Lewis, "Chapter G of the IMSL Library-Generation and Testing of Random Variables," Proceedings 1980 Winter Simulation Conference, 1980, IEEE, New York, 353-360.

P. A. W. Lewis and A. J. Lawrance, "The Exponential Autoregressive-Moving Average EARMA(p,q) Process," Journal Royal Statistical Society 43, 2, 1980, 150-161.

P. A. W. Lewis and P. Heidelberger, "Regression Adjusted Estimates for Regenerative Simulations with Graphics," Communications of the ACM 24, 4, 1981, 260-273.

P. A. W. Lewis and A. J. Lawrance, "A New Autoregressive Time Series Model in Exponential Variables (NEAR(1))," Journal of Applied Probability, 1981, to appear.

P. A. W. Lewis and A. J. Lawrance, "A Mixed Exponential Time Series Model, NMEAR(p,q)," Naval Postgraduate School Technical Report, NPS55-80-012, March 1980; to appear in Management Science.

P. A. W. Lewis and A. J. Lawrance, "Generation of Some First-Order Autoregressive Markovian Sequences of Positive Random Variables with Given Marginal Distributions," NPS Technical Report, NPS55-81-003, March 1981; to appear in Proceedings Applied Probability/Computer Science, R. Disney, ed.

P. A. W. Lewis and L. Uribe, "The New Naval Postgraduate School Random Number Package LLRANDOM II," NPS Technical Report, NPS55-81-005, February 1981.

P. A. W. Lewis and P. Heidelberger, "Quantile Estimation for Dependent Sequences" NPS Technical Report, NPS55-81-015, September 1981; submitted to Operations Research.

P. A. W. Lewis, G. Richardson and W. Dement, "Serial Correlation in Sleep and Wakefulness States in the Mouse: Dependence on Circadian Phase," NPS Technical Report, NPS55-81-022, September 1981.

Conference Presentations:

P. A. W. Lewis, "Discrete Time Series Generated by Mixtures," Joint Civil Engineering-Statistics Seminar, Purdue University, 1 October 1980.

P. A. W. Lewis, "Graphical and Statistical Methodology for Analysis of Circadian Rhythms in EEG States," Stanford Biostatistics Seminar, Stanford, CA, 30 October, 1980 (with G. Richardson).

P. A. W. Lewis, "Some Models for Time Series of Positive, Continuous Variables," U.S. Army Corps of Engineers, Water Experimental Station, Vicksburg, Mississippi, 12 November 1980.

P. A. W. Lewis, "Serial Correlation in Sleep and Wakefulness States in the Mouse: Dependence on Circadian Phase," Stanford Psychiatry Department Sleep Research Seminar, 11 December 1980.

P. A. W. Lewis, "Some Schemes for Autoregression of Continuous Random Variables," University of North Carolina, Joint Statistics and Operations Research Seminar, 1 December 1980.

P. A. W. Lewis, "Chapter G. of the IMSL Library-Generation and Testing of Random Variables," Winter Simulation Conference, Orlando, Florida, 3-5 December 1980.

P. A. W. Lewis, "Some Schemes for Autoregression of Continuous Random Variables," University of Georgia, Statistics and Computer Science Seminar, 6 December 1980.

P. A. W. Lewis, "Generation of Random Variables by Poisson Thinning," Applied Probability/Computer Science Symposium, Boca Ratan, Florida, 3 January 1981.

P. A. W. Lewis, "Generation of Random Variables by Thinning Poisson Processes," 1981 Computer Science/ Statistics Interface Symposium, Pittsburgh, PA, 12-13 March 1981.

P. A. W. Lewis, "Regression Adjusted Regenerative Simulation, with Graphics," Naval Postgraduate School Seminar (with P. Heidelberger), 18 March 1981.

P. A. W. Lewis, "Regression Adjusted Regenerative Simulation, with Graphics," Imperial College, University of London Statistics Seminar, 1 April 1981.

P. A. W. Lewis, "Regression Adjusted Regenerative Simulation, with Graphics," University of Birmingham Statistics Department Seminar, 2 April 1981.

P. A. W. Lewis, "Regression Adjusted Regenerative Simulation, with Graphics," Bell Telephone Laboratories, Murray Hill, NJ, 19 May 1981.

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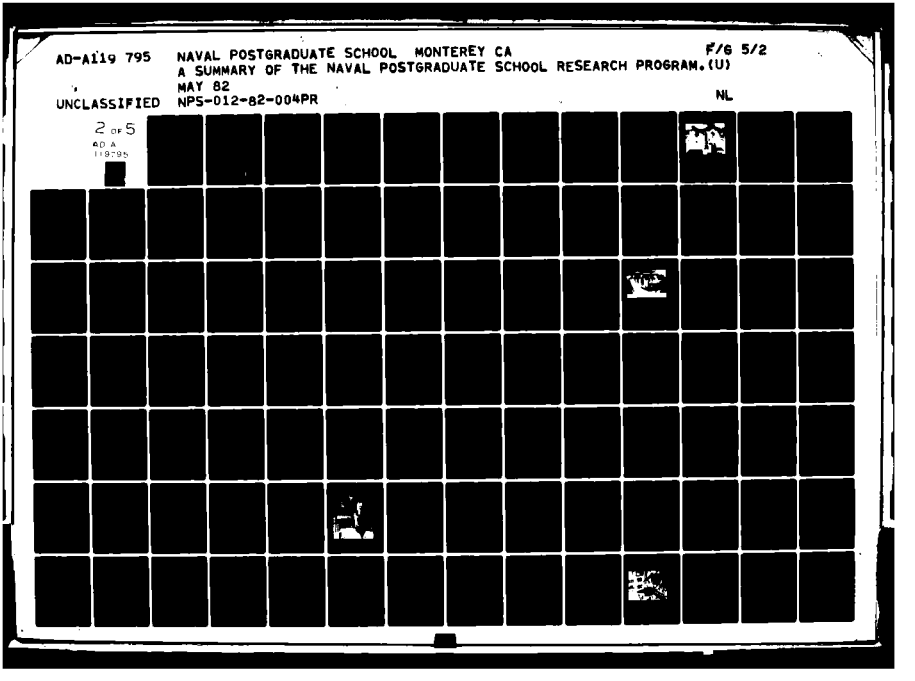
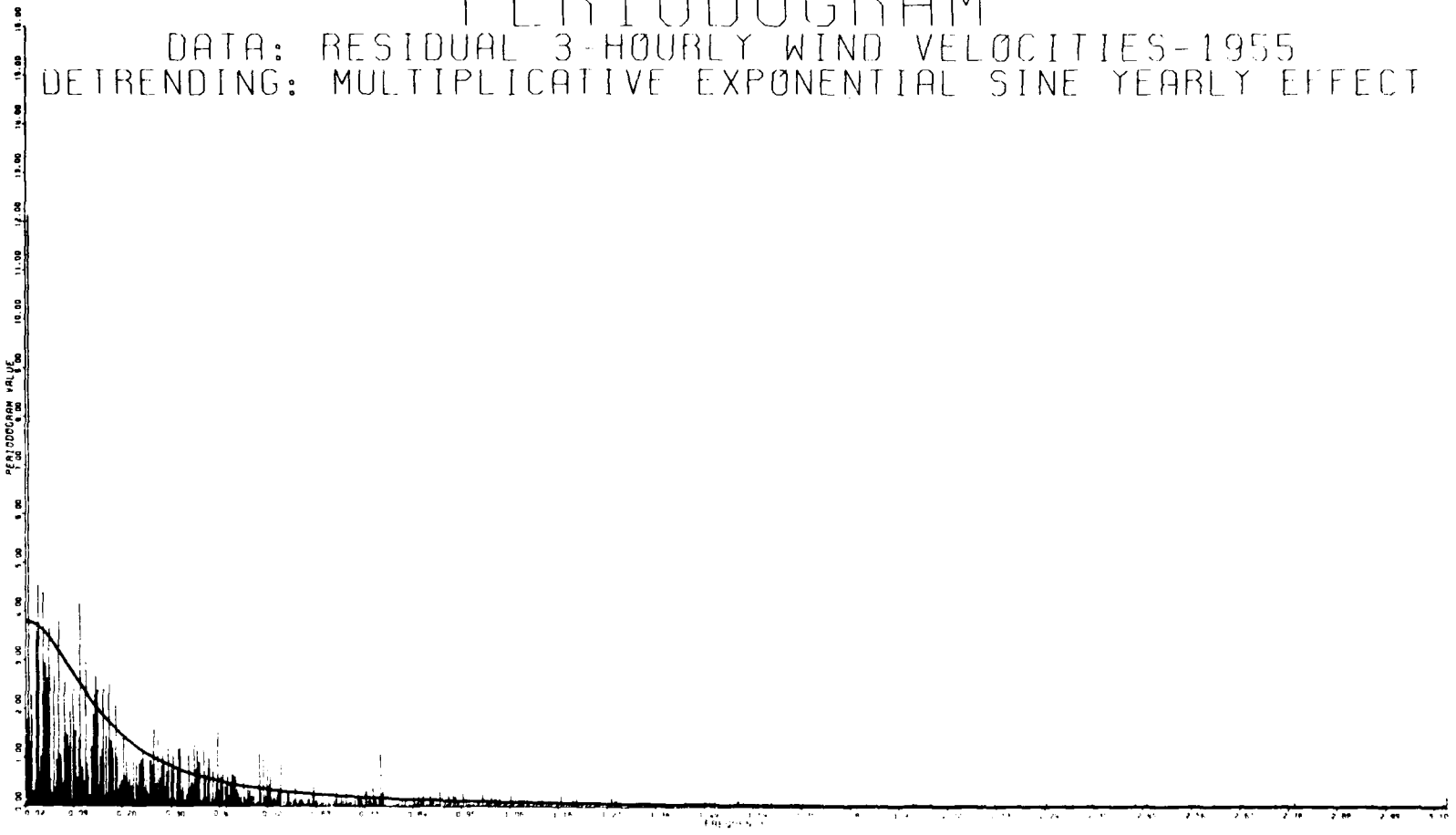


P. A. W. Lewis, "Quantile Estimation for Dependent Sequences," University of California, San Diego, Statistics Seminar, 1 June 1981.

P. A. W. Lewis, "Simple Time Series with Exponential, Gamma and Hyperexponential Marginal Distributions," IBM Research Labs, Yorktown Heights, 22 July 1981.

P. A. W. Lewis, "Simple Time Series with Exponential, Gamma and Hyperexponential Marginal Distributions," IBM Systems Research Center, NY, August 1981.




PERIODOGRAM OF WINDSPEED DATA WITH THE SPECTRUM OF A THEORETICAL AUTO-REGRESSIVE MODEL SUPERIMPOSED.

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| Title: | NPS Support for the R&D Function of the Development Center |
| Investigator: | Glenn F. Lindsay, Associate Professor of Operations Research |
| Sponsors: | United States Marine Corps Development Center, Marine Corps Development and Education Center |
| Objective: | Continuation of a program of general technical support for the Development Center, together with specific activities aimed at increasing the use of Operations Research and modern managerial techniques at the Center. |
| Summary: | In addition to a variety of advisory tasks, NPS faculty worked on site with newly arrived development project officers. This included a series of workshops emphasizing concepts of scientific investigation, technical terminology, investigative practices, and R&D management, with the objective of accelerating the development project officer's progress over his on-the-job learning curve. This is a continuation of work sponsored by the Development Center since 1975. |

Title: Navy Officer Sea Tour Opportunity Models (Part of the research in Officer Manpower and Personnel Planning with Professor J. K. Arima)

Investigator: Paul R. Milch, Associate Professor of Operations Research and Statistics

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

Objective: To model sea tour opportunities of the URL communities of the Navy Officer Corps to enable manpower managers to observe the long-term effects of policy decisions and facilitate their long-range planning. This is a continuing program.

Summary: The models listed below are interactive, highly user oriented, models that compute Sea Tour Opportunities and/or Billet Shortfalls. They are available on Scientific Time Sharing Corporation's (STSC) computer facilities. All models include the options to change the following:

- number of ships by shiptype;
- tour position indicators (TPIC's);
- numbers of billets by shiptype and TPIC's;
- assignment of officer grades to TPIC's;
- officer inventories;
- officer continuation rates;
- officer promotion rates.

Sea Tour opportunities (or shortfalls) may then be recomputed subject to changes made earlier. This procedure permits manpower managers to test out proposed policy changes that affect either manpower requirements or supplies or both.

Models:

1. Surface Warfare Officer Model

2. Air Warfare Officer Model

Consists of five submodels:

- Prop Pilot Model
- Prop NFO Model
- Jet Pilot Model
- Jet NFO Model
- Helo Pilot Model

This model has the additional feature of computing an allocation of "non-discrete" aviation billet requirements among relevant subcommunities; e.g. pilot billet requirements must be allocated among the Prop Pilot, Jet Pilot and Helo Pilot subcommunities.

3. Submarine Warfare Officer Model

Consists of three submodels:

- Nuclear Submarine Model
- SWS Submarine Model
- Aggregate Model

As an additional feature two types of tour opportunity computation are available:

- In Model A tour opportunities are computed at the actual time when each tour occurs in the officer career path.

- In Model B tour opportunities are computed at the point of selection for each tour. This point may be several years before the tour actually occurs in the career path.

Publication:

P. R. Milch, "An Interactive Computer Model to Analyze the Surface Warfare Community of the U.S. Navy," NPS Technical Report (forthcoming).

Theses:

M. L. Scholes, "AIRTOURS: Application of an Interactive Computer Model to Analyze the Manpower Requirements and Operational Tour Opportunities of the Aviation Warfare Community," Master's Thesis, December 1980.

W. D. Ferree, "SWOTOURS: A Modification of an Interactive Computer Model to Analyze the Manpower Requirements of the Operational Tours of U.S. Navy Surface Warfare Officers," Master's Thesis, June 1981.

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| Title: | Examination of the Ability of the T600 Voice Recognition System to Function in a Bilingual Mode |
| Investigators: | Douglas E. Neil, Assistant Professor of Operations Research |
| Sponsor: | Naval Electronics Systems Command |
| Objective: | To examine potential for recognition error in environments in which operators are bilingual. |
| Summary: | Effort involved an experiment in which bilingual subjects (German/English) were used to examine the capability of Threshold Technology T600 voice recognition system to function in a bilingual mode. Results suggested that the system was capable of functioning equally well in either language when training and testing were in only one language. However, significant degradation was observed when the system was required to function in the bilingual mode. |
| Publications: | D. E. Neil and T. Andreson, "Examination of the Capability of Voice Recognition Systems to Function in a Bilingual Mode," NPS Technical Report, NPS55-81-004, March 1981. |

Title: Air/Land Combat Model Research and Development

Investigators: Samuel H. Parry, Associate Professor of Operations Research and Principal Investigator
James K. Hartman, Associate Professor of Operations Research and Co-Investigator
James G. Taylor, Professor of Operations Research and Co-Investigator
Arthur L. Schoenstadt, Associate Professor of Mathematics and Co-Investigator

Sponsor: U.S. Army Training and Doctrine Command

Objective: To continue development and implementation of modules for the Simulation of Tactical Alternative Responses (STAR) air/land combat model. In addition, initiate research to investigate a self-contained hierarchical construct for the modelling of air/land combat.

Summary: During the past four years, the investigators have conducted research leading to the development of the STAR model. STAR is designed for high resolution analysis of combined arms task force operations at the Blue Brigade-Red Division level.

A major focus of the research for this year was the continued development of the STAR combat simulation model. The existing model code was streamlined in preparation for distribution of a release version of the model. An improved preprocessor program was developed for the STAR functional terrain, enabling the STAR model to function efficiently on larger battlefield areas.

Research on a new target acquisition module for STAR was completed. The new module includes a variety of electro-optical sensors, limited visibility environments, flexible search tactics, and varying target information levels, and is now ready for implementation.

Explicit FM communications for tactical movement coordination and for the field artillery model have been implemented in the STAR model. Initial development of Electronic Warfare modelling in STAR included models for signal interception, direction finding, and jamming.

Research was initiated to investigate a self-contained hierarchical structure as an alternative to a hierarchical structure which requires development of external linkages to transfer data and information to the various models in the structure. The self-contained structure begins with a model construct which represents combat from theatre down to individual item (vehicle) level. The construction permits the interchange of models at the various levels as determined by the analysis requirement.

Other areas investigated during the research period are indicated in the thesis section below.

Publications:

S. H. Parry and Edward P. Kelleher, "Range Band Analysis Using STAR," Letter report for General Donn A. Starry, CG, U.S. Army TRADOC, Fort Monroe, VA, May 1980, 100 pp.

J. K. Hartman, "A Target Acquisition Module for the STAR Combined Arms Combat Simulation Model," Vol. I, Users Manual; Vol. II, Technical Manual (forthcoming).

Conference Presentations:

S. H. Parry, "High Resolution Air/Land Combat Models," Faculty of Armed Forces University, Munich, West Germany, 3 December 1980.

S. H. Parry, "A Quantitative Approach to Civil Affairs," 34th Civil Affairs Association Annual Conference, San Francisco, CA, 4 March 1981.

Theses Directed:

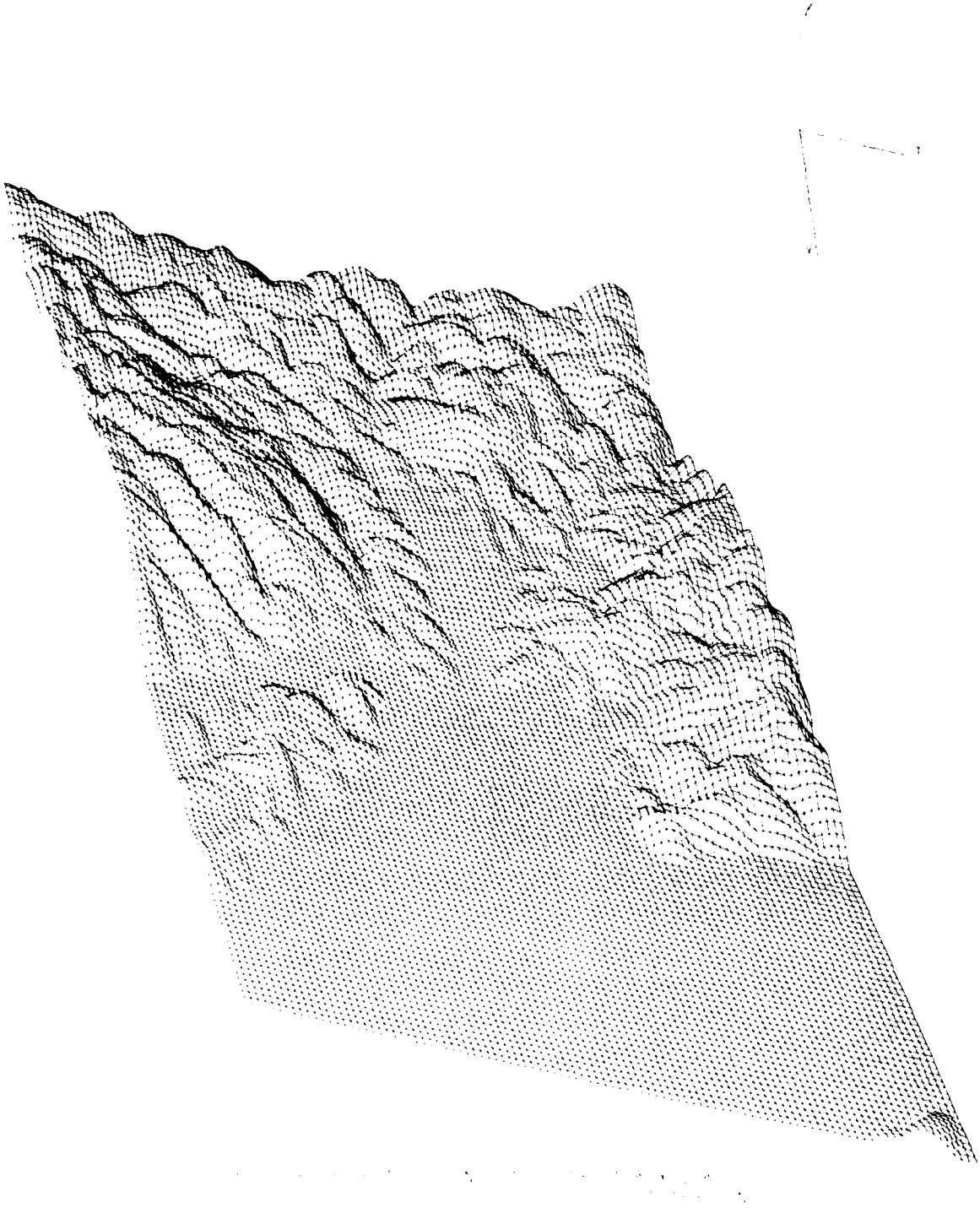
P.R.M. Situmorang, "Dynamic Route Selection for Land Combat Simulation Model," Master's Thesis, March 1981.

H. P. Stuart, "Soviet Tactical Command, Control and Communications: An Overview," Master's Thesis, March 1981.

R. R. Crawford, "An Application of Living Systems Theory to Combat Models," Master's Thesis, December 1980.

B. Loo, "Design of a High Resolution Urban Terrain Module for STAR," Master's Thesis, September 1981.

J. B. Norwood and T. W. Ogilvy, "Analysis of Hellfire Engagement Modes for Computer Simulation," Master's Thesis, March 1981.



COMPUTER REPRESENTATION OF TERRAIN FOR COMBAT MODELLING.

GEN GLENN K. OTIS, COMMANDER U.S. ARMY TRAINING AND DOCTRINE COMMAND, IS BRIEFED BY DR. SAM PARRY AND LCDR ELLEN ROLAND ON APPLICATIONS OF VOICE RECOGNITION SYSTEMS.

Title: Voice Input for Command and Control

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

Sponsor: NAVELEX

Objective: To investigate the feasibility of using voice recognition equipment to recognize spoken commands and then take actions automatically instead of having the human do lots of manual typing entries.

Summary: Several experiments were carried out with military officers. In one case, military officers were able to use voice recognition to do a photo interpreter's job in one-third the normal time. Other pilot experiments at Pearl Harbor, CINCPACFLT, showed it was possible to access data base information for quick retrieval and graphic display using the OSIS baseline system. Operators were able to query the data base with voice very easily and very fast. This is still in a pilot stage but there have been no problems. Other results are shown below in the theses and publications.

Publications:

G. K. Poock, "A Longitudinal Study of Computer Voice Recognition Performance and Vocabulary Size," NPS Technical Report, NPS55-81-013, June 1981.

G. K. Poock and J. W. Armstrong, "Effect of Operator Mental Loading on Voice Recognition System Performance," NPS Technical Report, NPS55-81-016, August 1981.

G. K. Poock and J. W. Armstrong, "Effect of Task Duration on Voice Recognition System Performance," NPS Technical Report, NPS55-81-017, September 1981

G. K. Poock and R. J. Roland, "Enhancing Technology Transfer of Computer Hardware and Software Architectures Using Human Factors in Initial Design," NPS Technical Report, NPS55-81-019, September 1981.

Conference Presentation:

G. K. Poock, "Applications of Automatic Speech Recognition Equipment for Command and Control," Annual Human Factors Society Conference, Los Angeles, October 1980.

Theses Directed:

M. P. Batchellor, "Investigation of Parameters Affecting Voice Recognition Systems in $C^3$ Systems," Master's Thesis, March 1981.

P. H. Bragaw, "Investigation of Voice Input for Constructing Joint Chiefs of Staff Emergency Action Messages," Master's Thesis, March 1981.

G. T. Jay, "An Experiment in Voice Data Entry for Imagery Intelligence Reporting," Master's Thesis, March 1981.

W. J. McSorley, "Using Voice Recognition Equipment to Run the Warfare Environment Simulator (WES)," Master's Thesis, March 1981.

Taggart, J. L. and C. D. Wolfe, "Speech Recognition as an Input Medium for Preflight in the P3C Aircraft," Master's Thesis, March 1981.

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| Title: | Federal Supply Service Inventory Analysis |
| Investigator: | F. Russell Richards, Associate Professor of Operations Research |
| Sponsor: | General Services Administration (Federal Supply Service) |
| Objective: | To develop central item management assignment criteria to identify commodities which should be centrally managed, and develop criteria for determining the appropriate central item manager. |
| Summary: | The move toward a uniform procurement system for all Executive agency procurement of property, services, construction, repair and maintenance requires that management criteria be developed to select items appropriate for central government-wide item management. A list of specific criteria for selection were proposed, data were identified to support the item selection criteria, and a strategy for implementing the item screening process was suggested. |
| Publications: | F. Russell Richards, "Central Item Management for the Uniform Procurement System," Working paper submitted 10 January 1981 to the Commissioner of the Federal Supply Service. |

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| Title: | Operational Availability Analysis of Weapon Systems with Finite Spares Support |
| Investigator: | F. Russell Richards, Associate Professor of Operations Research |
| Sponsor: | NPS Foundation Research Program |
| Objective: | To develop an algorithm for the determination of spares allocation to support weapon systems by maximizing the operational availability of weapon systems subject to a budget constraint. |
| Summary: | Mathematical results were obtained for the component availability at any time given any number of spares for support of the component. Various operational deployment scenarios were investigated and expressions derived for system availability as a function of configuration and deployment scenario. A spares allocation algorithm was developed. A computer simulation model was developed to explore the sensitivity of system availability to the various model parameters and to allow comparison of effectiveness of the allocation procedure developed here with other allocation policies. |
| Publications: | F. R. Richards, "Operational Availability Analysis of Weapon Systems with Finite Spares Support," NPS Technical Report (forthcoming). |
| Conference Presentations: | F. R. Richards, "Operational Availability Analysis," Military Operations Research Society (MORS), 46th Symposium, U.S. Naval War College, Newport, Rhode Island, 2-4 December 1980. |
| Thesis Directed: | Pat O'Reilly, "An Evaluation of Alternative Spares Stockage Policies," Thesis in progress. |

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| Title: | Cost Control Methodology |
| Investigator: | Michael G. Sovereign, Professor of Operations Research |
| Sponsor: | Office of Secretary of Defense (Comptroller) |
| Objective: | To develop improved systems for monitoring the progress and expenditures of major weapon systems programs. |
| Summary: | The DOD currently has over 300 billion dollars worth of major acquisition programs. These receive considerable Congressional scrutiny through the Selected Acquisition Reports (SAR). Although well-established and respected, the SAR is not widely used as an internal financial management control device. Integration of the Congressional reporting system and the internal cost monitoring systems through DODI 7000.2 systems and budgeting requirements may be desirable. The principal investigator has been involved with the definition of this problem within OSD and will develop alternatives to the current cost control methodology through on-site discussions and will evaluate models of alternative systems. |
| Conference Presentations: | M. G. Sovereign, "Linkage of Planning and Execution," 48th MORS Symposium, Monterey, 2 December 1981. |

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| Title: | Improved Attrition Methodology for TACWAR Model |
| Investigator: | James G. Taylor, Professor of Operations Research |
| Sponsor: | Command and Control Technical Center |
| Objective: | To develop improved force-on-force attrition methodology for aggregated-force ground-combat models (in particular, for improving ground-force casualty assessment in the TACWAR model). In support of this overall objective, the current modelling of conventional-ground-combat attrition processes in TACWAR was to be investigated in detail and consistent methodology for determining single-weapon-system-type kill-rate matrices was to be proposed. |
| Summary: | A first cut for estimating Lanchester attrition-rate coefficients (i.e. single-weapon-system-type kill rates) was developed, and a letter report documenting all such progress was sent to the sponsor. This report explained the conceptual setting for such improved quantitative methodology for the assessment of force-on-force attrition in conventional-ground-combat models and delineated associated conceptual difficulties. Besides the first cut at estimating attrition-rate coefficients, further model enrichments [(1) representation of the line-of-sight process, (2) options for modelling target acquisition, (3) control of "the pace of battle," and (4) the fitted-parameter approach] were also briefly discussed. |
| Publication: | J. G. Taylor, "Preliminary Investigation of Improved Attrition Methodology for Aggregated-Force Ground-Combat Models," NPS Letter Report, June 1981. |

Title: Representation of Additional Operational Factors in Combat Models

Investigator: James G. Taylor, Professor of Operations Research

Sponsor: NPS Foundation Research Program

Objective: To investigate how operational factors such as terrain effects, weapon-system capabilities, logistics constraints, etc., may be quantitatively included in force-on-force combat models and to analytically investigate how these included factors influence engagement outcome in such simulated combat. In support of this overall objective, the current state of the art for quantitative methodology for determining numerical values for Lanchester attrition-rate coefficients and for representing various tactically relevant operational factors in them was to be extended. Additionally, the consequences of representing the attrition process as either a deterministic or a stochastic process was to be investigated with respect to engagement outcome and the structure of the optimal combat strategies.

Summary: This research investigated the basic paradigms out of which complex operational Lanchester-type models have been developed through the process of model enrichment. It focused on (1) representing operational factors such as the line-of-sight process, target acquisition, weapon-system capabilities, logistics constraints, etc., in Lanchester attrition-rate coefficients, and (2) assessing the consequences of such functional representations with respect to engagement outcomes. A simple transparent derivation of the expected time for a single typical firer to kill a target was given under more general conditions than previously considered in the literature. The representation of the line-of-sight and the target-acquisition processes in Lanchester attrition-rate coefficients was investigated. The mathematical behavior of the models thusly formulated was also investigated: the qualitative behavior (including battle-outcome prediction) of solutions to these nonlinear Lanchester-type models that consider parallel acquisition of targets was determined. Other work investigated how the occurrence of force annihilation in such simulated combat depends on model parameters through the functional

dependence of the so-called modified parity-condition parameter on its argument for a particular important class of Lanchester-type equations for modern warfare. Force-annihilation-prediction conditions were also developed for Lanchester-type equations of modern warfare in which an important type of logistics constraint (limited ammunition) has been incorporated into the attrition-rate coefficients. Finally, the consequences of representing such a Lanchester-type attrition process as either a deterministic process or a stochastic one was investigated with respect to engagement outcome and optimal combat strategies. In particular, the structure of the optimal time-sequential fire-distribution policy obtained for a deterministic Lanchester-type attrition model was compared with that for a stochastic one.

Publications:

J. G. Taylor, "Analysis of the Functional Dependence of the Modified Parity-Condition Parameter on Its Argument for an Important Class of Lanchester-Type Equations for Modern Warfare," International Journal of Systems Science, (forthcoming).

J. G. Taylor, "A Simple Derivation of an Expression for the Lanchester Attrition-Rate Coefficient for 'Aimed-Fire' Combat," submitted to Journal of the Franklin Institute.

J. G. Taylor, "Annihilation Prediction for Lanchester-Type Models of Modern Warfare with Logistics Constraints," submitted to Mathematical Modelling.

J. G. Taylor and R. L. Powers, "Comparison of Optimal Time-Sequential Fire-Distribution Policies Determined from Deterministic and Stochastic Lanchester-Type Combat Models," submitted to Computers and Operations Research.

J. G. Taylor, "Qualitative Behavior of Solutions to Some Nonlinear Lanchester-Type Models that Consider Parallel Acquisition of Targets," submitted to International Journal of Systems Science.

Conference Presentation:

J. G. Taylor, "Survey of Stochastic Lanchester-Type Models," ORSA/TIMS Joint National Meeting, Houston, Texas, 13 October 1981.

Theses Directed:

G. K. Jenkins, "Decomposition of Attrition Processes in Hierarchical Models," Master's Thesis, June 1981.

S. D. Park, "An Operational Lanchester-Type Model of Small-Unit Amphibious Operations," Master's Thesis, September 1981.

Title: Instrumental Range Studies - Torpedo Track Smoothing

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

Sponsor: Naval Undersea Warfare Engineering Station (NUWES)

Objective: To develop theory and computational procedures to improve existing track smoothing programs in use at NUWES.

Summary: The research covered in this report is a continuation of the effort to improve and extend the general track smoothing program in current use at NUWES. The following results were obtained.

1) A 3-D Data Smoothing Algorithm using 7-points Least Squares Polynomials and including treatment of missing points and outliers was completed and documented.

2) The 7-point Least Squares Polynomial procedure was modified to handle 5, 9, or 11 points. A comparison of the relative capabilities using 3-D data from NUWES indicates that the 7-point procedure is preferred.

3) A brief comparison of a 7-point Least-Squares Linear Regression with a Second Order Kalman Filter truncated at 7 points indicated that the former is preferable for post-operational data smoothing but the latter is preferable for real-time prediction of the next observation.

4) Possibility of modification of smoothing techniques to handle Shallow Water Range data will be postponed until data becomes available from that range.

Publications: J. B. Tysver, "A 3-D Data Smoothing Algorithm," NPS Technical Report, NPS55-81-001, January 1981.

J. B. Tysver, "A Simple Second-Order Kalman Filter," Letter Report, June 1981.

J. B. Tysver, "A 9-Point Least-Squares Polynomial Model for Fitting 3-D Data," Letter Report, June 1981.

Title: Detection Models in Unconventional ASW

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

Sponsor: Naval Underwater Systems Command

Objective: Two parameters must be determined by minimizing a least squares objective function that includes a nonlinear function of the parameters. Two approaches are compared:

a) try all possible parameter combinations,

b) linearize the function and apply ordinary linear regression.

The objective was to compare a) and b).

Summary: Approach a) takes longer than b), but provides significantly better estimates with simulated data as input. The improvement is equivalent to several decibels gain in signal-to-noise ratio.

Publications: A. R. Washburn, B. O. Shubert, "Summary of 1981 Activity," NPS Technical Report, NPS55-81-023, September 1981.

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| Title: | "NOMBAS: A Procedure for Selecting the Largest Mean" |
| Investigator: | Alan R. Washburn, Associate Professor of Operations Research |
| Sponsor: | None |
| Objective: | To investigate a NOrmal Myopic BAyesian Sequential procedure for selecting the alternative with the best performance, and to compare NOMBAS with other techniques. |
| Summary: | Like most Bayesian procedures, NOMBAS is extremely efficient when the prior estimates are in rough correspondence with reality. The procedure is also very easy to use, comparing favorably with competitors. |
| Publications: | A. R. Washburn, "NOMBAS: A Procedure for Selecting the Largest Mean," submitted to Applied Statistics. |

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| Title: | Tracking in the Presence of False Alarms |
| Investigator: | Alan R. Washburn, Associate Professor of Operations Research |
| Sponsor: | Strategic Systems Project Office |
| Objective: | Investigation of various tracking algorithms. |
| Summary: | This is a continuation of the work reported in "Analysis of the memoryless tracker" (NPS55-80-14) and extended in Conrad's thesis. Efforts this year have been devoted to making the maximum likelihood computations more efficient by identifying an embedded shortest route problem. The method appears to be promising, but the investigation is not yet complete. |
| Thesis Directed: | R. Conrad, "A Maximum Likelihood Tracker," Master's Thesis, March 1981. |

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|---|---|
| Title: | Air Training Support System (ATSS) Instructional Development |
| Investigators: | W. Max Woods, Dean, Continuing Education<br>Peter W. Zehna, Professor of Operations Research and Statistics |
| Sponsor: | Naval Weapons Center |
| Objective: | To initiate development of computer assisted instructional (CAI) materials to support the ATS system. Such effort to consist of the development of specific modules, act as subject matter experts and consult with NWC staff. |
| Summary: | Approximately half of the allotted time (one quarter plus intersessional period) was spent in becoming proficient with the use of the Apple II microcomputer system and the related software packages, particularly Apple Pilot. The writer then developed two modules in the CAI mode to support the CE text Introduction to the Sonar Equations. This included complete self-teaching units on floppy discs for use on the Apple II system. |

# DEPARTMENT

# OF

# NATIONAL SECURITY AFFAIRS

## DEPARTMENT OF NATIONAL SECURITY AFFAIRS

Research interests of the Department of National Security Affairs conform in general to the curricula covered, namely (1) Geographical Area Studies, including the Middle East, Africa, South Asia, the Far East, Southeast Asia, the Pacific Basin, Europe and the USSR, and (2) Functional Specialty Studies, including International Organizations and Negotiations, Strategic Planning, and Intelligence. The research efforts are accordingly broad, focussing on the security interests of the United States in conjunction with other major international entities. Particular emphasis is placed upon the role of the military with respect to world wide economic, political, legal, technological, cultural and historical factors which shape the global interests, capabilities and security policies of the United States. The general areas of research, then, are as follows:

### REGIONAL POLITICO MILITARY ANALYSIS

These analyses have continued to focus on those areas of the world of vital interest to the United States, including Europe, Central America, Africa and Asia.

Research in the European region included a major research project on French security policies with respect to nuclear weapons, interventionary forces, arms control and European security as well as research on the balance of conventional forces between NATO and the Warsaw pact.

In Central America, an intensive survey of Soviet and Cuban policies in the Caribbean basin was completed, as well as an analysis of Mexican alternatives to develop an optimal control-type macroeconomic model of the Mexican economy from which a series of forecasts of the Mexican Economy will be made under different assumptions concerning oil revenues.

Ongoing research concerning United States policy towards conflict in Africa involves, to date, tracing the evolution of political conflicts in Rhodesia and Namibia. Initial studies have begun to expand the scope of this research to cover the Angolan Civil War and the Algerian revolution.

Research is also in progress to identify in a more comprehensive way the likely patterns of change in Africa that could impact on American interests on the continent in the 1980s.

Asian research efforts included a specific study to determine the role of South Korean nationalism in shaping the Park Chung-hee and Chun Du-hwan governments and how it is being modified today, as well as several studies now in progress which are expected to lead to a comprehensive examination of the role of military forces throughout Asia.

### ANALYSIS OF SOVIET MILITARY ACTIVITIES

Continued comprehensive research concerning Soviet Decisionmaking for Security resulted in completion of a manuscript which supports the hypothesis

that such decisionmaking is not only complex, but is frequently altered or affected by seemingly extraneous political, cultural and bureaucratic interests of the individuals involved.

Research is also underway under the sponsorship of the Council on Foreign Relations and the Rockefeller Foundation to compare Soviet military interventions in Hungary 1956, Czechoslovakia 1968, Afghanistan 1979 and Soviet intimidation of Poland in 1956 and 1980-81 and to draw implications for the United States. This comprehensive study of Soviet use of military force (in direct, or indirect ways) in neighboring Communist countries has been included to test the Soviet propensity toward use of force. The Polish crisis of 1980-81, has been a particular focus of the ongoing examination. The need to develop a U.S. preventative diplomacy to deter Soviet intervention has been identified and efforts have been made to develop policy guidelines for such a creative diplomacy.

MILITARY DECEPTION AND PERCEPTION MANAGEMENT

Continued research in this area summarized and synthesized the findings of seven theoretical NPS studies completed in 1980. The findings from these studies were compared, contrasted, and juxtaposed against historical cases of strategic deception to provide the basis for extrapolating the findings in order to arrive at new insights about deception's role.

Related research in the perception area included Ford Foundation sponsored research on Antisubmarine Warfare and Strategic Stability undertaken to evaluate trends in superpower ASW capabilities and to determine to what extent perceptions of these trends pose a destabilizing threat to submarine survivability. This research is ongoing.

The findings of a group research project on military strategic deception were summarized under the topics: defining deception, tracing the deception process, judging the likelihood of deception, the difficulties of deception, the advantages of the deceiver, the advantages of the offensive in deception, the impact of astuteness, doing counterdeception, and conclusions.

OPERATION TEST AND EVALUATION

Based on prior research concerning the effectiveness of the A-10 aircraft against simulated Soviet tank formations, the combat effectiveness of ammunition for the 30mm gun system is being evaluated. The reports of these evaluations, which describe the results of firings of the ammunition, will be used during the next year in a systematic, mathematically based analysis of the overall results of aircraft anti-tank effectiveness.

THEATER NUCLEAR POLICY

The Department has extended its research interests in Maritime Theater Nuclear Warfare to include policy issues with respect to French and Soviet perspectives on theater nuclear arms. The broader objective of the ongoing research is to advance the understanding of NATO interests and perceptions regarding theater nuclear arms control negotiations.

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| Title: | Africa in the 1980s: Continuity and Change |
| Investigators: | Michael Clough, Adjunct Professor, Department of National Security Affairs, and Helen Kitchen, Director of African Studies, CSIS, Georgetown University |
| Sponsor: | Office of Naval Research |
| Objective: | To identify likely patterns of change in Africa that could impact on American interests on the continent in the 1980s. |
| Summary: | A major conference will be held in May 1982 at the Naval Postgraduate School. Papers will be presented by regional experts on North Africa, West Africa, the Horn of Africa and Southern Africa. Based on the findings of this conference the principal investigators will attempt to project future political, economic and military trends in the region and provide a set of guidelines for future U.S. policy. |

Title: United States Policy Toward Conflict in Africa

Investigator: Michael Clough, Adjunct Professor of National Security Affairs

Sponsor: NPS Foundation Research Program

Objective: To examine the role of the United States in the resolution of revolutionary conflicts in Africa.

Summary: To date, this research has involved tracing the evolution of political conflicts in Rhodesia and Namibia. It has used a loose bargaining model to identify major shifts in the nature of these conflicts and to isolate the specific effect of United States policy in relation to these shifts. Initial studies have begun to expand the scope of this research to cover the Angolan Civil War and the Algerian revolution.

Publications:

M. Clough, "From Rhodesia to Zimbabwe," in M. Clough (ed.) Political Change in Southern Africa, Institute of International Studies, University of California, Berkeley, (forthcoming).

M. Clough, "From Southwest Africa to Namibia," in M. Clough (ed.) Political Change in Southern Africa, Institute of International Studies, University of California, Berkeley, (forthcoming).

M. Clough, "Why Carrots Alone Won't Work," African Index, June 30, 1981.

M. Clough, "Namibia 1981?" African Index, December 17, 1980.

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| Title: | The United States and Revolution |
| Investigator: | Michael Clough, Adjunct Professor, Department of National Security Affairs |
| Sponsor: | None |
| Objective: | To develop an explanatory model of American policy toward revolutionary change in the third world. |
| Summary: | This research has involved examining the cognitive decision making literature and American Foreign policy making literature in order to develop a model of the foreign policy making process that will permit us to determine the impact of the beliefs held by policy makers on American policy toward revolutionary change in the third world. It traces the evolution of American attitudes toward revolution since 1776 and explains how such attitudes have interacted with beliefs about American strategic interests to determine the U.S. response to specific revolutions. |
| Publications: | M. Clough, The United States and Revolution, (forthcoming). |

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| Title: | Antisubmarine Warfare and Strategic Stability |
| Investigator: | Donald C. Daniel, Associate Professor, Department of National Security Affairs |
| Sponsor: | Ford Foundation |
| Objective: | Evaluate whether trends in superpower antisubmarine warfare capabilities pose a destabilizing threat to the survivability of ballistic missile submarines. I am continuing this research. |
| Summary: | An extensive in-depth survey of the literature was conducted while the researcher was at the Brookings Institution, Washington, DC, from January through June 1981. The researcher also interviewed numerous individuals in the Washington area, at MIT, and abroad. Data gathering is complete except for review of 1981 congressional testimonies, which have not yet been received by the NPS Library. An extended outline of the research project report was also completed and is now being circulated for comment. |
| Publications: | D. C. Daniel, "New Factors in Security: Antisubmarine Warfare" in International Institute of Strategic Studies, Strategic Survey 1980-81 (London: IISS, 1981), pp. 31-36. |
| Conference Presentations: | D. C. Daniel, "Antisubmarine Warfare and the Survivability of Strategic Submarines," Brookings Institution Foreign Policy Seminar, Washington, DC, 16 April 1981. |

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| Title: | Battle of Wits: Synthesizing and Extrapolating from NPS Research on Strategic Military Deception |
| Investigators: | Donald C. Daniel, Associate Professor, Department of National Security Affairs and Katherine L. Herbig, Adjunct Professor, Department of National Security Affairs |
| Sponsor: | Office of the Director of Net Assessment, Office of the Secretary of Defense |
| Objectives: | To synthesize findings of NPS research on strategic military deception and extrapolate from those findings so as to provide new or original insights on the role of strategic deception in warfare. |
| Summary: | Investigators summarized and synthesized the findings of seven theoretical NPS studies completed in 1980. The findings from these studies were compared, contrasted, and juxtaposed against historical cases of strategic deception. So doing provided the basis for extrapolating the findings in order to arrive at new insights about deception's role. The study focussed on: the definition of deception, the deception process, the difficulties of deception, the advantages of the deceiver, the advantages of the offensive in deception, the impact of astuteness, and the problems and prospects for counterdeception. |
| Publications: | D. Daniel and K. Herbig, "Battle of Wits: Synthesizing and Extrapolating from NPS Research on Strategic Military Deception," NPS Technical Report, NPS56-81-002, January 1981.<br><br>D. Daniel and K. Herbig, Strategic Military Deception, New York: Pergamon Press, 1982.<br><br>D. Daniel and K. Herbig, "Propositions on Military Deception," Journal of Strategic Studies Vol. IV, (March 1982).<br><br>D. Daniel and K. Herbig, "Review of Charles Cruickshank's Deception in World War Two," Journal of Strategic Studies Vol. III, (December 1980), pp. 104-106. |
| Conference Presentations: | D. Daniel, "Military Strategic Deception: Patterns in Performance," International Studies Association Convention, Philadelphia, March 19, 1981. |

Conference Presentation: K. Herbig and D. Daniel, "Strategic Deception: Four Case Studies," International Studies Association Convention, Philadelphia, March 19, 1981.

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| Title: | Cry Wolf Effects |
| Investigator: | Katherine L. Herbig, Adjunct Professor of National Security Affairs |
| Sponsor: | NPS Foundation Research Program |
| Objective: | To investigate the phenomena labeled "cry wolf effects," i.e., repeated exposure to alarms which prove false, and the psychological impact such a pattern has on military readiness and response. |
| Summary: | A survey of the literature on warning and strategic surprise revealed a variety of situations labeled "cry wolf effect." These were compared and analyzed; historical instances were discussed in the light of four psychological concepts relevant to the problem: availability, expectancy, desensitization, and decision-making process. |
| Publication: | Katherine L. Herbig, "The Cry Wolf Effects," NPS Technical Report (forthcoming). |
| Conference Presentation: | Katherine L. Herbig, "The Cry Wolf Effect on Military Surprise," International Studies Association Conference, Philadelphia, Pennsylvania, March 1981. |

Title: Analysis of Mexican Growth Alternatives

Investigators: Robert Looney, Associate Professor of National Security Affairs, principal investigator and Peter C. Frederiksen, Associate Professor, Defense Resources Management Education Center

Sponsor: NPS Foundation Research Program

Objective: The major objective is to develop an optimal control-type macro-economic model of the Mexican economy from which a series of forecasts of the Mexican economy will be made under different assumptions concerning oil revenues.

Summary: The macro-economic model of twenty-six structural equations has been developed. These are determined by two stage least squares estimations for annual data covering the period 1951-1980. All in all there are thirty-eight endogenous and exogenous variables from which the model is constructed.

Preliminary optimal control analysis has been made of the expenditure of oil revenues by the Mexican Government over the period 1976-1979. A welfare loss function was selected that optimized growth with inflation setting a limit on the rate of expansion of the economy. Preliminary results indicate that the economy has not been able to effectively absorb the oil revenues and that a considerable amount of waste has resulted from the government's past patterns of expenditures in the sense that much of the oil receipts have in effect been used to finance imports.

Forecasts are now under way to determine the optimal rate of oil depletion under various assumptions as to international oil prices. Preliminary results indicate that it will be possible within a constraint on inflation for the government to gradually expand the rate of oil production from about 2.75 million barrels per day in 1980 to about 5.8 million barrels per day in 1990 without incurring excessive rates of inflation. In general it is assumed that at least half of this production will be exported to the United States.

A series of policy implications is being drawn for U. S. policy makers.

Publication: R. Looney, Development Alternatives for Mexico (Praeger Publishers: New York, New York, forthcoming).

PROFESSOR LOONEY DISCUSSES DATA PROCESSING PROBLEMS WITH STUDENTS OF NATIONAL SECURITY AFFAIRS.

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| Title: | South Korean Nationalism: Roots, Impact, and Prospects |
| Investigator: | E. A. Olsen, Adjunct Professor, National Security Affairs |
| Sponsor: | NPS Foundation Research Program |
| Objective: | To determine the role of South Korean nationalism in shaping the Park Chung-hee and Chun Du-hwan governments and how it is being modified today. |
| Summary: | A survey of the relevant literature was made, supplemented by interviews with several Korean academic authorities and American academic and governmental specialists on Korea. Several distinct patterns in the growth of South Korean nationalism became evident: a formative stage, a separatist stage, a nation-building stage, and a utilitarian stage. Over these stages South Korean nationalism evolved from a "cause" to a "result." |
| Publications: | E. A. Olsen, "The Political Implications of Resource Scarcity on the Korean Peninsula," Korean Observer (December 1981), pp. 395-405.<br>It also will be published in a book co-edited by the investigator and Professor Y.S. Yim, due in early 1982.<br><br>E. A. Olsen, "South Korean Nationalism," Pacific Community (forthcoming). |
| Conference Presentation: | E. A. Olsen, "The Political Implications of Resource Scarcity on the Korean Peninsula," American Political Science Association Annual Meeting, New York, September 1981. |

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| **Title:** | A-10/GAU-8 Empirical Firing Tests |
| **Investigator:** | Russel H. S. Stolfi, Associate Professor, Department of National Security Affairs |
| **Sponsor:** | Wright-Patterson AFB |
| **Objective:** | To verify the combat effectiveness of ammunition for the GAU-8 30mm gun system. |
| **Summary:** | Results developed this year from firings of ammunition will be used during the next year in a systematic, mathematically based analysis of these results. |
| **Publication:** | R. H. S. Stolfi and R. R. McEachin, "A-10/GAU-8 Low Angle Firings Versus Simulated Soviet Tank Company (Array 25) (4 December 1979)," NPS Technical Report, NPS56-80-012, October 1980. |

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| Title: | Soviet Decisionmaking for the National Security |
| Investigator: | J. Valenta, Associate Professor and Coordinator of Soviet and East European Studies, NSA<br>W. Potter, Assistant Director, CSIS, UCLA |
| Sponsor: | NPS Foundation Research Program |
| Summary: | The joint work to complete a manuscript based on the conference sponsored by the NPS/UCLA has been completed. The chapters have been updated and edited. The editors wrote the introduction and conclusion. The major findings of the book support the hypothesis about the complex nature of Soviet decisionmaking for national security often circumspected by the specific political culture and sometimes by the bureaucratic and organizational interests of the people involved. |
| Publications: | J. Valenta and W. Potter, eds., Soviet National Security Decisionmaking (London: Allen and Unwin Publishers), (forthcoming).<br><br>J. Valenta, "From Prague to Kabul: The Soviet Style of Invasion," International Security, Fall 1980, pp. 114-141. |
| Conference Presentations: | J. Valenta and S. Butler, "Soviet Interests in Southwest Asia," Strategic Institute, U.S. Army War College, October 15-16, 1981. |
| Thesis Directed: | M. Hesson, "Demographic, Economic and Ethnic Factors and the Soviet Armed Forces," Master's Thesis, September 1981. |

Title: Soviet Interventions in Neighbouring Communist Countries: Implications for the U.S.

Investigator: J. Valenta, Associate Professor and Director of Soviet and East European Studies, Graduate School of National Security Affairs

Sponsor: Council on Foreign Relations, Rockefeller Foundation and Research Institute on International Change, Columbia University.

Objective: To compare Soviet military intervention in Hungary 1956, Czechoslovakia 1968, Afghanistan 1979 and Soviet intimidation of Poland in 1956 and 1980-81 and to draw implications for the United States.

Summary: A comprehensive study of Soviet use of military force (in direct, or indirect ways) in neighbouring Communist countries has been included in the program. The national security decisionmaking and bureaucratic politics models have been developed and operated to test the Soviet propensity toward use of force. The Polish crisis of 1980-81, has been a particular focus of ongoing examination. The need to develop a U.S. preventative diplomacy to deter Soviet intervention was identified and efforts have been made to develop policy guidelines for such a creative diplomacy.

Publications:

J. Valenta, V. Aspaturian, and A. Dallin, The Soviet Invasion of Afghanistan: Three Perspectives, Los Angeles: Center for Int'l and Strategic Affairs, 1980.

J. Valenta, "Soviet Use of Surprise and Deception: Czechoslovakia, Afghanistan and Poland," Surival (March-April 1982).

J. Valenta, "Czechoslovakia and Afghanistan: Comparative Comments," Studies in Comparative Communism (Winter 1981), pp. 332-342.

J. Valenta, "Soviet Options in Poland," Survival (London) (March-April 1981), pp. 50-59.

J. Valenta, "Soviet Decisionmaking and the Crisis in Hungary in 1956," in Repercussions of the Hungarian Revolution, edited by B. Kiraly, Boulder: Westview Press, 1982.

J. Valenta, "Czechoslovak Armed Forces: Origins and Developments" in Communist Armies and Politics: Their Formation and Development, edited by J. Adelman, Boulder: Westview Press, 1981.

J. Valenta, "Soviet Policy Toward Hungary and Czechoslovakia," in Soviet Policy in Eastern Europe, edited by S. Terry, New Haven: Yale University, 1982

J. Valenta, "Czechoslovakia: A Prolétariat Embourgeoise?", in Labor in Socialist Countries, edited by J. Triska and C. Gati, London: Allen and Unwin, 1981.

Conference Presentations:

J. Valenta, "Soviet Use of Surprise and Deception: Czechoslovakia, Afgahnistan and Poland," Research Institute on International Change, Columbia University, November 19, 1981.

J. Valenta, "Soviet Invasion in Hungary 1956 Reassessed: Could the USSR have Stayed Out?", Annual National Convention of the American Association for the Advancement of Slavic Studies (AAASS), Asilomar, California, September 23-26, 1981.

J. Valenta, "Poland: Continuous Soviet Intervention or Definitive Invasion?", Annual National Convention of the American Political Science Association, New York, September 3-6, 1981

J. Valenta, "Soviet Views on Deception and Strategic Surprise," The Rocky Mountain Association for Slavic Studies Conference, San Diego, April 23-25, 1981.

J. Valenta, "Czechoslovak Armed Forces: Their Origins and Development," Annual National Convention of the International Studies Association (ISA), Philadelphia, March 1981.

Theses Directed:

V. Grunwald, "USSR and Polish Crisis," Master's Thesis, June 1981.

L. Tatsch, "German Reunification," Master's Thesis, June 1981.

D. Fraze, "Yugoslavia Territorial Defense, Master's Thesis, June 1981.

Title: USSR and Cuba in the Critical Region of the Third World: Central America

Investigator: J. Valenta, Associate Professor and Coordinator of Soviet and East European Studies, Department of National Security Affairs

Sponsor: Office of Net Assessment, DOD

Summary: An intensive survey of Soviet and Cuban policies in the Caribbean basin was completed. The Soviet and Cuban strategic objectives in the Caribbean region in general and the tactics in Nicaragua and El Salvador have been identified and efforts have been made to assess the internal and external constraints upon Soviet and Cuban behavior. The need to develop a coherent, U.S. strategy for the Caribbean, encompassing not only military, but also political and economic objectives has been determined.

Publications:

J. Valenta, "The USSR and Cuba in Africa and the Caribbean Basin," The World Today (London) Vol. 37, No. 2 (February 1981), pp. 45-53.

J. Valenta, "The USSR, Cuba and the Crisis in Central America," ORBIS Vol. 25, No. 3 (Fall 1981), pp 715-746.

J. Valenta, "Soviet Strategy in the Caribbean Basin: Implications for the United States," Naval Review, (April 1982).

J. Valenta, "Soviet-Cuban Intervention in Ethiopia, 1978," Journal of International Affairs (June 1981).

J. Valenta, "The USSR, Cuba and the Crisis in Central America," in The International Aspects of the Crisis in Central America, edited by R. Feinberg, New York: Holmes and Meyer, (forthcoming).

J. Valenta, "The Caribbean Policy of the USSR," in Colossus Challenged: The Struggle for Caribbean Influence, edited by H. Erisman and J. Martz, Boulder: Westview Press, (forthcoming).

Conference Presentations:

J. Valenta, "The USSR, Cuba and the Crisis in Central America," Conference on International Aspects of the Crisis in Central America, Washington, DC, April 2-3, 1981.

J. Valenta, "The USSR, Cuba and the Crisis in Central America," The Latin American Program of the Woodrow Wilson Center, Washington, DC, April 2-7, 1981.

Thesis Directed:

L. W. Chapple, "Soviet Strategy in Iran," Master's Thesis, June 1981.

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| Title: | French and Soviet Perspectives on Theater Nuclear Policy and Arms Control |
| Investigator: | David S. Yost, Assistant Professor of National Security Affairs |
| Sponsor: | NPS Foundation Research Program |
| Objective: | Advance understanding of NATO interests and perceptions regarding probable theater nuclear arms control negotiations. |
| Summary: | The first phase of this project (Summer 1980) focused primarily on France (in the context of NATO Europe in general), while the second phase (Winter 1981) focused on the Soviet Union and the probable content and course of imminent theater nuclear arms control negotiations. The research clarified West European and Soviet interests and perceptions regarding SALT II and SALT III issues, and reached conclusions as to U.S. policy alternatives. |
| Publications: | D.S. Yost, "Beyond SALT II: European Security and the Prospects for SALT III," in Orbis, 24 (Fall, 1980), 625-655.<br><br>D.S. Yost, "SALT and European Security," in D.S. Yost, ed., NATO's Strategic Options: Arms Control and Defense (New York: Pergamon Press, 1981).<br><br>D.S. Yost, Der SALT-Prozess und die sicherheitspolitische Lage Westeuropas (Sankt Augustin/Bonn, Federal Republic of Germany: Konrad-Adenauer-Foundation, 1980).<br><br>D.S. Yost, European Security and the SALT Process, Washington Paper no. 85 (Beverly Hills and London: Sage Publications, 1981), series sponsored by Georgetown University's Center for Strategic and International Studies. |

Conference Presentations:

D.S. Yost, "SALT, Strategic Doctrine, and Strategic Forces in the Light of Soviet Force Programs," 20th anniversary conference of the Inter-University Seminar on Armed Forces and Society, University of Chicago, October 23-25, 1980.

D.S. Yost, "National Outlooks on Security Issues in Western Europe," Naval Air Systems conference on National Security and Foreign Affairs in the 1980s, Annapolis, Maryland, December 7-10, 1980.

Theses Directed:

T.C. Glad, "Theater Nuclear Force Modernization as an Issue in West German Politics, 1977-1980," Master's Thesis, December 1980.

M. Helgeson, "Domestic Determinants of American Strategic Nuclear Doctrine, 1965-1980," Master's, Thesis, December 1980.

G. Caughey, "Naval Implications of the Strategic Arms Limitation Talks," Master's Thesis, December 1980.

M. Carr, "The Campaign for Nuclear Disarmament in Britain 1958-1964 and 1979-1981: Apparent Impacts on Britain's Contribution to NATO," Master's Thesis. June 1981.

# DEPARTMENT

# OF

# PHYSICS AND CHEMISTRY

## DEPARTMENT OF PHYSICS AND CHEMISTRY

Our effort during FY 1981 has continued the trend toward interdisciplinary and group research involving colleagues from other departments as well as increased interaction among major research centers within the department. Our research effort has benefited from the occupancy of the Chair in Underwater Acoustics, the presence of a visiting scientist from the Direction des Recherches, Etudes et Techniques (DRET) in France and a NSF sponsored Post - Doctoral Associate. This trend, and the increased number of scholars from outside of our own faculty, seems sure to increase in the next year and leads to optimism that our research program is gaining in quality and productivity in a very satisfactory manner.

Details of research initiatives follow on the next several pages, but some highlights are worth noting. First, the trend toward research which deals with the interface between man-made systems and their operation in the real environment, has continued. One important area of the department's research effort - underwater acoustics - has been strengthened by visitors and the Underwater Acoustic Chair; and very recently, by the infusion of new talent in the form of new faculty. The efforts in this area are on the increase.

Several areas of research should be noted because of their increased activity. The Environmental Physics Group has added to its reputation during the year. Our Geomagnetic research has increased, and has recently attracted a Chairholder in that area. The LINAC has continued to find new and innovative directions of sponsored research. The department is re-entering the area of nuclear weapons effects as a curriculum, and research will soon follow. Other projects, mentioned last year, continue to be viable and of high quality.

### LINEAR ELECTRON ACCELERATOR

New work at the LINAC this year featured the start of investigations concerning the stimulated Cerenkov radiation produced by high-energy (30-100 MeV) electrons. This process may provide an alternative to the free electron laser in producing radiation from the milimeter-wave region through the infrared optical region. The use of high energy electrons in this experiment makes possible the expansion of this technique to the optical range. An unexpected result has already been found: the effectiveness of this technique for monitoring the temporal structure of the pulses from the LINAC in the $10^{-9}$ region. This will be investigated more fully during the coming year.

Research into the properties of a new scintillation detector, bismuth germinate, which can replace sodium iodide crystals in many X-ray and gamma ray detectors, will continue. Particular effort will be directed to determining the energy resolution of these crystals in the energy range of 30 to 100 MeV. In addition, other new solid state detectors, some just appearing to be interesting for practical applications, will be studied in the near future.

It is expected that the LINAC facility will continue to focus its efforts on novel radiation sources for the coming year.

This work is carried on primarily by Professor Fred R. Buskirk and collaborators from Stanford University.

EXPLOSIVE CHEMISTRY

Professors Richard A. Reinhardt and Gilbert F. Kinney have continued their computational investigation of chemical equilibria and overpressures resulting from the internal explosions of conventional and explosive fuels in the presence of reactive metals. This work continues to be supported by the Naval Weapons Center, China Lake, CA.

DEFENSE SCIENCES

Primary efforts in the area of Defense Sciences have centered on Professor William Reese's participation on the CNO Executive Panel, Science and Technology Sub-panel. Major emphasis has been on surveying high leverage potentials within the technologic base and from the perspective of the recently established warfare appraisals. An unrelated effort in the same general area involved a workshop on Technical Intellignece sponsored by the Naval Studies Board of the National Research Council which was held at NPS. This workshop considered prospects for and a means of enlarging the pool of technical expertise available to contribute to the solution of technical intelligence problems. Special interest was on areas of potential "breakthroughs" or those in which technical approaches differed from those of the West have been adopted.

ENVIRONMENTAL PHYSICS

Professor Gordon E. Schacher and Associate Professor Kenneth L. Davidson (of the Department of Meteorology) are continuing their efforts on marine atmospheric boundary layer modeling and model verification. Modeling of the temporal variation of boundary layer properties has progressed very well and several aspects of the modeling are in the final verification stage. An attempt is being initiated to adapt the model to account for spatial variations. It is planned to make this a major effort of the group.

The model has been adapted for use on a mini-computer to make real-time assessments of boundary layer evolution. The final output of the program is predictions of radar, radio, and optical propagation parameters. The program will be coupled to the Navy's Integrated Refractive Effects Prediction System, which is currently in operational use. The ultimate aim of this program is to produce a real-time, in situ assessment capability for the Navy for both temporal and spatial variations of operationally important atmospheric parameters. This capability would be incorporated into the Navy's upcoming Tactical Environmental Support System.

Two major cruises were undertaken in the past year to gather overwater transport and dispersion data. The data has been used to evaluate Gaussian model performance and work is underway on puff model evaluation. An effort is beginning to couple the dispersion and boundary layer models.

During the year a long range electromagnetic propagation experiment was performed. Propagation quality from an airborne transmitter to a shore based receiver was determined by measuring received signal strength as a function of range. Ranges to 150 nmi were examined during atmospheric ducting conditions. The aircraft carried equipment to completely characterize meteorological properties of the atmosphere. Analysis of the resulting data is underway.

UNDERWATER ACOUSTICS

Increased activity in the general area of Underwater Acoustics can be reported this year. The department's efforts have been augmented by the presence of Professor A.O. Williams, the Chairholder of the ONR Chair in Underwater Acoustics and also by the presence of Dr. Francois Jouaillec who is visiting from the Direction des Recherches, Etudes et Techniques (DRET) for a year.

Associate Professors James V. Sanders and Alan B. Coppens, in cooperation with Professor Williams, have continued their investigations into the problem of the transmission of acoustic energy from a fluid wedge into a fast bottom. Since last year, a way has been found to model the problem into a laboratory-sized facility, and such a facility is being constructed. Comparisons between experimental measurements and computer simulations are expected soon.

Professor O.B. Wilson, Jr., with Assistant Professor Harvey A. Dahl and cooperation from the NRL, is continuing his investigation into the underwater acoustic noise due to surf phenomena. The objectives of this research are to determine whether surf generated noise is indeed a significant component of the shallow water ambient noise, and to determine the horizontal anisotropy of such noise under a variety of sea conditions and ranges in the Monterey Bay.

Assistant Professor Harvey A. Dahl has collaborated with Professor Paul H. Moose (of the Department of Electrical Engineering) in an investigation of underwater acoustic parameters in the Arctic. The purpose of this project has been to analyze acoustic backscattering (reverberation) and propagation data in order to identify requirements for further data gathering in Arctic waters.

Profesors O.B. Wilson and G.L. Sackman (of the Department of Electrical Engineering) have continued their interaction with the Naval Undersea Warfare Engineering Station, Keyport, WA, in order to study the long-term requirements and plans for that station.

ATOMIC PHYSICS

The Spectroscopic Data Center, under the direction of Professor Raymond L. Kelly, has continued a critical compilation of long wavelength ultraviolet lines in support of space exploration and solar physics. An initial compilation of some 30,000 lines has been completed and published, and work has started on adding the classifications to each line as an extension of the initial compilation. It is expected that this work will continue for another three years. This work has been supported during the last year by NASA.

SURFACE PHYSICS

Professor Don E. Harrison, Jr., with continuing support from the National Science Foundation and in conjunction with Dr. Roger P. Webb, Post Doctoral Associate, has continued study of the effects produced when ions bombard clean and chemically reacted single crystal metal surfaces in order to understand mechanisms and to coordinate theory and experiment. His simulations have developed to the point where it is possible to follow the cascade produced by an ion impact event. Based upon studies during the year, it appears possible to obtain useful atom-atom potential functions by comparing simulation results to experimetal data.

ELECTRO-OPTICS

Research concerning the optical properties of the atmosphere has continued with Professors Eugene C. Crittenden, Alfred W. Cooper, Edmund A. Milne, Sidney H. Kalmbach and their students.

Work sponsored by the Naval Air Systems Command has investigated the effectiveness of the Compass Hammer system by computer simulation of its operation in a Naval engagement. The details of this work are classified at the SECRET level.

Related to this, unsponsored research has continued into the measurements of the effects of turbulence on airborne optical projectors, in particular, measurements of $C_n^2$ for optical paths from an aircraft to ground.

Finally, a feasibility study of a designator spot wander determination system has been undertaken. These measurements should permit separation of the spot wander due to atmosphere from that due to platform instability. Field tests are planned for this experiment later in the year.

Our electro-optics and environmental physics groups will continue their close interaction.

LASER AND PLASMA PHYSICS

Activities in this area have continued to center on the connected topic of breakdown and unipolar arcing which occurs in laser metal-target interactions.

One experiment, carried on by Professor Fred R. Schwirzke with support from the Naval Research Laboratory, has been designed to determine the threshold value of laser irradiance for the onset of breakdown and arcing, this arcing having been shown to be the primary damage mechanism when a plasma is formed in laser metal-target interactions. This research has shown that in any situation in which a plasma exists, there will be plasma surface interactions, and a model has been developed which predicts this phenomenon.

Related experiments, supported by the NPS Foundation Research Program, investigate unipolar arc damage of several materials, including stainless steel and TiC.

Finally, in conjunction with the Center for Plasma Physics and Fusion Engineering, UCLA, Professor Schwirzke has investigated methods of impurity control and diagnostics for impurities released by plasma-surface interactions which influence the operation of many of today's magnetic fusion machines, especially tokamaks.

GEOMAGNETIC PHENOMENA

Professor Otto Heinz is continuing and expanding his studies of geomagnetic fluctuations on the ocean floor. The purpose of these studies is to obtain improved long term data and estimate sea-floor conductivities, and also to identify the separate origins of the contributing signal sources.

During the year measurements of fluctuations on the floor of Monterey Bay were continued and land based measurements were initiated from a monitoring station on Chew's Ridge. Comparisons of the land and sea measurements are continuing.

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| Title: | Exploratory Experiments of the Stimulated Cerenkov Radiation Using 30-100 MeV Electrons |
| Investigator: | Fred R. Buskirk, Professor of Physics |
| Sponsor: | Office of Naval Research |
| Objective: | Preliminary measurements of stimulated cerenkov effect using high energy electrons. |
| Summary: | The stimulated Cerenkov process may provide an alternative to the free electron laser in producing radiation from the mm microwave range through the infrared optical region. Previous work has employed electron of about 0.3 MeV energy interacting with a dielective slab resonator to produce microwaves. The present experiments start to explore the possibility of using higher energy electron which would be necessary to future extension of the methods to the optical range. An unexpected result from these early measurements in the effectiveness of the techniques for monitoring the temporal structure of electron accelerator beams in the $10^{-9}$ sec region. |
| Theses Directed: | D. E. McLaughlin, "Cerenkov Radiation Produced by 100 MeV Electrons," Master's Thesis, June 1981.<br><br>L. E. Brown, "Stimulated Cerenkov Radiation Experiments," Master's Thesis, December 1981. |

Title: Performance of Electro-Optical Systems in the Compass Hammer Program

Investigators: Alfred W. Cooper, Professor of Physics, and Edmund A. Milne, Associate Professor, Department of Physics and Chemistry

Sponsor: Naval Air Systems Command

Objective: To evaluate the effectiveness of the Compass Hammer system by computer simulation of operation in a Naval engagement.

Summary: Existing computer programs were evaluated for applicability to the Naval Compass Hammer problem. The selected code was adapted to the situation addressed, and to the NPS computer system. The program was modified to provide a more realistic description of the environment. Simulation of engagements under a variety of circumstances were performed and system performance evaluated.

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| Title: | Feasibility Study of Designator Spot Wander Determination System |
| Investigators: | E. C. Crittenden, Jr., Professor of Physics, Edmund A. Milne and G. W. Rodeback, Associate Professors of Physics |
| Sponsor: | U. S. Army Proving Grounds, Aberden, MD |
| Objective: | Study the feasibility for the determination of designator spot wander by means of measurements of the image-centered spot profile during designator tests. The measurements should permit separation of the spot wander due to atmosphere from that due to platform instability. |
| Summary: | The necessary equipment has been procured and set up for bench tests. Some of the programs have been written for procesing the data. Further work is continuing on program development for controlling the equipment. Field tests are planned for later in the year. |

Title: Measurement of the Effects of Turbulence on Airborne Optical Projectors

Investigators: E. C. Crittenden, Jr., E. A. Milne , G. W. Rodeback, and S. H. Kalmbach, Professors of Physics

Objectives: Measurement of $C_n^2$ for optical paths from an aircraft to ground during tests, at China Lake, of the Compass-Hammer device.

Summary: Comparative measurements were carried out during several one week field experiments at China Lake. $C_n^2$ (the turbulence structure constant for optical index fluctuation) was measured both by means of MTF (Optical resolution as expressed by means of Modulation Transfer Function) and by means of scintillation. Comparison of these results and with results obtained by another group (Pacific Sierra Research) made it apparent that direct measurement of intensity fluctuation should be carried out for these experiments. As a result two more field experiments were carried out with new equipment, utilizing GaAs laser sources on the aircraft tracked to the ground receiving station.

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, and Roger P. Webb, Post Doctoral Associate, with K. E. Foley, B. J. Garrison and N. Winograd, Pennsylvania State University

Sponsor: 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 establised that many atom ejection effects normally attributed to the ion mass are actually caused by the ion's size. The influence of the atom-atom potential also has been studied. It appears possible to obtain useful atom-atom potential functions by comparing simulation results to experimental data. Small mass ratio, heavy target atoms, lead to a larger fraction of high energy ejected atoms.

Publications: N. Winograd, K. E. Foley, B. J. Garrison and D. E. Harrison, Jr., "Evidence for a Recombination Mechanism of Cluster Emission from Ion Bombarded Metal Surfaces," Physics Letters 73A(3) (1979) 253-55.

D. E. Harrison, Jr., "Atom Ejection Studies by Classical Trajectory Simulation," AIP Conference Proceedings No. 61, Aspects of the Kinetics and Dynamics of Surface Reactions (La Jolla Institute- 1979) ed. U. Landman, American Institute of Physics, New York, 1980, pp 307-18.

D. E. Harrison, Jr., B. J. Garrison and N. Winograd "Atom Ejection Mechanisms and Models," Secondary Ion Mass Spectrometry: SIMS II, ed. A. Benninghoven, et. al., Springer-Verlag New York (1979) pp 12-14.

B. J. Garrison, N. Winograd and D. E. Harrison, Jr., "Classical Trajectory Calculations of the Energy Distribution of Ejected Atoms from Ion Bombarded Single Crystals," Surface Science 87, (1979) 101-111.

D. E. Harrison, Jr., "Full Lattice Simulations of Atom Ejection Mechanisms," Proceedings: Symposium on Sputtering, Perchtoldsdorf/Vienna, Austria, April 2830, 1980, ed. P. Varga, et. al., pp 36- 61. *(unpublished).*

Title: Geomagnetic Fluctuations on the Ocean Floor

Investigator: O. Heinz, Professor of Physics

Sponsor: Office of Naval Research

Objective: The objective of this research is the study of the spatial and spectral properties of naturally occurring electromagnetic fields on and near the ocean floor. The purpose of these studies is to obtain improved long term data, to estimate sea-floor conductivities and to identify the separate origins of the contributing signal sources.

Summary: During FY 81 we continued and extended our measurements of geomagnetic field fluctuations on the floor of Monterey Bay and also initiated data transmission from Chew's Ridge Monitoring Station. A comparison of our land and sea data shows that in addition to a large swell induced signature at about .07 Hz the power spectrum of the sea signals is consistently higher by 10 to 15 db over the entire frequency range (.01 to 1 Hz). Simultaneous measurements of the vertical and horizontal component of the sea floor signal were carried out over the frequency range 0.01 Hz to 20 Hz.

Thesis Directed: Gary M. McKinley and Robert M. Santos, "Characteristics of Geomagnetic Power Spectra on Land and Sea in the Period Range .2 to 400 sec.", Master's Thesis, December 1980.

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 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 24 elements, Hydrogen through Chromium, 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: Raymond L. Kelly, "The Atomic Energy Levels of Iron," *NPS Technical Report*, NPS61-81-026, June 1981.

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| Title: | Spectroscopic Data Center Compilations of Near Ultraviolet Spectra |
| Investigators: | Raymond L. Kelly, Professor of Physics |
| Sponsor: | National Aeronautics and Space Administration |
| 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. |
| Publication: | R. L. Kelly, "Atomic Emission Lines in the Near Ultraviolet; Hydrogen Through Krypton" NASA Technical Memorandum 80268, (April 1979). |

Title: Spectroscopic Data Center Compilations of Vacuum Ultraviolet Spectra

Investigators: Raymond L. Kelly, Professor of Physics

Sponsor: Office of Standard Reference Data, National Bureau of Standards

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 1983.

Title: Investigation of Underwater Acoustic Parameters in the Arctic

Investigators: P. H. Moose, Associate Professor of Electrical Engineering, and H. A. Dahl, Assistant Professor of Physics

Sponsor: Naval Surface Weapons Center

Objective: To analyze acoustic backscattering (reverberation) and propagation data taken in the Artic. To identify requirements for further acoustic data gathering in Arctic waters.

Summary: Acoustic backscattering measurements were made by personnel from the Applied Physics Laboratory, University of Washington, in the marginal ice zone of Baffin Bay in the time period of 23 February to 20 March 1976. Measurements were made at frequencies of 20, 60, and 105 kHz in waters of depth to about 1000 meters. The data from these measurements were recorded in analog form on magnetic tape, but were never previously analyzed.

The volume reverberation tapes were analyzed in this report period by one of us (and by a student) at APL using the APL/UW PDP 11-45 computer in conjunction with signal digitizing circuits and programs developed at APL specifically for this project. The analysis proved disappointing in that the measured volume scattering coefficients were not reproducible from run to run with any great accuracy. The timing of the returning echo seems to have been erratic. With these uncertainties overlooked, the measured volume scattering strengths proved to be lower by about 10 dB than those measured off Alaska by APL in 1974.

Magnetic tapes and strip chart transcriptions of sound pulses emitted under the ice by a moving source and detected under the ice in the Chukchi Sea off Alaska on 25 October 1978 by APL/UW personnel were alos partially analyzed at APL by one of us. The relatively small number of reliable data points obtained for different ranges have provided under-ice transmission loss values of only limited scope. More complete analysis of these transmission loss data and comparison with a theoretical model must yet be made.

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| Title: | Internal Explosions with Reactive Metal Present |
| Investigators: | R. A. Reinhardt, Professor of Chemistry, and G. F. Kinney, Distinguished Professor of Chemistry Emeritus |
| Sponsor: | Naval Weapons Center |
| Objective: | Continuation of the computational investigation of chemical equilibria and overpressures resulting from the internal explosions of conventional and explosive fuels in the presence of reactive metals. |
| Summary: | Calculations have been started for systems containing air, fuel, and both aluminum and magnesium. A severe complication not encountered in previous systems, is the interaction of the metal oxides, including the formation of the compound spinel (magnesium aluminate). Programming has been accomplished for the first stage of approximation, which considers no mutual solubilities of the metal oxides in either liquid or solid phase. A number of trial calculations on this unrealistic basis has been carried out, with satisfactory convergent solutions in about 90% of the cases chosen. |
| Publication: | R. A. Reinhardt and A. K. McDonald, "Adiabatic Computation of Internal Blast from Aluminum-cased Charges in Air", NWC Technical Publication 6287, China Lake, CA, (forthcoming). |

Title: Transmission of Acoustic Energy from a Fluid Wedge into a Fast Bottom

Investigators: James V. Sanders and Alan B. Coppens, Associate Professors of Physics

Sponsor: Office of Naval Research

Objective: To develop the ability to predict the properties of a sonic beam transmitted into a fast bottom underlying a wedge-shaped fluid-like layer.

Summary: This is a continuation of an ongoing project. Since the summary presented in last year's activity report, a commercial sand (#30 fine) has been shown to have the values of density, speed of sound, and attenuation suitable for modeling the problem in a laboratory size facility. With proper degassing procedures, the reflection and transmission coefficients of the sand at normal incidence have been shown to be in agreement with those predicted from the measured values of density and sound speed. This demonstrates that microbubble retention need not be a serious problem and that measurements made with buried receivers will be reliable. An experimental facility has been designed to make measurements over and within a sloping sand bottom. The tank will be 10 ft long, 4 ft wide, and 3 ft deep, and will allow bottoms with slopes greater than 6° to be studied at 100 kHz. The source can be positioned 20 dump distances or more from the shore, and the beam in the bottom can be measured at distances at least 10 dump distances inland from the shore. The latest computer program for the WANG, WEDGE 13, the thirteenth generation program based on the simple physical model (incorporating stationary phase and steepest descent approximations) is virtually complete. One revision is required to approximate the pressure just beneath the boundary, and then complete agreement is expected between

the WEDGE program and the older and more time consuming ASMT program. Losses in the bottom have been incorporated and the subroutine incorporating the effect of bottom losses on the reflection coefficient has been designed and implemented.

Publications: A. B. Coppens, J. V. Sanders, G. I. Ioannou, and M. Kawamura, "Two Computer Programs for the Evaluation of the Acoustic Pressure Amplitude and Phase at the Bottom of a Wedge-Shaped, Fluid Layer Overlying a Fast, Fluid Half Space", NPS Technical Report, NPS-61-79-002, 1980.

Theses Directed: J. Bradshaw, "Laboratory Study of Sound Propagation into a Fast Bottom Medium", Master's Thesis, June 1981

Title: Comparison of Satellite Determined Friction Velocities with Surface Measured Values, Stability Effects

Investigator: G. E. Schacher, Professor of Physics, Department of Physics and Chemistry, and K. L. Davidson, Associate Professor, Department of Meteorology

Sponsor: National Oceanic and Atmospheric Administration

Objective: Compare surface measured and satellite determined friction velocities to assess the effects of atmospheric hydrostatic stability.

Summary: The algorithm for determining surface winds from radar backscatter has been developed and validated using 19.5 m neutral winds. It is more reasonable to assume that backscatter depends on the wind stress at the surface and that the friction velocity rather than the wind should have been used. Until this time uncertainty in the wind speed - surface stress relationship prevented this from being done, but recent evaluation of the relationship using the extensive NPS data sets has changed the situation. Initial comparison of satellite and surface measured friction velocities for the JASIN experiment shows differences that may be due to incorrectly accounting for stability in the algorithm development. Completion of the project awaits delivery of satellite data for the MABLE experiment by NOAA.

Publications: G. E. Schacher, W. L. Jones, "The Seasat-A Satellite Scatterometer: The Geophysical Evaluation of Remotely Sensed Wind Vector", submitted to Journal of Geophysical Research.

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| Title: | Experimental Investigation of Electromagnetic Interference Zones during Ducting Conditions |
| Investigator: | G. E. Schacher, Professor of Physics |
| Sponsor: | NPS Foundation Research Program and Naval Ocean Systems Center |
| Objective: | Investigate the interference pattern produced by multimode propagation in an atmospheric electromagnetic duct. |
| Summary: | During September, 1980 signal strength measurements were performed over a 150 nmi range on Monterey Bay for a two week period. An aircraft carried a UHF transmitter and the receiver was located on Pt. Pinos. The aircraft had a complete suite of meteorological sensors so that the properties of the atmosphere were determined. Non-monatonic variations of signal strength with range were detected. The coupling of electromagnetic energy into the duct when the transmitter was outside its boundaries was found to be larger than predicted. Analysis of the data is proceeding. |

Title: Marine Boundary Layer Modeling for the Aerosol Contribution to Optical Extinction

Investigator: G. E. Schacher, Professor of Physics, Department of Physics and Chemistry, and K. L. Davidson, Associate Professor, Department of Meteorology

Sponsor: Naval Ocean Systems Center (EO/MET program)

Objective: Validate a model that will have real time assessment capability and the ability to predict on a 6-24 hour time period the affect of aerosols on optical propagation in the marine atmospheric boundary layer.

Summary: Several tasks have been completed to check the physical assumptions of the modeling approach. They are:
a. Verification of Wells, Munn, Katz (WMK) equilibirum model using CEWCOM-78, JASIN, and MAGAT data sets;
b. Verification of physical assumptions of the integrated model approach and verification of the NPS model using CEWCOM-78 and MAGAT data;
c. Verification of the ability to determine optical extinction from aerosol size distribution measurements using MAGAT data;
d. Completed STREX experiment and preliminary reduction of aerosol data.

Publications: G. E. Schacher, K. L. Davidson, and C. W. Fairall, "Calculation of Optical Extinction from Aerosol Spectral Data", Applied Optics, Nov 1, (1981).

G. E. Schacher, K. L. Davidson, and C. W. Fairall, "Optical Aerosol Spectrometers: Factors Affecting Optical Extinction Predictions", NPS Technical Report, NPS 61-80-013 (1980).

G. E. Schacher, C. W. Fairall, and K. L. Davidson, "Atmospheric Optical Propagation Comparisons During MAGAT-80", NPS Technical Report, NPS-61-81-002, (1981).

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| Title: | Measurement of Sea-Surface Temperature by the SEASAT Scanning Microwave Radiometer in the Near Coast Regime |
| Investigator: | G. E. Schacher, Professor of Physics |
| Sponsor: | National Oceanic and Atmospheric Administration |
| Objective: | Determine the validity of SEASAT satellite sea-surface temperature determinations in the near coast regime. |
| Summary: | Sea-surface temperatures determined by the SEASAT radiometer during the JASIN experiment have been obtained from JPL. They have been compared to measurements from ships and buoys that participated in the experiment. It has been found that by a judicious choice of type of orbit (ascending or descending) and orbit location it may be possible to obtain accurate temperature determinations to within 200 km of the coast. |
| Publications: | G. E. Schacher, J. Jarrell, and G. Lucas, "SMMR-JASIN Sea-Surface Temperature Comparisons, the Near Shore Regime", submitted to Jour. of Geophysical Research. |

Title: Overwater Tracer Studies in the California Coastal Region

Investigator: G. E. Schacher, Professor of Physics, Department of Physics and Chemistry, and K. L. Davidson, Associate Professor, Department of Meteorology

Sponsor: Bureau of Land Management

Objective: Conduct tracer experiments in order to parameterize air pollution models for the overwater regime.

Summary: Two two-week tracer experiments have been conducted off Ventura, CA in cooperation with Aerovironment, Inc. The data have been completely evaluated and used to validate Gaussian and trajectory models. The commonly used Pasquill stability classification scheme has been reparameterized for the overwater regime. It was found that the transport and dispersion in this area are controlled by area geographic effects.

Publications:

G. E. Schacher, F. Shair, E. Saski, D. Carlan, G. Cass, W. Goodwin, and J. Edinger, "Transport and Dispersion of Airborne Pollutants Associated with the Land-Sea Breeze System", accepted Atmospheric Environment.

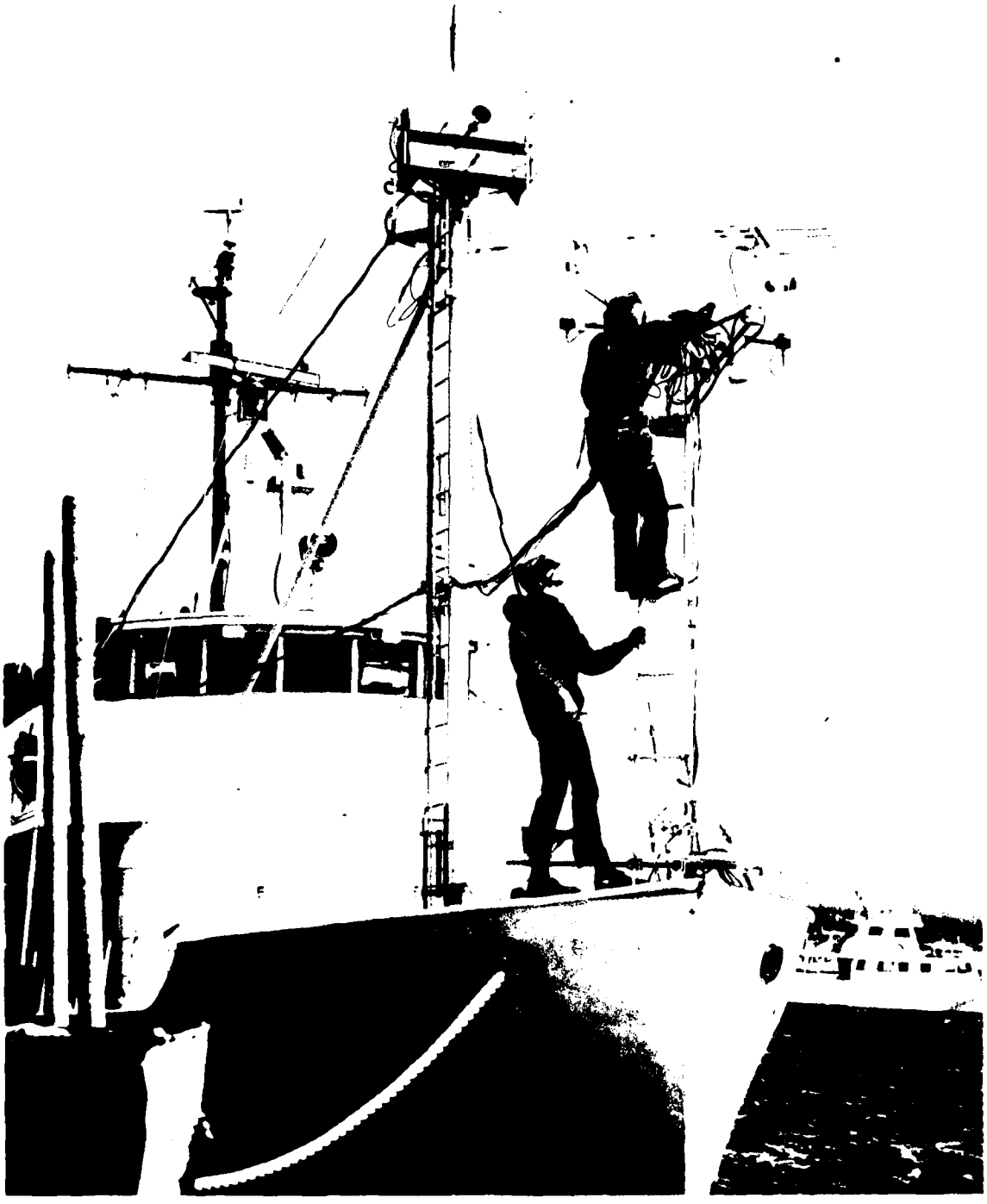
G. E. Schacher, C. W. Fairall, and K. L. Davidson, "Atmospheric Boundary Layer Convective Mixing Velocities in the California Coastal Region", accepted Atmospheric Environment.

G. E. Schacher, J. Jarrell, K. L. Davidson, and C. W. Fairall, "Observational Results Pertaining to Scatterometer Interpretations", Oceanography from Space, Ed. J.F.R. Gower, Plenum Press, N.Y., 597-607 (1981).

G. E. Schacher, K. L. Davidson, C. W. Fairall, and D. E. Spiel, "Offshore Transport and Diffusion in the Los Angeles Bight-I, NPS Data Summary", NPS Technical Report, NPS-61-81-004 (1981).

G. E. Schacher, K. L. Davidson, and C. W. Fairall, and D. E. Spiel, "Offshore Transport and Diffusion in the Los Angeles Bight-II, NPS Data Summary", NPS Technical Report, NPS-61-81-025 (1981).

G. E. Schacher, P. Zannetti, D. Wilbur, and B. Baxter, "Southern California Offshore Air Quality Model Validation Study", Aerovironment, Inc. report AV-FR-81/559 (1981).



PROFESSOR GORDON E. SCHACHER AND CHRIS FAIRALL INSTALLING INSTRUMENTATION ON R V ACANIA FOR OBSERVATIONAL STUDIES ON THE MARINE ATMOSPHERIC BOUNDARY LAYER.

Title: *Impurities in Tokamaks*

Investigators: F. Schwirzke, Associate Professor, Department of Physics and Chemistry and R. J. Taylor, Center for Plasma Physics and Fusion Engineering, University of California, Los Angeles

Sponsor: Research at UCLA supported by the Department of Energy

Objective: In this project methods of impurity control are studied and diagnostics are developed.

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. 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.

Surface analytic techniques like auger spectroscopy, SEM and energy electron diffraction have been used to measure after many discharges the integrated accumulation of impurities on titanium coated surfaces. The resiliency of metals and protective coatings to plasma contact and unipolar arcing has been studied.

Publications: R. J. Taylor, R. F. Bunshah, and F. Schwirzke, "Impurity Control of Tokamaks with In Situ Metal Deposition", Journal of Nuclear Materials, 94 & 95, p 780-784, (1980).

F. Schwirzke, R. F. Bunshah and R. J. Taylor, "Observation of Unipolar Arc Damage on Stainless Steel and TiC Coatings on Stainless Steel", Thin Solid Films, 83, 117 (1981).

L. Keller, C. N. J. Wagner, F. Schwirzke and R. J. Taylor, "Analysis of Titanium Coatings Deposited and Operated in Macrotor and Microtor", Journal of Nuclear Materials, forthcoming.

Conference Presentations:

F. Schwirzke, R. J. Taylor, L. Keller and C. Wagner, "Analysis of Titanium and Chromium Coatings from Surfaces of Macrotor and Microtor", Twenty-second Annual Meeting of the Division of Plasma Physics of The American Physical Society, San Diego, California, November 10-14, 1981.

F. Schwirzke, R. F. Bunshah and R. J. Taylor, "Observation of Unipolar Arc Damage on Stainless Steel and TiC Coatings on Stainless Steel", International Conference on Metallurgical Coatings, San Francisco, California, April 6-10, 1981.

L. Keller, F. Schwirzke, R. J. Taylor and C. N. J. Wagner, "Analysis of the Microstructure of Titanium Coatings Formed in the UCLA-Macrotor", 1981 IEEE International Conference on Plasma Science, Santa Fe, New Mexico, May 18-20, 1981.

R. J. Taylor, P. Lee, N. C. Luhmann, Jr., A. Mase, G. J. Morales, W. A. Peebles, A. Semet, F. Schwirzke, S. Talmadge, S. J. Zweben, M. A. Hedemann, B. S. Levine, and R. W. Gould, "ICRF Heating and Particle Transport in Tokamaks", Plasma Physics and Controlled Nuclear Fusion Research, Nuclear Fusion Supplement 1981, 8th Conf. Proceedings, Volume II, pp 61-73, Brussels, 1980.

Title: Plasma Surface Interaction

Investigator: F. Schwirzke, Associate Professor of Physics and Chemistry

Sponsor: NPS Foundation Research Program

Objective: To investigate unipolar arc damage of several materials, including stainless steel and TiC

Summary: Plasma-surface effects are of importance during the operation of high power plasma facilities like beam weapons, some high power lasers, high power x-ray generators, high power switches and controlled thermonuclear fusion devices, when material surfaces are exposed to particle and photon fluxes from a hot plasma. Such exposure causes surface damage via physical and chemical sputtering, evaporation and unipolar arcing. The last one, arcing represents one of the most damaging plasma-surface interaction processes. Arc craters produced by plasma surface contact were detected with the scanning electron microscope on a stainless steel surface which was exposed to the plasma produced by a Q-switched Laser pulse. The laser produced plasma with an electron temperature of about 100 eV expands rapidly from the focal spot on the target surface in normal and in radial direction. Although no external voltage is applied, about 20,000 unipolar arc craters are observable on the stainless steel surface which was exposed to the radially expanding plasma for the short time of a few hundred nanoseconds. The size of the arc craters become smaller with increasing distance from the focal spot. This evidence shows that a laser produced plasma can be used to study plasma-surface effects. A new unipolar arc model has been developed.

**Publications:**

F. Schwirzke and R. J. Taylor, "Surface Damage by Sheath Effects and Unipolar Arcs," Journal of Nuclear Materials, 94 & 95 (1980) 780.

F. Schwirzke, R. F. Bunshah and R. J. Taylor, "Observation of Unipolar Arc Damage on Stainless Steel," Thin Solid Films, 83 (1981) 117.

**Conference Presentations:**

F. Schwirzke, "Unipolar Arcing," Invited Paper, 1981 IEEE International Conference on Plasma Science, Santa Fe, NM, May 18-20, 1981.

F. Schwirzke, J. H. Barker III, M. T. Keville, R. W. Lautrup, R. J. Rush, and R. J. Taylor, "Unipolar Arc Studies on Selected Materials," 1981 IEEE International Conference on Plasma Science, Santa Fe, NM, May 18-20, 1981.

F. Ryan and F. Schwirzke, "The Role of Grain Boundaries in Cold Cathode Arc Initiation," 1981 IEEE International Conference on Plasma Science, Santa Fe, NM, May 18-20, 1981.

F. Schwirzke, R. F. Bunshah and R. J. Taylor, "Observation of Unipolar Arc Damage on Stainless Steel and TiC Coatings on Stainless Steel," International Conference on Metallurigical Coatings, San Francisco, CA, April 6-10, 1981.

F. Schwirzke, "Unipolar Arcs," NATO Advanced Study Institute on Electrical Breakdown and Discharges in Gases, Les Arcs, France, June 28-July 10, 1981.

**Theses Directed:**

J. H. Barker III and R. J. Rush, "An Investigation of Plasma-Surface Interactions on Selected Conductors and Insulators," Master's Thesis, December 1980.

F. T. Ryan and S. T. Shedd, "A Study of the Unipolar Arcing Damage Mechanism on Selected Conductors and Semiconductors," Master's Thesis, June 1981.

M. H. Beelby and H. G. Ulrich, "A Study of the Breakdown Mechanism of AISI 304 Stainless Steel, AISI 2024 Aluminum and Various Titanium Coatings," Master's Thesis, December 1981.

Title: Study of Basic Mechanisms that Lead to Laser Target Damage

Investigators: F. Schwirzke, Associate Professor of Physics

Sponsor: Naval Research Laboratory

Objective: To determine the threshold value of laser irradiance for the onset of breakdown and arcing.

Summary: Unipolar arcing has been shown to be the primary damage mechanism when a plasma is formed in laser metal-target interaction. About 300,000 to 500,000 arc craters per $cm^2$ have been observed on laser illuminated metal surfaces although no external voltage is applied. Cratering was observed even with a defocused laser. The minimum laser power density required for the onset of breakdown on the surface is also sufficient to cause arc damage. Once breakdown occurs, arcing also occurs. Never was there a plasma evident without attendant unipolar arcs.

Unipolar arcing concentrates the available laser-plasma energy towards the cathode spots. Metal erosion is much more severe than for homogeneous energy deposition. Our model shows that the local increase of the plasma pressure above the cathode spot leads to an increased electric field to drive the arc current. This research has wide spread applications. Any situation in which a plasma exists there will be plasma surface interactions. The physics relates to other forms of electrical breakdown on surfaces and electrodes.

Publications: F. Schwirzke, M. H. Beelby and H. A. Ulrich, "Basic Mechanisms that Lead to Laser Target Damage", NPS Technical Report, NPS-61-82-002, October 1981.

Theses Directed: M. H. Beelby and H. A. Ulrich, "A Study of the Breakdown Mechanism of AISI 304 Stainless Steel, AISI 2024 Aluminum and Various Titanium Coatings", Master's Thesis, December 1981.

Title: Measurement of Underwater Acoustic Noise Due to Surf Phenomena

Investigators: O. B. Wilson, Professor of Physics, and H. A. Dahl, Assistant Professor of Physics

Sponsor: NPS Foundation Research Program

Objective: To determine by means of a steerable receiving array the horizontal anisotropy of ambient noise in Monterey Bay under a variety of sea conditions and ranges from shore.

Summary: This was a continuation of the ambient noise directionality measurements in Monterey Bay begun in a previous year. As in the earlier work the measurements were made using Difar sonobuoys were modified to extend their lifetimes to periods of several days. The modified buoys, however, did not prove to be entirely reliable, often failing within a period of a few hours. Computer programs were written to facilitate the measurement and graphic recording of sonobuoy sensitivities prior to deployment in the water. Computer programs that process real time noise data and plot the results as normal, surf conditions in the spring and summer, showed significant anisotropy in the ambient noise, being as much as 10 dB more pronounced in the shoreward direction, for ranges out to 15 km from the beach in the frequency band of 20 Hz to 700 Hz.

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| Title: | Range Studies Program |
| Investigators: | O. B. Wilson, Jr., Professor of Physics, G. L. Sackman, Professor of Electrical Engineering |
| Sponsor: | Naval Undersea Warfare Engineering Station, |
| 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: | About 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.<br><br>The investigators serve as coordinators for this program and as individual investigators. The program task titles for this reporting period include: Kalman Filtering Applications; Improvements in Accuracy Tests for Sonar and Weapons Systems; Electromagnetic Wave Propagation Studies; Acoustic Imaging in Sediment; Torpedo Path Smoothing Fiber Opticsin Underwater Range Applications; Planning for Measurements of Directionality of Ambient Noise. |
| Publications: | O. B. Wilson, Jr., "Annual Summary Report of Range Studies Program", NPS Project Report, NPS-61-82-001 PR, October 1981. |

Title. Underwater Acoustic Noise Due to Surf Phenomena

Investigators: O. B. Wilson, Professor of Physics, and Harvey A. Dahl, Assistant Professor of Physics, Department of Physics and Chemistry. Stephen N. Wolf, Naval Research Laboratory

Sponsor: NPS Foundation Program and Naval Sea Systems Command

Objective: To determine whether surf generated noise is a significant component of the shallow water ambient noise. This is a continuation of work started in FY 1980.

Summary: Horizontal directionality of ambient noise was measured at ranges up to 15 km from the eastern shore of Monterey Bay, California. Water depths at the sites ranged from 8 to 175 m. A steerable cardioid receiving pattern was formed using signals telemetered from dipole and omnidirectional hydrophones suspended from tethered buoys. With no nearby shipping, whenever the maximum of the cardioid pattern was directed toward the beach, noise levels in the range 20 to as much as 700 Hz were greater than those obtained when the maximum was directed seaward. This difference or anisotropy (seaward vs. shoreward), which depended on range from the beach and on frequency, was 10 dB at 300 Hz at the 9 km site during very heavy surf. Surf beat was clearly audible when the cardioid maximum was steered shoreward at ranges as great as 2 km. During heavy surf, the ambient noise levels increased significantly in the same frequency range at which the anisotropy is evident. Also, the spectrum levels at these same frequencies decreased with increasing range from shore. The anisotropy diminished both in magnitude and in frequency range with lower wave height but was still observable during very light surf. The evidence is very strong that when wind and surf are high, breaking surf can contribute significantly to ambient noise in fairly deep continental shelf waters.

Publications: A manuscript for a Technical Report is in preparation. These results will also be submitted to the Journal of the Acoustical Society of America for publication as a paper.

Conference Presentations: The results will be reported at the December 1981 meeting of the Acoustical Society of America. Results of work in 1980 were presented at a similar meeting in Nov 1980.

Thesis Directed: J. Gagliardi, "Measurements of Horizontal Directionality of Ambient Noise in Monterey Bay", Master's Thesis, December 1981.

# DEPARTMENT

# OF

# ELECTRICAL ENGINEERING

## ELECTRICAL ENGINEERING DEPARTMENT

The Research Program of the Electrical Engineering Department covers the following areas: Electronic Warfare Systems; Electromagnetics, Antennas and Microwaves; Communications; Signal Processing; Range Studies; Digital Systems; Control Systems; and Command, Control and Communications (C3). Projects in these areas generally involve one or more faculty members working with several thesis students.

### ELECTRONIC WARFARE SYSTEMS (EW)

Professor Lonnie Wilson continued his research on electronic support measures (ESM), target classification, and signal processing. An analysis was performed to determine the effectiveness of classic emitter parameters for emitter sorting and emitter classification. Prof. Wilson also continued his research on automatic ship target classification using a radar sensor. Several ship classification techniques are currently under investigation and preliminary classification analysis and results are encouraging.

Prof. Wilson initiated two research programs. One concerns the theoretical analysis of the modulation-on-pulse (MOP) signature. The other involves multi-sensor track management (MSTM). It is thought MOP may result in a significant signature for emitter sorting and classification. Theoretical analysis and system tradeoff analysis for the MSTM function of the Advanced Combat Direction System are being pursued.

A program to analyze the effects of various ECM against Soviet missile systems was continued by Professor Harold Titus. A simulation was conducted on ECM against the SA-6, SA8, and SA11 missiles.

Prof. Titus is also developing a Kalman Filter torpedo tracking program for the range at NUCWES and is studying sensor integration in USMC surveillance problems.

### ELECTROMAGNETICS, ANTENNAS, AND MICROWAVES

Professor O.M. Baycura found microcomputer RF radiation exceeded FCC standards and emission reduction was impossible because keyboard radiation could not be stopped by metallic screens. Replacement of keyboard plastic covers was too costly.

Professor Steven Jauregui is continuing work on shipboard, submarine and shore based noise and interference problems as seen by radio receiving systems. Recent data has been taken aboard one outboard ship and one underway submarine. Work is being done on both HF line of bearing and time difference of arrival location techniques. Prof. Jauregui and thesis students will participate in a feasibility test of TDOA in the Bermuda Triangle in Mar 82.

Professors Jeffrey Knorr and Kenneth Gray continued their project on transmission media for millimeter wave integrated circuits. A theoretical and experimental investigation of the equivalent reactance of a septum discontinuity in fin-line was completed. Studies involving several other discontinuities are in progress.

Prof. Knorr initiated a project on development of a simplified elevated duct propagation code. This code should make it possible to carry out elevated duct circuit calculations using a desk-type computer.

Professor Michael Morgan continued his work on radar target identification by investigating optimum signal processing methods for extracting complex natural resonances in presence of noise and clutter. Prof. Morgan also continued the supporting analysis and measurement of nuclear EMP vulnerability of the Standard Missile.

Additionally, Prof. Morgan initiated a new experimentally oriented project for broadband evaluations of radar cross sections of aircraft by use of transient measurements of scattering from scale models.

Prof. Gray continued his work on radio frequency interference (RFI) in support of the Navy EHF Satellite program. Recent work involved characterizing the expected RFI environment due to carrier-based aircraft transmitters.

Professors Paul Moose and Otto Heinz (Physics) have obtained and analyzed initial data from the magnetic monitoring station at Chew's Ridge. Preliminary comparison with data in the same frequency range from the floor of Monterey Bay indicates the ocean data is 10-20 dB higher in intensity. A 3-axis sensor is being installed at Chew's Ridge and a telemetry link is being established to the sea floor instruments so coherence studies can be carried out. This ongoing project has been joined by Dr. Mike Thomas of APL/JHU who will spend a year at NPS working with Professors Moose and Heinz.

SIGNAL PROCESSING

Equipment needed by Prof. Jauregui for the automatic voice exploitative problem has arrived and work is progressing in the language identification and uncooperative keyword recognition continuing projects. LT Jay Benson is working on this program with Prof. Jauregui in hopes of having this capability in a microprocessor size system eventually.

Professor Sydney Parker continued his research in the application of signal processing techniques to the macroscopic modeling of linear and nonlinear circuits. The multichannel lattice parameter approach has been applied successfully to the identification of faults in an analog operational amplifier circuit obtained from NOSC and to the discrete time modeling of a phase locked loop. Continuing effort is directed toward improving modeling procedure efficiency and toward analytical studies to gain insight into signal processing procedures.

Professor John Powers continued work on his projects on computer-aided acoustical imaging and techniques of accusto-optical RF signal analysis. Data acquisition and image display methods were improved and a design implemented on a microcomputer system to control detector scan and data collection. For the second project, effort continued on modeling the Bragg cell interaction on an interactive bases.

In an ongoing project by Professor George Sackman a prototype digital receiver beamformer has been implemented using the trace function concept and using multiple microprocessors to accomplish simultaneous parallel and pipeline

processing of acoustic data in real time. A prototype transmitting transducer using the parametric self-demodulation effect has been constructed.

COMMUNICATION

Professor Glen Myers initiated a project on low-probability-of-intercept (LPI) communications using asynchronous receivers. Spread spectrum techniques are used and results are encouraging.

Prof. Myers initiated an additional project on use and performance of a simple circuit to generate arbitrary composite ASK and PSK carriers for simultaneous transmission of 4 bits of digital data.

Prof. Myers continued a project to measure probability of error versus signal-to-noise ratio (SNR) for various types of combined ASK and PSK.

Prof. Gray has brought the Satcom Signal Analyzer (SSA) program to completion. The prototype system is in the process of being transferred to NAVELEX.

RANGE STUDIES

Work on fiber optic applications for underwater ranges continued under direction of Prof. Powers. Work done involved design and testing of PCM modulation formats, design and test of an underwater video line using a diver's handheld camera and bi-directional interconnection of a computer and its peripheral devices over a single fiber.

DIGITAL SYSTEMS

Professor Tien Tao continued a project on the development of a distributed multiple microcomputer system for concurrent computing and fault tolerance applications. A multiple cluster architecture has been selected. Hardware and software have been developed such that the system can be used for application programs. Three image processing applications for surveillance using combined parallel and pipeline computations are being implemented. Two of these applications also include fault tolerance capabilities. One multiple sensors/multiple tracks applications, also for surveillance, is being implemented. The image processing project consists of an end-to-end program which includes adaptive spatial/temporal filters for background clutter suppression, adaptive distribution free thresholding, target acquisition to discard fault target hits and track association using pattern test based on several combined spatial, temporal, and spectral information.

Professors Mitchell Cotton, Rudolf Panholzer, and Uno Kodres (Computer Science) continued a project investigating application of parallel microcomputer networks to large scale, real time problems (AEGIS radar control and tracking). A hierarchial processing mode and bus architecture have been evolved and they are well matched to system requirements.

Systematic methods for module design and process synchronization and intercommunication have been developed. A computer simulation program which will model in realtime phased array radar performance is being developed.

CONTROL SYSTEMS

Professors Alex Gerba and George Thaler continued work on their project on a sequential steering algorithm for the Project Courageous Programs. An automatic, regulator type of control design has been developed. This design lends itself to improved performance through Kalman Filtering and adaptive control techniques.

A project on control system design studies was continued by Professors Robert Strum and Donald Kirk. A new design for strategic missile control included a digital elliptic bandpass filter and a Kalman Filter for center-frequency estimation.

COMMAND, CONTROL AND COMMUNICATIONS (C3)

Prof. Moose received foundation support to develop a theoretical model for modern military conflicts. Sensitivity and stability analyses are being carried out. A mathematical technique has been developed to determine a system equilibrium point as a solution to a linear problem. This technique guarantees stability predictions of phase changes are practical possibilities.

Professor John Wozencraft continued work on designing robust communication networks for tactical command and control and on developing analytical procedures for optimizing the redistribution of forces in response to an uncertain threat.

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| Title: | Digital System Electromagnetic Interference Study |
| Investigator: | O. M. Baycura, Professor of Electrical Engineering |
| Sponsor: | Naval Air Systems Command |
| Objective: | To study the magnitude polarization and frequency of the electromagnetic radiation from a TRS-80 digital computer. |
| Summary: | The radiated frequencies of the TRS-80 computer ranged from 1 - 310 MHz in both polarizations and exceeded FCC radiation limits for indoor and outdoor environments.<br><br>Shielding was tried to reduce the radiation but suppression in indoor and outdoor locales was different for identical shielding caused by the connected cabling. Suppression by extensive shielding of the keyboard reduces the radiation by 60% in both environments. |
| Publication: | O. M. Baycura, C. Hollands and D. Achyanto, "Digital System Electromagnetic Interference," NPS Technical Report, NPS-62By-80-022TR, December 1980. |
| Thesis Directed: | C. Hollands and D. Achyanto, "Digital System Electromagnetic Interference," Master's Thesis, December 1980. |

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|---|---|
| Title: | NPS Sequential Steering Algorithm, Project Courageous Program |
| Investigators: | A. Gerba, Jr., Associate Professor of Electrical Engineering and George J. Thaler, Distinguished Professor of Electrical Engineering. |
| Sponsor: | Naval Underwater Systems Center, Weapons Technology Program Office |
| Objective: | A continuing program to design and develop advanced control schemes which successfully optimize the torpedo steering performance for Project Courageous. |
| Summary: | Work on this project continued throughout the year with major emphasis on the development of a search algorithm by thesis student Carpenter using the modern interactive Vector General Graphics terminal in the NPS Computer Laboratory. Considerable progress was accomplished in reaching the desired goals, however, the task is so complex that much work yet remains in order to complete the objectives. The complete solution to the problem involves the need for both a tracking and a search control algorithm and the present effort is directed towards a more generalized direction-vector control scheme that will incorporate both tracking and search patterns of control. |

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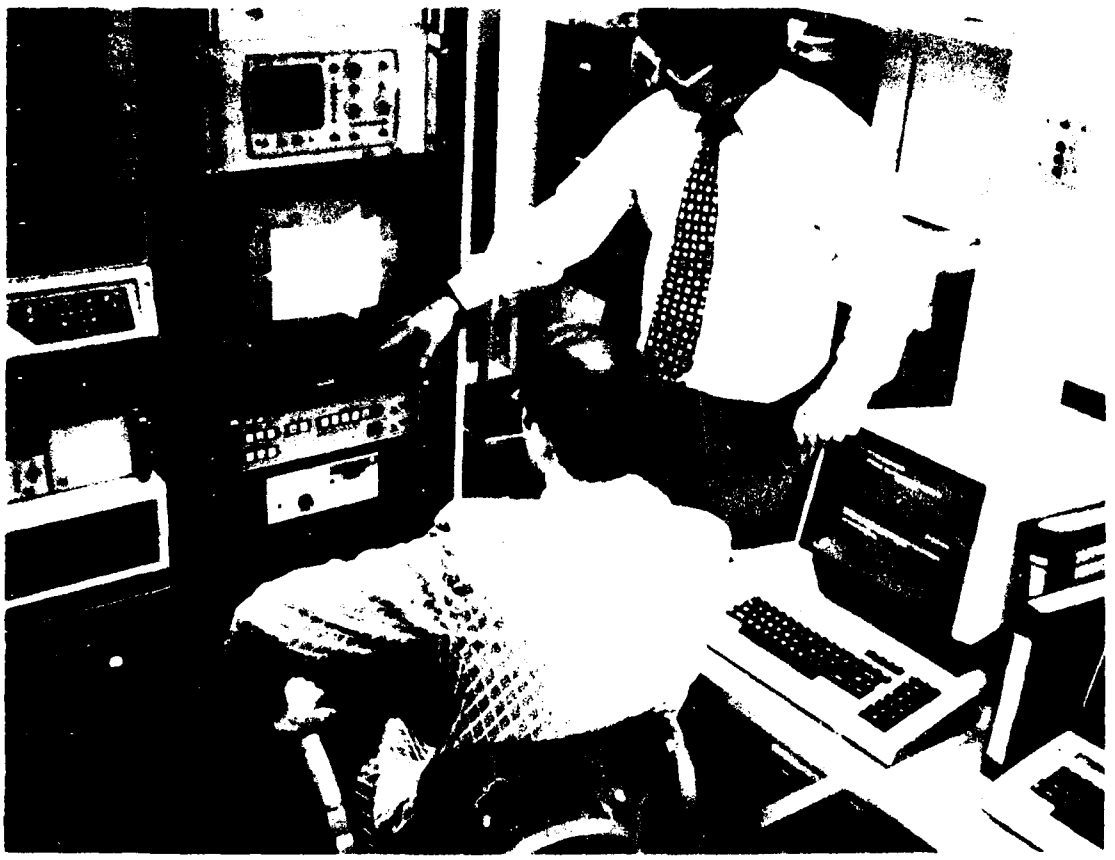
|---|---|
| Title: | Aircraft and Missile RFI at Microwave Frequencies |
| Investigator: | Kenneth G. Gray, Associate Professor of Electrical Engineering |
| Sponsor: | NAVELEX |
| Objective: | To determine the effects of missile and aircraft RFI on future U.S. Navy EHF satellite communication systems. |
| Summary: | The shipboard RFI threat at 7, 20, and 40 GHz was ascertained. In this phase of the project, radars on carrier-based aircraft and emitters on shipboard missile systems were considered. |
| Publications: | K. G. Gray and J. E. Ohlson, "A System for Shipboard RFI Measurements at Microwave Frequencies", submitted for publication in IEEE Trans. on Electromagnetic Compatibility.<br><br>K. G. Gray and D. Hammer, "Aircraft and Missile RFI at Microwave and Millimeter Wave Frequencies", NPS Technical Report (forthcoming). |
| Conference Presentation: | K. G. Gray and J. E. Ohlson, "The Measurement of Shipboard RFI at Microwave Frequencies", URSI Conference in Boulder, CO, January 1982. |
| Thesis Directed: | D. Hammer, "Aircraft and Missile RFI for Navy EHF Satellite Program", Master's Thesis, June 1981. |



THE OPERATION OF THE SATELLITE COMMUNICATIONS SIGNAL ANALYZER IS BEING DEMONSTRATED FOR A STUDENT BY PROFESSOR K. GRAY. THE ANALYZER WAS BUILT BY STUDENTS AND FACULTY AT NPS AND WILL BE USED BY THE NAVY TO MONITOR UHF SATELLITE COMMUNICATIONS.

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| Title: | An Investigation of HF Multicoupler Investigations |
| Investigator: | Stephen Jaurequi, Jr., Adjunct Professor of Electrical Engineering. |
| Sponsor: | Naval Electronic Systems Command |
| Objective: | To determine tradeoffs in measuring spurious free dynamic range on HF (2-32 miles) multicouplers using the two-tone and wideband noise methods. |
| Summary: | Data was taken using both the standard two-tone test and the Marconi noise test, used for testing superchannels on telephone circuits, as drivers into standard HF multicouplers used at Navy receiving stations. Difficulties were encountered in obtaining enough pure signal drive from signal generators to do the two-tone tests without confusing spurs from the signal generators with intermodes from the multicouplers. This was overcome by putting an intermediate power simulator and filters between the multicoupler and the signal generators.<br><br>The noise sources were used to drive the same intermediate simulators that were used for the two-tone tests. Procedures were formulated and relative measurements were made on these high dynamic range broadband HF multicouplers. Absolute measurement techniques will be determined in follow-on work. |
| Thesis Directed: | J. Jacobs, "An Investigation of Multicoupler Specifications", Master's Thesis, September 1981. |

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|---|---|
| Title: | An Investigation Into Soviet Radar Design Flexibilities and Possibilities of War Time Operational Changes |
| Investigator: | Stephen Jauregui, Jr., Adjunct Professor of Electrical Engineering. |
| Sponsor: | Naval Electronic Systems Command |
| Objective: | To determine practical limitations of radar change capability for war time usage. |
| Summary: | Typical soviet radars were investigated for the maximum amount of parameter change that could be accomplished in the field without severe degradation of operational capability. Investigations were also made as to any current evidence of such capability. |
| Theses Directed: | A. Colton, "Out-of-Band Performance of Selected Reflector Antennas", Master's Thesis, June 1981.<br><br>J. Daly, "Design Parameters for Military Radar Reserve Modes", Master's Thesis, March 1981.<br><br>W. Holloway, "Soviet Reserve Modes", Master's Thesis, March 1981. |

Title: An Investigation of Time Difference Arrival (TDOA) Technique and Line of Berring Location Systems at HF

Investigator: Stephen Jaurequi, Jr., Adjunct Professor of Electrical Engineering.

Sponsor: Naval Electronic Systems Command

Objective: To measure and determine some of the ionospheric effects and correlation techniques for HF TDOA systems and Line of Berring systems.

Summary: To augment current Line of Berring techniques for location of uncooperative HF targets, time difference of arrival techniques have been proposed. This year's work pursued improvement possibilities in Line of Berring fixing and HF TDOA techniques. The Line of Berring work utilized both propagation prediction and geometry for selecting the "best" Lines of Berring to obtain a fix. This study was simulated on the IBM 3033 computer.

The HF TDOA work utilized both predicted data and actual data to determine the effects of a rapidly changing ionosphere on the accuracy of TDOA. In addition, a mathematical analysis was made on the effects of multipath on the correlation techniques. Continuing work will address the mixture of single TDOA lines of position with Lines of Berring for better fixing.

Theses Directed: C. Jannusch, "Statistical Analysis of Three High Frequency Direction Finding Algorithms with Berring Selection Based on Ionospheric Models", Master's Thesis, September 1981.

T. Murdock, "HF TDOA Techniques", Electrical Engineer's Thesis, June 1981.

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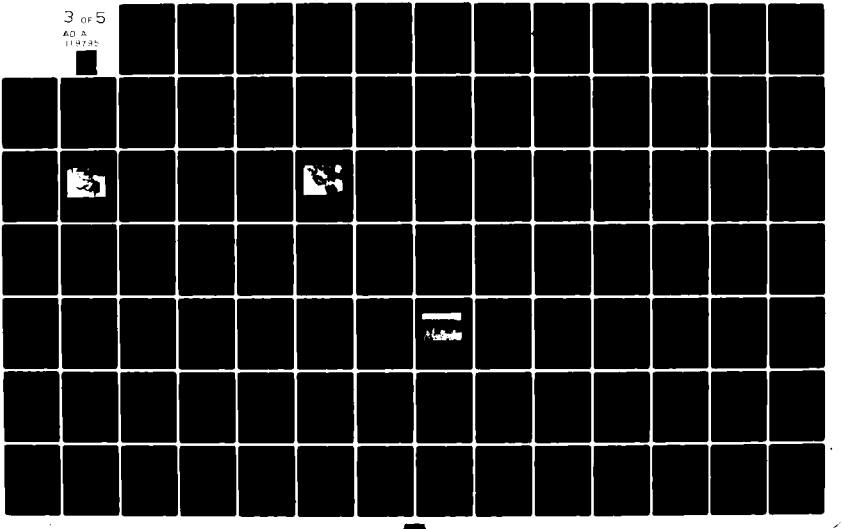

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| Title: | Noise and Interference Investigation of Shipboard Antennas |
| Investigator: | Stephen Jauregui, Jr., Adjunct Professor of Electrical Engineering. |
| Sponsor: | Naval Electronic Systems Command |
| Objective: | To determine the amount of noise and interference present in shipboard receiving antennas during operations. |
| Summary: | Measurements were made on both surface ship and submarine antenna systems to determine the amount of noise and interference, to identify the probable sources and, where possible, to recommend methods of correction. |
| Thesis Directed: | D. Simmons, "Signals and Noise in Shipboard Antenna Systems", Master's Thesis, December 1980. |

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|---|---|
| Title: | Over-The-Horizon Targeting from Surface Ships |
| Investigator: | Stephen Jauregui, Jr., Adjunct Professor of Electrical Engineering. |
| Sponsor: | Naval Electronic Systems Command |
| Objective: | To investigate various aspects of over-the-horizon targeting including signal fusing and correlation for surface ships. |
| Summary: | There are a number of problems in the over-the-horizon targeting from surface ships that need addressing. Among these are the collection of HFDF data on the target, the correlation of this data with other inputs and the expectation of firing missiles. Studies and simulations were made in this area. |
| Theses Directed: | H. Carter, "Surface Combatant Over-The-Horizon Targeting and Electronic Warfare", Master's Thesis, September 1981.<br><br>D. Stafford, "Computer Simulation of Special Intelligence Support for Outboard, Combat DF and the Cryptologic Combat Support Console", Master's Thesis March 1981.<br><br>G. Mitchell, "An Evaluation of HF System Requirements for Support of OTH DC & T", Master's Thesis, March 1981. |

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|---|---|
| Title: | Shipboard Direction Finding for HF and VHF |
| Investigator: | Stephen Jauregui, Jr., Adjunct Professor of Electrical Engineering. |
| Sponsor: | Naval Electronic Systems Command |
| Objective: | To determine best aspect of ship for HFDF accuracy and to determine effects of nearby structures on VHF DF patterns. |
| Summary: | Actual data from outboard ships calibration data was used to determine the best aspect angles for accuracy in the HF range. This was follow-on work to that reported last year on the effects of signal duration on DF accuracy for the HF antenna systems on outboard ships.<br><br>To determine the best location for the VHF mast-mounted antenna, with and without TACAN, etc., simulations were done using the Numerical Electromagnetic Simulation. |
| Theses Directed: | R. Nisbet, "Signal Azimuth of Arrival Effects on Shipboard HFDF Accuracy", Master's Thesis, March 1981.<br><br>W. Skinner', "Computer Simulation on AN/SRD-19 Mast-Mounted DF Antenna by Numerical Electromagnetic Code (NEC)", Master's Thesis, December 1980. |

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| Title: | *Use of HF Prediction To Improve HF Ship to Shore and Ship to Ship Communications* |
| Investigator: | Stephen Jauregui, Jr., Adjunct Professor of Electrical Engineering. |
| Sponsor: | Naval Electronic Systems Command |
| Objective: | To investigate the use of desk to calculator prediction capability to improve HF Shipboard communications and at the same time to decrease the probability of intercept and fix for opposition forces. |
| Summary: | An investigation was made using the miniprophet module developed by NOSC for the Tektronix 4052 desktop computer of varying HF operational techniques that might be used to increase the probability of U.S. HF communications and at the same time to decrease the opposition forces capability to intercept and locate these HF signals. |
| Thesis Directed: | C. Kennedy, "'Mini' Prophet, A High Frequency (HF) Tactical Communications Improvement System", Master's Thesis, March 1981. |

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| Title: | Millimeter Wave Transmission Media |
| Investigator: | Jeffrey B. Knorr, Associate Professor of Electrical Engineering |
| Sponsor: | NPS Foundation Research Program |
| Objective: | To determine the characteristics of transmission media for millimeter wave integrated circuits including propagation, discontinuities and circuits. |
| Summary: | An analysis of wave propagation on fin-lines has been completed and the reactance of a shorting septum in fin-line has been determined. Numerical and experimental studies of other fin-line discontinuities and circuits are in progress. |
| Publications: | J. B. Knorr & P. M. Shayda, "Millimeter Wave Fin-Line Characteristics," IEEE Trans. on Microwave Theory and Techniques, Vol. MTT-28, pp 737-743, July 1980.<br><br>J. B. Knorr, "Equivalent Reactance of a Shorting Septum in a Fin-Line: Theory and Experiment, IEEE Trans. on Microwave Theory and Techniques, Vol. MTT-29, pp 1196-1202, November 1981. |
| Theses Directed: | P. M. Shayda, "Spectral Domain Analysis of Fin-Line," Master's Thesis, December 1979.<br><br>G. Miller, "An Experimental Investigation of Some Fin-Line Discontinuities," Master's Thesis, December 1980.<br><br>S. Vlachos, "Equivalent Circuit Models for Some Fin-Line Discontinuities," Master's Thesis, June 1981. |

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| Title: | Geomagnetic Fluctuations on the Ocean Floor |
| Investigators: | Paul Moose, Associate Professor of Electrical Engineering |
| Sponsor: | Office of Naval Research |
| Objective: | The objective of this research is the study of the spatial and spectral properties of naturally occuring electromagnetic fields on and near the ocean floor. The purpose of these studies is to obtain improved long term data, to estimate sea-floor conductivities and to identify the separate origins of the contributing signal sources. |
| Summary: | During FY 81 we continued and extended our measurements of geomagnetic field fluctuations on the floor of Monterey Bay and also initiated data transmission from Chew's Ridge Monitoring Station. A comparison of our land and sea data shows that in addition to a large swell induced signature at about .07 Hz the power spectrum of the sea signals is consistently higher by 10-15 dB over the entire frequency range (.01 to 1 Hz). Simultaneous measurements of the vertical and horizontal component of the sea floor signal were carried out over the frequency range 0.01 Hz to 20 Hz. |
| Thesis Directed: | Gary M. McKinley & Robert M. Santos, "Characteristics of Geomagnetic Power Spectra on Land and Sea in the Period Range .2 to 400 sec.," Master's Thesis, Dec 80. |

Title: Investigation of Underwater Acoustic Parameters in the Arctic

Investigators: Paul Moose, Associate Professor of Electrical Engineering

Sponsor: Naval Surface Weapons Center

Objective: The objective of this research is to analyze acoustic backscattering data taken in the Arctic. The purpose is to determine volume scattering strengths as a function of depth.

Summary: During the summer of 1981, over one hundred data files were processed using a digital integrator system at APL/VW in Seattle, WA. It was found that the volume scattering strengths in the Eastern Arctic during February were 10 to 20 dB lower than the strengths that were measured in the Western Arctic in August. The cause of these differences is under further investigation.

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| Title: | An Experimental and Computer-Aided Investigation of Canted Yagi Antenna Characteristics |
| Investigators: | Michael A. Morgan, Assistant Professor of Electrical Engineering |
| Objective: | To investigate and optimally synthesize a unique antenna type for high-frequency communications. |
| Summary: | In this student-inspired project a new antenna configuration was considered for transmitting HF communications signals. The investigation followed two parallel tracks: computational and experimental. Using the Numerical Electromagnetics Code (NEC) the physical structure of the antenna was optimized by repetitive analysis. An experimental range was constructed and measurement accuracy was verified using a simple dipole antenna. Finally, a scale model of the Canted Yagi Antenna was constructed and pattern input impedance measurements were found to agree closely with the NEC results. |
| Thesis Directed: | T. Mayhan, "An Experimental and Computer-Aided Investigation of Canted Yagi Characteristics", Master's Thesis, Sep 81. |

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|---|---|
| Title: | Measurement of Natural Resonance Parameters for Radar Target Identification |
| Investigators: | Michael Morgan, Assistant Professor of Electrical Engineering |
| Sponsor: | Office of Naval Research |
| Objective: | To investigate various signal processing techniques for extraction of natural resonance data in the presence of noise and clutter. |
| Summary: | This new project, being initiated in Jul 81, is a follow-on to that sponsored by the NPS Research Foundation. Experimental measurements of complex natural resonances are being performed for a variety of radar targets of military interest. Investigations of optimum classification schemes using noisy data are being conducted. A parallel theoretical effort directed at relating natural resonances to target geometry is being pursued. |
| Thesis Directed: | D. Papaspiradakos, "Signal Processing Techniques for Radar Target Identification", Master's Thesis, Sep 81. |

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| **Title:** | Radar Target Identification via Time-Domain Scattering Signatures |
| **Investigators:** | Michael Morgan, Assistant Professor of Electrical Engineering and Michael Hamid, Adjunct Professor of Electrical Engineering |
| **Sponsor:** | NPS Foundation Research Program |
| **Objective:** | The long-range goal of this investigation is to establish the feasibility of developing advanced radar systems which are capable of target discrimination and classification via transient time-domain scattering returns. To achieve this objective, a comprehensive research program has been established in transient scattering, both from the aspects of analysis-computation and experimental modeling measurements. |
| **Summary:** | Using the transient scattering laboratory, which was designed and constructed during the first year of this effort, the resonance region imaging of axisymmetric metallic targets was successfully demonstrated. By way of digital signal processing techniques it was possible to synthesize the ramp scattering responses of the targets which are, in turn, directly related to the projected images of the targets. The output of the processed measurement of target scattering is a facsimile image of the target. This technique provides an in-depth image and even allows viewing the back side of the target. |
| **Conference Presentation:** | M. A. Morgan, "Data Acquisition & Processing in Transient Scattering Measurements," 1981 IEEE/AP-S Symposium, Los Angeles, CA, June 1981. |
| **Thesis Directed:** | C. Hammond, "The Development of a Bistatic Electromagnetic Scattering Laboratory," Master's Thesis, December 1980.<br><br>M. Morag, "Radar Target Imaging by Time-Domain Inverse Scattering," Master's Thesis, March 1981.<br><br>L. Sorrentino, "Radar Target Imagery via Transient Response Processing," Master's Thesis, June 1981. |

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| Title: | Recovery of Cross-Polarized Channels in Antenna Sidelobes |
| Investigators: | Michael Morgan, Assistant Professor of Electrical Engineering |
| Sponsor: | National Security Agency |
| Objective: | Investigation of algorithms to decouple cross-polarized channels in antenna sidelobes. |
| Summary: | Several techniques have been considered to perform the objective. The most versatile method found yet was originally proposed for use in dual polarized transmission links in the presence of rain along the path. This algorithm which incorporates a minimization procedure for a cross-correlation function, is being brought to fruition in this application. Computer modelling of realistic cross-polarization between randomly encoded binary signals is being used as a test of the procedure. |
| Thesis Directed: | R. Grant, "Recovery of Cross-Polarized Channels in Antenna Sidelobes", Master's Thesis, Dec 80. |

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| Title: | SM-2 EMP Vulnerability Study |
| Investigators: | Michael Morgan, Assistant Professor of Electrical Engineering |
| Sponsor: | Naval Surface Weapons Center |
| Objective: | To investigate the vulnerability of the Standard Missile to high electromagnetic pulse (EMP) field strengths generated by nuclear detonations. |
| Summary: | Research related to various aspects of the EMP response of the standard missile were performed. This included a computer analysis of voltage responses at the various output channels of the seeker antenna, as well as a computer analysis of EMP coupling into dorsal fin launch cables and investigation of the shielding effectiveness of metallic and composite material fin structures. |
| Thesis: | E. Isajewicz, "EMP Vulnerability Study for the SM-2 Missile," Master's Thesis, December 1981. |

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| Title: | Jamming Analysis and Monitoring Subsystems |
| Investigators: | J. E. Ohlson, Professor of Electrical Engineering and K. G. Gray, Associate Professor of Electrical Engineering |
| Sponsor: | Defense Communications Engineering System |
| Objective: | To design a system that would identify and characterize jamming signals in the DSCS III satellite communications system. |
| Summary: | Project was terminated as a result of Professor Ohlson's departure from NPS. |
| Publications: | K. G. Gray, W. Sander and J. E. Ohlson, "Design and Development of an Automatically Controlled Jamming and Signal Simulator", NPS Technical Report, NPS-62-81-030TR, January 1981.<br><br>J. Helm, J. E. Ohlson and K. G. Gray, "The Electromagnetic Threat to DSCS III - A Technical Assessment", NPS-Technical Report, NPS 62-81-029TR, January 1981.<br><br>C. Hendrickson, K. G. Gray and J. E. Ohlson, "Spread Spectrum Power Monitoring", NPS Technical Report (forthcoming). |
| Theses Directed: | W. Sander, "Design and Development of an Automatically Controlled Jamming and Signal Simulator", Master's Thesis, December 1980.<br><br>C. Hendrickson, "Spread Spectrum Power Monitoring", Master's Thesis, June 1981. |

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| Title: | Digital Signal Processing |
| Investigator: | S. R. Parker, Professor of Electrical Engineering, and Y. C. Lim, Research Associate |
| Sponsor: | NPS Foundation Research Program |
| Objective: | The development of efficient algorithms and numerical techniques for digital filters, signal processing, and system modeling. |
| Summary: | New results have been achieved for the efficient design of finite impulse response digital filters with discrete coefficients based upon a L.M.S. criteria, and finite wordlength FIR filter design using integer programming over a discrete coefficient space. |
| Publications: | Y. C. Lim and S. R. Parker, "A Discrete Coefficient FIR Digital Filter Design Based Upon L.M.S. Criteria," IEEE Trans. on Circuits and Systems, (forthcoming).<br><br>Y. C. Lim and S. R. Parker, "Finite Wordlength FIR Filter using Integer Programming Over a Discrete Coefficient Space," IEEE Trans. on Accoustics Speech and Signal Processing, (forthcoming). |
| *Conference* Presentations: | Y. C. Lim and S. R. Parker, "Digital Lattice Filter Design using a Frequency Domain Modeling Approach," 1982 IEEE International Conference on Acoustics, Speech and Signal Processing, (forthcoming).<br><br>Y. C. Lim, T. Constantinides, and S. R. Parker, "Passband Gain Centering in Discrete Coefficient Value FIR Filter Design," 1982 IEEE International Conference on Acoustics Speech and Signal Processing, (forthcoming).<br><br>Y. C. Lim and S. R. Parker, "Discrete Coefficient FIR Digital Filter Design using a L.M.S. Criteria," 1982 IEEE International Symposium on Circuits and Systems, (forthcoming). |
| Thesis Directed: | I. K. Chang, "The Application of Adaptive Techniques for the Design of Digital Filters with Discrete Coefficients," Master's Thesis, (forthcoming). |

Title: Discrete Signal Processing Studies

Investigator: S. R. Parker, Professor of Electrical Engineering

Sponsor: Naval Electronics Systems Command

Objective: To develop new algorithms for the processing of discrete signals with applications to systems identification, speech, image processing, & radar.

Summary: Work on the identification of systems in terms of multichannel lattice parameters has been completed successfully with specific application to an operational amplifier circuit obtained from NOSC. In the area of block adaptive processing, it has been shown that, in terms of convergence properties and complexity, the block adaptive filter permits fast implementation while maintaining performance equivalent to that of the L.M.S. algorithm. Other results in adaptive processing include the development of a combined random and gradient search algorithm for ARMA systems and a study of constrained adaptive filters.

Publications: G. A. Clark, S. K. Mitra, & S. R. Parker, "Block Implementation of Adaptive Filters", Special joint issue of the IEEE Trans. on Circuits & Systems, Vol. CAS-28, No. 6, pp 584-596, & the IEEE Trans. on Acoustic Speech & Signal Processing, Vol. AASP-29, No. 3, pp 744-752, Jun 81.

S. R. Parker & L. J. Griffiths, Guest Co-Editors, Editorial Joint Special Issue on Adaptive Signal Processing, IEEE Trans on Circuits & Systems, Vol. CAS-28, No. 26, p 465, Jun 81 & IEEE Trans on Acoustics, Speech & Signal Processing, Vol. AASP-29, No. 3, p 625, Jun 81.

Conference Presentations: S. R. Parker, "A Combined Random & Gradient Search Algorithm for Recursive Adaptive Filters", Proc. of IEEE International Symposium on Circuits & Systems, pp 428-431, Apr 81.

Theses Directed:

V. A. Xiouras, "Adaptive ARMA Modeling," Master's Thesis, December 1980.

M. Davis, "Constrained Adaptive Filters," Master's Thesis, June 1981.

Title: Reduced Order Characterization of Circuits and Systems

Investigator: S. R. Parker, Professor of Electrical Engineering

Sponsor: Office of Naval Research

Objective: To investigate techniques for the macroscopic modeling of linear and nonlinear circuits and systems for purposes of performance analysis and fault detection.

Summary: Our research has extended the single channel lattice autoregressive model to the multichannel case so as to be able to model both linear and nonlinear autoregressive moving average (ARMA) systems. Batch (block) processing and on-line (sequential) adaptive algorithms have been developed and tested to successfully model zero/pole linear systems as well as nonlinear ARMA systems including band pass nonlinearities and phase locked loops.

Publications:

S. R. Parker & F. A. Perry, "A Discrete ARMA Model for Nonlinear System Identification", IEEE Transactions on Circuits & Systems, Vol. CAS-28, No. 3, pp 224-233, Mar 81.

S. R. Parker, "Macroscopic Modeling of Linear & Nonlinear Circuits & Systems", NPS-62Px-81-034, Sep 81.

Conference Presentations:

F. A. Perry, S. R. Parker, & M. Romeo, "The Use of Lattice Modelling for Large Scale Linear & Nonlinear Filters", Proc. of IEEE International Conference on Circuits & Computers, pp 800-803, Oct 80.

S. R. Parker & F. A. Perry, "Transitional Formulas for Zero Pole Modeling", Proc. of International Conference on Digital Signal Processing, pp 734-741, Sep 81.

S. R. Parker, "Discrete Signal Processing Applied to the Macroscopic Modeling of Linear and Nonlinear Circuits & Systems", Proc. of the 1981 European Conf. on Circuit Theory & Design, Delft University Press, North Holland Publishing Co., pp 127-131, Aug 81.

S. R. Parker, "The Mathematics of Multichannel Recursive in Order Lattice Parameter Modeling", 1981 Proc. of International Symposium on the Mathematical Theory of Networks & Systems (MTNS)", p 227, Aug 81.

Thesis Directed:

M. Romeo, "Multichannel ARMA Lattice Modeling with Application to the Phase Locked Loop", Elec Engr Thesis, Dec 80.

L. Mayoral, "Adaptive ARMA Modeling Based upon a Kalman Filter Formulation", Elec Engr Thesis, Jun 81.

I. Tumenbatur, "The Calculation of High Order Correlations & Nonlinear System Identification", Master's Thesis, Dec 80.

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| Title: | Eleventh International Symposium on Acoustical Imaging |
| Investigator: | John P. Powers, Associate Professor of Electrical Engineering |
| Sponsor: | Office of Naval Research |
| Objective: | Seed funds to hold the subject symposium at the Naval Postgraduate School, Monterey, CA, 4-7 May 81 |
| Summary: | The 11th Symposium on Acoustical Imaging was held as indicated. Eighty-eight researchers from industry, government and academia heard forty-three papers presented on various aspects of acoustical imaging including medical applications, underwater viewing, nondestructive testing and acoustic tomograpy. |
| Publications: | J. P. Powers, Editor, Acoustical Imaging, Vol. 11. to be published by Plenum Publishing, New York. |

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| Title: | Fiber Optics in Underwater Range Applications |
| Investigator: | John P. Powers, Associate Professor of Electrical Engineering |
| Sponsor: | Naval Underwater Warfare Engineering Station |
| Objective: | This project is investigating the feasibility and design of fiber optic communications in underwater torpedo ranges. |
| Summary: | An underwater fiber optic video uplink was designed, built and tested. A small TV camera and fiber optic transmitter was placed in a handheld underwater housing. The receiver was housed on the support boat. Designed for operation at depths of 1000 meters, the link was successfully tested in 60 feet of water in diver operations. Additionally a single fiber bidirectional link is being implemented between a microcomputer and peripheral devices as a testbed for digital data transmission and modulation studies. |
| Publications: | J. P. Powers and J. M. Davis, "A Fiber Optic Video Uplink for Shallow Water Application", to be published in Fiber Optics in Adverse Environments, Society of Photo-optical Instrumentation Engineers, Bellingham, WA. |
| Conference Presentation: | J. P. Powers and J. M. Davis, "A Fiber Optic Video Uplink for Shallow Water Application", SPIE International Symposium, 24-28 August 1981, San Diego, California. |
| Theses Directed: | M. Moraitakis, "An Analog Signal Fiber Optic Link Design for Quinault Underwater Tracking Range", Master's Thesis, December 1980.<br><br>J. M. Davis, "An Underwater Fiber Optic Linked Video System", Master's Thesis, March 1981. |

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| Title: | Systems Design for Fiber Optic Sensors |
| Investigator: | John P. Powers, Associate Professor of Electrical Engineering |
| Sponsor: | Naval Research Laboratory |
| Objective: | This project would perform a first order parametric analysis of a towed sonar array utilizing fiber optic sensors. This analysis would indicate system tradeoffs and technical feasibility. |
| Summary: | This project is in an initial phase of gathering data on fiber optic sensors available from industry and government labs and in surveying current models of conventional towed arrays. |

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| Title: | Techniques of Acousto-optical RF Signal Analysis |
| Investigator: | John P. Powers, Associate Professor of Electrical Engineering |
| Sponsor: | None |
| 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 a Bragg cell processor. Our objective is to develop a first order model relating the laser beam, Bragg cell, excisor, and detector parameters. This involves working in time, frequency, and space domains since they are all interrelated by this system. An experimental test bed is also being constructed. |
| Summary: | A computer-based model incorporating features of the Bragg cell, laser beam, and RF signal has been implemented and tested. This model includes effects due to the beam profile, Bragg diffraction inefficiency, transducer response and laser diffraction effects. The model has been used to study sensitivity of spectral analysis systems and optical excision effects. |
| Publications: | J. P. Powers, D. E. Smith, M. Carmody, & F. W. Regan, "A Computer-based Model of Space Integrating Acousto-optic Signal Processing", to be published in the Proc. of the 1981 IEEE Ultrasonics Symposium, IEEE Press, New York.<br><br>M. Carmody & J. P. Powers, "Acousto-optic Spectrum Analysis Modeling", NPS Technical Report 62-81-033, 1981. |
| Conference Presentation: | J. P. Powers, D. E. Smith, M. Carmody, & F. W. Regan, "A computer-ased model of space integrating acousto-optical signal processing", 1981 IEEE Ultrasonics Symposium 14-16 Oct 81, Chicago, IL. |
| Thesis Directed | M. J. Carmody, "Acousto-optic Spectrum Analysis Modeling", Master's Thesis, Jun 81. |

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| Title: | Acoustic Imaging in Sediment |
| Investigator: | George L. Sackman, Professor of Electrical Engineering |
| Sponsor: | Naval Undersea Warfare Engineering Station |
| Objective: | To develop an acoustic echo ranging system capable of locating and imaging objects buried in marine sediment. |
| Summary: | Effort this year has been directed to development of an acoustic transducer to exploit the parametric transient effect. It is desired to produce an extremely short pulse with spectral components below 10 KHz, beamwidth on the order of one degree from an aperture less than 0.5 m diameter. A 1/4 scale experimental planar transducer mounted in a corner reflector has shown good pulse shapes with beamwidth appropriate to the reduced aperture size. |
| Publications: | G. L. Sackman, "Acoustic Imaging in Sediment," Task 81-4, in Annual Summary Report - Range Studies Program, prepared by O. B. Wilson, NPS Technical Report, NPS-61-82-001, October 1981. |
| Conference Presentation: | G. L. Sackman & G. R. Vermaner, "Acoustic Imaging in Marine Sediment: A Multiple Microprocessor Array Processor using the Trace Function," presented at the 11th International Symposium on Acoustical Imaging, May 1981, to be published in Acoustical Imaging, Vol. 10, Plenum Pub., NY, 1981. |
| Thesis Directed: | G. R. Vermander, "A Signal Processing Algorithm Based on Multiple Microprocessors for an Underwater Acoustic Imaging System," Master's Thesis, December 1980. |

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| Title: | Control Systems Design Studies |
| Investigators: | Robert D. Strum, Professor of Electrical Engineering |
| Sponsor: | Strategic Systems Projects Office |
| Objective: | Long term objectives are to investigate the utility of modern control theory in solving strategic missile control problems. Techniques to be considered include adaptive control, extended Kalman filters and model following. The short-term goal was to design a control system improvement to compensate for bending modes in next generation ballistic missiles. |
| Summary: | A dual-channel filter was designed, with each channel featuring a digital elliptic bandpass filter, a frequency detector measurement a Kalman filter for center-frequency estimation and an adaptive notch digital notch filter for suppression of the bending-mode contamination in the control signal. |
| Thesis Directed: | B. W. Buckley, "Parameter Estimation and Digital Filtering Techniques for Bending Node Suppression," Master's Thesis, Jun 81. |

Title: Development of Focal Plane Processing for Surveillance System Applications

Investigator: Tien F. Tao, Professor of Electrical Engineering

Sponsor: Air Force Space Division

Objective: Develop and evaluate new focal plane processing algorithms. Develop a multiple microcomputer system for simulation and evaluation of focal plane processing and for on-board implementation.

Summary:

(1) New focal plane processing algorithms:

Statistical temporal and spatial filters have been the major emphasis of image processing research during the last report period. During this period, the emphasis is in two areas. First, post-threshold image processing techniques have been pursued for the purpose of acquiring targets and discarding false alarms. These techniques include several stages. The first stage immediately after the thresholding is based on a "side-lobe consideration in multiple frame time domain" to discriminate moving targets from stationary false alarms. This is followed by a multiple frame track association technique to accumulate new target hits into old tracks, to launch new tracks, to drop false tracks which are found to be unacceptable and finally to declare true target tracks. The test images are a sequence of 15 frames based on the infrared images taken by the HCMM satellite and modified by IBM, West Lake, California. These post-threshold processing techniques are based on combined pattern tests in temporal and spatial domains. Special efforts have been made not to duplicate other post-threshold algorithms being developed by contractors in the industries working on the same problem. Second, an evaluation procedure of the effectiveness of the end-to-end image processing program has been developed. The figures of merit are based on the probability of detection of tracks and probability of hits in false tracks. The procedure is not statistical as the Monte Carlo techniques. Instead, tracks in specified directions and selected numbers are added to the test images. The probability of track detection and the probability of false hits are calculated after the end-to-end image processing program by comparing the known simulated tracks and those detected. The parameters which can be varied during evaluation are: relative drifts between successive frames of images, the direction of tracks, the relative speed of targets with respect to the frame time, types of filters used for background clutter suppression, the number of hits to be collect-

ed during the adaptive thresholding stage, the techniques of moving target acquisition immediately after the thresholding, the techniques used to build up, accept and drop tracks based on multiple frames of moving target hits. One of the emphasis of this year's of the methods to use new image data base which are being developed to assist the development of new sensor systems, signal processing algorithms and processor implementations. Two of such programs are the Air Force Measurements Program and the DARPA Background Phenemnology Program.

(2) Multiple microcomputer simulation of end-to-end image processing program:

This effort is a continuation of last year's project although it has not been the major emphasis of this year's support. A multiple clusters microcomputer system is being developed. Hardware controllers for a three-level cluster system has been tested. Memory reference errors have been encountered beyond one cluster. However, within one cluster the system bus errors are low enough to allow substantial development of application programs. During this reporting period, the following image processing programs have been developed. An end-to-end image processing program including background clutter suppression, adaptive thresholding, target acquisition and track association using four 16-bit microcomputers and one shared memory. Some fault tolerance demonstration showing the switching of programs running on one microcomputer to another spare microcomputer when its memory address is faulty has also been included. Another image processing program is a concurrent parallel computation including a spatial filter design and the application of this spatial filter to 16 frames of infrared images of 32 x 32 pixels using four microcomputers and a shared memory.

Theses Directed:

J. Jacobson, "Two Color Infrared Image Processing for Target Detection and Its Implementation on a Microcomputer", Engineer's Thesis, September 1980.

J. Jan, "Image Processing Using Multiple Microprocessors", Master's Thesis, December 1980.

B. Eren, "Performance Evaluation of an End-To-End Image Processing Program for Detection of Moving Targets in Infrared Images", Engineer's Thesis, December 1980.

H. Amir, "Adaptive Image Processing and Implementation by Multiple Microcomputer System", Ph.D. Thesis, December 1980.

T. Warner, "Development and Implementation of Infrared Image Processing Target Detection and Track Association Algorithms Using an Array Processor Enhanced Microcomputer", Engineer's Thesis, March 1981.

PROFESSOR TIEN F. TAO AND STUDENT INVOLVED IN DISTRIBUTED MULTIPLE MICROCOMPUTER SYSTEM RESEARCH.

Title: Fault Tolerant Memory

Investigator: Tien F. Tao, Professor of Electrical Engineering

Sponsor: Naval Air Development Center

Objective: (1) Study the impacts of new memory technologies to microcomputer systems.

(2) Develop concepts for fault tolerant memory architecture.

Summary: This is a new study started during this reporting period.
(1) Impacts of new memory technologies to microcomputer systems:

Studies in this area included two efforts. The first effort is a survey of past works in the fault tolerant memory area. Items included are the following: computers and memory types involved in past fault tolerant memory studies; fault mechanisms; fault detection approaches; fault diagnosis; fault correction and recovery; fault confinement approaches and reliability issues. The second effort is to select a type of microcomputer system to be considered in this study for the development of new fault tolerant memory approaches. The microcomputer systems selected belong to a class of multiple microcomputer systems using shared memory and common system bus. This is selected because a generic type of multiple microcomputer system interconnected on a system bus and intercommunicated by way of shared memory is being developed by the NADC group which is supporting this research effort. Further, special attention has been given to transient errors which are expected to occur more frequently in new VLSI and VHSIC devices.

(2) New concepts of fault tolerant memory architectures:

Two new concepts are being developed. The first concept is to partition the memory into small software blocks which will be checked for faults everytime it will be used. This partition is created by software memory management assignment. Therefore, it will complement hardware partitions of memory. Working together, they will limit the extent of damages caused by component failures to a small area instead of disabling a larger bank of memory if partitions are not provided. This concept will be more effective dealing with permanent memory failures because transient failures may not occur during the fault checking period before the assignment of a memory

block for usage. The second concept will be more effective to deal with transient faults. It is based on the majority voting concept. Any critical computations in this majority voting approach will be performed an odd number of times. The most common number is 3 such that there will always be a majority if disagreement occurs during voting. If all three copies agree, the computation will proceed to the next step. If a disagreement occurs, there could be two cases. In one case, a majority is detected. The minority component will be considered "faulty" and removed from computation and sent to a fault diagnosis procedure to determine if the fault is transient or permanent. At the same time, a spare component will be switched into operation and continue the computation with majority voting. On the other hand, if all three copies do not agree, a software rollback will be made to repeat the process which has just been voted on. During this reporting period, a "Triple Modular Redundancy" approach using three microcomputers and three copies of results stored in memory and to be voted has been developed. However, the test has only been demonstrated for three copies of microcomputers and not for three copies of redundant memories yet. Thee types of redundancies and spares using majority voting will be effective to deal with transient faults. Continuing research in developing redundant memory and buses will be pursued.

Theses Directed:

E. Giotis, "Development of Bus Switches and Fault Diagnosis Software for a Multiple Microcomputer System", Master's Thesis, December 1980.

L. Schneider, "Development and Implementation of a Multiple Microcomputer System", Master's Thesis June 1981.

C. Droz, "Fault Tolerant and Multisensor Applications of a Multiple Microcomputer System", Master's Thesis, September 1981.

Two thesis are in progress at the end of this reporting period.

D. Mermigas, "Design of Memories with Memory Management and Error Corrections for a Multiple Microcomputer System", Master's Thesis, December 1981.

K. Webb, "Aspects of Memory Management and System Configuration in a Multiple Microcomputer System," Master's Thesis, December 1981.

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| Title: | Automatic Ship Classification for Cruise Missiles |
| Investigator: | Lonnie A. Wilson, Associate Professor of Electrical Engineering |
| Sponsor: | Joint Cruise Missiles Project Office |
| Objective: | To develop automatic ship classification techniques and technologies for cruise missile applications. |


Summary: The US Navy has limited target classification capabilities for long stand-off range, all weather, multiple targets and day/night applications. In the past, the Navy has focused significant resources on the target detection and target tracking problems. Now that the target detection problem has been largely solved, target classification stands out as a major deficiency for numerous Navy missions. Several target classification system developments are currently being pursued in exploratory and advanced developments for the US Navy. These developments are currently emphasizing techniques and technology that fit aircraft platforms, little work has been done for missile applications. Significant research and technology advances are required to solve this target classification problem.

This research has investigated new signal processing feature extractions and target classification concepts for the cruise missile system applications. Significant analysis and evaluation have been completed on the Fourier-Mellin transform combination and on the direct Mellin transform.

A new correlation classifier concept has been developed and will be fully analyzed in the next fiscal year. Also, a probability density function/entropy classifier is being investigated. These algorithms will be more fully evaluated next fiscal year.


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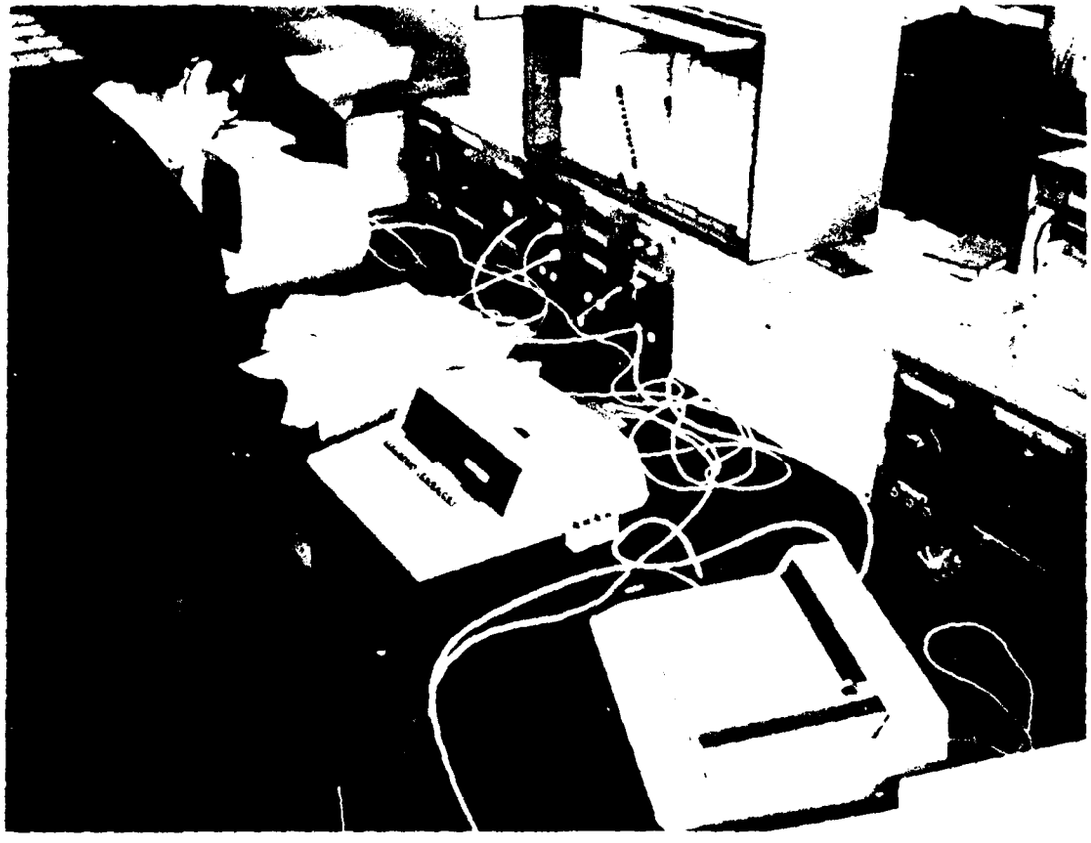
| Conference Presentation: | C. E. Faison, "Radar Target Classification for Cruise Missiles", Naval War College Tactical Symposium, September 1982. |
| Patent Application: | L. A. Wilson & C. E. Faison, "Automatic Radar Target Classification for Cruise Missiles", applied October 1980. |



STUDENT DEVELOPING DIGITAL COMPUTER ALGORITHM TO ASSIST IN THE AUTOMATIC SHIP CLASSIFICATION FOR CRUISE MISSILES PROJECT.

Title: Dimensionality Reduction and MOP Characterization for Target Classification

Investigator: Lonnie A. Wilson, Associate Professor of Electrical Engineering

Sponsor: Naval Air Systems Command

Objective: To develop nonlinear mapping techniques for dimensionality or feature reduction and to investigate discrete implementation of the Mellin transform. Also to investigate the modulation-on-pulse (MOP) characteristics of selected radar systems.

Summary: The second task, which was directed by the sponsor, involved the investigation and characterization of the MOP characteristics of radar emissions. Theoretical, experimental and computer analysis were conducted during the study. This effort attempted to fundamentally understand the MOP sources, the MOP characteristics for generic radar classes, the repeatability or nonrepeatability of MOP and determine MOP's value for Navy applications.

MOP models and signal processing techniques were developed to determine theoretical radar pulse signatures. Signatures were generated for numerous postulated radar emissions. Analysis will continue next fiscal year.

Publications:

L. A. Wilson and N. E. Huston, "The Design and Tactical Implementations of a Sorting Parameter Tradeoff Study", Target Identification Conf. Proc., October 1981.

L. A. Wilson, "Unintentional Modulation of RF Emitters", (forthcoming).

Theses Directed:

T. S. Swafford, "Theoretical Investigation of Modulation on a Radio Frequency Pulse", Master's Thesis, March 1981.

J. E. Landers, "Radar Emitter-Modulation on Pulse Characterization", Master's Thesis, June 1981.

# DEPARTMENT

# OF

# METEOROLOGY

## DEPARTMENT OF METEOROLOGY

The research program in the Department of Meteorology continues in several areas: (1) numerical air and ocean modeling and prediction, (2) analysis and dynamics of tropical weather systems, (3) marine atmospheric boundary layer studies, (4) marine fog/visibility analysis and prediction, (5) regional weather studies and (6) 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 investigating various finite element formulations with respect to treatment of small-scale flow fields. He will apply the techniques to the prediction of air flow near mountains, and to tropical cyclones. 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 model to predict the upper ocean response to atmospheric forcing on time scales ranging from diurnal to seasonal changes. In a joint effort with R. L. Haney, the mixed-layer model has been embedded into an oceanic general circulation model. This new model will now be used in a variety of oceanic investigations including the response of the ocean to tropical and extratropical storms (Elsberry) and the dynamics of large scale anomalies observed in the North Pacific Ocean (Haney).

A combined diagnostic-prognostic approach is being used by R. L. Elsberry, C. H. Wash and S. A. Sandgathe to study maritime extratropical cyclones. The atmospheric model being implemented at the Fleet Numerical Oceanography Center has been used to study the role of air-sea fluxes in extratropical cyclogenesis. Diagnostic studies of the numerically-predicted fields are being made for comparison with similar studies using real data.

Other modeling efforts include (1) a dynamical-statistical model for predicting the movement of tropical cyclones, led by R. L. Elsberry, (2) a marine atmospheric boundary layer model for predicting (6-18 hours) properties which affect radar and optical propagation within the boundary layer and those factors (radiation and boundary fluxes) which affect the upper part of the ocean, directed by K. L. Davidson, and (3) the beginning of a comparison of several global initialization schemes by a Ph.D. candidate under the supervision of R. T. Williams.

### ANALYSIS AND DYNAMICS OF TROPICAL WEATHER SYSTEMS

C. P. Chang, R. L. Elsberry and R. T. Williams continue to investigate various aspects of the dynamics of tropical weather systems, including development of hurricanes and typhoons by R. L. Elsberry, the dynamics and energetics of tropical synoptic and planetary scale waves by C. P. Chang and R. T. Williams, and the diagnostic analysis of winter and summer monsoon circulations by C. P. Chang.

C. P. Chang and K. M. Lau continue to use domain-averaged climatic numerical models to investigate the various mechanisms pertinent to the large-scale interaction between the tropical atmosphere and oceans. Among the phenomena being studied are the Walker circulation, the Hadley circulation and the El Nino fluctuations.

MARINE ATMOSPHERIC BOUNDARY LAYER STUDIES

Research in this area includes several interdisciplinary shipboard/aircraft observational and theoretical projects involving K. L. Davidson. Objectives of the individual projects are: (1) to evaluate and formulate models which relate changes in the depth and structure of the atmospheric mixed layer (capped by an inversion) to surface fluxes and sky conditions, (2) to evaluate and formulate models for equilibrium marine aerosol distributions, (3) to establish synoptic-scale descriptions of the magnitude and height variations of optical turbulence, (4) to relate near-surface aerosol distributions to whitecap coverage, (5) to determine pollutant dispersion properties of the atmospheric boundary layer in the California coastal region and (6) to evaluate synoptic-scale forcing on the boundary processes and evolutions utilizing data from single (in situ) stations. Long range objectives of this work are to provide tactical assessment and predictive procedures for electromagnetic, optical and dispersion properties of the marine boundary layer.

Two NAVAIRSYSCOM G. J. Haltiner Research Chair occupants in FY 81, J. A. Businger and E. C. Monahan, contributed in boundary layer research areas of stratocumulus-covered mixed layer evolutions (Businger) and local generation of sea-salt aerosols (Monahan).

MARINE FOG/VISIBILITY ANALYSIS AND PREDICTION

An interdisiplinary project involving R. J. Renard, and D. F. Leipper and G. H. Jung from the Department of Oceanography, is concerned with the climatology, analysis and numerical/statistical prediction of fog and visibility over open ocean and coastal regimes, both on a regional and a hemispheric scale. On a regional basis a synoptic-oriented marine fog visibility sequential development model continues under study for the eastern North Pacific Ocean coastal area and an open ocean version for the Gulf of Alaska. On a whole ocean basis, a surface visibility climatology has been developed and a marine fog/visibility model output statistics scheme has been tested for the North Pacific Ocean.

## REGIONAL WEATHER STUDIES

In the final stage of the NSF project, R. J. Renard's research has been concerned with the observational network commensurate with synoptic/mesoscale weather events over the Antarctic area. In addition to conventional and weather-satellite observations, data from Antarctic remote automatic weather stations have been analyzed to establish their contributions to both the scientific and operational weather endeavors in support of the U.S. mission in Antarctica.

R. J. Renard has initiated a study to assess the status of and make improvements on operationally-important weather parameters over the Southern African Continent and surrounding ocean areas.

## SATELLITE REMOTE SENSING

K. L. Davidson was involved with observational studies concerned with surface truth evaluation of satellite-borne scatterometer derived estimates of the oceanic surface layer wind and satellite-borne microwave radiometer derived estimates of the sea-surface temperature. Furthermore, aerosol distribution data obtained off the California coast are being used to assess the role of atmospheric extinction of 'grey shade' patterns within usual satellite imagery (DMSP). C. H. Wash is applying interactive computer techniques to GOES and NOAA visual, infrared and other radiometric data to specify cloud and precipitation patterns using the NEPRF Satellite Processing and Acquisition System.

Title: Synoptic and Numerical Studies of Disturbances over Tropical Oceans

Investigator: Chih-Pei Chang, Associate Professor of Meteorology

Sponsor: Naval Air Systems Command

Objective: To study the typical structure and behavior of synoptic disturbances over oceans.

Summary: Synoptic scale weather disturbances over the western Pacific and adjacent seas are analyzed using conventional radiosonde and satellite (GMS, DMSP) data. The structure of the disturbances during northeast monsoon in the South China Sea has been composited. Preliminary results show a strong influence of the monsoon surges on the disturbance-associated convection. Studies of the "Mei-Yu front" disturbances over East Asia coastal region and East China Sea are also carried out. Synoptic cases documented by DMSP imageries and FNOC prognostics are used to illustrate possible techniques for forecasting the severe weather due to these disturbances.

Publications: C.-P. Chang, B. K. Cheang, and G. T. Chen, "Regional Synoptic Analysis during Phase I of Winter MONEX," Winter MONEX Technical Report, March 1981.

**Title:** A Synoptic Study of Summer Monsoon Depressions

**Investigators:** C. P. Chang, Associate Professor of Meteorology, and K. R. Saha, Senior Research Associate

**Sponsor:** NPS Foundation Research Program

**Objective:** To study the structure and development processes of the summer monsoon depressions in the vicinity of the Bay of Bengal.

**Summary:** The diagnostic analysis of two depressions with quite different orgins show many basic similarities in structure and development. They both have a baroclinic structure with well-defined warm and cold sectors, the latter being situated to the east of the former in a region where the thermal wind is easterly throughout the troposphere. The axis of the depression tilts eastward with height. In a developing depression, the geopotential and the temperature fields differ in phase such that warm advection from the north occurs to the west of the depression center and cold advection from the south to the east. There is also strong convergence to the west and divergence to the east of the depression center in the lower troposphere, and vice versa in the upper troposphere. Thus a divergent secondary circulation exists in the zonal vertical plane with warm air rising to the west and cold air sinking to the east. Computed perturbation vertical velocity, which is in good agreement with the distribution of satellite-observed clouds, and relative divergence (divergence at 200 mb-divergence at 850 mb) show that there is marked increase in upward motion and relative divergence in the southwest sector during the period of development. A decrease in vertical zonal wind shear ($U_{200}$-$U_{850}$) in the depression area is also noted, apparently a result of the effects of the finite amplitude baroclinic depression. Intensity and movement of the depressions are found to be strongly influenced by thermal advection from mid-latitude disturbances moving across central Asia and China. Warm advection from these disturbances to the west of the depression center favors development and accelerates westward movement of the depression whereas cold advection inhibits development and retards the movement.

**Publications:** K. R. Saha, and C. P. Chang, "On the Structure and Development of Monsoon Depressions," Submitted to the Monthly Weather Review.

Title: Temporal and Spatial Variations of Large-Scale Tropical Flows

Investigator: Chih-Pei Chang, Associate Professor of Meteorology

Sponsor: National Oceanic and Atmospheric Administration

Objective: To study the interannual and intraseasonal variations of planetary-scale circulations.

Summary: Objectively analyzed 200-mb winds of four winters are used to study the short term (several days) teleconnections between planetary-scale circulation components over the monsoon regions. The composited structures suggest that during very active northeasterly monsoon (surge) periods the midlatitude and tropical circulation components vary in a coherent way. The jet streak and local Hadley circulation over East Asia, the divergent outflow over the maritime continent, and the equatorial Walker circulations over the Pacific and Indian Oceans all strengthen steadily, while the secondary jet streak over West Asia weakens. During inactive (break) periods the midlatitude circulation components all exhibit reversed changes, while the variations in the tropics are less coherent although still showing reversed tendencies. The results basically verify the short-term teleconnection model proposed by Chang and Lau (1980), but more complex processes in the acceleration of the midlatitude jet streaks are indicated. In addition, the contrast between the very active and break monsoon periods suggests the relative importance of tropical vs. midlatitudinal forcings in different regions of the monsoon circulation.

Publications: C.-P. Chang, and K. M. Lau, "Short-Term Planetary-Scale Interactions over the Tropics and Midlatitudes during Northern Winter. Part I: Contrasts between Active and Inactive Periods", Monthly Weather Review, (submitted).

Conference Presentations: C.-P. Chang, and K. M. Lau, "Planetary Scale Motions in Winter Monsoons during Cold Surge and Break Periods (Invited Paper)", International Conference on the Scientific Results of FGGE and Large-Scale Aspects of Its Monsoon Experiment, Tallahassee: World Meteorological Organization, 1981.

C.-P. Chang, "Winter Monsoon Circulations (Invited Paper)", Second National Conference of Atmospheric Sciences, Chinese Meteorological Society, Taipei, Taiwan, December 10-11, 1980.

Title: Tropical Large-Scale Ocean-Atmosphere Ocean Coupling

Investigators: Chih-Pei Chang, Associate Professor of Meteorology and K. M. Lau, Visiting Assistant Professor of Meteorology

Sponsor: National Science Foundation

Objective: To study the mutual influence of tropical large-scale atmospheric circulation and the upper layer of the ocean over time scales synoptic to interannual.

Summary: Simple models of the ocean-atmosphere coupled system were developed to study tropical large-scale air-sea interaction in time scales of Southern Oscillation/El Nino. In one such model, the equatorial ocean-atmosphere is represented by a coupled barotropic ocean and atmosphere system. Analyses showed that the Kelvin modes of the system exhibit two widely different time scales. The first mode, pertaining to the atmosphere, is little affected by air-sea coupling; whereas the time scale of the slow mode is significantly increased as the strength of the coupling increases. This latter mode possess time scale of the order of months to years and length scale of ~ 10,000 km. It is likely to be related to the observed interannual variation in the tropical planetary scale oscillation. A positive feedback mechanism was postulated to exist between the equatorial zonal circulations in the ocean and the atmosphere. Analysis of the FNOC wind data was also carried out to study the short time scale teleconnections between planetary-scale circulation components over the monsoon regions. The results show a coherent variation of the circulation components during both active and inactive periods of the winter monsoon, and the importance of midlatitude forcing of the tropics.

Publications:

K. M. Lau, "Oscillation in a Simple Equatorial Climate Model." Journal of Atmospheric Science, 38, 248-261, February 1981.

C.-P. Chang and K. M. Lau, "Short-Term Planetary-Scale Interactions over the Tropics and Midlatiudes during Northern Winter. Part I: Contrasts between Active and Inactive Periods," Submitted to Monthly Weather Review.

Title: Tropical and Monsoon Studies

Investigators: Chih-Pei Chang, Associate Professor of Meteorology and R. T. Williams, Professor of Meteorology

Sponsor: National Science Foundation

Objective: To study the structure and dynamics of large-scale flow in the tropics and other areas influenced by monsoons. This is a continuing research project.

Summary: The research project includes several parts, the most important parts are the following: 1) Synoptic scale diagnostic study of winter monsoon: Main efforts this year were the completion of the Winter MONEX synoptic atlas and the initiation of a composite study of disturbances near Borneo. 2) Planetary scale diagnostic study of winter monsoon: A study showing the teleconnection of planetary scale circulation components was completed, and a study using the Winter MONEX data started. 3) Theoretical study of winter monsoon: A linear equatorial beta plane theory showed the generation of transient and wave motions which caused tropical responses similar to those observed. 4) Theoretical study of waves in a variable mean flow: nonlinear numerical experiments were carried out to simulate the barotropic effects of waves propagating in zonally-asymmetric, forced basic flows. 5) Summer monsoon depressions: A synoptic study of two depression cases revealed the importance of baroclinic processes in the structure and development of the summer monsoon depressions.

Publications:

H. Lim, C.-P. Chang, "A Theory for Midlatitude Forcing of Tropical Motions during Winter Monsoons", Journal of Atmospheric Sciences, 38-11, November 1981 (forthcoming).

C.-P. Chang, S. T. Wang, "Possible Two-Day Oscillations in the Troposphere and Lower Stratosphere", Papers in Meteorological Research, 4 (forthcoming).

C.-P. Chang, K. M. Lau, "Short-Term Planetary-Scale Interactions over the Tropics and Midlatitudes during Northern Winter. Part I: Contrasts between Active and Inactive Periods", Monthly Weather Review (submitted).

K. R. Saha, C.-P. Chang, "On the Structure and Development of Monsoon Depressions", Monthly Weather Review (submitted).

C.-P. Chang, H. Lim, "Viscous Rossby Waves on an Equatorial Beta Plane", Journal of Atmospheric Sciences (submitted).

C.-P. Chang, R. T. Williams, "Final Technical Report of NSF Grant ATM 77-14821 Dynamics of Tropical Waves and Monsoons", NPS Technical Report, NPS63-81-001, April 1981.

C.-P. Chang, B. K. Cheang, G. T. Chen, "Regional Synoptic Analysis during Phase I of Winter MONEX", Winter MONEX Technical Report, March 1981.

R. T. Williams, L. C. Chou, C. J. Cornelius, "Effects of Condensation and Surface Motion on the Structure of Steady-State Fronts", Journal of Atmospheric Sciences, 38, November (forthcoming).

**Conference Presentations:**

C.-P. Chang, K. M. Lau, "Planetary Scale Motions in Winter Monsoons during Cold Surge and Break Periods (Invited Paper)", International Conference on the Scientific Results of FGGE and Large-Scale Aspects of Its Monsoon Experiment, World Meteorological Organization, Tallahassee, January 1981.

C.-P. Chang, H. Lim, "A Linear Theory for the Midlatitude Forcing of Tropical Motion by Pressure Surges (Invited Paper)", Tropical Dynamics Symposium of the 3rd Scientific Assembly of the International Association of Meteorology and Atmospheric Physics, Hamburg, FRG, August 1981.

C.-P. Chang, "Winter Monsoon Circulations (Invited Paper)", Second National Conference of Atmospheric Sciences, Chinese Meteorological Society, Taipei, Taiwan, December 10-11, 1980.

R. T. Williams, C.-P. Chang, H. Lim and O. Haney, "Nonlinear Barotropic Interaction between Synoptic-Scale Waves and a Zonally Varying Mean Flow", Third Conference on Atmospheric and Oceanic Waves and Stability of the American Meteorological Society, San Diego, Janaury 19-23, 1981.

R. T. Williams and L. C. Chou, "Effects of Condensation on Steady-State Fronts", Pacific Division, AAAS, Eugene, Oregon, June 15-19, 1981.

**Theses Directed:**

J. E. Millard, "Surface Structure of Cold Surges during Winter MONEX over the South China Sea Region", Master's Thesis, June 1981.

T. E. Gerish, "Composited Structure of the Near-Equatorial Disturbances near Bornea during Winter MONEX", Master's Thesis, September 1981.

Title: Observational Studies of Marine Boundary Layer Processes

Investigators: K. L. Davidson, Associate Professor, Department of Meteorology, and G. E. Schacher, Professor of Physics, Department of Physics and Chemistry

Sponsor: Naval Air Systems Command

Objective: Prediction of the evolution of a marine atmospheric boundary layer.

Summary: This research program consists of a boundary layer model development 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 routine shipboard radiosonde and future surface layer winds. 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. The field work includes both ship and aircraft measurements of mean and turbulence parameters. An experiment was conducted in May 1980 in which aircraft and shipboard measurements were coordinated to observe temporal and spatial factors in the zero order models. The data were analyzed and preliminary interpretations performed in FY 81 (Fairall, 1981). During Nov-Dec 1981 an experiment was conducted from the NOAA Ship Oceanographer in the Gulf of Alaska (Storm Transfer and Response Experiment - STREX). Surface layer data to estimate boundary fluxes and SODAR data were obtained. These data are being analyzed.

Publications: K. L. Davidson, G. E. Schacher, C. W. Fairall and T. Houlihan, "Observations of Atmospheric Mixed-Layer Changes off the California Coast", Proceedings at 2nd Conference on Coastal Meteorology, January 1980, 63-71, (1980).

K. L. Davidson, and V. Noonkester, "Observations of the Occurance of Encroachment within the Marine Atmospheric Boundary Layer (CEWCOM-78)", Proceedings of 2nd Conference on Coastal Meteorology, January 1980.

K. L. Davidson, T. 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, (1980).

C. W. Fairall, R. Markson, G. E. Schacher, K. L. Davidson, and T. Houlihan, "Atmospheric Marine Boundary Layer Measurements in the Vicinity of San Nicolas Island During CEWCOM-78", Proceedings of 2nd Conference on Coastal Meteorology, January 1980, 71-75, (1980).

C. W. Fairall, R. 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", Boundary Layer Meteorology, 19, 453, (1980).

K. L. Davidson, G. E. Schacher, C. W. Fairall, E. C. Crittenden, and E. A. Milne, "Verification of the Bulk Model for Calculations of the Overwater Index of Refraction Structure Function, $C_N^2$", NPS Technical Report, NPS 61-80-016, (1980).

G. E. Schacher, K. L. Davidson, and C. W. Fairall, "Observation on Turbulent Kinetic Energy Dissipation Rates, $\varepsilon$, Over the Ocean", Boundary Layer Meteorology, 20, 321-330 (1981).

K. L. Davidsdon, G. E. Schacher, C. W. Fairall and A. Goroch, "Verification of the Bulk Method for Calculating Overwater Optical Turbulence", Applied Optics, 20, 2919-2924m (1981).

K. L. Davidson, G. E. Schacher, and C. W. Fairall, "Meteorological Descriptions for Optical Properties", AGARD Conference Proceedings No. 300, Special Topics in Optical Propagation, 6-1 to 6-9, (1981).

C. W. Fairall, K. L. Davidson, and G. E. Schacher, "Meteorological Models for Optical Properties in the Marine Atmospheric Boundary Layer", Proceedings, S.P.I.E. 25th International Technical Symposium, August 1981, 16 pp, 1981.

G. E. Schacher, K. L. Davidson, D. E. Speil, and C. W. Fairall, "Marine Atmospheric Surface Layer Measurements on the NOAA Ship Oceanographer during STREX", U.S. Department of Commerce report Storm Transfer and Response Experiment, pp 137-141, (1981).

Title: Optical Turbulence in the Marine Boundary Layer

Investigator: K. L. Davidson, Associate Professor, Department of Meteorology, and G. E. Schacher, Professor of Physics, Department of Physics and Chemistry

Sponsor: High Energy Laser Program Office

Objective: Relate surface layer optical turbulence ($C_N^2$) to seasonal and geographic synoptic meteorological regimes and to examine predictability of $C_N^2$ for 6-18 hours using an integrated marine atmospheric boundary layer.

Summary: Mean and median $C_N^2$ values were related to synoptic scale features on an approach which used to describe EM wave propagation (Refractive Effects Guidebook). Observed surface layer wind, temperature, and humidity values and surface temperatures were used with bulk aerodynamic expression to estimate $C_N^2$. Data used were from experiments conducted by NPS personnel over the past 7 years and also included published data from the Global Atmospheric Tropical Atlantic Experiment (GATE).

Publications: K. L. Davidson, G. E. Schacher and C. W. Fairall, "Meteorological Descriptions for Optical Properties", AGARD Conference Proceedings No. 300, Special Topics in Optical Propagation, Monterey, CA, 6-10 April 1981, 6-1 to 6-9.

C. W. Fairall, K. L. Davidson and G. E. Schacher, "Meteorological Models for Optical Properties in the Marine Atmospheric Boundary Layer", Proceedings, S.P.I.E. 25th International Technical Symposium, August 1981, 16 pp.

K. L. Davidson, G. E. Schacher, C. W. Fairall, E. C. Crittenden and E. A. Milne, "Verification of the Bulk Model for Calculations of the Overwater Index of Refraction Structure Function, $C_N^2$", NPS Technical Report, NPS-61-80-016, 1980.

G. E. Schacher, K. L. Davidson, T. M. Houlihan and C. W. Fairall, "Measurements of the Rate of Dissipation of Turbulent Kinetic Energy, $\varepsilon$, Over the Ocean", Boundary-Layer Meteor., 20, 321-330, 1981.

K. L. Davidson, G. E. Schacher, C. W. Fairall and A. Goroch, "Verification of the Bulk Method for Calculating Overwater Optical Turbulence", Applied Optics, 20, 2919-2924, 1981.

T. R. McPherson, "Synoptic Classification of Optical Turbulent Regimes", Master's Thesis, Dec 1981

Title: Relating Marine Aerosol Distribution to Oceanic Whitecaps

Investigator: K. L. Davidson, Associate Professor, Department of Meteorology, and G. E. Schacher, Professor of Physics, Department of Physics and Chemistry

Sponsor: Office of Naval Research

Objective: To determine aerosol production per unit whitecap coverage on the basis of laboratory measurements and to relate open ocean aerosol data and whitecap coverage.

Summary: Measurements of seasalt aerosols were made in June 1980 over laboratory generated whitecaps at University College Galway. Preliminary estimates were obtained of the produced aerosol size distributions as a function whitecap coverage (Monahan et al, 1982), based on data obtained in 1979. Aerosol size distributions obtained during the JASIN (North Atlantic) experiment in 1978 have been interpreted relative to aerosol flux spectra (Fairall et al, 1982).

Publications: E. C. Monahan, K. L. Davidson and D. E. Spiel, "Whitecap Aerosol Productivity Deduced from Simulation Tank Measurements", Journal of Geophysical Research, forthcoming.

C. W. Fairall, K. L. Davidson and G. E. Schacher, "An Analysis of the Surface Production of Sea-Salt Aerosols", Tellus, forthcoming.

Title: Slant Path Climatology

Investigator: K. L. Davidson, Associate Professor, Department of Meteorology

Sponsor: Naval Surface Weapons Center

Objectives: To relate routinely available climatological and observed meteorology data to slant path IR extinction

Summary: Consultation and interpretations were provided on the application of climatological data and spot weather observations for slant path optical (IR) extinction estimates. The utility of an integrated marine atmospheric boundary layer model for identifying relevant observed properties.

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

Objective: Application of a one-dimensional oceanic boundary layer model for prediction of the upper ocean thermal structure.

Summary: Our ultimate goal of this continuing project is to assist in the development of an ocean model to predict ocean thermal structure changes that have an important impact on environmental support for fleet operations. Our particular interest is in ocean prediction on time scales ranging from diurnal to seasonal periods. The suitability of the atmospheric forcing derived from the Fleet Numerical Oceanography Center analyses and models has been tested by comparison with the change in oceanic heat content from the North Pacific Experiment TRANSPAC monthly analyses (Gallacher, Elsberry and Garwood, 1980). A correction to the heat flux field has been derived for the spring transition period, but this correction needs to be tested during other seasons and years. This corrected heat flux field will be used to derive the Garwood ocean model (Gallacher and Garwood, 1981).

Publication: P. C. Gallacher and R. W. Garwood, Jr., "Schematic Description of the Garwood OPBL Model for Quasi-Steady Conditions," NPS Technical Report (forthcoming).

Conference Presentation: P. C. Gallacher, R. L. Elsberry and R. W. Garwood, Jr., "A Heat Budget of the North Pacific (1976-1979)," American Geophysical Union Fall Meeting, San Francisco, CA, (abstract in EOS, 61, 990-1).

Title: Oceanic Thermal Response to Atmospheric Forcing

Investigator: R. L. Elsberry, Professor of Meteorology

Sponsor: Office of Naval Research, Ocean Sciences Division

Objective: Understand and predict those changes in near-surface oceanic variables that are related to atmospheric forcing, especially on diurnal and synoptic time scales.

Summary: Oceanographic and meteorological observations and numerical simulations are used to understand the role of atmospheric forcing of the upper ocean layers. An ocean circulation model with an embedded mixed layer has been developed (Adamec, Elsberry, Garwood and Haney, 1981) as a tool to better understand the three-dimensional response to strong forcing. A review of modeling studies of ocean-hurricane interaction has been published (Elsberry, 1981). The primary thrust has been in the development of data assimilation techniques appropriate for ocean prediction (Warrenfeltz, 1980; Elsberry and Warrenfeltz, 1981; Warrenfeltz and Elsberry, 1981).

Publications:

D. Adamec, R. L. Elsberry, R. W. Garwood, Jr., and R. L. Haney, 1981: "An Embedded Mixed Layer-Ocean Circulation Model," Dynamics of Atmospheres and Oceans, 6, pp. 69-96.

R. L. Elsberry, 1981: "Oceanic Response to Hurricanes Part 2. Modeling Studies.," Proceedings 13th Technical Conference on Hurricanes and Tropical Meteorology, American Meteorological Society (Boston), pp. 58-62.

R. L. Elsberry and L. L. Warrenfeltz, 1981: "Data Assimilation Tests With An Oceanic Mixed Layer Model," Journal Physical Oceanography. (in review)

Conference Presentations:

R. W. Garwood, Jr., R. Shook, and R. L. Elsberry, "One-Dimensionality of the Ocean Boundary Layer During the NORPAX POLE Experiment," Annual Fall Meeting AGU, San Francisco, December 1980.

S. A. Sandgathe and R. L. Elsberry, "An Unsolved Problem--What Factors Produce Ocean Cyclogenesis?," Symposium on Current Problems of Weather Prediction, Vienna, Austria, June 1981.

L. L. Warrenfletz and R. L. Elsberry, "Insertion of Data in A One-Dimensional Oceanic Mixed Layer Model," Ocean Prediction Workshop, Monterey, CA, 1981.

Thesis Directed: L. L. Warrenfeltz, "Data Assimilation in A One-Dimensional Oceanic Mixed Layer Model," Master's Thesis, December 1980.

Title: The Role of the Ocean in Extratropical Cyclone Evolution

Investigator: Russell L. Elsberry, Professor of Meteorology

Sponsor: NPS Foundation Research Program

Objective: The purpose of this research is to improve our understanding of the role of the air-sea fluxes in the extratropical cyclone evolution. A study of the cyclone and its environment will be carried out in a numerical model by systematically introducing the air-sea fluxes.

Summary: The approach in these experiments is to systematically add or subtract physical processes in the numerical model. The resulting effect on the development, maintenance and movement of the extratropical cyclones over the ocean is being studied from the history files of the computer runs. The wavelength of the cyclones in the diabatic model runs is only half that found in the adiabatic model results. Diagnostic interpretations using the Petterson Development equation have been made with the atmospheric model results. Future experiments will involve the use of a finer-resolution atmospheric model to study cyclogenesis in polar air streams over the ocean and over land.

Conference Presentations: S. A. Sandgathe and R. L. Elsberry, "An Unsolved Problem--What Factors Produce Ocean Cyclogenesis," Proceedings Symposium on Current Problems of Weather Prediction, Publication 253, Zentral Anstalt fur Meteorologie and Geodynamik, Vienna, Austria, 34-37.

Theses Directed: S. A. Sandgathe, "A Numerical Study of the Role of Air-Sea Fluxes in Extratropical Cyclogenesis," Ph.D. Dissertation, September 1981.

Title: Tropical Cyclone Studies

Investigator: Russell L. Elsberry, Professor of Meteorology

Sponsor: Naval Air Systems Command

Objective: Improvement of numerical prediction of tropical cyclone tracks over the Pacific Ocean.

Summary: A cooperative effort to develop an operational numerical forecast model for tropical cyclones in the North Pacific was begun in 1975. Recent work on this project has focused on development of statistical post-processing techniques for removing systematic errors in the track forecasts (Gilchrist and Elsberry, 1981; Peterson and Elsberry, 1981; Elsberry, Gilchrist and Peak, 1981). This work is continuing with tracks predicted by the nested two-way model and operational model (Peak and Elsberry, 1981). An empirical orthogonal function technique for efficiently representing the large-scale environment around the tropical cyclone has been developed (Brown, 1981). A paper (Thompson et al, 1981) has been published that summarizes the official tropical cyclone track forecast errors in the eastern North Pacific after normalization by a climatology-persistence forecast error.

Publications:

R. L. Elsberry, R. C. Gilchrist, J. Peak, 1981: "Statistical Post-Processing of HATRACK Tropical Cyclone Track Forecasts," Papers in Meteorological Research, 1981.

J. Peak, and R. L. Elsberry, 1981: "Statistical Post-Processing of the Navy Nested Tropical Cyclone Model and the Operational Tropical Cyclone Model," NPS Technical Report, NPS63-81-003, September 1981.

W. J. Thompson, R. L. Elsberry, and R. G. Read, 1981: "An Analysis of Eastern North Pacific Tropical Cyclone Forecast Errors," Monthly Weather Review, 109, pp. 1930-1938.

Conference Presentations:

R. C. Gilchrist and R. L. Elsberry, "Statistical Adjustment of HATRACK Forecasts," 13th Technical Conference on Hurricanes and Tropical Meteorology, Miami Beach, December 1-5, 1981 (Abstract in Bulletin American Meteorological Society, 61, pp. 1126).

K. Peterson and R. L. Elsberry, "Improvement of TYAN by Statistical Regression Equations For Rotation of Analog Tracks," 13th Technical Conference on Hurricanes and Tropical Meteorology, Miami Beach, December 1-5, 1980. (Abstract in Bulletin American Meteorological Society, 61, pp. 1126)

Thesis Directed: D. W. Brown, "Tropical Storm Movement Based On Synoptic Map Typing Using Empirical Orthogonal Functions," Master's Thesis, June 1981.

Title: Numerical Modeling of Large-Scale Ocean Variability

Investigator: Robert L. Haney, Associate Professor of Meteorology

Sponsor: Office of Naval Research

Objective: To continually develop and improve a numerical model of the North Pacific Ocean and to use the model to identify processes responsible for the formation and evolution of large-scale thermal anomalies in the ocean.

Summary: Two studies of synoptic storm activity over the North Pacific Ocean and its relation to large scale sea surface temperature anomalies have been made using a special data set of 6-hourly surface wind analyses prepared by FNOC. These wind data have been used to drive a new embedded mixed layer ocean circulation model in a 10-year hindcast (1969-1978) of the currents and temperature structure in the Central Midlatitude North Pacific Ocean.

Publications:

R. L. Haney, M. S. Risch and G. C. Heise, "Wind Forcing Due to Synoptic Storm Activity over the North Pacific Ocean", Atmosphere-Ocean, 19(2), (forthcoming).

D. Adamec, R. L. Elsberry, R. W. Garwood, Jr. and R. L. Haney, "An Embedded Mixed Layer-Ocean Circulation Model", Dyn. Atmos. Oceans, 5, (forthcoming).

R. L. Haney, "Preliminary Results from an Embedded Mixed Layer-Ocean Circulation Model", Proceedings Workshop on Ocean Prediction, (forthcoming).

Conference Presentations:

R. L. Haney, "Model Simulated Relationship between Surface Winds and Surface Currents in the North Pacific", Fall Annual Meeting of the AGU, San Francisco, CA, Dec 8-10, 1980.

R. L. Haney and W. H. Little, "A Statistical Study of Monthly Anomalies of Synoptic Storm Activity and Sea Surface Temperature over the North Pacific", AMS First Conference on Climate Variations, San Diego, CA, Jan 19-23, 1981.

R. L. Haney, "Preliminary Results from an Embedded Mixed Layer-Ocean Circulation Model", Proceedings Workshop on Ocean Prediction, Naval Postgraduate School, Monterey, CA, 29 Apr-2 May 1981.

Title: Marine Boundary Layer Forecasting

Investigators: R. J. Renard, Principal Investigator, Professor and Chairman, Department of Meteorology; D. F. Leipper, Professor Emeritus, G. H. Jung, Professor, Department of Oceanography; and W. J. Thompson, Meteorologist, Department of Meteorology

Sponsor: Naval Air Systems Command

Objective: To improve the analysis and forecasting of marine boundary layer parameters over the open ocean and coastal areas.

Summary: Prototype model output statistics (MOS) analysis/forecast schemes for both marine fog and horizontal visibility were completed, using North Pacific Ocean (30-60N) summer season data from 1976, 77 and 79. Fleet Numerical Oceanography Center (FNOC) direct and derived, continuous and binary model-output parameters (over 150) and a fog climatology parameter were used to derive a probabilistic multiple linear regression approach to estimate fog/visibility out to 48 hrs. Extensive verification indicated considerable excellence over known existing techniques. A prototype surface visibility climatology for the North Pacific Ocean (20-70N) was developed from a 20-year data base using over one-third million observations per month. The visibilities were compared to a 10-year marine fog climatology derived by the National Climatic Center. Analyses of diurnal variations of marine visibility indicate a bias toward low visibility for intermediate observation times (03, 09, 15, 21 GMT). Work with the synoptic-oriented sequential marine fog/visibility development model continued. The United States west-coast version of the model has been developed for the test operational phase, currently underway at Pacific Missile Test Range, Pt. Mugu, CA. In its present form, visibility in one of four categories, may be probabilistically estimated out to eight days for non-frontal events, as a function of the normal sequential variation of boundary-layer inversion height. The coastal version of the development model has been adapted to the summer season (1973, 1977) open ocean using North Pacific Ocean OSV "P" (50N-145W) as focal point of the test area. Independent testing (1975) indicates success in predicting advection fog occurrences as a function of our indices, namely the boundary-layer inversion height, and air/sea temperature, moisture and wind parameters.

Publications:

R.L. Clark, "An Open-Ocean Marine Fog Development and Forecast Model for Ocean Weather Station PAPA," NPS Technical Report, NPS68-81-005, June 1981.

T. N. Talbot and R. J. Renard, "Development of a Prototype North Pacific Ocean Surface Visibility Climatology Stratified by Observation Times," NPS Technical Report, NPS63-81-002, June 1981.

Conference Presentations

R. L. Clark and G. H. Jung, "Open-Ocean Marine Fog Forecast Model," Am. Geophysical Union Spring Meeting, Baltimore, 25-29 May 1981. Abstract: EOS 62 (17) p. 291.

Theses Directed:

M. C. Koziara, "Further Development of a Statistical Model to Specify Marine Fog Probability Using Numerically-Derived Model Output Parameters," Master's Thesis, December 1980.

H. D. Selsor, "Further Experiments Using a Model Output Statistics Method in Estimating Open-Ocean Visibility," Master's Thesis, December 1980.

R. L. Clark, "An Open-Ocean Marine Fog Development and Forecast Model for Ocean Weather Station PAPA," Master's Thesis, June 1981.

T. N. Talbot, "Development of a Prototype North Pacific Ocean Surface Visibility Climatology Stratified by Observation Times," Master's Thesis, June 1981.

Title: Mesoscale Atmospheric Events--Antarctica

Investigator: R. J. Renard, Principal Investigator, Professor and Chairman, and W. J. Thompson, Meteorologist, Department of Meteorology

Sponsor: National Science Foundation, Office of Polar Programs

Objective: 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 observations taken by weather satellites (visual and infrared), specially-configurated 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, demonstrating thereby the unique combined use of the aforementioned data sources. 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. Project will terminate 31 May 1981.

Summary: The final stage of the project, and its continuation beyond 19 May 1981, was devoted to the processing and analysis of data from a network of six remote-site Automatic Weather Stations (AWS) on the Antarctic Continent and the nearby Ross Ice Shelf area. Five of the stations are within 150 km of McMurdo, while the sixth at Byrd is 1500 km east southeast of McMurdo. Pressure, temperature and vector-wind data from the AWS are collected via the polar orbiting satellites (collection systems) as follows-- The RAMS aboard NIMBUS VI in the period January 1979-February 1980 and the ARGOS aboard TIROS N and NOAA 6/7 from February 1980. The data have been collected in cooperation with the AWS developers at Stanford University and the current station managers, University of Wisconsin, then analyzed interpreted and displayed. Presently, up to 45+ observations/day at each station are available. Climatological presentations of the data have been prepared for annual, seasonal, monthly and intra- and inter- diurnal periods. Correlation of data from McMurdo and each AWS station, with and without time

lag, have been accomplished to give a statistical measure of the physical relationship of parameters at the pairs of stations.

Publications: R. J. Renard and S. Hervey, "Statistical Analysis of Antarctic Remote-Site Automatic Weather Station Data for the Period 1980 and 198[illegible]" NPS Technical Report, (forthcoming).

Thesis Directed: K. M. Scarbo, "Analysis of the Remote Antarctic Automatic Weather Station Data for 1979," Master's Thesis, (forthcoming).

NAVAL POSTGRADUATE SCHOOL AND UNIVERSITY OF WISCONSIN PERSONNEL PERFORM MAINTENANCE CALIBRATION CHORES ON A REMOTE AUTOMATIC WEATHER STATION AT MARBLE POINT, ANTARCTICA (77°26'S 163°45'E) 28 NOVEMBER 1981.

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|---|---|
| Title: | Regional Synoptic Forecasting: Southern Africa |
| Investigators: | R. J. Renard, Pricipal Investigator, Professor and Chairman, and W. J. Thompson, Meteorologist, Department of Meteorology |
| Sponsor: | Naval Air Systems Command |
| Objective: | To assess the status of and make improvements on the analysis and forecasting of weather parameters important to air/sea operations over the Southern African Continent and surrounding South Atlantic/ Indian Ocean areas (approximately 10-60S, 75E-15W). |
| Summary | FY81--In the start-up phase of the project the following were accomplished: Literature regarding the synoptic-scale dynamical, thermal and moisture structures of the defined Southern Africa region were assembled. The climatologies of important dynamic, thermal and moisture parameters of the area were assembled. |

Title: Diagnostics of Oceanic Extratropical Cyclones

Investigator: C. H. Wash, Assistant Professor of Meteorology

Sponsor: NPS Foundation Research Program

Objective: To transfer and develop a variety of limited area diagnostic programs for the study of both observed and numerically-simulated extratropical cyclone studies and to apply these techniques to the study of oceanic cyclogenesis.

Summary: During FY 81 the limited area quasi-Lagrangian budget programs were converted to NPS IBM 3033 system. Mass and angular momentum programs are complete with associated interpolation and utility programs while development in circulation and kinetic energy routines was initiated. Data from the First Global GARP Experiment of an intense oceanic cyclone were obtained and a mass budget study for the February 11-19, 1979 'President's Day Storm' completed.

Publication: C. Wash with L. Uccellini and P. Kocin, "An Analysis of Jet Streak Interaction in the President's Day Storm," February 17-18, 1979. Submitted to Monthly Weather Review.

Theses Directed: Don Roman, "Application of Quasi-Lagrangian Diagnostics and FGGE Data in a Study of East-Coast Cyclogenesis", Master's Thesis, September 1981.

Title: Numerical Prediction Model Development

Investigator: R. T. Williams, Professor of Meteorology and A. L. Schoenstadt, Associate Professor of Mathematics

Sponsor: Naval Air Systems Command

Objectives: To develop and test better procedures for global and regional weather predictions.

Summary: A finite element model of the advective equation was successfully tested with smoothly varying finite elements. A finite element, vorticity-divergence form of the shallow-water equations with semi-implicit time differencing was developed. This formulation gave much better forecasts with less computer time. The basic primitive equation model which was developed by Monaco and Williams was generalized to handle moisture and condensation, and the finite differencing was also improved. This model was evaluated with topography and cyclogenesis cases. A spectral prediction model which was developed by Dr. T. Rosmond was adopted for comparative testing with other prediction models.

Publications: R. T. Williams, "1981: On the Formulation of Finite-Element Forms for the Shallow Water Equations," International Journal of Numerical Methods of Fluid Mechanics, 1, 81-97.

R. T. Williams, "1981: On the Formulation of Finite-Element Prediction Models," Monthly Weather Review, 109, 463-466.

R. T. Williams and O. C. Zienkiewicz, "1981: Improved Finite Element Forms for the Shallow Water Wave Equations," International Journal of Numerical Methods of Fluid Mechanics, 1, 81-97.

Conference Presentations: R. T. Williams, "On the Formulation of Finite Element Prediction Models," American Geophysical Union, Fall Meeting, San Francisco, December 1980.

Theses Directed: Mark Older, "A Two-Dimensional Finite Element Advection Model with Variable Resolution," Master's Thesis, June 1981.

Edward Woodward, "Development of Improved Finite Element Forms for the Shallow Water Equations," Master's Thesis, September 1981.

# DEPARTMENT

# OF

# AERONAUTICS

## 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 STUDIES

Professor Ball is continuing his research in aircraft survivability with support from the Naval Air Systems Command and the Joint Technical Coordinating Group for Aircraft Survivability (JTCG/AS). Completed research projects include a study of the techniques and areas of applicability of several endgame computer programs; a study of various programs and organizations involved cruise missile survivability of an A-6E aircraft in a war-at-sea scenario; and examination of the P-3 aircraft; and a computer program (ATER) was written to determine the number of expendables required by U.S. Navy and Marine Corps aircraft.

### INVESTIGATION OF THE POTENTIAL FOR MINGLING TANDEMLY EMITTED PARALLEL JETS

Professor Bell has completed preliminary investigation on the feasibility of deliberately forcing interference, at small scale, of tandem cold jets in order to establish whether adequate flow mechanisms exist to ensure efficient mingling of the jets. Xenon flashtubes/power supplies for short duration and/or rapid pulse rate exposure have recently been acquired in a planned attempt to improve visual assessment of flow and mixing characteristics in shadowgraph, schlieren and front-lighting modes.

### STABILIZATION OF GASEOUS DISCHARGES

Professor Biblarz has continued his studies on defining practical aerodynamic means for stabilizing discharges of interest for electrical lasers and other applications. Comparison was made on the cross flow geometry and parallel flow. A multiplicity of precursors to breakdown can be witnessed together with glow regions that charge as a function of current. A downstream cathode has been used to observed current convection.

### STUDY OF BASIC MECHANISMS THAT LEAD TO ARCING

Professor Biblarz has continued with a new direction to study the basic mechanisms that lead to arcing in laser discharges and to develop a discharge model which will aid in the prediction of discharge conditions. Arcing or glow collapse severely limits high energy laser performance even in the ionizer/sustainer discharge. Using a two-dimensional model for the anode, it was established that Joule heating is not significant for common flush times in pulse molecular lasers.

LDA INVESTIGATIONS AND APPLICATIONS OF MODERN CONTROL THEORY

Professor Collins has continued his work on the measurement of instantaneous velocity profiles in turbomachinery and oscillatory flows. Further measurements of the vane excited jet have been made with the calculation of all main tubulent quantities. The two-color LDA system has been assembled. The electronics for the instantaneous profiles is currently being assembled.

Professor Collins is also conducting a study of robust controllers with particular application to engine and flight technology. The F-100 nonlinear engineer program is now available on the NPS computer. Several low order linear models have been developed from the program. A project in the area of robust controller is currently in progress.

NUMERICAL MODELING OF THE FLOW IN TRANSONIC AXIAL COMPRESSORS

Dr. Eidelman, with Dr. Shreeve, has developed a computer code to be used to solve efficiently and accurately the transonic flow between the blades of a turbocompressor.

EXCIMER LASERS

Dr. Fuhs, with LT Lonnie W. Cole, CAPT James Etchebury (USA), Mr. Gregory A. Blaisdell, is continuing his investigation on the transient index of refraction in an e-beam pumped XeF excimer laser.

AIRBORNE LASER TURRET

Dr. Fuhs, with several of his thesis students, has investigated experimentally the efficacy of flow control using suction in the fairing for a laser turret or using vortices.

A laser turret was built and mounted in the Naval Postgraduate School smoke tunnel.

AERO-OPTICS FOR AN ARRAY OF LAMINAR FLOW LASER TURRETS

Dr. Fuhs is investigating far field diffraction from an array of apertures of small size.

PROBE FOR PRESSURE ALTITUDE FUZE

Dr. Fuhs developed and built a probe which senses ambient pressure from a supersonic projectile or missile. Various tests were made on this probe using the Naval Postgraduate School's supersonic wind tunnel.

GUN LAUNCHED RAMJET GUIDED MISSILE

Dr. Fuhs, with several of his thesis students, is screening various Navy missions which are appropriate for a gun launched ramjet guided projectile.

A ramjet guided projectile is currently being designed for the anti-ship missile defense (ASMD). Other missions are being examined.

SYSTEM SAFETY IN MILITARY AVIATION

Professor Layton is developing several research programs that could lead to the reduction in number and severity of the human factor involvement in military aviation mishaps.

LIGHTER-THAN-AIR (LTA) ANALYTICAL STUDIES

Professor Layton conducted two analytical studies on the enhanced performance of LTA vehicles using dynamic lift hybridization and the other on the effects of turbulence on the stability and control of LTA vehicles. In addition a system safety review of all Navy LTA mishaps since 1950 has been conducted and a request for proposal for a Maritime Patrol Airship has been reviewed for technical matter.

AIRCRAFT FATIGUE STUDIES

Professor Lindsey is continuing to develop improved methods of aircraft fatigue life prediction using data from fatigue monitoring devices currently being flight tested. This work also involves microprocessor technology, photoelasticity, finite element numerical analysis and analytical methods, all of which are yielding results.

INSPECTION TECHNIQUES FOR UNDERGROUND STEAM LINES

Professor Miller is conducting a study to investigate and develop methods and techniques for activity level public works inspection of underground steam lines.

A procedure which employs sulphur hexaflouride as a leak tracer has been developed and field tested. Also, a procedure employing a complete energy balance including direct measurement of mass flow rate and enthalpies proximal and distal ends of steam distribution lines has been designed for the determination of steam line heat loss. The latter has also been field tested and is currently being refined to include direct digital readout instrumentation in order to simplify use.

ELECTROHYDRODYNAMIC CONTROL OF FUEL INJECTION IN GAS TURBINE COMBUSTORS

Professors Miller and Biblarz are evaluating the merits of electrohydrodynamically - augmented fuel injection for gas turbine combustors. Spray characteristics are being studied with an optical transmission technique and the effects on combustion are being evaluated from measurements of combustion product temperatures. The goal of this program is to optimize combustion efficiency for a variety of gas turbine fuels.

A T-56 aircraft injector and combustion can have spray characteristics investigation and combustion apparatus. Results indicate that a centerline electrode charged up to 30kV is capable of producing large charges

in fuel spray characteristics and it has been possible with this technique to match the spray characteristics of JP-5 to those of the design fuel, JP-4, over the operating envelope of the injector.

AIR QUALITY ASSESSMENT MODEL FOR NAVAL AIR OPERATIONS

Professor Netzer has continued his research work in determining the emission levels and air quality effects from Naval Air Station aircraft operations and test cells. The air quality assessment computer model has been developed for Naval air operations and validation efforts have been conducted at NAS, Miramar, CA.

SOLID FUEL RAMJET COMBUSTION

Professor Netzer has continued his work on the development of computer simulation of the combustion process. Bypass air apparently quenches chemical reactions, reducing the efficiency by eight percent when burned at low air flow rates.

Professor Netzer is also conducting a study to estimate expected peformance from new fuel formulations and combustor geometries by using non-reacting flow characteristics and fundamental fuel properties. Combustion instability significantly increases the rate of fuel regression with PMM grains. The determination of the effects occuring when combustion pressure oscillations are applied to combustor/inlet geometry and flow conditions is also being made. All combustion instabilities observed have been at low frequency and the predicted fuel regression rate profile has been improved.

TURBOJET TEST CELL AERODYNAMICS AND EMISSION LEVELS

Professor Netzer is continuing to 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 augmentor tube. He is also experimentally determining the effects of fuel additives and test cell design on emitted particulate levels.

A final report on computer model validation was issued. Subscale test cell was improved. An initial test series was completed using various propellants.

PARTICULATE BEHAVIOR IN SOLID PROPELLANT ROCKET MOTORS

Professor Netzer is currently conducting a combustion study of composite solid propellants using holography, high-speed motion pictures, light scattering measurements and postfire particle collection scanning electron microscopic examination. The immediate goal of this study is to evaluate the relative advantages and disadvantages of the different experimental techniques for obtaining two-phase flow characteristics within the combustion environment of a solid propellant grain. Several tests were made with positive results.

## V/STOL PROPULSION PROBLEMS

Professor Platzer investigated the flow phenomena in V/STOL aircraft propulsion systems and performed V/STOL aircraft concept feasibility studies. A new jet excitation mechanism has been identified which increases secondary flow entrainment in thrust augmenting ejectors without impairing nozzle efficiency. A patent application is currently being processed. Also, the analysis of unsteady supersonic cascade flows has been continued.

## APPLIED RESEARCH IN ENGINEERING TECHNOLOGY

Professor Schmidt assumed the position of Acting Assistant for Engineering Technology in the OASN (RE&S). Duties included administering research contract reviews, visiting laboratory facilities and assisting in policy establishment for Navy 6.1, 6.2 and 6.3A research upon aircraft, missile, ship, submarine and boat platforms in the disciplines of fluid mechanics, propulsion and structures.

## AXIAL COMPRESSOR FLOW FIELDS

Dr. Shreeve is continuing his study of flow fields in axial compressors required to formulate new analytical prediction models to obtain detailed measurements against which new computer analysis codes can be verified.

A new measurement technique "Dual-Probe Digital," or DPDS was developed. First measurements of all three components of the rotor exit velocity across two selected rotor blade passages have been obtained. Tests to obtain similar data at transonic relative Mach numbers, both on- and off- design are planned. The calibration of a second-generation probe system was completed.

## TRANSONIC COMPRESSOR INVESTIGATIONS

Dr. Shreeve, with Mr. F. Neuhoff, has continued his work 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.

A single stage axial transonic compressor and complete test rig were designed and built in earlier phases of the present program. Preliminary compressor tests were made and new instrumentation techniques necessary to the planned study were developed. Using high speed digital sampling synchronized to rotor rotation, techniques for measuring periodic (unsteady) wall pressure distributions and time-resolved rotor exit velocity field have been generated. Tests to systematically collect full performance and aerodynamic data on the prototype stage are underway. Plans for an advanced aerodynamic stage, to test design and analysis procedures while serving as a vehicle for basic tip design and inlet distortion studies are underway.

## DEVELOPMENT OF A TRANSONIC COMPRESSOR MODEL

Dr. Shreeve, with Mr. F. Neuhoff, is continuing to develop a small transonic axial air compressor model and establish methods of measuring performance and flow behavior.

This project is directly associated with the project "Transonic Compressor Investigations." A fully instrumented transonic axial compressor models has been built. The test program to date has achieved operation to 70% speed. Computer acquisition hardware and software and needed instrumentation have been developed and tests are now underway toward design speed.

## CASCADE STUDIES OF FLOWS THROUGH COMPRESSOR BLADINGS

Dr. Shreeve is trying to obtain data using subsonic cascade wind tunnel to verify computational codes used in the design and analysis of controlled diffusion compressor blading.

Following a preliminary program to verify cascade test conditions and select suitable blade chord and spacing, tests were conducted using a reference set of DCA blades. Data were obtained for turning angle, losses, AVDR and blade pressures distribution for variations in incidence. Modification of the cascade IGV's was implemented to improve inlet flow and controlled-diffusion blade test will follow.

## MULTI-STAGE COMPRESSOR STUDIES

Dr. Shreeve, with Mr. I. Moyle, has continued his investigation of the flow characteristics in a low speed three-stage axial compressor, with special emphasis on tip clearance effects.

## VERY HIGH REACTION TURBINES

Dr. Shreeve's current and new project is to investigate analytically and experimentally the potential of two proposed very high reaction turbines of original design.

Title: Aircraft Combat Survivability Studies

Investigator: Robert E. Ball, Professor of Aeronautics

Sponsor: Naval Air Systems Command

Objective: To provide continuing technical support to AIR-5164, the Combat Survivability Branch of the Naval Air Systems Command. The following projects were completed this fiscal year:

a) Endgame Program Assessment Studies
b) Cruise Missile Survivability Study
c) Aircraft Survivability in a War-at-Sea Scenario
d) P-3 Survivability Enhancement Study
e) Expendables Requirements for U. S. Navy and Marine Corps Aircraft

Summary:

a) This project consisted of a study of the techniques and areas of applicability of several endgame computer programs currently in use at various research facilities and aircraft companies around the country. An endgame program is one which simulates an encounter between a detonating missile warhead and an aircraft. The predicted output consists of the aircraft components hit by the warhead fragments, their probability of kill, and the probability the aircraft is killed. The endgame programs ATTACK and SCAN were modified for installation on the NPS IBM 3033 computer, and the pre and post processor SCAN graphics routines were modified to execute using the NPS Textronix 4081 and 4012 terminals. The first three theses listed below were associated with this project.

b) This project consisted of a study of the various programs and organizations involved in cruise missile (HARPOON, TOMAHAWK, ALCM, and GLCM) survivability assessment and testing. The controlling organizations included the Naval Air Systems Command, the Joint Cruise Missile Project Office, and the Air Force Systems Command. The contractors consisted of General Dynamics, Boeing, and McDonnell-Douglas.

c) This project consisted of an examination of the survivability of an A-6E aircraft in a war-at-sea scenario. Particular emphasis was put on determining the effectiveness of electro-optical countermeasures in increasing aircraft survivability.

d) The susceptibility of the P-3 aircraft was examined, and a proposal was made for a "quick-fix" to reduce the probability that the aircraft would be detected and/or damaged by hostile weapons systems.

e) A computer program (ATER) was written to determine the number of expendables required by U. S. Navy and Marine Corps aircraft in several theaters of operation, based upon user-specified input data on the threat type and intensity, the type of mission and typical flight paths.

Theses Directed:

J. E. Parr, "Attack vs Scan: A Comparison of Endgame Aircraft Survivability Computer Programs", Master's Thesis, December 1980.

C. K. Fair, "A Comparison of Computer Warhead - Target Endgame Simulation and Recommendations Pertaining to Future Endgame Programs", Master's Thesis, June 1980.

T. M. Hayes, "The Installation of Computer Graphics for Survivability Studies and a Discussion of Pk/d Functions", Master's Thesis, June 1980.

K. D. Via, "Cruise Missile Survivability: An Overview", Master's Thesis, June 1980

G. D. Hobby, "A User's Manual and Program Description of SEA PLOT: A Three-dimensional Graphics Program Depicting a War-at-Sea Encounter Between a Single Ship and a Single Aircraft", Master's Thesis, June 1980

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| **Title:** | Investigation of the Potential for Mingling Tandemly Emitted Parallel Jets |
| **Investigator:** | R. W. Bell, Professor of Aeronautics |
| **Sponsor:** | Naval Weapons Center |
| **Objective:** | In cruise mode, the cold (engine bypass) forward exhaust jet of the Harrier aircraft's Pegasus engine trails into the neighborhood of the hot rear turbojet exhaust. Efficient mingling of these exhausts might advantageously affect IR signature. Preliminary assessment of feasibility is to be examined by deliberately forcing interference, at small scale, of tandem cold jets in order to establish whether adequate flow mechanisms exist for the purpose. |
| **Summary:** | Xenon flashtubes/power supplies for short duration and/or rapid pulse rate exposure have recently been acquired in a planned attempt to improve visual assessment of flow and mixing characteristics in shadowgraph, schlieren and front-lighting modes. |

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| Title: | Aerodynamic Stabilization of Gaseous Discharges |
| Investigator: | Oscar Biblarz, Associate 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, plasma-chemical devices, etc. Particular objectives is to compare discharge geometries as a function of flow velocity and of turbulence. This is a part of a continuing program. |
| Summary: | The cross flow geometry shows interesting phenomena when compared to the parallel flow. A multiplicity of precursors to breakdown can be witnessed together with glow regions that charge as a function of current. A downstream cathode has been used to observe current convection. |
| Publications: | J. L. Barto, "Study of Gas Dynamic Effects on Non-Equilibrium, High-Pressure, Electric Discharges," NPS Report NPS 67-80-005, August 1980. |
| Conference Presentations: | J. L. Barto and O. Biblarz, "Gasdynamic Interactions in Non-Uniform High Pressure Discharge," 33rd Gaseous Electronics Conference, Norman, Oklahoma, October 7-10, 1980.<br><br>O. Biblarz, "Some Aspects of Aerodynamic Stabilization of Gaseous Discharges," 1981 IEEE International Conference on Plasma Science, Santa Fe, New Mexico, May 18-20, 1981. |
| Thesis Directed: | J. W. Wainionpaa, "Electric Discharge Interaction in Parallel and Cross-Flow Electric Fields," Master's Thesis, September 1981. |

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| Title: | Study of Basic Mechanisms that Lead to Arcing |
| Investigator: | Oscar Biblarz, Associate Professor of Aeronautics |
| Sponsor: | NPS Foundation Research Program |
| Objective: | The main objective is to study the basic mechanisms that lead to arcing in laser discharges and to develop a discharge model which will aid in the prediction of discharge conditions. This is a new direction for a continuing project. |
| Summary: | Arcing or glow collapse severely limits high energy laser performance even in the ionizer/sustainer discharge. This arcing may be caused by a variety of conditions. Using a two-dimensional model for the anode, we have established that Joule heating is not significant for common flush times in pulsed molecular lasers. We are presently looking at a model for unipolar arcing. |
| Publications: | O. Biblarz, R. E. Ball, and S. T. Van Brocklin, "Electrode Boundary Layers in Dense, Diffuse Plasma," NPS Report No. NPS67-80-011, March 1980. AFWAL-TR-80-2088, October 1980.<br><br>S. T. Van Brocklin and O. Biblarz, "The Plasma Boundary Layer Over a Positive Electrode," IEEE Transactions of Plasma Science--*Decision pending.* |
| Conference Presentation: | S. T. Van Brocklin and O. Biblarz, "Plasma Boundary Layer Over a Positive Electrode," 34th Annual Gaseous Electronics Conference, Boston, MA, October 20-23, 1981. |
| Thesis Directed: | S. T. Van Brocklin, "A Computer Analysis of the Plasma-Boundary Layer Behavior Over a Positive Electrode," Aeronautical Engineer Thesis, June 1981. |

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| Title: | LDA Investigations and Applications of Modern Control Theory |
| Investigator: | Daniel J. Collins, Professor of Aeronautics |
| Sponsor: | Naval Air Systems Command |
| Objectives: | Measurement of instantaneous velocity profiles in turbomachinery and oscillatory flows.<br><br>Study of robust controllers with particular application to engine and flight technology. |
| Summary: | The two color LDA system has been assembled. Further measurements of the vane excited jet have been made with the calculation of all the main turbulent quantities. Assistance in obtaining these measurements was obtained from a postdoctoral associate from Australia at no cost to the project. The electronics for the instantaneous profiles is now being assembled.<br><br>In the control area one thesis has been completed. The F-100 nonlinear engineer program is now available on the NPS computer. Several low order linear models have been developed from the F-100 program. A thesis will be finished shortly looking at control strategies using the linear models. A doctoral student (Naval Officer) has begun working on the project in the area of robust controller. |
| Thesis Directed: | B. L. Dougherty, "Effect on Fuel Efficiency of Parameter Variation in the Cost Function for Multivariable Control of a Turbofan Engine," Master's Thesis, September 1981. |

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| **Title:** | Aero-Optics for an Array of Laminar Flow Laser Turrets |
| **Investigator:** | Allen E. Fuhs, Distinguished Professor of Aeronautics and Physics and Chemistry |
| **Sponsor:** | Air Force Weapons Laboratory |
| **Objective:** | To investigate far field diffraction from an array of apertures of small size. |
| **Summary:** | Turbulent and separated flow over laser turrets greatly degrades beam quality. By reducing scale of the laser turret and using multiple apertures, the flow environment may be laminar. The far field intensity for an array of laminar flow laser turrets was calculated. The questions concerning the aerodynamic shape of the individual turrets were addressed. In addition, the distribution of laser power to multiple turrets was considered. |
| **Thesis Directed:** | Brian Tousley, "Distributed Apertures in Laminar Flow Laser Turrets," Master's Thesis, September 1981. |

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| Title: | Amiable Warhead Design for SOJS Missile |
| Investigator: | Allen E. Fuhs, Distinguished Professor of Aeronautics and Physics and Chemistry |
| Sponsor: | AEGIS Land Based Combat System Test Site |
| Objective: | The Standoff Jammer Suppression, SOJS, Missile has very stringent warhead requirements. The feasibility of an aimable warhead was investigated. |
| Summary: | Various aimable warhead designs were examined. |
| Thesis Directed: | Stephen A. Jones, "Aimable Warhead Design for SOJS Missile," Master's Thesis, December 1980. |

Title: Beam Quality in Excimer Lasers

Investigators: Dr. Allen E. Fuhs, Distinguished Professor of Aeronautics and Physics and Chemistry and 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 laser having initial concentrations Ne:Xe:-$NF_3$::95.5:4.3:0.2. The calculation used Ne in excited states including the transistion array 3s → 4p and all other constituents in ground state. Lines in 3s → 4p array may be resonant with XeF radiation. To obtain the transient populations for Ne, a modification was made to a Naval Research Laboratory computer code which typically accounts for 180-200 reactions involving 50-60 different species. The modified program includes populations in 12 electronic configurations of Ne. Electron beam current was changed 10 percent at constant voltage to simulate the influence of a hibachi shadow. For a nonresonant laser wavelength, an optical pathlength in the laser, L, less 35 meters will have distortion $\delta/\lambda$ less than 0.1; however, for a laser wavelength in resonance with Neon, L of only 0.11 meter will cause $\delta/\lambda = 0.1$. The difference in optical pathlength is $\delta$.

Publication: Allen E. Fuhs, James Etchechury, Lonnie Cole, and Gregory A. Blaisdell, "Transient Refractive Index in a XeF Laser," Naval Postgraduate Technical Report NPS-67-80-012, September 1980, 45 pp., Submitted to Journal of Optical Society of America.

Conference Presentation: A. E. Fuhs, "Transient Retractive Index in XeF Laser," Meeting of the Optical Society of America, Chicago, IL, 14-17 October 1980.

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| Title: | Flow Control for an Airborne Laser Turret |
| Investigator: | Allen E. Fuhs, Distinguished Professsor of Aeronautics |
| Sponsor: | Air Force Weapons Laboratory |
| Objective: | To investigate experimentally the efficacy of flow control using suction in the fairing for a laser turret or using trapped vortices. |
| Summary: | A laser turret with 18-inch diameter and fairing was built and mounted in the Naval Postgraduate School smoke tunnel. A large centrifugal blower with 17 inches water and 7500 cfm performance provides suction. The suction does remove regions of flow separation from the turret/fairing interface. |
| Publication: | J. R. Schonberger, A. E. Fuhs, and A. M. Mandigo, "Flow Control for an Airborne Laser Turret,". Journal of Aircraft (forthcoming). |
| Conference Presentation: | J. R. Schonberger, A. E. Fuhs, and A. M. Mandigo, "Flow Control for an Airborne Laser Turret," AIAA Aircraft Systems and Technology Conference, Dayton, Ohio, 11-13 August 1981, AIAA Preprint 81-1637. |
| Theses Directed: | James R. Schonberger, "Flow Control about an Airborne Laser Turret," Master's Thesis, December 1980.<br><br>Alan M. Mandigo, "Control of Airflow about a High Energy Laser Turret," Master's Thesis, December 1980.<br><br>David Rippel, "Laser Turret Flow Control," Master's Thesis, December 1981.<br><br>James E. Burd, "Boundary Layer Control of the High Energy Laser Turret Using Suction of Trapped Vortices," Master's Thesis, December 1981. |

**Title:** Gun Launched Ramjet Guided Missile

**Investigator:** Allen E. Fuhs, Distinguished Professor of Aeronautics

**Sponsor:** Defense Advance Research Projects Agency, Tactical Technology Office

**Objective:** To screen various Navy missions which are appropriate for a gun launched ramjet guided projectile.

**Summary:** A ramjet guided projectile is being designed for the antiship missile defense, ASMD, mission. The projectile will be fired from MK 45 mounts having a 5"54 gun. Other missions are being examined.

**Theses Directed:**

William Hutchinson Parks, "Warhead Design for a Ramjet Propelled 5-Inch Guided Projectile for Use in Anti-Ship Missile Defense," Master's Thesis, December 1980.

John S. White, "Aerodynamics and Control of a 5"/54 Gun Launched Missile," Master's Thesis, December 1980.

Robert Leo Frazier, "Exterior Ballistics, Guidance Laws and Optics for a Ramjet Propelled Gun-Launched Missile," Master's Thesis, December 1980.

Gary L. Brown, "Propulsion for Ramjet Propelled Guided Projectile for 5-Inch 54," Master's Thesis, December 1980.

James M. Terrell, "Conical Lens for 5"/54 Gun Launched Missile," Master's Thesis, June 1981.

John Francis Moran, "Performance of an Oswarisch Inlet with Hemispherical Centerbody at Zero Angle of Attack," Master's Thesis, June 1981.

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| Title: | Probe for Pressure Altitude Fuze for a Broadband Jammer |
| Investigator: | Allen E. Fuhs, Distinguished Professor of Aeronautics |
| Sponsor: | Naval Weapons Center |
| Objective: | To develop a probe which senses ambient pressure from a supersonic projectile or missile. |
| Summary: | The jammer is to be activated at 25,000 feet altitude using a probe. The Mach number range is from 1.4 to 2.0, and the angle of attack varies ±20 degrees. A probe which senses ambient pressure was built and tested in the Naval Postgraduate School supersonic wind tunnel. Maximum error in measuring ambient pressure was 6 per cent over the range of angle of attack at Mach 2. The wind tunnel could not be started at Mach 1.4. |
| Thesis Directed: | Kenneth Delmer Tillotson, "Analysis and Wind Tunnel Tests of a Static Pressure Probe Used to Sense Altitude Through Measurement of Static Pressure," Master's Thesis, December 1980. |

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| Title: | Lighter-Than-Air (LTA) Analytical Studies |
| Investigator: | Donald L. Layton, Professor of Aeronautics |
| Sponsor: | United States Coast Guard Headquarters |
| Objective: | To conduct several studies in the area of Lighter-Than-Air technology and to act as a technical advisor in LTA matters. |
| Summary: | Analytical studies have been conducted in two areas: (1) Enhanced performance of LTA vehicles by the use of dynamic lift hybridization; and (2) the effects of turbulence on the stability and control of LTA vehicles. In addition, a system safety review of all Navy LTA mishaps since 1950 has been conducted and the Coast Guard Request for Proposal for a Maritime Patrol Airship has been reviewed for technical matters. |
| Publication: | D. M. Layton, "Quasi-Hybrid Airships," in Proceedings of Fourth Lighter-Than-Air Technology Conference, pp. 137-139, Annapolis: American Institute of Aeronautics and Astronautics. |
| Conference Presentation: | D. M. Layton, "Quasi-Hybrid Airships," AIAA Fourth Lighter-Than-Air Technology Conference, Annapolis, MD, July 8-10, 1981. |
| Thesis Directed: | M. B. Bender, "Lift and Drag Variations of a Lighter-Than-Air Vehicle with Bow and Stern Planes for Hybrid Operation," Master's Thesis, December 1979. |
| | J. R. Wrobleski, "Effect of Turbulence on the Stability and Control of a Lighter-Than-Air Vehicle, Aeronautical Engineer Thesis, December 1981. |

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| Title: | System Safety in Military Aviation |
| Investigator: | Donald M. Layton, Professor of Aeronautics |
| Sponsor: | Naval Aerospace Medical Research Laboratory |
| Objective: | To develop several research programs that could lead to the reduction in number and severity of human factor involvement in military aviation mishaps. |
| Summary: | An increasing incidence of human factors involvement in military aviation mishaps dictates that action be taken to reduce the number and severity of this type of mishap. Several definitive research programs have been developed and suggestions have been made as to the establishment of these programs by the Naval Aerospace Medical Research Laboratory, other Navy activities and non-Navy activities. The goal of all these research programs is the identification, analysis and reduction of human factor causal factors. |
| Publication: | D. M. Layton, "Proposed Research Tasks for the Reduction of Human Error in Naval Aviation Mishaps", NPS67-81-018, October 1981. |

Title: Fatigue in Aircraft Structures

Investigator: G. H. Lindsey, Professor of Aeronautics

Sponsor: Naval Air Systems Command

Objective: To develop sufficient understanding of fatigue in aluminum that fatigue failures at stress risers can be predicted from known fatigue behavior of plain, uniaxial specimens. With this understanding fatigue monitoring information soon to come forth can be more fully used to calculate damage of fleet aircraft.

Summary: A variety of notches covering a range of stress concentration factors have been investigated in detail as they have been loaded into the nonlinear range. Finite elements, photoelasticity and some classical analytic techniques have all been used to determine stress and strain behavior during loading and unloading and after unloading is complete and residual stresses and strains remain. A model has been developed and evaluated which accurately describes most of the behavior at the notch tip. Only one important element remains undetermined by means of the model and that is the residual stress. At present that must be measured.

Publications:

G. H. Lindsey, "A Study of Notch Fatigue Part I: Static Photoelatic Measurements," NPS Technical Report NPS 67-81-004, June 1981.

G. H. Lindsey, "A Study of Notch Fatigue Part II: Elastic Stress Analysis of Notches," NPS Technical Report NPS67-81-005, June 1981.

G. H. Lindsey, "A Study of Notch Fatigue Part III: Plastic Stress Analysis of Notches," NPS Technical Report NPS67-81-006, June 1981.

Theses Directed:

Frank E. Stenstrom, "Photoelastic Study of Elastic and Plastic Stress Fields in the Vicinity of a Notch," Master's Thesis, December 1980.

Michael John Kaiser, "An Elastic-Plastic Finite Element Analysis of Notched Aluminum Panels," Master's Thesis, March 1981.

Jerry Wayne Dalton, "Design of a Data Acquisition and Reduction System for Fatigue Testing," Master's Thesis, September 1981.

Title: Electrohydrodynamic Control of Fuel Injection in Gas Turbine Combustors

Investigators: J. A. Miller and O. Biblarz, Associate Professors of Aeronautics

Sponsor: Naval Air Systems Command

Objective: A program is in progress to evaluate the merits of electrohydrodynamically - controlled fuel injection for gas turbine combustors. Fuel injection spray characteristics are being studied with an optical transmission technique and the effects on combustion are being evaluated from measurements of combustion product temperatures. The goal of this program is to evolve practical means of using electrostatic elements within the combustion chamber to control fuel spray characteristics and thus optimize combustion efficiency for a variety of gas turbine fuels.

Summary: A T-56 aircraft injector has been employed in the spray characteristics investigation and a T-56 injector and combustion can liner have been incorporated into a combustion apparatus. Preliminary results indicate that a very simple centerline electrode charged with voltages typical of spark plugs, (~30kV), is capable of producing large charges in fuel spray characteristics and it has been possible with this technique to match the spray characteristic of JP-5 to those of the design fuel, JP-4, over the operating envelope of the injector. Some practical difficulties in maintaining electrode voltage in the presence of ionizing flame fronts has been encountered and a development program to overcome this difficulty is underway. Additionally, studies are being conducted to better understand the effects of electrostatic fields on spray characteristic modification and the subsequent implications to the burning process and combustion efficiency.

Theses Directed: R. J. Laib, "Electrical Spraying of Fuels," Aeronautical Engineer Degree (extension to March 1982).

L. L. Todd, "Design of an Apparatus for the Study of Electrostatic Effects on Gas Turbines Fuel Sprays and Combustion," Master's Thesis, September 1981.

Patent Application: O. Biblarz, J. A. Miller, and L. Laib, "Electro-hydrodynamic Control of Fuel Injection in Gas Turbines." Navy Case No. 65,293.

Title: Inspection Techniques for Underground Steam Lines

Investigator: J. A. Miller, Associate Professor of Aeronautics

Sponsor: Naval Civil Engineering Laboratory

Objective: To investigate and develop methods and techniques for activity level public works inspection of underground steam lines including development of (1) sulphur hexaflouride leak detection field procedures; (2) heat loss measurement field procedure; and (3) overall procedures/guidelines manual.

Summary: A procedure which employes sulphur hexaflouride, a nontoxic electronegative gas, as a leak tracer has been developed and field tested with success. Additional refinement of the field equipment to ruggedize and simplify use by unskilled personnel is currently underway. Additional field tests will be followed by a comprehensive field kit design/specification and field manual.

A procedure employing a complete energy balance including direct measurement of mass flow rate and enthalpies at proximal and distal ends of steam distribution lines has been designed for the determination of steam line heat loss. Use is made of obstruction flow meters and throttling cabrimeters which may be "hot-tapped" or introduced without need of securing the system. The procedure has been successfully field tested and is currently being refined to include direct digital readout instrumentation to simplify use by untrained personnel. A field manual and detailed field kit design/specification will follow additional field tests.

Title: Particulate Behavior in Solid Propellant Rocket Motors

Investigator: David W. Netzer, Professor of Aeronautics

Sponsor: Air Force Rocket Propulsion Laboratory

Objective: Holography, high speed motion pictures, light scattering measurements and postfire particle collection/scanning electron microscopic examination are to be used to study the combustion of composite solid propellants. The immediate goal of the study is to evaluate the relative advantages and disadvantages of the different experimental techniques for obtaining two-phase flow characteristics within the combustion environment of a solid propellant grain.

Summary:

Combustion Bomb Studies

High speed motion pictures (5000 pps) and scanning electron microscopy (SEM) of post-fire residue have been used to study the burning characteristics of seven aluminized composite propellants with aluminum loadings to 15%. Tests were conducted using a windowed combustion bomb with propellant strands burned at 500 and 1000 psi. Data obtained include burning rates, burning particle diameters, post-fire particle diameters and burning particle velocities. A 14 μm resolution capability was obtained with a HYCAM camera using a 1.12 magnification on the film.

Particle Size Determination by Light Scattering

A helium-neon laser and translating photo-diode were used to measure the scattered laser power spectra from the particles in the exhaust of a small, end-burning motor. The apparatus was calibrated using glass beads and $Al_2O_3$ particles of various sizes.

$D_{32}$ values obtained from the scattered light measurements agreed closely with scanning electron microscope photographs of collected exhaust particles.

Holographic Investigation

Holograms have been obtained of all seven propellants burning in strand form (4 mm wide x 1.5 mm thick) at 500 and 1000 psia.

10 μm resolution from the reconstructed holograms has been obtained using the spinning mylar disc technique originally used by Briones and Wuerker. Particle data can be obtained from the above holograms to the 10 μm resolution limit.

A technique for obtaining holograms in a 2-D slab motor has been developed and successfully applied to a propellant burning at approximately 450 psia. Laser power density had to be increased by reducing the beam diameter in order to obtain the hologram.

High speed motion pictures of the 2-D motor combustion process have also been successfully obtained.

Conference Presentations:

D. W. Netzer, "Solid Propellant Combustion," JANNAF Performance Standardization Subcommittee Meeting, 26-27 February 1981, Sunnyvale, CA.

V. D. Diloreto, S. G. Karagounis, P. J. Hickey, and D. W. Netzer, "Solid Propellant Combustion," 1981 AFOSR/-AFRPL, Rocket Propulsion Research Meeting, 24-26 March 1981, Lancaster, CA.

*Theses* Directed:

S. G. Karagounis, "An Investigation of Particulate Behavior in Solid Propellant Rocket Motors," Aeronautical Engineer's Thesis, June 1981.

T. Gillespie, "Holographic Investigation of Solid Propellant Particulates," Master's Thesis, (forthcoming).

Title: Solid Fuel Ramjet Combustion

Investigator: D. W. Netzer, Professor of Aeronautics

Sponsor: Naval Weapons Center

Objectives:

(a) To continue development of computer simulation of the combustion process.

(b) To determine whether non-reacting flow characteristics and fundamental fuel properties can be used to estimate expected performance from new fuel formulations and combustor geometries.

(c) To determine the effects of combustor/inlet geometry and flow conditions on the occurrence of combustion pressure oscillations.

Summary:

Combustion is approximately 92% complete within the fuel port of PMM grains when burned at low air flow rates. The remaining 8% is often achieved in the aft mixing chamber without bypass air. For these conditions bypass air apparently quenches chemical reactions, reducing the efficiency by 8%.

Bypass air can significantly affect the combustion process within the fuel port. With PMM grains, combustion instability significantly increases the fuel regression rate.

Variation in fuel properties does appear to affect the obtainable $\eta_{\Delta T}$ but the differences are not large when compared to the effects of mixing.

PMM unzips to a monomer at both high and low heating rates whereas HTPB releases hydrocarbons with a very broad spectrum of molecular weights. Below 500° C PMM has a dominant endothermic reaction whereas HTPB has a dominant exothermic reaction.

All combustion instabilities observed to data have been at low frequency and have resulted from a coupling with the inlet air feed system.

Addition of radiative heat transfer into the primitive variable computer model improved the predicted fuel regression rate profile.

Publications:

C. A. Stevenson and D. W. Netzer, "Primitive-Variable Model Applications to Solid Fuel Ramjet Combustion," Journal of Spacecraft and Rockets, Vol. 18, No. 1, (January-February 1981), pp. 89-94.

M. E. Hewett and D. W. Netzer, "Light Transmission Measurements in Solid Fuel Ramjet Combustors," Journal of Spacecraft and Rockets, Vol. 18, No. 2, (March-April 1981), pp. 127-132.

B. A. Binn, W. E. Scott, and D. W. Netzer, "Combustion Behavior of Solid Fuel Ramjets, Vol. I - Correlation of Reacting and Non-Reacting Flow Characteristics," NPS Technical Report, NPS67-81-010, July 1981.

M. E. Metochianakis, W. V. Goodwin, U. Katz, and D. W. Netzer, "Modeling Solid-Fuel Ramjet Combustion Including Radiation Heat Transfer to the Fuel Surface," NPS Technical Report, NPS67-81-012, August 1981.

M. E. Metochianakis, W. V. Goodwin, U. Katz, and D. W. Netzer, "Combustion Behavior of Solid Fuel Ramjets, Vol. II - Effects of Fuel Properties and Fuel Air Mixing on Combustion Efficiency," NPS Technical Report, NPS67-81-011, August 1981.

Theses Directed:

W. V. Goodwin, "An Investigation of the Combustion Process in Solid Fuel Ramjets," Master's Thesis, June 1981.

M. E. Metochianakis, "An Investigation of the Combustion Behavior of Solid Fuel Ramjets," Master's Thesis, December 1980.

Title: Turbojet Test Cell Aerodynamics and Emission Levels

Investigator: David W. Netzer, Professor of Aeronautics

Sponsor: Naval Air Propulsion Center

Objectives:
(a) 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 augmentor tube.
(b) Experimentally determine the effects of fuel additives and test cell design on emitted particulate levels.

Summary:
(a) A final report on computer model validation was issued.
(b) The subscale test cell was improved by incorporating (i) two precision pumps for fuel additives, (ii) a stack gas $NO_x$ analyzer, (iii) an engine exhaust particulate sampler, and (iv) three-wavelength particle detectors at the engine and stack exhausts.
(c) An initial test series was completed using Ferrocene, 12% Rare Earth Hex-Cem, and 12% Cerium Hex-Cem in concentrations from 0 to 50 ml/gallon of JP4. Ferrocene and 12% Cerium Hex-Cem were found to be effective (25 - 30 percent reduction in stack gas opacity) in concentrations of between 20 and 30 ml/gallon. Mean particulate diameters at the stack and engine exhausts were between 0.18 and 0.21 microns. Light transmission measurements of $D_{32}$ were in good agreement with photomicrographs of collected particulates. The additives also were found to have only small effects on stack gas concentrations of $NO_x$.

Publications: P. J. Mallon, P. J. Hickey, and D. W. Netzer, "Validation of a Two-Dimensional Primitive Variable Computer Code for Flow Fields in Jet Engine Test Cells," NPS Technical Report, NPS67-80-014, Oct 1980.

Thesis Directed: D. W. Thornburg, "An Investigation of Engine and Test Cell Operating Conditions on the Effectiveness of Smoke Suppressant Fuel Additives," Master's Thesis, (forthcoming).

Title: Validation of Air Quality Assessment Model for Naval Air Operations

Investigator: David W. Netzer, Professor of Aeronautics

Sponsor: Naval Air Propulsion Center

Objective: To complete the development of AQAM for Naval Air Operations and validate the model with data obtained at NAS Miramar, CA

Summary: An initial validation of an Air Quality Assessment Model for Naval Air Operations was conducted at NAS Miramar, CA. A previously developed model was updated to appropriately represent 1978/79 operations and then evaluated for prediction sensitivity to variations in meteorological and dispersion model parameters. A joint effort with the Naval Air Propulsion Center, the Environmental Protection Agency/Northrup Services, Inc. and PMTC, Pt. Mugu was conducted to obtain detailed data over a one-week period. Much of the measured pollution concentration data (including all of the suspended particulate data) was lost due to instrument and measurement technique problems. This severely limited the validation effort. Comparison of model predictions with the limited initial measured concentration data indicated that: (1) predicted CO concentrations were in good agreement with measurement, (2) predicted NOX concentrations from aircraft idle/taxi operations were too low, and (3) predicted total hydrocarbons and particulate concentrations were too high for aircraft idle/taxi operations and too low for environ sources. Model predictions were significantly improved by increasing engine RPM settings to above idle for all modes normally specified as idle. Model validation efforts would be improved if one-half integer stability categories could be measured and used in the model.

Publications: T. S. Douglas and D. W. Netzer, "Initial Validation of an Ambient Air Quality Model for Naval Air Operations," NPS Technical Report, NPS67-81-002, Dec 1980.

AD-A119 795 NAVAL POSTGRADUATE SCHOOL MONTEREY CA F/G 5/2
A SUMMARY OF THE NAVAL POSTGRADUATE SCHOOL RESEARCH PROGRAM.(U)
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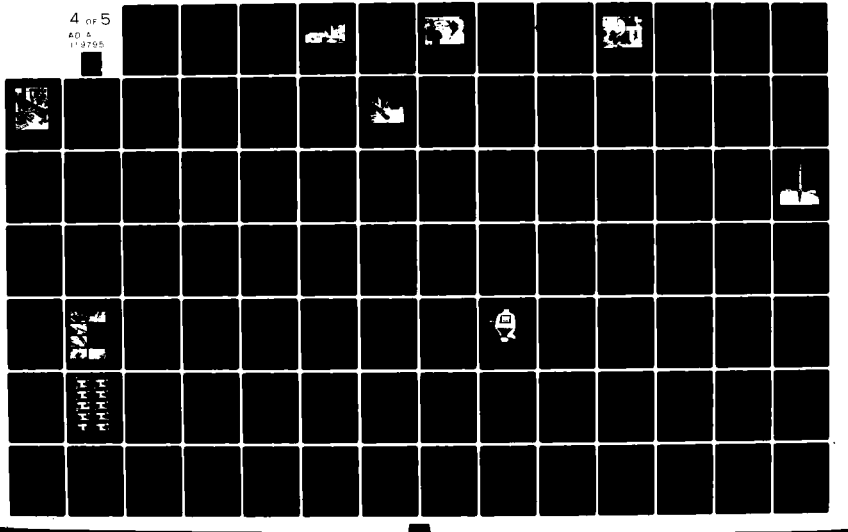

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| Title: | Investigation of V/STOL Propulsion Problems |
| Investigator: | M. F. Platzer, Professor of Aeronautics |
| Sponsor: | Naval Air Systems Command |
| Objective: | To investigate flow phenomena in V/STOL aircraft propulsion systems and to perform V/STOL aircraft concept feasibility studies. |
| Summary: | A new jet excitation mechanism has been identified which shows the potential of significantly increasing the secondary flow entrainment in thrust augmenting ejectors without impairing the nozzle efficiency. Mean velocity measurements using pilot tubes and laser-doppler anemometry demonstrated significant entrainment increases for three pressure ratios. A patent application is currently being processed by the Navy Patent Office in San Francisco. Also, the analysis of unsteady supersonic cascade flows has been continued. |
| Publication: | J. M. Simmons, J. C. S. Lai, M. F. Platzer, "Jet Excitation by an Oscillating Vane," AIAA Journal, Vol. 59, No. 6, pp. 673-676, June 1981. |
| Thesis Directed: | R. McClellan, "Experimental Investigation of Vane-Excited Jets," Master's Thesis, March 1982. |
| Conference Presentation: | D. J. Collins, M. F. Platzer, J. C. S. Lai, J. M. Simmons, "Experimental Investigation of Oscillating Subsonic Jets," Workshop on Thrust Augmenting Ejectors, Dayton, Ohio, August 1981. |

| | |
|---|---|
| Title: | Applied Research in Engineering Technology |
| Investigator: | L. V. Schmidt, Professor of Aeronautics |
| Sponsor: | Office of the Assistant Secretary of the Navy |
| Objective: | Provide technical support to the assistant for Engineering Technology. |
| Summary: | Assumed the position of Acting Assistant for Engineering Technology in the OASN (RE&S). Duties included administering research contract reviews, visiting laboratory facilities and assisting in policy establishment for Navy 6.1, 6.2 and 6.3A research upon aircraft, missile, ship, submarine and boat platforms in the disciplines of fluid mechanics, propulsion and structures. |

Title: Axial Compressor Flow Fields

Investigator: Dr. Raymond P. Shreeve, Director, Turbopropulsion Laboratory, Department of Aeronautics

Sponsor: Office of Naval Research

Objective: To obtain an improved understanding of the flow fields in axial compressors required to formulate new analytical prediction models and to obtain detailed measurements against which new computer analysis 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 the primary goal. A new measurement technique termed "Dual-Probe Digital Sampling," or DPDS, involving two semi-conductor probes of simple geometry, was developed for this purpose. The measurements to be obtained using DPDS will be compared with LDV measurements of the same flow. To date first measurements of all three components of the rotor exit velocity as a map across two selected rotor blade passage have been obtained. Tests to obtain similar data at transonic relative Mach numbers, both on- and off-design, are planned. The calibration of a second-generation probe system was recently completed. The DPDS technique is thought to have a significant potential as a diagnostic technique for turbomachines.

A number of publications have been generated since the projects inception; only those for FY 81 are listed.

Publications:

D. Adler, and P. M. Taylor, "A Procedure for Obtaining Velocity Vector from Two High Response Impact Pressure Probes," NPS Technical Report, NPS67-80-007, August 1980.

R. P. Shreeve and F. Neuhoff, "Compressor Measurements Using a Dual-Probe Digital Sampling (DPDS) Technique," submitted for presentation at the AIAA/ASME/SAE 18th Joint Propulsion Conference to be held in Cleveland, Ohio, June 21-23, 1982.

Conference Presentation:

R. P. Shreeve, "A Simple Fixed-Probe Technique for Periodically Unsteady Flows," Aeroelasticity of Turbine Engines, Joint NASA/AF/Navy Symposium, Cleveland, Ohio, October 27-29, 1980.

TEST CELLS AND NEW OFFICES OF THE TURBOPROPULSION LABORATORY.

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|---|---|
| Title: | Cascade Studies of Flows Through Compressor Bladings |
| Investigator: | Dr. Raymond P. Shreeve, Director, Turbopropulsion Laboratory, Department of Aeronautics |
| Sponsor: | NASA Lewis Research Center |
| Objective: | To obtain data using a large (60" x 10") subsonic cascade wind tunnel to verify computational codes used in the design and analysis of controlled diffusion compressor blading. |
| Summary: | Following a preliminary program to verify cascade test conditions and select suitable blade chord and spacing, tests were conducted using a reference set of DCA blades. Data were obtained for turning angle, losses, AVDR and blade pressure distribution for variations in incidence. Modification of the cascade IGV's was implemented to improve inlet flow and controlled-diffusion blade tests will follow. |
| Publications: | Donald M. McElligot, "Uniform Inlet Conditions for the NPS Subsonic Cascade Wind Tunnel," NPS Project Report, NPS67-81-019PR, December 1981. |
| Theses Directed: | Richard Carl Moebius, "Analysis and Testing to Improve the Flow from the Plenum of a Subsonic Cascade Wind Tunnel," Master's Thesis, March 1980.<br><br>David A. DuVal, "Evaluation of a Subsonic Cascade Wind Tunnel for Compressor Blade Testing," Master's Thesis, September 1980.<br><br>Frank S. Cina, "Subsonic Cascade Wind Tunnel Tests Using a Compressor Configuration of DCA Blades," Master's Thesis, June 1981. |

STUDENT INVOLVED IN RESEARCH ON THE SUBSONIC CASCADE WIND TUNNEL.

**Title:** Development of a Transonic Compressor Model

**Investigator:** Dr. Raymond P. Shreeve, Director, Turbopropulsion Laboratory, Department of Aeronuatics

**Sponsor:** Naval Air Systems Command

**Objective:** To develop a small transonic axial air compressor model and establish methods of measuring performance and flow behavior.

**Summary:** This project is directly associated with the project "Transonic Compressor Investigations." A full instrumented 11 inch O.D. transonic axial compressor model has been built to be capable of operation to 30,460 R.P.M. at 450 H.P. The test program to date has achieved operation to 70% speed. Computer acquisition hardware and software and needed instrumentation have been developed and tests are now underway toward design speed. Future use of the model to help solve specific engine compressor problems such as sensitivity to distortion is intended.

A number of publications and theses have been generated since the projects inception; only those for FY 81 are listed.

**Thesis Directed:** R. Cirone, "Computer Evaluation of the On- and Off-Design Performance of an Axial Air Turbine," Master's Thesis, March 1981.

Title: Multi-Stage Compressor Study

Investigator: Dr. Raymond P. Shreeve, Director, Turbopropulsion Laboratory, Department of Aeronautics

Sponsor: NPS Foundation Research Program

Objective: To reblade and instrument a large 3-stage axial compressor and carry out baseline measurements of the performance of newly designed "symmetrical" blading. The purpose is to enable a study which is aimed to reduce the sensitivity of current compressor designs to tip gap variations.

Summary: The compressor is 36 inches O.D. with a cylindrical flow path 7.2 inches high. The compressor was rebladed first with IGV's, single stage and EGV's. Techniques for grinding and individually setting blades to uniform .001" tip gap were developed. The blades were of cast epoxy. Failure of some blading occurred from contact with a survey probe requiring new blades to be cast and installed. Preliminary measurements of the flow field and complete stage performance at 1200 RPM were completed and the conclusions from this phase of the program were documented. Composite construction to stiffen and strengthen the rotor blades will be used in blade designs required for the tip clearance study and different approaches are currently under study.

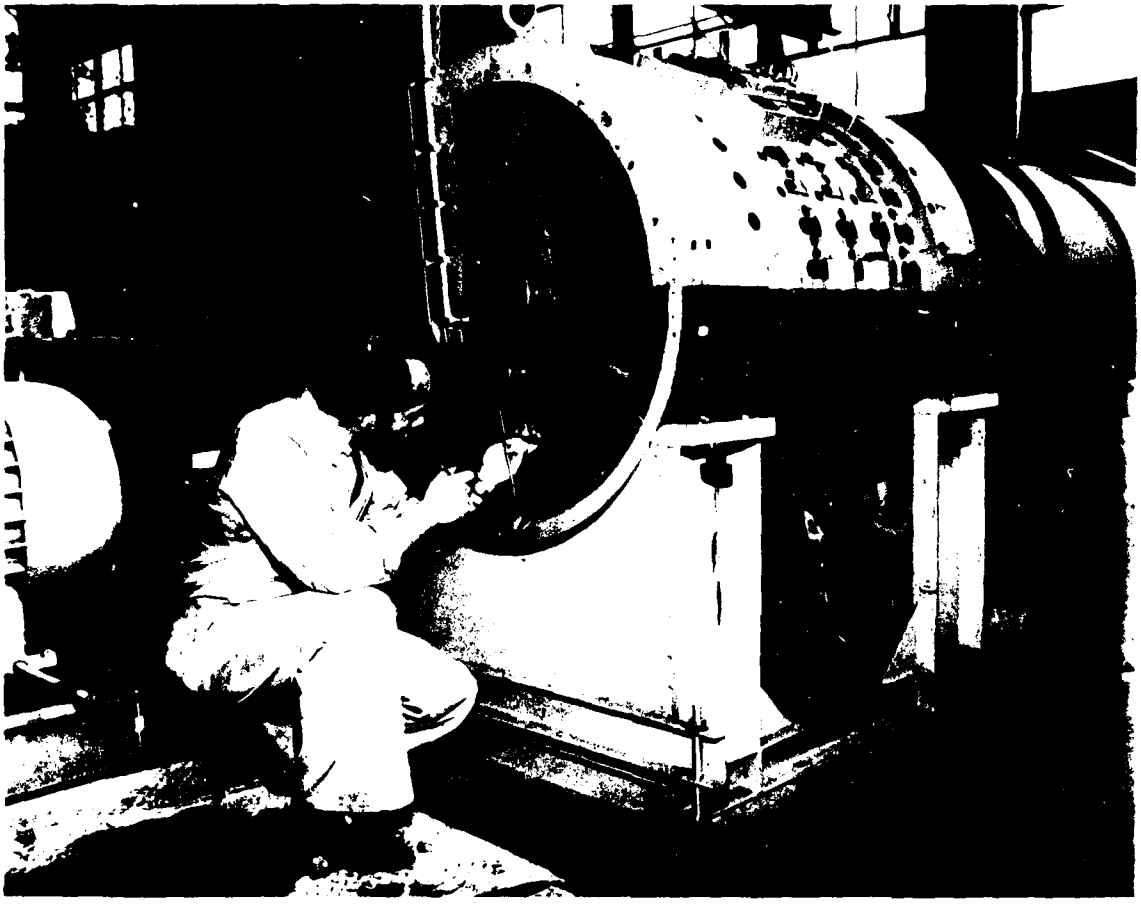
Publications:

I. Moyle, "Progress Report - Multistage Axial Compressor Program on Tip Clearance Effects," NPS Contractor Report, NPS67-81-01CR, August 1981.

I. Moyle, "Multistage Compressor - Survey of Literature on Tip Clearance and Blade Tip Flow Effects in Axial Turbomachines," NPS Technical Note, TPL TN 81-01, September 1981.

I. Moyle, "Multistage Compressor - Blade Aeromechanical Design," NPS Technical Note, TPL TN 81-02, September 1981.

I. Moyle, "Multistage Compressor - Fabrication of Molds and Casting of Epoxy Blades," NPS Technical Note, TPL TN 81-03, September 1981.



REASSEMBLY OF THE 3-STAGE AXIAL RESEARCH COMPRESSOR.

Title: Numerical Modeling of the Flow in Transonic Axial Compressors

Investigators: Dr. R. P. Shreeve, Director, Turbopropulsion Laboratory, and S. Eidelman, Research Associate, Department of Aeronautics

Sponsor: NPS Foundation Research Program

Objective: To develop a computer code which solves efficiently and accurately the transonic flow between the blades of a turbocompressor.

Summary: As the first step in the code development, a program which solves the basic Reimann problem was written. The effectiveness of the program was checked. The program will be used in the coming months by the Turbopropulsion Laboratory as a tool for wave engine analysis. Using the Riemann problem solver, a two-dimensional code was developed, which solved the problem of the shock wave propagating through a tube. Next the code was extended to solve the problem of the transonic flow in a tube containing one or two rectangular obstacles. This test problem showed that in order to complete the initially proposed research we will need to include three additional modifications; namely, (a) a multigrid solution; (b) solution in body fitted coordinates, and (c) application of the radiation boundary conditions for the subsonic in and out flow. The modification (a) has already been made, and work on modification (b) is currently in progress. Analytical work on calculation of the critical energy for direct initiation of detonation was finished and results of the work were reported in a paper entitled "A Method of Calculation of the Critical Energy for Direct Initiation of Unconfined Detonation." The paper was submitted for publication to Combustion Science and Technology.

Publications: S. Eidelman, "Model of Director Initiation of Unconfined Detonations," NPS Contractor Report, NPS67-81-02CR, March 1981.

Title: Transonic Compressor Investigations

Investigator: Dr. Raymond P. Shreeve, Director, Turbopropulsion Laboratory, Department of Aeronuatics

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: A single stage axial transonic compressor and complete test rig were designed and built in earlier phases of the present program. Following preliminary compressor tests, new instrumentation techniques necessary to th planned experimental study were developed. Using hig speed digital sampling synchronized to rotor rotation techniques for measuring the periodic (unsteady) wall pressure distributions and time-resolved rotor exit velocity field have been generated. Following a 12-month test delay because of rig drive turbine bearing failures, tests to systematically collect full performance and aerodynamic data on the prototype stage are underway. Plans for an advanced aerodynamic stage, to test design and analysis procedures while serving as a vehicle for basic tip design and inlet distortion studies, are underway.

Publications: Ten items (reports, papers and theses) have preceded the following list of recent publications.

H. Zebner, "Procedure and Computer Program for the Representation of Calibration Surfaces (with Application to Multiple Sensor Flow Probes)," NPS Contractor Report, NPS67-80-01CR, August 1980.

H. Zebner, "Transonic Compressor: Program System TXCO for Data Acquisition and On-Line Reduction," NPS Contractor Report, NPS67-80-02CR, October 1980.

W. Schlater, "Calculations for Axial Compressor Blading with Uniform Inlet Enthalpy and Radial Enthalpy Gradient," NPS Technical Report, NPS67-81-008, May 1981.

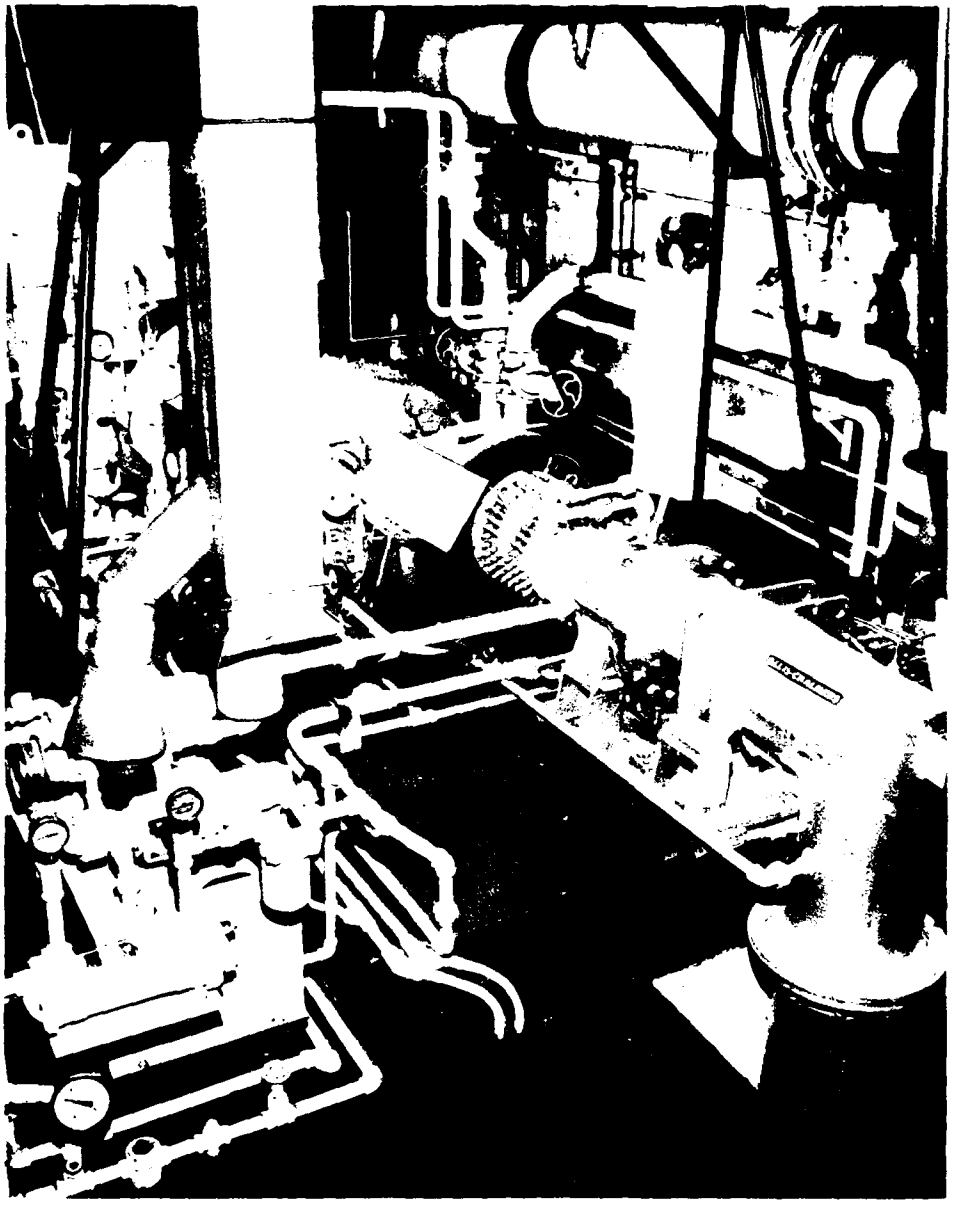
R. E. Peacock, "Blade Tip Gap Effects in Turbomachines - A Review," NPS Technical Report, NPS67-81-016, November 1981.

Conference Presentations:

R. P. Shreeve, "A Simple Fixed-Probe Technique for Periodically Unsteady Flows," Aeroelasticity of Turbine Engines, Joint NASA/AF/Navy Symposium, Cleveland, Ohio, October 27-29, 1980.

Thesis Directed:

P. A. McCarville, "Hardware and Software Improvements to a Paced Data Acquisition System for Turbo-machines," Master's Thesis, June 1981.



1250 HP CONTINUOUS COMPRESSED-AIR SUPPLY SYSTEM AT THE TURBOPROPULSION LABORATORY.

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|---|---|
| Title: | Very High Reaction Turbines |
| Investigator: | Dr. Raymond P. Shreeve, Director, Turbopropulsion Laboratory, Department of Aeronautics |
| Sponsor: | NPS Foundation Research Program |
| Objective: | To investigate analytically and experimentally the potential of two proposed very high reaction turbines of original design. |
| Summary: | An unusually simple geometry of gas turbine rotor has been proposed to ONR and other agencies. Calculations of the potential performance of the geometry and tests of a small prototype are planned in order to provide an assessment of the potential. A second suggestion to obtain high energy conversion efficiencies using staged detonative combustion within a series of rotors of particular design is also being examined. |

# DEPARTMENT

# OF

# OCEANOGRAPHY

# DEPARTMENT OF OCEANOGRAPHY

The research program of the Department of Oceanography may be considered under five headings according to the facilities utilized and topics considered. These headings are: R/V ACANIA programs; coastal ocean studies; shore processes studies; open ocean studies; and special studies.

## R/V ACANIA PROGRAMS

In this category are efforts to upgrade the research capabilities of the Naval Postgraduate School's R/V ACANIA, an oceanographic research vessel supported by the Commander, Naval Oceanography Command. (Some investigators also make use of other research ships.) This year, the ACANIA underwent a periodic major overhaul in a San Francisco shipyard. An acoustic doppler speed profiler, sponsored by the NPS Foundation Research Program, was received and installed in the ACANIA.

## COASTAL OCEAN STUDIES

A. J. Willmott commenced a theoretical study of countercurrents and eddies in the California Current System. The coupling of shallow water and deep water circulation is being examined. The sponsor is the Office of Naval Research.

C. N. K. Mooers uses the ACANIA to study the physical dynamics of the Pt. Sur coastal upwelling center. The role of eddies in the circulation and transport processes of the upwelling center is a central focus of this study. An autonomous profiling current meter/CTD system (a Cyclesonde) was acquired and field tested. The sponsor is the NPS Foundation Research Program.

J. B. Wickham and S. P. Tucker commenced the data processing phase of an observational study of the California Countercurrent. The field study had included (1) a year's continuous monitoring of the core of the Countercurrent with an array of moored current meters, and (2) a broader monthly sensing of the region 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 of Big Sur. The sponsors of the earlier phases were the NPS Research Foundation and NASA. The BLM/OCS program has agreed to provide support for the analysis phase.

E. C. Haderlie uses ACANIA to study the biology of stone and wood boring organisms in the deeper waters of 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 the Office of Naval Research.

E. D. Traganza uses ACANIA off the coast of California in a study of the chemical mesoscale associated with ocean fronts in the coastal upwelling region off Pt. 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 the Office of Naval Research.

SHORE PROCESSES 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 have been made at La Jolla and Santa Barbara as part of the National Nearshore Sediment Transport Study. NOAA/Sea Grant, Office of Naval Research, and National Science Foundation are the sponsors.

E. C. Haderlie uses concrete wharf pilings and other structures on the coast in investigations of organisms responsible for deterioration of engineering materials placed in the sea and in determining the general biology and destructive effects of these organisms. NCEL was the sponsor.

OPEN OCEAN STUDIES

R. G. Paquette and R. H. Bourke have used U. S. Coast Guard ice-breakers to observe and analyze ocean fronts and thermal fine-structure near the ice margin in the Chukchi Sea, East Greenland Sea, and elsewhere. These studies have environmental acoustical applications. The sponsor is the Arctic Submarine Laboratory, NOSC.

E. B. Thornton is studying physical factors affecting sound propagation in the ocean. Spatial and temporal variability of upper ocean physical and acoustical variables have been measured from arrays deployed from ACANIA. The sponsor is the NPS Foundation Research Program.

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. The Office of Naval Research 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 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.

J. L. Mueller and S. Aranuvachapun are investigating marine aerosol estimation from the Nimbus-7 Coastal Zone Color Scanner (CZCS) in support of electro-optical propagation forecasts. NEPRF is the sponsor.

J. L. Mueller is investigating the effects of horizontal variability in ocean properties on the validity of optical propagation predictions based on 1-dimensional models of the upper ocean. This is part of a Selected Research Opportunity (SRO) program sponsored by ONR in support of the proposed Strategic Laser Communications (SLC) system.

G. H. Jung is using ocean observations taken along latitude sections in the Atlantic Ocean during IGY as the basis for new geostropic 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.

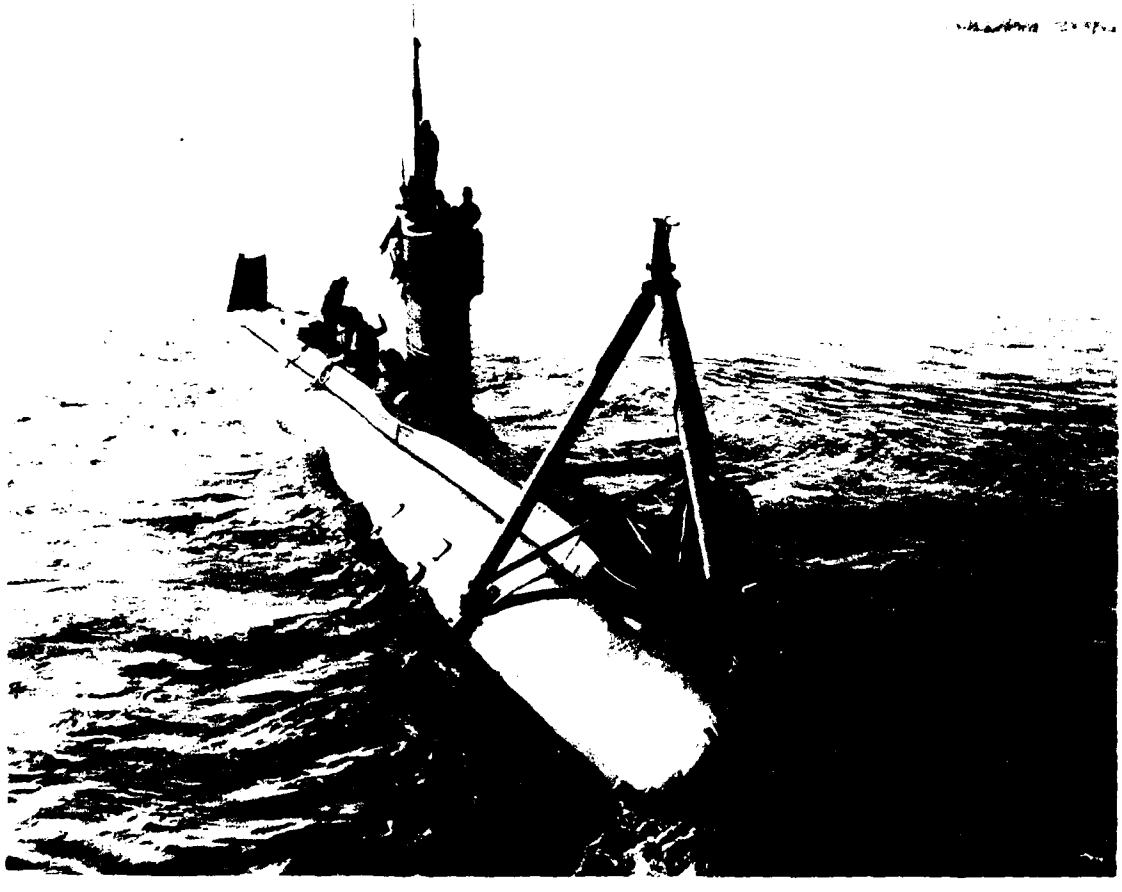
C. N. K. Mooers has participated in FRONTS, a multi-institutional experiment to analyze the subtropical front of the North Pacific. His role is to analyze the atmospheric forcing, make use of the FNOC and NEPRF ocean surface and subsurface fields, and develop a diagnostic model for oceanic fronts. The sponsor is the Office of Naval Research.

SPECIAL STUDIES

P. Wadhams, who occupied the ONR Chair in Arctic Marine Science, studied the influence of surface gravity waves on the deterioration of icebergs in the Antarctic, and of pack ice in the Arctic. The sponsor is the Office of Naval Research.

G. H. Jung, R. H. Bourke, LCDR C. Dunlap, and R. W. Garwood study relations between atmospheric and oceanic variations and long-range, low-frequency sound propagation and ambient noise in the North Pacific Ocean. The sponsor is NOSC (for COSP and NAVELEX).

S. P. Tucker is investigating the distribution of the spectral irradiance of natural light and the optical beam spread function of the ocean. The sponsor is DARPA.



TURBULENCE PROBES MOUNTED ATOP A SPECIAL TRIPOD ON BOARD THE USS DOLPHIN. THIS SYSTEM WAS DEVELOPED TO STUDY THE HORIZONTAL VARIATION OF TURBULENCE IN THE OCEAN. THE WORK IS PART OF A COHERENT PROGRAM AT THE POSTGRADUATE SCHOOL TO STUDY THE ROLE OF TURBULENCE IN THE OCEAN AND THE RESPONSE OF THE TURBULENCE TO TIME VARYING STRATIFICATION AND SHEAR.

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| **Title:** | Environmental Acoustic Applied Research |
| **Investigator:** | LCDR C. R. Dunlap, Assistant Professor, Department of Oceanography |
| **Sponsor:** | COMTHIRDFLT |
| **Objective:** | To assess the impact of various environmental acoustic features on fleet operations. |
| **Summary:** | COMTHIRDFLT by message requested assistance in assessing the impact of specified environmental acoustic features. |
| **Publication:** | C. R. Dunlap and G. P. Tierney, "Fleet Acoustic Prediction Systems: Where Are We?," The Naval Institute Proceedings, January 1981 98-100. |
| **Conference Presentation:** | C. R. Dunlap, "A Review of Shallow Sound Channel Formation, Geographic Distribution and Acoustic Characteristics," 34th Navy Symposium on Underwater Acoustics, San Diego, CA, December 1981. |

Title: Oceanographic Studies in Support of COMOCEANSYSPAC

Investigators: LCDR C.R. Dunlap, Assistant Professor of Oceanography, Principal Investigator; Dr. Glenn H. Jung, Professor of Oceanography; Dr. Robert H. Bourke, Associate Professor of Oceanography; Dr. R. William Garwood, Jr., Assistant Professor of Oceanography.

Sponsor: Naval Electronics Systems Command and Naval Ocean Systems Center

Objective: To provide environmental acoustic support to COMOCEANSYSPAC by investigating: 1) the development of operational/environmental case studies to determine environmental effects upon OCEANSYSPAC performance; 2) forecasting the impact of the mixed layer depth and changes in mixed layer forcing functions upon OCEANSYSPAC; and 3) the use of satellite products in determining the effect of fronts and eddies upon OCEANSYSPAC.

Summary: An analysis was performed using the variability of daily low-frequency ambient noise data as it is related to storm data and to empirically-modelled data for a bottom hydrophone in the Norwegian Sea over a period of three years. Noise levels were cross-correlated with windspeed data in this study, which received the CNO ASW award for NPS thesis work in 1981. In the North Pacific Ocean, the effects of the environment on ambient noise were evaluated by making use of three years of noise measurements obtained from P-3 aircraft-dropped sonobuoys. These results were requested by CNO prior to publication of the related NPS technical report, and have been applied to current operations conducted by squadron aircrews and ASW Operations Center mission planners.

An analysis of coupled mixed layer-acoustic models performance was made for OWS PAPA in the Northeast Pacific Ocean for May 1980. The model systems displayed more day-to-day variability in acoustic median detection range than was shown by the direct environmental input. The ability of two computer models to depict the ocean thermal structure was evaluated, with the EOTS model correlating poorly with observed mixed layer depths, while the ODT model correlated well. As part of the Acoustic Storm Response and Transfer Experiment

(ASTREX) in the Northeast Pacific Ocean in November-December 1980, distant storm effects on acoustic transmission loss were evaluated; storm-related surface waves may affect low-frequency transmission loss from shallow sources. From ASTREX data demonstrated that thermal structure mixed-layer depth variability has a maximum effect of 3 decibels on very low frequency sound transmission.

The use of satellite-derived sea surface temperatures to indicate subsurface thermal structure was investigated along the route of P-3 flights associated with ASTREX. Major navigation problems were solved in relating the satellite readouts to exact locations at sea. A good correlation was noted between machine-massaged satellite temperatures at the sea surface (GOSSTCOMP) and those measured by aircraft-dropped bathythermographs. Significant differences occured in absolute values of sea surface temperature when raw values measured by satellite were compared to those measured by aircraft; however, the gradient field is indicated better by raw satellite values rather than by GOSSTCOMP values.

**Publications:**

R. H. Fisher, C. R. Dunlap, and R. W. Garwood, Jr., "Variability and Sensitivity of Coupled Mixed Layer--Acoustic Model Systems," NPS Technical Report NPS68-81-002, March 1981.

G. W. Lundell, G. H. Jung, and C. R. Dunlap, "Rapid Oceanographic Data Gathering: Remote Sensing of the Subsurface Thermal Structure in the Northeast Pacific Ocean," NPS Technical Report NPS68-81-006, September 1981.

**Conference Presentations:**

C. R. Dunlap, "Acoustical ASW Requirements for Ocean Prediction," Ocean Prediction Workshop, NPS, 29 April and 2 May 1981.

C. R. Dunlap, "Naval Postgraduate School ASTREX Measurements," STREX Workshop, University of Washington, Seattle, 28-30 July 1981.

Theses Directed:

R. H. Fisher, "Variability and Sensitivity of Coupled Mixed Layer--Acoustic Model Systems," Master's Thesis, March 1981.

G. W. Lundell, "Rapid Oceanographic Data Gathering: Remote Sensing of the Subsurface Thermal Structure in the Northeast Pacific Ocean," Master's Thesis, September 1981.

Title: Studies of the Oceanic Planetary Boundary Layer

Investigator: Roland W. Garwood, Jr., Assistant Professor, Department of Oceanography

Sponsor: Office of Naval Research

Objective: To understand by means of model studies and data analyses the role of the oceanic planetary boundary layer in the distribution of momentum, energy and mass in the upper ocean.

Summary: The present understanding and predictive capabilities of one-dimensional mixed layer models has matured to the point that many practical applications of these models are now being attempted. From knowledge of the limitations of the one-dimensional approximation, the impetus has been to include horizontal advection to study two and three-dimensional upper ocean problems. A milestone for this project was the successful embedding of a bulk turbulence closure mixed layer model in a multi-level primitive equation model for ocean circulation. This embedded model is now being used for a study of the response of upper ocean density fronts to local atmospheric forcing, and the interaction between the ocean mixed layer and planetary waves and eddies.

Publications:

D. D. Adamec, R. L. Elsberry, R. W. Garwood, Jr., and R. L. Haney, "An Embedded Mixed Layer Ocean Circulation Model," Dynamics of Atmospheres and Oceans, 6: 69-96, (forthcoming).

L. K. Coachman and R. W. Garwood, Jr., "Response of the Upper Ocean to Calm Wind--Observations of the Bering Sea Shelf," PROBES, Processes and Resources of the Bering Sea Shelf, V. II, 1-48, (forthcoming).

R. L. Elsberry and R. W. Garwood, Jr., "Numerical Ocean Prediction Models--Goal for the 1980's," Bulletin of the American Meteorological Society, 61: 1556-1566, 1980.

R. W. Garwood, Jr., R. Lasker, and L. K. Coachman, "One-Dimensional Model Simulation of the Central Shelf Domain of Bristol Bay for the Period 8-10 June 1979," PROBES, Processes and Resources of the Bering Sea Shelf, V. II, 261-174, 1980.

R. W. Garwood, Jr., R. W. Fett, K. M. Rage, and H. W. Brandli, "Ocean Frontal Formation Due to Shallow Water Cooling Effects as Observed by Satellite and Simulated by a Numerical Model," Journal of Geophysical Research, (*forthcoming*).

Conference Presentations:

R. W. Garwood, Jr., R. Shook, and R. L. Elsberry, "One-Dimensionality of the Ocean Boundary Layer During the Norpax Pole Experiment," Transactions American Geophysical Union, 62: 990, 1980.

R. W. Garwood, Jr., "Use of a Desk-Top Computer for Local Upper Ocean Thermal Structure Forecasts," Ocean Prediction Workshop 81, Monterey, 1981.

Theses Directed:

J. M. Fernandez, "Analysis and Simulation of Wind-Driven Currents During the Mixed Layer Experiment," Master's Thesis, March 1981.

R. Fisher, "Variability and Sensitivity of Coupled Mixed Layer Acoustic Model System," Master's Thesis, March 1981.

**Title:** Biology of Stone and Wood Boring Animals in the Monterey Submarine Canyon and the Deeper Waters off the Central California Coast

**Investigator:** Eugene C. Haderlie, Professor, Department of Oceanography

**Sponsor:** Office of Naval Research and NORDA

**Objectives:** To determine the vertical and horizontal distribution of stone and wood boring marine animals of the deeper waters of Monterey Bay and offshore, and to determine the rates of destruction of wood, stone, concrete and various plastics.

**Summary:** During the past year new arrays have been planted in deeper water and have been successfully recovered for laboratory analysis for borers. The larval stages of some of these were collected and studied for the first time. Samples of stone with known infestations of stone borers were brought to the laboratory at regular intervals and x-rayed to determine rates of growth and stone destruction.

**Publications:**

E. C. Haderlie, "Influence on Terminal End of Burrow on Callum Shape in the Rock Boring Clam Penitella penita (Conrad, 1837)," The Veliger 24: 51-53, 1981.

E. C. Haderlie, "Growth Rates of Penitella penita (Conrad, 1837), Chaceia ovoidea (Gould, 1851) (Bivalvia: Pholadidae) and Other Rock Boring Marine Bivalves in Monterey Bay," The Veliger 24: 109-114, 1981.

**Conference Presentations:**

E. C. Haderlie: "Effects of Macrofouling and Biodeterioration on Engineering Materials in the Sea," Symposium on Marine Biodeterioration, Washington, D.C., April 1981.

E. C. Haderlie: "Monitoring Growth Rates of Wood and Stone Boring Marine Bivalves Using Radiographic Techniques," 5th International Biodeterioration Symposium, Aberdeen, Scotland, September 1981.

**Thesis Directed:**

R. G. Hoffman, "The Ecology of Benthic and Endolithic Communities of a Rocky Reef in the Kelp Beds off Del Monte Beach, Monterey, California," Master's Thesis, June 1981.

Title: Cooperative Studies of the California Current

Investigators: C. N. K. Mooers, Professor of Oceanography; Principal Investigator, J. B. Wickham, Associate Professor, Department of Oceanography, and Stevens P. Tucker, Assistant Professor, Department of Oceanography

Sponsor: Bureau of Land Management

Objective: The overall objective is to characterize statistically and interpret dynamically the ontime scale of hours-to-months variability and mass fields in the circulation over the continental slope off Central California, taking into account wind-driven and California Current eddy-driven perturbations and the effects of density stratification, bottom slope, and the Earth's rotation.

Summary: Project goals are to analyze (1) current meter data from meters moored on continental slope off-shore of Cape San Martin during 1978 and 1979, and (2) ancillary data from serial stations on lines extending over the shelf on lines normal to the coast from Cape San Martin and Slate Rock. Parts of these studies are pursued in cooperation with investigators at Oregon State University and University of Wisconsin.

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| Title: | Real-Time Ocean Profiling and Modeling in Monterey Bay |
| Investigator: | C. N. K. Mooers, Professor and Chairman, Department of Oceanography |
| Sponsor: | NPS Foundation Research Program |
| Objectives: | Develop a predictive capability for surface mixed layer and seasonal thermocline phenomena based upon a one-dimensional model and real-time, vertical profiles of temperature, salinity, horizontal velocity, and sound speed, together with coastal wind data. |
| Summary: | This project makes use of an antonomous profiling current meter system called the Cyclesonde. One Cyclesonde is on indefinite loan from NAVOCEANO; another was procured by NPS, and it was received at NPS in the summer of 1981. Both Cyclesondes have been put through shakedown exercises, either at the end of Monterey Bay or in Carmel Canyon. The Monterey Bay station has been run in the telemetry mode, with RF signals received and decoded at Spanagel Hall. This project has allowed procurement of the telemetry system and spare parts, and it has supported marine technician time for field testing and computer programmer time for software development. All phases of the system have been exercised, including data processing through to data archives on the IBM 3033. Currently, the instruments are undergoing refurbishment and modification with the manufacturer. |

Title: Synoptic Studies of Oceanic Fronts and Upper Ocean Prediction

Investigator: C. N. K. Moores, Professor and Chairman, Department of Oceanography

Sponsor: Office of Naval Research

Objective: The long-range scientific objective is to develop a predictive capability for the mass and circulation fields in the upper ocean. The phenomena to be addressed are upper ocean fronts and eddies. The first step is to produce synoptic analyses, with the aid of observations and diagnostic models, of the present physical state in and around upper ocean fronts and eddies. The second step is to develop prognostic models, and validation schemes, for short range forecasts.

Summary: The present project involves the analysis of large scale fields in the time and space domain of the FRONTS experiment conducted in the winter of 1979/1980 on the North Pacific Subtropical Front. The surface atmospheric fields and surface and subsurface temperature fields available in the Fleet Numerical Oceanography Center archives form the core of the analyses. The Naval Environmental Prediction Research Facility's satellite data processing facility (SPADS) is being used to process several GOES WEST IR images to be incorporated in the analyses. These products will be used in a cooperative synthesis of the FRONTS experiment, where additional higher spatial resolution, but lower temporal resolution and less spatial coverage, thermal as well as velocity data are available. From this, an assessment of present operational products will be made, and future directions in synoptic ocean studies will be defined. The current status of the project (commenced in October 1979), includes the creation of the above mentioned data bases for FRONTS and completion of some preliminary analyses. Ocean Prediction Workshop 1981 was convened in April at NPS under partial sponsorship of this project. There were about 80 civilian and naval attendees. The proceedings are in preparation. Status and requirements were reviewed, and new ideas were brought forward.

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| Publication: | C. N. K. Mooers, "Surface Atmospheric and Oceanic Variables," pp. 45 to 50, In: FRONTS 80: Preliminary Results From an Investigation of the Wintertime North Pacific Subtropical Front (Ed. C.A. Paulson and P.P. Niiler), School of Oceanography, Oregon State University, Reference 81-2 (January 1981), 108 numbers v. leaves. |
| Conference Presentation: | C. N. K. Mooers, "Amospheric Forcing and GOES IR Imagery During FRONTS," AGU Fall Annual Meeting, San Francisco, 8 to 12 December 1980. (Abstract in EOS, 61: 981). |
| Thesis Directed: | L. Monsaingeon, "Ocean Thermal Analysis and Related Naval Operational Considerations in the Ionian Sea--June 1980," Master's Thesis, September 1981. |

Title: Aerosol Estimation from the Nimbus-7 CZCS

Investigators: James L. Mueller, Adjunct Professor, Department of Oceanography

Sasithorn Aranavachapun, Adjunct Research Professor, Department of Oceanography.

Sponsor: Naval Environmental Prediction Research Facility

Objective: Develop & implement algorithms for using CZCS data (as obtained by Nimbus-7 or a follow-on operational satellite) to map aerosol distribution variation in support of electro-optical propagation forecasts for weapons systems.

Summary: An inherent byproduct of the CZCS atmospheric correction is an image of "aerosol radiance" at a wavelength of 670 nm. Aerosol radiance is the fraction of radiance measured from space due to backscatter of solar radiation by atmospheric aerosols. Over space scales less than the synoptic scale, it is probable that variations in aerosol radiance relate directly to variations in the concentration and/or size distribution of aerosols in the marine boundary layer. If comparisons between CZCS aerosol radiances and in-situ aerosol measurements support this hypothesis, then the variability in aerosol radiance (spatial variability, that is) can be utilized as a "horizontal inhomogeneity" input to electro-optical propagation models of the marine boundary layer. Predictions made with such models are important support products for certain weapons systems.

CZCS level-I & II algorithms are in the process of being implemented and tested on the NPS IBM-3033 computer. Unpack & landmark-display modules are completed; Rayleigh correction, aerosol radiance, and image navigation modules will be completed within 30 days; re-sampling modules will be completed in 60 days. CZCS tapes have been acquired and screened (for quality) coincident with the MAGAT aerosol measurements made by NPS investigators in April-May 1980; processing of this data is proceeding in parallel with software development. Mie scattering codes and a two-stream radiative transfer model have been implemented on the IBM 3033; Mie codes have been verified and

the two-stream model is undergoing testing and evaluation. These data and software will be used to compare CZCS aerosol radiances with expected values calculated from the MAGAT data.

Title: Horizontal Variability Effects on Optical Propagation in the Upper Ocean

Investigator: J. L. Mueller, Adjunct Professor of Oceanography

Sponsor: Office of Naval Research and Ocean Science and Technology Detachment

Objective: This proposal is part of the "Environmental Effects on Optical Propagation" project, funded by the Office of Naval Research (Code 486) under the Selected Research Opportunity (SRO) program, which is targeted at performance evaluation of the proposed Strategic Laser Communications (SLC) system. This particular proposal is for work to assess the effects which horizontal variability of ocean properties will have on optical propagation predictions based on 1-dimensional models of the upper ocean.

Summary: As part of the Office of Naval Research sponsored Selected Research Opportunity project entitled "Environmental Effects on Optical Propagation," it is proposed to investigate the effects of horizontal variability of the downward vector irradiance coefficient $K_T$ on the accuracy and interpretation of 1-dimensional model predictions of that parameter. A major goal of the parent research project is the development and testing of a 1-dimensional model of the upper ocean in support of the Navy's performance evaluation of the proposed Strategic Laser Communications (SLC) systems. The work proposed here will contribute to the testing of 1-dimensional $K_T$ predictability. The approach will be to first characterize the spectrum of horizontal $K_T$ variance in the open ocean regime through analysis of Nimbus-7 Coastal Zone Color Scanner (CZCS) data. Then, on the basis of that information, the sensitivities of $K_T$ variations to horizontal transports and sub-grid scale fluctuations will be analyzed.

Title: Marginal Sea-Ice Zone Studies, 1981

Investigators: Robert G. Paquette, Professor, Department of Oceanography.

Robert H. Bourke, Associate Professor, Department of Oceanography.

Sponsor: Arctic Submarine Laboratory, Naval Ocean Systems Center

Objectives: Carry out physical oceanographic research, including field measurements, in the Marginal Sea-Ice Zone of the Bering, Chukchi and Greenland Seas. This work has the long-term applied objective of facilitating the operation of submarines under ice. It is part of the continuing MIZPAC and MIZLANT programs.

Summary: The results of six cruises to the marginal sea-ice zone of the Chukchi Sea were analyzed. Several types of front and their typical locations were described. Bays melted into the ice margin were interpreted as evidence of filaments of warm-water flow, bathymetrically controlled. These results were published. The results of field measurements in the ice of the Bering Sea in March-April 1980 were analyzed and reported. Studies of oceanographic conditions in the Greenland Sea were begun in preparation for field work in the marginal ice zone of the East Greenland Drift Stream in October-November 1981.

Publications: Robert H. Bourke and Robert G. Paquette, "Winter Conditions in the Bering Sea," NPS Technical Report, NPS68-81-004, May 1981.

Robert G. Paquette and Robert H. Bourke, "Ocean Circulation and Fronts As Related to Ice Melt-back in the Chukchi Sea," Journal of Geophysical Research 86, (C5), 4215-4230, May 20, 1981.

Conference Presentations: Robert G. Paquette and Robert H. Bourke, "Winter Conditions in the Bering Sea," American Geophysical Union Fall Annual Meeting, San Francisco, 8-12 December 1980.

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| Title: | Studies of Oceanographic Conditions Near the Marginal Sea-Ice Zone |
| Investigators: | Robert G. Paquette, Professor, Department of Oceanography |
| | David C. Smith IV, Adjunct Professor, Department of Oceanography |
| Sponsor: | NPS Foundation Research Program |
| Objectives: | Produce a numerical model of water circulation in the Chukchi Sea in general and near the sea-ice margin in particular. |
| Summary: | A previous "Gulf Stream Ring Model" has been converted to run on the NPS 3033 Computer. The model is now being adapted to simulate the Chukchi Sea. |

Title: Acoustic Variability Experiment

Investigators: E. B. Thornton, Professor, Department of Oceanography.

T. P. Stanton, Adjunct Professor, Department 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: 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 4 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 are also mounted on the current meter packages to give long time series of the temperature. Papers are being prepared describing these results.

Publication: E. B. Thornton, "Temperature Induced Phase and Amplitude Fluctuations of 20 kHz Pulses in the Upper Ocean," (forthcoming).

Thesis Directed: M. Wakeman, "Acoustic Amplitude Fluctuations of 20 kHz Pulses in the Upper Ocean," Master's Thesis, December 1981.

Title: Breaking Wave Design Criterion

Investigators: E. B. Thornton, Professor, Department of Oceanography;

Dr. Sasithorn Aranavachapun, Adjunct Professor, Department of Oceanography.

Sponsor: National Science Foundation

Objective: This is a new two year program devoted to developing a new set of breaking wave design criteria based on field measurements of random waves. The impetus for this study is due to the deficiencies of the present methods based on monochromatic laboratory waves. The design criteria will be stated in statistical terms based on a probabilistic model.

Summary: A model describing the transformation of random wave heights was developed based on energy flux balance. Dissipation is considered due to wave breaking and bed friction. Wave breaking is characterized after periodic bores. The random nature of the wave heights is described starting with the Rayleigh distribution in deep water. The Rayleigh distribution is modified by wave breaking with an empirical transfer function. The modified distribution is itself the Rayleigh distribution. Field experiments were conducted at Soldiers Beach, Fort Ord, California, during the month of May and again for three weeks in August. The experiments were conducted in cooperation with the U.S. Geological Survey and Oregon State University.

Publication: E. B. Thornton and R. T. Guza, "Transformation of Wave Height Distribution," submitted to the Journal of Geophysical Research.

**Title:** Field Measurements of Surf Zone Energetics

**Investigator:** Edward B. Thornton, Professor, Department of Oceanography

**Sponsor:** Nearshore Sediment Transport Study (NSTS) funded by NOAA through National Sea Grant Program

**Objective:** The forcing function for sediment transport processes as a function of incident wave and beach paramenters are measured in the field and characterized. Specific measurements include waves, onshore and alongshore velocities both inside and outside the surf zone and the winds and tides.

**Summary:** The forcing functions for sediment transport, the bed shear stress, turbulent or wave-induced velocities and mean currents, were measured during one-month experiments at Torrey Pines Beach, California, and Santa Barbara, California. The dynamics instrumentation included 22 electromagnetic current meters, 10 wave staffs, 9 pressure meters, 3 run-up meters and a wind anemometer. The along-shore momentum flux balance was measured in which the wave induced momentum flux is balanced by the mean bed shear stress. The heretofore undetermined bed shear stress coefficient was measured, varying between 0.002-0.30 with a mean of 0.013.

**Publications:**

R. T. Guza and E. B. Thornton, "Wave Set-up on a Natural Beach," Journal of Geophysical Research, 86, 4133-4137, 1981.

D. A. Huntley, R. T. Guza and E. B. Thornton, "Field Observations of Surf Beat: Part 1, Progressive Edge Waves," Journal of Geophysical Research, 86, 1981.

E. B. Thornton and R. T. Guza, "Longshore Currents and Bed Shear Stress," Proceedings of the Euromech 114 Conference on Waves and Changes in the Surf Zone, Polish Academy of Sciences, 1980.

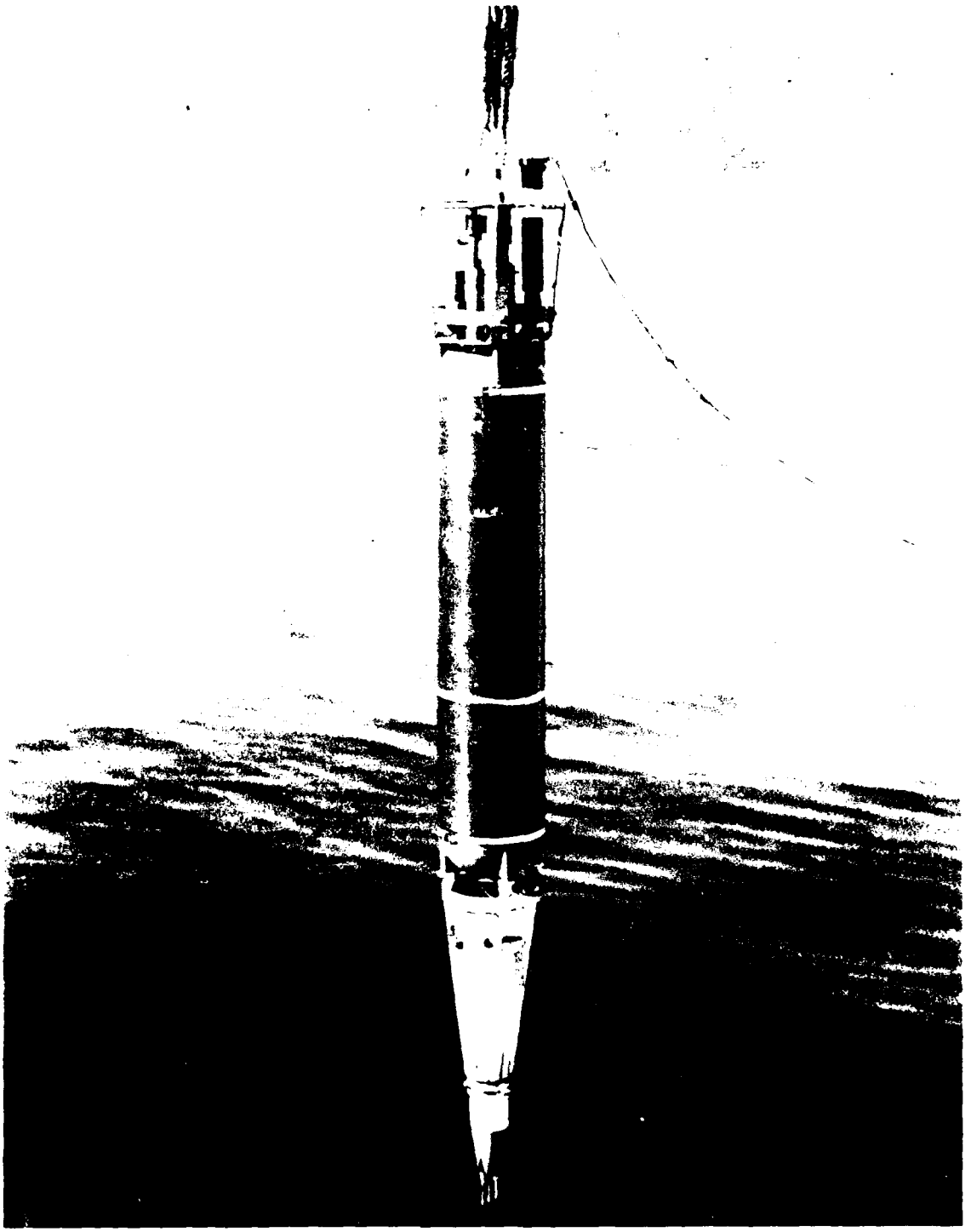
R. T. Guza and E. B. Thornton, "Swash Oscillations on a Natural Beach," (Accepted Journal of Geophysical Research).

E. B. Thornton and R. T. Guza, "Phase Speeds and Energy Saturation Measured on a Natural Beach," submitted to the Journal of Geophysical Research.

E. B. Thornton and R. T. Guza, "Transformation of Wave Height Distribution," submitted to the Journal of Geophysical Research.

Conference Presentation: E. B. Thornton, "Longshore Currents and Bed Shear Stress," Wave Directional Measurement Conference '81, Berkeley, California, September 14-17, 1981.

Thesis Directed: Gallo Padillo Teran, "Transformation of Waves Across the Surf Zone," Master's Thesis, March 1981.



FREELY FALLING INSTRUMENT FOR MEASURING SMALL SCALE VELOCITY FLUCTUATIONS IN THE OCEAN. MEASUREMENTS FROM THESE INSTRUMENTS ARE USED TO ESTIMATE THE ENERGY DISSIPATION RATE IN THE OCEAN. THIS INFORMATION PROVIDES A DIRECT QUANTITATIVE INDICATION OF THE LOCAL TURBULENT INTENSITY

Title: Kinematics of Breaking Waves in the Surf Zone

Investigator: Edward B. Thornton, Professor, Department of Oceanography

Sponsor: Office of Naval Research, Geography Branch

Objective: Basic studies are being made on the kinematics of breaking waves within the surf zone in the field. The specific objectives of the proposed research are: (1) determine breaking criterion as a function of depth, beach slope and wave frequency and (2) determine the transformation of waves across the surf zone due to energy conversion and dissipation in the breaking process.

Summary: Research this past year emphasized the continued analysis of the results of the major field experiments at Torrey Pines, California and Santa Barbara, California, and the development of predictive models. A model describing the transformation of random wave heights was developed based on energy flux balance. Dissipation is considered due to wave breaking and bed friction. Wave breaking is characterized after periodic bores. The random nature of the wave heights is described starting with the Rayleigh distribution in deep water. The Rayleigh distribution is modified by wave breaking with an empirical transfer function. The modified distribution is itself the Rayleigh distribution. The model is compared both with laboratory results and an extensive set of field measurements collected at Torrey Pines Beach, California. The model is able to predict the increase in averaged wave height due to shoaling and subsequent decrease due to wave breaking. The model has only one adjustable parameter ($\gamma = 0.68$) and is able to predict rms wave heights to within a standard error of 9.3% throughout the region from offshore to the beach.

The Rayleigh distribution gives surprisingly good estimates of wave height statistics, even $H_{max}$, for the spilling breakers measured at Torrey Pines Beach. The percent mean errors over the measured ranges compared with the Rayleigh statistics of $H_{1/3}$, $H_{1/10}$ and $H_{max}$ were -0.2, -1.8 and -6.8%, respectively. The results show the Rayleigh distribution to slightly overpredict the number of

waves in the tail of the distribution, but it is nevertheless able to predict the central statistics of $H_{1/3}$ and even $H_{1/10}$ quite well.

Publications:

R. T. Guza and E. B. Thornton, "Wave Set-up on a Natural Beach," Journal of Geophysical Research, 86, 4133-4137, 1981.

D. A. Huntley, R. T. Guza and E. B. Thornton, "Field Observations of Surf Beat: Part 1, Progressive Edge Waves," Journal of Geophysical Research, 86, 1981.

E. B. Thornton and R. T. Guza, "Longshore Currents and Bed Shear Stress," Proceedings of the Euromech 114 Conference on Waves and Changes in the Surf Zone, Polish Academy of Sciences, 1980.

R. T. Guza and E. B. Thornton, "Swash Oscillations on a Natural Beach" (Accepted J. of Geophysical Research).

E. B. Thornton and R. T. Guza, "Phase Speeds and Energy Saturation Measured on a Natural Beach," submitted to the Journal of Geophysical Research.

E. B. Thornton and R. T. Guza, "Transformation of Wave Height Distribution," submitted to the Journal of Geophysical Research.

Thesis:

Teran, Gallo Padillo, "Transformation of Waves Across the Surf Zone," Master's Thesis, March 1981.

Title: Satellite and Synoptic Studies of Chemical Fronts in the California Current and Coastal Upwelling Zone

Investigator: E. D. Traganza, Associate Professor of Oceanography

Sponsor: Office of Naval Research

Objective: To develop a satellite referenced bio-chemical model of oceanic fronts: to optimize the interpretation of satellite images with respect to thermal, chemical and bio-optical information.

Summary: During the current year we have seen the successful completion of important objectives including (1) the conversion of digitized satellite infrared images to sea surface nutrient maps, (2) the comparison (and remarkable agreement) between in situ distribution of chlorophyll-biomass "blooms" in association with thermonutrient fronts and the distribution of chlorophyll-biomass "blooms" inferred from the Nimbus-7 Coastal Zone Color Scanner (CZCS), (3) investigation of the capability of analyzing plankton production over large frontal regions by using ratios of guanosine triphosphate (GTP) to adenosine triphosphate (ATP) for determining microplankton growth rates, and (4) the completion and successful performance of the towed oceanwater sampling system (TOSS).

Over the past three years there have been thirteen publications (four of which are full papers) and eight masters theses. Three talks (two invited) have been given to international audiences, viz., at the 1980 I.D.O.E. International Symposium on Coastal Upwelling, the 1981 Gordon Research Conference on Chemical Oceanography (invited) and the 1981 NATO Advanced Research Conference on Coastal Upwelling: Its Sedimentary Record (invited). This project has attracted the attention of numerous scientists. Some have initiated studies off Pt. Sur, including dynamic studies by Dr. C. N. K. Mooers and L. C. Breaker (a Ph.D. student) of NPS and satellite ocean color studies by Dr. J. Mueller of NPS, and acoustic studies by Dr. P. Scully-Powers and D. Browning of NUSC. Dr. Neil Andersen of NSF has used this work as an example of the future potential role of satellites in chemical oceanography. Dr. R. Stevenson and Mr. Ben Cagle of ONR have extrapolated our findings to an area of strategic Naval importance.

**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, 85, 4101-4106, 1980.

E. D. Traganza, J. C. Conrad and L. C. Breaker, "Satellite Observations of a 'Cyclonic Upwelling System' and 'Giant Plume' in the California Current," In: Coastal Upwelling, American Geophysical Union, Washington, D.C., 1981.

E. D. Traganza, "Nutrient Distribution and Recurrence of Coastal Upwelling Centers by Satellite Remote Sensing: Its Implication to Primary Production and the Sediment Record," NATO Advanced Research Conference on Coastal Upwelling: Its Sediment Record. Plenum Press, 1982, (forthcoming).

E. D. Traganza, D. A. Nestor and A. K. McDonald, "Satellite Observations of a Nutrient Upwelling Off the Coast of California," EOS Transactions, American Geophysical Union, 61 (14), GAP Abstract 4710, 1980.

E. D. Traganza, W. E. Hanson, S. H. Bronskink and D. M. Austin, "Satellite Inferences, GTP-Microplankton Productivity and Chemodynamic Effects of Upwelling Systems Off Pt. Sur, California," Abstract in: EOS Transactions, American Geophysical Union, 61 (46): 1013, 1980.

**Conference Presentations:**

E. D. Traganza, "Satellite and Synoptic Studies of the Pt. Sur 'Cyclonic Upwelling System,'" Abstract in Proceedings of: 27th Annual Eastern Pacific Oceanic Conference, UCLA Conference Center, Lake Arrowhead, California, October 8-10, 1980.

E. D. Traganza, "The Use of Satellite Infrared Imagery in Investigating Nutrient Fronts in the Ocean," Invited talk: Gordon Research Conference on Chemical Oceanography at Plymouth State College, Plymouth, N.H., Announced in: Science, Vol. 211, No. 4487, August 3-7, 1981.

E. D. Traganza, "Nutrient Distribution and Recurrence of Upwelling Centers by Satellite Remote Sensing," Invited talk, abstract in Proceedings: NATO Advanced Research Conference on Coastal Upwelling: Its Sediment Record, Villamoura, Portugal, September 1-5, 1981.

Theses Directed:

R. W. Phoebus, "Biological Patchiness in Relation to Satellite Thermal Imagery and Associated Chemical Mesoscale Features," Master's Thesis, June 1981.

C. D. Jori, "Estimating the Distribution and Production of Microplankton in a Coastal Upwelling Front, from the Cellular Content of Guanosine-5' -Triphosphate and Adenosine-5' -Triphosphate," Master's Thesis, September 1981.

V. M. Silva, "Thermal Calibration of Satellite Infrared Images and Correlation with Sea-Surface Nutrient Distribution," Master's Thesis, (forthcoming).

Title: Investigation of the Distribution of the Spectral Irradiance of Natural Light and the Optical Beam Spread Function of the Ocean

Investigator: Stevens P. Tucker, Assistant Professor, Department of Oceanography.

Sponsor: Defense Advanced Research Projects Agency

Objective: The primary long term objective is the prediction on an ocean-regional basis the temporal and spatial distributions of certain fundamental ocean optical properties, including the volume scattering and diffuse attenuation in the upper ocean.

Summary: The approach has been to examine available records of pertinent data, especially scattering, gathered to date for some eight ocean regions (per letter modification of original work statement) for the purpose of cataloging and assessing the relevant data (a) developing "representative" profiles for the upper 200 m of the ocean, (b) relating in so far as possible optical and non-optical ocean parameters, (c) and assessing the spatial and temporal variability of the optical parameters. In addition, in cooperation with SRI, International, instruments have been assembled for the purpose of measuring in situ and simultaneously several inherent and apparent optical properties, including the beam attenuation coefficient.

A detailed search for optical data has been conducted and a report per (a)-(c) above is in the final stages of preparation. In addition some four joint NPS-SRI optics cruises have been carried out in California waters with the Naval Postgraduate School's research vessel ACANIA. Beam attenuation measurements were made under this contract.

Title: Countercurrents and Eddies in the California Current System

Investigator: A. J. Willmott, Assistant Professor, Department of Oceanography

Sponsor: Office of Naval Research

Objective: To develop theoretical models for the interaction of eddies with mesoscale coastal and bottom topographic irregularities in eastern boundary current regimes. The long term objective of this research is to understand how continental shelf and shelf break circulation is coupled with mid-ocean dynamics. This research effort is part of a continuing program.

Summary: A study of the steady state circulation of a constant barotropic current around an idealized Gaussian headland, located on a flat bottom, mid-latitude β-plane was completed. Coastal orientation and headland geometry were shown to be critical parameters in determining the flow field. The study has shown that eddies observed in the vicinity of the major California headlands may be produced by a flow separation mechanism. A study has also been initiated on the generation of topographic Rossby waves in an oceanic trench. It was shown that surface wind stress directed alongshore can generate a large topographic Rossby wave response along the Aleutian trench. For the Japan-Kuril trench system, the fluctuations within the Kuroshio current, where it flows across the trench, were shown to be capable of generating a significant northward propagating topographic Rossby wave response.

Publications: L. A. Mysak and A. J. Willmott, "Forced Trench Waves," Journal of Physical Oceanography. (forthcoming).

A. J. Willmott, "The Influence of a Coastal Headland on Oceanic Boundary Currents," Geophysical and Astrophysical Fluid Dynamics. (forthcoming).

Conference Presentation: A. J. Willmott, "Forced Trench Waves," Third Conference on Atmospheric and Oceanic Waves and Stability, San Diego, January 19-23, 1981.

# DEPARTMENT

# OF

# MECHANICAL ENGINEERING

# DEPARTMENT OF MECHANICAL ENGINEERING

The research program in the Department of Mechanical Engineering has continued in several areas: applied mechanics; design and optimization; heat transfer; hydrodynamics and fluid mechanics; and materials science.

## APPLIED MECHANICS

Professor Cantin continued his attempts to solve large problems using small computers. A number of programs were written and tested on the TEKTRONIX system 4081 to verify new approaches to the numerical solution of classical problems encountered in both solid and fluid mechanics and in heat transfer. Continued improvements have been made on the GIFTS-5 system (a large interactive Finite Element System with a rich collection of graphics interactions) for both research and teaching

Professor Nunn continued his investigation of the ball-obturated spinning tubular projectile. An analytical model, incorporating three degrees of freedom, has been formulated for the ball-obturator and the model has been shown to adequately predict the motion obtained in laboratory experiments. A linear approximation to this model has proven useful in the development of design criteria. Work is continuing in the laboratory to evaluate the complex force field which occurs on this projectile during supersonic flight.

Professor Salinas continued his investigation of the response of a graphite-epoxy composite to a fire environment. Analytical models were developed and computer programs were written to determine both the thermal and strength response. A series of experimental tests of various specimens subjected to hot jet exhaust were completed. Work continues in order to better understand the fundamental mechanisms involved.

## DESIGN AND OPTIMIZATION

Professors Kelleher and Vanderplaats completed their investigations of the optimal design of liquid to gas heat exchangers and also of non-imaging solar collectors. Their results on heat exchanger design were accepted for publication in the Journal of Heat Transfer.

Professor Nunn continued his efforts to apply modern optimization theory to the design of marine steam condensers. A computer program has been written and is continuing to be verified and improved.

Professor Sladky has initiated a project to develop an insight into the concept of modularization in diverse technologies. The objective of the study is to attempt to formulate a model to determine the desirability, effectiveness and cost of modularization. An extensive literature study has been initiated in order to compile a sufficient data base for analysis.

Professor Vanderplaats continued his work for NASA on the development of a library of computer codes for automated design optimization. A literature search has been completed and a comprehensive FORTRAN code was developed which contains numerous subroutines for flexibility. Professor Vanderplaats completed his study of the optimum design of torsional shafts using composite materials. A model was developed to design hollow cylindrical shafts with various limitations. A technical paper on this topic is expected to be published in the open literature. Professor Vanderplaats initiated a project to develop a fully-automated design capability for three-dimensional elastic truss structures. Results to date show that the optimum truss configuration is found to be strongly dependent on the design constraints.

HEAT TRANSFER

Professor Marto has continued his investigation of heat transfer augmentation techniques which occur in two-phase heat exchange equipment such as boilers and condensers. Together with Professor Nunn, an extensive effort has been made to develop a comprehensive computer model for the analysis of compact Naval condensers. The model is continually updated with new experimental data observed in the literature or taken in the laboratory. Professor Marto initiated an experimental study of nucleate boiling of dielectric fluids and refrigerants from various enhanced tubular surfaces. Heat transfer coefficients on some surfaces were as much as ten times those of smooth surfaces.

Professors Salinas and Marto continued their work on the use of the Finite Element Method to predict heat transfer performance in an internally finned rotating heat pipe. A computer program was developed to show the effects of heat pipe working fluid, wall material, fin geometry and heat pipe operating characteristics upon heat pipe thermal performance.

A variety of other studies by Professors Kelleher and Pucci have been undertaken to investigate various heat transfer phenomena such as heat exchange in fluidized beds, cooling of turbomachinery, heat transfer in curved channels and cooling of electronic equipment.

HYDRODYNAMICS AND FLUID MECHANICS

Professor Culbreth, a new faculty member, initiated an experimental program to study the fluid mechanics of buoyant liquid plumes using a Laser Doppler Velocimeter and high speed micro-computer. He also initiated a study of flow visualization using a pulsed-nitrogen laser and photochromic dye.

Professor Gebhart, NAVSEA Chair Professor for FY81, investigated the behavior of buoyant jets in a co-flowing stratified ambient. In conjunction with Professor Kelleher, a two-dimensional model was developed to study the motion of a submerged horizontal buoyant jet, left behind by a moving source, as the jet rises in a density stratified ocean. The model includes the possible use of eleven different entrainment functions.

Professor Kelleher initiated a project for the Naval Research Laboratory to investigate the utility and range of validity of linearized boundary conditions in numerical investigations of flow over wavy surfaces. A copy of a code using spectral analysis, developed by Cambridge Hydrodynamics, Inc., has been installed and is being modified to incorporate these simplified boundary conditions.

Professor Nunn continued his work on the investigation of jet crossflows as might occur in bow-thruster flow fields. The problem has been approached by both experimental and analytical means. Attempts have been made to map the surface pressure disturbance region using liquid crystal thermography.

Professor Pucci continued his work on gas turbine exhaust stack eductor systems. A new and novel exhaust stack geometry was tested in FY81 to visually shield primary nozzles from overhead view. Results show that significant reductions in stack length are possible. Professor Pucci also continued his study of the effect of cannister geometry on carbon dioxide removal using Sodasorb. The effect of five different length to diameter ratio cylindrical cannisters with and without annular ring and/or central disk baffles was determined for a given air-carbon dioxide mixture and flow rate.

Professor Sarpkaya and his students continued a comprehensive study of the hydroelastic oscillation of cylinders in harmonic flow for the National Science Foundation. Experiments have been performed with smooth and rough cylinders. A numerical model based on the discrete vortex analysis has been developed. Predictions of this model compare extremely well with the experimental data. These results have been presented at various locations around the world. Related studies on the determination of wave forces on risers and on submarine pipelines, as well as other time-dependent flows, are currently in progress. Professor Sarpkaya also continued his work on low airspeed sensors for the Naval Air Systems Command. After a comprehensive literature search, the characteristics of existing low airspeed sensors were critically assessed. A new concept was then proposed and a new sensor was designed for future testing.

Professor Sarpkaya initiated a project on impulsively-started flow about submarine-shaped bodies. The objective of this work is to experimentally determine the force coefficients acting on two-dimensional bodies in impulsively-started flows in order to support an ongoing program at the David W. Taylor Naval Ship Research and Development Center. Professor Sarpkaya also initiated a new project to study the motion of submerged bodies in stratified fluids. A unique water channel has been constructed and equipped with a towing carriage to pull models without distorting the flow field and free surface. Experiments have been carried out with delta-wing bodies, and will continue with other body shapes.

Professor Sladky initiated a project to study nozzle flow where the flow media is a mixture of liquid and gas. The objective of this program is to provide a correlation between computer predictions and experimental examples of different nozzle geometries.

MATERIALS SCIENCE

Adjunct Professor Boone continued his work on hot corrosion of gas turbine blade materials. The influence of surface coatings and various metallic additions, such as platinum, upon hot corrosion performance has been experimentally studied.

Professor Challenger continued his work on the elevated temperature fatigue of alloys used in propulsion systems. The objective of this work is to discover the damage mechanism that exists when creep and fatigue are imposed on materials at high temperatures. During this year, a new test facility has been designed and assembled which has the capability of testing the properties of metals in controlled environments. This experimental study will continue to elucidate what damage mechanisms occur. Professor Challenger also initiated a program to study the facture properties of HY-130 weldment for the David W. Taylor Naval Ship Research and Development Center. An instrumented multi-pass weld of an HY-130 plate has been completed. Data have been gathered to assess the influence of one weld pass on an existing weld bead. Considerable tempering has been shown to occur.

Professor McNelley continued his work on the thermomechanical processing of AISI 52100 steel. It has been shown that warm rolling of the steel following an initial heat treatment produces ultra-fine microstructure in this high carbon steel. This may lead to improved performance bearing material. Professor McNelley has also continued his research for the Naval Air Systems Command on thermomechanical processing of aluminum-magnesium alloys containing high weight percentages of magnesium. The effect of thermomechanical processing on these alloys of various compositions, and the detailed changes in microstructure, have been systematically studied.

Professor Perkins initiated a project for the Naval Civil Engineering Laboratory on corrosion control of marine reinforced concrete. Four electrochemical methods have been used to determine the relationship between corrosion rate and environmental variables. Professor Perkins also initiated a project to determine the effect of microstructural defects on the kinetics of martensitic transformations. Basic studies of rapidly solidified shape memory alloys will be forthcoming.

Title: The Substrate Effect in Low Temperature Hot Corrosion Resistant Coatings

Investigator: Donald H. Boone, Adjunct Professor of Mechanical Engineering

Sponsor: Naval Sea Systems Command

Objective: A study of the effect of superalloy substrate compositions on the performance of protective coatings in gas turbine engines is being studied. These systems are used in severe marine environmental conditions which often results in reduced lifetimes of critical components. Substrate alloying changes designed to improve creep life can often reduce coating oxidation/hot corrosion life. The kinetics of interaction are not understood nor are the specific detrimental elements. Such information is required for the proper design of substrate and coating alloy composition and then selection and application for specific engine requirements.

Summary: Cobalt base superalloys coated with an EB-PVD CoCralY were found to be significantly less detrimental to low temperature hot corrosion (LTHC) resistance than nickel base alloys where in addition differences were seen between various compositions. The effect of a platinum inner layer was found to strongly depend upon the specific coating/substrate combination. LTHC was reduced with Pt layer addition to cobalt alloys while in general these layers provided improved protection for the nickel based superalloys. In the later case, lifetimes varied with specific substrate and thermal exposure.

Studies of the LTC resistance of uncoated alloys were also conducted to be used to better understand effects of subsequent coating.

Theses Directed: Richard N. King, "An Investigation of the Substrate/Platinum Effect in Low Temperature Hot Corrosion of Marine Gas Turbine Materials," Master's Thesis, December 1980.

John R. Exell, "The Substrate Effect of Active Element Hafnium in Aluminide Coatings," Master's Thesis, June 1981.

Title: Elevated Temperature Fatigue of Alloys Used in Propulsion Systems

Investigator: K. D. Challenger, Assistant Professor of Mechanical Engineering

Sponsor: NPS Foundation Research Program

Objective: This was the first year for this presently on-going program at NPS. The objective of the research is to discover the damage mechanism that exists when combined creep (sustained loads) and fatigue (cyclic loads) are imposed on the materials used in propulsion systems in various types of environments at elevated temperature. The knowledge of the damage mechanisms will then be used to develop design correlations that could be used to extrapolate laboratory test data to actual service conditions.

Summary: In the past we have used 2¼ Cr - 1Mo steel to examine the effect of an oxidizing environment on the fatigue crack growth rate for continuously cycled specimens and specimens subjected to a loading wave form that included a constant strain hold period (creep damage). We found, to everyone's surprise, that compressive hold periods accelerated the fatigue crack growth rate as much as tensile hold periods. This indicates that the principal effect of the hold periods is to allow more oxidation to occur at the crack tip. We also examined the dislocation-precipitate substructure of these samples. The hold periods promoted a cellular dislocation structure indicating that some creep damage had occurred; this tells us that, even though the environmental effects were large, creep damage was also occurring. Thus for different testing conditions or different environments creep damage may overshadow the environmental effect and it must be considered important.

Also in the past year, we have designed and assembled a test facility for testing the elevated temperature properties of metals in controlled environments.

Publications: K. D. Challenger, A. K. Miller and R. L. Langdon, "Elevated Temperature Fatigue with Hold Time in a Low Alloy Steel: A Predictive Correlation,"

Publications: (continued)

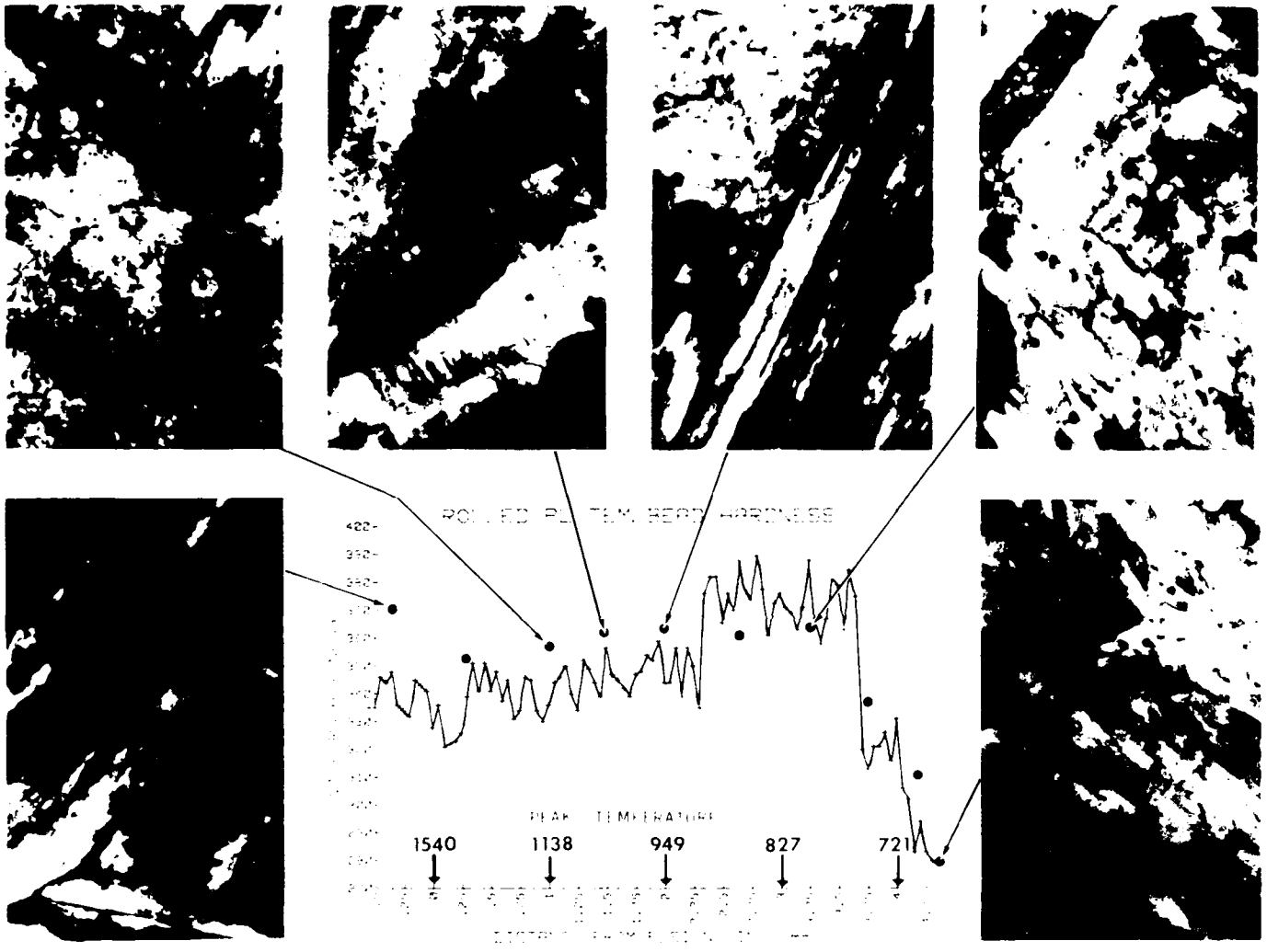
accepted for publication in the Journal of Material for Energy Systems, August 1981.

K. D. Challenger and P. G. Vining, "The Effects of Hold Time in the Fatigue Crack Growth Rate of 2¼ Cr - 1Mo Steel," (forthcoming).

Theses Directed:

P. G. Vining, "Mechanisms of Elevated Temperature Fatigue Damage in 2¼ Cr - 1Mo Steel," Mech. Engr. Thesis, June 1981.

W. Hastie, "Design and Construction of an Environmentally Controlled Elevated Temperature Fatigue Facility," Master's Thesis, September 1981.




THE PROPERTIES OF HIGH STRENGTH STEEL WELDMENTS ARE BEING CHARACTERIZED IN CONJUNCTION WITH THE FABRICATION TECHNOLOGY BRANCH OF NSRDC. THE ABOVE FIGURE DEPICTS THE RELATIONSHIP BETWEEN MICROSTRUCTURE (AS VIEWED WITH A TRANSMISSION ELECTRON MICROSCOPE) AND HARDNESS IN THE HEAT AFFECTED ZONE OF A GAS METAL ARC WELD OF HY-130 STEEL.

Title: Fracture Properties of HY-130 Weldment

Investigator: Kenneth D. Challenger, Assistant Professor of Mechanical Engineering

Sponsor: Naval Sea Systems Command

Objective: This was the first year for this on-going research program at NPS. The objective of this program is to improve the fracture properties of HY-130 steel weldments. HY-130 is the favored candidate to replace HY-80 as the structural steel for naval ship construction. The current road block to its acceptance is poor resistance to fracture when welded.

Summary: In this first year we have been able to identify the weld bead sequence for multipass welds as a major cause of the poor fracture properties of HY-130 weldments. Certain sequences yield better fracture properties than others because of the tempering effect that subsequent weld passes have on the initial weld passes. NAVSEA has been notified that the temper bead technique should be required if improved weldment properties are to be achieved.

We have performed an instrumented multipass weld similar to the thick plate welds used in submarine hull construction. This data has been used to quantitatively assess the effect of one weld pass on an existing weld bead. We have shown that considerable tempering can be effected with proper welding techniques. This data has also been used to develop laboratory heat treatments to simulate the welding thermal cycles. These laboratory heat treatments have been performed and shown to be a valid simulation of the welding process. Thus, we can prepare fracture and mechanical property test specimens without resorting to welding.

Theses Directed: B. R. Brucker, "Fracture Properties of HY-130 Cast Plate Weldments," Master's Thesis, December 1980.

P. Cincotta, "The Effects of Simulated Welds on HY-130 Cast and Wrough Plate and Weld Metal Miscrostructure," Master's Thesis, September 1980.

M. J. Sorek, "A Correlation Between Heat Affected Zone Microstructure and the Thermal History During Welding HY-130 Steel," Master's Thesis, September 1980.

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| Title: | Experimental Investigation of the Fluid Mechanics of Buoyant Liquid Plumes |
| Investigator: | W. G. Culbreth, Assistant Professor of Mechanical Engineering |
| Sponsor: | NPS Research Foundation Program |
| Objective: | To analyze the velocity distribution of turbulent, buoyant liquid plumes through the use of a Laser Doppler Velocimeter and to test the validity of various mathematical models used to predict turbulent entrainment in plumes and plume configuration. |
| Summary: | A program of investigation has been developed and a commercial Laser Doppler Velocimeter has been ordered. A high speed microcomputer system has also been ordered to acquire turbulent velocity data from the velocimeter. |

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| Title: | Flow Visualization and Measurement Using a Pulsed-Nitrogen Laser |
| Investigator: | W. G. Culbreth, Assistant Professor of Mechanical Engineering |
| Sponsor: | None |
| Objective: | To obtain the velocity distributions in liquid, buoyant plumes by analyzing the distortion of traces of a photochromic dye excited along the path of a pulsed-nitrogen laser beam. Photochromic dye dissolved in the buoyant plume fluid changes from transparent to opaque when exposed to ultraviolet light generated by the laser. The internal hydrodynamics of buoyant plumes distort linear traces yielding both a visual indication of the flow field and, through photographs, a method of measuring velocity distributions. |
| Summary: | A pulsed-nitrogen laser has been obtained and a photochromic pyrospiran dye has been acquired. Plans have been developed for the construction of a flume for the generation of buoyant plumes. Suitable software is under development to digitize and record the position of the distorted traces obtained from photographs. |
| Thesis Directed: | August F. Pellin III, "Flow Visualization and Measurement Using a Pulsed Nitrogen Laser," Master's Thesis, March 1982. |

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| Title: | Behavior of Buoyant Jets in a Co-Flowing Stratified Ambient |
| Investigators: | Matthew D. Kelleher, Associate Professor of Mechanical Engineering and Benjamin Gebhart, NAVSEA Research Chair Professor of Mechanical Engineering (Samuel Landis Gabel Professor of Mechanical Engineering, University of Pennsylvania). |
| Sponsor: | Naval Sea Systems Command |
| Objective: | To study the behavior of a submerged horizontal buoyant jet, left behind by a moving source, as the jet rises in a density stratified ocean, and to calculate the jet diffusion toward plume behavior, the rate of the jet spread and rise, and the residual temperature excess and salinity difference which appears at and near the ocean surface. |
| Summary: | A two-dimensional entrainment model has been developed to predict the behavior of a fully turbulent buoyant water jet discharging into an infinite ambient. The model can selectively employ any of eleven different entrainment functions. The model assumes gaussian similar profiles in the jet and calculates jet trajectory and rate of spread of the jet. Included in the model are the effects of ambient velocity and ambient density stratification. The model incorporates a very accurate equation of state for seawater. |
| Theses Directed: | David H. Hilder, "Two-Dimensional Entrainment Model of Buoyant Jets in Water," Mechanical Engineer and Masters Thesis, December 1981. |

Title: Linearized Boundary Conditions for Flow Over Wavy Surfaces

Investigator: Matthew D. Kelleher, Associate Professor of Mechanical Engineering

Sponsor: Naval Research Laboratory

Objective: To determine the utility and range of validity of linearized boundary conditions in numerical investigations of flow over wavy surfaces.

Summary: An investigation is being conducted into the feasibility of using simplified, linearized boundary conditions to describe the flow over wavy walls. The shape of the wavy wall is specified by some periodic function $\eta(x,t)$, where x, is the streamwise coordinate and t, is the time. The boundary conditions to be imposed on the Navier-Stokes equations at the wall are that the velocity components must take on the velocity of the wall. If it is assumed that the wall motion in the x direction is negligible, these can be written as:

$$y = \eta(x,t) \quad u = 0$$

$$v = \frac{\partial \eta}{\partial t}$$

If the velocity components are expanded in a Taylor series about $y = 0$, and only the linear terms are retained, a linearized version of the boundary conditions evaluated at $y = 0$, can be written as:

$$y = 0 \qquad u + \frac{\partial u}{\partial y}\eta = 0$$

$$v + \frac{\partial v}{\partial y}\eta = \frac{\partial \eta}{\partial t}$$

The fact that these boundary conditions are evaluated at $y = 0$, is a great simplification.

The objective of this work is to investigate the region of validity in terms of wave amplitude and wave length, of these simplified, linearized boundary conditions. To carry out this task a copy of the spectral code for the analysis of the flow over wavy walls, developed by Cambridge Hydrodynamics Inc., has been obtained. This code has been installed on the CYBER 170/175 Computer at Fleet Numerical Ocea phic Center, Monterey. This code is being modif to incorporate the simplified boundary condition .

Title: Condenser Heat Transfer Augumentation

Investigators: P. J. Marto, Professor and Chairman of Mechanical Engineering, and R. H. Nunn, Professor of Mechanical Engineering

Sponsor: David W. Taylor Naval Ship Research and Development Ctr.

Objective: To develop a comprehensive computer model for the analysis of compact Naval condensers so that condensers may be designed for minimum volume, weight, etc..

Summary: An extensive literature survey was made of all commercially available enhanced tubing. Existing heat transfer and pressure drop data were assessed and utilized in an existing one-dimensional computer code to size submarine condensers. A 100 tube bundle apparatus was formulated and sized for possible acquisition. A new one-dimensional code, title CONDIP, was developed and its preliminary operation was completed.

Publications: P. J. Marto and R. H. Nunn, "Condenser Heat Transfer Augumentation - Progress Report," April 1981.

P. J. Marto and R. H. Nunn (Editors). Power Condenser Heat Transfer Technology, McGraw-Hill (Hemisphere) Publishing, 1981.

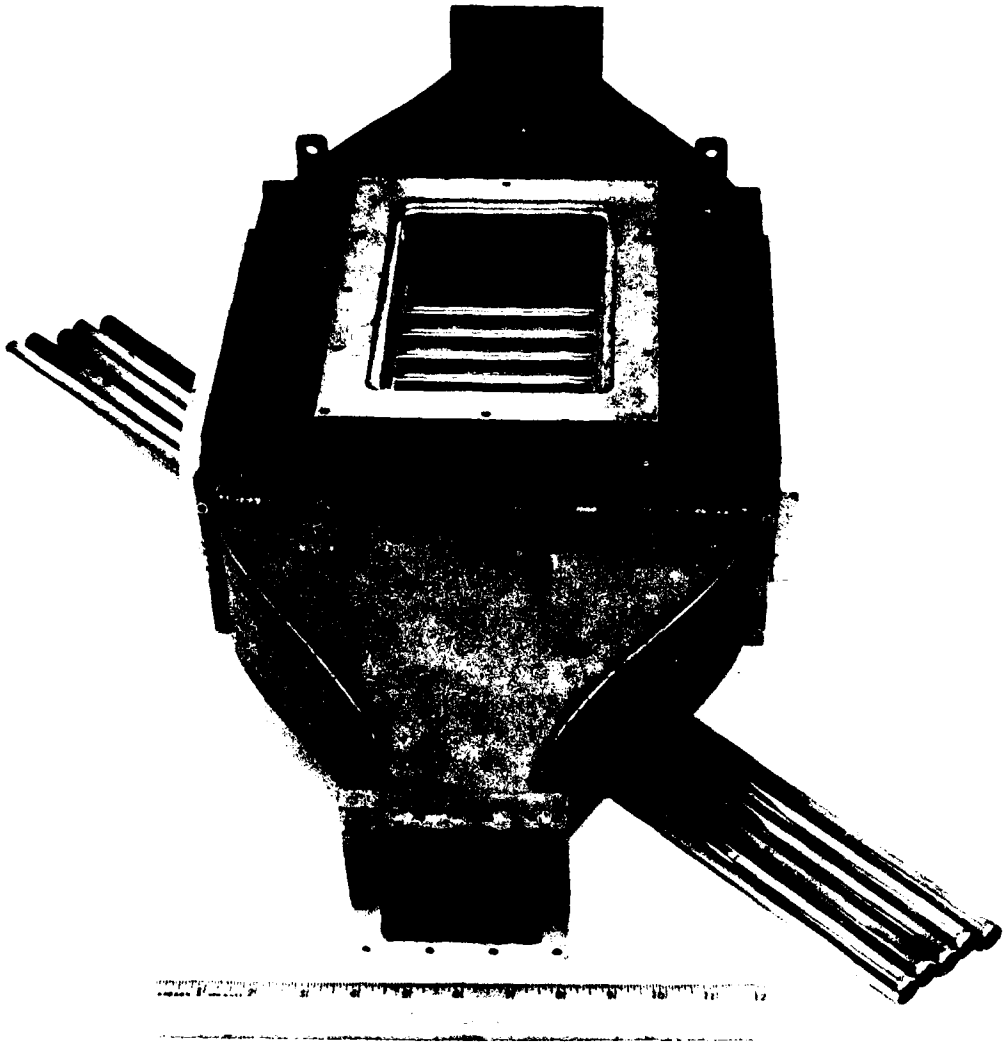
Conference Presentation: P. J. Marto and R. H. Nunn, "The Potential of Heat Transfer Augmentation in Naval Surface Condensers," Navy Symposium on Heat Transfer, Annapolis, MD, 23-24 July 1981.

Theses Directed: I. Demirel, "The Effect of Condensate Inundation on Condensation Heat Transfer in Tube Bundles of Marine Condensers," Master's Thesis, December 1980.

D. Burns, "Condenser Modelling for Numerical Optimization," Master's Thesis, (forthcoming).

R. H. Morrison, "A Test Condenser to Measure Condensate Inundation Effects in a Tube Bundle," Master's Thesis, March 1981.

H. M. Holland, "The Effect of Circumferential Tube Wall Heat Conduction Upon Laminar Filmwise Condensation on the Outside of Condenser Tubes," Master's Thesis, December 1980.



STEAM CONDENSER TEST SECTION. THIS APPARATUS IS BEING USED TO STUDY THE EFFECT OF CONDENSATE INUNDATION ON STEAMSIDE HEAT TRANSFER COEFFICIENTS USING GIVE ACTIVE TEST TUBES. A SIXTH TUBE, MADE OF POROUS WALLS, IS USED TO PROVIDE ADDITIONAL FLOODING CAPABILITY TO SIMULATE TUBES LOCATED WITHIN VERY LARGE TUBE BUNDLES

Title: Thermomechanical Processing of AISI 52100 Steel

Investigator: Terry R. McNelley, Associate Professor of Materials Science, Department of Mechanical Engineering

Sponsor: None

Objective: To investigate the influence of prior warm rolling on the response to heat treatment of the bearing steel AISI 5200 and to further characterize the influence of such processing on the fracture toughness and fatigue resistance of this steel.

Summary: An ongoing research effort into the effects of thermomechanical processing on 52100 steel is being conducted at the U.S. Naval Postgraduate School. The thermomechanical processes employed are derived from the efforts of Sherby and his coworkers at Stanford University. The essential feature of the thermomechanical process is warm rolling of the steel following an initial heat treatment. The result of this warm rolling is the production of an ultra-fine microstructure in such a high carbon (1.0 wt. pct.) steel. Carbide particles in the steel may be reduced to sizes of 0.1 to 0.2 μm in a ferrite matrix of 0.5 μm grain size. Carbide refinement as such is known to result in improved performance in bearing steels and it is generally believed that grain refinement is beneficial to fracture toughness in steels. In such grain refined steels, however, it might be expected that the heat treatment response of the steel be altered. Fine carbides may dissolve more quickly on austenitizing, grain growth may occur, the Martensite start temperature may be altered and retained austenite content affected. These areas have been of most immediate concern in this effort to date. Other questions of future interest include the effect of such microstructural refinement on the response of such materials to rapid heat treatment processes, e.g. utilizing electron beam hardening, and on response to coatings applied to such materials.

Conference Presentations:

D. H. Boone, C. W. Schultz, T. R. McNelley and A. Doig, "Effect of Initial Processing and Structure on the Hardening Response of AISI 52100 Bearing Steel," 110th Annual Meeting of AIME, Chicago, IL, 23-27 February 1981.

J. F. McCauley, T. R. McNelly and D. H. Boone, "The Influence of Prior Warm Rolling on Microstructure and Fracture Toughness of Heat Treated 52100 Steel," 110th Annual Meeting of AIME, Chicago, IL, 23-27 February 1981.

Theses Directed:

C. W. Schultz, "The Effect of Thermomechanical Treatment on the Microstructure and Mechanical Properties of AISI 52100 Steel," Master's Thesis, June 1981.

D. M. Tufte, "The Effect of Grain and Carbide Refinement on the Isothermal Transformation Characteristics of AISI 52100 Steel," Master's Thesis, September 1981.

Title: Thermomechanical Processing of Aluminum-Magnesium Alloys Containing High Weight Percentages of Magnesium

Investigator: Terry R. McNelley, Associate Professor of Materials Science, Department of Mechanical Engineering

Sponsor: Naval Air Systems Command

Objective: Development of thermomechanical processing procedures for Aluminum-Magnesium alloys containing 8 to 14 weight percent Magnesium and characterization of the mechanical properties of the materials.

Summary: Continuation of efforts to evaluate the effect of the thermo-mechanical process on microstructure with particular emphasis on transmission electron microscopy study of $\beta(Al_8Mg_5)$ precipitate distribution and dislocation substructure.

Study of the fatigue resistance has revealed that a warm-rolled 10% Mg alloy may exhibit a fatigue limit at a stress amplitude equal to 0.47 of the ultimate tensile stress. This alloy also cyclically hardens at high stress amplitude. For this alloy, the ultimate tensile strength is 65 Ksi (448 MPa) and the fatigue limit is about 31 Ksi (210 MPa). The fatigue characteristics of these alloys are sensitive to processing; those processing conditions resulting in the presence of a dispersion of relatively coarse $\beta(Al_8Mg_5)$ particles, of size up to 1 - 2 μm, exhibit improved fatigue resistance as a result of the slip-dispersing effect of these particles.

The stress-corrosion cracking resistance of these alloys is better than that of 7075-T6 Aluminum. Binary 8% Mg and 10% Mg alloys generally retain a large portion of their warm rolled strength and ductility after stress-corrosion exposure. Modification of such alloys by addition of Cu and Cu plus Mn results in microstructure homogenization and enhanced strength. The modified alloys are more susceptible to stress corrosion in the as-rolled condition but become less sensitive when annealed at 100°C for seven days while the binary alloys, especially the 10% Mg alloy, become more sensitive.

Theses Directed:

C. A. Cadwell, "Fatigue Characteristics and Microstructural Analysis of Thermo-Mechanically Processed, High-Magnesium Aluminum-Magnesium Alloys," Master's Thesis, June 1981.

L. E. Beberdick, "A Preliminary Investigation of the Corrosion and Stress-Corrosion Susceptibility of Thermomechanically Processed, High-Magnesium Aluminum-Magnesium Alloys," Master's Thesis, September 1981.

Title: Ball-Obturated Spinning Tubular Projectile

Investigator: Robert H. Nunn, Associate Professor of Mechanical Engineering

Sponsor: Technology Programs Management Office

Objective: This project is aimed at developing a predictive capability by means of which the designer of tubular projectile systems may create feasible designs that are best suited to system/mission specification.

Summary: An analysis incorporating three degrees of freedom has been formulated to describe the motion of the ball-obturator within the spinning tubular projectile. The analytical model has been shown to adequately predict the motion obtained in laboratory experiments with a stationary (i.e. not in flight) spinning projectile. A series of computer experiments has been conducted to show the sensitivity of the ball motion to various design parameters such as ball geometry, and material, and projectile launch conditions (Mach number and altitude). A linear approximation to the nonlinear model has also been developed and has proven useful in the development of design criteria including the formulation of design conditions necessary to avoid hovering motion of the ball. These developments have been summarized and reported in a formal project report as well as in the open literature. Work is continuing to experimentally evaluate the complex force field surrounding the projectile and ball during supersonic flight.

Publications:

R. H. Nunn, and J. W. Bloomer II, "Ball Motion in a Ball-Obturated Tubular Projectile," NPS Technical Report, NPS69-81-001, January 1981.

R. H. Nunn, J. W. Bloomer II, "Motion of a Bored Sphere in a Spinning Spherical Cavity," Journal of Dynamic Systems, Measurement and Control, December 1981.

R. H. Nunn, J. W. Bloomer II, "Ball-Obturation of a Spinning Tubular Projectile," Journal Spacecraft and Rockets, (September/October 1981).

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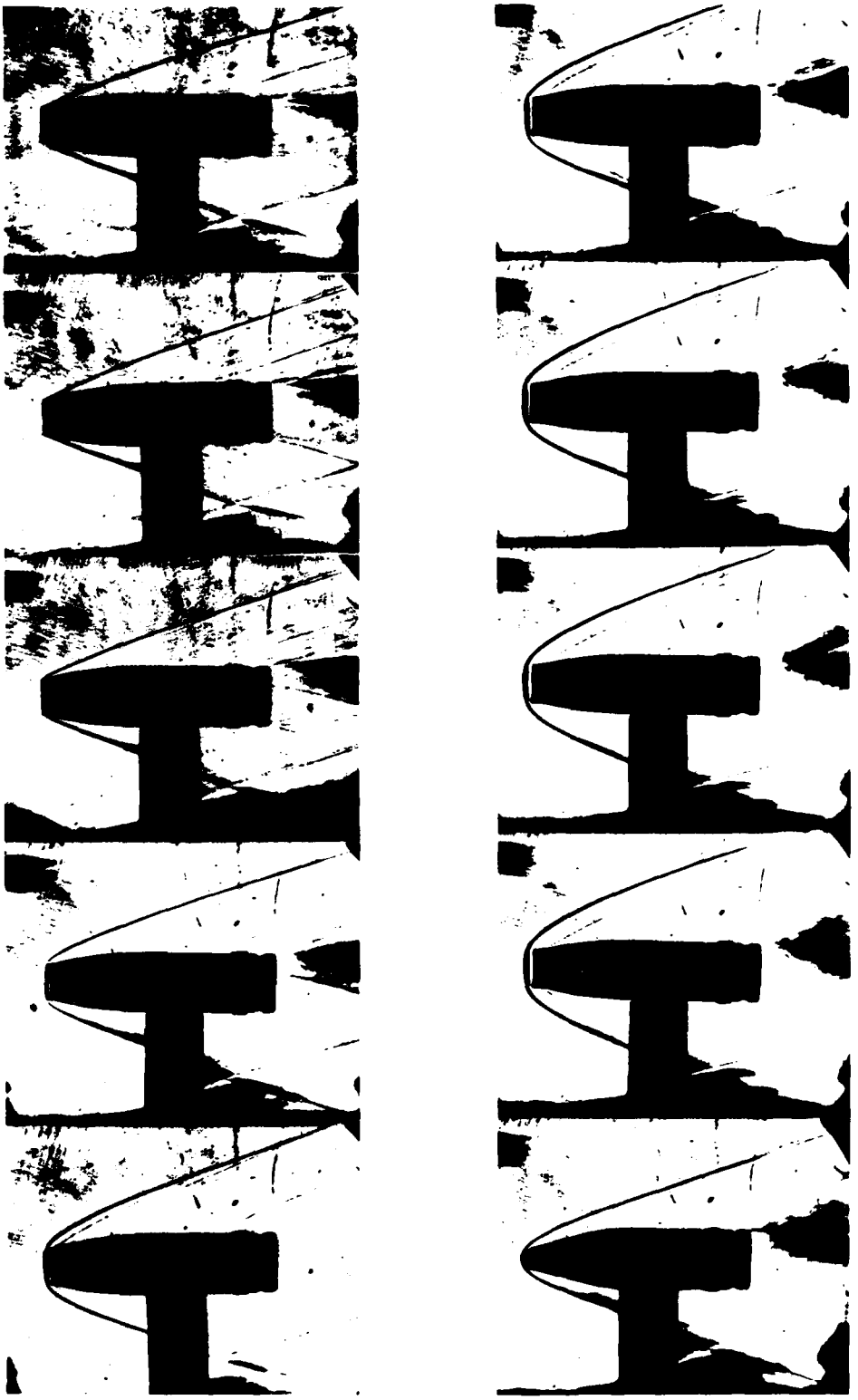
| Conference Presentations: | R. H. Nunn, "Ball Obturated Spinning Tubular Projectile," Ordnance Technology Program Review, Naval Weapons Center, China Lake, 27-28 April, 1981. |
| Theses Directed: | J. W. Bloomer II, "Ball Obturation of a Spin Stabilized Tubular Projectile," Master's Thesis, June, 1980. |
| | W. Bry, "Experimental Determination of Ball-Obturator Forces," Master's Thesis, (forthcoming). |
| | T. Stowell, "Method and Device for Measurement of Sliding Friction - Friction Driven Gyroscopic Mass," Master's Thesis, (forthcoming). |
| Patent Application: | R. H. Nunn, "Method and Device for Measurement of Sliding Friction - Friction Driven Gyroscopic Mass" (This is a spin-off benefit project evolved from the NWC-sponsored projectile program.) |



EXPERIMENTAL DETERMINATION OF THE AERODYNAMIC CHARACTERISTCS OF TUBULAR PROJECTILES.

SHOWN IS A SEQUENCE OF SCHLEREN PHOTOGRAPHS WITH FLOW PAST THE PROJECTILE OF MACH 4. BLOCKAGE OF THE FLOW THROUGH THE PROJECTILE IS SUCCESSIVELY INCREASED WITH ZERO BLOCKAGE IN THE UPPER LEFT AND TOTAL BLOCKAGE IN THE LOWER RIGHT (NEXT FROM BOTTOM). AT THE BOTTOM RIGHT IS A STANDARD 20-mm PROJECTILE.

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| Title: | Experimental and Theoretical Investigation of Bow-Thruster Flow Fields |
| Investigator: | Robert H. Nunn, Professor of Mechanical Engineering |
| Sponsor: | None |
| Objective: | To develop a comprehensive analytical model of the flow field established when a jet is injected into a crossing flow. The primary application of this research is to develop a capability to predict the complex pressure distribution that is created on ship hulls in the vicinity of bow-thruster jets. |
| Summary: | The problem has been approached by both experimental and analytical means. Analytically, the jet/crossflow problem has been modelled in terms of a distribution of hydrodynamic singularities. The far-field disturbances are modelled by a distribution of horseshoe vortex patterns whose strengths are related to the trajectory of the jet. Near-field disturbances are modelled by source/sink distributions intended to produce the effect of blockage, entrainment, and wake flows. The experimental program has begun with attemps to map the surface pressure disturbance region by means of liquid crystal thermography. |
| Theses Directed: | B. B. Waterman, III, "Analysis of Jet-Crossflow Interactions with Applications to Ship Bow Thrusters," Mechanical Engineer Thesis, March 1980.<br><br>T. Cooper, "Theoretical Model for the Jet-Crossflow Interaction," Master's Thesis, (forthcoming).<br><br>M. Johnson, "Liquid Crystal Mapping of Jet-Crossflow Interactions," Master's Thesis, (forthcoming). |

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| Title: | Differential Scanning Calorimetry Study of Rapidly Solidified Shape Memory Alloys |
| Investigator: | Jeff Perkins, Associate Professor of Mechanical Engineering |
| Sponsor: | NPS Foundation Research Program |
| Objective: | To experimentally determine the effect of microstructural defects, particularly grain boundaries and dislocations, on the kinetics of martensitic transformations. |
| Summary: | The effect of cold work and annealing have been investigated in terms of their effects on the temperature range of martensitic transformation in several Cu-Zn-Al alloys. |
| Publication: | J. Perkins, et al., "Grain Boundary Structures in Rapidly Solidified Cu-Zn-Al Alloys," Scripta Met. 15, pp 771-76, 1981. |

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| Title: | Electrochemical Investigation of Corrosion Control for Marine Reinforced Concrete |
| Investigator: | Jeff Perkins, Associate Professor of Mechanical Engineering |
| Sponsor: | Naval Civil Engineering Laboratory |
| Objective: | To determine corrosion rates for 1020 steel in a calcium hydroxide Ca(OH)2, solution, simulating the environment in concrete under conditions of various pH levels and various Cl - and $O_2$ concentrations. |
| Summary: | Four electrochemical methods, as well as microscopic evaluations, have been used to determine the relationships between corrosion rate and environmental variables. |
| Thesis Directed: | D. R. Scott, "An Electrochemical Investigation of Corrosion Control for Steel in Environments Which Simulate Conditions in Marine Reinforced Concrete," Master's Thesis, June 1981. |

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|---|---|
| Title: | Effect of Cannister Geometry on Carbon Dioxide Removal by Sodasorb |
| Investigator: | Paul F. Pucci, Professor of Mechanical Engineering |
| Sponsor: | Naval Coastal Systems Center |
| Objective: | To determine the effect of certain cannister geometries on the effectiveness of a packed bed of Sodasorb to remove carbon dioxide. |
| Summary: | The effect of five different length to diameter ratio cylindrical cannisters with and without annular ring and/or central disk baffles was determined for a given air-carbondioxide mixture and flow rate. A constant mass of sodasorb was used for each geometry. |
| Theses Directed: | Peter E. Louden, "The Effect of Cannister Geometry on the Effectiveness of Removing Carbon Dioxide with a Constant Mass of Soda Lime," Master's Thesis, December, 1980. |

Title: Gas Turbine Exhaust Stack Eductor Systems

Investigator: Paul F. Pucci, Professor of Mechanical Engineering

Sponsor: Naval Ship Research and Development Center

Objective: To determine the performance of scale models of gas turbine exhaust stack eductor system and to recommend criteria for the design of such systems for naval ships.

Summary: A new and novel exhaust stack geometry was tested in FY81. A two-dimensional plug was centrally located in a rectangular mixing stack to visually shield the primary nozzles from overhead view. In addition, a new series of tests was begun to study the effect of tilted and canted nozzles. Significant reduction in stack length is possible.

Theses Directed: Richard S. Shaw, "Performance of a Multiple Nozzle Exhaust Gas Eductor System for Gas Turbine Powered Ships," Master' Thesis, December, 1980.

Dennis L. Ryan, III, "Flow Characteristics of a Multiple Nozzle Exhaust Gas Eductor System," Master's Thesis, March, 1981.

Charles C. Davis, "Performance of Multiple Angled Nozzles with Short Mixing Stack Eductor Systems," Master's Thesis, September, 1981.

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|---|---|
| Title: | Advanced Composites Response |
| Investigator: | D. Salinas, Associate Professor of Mechanical Engineering |
| Sponsor: | Naval Weapons Center |
| Objectives: | Development of an analytical model to predict the thermal response of a composite in a fire environment. Development of an analytical model to predict the strength of a composite in a fire environment. The determination of the effects of jet exhaust on carrier deck aircraft. |
| Summary: | Analytical models for the determination of thermal and strength response were developed. Computer programs have been implemented. A series of computer analyses have been executed, and the results have provided fundamental understanding of the effects of environment and design on system behavior. A series of experimental tests of specimens subjected to jet exhaust were completed. |
| Publications: | D. Salinas, "Strength Analysis of Composites in a Thermal Environment," NPS Technical Report, NPS-69-81-005, September 1981.<br><br>C. S. Vatkiotis, and D. Salinas, "Combustion and Heat Transfer Model of a Porous Medium," submitted to the Journal of Heat Transfer, ASME, November 1981. |
| Theses Directed: | J. M. Hampey, "The Effects of Jet Exhaust Blast Impingements on Graphite-Epoxy Composites," Master's Thesis, June 1981.<br><br>R. E. Luby, Jr., "Analysis of Combustion of a Composite Plate," Master's Thesis, June 1981. |

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|---|---|
| Title: | FEM Analysis of an Internally Finned Rotating Heat Pipe |
| Investigators: | D. Salinas, Associate Professor of Mechanical Engineering, and P. J. Marto, Professor and Chairman of Mechanical Engineering |
| Sponsor: | None |
| Objective: | Development of an analytical model for the determination of behavior of internally finned rotating heat pipes. |
| Summary: | A mathematical model of a finned rotating heat pipe has resulted in a computer program. A series of computer analyses shows the effects of design parameters, such as coolant, fin material, fin geometry, and rotational RPM, on heat transfer. |
| Publications: | D. Salinas and P.J. Marto, "FEM Analysis of an Internally Finned Rotating Heat Pipe," submitted for publication in J. of Numerical Heat Transfer. |

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 paramaters 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 analysed 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, rediscretization of shear layers, and circulation dissipation. The predictions of the model compared extremely well with those obtained experimentally.

A number of publications and theses have been generated since the project's inception; only those for FY '81 are listed.

Publications:

T. Sarpkaya, F. Rajabi, M. F. Zedan and F. J. Fischer, "Hydroelastic Response of Cylinders in Harmonic and Wave Flow," Proceedings of the Offshore Technology Conference, Vol. I, pp. 383-390, OTC-3992, 1981.

T. Sarpkaya, "A Critical Assessment of Morison's Equation," Hydrodynamics in Ocean Engineering, Vol. 1, pp. 447-467, University of Trondheim, Norway, 1981.

Thesis Directed:

Thomas S. Raines, "Harmonic Flow About Yawed Cylinders," Master's and Engineer's Thesis, September 1981.

**Title:** Impulsively-Started Flow About Submarine-Shaped Bodies

**Investigator:** Turgut Sarpkaya, Distinguished Professor of Mechanical Engineering

**Sponsor:** David W. Taylor Naval Ship Research and Development Center

**Objective:** To perform experimental investigations in support of DTNSRDC's analytical modeling of separated flow past submarine-shaped bodies of special interest to naval hydrodynamics.

**Summary:** The research efforts have been designed to experimentally determine the force coefficients acting on two-dimensional bodies in impulsively-started flows. Investigators have included within the limitations of the experimental facility, force coefficients versus time for a variety of flow/body orientations (e.g., angle of attack) and Reynolds number. Experiments have been carried out in a vertical water tunnel with a D-shaped cylinder. Additional experiments will be performed during the coming year.

A number of publications and theses have been generated since the project's inception; only those for FY 81 are listed.

**Publications:** T. Sarpkaya and H. K. Kline, "Impulsively-Started Flow About Four Types of Bluff Body," Journal of Fluids Engineering of ASME, ASME paper No. 81-WA/FE-9, pp 1-8, December 1981.

**Thesis Directed:** H. Kline, "Impulsive-Flow About Submarine-Shaped Bodies," Master's Thesis, March 1981.

**Conference Presentation:** T. Sarpkaya and H. K. Kline, "Impulsively-Started Flow About Four Types of Bluff Body," ASME paper No. 81-WA/FE-9, 101st ASME Winter Annual Meeting, Chicago, IL, November 16-21, 1980.

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|---|---|
| Title: | Internal Waves in Stratified Fluids |
| Investigator: | T. Sarpkaya, Distinguished Professor of Mechanical Engineering |
| Sponsor: | DARPA |
| Objective: | To perform analysis and experiments to determine the characteristics of the internal waves generated by the motion of underwater bodies. |
| Summary: | A large water channel has been constructed and equipped with filling and emptying facilities and a towing carriage. The channel may be stratified at any desired stratification gradient.<br><br>Experiments have been carried out with Delta-wing bodies at various angles of attack and forward speed. The characteristics of vortices and the internal waves have been evaluated. The work is continuing. |
| Thesis Directed: | Christos Striftos, "Motion of Submerged Bodies in Stratified Fluids," Master's Thesis, December 1981. |

Title: Low Airspeed Sensors

Investigators: Turgut Sarpkaya, Distinguished Professor of Mechanical Engineering

Sponsor: Naval Air Systems Command

Objective: To investigate air data measurement requirements for helicopters and V/STOL aircraft. Included in the research are the factors of omnidirectional low airspeed measurement, wind and gust data at remote and unprepared sites, rapid and accurate determination of the sink rate in vertical-mode operation, and the measurement of flow angle at low airspeed.

Summary: The characteristics of the existing low airspeed sensors have been critically assessed in terms of their accuracy, range, reliability, sensitivity to environmental conditions, electronics, and price. This has led to the recommendation that new concepts and devices are needed to meet the airdata needs of the current and future naval aircraft.

A speed sensor based on jet-interaction principle has been designed and is currently being tested.

A number of publications and theses have been generated since the project's inception; only those for FY 81 are listed.

Publication: T. Sarpkaya and R. E. Duncan, "Low-Range Airspeed Sensors,", NPS-69SL-81-042, April 1981.

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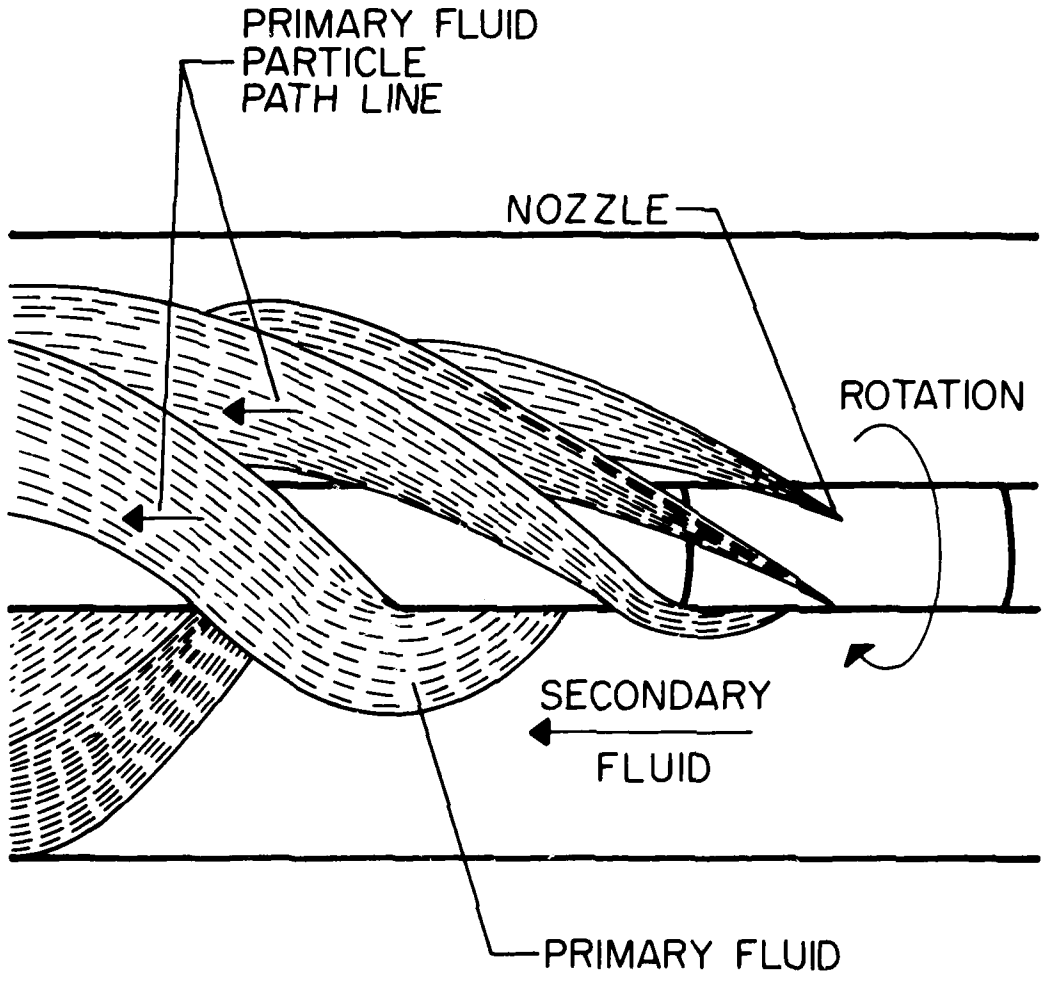
|---|---|
| Title: | Dual-Component Nozzle Flow |
| Investigator: | J. F. Sladky, Jr., Adjunct Professor<br>Mechanical Engineering |
| Sponsor: | Naval Ship Research and Development Center |
| Objective: | To develop experimental and analytic capability in nozzle flow technology where the media is a mixture of liquid and gas. The ultimate product is to provide correlation between analytic models and experimental examples of various nozzle geometries. |
| Summary: | An experimental facility has been designed and fabricated, the function of which is to allow the testing of dual-phase nozzles. Preliminary tests and flow visualization of the phenomenon have been successful. The development of diagnostic flow-field instrumentation is continuing. An existing "dated" computer code is being refined and will be used to develop nozzle test geometries. |
| Thesis Directed: | M. Flanniken, "Research on Bi-Phase Nozzles," Master's Thesis, June 1981. |

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|---|---|
| Title: | Morphology of Modularity |
| Investigator: | J. F. Sladky, Jr., Adjunct Professor, of Mechanical Engineering |
| Sponsor: | Office of Naval Research |
| Objective: | To develop an insight into the concept of modularization and to attempt to formulate a model that will assist in determining the desirability, effectiveness, and cost of modularization. |
| Summary: | The study has focused on the examination of modularization efforts in diverse technologies. The project is following a "case study" route and, as such, involves extensive literature and data base developments. The emphasis to date has been on the electronics and transportation industries. |

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|---|---|
| Title: | Configuration Optimization of Trusses Subject to Strength, Displacement and Frequency Constraints |
| Investigator: | Garret N. Vanderplaats, Associate Professor of Mechanical Engineering |
| Sponsor: | None |
| Objective: | To develop a fully-automated design capability for three-dimensional elastic truss structures to support multiple loading conditions, subject to limits on member stresses, Euler buckling, joint displacements and system natural frequencies. The design objective is to determine the optimum member sizes and joint locations to provide minimum weight. |
| Summary: | The analysis capability uses the finite element method and eigenvalues are calculated by the sub-space iteration technique. All required gradient information for design is obtained analytically.<br><br>The design problem is cast as a multi-level numerical optimization problem. The joint coordinates are treated as system level variables. For each proposed configuration, the member sizes are updated as a sub-optimization problem. This sub-problem is efficiently solved using approximation concepts in the reciprocal variable space. The multi-level approach is shown to be an effective approach which conveniently takes advantage of the most efficient methods available for member sizing, while dealing with the nonlinearities of the configuration problem. The technique has been programmed for computer solution and numerous example design problems have been solved. The optimum configuration is found to be strongly dependent on the constraints which are imposed on the design. |
| Conference Presentations: | Vanderplaats, G. N. and Felix, Jorge E,, "Configuration Optimization of Trusses Subject to Strength Displacement and Frequency Constraints," to be presented at the Second International Computer Engineering Conference, San Diego, CA, August 1982. |
| Thesis Directed: | Jorge E. Felix, "Configuration Optimization of Trusses Subject to Strength, Displacement and Frequency Constraints," Master's Thesis, December 1981. |

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|---|---|
| Title: | Development of a Library of Numerical Optimization Programs for Engineering Design |
| Investigator: | Garret N. Vanderplaats, Associate Professor, of Mechanical Engineering |
| Sponsor: | NASA Langley Research Center |
| Objective: | To develop a library of FORTRAN programs for engineering design optimization using state-of-the-art techniques. |
| Summary: | Initial steps have been completed to perform a literature search to identify the most promising optimization algorithms. Work has begun on development of the FORTRAN program structure and over 70 subroutines have been developed which will be incorporated into the program.<br><br>This is a three year project and only the initial phases of the research have been performed at this time. A preliminary version of the program is expected to be completed by October, 1982. |
| Theses Directed: | LeRoy Madson, "Design Optimization using the Augmented Lagrange Multiplier Technique", Master's thesis, March, 1981. |

| | |
|---|---|
| Title: | Optimum Design of Torsional Shafts Using Composite Materials |
| Investigator: | Garret N. Vanderplaats, Associate Professor of Mechanical Engineering |
| Sponsor: | NPS Foundation Research Program |
| Objective: | To develop the analytic capability and FORTRAN program for the analysis of shafts made of multi-layered composite materials and couple this to a numerical optimization program to provide a general automated design capability. |
| Summary: | The analytic capability has been developed to evaluate the response of hollow cylindrical shafts including synchronous whirl caused by mass imbalance. Failure modes which are evaluated include static and fatigue strength, maximum deflection, column buckling, axial and torsional cylinder buckling and critical speed. The constituitive equations have been formulated and programmed for shafts made of multi-layered fiber composites and metal-composite combinations. Shafts have been designed for strength, deflection, dynamic and buckling limits. This has been programmed in FORTRAN and coupled to the optimization program COPES/CONMIN. The capability has been demonstrated with the design of isotropic and composite shafts. |
| Theses Directed: | Virgilio S. Merced, "Drive Shaft Design Using Numerical Optimization," Master's Thesis, June, 1980.<br><br>Amhet Onal, "Design of Composite Driveshafts Using Numerical Optimization," Master's Thesis, December, 1981. |

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