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A SUMMARY OF THE NAVAL POSTGRADUATE SCHOOL RESEARCH PROGRAM. (U)
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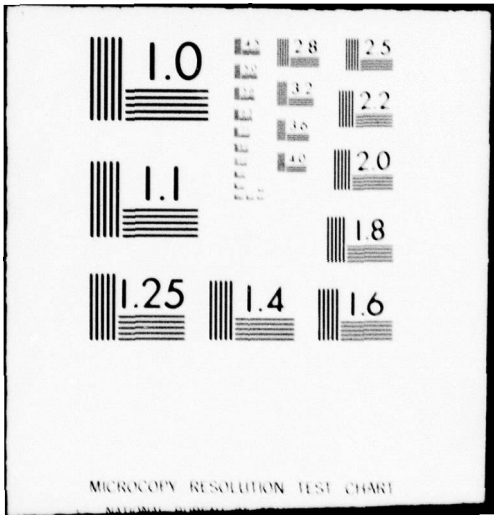
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MICROCOPY RESOLUTION TEST CHART

Lewis, P. A. W., and Shedler, G. S., "Simulation of Non-Homogeneous Poisson Processes by Thinning", Technical Report, NPS-55-77-15, August 1977.

Jacobs, P. A. and Lewis, P. A. W., "Discrete Time Series Generated by Mixtures II. Asymptotic Properties", to appear in J. Roy. Stat. Soc. B, June 1978.

Title: Optimal Carrier Landing Patterns

Investigator: K. T. Marshall, Professor of Operations Research

Sponsor: None.

Objective: When an aircraft fails to arrest or is "waived off" on an approach to a carrier, it is said to bolter, and enter a bolter queue at 1200' to await a second landing attempt. Aircraft who have not yet attempted to land are stocked in a holding pattern at higher altitudes. Since fuel consumption increases significantly at low altitudes, bolter holes are often left in the approach landing pattern to allow aircraft which bolter a further landing attempt without waiting for the entire squadron to be recovered. The optimal spacing of these bolter holes as a function of the probability of a successful landing needs to be determined, and could lead to significant savings in fuel.

Summary: Work is underway on this project. Simulation was used by a thesis student, whose results are to appear. Progress has been made on an analytic solution, and these results should appear early in 1978.

Publications: None.

Title: Manpower Planning and Budgeting Models

Investigator: K. T. Marshall, Professor of Operations Research

Sponsor: Headquarters Marine Corps, via Navy Personnel Research and Development Center

Objective: This project was a continuation of earlier work in both enlisted and officer planning models. An earlier enlisted endstrength forecasting model was to be modified with the implementation of more interactive features. These features would allow the user to determine the effects of changing attrition on both the total endstrength and on the racial and educational mix of the enlisted force. Enhancements were also planned for an interactive model which calculates the Officer Manpower Plan.

Summary: The enhancements were made as planned and are in current use by the staff in HQMC. In addition, research was carried out to find more efficient ways to compute results with 2-dimensional state spaces. Such models occur frequently in manpower planning. Efficient inversion techniques were found for special-structured matrices. These techniques are well suited for use in interactive APL programs.

Conference Presentations: K. T. Marshall, "Efficient Computation and Long Range Optimization Applications Using a Two-Characteristic Markov-Type Manpower Flow Model", presented at the NATO Conference on Manpower Planning, Stresa, July 1977.

Publications: K. T. Marshall, W. J. Hayne, "Two-Characteristic Markov-Type Manpower Flow Models", Naval Research Logistics Quarterly 24 (June 1977), 235-255.

K. T. Marshall, "Efficient Computation and Long Range Optimization Applications Using a Two-Characteristic Markov-Type Manpower Flow Model", Technical Report, NPS55-77-23, March, 1977.

K. T. Marshall, "Forecasting the Number and Types of Enlisted Personnel in the United States Marine Corps: An Interactive Cohort Model", Technical Report, NPS55-77-24, May, 1977.

K. T. Marshall, "An Interactive Model to Compute the Officer Manpower Plan for the United States Marine Corps", Technical Report, NPS55-77-37, August 1977.

Thesis Directed: B. T. Babin, R. Patrow, "Determination of Student Quotas for the Marine Corps Special Education Program", Master's Thesis, March 1977.

Title: Navy Enlisted Personnel Modelling Project

Investigator: P. R. Milch, Associate Professor of Operations Research

Sponsor: Bureau of Naval Personnel

Objective: To develop parametric distributions for the length of service (LOS) distribution of advancees in the Navy Enlisted Force.

Summary: A previously developed regression model was used as a starting point to build an analytic model for estimating the LOS distribution of advancements to a pay grade of a rating of the Enlisted Navy. This distribution is linked through fifteen parameters to the net inventory distribution in the pay grade below (resource population for advancees) and the total "volume" of advancements to be made to the pay grade in question.

Publications: P. R. Milch, "Estimation of Parametric Length of Service Distributions of Advancees of the Navy Enlisted Force", Technical Report, NPS 55Mh76121, December 1976.

P. R. Milch, "Models for the Estimation of Parametric Length of Service Distributions of Advancees of the Navy Enlisted Force", Submitted to Naval Research Logistics Quarterly on June 2, 1977.

Title: Balancing, Manpower Requirements and Personnel Resources

Investigator: P. R. Milch, Associate Professor of Operations Research

Sponsor: Naval Personnel Research and Development Center, San Diego, CA

Objective: To validate procedures currently used by BUPERS' personnel planning mode, FAST, to estimate various gain and loss variables for all ratings in the Enlisted Navy. To compare estimating procedures of the FAST model and the previously developed parametric model for the length of service (LOS) distribution of advancement to each of the six upper pay grades of every rating of the Navy Enlisted Force.

Summary: Three measures of error were developed and evaluated for six gain and loss variables to evaluate the accuracy of currently used estimating procedures by FAST. The parametric LOS distribution model for estimating advancement in the Enlisted Navy was extended to all ratings. This method was then compared, in terms of three error measures, to the currently used FAST method. The results were sufficiently encouraging to proceed with plans for implementation, i.e., incorporation of the new method in the FAST model.

Publications: None.

Title: East-European Event/Interaction as Seen Through the New York Times

Investigator: P. R. Milch, Associate Professor of Operations Research

Sponsor: None

Objective: To provide a summary of Event/Interaction data about the six Warsaw Pact Allies of the Soviet Union available through the WEIS Project.

Summary: Tabularized and graphical summaries have been developed by APL manipulation of the data regarding event/interactions involving the six Warsaw Pact Allies of the Soviet Union either as "Actor" or as "Target" countries during the 1967-1977 period. These summaries show how these six countries have changed their relationships with each other and the rest of the world during above period. The results are strongly biased because they are based on New York Times reports only.

Publications: None.

Title: Skill Deterioration and Its Management

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

Sponsor: Program Planning Office, Department of the Navy

Objective: Analyze requirements for enlisted skill retraining for personnel returning to skill areas following period of nonutilization. Recommendations as to a feasible research and study program to develop the knowledge and methods necessary to manage the skill deterioration problem.

Summary: The project indicated that skill deterioration among Navy personnel due to nonutilization of learned skills is a serious problem with no easy solution. Recommendations were made for a short-range program utilizing expert opinion to determine skill levels and retraining requirement. In addition, a long-range approach to the question was suggested which would result in a valid skill assessment and retraining requirement program. This latter effort would require time to implement and relies on data accumulated from the first phase for development.

Publications: D. E. Neil, "Skill Deterioration and Its Management," Technical Report, NPS-55Ni77-061, June 1977

Title: Conference on Occupational Safety and Health Analyses

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

Sponsor: Office of Naval Research

Objective: Project designed to examine the questions of identification, evaluation, analysis and prediction through convening of a conference on the general subject of occupational safety and health.

Summary: As a result of conflict with elements within NAVSEA actual convening of the conference could not proceed as originally scheduled. However, meetings have been held with various agencies involved with occupational safety and health within the Navy and several contractors currently examining the problem. The conference has been delayed but will be held at a later date.

Publications: None.

Title: Model Development and Analysis in Support of the Army Combat Vehicle Technology Program

Investigator: Sam H. Parry, Associate Professor of Operations Research

Sponsor: U.S. Army Armor and Engineer Board

Objective: To coordinate the utilization of combat models in support of the ACVT Program and to develop simplified models for parametric analysis of combat vehicles. In addition, the investigator is assisting in the design and execution of the HIMAG Program and in the analysis of apparent target motion parameters from experimental data. This is a continuing project.

Summary: Several models have been developed and utilized in the assessment of the contribution of mobility and agility to battlefield survivability. Results to date indicate a payoff for increased agility, but at thresholds of apparent motion below that which was originally anticipated. In addition, a significant quantification of crew variability has been made, and specific recommendations for improving crew performance suggested. Milestone dates and tasks for the development and employment of force-on-force models in support of the ACVT Program have been established. Additional experiments to be conducted in 1978 and 1979 will be analyzed and the results synthesized with those currently available.

Conference Presentations: S. Parry, "A Quantification of Mobility and Agility", presented at the Fifteenth Army Operations Research Symposium, Fort Lee, VA, 26-29 October 1976.

S. Parry, "The Effect of Target Vehicle Agility on Tank Gunners", presented at the Fifteenth Army Operations Research Symposium, Fort Lee, Va, 26-29 October 1976.

S. Parry, "The Effect of Target Vehicle Agility on Tank Gunners", presented at the Sixteenth Army Operations Research Symposium, Ft. Lee, VA, October, 1977.

S. Parry, "The Generation and Use of Parameterized Terrain in Land Combat Simulation", 1977 Winter Simulation Conference, National Bureau of Standards, Gaithersburg, MD, December, 1977.

Publications: S. Parry, "S-Tank Agility/Survivability Test", seven of eight chapters and the entire portion of hit avoidance-St. Vith (5 Chapters).

S. Parry, "Contributions of Agility to Survivability", to appear in J. of Defense Research, March 1978.

Thesis Directed: W. W. Cannon and J. J. Sweeney, "Error Budget Analysis of Automatic Cannons on Armored Combat Vehicles", Master's Thesis, September, 1977.

Kelleher, A. P., "Simulation of the Tactical Employment of Field Artillery", Master's Thesis, December 1977.

Kelley, J. R., "Simulation and Analysis of Ammunition Transport Capability in Support of a Combat Unit", Master's Thesis, March, 1978.

Title: Experimental Design and Analyses for ACCAT

Investigator: G. K. Poock, Professor of Operations Research

Sponsor: Naval Oceans Systems Command

Objective: To provide experimental designs and analyses for experiments run in the ACCAT laboratory. This lab is a testbed to evaluate new concepts in software and hardware for their use in fleet command and control activities.

Summary: Experiments were designed and provided NOSC on time per their requirement. Current activities are directed to design of experiments for FY78.

Publications: G. K. Poock, D. R. Barr, and F. R. Richards, "Experimental Designs and Analyses for Initial ACCAT Testbed Experimental Demonstrations", Technical Report, NPS55-77-21, 1977.

Title: Study of Student Opinion Form Data

Investigator: R. R. Read, Professor of Operations Research

Sponsor: Provost, Naval Postgraduate School

Objective: To explore the SOF data looking for important sources of variability.

Summary: The SOF profiles of the various academic departments are distinct. The most important discriminating variables are the overall rating of the instructor and the instructor's knowledge of his subject. The overall rating (No. 12) summarizes much but not all, of the information on the form. The variability of this component is highly dependent upon the course itself and the group of students. The quality of the data needs to be improved.

Publications: None.

Title: Sampling Methods for the Analysis of Large Contracts Prior to Negotiation

Investigator: R. R. Read, Professor of Operations Research

Sponsor: Strategic Systems Project Office

Objective: To determine the usefulness of statistical sampling for compressing the time frame of sole source contract negotiation.

Summary: The records of selected previously negotiated large contracts were reviewed to study the efficacy of sampling. Generally they lacked sufficient detail to support a quantitative study. It was recommended that future large contracts be flow-charted (i.e., a decision tree formed) in terms of the structure of the tasks to be performed and that the relevant associated information be computerized. This alone would help compress the negotiation time and pave the way for additional gains using sampling.

Publications: None.

Title: Balancing Manpower Requirements and Personnel Resources

Investigator: R. R. Read, Professor of Operations Research

Sponsor: Navy Personnel Research and Development Center, San Diego

Objective: To determine the usefulness of regression methods in the forecasting of manpower changes.

Summary: Eleven years data are available broken out by pay grade and length of service; and also according to the categories of eligible, separations, re-enlistments, and total inventory. The regression methods are competitive with the currently used non-parametric time series smoothing. These are indications that a deeper study might show them to be superior.

Publications: R. R. Read, "Study of the Prediction of Manpower Change Behavior Using Regression Methods," Technical Report NPS55-77-26, June 1977.

Title: Efficiency of Estimators

Investigator: R. R. Read, Professor of Operations Research

Sponsor: None

Objective: Examine the asymptotic efficiencies of point estimators other than maximum likelihood when maximum likelihood is too hard to achieve.

Summary: The asymptotic covariance matrices have been related to the information matrix when some of the likelihood equations have been replaced. Efficiencies have been computed in several cases including the important Gamma and Negative Binomial cases. Some useful alternatives have been found.

Publications: R. R. Read, "Characterization of the Asymptotic Covariance Matrix of Some Altered Maximum Likelihood Estimators," Bulletin, Inst. Math. Stat., June 1977.

R. R. Read, "Methodology for Efficiency and Alteration of the Likelihood System," Technical Report, NPS55-77-9, March 1977.

R. R. Read, "Asymptotic Efficiency and Some Quasi Method of Moments Estimators," Technical Report, NPS55-77-7, March 1977.

Title: Principal End-Item Equipment Management

Investigator: F. R. Richards, Associate Professor of
Operations Research

Sponsor: Naval Electronics Systems Command

Objective: The purpose of this study is to analyze the data for 2Z cog items and to estimate the workload for each of the 2Z inventory managers. A second objective is to analyze the procedures for transferring control of principal end-item equipment from NAVELEX to the Supply System.

Summary: Data was obtained and computer programs were written to extract the required information concerning the activity of each 2Z cog item. The items were stratified by inventory manager and a workload measure of effectiveness was determined for each inventory manager. Historical data has been studied and existing procedures for controlling the migration of items have been studied. Decision rules and milestones are being identified.

Publications: None.

Title: Computer Assisted Target Positional Analysis for P3 Aircraft

Investigator: Rex H. Shudde, Associate Professor of Operations Research

Sponsor: Commander, Third Fleet

Objective: The objective is to optimize new and existing algorithms for in-flight use of fleet tactical ASW aircraft. Major areas include acoustic and nonacoustic search, target classification, and sensor data processing.

Summary: Seven Hewlett-Packard HP-67/97 programmable calculator programs for in-flight processing of acoustic sensor data were designed and written. The titles of these programs that are in the Fleet Mission Program Library unit are listed as follows:

1. HYFIX - Hyperbolic Fixing with Three Sonobuoys
2. HYLOP - Hyperbolic Lines-of-Position with Two Sonobuoys
3. DIFAR - Bearings Only Tracking with Least Squares
4. DIACTIVE - Least Squares Tracking with Time, Bearing and Range
5. Bearing, Speed, and Course given Range and Doppler Data from Two Sonobuoys
6. Speed and Course Given Range-Only Data from Two Sonobuoys at Two or More Times

Publications: R. H. Shudde, "Tactical Analysis on the Personal Programmable Calculator - Six Algorithms", Technical Report, NPS55-71-31, July 1977.

R. H. Shudde, "On-Station Update of Oceanographic Information with Programs for the HP-67 Calculator", Technical Report, NPS55-77-41, June 1977.

Title: Computer Assisted Target Positional Analysis
for P3 Aircraft

Investigator: Rex H. Shudde, Associate Professor of
Operations Research

Sponsor: Department of the Navy and COMPATWINGSPAC

Objective: This program is a continuation of the program
sponsored by Commander, Third Fleet.

Summary: An analysis of the Lloyd's Mirror Phenomena
under constant negative sound velocity condi-
tions has been performed. A Hewlett-Packard
HP-67 programmable calculator program has
been written using results of this research;
this program has been submitted to the Fleet
Mission Program Library.

Publications: R. H. Shudde, "Lloyd Mirror Phenomenon Under
Constant Velocity Gradient Conditions," Te-
chnical Report, NPS55-77-36, May 1977.

Title: FBM Effectiveness Studies

Investigator: R. H. Shudde, Associate Professor of Operations Research

Sponsor: Department of the Navy

Objective: The technical objective of this work is to develop models for use in FBM effectiveness studies.

Summary: An analysis has been completed on a phase of FBM operations.

Publications: R. H. Shudde, "A Distribution Model of Re-Entry Bodies from a Single MIRV System", Technical Report, NPS55-77-14, March, 1977.

Title: Tactical ASW Programs for the Handheld Calculator

Investigator: R. H. Shudde, Associate Professor of Operations Research

Sponsor: None.

Objective: Development of tactical ASW programs for the handheld calculator.

Summary: A tactical algorithm for bearings-only tracking from two moving sensor platforms has been developed and a program for the Hewlett-Packard HP-67 Calculator has been written.

Publications: R. H. Shudde, "Estimation of a Contacts' Course, Speed and Position Based on Bearings-Only Information from Two Moving Sensors with a Program for an HP-67/97 Calculator", Technical Report, NPS55-77-43, November 1977.

Title: Maintenance System Development Program
(MDSP) Review

Investigator: Michael G. Sovereign, Associate Profes-
sor of Operations Research

Sponsor: Naval Sea Systems Command

Objective: Provide independent operations research
review of the progress of the Maintenance
System Development Program, a large study
relating to surface ship maintenance.

Summary: This project consists of monitoring weekly
contractor reports, attending quarterly re-
views and writing evaluations of the con-
tractors' output. Several faculty members
participate along with the principal inves-
tigator.

Publications: None.

Title: Munitions Planning

Investigators: M. G. Sovereign, Associate Professor of Operations Research, J. K. Hartman, Associate Professor of Operations Research

Sponsor: Naval Weapons Center

Objective: Objective of this research is to develop concepts for the determination of the optimal mix of air-to-ground munitions to be developed and procured by the Navy.

Summary: The approach is to first explore problem formulation in the broadest sense including training, maintenance and other life cycle cost elements, as well as effectiveness and computational frameworks have been reviewed and a conceptual model stated. Formulation of an optimization model has been completed.

Publications: None.

Title: Conceptual Analysis Project

Investigators: Michael G. Sovereign, Associate Professor
of Operations Research
Douglas Neil, Assistant Professor of
Operations Research
James Arima, Associate Professor of
Administrative Sciences

Sponsor: Office of the Chief of Naval Operations,
Systems Analysis Division (OP-96).

Objective: Objective of this program is to utilize NPS
faculty in the development and evaluation of concepts
of analysis of Navy problems.

Summary: The approach of this program is to coordinate
faculty research with current problems faced
by OP-96. Naval Postgraduate School faculty are
assigned as the independent review agent in CNO
study plans. This year the efforts have included
a study requested by OP-96 on the problem of skill
determination when Navy personnel leave their
occupations and a review of a major ASW force
mix analysis.

Publications: M. G. Sovereign, "Report on the Center for Naval
Analysis Force Mix Study," Volume I, II, III and
IV.

J. K. Arima and D. E. Neil, "Skill Delineation
and its Management," Technical Report, NPS-54Aa-
77111A, November 1977.

Title: Lanchester-Type Models of Warfare (Monograph)

Investigator: J. G. Taylor, Associate Professor of Operations Research

Sponsor: Foundation Research Program (6.1)

Objective: To continue writing a monograph on Lanchester-type (i.e. differential-equation) models of warfare. The monograph will be a state-of-the-art summary as well as an introduction to analytical models of combat attrition and will attempt to integrate and synthesize widely scattered results and modelling ideas.

Summary: The writing of the monograph was continued, with the outline of the book undergoing major revision. Substantial portions of the first three chapters were written, and the the first chapter on background and introduction (i.e. the general nature of combat models) was revised. The initial portions of the book have been largely tutorial in nature, and consequently numerous examples have been given to illustrate many points about various basic Lanchester-type models. Additionally, some previously pending related research (to ultimately be incorporated into the monograph) was completed, and also an invited address entitled "State-of-the-Art Summary of Lanchester Theory" was delivered at the 15th Army Operations Research Symposium.

Conference Presentations: J. G. Taylor, "Concentration of Forces in Some Lanchester-Type Combat Models," presented at the Western Section of ORSA 1976 Meeting, Los Angeles, CA, 16-17 September 1976.

J. G. Taylor, "State-of-the-Art Summary (Lanchester Theory)," presented at the Annual U.S. Army Operations Research Symposium, Fort Lee, VA, 27-29 October 1976. (invited by program committee).

J. G. Taylor and G. G. Brown, "Further Canonical Methods in the Solution of Variable-Coefficient Lanchester-Type Equations of Modern Warfare: A New Definition of Power Lanchester Functions", presented by J. G. Taylor at the Miami Joint ORSA/TIMS National Meeting, Miami Beach, FL, 3-5 November 1976. Abstract in ORSA Bulletin.

Publications:

J. G. Taylor and G. Comstock, "Force-Annihilation Conditions for Variable-Coefficient Lanchester-Type Equations of Modern Warfare", Naval Research Logistics Quarterly 24, 349-371 (1977).

J. G. Taylor, "Predicting Battle Outcome with Liouville's Normal Form for Lanchester-Type Equations of Modern Warfare", Opsearch 14, 185-203 (1977).

J. G. Taylor, "Optimal Commitment of Forces in Some Lanchester-Type Combat Models", Technical Report, NPS55-77-2, January 1977.

J. G. Taylor and G. G. Brown, "Numerical Determination of the Parity-Condition Parameter for Lanchester-Type Equations of Modern Warfare", Technical report, NPS55-77-10, March 1977.

J. G. Taylor, "Error Bounds for the Liouville-Green Approximation to Initial-Value Problems", Technical report, NPS55-77-29, June 1977.

Theses Directed:

Herbert H. Mauerer (Captain, West German Army), "Design Considerations for Lanchester-Type Models of Warfare (LATMW)", Master's Thesis September 1976.

Title: Lanchester-Type Models of Warfare (Monograph)

Investigator: James D. Taylor, Associate Professor of Operations Research

Sponsor: Office of Naval Research

Objective: To write a monograph on Lanchester-type (i.e., differential-equation) models of warfare. The monograph will be a state-of-the-art summary as well as an introduction to analytical models of combat attrition and will attempt to integrate and synthesize widely scattered results and modelling ideas.

Summary: Some background research was done, and writing of the monograph was initiated. During this report period, the entire monograph was planned: a general outline and then a more detailed one were developed. Writing of the monograph itself was then initiated and about 390 typewritten pages were written. These pages constitute substantial portions of the first six chapters of the monograph (out of nine now planned), with the first three chapters being completely done. The initial portions of the book have been largely tutorial in nature, and consequently numerous examples (i.e. evaluations and graphical plots of analytical solutions to particular Lanchester-type models) have been given to illustrate modeling points. Existing results were extended in several places. The material completed is as follows:

- Chapter 1: Background and Introduction
- Chapter 2: Lanchester's Classic Combat Formulations
- Appendix A: Background for the Mathematics of Lanchester's Classic Combat Formulations
- Chapter 3: Some Simple Models of Battle Termination
- Appendix B: The Probability that One Random is Less than Another

Future plans are to revise completed portions of the manuscript and try to complete the monograph during the next FY.

Thesis Directed: Felix G. Banix, "Modeling of the Non-Integral FEBA," Master's Thesis, June 1977.

Title: The Packaging Numbers Problem with Application to Missile Submarine Systems

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

Sponsor: Department of the Navy

Objective: To develop methodology for combining probability of package survival and packaging costs as functions of the number of items in a package so that appropriate package sizes can be selected on a rational basis. Special consideration should be given to military applications and, in particular, to the number of missiles (the packaged items) to be carried by a submarine (the package).

Summary: The total cost of a system which provides an acceptable specified probability for survival of a given number of packaged items is proposed as an appropriate measure for comparing package sizes. Military applications differ from most of the other packaging applications in that packaging costs can be substantially greater than the cost of the items packaged.

Publications: None.

Title: Investigation of Gross Measures of Effectiveness for Naval Ships

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

Sponsor: Naval Service Weapons Center

Objective: This research was in response to a request from the technical director of NSWC for a study showing in gross terms how the firepower of ships and/or navies has been changing over time, with emphasis on the United States.

Summary: The firepower of any weapon system was defined to be the equivalent rate of delivering 8" rounds to a target, as a function of range to the target. With this scale, aircraft carriers can be measured on the same scale as destroyers, and the firepower of a fleet is just the sum of the firepowers of its elements.

Publications: None.

Title: Sonobuoy Management

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

Sponsor: Commander, Third Fleet

Objective: In joint exercises such as the RIMPAC series conducted by COMTHIRDFLT, the same 31 sonobuoy radio frequency channels must suffice for carrier and land based patrol aircraft, carrier and destroyer based helicopters, and submarines. There is the possibility that multiple sonobuoys on the same channel will interfere with each other. The objective was to allocate channels so as to minimize interference.

Summary: After examining reports of past exercises, talking to the various communities involved, and doing some probability modeling, a "loose" frequency management plan was recommended.

Publications: None.

Title: Convexity in an Inventory Model

Investigator: P. W. Zehna, Professor of Operations Research

Sponsor: Foundation Research Program (6.2)

Objective: The Hadley-Whitin Q-r models in inventory theory have been widely used by practitioners for some time now in spite of questions regarding their validity. The purpose of this research was to extend the author's investigations in these matters to hopefully characterize the proper solutions.

Summary: Beginning with some recently completed research in the backorders case, the author was able to successfully complete the research and give a full characterization of the solutions. Continuing with the lost sale case, one that had not been previously studied, the investigator was able to show that, while the situation was not as bad in this case, a similar anomaly existed and again, it was possible to completely characterize the solution in this new case also.

Publications: P. W. Zehna, "Solutions in Hadley-Whitin Q-r Models" submitted to the Naval Logistics Quarterly.

Lenna, Peter W., "Solutions in Hadley-Whitin Q-r Models", Naval Postgraduate School Technical Report NPS 55-78-4, January, 1978.

DEPARTMENT OF NATIONAL SECURITY AFFAIRS

NATIONAL SECURITY

The Research Program of the National Security Affairs Department is diverse and spans a wide range of work on various aspects of International Politics, military strategy and National Security as well as detailed quantitative analysis of Soviet Naval exercises and tank/anti-tank warfare in the October War. Notable recent published work includes a monograph on Soviet decision processes leading up to the 1968 intervention in Czechoslovakia, a review article on the relationship between Eurocommunism and the Eastern European Communist Parties, an analysis of the Soviet and Cuban intervention in Angola, development of a machine retrievable data base for Soviet Naval exercises, development of a methodology, now widely used in the intelligence community, for technological threat forecasting, development of methods to analyze the impact of arms transfers to the Third World, management of a worldwide arms transfer data base for the JCS, and management of the WEIS data base. All of this work is directly related to the unique advanced course offerings in the Department.

Title: Canadian Armed Forces Unification: The Effects After Ten Years

Investigator: D. P. Burke, Assistant Professor of National Security Affairs

Sponsor: Foundation Research Program (6.1)

Objective: To update, through research in Canada, a previous study by the principal investigator on the unification of the Canadian Armed Forces.

Summary: Ten years have passed since the abolition of the Canadian Army, Navy and Air Force and the creation of a single service in their place. Most of the dire effects on morale and efficiency which were predicted by opponents of the step have not occurred. Severe budgetary stringency (which was relieved somewhat by unification) has had a much more serious effect, and preference in promotion and assignment given to French Canadians is of much more immediate concern, at least to English speakers. However, the expectations of the authors of unification have also been partly disappointed. With the 1976 creation of Air Command, institutions which parallel each of the old services now exist in the new, and the terms "army", "navy" and "air force" are again in daily use. Significant savings in overhead have been made, but flexibility in personnel policy is seriously hampered by the persistence of regimental and corps organization in the new Service. There is no serious sentiment in the Forces or the Government for a return to a three-service organization.

Publication: None

Title: The Soviet Merchant Marine

Investigator: Donald C. Daniel, Assistant Professor of
National Security Affairs

Sponsor: Soviet Armed Forces Review Annual

Objective: Review of major Soviet Merchant Marine de-
velopments of mid-1970s.

Summary: Same as objective.

Publications: Soviet Armed Forces Review Annual, Vol. II.

Title: Beyond the Rise of the Soviet Navy: The
VMF of the Mid-to-Late Seventies

Investigator: Donald C. Daniel, Assistant Professor of
National Security Affairs

Sponsor: Soviet Armed Forces Review Annual

Objective: Analysis of the development of the Soviet
Navy in the mid-to-late 1970s.

Summary: Analysis of the present makeup, mission
structure and factors conditioning the fu-
ture development of the Soviet Navy.

Publications: Soviet Armed Forces Review Annual, Vol. II.

Title: Defense Nationale Perceptions of the US-Soviet Military Balances

Investigator: Donald C. Daniel, Assistant Professor of National Security Affairs

Sponsor: Defense Advanced Research Project Agency

Objectives: (1) To ascertain trends and patterns in perceptions of the US-Soviet military balances from 1955 through 1974 as these are contained in a highly authoritative French journal.

(2) To ascertain in addition trends and patterns in stated reasons for views as to perceptions, in sources relied upon for information about the balances, and in policy recommendations made in view of the balances as perceived.

Summary: Trends and patterns relative to the areas outlined under "Objectives" were obtained for ten balance areas over the twenty year period and, on a comparative basis, for the last two 5-year periods.

Publications: D. C. Daniel, "Defense Nationale: Perceptions of the US-Soviet Military Balance", Technical Report, NPS-56D176111, 1976.

Title: Comparative Analysis of Major Soviet Fleet Exercises

Investigator: Donald C. Daniel, Assistant Professor of National Security Affairs

Sponsor: Naval Intelligence Command

Objective: Conduct analytic investigations of Soviet Naval Exercise Activity with emphasis on trends displayed in major exercises during the past decade.

Summary: During FY 77, the research has taken three major directions:

(a) At the request of CO NF010 an investigation was made of developing a systematic data base of Soviet Naval Exercise activity from archival intelligence sources. The result was that the resources required for the development of a reliable and replicable historical data base from these sources was incommensurate with the potential benefits of such a data base.

(b) At the request of CO NF010 an investigation was made of the problems of occurrence and indications of major Soviet exercises. As of the end of FY 77, this investigation was 75% complete.

(c) A detailed review of reports of major Soviet Naval Exercises in the Norwegian Sea area since 1970 is being conducted in order to determine trends as to participants, areas of operations, and mission performance features. As of the end of FY 77, 50% of this effort (primarily data-gathering) was completed.

Publications: D. C. Daniel, "Trends and Patterns in Major Soviet Naval Exercises", Naval War College Review (Spring 1978). Also to be published in Paul Murphy, ed., Naval Power and Soviet Policy (Washington: Government Printing Office, 1978) forthcoming. Vol II in Studies in Communist Affairs Series.

D. C. Daniel, "Developing a Machine-Retrieveable Data Base of Soviet Naval Exercises from Archival Data", Technical Report, NPS-56DL76081, August 1976.

- Title:** Perceptions of the Superpower Military Balances: Considerations and Evidence
- Investigator:** Donald C. Daniel, Assistant Professor of National Security Affairs
- Sponsor:** Chief of Naval Research
- Objectives:**
- (1) Specifying the major analytical and policy considerations associated with research in this field.
 - (2) Offering empirically-based conclusions as to the comparative ranking of the superpowers in perceived strength, the factors which condition those views, and the policy consequences flowing from them in the minds of perceivers.
- Summary:** This brought together a number of papers fulfilling the above objectives. Three papers dealt with the first objective and five (each a separate case study) dealt with the second objective. The major findings of the case studies were brought together in a concluding paper.
- Publications:** D. C. Daniel (ed.), "International Perceptions of the Superpower Military Balances: Considerations and Evidence" (New York: Praeger, Accepted for publication).
- D. C. Daniel, "Perceptions of the Superpower Military Balance: Considerations and Evidence" Technical Report, NPS 56-78-001, January 1978.

Title: The Radford Memoirs

Investigator: Stephen Jurika, Jr., Assistant Professor of National Security Affairs

Sponsor: The Hoover Institution on War

Objective: A biography of Admiral Arthur W. Radford, exponent of naval aviation, brilliant analyst of inter-service conflicts, thoughtful strategist, advocate of national interests, and Chairman, JCS, for four years under President Eisenhower. His observations of Truman, Eisenhower, Dulles, world leaders and his notes on his participation in unification, post-war forces and the cold war are a major contribution to history.

Summary: I have chosen material, photographs, checked accuracy of all names, dates and places; edited text and prepared glossary, index and forward.

Publications: The Radford Memoirs, The Hoover Institution on War, Revolution and Peace, Accepted for Publication.

Title: The Use of Data Analysis in National Security Policymaking

Investigator: Edward J. Laurance, Assistance Professor of National Security Affairs

Sponsor: Office of the Joint Chief of Staff

Objective: To explore methods of improving policymaking concerning the transfer of conventional arms.

Summary: The substantive focus of this research was conventional arms transfers. The first product of the research was extensive progress toward the construction of a DoD data base which can give a timely picture of conventional arms being transferred internationally by the U.S., its allies and the Soviet Union. Second, a long range estimate of the impact of international conventional arms transfers on U.S. defense policy was submitted. Third, an impact statement was written regarding the U.S. transfer of side-winder missiles to Saudi Arabia. Fourth, a technique for assessing military capability applicable to arms transfer decision making was developed termed the multiple-attribute utility technique; it was used in a thorough analysis of world-wide sea denial capability (missile boats and diesel submarines).

Conference Presentations: E. J. Laurance, "The International Transfer of Conventional Arms: Problems of Measurement and Conceptualization", paper presented to the Midwest Political Science Association, April 1977.

Publications: E. J. Laurance, Ronald Sherwin, "Understanding Arms Transfers Through Data Analysis", In Kemp, R'anan and Pfaltzgraff (Eds.), Arms Transfers to the Third World, (Denver Westview Press).

Title: The Use of Expert Opinion in Congressional Roll Call Analysis

Investigator: E. J. Laurance, Assistant Professor of National Security Affairs

Sponsor: Foundation Research Program (6.1)

Objective: To experiment with quantified judgment techniques in assessing Congressional behavior.

Summary: One of the methods commonly used to assess Congressional behavior regarding defense policy is the construction of scales based on roll call votes on defense issues. Typically, these are constructed using Guttman scaling or factor analysis, both of which assume that all votes in the scale are of equal importance. This research involved experimenting with several types of weighting techniques which relied on the judgments of experts knowledgeable of the defense issues involved. Techniques such as paired comparison and constant sum were used to construct weighted scales and compared with scales constructed in a purely statistical manner.

Publications: None

Title: The CENTO Alliance: Status and Prospects

Investigator: R. H. Magnus, Assistant Professor of National Security Affairs

Sponsor: Foundation Research Program (6.1)

Objective: To determine the current status of the alliance among its member and associated states. What should be the policy of the United States towards it?

Summary: Although there are differences in the perceptions of the member and associated states, there still remains a common core of agreement on the utility of the alliance centered around a shared antagonism towards Soviet activities in the area. Regional members would, in general, like to see the alliance take a more active role in regional issues. The United States has consistently resisted these pressures. In view of the increasing importance of the resources of the Persian Gulf for the United States, it is recommended that the alliance should be, at least, maintained and, quite possibly, strengthened.

Publications: None

Title: The Military Balance in Southern Africa

Investigator: B. Schutz, Assistant Professor of National Security Affairs

Sponsor: Office of Net Assessment, Department of Defense

Objective: Analyze the dynamics of the politico-military balance in Southern Africa including the states of South Africa, Botswana, Namibia, Rhodesia, Zimbabwe, Angola, Mozambique, and Zambia.

Summary: The capacity of both the internal and external factors in the area will be measured in terms of arms transfers, personnel build-up and strategic/economic linkages. Strategic and ideological coalitions will be assessed through the use of coalition theory, game theory, and other models which might be useful in comprehending the dynamics of conflict and change in the area.

Publications: None.

Title: Data Analysis in National Security Policy Making

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

Sponsor: Office of Joint Chief of Staff and Defense Advance Research Project Agency

Objective: Develop computerized decision aids for making security assistance policy.

Summary: For the past two years Professors Laurance and Sherwin have refined some analytical concepts for assessing the multifaceted technical and political impact of conventional arms transfers to third world countries. Currently, the concepts are being transformed to data-based decision aids intended for operational use. Also, under DARPA sponsorship, the project has been responsible for collecting and disseminating international political interaction data throughout the academic and policy communities. These data are being used in conjunction with attempts to develop reliable indicators to warn of developing crises and threats in the international political arena.

Publications: None.

Title: A General Methodology for Forecasting the Technological Threat from a Soviet Navy

Investigators: Russel H. S. Stolfi, Associate Professor of National Security Affairs, Peter C. C. Wang, Associate Professor of Mathematics

Sponsor: Naval Intelligence Support Center

Objective: To develop a general, reproducible methodology for forecasting future generations of Soviet weapon systems.

Summary: The principal investigators have developed a reproducible general structural model of the Soviet weapons acquisition process which has given effective forecasts of future Soviet weapon systems in numerous cases.

Publications: R. H. S. Stolfi, P. C. Wang, "An Analyst's Guide to Technological Threat Forecasting", (U), (NISC, Suitland, Md, 1977) 346 pp. (This publication is classified SECRET.)

Title: The USSR, Eastern Europe and Eurocommunism

Investigator: J. Valenta, Assistant Professor of National Security Affairs

Sponsor: Foundation Research Program (6.1)

Objective: To write a paper on Soviet and East European perceptions of and responses to Eurocommunism in Western Europe.

Summary: The research of this paper was conducted and concluded. The paper drew extensively on Soviet and European sources. After the paper was completed an invited address entitled "Eurocommunism in Eastern Europe" was delivered at the 1977 Annual Convention of the American Association for the Advancement of Slavic Studies, Washington, DC.

Publications: J. Valenta, "The Impact of Eurocommunism on Eastern Europe," Problems of Communism, March-April 1978 (forthcoming).

J. Valenta, "The USSR and Eurocommunism," The USSR and Eastern Europe, T. Rakowska and A. Gyorgy (eds.) (Indiana University Press, forthcoming, 1979.)

Title: The Soviet Intervention in Czechoslovakia, 1968

Investigator: J. Valenta, Assistant Professor of National Security Affairs

Sponsor: Foundation Research Program (6.1)

Objective: To finish writing a revised manuscript on the Soviet intervention in Czechoslovakia in 1968. The manuscript will be a comprehensive study analyzing the Soviet management of the Czechoslovak crisis of 1968. It will also be a test of the bureaucratic politics paradigm as a methodological tool to be used in explaining Soviet foreign policy behavior.

Summary: The first chapter on the bureaucratic politics model was revised and substantial portions of the following three chapters were rewritten. The monograph was completed and sent to the publisher. Also, an invited address entitled "Bureaucratic Politics and Soviet Foreign Policy" was delivered at the Annual Convention of the American Association for the Advancement of Slavic Studies, Washington, DC, October, 1977.

Publications: J. Valenta, Anatomy of a Decision: Soviet Intervention in Czechoslovakia, 1968, manuscript in which Johns Hopkins University Press has expressed great interest and is now considering for publication.

J. Valenta, "Soviet Intervention in Czechoslovakia," in Ivan Volgyes (ed.), Czechoslovak Political Tradition (Festschrift for Professor J. Korbelt), Columbia University Press, forthcoming, 1978.

Title: The Soviet-Cuban Intervention in Angola

Investigator: J. Valenta, Assistant Professor of National Security Affairs

Sponsor: Foundation Research Program (6.1)

Objective: To continue writing a monograph on the Soviet and Cuban intervention in Angola in 1975. The monograph will be an analytical research summary of the external and internal factors which influenced the Soviet-Cuban management of the Angolan crisis of 1975. It will likewise be a useful introduction to further research testing the formation of a probable pattern for the prediction of future Soviet and Cuban military involvement in Africa.

Summary: The writing of the monograph, which draws extensively on Soviet, Cuban and African sources, has been compiled and substantial portions of the manuscript will be published. Furthermore, some previously pending related research was completed.

Publications: J. Valenta, "The Soviet-Cuban Intervention, 1975," in David Albright (ed.) The Great Powers in Africa (Westview Press, forthcoming, 1978).

J. Valenta, "The Angolan Intervention, 1975," Studies in Comparative Communism, forthcoming, winter 1979 (The editor-in-chief of the journal requested the paper which is now being considered for publication.)

DEPARTMENT OF PHYSICS AND CHEMISTRY

The research program in the Department of Physics and Chemistry has continued along several main lines: (1) Underwater Acoustics, (2) Atmospheric Optics, (3) Laser and Plasma Physics, (4) Atomic Physics, (5) Nuclear Physics, (6) Weapons Effects, (7) Solid State and Surface Physics, (8) Geophysical Phenomena, and (9) Weapon System Analysis.

UNDERWATER ACOUSTICS

Influence of ocean surface fluctuations on the propagation of sound is the general theme of studies conducted by H. Medwin. In particular, interfrequency correlation of specularly scattered underwater sound and relative contributions of diffraction, facet reflections and interference to the backscatter from randomly rough ocean surfaces have been investigated together with J. Novarini. Recently spectral source levels of marine mammals are studied by H. Medwin.

Underwater acoustic range studies for the Naval Torpedo Station have continued involving O. B. Wilson, A. Coppens, H. Dahl, and J. V. Sanders. Properties of acoustic absorbers for torpedo test facility and low frequency acoustic reverberation in DeBob Bay are studied by O. B. Wilson and Sanders; H. Dahl has developed an improved ray tracing algorithm for underwater acoustic ranges. Effects of fluid loading on flexural waves in thick plates are studied by O. B. Wilson. Acoustic variability and air sea exchange is studied by J. V. Sanders together with members of the Oceanography Department. J. V. Sanders and A. Coppens recently engaged in theoretical and experimental studies of transmission of sound from a water layer of decreasing depth into the underlying fast bottom.

ATMOSPHERIC OPTICS

This activity still remains one of the strongest in the department and is done in cooperation with the Meteorology Department: Study of the optical propagation in the marine boundary layer as a function of turbulence and aerosols/fog at militarily important atmospheric window wavelengths, by E. C. Crittenden, A. W. Cooper, E. Milne, W. Rodeback, S. H. Kalmbach, and R. Armstead. Recently emphasis has been on the development of a portable compact measurement system for on-site measuring modulation transfer functions in connection with optical experiments at other locations.

Scaling laws for vertical distributions of marine aerosols, relation of small scale turbulence and aerosol properties in the marine boundary layer to stability and wave conditions, influence of ocean surface near atmospheric turbulence on radar and radio wave propagation, turbulent transfers and ele-

vated layers in marine fog and at sea studies of air pollution in the marine boundary layer are pursued by G. Schacher and C. Fairall in cooperation with members of the Meteorology and Mechanical Engineering Departments.

LASER AND PLASMA PHYSICS

In the Laser and Plasma Laboratory the dynamics of plasma production by impact of pulsed laser radiation on solid targets is investigated by F. Schwirzke and A. Cooper, using neodymium glass and carbon dioxide lasers. Generation of spontaneous magnetic field, emission of x-rays and momentum transfer to the target are studied in detail. Laser development is carried out in conjunction with this program. A DF laser and iodine laser have recently been developed and put into operation by A. Cooper and F. Schwirzke. F. Schwirzke also engaged in a study on Plasma Surface Interaction in connection with impurity studies in TOKOMAK Systems funded by ERDA. Anti-Stokes Raman Scattering (CARS) as an analytical probe is under study by W. Tolles. A compilation of mostly classified data on effects of high energy laser irradiation of materials was completed by J. R. Neighbours. Atmospheric Scattering of UV-light is studied by Tolles.

ATOMIC PHYSICS

Our spectroscopic data center's compilation of vacuum ultra-violet spectral lines is continuing, emphasizing at present rocket borne stellar spectroscopy, R. L. Kelly.

NUCLEAR PHYSICS

F. R. Buskirk, J. N. Dyer and R. Pitthan are continuing their investigations of giant multipole resonances in various nuclei by inelastic electron scattering at the LINAC.

WEAPONS EFFECTS

Study of the thermodynamics of internal explosions is continued by G. E. Kinney, R. A. Reinhardt, and K. Graham.

SOLID STATE AND SURFACE INTERACTION PHYSICS

Investigation by means of computer simulation of ion-surface interactions is carried out by D. E. Harrison, Jr.

GEOPHYSICAL PHENOMENA

A new activity in the department is the study of geomagnetic phenomena with emphasis on the analysis of geomagnetic noise above and in the ocean. This effort is carried out in cooperation with the VLF Laboratory at Stanford University.

WEAPON SYSTEM ANALYSIS

In this category a number of efforts are summarized which are cross disciplinary and not actually physics or chemistry activities. D. E. Harrison has conducted simulations of tactical situations of various kinds, and investigated Soviet ASW strategies. W. Reese and P. Cunningham are engaged in a net assessment study of Soviet ASW exercises.

- Title:** Investigation of Nuclei Giant Multipole Resonances by Inelastic Electron Scattering
- Investigators:** F. R. Buskirk, Professor of Physics, J. N. Dyer, Professor of Physics, R. Pitthan, Adjunct Professor of Physics
- Sponsor:** Foundation Research Program (6.1) and National Science Foundation Grant
- Objective:** The inelastic electron scattering experiments with ^{58}Ni , ^{60}Ni and ^{238}U were undertaken with excitation energies up to 40 MeV. The present measurements combined with earlier work on ^{208}Pb , ^{197}Au , ^{165}Ho and ^{89}Y form part of a survey of the systematics of the giant resonances in medium and heavy nuclei.
- Summary:** The Nickel experiments (^{58}Ni and ^{60}Ni) were performed at 102 MeV and scattering angles of 45, 60, 75 and 90 degrees. One striking result concerns the giant dipole resonance, which in (γ, n) experiments is much smaller for ^{58}Ni compared to ^{60}Ni . Our experiments, which measure the total E1 strength, not just the (γ, n) channel, show precisely the opposite results, namely that ^{58}Ni has the larger E1 strength. If (e, e') and (γ, n) results are to be reconciled, either the (γ, p) experiments are wrong or some other channel, possibly (γ, D) must be present and large in ^{58}Ni , but small in ^{60}Ni .
- The Uranium experiments 87.5 MeV at angles of 45, 60, 75 and 90 degrees were undertaken to extend our survey to an extremely heavy nucleus, which is not only deformed, as is ^{165}Ho , but fissionable. The established resonances were seen including the split dipole resonance. Unexpected results for both the isoscalar and isovector quadrupole modes were the small strengths corresponding to about half the sum rule in both cases. Also these states were not as broad as one would expect for a deformed nucleus.
- The resonance highest in energy, at 28.4 MeV or $176 A^{-1/3}$ MeV, fits an E3 angular distribution and corresponds to 90% of the sum

rule. Possibly this state corresponds to the ones seen in ^{197}Au , ^{208}Pb and ^{165}Ho , which were not identified at the time. If these are the same state, it may be noted that the energy expressed in $A^{-1/3}$ units shifts from $175 A^{-1/3}$ for the deformed fissionable to $195 A^{-1/3}$ MeV for spherical nuclei.

Publications:

R. Pitthan, R. R. Buskirk, E. B. Daley, J. O. Shannon and W. H. Smith, "Giant Resonances and Bound Collective States Observed in the Scattering of 92.5 MeV electrons from the Closed-Neutron-Shell Nucleus ^{89}Y Between Excitation Energies from 2.0 to 55 MeV", Physical Review C16, 970 (1977)

R. Pitthan and F. R. Buskirk, "Isospin of the Fine Structure Between 8 and 12 MeV in ^{208}Pb and its Implication for the Multipole Assignment of the 8.9 MeV Resonance", Physical Review C16, 983 (1977).

R. Pitthan, J. S. Beachy, F. R. Buskirk and S. J. Kowalick, "Resonant Octupole Strength at 13 MeV in ^{58}Ni and ^{60}Ni and the Character of the $53 A^{-1/3}$ State in Heavy Nuclei", (Submitted).

J. S. Beachy, S. J. Kowalick, F. R. Buskirk and R. Pitthan, "Difference in E1 Strength of ^{58}Ni (T=1) and ^{60}Ni (T=2) at Deuteron Threshold", (submitted).

W. A. Houk, R. W. Moore, F. R. Buskirk and R. Pitthan, "Evidence for an Isovector Octupole Resonance at 28.4 MeV and Other Giant Resonances in ^{238}U ", (submitted)

Title: Laser Produced Plasmas

Investigators: A. W. Cooper, Professor Physics
F. Schwirzke, Associate Professor of Physics

Sponsor: Foundation Research Program (6.1)

Objective: In the continuing project, the interaction is investigated between intense laser pulses and targets. The dynamics of the laser produced plasma and self-generated magnetic fields are studied.

Summary: Experimental evidence has been found that magnetic fields are generated in the steepened front of a fast moving plasma plume which is interacting with a background plasma. A laser produced plasma expands in z-direction normal to the target surface with a velocity of about 10^7 cm/sec. If the laser produced plasma flows into a photo-ionized background plasma of sufficient density, shock heating at the front will produce a temperature gradient in z-direction. Magnetic fields in azimuthal direction are then generated long after laser shutoff by the cross product of the radial density gradient and the electron temperature gradient in z-direction. The location of the peak magnetic field coincides with the steepest gradient in the shock front. Very basically, spontaneous magnetic fields should be generated whenever a shock is produced by a plasma streamer.

Conference Presentations: F. Schwirzke, "Spontaneous Magnetic Fields in Laser-Impact Craters", presented at the Eighteenth Annual Meeting of the Division of Plasma, American Physical Society, 15-19 November 1976, San Francisco, CA. (abstract published in Bulletin American Physical Society 21, 1029 (1976), paper co-authored with A. W. Cooper).

F. Schwirzke, "Spontaneous Magnetic Field Generation in Shock Waves", presented at the Nineteenth Annual Meeting of the Division of Plasma Physics of the American Physical Society, 7-11 November 1977, Atlanta Georgia (Abstract published in Bulletin of the American Physical Society, 22 1160 (1977), co-authored with A. W. Cooper.

- Title:** Transmission of Sound From a Water Layer of Decreasing Depth into the Underlying Fast Bottom
- Investigators:** A. B. Coppens, Associate Professor of Physics and Chemistry, J. V. Sanders, Associate Professor of Physics and Chemistry
- Sponsor:** Naval Ocean Systems Center
- Objective:** To determine the acoustical properties of the highly-collimated beam of sound which is transmitted into a bottom whose speed of sound exceeds that of the overlying water layer when the depth of the water layer decreases below that necessary to maintain normal mode propagation in the water layer. Specifically, this deals with the detection of low frequency sound transmitted up the continental shelf and then into the bottom when it encounters sufficiently shallow water depths.
- Summary:**
- Theoretical:** A combination of normal mode theory and ray theory has resulted in the description of the pressure distribution at the bottom of the water layer over the region wherein sound is transmitted into the bottom. Using the pressure distribution as a distributed source, a Green's function approach yields an integral expression for the transmitted field in the bottom. This integral is being investigated using the method of stationary phase. Results are being compared with experiment.
- Experimental:** Subsequent to the first set of experiments, a more refined scale model of a fluid layer overlying a fast fluid bottom has been constructed. The inclined interface between the two fluids is a stretched sheet of Mylar, so that the fluids are prevented from mixing or reacting. A wide-frequency capacitive dielectric acoustical source has been constructed for the generation of tone bursts with negligible rise-and fall-times. The spatial distribution of the transmitted beam in the bottom is being studied for comparison with theoretical predictions.
- Publications:** None.

Thesis Directed: J. Edwards, "A Preliminary Investigations of Acoustical Energy Transmission from a Tapered Fluid Layer into a Fast Bottom". Masters Thesis, December 1976.

Title: Optical Propagation in the Marine Boundary Layer (Optics)

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

Sponsor: Naval Sea Systems Command

Objective: This is a continuing program to develop methods for predicting the optical propagation properties in the marine boundary layer on the basis of the bulk properties of the atmosphere, and to determine the dependence of the optical properties on the micrometeorology in the marine boundary layer.

Summary: Knowledge of the optical properties of the atmosphere over land has been sketchy, and over the ocean has been almost non-existent. Such knowledge is vital for the design, and prediction of performance in the marine environment, of a wide range of military applications of electro-optics—specifically for target detection, ranging, pointing, tracking, homing, imaging and communications. The major properties of interest are the "seeing" or resolution through the atmosphere, as it is degraded by turbulence and aerosols, the "scintillation" or intensity fluctuations and the angle-of-arrival fluctuations (image wander) of a transmitted beam, and the extinction or loss of energy from a beam, by absorption and scattering of radiation by fog and aerosol particles. The "seeing" is characterized by the Modulation Transfer Function (MTF) and the closely related Mutual Coherence Function (MCF) which also determines the signal-to-noise ratio in a coherent detection receiver. Image wander and its frequency spectrum are also involved in determination of seeing. The scintillation is characterized by Optical Turbulence Structure constant C_n . Measurement of scintillation over a horizontal path yields a value of C_n

averaged over the path; point values of C_n^2 can be obtained by meteorological methods. Techniques have been developed for measuring these parameters under open-ocean conditions with both shore-to-shore and ship-to-ship paths, using the Naval Postgraduate School (NPS) research vessel, ACANIA, for ranges up to 20 km. Optical measurements of scintillation, image wander, MTF and extinction are made simultaneously with meteorological measurements.

Measurements have been made under a variety of conditions with lasers at wavelengths of .488 μm (blue), .6329 μm (red), 1.06 μm (near IR), and 10.6 μm (far IR). Broad band detection with black body sources has been carried out in the middle IR range from 3-5 μm and in the far IR from 8-14 μm . On-line data reduction is in operation for the determination of C_n from scintillation.

MTF is determined by Fourier analysis of the line spread image function obtained with a telescope. The data is recorded for later processing by computer, and a on-line mini-computer yields direct MTF results in the field. A portable compact system has been completed for measuring MTF on-site in connection with optical experiments at other locations.

Extinction, the loss of light from a beam as a result of aerosol scattering, has been measured over the same optical paths as for MTF and C_n , in order to incorporate the effects of scattering into the predictions of MTF. Measurements of fog/aerosol parameters are simultaneously made on shipboard during the optical measurements, in a companion research project headed by Professor Schacher. The micrometeorology is simultaneously measured in another companion research project headed by Professor Davidson in the Department of Meteorology. Comparisons of experimental values of C_n measured by long-path scintillation and from point thermal fluctuations at the receiver and at the mid point of the path, with the values deduced theoretically from long term and short term MTF have been made. It has been shown that the C_n measured by scintillations, which emphasizes the mid-point of the path, is not adequate to predict image resolution in in-homogeneous turbulence

conditions, which are normally experienced. The MTF measurement, however, automatically provides the correct weighting for prediction of both the resolution and beam spot size. Software has been developed for the portable MTF system to provide immediate online prediction of resolution and laser spot size over the same propagation patch.

Conference
Presentations:

A. W. Cooper, E. C. Crittenden, Jr., E. A. Milne, G. W. Rodeback, S. H. Kalmbach, "Long Path Optical Measurements of Turbulence in the Marine Boundary Layer", presented at the Navy Workshop on Remote Sensing in the Marine Boundary Layer, Vail Colorado, 9-11 August, 1976.

E. C. Crittenden, Jr., A. W. Cooper, E. A. Milne, G. W. Rodeback, S. H. Kalmbach, R. L. Armstead, "Optical Propagation through Turbulence in the Marine Boundary Layer", Naval Postgraduate School, Monterey. D. Land and B. Katz, Naval Surface Weapon Center, White Oak, Maryland. Presented at DDR&E Conference on Optical and Submillimeter Wave Propagation, Colorado Springs, 6-9 December 1976. Full manuscript in Conference Proceedings.

E. C. Crittenden, Jr., A. W. Cooper, E. A. Milne, G. W. Rodeback, S. H. Kalmbach, R. L. Armstead, "Measured Atmospheric MTF over the Ocean for Visible to Far Infrared", presented at Optical Society of American, Topical Conference on Optical Propagation through Turbulence, Rain and Fog; Boulder, Colorado, 9-11 August, 1977.

E. C. Crittenden, Jr., A. W. Cooper, E. A. Milne, G. W. Rodeback, S. H. Kalmbach, R. L. Armstead, "Image Resolution (OTF) through Atmospheric Turbulence over the Ocean", presented at the 21st International Technical Symposium of the Society of Photo-Optical Instrumentation Engineers, San Diego, 22-25 August, 1977

E. C. Crittenden, Jr., A. W. Cooper, E. A. Milne, G. W. Rodeback, S. H. Kalmbach, R. L. Armstead, "Image Resolutions Through Atmospheric Turbulence", SPIE meeting, Fort Walton Beach, 13-14 March 1978. Paper No. 5, Vol. 134, SPIE Proceedings.

E. C. Crittenden, Jr., A. W. Cooper, E. A. Milne, G. W. Rodeback, S. H. Kalmbach, R. L. Armstead, "Effects of Turbulence Imaging Through the Atmosphere", SPIE meeting, Washington, D.C., 30-31 March 1978. Paper No. 19, Vol. 142, SPIE Proceedings.

Title: Development of Improved Ray-Tracing Algorithms for Underwater Acoustic Ranges

Investigator: H. A. Dahl, Assistant Professor of Physics and Chemistry

Sponsor: Naval Torpedo Station

Objective: The purpose of this work was to produce and test improved computer programs through which the position of a sound source in an underwater range can be determined accurately from the arrival times of a signal at the four hydrophones of a given array.

Summary: The flight times to the four hydrophones and an average sound speed gradient are used to obtain both the direction of arrival at the array center and the effective time of flight on an incoming signal. A ray is then traced back through the refractive medium, beginning with the proper direction and proceeding until the effective time of flight is consumed and the predicted source position is reached.

In the new NPS program the calculation of entry angle and effective flight time use the model of constant-gradient water. The trace-back is achieved with the assumption of constant-gradient layers of water. This contrasts with the NTS approach in which the model assumes constant sound speed or constant speed in layers.

The accuracy of the new program has been tested extensively on a model composed of one, two, or three constant-gradient layers. The gradients chosen were those found in typical sound-speed profiles at Dabob Bay. Specific aspects of the new program have been tested and compared with existing NTS programs as follows:

(a) Errors in position, particularly in the depth coordinate, resulting from entry angle error, effective time of flight error, tilt correction error, and trace-back error are much reduced in the new NPS program.

(b) It is found that receiver timing errors, if not carefully controlled, can dominate the ranging errors to the extent of removing the advantages of the new program.

(c) Running time of the new NPS program is 1.8 times that of the old program when the same number of layers are used in each program. Use of a smaller number of thicker layers, which gives little reduction in accuracy in the new NPS program, could result in a time requirements of only one-half that of the program currently used.

Publications: None.

Title: Computer Simulation of Sputtering by Molecules

Investigator: D. E. Harrison, Jr., Professor of Physics

Sponsor: Foundation Research Program (6.1)

Objective: To examine the containment and interaction of collision cascades when the sputtering of a copper crystal by a diatomic ion is simulated in the computer.

Summary: Most of the time was devoted to the development of a new generation of the computer program which has been the basis of this line of research. The computer results have now been interpreted to indicate that the interaction of collision cascades is much more prevalent and important than previously assumed. The research will continue.

Publications: None

Title: Magnetic Noise in and near The Ocean

Investigator: O. Heinz, Professor of Physics

Sponsor: Foundation Research Program (6.1)

Objective: The objective is to obtain improved long term data on the magnetic noise on the ocean floor, within the ocean and immediately above the surface. By using a combination of total field magnetometers and VLF receivers it is planned to cover the frequency range from mHz to KHz.

Summary: Using a Cs vapor optically pumped magnetometer, we are currently measuring the spectrum of the geomagnetic field fluctuations in two frequency bands: 0.1 Hz to 25 Hz and 1 Hz to 256 Hz. This work is being done at our field site at La Mesa Village in Monterey. At the same time measurements were initiated from the Research Vessel Acania using a self contained VLF Receiver and tape recorder which was lowered into Monterey Bay. Measurements were taken at 50 foot intervals (during descent and ascent) and the instrument package was placed on the ocean floor at a depth of 300 feet for about 15 minutes. Since both of these measurements are still in their initial phases no results are available at this time.

Publications: None.

Title: Spectroscopic Data Center: Compilation of Short Ultraviolet (XUV) Spectra

Investigator: R. L. Kelly, Professor of Physics

Sponsor: Foundation Research Program (6.1), and National Aeronautics and Space Administration

Objective: It is planned to maintain, on a continuing long-term basis, a complete and critical compilation of atomic and ionic spectrum lines with wavelengths below 2000 Angstroms, for the first 36 elements.

Summary: The published literature is searched and relevant publications obtained. The observed spectrum lines are compared on a line-by-line basis, with those predicted from the known atomic energy levels (a complete file of energy levels is maintained). Those lines satisfying established criteria are retained in the files. The published intensities are normalized, and multiplet numbers are added. Approximately 70,000 lines are presently stored in the files.

Publications: None

Title: Spectroscopic Data Center: Compilation of Long Ultraviolet Spectra

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

Sponsor: National Aeronautics and Space Administration

Objective: It is planned to prepare a complete and accurate compilation of atomic and ionic spectrum lines with wavelengths between 2000 and 3500 Angstroms, for the first 36 elements. This has been a continuing project.

Summary: The published literature has been thoroughly searched and all relevant publications obtained. Observed spectrum lines have been entered into a file and the wavelengths sorted and compared to remove redundancy and internal inconsistency. The reported intensities have been normalized. Approximately 30,000 lines are presently stored in the files.

Publications: None.

Title: Thermochemical Calculations Related to Internal Blast

Investigators: G. F. Kinney, Distinguished Professor Emeritus of Physics and Chemistry, R. A. Reinhardt, Professor of Physics and Chemistry, K. J. Graham, Chemist of Physics and Chemistry

Sponsor: Naval Weapons Center

Objective: Calculations on the hydrostatic pressure generated as a result of combustion (or detonation) in a confined air volume. Materials considered include organic (CHNO) fuels and explosives, and these fuels with reactive metals, such as magnesium and aluminum, as additives. Both non-vented adiabatic explosions, and the effects of venting and heat transfer are considered. This is a continuation of research begun in 1974.

Summary: During the past three years, Professor Kinney and Mr. Graham have developed a program for use on the Wang 720C desktop computer to solve the equations relating the thermochemistry and thermodynamic equilibria for the twelve products obtained in the combustion of a CHNO fuel (or explosive). Calculations were performed on a number of such materials over a wide range of fuel-to-air ratios. These have been assembled into comprehensive tables and graphs that describe internal explosions with both conventional and explosive fuels.

A necessary part of this project has been the assembly of thermochemical data on CHNO compounds from diverse sources in the literature, recomputing them for consistent conditions and into modern (i.e., SI) units. This compilation will continue.

Since joining the project in January 1977, Professor Reinhardt, in a similar way, has carried out pressure calculations on the magnesium-air system over a range of compositions. Comparison with the results from CHNO compounds show maximum temperatures as much as 1000 K higher in the metal-air system, but maximum pressures of the same

order of magnitude (ca ten bars). Some rough calculations have also been done on the more complex aluminum-air system; qualitatively similar results are to be seen.

Publications:

G. F. Kinney, R. G. S. Sewell, K. J. Graham, "Internal Blast from Fuel-Air Explosions", Transactions of the Eighth Naval Weapons Center Warhead Research and Development Symposium, October 1976, NWC TP 5920, Part I, pp 329-35, Naval Weapons Center, China Lake, California.

G. F. Kinney, K. J. Graham, Naval Weapons Center Technical Report dealing with the CHNO compounds (In preparation).

R. A. Reinhardt, "Reactive Metals in Internal Explosions, The Combustion of Magnesium in Air.", Feb. 1978, NWC TM 3429.

Title: Ocean Parameters Affecting Sound Propagation

Investigator: H. Medwin, Professor of Physics

Sponsor: Office of Naval Research

Objective: To characterize the statistical relations between ocean wave spectra, underwater turbulence, temperature microstructure, bubble populations, bottom roughness and the propagation of acoustic energy.

Summary: Computerized equipment has now been used to obtain data on sound speed dispersion, attenuation and inferred micro-bubbles in the turbulent upper ocean. The experiment is continuing in search of the interrelations between physical and biological ocean parameters, and sound propagation under various ocean conditions.

Publications: H. Medwin, "In Situ Acoustic Measurements of Micro-Bubbles at Sea", Journal of Geophysical Research, Vol. 82, No. 6, February, 1977.

H. Medwin, "Counting Bubbles Acoustically; A Review", ULTRASONICS, January 1977, Vol. 15, No. 1, pp 7-13.

H. Medwin, "Acoustical Determinations of Bubble Size Spectra", Journal of the Acoustical Society of America, Vol. 62, No. 4, October 1977, pp 1041-1044.

C. S. Clay, H. Medwin, "Acoustical Oceanography: Principles and Applications", Wiley-Interscience, New York City, New York, 544 Pages.

J. D. Novarini, H. Medwin, "Impulse Response, Spectral Characteristics and Acoustical Shadowing in Rough-Surface Backscattering", Accepted for publication in the Journal of the Acoustical Society of America.

U. S. Patent No. 4,017,859, issued 12 April 1977 for "Multi-Path Signal Enhancement Apparatus", processed by the Office of Naval Research; assigned to the U.S. Navy by inventor, Herman Medwin.

Title: Relative Contributions of Diffraction, Facet Reflections and Interference to the Field Backscattered by a Randomly Rough Surface

Investigator: H. Medwin, Professor of Physics

Sponsor: Office of Naval Research

Objective: To understand and to be able to predict the near grazing back scatter from an ocean surface, and in particular, to determine shadowing effects near grazing.

Summary: Near grazing acoustical shadowing has been studied in terms of the results of a computer model study of boundary diffracted waves in order to clarify the contributions due to diffraction as well as facet reflection from long-crested surfaces having a Neumann-Pierson spectrum. The technique shows the importance of wave height and facet reflections with interference near normal incidence contrasted with wave slope and diffractions away from normal. Results have been obtained for backscattering strength as a function of frequency and angle of incidence for wind speeds of 5, 10, and 20 m/s. These results provide a baseline for true surface scatter, enabling the additive effects of bubbles to be separately considered.

Publications: None.

Title: Interfrequency Correlation of Specularly Scattered Underwater Sound

Investigator: H. Medwin, Professor of Physics

Sponsor: Office of Naval Research

Objective: To determine whether frequency switching can be used to enhance the strength of surface scattered sound during fading.

Summary: The wind-driven surface of a large anechoic tank was used to study the interfrequency correlation between the amplitude fluctuations of 32 specularly scattered harmonic frequencies from 5 to 160 Khz. The temporal variations of the scattered pressure show maxima and minima that depend on the sound frequency. The interfrequency correlation of the pressure amplitude fluctuations calculated over several "ocean" periods exhibits peaks and troughs. A maximum anti-correlation occurs for the frequency ratio 2:1, and significant enhancement can be gained by switching from a lower frequency at roughness approximately unity during the fades to the octave above.

Publications: None.

Patent Application: Patent for Signal Defader filed by the Office of Naval Research (Case 62,580).

Title: Single Hydrophone Technique for Obtaining Spectral Source Levels of Marine Mammals in Coastal Waters

Investigator: H. Medwin, Professor of Physics

Sponsor: Office of Naval Research

Objective: To find a simple way to record transient sounds in coastal waters avoiding the effects of surface and bottom reverberation.

Summary: Using the theory of rough surface scattering, the knowledge of the bottom impedance, and correlation techniques, it has been shown that it is possible to decompose the shallow water reverberation into the contributions from different paths. From this, the range, the depth and the spectral source levels of the sounds of the mammal can be determined by use of only one hydrophone rather than the conventional three or four. The theory has been developed and tested in a laboratory model using an up-chirp amplitude and frequency modulated sound.

Publications: None.

Patent Application: Patent for Acoustical Deverberator filed by Office of Naval Research (Case No. 62,582).

Title: Elastic Waves in Crystals

Investigator: J. R. Neighbours, Professor of Physics

Sponsor: Foundation Research Program (6.1)

Objective: The objectives of this research are two-fold. First, to formulate a vector relation similar to the Poynting vector in electromagnetism for describing the flow of elastic energy in an anisotropic crystal. Second, to investigate the reflection of an elastic wave at the boundary between two anisotropic media.

Summary: Elasticity is a fourth rank tensor, a relation between two second order tensors. However, as a result of various symmetries, the elastic constants are describable by a symmetric 6 x 6 array rather than by 81 components. Thus they can be represented as a matrix and transformed accordingly.

Propagation of elastic waves is similar to optical birefringence except that elastic waves can also have longitudinal polarization and might properly be called a case of trirefringence.

Progress on this project has been to carefully formulate the matrix transformation in coordinates rotated with respect to the primary stress reference axes, and to find the solutions to the eigenvalue problem in the rotated coordinates. A computer program in BASIC has been written for this purpose. From the eigenvalues, both wave velocity and wave slowness (similar to an index of refraction surface) surfaces have been constructed. So far these calculations have been confined to cubic, hexagonal and orthorhombic crystals. Many real crystals have been investigated and the special pure mode directions have been tabulated.

A related problem is the sensitivity of the elastic constants to inversion. The elastic

constants are the coefficients when the stresses are expressed as linear functions of the strains. An alternative formulation is of the strains in terms of the stresses. The product of the two matrices is the unit matrix, and different types of experiments measure components of one or the other of the matrices. In order to compare different types of measurements, it is desirable to know how the elements of one matrix vary with respect to variation of a single element of the other. A program has been written for this purpose and many real crystals have been investigated.

This project is now being actively carried out on an extracurricular basis.

Publications: None

Title: Technical Evaluation of ASMP/AAW Methodology

Investigator: W. Reese, Professor of Physics

Sponsor: Naval Intelligence Support Center

Objective: Provide analysis support of Naval Intelligence Support Center, Code OOW13, threat support functions.

Summary: During the reporting period support has been provided through a critical review of the forthcoming AAW integrated threat publication and through support of the Survivability Assessment Program. Program review meetings have been attended and memoranda have been prepared responding to specific questions.

Publications: None.

Title: Comparitive Analysis of Major Soviet Fleet Exercises

Investigator: W. Reese, Professor of Physics

Sponsor: Naval Intelligence Command

Objective: Conduct analytic investigations of Soviet Naval Exercise Activity with emphasis on trends displayed in major exercises during the past decade.

Summary: During FY 77 the research has taken three major directions: (a) At the request of CO NF010 an investigation was made of developing a systematic data base of Soviet Naval Exercise activity from archival intelligence sources. The results were that the resources required for the development of a reliable and replicable historical data base from these sources were incommensurate with the potential benefits of such a data base. (b) At the request of CO NF010 an investigation was made of the problems of OCCURRENCE AND INDICATIONS OF MAJOR Soviet exercises. As of the end of FY 77, this investigation was 75% complete. (c) A detailed review of reports of major Soviet Naval Exercises in the Norwegian Sea area since 1970 is being conducted in order to determine trends as to participants, areas of operations, and mission performance features. As of the end of FY 77, 50% of this effort (primarily data-gathering) was completed.

Publications: None.

Title: Homogeneous Catalysis by Palladium Complexes

Investigator: R. A. Reinhardt, Professor of Chemistry

Sponsor: Foundation Research Program (6.1)

Objective: Determination of rate laws for the oxidation of the olefin trans-2-butene by several palladium (II) complexes. This research was initiated in late 1975 and continued to the end of calendar year 1976.

Summary: The experiments were conducted by use of gas chromatography to analyze for both reactant olefin and product ketone. Early results using PdCl_4^{2-} as oxidant, gave results in accord with published data on the system obtained by a totally different technique. Preliminary results on the PdBr_4^{2-} - olefin system, though showing internal inconsistencies, showed promise of ultimately yielding reliable results and these formed the basis of a paper presented before the Northwest Regional Meeting of the American Chemical Society in Reno, Nevada, June 1976.

Continued studies, however, were unable to improve the discrepancies. In particular, the analyses for reactant and product could not be reconciled with material balance in the system. In addition, data of a given run would show wide scatter, and, in many cases, replicate runs gave differences in computed rate parameters far outside any tolerable error.

It can be surmised that the difficulties are inherent in the experimental method, which is thus inappropriate for the system. A real possibility is loss through vaporization of the extremely volatile substrate olefin at varying rates during the course of a run. It is not proposed to continue the investigation.

Publications: None.

Title: Acoustic Absorbers

Investigators: J. V. Sanders, Associate Professor of Physics, O. B. Wilson, Professor of Physics

Sponsor: Naval Torpedo Station

Objective: To provide consulting services on the area of acoustic absorbers for use in a proposed torpedo testing facility.

Summary: In response to an informal request from NTS, a small scale effort was devoted to a literature survey of the present status of underwater sound absorbers. We provided a Report Bibliography and commented on various approaches to the problem. We also reviewed a contractor's report on absorber design analysis.

Publications: None.

Title: Frequency Response of Cold Wires Used for Atmospheric Turbulence Measurements in the Marine Environment

Investigators: G. A. Schacher, Associate Professor of Physics
G. W. Fairall, Assistant Professor of Physics

Sponsor: Foundation Research Program (6.1)

Objective: The purpose of this project is to determine the effect of sea salt deposition on the frequency response of platinum wires used for measuring thermal turbulence. These wires are operated at ambient temperature, are very small ($\sim 2 \mu$ diameter), and their small time constant allows them to follow temperature changes as rapid as several kilohertz. When they are operated in the marine environment spray and aerosols deposit sea salt on the wires. This salt can form a film which could alter the wires' frequency response.

Summary: We have developed methods for coating the wires and measuring their frequency response in controlled conditions in the laboratory. The salt is deposited by spraying a fine mist of salty water over the wires and allowing the droplets to evaporate on the wires. This is accomplished in a large chamber 4ft high by 1½ft diameter. The salted wire is tested in an airstream which contains a "white" spectrum of temperature fluctuations, and its response is determined with a spectrum analyzer.

Development of the system to create the white temperature spectrum has been completed and the salted temperature wires have been tested. the results show that the frequency response of the wires can be significantly affected as low as 10 Hz, but only with amounts of salt that are far in excess (about 100 x) of that normally encountered in experiments at sea. The experimental portion of the work has been completed and comparison with theory is underway.

Publications: None

Title: Environmental Survey: SSBN Security Program

Investigator: G. Schacher, Associate Professor of Physics

Sponsor: Oceanographer of the Navy

Objective: The objective of this research is to obtain near surface profile and turbulence descriptions in open ocean regions for the purpose of defining radar and radio wave propagation conditions during times associated with other experiments (classified or unknown).

Summary: A multi-level profile (wind, temperature and humidity) and turbulence (wind and temperature) systems and an acoustic sounder have been installed on a USN Oceanographic Ship (USNS Kane) for a month long observational experiment to be performed in the Mid-Atlantic during February 1978. The parameter of interest is the index of refraction, N , for radar and radio frequencies and its vertical gradient within the first 20 meters above the surface. N will be estimated on the basis of its computation from coincident temperature and humidity measurements. Estimates of the evaporative duct thickness will be made from computed N gradients and stability, i.e., Richardson numbers. Elevated critical N gradient will be discerned from acoustic sounder records. Preliminary and final reporting procedures and hence, analysis, will be carried out in such a way to provide timely information to parallel experiments being managed by NAVOCEANO.

Publications: None.

Title: At Sea Studies of Air Pollution in the Marine Boundary Layer in the Los Angeles Air Basin

Investigator: G. Schacher, Associate Professor of Physics

Sponsor: California Air Resources Board

Objective: To initiate shipboard studies of air pollution along the California coast. These studies are to characterize the marine boundary layer by shipboard measurements, and these measurements are to be done in coordination with air pollution monitoring. Initial measurements are to be made in the Los Angeles air basin.

Summary: The initial cruise has been completed and results obtained for the following objectives: (1) Obtain parameters for ocean boundary of air pollution model for Los Angeles air basin, (2) Characterize the atmosphere for air pollution studies of the Santa Barbara Channel and for various at sea pollution studies. Tracer studies of airflow from a shoreline source have clearly identified the extent of the "sloshing mode" that traps pollutants in the air basin. Future cruises are planned.

Publications: None.

Title: Plasma - Surface - Interaction

Investigator: F. Schwirzke, Associate Professor of Physics

Sponsor: Energy Research and Development Administration, Division of Magnetic Fusion Energy

Objective: To perform an independent review of impurity studies and diagnostics in tokamak systems, make recommendations and submit a comprehensive plan for action.

Summary: Since adequate plasma confinement and heating seems possible, impurity evolution and control are recognized now as being critical remaining obstacles on the way to magnetic fusion energy. Too high impurity concentrations adversely influence almost every aspect of plasma behavior in the toroidal magnetic confinement system tokamak. Usually a large fraction of the ohmic power input is lost from the plasma by impurity radiation. In situ surface analysis of the impurities on the walls just before and during the tokamak discharge is most important for a better understanding of processes related to plasma wall interactions, discharge cleaning, recycling, and impurity transport.

A joining experiment has been performed at the Center for Plasma Physics and Fusion Engineering at the University of California at Los Angeles to investigate the laser induced desorption of impurities from tokamak walls. Flash-heating by a laser pulse has been used to desorb loosely bound species from a spot on the tokamak wall. Spectral analysis of the suddenly increased impurity radiation from the plasma in front of the laser heated spot gives information on the species and the amount of impurity atoms present on the surface at a specific point in time of the tokamak discharge. Loosely bound chromium has been found on the stainless-steel surface.

Publications: F. Schwirzke, "Impurities on Tokamaks", U. S. Energy Research and Development Administration Order Number WA-76-4205, July 9, 1976.

K. Bol, A. Bers, K. Gentle, J. Luxor, J. F. Lyon, F. Schwirzke, "Report of the Ad Hoc Panel for the UCLA Microton Macrotron Proposal," submitted to U.S. Energy Research and Development Administration, July 12, 1976.

Thesis Directed: J. S. Polk, "Laser Induced Desorption of Gas from Stainless-Steel Surfaces", Master's Thesis, June 1977.

Title: X-Ray and Particle Emission From Laser Irradiated Targets

Investigator: F. Schwirzke, Associate Professor of Physics

Sponsor: Air Force Office of Scientific Research

Objective: To investigate the processes which influence the emission of x-rays and fast particles from a laser produced plasma.

Summary: The dynamics of a laser-produced plasma and the dependence of the self-generated magnetic fields in position, time, laser, power density, and ambient background pressure have been systematically investigated. Magnetic fields are generated in a laser produced plasma by nonaligned density and temperature gradients. These magnetic fields may be quite large near the focal spot region and thus can influence the dynamics and heat conduction of the electrons. After successive burst of laser energy on the same spot a crater is formed in a metal target. In this case the lateral escape of plasma to the walls of the crater will be reduced by the existence of strong self-generated magnetic fields which can not diffuse into the conducting walls of the crater during the short time of the laser pulse. Due to limited expansion and heat conduction loss in radial direction the electrons can be heated to higher temperatures, and consequently the x-ray emission from the plasma in the crater can escalate to higher values.

Conference Presentations: F. Schwirzke, "Spontaneous Magnetic Fields in Laser-Impact Craters", by F. Schwirzke, A. W. Cooper, F. T. Williamson, Presented at the Eighteenth Annual Meeting of the Division of Plasma Physics of the American Physical Society, 15-19 November 1976, San Francisco, Ca. Abstract published in Bulletin, American Physical Society, 21, 1976.

F. Schwirzke, "Spontaneous Magnetic Field Generation in Shock Waves", by F. Schwirzke, A. W. Cooper, Presented at the 19th Annual Meeting of the Division of Plasma Physics of the American Physical Society, 7-11 November 1977, Atlanta, Georgia. Abstract published in Bulletin of American Physical Society, Society 22, 1977.

Publications:

F. Schwirzke, L. Oren, S. Talmadge, R. J. Taylor, "Laser-Induced Desorption of Impurities from the Macrotron Tokamak Walls", submitted for publication to Physical Review Letters, to be published May 1, 1978.

Title: Improved Procedure for Obtaining RIKE Spectra: Optical Heterodyning

Investigator: W. M. Tolles, Professor of Chemistry

Sponsor: Office of Naval Research

Objective: To investigate a new procedure (both theoretically and experimentally) for obtaining Coherent Raman Spectra utilizing the Raman Induced Kerr Effect (RIKE). The effects of optical heterodyning for improving signal-to-noise ratios are to be determined.

Summary: The effects of optical heterodyne mixing of the Coherent Raman Signal obtained from RIKE spectra has been observed and modeled. Improved signal-to-noise ratios are observed using these techniques (by as much as an order of magnitude). A comparison of this method with all other currently utilized Coherent Raman Spectroscopic phenomena suggests that this is a preferred method for examining clear condensed media whenever classical laser noise is present on the probe laser.

Conference Presentations: G. L. Eesley, M. D. Levenson, J. J. Song, W. M. Tolles, "Heterodyne Coherent Raman Spectroscopy", presented at the Conference on Laser Engineering and Applications, Washington, D.C., June 2, 1977.

W. M. Tolles, G. L. Eesley, M. D. Levenson, "Heterodyne Detection of Coherent Raman Signals", presented at Society of Photo-Optical and Instrumentation Engineers, San Diego, California, August 24, 1977. To appear in S.P.I.E. publication.

Publications: G. L. Eesley, M. D. Levenson, and W. M. Tolles, "Optically Heterodyned Coherent Raman Spectroscopy", to appear in J. Quantum Electron.

Title: Range Studies Program

Investigators: O. B. Wilson, Jr., Professor of Physics, and D. B. Hoisington, Professor of Electrical Engineering

Sponsor: Naval Torpedo Station

Objective: Study long-term requirements and plans of the Naval Torpedo Station in areas of ship and underwater weapons testing, and, based on the 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 fifteen faculty members from various disciplines and a number of officer-students participated in various task projects. Individual summaries are reported elsewhere in this document. A very brief summary of task activities follows:

Acoustic ray tracing algorithms for calculating range of an underwater sound source have been studied to help determine better compromise between desired accuracy of ranging, detail of environmental data needed and computational effort. Algorithms which incorporate Kalman Filter techniques for range tracking of underwater vehicles have been developed and tested. Development of small acoustic transmitters for range tracking has continued. Effects of fluid loading on flexural waves in plates have been studied experimentally. Experimental studies of low frequency acoustic reverberation in a large bay and its effects on radiated noise measurements have continued. Calculations of effects of terrain and troposphere and effects of electromagnetic interference on radio communications in selected areas with selected systems were continued and experiments were planned. Literature studies of ship deperming and degaussing and of magnetic sensors were completed. Investigation of alternative methods for determining and recording vehicle positions for possible use for at-sea test ranges was continued.

Publications: O. B. Wilson, Jr., "Annual Summary Report of Range Studies Program", Technical Report, NPS-71-78-002PR, December 1977.

Objective: To assess the problem associated with measuring the predicted acoustic noise levels of large, low-frequency pistons of sound, such as a submarine, in a reverberant body of water, such as Babob Bay, Washington.

Summary: The first effort was directed to an extent to which relative sound levels were measured using the reverberation chamber method of Babob Bay. The result is a measure of the relative amount of sound energy that would be a source to a receiver by both the direct wave and by reflected waves. The description of the experimental procedures and the initial data that were recorded in a sound chamber. The analysis of the data is now complete and the final report is being prepared. The analysis indicates that as the level within the chamber, with the source and receiver at 100 foot distance, the effect of reverberant sound on range is that of the direct sound by an additional 100 feet. The reverberant sound is small at ranges of 100 yards, significant at ranges of 200 and 300 yards. The level of reverberant energy is about 100 times that of the direct wave at ranges of about 1000 yards. The conclusion is that if the field was without the desired, a directional receiver array may be used to discriminate between direct and reverberant sound if certain receiver levels are to be guaranteed.

These Direct...
Acoustic Investigation in Babob Bay, I.
Description of Procedures and Data Analysis
O. B. Wilson, Jr., March 1977.

Title: Low-Frequency Acoustic Reverberation in Dabob Bay

Investigators: O. B. Wilson, Professor of Physics and J. V. Sanders, Associate Professor of Physics

Sponsor: Naval Torpedo Station

Objective: To assess the problems associated with measuring the radiated acoustic noise levels of large, low-frequency radiators of sound, such as a submarine, in a reverberant body of water, such as Dabob Bay, Washington.

Summary: The major effort was devoted to an experiment in which explosive sound sources were used to measure the reverberation characteristics of Dabob Bay. The result is a comparison of the relative amounts of sound energy that travels from a source to a receiver by both the direct paths and by reflected paths. The description of the experimental procedures and the initial data analysis were reported in a student thesis. The analysis of the data is now complete and the final report is being prepared. The analysis indicates that at the lower audio frequencies, with the source and receiver at 300 feet depth, the effect of reverberant sound on reception of the direct sound by an omnidirectional receiver is small at ranges of 100 yards, significant at ranges of 250 and 300 yards (the ratio of reverberant energy to direct energy varied from 0 to -6 dB) and overwhelming at ranges of about 1000 yards. The conclusion is that if far field measurements are desired, a directional receiving array must be used to discriminate between direct and reverberant sound if accurate source levels are to be measured.

Publications: None.

Thesis Directed: M. E. Elsen, "Measurement of Low Frequency Acoustic Reverberation in Dabob Bay, I. Description of Procedures and Data Analysis", Master's Thesis, March 1977.

DEPARTMENT OF ELECTRICAL ENGINEERING

The Electrical Engineering research program encompasses a variety of areas, including: (1) Electronic Warfare Systems; (2) Electromagnetics; (3) Acoustics and Electro-Optics; (4) Communications; (5) Toxic Vapor Level Detection/Recording; (6) Estimation and Control Systems; (7) Signal Processing; (8) Range Studies; (9) Solid State Devices; and (10) Wave Propagation. The projects in each of these areas generally involve one or more faculty member working with several thesis students. A summary of the projects follows:

ELECTRONIC WARFARE SYSTEMS

Professor David Hoisington continued a study of phase-front distortion jamming systems for disruption of radar tracking systems. Techniques for phase-front distortion jamming of mono-pulse tracking radar systems are being developed. It is hoped that a feasible hardware implementation of the jammer can be developed.

Professor Jeffrey Knorr and Professor David Hoisington carried out an investigation of the effectiveness of jamming signals on various Navy radars. Professor Jeffrey Knorr continued a study of HF signal intercept probability.

ELECTROMAGNETICS

Dr. Richard Adler served as technical coordinator and editor for an electromagnetic compatibility (EMC) survey which summarizes the existing state of technology and listed the Navy's technical capability in EMC. Recommendations included increased technology transfer from the technologist who develops new analytical processes to the user who must carry out the system design.

Professor Robert Burton continued experimental and analytical work on electromagnetic pulse (EMP) effects on command and control aircraft. He has also demonstrated the feasibility of measuring surface current density distribution on complex scattering objects such as ships and aircraft.

Professors George Sackman and Otto Heinz (Physics/Chemistry) made measurements and analyzed data in a study of magnetic background noise with the objective of improving Navy systems for magnetic detection and degaussing of submarines.

ACOUSTICS AND ELECTRO-OPTICS

Professor John Powers did research on computer-aid acoustical imaging constructing a prototype system to obtain three dimensional ultrasonic images. Preliminary work on performing computer image processing on these acoustic images was also performed. He has also worked on the construction and testing of fiber optic data links emphasizing wide band analog transmission and multichannel multiplexed digital transmission.

COMMUNICATIONS

Professor John Ohlson continued the program in ship-board radio-frequency interference (RFI) in UHF satellite communications. A hardware simulator was developed to test the effects of RFI upon Navy ship-board equipment. A satellite monitoring system using high-speed digital processing is being developed for analysis of uplink RFI.

Professor Glen Myers completed work on an investigation to determine the effectiveness of counting zeros to detect the presence of frequency modulated carrier signals in noise. Professor Myers is currently doing research on combining particular techniques of pulse modulation representation of voice with those of spread spectrum to obtain low probability of intercepting radio transmission of voice signals. Current work on binary codes proceeds along two lines: (1) the synthesis of waveforms having prescribed power spectra. This involves first the selection of appropriate binary sequences and then the shaping of the binary pulses to generate a waveform whose autocorrelation function suits the prescribed power spectra, (2) the synthesis of "almost complementary" series or sequences of binary digits.

TOXIC VAPOR LEVEL DETECTION/RECORDING

Professor John Duffin initiated a program to detect and record toxic vapor levels in Naval Rework Facility areas. Infra-red techniques are used.

ESTIMATION AND CONTROL SYSTEMS

Professor George Thaler and Professor Alex Gerba continued validating and updating a digital simulation program for captured air bubble type surface effect ships. They have developed and validated a simplified model for control studies.

Professor Harold Titus has continued work in the missile control/decontrol area and missile evasion area. Optimum methods of missile decontrol were proposed as were maneuvering strategies for optimal evasion of a proportionally navigated missile.

SIGNAL PROCESSING

Professor Stephen Jaurequi worked on various aspects of the new BULL DOG system including computer simulation, noise and interference. He also investigated various aspects of the manual Morse decoding problem and over-the-horizon targeting concepts for Harpoon.

Professor Tien Tao worked on two-dimensional image processing using statistical estimation techniques with the objective of detecting weak target signals in surveillance pictures contaminated by clutter.

RANGE STUDIES

Professor George Sackman led a task group investigating applications of non-acoustic systems to range problems. He made a study of simultaneous magnetic and acoustic signature measurements.

Professor Donald A. Stentz has studied adaptive control systems in an effort to determine how this rapidly advancing technology can be used on the acoustic tracking ranges operated by the Naval Torpedo Station, Keyport, Washington.

Professors Victor Powers and Mitchell Cotton studied modernization of data gathering and processing systems for range study programs at the Naval Torpedo Station, Keyport, Washington. For this same program Professor Jeffrey Knorr studied UHF and VHF tropospheric paths proposed for communication links. Professor David Hoisington reviewed the state-of-the-art in magnetometers for use as possible sensors for magnetic ranging and Professor Harold Titus studied possible use of Kalman Filters to improve torpedo tracking accuracy. Professors Harold Titus and Donald Stentz studied system concepts and navigation methods in relation to at-sea tracking.

Professors Milton Wilcox, Charles Rothauge, Robert Burton and Orestes Baycura studied antenna propagation problems for the U.S. Army CDEC project involving ranging location of objects moving in real-time in a potential ground encounter area.

SOLID STATE DEVICES

Professor Tien Tao directed a research project concerning application of large scale intergration (LSI) and charge transfer devices (CTD) for real-time signal processing. Two objectives are a real-time hardware implementation of statistical spatial filters and a real-time hardware Fast Fourier Transform (FFT) device using a 16-bit microcomputer and LSI hardware.

WAVE PROPAGATION

Professor Jeffrey Knorr conducted an investigation of finline for millimeter wave circuits in which the wavelength and impedance were determined for the 26-60 gigahertz range. Professor Knorr also initiated a study of optimum strategies for communicating at HF in the presence of interceptors. A project to measure path loss on a tropospheric voice and data communication circuit also was continued by Professor Knorr.

Title: Thermal Detection and Infrared Imaging of Surface Current and Charge Density Distributions

Investigator: R. W. Burton, Associate Professor of Electrical Engineering

Sponsor: Foundation Research Program, Naval Air Development Center, Rome Air Development Center

Objective: To reduce to working practice the technique of Thermal detection and infrared imaging of surface current and charge density distribution for use as an on-board diagnostic tool for ships and aircraft.

Summary: This technique is a major breakthrough in the real-time detection of currents and charges vis-a-vis the laborous and costly methods currently used. Military applications are in EMI, EMC and the ongoing study of composite materials.

Publications: R. W. Burton, J. D. Selim, "Infrared Detection of Surface Charge and Current Distributions", Proceedings 1977 International Microwave Symposium, June 1977, San Diego, California.

R. W. Burton, J. D. Selim, "Rapid Detection of Charge and Surface Current Distributions on Radiating and Scattering Structures", Proceedings National Radio Science Meeting of the International Union of Radio Science, Boulder, Colorado, January 1978, (accepted for publication).

Title: Improvement of Reliability of RMS System

Investigator: R. W. Burton, Associate Professor of Electrical Engineering

Sponsor: Combat Development Experimentation Command (CDEC)

Objective: To conduct systematic analyses of the antennas and propagation anomalies associated with the RMS system and to recommend methods to improve system effectiveness.

Summary: The RMS System employed by CDEC is a sophisticated position reporting system which performs well in the large variety of combat evaluations conducted at Hunter Liggett field sites. Through the past year, a number of persistent problems have been identified, the solution of which can potentially lead to a significant improvement in the overall effectiveness of the RMS System.

To a very large extent, these persistent problems fall under the heading of antennas electromagnetic propagation, computer interfaces and equipment/player interfaces. It has become clear that a systematic analysis of these problems integrated into broad system study of reliability of the RMS system has the potential of significant payoff in the effectiveness of the overall system as well as contemplated future systems.

Publications: None.

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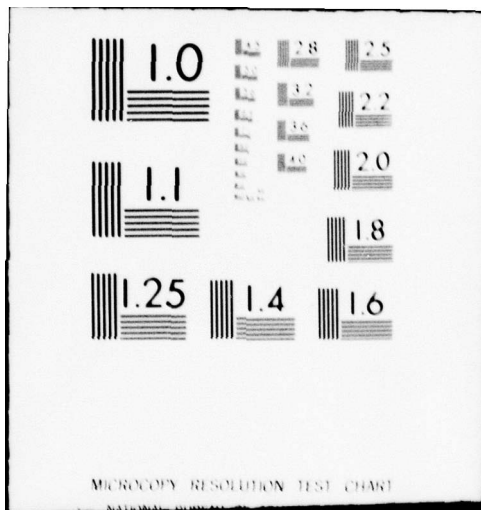
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MICROCOPY RESOLUTION TEST CHART

Title: EMP Effect on C³ Aircraft

Investigator: R. W. Burton, Associate Professor of Electrical Engineering

Sponsor: Air Force Weapons Lab, Rome Air Development Center, Naval Air Development Center

Objective: This continuing research project investigates the surface current and charge distributions on cylinders, crossed cylinders and flat plates used to model aircraft and missiles in an EMP environment.

Summary: NONE

Publications: R. W. Burton, "On Measuring Elliptically Polarized Surface Currents", Proc. of National Conference on Electromagnetic Scattering, pp. 132-135, June 1976.

R. W. Burton, R. W. P. King, L. C. Shen, "Electric and Magnetic Fields Induced on the Surfaces on Electrically Thin and Thick Cylinders and Crossed Cylinders by an Incident Plane Wave", Proc. of National Conference on Electromagnetic Scattering, Invited paper, pp. 45-58, June 1976.

R. W. Burton, R. W. P. King, "Surface Currents and Charges on a Thick Conducting Tube in an E-Polarized Plane-Wave Field I. Theory", Radio Science, Vol. 11, Nos. 8, 9., pp. 687-699, August-September 1976.

R. W. Burton, R. W. P. King, "Surface Currents and Charges on a Thick Conducting Tube in an E-Polarized Plane-Wave Field II. Measurements", Radio Science, Vol. 11, Nos. 8, 9, pp. 701-711, August-September 1976.

R. W. Burton, W. E. Beyatte, "Charge and Current Distributions on Cross-Monopole Transmitting Antenna", Proceedings 1977 International Scientific Radio Union (URSI), Stanford, California, June 1977.

R. W. Burton, R. W. P. King, "Surface Currents and Charges on an Electrically Thick and Long Conducting Tube in E- and H- Polarized, Normally Incident, Plane-Wave Fields", Radio Science, (accepted for publication).

R. W. Burton, R. W. P. King, "Surface Currents and Charges on Crossed Electrically Thick Cylinders in a Normally Incident, Plane-Wave Field", Radio Science, (accepted for publication).

R. W. Burton, R. W. P. King, "Currents and Charges Induced by a Normally Incident Plane-Wave on Single and Crossed Tubular Cylinders with $ka = 2$ ", Radio Science, (accepted for publication).

R. W. Burton, R. W. P. King, L. C. Shen, "Induced Currents and Charges on Cylinders and Crossed Cylinders by an Electromagnetic Field", to be published as a chapter in a book on Electromagnetic Scattering, edited by P. L. E. Uslenghi (accepted for publication).

Title: Air Pollution and Waste Disposal Study

Investigator: J. H. Duffin, Professor of Electrical Engineering

Sponsor: Naval Air Rework Facility

Objective: Consult and advise on disposal of "sludge" generated during operation of new jet engine test cell facilities at Norfolk and Jacksonville. Activity on this project is suspended due to change in administrative structure and personnel for NARF engineering effort.

Summary: Visits were made to Norfolk and Jacksonville to consult with responsible engineering personnel. Facilities were inspected. Sludge samples were obtained and preliminary lab work done to characterize sludge. On the basis of this work, a letter report was issued suggesting ways and means of sludge disposal. Actual method or methods used depend on getting representative samples of sludge from normally operating test cells. This has not occurred as yet so project is currently in a "suspended" state with its future finding and effort unsure.

Publications: None.

Title: The Effect of Ambient Pressure on the Vertical Plane Motion Characteristics of the Simulated XR-3 Craft

Investigators: A. Gerba, Jr., Associate Professor of Electrical Engineering, G. J. Thaler, Distinguished Professor of Electrical Engineering

Sponsor: Surface Effects Project Office (SESPO)

Objective: To determine the important parameters in the heave-pressure loop dynamics that control vertical motion characteristics. This is one part of a program leading to a procedure for scaling from towing tank model to full size craft.

Summary: Results of step-weight transients and frequency response analysis have shown that ambient pressure variations about standard sea-level value have negligible effects on the vertical motion characteristics of the XR-3 craft. A current report soon to be completed follows up this study with a scaling method from model to prototype craft.

Publications: A. Gerba, Jr., G. J. Thaler, NPS-62Tr77011.
A. Gerba, Jr., G. J. Thaler, NPS-62Tr77091.

Title: Phase-Front Distortion Jamming Investigation

Investigator: D. B. Hoisington, Professor of Electrical Engineering

Sponsor: Pacific Missile Test Center

Objective: This project is investigating modifications in the CROSSEYE phase-front distortion jamming technique to obtain a viable countermeasure against monopulse tracking radars.

Summary: This is a high-risk project, but with a very high payoff if success is achieved. Preliminary tests have been made by project and thesis students. The RV ACANIA will be used for full-scale tests against the NIKE AJAX monopulse and the MARK-25 conical scan tracking radars. Waveguide and fittings have been purchased for the ACANIA tests, and two AN/ALQ-41 repeaters have been obtained and refurbished for use as the amplifiers.

Publications: None.

Title: A Study of the Click Jammers, Their Intended Victims, and How They Effect U.S. Navy Systems

Investigators: D. B. Hoisington, Professor of Electrical Engineering, and J. B. Knorr, Associate Professor of Electrical Engineering

Sponsor: Naval Intelligence Support Center

Objective: To provide an estimate of how this foreign jammer series may be expected to be used, and how it will effect U.S. Navy radar systems.

Summary: Intelligence data on the subject jammer tests has been collected. The results of tests of a simulated system on the AN/SPS-48 radar have been examined. Calculations are being made of the jammer effect on this radar under various conditions of geometry and jammer operating conditions.

Publications: None.

Title: Communications System Studies

Investigator: J. B. Knorr, Associate Professor of Electrical Engineering

Sponsor: Naval Torpedo Station

Objective: To determine the propagation loss for several line-of-sight radio paths in the Pacific Northwest, including the effects of fading.

Summary: A data collection experiment is being planned.

Publications: None.

Thesis Directed: R. M. Cassidy, "Computer Prediction of Tropospheric Radio Transmission Loss for Selected Paths in the Pacific Northwest", Master's Thesis, June, 1976.

G. Westling, "The Statistics of Multipath fading at VHF to Communications Links at NAVTORPSTA, Keyport, Washington", Master's Thesis, September, 1977.

Title: Dielectric Loaded Finned Waveguide Study

Investigator: J. B. Knorr, Associate Professor of Electrical Engineering

Sponsor: Naval Electronic Laboratory Center

Objective: To determine the wavelength and impedance as a function of frequency for rectangular waveguide loaded with fins and dielectric and operated in the 26.5-60 GHz frequency range.

Summary: This project has been completed.

Publications: J. B. Knorr, "Dielectric Loaded Finned Waveguide Study", Technical Report, NPS 62K077031A, March 1977.

Title: Interval Modulation of a Sinusoidal Carrier

Investigator: G. Myers, Associate Professor of Electrical Engineering

Sponsor: Foundation Research Program (6.2)

Objective: This work is concerned with radio communications. This research investigated use of a modulated interval, between bursts of a sinusoidal carrier, to convey the information in a message waveform. We called this form of modulation "interval modulation" (IM).

Summary: IM produces a delay between bursts of the sinusoidal carrier. This delay is proportional to the amplitude of the modulating message waveform. Thus, IM is unlike AM, PM, or PM where the amplitude, frequency or phase of a sine wave vary in accordance with a message waveform.

The research resulted in mathematical descriptions of the IM carrier in the time domain and frequency domain. Early in the investigation, we completed the design of an IM modulator and demodulator. We then built and tested these circuits. The technique was then verified by transmitting voice and music signals through the system. The quality of the recovered signals was excellent.

Conference Presentations:

G. Myers, "Interval Modulation (IM) of a Sinusoidal Carrier", Technical Conference, SIEEM 77, Monterey, Mexico, September 77.

G. Myers, "Symposium on Spread Spectrum Communications", Naval Postgraduate School, September 1976.

Publications: G. Myers and E. L. Kilborn, Jr., "Interval Modulation (IM) of a Sinusoidal Carrier", Technical Report, NPS62Mv77031, February 1977.

Thesis Directed: E. L. Kilborn, Jr., "Interval Modulation (IM) of a Sinusoidal Carrier", Master's Thesis, December 1976.

Title: Researches in Digital Filters

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

Sponsor: Foundation Research Program (6.1)

Objective: To extend previous work on one dimensional filters to the multidimensional case in the general areas of synthesis, stability, and limit cycles.

Summary: A direct technique for expressing the impulse response of a multidimensional digital filter in terms of the coefficients of the transfer function is presented. This approach potentially leads to a synthesis procedure for recursive two dimensional signal processing.

An adaptive recursive digital filter has been developed and compared favorably with the optimal filter. The feedforward and feedback gains of the filter are adjusted adaptively to minimize a least square performance function on a sliding window average basis for gradient calculations.

Publications: S. R. Parker, L. Souchon, "Synthesis of N Dimensional Recursive Digital Filters by Taylor Series Expansion", IEEE Transactions on Circuits and Systems, Vol CAS24, No. 1, January 1977, pp 28-34.

Title: Signal Processing Studies and Techniques

Investigator: Sydney R. Parker, Professor of Electrical Engineering

Sponsor: Naval Electronic Systems Command

Objective: To investigate signal processing as applied to: (a) Voice Track simulation by digital filters, (b) recursive adaptive digital filters for separating images from background noise, (c) separation of stochastic signals such as radar target returns from clutter, and (d) the application of distributed arithmetic to digital filter realization techniques.

Summary: a. Voice Track Simulation by Digital Filters. It has been conjectured that the wave digital filter simulation of a low pass ladder network (voice track) has minimum sensitivity to variations of multiplier coefficients and therefore can be expected to have minimum noise due to finite precision arithmetic as well as requiring a minimum number of digits in the coefficients to achieve a given frequency response specification. This conjecture is based upon the fact that the wave digital filter is derived directly from the lossless ladder circuit being modelled, and the circuit element values appear in linear combination in the multiplier coefficients of the wave digital filter.

An alternate method for the modelling of the low pass ladder network of the voice track is also being investigated. It consists of a digital filter derived from the state-space formulation of the ladder network using forward Euler integration. This approach is much simpler and straight forward compared with the wave digital filter. It has the inherent advantage that there is a one to one correspondence between circuit elements values and digital filter multipliers. Thus, since the ladder network is minimum sensitive to element values, the digital filter is minimum sensitive to multiplier values and should be an efficient model in terms of noise generation and required multiplier coefficients accuracy.

Programs have been written for the wave digital filter and the state-space digital filter formulations and are currently being tested and compared. Fixed point arithmetic is being used initially.

In order to compare the two formulations, the question of scaling is being studied for optimizing signal to noise ratio. Scaling of wave digital filters has generally not been considered in the literature. Scaling for the state-space digital formulation appears to be straight forward.

b. Recursive Adaptive Digital Filters. The standard technique for adaptive filters as developed by Widrow involves the minimization of mean square error criteria, on a point by point basis, to adjust the weights of a non-recursive digital filter (finite impulse response). This approach has been extended to adaptive digital filters having both zeros and poles (infinite impulse response) using a suggestion by Feintuck. Successful application of adaptive techniques to recursive filters will have significant applications in the area of modelling and parameter estimation.

Little is known concerning the convergence of the adaptive recursive digital filter. The usual technique of formulating a mean squared error as a quadratic function of the filter coefficients, and obtaining a local minimum by gradient techniques on a point by point basis may not converge in the presence of noise.

In the current research the gradient of the mean squared error is estimated by the gradient of the finite point squared error averaged by sliding a finite window at every step of the iteration process rather than taking the gradient of the instantaneous squared error. The calculation of the gradient by means of the sensitivity or adjunct model of the filter is also being studied. This concept has been used successfully in computer aided design but has not been used in adaptive digital filters.

Experimental results indicate that the proposed methods work for one dimensional adaptive filters and approach the Weiner filter as the optimum.

The technique has also been extended to two dimensional image processing and the separation of images from background noise. The concept of two dimensional adaptive filters, particularly of the recursive type, have not been discussed in the literature heretofore. Experimental results appear to be promising.

c. Separation of Stochastic Signals. This research is concerned with the separation of stochastic signals where their probability density functions are known. The research is motivated by the tracking radar problem where the radar return contains both target and clutter. Target and clutter generally are uncorrelated with each other and have different probability density functions. The approach to the filtering problem is to use a digital filter to simulate stochastic versions of the chaff and radar signals respectively, and to adaptively mixing these two signals to produce a composite signal which approximates the incoming signal in a least squares sense. The weights of the adaptive mixing then estimates the relative energy in the received chaff and radar signals.

The problem has been formulated mathematically and some initial simulations for separating signals with Raleigh and exponential distributions have been performed.

d. Noise in Distributed Arithmetic Digital Filters. Of current interest is the concept of distributed arithmetic digital filters where the method of performing the multiplication of signals with coefficients is expressed in terms of a convolution process. The distributed arithmetic approach to digital filter design promises to be most efficient in the practical design of digital filters. To date, nothing has been done in the literature to investigate the effects of finite precision arithmetic noise generation, both noncoherent and coherent (limit cycles), in distributed parameter digital filter.

Studies are currently underway to formulate the noise problem so that the effects of noise generation can be calculated and taken into account in design procedures.

Publications:

S. R. Parker, S. J. Ko, "A Two Dimensional Adaptive Recursive Digital Filter in Image Processing", Proceedings of the IEEE International Symposium on Circuits and Systems, New York, May 1978.

Title: Computer Aided Acoustical Imaging

Investigator: J. P. Powers, Professor of Electrical Engineering

Sponsor: Foundation Research Program (6.2)

Objective: This work is part of a continuing effort to explore the use of computer processing of coherent (both amplitude and phase information present) data to generate images of objects from transmitted or reflected ultrasonic fields. The short term objective was to construct an experimental system to record the complex data fields of an ultrasonic wave for computer processing. Additionally it was desired to explore the presentation of the data on a computer driven video display for presentation of the data or resulting image.

Summary: The first acoustic images using this system have been obtained. The data acquisition system has been built and successfully tested. Preliminary acoustical images have been displayed on a Ramtek Gx-100 television display with 16 gray levels (limited by the display refresh memory capability). The data acquisition system consists of a logarithmic compressive amplifier with 60db of dynamic range, a phase detector, and a high accuracy positioning and recording system. Testing and calibration of the hardware implementation of these devices shows acceptably high degrees of accuracy and repeatability. The data is recorded on analog tape. After digitization of the recorded data and subsequent demultiplexing of the channels the data has been successfully stored in memory of PDP 11/40 computer for subsequent display or processing. Using the Ramtek Gx-100 display driven by a PDP 11/40, interactive display capability has been developed to allow the operator to call up displays of amplitude, phase or intensity data. He also has the capability to change the quantization levels, the gray scale assignment and to assign various pseudocolor values to the data. This interactive capability was designed and tested during the research period using both computer generated and experimentally recorded data. Future efforts include further expansion of this

interactive display capability, refinements in the data acquisition system and investigation of more experimental objects to assess the overall capabilities of the system.

Publications: J. P. Powers, "Computer Simulation of Linear Acoustic Diffraction, Acoustical Holography," Vol. 7, L. W. Kessler, Ed., Plenum Press, New York, 1977, pp. 193-205.

J.P. Powers, Lt. R. T. O'Bryon, Lt. J. W. Patton, "Ultrasonic Imaging System Incorporating Computer Aided Coherent Processing", Abstracts, Ninety-fourth Meeting of the Acoustical Society of America, Miami Beach, 12-16 December 1977, in J. Acoustical Society of America, 62 (Supplement 1): S22, 1977.

Title: Instrumented Range Studies, Non-Acoustics Group

Investigator: G. L. Sackman, Associate Professor of Electrical Engineering

Sponsor: Naval Torpedo Station

Objective: To examine sensors and systems suitable for measuring the magnetic signature of submarines, and other non-acoustic systems relevant to operation of an instrumented range.

Summary: Information on degaussing, modern magnetic sensor technology, and magnetic signal processing has been compiled and/or derived and analyzed in the context of an instrumented range. Applications of fibre optic transmission line technology to range requirements is being investigated.

Publications: None.

Title: Range Requirements - Adaptive Control Systems

Investigator: D. A. Stentz, Associate Professor of Electrical Engineering

Sponsor: Naval Torpedo Station

Objective: To study the range enhancement obtained through the use of modern sensors and array technology, in particular by making use of adaptive control systems. This is a continuing program.

Summary: Adaptive control systems can be described by the commonly used Index of Performance, IP's, and the three essential processes; identification, decision, and modification that are involved in all such systems. Applied to arrays of underwater sensors, interfering noise sources can be essentially eliminated. This results in an improvement in the signal to noise ratio. This technology may improve the target acquisition, and tracking on a test range, and make it possible to test various kinds of vehicles in environments otherwise adverse to this important function. Multipath and reverberation problems may be avoided. It may be possible to apply such adaptive systems to at-sea ranges where little control over noise and interfering signals is possible.

Publications: D. A. Stentz, "A Brief Survey of Adaptive Control Systems", Technical Report, NPS-62Sz77071, July 1977.

Title: Sampled Analog Signal Processing

Investigator: T. F. Tao, Professor of Electrical Engineering

Sponsor: Foundation Research Program (6.2)

Objective: To develop theory, design procedure and applications of sampled analog recursive filters using charge transfer devices.

To investigate the limitations and sensitivities of sampled analog signal processing.

Summary: Signal processing can be generally separated into four categories:

Filter	Recursive Nonrecursive
Spectral Analyzers	Fourier Type Non-Fourier Type

They can be implemented either digitally using computers, integrated circuits or in sampled analog ways using charge transfer devices. Sampled analog signals differ from digital signals because their amplitudes are not digitized. They are similar because both types of signals are sampled. This study is concerned with two aspects of sampled analog signal processing.

(1) Sampled Analog Recursive Comb Filters:

Theory, design procedure and applications of sampled analog recursive filters have been investigated. It was found that recursive filters using sampled analog delay lines behave in many ways similar to the digital recursive filters but with one major difference. Because a charge transfer delay line usually has delay of multiple sampling periods, the frequency characteristics of a sampled analog recursive filter has $N/2$ comb teeth below the Nyquist frequency. It is a comb filter. It was found that theories and design procedure

developed for digital recursive comb filters can be used for sampled analog recursive comb filters if two modifications are made: filter coefficients vary with frequency, charge transfer delay lines have delays of multiple sampling periods. Two types of comb filters have been studied: canceller type and integrator type. Their applications as MTI radar canceller and pulse-repetition-frequency sorter have been demonstrated.

(2) Sampled Analog Discrete Fourier Transforms:

Two algorithms have been used to implement sampled analog discrete Fourier transforms: Chirp Z Transform and Prime Transform. Both algorithms use the transversal filter which can be easily implemented using charge transfer devices. This study investigated the advantages and limitations of these two sampled analog discrete Fourier transforms in comparison with the digital FFT (fast-Fourier-transform) algorithm.

Publications:

S. Holmes, "Hardware Signal Processor Development-Session Summary", Proceedings 9th Asilomar Conference on Circuits, Systems, and Computers, pp. 289-299 (1976).

S. Holmes, M. Pollack and J. Campbell, "Sensitivity Study of Sampled Analog Signal Processing", Proceedings 19th IEEE Midwest Symposium on Circuits and Systems, pp. 430-439, (1976)

L. Saetre, S. Holmes and A. Ejaz, "Recursive CTD Comb Filter and Its Application to MTI Radar Signal Processing", Proceedings 1976 GOMAC Conference, (Government Microcircuit Applications Conference), pp. 246-249 (1976).

J. Campbell, T. F. Tao and M. Pollack, "Sensitivity Study of Chirp Z Transform and Prime Transform as Sampled Analog Discrete Fourier Transform Algorithms", Proceedings of 10th Asilomar Conference on Circuits, Systems and Computers, pp. 372-38- (1976)

T. F. Tao, S. Holmes A. Ejaz, F. Piazza, L. Saetre and B. Freund, "Theory and Applications of Sampled Analog Recursive CTD Comb Filters", Proceedings NASA/JPL Conference on Charge Coupled Device Technology and Applications, pp. 1-10, (1976)

Theses Directed:

J. Campbell, "Sensitivity Study of the Chirp Z Transform and the Prime Transform as Sampled Analog DFT Algorithms", Master's Thesis, December 1976

A. Ejaz, "Theory of Sampled Analog Recursive Comb Filters and Their Canceller Applications", Engineer Degree, December, 1976.

F. Piazza, "Theory and Applications of CTD Recursive Comb Filters", Master's Thesis, December 1976.

Sklivanos, "Sensitivity Study of Sampled Analog Tapped Delay Line Transversal Filters," Master's Thesis, September 1976.

DEPARTMENT OF METEOROLOGY

The research program in the Department of Meteorology has continued along several main lines as follows: (1) Numerical weather and ocean modeling and prediction, (2) Analysis and dynamics of tropical weather systems, (3) Marine boundary-layer turbulence, (4) Marine fog observation, analysis and prediction, and (5) Polar studies. Under each of these headings, a number of related investigations are being pursued by various faculty members, as described briefly below.

NUMERICAL PREDICTION

Under this heading are included: modeling the analysis and prediction of large-scale weather systems by G. J. Haltiner and R. T. Williams; numerical prediction of hurricanes by R. L. Elsberry; ocean circulation modeling and prediction by R. L. Haney; ocean mixed layer modeling by R. L. Elsberry; and boundary-layer parameterization by K. L. Davidson. With regard to Elsberry's projects, he and his students continue to cooperate in the Navy effort to develop an operational tropical cyclone prediction model. Preliminary tests with a quasi-operational version of the model seem to indicate the most important contribution to forecast error is due to data deficiencies in the western pacific region. Efforts are now directed toward adjusting the initial fields in the region of the typhoon to improve the short term forecasts.

Several one-dimensional, oceanic mixed-layer models have been used by Professor R. L. Elsberry and Professor Garwood (Oceanography) to predict the effects of atmospheric cyclones on the upper ocean. It has been demonstrated that significant changes in temperature and mixed depth occur during the cooling season in association with the passage of strong cyclones. The feasibility of using this type of model for real-time prediction of ocean thermal structure changes is also being tested.

ANALYSIS AND DYNAMICS OF TROPICAL WEATHER SYSTEMS

C. P. Chang, R. L. Elsberry and R. T. Williams are investigating various aspects of the dynamics of tropical weather systems, including development of hurricanes and typhoons by Elsberry, the dynamics and energetics of tropical wave disturbances and circulations by Chang and Williams, and the diagnostic analysis of tropical systems by Chang.

MARINE BOUNDARY LAYER TURBULENCE AND AEROSOLS

Research in this area includes four interdisciplinary observational and theoretical projects for which K. L. Davidson is principal investigator. Objectives of the individual projects are to (1) obtain surface layer scaling laws for marine

fog occurrences, (2) describe the height variation of optically relevant turbulence parameters in terms of stability and inversion characteristics, (3) obtain measurements of the EM index of refraction profiles within the surface layer (0 to 30 m) over the mid-Atlantic, and (4) develop an approach to relate marine aerosol total concentrations and size distributions to boundary layer fluxes using existing surface layer scaling techniques. The primary results in project will be relationships between small scale turbulence intensities or gradient measures and bulk parameters, such as wind speeds and air-water temperature and humidity differences.

MARINE FOG OBSERVATION ANALYSIS AND PREDICTION

An interdisciplinary project, involving R. J. Renard and K. L. Davidson, Department of Meteorology, and faculty members from the Departments of Oceanography, and Physics and Chemistry, is concerned with the observation, climatological analysis, and numerical/statistical prediction of fog over open ocean and coastal regimes, both on a regional and hemispheric scale.

POLAR WEATHER STUDIES

Currently R. J. Renard's research is concerned with the observational network commensurate with synoptic/mesoscale weather events over the Antarctic area. In addition to data from conventional and satellite sources data from prototype remote automatic weather stations and the Airborne Research Data-Handling System aboard an LC 130R Aircraft are being analyzed for their contributions both to the scientific and operational weather endeavors in support of the U. S. mission in Antarctica.

- Title:** Dynamics of Tropical Waves and Monsoons
- Investigators:** C. P. Chang, Associate Professor of Meteorology, R. T. Williams, Professor of Meteorology
- Sponsor:** National Science Foundation
- Objective:** To study the dynamics of large-scale flow in the tropics including stationary and propagating waves and monsoons, in terms of their development, maintenance and structure and interactions between them. This is a continuing project and the latest emphasis is shifted from completely theoretical to half theoretical and half observational in preparation for the international Monsoon Experiment (MONEX) of the Global Atmospheric Research Program to be implemented in FY 1979.
- Summary:** The thermal forcing mechanism of large-scale tropical waves are studied with inclusion of damping. Low frequency waves are found to have increased vertical wavelength and vertical attenuation. This result reconciles the equatorial wave theory, which can now be used to interpret consistently the observed tropical waves in both the troposphere and the stratosphere. Waves generated by local barotropic instabilities are studied using a numerical model which includes the significant zonal variation of the time-mean flow as found in the upper troposphere over South Asia during the northern summer monsoon. The results indicate substantial enhancement of the wave growth compared to parallel flow theory, with maximum wave activity shifted downstream from the most unstable region.
- Publications:** C. P. Chang, "Instability of Large-Scale Disturbances in the Tropics," Journal of the Atmospheric Sciences, 33, 1677-1668, August 1976.
- C. P. Chang, "Viscous Internal Gravity Waves and Low Frequency Oscillations in the Tropics," Journal of the Atmospheric Science, 34, 901-910, June 1977.

C. P. Chang, "Some Theoretical Problems of the Planetary Scale Monsoons," Pure and Applied Geophysics, 115, 1089-1109, December 1977.

U. S. MONEX Panel, "Plan for U.S. Participation in the Monsoon Experiment," National Academy of Sciences, 126 pp., 1977.

C. P. Chang and R. J. Pentimonti, "A Numerical Study of Time-Mean Northern Summer Monsoon with Fluctuating Heating," accepted by Indian Journal of Meteorology, Hydrology and Geophysics, 1978 (in press).

J. P. Tupaz, R. T. Williams, and C. P. Chang, "A Numerical Study of the Locally Unstable Barotropic Easterly Jet," accepted by Indian Journal of Meteorology, Hydrology and Geophysics, 1978 (in press).

Thesis Directed: J. B. Tupaz, "A Numerical Study of Barotropic Instability of a Zonally Varying Easterly Jet," Ph.D. Thesis, June 1977.

Title: Studies of Large-Scale Tropical Motions

Investigator: C. P. Chang, Associate Professor of Meteorology

Sponsor: Naval Environmental Prediction Research Facility

Objective: The northern summer monsoon contains significant planetary scale asymmetrics in the upper troposphere near 200mb. Two important aspects of this planetary scale flow are studied using numerical models: the requirement of a strong damping mechanism and the development of synoptic-scale disturbances due to localized barotropic instability. Several experiments in a forced global model using steady and fluctuating heating functions for the former have been carried out, with no discernable effect of the fluctuations in heating noticed. Experiments with spatially dependent damping functions according to cumulus convection distribution are planned. For the latter problem a linear model has been integrated and the results will be compared with that obtained from the forced global model. This project is also supported in part by the National Science Foundation.

Publications: C. P. Chang and R. J. Pentimonti, "A Numerical Study of Time-Mean Northern Summer Monsoon with Fluctuating Heating," accepted by Indian Journal of Meteorology, Hydrology and Geophysics, 1978 (in press).

J. B. Tupaz, R. T. Williams and C. P. Chang, "A Numerical Study of the Locally Unstable Barotropic Easterly Jet," accepted by Indian Journal of Meteorology, Hydrology, and Geophysics, 1978, (in press).

C. P. Chang, "Some Theoretical Problems of the Planetary Scale Monsoons," Pure and Applied Geophysics, 115, 1089-1109, December 1978.

Thesis Directed: G. W. Shwenke, "Numerical Modeling of the Evolution of Monsoon Circulation along 80° E," Master's Thesis, March 1977.

W. L. Patterson, "A Numerical Experiment of the Development of the Zonally Symmetric Northern Summer Monsoon," Master's Thesis, June 1977.

J. B. Tupaz, "A Numerical Study of Barotropic Instability of a Zonally Varying Easterly Jet," Ph.D. Thesis, June 1977.

- Title:** Interannual and Spatial Variations of Sea-Surface Temperature, Tropical Waves and Planetary Scale Flows
- Investigator:** C. P. Chang, Associate Professor of Meteorology
- Sponsor:** National Environmental Satellite Service, NOAA
- Objective:** To study the behavior and interrelationship between the interannual and spatial variations of sea-surface temperature and synoptic and planetary scale waves in the tropics, using composite analysis of radiosonde and satellite data.
- Summary:** Satellite cloud data over the tropical western and central Pacific for the 1972-1973 El Nino and counter El Nino periods have been digitized and analyzed using the composite technique. The radiosonde data have also been subjected to the same analysis. It was found that the effects of the local sea-surface temperature influence are most important only for the part of convective activity organized by the waves. On the other hand, the time-mean cloudiness is a factor of the large-scale sea-surface temperature gradient and the associated Walker circulation. The vertical structure of the waves may be a function of the mean vertical shear, but it is unrelated to convective activity. The data for the periods 1974-76 over the same area will be used to continue this study.
- Publications:** C. P. Chang and C. Miller III, "Comparison of Easterly Waves in the Tropical Pacific During Two Contrasting Periods of Sea-Surface Temperature Anomalies", Journal of the Atmospheric Sciences, 34, 615-628, April 1977.
- Thesis Directed:** E. Mass, Jr., "Composite Analysis of Easterly Waves in the Tropical Pacific During Two Contrasting Periods of Sea-Surface Temperature Anomalies," Master's Thesis, March 1977.

**D. M. Delaney, "A Composite Satellite
Study of the 1972-1973 Easterly Waves
in the Tropical Western Pacific," Master's Thesis, September 1977.**

[Faint, mostly illegible text, likely bleed-through from the reverse side of the page. Discernible words include: "Investigator:", "Sponsor:", "Opt. River", "Summary:", "References:", "D. M. Delaney and C. Miller III, 'Observations of Easterly Waves in the Tropical Pacific Ocean During the Easterly Wave Season of 1972-1973', Journal of the Atmospheric Sciences, 30, 1973, pp. 115-127.'"]

Title: Meteorological Effects on Optical Propagation in the Marine Boundary Layer

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

Support: Naval Sea Systems Command

Objective: The long-range objective of this research is to develop methods for predicting optical propagation properties in the marine boundary layer on the basis of its bulk properties, e.g., wind speeds and air-water temperature differences. The short-range objective is to obtain observational descriptions of coincident turbulent and mean properties, wind and temperature from the sea surface to 1km and also aerosol distribution. This is a continuing project.

Summary: A specific goal of this study is to relate small-scale turbulent and aerosol properties to the mean hydrostatic stability and wave conditions. Such stability is definable from measures of the surface wind speed and the near surface air-water temperature difference. Small-scale turbulent properties are expected to vary differently with height under different conditions of stability. Results from multi-level shipboard and kiteborne measurements under several conditions of stability reveal distinct differences in height variations of the small-scale parameters under different conditions of stability. The observed height dependencies approximate those predicted on the basis of overland investigations. The variations from the predictions have been related to wave influence and the aerodynamically smooth characteristics of the sea.

Publications: K. L. Davidson, "Describing Meteorological Conditions for Optical Propagation", Minutes--Meteorology Group (Appendix G), Range Commanders Council 35th Meeting, April 1973, pp G1-G20.

K. L. Davidson, T. Houlihan, "Shipboard Measurements of Small-Scale Turbulence Properties", ICIASF* Record, 1975, Oct 1975, pp 97-99 (*International Conference on Instrumentation in Aerospace Simulation).

K. L. Davidson, T. Houlihan, "Turbulence Effects upon Laser Propagation in the Marine Boundary Layer", Proceedings, Fourth Biennial Symposium on Turbulence in Liquids, Oct 1975, pp 19-1 to 19-6.

E. C. Crittenden, K. L. Davidson, "Laser Transmission in the Marine Environment", Naval Research Reviews, Vol. 26, Feb 1976, pp 6-11.

K. L. Davidson, T. Houlihan, "Turbulence Effects upon Laser Propagation in the Marine Boundary Layer", Proceedings, SPIE* Conference on Imaging through the Atmosphere, Vol. 75, Mar 1976, pp 62-68. (*Society of Photo-Optical Instrumentation Engineers).

K. L. Davidson, T. Houlihan, "Optically Relevant Turbulence Parameters in the Marine Boundary Layer", Advances in Engineering Science (Society of Engineering Science), Vol. 3, Nov 1976, pp 1137-1152.

NPS EO/LT Group, K. L. Davidson, "Laser Transmission in the Marine Environment", NAVSEA Journal, Vol. 25, Nov 1976, pp 2-8.

K. L. Davidson, C. W. Fairall, T. Houlihan, G. Schacher, D. Hinsman, "Description of Optically Relevant Turbulence Parameters", Technical Proceedings ODDR & E Optical/Submillimeter Atmospheric Propagation Conference, December 1976, 16 pp.

K. L. Davidson, C. Fairall, G. Schacher, "An Examination of Scaling Laws for C_T^2 in the Layer Adjacent of Ocean Waves", Proceedings, SPIE* Conference on Propagation through Turbulent Media, September 1977 (*Society of Photo-Optical Instrumentation Engineers).

C. Fairall, K. L. Davidson, G. Schacher,
"Turbulence and the Drag Coefficient over
the Ocean", Boundary Layer Meteorology,
(Submitted) October, 1977.

C. Fairall, K. Davidson, G. Schacher,
"Height and the Stability Influence on the
Dissipation of Turbulent Kinetic Energy, ϵ ,
in the Marine Boundary-Layer", Boundary-Layer
Meteorology, (submitted), November 1977.

C. Fairall, K. L. Davidson, G. Schacher,
"Observational Results on the Temperature
Structure Function Parameter, C_T^2 , Adjacent
to Ocean Waves", Journal of Applied Optics,
(submitted) November 1977.

C. Fairall, K. L. Davidson, G. Schacher,
"Experimental Aspects of a Shipboard System
Used in Investigations of Overwater Turbu-
lence and Profile Relationships", (submitted)
Journal of Applied Meteorology, November
1977.

Title: Scaling Laws for Vertical Distributions of Marine Aerosols

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

Support: Naval Air Systems Command

Objective: The near-term objective of this work is to examine existing scaling laws for the mean distributions of humidity and the intensity of turbulent transports for their application to the vertical distribution and transport of marine aerosol, 1 to 30m. The long-term objective is to formulate expressions which describe observed aerosol distributions, from predictions requiring only bulk meteorological parameter inputs.

Summary: An equilibrium distribution of marine aerosols depends, in part, on their transport from the surface, the ambient humidity at distances above the surface and the fall rates of both above and near the surface. On the basis of recent descriptions of turbulent processes within the non-neutral marine boundary layer, scaling laws can be formulated to relate both the ambient humidity distribution and turbulent transport intensities on the basis of wind speeds at one level and the humidity and temperature differences between that level and the surface. An early formulation for giant sea salt distributions in a neutral boundary layer (Toba, 1964) with verification by Chaen (1973) provide a background for this proposed formulation for a more general, non-neutral case.

Publications: None.

Title: Environmental Survey: SSBN Security Program

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

Sponsor: Oceanographer of the Navy

Objective: The Objective of this research is to obtain near surface profile and turbulence descriptions in open ocean regions for the purpose of defining radar and radio wave propagation conditions during times associated with other experiments (classified or unknown).

Summary: A multi-level profile (wind, temperature and humidity) and turbulence (wind and temperature) systems and an acoustic sounder have been installed on a USN Oceanographic Ship (USNS Kane) for a month long observational experiment to be performed in the Mid-Atlantic during February 1978. The parameter of interest is the index of refraction, N , for radar and radio frequencies and its vertical gradient within the first 20 meters above the surface. N will be estimated on the basis of its computation from coincident temperature and humidity measurements. Estimates of the evaporative duct thickness will be made from computed N gradients and stability, i.e., Richardson numbers. Elevated critical N gradient will be discerned from acoustic sounder records. Preliminary and final reporting procedures and hence, analysis, will be carried out in such a way to provide timely information to parallel experiments being managed by NAVOCEANO.

Publications: None.

Title: Turbulent Transfers and Elevated Layers in Marine Fog

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

Sponsor: Naval Air Systems Command

Objective: The near term objectives of this research are to obtain descriptions of turbulent transfers (Momentum, Sensible and Latent Heat) and hydrostatic stability within different stages of Marine Fog Regimes. The long term objective due to scalp observed mean conditions in terms of the boundary fluxes and depth of the marine boundary layer.

Summary: Marine fog formation, maintenance and dissipation is controlled by thermodynamic processes. These processes occur because of radiative and turbulent transfer of sensible heat from the ocean surface and from within the fog layers. Models designed to examine why fog forms in certain conditions and not in others have not been successful because the specification of boundary fluxes is, essentially, unknown. Application of proven scaling laws for non-neutral boundary layers capped by marine inversion will be used to delineate differences between fog and non-fog regimes. This can be accomplished from turbulence as well as profile measurements within fog and adjacent non-fog areas.

Publications: K. L. Davidson, C. Fairall, T. Houlihan, G. Schacher, "Observational Results on Marine Fog Related Variations of Small Scale Turbulence Parameters (C_T^2 and)", Technical Digest, Optical Propagation through Turbulence, Rain and Fog, August 1977, pp TVA 4, I-4.

K. L. Davidson, C. Fairall, T. Houlihan, G. Schacher, "Observations of the Marine Inversion with a Shipboard Acoustic Sounder", Technical Digest, Optical Propagation through Turbulence, Rain and Fog, August 1977, pp. TUB 4, I-3.

K. L. Davidson, C. Fairall, T. Houlihan,
G. Schacher, "Observations on Boundary Fluxes
and Hydrostatic Stability in Marine Fog",
Journal of Applied Meteorology (submitted)
November 1977.

Title: Oceanic Thermal Response to Atmospheric Forcing

Investigators: R. L. Elsberry, Associate Professor of Meteorology, R. W. Garwood, Adjunct Professor of Oceanography

Sponsor: Office of Naval Research

Objective: The objective of this research is to isolate and document those changes in near-surface oceanic thermal structure parameters that are related to atmospheric forcing.

Summary: A combined modeling and data analysis is used to obtain a more complete view of the time evolution in the absence of complete oceanic data, and to extend our understanding of the dominant physical processes. A statistical study of the role of atmospheric storm forcing during the heating season will be completed. Data gathered in the Mixed Layer Experiments (MILE) will be examined within the framework of recent bulk turbulent kinetic energy models. The interaction between the vertical turbulent mixing processes and quasi-geostrophic processes that lead to the development of fronts in the ocean will be numerically modeled.

One-dimensional models have been applied to: (a) illustrate the nature of thermal structure modifications associated with strong forcing events that occur during September to December; (b) demonstrate that these one-dimensional models can simulate a major fraction of the upper ocean response during these events; and (c) establish the relative importance of mechanically-and convectively-induced mixing. The long time series of surface marine observations at three weather ship locations have been analyzed to: (a) forcing events, and (b) to quantify the relative importance of the strong atmospheric events to the total fall and early winter evolution of the upper ocean. A description of a new one-dimensional bulk model of the mixed layer has been published. This model has been used to infer the variability of the turbulent mixing on diurnal and storm periods.

Conference
Presentations:

R. W. Garwood, "A Standardized Framework for Mixed Layer Model and Empirical Data Evaluation". Presented at AGU Annual Meeting, San Francisco, December 1976. Abstract in Trans., Am. Geophys. Un., 57, (12), 937.

R. W. Garwood, R. L. Elsberry, "Effects of Boundary Layer Processes on the Strength of an Upper Layer Density Front". Presented at Chapman Conference on Oceanic Fronts, New Orleans, October, 1978. Abstracts in Trans. Am. Geophys. Un., 58.

R. W. Garwood, "The Spring Retreat of the Ocean Surface Boundary Layer", presented at AGU Annual Meeting, San Francisco, December 1977. Abstract in Tran. Am. Geophys. Un., 58, (12).

N. T. Camp, R. L. Elsberry, "Role of Strong Atmospheric Forcing Events in Modeling of Oceanic Thermal Structure", presented at AGU Fall Meeting, Abstract in EOS, 57, p 937.

Publications:

R. W. Garwood, "An Oceanic Mixed Layer Model Capable of Simulating Cyclic States", Journal of Physical Oceanography, Vol 7, May 1977.

R. W. Garwood, N. T. Camp, "Climatological Numerical Models of the Surface Mixed Layer of the Ocean". Journal of Physical Oceanography, vol. 7, May 1977.

R. W. Garwood, "A Method for the Nondimensional Comparison of Mixed Layer Models". Ocean Modeling, Vol 6, June 1977.

R. C. Elsberry, R. W. Garwood, "Sea Surface Temperature Anomalies Generated by Atmospheric Forcing". Submitted to Bull. Am. Met. Soc., November 1977.

N. T. Camp, R. L. Elsberry, "Ocean Thermal Response to Strong Atmospheric Forcing. II. Simulations with Mixed Layer Models". Submitted to J. Phys. Oceanograph, 1977.

R. L. Elsberry, B. L. Holt, Jr., W. G. Schramm,
"Some Statistical Summaries of Oceanic Thermal Response to Typhoon Passage". Submitted to J. Geophys. Res., 1977.

Thesis Directed: L. V. Friese, "Buoy Observations of Oceanic Thermal Response to Hurricane Eloise". Master's Thesis, 1977.

B. L. Holt, Jr., "Some Observations of Ocean Thermal Response to Typhoon Passage". Master's Thesis, 1976.

W. F. Johnson, "Upper Ocean Thermal Structure Forecast Evaluation of a Model Using Synoptic Data". Master's Thesis, 1977.

S. D. Raney, "Characteristics of Atmospheric Forcing Functions". Master's Thesis, 1977.

Title: Modeling Upper Ocean Thermal Structure

Investigators: R. L. Elsberry, Associate Professor of Meteorology, R. W. Garwood, Adjunct Professor of Oceanography

Sponsor: Naval Ocean Research and Development Activity

Objective: The objective of this proposed research is the ocean-wide application (up to one year integrations) of a one dimensional oceanic boundary layer model for the upper ocean thermal structures.

Summary: To achieve this ultimate goal, three most important phases or tasks are identified: (1) the extraction of the surface heat flux and wind stress boundary conditions from FNWC analyses, (2) The ascertainment of the availability and suitability of ocean thermal structure data to initialize the model, and (3) the verification procedure aimed at judging model skill in predicting the observed thermal structure relative to climatology alone.

A one-dimensional, bulk turbulent kinetic energy model by Camp (1976) has been tested with atmospheric forcing derived from the Fleet Numerical Weather Central (FNWC) analyses and predictions. A 20-day period in August and a 36-day period in November-December were used at six locations expected to have initial and verifying bathythermographs. Except for the solar radiation field, the six-hourly values of the atmospheric forcing that are stored by FNWC seemed to be adequate to define the synoptic scale forcing. Significant changes in the mixed layer depth and temperature were predicted on diurnal and synoptic time scales. Whereas, the observed temperature and depth changes were generally similar to predicted values, there was considerable temporal variability in the observations. Thus selection of a representative initial BT was found to be important. These results suggest that upper ocean thermal profiles might be forecast in real-time at locations where advective effects are not dominant.

Conference
Presentations:

R. W. Garwood, "The Spring Retreat of the Ocean Surface Boundary Layer", presented at the AGU Annual Meeting, San Francisco, December 1977. Abstract in Tran. AGU, 58 (12).

N. T. Camp, R. L. Elsberry, "Role of Strong Atmospheric Forcing Events in Modeling of Oceanic Thermal Structure", presented at AGU Fall Meeting, Abstract in EOS, 57, p. 937.

Publications:

R. W. Garwood, "An Oceanic Mixed Layer Model Capable of Simulating Cyclic States". Journal of Physical Oceanography-Vol. 7, May 1977.

R. W. Garwood, N. T. Camp, "Comments on Climatological Numerical Models of the Surface Mixed Layer of the Ocean", Journal of Physical Oceanography, Vol. 7, May 1977.

R. W. Garwood, "A Method for the Nondimensional Comparison of Mixed Layer Models", Ocean Modeling, Vol 6., June 1977.

R. L. Elsberry, R. W. Garwood, "Sea Surface Temperature Anomalies Generated by Atmospheric Forcing", submitted to Bull. Am. Soc., November 1977.

N. T. Camp, R. L. Elsberry, "Ocean Thermal Response to Strong Atmospheric Forcing. II. Simulations with Mixed Layer Models", submitted to Journal Physical Oceanography, 1977.

Thesis Directed:

W. F. Johnson, "Upper Ocean Thermal Structure Forecast Evaluation of a Model Using Atmospheric Forcing Functions", Master's Thesis, 1977.

S. D. Raney, "Characteristics of Atmospheric Forcing Functions", Master's Thesis, 1977.

Title: Tropical Cyclone Studies

Investigator: R. L. Elsberry, Associate Professor of Meteorology

Sponsor: Naval Environmental Prediction Research Facility

Objective: This research is part of a continuing, cooperative effort to develop an operational, dynamic forecast model for typhoons in the North Pacific region.

Summary: Development of an operational tropical cyclone prediction model has been initiated in cooperation with other Navy research and operational units. A relatively simple three-layer model with coarse resolution that had been developed at NPS is serving as the quasi-operational test model at Fleet Numerical Weather Central (FNWC). A series of 41 cases from the 1975 typhoon season suggests that the most likely source of forecast error is due to data deficiencies in the Western Pacific region (Elsberry, 1977). Initial wind directions in the operationally analyzed fields used to drive the tropical cyclone model were compared with the Joint Typhoon Warning Center analyses that had available wind direction estimates based on the Defense Meteorological Satellite Program (DMSP) photographs. It was concluded the inclusion of the new data source of DMSP direction estimates should improve the operational analysis fields. A method to track the storm center objectively based on the streamfunction minimum was developed and implemented at FNWC. A technique of adjusting the initial wind field in the region of the typhoon to improve the short-term forecasts of tropical cyclone motion was shown to improve significantly the model forecasts. This adjustment technique was also implemented at FNWC.

Conference Presentation: R. L. Elsberry, "Progress in Tropical Cyclone Forecasting", presented at the Global Extended Range Automated Environmental Prediction System Coordination Meeting, Monterey, 16-17 November 1976.

Publications: G. W. Ley, R. L. Elsberry, "Forecasts of Typhoon Irma Using a Nested-Grid Model", Monthly Weather Review, 104, no. 9, 1154-1161, September 1976.

R. L. Elsberry, R. Perry, D. Hinsman, "Experiments with a Nested-Grid Model for Tropical Cyclone Motion Forecasts", Proceedings Conference on Simulation of Large-Scale Atmospheric Processes, Hamburg, 30 August - 4 September 1976, 162-165.

R. L. Elsberry, J. D. Shewchuk, "Improvement of Baroclinic Typhoon Motion Prediction by Adjustment of the Initial Wind Field", submitted to Monthly Weather Review.

R. L. Elsberry, "Operational Data Tests with a Tropical Cyclone Model", Technical Report, NPS-63Es77031, March 1977, 28 pp.

Thesis Directed: J. D. Shewchuk, "Development of a Biasing Scheme to Improve Initial Dynamical Model Forecasts of Tropical Cyclone Motion", Master's Thesis, June 1977.

S. M. Schrobo, "Numerical Simulation of Flow over Mountains Using a Channeled and Nested-Grid Model", Master's Thesis, September, 1977.

- Title:** Numerical Studies of the Dynamics of Large Scale Anomalies
- Investigator:** R. L. Haney, Associate Professor of Meteorology
- Sponsor:** Office of Naval Research
- Objective:** The objective of this project is to continually develop and improve the 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:** A ten-level primitive equation ocean circulation model has been used to investigate the formation and the evolution of large scale thermal anomalies in the North Pacific Ocean. Three numerical experiments have been completed at the present time. The first experiment made use of idealized anomaly patterns in both the atmosphere and the ocean and thereby provided background information for the interpretation of more complicated experiments using observed data. The two experiments utilizing observed data were for the Fall and Winter of 1971-72, and 1976-77 respectively. The numerical experiments have revealed the effect of anomalous atmospheric wind forcing on the development and evolution of the anomalies. A paper describing these results is in preparation.
- Conference Presentations:** R. L. Haney, "The Effect of Seasonally Varying Atmospheric Forcing on Ocean Circulation". Presented at the Fall Annual Meeting of the A.G.U. 6-10 December 1976, San Francisco, California.
- Publications:** R. L. Haney, R. W. Davies, "The Role of Surface Mixing in the Seasonal Variation of the Ocean Thermal Structure". Journal of Physical Oceanography, 1976, 6, 504-510.
- R. L. Haney, "Modeling Sea-Surface Temperature Anomalies". Ocean Modeling, 4, April 1977.

Title: Mesoscale Atmospheric Events--Antarctica

Investigator: R. J. Renard, Professor of Meteorology

Sponsor: National Science Foundation

Objectives: It is proposed to diagnose mesoscale atmospheric events and their relation to synoptic scale circulations during the Austral summer period over an area surrounding McMurdo, Antarctica, through the analysis of observations taken by weather satellites (visual and infrared), specially-configured aircraft, automatic weather stations and conventional means. The immediate goal is to identify the meso-synoptic scale processes relating to operationally significant weather in the McMurdo area, demonstrating thereby the unique combined use of the aforementioned data sources. Particular attention will be given to katabatic winds, poleward-directed moisture intrusions and regionally-induced thermal/circulation patterns. The longer term goal is to model mesoscale systems associated with significant weather-producing synoptic-scale circulations over a permanent ice/snow covered region of variable elevation and to show the applicability of weather satellite observations, with or without a supporting net of closely spaced stations, to monitor such atmospheric events. Extension of the mesoscale network to areas other than McMurdo and seasons other than summer is dependent on achieving the immediate goals of the proposal. Project extends through May 1980.

Summary: It was fortunate that during the first year of study a former member of the Naval Support Force (NSFA) Antarctica, Lt. R. Godin, was associated with the project. We demonstrated some characteristic synoptic-scale patterns leading to moisture influxes into the Antarctic continent in the McMurdo area, as associated with the peculiar regional aspects of the katabatic wind flow and associated thermal/circulation patterns nearby. DMSP satellite imagery played an important role in the analysis. A thesis resulted from the study. Further, the work above clearly demonstrated the lack of a mesoscale

observation network to accomplish the original project goals. Again, it was fortunate that a Lt. M. Salinas, now with the NSFA group in Antarctica, cooperated in analyzing the data from a prototype automatic weather station (AWS) constructed by Dr. Peterson's group, Stanford University. Working closely with that group the data from the prototype model were carefully evaluated paving the way for Mod II of the AWS which hopefully will be built in time and in quantity to satisfy the original project goals by 1978-79. Again, a documentary of this important phase of the project is now in print.

For the year ahead, concentration on the data from the Airborne Research Data System (ARDS), flown aboard the LC-130R aircraft, will be analyzed for its contribution to building a mesoscale network of the type originally envisioned.

Conference Presentations:

R. J. Renard, "The Prototype Automatic Weather Station Platform, Antarctica 1975-77 (and Errata)", 1977. Presented at "Polar Buoy Meeting", 1 September 1977, IAGA/IAMAP Conference of IUGG, University of Washington, Seattle Washington, 22 August - 3 September, 1977.

Publications:

R. H. Godin, "An Investigation of Synoptic and Associated Mesoscale Patterns Leading to Significant Weather Days at McMurdo, Antarctica", 1977.

M. G. Salinas, "Evaluation of the Sensors on the Prototype Automatic Weather Station Platform in the Antarctica", 1977.

R. J. Renard, M. G. Salinas, "The History, Operation and Performance of an Experimental Automatic Weather Station in Antarctica", Technical Report, NPS-63Rd77101.

Title: Climatology, Observation, Analysis and Prediction of Marine Fog

Investigator: R. J. Renard, Professor of Meteorology

Sponsor: Naval Environmental Prediction Research Facility

Objective: To improve the observation, analysis, climatology and forecasting of marine fog over the ocean and coastal areas.

Summary: The program has been divided into three phases: (a) climatology of marine fog frequencies, (b) observation and diagnosis (analysis) of marine fog, and (c) prognosis (forecasting) of marine fog. To date, mostly the first two phases have been researched; all stages are in various stages of completion.

Phase (a): (1) the climatology of marine fog over the open ocean is considered to be poorly documented, and, with reference to a source widely used by the Navy, the climatology is incorrect. The Naval Postgraduate School (NPS) group has developed a unique approach to deriving marine fog frequencies by synthesizing the information content of the visibility-weather group elements of the marine synoptic report into a computerized specification of the percentage of the synoptic period experiencing fog.

(2) Some 12 years of North Pacific ship-report data (over a half million reports, (30-60N) for the major fog season months of June, July, August and September have been processed to derive credible fog frequencies for each 1x1 degree lat/long square; the data have been further stratified to relate frequencies to wind direction and speed on 10 x 10 degree lat/long squares. As a prototype study, the results have universal application to all ocean areas. The National Climatic Center has already adopted, in part, the approach used here, and will produce a new world-wide marine fog climatology in early 1978.

Phase (b): (1) Until such time that marine-fog areas can be initially specified accurately and completely, the forecasting of marine fog will remain primitive. Conventional ship data, at best sparse, are not adequate. Therefore, weather satellite observations (infra-red (IR) and visual) are being researched as a potential prime source of specifying areas of marine fog.

(2) A statistical approach to identifying critical brightness (visual mode) and temperature (IR mode) count values associated with marine fog appears to have promise. Initially, digital NOAA-2 data for the North Pacific Ocean, July 1973, were computer processed, diagnosed and statistically compared to 3250 ship observations (ground truth) in the quest for a usable empirical scheme. Moreover, work involved the August 1976 period in the eastern North Pacific, for which DMSP and SMS-2 digital data and imagery were processed by the McIDAS computer at the University of Wisconsin in context with conventional data, climatology and numerical statistical parameters in pursuit of an operationally useful approach to initialize areas of marine fog over the open ocean. The results were suggestive but not definitive due to the limited data sample. Work will be extended to a 1978 sample of data.

Phase (c): (1) A successful means of forecasting marine fog by computer methods is, in part, dependent on Phase (a) and (b) above, combined with the identification of marine-fog indices compatible with the model output parameters of Fleet Numerical Weather Central, Monterey, California.

(2) Some 38 Fleet Numerical Weather Central (FNWC) model output parameters and locally developed climatological marine fog frequencies for the North Pacific Ocean, 1-30 July 1976, were statistically processed to derive a multiple linear regression scheme for specifying the distribution of marine fog in a probability mode. The forecast

equations were shown to have skill over climatology and the current FNWC fog forecast scheme, called FTER. Work is continuing on this phase, to include other months, parameters and areas.

Publications:

R. J. Renard, "The Observations, Analysis, Forecasting and Climatology of Marine Fog on the High Seas and Coastal Areas", published in the World Meteorological Organization Technical Conference on the Applications of Marine Meteorology to the High Seas and Coastal Zone Development, Geneva, Switzerland, 22-26 November 1976, Publication Number 454, pp. 211-223.

C. B. Ihli, Jr., R. J. Renard, "The Use of DMSP and SMS-2 Digital Satellite Data for Identifying Marine Fog in the Eastern North Pacific Ocean area, 1977, Technical Report, NPS 63Ih77301, 98 pp., March 1977

B. L. van Orman, R. J. Renard, "Statistical Diagnostic Modeling of Marine Fog Using Model Output Parameters", Technical Report NPS-63Rd77061, 94 pp., June 1977

Title: Numerical Modeling of Air Flow Over Mountains

Investigator: R. T. Williams, Professor of Meteorology

Sponsor: Fleet Numerical Weather Central

Objective: To develop and test methods for properly treating mountains in numerical forecasting models.

Summary: The global prediction model which was developed by Monaco and Williams (1975) was modified to treat airflow over a long mountain range which was oriented in the north-south direction. The solutions were computed with different spatial resolutions and different mountain heights. In general the flow formed a ridge over the mountain range which was damped with height. Much of this research is performed with the variable scale finite element model which was developed by Kelley and Williams (1976). In this barotropic model heating was simulated by the inclusion of sources of mass in the continuity equation. This allowed a crude simulation of a tropical cyclone. The variable element size worked well in the simulations.

Publications: J. L. Hayes and R. T. Williams, "Numerical Simulation of Air Flow over Mountains", Technical Report, NPS63Wu7741, 68 pp., April 1977.

Title: Global Modeling

Investigator: R. T. Williams, Professor of Meteorology

Sponsor: Naval Environmental Prediction Research Facility

Objective: To develop and test numerical procedures for global weather prediction.

Summary: The numerical modeling of airflow over a long high mountain range is a critical problem in global weather prediction. In this portion of the research, the global prediction model developed by Monaco and Williams (1975) was modified to treat airflow over a long mountain range which is oriented in the north-south direction. The solutions were computed with different spatial resolutions and different mountain heights. For the mountains considered, there was no tendency for the air to flow around the mountains. Much of this research is reported in Hayes and Williams (1977).

The prediction of tropical cyclones requires very high spatial resolution near the storm center, but this high resolution is not required outside of the storm area. In this portion of the research a finite element model with variable resolution was developed and tested as is reported in Kelley and Williams (1976). In this barotropic model heating was simulated by the inclusion of sources of mass in the continuity equation. This modification of the original model allows a crude simulation of a tropical cyclone. The finite element formulation handles the large gradient region very well.

Dr. T. Rosmond of NEPRF has recently developed a spectral global prediction model. In this portion of the research the model was tested with a growing baroclinic wave. The addition of quasi-geostrophic divergence to the initial conditions gave only a slightly smoother time prediction. However, the technique might be more useful when mountains are present. These results are reported in Lubeck, Rosmond and Williams (1977).

The First GARP Global Experiment (FGGE) is a year-long observational experiment which will begin in January 1979. Williams (1976a) has given a review of the experiment and discussed its potential usefulness to the Navy. Global prediction models often give problems when there is flow directly over one of the poles. In this portion of the research the model developed by Monaco and Williams (1975) was tested with a simple initial flow over the pole. This flow became distorted and eventually the flow became unstable. A modified procedure was tested which gave reasonable, stable integrations. These results were presented in the report by Williams (1976b).

Publications:

R. T. Williams, "FGGE and its Potential Benefits to the Navy", Technical Report, NPS-63Wu-76091, September 1976, 39pp.

R. G. Kelley and R. T. Williams, "A Finite Element Prediction Model with Variable Element Sizes", Technical Report, NPS-63Wu76101, October 1976, 109 pp.

R. T. Williams, "The Polar Problem in a Global Prediction Model", Technical Report, NPS-63Wu-76111, November 1976, 29 pp.

J. L. Hayes and R. T. Williams, "Numerical Simulation of Air Flow over Mountains", Technical Report, NPS-63Wu7741, April 1977, 68 pp.

O. M. Lubeck, T. Rosmond and R. T. Williams, "Divergent Initialization Experiments Using a Spectral Model", Technical Report, NPS-63Wu-7791, September 1977, 81 pp.

DEPARTMENT OF AERONAUTICS

The research effort of the Department of Aeronautics remains of broad scope, including projects both directly and indirectly related to aeronautics.

VULNERABILITY OF METALS

Professor Ball has continued his research on the vulnerability of metal and graphite-epoxy aircraft fuel tanks to small arms fire. He also initiated several computer studies of aircraft attrition due to anti-aircraft artillery and surface-to-air missiles and evaluated a methodology for the survivability design of combat aircraft developed by the Vought Corporation.

STABILIZATION OF GLOW DISCHARGE

Professor Biblarz has been involved with research on the stabilization of glow discharges by aerodynamic means for laser applications. He has also extended his work on electrode loss mechanisms in magnetohydrodynamic generators to higher currents.

LASER TECHNOLOGY

Professor Collins has developed a laser flutter monitor which will be installed on the transonic compressor. He has finished measurements on the oscillatory jet and is now starting work in the transonic compressor. Laser doppler velocimeter measurements are now computer controlled.

UNSTEADY FLOW MEASUREMENTS

In the area of unsteady flow measurements, Professors Miller and Schmidt have experimentally determined the aerodynamic lift and pitching moment transfer functions on a high lift circulation controlled airfoil due to an oscillating Coanda sheet blowing over the rounded edge. A theoretical predictive technique is currently under development as a parallel study effort to describe the unsteady aerodynamics on an elliptically shaped airfoil with an oscillating rear stagnation point. Professor Schmidt is continuing investigations in non-linear flight behavior of aircraft, and in particular has identified several candidate aerodynamic traits which can lead to an aircraft limit cycle type of motion, observed at high angles of attack, called wing rock.

GUN LAUNCHED PROJECTILE

Dean (Emeritus) Clauser and Professor Schmidt are developing a compact data acquisition system suitable for installation in a gun launched projectile in order to record and store in a recoverable memory the data information acquired

during the firing phase of the trajectory, including the time when the projectile is inside the gun barrel.

AEROSTATIC AND HYDRODYNAMIC FORCES

Professor Layton has completed a study of the aerostatic and hydrodynamic forces acting on the flexible seals of a captured air bubble surface effect ship using the Department's XR-3 SES testcraft. He is also conducting studies on the computerization of aircraft performance data for use with hand held computers in the aircraft during flight.

TRANSONIC TURBOMACHINES

Investigations have been continued by Professor Platzer into the theoretical analysis of oscillating flows in transonic turbomachines and he has obtained a complete solution for slowly oscillating finite and infinite flat plate cascades in supersonic flow. He has also continued the computation of non-linear thickness effects upon supersonic cascade flutter and has completed detailed measurements of the effect of jet oscillation on jet entrainment.

AIRCRAFT FATIGUE PROBLEMS

Professor Lindsey is working on aircraft fatigue problems directed toward fleet fatigue life monitoring by aircraft tail number. Current experimental and analytical studies deal with improving the accuracy of life predictions by tailoring the calculation models to make the best use of in-flight data that will soon be obtained via microprocessor monitors. These instruments are currently being developed at the Naval Air Development Center from preliminary work done under Professor Lindsey's direction at NPS.

AERODYNAMICS OF COMPRESSOR ROTORS

"Synchronized sampling" of fast response sensors was developed as a technique to measure the aerodynamics of compressor rotors using stationary instrumentation by Professor Shreeve. Transonic rotor case wall pressure signatures were obtained and rotor exit velocity vector measurements are to follow. In the turbine program, Professor Shreeve has analytically verified test rig measurements of turbine blade row losses, and the rig operation was extended to 200 horsepower.

AIR QUALITY EFFECTS

Professor Netzer has been active in the modeling of emission levels and air quality effects from Naval Air Station

aircraft operations and test cells. A subscale test cell is also being used to optimize augmentor designs and validate test cell modeling efforts. He is also active in the modeling and combustion diagnostics of solid fuel ramjets.

HYDRODYNAMIC STABILITY OF FLOW

In connection with his research on the hydrodynamic stability of flows in pipes, Professor Gawain has developed a new analysis which successfully accounts for the experimentally observed instability of pipe flow; no similar theoretical solution for this fundamental case has hitherto been known. In collaboration with experimental work conducted by Professor Netzer, he has also begun analytical studies of the performance of the dual chamber rocket.

Title: Failure at Connections in Composite Materials

Investigator: R. E. Ball, Associate Professor of Aeronautics

Sponsor: Naval Air Systems Command

Objective: To determine experimentally and theoretically the failure mechanisms and carrying capacity of graphite-epoxy composite fuel tank walls attached to ribs and spars with metal fasteners and subjected to hydraulic ram loading.

Summary: This is the first phase in a program to determine the failure of graphite-epoxy composite structures in aircraft fuel tanks. Two studies have been completed during this reporting period. In one, the relationship between the bending moment and the through-plane shear force in the vicinity of a mechanical fastener at failure was determined experimentally. The connection was similar to the connection planned for use on the F-18 composite wing and the AV-8B composite wing and fuselage fuel tanks. Two analyses were also made. In the second study, the reduction in ultimate bending moment due to an internal delamination was determined experimentally for several locations of the delamination and for two sizes of delaminations. The extent of damage to the F-18 simulated composite wing box due to small arms fire tests conducted by the Naval Weapons Center, was also briefly examined. Continued work on both these efforts is planned for the coming year.

Publications: None.

Thesis Directed: R. G. Sprigg, "An Experimental Study to Determine the Reduction in Ultimate Bending Moment of a Composite Plate Due to an Internal Delamination", Master's Thesis, December 1977.

R. N. Freedman, "A Study of Pull-Through Failures of Mechanically Fastened Joints", Master's Thesis, September 1977.

Title: Aircraft Fuel Tank Response to Small Arms Fire and Missile Fragments (Hydraulic Ram)

Investigator: R. E. Ball, Associate Professor of Aeronautics

Sponsor: Naval Weapons Center

Objective: To continue the development of analytical models and computer programs that adequately describe the fuel tank response to the penetrator, and to develop a manual containing fuel tank damage estimates that can be used by a fuel tank designer.

Summary: Metal aircraft fuel tanks that are subjected to ballistic impact and penetration by small arms fire and missile fragments can be severely damaged, with large petalling of the tank walls occurring at the entrance and exit points of the projectile. The damage mechanism, called hydraulic ram, is a very high pressure wave in the fuel caused by the passage of a ballistic penetrator through the fuel. An analytical and experimental hydraulic ram program has been in existence at the Naval Postgraduate School (NPS) for over four years. Fluid pressures and wall strains have been experimentally measured and analytically predicted at NPS for rectangular tanks with aluminum walls.

In this reporting period, the piston theory that accounts for the fluid-structure interaction was replaced with a finite difference routine that computes the pressure throughout the fluid volume due to tank wall motion. This routine was incorporated into the structural response code SATANS and comparisons of tank wall motion were made with the results from a study by California Research Technology. Good agreement between the results was noted. With regard to the second objective, a format for the fuel tank damage manual was proposed. Numerical results for the manual will be obtained in the coming year.

Conference Presentations:

W. J. Stronge, "Transient Response of Fluid-Backed Plates - A Comparison of Piston Theory and NASTRAN Solutions", with R. E. Ball, presented at the 15th Midwestern Mechanics Conference, March 23-25, 1977, University of Illinois, Chicago Circle, Conference Proceedings contains only abstracts.

Title: Ballistic Damage to Advanced Composite Material

Investigator: M. H. Bank, II, Assistant Professor of Aeronautics

Sponsor: Naval Air Systems Command

Objective: To find a suitable non-destructive method of inspecting graphite-epoxy laminated composite materials to determine the extent of the damaged area produced by ballistic impact, and to determine the "equivalent hole size" which will account for this damaged area to allow panel strength predictions.

Summary: This test series showed that x-ray inspection can be used to delineate the extent of damaged areas, especially if a radio-opaque dye is introduced into the damaged area to enhance contrast. Damaged area size varies with impact velocity, with smaller damaged areas resulting from lower velocities. An investigation of strain concentration factors around a hole in graphite-epoxy specimens at elevated temperatures showed that strain concentration factors were temperature dependent for the materials and lay-ups tested, with elevated temperature values of strain concentration factors reaching 120% of the room temperature values in some cases.

Publications: None.

Thesis Directed: G. A. Eaton, "Ballistic Damage of Graphite-Epoxy Plates". Master's Thesis, June 1977.

J. F. Chicoine, "Temperature Dependence of Stress Concentration Factors in Composite Materials". Master's Thesis, June 1977.

Title: Fiber Composite Structures Inspection Program

Investigator: M. H. Bank, II, Assistant Professor of Aeronautics

Sponsor: Naval Weapons Center

Objective: To inspect samples of graphite-epoxy material for internal flaws or damage.

Summary: Specimens provided by NWC China Lake were inspected using ultrasonic and liquid-crystal-thermal techniques.

Publications: None.

- Title:** Aerodynamic Stabilization of Gaseous Discharges
- Investigator:** Oscar Biblarz, Associate Professor of Aeronautics
- Sponsor:** Foundation Research Program (6.2)
- Objective:** The main objective is to define practical aerodynamic means for stabilizing discharges for electrical laser. Other applications in cold plasma chemistry are also envisaged. A particular objective was to become acquainted with supersonic flow and vortex flows as stabilizing agents and, furthermore, to examine the theoretical aspects of aerodynamic stabilization. This is one part of a continuing project.
- Summary:** The work undertaken complements the activities in turbulence stabilization which have been underway at the Naval Postgraduate School. First-hand experience with supersonic flow and vortex-flow equipment was obtained. The problem of analyzing the effects of turbulence in a discharge was given some perspective, and the classical or Schottky solution for the positive column in a flow discharge was re-examined in the light of the stability problem. The program will continue with more studies with turbulence.
- Conference Presentations:** O. Biblarz, E. Wassertrom and Y. Crispin, "Stabilization of Flow Discharges by Supersonic Flows", presentation at the 30th Annual Gaseous Electronics Conference, 18-21 Oct. 1977, Palo Alto, CA, (abstract in conference record and in bulletin of the American Physical Society.
- Publications:** O. Biblarz, J. L. Barto, and H. A. Post, "Gas Dynamic Effects on Diffuse Electrical Discharges in Air", Israel Journal of Technology, Vol. 15, No. 1-2.
- O. Biblarz, J. L. Barto, and H. A. Post, "Gas Dynamic Effects of Diffuse Electrical Discharges in Air", 19th Israel Annual Conference on Aviation and Astronautics, Tel Aviv-Haifa, March 2-3, 1977, (full paper on

conference record).

Y. Khait and O. Biblarz, "Influence of Turbulence on diffuse Electrical Gas Discharges Under Moderate Pressures". Paper submitted to the Journal of Applied Physics .

O. Biblarz, "Aerodynamic Stabilization of Gaseous Discharges", Technical Report, NPS-67Bi77111, 1 November 1977.

Title: Electrode Loss Mechanisms in Magneto-hydrodynamic (MHD) Generators

Investigator: O. Biblarz, Professor of Aeronautics

Sponsor: Air Force Office of Scientific Research

Objective: The principal objective is to define the nature and extent of voltage drops in MHD generators. In the vicinity of electrodes, the sheath and the boundary layer contribute to the voltage loss. The anode has been studied in some detail in a flow of frozen charge composition. This is a continuing project.

Summary: The sheath voltage drop with and without a magnetic field and with and without Joule heating has been calculated as a function of current. Also a simplified technique for the calculation of the boundary layer contribution has been developed. A new numerical technique (the Newton-Raphson method) has been introduced to overcome numerical instability problems. The program will continue with a study of non-frozen composition.

Publications: R. C. Dolson, O. Biblarz, "Analysis of the Voltage Drop Arising from a Collision Dominated Sheath", Journal of Applied Physics, Vol. 47, No. 12, December 1976, pp 5280-5287.

R. C. Dolson, O. Biblarz, "A Simplified Technique for Determining the Boundary Layer Loss in MHD Generators", Energy Conversion, Vol. 16, pp 205-211, 1977.

Title: Stability of Parallel Flows

Investigator: T. H. Gawain, Professor of Aeronautics

Sponsor: Un-sponsored

Objective: There have been long standing discrepancies between the experimentally observed instability of parallel flows, especially pipe flow, and the predictions of classical theory. Consequently, this investigator has undertaken a radical reformulation and generalization of the problem, starting from first principles, and continuing on a long term basis. The objective is to develop an improved theoretical model which is in better agreement with experimental observations. This research is basic rather than applied in nature.

Summary: The research at NPS has now verified that certain three-dimensional effects not considered in the classical theories, namely, streamwise variation in perturbation amplitude, do generate significant instabilities. In particular, specific instabilities of this kind have been found for pipe flow; this is a basic new result in the field. Moreover, our research has also disclosed that the customary methods of imposing the boundary conditions at the pipe axis are not entirely adequate, and the implications of this development are now being explored.

Publications: T. H. Gawain, "On the Stability of Two Basic Parallel Flows: Analysis, Progress Report and Proposal for Further Research", Technical Report, NPS-67Gn77061, June 1977.

Title: Aircraft Sensor Requirements

Investigator: D. M. Layton, Associate Professor of Aeronautics

Sponsor: Naval Air Systems Command

Objective: A study to determine the requirements and availability of air data sensors for Naval aircraft by the end of the 20th Century.

Summary: Several new state-of-the-art, or near state-of-the-art sensors were identified that would meet the projected requirements for both high speed and low speed Naval aircraft of the future. Some of these sensors do not, in their projected state, meet the accuracy needs, but software is proposed to make these sensors usable. These include sensors to detect pressure, temperature, velocity, acceleration, and displacement.

Publications: None.

Thesis Directed: LT R. D. Neil, "A State-of-the-Art Assessment of Air Data Sensors for Naval Aircraft", Master's Thesis, September 1977.

Title: Surface Effect Ship Seal Loads Study

Investigator: D. M. Layton, Associate Professor of Aeronautics

Sponsor: Naval Sea Systems Command

Objective: To determine the seal loads on a Surface Effect Ship under various conditions of loading and trim (Center of Gravity variations).

Summary: The aerostatic loads on the rear seal of the Surface Effect Ship Testcraft had previously been determined and reported. Gross loads on both the rear and bow seal were determined in both the Y-axis (lift) and X-axis (drag) directions under several conditions of loading (Testcraft Weight) and trim (Center of Gravity locations). These were individually reported by Thesis copies. Analyses were made of the effects of parameter changes on the Testcraft performance. In general, trim changes must be made to optimize performance with changes in loading.

Publications: D. M. Layton, "Seal Loads of the Surface Effect Ship Testcraft XR-3", has been prepared and is currently being reviewed by the Sponsor prior to publication.

Thesis Directed: LT J. A. Boland, "Lift and Drag Analysis of the Bow Seal of the Surface Effect Ship Testcraft XR-3", Master's Thesis, March 1977.

LT P. A. Alfieri, "Lift and Drag Analysis of the Bow Seal of the Surface Effect Ship Testcraft XR-3", Master's Thesis, September 1977.

Title: Aircraft Fatigue Studies

Investigator: G. H. Lindsey, Associate Professor of Aeronautics

Sponsor: Naval Air Systems Command

Objective: To develop methods of data reduction for the aircraft fatigue monitoring devices currently being prototyped, using microprocessor technology.

Summary: With new aircraft fatigue monitoring instruments under development, it is appropriate to investigate methods whereby the data from them can be used to make damage calculations. Three areas have been studied: (1) Calculation of local stress at the stress riser from far-field strain gage measurements via modified Neuber's equations, (2) Influence of counting method on fatigue life and (3) the relaxation behavior of compressive residual stress at the stress riser. Results have been obtained in all three areas and work in area (3) will be carried further this year.

Publications: G. H. Lindsey, "Microprocessors as Aircraft Fatigue Studies", Technical Report NPS-67Li-77091, September 1977.

G. H. Lindsey, "Microprocessors as Aircraft Fatigue Monitor", Technical Report NPS-67Li-77041, April 1977.

Theses Directed: L. D. Newsome, "Fatigue Crack Propagation Analysis of Aircraft Structures," March 1978.

J. C. Garske, "An Investigation of Methods for Determining Notch Root Stresses from Far Field Strains in Notched Flat Plates," September 1977.

R. A. Bentley, "An Investigation of the Recovery Processes in 7075-T651 Aluminum Responsible for Stress Decay During Dynamic Load Histories," March 1977.

S. J. Atkinson, "A Study of Spectrum Loading and Range - Pair Counting Method Effects in Cumulative Fatigue Damage," February 1977.

Title: Interior Ballistics of Solid Fuel Ramjets

Investigator: D. W. Netzer, Associate Professor of Aeronautics

Sponsor: Naval Weapons Center

Objective: To develop an interior ballistics model and to experimentally determine the effects of operating conditions and motor configuration on performance, flammability limits, and combustion mechanisms. This is a continuing project.

Summary: An experimental and analytical investigation was conducted of the combustion behavior in solid fuel ramjets. The effects of configuration variables on combustion performance were experimentally determined. Air ducting methods were found to affect combustion efficiency through fuel port flow rates, bypass dump momentum and geometry and bypass ratio. Bypass configurations with plexiglas fuel altered the heat transfer mechanisms within the port and decreased combustion efficiency. The computer model was found to be in qualitative agreement with experimental data. Finite rate kinetics and radiative transfer to the fuel surface will be required in the model to obtain more quantitative accuracy. Current experimental work is directed toward the effects of bypass and fuel composition on the amount of unburned carbon and combustion pressure oscillations. Current modeling efforts are directed at using the primary variables of pressure and velocity (rather than stream function - vorticity) and accounting for the aft mixing combustion process.

Publications: D. W. Netzer, "Modeling Solid Fuel Ramjet Combustion", Journal of Spacecraft and Rockets, December 1977.

D. W. Netzer, "Modeling Solid Fuel Ramjet Combustion", 13th JANNAF Combustion Meeting, September 13-17, 1976, Naval Postgraduate School.

C. J. Mady, P. J. Hickey, D. W. Netzer, "Combustion Behavior of Solid Fuel Ramjets", 14th JANNAF Combustion Meeting, August 15-19, 1977, USAF Academy, Colorado Springs, Colorado.

C. J. Mady, P. J. Hickey, D. W. Netzer, "Combustion Behavior of Solid Fuel Ramjets", to be published in Journal of Spacecraft and Rockets.

C. J. Made, P. J. Hickey, D. W. Netzer, "An Investigation of the Combustion Behavior of Solid Fuel Ramjets", Technical Report, NPS-67NT77092, September 1972.

D. W. Netzer, "Model Applications to Solid Fuel Ramjet Combustion", submitted for publication to Journal of Spacecraft and Rockets.

Title: Operating Characteristics of the Dual Chamber Rocket

Investigators: D. W. Netzer, Associate Professor of Aeronautics, T. H. Gawain, Professor of Aeronautics

Sponsor: Naval Weapons Center

Objective: Perform a coordinated experimental and theoretical investigation of the gas dynamic behavior within the dual-chamber configuration to obtain a sufficient data base and understanding which can be used to determine concept feasibility.

Summary: The experimental investigation will systematically examine the effects of configuration variables and operating conditions on the thrust obtainable from the dual-chamber configuration. A simulated axi-symmetric motor will be used for thrust measurements and a 2-D planar configuration will be used for schlieren studies. Initial tests with the axi-symmetric apparatus have been conducted.

The theoretical investigation will consider both simplified models and detailed flow analysis in order to predict the jet boundary and pressure distribution within the booster cavity. The theoretical modeling will be validated with the experimental data.

Publications: None.

Title: Emission Levels and Air Quality Effects From Naval Air Station Aircraft Operations and Test Cells

Investigator: D. W. Netzer, Associate Professor of Aeronautics

Sponsor: Naval Air Propulsion Test 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 and exhaust stack, (b) Experimentally determine the effects of test cell design and engine operating characteristics on pollutant concentrations in the exhaust stack, and (c) Develop an air quality assessment model for U.S. Navy operations. This is a continuing project.

Summary: Elliptic computer codes (stream function-vorticity) have been developed (including plot routines) which can be used to study the flow fields in test cells and exhaust stacks and in the augmentor tube for low thrust operation. Current work with the model includes comparison of predictions with experimental data which have been taken in a 1/8-scale test cell. In addition the computer codes are being improved to handle higher engine thrust conditions. The 1/8-scale test cell is also being used to experimentally determine the effects of augmentor design and location and engine operating conditions (nozzle total temperature, total pressure, and area ratio) on the augmentation ratio and augmentor temperature profile. A nine atmosphere burner has been fabricated and tested and will be employed to study the effects of augmentor/cell design and fuel additives on particulate concentrations.

The U.S. Air Force AQAM program has been modified to handle U.S. Navy operations. The effects of base operations and meteorological conditions on pollutant concentrations

have been studied. Model sensitivity to input data has also been determined. Current work is concerned with experimental determination of the effects of meteorological conditions on the atmospheric dispersion of jet exhausts during take-off.

Publications:

K. I. Weal, G. R. Thompson, D. W. Netzer, "Modification of an Ambient Air Quality Model for Assessment of U.S. Naval Aviation Emittants", Journal of the Air Pollution Control Association, Vol. 28, No. 3, March 1978, pp. 247-248.

G. C. Speakman, J. D. Hayes, D. W. Netzer, "Internal Aerodynamics of Turbojet Test Cells", Technical Report, NPS67Nt76121, December 1977.

H. W. Hewlett, P. J. Hickey, D. W. Netzer, "A Sub-scale Turbojet Test Cell for Design Evaluations and Analytical Model Validation", Technical Report, NPS67Nt77091, September 1977.

G. R. Thompson, D. W. Netzer, "An Ambient Air Quality Model for Assessment of U. S. Naval Aviation Emittants," Technical Report, NPS67Nt76-01, September 1976.

Title: Investigation of Aeroelastic and V/STOL Propulsion Problems

Investigator: M. F. Platzter, Professor of Aeronautics

Sponsor: Naval Air Systems Command

Objective: To perform investigations of the aeroelastic characteristics of transonic turbomachines and to explore the feasibility of advanced V/STOL propulsion concepts.

Summary: A solution for the supersonic passage flow between oscillating cascades of finite blade thickness was obtained using the method of characteristics. Also, detailed measurements of the flow and entrainment characteristics of oscillating and pulsating jets were obtained.

Publications: M. F. Platzter and R. J. Margason, "Prediction Methods for Jet V/STOL Propulsion Aerodynamics", AIAA paper No. 76-932, AIAA Aircraft Systems and Technology Meeting, Dallas, Texas, September 27-29, 1976, Journal of Aircraft, Vol. 15, No. 2, February 1978, pp. 69-77.

A workshop was held under ONR-NASC-AFOSR sponsorship on "Transonic Flow Problems in Turbomachinery", and the proceedings of this workshop were edited. Book published by Hemisphere Publishing Corporation, Washington-London, 1977.

M. F. Platzter, W. R. Chadwick and P. B. Schlein, "On the Analysis of the Aerodynamic and Flutter Characteristics of Transonic Compressor Blades", paper presented at the Symposium on Aeroelasticity in Turbomachines sponsored by IUTAM (International Union for Theoretical and Applied Mechanics), Paris, France, 15-23 October 1976, Revue Francaise de Mecanique Numero Speciale, 1976, pp. 65-72.

M. F. Platzter, J. M. Simmons, and T. C. Smith, "Velocity Measurements in an Oscillating Plane Jet Issuing into a Moving Airstream", Journal of Fluid Mechanics, Vol. 84, Part 1, 1978, pp. 35-53.

M. F. Platzter, J. M. Simmons, and K. Bremhorst,
"In the Entrainment Characteristics of Sub-
sonic Jet", AIAA Journal, Vol. 16, No. 3, pp.
282-284, March 1978.

M. F. Platzter and J. M. Simmons, "A Quasi-
Steady for Incompressible Flow Past Airfoils
with Oscillating Jet Flaps", AIAA Journal, Vol.
16, No. 3, March 1978, pp. 237-241.

Title: Transonic Compressor Investigations

Investigator: R. P. Shreeve, Associate Professor of Aeronautics

Sponsor: Naval Air Systems Command

Objective: The overall objective of this continuing program is 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. Better predictive methods are needed to improve the design and reduce the development time of new jet engines.

Summary: Measurements have been made in a small transonic axial (impulse) compressor stage operating to transonic speeds. In order to determine the flow in the rotor, time-averaged and real-time measurements were made. A combination temperature-pneumatic probe was used downstream of the rotor. Case wall pressure maps and the blade-to-blade impact pressure distribution in the frame of the rotor were obtained using Kulite transducers and "synchronised sampling". An extension of these techniques will be used to map the velocity at the rotor exit to compare with LDV measurements.

Publications: R. P. Shreeve, D. J. Anderson, J. A. Olson, "Velocity Vector Determination from Multiple-Sensor Pneumatic Probe Measurements", AIAA Journal, Vol. 15, No. 11, November 1977.

R. P. Shreeve, J. M. Simmons, K. A. Winters, "Determination of Transonic Compressor Flow Fields by Synchronised Sampling of Stationary Fast Response Transducers". Paper accepted for presentation at A.S.M.E. Gas Turbine Conference, London, April 1978, but subsequently submitted to Symposium on Non-Steady Fluid Dynamics, A.S.M.E. Winter Annual Meeting, December 1978 to meet review deadline.

R. P. Shreeve, F. J. Dodge, W. R. Hawkins, "Probe Measurement of the Flow from the Rotor in a Small Transonic Axial Compressor Stage", paper submitted to AIAA 11th Fluid and Plasma Dynamics Conference, 10-12 July 1978.

R. P. Shreeve, "Measurement Techniques Developed in Tests of a Small Transonic Compressor", paper submitted to AIAA/SAE 14th Joint Propulsion Conference, 25-27 July 1978.

J. M. Simmons, R. P. Shreeve, "Data Acquisition and Analysis Techniques for Measurement of Unsteady Wall Pressures in a Transonic Compressor", Technical Report, NPS-67Sf7701, July 1977.

Thesis Directed: V. J. Larson, "Unsteady Effects on the Measurement of Total Pressure in Rotating Machines". Master's Thesis, September 1977.

Title: Development of a Transonic Compressor Model

Investigator: R. P. Shreeve, Associate Professor of Aeronautics

Sponsor: Naval Air Systems Command

Objective: To develop a small transonic axial air compressor model and establish methods of measuring the performance and flow behavior in small machines.

Summary: A 450 HP, 11 inch diameter axial (impulse) stage was tested at 22,000 R.P.M. Performance map data was obtained and the blade element performance of the rotor was measured using a new combination probe corrected for wall interference effects. Further development and recalibration of the probe were completed for tests at increased Mach numbers.

Publications: None.

Thesis Directed: W. R. Hawkins, "Determination of the Blade Element Performance of a Small Transonic Rotor", Master's Thesis, December 1976.

Title: Small Turbine Blade Row Performance Measurements

Investigator: R. P. Shreeve, Associate Professor of Aeronautics

Sponsor: Un-sponsored

Objective: To determine by test rig measurements the losses occurring in the individual blade rows of a single stage axial transonic turbine, and to evaluate the rig as a possible tool for small turbine injection-cooling experiments.

Summary: A test rig for single stage axial air turbines has been developed for subsonic and supersonic stages producing less than 200 horsepower. The rig is instrumented to allow stator and rotor blade row losses to be calculated separately from measurements of torques, forces, temperatures and pressures. The losses measured for the stator of a transonic turbine were higher, and for the rotor, lower, than predicted. A computer program for the flow through the stage was written and it was found that the measured losses allowed a solution consistent with the measured performance, whereas the predicted loss values did not. Tests are being carried out to measure the effect of axial clearance on the individual blade row losses, to further assess the application of the test rig.

Publications: None.

Thesis Directed: B. C. Boatwright, "Analytical and Experimental Determination of the Characteristics of a Transonic Axial Turbine", Master's Thesis, December, 1976.

DEPARTMENT OF OCEANOGRAPHY

The research program of the Department of Oceanography may be considered under four headings according to the facilities utilized and the sources of data. These headings are: (1) ship programs, (2) coastal field studies, (3) deep ocean data analyses, and (4) special studies.

SHIP PROGRAMS

The investigators in this category make use of the Naval Postgraduate School research vessel ACANIA, a ship supported by the Oceanographer of the Navy; also, some investigations make use of other ships. The first of these studies is that conducted by J. B. Wickham, and S. P. Tucker. Their present observational effort in the continuing study of the California Countercurrent has two parts: (1) A year's continuous monitoring of the core of the countercurrent with an array of moored current meters and sensors of water mass properties, and (2) A broader monthly sensing of the region of the countercurrent with densely spaced continuous profiling of the water mass properties. The region of interest is one of relatively uncluttered sea floor topography on the continental slope and borderland south of Point Sur.

The second ship study is by S. P. Tucker and involves the definition of the optical properties of the waters in a band 30 nautical miles wide and 200 miles long off the California coast between Point Reyes and Point Buchon. The objective is to understand temporal and spatial variations in the optical properties in terms of the ordinary oceanographic observables.

Also, from the ACANIA, E. C. Haderlie carries out a survey of the biology of stone and wood boring organisms in the deeper waters of the Monterey Bay. His purpose is to determine the identity and the vertical and horizontal distribution of these borers as well as their growth rates, settlement times, and destructive effects.

In Chemical Oceanography E. D. Traganza used the ACANIA off the coast of California and participated in an ocean wide cruise on the HAYES in evaluation of biochemical measurements of plankton. These measurements may be used to link chemical biological and acoustic properties of the ocean.

Two other faculty members, namely R. G. Paquette and R. H. Bourke, make use of ice breakers furnished by the U. S. Coast Guard to observe and analyze ocean thermal finestructure near the ice margin in the Chukchi Sea. These studies have acoustical applications. Five mid-summer cruises have been conducted and one is scheduled for 1978.

Physical factors affecting sound propagation in the ocean are being studied under the interdisciplinary project AVAST by Professors Denner and Thornton. Other participants include Professors Davidson (Meteorology), Houlihan (Mechanical Engineering), and Sanders (Physics). Spatial and temporal variability of upper ocean physical parameters are being measured. The manner in which this relates to measured variability in sound propagation is being determined.

COASTAL FIELD STUDIES

The first of these studies, conducted under the direction of E. B. Thornton, concerns the kinematics of breaking waves in the surf zone. It is based on measurements of water particle motion and will provide increased understanding of the energy distribution within the surf zone and associated phenomena. Measurements are being made in Monterey and at La Jolla as part of a national field measurement program.

Dr. Haderlie has been using concrete wharf pilings and other structures on the coast in identifying organisms responsible for deterioration of engineering materials placed in the sea and in determining the general biology and destructive effects of these organisms.

Another study involving coastal field work is a program in marine fog being conducted by D. F. Leipper and G. H. Jung. This project involves relationships between measurements from the R/V ACANIA and regularly obtained meteorological observations at shore stations. The project also undertakes analyses of data gathered at sea by other means such as through aircraft, satellites and commercial and weather ships. The research has been expanded to include segments in the Departments of Meteorology and also Physics and Chemistry. An extensive coordinated survey is being conducted off Southern California in May 1978. (CEWCOM'78)

DEEP OCEAN DATA ANALYSIS AND PREDICTION

This study (modeling upper ocean thermal structure) is conducted by R. W. Garwood in conjunction with R. L. Elsberry and R. L. Haney of the Department of Meteorology. 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 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. A spin-off of this research is an effort to couple an oceanic general circulation model to an oceanic boundary layer model.

Ocean weather data from ocean station NOVEMBER are used by R. H. Bourke in examining the temperature and salinity fluctuations in the upper 250 meters of the water column. A divergent heat budget equation is used to establish the nature of the processes which may be responsible for creating the observed fluctuations. The pulse-like nature of the horizontal thermal advection term will be examined in light of perturbations of the frontal boundary at OWS NOVEMBER by baroclinic Rossby waves.

Ocean observations taken along latitude sections in the Atlantic Ocean during IGY are being used by G. H. Jung as the basis for new geostrophic calculations of mass, salt and heat transported in that ocean. Values of heat carried by these large scale circulations in the North Atlantic are being compared to values transported by various smaller scale phenomena there; South Atlantic Ocean computations are underway. Data for three Pacific Ocean sections are being readied for computation of more recent transport values for comparison with IGY Atlantic data. All ocean transports are being compared to associated climatic anomalies of the data period.

Under the ONR Chair in Arctic Marine Science Professor Denner has been conducting research into Navy related Arctic problems including ice modelling, ambient noise and weapon performance. Dr. Beal, the current occupant of this Chair, is working on Arctic bathymetry and geology.

E. C. Haderlie is working with Stanford University Press in doing final editorial work on a large textbook called Intertidal Invertebrates of the California Coast which will be published in late 1978 or early 1979.

J. J. von Schwind is preparing a detailed and systematic treatise covering the geophysical fluid dynamics of the ocean. This treatise will cover the fundamentals, ocean circulation theories and models, elementary and advanced wave theory, internal waves and tides, and advanced topics.

Warren C. Thompson served as Principal Investigator of two coastal warfare operations studies funded by the Naval Analysis Program (Code 431) of ONR. One, undertaken by LCDR Lawrence W. Nelson, is concerned with acoustic surveillance for offshore oil and gas platforms; the work has been completed and will be published shortly as a classified thesis/technical report. The other, under LT Linda C. Rawlinson, involves

assessment of the effects of 70 environmental parameters on the assault and post-assault stages of amphibious landings; this work is 70% completed. Under a newly funded contract with the State of California, Thompson is also investigating the wave-group phenomenon in ocean waves, with attention to physical properties, space and time distribution, and relationship to synoptic wave events. Entitled "Monterey Bay Ocean Wave Study", the project is a cooperative effort with the Army Corps of Engineers.

Title: Acoustic Variability and Air-Sea Exchange

Investigators: W. W. Denner, Associate Professor of Oceanography
K. L. Davidson, Associate Professor of Meteorology
T. M. Houlihan, Associate Professor of Mechanical Engineering
J. V. Sanders, Associate Professor of Physics
E. B. Thornton, Associate Professor of Oceanography

Sponsor: Foundation Research Program (6.1)

Objective: To better understand the relationship between air-sea interaction and the variability of underwater sound propagating through the upper layers of the ocean.

Summary: This project is an ambitious one preparing to make simultaneous measurements of air-sea exchange, ocean sound velocity microstructure and acoustic variability in the upper layers of the ocean. An experimental setup has been designed for high frequency measurements in shallow water. Preliminary designs have been considered for open ocean measurements. Available equipment has been calibrated and tested, necessary new equipment ordered. Analysis of results obtained in a previous experiment conducted by one of the Investigators (Dr. Denner) off New Zealand has been completed and the results submitted for publication. A correlation between surface heating and mixing and acoustical variability are shown. More carefully controlled experiments such as this effort are clearly justified. This work is essential to understanding the performance of Navy acoustical weapons such as the torpedo and mine.

Publications: W. W. Denner, B. G. Rickard and A. C. Kibblewhite "A temperature Microstructure Probe", Marine Sciences Communications, Vol 3 (1) P 61-91. 1977

W. W. Denner, B. F. Rickard and A. C. Kibblewhite "A Study of Temperature Microstructure in Coastal Waters, submitted to Deep Sea Research.

W. W. Denner, B. F. Richard and A. C. Kibblewhite, "Temperature Microstructure and its Influence Upon the Propagation of Ultrasonic Sound in the Sea", submitted to Deep Sea Research.

Title: Sonic Mixed Layer Experiment

Investigator: W. W. Denner, Associate Professor of Oceanography

Sponsor: Naval Ocean Systems Center

Objective: To study the impact of the mixed layer and change in the mixed layer depth on long range, low frequency sound propagation from a source within or below the mixed layer to a bottom mounted receiver.

Summary: In connection with the ONR Mixed Layer Experiment (MILE) conducted in August and September 1977 at Ocean Station PAPA (50° N, 145° W), Sound Underwater signals (MK61) were deployed from P-3 aircraft in a pattern around station PAPA. The sound waves from these signals were recorded at several locations in the Northeast Pacific. MILE was a multiship, U.S. and Canadian program, to study the response of the mixed layer of the ocean to the passage of a storm.

Received signals from flights before, during and after the passage of a storm are being analyzed to determine the effect of mixed layer changes on the propagation.

This is a continuing project in a cooperative program between NOSC and NPS.

Publications: None.

Title: Arctic Chair in Marine Science

Investigator: W. W. Denner, Associate Professor of Oceanography

Sponsor: Office of Naval Research

Objective: The ONR Chair in Arctic Marine Science was established in January 1977. The purpose of the Chair is to:

- (1) Foster an interest in the Arctic among naval officers
- (2) "Spotlight" the Navy's growing interest in the Arctic
- (3) Conduct research into problems in the Arctic that are of interest to the Navy.
- (4) Translate the growing basic research results into operational Navy Products.

Summary: During the first eight months of the Chair, a series of guest speakers were invited from the Arctic research community. These speakers were experts in various areas of interest to the Navy and were well received by NPS faculty and students. The following is a list of accomplishments under the Chair since its establishment.

1. A numerical sea ice dynamics model has been programmed on the FNWC computer and simulations of the Arctic ice pack have been made using FNWC atmospheric fields.
2. FNWC atmospheric analysis fields (surface pressure and temperature) have been evaluated in the Arctic and found to need further development.
3. The need for more meteorological observations from the Arctic has been established. Based on this result a program of satellite telemetry buoys has been justified and funded.
4. Ambient noise models are being developed for the Arctic.
5. The Navy needs for Arctic science is being reviewed and will be reported to the sponsor.
6. Bathymetric data collected by U.S. nuclear submarines has been analyzed and compared to available charts. Existing charts are found to be in substantial error.

7. A model simulating the performance of the MK48 torpedo under the ice has been developed and will be validated against available data.

All of the above projects involve NPS students for thesis work.

The following scientists have occupied the Chair:

January 1, 1977 - September 30 1977

Dr. Warren Denner, past Director of the Naval Arctic Research Laboratory

October 1, 1977 - September 30, 1978

Dr. Allan Beal, Senior Scientist, Arctic Submarine Laboratory, NOSC, San Diego.

October 1, 1978 - September 30, 1979

Dr. Wilford Weeks, Senior Research Scientist, Snow and Ice Branch, U.S. Army Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire.

Publications:

W. W. Denner, "The Operational Determination of Wind Stress on the Arctic Ice Pack", In: Proceedings of a Symposium on Sea Ice Processes and Models, September 6-9, 1977 Seattle, Washington, Vol 2, P108-119.

Title: Biodeterioration Studies in Monterey Bay

Investigator: E. C. Haderlie, Professor of Oceanography

Sponsor: Naval Facilities Engineering Command

Objective: To continue studies in the shallow water of Monterey Bay on the biodeterioration of engineering materials due to the activities of marine organisms.

Summary: This is a long-term project involving the study of the life cycles and destructive activities of a number of marine organisms. To date we have determined the species involved, their time of settlement, rates of growth, and extent of damage to a number of engineering materials.

Publications: E. C. Haderlie, "Fouling Communities in the Intertidal Zone on Wooden and Concrete Pilings at Monterey, California". Proceedings of the 4th International Congress on Marine Corrosion and Fouling, Centre de Recherches et D'Etudes Oceanographiques, Boulogne, France, pp. 241-251.

E. C. Haderlie, W. Donat. "Wharf Piling Fauna and Flora in Monterey Harbor, California". To be published in the Veliger, Vol. 21, January 1978.

Thesis Directed: W. Donat, "Subtidal Fauna of the Pilings in Monterey Harbor, California", Master's Thesis, 1977

Title: An Evaluation of Existing Data on Primary Organic Film Formation of Significance for OTEC Heat Exchanger Surfaces

Investigator: E. C. Haderlie, Professor of Oceanography

Sponsor: Energy Research and Development Administration

Objective: To make a complete literature survey and to contact all workers in the field to determine the significance of data on primary organic films for heat exchangers to be used in OTEC power plants.

Summary: A technical report has been published which evaluates all the existing data on primary films in the marine environment. A short paper has also been published.

Conference Presentations: E. C. Haderlie, "Primary Biofouling Films and OTEC Heat Exchangers", p. 24-25, In loup, G. E. (ed.) Proceedings of the 4th Annual Conference on Ocean Thermal Conversion. New Orleans, La., 1977

Publications: E. C. Haderlie, "The Nature of Primary Organic Films in the Marine Environment and their Significance for Ocean Thermal Energy Conversion (OTEC) Heat Exchanger Surfaces", Technical Report, NPS-68Hc77021, February 1977.

Title: Biology of Stone and Wood Boring Animals
in Monterey Submarine Canyon and the Deeper
Waters off the Central California Coast

Investigator: E. C. Haderlie, Professor of Oceanography

Sponsor: Office of Naval Research

Objectives: To determine the distribution of stone and
wood borers in the deeper water of Monterey
Bay and offshore, and to determine rates
of destruction of wood and various kinds
of stone in the sea.

Summary: Extensive dredging using R/V/ACANIA has
been carried out to determine the distri-
bution of stone borers in the Bay. Experi-
mental arrays containing samples of stone
and wood have been placed at various depths,
and are recovered periodically to measure
rates of deterioration by marine organisms.
So far 16 species of boring animals have
been found, and rates of penetration into
hard substrates are being monitored.

Publications: None.

Title: Low Wavenumber Ocean Energy Transport

Investigator: Glenn H. Jung, Professor of Oceanography

Sponsor: Office of Naval Research

Objective: This study is to evaluate the role of low wavenumber ocean circulations as possible energy sources for higher wavenumber regions of ocean turbulent temperature spectrum.

Summary: Dynamic calculations are made, using IGY data across several North Atlantic Ocean latitude sections, for ocean heat energy transport estimates. These values are to be compared with energy amounts in higher wavenumber regions of the spectrum as estimated by others. Computer results are available for transports across seven latitude sections and for three shorter sections in the North Atlantic Ocean. A summary of mass transport results and evaluation has been issued as a technical report (April 1977). A paper was presented at the Annual Fall Meeting of the American Geophysical Union and a manuscript is almost complete on heat transport results. Substantial progress has been made toward a salt transport summary.

Publications: W. J. Cummings, "A Description of the General Circulation in the North Atlantic Ocean Based on Mass Transport Values Derived from IGY (1957-58) Temperature and Salinity Data", Technical Report, NPS-68JG77031, March 1977.

Thesis Directed: W. J. Cummings, "A Description of the General Circulation in the North Atlantic Ocean Based on Mass Transport Values Derived from IGY (1957-58) Temperature and Salinity Data", Master's Thesis, March 1977.

Title: Observation, Analysis and Prediction of Marine Fog

Investigators: D. F. Leipper, Professor of Oceanography,
R. J. Renard, Professor of Meteorology

Sponsor: Naval Air Systems Command

Objective: To improve the observation, analysis, forecasting climatology of marine fog over the open ocean and coastal areas.

Summary: This is a long term project involving the study of the physics and microphysics of the marine fog phenomenon. Observations will be made at sea using the NPS oceanographic research vessel ACANIA. These will be analyzed and related to synoptic parameters representing the atmosphere and ocean. A credible marine fog climatology based on maximum information content of synoptic reports will be further developed; an attempt will be made to quantify the visual and infrared satellite imagery to identify marine fog over the open ocean and in the coastal areas. Data from these studies have been and will be arranged in forms suitable for computer processing; development continues on a statistical numerical approach for the analysis and forecasting of marine fog using model output parameters from FNWC and also using weather satellite imagery and conventional data. To date numerous field experiments have been made utilizing ACANIA, and coordinated experiments with ACANIA and various fleet and shore activities have been accomplished. A major field experiment, the Cooperative Experiment in West Coast Oceanography and Meteorology 1978 will be conducted in May of 1978.

Publications: D. A. Backes, D. F. Leipper, "Santa Ana Associated Marine Fog on the Southern California Coast: Forecasting with a Sequential Model", NPS Technical Report NPS-68LR77091. Also Master of Science Thesis, Department of Oceanography, Naval Postgraduate School, September 1977.

D. F. Leipper, "Summary Report NAVAIR Marine Fog Project, 1973-1977", dated January 1978.

Title: Analysis of Fine Structure in the Marginal Sea-Ice Zone

Investigators: R. G. Paquette, Professor of Oceanography, R. H. Bourke, Associate Processor of Oceanography

Sponsor: Arctic Submarine Laboratory, Naval Ocean System Center

Objective: Continue with data reduction, analysis, and reporting of oceanographic data from in and near the marginal sea-ice zone (MIZ) of the Chukchi Sea. Prepare for and carry out oceanographic measurements in the MIZ during summer 1977.

Summary: Oceanograph measurements have been carried out during midsummer in the vicinity of the MIZ of the Chukchi Sea since 1971. These studies are in support of submarine operations under ice. The extreme temperature finestructure observed in these waters is believed to be a results of interleaving of waters having different temperature-salinity relationships brought about by local lateral pressure gradients causing shearing at the convergence or divergence of isopycnals. A zone of ice-melt water, indicated by the 29‰ surface isohaline, is present normally within 50 km of the ice. Lack of appreciable fresh water accumulation at distances well south of the ice margin indicates that the near-surface northward flow of water is faster than the ice recession rate. A major article describing our findings to date is being readied for publication. Analysis of the MIZPAC 77 data is just commencing. A computerized salinity de-spiking routine is being developed and tested. Another cruise to the MIZPAC area is planned for early summer 1978 to investigate conditions when minimal heat is available for finestructure formation.

Conference Presentations: R. H. Bourke, R. G. Paquette, "Atlantic Water on the Chukchi Shelf", Annual Fall Meeting, American Geophysical Union, San Francisco, 6-9 December, 1976, presented plus abstract in: Trans., AGU, 57 (12): 939, 1976.

Publications:

R. H. Bourke, R. G. Paquette, "Atlantic Water on the Chukchi Shelf", Geophysical Research Letters 3 (10); 629-632, October 1976.

R. H. Bourke, R. G. Paquette, "Atlantic Water on the Chukchi Shelf", Technical Report, NPS-68BF76121, December 1976.

W. J. Zuberbuhler, J. A. Roeder, R. G. Paquette, R. H. Bourke, "Oceanography, Mesos-structure, and Currents of the Pacific Marginal Sea-Ice Zone--MIZPAC 75", Technical Report, NPS-58PA76091. September 1976.

R. G. Handlers, R. G. Paquette, R. H. Bourke, "On the Question of Accumulation of Ice-Melt Water South of the Ice in the Chukchi Sea", Technical Report, NPS-68PA77031, March 1977.

R. G. Paquette, R. H. Bourke, "The Oceanographic Cruise of USCGC BURTON ISLAND to the Marginal Sea-Ice Zone of the Chukchi Sea in July-August 1977", Technical Report, NPS-68PA77091, Internal Distribution.

Thesis Directed:

LT. R. G. Handlers, "On the Question of Accumulation of Ice-Melt Water South of the Ice in the Chukchi Sea", Master's Thesis, March 1977.

LCDR W. J. Zuberbuhler, LT. J. A. Roeder, "Oceanography, Mesos-structure, and Currents of the Pacific Marginal Sea-Ice Zone--MIZPAC 75", Master's Thesis, September 1976.

Title: Environmental Factors in Naval Coastal Warfare Operations

Investigator: Warren C. Thompson, Professor of Oceanography

Sponsor: Office of Naval Research

Objective: To evaluate the impact of the coastal marine environment on the following naval inshore warfare operations: (a) the movement of troops and equipment between offshore ships and the beach during the assault and immediate post-assault stages of an amphibious landing, and (b) sea surface and underwater surveillance for offshore oil and gas platforms.

Summary: The two components of the objective involve limitations of the marine environment on coastal warfare operations but are otherwise unrelated; each is being investigated by a naval officer graduate student working under the supervision of the Principal Investigator. The amphibious landing problem, under study by LT Linda Rawlinson, involves assessment of the effects of 70 environmental parameters on personnel and cargo transfer operations between ships offshore and the beach using analysis procedures developed at the Naval Coastal Systems Laboratory (NCSL), Panama City, Florida (ref: "Guide to the Analysis of Environmental Requirements for Naval Coastal Operations"; Dorman, Stewart, and Tolbert; NCSL, Feb 1975). The offshore platform surveillance problem, under investigation by LT Lawrence Nelson, involves underwater acoustical detection of unfriendly surface and subsurface targets in the vicinity of an offshore platform and evaluation of the limitations imposed by the marine environment on surveillance. The results being obtained on both problems are classified.

Publications: None.

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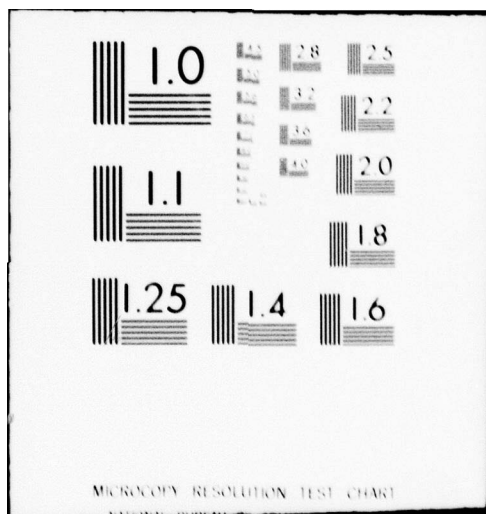
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MICROCOPY RESOLUTION TEST CHART

- Title:** Kinematics of Breaking Waves in the Surf Zone
- Investigator:** Edward B. Thornton, Associate Professor of Oceanography
- Sponsor:** Office of Naval Research
- Objective:** Basic studies are being made on the kinematics of breaking waves within the surf zone in the field. Criterion for incipient breaking are being determined empirically and theoretically. The transformation and attenuation of potential and kinetic energies across the surf zone as a function of incident waves and beach configuration is to be determined.
- Summary:** This research is being accomplished at various field sites for the conditions of spilling, plunging and breaking waves. Waves and orthogonal water particle velocities are measured at various locations within the surf zone. The spectral characteristics and probability density functions for breaking waves and water particle velocities are calculated. Measurements have been made on both sandy beaches and coral reefs. The dynamics of wave transformation are similar and are shown to be highly non-linear. Energy is transferred from the primary spectral wave frequency to higher and lower frequencies in the shoaling and subsequent breaking process. The energy transferred to higher frequencies results in secondary waves at harmonic frequencies and a cascade of energy in a saturation range above the harmonic region. The mean wave frequency inside the coral reef was found to be twice that outside the reef. Separation of wave-induced and turbulent kinetic energies shows that most of the kinetic energy is wave-induced even under breaking waves.
- Publications:** E. B. Thornton, "Rederivation of the Saturation Range in the Frequency Spectrum of Wind Generated Gravity Waves", Journal of Physical Oceanography, Vol. 7, No. 1, January 1977, pp 137-140.

E. B. Thornton, D. P. Richardson, F. L. Bub, J. J. Galvin, "Kinematics of Breaking Waves in the Surf Zone", Proceedings of the 15th Conference on Coastal Engineering, ASCE, 1976, pp 461-476.

E. B. Thornton, W. D. Morris, "Suspended Sediments Measured in the Surf Zone", Proceedings of the Coastal Sediments 77 Conference, ASCE, 1977, pp 655-668.

Thesis Directed:

V. S. Hulstrand, "Kinematics of Breaking Waves in the Surf Zone: Emphasizing Analysis of Identified and Classified Breakers", Master's Thesis, March 1977.

D. J. McReynolds, "Set Up and Set Down Due to a Narrow Frequency Wave Spectrum", Master's Thesis, March 1977.

C. S. Veitia-Garcia, "Bed Shear Stress Coefficient Within the Surf Zone", Master's Thesis, September 1977.

W. D. Morris, "Suspended Sediments Measured in the Surf Zone", Master's Thesis, September, 1977.

A. J. Olsen, "Kinematics of Breaking Waves in the Surf Zone", Master's Thesis, September, 1977.

Title: Biochemical Modelling of Marine Ecosystems
And Acoustic Prediction

Investigator: Eugene D. Traganza, Associate Professor of
Oceanography

Sponsors: Foundation Research Program (6.1),
Office of Naval Research, and
Fleet Numerical Weather Central

Objective: To utilize biochemical measurements of
plankton in models which link them with
environmental and acoustic properties of
the ocean.

Summary: Marine Ecosystems include many kinds of
organisms which affect sound in the sea,
ranging in size from microscopic plankton
in the surface layers to midwater fishes
and ubiquitous whales. Marine organisms
may either be sources of noise which can
mask the sounds of submarines or form dis-
continuities in the physical medium which
intercept and reradiate or "scatter" acous-
tic signals, an effect which can confuse
Naval weapons systems or seriously reduce
the active detection range of sonar. One
hypothesis is that zooplankton estimates
can be useful in predictive models of
"sound scattering" by virtue of their im-
portance in marine ecosystems. The eco-
system is the most suitable level of bio-
logical organization for application of
systems analysis techniques and should
lend itself to acoustic modelling.

A major problem with modelling marine eco-
systems is that understanding has been se-
verely limited by the inadequacy in assessing
zooplankton biomass, production or trophic
level and the consequent lack of a compre-
hensive knowledge of regional and seasonal
relationships with environmental parameters.

The first objectives of this study have been:

- (1) to evaluate the general feasibility of the zooplankton-sound scattering hypothesis.
- (2) to evaluate devices for collecting statistically significant numbers of samples of zooplankton of different sizes.
- (3) to evaluate the potential of making rapid biochemical measurements of zooplankton biomass in samples which may also contain phytoplankton and detritus.
- (4) to compare the seasonal variation of biochemically assayed biomass of size groups with zooplankton biomass predicted by an ecosystem model of the Monterey upwelling region.

Future objectives include (1) addition of biochemical methods which will distinguish which zooplankton are herbivorous and (2) comparison of seasonal/regional sound scattering with modelled and measured variation of phytoplankton, zooplankton and scattering.

A summary of progress so far is as follows:

- (1) A background study produced a "volume reverberation"-zooplankton regression model of the North Atlantic and North Pacific oceans (Traganza and Stewart, 1973; Solomon, 1975; Stewart, 1972) which indicated that regional and seasonal sound scattering can be quantitatively associated with the distribution of zooplankton.
- (2) The background, preliminary results, and the preliminary analytical scheme for relating herbivorous zooplankton to an ecosystem model were reviewed (Traganza and Graham, 1975).
- (3) A carbon method was developed in this study which has proven to be highly successful measure of total biomass of "net zooplankton" and has received a wide international response from other investigators (Traganza, Radney and Graham, 1976; Radney, 1975).

(4) Field and laboratory studies of the adenosine triphosphate (ATP) content of zooplankton indicated that it may be possible to distinguish between living and dead biomass in a sample of zooplankton pending development.

(5) A size sampling in situ net system (SSISNET) was developed and tested in wind tunnel experiments at NPS (Mitchke, 1976).

(6) Initial attempts have been made to simulate seasonal variation of plankton and nutrient levels in the Monterey ecosystem (Pearson, 1975 and Kendrickson, 1976) on the basis of cumulative historical trends of key forcing ~~parameters~~ including light, wind, temperature and depth of the mixed layer.

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New developments: Fifteen stations were occupied along a transect from Gibraltar to Dakar, Africa to Puerto Rico. A newly constructed SSISNET containing two standard 30 cm nets in series was used to collect 50 Meter samples of the 333 to 1800- μ m zooplankton in the upper 350 meters of the water column. The ATP content of these samples showed distinct maxima at the same geographic locations which showed distinct dissolved methane maxima. The ATP and methane maximum did not always occur at exactly the same depth, but both were in or near the thermocline. The results suggest that the biological production of dissolved methane may occur in situ in the pelagic ecosystem. A possible mechanism may be the presence of methane bacteria in the digestive tract of herbivorous zooplankton.

Publications:

E. D. Traganza, and K. J. Graham, "Carbon/Adenosine Triphosphate Ratios in Marine Zooplankton", Deep Sea Research, 24 10 pp, 1977.

E. D. Traganza, J. C. Radney, and K. J. Graham, "A Convenient Method For The Determination of Carbon In Marine Net Zooplankton", Marine Chemistry, Vol 7; 110-119, 1976.

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Theses Directed: D. E. Henrickson, "An Evaluation Of A Computer Simulation Model Of Plankton Dynamics In Monterey Bay", Master's thesis, September 1976.

R. P. Mitche, "Design And Wind Tunnel Test Of A Size Sampling In Situ Net System, (SSISNET)" Master's thesis, September 1976.

R. T. Pearson, "A Computer Simulation Model Of Seasonal Variations In Ocean Production For A Region Of Upwelling", Master's thesis, September 1976.

Marine Chemistry, Vol. 7, 110-117, 1976.
Graham, J. C. and K. J. Redney, "A Comparative Method for the Determination of Carbon-14 in Marine Microorganisms", Deep Sea Research, 24, 19, pp. 1977.

Title: Ocean Color Fronts: Optical and Physical Oceanographic Data Processing and Collecting

Investigator: Stevens P. Tucker, Assistant Professor of Oceanography

Sponsor: National Aeronautics and Space Administration

Objective: This study is to collect and process (jointly with a group from Oregon State University under separate contract) optical and physical oceanographic data as "ground truth" for simultaneous aircraft measurements of ocean color spectra and infra-red sea surface temperature near and in ocean color fronts in the vicinity of Monterey Bay, California.

Summary: Sites were selected for the oceanographic cruises and aircraft overflights on the basis of color fronts evident in existing NASA and U.S. Army Corps of Engineers aerial photographs. Two cruises were made with the Naval Postgraduate School's research vessel ACANIA (2-14 May and 6-16 September 1977) during which stations were for the most part occupied along lines normal to and crossing coastal color fronts either near Pt. Ano Nuevo or near Santa Cruz, California, which were located precisely by the NASA aircraft just prior to cruises. For most days the NASA overflights were made at 1500 ft, while for a few there were U-2 overflights at 65,000 ft. The data collected by NPS included temperature, salinity, oxygen and spectral irradiance as functions of depth in the upper 100 meters plus continuous surface temperature and the standard ship observations such as air temperature, relative humidity, atmospheric pressure, wind speed and direction, Secchi depths, Forel and Munsell colors, etc. About fifty percent of the data have been reduced to tabular form or graphs for a complete ground truth data report to be compiled by the end of March 1978. Analysis of the complete set of data collected by NPS, OSU and NASA will be performed under a continuation of the present contract during FY78.

Publications: None.

Title: Dynamics of Oceans

Investigator: J. J. von Schwind, Associate Professor of Oceanography

Sponsor: Naval Sea Systems Command

Objective: To prepare a detailed and systematic treatise covering the geophysical fluid dynamics of the oceans. When complete, the said treatise will include fundamental and advanced topics and be so structured and written as to be particularly useful to technical persons whose work involves the ocean environment but who may have little or no formal education in theoretical physical oceanography.

Summary: The treatise in its entirety will consist of four major parts: (1) Fundamentals of Geophysical Fluid Dynamics; (2) Ocean circulation Theories and Models; (3) Elementary and Advanced Wave Theories, Internal Waves, Tides; and (4) Advanced Topics in the Fluid Dynamics of the Ocean. At the present time, the subject matter to be covered is found only in a wide variety of sources, ranging from textbooks and technical journals to personal unpublished notes. To date most of the first section "Fundamentals of Geophysical Fluid Dynamics" has been completed.

Publications: None.

- Title:** Metered Studies Of The California Counter-current
- Investigators:** J. B. Wickham, Associate Professor of Oceanography
S. P. Tucker, Associate Professor, Oceanography
- Sponsor:** Foundation Research Program (6.1)
- Objective:** The objective for this study was to gather and test equipment to be used in a large-scale direct metering of currents and water mass properties of The California Counter-current. This effort was a part of continuing studies by these investigators of the California Countercurrent. It extends the previous work by use of direct measurements and continuous recording of currents and continuous recording of water mass properties. The ultimate objective is to document the form and variation of the countercurrent on a variety of time scales.
- Summary:** Foundation support has been used in the following activities:
1. Calibration of 4 Aanderaa current meters in towing tank at Scripps Institution of Oceanography.
 2. Visit to Oregon State University laboratory for demonstrations and discussion about deployment, recovery and maintenance of moored buoys and current meters.
 3. Bench testing of acoustic and timed releases to be used in metering project.
 4. Field testing of seven acoustic releases in water depths between zoo and zoom.
 5. Research into sources of supply and characteristics of equipment to be ordered for metering program and into procedures for mooring operations.
 6. Studies of recent theoretical models of eastern boundary currents, these to serve as the basis for appropriate design of out sensing array (or antenna).
- Publications:** None

DEPARTMENT OF MECHANICAL ENGINEERING

The Department of Mechanical Engineering has a diversity of research interest and talent as is evidenced by a variety of projects. These projects are categorized as follows: (1) materials science, (2) mechanical and component design, (3) heat transfer, (4) structures, vibrations, and solids, (5) hydrodynamics and fluid mechanics, (6) energy conversion, (7) laser technology, and (8) marine propulsion controls.

MATERIALS SCIENCE

The Naval Postgraduate School has a strong commitment in Materials Science, with excellent laboratory facilities and active faculty. Professor Jeff Perkins directs projects in several areas, including (1) materials development for ship silencing applications, (2) failure analysis and performance optimization of lead-acid and silver-zinc submarine batteries, (3) corrosion of sacrificial anode materials used for cathodic protection of ships hulls, (4) velocity effects on corrosion of structural materials in seawater, (5) corrosion of explosively bonded transition joints between aluminum (ships super-structure) and steel (deck) under salt-spray conditions.

Professor Terry R. McNelley is engaged in research in mechanical behavior of materials. Research in aluminum magnesium alloys has focused on thermo-mechanical processing of alloys containing from 11% to 19% magnesium; thus far, work has demonstrated that such materials, as processed, may exhibit strengths up to 90,000 psi at ambient temperatures and with the added feature of superplastic deformation at elevated temperatures. Ballistic characterization of ultra high carbon steels is being conducted at NPS. These steels have been developed by a group at Stanford University and contain from 1.0% to 2.0% carbon; they are processed by rolling to achieve a fine, spheroidized distribution of cementite in a fine-grained ferrite matrix. Work at NPS has focused on the ballistic response of such materials and has demonstrated that these fine-grained materials possess equal or superior ballistic resistance, as rolled, when compared to conventional armor steel. Numerical modeling of materials which exhibit the Protevin-LeChatlier effect has been conducted and the results of this work indicate that the magnitude of the oscillations or serrations in load, characteristic of this effect, are strongly dependent upon such test machine characteristics as stiffness and inertial mass, and upon material characteristics.

MECHANICAL AND COMPONENT DESIGN

The Mechanical Engineering Department is developing a research activity in the area of advanced marine vehicle syn-

thesis and design. A computer program for synthesis of destroyer-type ships has been obtained from the Center for Naval Analysis. The program is being adapted to use with the NPS IBM 360 computer. An evaluation of the vulnerability of the hull of a remotely controlled minesweeper is underway. The work is being accomplished for Minesweeper Squadron 12.

Professor A. J. Perkins and T. McNelley, together with several thesis students, have investigated material problems related to design. The areas of activity include corrosion of the interface between aluminum superstructure and steel decks, velocity effects of corrosion on structural materials in sea water, high damping capacity materials for ship silencing application, high strength-to-weight ratio aluminum-magnesium alloys, ballistic response of ultra-high carbon steels, and failure analysis of lead acid submarine batteries.

Interest and involvement have continued to grow in areas related to design optimization. Professors Kelleher, Marto and Nunn, together with several students, have begun to utilize the new NPS capability in the form of the NASA COPES/CONMIN Codes, to examine power systems and their components. These codes were introduced to NPS by Professor G. Vanderplaats during his tenure last year as a visiting faculty member. Work this year has centered around the minimization of various objective functions, such as volume, pumping power, and cost, related to heat exchangers. In addition, the optimization codes have been applied to develop design criteria for optimal ship propulsion control systems.

HEAT TRANSFER

Heat transfer considerations in the design of engineering systems have taken on new importance with the need to design for energy efficiency. The department has continued to engage in a vigorous heat transfer research program.

Professor Marto has been continuing his investigation into improving the performance of main steam condensers. A feasibility study of heat transfer improvement in marine steam condensers has recently been completed. A comparison was made between a standard condenser design and fifteen test cases where heat transfer was improved using a variety of techniques. Results show that with the present condenser volume, the heat load could be increased significantly or if the heat load is kept constant, the volume could be reduced. The results also indicate that many of the proposed improvement schemes may lead to increased pumping power cost or both.

Under Professor Marto's direction, a test facility for investigating condensation on plain and enhanced tubes has been built. Experimental work to measure the performance of a great many enhanced tubes is continuing. Professor Marto is also continuing the investigation of the heat transfer performance of rotating wickless heat pipes. Recent work has concentrated on examining the performance of internally finned condenser sections and on comparing experimental results on an existing finite element analysis.

Professor Kelleher is continuing his investigation of heat transfer in curved ducts. Experiments which have been conducted so far indicate that the secondary flow generated by the curvature increases the heat transfer in curved ducts over straight ducts of similar cross section. An experimental study of natural convection in thin horizontal liquid layers is also being conducted by Professor Kelleher. The results which have been obtained indicate a correlation between the Prandtl number and the critical Rayleigh number.

Under the leadership of Professor A. Fuhs, a interdisciplinary research team has been conducting heat transfer measurements using towed, instrumented icebergs, about the size of an automobile. Temperature measurements have been made in the seawater boundary layer as well as in the ice itself. A computer code is being developed to predict the trends which have been observed experimentally.

STRUCTURES, VIBRATIONS, AND SOLIDS

Professors G. Cantin and R. E. Newton have continued work on applications of the finite element method (FEM). Professor Cantin has studied dynamic and thermal stresses in ceramic turbine blades and the propagation of non-linear stress waves in solids. He has also supervised development of graphics pre and post-processors for the standard FEM systems SAP IV and ADINA.

Professor Newton has extended and refined previous FEM studies of the collapse of submarine hulls under nuclear attack. He also conducted a state-of-the-art survey on mitigation of underwater nuclear shock by resilient attenuators.

Professor J. Brock has undertaken a wide-ranging series of studies. In the field of elastic buckling, these have included a nonuniform strut, a simple structure consisting of two axially loaded members connected by a beam, and plates exhibiting "snap-through" behavior. He has obtained some new results for limit loads on plates and developed a three-particle model for representing the earth's gravitational field. He has made additions to both theory and applications

of his previously developed extension of the Dunkerly-Mikhlin method for estimating the fundamental frequency of a vibrating system. Brock has also demonstrated close agreement between predicted and measured strains during transient vibration of a cantilever beam.

HYDRODYNAMICS AND FLUID MECHANICS

Hydrodynamics and fluid mechanics are a vital technology for the Navy; the Mechanical Engineering Department has a strong research program in support of Navy needs.

Professor T. Sarpkaya has investigated the problem of cable strumming, periodic flow about bluff bodies, effects of polymers on the lift and drag characteristics of hydrofoils, the vortex breakdown phenomenon in connection with the flight of delta wing aircraft, and the stability of swirling flows. During the past year, Professor Sarpkaya continued his extensive tests on smooth and rough cylinders to predict wave forces on ocean structures. This work attracted world-wide attention and several letters of commendation from the Navy sponsors. Professor Sarpkaya is currently building a new vertical water tunnel to simulate impulsive flow about cylinders and flow about slender bodies at high angles of incidence. This effort parallels the discrete-vortex numerical simulation of the same phenomena carried out by his students under his direction.

Professor C. J. Garrison has continued his research in numerical free-surface hydrodynamics, his most recent effort being devoted to the second-order theory of wave-body interactions.

The research initiated in FY76 by Professor P. Pucci on the subject of optimized ship exhaust eductor has been continued. The purpose of this investigation is to assist NSRDC-Annapolis in the design of exhaust gas stack eductors for shipboard gas turbine propulsion plants. The program involves the design, construction and testing of scale models. The results of the first series of tests have been very encouraging.

Professor T. Houlihan has been a member of an interdisciplinary research team which is studying turbulent transfer processes of momentum, heat and specific humidity in marine fog regimes. A large amount of shipboard experimental data have been obtained and analyzed.

ENERGY CONVERSION

A recent experimental program has been initiated by Professor D. Salinas to understand the thermal-fluid operating

principles of the Fluidyne heat engine. A model engine has been constructed and instrumented, and a simplified computer program has been developed to predict the engine performance. Possible applications include activating and controlling pneumatic relays, monitoring nuclear reactors, and providing irrigation pumping in remote areas.

LASER TECHNOLOGY

The DoD annual budget in high energy lasers is approaching \$200,000,000. High energy lasers will have a significant impact on future military operations. The influence of HEL on military operations will be as great as the advent of nuclear detonations. The Mechanical Engineering Department has an active research program oriented to the many new and challenging laser problems.

Professor T. Houlihan is a member of an interdisciplinary research team measuring propagation of laser beams in the marine atmosphere. His knowledge concerning instrumentation and turbulence contributes to the overall goals of the propagation research.

Compressible flow over a laser turret causes phase distortion in the laser beam. Professor Fuhs has been studying the inviscid flow field surrounding three-dimensional laser turrets to find minimum phase distortion. He is also pursuing the concept of boundary layer control to minimize the effects of turbulence on laser beam propagation.

MARINE PROPULSION CONTROLS

Personnel in the Mechanical Engineering Department have begun a coordinated effort in marine propulsion control studies that will feature both new instructional materials, as well as new laboratory facilities. A new instructional sequence in controls system design features an advanced course in marine propulsion control systems. This course includes studies of optimal control developments with respect to boiler plants, gas turbine engines, controllable, reversible pitch propellers and ship hull dynamics. Analog simulations of steam system characteristics are operated on the NPS Hybrid Computer facility. Likewise, digital simulations of marine gas turbine powerplants are performed using CSMP-II - the IBM simulation language.

Several theses featuring state variable analyses of marine propulsion systems have been completed or are underway. Additionally, a comprehensive design program featuring optimal integral control synthesis has been developed and is operational at the NPS Computer Center. These studies are under

the guidance of Professor T. Houlihan.

While present efforts highlight analytical developments, future endeavors will incorporate experimental findings from a pneumatic simulator that will model the response of a ship-board 1200 boiler system. In addition to laboratory exercises featuring adaptations of classical control techniques, research studies involving multi-variable control analyses and applications of microcomputer systems will be accomplished with the new simulator.

Title: Studies in Applied Mechanics

Investigator: J. E. Brock, Professor of Mechanical Engineering

Sponsor: Foundation Research Program (6.1)

Objective: To develop and submit for publication several studies in the field of Applied Mechanics.

Summary: Several such studies were brought to completion, papers written up and submitted, and of these most have been accepted for publication. Other studies continue. Nine separate investigations are briefly described in the following numbered paragraphs.

(1) This study reports on the very close agreement between theory and experiment for behavior of a uniform cantilever beam excited in flexural vibrations by the sudden release of a lateral load at the tip. An experimentally generated trace of flexural stress vs. time at a point on the beam appears so spiky and grassy that analytical agreement appears unlikely. However, a computer generated graph, employing the complete eigensolution using the Bernoulli-Euler-Navier model of a beam, agrees in fine detail with the experimentally determined graph.

(2) The oblateness of the earth can be represented to a very high degree of accuracy by a simple model consisting of one positive and two negative mass particles located on the polar axis. At points exterior to the earth's surface, the geopotential exerted by this model is almost exactly the same as that exerted by the actual earth. This permits constructing very simple computer programs for the behavior of earth satellites, and, in particular, facilitates a demonstration of the phenomena of advance of perigee point and motion of the line of nodes.

(3) Snap-through behavior of structural elements is important in technology. For example, ship's plating behaves in this fashion, this behavior being called "panting." The phenomenon is difficult to treat analytically. This study treats a particularly simple case so that the student has ready access to a

complete illustrative example.

(4) A simple experiment is described which illustrates plastic bending and permits confirmation of the theoretical moment-curvature relation for a rectangular cross section.

(5) Although elastic buckling of a single strut-like element, with specified end conditions is well understood and relatively easily presented to students, the buckling behavior of structures is not at all well understood and is frequently mishandled in textbooks and in the general literature. Professor R. E. Newton and the writer have previously written on this subject. The present study traces the evolution of a simple structure as a spring-like element is modified so as to introduce a non-linear behavior and shows that quite unexpected phenomena are associated with the modified structure. The analysis is surprisingly difficult.

(6) In a recent publication in the Journal of Applied Mechanics the authors treated a very special problem involving estimating the gravest vibration frequency of a torsional system. The present study shows that the Dunkerley-Mikhlin estimates are immediately at hand for a significant generalization of the problem. It also provides an alternate treatment, using the Hamilton-Cayley theorem and Chebychev polynomials, for the special case treated by the earlier authors.

(7) The literature does not seem to afford a simple example of a complete solution for the Euler buckling of a practically realizable nonuniform strut. This study supplies such an example. The eigenfunctions are modified Gegenbauer polynomials.

(8) Several studies are still under way on the general subject of plastic behavior of structural plates. A general theorem has been formulated which permits obtaining upper bounds without the necessity of specifying or constructing a moment field. This theorem has yielded many of the classical results and has been used to treat the problem of an elliptical

plate with a concentrated load in a general position near the center of the plate. The theorem seems to lend itself to use with a computer optimizing program such as COPES which is implemented at the NPS computer center and it is anticipated that some analyses will be made using this facility.

(9) The writer presented the Dunkerley-Mikhlin formulas in a paper to the Journal of Applied Mechanics. The present paper provides a more elegant derivation based on the idempotency of the filtering matrix. Another physical example is presented illustrating the power of the method.

Publications: John E. Brock, "An experiment on the Vibration of Cantilevers," accepted for publication by IJMEE (International Journal of Mechanical Engineering Education).

John E. Brock, "A Simple Model of Oblate Earth," Accepted for Publication by IJMEE.

John E. Brock, "Simple Snap-through Behavior of a prismatic Bar," Accepted for publication by IJMEE.

John E. Brock, "Buckling of Simple Elastic Structures -- a Complicated and Deceptive Subject," Accepted for publication by IJMEE.

John E. Brock, "Lower Bounds for Gravest Torsional Frequencies," Accepted for publication by the Journal of Applied Mechanics.

John E. Brock, "An Euler Buckling Eigensystem for a Nonprismatic Strut," Submitted to the Journal of Applied Mechanics.

John E. Brock, "An Improved Derivation of the Dunkerley-Mikhlin Formula," The Shock and Vibration Bulletin, No. 47, Part 2, (September 1977), pp. 17-18.

John E. Brock, "A Simple Laboratory Experiment in Plastic Bending," Accepted for publication by IJMEE.

Title: Structural Integrity of Ceramics Components for Gas Turbines

Investigator: G. Cantin, Professor of Mechanical Engineering

Sponsor: Naval Ship Engineering Center

Objective: Improve Stress Analysis techniques used in the design of the components.

Summary: Deficiencies of some three dimensional finite element models have been detected and solutions or remedies rest on the use of more appropriate models. The 20 nodal point brick has been judged sufficient to adequately represent the geometry of the components under study. Some accurate geometrical models have been generated and used for stress analysis with the ADINA computer code. Extensive work has been accomplished to improve graphical representation of the models for data checking as well as the interpretation of the final computer results.

Publications: None.

Thesis Directed: LT Adrian Kibler, "A Finite Element Preprocessor for SAP IV and ADINA", Master's Thesis, September 1977

Title: Nonlinear Stress Strain Analysis

Investigator: G. Cantin, Professor of Mechanical Engineering

Sponsor: Naval Weapons Center

Objective: Explore the use of Finite Element codes to solve stress wave propagation problems.

Summary: Several codes have been used to solve this type of problem with little success so far. The most promising of the codes used at the Naval Postgraduate School, ADINA has given rise to a number of difficulties that have not yet been surmounted. We have experienced severe limitations due to the age of our computer (IBM 360-67), convergence studies undertaken months ago have not yet been completed. This work is continuing.

Publications: G. Cantin, W. J. Stronge, A. E. Kibler, "A Comparison of Various Computer Codes", presented at the ADINA Conference, August 4-5, 1977, Massachusetts Institute of Technology, preprints distributed at the conference the paper will also be included in an M.I.T. report.

Title: Holographic Nondestructive Test NDT

Investigator: A. E. Fuhs, Professor of Mechanical Engineering

Sponsor: Foundation Research Program (6.1)

Objective: To determine the suitability of holographic nondestructive test as a means of locating weld flaws in piping.

Summary: Real time holography is used to obtain fringe patterns. Fringe patterns are interpreted in terms of surface displacement. Flaws in piping welds have anomalous surface displacements. To check sensitivity a finite element computer code is used to predict surface displacement. Pipes with manufactured cracks are test specimens.

The holography system has been assembled. Holograms have been made. Test specimens have been assembled including the following: stainless steel piping with manufactured cracks for correlation with finite element computer code, reject piping from Mare Island shipyard, and aircraft components with known fatigue cracks obtained from NARF Alameda. The finite element computer code is 85 per cent complete.

Publications: A. E. Fuhs, B. W. Hannah and W. L. King, Jr., "Technical Comment on 'Extensions of Dual-Plate Holography Interferometry'," AIAA Journal, pp. 725-727, 1977. (Accepted for publication in AIAA Journal, February 1978)

Title: Shaped Charges For Neutralization of Buried Mines

Investigator: A. E. Fuhs, Professor of Mechanical Engineering

Sponsor: Foundation Research Program (6.2)

Objective: To develop a technique to neutralize buried mines. The technique is to be used by EOD officers and crew.

Summary: Mines may be buried at depths from a few inches to 6-8 feet. The buried mines are detected and located by magnetic means. Error in location may be comparable to buried depth. Some means of placing an explosive charge near the mine is required. A shaped charge can open a large hole through which a charge can be rammed.

An assembly of charges was designed, built, and tested. The assembly of charges consisted of a 2-inch diameter shaped charge with $\frac{1}{2}$ lb HE located on top of a cylinder containing liquid explosive. The cylinder had a coaxial tube which allowed passage of the metal jet from the shaped charge. It was found that the liquid explosive spray lined the hole; it was also found that the cylinder for the liquid explosive was rammed down the hole. As a result of these early tests, a series of tests is being planned using solid explosive located below the shaped charge. A time delay detonator will be used for the solid explosive.

Publication: None

Title: Melting of Ice Subjected to Turbulent Flow of Sea Water

Investigators: A. E. Fuhs, Professor of Mechanical Engineering
R. Stolfi, Associate Professor of National Security Affairs
W. W. Denner, Associate Professor of Oceanography
R. Bourke, Associate Professor of Oceanography
P. Wang, Associate Professor of Mathematics
LT W. Clifford, USN, Graduate Student in Naval Engineering
LT R. Erman, USN, Graduate Student in Naval Engineering
Dr. O. Griffin, Naval Research Laboratory

Sponsor: Foundation Research Program (6.1)

Objective: To determine the rate of regression of fresh-water ice subjected to turbulent flow of sea water. Further, to develop an analytical model which allows prediction of the ice melting rate and heat transfer rates.

Summary: Large blocks of ice with dimensions 16 x 4 x 2 feet are frozen. The ice blocks are instrumented with thermocouples to measure gradients in the thermal boundary layer and in the ice. The blocks are towed at speeds of 0.7 to 1.2 knots. Weights are obtained before and after towing. Measurements are made of the dimensions of the ice block before and after towing.

As of November 28, 1977, three blocks of ice have been towed in Monterey Bay. Nusselt numbers for heat transfer have been obtained. The regression rate has been correlated using the computer code of Dr. Owen Griffin. Ice ripples have been observed and measured. The observations of ice ripples correlate well with existing theories. Temperatures in the base flow region have been determined. A thermal boundary layer profile has been obtained.

Conference

Presentations: Allen E. Fuhs, Warren W. Denner, Matthew Kelleher, William Clifford, Reginald Erman, Russel Stolfi, Robert H. Bourke, and Peter C. C. Wang, "Self Propelled Iceberg." Paper presented by Allen E. Fuhs at the First International Conference on Iceberg Utilization for Fresh Water Production, Weather Modification and Other Applications, Ames, Iowa, October 2-6, 1977. Paper to be published in Proceedings.

Russel Stolfi, Allen Fuhs, Peter Wang, Robert Bourke and Lieutenants Reginald Erman, William Clifford, USN, "Ice Moving in Sea Water." Paper presented by R. Stolfi at the First International Conference on Iceberg Utilization for Fresh Water Production, Weather Modification and Other Applications, Ames, Iowa, October 2-6, 1977. Paper to be published in Proceedings.

Title: Aero-Optics: The Inviscid Density Field Surrounding Laser Turrets

Investigators: A. E. Fuhs, Professor of Mechanical Engineering, G. N. Vanderplaats, Adjunct Professor of Mechanical Engineering

Sponsor: Air Force Weapons Laboratory

Objective: To determine the inviscid flow field over small perturbation laser turrets in subsonic and supersonic flow. The inviscid flow field is used to predict the phase distortion of the laser beam.

Summary: To obtain the flow field, the solution of flow over a wavy wall was developed. Using Fourier series, the flow over any shape turret on a cylindrical fuselage is obtained. Optimum turret shapes are found using the COPES/CONMIN program developed by Dr. G. N. Vanderplaats.

A computer code yielding the optimum turret shape with minimum phase distortion is complete. The computer code has been delivered to the Air Force Weapons Laboratory and is operational on their computer.

Publications: A. E. Fuhs, G. N. Vanderplaats, "Phase Distortion due to Subsonic or Supersonic Flow over a Laser Turret on a Cylindrical Fuselage", Technical Report, NPS-6977002.

A. E. Fuhs, G. N. Vanderplaats, "Phase Distortion due to Subsonic Flow over a Laser Turret on a Cylindrical Fuselage", Submitted to Journal of American Institute of Aeronautics and Astronautics.

G. N. Vanderplaats, A. E. Fuhs, "Phase Distortion due to Supersonic Flow over a Laser Turret on a Cylindrical Fuselage", submitted to Optical Society of America.

G. N. Vanderplaats, A. E. Fuhs, "A Computer Code for Laser Turret Optimization in Subsonic or Supersonic Flow", Technical Report, NPS-6977001.

Title: Study of Digital Electronics ACC

Investigator: T. M. Houlihan, Associate Professor of Mechanical Engineering

Sponsor: Naval Sea Systems Command

Objective: To apply modern control analysis to naval boiler systems.

Summary: A model of the LHA boiler system will be developed in state variable form. Optimal Control analysis will be performed to develop proper control elements for the LHA boiler system simulation.

Publications: None.

Thesis Directed: C. Senanikrom, "State Variable Analysis of a Boiler System", Master's Thesis, March 1978

Title: Heat Transfer Enhancement in Naval Condensers

Investigator: P. J. Marto, Professor of Mechanical Engineering

Sponsor: Naval Sea Systems Command

Objective: The purpose of this study is to evaluate current state-of-the-art heat transfer augmentation techniques in condensers, including the promotion of dropwise condensation on the vapor side, and to conduct heat transfer research and exploratory development in an effort to increase the overall condenser heat transfer coefficient U in a reliable manner.

Summary: A feasibility design study of compact marine condensers has been started. The study uses a digital computer program, titled ORCON1, which was developed by Oak Ridge National Laboratory for the Office of Saline Water. This program permits design modifications to be made to an existing steam condenser, including enhanced heat transfer on both the steam and seawater sides. Using the main condenser of the aircraft carrier KENNEDY as a standard design, fifteen enhanced heat transfer cases have been evaluated.

The construction of an experimental test facility has been completed. Film condensation heat transfer data has been obtained for a single, horizontal, 5/8 OD, 0.049 inch wall, copper-nickel tube. Measured values of U and pressure drop agree with published data. A wide variety of enhanced tubes have been purchased, including three specially corrugated aluminum tubes manufactured by General Atomic Company. Film condensation data will be obtained for these tubes and compared to the smooth tube results. Dropwise condensation will be promoted in an effort to further enhance heat transfer results.

Publications: None.

Thesis Directed: L. Morgan, "Some Experimental Observations of Dropwise Condensation of Steam", Master's Thesis, December 1976.

A. C. Beck, "A Test Facility to Measure Heat Transfer Performance of Advanced Condenser Tubes", Master's Thesis, December 1976. (Also issued as NPS Technical Report, NPS-69Mx77011).

The purpose of this study is to evaluate the current state-of-the-art heat transfer test facility techniques in condenser tubes, including the use of a variety of test tubes, such as the V-tube, the U-tube, the double U-tube, the Z-tube, and the spiral tube, and to determine the effect of tube geometry on heat transfer performance. An effort is made to compare the overall condenser heat transfer coefficient to a reliable value.

A feasibility study of a test facility to measure the heat transfer performance of advanced condenser tubes is presented. The study uses a digital computer program, called COND, which was developed by the Office of Naval Research. This program details design modifications to be made to an existing steam condenser, including the addition of heat transfer tubes on both the steam and seawater sides. Using the program, condenser heat transfer characteristics are compared to a standard design. It is shown that transfer rates have been enhanced.

The construction of an experimental test facility has been completed. This facility includes heat transfer tubes of various geometries, a digital computer program, and a variety of sensors. A wide variety of advanced tubes have been purchased, including three specially constructed of various alloys constructed by General Atomics Company. The condenser data will be analyzed for these tubes and compared to the standard design. It is also anticipated that the data will be used in an effort to further enhance heat transfer rates.

Thesis Directed: J. W. ...
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- Title:** Improving the Heat Transfer Performance of Rotating Heat Pipes
- Investigator:** P. J. Marto, Professor of Mechanical Engineering
- Sponsor:** None.
- Objective:** The purpose of this study is to improve the heat transfer capability of rotating heat pipes by enhancing the condenser heat transfer characteristics.
- Summary:** A rotating heat pipe assembly was tested at rotational speeds of 700, 1400 and 2800 RPM with distilled water as the working fluid. Tests were made using a variety of copper condenser configurations, during film condensation conditions, and one condenser was also promoted for dropwise condensation using n - octadecyl mercaptan in octanoic acid. Measured heat transfer rates were plotted against the saturation temperature of the vapor. In all cases, performance improved with increasing RPM. Dropwise condensation showed substantial improvement in performance relative to film condensation, especially at 700 RPM. The performance of an internally finned cylinder and a truncated-cone were over 100 percent better than the equivalent smooth-wall cylinder. However, smooth-wall cylinders hold promise in a variety of applications due to their relatively low cost of fabrication.
- Conference Presentations:** P. J. Marto, "Augmenting the Condenser Heat Transfer Performance of Rotating Heat Pipes", presented at the Third International Heat Pipe Conference, Palo Alto, May 1978.
- Publications:** None.
- Thesis Directed:** L. L. Wagenseil, "Heat Transfer Performance of Various Rotating Heat Pipes", Master's Thesis, December 1976.
- C. Tankrakul, "Condensation Heat Transfer Inside Rotating Heat Pipes", Master's and Mechanical Engineer's Thesis, June 1977.

Title: Incipient Nucleate Boiling of Freon-113 in Thin Films

Investigator: Paul J. Marto, Professor of Mechanical Engineering

Sponsor: None.

Objective: The purpose of this study is to determine the nucleating characteristics of Freon-113 in thin liquid films so that heat transfer may be more clearly understood.

Summary: Experimental results have been obtained for distilled Freon-113 during nucleate boiling at atmospheric pressure from electrically heated foils of nickel and titanium. The Freon liquid level was adjusted from pool depths near 10mm down to thin films near 0.2mm. The measured heat transfer coefficient increased sharply as level was reduced below 3mm, and this increase was more pronounced at lower heat fluxes. It was further observed that thin films require lower wall superheats and heat fluxes at the onset, or incipience of bubble nucleation. A plausible explanation of these phenomena is given using heterogeneous nucleation theory.

Conference Presentations: P. J. Marto, "Nucleate Boiling in Thin Liquid Films", presentation with pre-print on microfiche at the 16th National Heat Transfer Conference, St. Louis, MO., August 1976.

Publication: P. J. Marto, D. K. MacKenzie, A. D. Rivers, "Nucleate Boiling in Thin Films", American Institute of Chemical Engineers Symposium Series, No. 164, Vol. 73, pp 228-235, 1977.

Thesis Directed: Soehana, "Nucleate Boiling of Freon-113 in Thin Liquid Films", Master's Thesis, December, 1976.

Title: Warm Working of Eutectic and Eutectoid alloys to produce Fine Microstructures

Investigator: T. R. McNelley, Assistant Professor of Mechanical Engineering

Sponsor: Foundation Research Program (6.2)

Objective: Production of fine, spherodized microstructures in Al-Cu and Al-Mg alloys by warm working and evaluation of subsequent mechanical properties, especially ambient temperature properties.

Summary: The objectives of this research were met. Fine two-phase microstructures were produced in both an Al-Cu alloy and several Al-Mg alloys. Subsequent mechanical characterization of these alloys has revealed that excellent mechanical properties can be developed in Aluminum-Magnesium alloys containing 11% to 14% magnesium by weight. Flow-stress values up to 90,000 psi were obtained, for example, in one alloy. This has led to a focusing of this research primarily on the Al-Mg system; some additional practical factors concerning this system are that these alloys are less dense than conventional aluminum alloys, and the alloys being studied also exhibit superplasticity at warm temperatures. Research will now focus on the processing and related mechanical properties of these Al-Mg alloys.

Publications: None.

Theses Directed:

A. L. Cipriani, "An Investigation of the Mechanical Properties of Warm-Rolled Aluminum-17.5 weight percent Copper alloy," Master's Thesis, December 1976

F. G. Ness, "High Strength to Weight Aluminum-18 Weight percent Magnesium alloy through Thermomechanical Processing," Master's Thesis, December 1976

T. L. Glover, "Effects of Thermo Mechanical Processing on Aluminum-Magnesium, Alloys Containing High Weight Percentage Magnesium" Master's Thesis, December 1977

C. P. Bingay, "Microstructural Response of Aluminum-Magnesium Alloys to Thermomechanical Processing," Masters Thesis, December 1977

Local Processing

Foundation Research Project (4-1)

Sponsor:

Objective:

Summary:

The objectives of this research were to: (1) produce two-phase microstructures in Al-Cu and Al-Mg alloys by warm working and (2) evaluate the mechanical properties of these alloys. The Al-Cu alloy was processed by warm working and the Al-Mg alloy was processed by warm working and aging. The mechanical properties of these alloys were evaluated by tensile and compression tests. The results of these tests are presented in this report. The Al-Cu alloy showed a significant increase in strength and ductility after warm working and aging. The Al-Mg alloy showed a significant increase in strength after warm working and aging. The results of these tests are presented in this report.

Publications:

None.

Thesis Director:

A. J. Clifton, "The Effect of Warm Working on the Mechanical Properties of Aluminum-Magnesium Alloys," Masters Thesis, December 1977.

F. G. Rose, "The Effect of Warm Working on the Mechanical Properties of Aluminum-Magnesium Alloys," Masters Thesis, December 1977.

T. J. Glynn, "The Effect of Warm Working on the Mechanical Properties of Aluminum-Magnesium Alloys," Masters Thesis, December 1977.

Title: Ballistic Characterization of Warm-Worked Ultra-High Carbon Steels

Investigator: T. R. McNelley, Associate Professor of Mechanical Engineering

Sponsor: Un-sponsored

Objective: The ballistic characterization of warm-worked ultra high carbon steels with reference to their potential for development/use as armor steels.

Summary: To date, ballistic testing has been accomplished on three ultra-high carbon steels, using a ballistic facility developed at NPS, and the results confirm that these steels, with their very fine, stable ferrite-carbide microstructure, exhibit ballistic characteristics equal or superior to current armor steels. Microscopy and Chenpy V-notch impact testing indicate that these steels possess a high degree of fracture toughness and a low ductile-brittle transition temperature due to the fine microstructure present. Thus, the excellent ballistic performance observed in steels, when impacted by fragment simulating projectiles, would be expected. Research is now focusing on improvements in mechanical properties attainable by controlled alloy treatments, control of processing conditions and control of heat treatment. Further, it is intended to evaluate laminated dual hardness ultra-high carbon steels to make use of the extremely high hardness ($>R_C68$) attainable in these steels by water or oil quenching after austenilization.

Publications: None.

Title: Underwater Shock Mitigation by Resilient Attenuators

Investigator: R. E. Newton, Professor of Mechanical Engineering

Sponsor: Defense Nuclear Agency

Objective: This survey was undertaken at the request of the sponsor to determine the state-of-the-art in underwater nuclear shock mitigation and to develop recommendations for continuing investigations in this area.

Summary: Discussions were held with members of the shock community from organizations including DNA, DINSRDC, NAVSEA, NAVSEC, NRL, NUSC, Lockheed Palo Alto Research Laboratory, Electric Boat, SRI International, and Weidlinger Associates. Relevant studies in the technical literature were reviewed and computer studies were conducted. Results were summarized in a written report together with recommendations for further work on shock mitigation.

Publications: None.

Title: Integrated Cost/Performance Analysis of Marine Propulsion Systems

Investigators: Robert H. Nunn, Associate Professor of Mechanical Engineering, M. D. Kelleher, Associate Professor of Mechanical Engineering

Sponsor: Naval Sea Systems Command

Objective: To develop Integrated Cost/Performance (ICP) methods for application to existing and proposed marine propulsion systems. The signal feature of the method is the simultaneous treatment of cost and performance factors in the design of optimized engineering plants.

Summary: Work during the reporting period has emphasized the implementation of the computer codes COPES (Control Program for Engineering Synthesis and CONMIN (Constrained Minimization) for the purposes of design and analysis of thermal propulsion systems. The development of the COPES/CONMIN package began at the NASA-Ames Research Laboratory and has continued recently at the Naval Postgraduate School. In its present form, this package represents one of the most powerful and comprehensive analysis and design tools available to engineers. In order to provide a vehicle to test and prove the capabilities of the system, an analysis has been developed for the description of a simple crossflow heat exchanger. This subroutine is debugged and running.

Publications: Interim Progress Report, dated 1 November 1977.

Title: Microgalvanic Aspects of Seawater Corrosion
(MASC)

Investigators: J. Perkins, Associate Professor of Materials
Science
K. J. Graham, Chemist, Physics and Chemistry
Department

Sponsor: Foundation Research Program (6.1)

Objective: To determine environmental effects on sea-
water corrosion of structural materials of
Navy interest, with an emphasis on the cor-
relation of electrochemical factors with
corrosion rates and with corrosion product
distribution, micromorphology and base metal
microstructural features.

Summary: Of constant concern to the Navy is the pro-
blem of seawater corrosion of ships' struc-
tural materials. Also, fouling of seawater
piping systems by marine organisms is a
serious problem. Unfortunately, the solutions
to these two coincidental problems are not
always compatible. For example, one method
of control of biological fouling involves the
addition of growth inhibitors such as hypo-
chlorite ion to the seawater prior to entry
into the piping system. Moderate levels of
hypochlorite ion are known to effectively
control biological growth. However, increases
in hypochlorite ion concentration also typi-
cally lead to increases in corrosion rate.
Also, the units which electrochemically produce
the ionic growth inhibitor tend to develop
very high concentrations of hypochlorite near
the generator, which is not diluted until
downstream in the condensers.

This problem is currently being studied
through a combination of electrochemical
techniques, corrosion rate determinations,
and direct microscopic observation techni-
ques. The effects of varying concentra-
tions of inhibitor ion and of other seawater
constituents on the corrosion rates of
various piping materials and marine fastener
materials is being considered. Specimens
are being evaluated potentiostatically in
known environments, with the data from these

experiments being correlated with microscopic observables using scanning electron microscopy and microbeam energy dispersive X-ray spectroscopy.

Work accomplished during this time period has included experiments involving aluminum structural alloys, MILSPEC zinc and developmental aluminum sacrificial anodes, and several copperbased alloys. Current work in concentrating on cupronickel alloys and brasses.

Publications:

J. Perkins, W. H. Leubke, K. J. Graham and J. M. Todd, "Anodic Corrosion of Zinc Alloys in Seawater", Journal of the Electrochemical Society, 124, (1977), 819-826.

J. Perkins, K. J. Graham, G. A. Storm, J. S. Locke and J. R. Cummings, "Effect of Velocity on Corrosion of Galvanic Couples in Seawater", NACE Unit Committee T-7C "Symposium on Marine Corrosion", to be presented at CORROSION/78, NACE, Houston, Texas, March 6-10, 1978.

J. Perkins, J. S. Locke, and K. J. Graham, "Effects of Dissimilar Metal Coupling, Potential Distribution, and Temper condition on Galvanic Corrosion of 5086 Aluminum Alloy in Synthetic Seawater", NPS Technical Report, NPS-69Ps-78-001, January 1978.

- Title:** Mechanisms Affecting the Performance of Lead-Acid Storage Battery Systems
- Investigator:** J. Perkins, Associate Professor of Mechanical Engineering
- Sponsor:** Energy Research and Development Administration (ERDA)
- Objective:** The goal of this research is to develop an understanding of microscopic mechanisms which affect battery capacity as a function of service history.
- Summary:** Microscopic and Microanalytical techniques have been used to characterize the evolution of structure in the positive electrode of lead-acid batteries after various service-like routines. Plates with Pb-Ca and Pb-Sb grid alloys have been compared. Service Routines involving trickle-discharge have been compared with float routines. Battery capacity in test discharges has been correlated with development of a fine substructural network or microgrid within the active material mass of the positive plate. Such a network does not form when batteries are utilized in a float mode.
- Conference Presentations:** J. Perkins, "Observations in an Operating Zinc Pore Electrode", presented at the Electrochemical Society Meeting, Atlanta, October 9-14, 1977. (Presentation and Abstract).
- Publications:** J. Perkins, "Materials and Mechanisms Determining the Performance of Lead-Acid Storage Batteries", Materials Science and Engineering (Invited Paper), 28, 1977, pp 167-199.
- J. Perkins, M. T. Coyle, "Observation of a Substructural Network in the Positive Plates of Lead-Acid Storage Batteries", Journal of the Electrochemical Society 124, 1977, pp. 524-528.
- Thesis Directed:** L. Pokorny, "Study of the Cyclic Performance of Submarine Type Lead-Acid Storage Batteries by Examination of the Positive Plate Structures", Master's Thesis in Mechanical Engineering, September 1976.

M. T. Coyle, "Microstructural Comparison of Positive Float and Trickle Discharge Operations on the Positive Electrodes of Submarine Type Lead-Acid Storage Batteries by Examination of the Positive Plate Structures", Master's Thesis in Mechanical Engineering, September 1976.

LT J. Savory, "SEM Study of Porous Zine Battery Electrode Oxidation After Service-Like Exposures in Potassium Hydroxide Electrolyte", Master's Thesis in Mechanical Engineering, June 1977.

Title: Materials Approaches to Ship Silencing

Investigator: J. Perkins, Associate Professor of Mechanical Engineering

Sponsor: Naval Sea Systems Command

Objective: To consider the potential of high damping alloys for application in shipboard structures and machinery.

Summary: The approach of this program is to experimentally and analytically investigate materials and design factors affecting sound and vibration associated with shipboard structures and machinery. In work to date, Mn-Cu, Ti-Ni, and Cu-Al alloys have been evaluated in the laboratory. These alloys all develop specific damping capacity (SDC) above 50%. Mn-Cu alloys have been found to be sensitive to thermomechanical processing history, but not so much as to make these alloys especially inconvenient or expensive to produce with useful properties. It has been found that Cu-Al alloys are also dependent on the thermal-mechanical processing history, more so than Mn-Cu alloys. It is considered that these alloys, and several others with similar metallurgical characteristics, have legitimate promise for noise reduction due to machinery sources. However, new design procedures should be developed to take full advantage of the much higher damping capacity.

Conference Presentations: J. Perkins, "Shape Memory Effects Associated with Strain-Reversible Martensitic Deformation: Correlation of Structural Features and Mechanical Behavior", presented at International Conference on Martensitic Transformations, May 16-20, 1977, Kiev, United Soviet Socialist Republic, (Full Paper in Proceedings).

Publications: J. Perkins, "ICOMAT 1977 - International Conference Martensitic Transformations, Kiev, Union Soviet Socialist Republic, 16-19 May 1977", Office of Naval Research London Conference Report, ONRL-C-9-77, 11 August 1977.

Thesis Directed: LT. E. Kelly, "Materials Approaches to Ship Silencing: Grain Size Effects on the Damping Capacity of Cu-13.5wt% Al Martensitic Alloys", Master's Thesis in Mechanical Engineering, December 1976.

- Title:** Microscopic Aspects of Marine Corrosion Processes
- Investigator:** J. Perkins, Associate Professor of Mechanical Engineering
- Sponsor:** Office of Naval Research
- Objective:** One of the primary objectives of this work is to study the mode and distribution of corrosion attack on anodic members of galvanic couples in seawater, and to correlate these observations electrochemical measurements and corrosion rate determinations. The program is also concerned with the relationship of corrosion attack to base metal microstructural and compositional factors, and to certain environmental factors, especially relative electrolyte velocity, and solution chemistry.
- Summary:** Extensive use has been made of surface micro-analytical techniques, particularly scanning electron microscopy, to examine corrosion product formation and the morphology of dissolution attack on a large number of marine engineering materials. Alloys in galvanic couples and in single metal exposure have been studied. Correlary electrochemical data has been obtained as well. Two unique apparatus for the study of velocity effects on corrosion have been developed; one of these involves a hydrodynamically designed specimen-carrying foil which circles at up to 200 rpm (about 10 m/sec) in a cylindrical tank, the other is a 1cm² cross-section flow channel with sea-to-sea flow capability at velocities up to 10 m/sec. Both apparatus have been fully instrumented for hydrodynamic, electrochemical, and corrosion rate measurements. Materials studied to date in this program include zinc and aluminum sacrificial anode alloys, copper-based alloys used in seawater piping systems, structural aluminum alloys, and carbon steels.
- Conference Presentations:** J. Perkins, "Effects of Microstructure on Corrosion of Zinc Alloys in Saltwater", presented at the TMS-AIME Annual Meeting, Atlanta, March, 1977 (presentation and abstract).

Publications:

J. Perkins, M. R. Keelean, "Interface Corrosion of Explosively Bonded Aluminum Steel Composites in Seawater Spray Atmospheres", Materials Performance 16, No. 7, July 1977.

J. Perkins, R. A. Bornholdt, "The Corrosion Product Morphology Found on Sacrificial Zinc Anodes", Corrosion Science 17, 377-384, 1977. Also issued as Technical Report, NPS-69PS77-001, Technical Report No. 1 to the Office of Naval Research, NR-036-120, September 1977.

J. Perkins, "Morphology of ZnO Microcrystals", Journal of Crystal Growth 40 (1977) 152-156. Also issued as Technical Report NPS-69PS77002, Technical Report No. 2 to the Office of Naval Research, NR-036-120, October 1977.

J. Perkins, W. H. Luebke, K. J. Graham, J. M. Todd, "Anodic Corrosion of Zinc Alloys in Seawater", Journal of Electrochemical Society 124 (1977) 819-826. Also issued as Technical Report, NPS-69PS77003, Technical Report No. 3 to the Office of Naval Research, ONR-36-120, November 1977.

J. Perkins, K. J. Graham, G. A. Storm, J. S. Locke, J. P. Cummings, "Effect of Velocity on Corrosion of Galvanic Couples in Seawater", to be presented at the NACE Unit Committee T-7C Symposium on "Marine Corrosion" at "Corrosion/78", Houston Texas, March 6-10, 1978; also submitted for publication in Corrosion; also issued as Technical Report, NPS-69PS77004, Technical Report No. 4 to the Office of Naval Research, ONR-036-120, December 1977.

J. Perkins, J. S. Locke, K. J. Graham, "Effects of Dissimilar Metal Coupling, Potential Distribution, and Temper Condition on Galvanic Corrosion of 5086 Aluminum Alloy in Synthetic Seawater", submitted for publication in Corrosion; also issued as Technical Report, NPS-69PS78001, Technical Report No. 5 to the Office of Naval Research, ONR-136-120, January 1978.

Thesis Directed: M. R. Keelean, "Microscopic Investigation of Interface Corrosion of Steel-Aluminum Explosively Bonded Material Exposed to Periodic Seawater Spray", Master's Thesis in Mechanical Engineering, September 1976.

LCDR P. Wright, "SEM Study of the Corrosion of Sacrificial Hull Anodes Under Simulated Ship Service Conditions", Master's Thesis IN Mechanical Engineering, December 1976.

LT. G. A. Storm, "The Effect of Velocity on Corrosion of Galvanic Couples in Seawater", Master's Thesis in Mechanical Engineering, September 1977.

LT. J. Locke, "Effect of Galvanic Coupling, Potential, and Temper Condition on the Mode and Distribution of Corrosion Attack of an Aluminum Alloy in Seawater", Master's Thesis in Mechanical Engineering, September, 1977.

Title: Gas Turbine Exhaust Stack Eductors Systems

Investigator: P. F. Pucci, Professor of Mechanical Engineering

Sponsor: Naval Ship Research and Development Center, Naval Sea Systems Command

Objective: A continuing program to evaluate the performance of gas turbine exhaust stack eductor systems for naval vessels.

Summary: Scale models of existing and proposed gas turbine exhaust stack eductor systems were fabricated and the experimental performance determined using "cold flow" facilities constructed for this purpose. Additional models were built and tested to determine some of the effects of geometry on performance. A "hot flow" facility was designed and construction begun, to be used to test scale models under actual operating temperatures.

Publications: C. P. Ellim, P. F. Pucci, "Model Tests of Multiple Nozzle Exhaust Gas Eductor Systems for Gas Turbine Powered Ships", Technical Report, NPS-69Pc77061, June 1977.

J. P. Harrell, Jr., P. F. Pucci, "Experimentally Determined Effects of Eductor Geometry on the Performance of Exhaust Gas Eductors for Gas Turbine Powered Ships", Technical Report, NPS-69PC77091, September 1977.

C. M. Moss, P. F. Pucci, "Effects of Several Geometric Parameters on the Performance of a Multiple Nozzle Eductor System", Technical Report, NPS-69PC77092, September 1977.

Title: Energy Conversion - Fluidyne

Investigators: D. Salinas, Associate Professor of Mechanical Engineering, R. H. Nunn, Associate Professor of Mechanical Engineering

Sponsor: Harry Diamond Laboratories

Objective: To install and instrument a model Fluidyne engine. To evaluate existing performance prediction models for the Fluidyne engine.

Summary: The existing theoretical models (two) have been carefully reviewed and improvements and corrections have been made where indicated. A technically coherent (but still vastly simplified) model has been developed based upon this review. A series of feasible designs for the experimental set-up have been created and materials and equipment have been ordered for the construction of the experimental apparatus. A rough-out experimental device has been operated.

Publications: None.

Title: Unsteady Flow About Bluff Bodies

Investigator: T. Sarpkaya, Professor of Mechanical Engineering

Sponsor: National Science Foundation

Objective: To determine the forces acting on bluff bodies immersed in time-dependent flows.

Summary: Experiments were conducted in a large U-shaped water tunnel with smooth and rough circular cylinders at very high Reynolds numbers. The lift, drag, and inertia coefficients for rigidly and elastically-mounted cylinders have been determined.

A potential flow model of two-dimensional vortex shedding was developed. The free shear layers which emanate from the sides of the body were represented by discrete vortices through the use of appropriate complex-velocity potential. The analysis was then applied to the prediction of the hydroelastic response of elastically mounted cylinders.

Publications:

T. Sarpkaya, "Hydroelastic Response of Flexibly-Mounted Cylinders in Harmonic Flow", Proceedings of the Offshore Technology Conference, Vol. III, 1977, pp: 155-159.

T. Sarpkaya, "In-Line and Transverse Forces on Cylinders Near a Wall in Oscillatory Flow at High Reynolds Numbers", Proceedings of the Offshore Technology Conference, Vol. III, 1977, pp: 161-166.

T. Sarpkaya, N. J. Collins, S. R. Evans, "Wave Forces on Rough-Walled Cylinders at High Reynolds Numbers", Proceedings of the Offshore Technology Conference, Vol. III, 1977, pp: 175-184.

T. Sarpkaya, "Hydrodynamic Resistance of Roughened Cylinders in Harmonic Flow", Journal of the Royal Institution of Naval Architects, No. 6, November, 1977, pages 363-386.

T. Sarpkaya, "A Theoretical and Experimental Investigation of the Hydroelastic Response of Cylinders in Harmonic Flow", Proceedings of the International Association of Hydraulic Research, Vol I, 1977, pp: 9-17.

T. Sarpkaya, "Transverse Oscillations of a Circular Cylinders in Uniform Flow", Technical Report, NPS-69SL-77071, July 1977.

T. Sarpkaya, "Unidirectional Periodic Flow about Bluff Bodies", Technical Report, NPS-69SL77051, May 1977.

T. Sarpkaya, "An Analytical Investigation of the Transverse Oscillations of a Cylinder in Uniform Flow", Technical Report, NPS-69SL-77052, May 1977.

Title: Cable Strumming - Potential Flow Model and Experiments

Investigator: T. Sarpkaya, Professor of Mechanical Engineering

Sponsor: Civil Engineering Laboratory

Objective: To extend Sarpkaya's potential flow model to circular cylinders oscillating longitudinally and/or transversely to the flow, for the purpose of determining added mass, lift, and drag coefficients for oscillating cylinders. Also, to carry out experiments to validate the analytical model.

Summary: The discrete vortex model has been applied to the determination of the flow characteristics about cylinders undergoing in-line and transverse oscillations. The results have been expressed in terms of a mean drag coefficient, and Fourier averaged drag and inertia coefficients. The results have shown that the mean flow has significant effects on the various coefficients, and that the results of experiments with harmonic oscillations in a fluid otherwise at rest are not applicable to oscillations of a cylinder in a uniform flow.

Publications:

T. Sarpkaya, "Fluid Forces on Oscillating Cylinders", American Society of Civil Engineers Fall Convention Preprint 2921, 1977, pp: 1-29.

T. Sarpkaya, "An Analytical and Experimental Study of the In-Line and Transverse Oscillations of a Circular Cylinder in Uniform Flow", Technical Report, NPS-59SL75051, May 1975.

T. Sarpkaya, "In-Line and Transverse Forces on Oscillating Circular Cylinders", Technical Report, NPS-59SL76071, July 1977.

Thesis Directed:

J. Fry, "In-Line Oscillations of a Circular Cylinder in Uniform Flow", Master's Thesis, December 1975.

D. F. Fortik, "Forced Oscillations of a Cylinder in Uniform Flow", Master's Thesis, June 1976.

P. Raposo, "Transvers Oscillations of a Cylinder in Uniform Flow", Master's Thesis, June 1976.

Z. Demirbilek, "Transverse Oscillations of a Cylinder in Uniform Flow", Master's Thesis and Engineer Degree Thesis, December 1977.

Objective:

Summary:

Publications:

Thesis Directed:

To extend Garpy's potential flow model to a circular cylinder oscillating longitudinally about its axis in a uniform flow. The purpose of determining added mass, lift, and drag coefficients for oscillating cylinders. Also, to carry out experiments to validate the analytical model.

The linear vortex model has been applied to the determination of the flow characteristics about cylinders undergoing in-line and transverse oscillations. The results have been expressed in terms of a mean drag coefficient, and Fourier averaged lift and inertia coefficients. The results show that the mean flow has significant effects on the various coefficients, and that the results of experiments with harmonic oscillations in a fluid otherwise at rest are not applicable to oscillations of a cylinder in a uniform flow.

T. Garpy, "Lift Forces on Oscillating Cylinders", American Society of Civil Engineers (All) Convention Preprints 1971, 1977, pp. 1-23.

T. Garpy, "An Analytical and Experimental Study of the In-line and Transverse Oscillations of a Circular Cylinder in Uniform Flow", Technical Report, NPS-581750-2, May 1975.

T. Garpy, "In-line and Transverse Forces on Oscillating Circular Cylinders", Technical Report, NPS-581750-1, July 1977.

J. Yip, "In-line Oscillations of a Circular Cylinder in Uniform Flow", Master's Thesis, December 1975.

D. F. Forth, "Forced Oscillations of a Cylinder in Uniform Flow", Master's Thesis, June 1976.

Title: Separated Flow About Missiles at High Angles of Attack

Investigator: T. Sarpkaya, Professor of Mechanical Engineering

Sponsor: Naval Air Systems Command

Objective: To develop analytical and experimental methods to predict the vortex rollup on axisymmetric bodies at high angles of attack and to calculate the out-of-plane forces.

Summary: A potential flow model of two-dimensional vortex shedding behind a circular cylinder has been developed. The free shear layers which emanate from the separation points have been represented by discrete vortices through the use of Pohlhausen's separation criteria and the discretization of the vortex sheet. The sensitivity of the calculations to the method of boundary-layer calculation, to intensity of the initial disturbance used to generate the asymmetry, the time step, rate of dissipation of vorticity, and to the method of concentration of the vortex clouds to a single vortex has been examined in great detail. The results have revealed much about the physics of the complex interaction between the vortices and the separation points, the relation between the vortex shedding, drag force, transverse force, rate of change of circulation, Strouhal number, and the oscillations of the front stagnation point and the separation points. The results have been used to calculate the out-of-plane force acting on missiles at high angles of attack through the use of the impulsive-flow analogy.

Publications: T. Sarpkaya, "Comment on the Theoretical Study of Lift-Generated Vortex Wakes to Avoid Rollup", AIAA Journal, Vol 13, No. 12, 1976, pp: 1680-1682.

T. Sarpkaya, "A Theoretical and Experimental Investigation of the Impulsively-Started Flow about a Circular Cylinder", Technical Report, NPS-69SL77091, September 1977.

Title: Computer Synthesis Program for VTOL Aircraft

Investigators: G. N. Vanderplaats, Adjunct Professor of Mechanical Engineering, A. E. Fuhs, Professor of Mechanical Engineering

Sponsor: Naval Ship Research and Development Center

Objective: To develop a computer aided aircraft design program for Class B VTOL aircraft.

Summary: The Aircraft Synthesis Program (ACSYNT) developed at NASA Ames was available and could be modified for VTOL.

The ACSYNT program was modified to allow for VTOL operation. Using the mission specifications, several aircraft were designed.

Publications: G. N. Vanderplaats, "Analysis of Ski Jump Takeoff", submitted to American Institute of Aeronautics and Astronautics.

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