NAVAL POSTGRADUATE SCHOOL
MONTEREY, CALIFORNIA

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A SUMMARY OF THE
NAVAL POSTGRADUATE SCHOOL
RESEARCH PROGRAM

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OCT 1987 TO SEPT 1988

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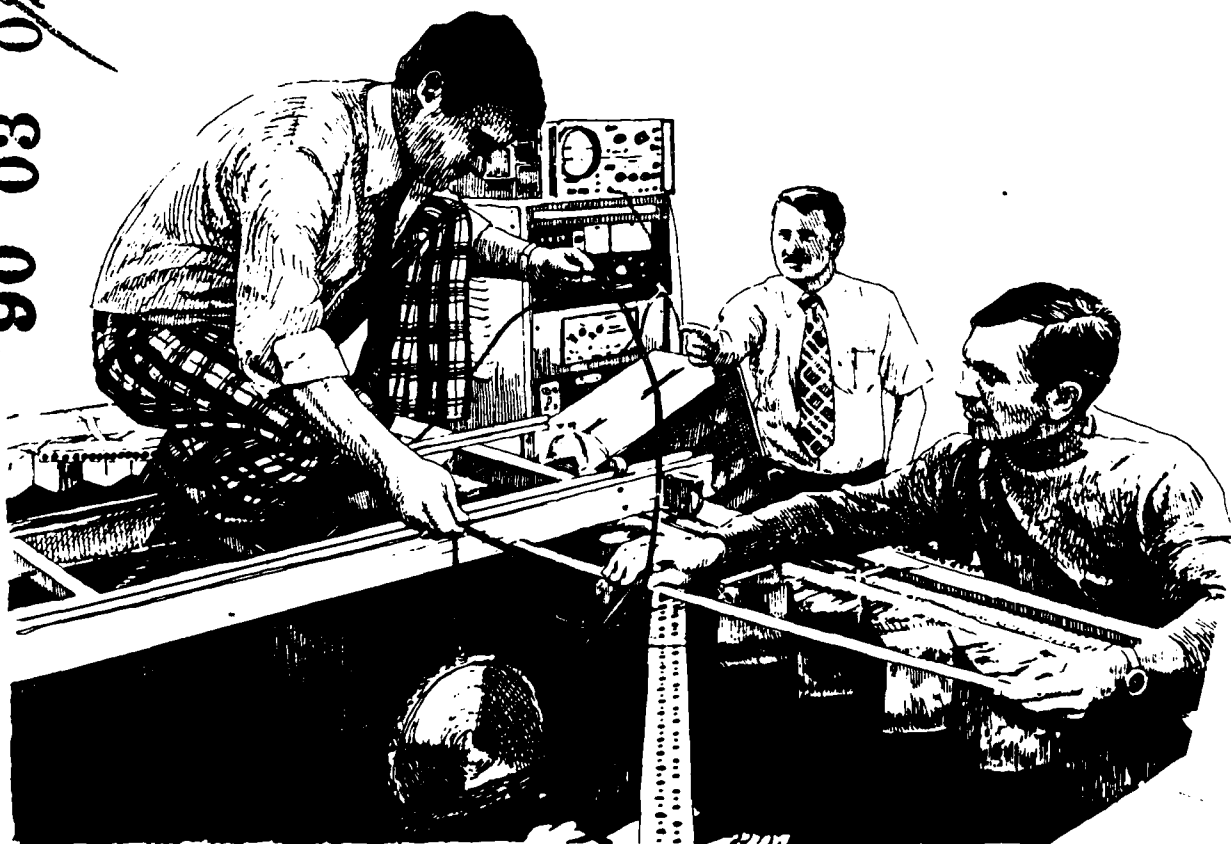
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This report contains 289 summaries of research projects which were carried out under funding of the Naval Postgraduate School Research Program. This research was conducted under the areas of Computer Science, Mathematics, Administrative Sciences, Operations Research, National Security Affairs, Physics, Electrical and Computer Engineering, Meteorology, Aeronautics and Astronautics, Oceanography, and Mechanical Engineering. The Table of Contents identifies specific research topics.

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INTRODUCTION

Faculty research activities at the Naval Postgraduate School during the fiscal year 1988 are summarized in this volume. Most projects also benefit from student contributions from research leading to a thesis in pursuit of an advanced degree.

The importance of research at the Naval Postgraduate School is recognized in the mission statement:

".......to encourage a program of research

in order to sustain academic excellence."

The Naval Postgraduate School provides a unique interface between academic institutions and the U.S. Navy. A substantially larger fraction of the R&D effort at NPS is in the exploratory development category than would be found in most universities. This is a result of student and faculty interests and institutional requirement to educate officers in areas of Navy interest and to support the educational programs with relevant research.

The Naval Postgraduate School wished to acknowledge the efforts of Jodie Steinbach for her eff,rts in preparation of this volume.

Additional information about research activities at NPS can be obtained from the Director of Research Administration, Code 012, Naval Postgraduate School, Monterey, California, 93943.

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

Superintendent
Naval Postgraduate School
Code 012
Research Administration Office
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DEPARTMENT OF COMPUTER SCIENCE

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

ARTIFICIAL INTELLIGENCE AND ROBOTICS

Prof. N.C. Rowe conducted research on path planning for military vehicles including both land vehicles and cruise missiles. He also investigated the use of Prolog for automated tutoring systems and for development of expert systems to solve Navy problems in such areas as air wind training scheduling and vehicle malfunction diagnosis. Prof. M.J. Zyda continued his work on human computer interaction in the context of three-dimensional graphics for command and control workstations, and three-dimensional representations of moving vehicle interactions. He delivered a complete FOG-M missile operator training system to the U.S. Army, including both hardware and software components. Prof. R.B. McGhee conducted research for DARPA in the area of computer vision and motion planning for autonomous off-road vehicles. He also completed a simulation study of mission planning and control for NPS Autonomous Undersea Vehicle currently under construction by the Mechanical Engineering Department. Prof. Y.-J. Lee initiated work in knowledge-based program debugging and investigated the application of such a methodology to F-14 software diagnosis.

MILITARY DATABASE SYSTEMS

Prof. C.T. Wu developed and demonstrated the ARGOS multi-media database system intended as a step toward achievement of the "paperless ship" concept. He also continued research on object-oriented and multi-media database systems for both computer-aided manufacturing and more general applications. Prof. D.K. Hsiao continued his research on multi-lingual, multi-modal database systems and extended the scope of this work to encompass software engineering environments. He also continued his work on temporal database systems with emphasis on weapons applications. In addition, he extended his work on computer security to encompass multilevel access. Prof. V.Y. Lum continued his work on multi-media database systems with special emphasis on the use of natural language text as an access means. Image data was of particular concern in this work. He also provided technology assessment assistance to the STARS program office in the area of database aspects of software engineering.

SOFTWARE ENGINEERING

The primary focus of research on software engineering in this department is on the development of more effective tools and environments for ADA language programming. Toward this end, Prof. Luqi completed the first phase of implementation of PDSL, a rapid prototyping language. This language, developed by Prof. Luqi in previous research, is the first specification and design level prototyping language able to deal with hard real-time constraints, a necessity for using ADA in embedded computer systems. Prof. V. Berzins worked on the theoretical foundations of automatic change combinations and version control, a topic vital to the construction and maintenance of large software systems. In addition, he cooperated with Prof. Luqi in the development of SPEC, a programming language with inheritance features especially suitable for automated merging of software revisions. During this year, he also initiated a study of the use of Petri nets for prototyping and evaluating real-time systems.

TACTICAL COMPUTER SYSTEMS

Prof. U.R. Kodres continued his earlier work on potential application of networks of Transputers to the Aegis system. A key feature of this work is the use of ADA in a multiple processor computer. Experimental work conducted this year shows that a 64 node transputer network can achieve a processing rate in excess of 400 MIPS at the cost of communication overhead amounting to only 30% of the total processor capacity. Prof. H. Amer initiated research relating to mean time to failure in fault-tolerant systems. This work is of potential value in performance analysis for tactical computer systems applied to critical tasks such as aircraft and autonomous vehicle control.

Title:	Automated Merging of Software Revisions
Sponsor:	NPS Research Council
Investigator:	V. Berzins, Associate Professor of Computer Science
Objective:	To develop a theory of combining the features of several versions of a software system and practical algorithms for automatically carrying out this process with a guarantee of correctness and detection of conflicts.

Summary:

The problems of automatically combining specifications of different aspects of a software system was investigated in the context of the specification language Spec. The process of multiple inheritance was identified as an instance where specifications must by combined, and a set of computable rules developed for realizing multiple inheritance in the Spec language. This project has extended earlier work on combining multiple versions of a program which investigated the special case of compatible extensions. While compatible extension can be formulated in terms of a well developed lattice theory that has been used in the formal semantics of programming languages for many years, a treatment of incompatible changes has required an extended mathematical treatment involving lattices embedded in Boolean algebras. Work is underway to determine the properties of higher-order Boolean function spaces needed to characterize the process of correctly combining modifications to program, and to develop and verify algorithms for carrying out this process in practice.

Publications:

V. Berzins and Luqi, "The Semantics of Inheritance in Spec," Technical Report NPS52-87-032, Computer Science Department, Naval Postgraduate School, 1987.

V. Berzins, "Automatically Combining Changes to Programs," Acta Informatica, in progress.

Title: Fundamental   Theory   for   Automatically
                        Combining Changes to Software Systems

Sponsor: Office of Naval Research

Investigator: V. Berzins

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

Summary: The main goal of a research effort in the
                        Software Engineering Laboratory at the Naval
                        Postgraduate School is to enable a higher
                        level   of   computer-aided   design   in   the
                        development of large Ada software systems.
                        We have developed automatable methods for
                        simplifying the design of large software
                        systems and automated software tools which
                        guarantee some aspects of the software are
                        correct by construction or locate particular
                        classes of faults in specifications, designs,
                        and programs. The focus of our work has been
                        to explore automated methods for solving the
                        software combination problem. The software
                        combination problem is the task of combining
                        several independent updates to a software
                        system. Most useful software systems evolve
                        as the result of series of enhancements and
                        repairs which are too extensive to be handled
                        by a single person.   Typically different
                        people are assigned to extend or modify
                        different   aspects   of   a   software   system
                        concurrently, so that the results of their
                        work must be combined when the job is done.
                        We   applied   lattices   and   approximation
                        orderings to the problem, obtaining a set of
                        algorithms   for   pure   extensions   and   some
                        correctness   theorems.   To   extend   these
                        results to include incompatible changes as

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well as pure extensions, we treat such changes in a two-stage process, where the software is decomposed into common parts and incompatible deltas, and the new version is constructed by applying previously developed methods to extending the common part using the appropriate delta.

Publications:

M. Ketabchi and V. Berzins, "Mathematical Model of Composite Objects and its Application for Organizing Efficient Engineering Data Bases," IEEE Transactions on Software Engineering, pp. 71-84, January, 1988.

R. Hemdon, V. Berzins, "The Realizable Benefits of a Language Prototyping Language," IEEE Transactions on Software Engineering, pp. 803-809, June, 1988.

Luqi, V. Berzins,"Rapidly Prototyping Real-Time Systems," IEEE Software, pp. 25-38 September, 1988.

Luqi, V. Berzins, and R. Yeh, "A Prototyping Language for Real Time Software," IEEE Transactions on Software Engineering, pp. 1409-1423, October, 1988.

Conference
Papers:

V. Berzins, "Object-Oriented Techniques Based on Specifications," COMPSAC, Chicago, Illinois, pp. 437-438, October 5-7, 1988.

V. Berzins, "The Design of Software Interfaces in Spec." International Conference on Computer Languages, pp. 266-270, Miami Beach, Florida, October 9-13, 1988.

V. Berzins and Luqi, "Semantics of Real Time Language," 9th IEEE Real-Time Systems Symposium, Huntsville, Alabama, December 6-8, 1988.

Luqi, and V. Berzins, "Execution of a High Level Real-Time Language," 9th IEEE Real-Time Systems Symposium, Huntsville, Alabama, December 6-8, 1988.

Technical
Reports:
      V. Berzins, "An Introduction to the Specification Language Spec," NPS52-88-031, 1988.

V. Berzins, Luqi, "Semantics of Real-Time Language," NPS52-88-033, 1988.

Luqi, V. Berzins, "Execution of a High Level Real-Time Language," NPS52-88-035, 1988.

V. Berzins, Luqi, "Languages for Specification, Design, and Prototyping," NPS52-88-038, 1988.

J. Weigand, V. Berzins, "Design and Implementation of a Pretty Printer for the Specification Language Spec," NPS52-88-040, 1988.

V. Berzins, "Architectural Design via Formal Specifications and Automation," NPS52-88-041, 1988.

V. Berzins, "A Formal Framework for Requirements Analysis," NPS52-88-042, 1988.

V. Berzins, "Generating Displays for Specifications Using Attribute Grammars," NPS52-88-043, 1988.

V. Berzins, "Objects-Oriented Rapid Prototyping," NPS-88-044, 1988.

V. Berzins, "The Design of Software Interfaces in Spec," NPS52-88-045, 1988.

V. Berzins, "Distributed Algorithms for Generating Unique Identifiers," NPS-88-046, 1988.

Conference
Presentations:
      V. Berzins, "Tutorial on Computer Aided Software Engineering, IEEE Systems Design and Networks Conference, April, 1988.

V. Berzins, "The Design of Software Interfaces in Spec," International Conference on Computer Languages, Miami Beach, Florida, October 9-13, 1988.

V. Berzins, "Semantics of Real-Time Language," 9th IEEE Real-Time Systems Symposium, Huntsville, Alabama, December 6-8, 1988.

Luqi, V. Berzins, "Execution of High Level Real-Time Language," 9th IEEE Real-Time Systems Symposium, Huntsville, Alabama, December 6-8, 1988.

V. Berzins, "A Graphical Interface for Computer-Aided Prototyping Systems," Hawaii International Conference on System Sciences, January 3-6, 1989.

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Title:	Database-System Approach to Software Engineering Environments (SEEs)
Investigators:	D.K. Hsiao, Professor of Computer Science D. Gaiser, Staff Researcher M. Pitargue, Staff Researcher LT J. Zavis, USN
Sponsors:	NOSC, NADC, and DOD STARS Program Office
Objective and Summary:	As an alternative approach to a SEE, we propose to use the multimodel and multilingual database systems as a building block or test vehicle for the SEEs known as SETECS in NOSC and FASP in NADC.
Thesis Directed:	J.A. Zavis, "Assessing Hierarchical Databases via SQL Transactions in a Multimodel Database System," M.S. Thesis, December, 1987.
Publications:	S. Demurjiam, P. Fenton, D.K. Hsiao, and J.R. Vincent, "A Computer-Aided Benchmarking Software for Parallel and Expandable Database Computers," Proceedings of 1987 Fall Joint Computer Conference, October, 1987. S. Demrujiam, D.K. Hsiao, "Towards a Better Understanding of Data Models Through the Multilingual Database System," IEEE Transactions on Software Engineering, SE-14, 7, 1988.

Title:	Multilevel Database Security
Investigators:	D.K. Hsiao, Professor of Computer Science D. Gaiser, Staff Researcher M. Pitargue, Staff Researcher LT G. Hoppenstand, USN
Sponsors:	NSGC (Direct Funding), NSGC (External Funding), and National Security Center.
Objective and Summary:	Multilevel security is supported in an experimental database system via a compartmentalization technique. This technique can improve the access precision of the database operations and eliminate the pass-through problem which is typical in an insecure database system. Our object is to show that the technique is practical, i.e., demonstrable via our research software.
Thesis Directed:	G. Hoppenstand, "Secure Access Control with High Access Precision," M.S. Thesis, March, 1988.
Publications:	D.K. Hsiao, "Database Security Course Module," and "Discussion Notes Revised Question List," Database Security: Status and Prospects, North Holland, pp. 269-302, and pp. 303-330, 1988.

Title: Temporal Database Management and Real-Time
                          Database Computers

Investigators: D.K. Hsiao, Professor of Computer Science
                          D. Gaiser, Staff Researcher
                          M. Marciano, Staff Researcher
                          CAPT D. Hom, USMC

Objective and
Summary: Temporal Databases are used in real-time
                          weapon systems for data-intensive and data-
                          voluminous operations. Objectives are first
                          to characterize temporal databases via a
                          temporal data model and then to devise a
                          temporal data language for the manipulation
                          of temporal data-bases. Finally, we will
                          propose an architecture for a temporal
                          databases computer for real-time (weapon)
                          applications.

Thesis Directed: D.D. Hom, "Temporal Data, Temporal Data
                          Models, Temporal Data Languages, and Temporal
                          Database Systems," M.S. Thesis, June, 1988.

Publications: S. Demurjian, D.K. Hsiao, and R. Marshall,
                          "Design Analysis and Performance Evaluation
                          Methodologies for Database Computers,"
                          Prentice-Hall. D.K. Hsiao, "The Impact of
                          Interconnecting Network on Parallel Database
                          Computers, Proceedings of the 5th
                          International Workshop on Database Machines,
                          October, 1987.

Title:	The Multi-Lingual, Multi Model, Multi-Backend Database Management System
Investigators:	D.K. Hsiao, Professor of Computer Science, Department of Computer Science. M.N. Kamel, Assistant Professor of Information, Department of Administrative Sciences
Sponsor:	The project is partially sponsored by the following organizations: Naval Security Group Command Naval Air Development Center Naval Ocean Systems Center National Computer Security Center
Objective:	To develop a single database system capable of executing transactions written in different data languages and supporting database structures of their corresponding data models. The system also allows cross-access of the different databases.
Summary:	This is a long term research project that represents a new and unconventional approach to the design of a database system. As indicated, its objective is to build a database that supports many database models and their corresponding languages. It also allows users to access different databases using their favorite model and language. During this quarter, my involvement in the project included contributing new ideas, setting directions on the implementation and experimentation work, and working on a major paper related to the project.
Publications:	D.K. Hsiao and M.N. Kamel, "Heterogeneous Databases: Proliferations, Issues and Solutions," (In Progress).

Title:	Real Time Prototyping on a Multiple Transputer System
Investigator:	U.R. Kodres, Professor of Computer Science
Sponsor:	LCDR Larry Sentman, Strategic Project Office/NPS Research Council
Objective:	The project explores the use of a single chip computer, the so called "TRANSPUTER", as a component of a larger multicomputer network. The software and hardware design to make such a network a reliable as well as fault tolerant system is the main long-term objective of this project.

Summary: The past year's study has indicated the processing capacity of a network of transputers. Namely that the communications do not consume excessive real time. Communications take place concurrently with computation at a maximum loss of 30% of computing time. This fact has far-reaching implications in the use of a network of transputers. Namely that data communications can at most reduce the computational capacity of a network by 30%. That means that a network of transputers can reach a minimum of 70% capacity of linear increase in computing capacity of transputers in the network. This is a result worthy of verification. Because the individual transputers computational capacity is 10 million instructions per second, N such transputers in a network can reach 10*N MIPS. If there is no slowdown of the computation due to busy waiting time, then our results indicate that a network of N transputers can ideally reach .7*10*N MIPS. If there is no slow down of the computation due to busy waiting time, then our results indicate that a network of N transputers can ideally reach .7*10*N MIPS, which for say 64 transputers comes to 448 MIPS as a network. Some of these results are documented in the thesis entitled "Design, Implementation and Evaluation of an Abstract Programming and Communications Interface for a Network of Transputers", by G.R. Bryant, June, 1988.

Theses
Directed: S. Hart, "Design, Implementation, and
Evaluation of Virtual Shared Memory System
in a Multi-Transputer Network," March, 1988.

J. Frazao, "Design, Implementation, Building
Evaluation of a Transitive Closure Network
of Transputers, June, 1988.

G.R. Bryant, "Implementation, and Evaluation
of an Abstract Programming and Communications
Interface for a Network of Transputers, June,
1988.

Title:	Knowledge Based Program Debugging
Investigator:	Y. Lee, Assistant Professor of Computer Science
Sponsor:	NPS Research Council
Objectives:	To develop general algorithms for reasoning about logic programs and their specifications; to develop a knowledge base of debugging expertise for use with logic programs; to implement a program debugger that can utilize general inference strategies and expert debugging knowledge.
Summary:	We have developed a computer model that encodes domain knowledge for debugging and possesses reasoning capabilities. The domain knowledge includes a classification of program bugs, operational semantics of programming language, intended behavior of programs, and some debugging heuristics. The reasoning strategies include deductive and inductive inferences. We have also built a primitive prototype of a functional debugging system. The debugger can accept a buggy program and its specifications, and generate test cases for program execution. Should the execution fail to produce the expected result, the debugger is able to locate and fix errors in the program, based on its knowledge about the program and its reasoning abilities. We are currently investigating the feasibility of applying the debugging methodology for F-14 software diagnosis.
Publications:	Y. Lee, "A Theorem Prover for Debugging and Verification of Logic Programs," NPS-52-88-048, September, 1988.

Title:	Review and Assessment of Software Engineering Issues and Technology
Investigators:	V.Y. Lum, Professor of Computer Science, and D.K. Hsiao, Professor of Computer Science
Sponsor:	STARS Program Office
Objective:	To provide advice, assistance, and evaluation to the STARS Program Office on subjects related to their interest. These include technology assessment, reports on current development and the state of the art, consultation on various matters related to the office's interests, etc.
Summary:	Investigators and faculty in the department gave verbal and assessments on various topics interested by the sponsor. Written reports were not required because these communications were internal assessments and recommendations for the program manager to use.
Publications:	None
Theses Directed:	None

Title: Synthesis of Multimedia Database Management System

Investigators: V.Y. Lum, Professor of Computer Science. D.K. Hsiao, Professor of Computer Science. N. Rowe, Associate Professor of Computer Science and C.T. Wu, Associate Professor of Computer Science.

Sponsor: NOSC

Objective: Investigate and find solutions for the various issues pertaining to the handling of multimedia data such as text, graphics, images, sound signal, etc. Define and develop a database management system with the capability of handling multimedia data, including contents of search of these data.

Summary: An intensive investigation into the current state of the art of handling multimedia data and the approaches proposed in projects in the professional community was conducted. Some major issues surfaced in attempts to handle multimedia data were found to include the large size of these data, the complex semantic information always associated with them. After much study and consideration, it was decided that to solve these problems, both AI and database techniques will be needed. The adopted approach is to describe multimedia data by natural language text. The text descriptions are converted into predicates and sorted in the system. Queries are to be given also in natural text form and are converted into predicates before searching and retrieval are to begin. The query predicates are then matched with the description predicates and those multimedia data having descriptions matching the query specifications are then retrieved.

As natural language description generally give imprecise information, and the scope is very broad, it becomes necessary to find methods to help provide better focus. A dictionary or lexicon is to be created for this purpose. The dictionary is expected to be defined by the database administrator and a different dictionary is needed for each different application that the system will handle.

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A system architecture has been defined using the above approach. This system was carefully structured in a modular fashion so that new techniques in AI and database that may be forthcoming can be incorporated into the system without much difficulty. Implementation for part of the system has begun.

In addition, as multimedia data organization and usage are different than the traditional alphanumeric data, we must perform research to see how multimedia data influence the data modeling and user interface aspects. For the interface, a graphical user interface is deemed to be appropriate and a proposal of such an interface and its implementation have initiated. Currently, we are exploring the integration of this proposal in an object oriented relational system.

Publications:

C.T. Wu, "GLAD Graphics language for Database," Proceedings of the IEEE Computer Society's 11th International Computer Software and Applications Conference, Tokyo, Japan, October, 1987.

C.T. Wu, "Towards a Fully-Computerized Database Maintenance for Non-Traditional Applications," Proceedings of the 1987 ACM-IEEE Computer Society Fall Joint Computer Conference, Dallas, October, 1987.

D.E. Madison and C.T. Wu, "A Database Approach to Computer Integrated Manufacturing: Scheduling and Shop Floor Layout," NPS Technical Report, NPS52-87-047, November, 1987.

W.Y. Lum, C.T. Wu, and D.K. Hsiao, "Integrating Advanced Techniques into Multimedia Data," Proceedings of IFIP Working Conference on the Role of Artificial Intelligence in Databases and Information Systems, Guangzhou, China, July 4-9, 1988. Also in Technical Report (NPS52-87-050), November, 1987.

K. Meyer-Wegener, V.Y. Lum, and C.T. Wu, "Managing Multimedia Data-An Exploration," NPS Technical Report NPS 52-88-010, March, 1988.

C.T. Wu, "An Effect of Set Type to Query O Formulation in Relational Database Systems," NPS Technical Report NPS52-88-018, July, 1988.

V.Y. Lum and K. Meyer-Wegener, "A Conceptual Design of Multimedia DBMS for Advanced Applications," Proceedings of the 4th National Encounter on Cooperative Processing, Medellin, Colombia, July 24-30, 1988. Also as NPS Technical Report NPS52-88-025, August, 1988.

K.Meyer-Wegener, V.Y. Lum, and C.T. Wu, "Image Database Management in Multimedia System," NPS Technical Report NPS52-88-024, August, 1988.

P.C. Lockemann, "Multimedia Databases: Paradigm, Architecture, Survey and Issues," NPS Technical Report NPS52-88-047, September, 1988.

C.T. Wu, and D.K. Hsiao, "Implementation of Visual Database Using an Object-Oriented Language," NPS Technical Report NPS52-88-050, September, 1988.

Conference Presentations:

C.T. Wu, "Data-Oriented Approach in INtegrating Manufacturing Function," Information Processing Society of Japan, Kyushu Chapter, Oita, Japan, October, 1987.

V.Y. Lum, "A Conceptual Design of Multimedia DBMS for Advanced Applications," The 4th National Encounter on Cooperative Processing, Medellin, Colombia, July 24-30, 1988.

V.Y. Lum, "Intelligent DB Systems," 4th National Encounter on Cooperative Processing Medellin, Colombia, July 24-30, 1988.

C.T. Wu, "Argos: A Step Toward Paperless Ship," Chief Design Engineers' Conference.

Title:	Automated Software Tools for the Design of Large Ada Software Systems
Investigators:	Luqi, V. Berzins
Sponsor:	Office of Naval Research
Objective:	The Software Engineering Laboratory in the Department of Computer Science at the Naval Postgraduate School is developing new technologies for computer-aided design of Ada software systems. A set of software tools for validating requirements and formalizing design efforts of Ada Software Systems are under design and development by applying and extending current state of the art research results in software engineering and in artificial intelligence to automate a larger part of the effort in software development. This project emphasizes the refinement of a formal specification tool set suitable for supporting computer-aided development of large Ada programs. To meet urgent needs of DoD, the primary goals of this work are to improve programmer productivity and the quality, reliability, and flexibility of software systems.

Summary:

This project involves the investigation of automated tools for designing and constructing large software systems. Specific subjects addressed by our work include:

1. Generating tools for checking the consistency constraints associated with the formal specification language.

2. Testing language analysis tools through test cases to ensure the correctness of such tools.

3. Building a syntactic checking facility as an initial step towards an intelligent user interface and to serve a vehicle for further research.

4. Investigating techniques for automatic design completion based on consistency constraints and engineering database support.

5. Incorporating the design completion methods into the developed tool set to demonstrate the feasibility of such tools.

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Publications: (see   summary   "An   Automated   Prototyping
                         Environment")

Thesis
Directed: (see   summary   "An   Automated   Prototyping
                         Environment")

Title:	Execution Support of a Computer Aided Prototyping System for Real-Time Systems
Sponsor:	Office of Naval Research
Investigators:	Luqi, V. Berzins

Objective: A computer aided rapid prototyping system to support the development of software systems with hard real-time constraints is especially important for the critical early stages of software design. This research focuses on formal techniques for specifying such complex systems using a Prototype System Description Language and the associated tools for further analysis and design. A major goal of this work is to enable the automation of a larger part so hard real-time software development via execution of real-time prototypes. A special scheme is used to treat the hard real-time constraints and to integrate guideline beyond conventional compiler technology.

Summary: This project studied automated tools for designing and constructing large real-time software systems. Specific subjects that were addressed include:

1. Providing the conceptual design of CAPS tools, e.g., static scheduler, dynamic scheduler, run-time debugging system, etc.

2. The application of CAPS tools to the specification of real-time systems to establish its ability to handle practical problems.

3. Proposing simplifications and extensions to the PSDL language to improve the treatment of hard real-time constraints.

4. Developing execution support tools to handle a subset of the PSDL language constructs sufficiently rich to illustrate the feasibility of automatic generation of executable prototypes for the specified systems.

This research uniquely links the two major research flows on modeling of real-time systems and complexity studies on scheduling algorithms in this research area. The hard real-time computational model used and

specification based prototyping language provide systematic and unified constructs for modeling, specifying, designing and testing software systems with hard real-time properties.

Publications: (see summary "An Automated Prototyping Environment")

Thesis
Directed: (see summary "An Automated Prototyping Environment")

Title:	Software Test Site for Knowledge Based Software Assistant
Investigators:	Luqi, R. Adams, J. Isett, and V. Berzins
Sponsor:	Rome Air Development Center
Objective:	Progress in improving the software development process is limited by the current informal approaches to software construction, which leave many of the justifications for design decision informal, implicit, and unavailable to software maintainers. The objective of the Knowledge Based Software Assistant Project is to formalize the software design process and to capture justifications for design decisions in a form that can be subjected to a machine reasoning, so that software maintenance and the process of propagating consequences of design decisions can be largely automated. This project has produced prototyping versions of tools for this purpose. The role of the Software Test Site Project of KBSA is to test these tools for pilot applications and to evaluate their usefulness in practice.

Summary:	Our effort as a Software Test Site for the Knowledge Based Software Assistant provides important Technical evaluation of the current AI technology in practice. Experimental evidence in terms of the functionality and reliability of the research software is used to judge the proposed software techniques and justify both the direction of future research emphasis of future funding. During the process, knowledge and technologies of both Software Engineering and Artificial Intelligence are merged to achieve the goal to enable advances in those areas to enhance the research on computer software

As a member of the RADC Technology Transfer Consortium, we attended RADC annual KBSA conference, read the documentations on the research products, and analyzed the yearly progress reports. The technologies and concepts were used in the research projects, student theses and reading courses at NPS. We made effort to accomplish the goal of facilitating technology transfer whenever possible. |

The understanding gained by exploring KBSA allows us to learn state of the art research results from a large group of top quality research and funding efforts, especially in the DoD community.

Publications: (see project "An Automated Prototyping Environment")

Thesis
Directed: (see project "An Automated Prototyping Environment")

Title:	Normalizing Specifications for Rapid Prototyping
Investigator:	Luqi,
Sponsor:	NPS Research Council
Objective:	Rapid prototyping is a promising new approach for improving the productivity and reliability of software development. A rapid prototyping environment is urgently needed for large scale programming in Ada. A practical method and its theoretical background for normalizing component specifications are the important subjects to solve the critical issue of identifying and retrieving reusable components in the environment. Both formal and informal methods of specification normalization will be explored. The result of this research will be integrated with all the research directions associated with rapid prototyping. Consistency checking among the tools will apply to this research and will contribute to realizing the benefits of rapid prototyping in practice.

| Summary: | Reusing software is attractive when used together with a rapid prototyping approach to software development. An effective way to retrieval reusable software components form a software is needed for this process. Automated component retrieval requires normalized specifications of the reusable components to achieve a good success rate for retrievals. Methods for normalizing specifications were explored in this research. None of the previously proposed systems for retrieving reusable software is able to do so based on semantic specifications. Such a facility is critical for the application of reusable software to rapid prototyping, where designer time is restricted. Our approach requires normalized component specifications to be stored in the software base along with the implementations of the reusable components. Component specification in queries must also be normalized before being submitted to the software base management system. |

| Publications: | (see summary "An Automated Prototyping Environment") |

Thesis
Directed: (see summary "An Automated Prototyping
                             Environment")

Title: An Automated Prototyping Environment

Investigator: Luqi

Sponsor: National Science Foundation

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

Summary: Formal specifications and conceptual system
                          design models are the fundamental basis for
                          our approach. The proposed environment
                          consists of prototyping language, a software
                          base, and many other tools. The state of the
                          art research problems we have addressed are
                          developing transformation techniques for the
                          prototyping language and exploring ways to
                          realize a software base with capabilities for
                          retrieving reusable software based on
                          formalized component specifications. Program
                          construction is sped up with mechanical
                          assistance on automated management of
                          software and automated generation of code
                          interconnecting available modules and tasks.
                          After a one-year feasibility study, we have
                          successfully built an executable software
                          prototype of an automated prototyping tool
                          set including user interface, run-time
                          support, dynamic and static scheduling,
                          translator generation, software base and
                          management system, project database, graphic
                          editor, etc.

Journal
Publications: Luqi, "Knowledge-Based Support for Rapid
                          Prototyping," IEEE Expert, November, 1988.

                          Luqi, V. Berzins, and R. Yeh, "A Prototyping
                          Language for Real-Time Software," IEEE
                          Transactions of Software Engineering,
                          October, 1988.

Luqi, M. Ketabchi, "A Computer Aided Prototyping System," IEEE Software, pp. 66-72, March, 1988.

Luqi, V. Berzins, "Rapidly Prototyping Real-Time Systems," IEEE Software, pp. 25-36, September, 1988.

Conference Papers:

Luqi, V. Berzins, "Execution of a High Level Real-Time Language," Proceedings of the IEEE 9th Real-Time Symposium, Huntsville, Alabama, December 6-8, 1988.

V. Berzins, Luqi, "Semantics of a Real-Time Language," Proceedings of the IEEE 9th Real-Time Symposium, Huntsville, Alabama, December 6-8, 1988.

D. Janson, Luqi, "A Static Scheduler for the Computer Aided Prototyping System: An Implementation Guide," Proceedings of the 3rd Annual COMPASS Conference, Washington, D.C., June 27 - July 1, 1988.

Luqi, "Specification Languages in Computer Aided Software Engineering," Proceedings of IEEE Conference on Systems Design and Networks, Santa Clara, CA., April, 1988.

Technical Reports:

Luqi, "Automated Rapid Prototyping Environment," NPS52-88-049, Naval Postgraduate School, 1988.

Luqi, "Software Evolution Via Prototyping," NPS52-88-039, Naval Postgraduate School, 1988.

V. Berzins, Luqi, "Languages for Specification, Design, and Prototyping," NPS52-88-038, Naval Postgraduate School, 1988.

Luqi, "Computer Aided Maintenance of Prototyping Systems," NPS52-88-037, Naval Postgraduate School, 1988.

Luqi, "Handling Timing Constraints in Rapid Prototyping," NPS52-88-036, Naval Postgraduate School, 1988.

Luqi, V. Berzins, "Execution of a High Level Real-Time Language, NPS52-88-035, Naval Postgraduate School, 1988.

Luqi, "Automated Prototyping Data and Knowledge Translation," NPS52-88-034, Naval Postgraduate School, 1988.

V. Berzins, Luqi, "Semantics of a Real-Time Language," NPS52-88-033, Naval Postgraduate School, 1988.

J. O'Hern, Luqi, "A Conceptual Design for a Static Scheduler for Hard Real-Time Systems," Naval Postgraduate School, 1988.

V. Berzins, Luqi, "An Introduction to the Specification Language Spec," NPS52-88-031, Naval Postgraduate School, 1988.

Luqi, C. Moffitt, "An Automated Language Translator for a Computer Aided Prototyping System," NPS52-88-021, Naval Postgraduate School, 1988.

Luqi, D. Janson, "A Static Scheduler Implementation Guide for a CAPS Tool," NPS52-88-020, Naval Postgraduate School, 1988.

Luqi, S. Eaton, "A Dynamic Scheduler for a Computer Aided Prototyping System," NPS52-88-019, Naval Postgraduate School, 1988.

Luqi, "Knowledge Base Support for Rapid Prototyping," NPS52-88-016, Naval Postgraduate School, 1988.

C. Moffitt, Luqi, "Automated Translation from a Prototyping Language into Ada," NPS52-88-009, Naval Postgraduate School, 1988.

D. Galik, Lqui, "An Integrated Tool Environment for Embedded Real-Time Software," NPS 52-88-008, Naval Postgraduate School, 1988.

D. Janson, Luqi, "Astatic Scheduler for the Computer Aided Prototyping System: An Implementation Guide," NPS52-88-007, Naval Postgraduate School, 1988.

Luqi, R. Herndon, "Generating a Language Translator Based on an Attribute Grammar Tool," NPS52-88-006, Naval Postgraduate School, 1988.

Luqi, "Specification Languages in Computer Aided Software Engineering," NPS 52-88-005, Naval Postgraduate School, 1988.

Conference
Presentations:
Luqi, "Execution of High Level Real-Time Language," IEEE 9th Real-Time Symposium, Huntsville, Alabama, December 6-8, 1988.

Luqi, "A Static Scheduler for the Computer Aided Prototyping System: An Implementation Guide," 3rd Annual COMPASS Conference, Washington, D.C., June 27 - July 1, 1988.

Luqi, "Specification Languages in Computer Aided Software Engineering," IEEE Conference on Systems Design and Networks, Santa Clara, CA., April, 1988.

Theses
Directed:
C. Moffitt, II, "An Automated Language Translator for a Computer Aided Prototyping System," March, 1988.

S. Eaton, "An Implementation Design of a Dynamic Scheduler for a Computer Aided Prototyping System," March, 1988.

J. O'Hern, "A Conceptual Design for a Static Scheduler for Hard Real-Time System," March, 1988.

D. Janson, "A Static Scheduler for Hard Real-Time Constraints in the Computer Aided Prototyping System (CAPS)," March, 1988.

L. Marlowe, "A Scheduler for Critical Timing Constraints," December, 1988.

C. Altizer, "Implementation of a Language Translator for a Computer Aided Prototyping System," December, 1988.

M. Wood, "A Debugging System for Rapid Prototyping," December, 1988.

H. Rau, "An Expert System for Prototyping Interfaces," December, 1988.

R. Thorstenson, "An Interactive Graphical Editor for Rapid Prototyping," December, 1988.

D. Galik, "A Conceptual Design of a Software Base Management System for the Computer Aided Prototyping System," December, 1988.

S. Porter, "Generation of a Syntax Directed Editor for the Prototype System Description Language," December, 1988.

Title:	Graphics Language for Accessing Command Database
Investigator:	C.T. Wu, Associate Professor of Computer Science
Sponsor:	Naval Data Automation Command
Objective:	Commanding officers and executive officers of Naval bases and stations require an efficient access to an up to date information to perform an effective operation. This research investigated the use of visual interface as an effective access method to the database, where the commanding and executive officers visually interact with the database to extract the required information.
Summary:	We designed and developed a prototype graphical interface to access the database created by the BASIS activity. The prototype was developed with MS-Windows and object oriented language Actor. The current prototype has data definition and data browsing capabilities.
Publications:	C.T. Wu, "GLAD: Graphics Language for Database", in Proceedings of the 11th International Computer Software and Applications Conference, Tokyo, Japan, pp. 164-170, October, 1987.
	C.T, Wu, "Towards a Fully-Computerized Database Maintenance for Non-Traditional Applications", in Proceedings of the 1987 ACM-IEEE Computer Society Fall Joint Computer Conference, Dallas, pp. 469-474, October, 1987.
	C.T. Wu, "An Effect of Set Type to Query Formulation in Relational Database Systems", Technical Report, NPS52-88-018, July, 1988.
	C.T. Wu, "Implementation of Visual Database Interface Using an Object-Oriented Language," Technical Report, NPS52-88-050, September, 1988.
Conference Presentations:	C.T. Wu, "GLAD: Graphics Language for Database," 11th International Computer Software and Applications Conference, Tokyo, Japan, October, 1987.

C.T. Wu, "Towards a Fully-Computerized Database Maintenance for Non-Traditional Applications," 1987 ACM-IEEE Computer Society Fall Joint Conference, Dallas, October, 1987.

Theses
Directed:

P.D. Grenseman, "Data Structures and Algorithms for Supporting GLAD Interfaces," MS, June, 1988.

R. Schuett, "Prototyping Visual Databases Interface by Object-Oriented Language," MS, June, 1988.

M.L. Williamson, "Implementation of GLAD Data Definition Language," MS, December, 1988.

Title:	The Integration of a High Resolution Digital Terrain Database with the Moving Platform Simulator
Investigator:	M.J. Zyda, Associate Prof. of Computer Science
Sponsor:	U.S. Army Combat Developments Experimentation Center
Objective:	The Graphics and Video Laboratory of the Department of Computer Science at the Naval Postgraduate School is currently conducting research on terrain visualization through the production of a system called the Moving Platform Simulator (MPS). That simulator uses Defense Mapping Agency digital terrain elevation data on commercially available, high-performance, graphics workstations. The thrust of the current effort is to integrate a high-resolution digital terrain database with the MPS simulator. An additional set of tasks concerns the computation of player visibilities from each vehicle in the simulator.
Summary:	The initial work for this project was to finish and document the moving platform simulator (MPS) {Jennings + Fichten Thesis and Fichten, Jenning and Zyda paper}. The next set of work, currently underway, is to integrate a new high-resolution terrain elevation database with MPS {Breden and Zanoli thesis}. Also underway is work on computing the intervisibility of players in the simulators {Strong and Winn thesis}. Additional capabilities are being added to MPS such as aerial platforms {Christian thesis} and weapons firing {Drummond and Mizolak thesis}.
Publications:	M.A. Fichten, D.H. Jennings, and M.J. Zyda, "Meaningful Real-Time Graphics Workstation Performance Measurements," NPS-52-89-004, November, 1988.
Thesis Directed:	D.H. Jennings and M.A. Fitchten, "Meaningful Real-Time Graphics Workstation Performance Measurements," M.S. Thesis, December, 1988.

Title: Real-Time, Interactive Simulation for the
                          Future Command and Control Workstation

Investigator: M.J. Zyda, Associate Prof. of Computer
                          Science

Sponsor: Naval Underwater Systems Center

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

Summary: The initial work for this project was to
                          document and enhance the current surface view
                          version of the command and control
                          workstation of the future (CCWF) [Cobb
                          thesis]. The next set of work, currently
                          underway, is the development of a subsurface
                          visual simulator for the CCWF [Phillips and
                          Weeks thesis]. A prototype version of that
                          simulator, with periscope view, is currently
                          operational.

Thesis
Directed: R. Cobb, "Enhancements to the Command and
                          Control Workstation of the Future," M.S.
                          Thesis, December, 1988.

Title:	Inexpensive, Three-Dimensional Visual Simulation for the Future Command and Control Workstation
Investigator:	M.J. Zyda, Associate Prof. of Computer Science
Sponsor:	Naval Ocean Systems Center
Objective:	The Graphics and Video Laboratory in the Department of Computer Science at the Naval Postgraduate School is designing and implementing a prototype command and control system utilizing three-dimensional, real-time interactive graphics on high-performance, commercially available graphics workstations. The primary goal of this work is to develop real-time visualization tools and techniques useful for rapidly producing three-dimensional scenes such as would be seen form the bridge of a surface ship, the cockpit of an airplane, the periscope of a submarine, and the bridge of a submarine (synthetic view). An additional goal of this project is a continuation of the development of a software architecture for interactive, real-time graphics between workstations on the same network.

Summary:	The initial work for this project was to document and enhance the current surface view version of the command and control workstation of the future (CCWF) [Cobb thesis]. The next set of work, currently underway, is the development of a subsurface visual simulator for the CCWF [Phillips and Weeks thesis]. A prototype version of that simulator, with periscope view, is currently operational. Additional work being conducted on the CCWF system is the addition of three dimensional ship hulls into the surface and subsurface views [Munson thesis].

Title:	An Architecture for Interactive, Real-Time Graphics Between Networked Workstations--Year 2
Investigator:	M.J. Zyda, Associate Prof. of Computer Science
Sponsor:	Naval Ocean Systems Center
Objective:	The primary goal of this research is to examine the architecture necessary to support high-performance computer graphics interactions between multiple workstations of the same network. The focus of this work will be on commercially available graphics workstations running the Unix operating system. The application area focus for the work is the architecture of the command and control workstation of the future.
Summary:	The major work for this project was to produce support software and documentation on how one communicate between networked graphics workstations (Frand and Barrow theses, Zyda, McGhee, McConkle and other papers and technical report). Initial work was performed on the command and control workstation of the future (CCWF) project (Abner and Harris theses, Harris Technical Report). A three-dimensional surface view visual simulator was generated as part of the CCWF system (Harris Tech. Report). Support software for the CCWF was generated in the form of font editor (Mariscal thesis and tech. report).
Publications:	T.H. Barrow, J.M. Yurchak, and M.J. Zyda, "Distributed Computer Communications in Support of Real-Time Visual Simulations," NPS-52-88-028, September, 1988. (Derived from a NPS Thesis).
	F.E. Harris, J.M. Yurchak, and M.J. Zyda, "Preliminary Work on the Command and Control Workstation of the Future," NPS-52-88-027, August, 1988, (Derived from a NPS thesis).
	M.J. Zyda, R.B. McGhee, R.B. McConkle, C.M. Nelson, H. Andrew, and R.S. Ross, "A Real-Time, Three-Dimensional Moving Platform Visualization Tool," NPS-52-88-022, July, 1988.

Conference
Presentations: M.J. Zyda, "New Developments in Inexpensive,
                              Real-Time   Three-Dimensional   Visual
                              Simulators," International IRIS User Forum
                              held at the SIGGRAPH Conference, Atlanta
                              Georgia, August, 1988.

                              M.J.   Zyda,   "Inexpensive,   Real-Time
                              Interactive   Three-Dimensional   Visual
                              Simulator," Invited Speaker to the Symposium
                              on   Data   Visualization,   Applied   Physics
                              Laboratory   at   Stanford   University,   July,
                              1988.   Also at the Symposium on Advances in
                              Computer   Technology,   University   of   North
                              Carolina,   March,   1988;   and   Graphics
                              Colloquium at the University of California,
                              Santa Cruz, May, 1988.

                              M.J. Zyda, "Visual Simulation Research an the
                              Naval   Postgraduate   School,"   Princeton
                              Symposium   on   Visualization   in   Scientific
                              Computing, Princeton University, May, 1988.
                              Also at NOSC San Diego as part of the Command
                              and   Control   Program   Review,   March,   1988;
                              Department of Computer Science, University
                              of   North   Carolina,   Chapel   Hill,   January,
                              1988; and Real-Time Simulation Applications
                              on   IRIS   Workstations   Users   Working   Group,
                              Bell Helicopter-Textron, Fort Worth, Texas,
                              January, 1988.

Theses
Directed: M.D. Abner, "Three-Dimensional Visual Display
                              for   a   Prototype   Command   and   Control
                              Workstation," M.S. Thesis, June, 1988.

                              T.   Barrow,   "distributed   Computer
                              Communications in Support of Real-Time Visual
                              Simulations," M.S. Thesis, June, 1988.

                              F. Harris, "Preliminary Work on the Command
                              and Control Workstation of the Future," M.S.
                              Thesis, June, 1988.

                              C. Frank, "Unix Based Programming Tools for
                              Locally Distributed Network Applications,"
                              M.S. Thesis, December, 1987.

                              H.O. Mariscal, "Editfont - An Interactive
                              Font Editing System," M.S. Thesis, December,
                              1987.

Title: Real-Time Modeling and Animation Tools in Support of Three-Dimensional Simulation

Investigator: M.J. Zyda, Associate Prof. of Computer Science

Sponsor: U.S. Army Combat Developments Experimentation Center

Objective: The goal of this research is to develop real-time modeling and animation tools to support three-dimensional simulation. We will begin by examining the capabilities and limitations of both currently available and near-term, high performance graphics workstations. We will build prototype simulations on such systems in order to characterize what can and cannot be done with respect to real-time animations. Our goal is the development of a coherent, high-level system useful for rapidly prototyping simulations for the weapons testing scenario.

Summary: The initial work for this project was to develop the vehicle view three-dimensional visual simulator (VEH), integrated with the previously developed FOGM visual simulator (Stahl and Oliver thesis, Zyda, McGhee, and Ross and other papers). Work was done to explore utilizing the visual simulators as visual tools, networked with other processors (Zyda, McGhee, McConkle and others paper and technical report). Enhancements and performance measurements was performed to the developed visual simulators (Fichten, Jennings, and Zyda paper, tech. report and Fichten and Jennings thesis). We explored the possibility of realistically texturing the three dimensional terrain with textures extracted form visual images (Meier thesis and tech. report). Enhancements to the beginning and advanced graphics courses were made based on the needs of the visual simulators developed for this project (Zyda paper on Teaching Computers Graphics).

Publications: M.J. Zyda, R.B. McGhee, B. Ross, R.S. Smith, D.B. Streyle, and G. Dale, "Flight Simulators for Under $100,000," IEEE Computer Graphics and Applications, vol. 8, no. 1, January, 1988.

R.S. Ross, R.B. McGhee, M.J. Zyda, and N.C. Rowe, "A Context-Dependent Classification Paradigm for Land Mobility Problems," Proceedings of the 3rd Annual Expert Systems in Government Conference, October 19-23, 1987.

M.J. Zyda, "Teaching Computer Graphics," IRIS Universe, the IRIS Community magazine, Winter/Spring, 1988, pp. 14-17.

M.A. Fichten, D.H. Jennings, and M.J. Zyda, "Meaningful Real-Time Graphics Workstation Performance Measurements," NPS-52-89-004, November, 1988. (Derived from a NPS Thesis).

M.J. Zyda, R.B. McGhee, C.M. McConkle, A.H. Nelson, and R.S. Ross, "A Real-Time, Three-Dimensional Moving Platform Visualization Tool," NPS-52-88-022, July, 1988.

A.H. Nelson, R.B. McGhee, and M.J. Zyda "Investigation into the Use of Kyoto Common Lisp for Real-Time Computer Animation," NPS-52-88-015, June, 1988.

T.W. Meier, R.B. McGhee, and M.J. Zyda, "Investigation into the Use of Texturing for Real-Time Computer Animation," NPS-52-88-003, March, 1988. (Derived from NPS Thesis).

M.R. Oliver, D.J. Stahl, R.B. McGhee, and M.J. Zyda, "Interactive, Networked, Moving Platform Simulators," NPS-52-88-002, February, 1988. (Derived from NPS Thesis).

Conference
Presentations: See Summary "An Architecture for Interactive, Real-Time Graphics Between Networked Workstations--Year 2"

Theses
Directed: P.J. Collins, "Three Dimensional Fractal Mountains," M.S. Thesis, December, 1988.

D.H. Jennings and M.A. Fichten, "Meaningful Real-Time Graphics Workstation Performance Measurements," M.S. Thesis, December, 1988.

DEPARTMENT
OF
MATHEMATICS

DEPARTMENT OF MATHEMATICS

Departmental Research Summary

The research program of the mathematics department was focused mainly on linear algebra, numerical analysis, and fluid dynamics, though some work was also done on statistics, geometry, mathematical modeling, and decision theory.

Linear Algebra

W. B. Gragg, working with L. Reichel and G. S. Ammar, has developed several techniques for eigenvalues and factorization of matrices. He has also studied computation times for these techniques.

Numerical Analysis

I. B. Russak and A. A. Goldstein have developed methods for the application of Newton like algorithms to "noisy" problems, i.e. problems where functions are known only subject to errors.

B. Neta and A. L. Schoenstadt, working with Prof. R. T. Williams of Meteorology, have continued to work on the development of finite element methods for weather prediction.

B. Neta, on a separate project, working with Paul Nelson of Texas A & M University and C. P. Katti of J. L. Nehru University (India), has conducted research on the solution of initial-value problems by hybrid methods.

D. A. Danielson, working with D. Kihl of the David Taylor Research Center and Professor Dewey Hodges of Georgia Tech University, has developed formulas to calculate the buckling loads of stiffeners.

Danielson, on a separate project, developed new techniques for calculating the orbits of satellites.

Fluid Dynamics

D. Canright is developing analytic techniques for buoyant convection effects.

C. Scandrett is studying the dynamics of flow near the bottom of the ocean.

Statistics

T. Jayachandran has worked with Professor H. J. Larson of the Operations Research Department to improve the aircraft maintenance program at an Air Force base through the use of spectrometric oil analysis.

Combinatorics

K. Hefner has continued work into tournaments and graph coverings.

Decision Theory

G. Owen, working with B. Grofman of the University of California, Irvine, has continued work into stability of voting patterns and commenced work into the use of autocorrelation to denote gerrymanders. On a different project, Owen has worked with F. Carreras of the Polytechnic University of Catalunia (Spain) to analyze coalitions in the several Spanish (regional) parliaments.

Number Theory

C. Wilde has studied a technique which may prove useful in solving Fermat's last theorem.

Title: Buoyant Convection Effects in Dendrite Growth

Investigator: D.R. Canright, Adjunct Teaching Professor of
                  Mathematics

Sponsor: NPS Research Council

Objective: To develop a consistent theoretical model of the
                  steady solidification of a smooth dendrite in an
                  undercooled melt flowing due to buoyancy, using
                  analytic techniques.

Summary: Starting from the well-known solution for a
                  solidifying paraboloid in the absence of gravity,
                  a linearized analysis for the buoyant flow near
                  the paraboloid tip was completed, in the
                  asymptotic limit of small buoyant parameter
                  (Grashof number). This buoyant flow solution
                  was in turn used to find a solution for the
                  temperature and interface shape perturbations.
                  These analytic solutions include the parameters
                  (Prandtl and Stefan numbers), so can be used to
                  explore the effects of varying the materials and
                  undercooling. However, the solutions are of a
                  complicated form, so a computer program will be
                  written to aid interpretation, and the results
                  will be compared with published experiments.
                  Future research will determine a boundary-layer
                  solution for the flow far from the tip (where
                  nonlinear effects become important), and match
                  the two solutions together.

Conference   D.R. Canright and S.H. Davis (Northwestern
Presentation: University), "Similarity Solutions for Solid-
                  ification with Convection," APS Div. of Fluid
                  Dynamics Annual Meeting, Buffalo, NY, November
                  20-22, 1988.

Title: Satellite Motion Around an Oblate Planet

Investigators: D.A. Danielson, Associate Professor of
                  Mathematics and LTCOL J.R. Snider, Aeronautics
                  Department

Sponsor: NPS Foundation Research Council

Objective: To obtain an analytical orbit for the motion of a
                  satellite including the effects arising from the
                  earth's oblateness.

Summary: A completely analytical orbit was obtained
                  including the effect of the dominant J_2 terms
                  in the geopotential. The method of derivation
                  was based upon a perturbation technique designed
                  by Professor Gordon Latta and use of the symbolic
                  manipulation program MACSYMA. The solution is
                  valid for 1,000 revolutions with a relative error
                  of order 10^{-6}. Result could be used to
                  shorten computer time required to calculate orbits
                  and reduce frequency of measured observations;
                  e.g., for GPS satellites used by the Navy to
                  locate the positions of ships.

Publication: J.R. Snider and D.A. Danielson, "Satellite Motion
                  Around an Oblate Planet: Completely Analytical
                  Perturbations for all Orbital Parameters", in
                  progress.

Title: Fiber Optic Ellipsoidal Hydrophones

Investigators: D.A. Danielson, Associate Professor of
                 Mathematics, and S.L. Garrett, Associate
                 Professor of Physics

Sponsors: Office of Naval Research and U.S. Space and
                 Naval Warfare Systems Command

Objective: To develop a mathematical model for the mechanical
                 behavior of fiber-optic interferometric
                 hydrophones.

Summary: Shell theory was used to predict circumferential
                 strains, deflections, buckling pressures,
                 vibration frequencies, and optical sensitivity
                 of hydrophones made by winding optical fiber
                 around spheroidal shells. Sample designs based
                 on these calculations were compared to other
                 fiber-optic sensors of similar dimensions and
                 materials. Results could lead to improved design
                 of hydrophones used by the Navy for the detection
                 of underwater sounds.

Publication: D.A. Danielson, and S.L. Garrett, "Fiber-Optic
                 Ellipsoidal Flextensional Hydrophones", sub-
                 mitted to Journal of Lightwave Technology.

Conference   S.L. Garrett and D.A. Danielson, "Theoretical
Presentation: Analysis of a Class V Flextensional Fiber-Optic
                 Interferometric Hydrophone", 2nd Joint Meeting
                 of the Acoustical Societies of American and Japan
                 Honolulu, Nov. 14-18, 1988.

Patent: Navy patent applied for.

Title: Lateral Instability of Stiffened Plates and Shells Using a Refined Beam Theory - Buckling of T-Stiffened Plates Used in Ships and Submarines

Investigator: D.A. Danielson, Associate Professor of Mathematics

Sponsor: Office of Naval Research

Objective: To develop a mathematical model for the lateral buckling of stiffeners welded to shells.

Summary: A refined nonlinear beam theory was used to predict the buckling loads of thin-walled beams with an enforced axis of rotation subjected to lateral pressure and longitudinal compressive loading. The predictions were shown to agree with those of other authors and with a finite element code. The theory was used to model experiments performed at the Naval Postgraduate School and at the David Taylor Research Center. Also, it was shown that shell theory can be derived from the same framework upon which the beam theory was constructed. Results could be used to improve current Navy design code for ship and submarine grillages and hulls

Publications: D.A. Danielson, "Tripping of Stiffened Plates Using a Refined Beam Theory", Naval Postgraduate School Technical Report NPS-53-88-003, 1988.

D.A. Danielson and D.H. Hodges, "A Beam Theory for Large Global Rotation, Moderate Local Rotation and Small Strain", Journal of Applied Mechanics, Vol. 55, March 1988, pp. 179-184.

D.A. Danielson, D.P. Kihl, and D.H. Hodges, "Tripping of Thin-Walled Plating Stiffeners in Axial Compression", submitted to Thin-Walled Structures.

D.A. Danielson, "Finite Rotation with Small Strain in Beams and Shells", forthcoming.

Conference Presentation: D.A. Danielson, "Tripping of Stiffened Plates Using a Refined Beam Theory", Applied Mechanics and Engineering Science Conference, University of California at Berkeley, June 20, 1988.

Title: Numerical Linear Algebra with Applications to
                Signal Processing, Systems and Control

Investigator: W. Gragg, Professor of Mathematics

Sponsor: NPS Research Council

Objective: To investigate numerical linear algebra aspects
                of, and develop associated software for:

                1) Adamjan-Arov-Krein theory of singular values
                of Hankel operators;

                2) Toeplitz systems of linear equations and
                unitary Hessenberg eigenproblems;

                3) Inverse eigenproblems;

                4) Updating QR factorizations.

                Continuation of this work is funded by the NPS
                Research Council (six months 1989)

Summary: More stable and efficient algorithms were given
                for computing singular values of Hankel operators
                of finite rank. Numerical experience with our
                "superfast" Toeplitz solver shows it to be
                reliable and extremely efficient for systems of
                large order. Two fundamental inverse eigen-
                problems were solved with good computational
                algorithms. A modular set of routines for up-
                dating QR factorizations, which execute well on
                vector processors, were developed. Substantial
                speedups were noted. Theory and computational
                experience with our "divide and conquer" algorithm
                for unitary Hessenberg matrices were completed.
                Convergence results for the unitary Hessenberg
                QR algorithm were completed.

Publications: W. Gragg, "On Singular Values of Hankel Operators
                of Finite Rank" (with L. Reichel), Linear Algebra
                and its Applications, forthcoming.

                W. Gragg, "Numerical Experience with a Superfast
                Real Toeplitz Solver" (with G.S. Ammar), Linear
                Algebra and Its Applications, forthcoming.

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W. Gragg, "Constructing a Unitary Hessenberg Matrix from Spectral Data" (with G. Ammar and L. Reichel), in Proceedings NATO Advanced Study Institute on Numerical Linear Algebra Digital Signal Processing, and Parallel Algorithms (P. Van Dorren, editor), Springer NATO ASI Series, forthcoming.

W. Gragg, "A Note on an Inverse Eigenproblem for Band Matrices" (with G.S. Ammar), SIAM Journal on Matrix Analysis and Applications, submitted for publication.

W. Gragg, "FORTRAN Subroutines for Updating the QR Decomposition" (with L. Reichel), ACM Transactions on Mathematical Software, submitted for publication.

W. Gragg, "A Divide and Conquer Method for Unitary and Orthogonal Eigenproblems", (with L. Reichel), Numerische Mathematik, submitted for publication.

W. Gragg, "Convergence of the Shifted QR Algorithm for Unitary Hessenberg Matrices", (with Tai-Lin Wang), to be submitted for publication.

W. Gragg, "Convergence of the Unitary Hessenberg QR Algorithm with Unimodular Shifts", (with Tai-Lin Wang), to be submitted for publication.

Presentations: W. Gragg, "Computational Aspects of Polynomials Orthogonal on the Unit Circle", (by invitation), Tenth Gatlinburg Conference on Numerical Linear Algebra, Fairfield Glade, Tennessee, October 1987.

W. Gragg, "Singular Values of Hankel Operators of Finite Rank", Tenth Gatlinburg Conference on Numerical Linear Algebra, Fairfield Glade, Tennessee, October 1987.

W. Gragg, "Computational Aspects of Polynomials Orthogonal on the Unit Circle", Department of Mathematics, Kent State University, Kent, Ohio, October 1987.

W. Gragg, "The Unitary Eigenvalue Problem", Numerical Analysis Seminar, University of California, Berkeley, February 1988.

W. Gragg, "Singular Values of Hankel Operators of Finite Rank", American Mathematical Society

Regional Meeting, Knoxville, Tennessee, March 1988
W. Gragg, "Singular Values of Hankel Operators of
Finite Rank", Third SIAM Conference on Applied
Linear Algebra, Madison, Wisconsin, May 1988.

W. Gragg, "The Unitary Eigenvalue Problem",
Department of Mathematics, University of
California, San Diego, June 1988.

W. Gragg, "Singular Value Decompositions of
Complex Symmetric Matrices", (presented by co-
author Angelika Bunse-Gerstner), Conference on
Applications of Matrix Theory, University of
Bradford, Great Britian, July 1988.

W. Gragg, "Constructing a Unitary Hessenberg
Matrix from Spectral Data", (presented by co-
author G. Ammar), NATO Advanced Study Institute
on Numerical Linear Algebra, Digital Signal
Processing, and Parallel Algorithms, Leuven,
Belgium, August 1988.

W. Gragg, "A Divide and Conquer Method for the
Unitary Eigenproblem and Applications", (presented
by co-author L. Reichel), NATO Advanced Study
Institute on Numerical Linear Algebra, Digital
Signal Processing and Parallel Algorithms,
Leuven, Belgium, August 1988.

W. Gragg, "The Unitary Eigenproblem", American
Mathematical Society Regional Meeting, University
of Kansas, Lawrence, Kansas, October 1988.

Thesis   Tai-Lin Wang, "Convergence of the QR Algorithm
Directed: With Origin Shifts for Real Symmetric Tri-
              diagonal and Unitary Hessenberg Matrices",
              <u>Doctoral</u> <u>Disseration</u>, University of Kentucky,
              Summer 1988.

Title: Conflict Graphs for Communications Networks

Investigators: K.A. Hefner, Asst. Professor of Mathematics,
                    J.R. Lundgren, Chairman of Mathematics, Univ.
                    of Colorado at Denver

Sponsor: NPS Foundation Research

Summary: Study graph theoretic algorithms to attack a class
                    of networking problems. These networks will
                    ultimately have applications to the problem of
                    communication channeling in DoD and DoN areas.

Title: Numerical Solution of Initial-Value Problems

Investigators: B. Neta, Assoc. Professor of Mathematics,
                 P. Nelson, Professor at Texas Tech,
                 C.P. Katti, Professor at Jawahrlal Nehru
                 University, India

Sponsor: National Science Foundation

Summary: The solution of second-order initial-value prob-
                 lems by means of hybrid finite difference methods
                 is investigated. These methods have the potential
                 of achieving maximum order without destroying the
                 zero-stability.

Title:	Consensus - Facilitating Features of Collective Preference
Investigator:	G. Owen, Prof. of Mathematics
Sponsor:	Internally funded, reviewed by Office of Naval Research
Objective:	To develop methods for obtaining a consensus in situations where several members of a group have conflicting information as to the real state of the world and conflicting opinions as to the optimal decision.
Summary:	Group decision situations were represented as voting games. By doing this we were able to model the way in which a consensus is reached as one or another group of decison-makers rejects less favored alternatives until a compromise is reached. In particular, we developed mathematical models which choose one alternative as the best compromise, even in cases where previous theory predicted that no stability could be expected.
Publications:	G. Owen and F. Carreras, "Analysis of the Euskarian Parliament", to appear in <u>Parliamentary Coalitions</u>, ed. N. Schofield, Kluwer-Nyhoff, forthcoming 1989.
	G. Owen, "Stable Outcomes in Spatial Voting Games," submitted.
	G. Owen, "The Finagle Point for Characteristic Function Games," submitted.
	G. Owen, M. Maschler, and B. Peleg, "Paths Leading to the Naoh Set." In <u>The Shapley Value,</u> ed. A. Roth, Cambridge University Press, 1988, pp. 321-330.

Title: Asymptotic and Numerical Methods in the Solution
                    of Scattering from Submerged Structures

Investigator: C. Scandrett, Asst. Professor of Mathematics

Sponsor: NPS Research Council

Objective: To apply a new asymptotic approximation to the
                    problem of scattering from fluid loaded membranes/
                    plates/and shells.

Summary: The new approximation has proved to be highly
                    accurate for the problem of scattering of pressure
                    waves from a fluid loaded membrane. The
                    approximate method essentially decouples the
                    fluid/structure interaction problem allowing the
                    general scattering problem to be solved very
                    efficiently and with high accuracy. Extension of
                    the method to the more realistic case of
                    scattering from shells is currently underway.

Publication: An Approximate Boundary Condition for Structural
                    Acoustic Interactions submitted to the Journal
                    Acoust. Soc. of America.

Conference   C. Scandrett: Paper to be presented at '89 SIAM
Presentation: Annual Meeting in San Diego

DEPARTMENT
OF
ADMINISTRATIVE SCIENCES

DEPARTMENT OF ADMINISTRATIVE SCIENCES

The Department of Administrative Sciences is responsible for academic programs designed to educate officers and DoD civilian employees in a variety of functional management specialties. The diversity of faculty's professional expertise is reflected in the wide variety of research projects conducted in the department.

In addition to the permanent staff, the department research effort was augmented by, and has benefitted from, the presence of a number of adjunct professors. The research projects span broad spectra of public sector management issues, ranging from basic scholarly pursuits to applied research designed to assist policy and operational decision making. For ease of exposition the research projects may be grouped into the following areas: acquisition; logistics and transportation; information and telecommunication systems; financial management; manpower analysis; personnel,training and testing; policy analysis and other general management.

ACQUISITION

Dan Boger and Shu Liao began a multi-year project under the sponsorship of Naval Air Systems Command. The objective of the project is to develop parametric cost estimation models for aircraft modification (MOD) programs. The focus in Phase I is to identify available programs for inclusion in the study and to develop a data collection format. Research program in acquisition will be augmented with the addition of new faculty.

LOGISTICS AND TRANSPORTATION

Research in logistics focuses on providing support to the Supply Corp in inventory modeling. Professor McMasters continued his long term research effort to develop improved wholesale inventory models under the sponsorship of Navy Fleet Material Support Office. Professors McMasters also completed the second phase of a project to develop expert systems to facilitate decision making by inventory managers at Navy Stock Points. Under the sponsorship of NPS Research Council, Professor Dan Trietsch studied optimal scheduling of PERT activities with tree precedence networks and its application to hub operations.

INFORMATION AND TELECOMMUNICATION SYSTEMS

NPS Research Council supported the research efforts by three faculty members. Professor Abdel-Hamid's project was designed to investigate the viability of incorporating PROLOG rules in a system dynamics model of software project management. Professor Moshe Zviran's project objective was to apply the multiple criteria analysis method to the computer family selection procedure and to establish a comprehensive methodology for this process. Professor James Suchan's study sought to determine if a non-distributed Group Decision Support System using Co-oP will help decision groups make better and faster decisions when faced with complex high task/high

relationship problems than groups working in a traditional meeting room environment.

Professor Magdi Kamel has just begun a collaborative work with Professor David Hsiao of the Department of Computer Science in the development of a single database system capable of executing transactions written in different data languages and supporting database structures of their corresponding data models. Professor Norman Schneidewind was supported by the Navy Management Systems Support Office for the development of a software quality metrics methodology and enhancement of a software reliability model. Professors Daniel Dolk and Barry Frew continued the development of the Emergency Preparedness Management Information System decision support system for maintaining communications during a national emergency. This a multi-year project supported by National Communications Systems.

FINANCIAL MANAGEMENT

Professor Ken Euske was supported by Defense Personnel Security Research and Education Center in his analysis of personal security-related financial data for individuals in sensitive positions. Professor Euske also collaborated with Professor Dolk in a project analyzing the management control and information system implications of Navy's RAMP Project. Professors Euske and Jones began a study to analyze the impact of budget cuts on squadron operations of the Pacific Fleet Air Forces. Professors Euske and McCaffery began a study to analyze the effect of the Goldwater-Nichols Act upon POM preparation at CINCPACFLT. Professor Larry Jones initiated a project, under the sponsorship of Department of the Navy Office of the Comptroller, to formulate and test hypotheses to explain the increase in Congressional control of Navy budget execution documented to have occurred since the late 1960.

MANPOWER ANALYSIS

US Army Recruiting Command continued to be the major sponsor of the manpower research program in the department. During AY1988, six projects were funded. Investigators include Professors George Thomas, Stephen Mehay, Loren Solnick, Ben Roberts, Kathryn Kocher, and Laura Johnson (Operations Research). These studies cover a wide range of recruiting issues, including the development of management decision models for local labor market analysis, the comparison of the demographics and enlistment motivations of Army reserve enlistees and Army National Guard enlistees, the determination of the desired level of female participation in the reserves, analyzing the loss profiles of Army Nurse Corps officers assigned to Reserve Centers, the development of local measures of Qualified Military Available and Interested for the Year 2000, and the analysis and comparison of patterns of geographic transfers within the US Army Reserve as well as civilian labor migration from place to place.

Under the sponsorship of Deputy Chief of Naval Operations

(Manpower), Professor David Henderson examined several key issues relating to military compensation, particularly the bonus systems. Professor Loren Solnick's study sought to assess the state of knowledge of the retention effects of sea pay and to recommend an agenda for future research. Professor Richard Elster returned to the department to occupy the Chair of Manpower, Personnel and Training Analysis.

PERSONNEL, TRAINING AND TESTING

Professor Ken Thomas was supported by the NPS Research Council to develop a model of intrinsic task motivation for testing. Professor James Suchan was supported by Defense Personnel Security Research and Education Center (PERSEREC) to conduct an analysis of field agents and adjudicators written communication skills to determine if their reports of investigation were easy for adjudicators to read and comprehend. Professor William Haga conducted a study, through PERSEREC, to assess the state of security violation reporting and databases within military departments, DoD agencies and the defense contractor community.

POLICY ANALYSIS AND OTHER GENERAL MANAGEMENT

Nancy Roberts continued her multi-year study of collective power. The project involves theoretical as well as laboratory study to measure collective power using network analysis. She also collaborated with James Tritten of National Security Affairs Department in the defense strategic planning project. Professors Roger Evered and Joseph San Miguel started a project to design and evaluate management systems for Naval Industrial Improvement Program. Professors Dan Boger and M. W. Jee examined the roles and contributions Korea could make to help U.S. mobilization without increasing foreign dependence. The project was supported by the Comptroller of the Army.

Professor David Henderson examined the evidence bearing on the supply-side economists' claim that cuts in the marginal tax rates for the highest-income taxpayers caused little or no loss in tax revenue for the Federal government. He also analyzed the microeconomics of a variable import fee on oil.

Title:	Investigating the Incorporation of Expert systems Technology into System Dynamics Simulation Modeling
Investigator:	Tarek K. Abdel-Hamid, Assistant Professor of Information Systems
Sponsor:	NPS Research Council
Objective:	Investigate the Viability of Incorporating PROLOG rules in a System Dynamics Model of Software Project Management.

Summary: Simulation modeling of organizational systems represents a fertile application area for AI. This is especially true for simulations with multiple decision-making agents where each is performing tasks such as planning and scheduling. Advances in AI and Expert Systems (ES) have opened up possibilities in designing and implementing such coupled systems, that interleave symbolic and numerical processing efficiently and effectively. Subprocesses that are heuristic and symbolic (e.g., decision making) could be modelled by expert systems; while continuous physical subprocesses are modelled as dynamic systems. In this research effort we investigate the feasibility as well as the utility of incorporating an expert system module for human resource planning in a system dynamics model of software project management. The implications of capturing such decision making processes in a rule-based knowledge base, rather than using the traditional representation in procedural code will be analyzed from two viewpoints: model development (e.g., the flexibility of PROLOG rules versus a representation in procedural DYNAMO code), and model use (e.g., the user-machine interface).

Conference
Presentations: "Incorporating Expert Systems Technology into Simulation Modeling: An Expert-Simulator for Project Management," The 1988 Society for Computer Simulation Western Multiconference, February 1988.

Title:	Korean Contribution to US Mobilization
Investigators:	D. C. Boger, Associate Professor of Economics, and M. W. Jee, Adjunct Professor of Operations Research
Sponsor:	Resource Management Systems, Comptroller of the Army
Objective:	To examine the roles and contributions Korea could make to help U.S. mobilization without increasing foreign dependence.
Summary:	Various weapon systems which are being used by Korean forces but which are no longer being manufactured in the U.S. or are now only marginally profitable to the former U.S. manufacturers were surveyed. Additionally, the Korean defense industry was surveyed to determine which of the prior weapon systems might be available for manufacture in Korea. Such arrangements, if successfully introduced, could significantly add to Korea's defense burden sharing with the U.S.
Publication:	D. C. Boger and M. W. Jee, "Potential Korean Contributions to the U.S. Mobilization Base," Proceedings of the Seventh Mobilization Conference, National Defense University, April 1988, pp.171-197.
Conference Presentation:	D. C. Boger and M. W. Jee, "Potential Korean Contributions to the U.S. Mobilization Base," Seventh Mobilization Conference, National Defense University, April 1988.

Title:	Methods for Estimating Aircraft Modification and Derivatives
Investigators:	D. C. Boger, Associate Professor of Economics, and S. S. Liao, Professor of Accounting
Sponsor:	Naval Air Systems Command, Cost Analysis Division
Objective:	The objective of this multi-year project is to develop parametric cost estimating models for aircraft modifications. Phase I of the project focuses on the development of data format to facilitate subsequent data collection and analysis.
Summary:	An extensive survey of recent aircraft modification programs was conducted to identify suitable candidate program for inclusion in the study. From the initial list, initial inquiry was made by both NAVAIR and the PIs as to the possibility of obtaining cooperation from the contractor. NAVAIR and the PIs then visited the contractors to explain the type and format of data we need for the study and inquire about their availability. We then trained our thesis students on data collection techniques and sent them out to extract relevant data from the contractor's data file. Four contractors with a total of 8 programs were visited in Phase I.
Publication:	Technical Report in preparation.
Thesis Directed:	"Toward a Cost Estimation Model for Aircraft Modification" H. H. Nelson, R. L. Maki, and J. C. Gernand, Master's Thesis, December 1988.

Title:	Analysis of the Management Control and Information System Implications of RAMP
Investigators:	D. R. Dolk, Associate Professor of Information Systems and K. J. Euske, Associate Professor of Accounting Department of Administrative Sciences
Sponsor:	Commander, Naval Supply Systems Command
Objective:	The RAMP Project within the Navy is concerned with developing highly automated manufacturing facilities using advanced robotics. A prototype facility currently exists. A full scale operating facility is being constructed. Information and accounting systems in the U.S., both in the private and public sectors, are not designed to support this technology. This project is designed to systematically analyze the information needs for efficient and effective resource allocation and control of such facilities.

The specific goal of this research project is to:

(1) Analyze the current management control and information systems currently in place to support the RAMP project.

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

(3) Ensure that the systems provide valid and reliable information regarding the cost, effectiveness, and efficiency of the RAMP project.

Summary:	The accounting and reporting requirements for the system have been developed. Compatibility of these requirements with existing Navy systems have been analyzed. Currently, operational specifications are being developed for the system.
Theses Directed:	"Data Administration for the Rapid Acquisition of Manufactured Parts", Catherine T. Eads and Pamela A. Smith, Master of Science in Information Systems, September 1988.

"Resolving Inadequacies of the Navy Industrial Fund Cost Accounting System to Enable Its Use in the RAMP SMP Facility", Joseph W. Murphy, <u>Master's Thesis</u>, December 1988.

"A Study of the Adequacy of the Navy Industrial Fund Accounting System for Use with the RAMP SMP Facility", Michael Bently Bryant, <u>Master's Thesis</u>, June 1988.

"Cost Accounting in the Automated Environment", John Thomas Hastings, <u>Master's Thesis</u>, June 1988.

Title: A Decision Support System for Emergency
                        Communications

Investigators: D. R. Dolk, Associate Professor of Information
                        Systems Department of Administrative Sciences
                        Barry Frew, Adjunct Professor of Information
                        Systems Department of Administrative Sciences

Sponsor: National Communications Systems

Objective: This project is involved with the development of
                        the EPMIS (Emergency Preparedness Management
                        Information System) decision support system for
                        maintaining communications during a national
                        emergency. It 's an ongoing effort in which NPS
                        has participated the past three years. This was
                        my first year as Principal Investigator.

                        NPS' involvement is threefold:

                        (1) Serve as an internal validation and
                        verification agent to NCS upon the design of the
                        overall system which they have contracted out to
                        several subcontractors.

                        (2) Develop a more realistic damage assessment
                        module for the EPMIS than currently exists.

                        (3) Investigate the feasibility of incorporating
                        optical disc technology into the EPMIS
                        architecture.

Summary: Delivery of the EPMIS and a MicroVax environment
                        in which to test it has taken place. A thorough
                        analysis of the database design is taking place.
                        Several recommendations have been made to NCS to
                        integrate the various software and hardware which
                        each of the subcontractors has chosen for their
                        piece of the pie. An expert system approach to
                        the design of the overall project is currently
                        being considered. This internal validation and
                        verification is being done by Prof. Dolk. The
                        damage assessment module has been contracted to
                        Roland and Associates who are in the process of
                        developing a more sophisticated model. Prof.
                        Frew is investigating the optical disc technology
                        and is currently awaiting the delivery of several
                        pieces of hardware.

Title: Chair of Manpower, Personnel and Training Analysis

Investigator: Richard S. Elster, Professor, Department of Administrative Sciences

Sponsor: CNO (OP-01)

Objective: To enhance the abilities of MPTA graduates to assume policymaking billets within DoD. To conduct research on the implications of Title IV of the Goldwater-Nichols Act for the Navy, including the effects of the Act on the incidence of graduate education in the Navy.

Summary: The incumbent has taught at least one MPTA class each quarter and has given a number of presentations to other classes. Professor Milch, with advice from Dean Marshall, has developed a model to assess the effects of Title IV on graduate education. Construction of a data base to allow the model to be used to conduct the needed analyses is now underway using Navy and Defense Manpower Data Center files. Data base construction will continue to require considerable time and judgement from this investigator.

Title:	Analysis of Financial Management Issues at the Fleet Level
Investigators:	K. J. Euske, Associate Professor of Accounting and L. R. Jones, Professor of Financial Management, Department of Administrative Sciences
Sponsor:	Commander, Naval Air Forces, Pacific Fleet
Objective:	The objective of this project is to:

1)Analyze budget cuts and their effects on squadron operations and productivity.
2)Analyze the effectiveness and efficiency of contracting out for selected base activities.
3)Compare selected operations to current models and suggest approaches for dealing with the problems to improve cost-effectiveness and productivity.

Summary: This project is designed to investigate two areas of concern at the Fleet level. The first is an analysis of budget cuts and their effect on squadron operations. The second is the effectiveness and efficiency of contracting out for base activities.

Theses Directed: "Budgeting for Critical Mass for the Navy: An Approach to Planning for a Steady State Defense Budget," Julia F. Gilbert, Master's Thesis, December 1988.

"Evaluation of Commercial Activities in the Marine Corps," Michael D. Breneman, Master's Thesis, December 1988.

"Managing the F-14 Flight Hour Budget in an Environment of Decreasing Financial Resources," Jeff C. Kuhnreich, Master's Thesis, September 1988.

Title: Analysis of Financial Management at the
                       CINCPACFLT Level

Investigators: K. J. Euske, Associate Professor of Accounting
                       and J. L. McCaffery, Professor of Financial
                       Management, Department of Administrative
                       Sciences

Sponsor: Commander in Chief, United States Pacific Fleet

Objective: The objective of this project is to document
                       accounting information generation and usage in
                       CINCPACFLT and to analyze the effect of the
                       Goldwater-Nichols Act upon POM preparation at
                       CINCPACFLT.

Summary: The purpose of this project is to investigate
                       the process and analyze the efficiency of areas
                       of concern at CINCPACFLT. The issue of data
                       generation and reporting will be studied. The
                       effect of the Goldwater-Nichols Act upon the
                       programming process at the Cincpacflt level
                       will also be investigated.

Title:	Analysis of Personal Security-Related Financial Data for Individuals in Sensitive Positions
Investigator:	K. J. Euske, Associate Professor of Accounting, Department of Administrative Sciences
Sponsor:	Defense Personnel Security Research And Education Center (PERSEREC)

Objective: The objective of this project was to assist PERSEREC in the identification of methods to screen characteristics of financial health and behavior of individuals in sensitive positions and review products that were developed by analysts at PERSEREC.

Summary: Two different types of models were identified that can be useful in this process. One is the use of discriminant analysis. Discussions were held with policy makers in the Defense Investigative Service (DIS) to adopt a discriminant function similar to that used by the Internal Revenue Service. Adoption of this analysis technique should both save the federal government significant amounts of money in adjudication of cases and allow more frequent and more sophisticated financial screening of individuals in sensitive positions. The new metł)d would allow a yearly review instead of only once every five years, and at a lower cost. Additionally, the review tech¬ique would use much more sophisticated financial risk prediction models than those currently used. The second method that has been demonstrated to be useful is artificial intelligence (AI). One of the other faculty members working on a related project developed an AI model to review individual case records that are deemed to be high risk.

Publications: "The Use of Financial Information in Security Clearance Procedures," with D. P. Ward, Naval Postgraduate School Project Report, NPS 54-88-009PR, August 1988.

Conference Presentations: "Financial Information as an Indicator of Individual Integrity: Finding the Link," with D. P. Ward. Seventeenth Annual Meeting of the Western Decision Sciences Institute, March 30-31, April 1, 1988. NPS Working Paper 88-07. The audience consisted of approximately 10 individuals.

Theses Directed: A Literature Survey of Private Sector Methods of Determining Personal Financial Responsibility, Martin Bodzin, <u>Master's Thesis</u>, September 1988.

Title: Design and Evaluation of Management Systems for
                Naval Industrial Improvement

Investigator: Roger Evered, Professor of Management, and Joseph
                G. San Miguel, Professor of Accounting,
                Department of Administrative Sciences

Sponsor: Under Secretary of the Navy, Naval Industrial
                Improvement Program

Objective: To evaluate the effectiveness of the current
                management systems used by the Naval industrial
                activities. These systems include the strategic
                policy and planning system, the organizational
                structure, the internal reporting system, and
                the performance evaluation system.

Summary: Available information on the Department of the
                Navy's industrial activities was obtained from
                relevant sources including top officials' report
                and policy statements.   Reports of outside
                consultants were critically analyzed.   The
                practices of private companies were used for
                comparative purposes. Interviews were held at a
                representative sample of public and private
                shipyards. Also, interviews were held with Flag
                and Secretariat level officials including Naval
                Sea Systems Command Headquarters, the Comptroller
                Office, Office of Naval Operations for Logistics
                and several others involved in the corporate
                management process.   An analysis of the key
                corporate management issues was prepared and
                findings and recommendations were made to both
                the sponsor and relevant Flag officers involved
                in improving public shipyard performance.   In
                addition, a critical review of the Ship Depot
                Maintenance Study Report tasked by the CNO was
                presented to OPNAV 04 and to the sponsor at
                SECNAV.   ᴿ ᵤ̲ ᵗance and source materials for
                improving tne shipyards' strategic planning was
                provided to the NAVSEA 07.

Publications: Technical report in progress.

                Case study in progress.

Title: Security Violation Reporting and Databases in DOD

Investigator: William James Haga, Adjunct Professor, Department of Administrative Sciences

Sponsor: Defense Personnel Security Research and Education Center

Objective: Assess the state of security violation reporting and databases within military departments, DOD agencies and the defense contractor community in terms of:

1. Typology of definitions of security violations.
2. Magnitudes and trends in violations.
3. Violation reporting practices.
4. Databases on security violations within each agency.
5. Incentives and disincentives to accurate reporting.
6. Comparative security climates within organizations.

Summary: Inconsistencies were found among DOD agencies in defining security violations and assessing the relative severity of violations.

Inconsistencies in reporting detract from the utility of ISOO Standard Form 311 as an indicator of the magnitude of violations.

The number of SF 311 infractions in DOD has been falling. Violations have been rising among defense contractors.

In the absence of DOD policy and standards, military departments and agencies are developing diverse hardware and software solutions to tracking violations.

Military departments and DOD agencies largely adhere to 5200.1-R in investigating violations. However, they display variety in establishing hierarchies of penalties for security offenses.

Little was found in the way of systematic disincentives to the accurate reporting of violations to higher authority.

We undertook preliminary work in the development of a questionnaire to replace Project Insight's proposed ΓIS Security Survey to assess security climate in organizations.

Nine recommendations are made for changes in DOD policy and practices in the reporting and data management of security violations.

Publications: William J. Haga, "Security Violation Reporting and Databases in DOD," technical report, PERS-TR-88-X, December 1988.

Title: An Economic Analysis of the Military Compensation
                        System

Investigator: David R. Henderson, Associate Professor of
                        Administrative Sciences

Sponsor: Deputy Chief of Naval Operations (Manpower)

Objective: To examine several key issues relating to
                        military compensation. Several areas for
                        analysis include:

                        -- the cost effectiveness of bonuses relative to
                           other pay options
                        -- the effect of turbulence in the SRB program
                        -- the advantages and disadvantages of a salary
                           system
                        -- the use of deferred versus current
                           compensation
                        -- the decoupling of the close correlation
                           between pay, rank and length of service (LOS)

Summary: This research has been ongoing since December 1,
                        1986. It has focused so far on two issues: (1)
                        Selective Reenlistment Bonuses versus other means
                        of paying military personnel, and (2) the
                        economics of the draft versus the All-Volunteer
                        Force. In 1988, I revised previous reports on
                        bonuses and on the draft versus the AVF. A
                        critical issue in the analysis of the cost-
                        effectiveness of SRBs is the replacement cost of
                        a skilled enlistee. I wrote a preliminary
                        statement of the issues in estimating this
                        replacement cost.

Publication: David R. Henderson, "The Draft Versus the All-
                        Volunteer Force: An Analysis of the Issues,"
                        Naval Postgraduate School Technical Report, NPS-
                        54-88-003, March 1988.

Conference
Presentation: David R. Henderson, "The Draft Versus the All-
                        Volunteer Force: An Analysis of the Issues,"
                        Association for Public Policy Analysis and
                        Management (APPAM) Annual Research Conference,
                        Seattle, WA, October 27-29, 1988.

Theses   Kemalettin Gur, "Retention Behavior of Draftees
                        and Volunteers," Master's Thesis, December 1988.

                        Joseph W. Kroeschel, "Compensating Wage
                        Differentials and Military Labor Supply,"
                        Master's Thesis, December 1988.

Title:	"The Perverse Economic Effects of a Variable Import Fee on Oil"
Investigator:	David R. Henderson, Associate Professor, Department of Administrative Sciences
Sponsor:	Unsponsored
Objective:	To analyze the microeconomics of a variable import fee on oil.

Summary: A variable import fee on oil (VIF) was found to be very perverse. The VIF was shown, under a wide range of assumptions, to cause the elasticity of demand facing oil-exporting countries to fall. Thus, oil exporters with some degree of monopoly power would have a strong incentive to raise their price. The country imposing the VIF would then not receive as much revenue from the VIF as if it simply set a flat import fee that obtained the same domestic price.

Title: Are We All Supply-Siders Now? The Emerging
                    Consensus on Marginal Tax Rates

Investigator: David R. Henderson, Associate Professor,
                    Department of Administrative Sciences

Sponsor: Unsponsored

Objective: To present and assess the evidence bearing on
                    the supply-siders' claim that an x percent drop
                    in tax rates would cause a much less than x
                    percent drop in tax revenues, and to assess
                    whether there is a consensus on the importance
                    of marginal tax rates.

Summary: The study found agreement among researchers of
                    various political persuasions that cuts in the
                    marginal tax rates for the highest-income
                    taxpayers caused little or no loss in tax
                    revenue for the federal government. The main
                    reason for this result was not, as emphasized
                    in the preceding theoretical literature, that
                    people worked harder in response to lower
                    marginal tax rates, but that people avoided
                    taxes much less. That is, the elasticity of
                    tax avoidance with respect to tax rates turned
                    out to be much larger than the elasticity of .
                    labor supply. The study found some evidence
                    that a consensus is developing among tax
                    economists about the importance and
                    desirability of keeping marginal tax rates low.

Conference
Presentations: David R. Henderson, "Were the Supply-Siders
                    Correct?", Western Economic Association
                    International, Annual Meetings, Los Angeles,
                    CA, June 30-July 3, 1988.

                    David R. Henderson, "The Emerging Consensus on
                    Marginal Tax Rates: Are We All Supply-Siders
                    Now?", Western Economic Association
                    International, Annual Meetings, Los Angeles,
                    CA, June 30-July 3, 1988.

Title:	The Multi-Lingual, Multi-Model, Multi-Backend Database Management System
Investigators:	David K. Hsiao, Professor of Computer Science, Department of Computer Science and Magdi N. Kamel, Assistant Professor of Information, Department of Administrative Sciences
Sponsor:	The project is partially sponsored by the following organizations: Naval Security Group Command Naval Air Development Center Naval Ocean Systems Center National Computer Security Center
Objective:	To develop a single database system capable of executing transactions written in different data languages and supporting database structures of their corresponding data models. The system also allows cross-access of the different databases.
Summary:	This is a long term research project that represents a new and unconventional approach to the design of a database system. As indicated, its objective is to build a database that supports many database models and their corresponding languages. It also allows users to access different databases using their favorite model and language. During this quarter, my involvement in the project included contributing new ideas, setting directions on the implementation and experimentation work, and working on a major paper related to the project.
Publications:	David K. Hsiao and Magdi N. Kamel, "Heterogeneous Databases: Proliferations, Issues and Solutions," (In Progress).

Title:	Congressional Control of Navy Budget Execution
Investigator:	L.R. Jones, Professor of Financial Management
Sponsor:	Office of the Comptroller, Office of Budgets and Reports (NCB-1), Department of the Navy Objective: To identify, explain and evaluate the increase in Congressional control of Navy budget execution
Summary:	This project has focused on the manner in which Congress exerts control over both DoD and DoN budgeting. It has formulated and tested hypotheses to explain the increase in control documented to have occurred since the late 1960's, with emphasis on the 1980's.
Theses Directed:	"Congressional Control over the Department of Defense Budget," Glenn C. Bixler, Master's Thesis, December 1988.
	"Intent, Impact, and Public Policy Consequences of Congressional Control of Department of the Navy Budget Execution," Robert L. Williams, Master's Thesis, December 1988.
	"Maintenance and Repair of Naval Shore Facilities: Resources and Readiness," Thomas S. Hollinberger, Master's Thesis, December 1988.

Title: Resystemization Modelling Support

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

Sponsor: Navy Fleet Material Support Office

Objective: This is a continuing research effort to develop
                    improved wholesale inventory models for the U.S.
                    Navy.

Summary: The wholesale repairables replenishment model
                    development continued. An assumption made about
                    the probability distribution for the inventory
                    position of the ready-for-issue (RFI) units was
                    discovered to be incorrect. This led to the
                    model for RFI net inventory being reformulated
                    following the concepts developed by Hadley and
                    Whitin for non-repairable items. As a result, it
                    was also shown that the current Navy model for
                    net inventory of RFI units is incorrect.
                    Unfortunately, the new model does not provide
                    measures such as safety level and reorder point
                    of inventory position and net inventory which
                    wholesale level analysts and inventory managers
                    are used to. Therefore an investigation is
                    underway to determine if such measures can be
                    identified and quantified in the new model. A
                    simulation program has been developed to help
                    with this effort and to test certain other
                    assumptions of the new formulation. Two theses
                    were also written which deal with two important
                    aspects of the modelling effort.

Theses Directed: K. T. Adams, "The Effect of the Covariance Factor
                    on the Procurement Problem Variance of Net
                    Leadtime Demand," Master's Thesis, September
                    1988.

                    R. L. Schwaneke, "Essentially Weighted Models for
                    Wholesale Level Inventory Management," Master's
                    Thesis, December 1988.

Title:	Stock Point Expert Systems
Investigator:	A. W. McMasters, Professor of Operations Research and Administrative Sciences
Sponsor:	Naval Supply Systems Command, Code 0472
Objective:	This is a continuing research effort to develop expert systems to facilitate decision making by inventory managers at Navy Stock Points.

Summary: The development of a set of expert systems for use by Navy stock point inventory managers continued. This year a major refinement to the Delinquent Dues System, begun last year, was completed. This included an additional component to handle order cancellations. Now a stock point inventory manager can use this complete system to investigate overdue orders from the Defense Logistics Agency and efficiently cancel any which are excessively late. Another system was also developed this year; it is known as Causative Research. This system deals with the continual problem of inventory accuracy. The purpose of this system is to identify the reasons for inventory adjustments being needed. It seeks to eliminate the errors creating discrepancies between inventory records and actual inventory held in the warehouses. This system received such enthusiastic response from stock point personnel and the personnel at NAVSUP concerned with quality control in the work place that it is going to be used this year as a training tool for new inventory managers.

Theses Directed: W. D. and J. D. Ellison, "An Expert System in Causative Research for Inventory Management," Master's Thesis, June 1988.

A. F. Potwin, "A Dues Management Expert System for Inventory Managers at Retail Stock Points," Master's Thesis, March 1988.

Title: Army Reserve Migration Study

Investigator: Stephen L. Mehay, Professor of Economics,
                    Department of Administrative Sciences

Sponsor: U.S. Army Recruiting Command

Objective: This project has four objectives: (a) to profile
                    the pattern of internal geographic transfers
                    within the U.S. Army Reserve; (b) to compare the
                    internal transfer pattern with the pattern of
                    civilian labor force migration from place to
                    place; (c) to estimate structural models of
                    migration by Army Reservists; and (d) to
                    integrate this information into USAREC management
                    and mission models.

Summary: We are currently creating longitudinal data files
                    of all transactions of Army Reserve members from
                    1981 to 1988. This file will be used to
                    determine the geographic pattern of internal
                    transfers within and between Army Reserve
                    commands. The second step is to obtain and
                    analyze civilian migration files from the Census
                    Bureau.

Thesis Directed: J. Northcut, "Migration of Army Reserve Members,"
                    Master's Thesis, December 1988.

Title:	Collective Power
Investigator:	Nancy Roberts, Associate Professor, Department of Administrative Sciences
Sponsor:	NPS Research Council
Objective:	This research is part of a continuing research program that has four basic objectives: (1) A theoretical statement on the concept of collective power derived from case studies; (2) the refinement and development of a research methodology derived from laboratory studies to measure collective power using network analysis; (3) the study of collective power in organizations using the theoretical and methodological tools developed in 1 and 2 above; and (4) the organization of a national conference and the editing of a book on the concept of collective power.

Summary:	Collective power is defined as a special type of power in which social actors share their resources, and cooperate to achieve ends they have collectively defined. It is important for our understanding of management in all types of organizations, for it derives from working with others rather than against them.

Unlike other forms of power, collective power evolves from a merging or fusion with others to create a whole that is more than the sum of the parts. It is built on positive affect and feelings of unity and oneness with others. It differs from other traditional forms of power that conceptualize power as dominance and control (e.g. power is the ability to get what one wants despite the resistance of others).

In this past reporting period, the following objectives have been accomplished: 1) Continued data analysis on the two data sets collected. 2) Theoretical papers on the various aspects of collective power and empirical papers on the results from these studies have been written (see below). 3) Papers have been presented at various national conferences for feedback and criticism (see below). 4) One conference has been held and another scheduled for 1988. |

Publications	Nancy Charlotte Roberts, "Toward a Synergistic Model of Power, in <u>Shared Power</u>, J.M. Bryson and R.C. Einsweiler (EDs.), Lanham, MD: University Press of America (Forthcoming).

Nancy Charlotte Roberts and Raymond Trevor Bradley, "Limits to Charisma," in <u>Charismatic Leadership in Management</u>, Jay Conger and Rabindra Kanungo, (Eds.), San Francisco: Jossey-Bass, 1988.

Nancy Charlotte Roberts and Paula King, "The Process of Public Policy Innovation," in <u>Research on the Management of Innovation</u>, Vol. 2. A. Van de Ven, S.Poole, and H. Angle (Eds.) New York: Ballinger, 1988.

Nancy Charlotte Roberts and Paula King "Policy Entrepreneurs: Catalysts in Innovative Public Policy", (submitted).

Nancy Charlotte Roberts, <u>Collective Power</u>, (in progress).

Nancy Charlotte Roberts and Paula King, "The Stakeholder Audit: A Key Political Tool in the Change Process," (in progress).

Nancy Charlotte Roberts, "Power Structures in Work Groups: A Test of Hologramic Theory," (in progress)

Nancy Charlotte Roberts, "A New Typology of Power: Collective, Distributive and Intercursive Power," (in progress).

Nancy Charlotte Roberts, "Power Styles Inventory: Measurement of Collective and Competitive Paths to Organizational Power," (in progress).

Nancy Charlotte Roberts, "The Exercise of Power in Organizations: A Test of Empowerment Hypothesis," (in progress)

Conference
Presentations: Nancy Charlotte Roberts and Paula King, "Policy Entrepreneurs: Key Participants in the Policy Formulation Process," paper presented to the Eighth Annual APPAM Conference, Lyndon B. Johnson School of Public Affairs, University of Texas at Austin, October 30-November 1, 1987.

Nancy Charlotte Roberts, "A Developmental Perspective on Power: Some Preliminary Findings," paper presented to the Social Psychology and Personality Colloquium, University of California, Santa Cruz, Nov. 12, 1987.

Thesis Directed: John Garner, "Military Leadership from a Developmental Perspective," <u>Master's Thesis</u>, March 1988.

Title:	The Effects of Sea Pay on Reenlistments and Voluntary Extensions
Investigator:	Loren M. Solnick, Associate Professor of Economics
Sponsor:	Economic Analysis Section, Military Compensation Branch (OP-134E)
Objective:	To assess the state of knowledge of the retention effects of sea pay, and to recommend an agenda for future research based on revealed knowledge gaps and Navy manpower planning needs.
Summary:	The study reviews the recent major theoretical and empirical studies of the retention effects of sea pay. The study concludes that the theoretical works are sound, being well grounded in accepted economic theory, but that the empirical studies are deficient for several reasons (use of aggregated data; failure to account for certain personal and demographic factors that influence retention; use of less than ideal statistical procedures, due to use of aggregated data). The study concludes that analyses using individual level data, incorporating information from the Annual Survey of Officers and Enlisted Personnel, and utilizing appropriate statistical models, would produce better estimates. The study recommends that future research also consider the effects of sea pay on the quality of personnel who reenlist, a previously unexplored issue.
Publications:	"The Effects of Sea Pay on Reenlistments and Voluntary Extensions," NPS Technical Report 54-88-012 November 1988.

Title:	Effectiveness of Group Decision Support Systems in Solving Specific Problem Types
Investigator:	James Suchan, Associate Professor of Managerial Communications, Department of Administrative Sciences
Sponsor:	NPS Research Council
Objective:	This project sought to determine if a non-distributed Group Decision Support System (GDSS) using Co-oP will help decision groups make better and faster decisions when faced with complex high task/high relationship problems than groups working in a traditional meeting room environment. Also, the project determined if a GDSS froze communication channels among group members.

Summary:	No statistically significant differences were observed in decision quality and decision speed between groups using a GDSS and groups working in a traditional meeting room environment. Interestingly, groups using the GDSS were less satisfied with their decision outcomes and the decision process than the non-GDSS group. The reason for this dissatisfaction stems from GDSS blocking customary communication channels traditionally used by group members in a typical meeting environment. GDSS group members' principle means of communication consisted of keyboarding; very little verbal and non-verbal communication interchange occurred in the GDSS environment.

Publications:	James Suchan, "An Analysis of Communication Channel Use in Non-Distributed Group Decision Support Systems," Management Communication Quarterly, (under review)
	James Suchan, "A Contingency Model for GDSS Use: A Communications Perspective," (in progress)
Thesis Directed:	James P.Driscoll and Jeffrey A. King, "An Empirical Experiment Evaluating the Effectiveness of Group Decision Support Systems," Master's Thesis, September 1988.

Title:	Analysis of Field Agents and Adjudicators Written Communication Skills
Investigator:	James Suchan, Associate Professor of Managerial Communications, Dept. of Administrative Sciences
Sponsor:	PERSEREC
Objectives:	This project analyzed Department of Investigative Service (DIS) field agents' written communication skills to determine if their Reports of Investigation (ROIs), particularly the subject interview sections, were easy for adjudicators to read and comprehend.
Summary:	Semi-structured interviews were conducted with DIS field agents and adjudicators. Also, protocol analysis was done with field agents to determine their composing process patterns. Finally, over 120 ROIs were examined to assess field agents' written communication habits. Results indicated that field agents composed reports that were poor in document design and syntactic structure. Adjudicators, the end users of these reports, complained of eye strain and fatigue largely because of the poor document design and organization of these reports. Also, field agents did not consider the information processing needs of the adjudicators when they composed their ROIs. This lack of reader awareness also made the composing of easy to read and understand reports virtually impossible.
Publications:	James Suchan, "An Analysis of Field Agents' Written Communication Skills," PERSEREC Technical Report (under review by PERSEREC).

Title:	USAR Market Study, Phase I USAR Market Study, Phase II USAR Market Study, Phase III
Sponsor:	U. S. Army Recruiting Command
Investigators:	George W. Thomas, Associate Professor of Economics S. Mehay, Professor of Economics L. Solnick, Associate Professor of Economics L. Johnson, Assistant Professor of Operations Research
Objective:	Phase I: The development of local (zip code level) labor market geo-demographic attitudinal data base. Phase II: Identification and estimation of the magnitude of relevant market segments of the USAR national market. Specific segmentation will include development of prior service and nonprior service Reserve accessions models. Phase III: Incorporation of results of Phase II into sponsor's Market Supportability Study management model.
Summary:	This is an ongoing program of research with Army Recruiting Command. Phase I was the construction of nationwide local labor market data bases for estimating military available population. This phase was completed in 1986. Phase II, begun in 1987, was a series of analyses of data bases constructed and accumulated in Phase I. This phase continued into 1988. Phase III is the incorporation of Phase II results into the management decision models at Headquarters USAREC. This phase was started in 1988.
Publications:	USAR Prior Service Market: A Comparison of Active Duty Reenlistment Motivations with Reserve Enlistment Intentions of Active Duty Personnel, NPS 54-88-016, December 1988.
Conference Presentations:	"USAR Market Study" with S. Mehay, Army Recruiting Research Coordination Conference, Evanston, IL, November 1988.
Theses Directed:	"An Analysis of Retention of First Term Enlisted Personnel in the Selected Reserves," Master's Thesis, June 1988.

Title: USAR Enlistment Motivations (RUPTE)

Sponsor: US Army Recruiting Command

Investigators: George W. Thomas, Associate professor of
                    Economics, Department of Administrative Sciences,
                    and Kathryn Kocher, Labor Economist, Department
                    of Administrative Sciences

Objective: To study and contrast the demographics and
                    enlistment motivations of USAR enlistees and ARNG
                    enlistees as well as to contrast NPS and PS USAR
                    enlistees using survey data at time of
                    enlistment.

Summary: During this period we used the 1987 new Recruit
                    Survey to determine: 1) the demographic
                    compositions of entering recruits; 2) the
                    recruiting resources that target high quality
                    recruits; 3) enlistment motivations; 4)
                    propensity for remaining in service; and 5) the
                    recruiting and advertising practices that are
                    the most successful. These data will be analyzed
                    by separate components: USAR and ARNG.
                    Knowledge of enlistment options, enlistment
                    motivations, and successful recruiting and
                    advertising practices were analyzed by
                    demographic characteristics such as age, region
                    of the country, gender, and ethnicity as well as
                    recruit quality indications such as AFQT scores
                    and education.

Publications: "USAR Enlistment Motivations" under draft January
                    1989.

Theses Directed: "USAR High Quality Enlistment Motivations," D.
                    Halvorson, MS in Operations Research, due March
                    1989.

Title:	Analysis of USAR Female Recruiting (RUGTE)
Sponsor:	US Army Recruiting Command
Investigators:	George W. Thomas, Associate Professor of Economics, and S. Mehay, Professor of Economics
Objective:	To determine the desired level of female participation in the Reserves. This study will provide the recruiting command with a knowledge base of current levels of female participation in the Reserves, attrition factors for women, incentives relevant to women, and an assessment of female qualified military available by regions.
Summary:	This project is related to the NPS projects on Reserve Market Studies (RHUTE, RCSTE). The project has five tasks: 1) a literature and data review of female participation in the Reserves; 2) a socioeconomic profile of current female USAR members including military skill and unit type using uSAREC provided data; 3) a summary of attrition by reason code and demographic/military factors using USAREC provided data; 4) a summary of incentives that are relevant to female uSAR members using existing literature and attitude surveys; and 5) a preliminary identification of female military available population for local Reserve markets using adjusted census data taking into consideration those enlisted restrictions IAW AR 6-1-210. Tasks 2 and 4 were undertaken in this report period.
Publication:	Profile of USAR Female Membership, technical report under draft January 1989.
Thesis Directed:	Female Enlistment in the United States Army Reserve: Membership and Motivations, Spencer, Murray, December 1987, <u>Master's Thesis</u>.

Title:	USAR Nurse Attrition/Retention Study (RUVTE)
Sponsor:	US Army Recruiting Command
Investigators:	George W. Thomas, Associate Professor of Economics, B. Roberts, Adjunct Professor of Administrative Sciences, K. Kocher, Labor Economist
Objective:	To provide valid loss profiles of Army Nurse Corps (ANC) officers assigned to Reserve Centers; and to analyze factors influencing the retention of nurses in the Reserves.
Summary:	During this period, we developed socio-demographic profiles of Army Nurse Corps membership and estimated loss profiles of ANC officers. We are awaiting survey results from colleagues at the University of Utah in order to undertake our retention analysis. These studies should lead to improved methods for addressing current DOD nurse shortages.
Publication:	"The Reserve Intention of Active Duty Army Nurses" with K. Kocher, NPS 54-88-014, December 1988.
Theses Directed:	E. Macaraeg, "An Analysis of Factors Affecting the Career Plans of Military Nurses," Master's Thesis, December 1988.
	T. Gaffney, "A Turnover analysis for Department of Defense Physicians," Master's Thesis, June 1988.

Title:	Market analysis for the Year 2000 (RATTE)
Sponsor:	US Army Recruiting Command
Investigators:	George W. Thomas, Associate Professor of Economics, S. Mehay, Professor of Economics, and L. Solnick, Associate Professor of Economics
Objective:	The objective of this study is to develop local measures of Qualified Military Available and Interested for the Year 2000. These measures will then be incorporated into the sponsor's National Market Analysis Management model.
Summary:	In this period we were able to review the methodology for estimating local area QMA&I. Preliminary estimates of QMA were completed in Fall 1988.
Publication:	"Estimates of Local Area Qualified Military Available," with L. Goldberg, in progress.

Title: Testing a Cognitive Model of Work Motivation

Investigator: K. W. Thomas, Professor of Administrative
                    Sciences

Sponsor: NPS Research Council

Objective: To provide a tested version of the
                    Thomas/Velthouse model of intrinsic task
                    motivation, including model refinement and the
                    development and testing of measures

Summary: Briefly, the model states that intrinsic task
                    motivation (along with job satisfaction and job-
                    related stress) depends upon four cognitive
                    assessments which individuals make regarding
                    their task, which are in turn shaped by
                    individuals' "interpretive styles."
                    Questionnaire measures of task assessments and
                    interpretive styles were refined and
                    administered to managers in three organizations.
                    Results strongly supported the basic model and
                    suggested refinements in the definition of the
                    interpretive styles. A second-generation
                    questionnaire was developed based upon the
                    findings, which will be used in future research.

Publications: K. W. Thomas and B. A. Velthouse, "Cognitive
                    Elements of Empowerment: An 'Interpretive' Model
                    of Intrinsic Task Motivation" (completed
                    manuscript, to be submitted to the Academy of
                    Management Review).

Conference
Presentations: K. W. Thomas and W. G. Tymon, Jr., "Testing an
Presentation: Interpretive Model of Intrinsic Work
                    Motivation," 24th International Congress of
                    Psychology, Sydney, Australia, September, 1988.

Thesis Directed: W. G. Tymon, Jr., "An Empirical Investigation of
                    a Directed: Cognitive Model of Empowerment,"
                    Ph.D. dissertation, Temple University, 1988.

Project Title: Optimal Scheduling of PERT Activities with Tree
                   Precedence Networks and an Application to Hub
                   Operations

Sponsor: NPS Research Council

Investigator: Dan Trietsch

Summary: In a typical hub airport, incoming flights from
                   many origins feed outgoing flights to many
                   destinations. If an incoming flight is late,
                   outgoing flights which are fed by it may also be
                   delayed eventually. Alternately, planes may
                   leave before some feeding flights arrive, thereby
                   incurring high misconnection penalties. Clearly,
                   if we plan for very long scheduled ground time
                   between the last incoming flight and the first
                   outgoing one, we can reduce the risk of
                   unscheduled delays or misconnections. However,
                   such a schedule may cost the airline too much in
                   terms of idle personnel and equipment and will
                   not be attractive to the passengers either. On
                   the other hand, if we plan for very short
                   scheduled ground time, we run the risk of
                   excessive unscheduled delays, and/or
                   misconnection penalties. In this report we
                   develop models designed to optimize the scheduled
                   ground time under two pure policies: (i) to wait
                   as long as necessary to ensure all connections,
                   and (ii) not to wait at all (i.e., pay
                   misconnection penalties rather than delay
                   penalties).

                   The hub-scheduling model, in addition to air
                   transportation applications, has direct relevance
                   to the problem of handling items at a central
                   depot. Here, as soon as all the requested items
                   are received, they are ready to be transferred
                   to the customer.

Publications: Project Output: Scheduling Flights at Hub
                   Airports, NPS-54-88-007, June 1988, submitted to
                   Transportation Science.

Title:	Applying Analytical Hierarchies to Computer-Family Selection Procedure
Investigator:	Moshe Zviran, Assistant Professor, Department of Administrative Sciences
Sponsor:	NPS Research Council
Objective:	To apply the Multiple Criteria Analysis (MCA) method to the computer family selection procedure and establish a comprehensive methodology for this process.
Summary:	An intensive survey on the methodologies in selecting computer hardware was completed, indicating that most current selection models have one feature in common - they address the issue of acquiring a specific system, but fail to address the problem of the need to select a whole family of computer systems. This project suggests the utilization of Saaty's Multiple Criteria Analysis (MCA) method in the procedure of selecting a computer-family.
Thesis Directed:	E.S. Davis, "Developing a Comprehensive Methodology for Computer-Family Selection Procedure" (in progress).

DEPARTMENT
OF
OPERATIONS RESEARCH

DEPARTMENT OF OPERATIONS RESEARCH

The research program in the Department of Operations Research seeks to advance the field's state of knowledge in areas important to the Department of the Navy, the Department of Defense, and military planning. The study of operational problems often leads to the mathematical integration and structuring of a number of interdisciplinary components, and the potential exists for a huge variety of applications. The summaries that follow are organized according to academic content, and the nature of applications are attached.

The specific areas currently represented are large-scale optimization, stochastic modelling, statistics and data analysis, operations studies, warfare modelling and combat analysis. The efforts of twenty-two department faculty and their students are reported. Sponsors are not included but can be found on the individual summaries.

Tangible output appears in the form of student theses, reports to sponsors, Naval Postgraduate School Technical Reports, conference presentations and refereed journal articles in the open literature. The research summaries of department faculty whose efforts involved projects sponsored outside the department are reported elsewhere.

OPTIMIZATION

Large-scale optimization generally deals with the construction and efficiency of algorithms for selecting values for a large number of variables in order to optimize a deterministic objective function. Professors Bradley, Brown and Wood continue their work on exploiting special problem structure. A mathematical programming system is being developed to allow direct execution of optimization models. The main impetus is provided by large mixed integer models arising in diverse contexts ranging from capital budgeting to manpower planning.

Professor Lawphongpanich is exploring the relationship between the generalized linear programming problem and a feasible direction technique. The impetus is the need for efficient algorithms for planning military deployments in time sensitive situations.

Professor Rosenthal is continuing his work on a large-scale network optimization model for assigning officers to billets during mobilization. The primary advance this year was in terms of improving the program's speed.

Professor Milch continues his modeling work for the United States Marine Corps. Investigations for the current period include: (1) the feasibility of converting certain billets to civilian jobs, and (2) the management of officer career paths in light of the newly created joint duty assignments created by Title IV of the Goldwater-Nichols Act.

STOCHASTIC MODELING

Stochastic modeling deals with the description of systems, networks, or other entities that have random components of sufficient variability to affect the output or performance of the system. Use of such models further requires the modeling or empirical estimation of the parameters used by the probability laws. Professors Gaver and Jacobs have a longstanding involvement and, for the current reporting period, have used empirical Bayes modeling in non-Gaussian situations arising in the tracking of targets, reliability and availability of equipment, logistics support, time dependent queueing. These faculty are also developing stochastic models to analyze the effects of packet and message size variation on network throughput for DCA.

Professor Purdue continues his work in modeling the movement of particles through a network subject to a variety of restrictions. Applications include manpower systems and data communication systems.

Professor Lewis continues his modeling work in time series and point processes. A class of minification and maxification processes have been derived for use in nonlinear applications. His simulation packages have been improved; advances have been made at the access interface between large data sets and statistical packages.

A new faculty member, Professor Bailey, works on the stochastic nature of clutter optimization schemes. Applications include the performance of integrated air defense systems.

STATISTICS AND DATA ANALYSIS

Professors Larson and Jayachandran continue their work on the spectrometric analysis of used engine oil samples. Current efforts centered around the calibration of the production model portable analyzer and the development of conversion methodology.

Professor Read continues his work on the use of empirical Bayes shrinkage methods to the development of an attrition rate generator for large manpower models. Current work involves the development of policies for combining small cells (of personal categories) into groups that have statistical stability and blend with the organizational structure.

Professor Woods continues his study of point estimation schemes and failure discounting methods that have found use in the reliability development of new, large hardware systems.

A new faculty member, Professor Johnson, is studying the relationship of a variance function to the smoothing and contour estimation of spatial data. Applications include the forecasting of sea water variables.

OPERATIONS STUDIES

These studies are geared to support more immediate operational problems. Professor Poock continues his work on speech input technology. Experimental work with prototype equipment was featured in this reporting period. Professor Eagle developed and is testing a new method of determining the optimal search path for a moving target using a Markovian model.

Professor Washburn addressed the mine warfare problem of allocating mine stockpiles, diverse in type and widely distributed to several theaters simultaneously.

WARGAMING AND COMBAT ANALYSIS

Professor Parry, in collaboration with Professor Schoenstadt, is developing a data base for and demonstrating the use of the Generalized Value System in support of the ALARM planning model. This system predicts battlefield status; assigns values to sets of states; aids in the dynamics of battlefield decisions.

Professor Shudde in collaboration with CDR Stewart and CDR Halwachs is working on a computer program which depicts satellite orbit parameters in support of the Enhanced Navy Warfare Gaming System and the Joint Theater Level Simulation. LCDR Mitchell is working on the compilation and maintenance of display symbology for fixed wing tactical aircraft for use in the proposed HUD formats.

Professor Hughes is extending his concepts (described in his book, Fleet Tactics) to develop a theory that includes interrelationships between force, maneuver and suppression as an alternative to attrition centered analyses of combat.

Title: Stochastic Clutter Systems

Investigator: M.P. Bailey, Assistant Professor of Operations
                Research

Sponsor: Naval Postgraduate School Research Council

Objective: To exploit known combinatorial properties of
                clutter structures so that the stochastic
                nature of clutter optimization schemes on
                random data can be studied analytically.

Summary: A clutter is a set of subsets such that no two of
                these subsets may be ordered by inclusion.
                Examples are often found in networks, eg. paths,
                cutsets, spanning trees, cliques. This is a study
                into the structural properties of a set of
                optimization problems in which the minimum or
                maximum weight clutter object is found. The
                interest is in developing properties which carry
                through to the case where the weights are
                independent random variables. The theory
                developed has applications in the study of the
                optimal objective function value of a set of
                combinatorial optimization problems, such as the
                distribution of the weight of the minimum weight
                spanning tree in a network with independent arc
                weights.

Publications: M.P. Bailey, "Constant Access Systems: A Framework
                for Stochastic Network Optimization," in progress.

                M.P. Bailey, "Performance of Integrated Air
                Defense Systems," in progress.

                M.P. Bailey, V.G. Kulkarni, "Markov Matroids
                and Stable Access Systems," in progress.

Conference   M.P. Bailey, "Performance of Integrated Air
Presentations: Defense Systems," MORS Annual Meeting, Monterey,
                June 26, 1988.

                M.P. Bailey, "K-trigger Networks Used in the
                Analysis of Air Defense Systems," ORSA/TIMS
                Meeting, Denver, October 22, 1988.

Thesis   None
Directed:

Patent: None

Title: Large-Scale Optimization

Investigators: G.H. Bradley, Professor of Operations Research,
                 G.G. Brown, Professor of Operations Research, and
                 R.K. Wood, Associate Professor of Operations
                 Research

Sponsor: Office of Naval Research

Objective: Develop theory and algorithms for solution of
                 large-scale optimization models (continuing
                 project).

Summary: A continuing research effort emphasizing exploit-
                 ation of special problem structure. Decomposition
                 and relaxation methods are being developed and
                 applied in concert with specialized algorithms to
                 solve the subproblems produced. The main impetus
                 of this work is provided by large mixed integer
                 models arising in diverse contexts ranging from
                 capital budgeting to manpower planning. Special
                 integer enumeration control structures are being
                 developed which employ a novel elastic model
                 formulation especially useful for difficult
                 integer master problems generated by primal
                 decomposition schemes. A mathematical programming
                 modeling system to allow direct execution of
                 optimization models is being developed. Each
                 major avenue of research is thoroughly tested on
                 real-life problems provided by other researchers,
                 government agencies and commercial sources. A new
                 research effort is directed at designing and
                 prototyping a computer-based system to support
                 researchers who are developing optimization models
                 and algorithms.

Publications: G.G. Brown, C. Goodman, and R.K. Wood, "Annual
                 Scheduling of Atlantic Fleet Naval Combatants,"
                 Operations Research, forthcoming.

                 G.G. Brown, G. Graves, H. Lange, C. Staniec, and
                 R.K. Wood, "Dual Decomposition Methods for Solving
                 Multicommodity Flow Problems," in progress.

                 D. DeWolfe, J. Stevens, and R.K. Wood,
                 "Determination of Military Reenlistment Bonuses,"
                 in progress.

                 R.K. Wood, "Primal Decomposition by Fictitious
                 Play of a Two-Person Game," in progress.

                 G.G. Brown, G. Graves, and T. Harrison, "Large-
                 Scale Production Planning in the Pharmaceutical
                 Laboratory," in progress.

R. Clemence, W. Teufert, G.G. Brown, and R.K. Wood, "Phoenix: Developing and Evaluating Army Aviation Modernization Policies Using Mixed Integer Linear Programming," Proceedings of 27th U.S. Army O.R. Symposium, forthcoming.

G.G. Brown, "Operations Research in Optimization at the Naval Postgraduate School," Naval Research Reviews, 39, (1987), pp. 9-13.

G.G. Brown, G. Graves, and M. Honczarenko, "Design and Operation of a Multicommodity Production/ Distribution System Using Primal Goal Decomposition," Management Science, 33, No. 11, (November, 1987), pp. 1469-1480.

D. Bausch, G.G. Brown, "NDP FORTRAN and Phar Lap Tools," OR/MS Today, 15, No. 3, (June 1988), pp. 20-25.

G.H. Bradley, R. Clemence, "A Type Calculus for Executable Modeling Languages," IMA Journal of Mathematics in Management, 1, 1988, pp. 277-291.

G.H. Bradley, R. Clemence, "Model Integration with a Typed Executable Modeling Language," Proceedings of the 21st Annual Hawaii International Conference on System Sciences, III, IEEE Computer Society, Washington, D.C., (1988) pp. 403-410.

G.H. Bradley, "Mathematical Programming Modeling Project - Overview," Proceedings of the Impact of Recent Computer Advances on Operations Research, forthcoming.

G.G. Brown, A. Vassiliou, "ARES, A System for Real-Time Optimization of Disaster Relief", in progress.

Conference Presentations:

G.H. Bradley, "Mathematical Programming Modeling Project - Overview," IMPS Roundtable, Denver, October 27, 1988.

G.H. Bradley, panel on "Data Formats for Mathematical Programming," ORSA/TIMS Fall Meeting, Denver, October 24-26, 1988.

R. Clemence, W. Teufert, G.G. Brown, and R.K. Wood, "Phoenix: Developing and Evaluating Army Aviation Modernization Policies Using Mixed Integer Linear Programming," 27th U.S. Army O.R. Symposium, Fort Lee, October 12-13, 1988.

G.G. Brown, C.E. Goodman, and R.K. Wood, "Annual Scheduling of Atlantic Fleet Naval Combatants," EUROIX TIMS XXVIII Joint International Conference, Paris, July 6-8, 1988.

G.H. Bradley, R. Clemence, "A Type Calculus for Integrating Models," ORSA/TIMS Spring Meeting, Washington, D. C. April 25-27, 1988.

G.H. Bradley, "A Type Calculus for Integrating Models, University of North Carolina, Chapel Hill, March 22, 1988.

G.H. Bradley, R. Clemence, "Model Integration with a Typed Executable Modeling Language," 21st Annual Hawaii International Conference on System Sciences, Honolulu, January 5-8, 1988.

G.H. Bradley, "A Type Calculus for Integrating Models," Western Management Science Institute, Los Angeles, December 1, 1987.

G.G. Brown, G. Graves, T. Harrison, R. Graber, J. Larson, and R. Park, "Large-Scale Production Planning in the Pharmaceutical Industry," EURO IX TIMS XXVIII Joint International Conference, Paris. July 6-8, 1988.

Theses Directed:	D. Randall, "Software Reusability: A Decision Tree Model, <u>Master's Thesis</u>, June 1988.
	H. Lange, "Solution of Large-Scale Multicommodity Network Flow Problems Via a Logarithmic Barrier Function Decomposition," <u>Master's Thesis</u>, March 1988.
	T. Nachtscheim, "Design and Implementation of a Program Family for Type Evaluation," <u>Master's</u> Thesis, December 1987.
	M. Hayes, "Design for a Prototype Marine Corps Office Staffing Model," <u>Master's Thesis</u>, December 1987.
Patent:	None

Title:	Development and Evaluation of a Method for Computing Optimal Search Paths when Path Constraints Exist
Investigator:	J.N. Eagle, Associate Professor of Operations Research
Sponsor:	Office of Naval Research
Objective:	The objective of the research was to develop and test a new method of determining the optimal search path for a moving target.
Summary:	A search is conducted for a target moving in discrete time among a finite number of cells according to a known Markov process. The searcher must choose one cell in which to search in each time period. The set of cells available for search depends upon the cell chosen in the last time period. The problem is to find a search path, i.e., a sequence of search cells, that maximizes the probability of detecting the target in a fixed number of time periods. Closely following earlier work by Theodor Stewart, a branch-and-bound procedure is developed which finds optimal search paths. This procedure is tested and appears to be more efficient than existing dynamic programming solution methods.
Publication:	J.N. Eagle, J.R. Yee, "An Optimal Branch-and-Bound Procedure for the Constrained Path, Moving Target Search Problem," Operations Research, forthcoming.
Conference Presentations:	None
Thesis Directed:	J.F. Caldwell, Jr., "Investigation and Implementation of an Algorithm for Computing Optimal Search Paths," Master's Thesis, September 1987.
Patent:	None

Title:	ASW Nonacoustic Detection Systems
Investigator:	R.N. Forrest, ASW Academic Group Chairman and Professor of Operations Research
Sponsor:	Naval Technical Intelligence Center
Objective:	The objective of the research was to develop a model submarine detection by magnetometer based detection systems.
Summary:	A model was developed that can be used to generate lateral range functions for encounters between a submarine and a magnetometer based detection system. A program to implement the model was written which generates lateral range functions for various input parameters including encounter characteristics, geographic location, submarine dipole moments and the allowed false alarm rate.
Publications:	R.N. Forrest, "A Program to Compute Magnetic Anomaly Detection Probabilities," Naval Postgradaute School Technical Report, NPS71-88-001 (Revised), Octoᴸ ᒋᐧᐧᐧ

Title: Acoustic Cover and Deception

Investigator: R.N. Forrest, ASW Academic Group Chairman and
                      Professor of Operations Research, and J.N.
                      Eagle, Associate Professor of Operations
                      Research

Sponsor: Chief of Naval Operations, OP 71

Objective: The objective of the research was to
                      investigate the impact of acoustic cover and
                      detection devices on the localization
                      effectiveness of submarines.

Summary: Analytic and simulation models have been
                      developed that can be used to estimate bounds
                      on localization times as a function of decoy
                      numbers and target area size. This is an
                      ongoing project.

Publications:

Title:	NSW Nonacoustic Detection Systems
Investigators:	R.N. Forrest, ASW Academic Group Chairman and Professor of Operations Reserach
Sponsor:	Naval Technical Intelligence Center
Objective:	The objective of the research was to develop a model submarine detection by magnetometer based detection systems.

Summary: A model was developed that can be used to generate lateral range functions for encounters between a submarine and a magnetometer based detection system. A program to implement the model was written which generates lateral range functions for various input parameters including encounter characteristics, geographic location, submarine dipole moments, and the allowed false alarm rate.

Publications: R.N. Forrest, "A Program to Compute Magnetic Anomaly Detection Probabilities," Naval Postgraduate School, NPS71-88-001, October, 1988.

Title: Stochastic Modelling and Data Analysis

Investigators: D.P. Gaver, Professor of Operations Research,
                and P.A. Jacobs, Professor of Operations
                Research

Sponsor: Office of Naval Research

Objective: The objectives of this continuing project are
                    to develop, apply, test and validate new methods
                    of probability modelling and statistical inference
                    and data analysis for solving problems arising in
                    applications, especially in the Navy and the
                    military.

Summary: Emphasis in the current reporting period was upon
                    empirical Bayes statistical modelling in non-
                    Gaussian situations arising in tracking targets;
                    also reliability and availability of military
                    equipments, and logistics support, and time-
                    dependent queueing arising when repairs are
                    required. The modelling, and assessment from
                    data, of the availability of a system was studied
                    (availability refers to the probability that the
                    system is up when needed). The nonparametric
                    estimation of measures of performance in queueing
                    models waš also investigated. In addition,
                    initial models for assessing the response times of
                    human operators carrying out complex tasks were
                    constructed, and statistical estimation (model
                    fitting) and model criticisms were also addressed.
                    The models have been applied to operator data
                    obtained from simulators. Further applications
                    are envisioned.

Publications: D.P. Gaver, P.A. Jacobs, "Nonparametric
                Estimation of the Probability of a Long Delay
                in the M/G/1 Queue, Journal of the Royal
                Statistical Society, Series B, 50 (1988),
                pp. 392-402.

                D.P. Gaver, P.A. Jacobs, "System Availability:
                Time Dependence and Statistical Inference by
                (Semi) Non-Parametric Methods," Naval Postgraduate
                School Technical Report, NPS55-88-008, August
                1988.

                P.A. Jacobs, "Estimation of the Probability of a
                Long Time to the First Entrance to a State in a
                Semi-Markov Model," Naval Postgraduate School
                Technical Report, NPS55-88-012, September 1988.

D.P. Gaver, P.A. Jacobs, "Robustifying the Kalman Filter," Naval Postgraduate School Technical Report, NPS55-87-014, November 1987.

D.P. Gaver, E.G. Coffman, and L. Flatto, "Performance Analysis of a Buffer Under Locking Protocols," Naval Postgraduate School Technical Report, NPS55-88-003, February 1988.

D.P. Gaver, H.B. Mutlu, "An Operational Analysis of System Calibration," Naval Postgraduate School Technical Report, NPS55-88-002, February 1988.

D.P. Gaver, H.B. Mutlu, "An Operational Analysis of System Calibration," <u>Naval Research Logistics Quarterly</u>, forthcoming.

P.A. Jacobs, D.P. Gaver, "Inferring Finite-Time Performance in the M/G/1 Queueing Model," forthcoming.

I.G. O'Muircheartaigh, D.P. Gaver, "Prediction of Polytomous Events: Model Description, Algorithm Development and Methodological Aspects, with an Application," Naval Postgraduate School Technical Report, NPS55-87-010, September 1987.

D.P. Gaver, I.G. O'Muircheartaigh, "Latent Factor Models and Analyses for Operator Response Times," in progress.

Conference Presentations:
D.P. Gaver, P.A. Jacobs, "Modeling and Data Analysis of System Availability Revisited," TIMS/ORSA Joint National Meeting, Washington, D.C. April 25-27, 1988.

D.P. Gaver, P.A. Jacobs, "Estimation of Measures of Performance for a Queueing Models," ORSA/TIMS Joint National Meeting, St. Louis, October 25-28, 1987.

D.P. Gaver, P.A. Jacobs, "Statistical Estimation of Measures of Performance for Queues," Institute of Mathematical Statistics sponsored Symposium on Probability and Its Applications, Fort Collins, August 16-19, 1988.

E.G. Coffman, Jr., L. Flatto, and D.P. Gaver, "Performance Analysis of a Buffer Under Locking Protocols," 4th International Conference on Modelling Techniques and Tools for Computer Performance Evaluation, Palma, Mallorca, September 1988.

Theses
Directed:

D.G. Park, "Simulatin Study of Estimators for the Survival Probability of a First Passage Time for a Semi-Markov Process Using Censored Data," Master's Thesis, September 1988.

C.H. Lee, "Study of Estimates of System Availability," Master's Thesis, September 1988.

Patent: None

Title: DDN Performance Analysis

Investigators: D.P. Gaver, Professor of Operations Research,
                    P.A. Jacobs, Professor of Operations Research,
                    and P. Purdue, Professor and Chairman of
                    Operations Research

Sponsor: Defense Communications Agency

Objective: To conduct research in support of Defense Data
                    Network Performance Analysis Support project.

Summary: Stochastic models are developed to analyze the
                    effect of packet and message size variation on
                    network throughput, and to investigate the effects
                    of small scale congestion in a subnetwork.

Publications: None

Conference   D.P. Gaver, P.A. Jacobs, and P. Purdue, "Modelling
Presentations: and Scheduling Network Growth," Joint National
                    Meeting, Denver, October 24-26, 1988.

Thesis   None
Directed:

Patent: None

Title: Statistical Analysis of Multivariate Observations

Investigators: D.P. Gaver, Professor of Operations Research, and P.A. Jacobs, Professor of Operations Research

Sponsor: National Security Agency

Objective: The objective of this ongoing project is to solve various statistical and probabilistic problems posed by the sponsor.

Summary: Research was conducted on problems posed by the sponsor.

Publications: None

Conference
Presentations: None

Thesis
Directed: None

Patent: None

Title:	Development of Theory of Combat
Investigator:	W.P. Hughes, Jr., Adjunct Professor of Operations Research
Sponsor:	Chief of Naval Operations
Objective:	To combine and extend concepts in the investigator's book, <u>Fleet Tactics</u>, with his research with the Military Conflict Institute, to develop a theory that includes inter-relationships between force, maneuver, and suppression as an alternative to attrition-centered analysis of combat.

Summary:	Work to date consists of two products: (1) a detailed outline of the theory, including precise definitions, the aim of combat, components of force, functions, and processes (dynamics). Special emphasis is placed on the role of command, (2) within the theory, the explicit role of command and leadership. C^2 is viewed as the function that activates combat power and is described as a general equation. Core concepts are the relationships between forces (as tangible elements of force), combat potential, combat power, forces, and results. The unusual if not original hypothesis is formulated that results of combat are a function of the <u>difference</u> in force generated by the two sides, rather than the force <u>ratio</u>.

Publication:	W.P. Hughes, Jr., Chapter 18 of, "Command and Leadership," in progress.
Conference Presentation:	None
Thesis Directed:	None
Patent:	None

Title:	Smoothing Spatial Data by Estimating a Variance
Investigator:	L.D. Johnson, Assistant Professor of Operations Research
Sponsor:	Naval Postgraduate School Research Council
Objective:	To develop a variance function which describes spatial variability useful for irregularly spaced data. To relate the appropriate level of smoothing in a nearest neighbor density estimate to the spatial variance measured by this variance function.

Summary:	A variance function was developed and named mean local variance (MLV). This function is dependent on distance. It was evaluated empirically and related to the optimal smoothing parameter in a nearest neighbor estimation technique. Simulations of air quality data were done and mean local variance was calculated. The plots of MLV for simulated data looked very similar to the variogram, a concept of spatial variance often used in geostatistics. Further research needs to be done on the possibility of MLV as an estimate of the variogram for irregularity spaced data.

Publication:	L.D. Johnson, "Smoothing Spatial Data by Estimating Mean Local Variance," Naval Postgraduate School Technical Report, NPS55-88-005, April 1988.
Conference Presentation:	L.D. Johnson, "Smoothing Spatial Data by Estimating Mean Local Variance," American Statistical Association, New Orleans, August, 1988.
Thesis Directed:	None
Patent:	None

Title: Statistical Support Services for the Joint Oil
                Analysis Program

Investigators: H.J. Larson, Professor of Operations Research
                T. Jayachandran, Professor of Mathematics

Sponsor: Kelly Air Force Base

Objective: To compare proposed and current methodology for
                the Joint Oil Analysis Program correlation
                program, design and analyze data resulting from a
                field test of the production model portable
                analyzer, develop conversion methodology for
                relating portable readings to laboratory atomic
                emission instructions.

Summary: The Joint Oil Analysis Program supports the
                spectrometric analyses of used oil samples for
                all three services. This program runs a
                correlation program designed in 1974 to monitor
                the accuracy and repeatability of all laboratories
                participating in the program on a monthly basis.
                Previous review of this methodology led to
                recommended changes; APL programs were developed
                to apply this changed methodology and to compare
                its results with the current results over time,
                using the raw data submitted by the laboratories.
                Programs were prepared to give tabular comparisons
                of the two procedures, and additional APL programs
                were designed to augment these tabular outputs
                with graphical displays, making monthly
                comparisons feasible at a number of levels. The
                design of a field test for the production models
                of the new portable analyzer was completed; since
                the production models proved to be less reliable
                than expected, in a laboratory setting, the actual
                field testing did not materialize. Similarly,
                while some methodology had been investigated for
                converting between portable and laboratory
                instruments, no converted tables were produced. A
                study of the possible effects of particle sizes on
                the readings of different types of instruments was
                conducted; a preliminary look at the historical
                records observed for a few engine types, versus
                the decision-triggering limits given in the
                laboratory manual for the same engines, was also
                undertaken. This ongoing relationship with the
                services' oil analysis program has led to many
                student theses and to numerous classroom examples
                for statistics courses in the past years.

Title: A Column-Generation Approach to a Time-Sensitive
                  Deployment Planning Problem

Investigators: S. Lawphongpanich, Assistant Professor of
                  Operations Research, and R.E. Rosenthal, Professor
                  of Operations Research

Sponsor: Oak Ridge National Laboratory

Objective: To develop efficient algorithms for planning
                  military deployments in time-sensitive or crisis
                  situations. This work is sponsored by Oak Ridge
                  National Laboratory as a subset of a larger
                  project that Oak Ridge National Laboratory is
                  working on for the United States Transportation
                  Command. The United States Transportation
                  Command, formerly the Joint Deployment Agency, is
                  responsible for coordinating airlifts, sealifts
                  and road/rail movements carried out by its
                  component commands, MAC, MSC and MTMC.

Summary: This work has only just begun. We have developed
                  an integer programming formulation for a
                  deployment problem and a solution strategy based
                  on solving a sequence of related, but easier,
                  feasibility-seeking subproblems. Each of these
                  subproblems, for a given t, addresses the
                  question: "can the deployment of the given
                  movement requirements with the given assets be
                  completed in t days?" We are working on efficient
                  strategies for dealing with the subproblems and
                  for controlling the overall procedure using a
                  decomposition algorithm. An early implementation
                  of the proposal has been implemented in two
                  student theses.

Publications: None

Conference   None
Presentations:

Theses   S. Buvik, "An Algorithm for Generating Ship
Directed: Schedules for a Crisis Deployment Problem,"
                  Master's Thesis, September 1988.

                  N.R. Lima, "A Column-Generation Technique for
                  a Crisis Deployment Planning Problem," Master's
                  Thesis, September 1988.

Patent: None

Publications: T. Jayachandran, H.J. Larson, "Sampling
                   Intervals," Naval Postgraduate School Technical
                   Report, NPS53-87-005, October 1987.

                   H.J. Larson, T. Jayachandran, "Suggested
                   Improvements for the Joint Oil Analysis
                   Correlation Program," Naval Postgraduate School
                   Technical Report, NPS55-87-013, October 1987.

Conference   None
Presentations:

Thesis   None
Directed:

Patent: None

Title:	Generalized Linear Programming as a Feasible Direction Technique
Investigator:	S. Lawphongpanich, Assistant Professor of Operations Research
Sponsor:	Naval Postgraduate School Research Council

Objective: To gain a deeper understanding about the relationship between generalized linear programming and a feasible direction technique. In particular, we wish to explore properties of the direction produced by the generalized linear programming.

Summary: This research demonstrates that the Generalized Linear Programming (GLP) direction always ascends the dual function, L, at a point where L is differentiable. At nondifferentiable points, the choice of column entering the master problem is not unique and an arbitrary choice can produce a nonascent direction. However, by appropriate choice of entering column(s), the GLP direction will be an ascent direction. Computational results on random problems indicate that adding line searches along the GLP direction can improve the performance of GLP.

Moreover, it is also shown that the GLP direction solves an associated direction finding problem (DFP). This associated DFP belongs to a class of DFP's for nondifferentiable optimization problems. Based on this finding, a modification of GLP is proposed and shown to converge to a solution.

Publications: D.W. Hearn, S. Lawphongpanich, "Lagrangian Dual Ascent by Generalized Linear Programming," Operations Research Letters, forthcoming.

S. Lawphongpanich, D.W. Hearn, "A Demyanov-Type Modification for Generalized Linear Programming," Naval Postgraduate School Technical Report, NPS55-87-016, December 1987.

Conference Presentation: D.W. Hearn, S. Lawphongpanich, "Lagrangian Dual Ascent by Generalized Linear Programming," TIMS/ORSA Joint National Meeting, Washington, D.C., April 25-27, 1988.

Thesis Directed: None

Patent: None

Title: Stochastic Modelling, Time Series Analysis and
                  Simulation

Investigator: P.A.W. Lewis, Professor of Operations Research

Sponsor: Office of Naval Research

Objective: The purpose of this research is to develop
                  models and theory for time series and stochastic
                  point processes, develop new statistical
                  methodology for use in the simulations which are
                  required in mathematical statistics and in the
                  analysis of stochastic systems, and to develop
                  methods for the analysis, display and editing of
                  large scale, non-normal time series.

Summary: In simulation an introductory test on simulation
                  methodology has been completed, as well as work
                  on a new edition of the associated software
                  entitled, "The Enhanced Simulation and Software
                  Package". The key and novel item in this package
                  is the program SUPER-SIMTBED for output analysis
                  with graphics, in simulation. An even more
                  advances version of this program is being
                  developed. It includes a restart capability, and
                  color coded output on cheap dot matrix printers
                  for multi-factor simulation experiments.
                  Significant progress has been made on methodology
                  for variance reduction using nonlinear control
                  variables.

                  In time series, a new class of processes called
                  minification and maxification processes has been
                  derived. These should have applications in all
                  areas where nonlinear phenomena occur. To analyze
                  nonlinear time series, earlier work on residual
                  analysis for autoregressive processes have been
                  extended to reversed residuals.

Publications: P.A.W. Lewis, E.J. Orav, "Simulation Methodology
                  for Statisticians," Operations Analysts and
                  Engineers, 1, Wadsworth & Brooks/Cole, 1988.

                  L.C. Breaker, P.A.W. Lewis, "A 40-50 Day
                  Oscillation in Sea-Surface Temperature Along the
                  Central California Coast, Estuarine, Coastal,
                  Shelf Science, 26, pp. 395-408.

                  P.A.W. Lewis, E. McKenzie, "Minification
                  Processes," Naval Postgraduate School Technical
                  Report, NPS55-88-010, September 1988.

P.A.W. Lewis, E. McKenzie, "Minification Processes," Journal of Applied Probability, in progress.

L.S. Dewald, Sr., P.A.W. Lewis, and E. McKenzie, "1-Laplace Processes," Naval Postgraduate School Technical Report, NPS55-88-011, November 1988.

L.S. Dewald, Sr., P.A.W. Lewis, and E. McKenzie, "1-Laplace Processes," Stochastic Processes and Their Applications, in progress.

Conference Presentations:

P.A.W. Lewis, "Nonlinear Controls for Variance Reduction," International OR Societies Meeting, Paris, June 1988.

P.A.W. Lewis, "Nonlinear Controls for Variance Reduction," 1988 Winter Simulation Conference, Atlanta, December 1987.

P.A.W. Lewis, "Gamma Processes," University of London Seminars, London, July 1988.

P.A.W. Lewis, "SUPER SIMTBED: A Program for the Analysis of Simulation Output," University of Strathclyde, Scotland, June 1988.

P.A.W. Lewis, "SUPER SIMTBED: A Program for the Analysis of Simulation Output," American Statistical Association Annual Meeting, New Orleans, August 1988.

Thesis Directed:

C.C. Song, "Simulation Study of Traffic Flow at a Three Way Intersection," Master's Thesis, September 1988.

R.L. Youmans, "The Use of Color in the Output Analysis of Statistical Simulations, and Analysis of Estimators of Serial Correlation," Master's Thesis, September 1988.

Patent: None

Title:	Exploratory Analysis of Large Scale (Personnel Security) Data Sets
Investigator:	P.A.W. Lewis, Distinguished Professor of Operations Research
Sponsor:	Defense Personnel Security Research and Education Center
Objective:	The purpose of this research is to investigate interfaces between large scale data sets, statistical data bases and interactive data analysis packages. The object is to make the data rapidly available for analysis, and in particular to use modern statistical methods to identify outliers and aberrant facets of the data.

Summary:	Progress has been made in inviting programs to enhance the capabilities of the Statgraphics full screen, scrollable file editor. The initial part is a program which will easily convert ASCII files to Statgraphics files, or APL files. The program also supplies extensive capabilities for cross tabulation and continguency table analysis. An analysis of a large data base on Security Back ground Information for 560 Navy enlistees was undertaken as part of a thesis. Many interesting insights were obtained from this data. Investigations of several other data bases were initiated.

Publications:	None
Conference Presentations:	None
Thesis Directed:	E. Koucheravy, "An Analysis of Security Background Information Data with Relation to Subsequent Discharge," Master's Thesis, September 1988.
Patent:	None

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

Sponsor: United States Marine Corps

Objective: The following topics were investigated: (1) the
                  feasibility of civilianization of some jobs at
                  Marine Corps commands, and (2) the management of
                  officer career paths with special attention to
                  the impact of the newly created joint duty
                  assignment on such career paths.

Summary: The topic of the feasibility of civilianization
                  of some Marine Corps billets has been initiated
                  with the selection of the Camp Pendleton Marine
                  Corps base as the subject base for a prototype
                  study. Some preliminary investigation into
                  currently used standards for military to civilian
                  job conversion procedures has also begun. It has
                  been determined that billets in the Fleet
                  Assistance Program are primary candidates for such
                  job conversions. The project is continued in a
                  FY89 project of the same title.

                  The topic concerning the officer career path study
                  was initiated in light of the creation of joint
                  duty billets and joint service officers by Title
                  IV of the Goldwater-Nichols Department of Defense
                  Reorganization Act passed by Congress in 1986.
                  Under this project a mathematical model was
                  constructed for analyzing career structures of
                  military officers. The model assumes that
                  officers advance through their career by a
                  sequence of consecutive tours during each of which
                  they perform specific jobs (billets). These jobs
                  may be categorized into a handful of activity
                  types whose choice and definition depends on the
                  military service, the specialty of the officers
                  within the service and the purpose of the career
                  analysis to be performed. It remains for the
                  continuation of this project in FY89 to define
                  these activity types for a specific segment of the
                  Marine Corps (e.g. Infantry) and to carry out the
                  analysis, using the model, as to how creation of
                  joint duty billets has affected the career
                  structure of officers within that segment. A
                  simpler goal of ascertaining the Marine Corps'
                  sustained ability to comply with Title IV
                  provisions while fulfilling its regular billet
                  commitments has also been started and will be
                  continued in FY89.

Publication: P.R. Milch, "An Analytical Model for Forecasting
                   Navy Officer Career Paths," Naval Postgraduate
                   School Technical Report, NPS55-88-009, September
                   1988.

Conference   P.R. Milch, "An Analytical Model for Forecasting
Presentation: Navy Officer Career Paths," Joint National ORSA/
                   TIMS Meeting, Denver, October 25, 1988.

Thesis   None
Directed:

Patent: None

Title:	Optimal Formatting and Standardization of Aircraft Head Up Display (HUD) Symbology
Investigator:	T.M. Mitchell, Assistant Professor of Operations Research
Sponsor:	Naval Air Systems Command
Objective:	To compile and maintain a data base library of head up display symbology for U.S. fixed wing tactical aircraft. This data base will then be utilized in constructing proposed standardized HUD symbology formats and revising current symbology design specifications.
Summary:	Completing the compilation of a data base library of all current HUD symbology for the following fixed wing tactical and attack aircraft: A-6E, A-7E, A-4M, AV-8A, AV-8B, F-14A, F-14D, F-15, F-16, F/A-18, F-111. In addition to the inclusion of all baseline symbology the data base is being continually updated with the addition of new aircraft and/or the modification of current HUD symbology. The data base is being maintained on an IBM-PC utilizing a PC Paint graphics package in conjunction with DBASE III to update and modify symbology and related functional descriptions.
Publications:	None
Conference Presentation:	T. Mitchell, "Data Base Update," Aircraft Display Working Group Meeting, San Antonio, December 14-15, 1988.
Thesis Directed:	None
Patent:	None

Title: Airland Research Model

Investigators: S.H. Parry, Associate Professor of Operations
                  Research, and A.L. Schoenstadt, Professor of
                  Mathematics

Sponsor: United States Army TRADOC Analysis Command

Objective: To develop a data base for and demonstrate the
                  use of the Generalized Value System (GVS) in a
                  subset of the ALARM Planning Model.

Summary: The GVS of the Airland Research Model (ALARM) is
                  used: (1) to predict the future states,
                  capabilities, and situations of entities on the
                  battlefield; (2) to assign consistent
                  quantitative measures (power and value) based on
                  actual and predicted states, to all entities on
                  the battlefield, and (3) to make decisions
                  (allocations) or alter current plans, based on the
                  values computed.

                  Three aspects of the GVS were investigated.
                  First, an experimental design methodology was
                  designed and implemented to provide a regression
                  mapping function from a unit's multidimensional
                  state vector to a single dimension unit power.
                  The basic methodology is applicable to a wide
                  variety of situations in which the decision-
                  maker is required to view the current situationn
                  and make an assessment of the unit's combat power.,
                  Secondly, a prototype GVS future state decision-
                  making capability was implemented in the Army's
                  Vector-in-Commander (VIC) Model. This prototype
                  replaced the existing decision tables with GVS
                  modules to make various maneuver decisions within
                  VIC. Finally, a prototype Semi-Markiov (Renewal)
                  Model was developed as a possible surrogate for
                  large scale force-on-force simulation. ALARM is
                  committed to viewing decision alternatives in
                  relation to a predicated future state
                  approximation. If a Renewal Model is a quick and
                  acceptable surrogate, it can be used to develop a
                  computationally effic'ent alternative comparison
                  decision process.

Publications: None

Conference   S.H. Parry, "Mapping of High Resolution Terrain
Presentation: Data to Network's," 56th MORS, Monterey,
                  June 28-30, 1988.

Theses Directed:	P.M. Crawford, "Dynamic Study of Factors Impacting on Combat Power," <u>Master's Thesis</u>, September 1988.
	M.O. Kierzewski, "Analysis of Chemical Warfare Using a Transient Semi-Markov Formulation," <u>Master's Thesis</u>, September 1988.
	G. Reuss, "Analysis of Aircraft Combat Sustainability Using a Markov Chain," <u>Master's Thesis</u>, September 1988.
Patent:	None

Title:	Evaluating Speech Input to Voice Operated Status Boards
Investigator:	G.K. Poock, Professor of Operations Research
Sponsor:	Naval Ocean Systems Center
Objective:	Determine the feasibility of using automatic speech recognition equipment for data entry and automatic updating of information on status boards in command centers.
Summary:	An extensive investigation was carried out using automatic ITT speech recognition equipment and a series of seven automated status boards simulated on computer CRT screens. All the equipment was set up in San Diego in prototype fashion and then delivered to the Naval Postgraduate School for testing by military officers familiar with carrier air traffic control operations. Experimental designs looked at such variables as noise conditions, length of commands used in the air traffic control environment, and subjective opinions were also gathered. In addition, problem areas with the prototype were discovered and suggested improvements for the next generation prototype were pointed out, in addition to meetings during on-site visits of NOSC personnel to the Naval Postgraduate School.
Publications:	None
Conference Presentations:	None
Theses Directed:	R. Jensen, "An Evaluation of Automating Carrier Air Traffic Control Center (CATCC) Status Boards Utilizing Voice Recognition Input," Master's Thesis, September 1988. J. Spegele, "An Evaluation of Automating Carrier Air Traffic Control Center (CATCC) Status Boards Utilizing Voice Recognition Input," Master's Thesis, June 1988.
Patent:	None

Title: Stochastic Compartmental Systems

Investigator: P. Purdue, Professor and Chairman of Operations
                   Research

Sponsor: National Science Foundation

Objective: Investigate the movement of particles around a
                   graph with a finite number of nodes.

Summary: This research develops stochastic models for the
                   movement of particles through a network subject
                   to a variety of restrictions. The models arise
                   in some manpower, biological and data
                   communications systems. Steady state moments and
                   measures of variability as functions of inter-
                   particle interaction mechanisms have been
                   examined.

Publication: None

Conference   P. Purdue, "Variability in Compartmental Systems,"
Presentation: Conference of Irish Statisticians, Northern
                   Ireland, March 24-25, 1988.

Thesis   None
Directed:

Patent: None

Title: Attrition Rate Generation for Manpower Models

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

Sponsor: United States Marine Corps

Objective: To develop versions of shrinkage type estimators
                    for forecasting the numerous and various attrition
                    loss rates that appear in the Marine Corps
                    manpower planning models. Particular attention is
                    to be paid to "small cell" problem.

Summary: This is a continuing project. Previous work
                    that applied shrinkage type estimators to the
                    problem of estimating officer attrition rates
                    has been reported. The methods tested have been
                    successful in the comparative sense. That is,
                    they perform better than the raw historical rates
                    that might be used in an ad hoc fashion. But
                    their behavior in the absolute sense still has
                    erratic aspects. Moreover, we do not have a solid
                    way to anticipate the areas of unstable
                    performance.

                    The acquisition and use of a much more refined
                    data tape has lead to greater insight to this
                    problem. In particular the new data covers ten
                    years, breaks out officer grade by above zone and
                    in/below zone, regular or reserve, etc. This
                    allows the exploitation of cross classified cells
                    having greater homogeniety of attrition behavior.

                    We have identified some important break points in
                    the YCS scale and some MOS categories that must be
                    treated separately. Some isolated details have
                    been explored. A new empirical Bayes method is
                    being tested. It appears to manage better the
                    unevenness of the cell inventories.

Publication: R.R. Read, "The Use of Shrinkage Techniques in the
                    Estimation of Attrition Rates for Large Scale
                    Manpower Models," Naval Postgraduate School
                    Technical Report, NPS55-88-006, July 1988.

Conference   None
Presentations:

Theses   R.W. Larsen, "The Aggregation of Population Groups
Directed: to Improve the Predictability of Marine Corps
                    Officer Attrition Estimation," Master's Thesis,
                    December 1987.

C.R. Dickenson, "Refinement and Extension of Shrinkage Techniques in Loss Rate Estimation of Marine Corps Officer Manpower Models," <u>Master's Thesis</u>, March 1988.

Patent: None

Title:	Large-Scale Network Optimization for Marine Corps Officer Assignment During Mobilization
Investigator:	R.E. Rosenthal, Professor of Operations Research
Sponsor:	United States Marine Corps
Objective:	To continue the design and implementation of a large-scale network optimization model for assigned officer ; to billets during mobilization.

Summary: At the end of last year's activity reporting period, for a sample problem involving 33,000 officers, our prototype mobilization model was producing officer-to-billet assignments that were significantly better than Headquarter's, Marine Corps's previous best solution. Improvement was demonstrated with respect to all the criteria considered (number of billets filled, quality of officer/billet fit, and relocation cost). The follow-on work was devoted primarily to making our computer programs run faster. By the application of principles of computer science data structures, and with the voluntary assistance of Professor G.G. Browm, the computing time on the Naval Postgraduate School IBM mainframe for the 33,000 officer example was reduced from 30 minutes to 10 seconds. This improvement makes it possible for the Marine Corps to use the model within its computing environment.

Publications: None

Conference Presentations: D.O. Bausch, G.G. Brown, D.R. Hundley, S.H. Rapp, and R.E. Rosenthal, "Mobilizing Marine Corps Officers," ORSA/TIMS Joint National Meeting, Denver, October 1988.

Thesis Directed: None

Patent: None

Title:	Issues, Modifications and Ancillary Support for Remote Gaming Using the Enhanced Naval Warfare Gaming System
Investigators:	J.S. Stewart, Assistant Professor of Operations Research, T.E. Halwachs, Instructor of Operations Research, and R.H. Shudde, Associate Professor of Operations Research
Sponsor:	Naval War College
Objective:	The Enhanced Navy Warfare Gaming System and the Joint Theater Level Simulation, both of interest to the sponsor, each lack a suitable, useful satellite model that realistically provides intelligence information in any form. Since time on the big gaming system is at a premium, the Naval War College favors writing programs on microcomputers as adjuncts to the mainframe. This research is to provide a computer program (or programs) which accurately depicts satellite orbits including apogee, perigee, time above the horizon for selected "stations", the associated satellite "look-angles", etc. and the resulting footprints for a variety of sensors and a number of simultaneously orbiting vehicles.
Summary:	A computer program and a number of subroutines have been written in structured BASIC which simulate a satellite in orbit around an oblate earth. Output includes: satellite latitude, longitude, heading, right ascension and declination; satellite azimuth, elevation and range from a specified ground station; and the look-angle from the satellite to the ground station.
Publications:	None
Conference Presentations:	None
Thesis Directed:	None
Patent:	None

Title:	An Analysis of the Effect of ASW and Mine Countermeasures on Logistic Requirements
Investigator:	A.R. Washburn, Professor of Operations Research
Sponsor:	Chief of Naval Operations
Objective:	This research deals with the problem of allocating mine stockpiles diverse in type and widely distributed to several theaters simultaneously. The object is to produce an algorithm that will allocate the mines "optimally" in some sense meaningful to mine warfare.
Summary:	An algorithm has been developed and encoded (FORTRAN) for solving the problem of allocating several types of mines to several theaters. The objective function is a weighted version of the classic "threat" measure that is widely used in mine warfare. The algorithm is extremely fast, and appears to be generally applicable when a variety of "attackers" are available to attack a variety of "targets" (Search Theory problems with multiple kinds of searcher, for example).
Publications:	None
Conference Presentations:	None
Thesis Directed:	None
Patent:	None

Title: An Accuracy Analysis of Reliability Growth Models
Using Failure Discounting

Investigator: W.M. Woods, Professor of Operations Research

Sponsor: Naval Postgraduate School Research Council

Objective: To determine the affect of various failure dis-
counting methods on the accuracy of several
reliability growth models, and to develop
procedures and computer programs that can be
used by a DOD agency or contractor to evaluate
a proposed reliability growth procedure with or
without failure discounting.

Summary: A discrete reliability growth model was extended
to provide a uniformily minimum variance unbiased
estimator for reliability under attribute testing
with no failure discounting. A method was con-
structed for successively reducing fractions of
a failure as groups of N tests are completed
without failure for the same cause that produced
the original failure. The discrete growth model
was again extended to accommodate this type of
failure discounting. A computer program was
developed to analyse the accuracy of this discrete
reliability growth model and other growth models
with and without various failure discounting
scenarios for a variety of reliability growth
patterns. The average of each growth model and
the true growth pattern is presented on the same
graph. This provides a comparative accuracy
analysis of each growth model. One graph is
provided for each set of parameters that determine
the reliability growth pattern and the discounting
procedure. The results show that a commonly used
reliability growth procedure and discounting
procedure is overly optimistic for some growth
patterns. One reliability growth model appears
to be reasonably accurate under many failure
discounting scenarios. Computer programs and
user's guides are available for external users.

Publication: W.M. Woods, "Analysis and Evaluation of Discrete
Reliability Growth Model With and Without Failure
Discounting," Naval Postgraduate School Technical
Report, NPS55-88-013, December 1988.

Conference   None
Presentation:

Theses   J. Drake, "Discrete Reliability Growth Using
Directed: Failure Discounting," <u>Master's Thesis</u>,
                September 1987.

                J. Chandler, "Estimating Reliability with
                Discrete Growth Models," <u>Master's Thesis</u>,
                March 1988.

DEPARTMENT
OF
NATIONAL SECURITY AFFAIRS

NATIONAL SECURITY AFFAIRS

The National Security Affairs Department has been productive in its research, performing a variety of work for assorted sponsors. Research supported by the U.S. Navy included projects funded by the CNO. Deputy Under Secretary for Policy, and the Naval Postgraduate School Research Council. The CNO funded Professor Thomas Bruneau's study of boundary issues from Portugal to the Azores (which yielded a Technical Report [T.R.]. CNO, OP-65 supported Professor Kerry Kartchner's analysis in a T.R. of planning for nuclear war at sea and theater nuclear war (one T.R.). CNO, OP-603 funded Professor James J. Tritten's use of the Rand Strategy Assessment System (RSAS) program to assess the Maritime Strategy in European land Campaigns (three articles, ten T.R.'s, and seven conference papers) and his preparation of bibliography on the Maritime Strategy. CNO, OP-603K supported Professor Donald Abenheim's analysis of the West Germany Navy's role in the U.S. Maritime Strategy in Europe. CNO, OP-612 supported Professor Edward Olsen's analysis of prospects for the ROK Navy (a forthcoming T.R. and conference paper). He also ran a Maritime Strategy in the Pacific Conference funded by DUSN/P which familiarized an influential audience with that issue (A video tape and T.R. forthcoming).

The Office of the Secretary of Defense (OSD) supported five NSA research projects. OSD-Policy supported Professor Ralph Magnus' analysis of the prospects for postwar Afghanistan (two conference papers) and Professor David Yost's analysis of European structural factors in ling-term US-USSR competition (two articles and a conference paper). OSD-Net Assessment funded Professor Patrick Parker's study of the role of the military in making U.S. nuclear strategy. OSD/NA also supported Professor James Tritten's analysis of how DoD might improve its strategic management (two T.R.s and a conference paper) and his assessment of war game designs (fourteen T.R.s, five articles, and ten conference papers).

The Naval Postgraduate School Council supported Professor Thomas Bruneau's comparison of Brazil's constitution-making in 1985 and 1988 (a T.R. and book chapter), Professor Mikhail Tsypkin's analysis of Perestorika's impact on USSR military policy (forthcoming T.R. and tow conference papers), and Professor David Winterford's evaluation of the roles of Southeast Asian Navies (a T.R. and conference paper).

External defense-related research support came from the U.S. Army's TRADOC which funded Professor Russell Stolfi's analysis of the application of Operational Arts to a Naval warfare (a T.R. and three conference papers) and the Defense Nuclear Agency which is funding Professor James Tritten's multi-year analyses of the role of strategic nuclear forces in the context of the INF Treaty and SDI.

Our non-governmental research project was supported by the MacArthur Foundation, through the Northern California World Affair Council. Professor Edward Olsen Assessed the status of the US-Korean relations. His analysis was published by the Council as a book.

Title:	Federal Republic of Germany and U.S. Maritime Strategy
Investigator:	D. Abenheim, Assistant Professor of National Security Affairs
Sponsor:	Office of the Chief of Naval Operations OP-603K
Objectives:	This study examines West German Naval Perspectives on U.S. Maritime Strategy within the North Atlantic Alliance. This research attempts to understand West German perspective on contemporary issues of the role of the U.S. Navy in projecting power. This research has examined professional publications of the German armed forces as well as internal studies prepared by senior and junior Naval officers.
Summary:	The research which is still in progress suggests that, in contrast to the U.S. Maritime Strategy of the mid-1980's West German Naval and military figures better articulate the needs of a balanced continental and Maritime Strategy. West German Naval officers in their publications appear to fully support the U.S. Maritime Strategy although necessarily having a different vulnerabilities. My future research on this highly important subject will examine a number of studies prepared at the Command and Staff Academy of the West German Armed Forces in Hamburg.
Publications:	Position paper provided to Commander Michael Simpson CNO OP-603K. Technical Report in progress.

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Title: The U.S. Navy, Portugal, and the Boundary
                    Question

Investigator: T.C. Bruneau, Professor of National Security
                    Affairs

Sponsor: Office of the Chief of Naval Operations

Objective: To analyze the political implication
                    concerning the Portuguese attempt to redefine
                    the IBERLANT boundary Westward to include the
                    Azores which are now included in WESTLANT.

Summary: Conducted field research interviews at OP-
                    614 and the State Department on the issues
                    involved. Return to Washington for more
                    interview, go to Norfolk and spend two weeks
                    in Portugal in April, 1989. The result will
                    be a confidential Technical Report to be
                    provided to OP-614.

Publication: Technical Report will be provided.

Title:	Constitutional Change and Democratic Consolidation: Brazil in Comparative Perspective
Investigator:	T.C. Bruneau, Professor of National Security Affairs
Sponsor:	Naval Postgraduate School Research Council
Objective:	To analyze the political dynamic involved in the Brazilian experience in formulating a new constitution between 1986 and 1988.
Summary:	Field research conducted in Brazil in May 1988 as the constituent assembly was completing its work. Research builds on work done in Brazil in 1985=86. The materials collected and analyzed allow a evaluation of the prospects for democratic consolidation in Brazil.
Publication:	"The Constituent Assembly and Democratic Consolidation in Brazil," in James M. Malloy and Edurado Gamarra, (eds.), Latin America and Caribbean Contemporary Record volume III, 1987-1988. (New York: Holmes and Meir, forth coming, 1989). Completing a technical report based on this material which will then appear as a chapter in a book.

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Title:	Long-Range Planning Perspectives on the Maritime Strategy and Nuclear Warfare
Investigator:	K.M. Kartchner, Assistant Professor of National Security Affairs
Sponsor:	CNO. Strategic and Theater Nuclear Warfare Division (OP-65)
Objective:	To explore policy issues relating to nuclear war at sea, and to develop long-range planning perspective on the implications of maritime theater nuclear weapons in crisis situations.

Summary: This report examined the role of maritime tactical nuclear weapons in international crises. The analysis drew on the historical record of nuclear doctrine, and current thinking on crisis management. Four principal conclusions were reached: 1) Strategic nuclear weapons have played significant crisis control and termination functions in the pas: 2) Current U.S. Navy maritime theater nuclear warfare capabilities, by virtue of their dispersal throughout the fleet, are very likely to be involved either directly or indirectly in future crisis responses by Naval forces; 3) Crisis response is a key feature of the Maritime Strategy's plan for deterring war and controlling escalation; and 4) Maritime theater nuclear capabilities may both enhance and impede Naval crisis management objectives.

Title:	Post-Jihad Afghanistan: Ideology, Structure and Orientations
Investigators:	R.H. Magnus, Associate Professor of National Security Affairs
Sponsor:	Office of the Undersecretary of Defense (Policy)
Objectives:	The project is designed to evaluate the emerging post-war situation in Afghanistan following the withdrawal of Soviet military forces and the collapse of their puppet regime in Kabul. It will focus on the ability of the Afghan mujajidin to establish a stable and effective national government and examine the domestic and foreign policies likely to be pursued by an independent Afghanistan. Policy options for enhancing the interests of the United States in Afghanistan and the region will be addressed.
Summary:	The work on this project is continuing, with the termination date of the research as 30 September, 1989 as the project was renewed on 30 September, 1988. The major portion of the field research has been completed including domestic travel to New York, Massachusetts and Los Angeles and Foreign travel to Pakistan (twice), France, and England.
Conference Presentations:	"Impact of Soviet Withdrawal on the Arab Countries and Iran," Workshop presentation, Panel: Conflict and Peace in Afghanistan: The Regional Perspective 22nd Annual Meeting, The Middle Studies Association of North America, Beverly Hill, CA., November 3, 1988.

Title:	U.S. Policy and the Two Koreas
Investigator:	E.A. Olsen, Professor of National Security Affairs
Sponsor:	MacArthur Foundation & World Affairs Council of Northern California
Objective:	To evaluate the status of contemporary US relations with the tow Korean states at a point when economic, superpower, regional, and sports (Olympic) events are changing the circumstances in and around Korea.
Summary:	An intensive series of expert symposia was held monthly in San Francisco, coupled with library research. The PI wrote a lengthy analysis which served as the basis for a concluding international conference on Korea specialists in San Francisco. The results of the research and conference yielded a report to the sponsor which was published in book form and distributed by the World Affairs Council to a variety of policy-makers and other business and academic elites.
Publications:	E.A. Olsen, US Policy and the Two Koreas, San Francisco: World Affairs Council of Northern California (distributed by Westview Press), 1988.
Conference Presentation:	At the World Affairs Council Conference, January 9, 1988.

Title:	Maritime Strategy in the Asia-Pacific-Indian Ocean
Investigator:	E.A. Olsen, Professor of National Security Affairs
Sponsor:	DUSN/P
Objective:	To hold a conference on the role of the Maritime Strategy in the Asian Pacific Indian Ocean Region which would make the "Maritime Strategy known to a broader audience of influential strategic thinkers.
Summary:	A major conference was held on August 13-14, 1987 with 24 prominent invited participants, most of whom prepared written papers. There also were about 150 guests in attendance. The conference also was taped for record. The tape has been used by many student researcher and an edited condensed version was prepared by the PI for use by the Naval Postgraduate School.
Publications:	Technical Report forthcoming.

Title:	Prospects for an Increased Naval Role for the Security Republic of Korea in Northeast Asian Security
Investigator:	E.A. Olsen, Professor of National Security Affairs
Sponsor:	Office of the Chief of Naval Operations OP-612
Objective:	To determine the levels of interest in South Korea regarding an expanded Naval role in ROK security, how such roles visualized, and what factors are causing strategic change in and around Korea.
Summary:	A thorough search of the Korean, Japanese and English literature on trends in South Korean Naval shipping, and shipbuilding matters was conducted. Selected scholars and officials were interviewed. Based on this a comparison of ROK Naval goals and accomplishments to date was made with what the study call "new thinking" in Korea and in countries concerned with Korean security. The study concluded that the ROK has modest overt Naval goals which it is almost certain to achieve, but also harbors some larger ambitions regarding SLOC defenses and the possible creating of a "blue water" Navy which bear careful watching.
Publications:	Technical Report forthcoming.

Title:	The Role of the Military in the Formulation and Implementation of American Nuclear Strategy
Investigator:	P.J. Parker, Professor of National Security Affairs
Sponsor:	Director of Net Assessment, Office of the Secretary of Defense

Objective: The overall objective of this study has been to identify and analyze (1) the services role in nuclear planning, targeting, weapon acquisition, and deployments, (2) the evolution of the military's thinking towards the purpose and the usefulness of nuclear weapons in peacetime and war, (3) the assumptions and rationale that the armed forces operate under during the planning and targeting process of strategic nuclear war, and (4) their concerns with respect to planning and the prospects of fighting a war with nuclear weapons. An important aspect of this research effort is the identification of differences in perspective and approach between military and civilian planner and decision makers on these issues.

Summary: Over the years, a number of studies have been completed on the role of civilians in the formulation and implementation of American nuclear strategy and weapons procurement. Little, if any, systematic analysis has been made, however, on the role of pivotal groups in the U.S. governments with responsibilities for the policy process and overall responsibility for implementing policy, namely, the JCS and military services. This study analyzed the role, thinking, and approach to these issues by the military service and the JCS. This was done through a combination of archival research and interviews, focusing primarily on key military officials and some civilians involved with the development and implementation of American nuclear strategy. Particular attention was given to analyzing the decision and organizational processes of military elements responsible for procurement deployment, and operation of American strategic systems.

Title:	The Application of Operational Art to Naval Warfare
Investigators:	R.H. Stolfi, Professor of National Security Affairs, R. Bathurst, Adjunct Professor of National Security Affairs, M. Tsypkin, Assistant Professor of National Security Affairs, and CDR J.J. Tritten, USN, Associate Professor of National Security Affairs
Sponsor:	Soviet Army Studies Office, U.S. Army Training and Doctrine Command and Office of the Chief of Naval Operations OP-OOK and OP-603
Objective:	To make an inquiry into the subject of Soviet Naval operational art and to produce a study of the development, present state, and future possibilities of that part of Soviet military art.

| Summary: | Soviet Naval operational art is real and is taken in deadly earnest by the Soviets. The art was developed in late Imperial and early Soviet time (c. 1895-1936) as the art of linking together modern engagements, battles, strikes, and maneuvers into coherent operations with specific strategic goals. The Soviets claim mastery over the art by the end of the Great Fatherland War and further refinement to include the use of both conventional and nuclear weapons in the postwar period. With the Soviets, Naval operational art is a stiffly formal system of planning the Navy operation to achieve strategic goals. As such, the art operates in accordance with the well define principles and with formal style that makes it susceptible to anticipation and counterstroke. |

| Publications: | R.H. Stolfi, "Soviet Naval Operational Art," National Defense University Symposium, Proceedings, Thinking Red in War Games, Washington, DC, December, 1988. |
| | R.H. Stolfi, "Soviet Naval Operational Art, Naval Postgraduate School, NPS-56-89-002, December, 1988. |

Conference Presentations:	R.H. Stolfi, "Soviet Naval Operational Art," National Defense University Symposium, <u>Thinking Red in War Games</u>, June 22, 1988, Washington DC.
	R.H. Stolfi, "Soviet Naval Operational Art," 56th Military Operations Research Society Symposium, June 29, 1988, Monterey, CA.
Thesis Directed:	LT. D.J. Kern, USN, "Soviet Naval Operational Art," Naval Post Graduate School, Master's Thesis, June, 1988.

Title:	Gorbachev's Restructuring and Soviet Military Policies
Investigator:	M. Tsypkin, Assistant Professor of National Security Affairs
Sponsor:	Naval Postgraduate School Research Council
Objective:	Establish relationship between socio-economic conditions and Gorbachev's military polices under perestroika.

Summary: Quantitively superior general purpose forces have been characteristic of Soviet/Russian military tradition. The general deterioration of social conditions (health care, juvenile delinquency) and aggravation of interethnic relations in the USSR has made it difficult, however, to maintain armed forces at the current manpower level (more than 5 million troops). The revolution in military technologies which will result, in the Soviet view, in emergence of much more sophisticated, accurate and destructive conventional weapons make smaller armed forces manned with better personnel a logical choice. Indeed, several weeks after I had completed the first draft of technical report, Gorbachev announced unilateral troops cuts. Still, major obstacles to Soviet conventional force reductions remain, especially the military's role in controlling internal discontent.

Publication: M. Tsypkin, "The Human Factor in Gorbachev's Military Policy," Naval Post Graduate School, Forthcoming.

Conference Presentations: M. Tsypkin, "The New Thinking and Quality of Soviet Military Manpower," a John Olin Lecture, Hoover Institution for the Study of War, Revolution and Peace, Stanford University, Stanford, CA., December 15, 1988.

M. Tsypkin, "The New Thinking and Quality of Soviet Military Manpower", Paper presented at the 20th Annual Convention of the American Association for the Advancement of Slavic Studies, Honolulu, Hawaii, November 18-21, 1988.

Title:	Analysis of War Games
Investigators:	J.J. Tritten, Associate Professor, National Security Affairs Department, (Principal Investigator), R.B. Bathurst, Adjunct Research Professor, National Security Affairs Department.
Sponsor:	Director Net Assessment, Office of the Secretary of Defense (OSD/NA)
Objective:	Analysis of fourteen Nuclear Strategy Development Group (NSDG) seminar games, preparation of lesson learned, analysis of methodology, presentation of results, preparation of research design for next series. Second year of two-year project.
Summary:	Prepared research designs for NSDG games 9-14 and supervised the conduct of those games and the preparation of lessons learned during 1985-1986. This project ensured analysis of final games and the entire series of games.
Publications:	J.J. Tritten, "Withholding and Attacking SSBN'S," NPS-56-88-004, February, 1988. 21 p.
	J.J. Tritten, "Withholding and Attacking SSBN's," Naval Forces, vol. IX, no. II/1988. p. 44-51.
	J.J. Tritten, "Strategic Targeting by Soviet SSBN's," NPS-56-011, May, 1988. 11 p.
	J.J. Tritten, "Strategic Targeting by Soviet SSBN's," Naval Forces, vol. IX, NO. III/1988. pp. 14-16.
	J.J. Tritten, "Scenarios of Nuclear Escalation Dominance and Vulnerability," NPS-56-88-013, June, 1988. 38 p.
	J.J. Tritten, "Does Technology Lead to War?" NPS-56-88-016, June, 1988. 7 p.
	J.J. Tritten, "Is Naval Warfare Unique?" NPS-56-88-018, August, 1988. 29 p.
	R.B. Bathurst, "Some Problems in Soviet American War Termination: Cross/Cultural Asymmetries, NPS-56-88-028, September, 1988. 69 p.

J.J. Tritten, "Scenarios, Simulations and Games," NPS-56-88-029, 28 p.

J.J. Tritten, "Withholding and Attacking SSBN's," presented to faculty and students at UC Santa Cruz University of Miami, March, 1988.

J.J. Tritten, "Scenarios of Nuclear Escalation Dominance and Vulnerability," presented to the Maritime Security and Arms Control in the Pacific Region Conference at the University of British Columbia, May, 1988.

J.J. Tritten, "Is Naval Warfare Unique?" presented to the Thinking RED in Wargaming Workshop at the National Defense University, Washington, DC, June, 1988.

J.J. Tritten, "Is Naval Warfare Unique?" presented at the 56th Military Operations Research Society (MORS) Symposium at the Naval Postgraduate School, Monterey, CA., June, 1988.

J.J. Tritten presented A.S. Mobley's, "Beyond the Black Box: An Assessment of Strategic War Gaming," at the 56th Military Operations Research Society (MORS) Symposium, at the Naval Postgraduate School, Monterey, CA., June, 1988.

J.J. Tritten, "Scenarios, Simulations, and Games," presented at the Joint National Meeting of the Operations Research Society of America (ORSA) and the Institute of Management Sciences (TIMS), Denver, Colorado, October, 1988.

J.J. Tritten, "Scenarios, Simulations and Games," presented at the 27th Annual Conference of the North American Simulation and Gaming Association, Ashville, North Carolina, October, 1988.

J.J. Tritten, "Withholding and Attacking SSBN's," presented at the 14th Defense Advanced Research Projects Agency (DARPA) Strategic Systems Symposium, Naval Postgraduate School, Monterey, CA., October, 1988.

Theses
Directed:
A.S. Mobley, "Beyond the Black Box: An Assessment of Strategic War Gaming," Master's Thesis, December, 1987.

P.K. Siddons, "Use of Advanced Computer Techniques in Modern Political-Military Simulations, Master's Thesis, September, 1988.

Title:	Strategic Management of the Defense Department
Investigators:	J.J. Tritten, Associate Professor, National Security Affairs, and N.C. Robert, Associate Professor, Administrative Sciences, (principle investigators), D. Whitt, Associate Professor Defense Resource Management Education Center (DRMEC)
Sponsors:	Director Net Assessment (OSD/NA), OSD/Competitive Strategies Office, Office of the Under Secretary of Defense - Acquisition/Directorate for Program Integration, Strategic Planning Branch, and Director of Defense Policy on the National Security Council (NSC) Staff.
Objective:	This project is designed to conduct historical and current research and analysis in the area of strategic management for the DoD. This research will examine tow separate areas: first, strategic planning with the goal to define DoD philosophy and mission, to establish ling- and short-range objective for the DoD, and to select strategies to be used in achieving those objective; and second, strategic implementation with the goal to develop an organizational strategy, create functional activities necessary to support the strategy, and design control systems to monitor the effectiveness of the strategy in achieving DoD objectives. First year of a multi-year project.
Summary:	The investigators have research the subject area by visiting businesses and government agencies that have strategic planning staffs and programs interviewing civilian and military personnel connected with the varying aspects of strategic management within DoD, and sought the cooperation of industrial leaders in the project. They have revised two coursed in strategic planning and strategic management for the National Security and Administrative Science Departments and routinely offer these revised courses. They have developed initial historical cases for use in these courses.

Publications:	J.J. Tritten, Review of "Creating Strategic Vision, " by P.M. Smith, J.P. Allen, J.H. Stewart, and F.D. Whitehouse, The Friday Review of Defense Literature, no. 88-17, May 6, 1988. p. 4. Also in Naval War College Review, vol. XLI, no. 3, Summer, 1988. p. 139-141.
	J.J. Tritten and N.C. Roberts, " Strategic Management for the Defense Department," NPS-56-88-030PR, September, 1988. p. 135.
	J.J. Tritten and N.C. Roberts, Eds. "Student Reports in Strategic Planning, "NPS-56-88-031PR, September, 1988. p. 301.
	J.J. Tritten, Review of "Defending America's Security," by F. Hartmann, and R. Wendzel. The Friday Review of Defense Literature, no. 88-38, October 28, 1988. pp. 4-5.
Conference Presentations:	J.J. Tritten and N.C. Roberts, "Strategic Management for the Defense Department," Annual Meetings of the National Defense Executive Reserve in Chicago, IL., Monterey, CA., Atlanta GA., and Washington DC, September, 1988.
Theses Directed:	J.R. Hafey, "A Theory of Naval Strategic Planning," Master's Thesis, June, 1988.
	P.K. Siddons, "Use of Advanced Computer Techniques in Modern Political-Military Simulations," Master's Thesis, September, 1988.
	A.D. Konecny, "Net Assessment: An Examination of the Process and Recommendations for Practical Applications," Master's Thesis, December, 1988.

Title:	Relationship of War at Sea to Warfare Ashore
Investigators:	J.J. Tritten, Associate Professor, National Security Affairs, principal investigator; R.N. Channell, Adjunct Research Professor, National Security Affairs, R.H. Stolfi, Professor, National Security Affairs, T.B. Grassey, Associate Professor, National Security Affairs, W.P. Hughes, Adjunct Professor, Operations Research, J.S. Breemer, Adjunct Profess, national Security Affairs, and S.W. Affairs, Professor Emeritus, National Security Affairs.
Sponsor:	Office of the Chief of Naval Operations (OP-603)
Objective:	Use of RAND Strategy Assessment System (RSAS) to analyze impact of execution of maritime strategy on land campaigns in Europe. First year of a multi-year project.
Summary:	Primary emphasis has been on analyzing and providing an evaluation of the Naval models in the RSAS to OPNAV, RAND, and OSD/NA. Research team has become familiar with how to operate the RSAS and has installed sufficient components to permit analysis and limited gaming in support of teaching. Assistance has been provided to Naval War College and other new RSAS users.
Publications:	J.J. Tritten, "Military Uses of the Sea to the year 2000," NPS-56-88-006, February, 1988. p. 13.
	J.J. Tritten, "Withholding and Attacking SSBN's," NPS-56-88-004, February, 1988, p. 21.
	J.J. Tritten and R.N. Channell, "The RAND Strategy Assessment System at the Naval Postgraduate School," NPS-56-88-010, March, 1988. p. 65.
	J.J. Tritten, "Withholding and Attacking SSBN's," Naval Forces, vol. IX, no. II/1988, p. 44-51.
	J.J. Tritten, "Scenarios of Nuclear Escalation Dominance and Vulnerability," NPS-56-88-013, June, 1988. p. 38.

J.J. Tritten, "Is Naval Warfare Unique?" NPS-56-88-018, August, 1988, p. 29.

J.J. Tritten, "A Soviet View of U.S. National Security Strategy," NPS-56-88-019, August, 1988. p. 8.

R.N. Channell, "Problems in Modeling Navies," NPS-56-88-022, September, 1988. p. 31.

R.N. Channel, "Naval Model Priorities for the RAND Strategy Assessment System," NPS-56-88-023, September, 1988. p. 12.

A.D. Capron, "Tomahawk and SSGN's - Time to Re-Think the Option?" NPS-56-88-27, September, 1988. p. 19.

J.J. Tritten, Review of "Modern Sea Power," by G. Till, U.S. Naval Institute Proceedings, vol. 114, no. 12, December, 1988. p. 142.

Conference
Presentations:

J.J. Tritten, "Withholding and Attacking SSBN's," presented to faculty and students at UC Santa Cruz and University of Miami, March, 1988. Also presented at the 56th Military Operations Research Society (MORS) Symposium at the Naval Postgraduate School, Monterey, CA., June, 1988.

J.J. Tritten, "Scenarios of Nuclear Escalation Dominance and Vulnerability," presented to the Maritime Security and Arms Control in the Pacific Region Conference at the University of British Columbia, May, 1988.

J.J. Tritten and R.N. Channell, "The RAND Strategy Assessment System at the Naval Postgraduate School," presented at the 56th Military Operations Research Society (MORS) Symposium, at the Naval Postgraduate School, Monterey, CA., June, 1988.

J.J. Tritten, "Is Naval Warfare Unique?" presented to the thinking RED in Wargaming Workshop at the National Defense University, Washington, DC, June, 1988. Also presented at the 56th Military Operations Society (MORS) Symposium at the Naval Postgraduate School, Monterey, CA., June, 1988 and to the MIRE Corporation, McLean, VA., October, 1988.

Theses
Directed: D. Ricker, "The Nuclear Depth Bomb: Nemesis
                                 or Solution," Master's Thesis, June, 1988.

                                 K. Brown, "The Impact of the Purchase of
                                 Canadian SSNs on the Maritime Strategy,"
                                 Master's Thesis, September, 1988.

                                 L.D. Marquet, "The Strategic Employment of
                                 the Soviet Submarine Force," Master's Thesis,
                                 December, 1988.

Title:	Nuclear Assessments
Investigators:	J.J. Tritten, Associate Professor, National Security Affairs, principal investigator, R.N. Chanrel, Adjunct Research Professor, National Security Affairs, S. Garrett, Adjunct Research Professor, National Security Affairs, E.M. Alvarez, Adjunct Research Professor, National Security Affairs, K.M. Kartchner, Assistant Professor, National Security Affairs, M. Tsypkin, Assistant Professor, National Security Affairs, T.B. Grassey, Associate Professor, National Security Affairs, E.A. Olsen, Professor, National Security Affairs, J.S. Breemer, Adjunct Professor, National Security Affairs, and C.A. Buss, Adjunct Professor, National Security Affairs
Sponsor:	Defense Nuclear Agency (DNA)
Objective:	Use of RAND Strategy Assessment System (RSAS) to analyze role of strategic nuclear forces including impact of INF Treaty and SDI on strategy. First year of a multi-year project.
Summary:	Work is progressing into four main areas: the implication of the new INF Treaty on NATO, U.S., and Naval Strategy, the integration of theater and strategic nuclear forces, SDI and strategy and the role of the nuclear reserve force.
Theses Directed:	A.D. Capron, "Sea Launched Cruise Missiles in the Post-INF environment," Master's Thesis, March, 1988.
	D. Mitchell, "Strategic Nuclear Options for a Degraded Triad, "Master's Thesis, December, 1988.
	J.G. Rivenburg, "Implications of Nuclear Free Zones in the International System," Master's Thesis, December, 1988.

Title:	Prospects for an Increased Asian Naval Role in Southeast Asian Strategic Affairs
Investigator:	D. Winterford, Adjunct Professor of National Security Affairs
Sponsor:	Naval Postgraduate School Research Council
Objective:	To analyze ASEAN's potential for undertaking a larger Naval role in Southeast Asian regional security through examining several key areas: the evolving Soviet Naval challenge in Southeast Asia; 2) U.S. and ASEAN threat perception; 3) prospects for enhanced ASEAN Naval defenses; 4) feasibility of harmonizing U.S./ASEAN Naval relations and the significance of this for U.S. Naval planning for the region.

Summary:	This research analyzed the stark security challenges confronting ASEAN and China as a result of the substantial and continuous strengthening of Soviet Naval Capability in the Asia-pacific. The study discussed the commanding Coercive benefits accruing to Moscow from the Soviet Union's successful geo-strategic leapfrog to Naval air facilities at Cam Ranh Bay and Da Nang in Vietnam. Overall, this analysis concluded that the major objectives of the Soviet Naval buildup in the region are to compel Southeast Asia governments to accommodate Soviet foreign policy goals and to raise concerns in the region about the wisdom of close association with the U.S.. This study called for an enhanced Naval cooperation and defence burden-sharing between the U.S. and ASEAN in order to provide the requisite regional maritime security to counter Soviet threats.

Publications:	D. Winterford, "Assessing the Soviet Naval Build-up in Southeast Asia: Threats to Regional Security. Naval Postgraduate School. NPS-56-88-024, September, 1988.
Conference Presentations:	D. Winterford, "The Soviet Naval Build-up in Southeast Asia: Implications for SINO-ASEAN-U.S. Defense," Presented at the Annual Meeting of the Western Conference of the Association for Asian Studies, Seattle, Washington, October 21-22, 1988.

Thesis
Directed: LT. D.J. Kern, USN, "Soviet Naval Operational
                    ARt," Master's Thesis, June, 1988.

Title:	Structural Factors in the Long-Term Competition
Investigator:	D.S. Yost, Associate Professor of National Security Affairs
Sponsor:	Under Secretary of Defense for Policy
Objective:	Advance understanding of structural asymmetries - particularly political, social, and cultural factors - in the U.S.-Soviet (and East-West) long-term competition, particularly with respect to European security.
Summary:	Research has concentrated on security issue relating to Western Europe and nuclear deterrence in an effort to elucidate critical structural factors in the long-term East-West competition.
Publications:	D.S. Yost, "Western Europe and the U.S. Strategic Initiative," Journal of International Affairs, vol. 41, Summer, 1988. pp. 269-323. D.S. Yost, "France, West Germany, and European Security Cooperation,'Review Article in International Affairs, vol. 64, Winter, 1988. pp. 97-100.
Conference Presentations:	D.S. Yost, "Europe's Political-Economic Security Future, "Department of Defense Summer Seminar on National Strategy, Naval War College, Newport, Rhode Island, August 22-24, 1988.

DEPARTMENT
OF
PHYSICS

DEPARTMENT OF PHYSICS

During FY88 the research activities in the Physics department consisted of 28 identified individual projects.

The majority of these projects (75%) were funded through the Navy Direct Funding mechanism. The rest was externally funded as Reimbursable. The direct funded projects involved Navy sponsors in an advisory capacity. These sponsors were NAVSEA, NCSC, NEPRF, NSWC, NRL, ONR, OPNAV 09, and SPARWAR. Non Navy sponsors of the reimbursable funds were: Army, DARPA, NASA, SDIO, and AFWL.

The projects fall naturally into seven groups. They are:

1. Physical Acoustics
2. Electro-Optics/Infrared Technology
3. Space and Plasma Physics
4. Directed Energy and Radiation Physics
5. Environmental Physics
6. Application of Non Equilibrium Statistical Mechanics to Battle Dynamics
7. Surface Physics

Although broadly based this research program is the results of a long term carefully orchestrated evolution, designed to explore the physics of areas where modern technology, particularly Naval Weapons Technology, interfaces and is limited by our understanding of the natural environment. As a group, the department specializes in the physics of the interface between weapon systems and the environment. The nature and significance of the research in each area is outlined environment. The nature and significance of the research in each area is outlined here.

1. PHYSICAL ACOUSTICS

The department has now one of the strongest and largest groups in physical acoustics in the nation, with 8 faculty members participating in FY88. The research in this area in the department falls into four categories: (a) Ocean bubble dynamics, (b) Transducer physics, (c) Thermoacoustic energy transfer processes, and (d) Transducers Physics. The interaction of sound and Ocean Bubble swarms is investigated by Professor Atchley which led to the development of a dual frequency method of measuring size spectrum of bubble clouds and the damping constant of bubble oscillations. In the area of sensor technology, work continued on the development of the fiber optic sensor system (Garrett) and the design of the Space Shuttle Vibroacoustic Experiment. Work on the fiber optic sensor system concentrated on a flexural plate, fiber optic, interferometric, acceleration canceling omnidirectional hydrophone which appears to have the highest sensitivity reported in the literature to date. The work on the system to measure the airborne acoustic noise in the space shuttle cargo bay during the launch phase has concentrated on acoustic signal processing issues. The work on thermoacoustic energy transfer processes (Atchley, Garrett,

Hofler, Larrazza) has led to better understanding of the temperature gradient generated in thermoacoustic heat transport devices and experiments measuring the onset of thermally driven acoustics oscillations were made and seem to compare adequately with theory. The work on the development of a thermoacoustic refrigerator for a test on a Shuttle Get Away Special in late 89 was pursued vigorously. In the transducer physics area (Wilson, Baker, Kuntsal, Hamonic) work continued on the investigation of the usefulness of the Delta-Z method for monitoring the sensitivity of in-service sonar transducers installed in domes which can be flooded and purged. The method has been developed into a state of the art computer-controlled measuring system and has been used on the AN/BQR-7 and AN/BQQ-5 sonar systems and has been adapted for the AN/BQQ-6 sonar system on Trident submarines. The importance of this work lies in the ability to test large sonar system arrays on submarines in situ avoiding the very costly dry docking of the submarine for that purpose. A new project was the development of a compact apparatus to measure both the complex bulk modulus and the complex mass density of a fluid contained in a rigid porous solid. The visit of Dr. Hamomic from ISEN Lille, France brought a new capability in the modeling of sonar transducers and acoustic fields to NPS. The finite element code ATILA was adapted and implemented for Microvax computers, a graphics software package was adapted for ATILA and was thus made useful for work at NUSC, NRL, NOSC, and NPS. The new capabilities were tested in the analysis of various transducers. The coupling of the finite element code for transducers with the Helmholtz Integral equation for solving far-field radiation and scattering problems gives the department very significant new capabilities.

2. ELECTRO-OPTICS/INFRARED SENSOR TECHNOLOGY

The work in this area is concentrated in the Naval Center for Infrared Technology (NACIT) at NPS which is led by Professor A. Cooper. Work continued in four areas: The NACIT Infrared Search and Target Designation Research (Cooper, Cleary, Crittenden, Lentz, Walker) seeks to establish a program of measurement of target and background scenes for analysis, development and of measurements of target and background scenes for analysis, development and validation of detection and background suppression algorithms and for evaluation of IRST technology. The program revolves around the NPS modified Advanced Demonstration Model IRSTD system supported by the Navy's AN/SAR - 8 project office. Scanner and cooling system are installed. Work is in progress on the data handling and processing system. The Off-Board Countermeasures Program (Cooper, Crittenden, Milne, Rodeback, Lentz) is to carry out simulation analyses of performance and tactics for off-board decoys, development of hardware components for off-board devices and evaluation of passive ship defense techniques. A laser altimeter has been developed and tested from the Golden Gate Bridge at various sea states. The Evaluation and Validation of FLIR Performance models (Cooper, Milne, Crittenden, Lentz) centered on the participation in experimental comparison observation involving overflights of FLIR carrying Naval aircraft, with code predications

and the evaluation of improvements to existing codes. The IR Sensor integration into the AEGIS Weapon System project (Cooper, L. Wilson) which investigates the potential for integration of IR/Electro optical sensor data from the AN/SAR-8 into the AEGIS combat system and to evaluate the integration advantages, requirements, and implementation options has been continued. Plans are developed to investigate the synergism derived from various multisensor data fusion schemes.

3. SPACE AND PLASMA PHYSICS

Research in this area spans a wide array of phenomena where plasma processes at the interface between man made devices and their respective environments have detrimental effects on the devices and where a through understanding of these processes is necessary before hardening strategies can be developed. Investigation of Plasma Heating Processes near the Plasmapause of the earth's magnetosphere was carried out by Olsen and Gnanalingam to determine the total density and the contributions of hot and cold ion populations, using existing, satellite data. Of direct relevance to satellite survival is the investigation of methods for Satellite Charge Control with on board electron and ion sources (Olsen, Gnanalingam). Data from earlier satellite experiments were analyzed. Work in association with the NASA Lewis Research Center is in progress to define a new Plasma Contractor Flight Test that is to best basic processes in current emission and absorption for satellites in space. More down to earth Professor Schwirzke is investigating the unipolar arcing as a basic, potentially dangerous laser damage mechanism for vulnerability to Laser Directed Energy Weapon Systems. These basic phenomena are of equal importance in plasma opening switches which are considered for application in high power short pulse Directed Energy Systems.

4. DIRECTED ENERGY BEAMS/RADIATION PHYSICS

Our Directed Energy Beam and Radiation Physics Group consisting of Professors Buskirk, Neighbours, and Maruyama is now concentrated on two large experimental facilities, the Linear Electron Accelerator, a high energy (120 MeV), low current machine which has been working and producing results since 1965 and the new flash X-Ray Pulse Power Facility, a low energy (1.8 MeV) high current (35 KA) Pulserad 112A machine, which now operational. This year the FLX was put into operation and characterization of its performance is being done (Maruyama). An electron-photon transport code for dosimetry models has been made operational at NPS. Also made available at NPS through cooperation with Los Alamos National Laboratory was a Monte Carlo based neutron-photon radiation transport code, providing NPS with state of the art computational capability in this area (Maruyama). The LINAC facility was used to investigate the effects of radiation on the transition temperature of the new high temperature superconductor materials (Buskirk). The investigation of Cerenkov, Transition and EMP radiation from pulsed high energy electron beams has been continued (Buskirk, Neighbours, Maruyama) and measurements on beams at the

RL Linac at Livermore and the Advance Test Accelerator was conducted.

5. ENVIRONMENTAL PHYSICS

The research in this area falls into three categories: characterization of atmospheric optical turbulence, remote sensing of the lower earth thermosphere and investigation of flow and dispersion of hazardous gas plumes. The Optical Atmospheric Turbulence work is carried out by Professor Walters. The program provides continuous support to the Air Force by providing measurements and assessment of atmospheric distortions for the Strategic Defense Initiative program using instrumentation for measuring modulation transfer function, isoplanatic angle and acoustics sounder and rawinsonde systems characterize the entire troposphere. These instruments were used in particular to characterize the atmosphere above the Pacific coastal mountain range to find sites with very low optical turbulence degradation. NPS research in this field has made it the principle source of data for decision processes directed by SDIO together with NASA, ONR, and NRL. A continuous program of such measurements was carried out at the site for the ground based Relay Mirror Experiment on Kikei, Hawaii. Professor Cleary has begun a program of investigating possible techniques for remote sensing of the lower thermosphere ionospheric E-region at 100 Km altitude using remote UV spectroscopy of selected ionic species. The goal is a method for remote determination of global ion density distribution. The long existing program of investigation of airflow and dispersion patterns of hazardous gaseous plumes has continued (Schacher, Kamada, Skupniewicz). These investigations involving meteorological field measurements and computer models have now resulted in the completion of the Vandenberg AFB Meteorological Plume Dispersion Handbook.

6. STATISTICAL MECHANICS MODELS OF BATTLE DYNAMICS

Professor Ingber has continued his development of methods of bringing the path integral method of statistical mechanics to bear on models of complex dynamic systems involving internal forces and statistical behavior at the microscale and distinct patterns at the macroscale. Recently Ingber and his students have undertaken a mathematical comparison of computer models of battalion size land engagement (JANUS(T)) with actual exercise data available at the National Training Center. The results have shown that JANUS(T) can reasonably reproduce the given missions. This permits to begin the development of a "what-if" capability for JANUS(T) for a class of force-on-force mission. In a further development, the JANUS(T) conflict simulation was used in a joint role to measure the effect of the Navy's Land Attack missiles in support of the Army's Airland Battle.

7. SURFACE PHYSICS

Surface Physics was represented by Prof. D. Harrison who died suddenly and unexpectedly. In his last year, he was joined by Professor R. Smith from Loughborough University, England. Harrison's last work revolved around two new extensions of his basic work in computer simulation of molecular dynamics processes during ion bombardment of solids. One was the extension of his work to liquids; which led to the capability of giving the lattice atoms a temperature obeying the Boltzmann distribution of energies, and being able to study the difference of sputtering from liquids vice solids. The other significant accomplishment of Harrison and Smith is the capability to extend the simulation to silicon which required to treat the inner molecular forces in terms of a suitable manybody potential rather than one-on-one potentials. Results allowed to compare simulation of sputtering yields and angular distributions with experimental results by Winograd. Smith has applied the Harrison simulation code to the study of the surface bombardment with Ar+. Another extension of this work was the study of the motions and relaxation of defects in solids with the molecular dynamics simulation code.

Title:	Interaction of Sound and Ocean Bubble Swarms
Investigator:	A.A. Atchley, Assistant Professor Physics
Sponsor:	NPS Direct Funding/NCSC
Objective:	To continue the development of a dual frequency method of measuring the size spectrum of bubble clouds in the ocean with the goal of providing NCSC with the specifications for a prototype system to be used in conjunction with their optical bubble counter.

Summary: This project is a continuation of one sponsored by NCSC in fiscal year 1987. During fiscal year 1988, important progress occurred in three areas. The first is that an extensive set of quantative measurements were made using the dual frequency technique and preliminary specifications for a prototype system have been established. These measurements involved bubbles as well as solid particulates and hollow, gas-filled, glass microspheres. The results indicate that this technique is sensitive to gas volumes contained on or in solid contaminants, which may not be labeled as acoustically active by optical detectors. A second area of progress is in the self-reciprocity calibration of high intensity, focuses transducers. Calibration of such transducers has long been a problem in investigations of acoustic cavitation. We are unaware of any previous efforts to use self-reciprocity. Results based on this technique agree with (more standard yet more difficult) radiation force calibrations to within approximately 10%. Further development of this technique may be of great value to the cavitation community. The final area of progress is the realization that the dual frequency technique may be used to directly measurement the quality factor (Q), and therefore the damping constant, of bubbles. Previous methods of measuring the damping constant of bubbles involve acoustically levitating a bubble and are quire tedious requiring tens of mutes. If the dual frequency technique proves usual, damping constants should could be measured in a few seconds.

Cor   ence
P   entations: A.A. Atchley, "The Blake Threshold of a
                          Bubble Having Radius-dependent Surface
                          Tension," 115th Meeting of the Acoustical
                          Society of America, Seattle, Wa, May, 1988.

Thesis
Directed: E.R. Lineberger, "Bubble Detection Using a
                          Dual Frequency Sound Field," M.S. Thesis,
                          December, 1988.

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Title:	Basic Research in Physical Acoustics and its Applications

Investigators: A.A. Atchley, Assistant Prof. of Physics and S.L. Garrett, Associate Prof. of Physics

Sponsor: NPS Direct Funding/ONR

Objective: To perform basic measurements of heat transfer by thermoacoustic processes in refriger .tors usina closely spaced heat exchanger plates and the design and testing of thermoacoustic refrigerator for launch in a Get Away Special Canister from the Space Shuttle.

Summary: Although this research is a joint project between Prof. Garrett and Prof. Atchley, this summary covers only those aspects of the project in which Prof. Atchley was the principal investigator. Prof. Atchley's portion of the project followed two paths. The first puth is a continuation of the investigation of the observed discrepancy between theoretical values of temperature gradients generated across short plates and the analogous experimental values. (See the summary of "Investigation of Thermoacoustic Heat Transport"). An apparatus has been designed which will allow for complete computer control of the experiment. In a particular, the apparatus is able to position in a standing wave sound field, tune at the field to resonance, set the acoustic pressure amplitude, and measure the temperature of the stack of plates and the temperature difference across the stack. The apparatus designed for mean pressures up to 5 bars and acoustic pressure amplitudes of a lease 165 dB. Preliminary measurements are underway. The second patn of the project involved measuring the onset of thermally driven acoustic oscillations. The results are adequately explained by the basic theory of thermoacoustics.

Conference
Presentations: A.A. Atchley, T.J. Hofler, and M.D. Kite, "Acoustically Generated Temperature Gradients in Short Plates," 116th Meeting of the Acoustical Society, Am. 84, Suppl, 1, S36,(A), 1988.

D.C. Simard, A.A. Atchley, and S.R. Baker, "An Investigations of the Work Output of a Thermoacoustic Prime Mover," 115th Meeting of the Acoustical Society of America, Seattle, WA, May, 1988.

Theses
Directed:

D.C. Simard, "The Work Output of a Thermoacoustic Prime Mover," M.S. Thesis, December, 1987.

M.D. Kite, "Computerized Measurement of Thermoacoustically Generated Temperature Gradients," M.S. Thesis, December, 1988.

Title:	Investigation of a Novel Self-Reciprocity Method for the Calibration of SONAR Transducers
Investigators:	S.R. Baker, Assistant Prof. of Physics and O.B. Wilson, Prof. of Physics
Sponsor:	NRL-USRD
Objective:	To develop a method for determining the receiving sensitivity of in service sonar transducer form in-situ input electric impedance measurements.

Summary: A method is being investigated whereby the receiving sensitivity of reversible underwater transducer may be obtained from the difference in its measured input electric impedance when the transducer is alternately loaded by water and by air. Termed the Delta-Z method, it may be useful for monitoring the sensitivity of in-service sonar transducers installed in domes which can be flooded and purged. The Delta-Z method has been successfully applied to a six-inch hollow piezoelectric sphere (Bedard) and to a Navy type TR-317B transducer in a free field (Patton). Deviations from the results of a standard comparison calibration for the TR-317B were within approximately 1dB over a range of frequencies extending more than an octave above and below its nominal operating frequency. Current efforts include extending the Delta-Z method to other transducers and to transducers installed in arrays, particularly the AN/BQQ-5 and an/BQQ-6 systems.

Conference Presentations:

R. Bedard and S.R. Baker, "Reciprocity Calibration of an Underwater Transducer by the Delta-Z Metho'," Presented to the Acoustical Society of America, Seattle, WA., May, 1988.

M.D. Patton, S.R. Baker, and O.B. Wilson, "Reciprocity Calibration of a Tonpilz Transducer by the Delta-Z Method," Presented to the Joint Meeting of the Acoustical Society of American and the Acoustical Society of Japan, Honolulu, HI., November, 1988.

Theses
Directed:
R. Bedard, "Reciprocity Calibration of Underwater Transducer by the Delta-Z Method," M.S. Thesis, December, 1987.

M.D. Patton, "Reciprocity Calibration of an In-Service Transducer by the Delta-Z Method," M.S. Thesis, September, 1988.

Title: Development of a Compact Apparatus to Measure Both the Complex Bulk Modulus and the Complex Mass Density of a Fluid Contained in a Rigid Porous Solid

Investigators: S.R. Baker, Assistant Professor of Physics and O.B. Wilson, Professor of Physics

Sponsor: NRL-USRD

Objective: To develop a compact apparatus to measure both the complex bulk modulus and the complex mass density of a fluid contained in a rigid porous solid; to determine the characteristic frequency dependence of the complex fluid mass density for typical pore geometries.

Summary: This is a new program which began in FY88 and continued in FY89. The fundamental thrust of the program is to investigate the frequency dependence of the complex effective fluid mass density of a fluid contained in a rigid porous solid. There exists a simple formula, derived for a collection of straight channels, which it has been suggested can be used to describe this frequency dependence, provided the pore size is essentially uniform. However, it has never been put to a rigorous test. We are investigating several methods for measuring the complex mass density, utilizing a small cylindrical chamber containing the fluid-filled porous solid. The basic strategy is to cap each end of the chamber with identical transducers and to excite them in a push-pull fashion so as to produce oscillatory flow of the fluid as a plug, with little attendant compression. One means to make the measurement is to use acoustically soft transducers, and detect the load presented to the face of each by the oscillating fluid through its effect on the input electrical impedance. For his thesis, LT Grant initiated an investigation of this method (MS Sep 1988). A follow-on student, LT R. Mirick, is continuing LT Grant's work and is investigating a second technique whereby the load presented by the oscillating fluid is directly measured using a pair of accelerometers and force gauges.

Conference
Presentations: S.D. Grant, S.R. Baker, and O.B. Wilson,
                   "Development of a Compact Apparatus to
                   Measure Both the Complex Bulk Modules and
                   the Complex Mass Density of a Fluid Contained
                   in a Rigid Porous Solid," Presented to the
                   Joint Meeting of the Acoustical Society of
                   America and the Acoustical Society of Japan,
                   Honolulu, HI, November, 1988.

Thesis
Directed: S.D. Grant, "Development of a Compact
                   Apparatus for Determining Complex Parameters
                   of Fluid-Filled Porous Solids by Impedance
                   Techniques," M.S. Thesis, September, 1988.

Title:	Radiation Code Transport
Investigators:	F.R. Buskirk, Professor of Physics, J.R. Neighbours, Professor of Physics, and X.K. Maruyama, Professor of Physics
Sponsor:	NPS Research Council
Objective:	This project brought a visiting Scientist, Dr. J. Mack of Los Alamos National laboratory to NPS to install the radiation transport code MCNP which is a Monte Carlo neutron-photon transport code. Dr. Mack provided interactions with staff and students concerning radiation transport physics. This code provides us with state of the art computational capability to characterize radiation dose from the electron linear accelerator and the flash x-ray machine.

Title:	Radiation and Radiation Effects Research
Investigators:	F.R. Buskirk, Prof. of Physics, J.R. Neighbours, Prof. of Physics, and X.K. Maruyama, Prof. of Physics
Sponsor:	NAVSEA
Objective:	Research on the production of radiation and effects on materials. Experimental facility used is the NPS electron linear accelerator. Research on radiation damage cn high temperature superconductors was conducted.
Conference Presentations:	F.R. Buskirk, "Radiation Effects in Bulk Samples of High Tc Superconductors YBa2CU306+x and GdBa2CU306+x," 25TH NSREC, Conference, Portland, OR, July, 1988.
Theses Directed:	E.L. Sweigard, "Effects of 67.5 MeV Electron Irradiation on Y-Ba-Cu-O and Gd-Ba-Cu-O High Temperature Superconductors," M.S. Thesis, June, 1988.

Title: An Investigation of Techniques for Remote
                           Sensing of the Lower Thermosphere

Investigator: D. Cleary, Assistant Prof. of Physics

Sponsor: NPS Research Council

Objective: Research was undertaken to investigate simple
                           techniques   for   measuring   ionospheric
                           densities remotely from either rocket or
                           satellite observations.   The short term
                           objective of this project is to identify new
                           techniques to measure E-Region ion densities.
                           The long term objective is to define and
                           refine a strategy for the measurement of
                           global ion densities.

Title:	NACIT Infrared Search and Target Designation Research
Investigators:	A.W. Cooper, Prof. of Physics; W.J. Lentz, Research Associate; P.R. Walker, Research Physicist; D.D. Cleary, Assistant Prof. of Physics; and Dr. E.C. Crittenden, Distinguished Professor of Emeritus
Sponsor:	Naval Sea Systems Command
Objective:	To establish at Monterey a program of measurement of target and background scenes for analysis, development and validation of detection and background suppression algorithms, and for evaluation of IRST technology. Data gathered with the NPS-modified Advance Demonstration Model IRSTD system are to be analyzed statistically and compared with co-located TV and framing thermal imager data.

Summary: This is a continuing multiyear project, established by Memorandum of Understanding and supported by the AN/SAR-8 Project Office. During this year, dynamic calibration of the scanning unit was carried out and preliminary data from pairs of detectors viewing an outdoor scene transferred to the processing Masscomp computer. The scanner unit was moved to the final rooftop location with clear view of Monterey Bay and the surrounding including the Monterey Municipal Airport runway approach path. The liquid nitrogen cooling and flushing system now operated successfully unattended and individual detector scanning signals transmitted by multicoaxial line to the second floor recording and processing system. A software development contract has been negotiated to accomplish the transfer of scan data form the Ampex HBR30000I tape recorder to the Optimum 10000 optical disk at not less than the required minimum data rate (102 kBytes/sec.). This work is to be accomplished in quarter 1 FY89. Preliminary model digital filters for target discrimination have been developed and exercises on simulated background data. One dimensional version of these filter functions have been successfully applied to the single detector scan data. A remote control television system with "frame grabber" unit capable of data acquisition at 10 MBytes per

second has been acquired and is ready for mounting on the roof adjacent to the IRST scanner. Work is proceeding on adapting this for sector display of IRST scenes, and to register video pointing direction with scanner rotation.

Thesis
Directed: G.R. Ayers, "Calibration and Initialization of the NPS Modified IRSTD System," M.S. Thesis, December, 1987.

Title:	Off-Board Countermeasures Program Support
Investigators:	A.W. Cooper, Prof. of Physics; E.C. Crittenden, Jr., Distinguished Prof. of Emeritus of Physics; E.A. Milne, Associate Prof. of Physics; G.W. Rodeback, Associate Prof. of Physics; and W.J. Lentz, Research Associate, Physics
Sponsor:	Naval Sea Systems Command
Objective:	To carry out simulation analyses of performance and tactics for off-board decoys, development of hardware components for off-board devices and evaluation of passive ship defense techniques.

Summary:	The SNICES simulation program for IR decoy effectiveness evaluation was further refined to facilitate batch use on the VAX 11/780 and to provide access to program variables during execution. Modularity and ease of maintenance were improved. The program was used to evaluate optimal modes of deployment of Infrared decoys. The Anti-Ship Missile Defense with Chaff model previously developed (Nitzan, 1985) as a training simulation has been modified to include a ship parameter data base with defaults to improve operational realism. Equipment has been developed and filed experiments have been carried out to test pilot models of the laser altimeter and to verify the absolute reflectance of the rough ocean surface under a variety of sea state. Recently, the experiments have been carried out from the center span of the Golden Gate Bridge. Similar experiments over the open ocean are planned for later using a helicopter or a blimp. An anomalously high reflectance that has been observed in earlier work on this project continues to be verified. Permission for measurements from the Golden Gate Bridge could be obtained for daylight operation Consequently it has been necessary to replace the previous system, used at night, for determining the optical sea-state. This employed a video camera and bright point light source to provide digital measurements of the glitter pattern. In the new system, the laser transmitter and coaxial receiver of the laser altimeter are scanned through the angular range of the glitter pattern. At present, this is being modified to provide

fast data recording to surmount the problems of rapid changes in the optical sea-state. The new system also employs and improved leading edge signal detector, dial variable delayed detection over a range of 0 - 300 meters altitude, switch selectable single or dual sequence triggering, switch selectable time window width, switch selectable output to a pulse counter scaler or to an altitude trigger circuit such as would be used in a device descending on a parachute. Precise determination of the false alarm rate has been achieved through the use of the variable width time window for detection.

Publication: E.C. Crittenden, Jr., G.W. Rodeback, A.W. Cooper, and C.M. Bourne, "Laser Altimeter for Use Over the Ocean," NPS-61-89-001, October, 1988.

Thesis
Directed: C. Gatton, "Structural Improvement of SIREM IR Countermeasure Effectiveness Simulation Code," M.S. Thesis, December, 1988.

Title:	Evaluation and Validation of FLIR Performance Models
Investigators:	A.W. Cooper, Prof. of Physics; E.A. Milne, Associate Prof. of Physics; E.C. Crittenden, Jr., Distinguished Prof. of Physics; and W.J. Lentz, Research Associate of Physics
Sponsor:	Naval Environment Prediction Research Facility
Objective:	To validate and improve available Tactical Decision Aid codes for prediction of performance of operational FLIR devices by participation in experimental comparison of observations with code prediction and to evaluate improvements to existing codes.

Summary:

In this phase of this continuing project the RV Point Sur was instrumented with thermal sensors for two meteorological cruises during which over flights by FLIR carrying Naval Aircraft were scheduled. Comparison predictions of detection and classification ranges were made using the UFLIR TDA code using standard input and also using an NPS developed model of target/background temperature contrast. Related measurements were made of shallow incidence angle radiance from the rough sea surface and of direct sky radiance, using the Agema AGA780 radio metric thermal imaging system. These measurements were used for validation in the grazing incidence regime of the Schwartz and Hon algorithm for reflection of sky radiance, and additionally for comparison with LOWTRAN6 sky radiance predictions. An analysis was carried for the UFLIR Tactical Decision Aid Program for sensitivity of predicted range to each of the parameters used as inputs in the program. Results were target-to-background temperature difference and the absolute humidity of the atmosphere.

Theses Directed:	T. McKaig, "Determination of Temperature Distribution of IR Emitting Targets," M.S. Thesis, December, 1987.
	T. Kotsis, "Sky Radiance Distributions for Thermal Image Backgrounds," M.S. Thesis, December, 1987.

M. Ridgeway, "Modeling of Sea Surface Effects in FLIR Performance Codes," M.S. Thesis, September, 1988.

Title:	IR Sensor Integration into AEGIS Weapons System
Investigators:	A.W. Cooper, Prof. of Physics and Dr. L.E. Wilson, Sig-Pro Systems
Sponsor:	NSWC Dahlgren
Objective:	To investigate the potential for integration of infrared/electro-optical sensor data (particularly the AN/SAR-8) data into the AEGIS combat system and to evaluate the integration advantages, requirements and implementation options.

Summary:	In the first of this study the predicted output data of the SAR-9 IRSTD was examined with respect to quality and nature of the (two dimensional) track data, and the architecture of the AEGIS system was examined for possible integration nodes. The data handling procedures of the tow systems were evaluated and a preliminary examination made of the correlation methods and the associated track quality. Merits of Sensor Level, Central Level, Combined Sensor, and Central Level Tracking have been considered, and a summary evaluation of the multi-sensor correlation algorithms described n the available literature has been carried out, and further analyses identified to select from these techniques. Plans are being developed to investigate the synergism of the multisensor data using the Ship Combat System Simulation. The Phase VI version of this program with the appropriate modules have been received and will be implemented during FY89.

Title:	Fiber Optic Directional Hydrophone System
Investigator:	S.L. Garrett, Associate Professor of Physics
Sponsor:	Space and Naval Warfare Systems Command, PMW 180-4
Objective:	To design, fabricate and test an entirely fiber optic acoustic sensor system which is directional and compact as part of a continuing research program in fiber optic sensor systems.

Summary:

This was the third year of support for a program to develop an all optical equivalent of a DIFAR-like compact directional hydrophone system. The system consists of a pair of seismometer style, neutrally buoyant, fiber optic interferometric bi-directional hydrophones and an interferometric omnidirectional hydrophone. The three hydrophone signals can be combined to steer a cardiod array pattern throughout all azimuth. The system also includes a fiver optically read magnetic compass to relate heading information to the array beam axis. During this period, two high sensitivity omnidirectional hydrophones were developed. The first used four flat-spiral coils bonded to the surfaces of two plates which were flexed by the acoustic pressure. This geometry was constructed and tested and was found to have the highest sensitivity reported to date for a fiber-optic interferometric hydrophone. The design is also acceleration canceling. The other hydrophone was designed during this period, but not constructed. It is also a push-pull interferometric design which used two coils wound around the equatorial and meeridonial circumferences of a thin ellipsoidal shell.

Publications:

J.T. Newmaster, M.R. Brinistool, T. Hofler, and S.L. Garrett, "Channel Reduction Schemes for Fiber Optic Angular Orientation Sensors," Fiber and Integrated Optics, 7 (2), 115, 1988.

T. Hofler and S.L. Garrett, "Thermal Noise in a Fiber Optic Sensor," Journal Acoustics Society Am., 84 (2), 471, 1988.

D.L. Gardner and S.L. Garrett, "Thermal Noise in a Fiber Optic Sensor," Journal of Acoustics Society Am.,84 (2), 471, 1988.

Conference
Presentations:

S.L. Garrett and T. Hofler, "Thermal Noise Limitations in a Fiber Optic Seismic Sensor," J. Acoust. Soc. Am., 82 S56, 1987.

T. Hofler, D.A. Brown, and S.L. Garrett, "Fiber Optic Flexural Disk Microphone," J. Acoust. Soc. Am. 83, S19, 1988.

S.L. Garrett and D.A. Danielson, "Theoretical Analysis of a Class V Flextensional Fiber Optic Interferometric Hydrophone," J. Acoust. Soc. Am. 84, S102, 1988.

D.A. Brown, T. Hofler, and S.L. Garrett, "A Fiber Optic, Interferometric Acceleration Canceling, Flexural Disk Hydrophone," J. Acoust. Soc. Am. 84, S102, 1988.

S.L. Garrett, "Fiber Optic Sensor for Vibro-Acoustic Measurements," J. Acoust. Soc. Am. 84, S66, 1988.

Patent
Application:

S.L. Garrett and D.L. Gardner, "Multiple Axis Fiber Optic Interferometric Seismic Sensor," Navy Case No. 70-625.

S.L. Garrett, T. Hofler, J.T. Newmaster, and M.R. Brininstool, "Remote Fiber-Optic Angular-Orientation Sensor using Serial Digital Encoding," Navy Case No. 71-263.

M.R. Brininstool, T. Hofler, J.T. Newmaster, and S.L. Garrett, "Remote Fiber-Optic Angular-Orientation Sensor using Phase Detection of Two Orthogonal Oscillating Polarization Vectors," Navy Case No. 71, 392.

T. Hofler and S.L. Garrett, "Flexural Disk Fiber Optic Interferometric Omnidirectional Hydrophone," Navy Case No. 71, 502.

S.L. Garrett and D.A. Danielson, "Fiber Optic Interferometric Ellipsoidal Flextensional Hydrophone, Navy Case No. 71, 525.

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Title:	Space Shuttle Cargo Bay Vibroacoustic Measurement
Investigator:	S.L. Garrett, Associate Prof. of Physics; O.B. Wilson, Prof. of Physics; R. Panholzer, Prof. of Electrical and Computer Engineering
Sponsor:	Director of Navy Space
Objective:	To design, fabricate, and test autonomous system that will measure the acoustic levels in the cargo bay of the space shuttle during launch using a Get Away Special Canister.

Summary: This is an experiment which will "fly" on the Space Shuttle as a Get Away Special (NASA G-313) to measure the acoustic (air borne) noise in the cargo bay from launch until the vehicle is exoatomospheric. During this reporting period, we concentrated on the study of the acoustic signal processing system which would be used to analyze the data acquired during the Shuttle launch. This involved programs to remove the data from the magnetic bubble memory data recorder and condition it for analysis using ILS Software on an IBM PC Computer. An experiment was performed on a cargo bay scale model which verified the assumption that the modes could be classified in terms of the well known solutions for a right circular cylindrical enclosure since the deformation of that geometry into the cargo bay shape could be achieved by means of a process that was an adiabatic transformation (ie. no work was done against the "radiation pressure" so frequencies of the modes were not affected by the transformation).

Thesis Directed:	D.P. Kuebler, "Signal Acquisition and Processing for Autonomous Space Shuttle Cargo Bay Acoustic Measurements (NASA G-313)." M.S. Thesis, June, 1988.

Title: Basic Research in Physical Acoustic and its Applications

Investigators: S.L. Garrett, Associate Prof. of Physics and A.A. Atchley, Assistant Prof. of Physics

Sponsor: Office of Naval Research

Objective: To perform basic measurements of heat transfer by thermoacoustic processes in refrigerators using closely space heat exchanger plates and the design and testing of a thermoacoustic refrigerator (STAR) for launch in a get away special canister from the Space Shuttle.

Summary: The investigations of the basics of thermoacoustics followed two paths: The first path is a continuation of the investigation of the observed discrepancy between theoretical values of temperature gradients generated across short plates and the analogous experimental values. An apparatus has been designed which will allow for complete computer control of the experiment. In particular, the apparatus is able to position a stack of plates at predetermined position in a standing wave sound field, tune the field to resonance, set the acoustic pressure amplitude, and measure the temperature of the stack of plates and the temperature difference across the stack. The apparatus designed for mean pressures up to 5 bars and acoustic pressure amplitudes of at least 165 dB re:20 uPa. Preliminary measurements are underway. The second path of the project involved measuring the onset of thermally driven acoustic oscillations. The results are adequately explained by the basic theory of thermo-acoustics. The development of STAR during this period involved the fabrication and testing of an electroacoustic driver design using Neodymium-Iron-Boron magnets, automatic control systems for resonance tracking and temperature measurement, thermodynamic stack and heat exchanger optimization, He/Xe gas mixtures, and an almost countless assortment of other "small" projects in acoustics, materials, fabrication techniques, mechanical engineering, instrumentation, etc.

Publications:	M.B. Barmatz and S.L. Garrett, "Stable and Oscillating Acoustic Levitation," NASA Tech. Briefs 12 (11), 1988.
Conference Presentations:	A.A. Atchley, T.J. Hofler, and M.D. Kite, "Acoustically Generated Temperature Gradients in Short Plates," 116th Meeting of the Acoustical Society of America, Honolulu, HI., J. Acoust. Soc. Am. 84, S36, November, 1988.
	D.C. Simard, A.A. Atchley, and S.R. Baker, "An Investigation of the Work Output of a Thermoacoustic Prime Mover," 115th meeting of the Acoustical Society of America, Seattle, WA., J. Acoust. Soc. Am. 83, S6, May, 1988.
	M. Suzalla, T. Hofler, and S.L. Garrett, "Low Pradtl Number Gas Mixtures as a Working Fluid in a Thermoacoustic Refrigerator," 115th Meeting of the Acoustical Society of America, Seattle, WA., J. Acoust. Soc. Am. 83, S6, May, 1988.
	C.E.D. Haney, J.T. Newmaster, and G.L. Garrett, "A Magnetohydrodynamically Driven Hemholtz Resonant Projector," 115th Meeting of the Acoustical Society of America, Seattle, WA., J. Acoust. Soc. Am. 83, S6, May, 1988.
	S.L. Garrett, "Electric Condenser Microphones in Physical Acoustic Research," 115th Meeting of the Acoustical Society of America, Seattle, WA., J. Acoust. Soc. Am. 83, S62, May, 1988.
Theses Directed:	D.C. Simard, "The Work Output of a Thermoacoustic Prime Mover," M.S. Thesis, December, 1988.
	M.D. Kite, "Computerized Measurement of Thermoacoustically Generated Temperature Gradients," M.S. Thesis, December, 1988.
	M.P. Susalla, "Thermodynamic Improvements for the Space Thermoacoustic Refrigerator (STAR)," M.S. Thesis, June, 1988.
	M. Fitzpatrick, "Electrodynamic Driver for the Space Thermoacoustic Refrigerator (STAR)," M.S. Thesis, March, 1988.

Title:	Modeling of Sonar Transducers and Acoustic Fields Using Finite Element Methods
Investigators:	B. Hamonic, Adj. Res. Prof. of Physics, O.B. Wilson, Prof. of Physics, S.R. Baker, Asst. Prof. of Physics, and E.Kuntsal, Adj. Res. Prof. of Physics
Sponsor:	Naval Research Laboratory

Objective: The objectives were to adapt the Finite-Element computer code, ATILA, developed by the French Navy to our own MicroVax Computer, help train NPS faculty and students in its use and to conduct model analyses on transducers of interest to NPS and the U.S. Navy. A secondary objective was to apply ATILA to the analysis of the effects of rubber debonding on the vibrational modes of the DT-276 hydrophone.

Summary: Primarily thorough the efforts of Dr. Hamonic, ATILA was installed on our own MicroVax computer, we and our students were instructed in its use and analyses were made of the DT-574 hydrophone. Analysis was conducted on two other transducers in joint efforts which personnel at the Naval Research Laboratory, Orlando, and the Naval Underwater Systems Center, New London. A mini-workshop on ATILA applications was run in November, 1988 which was attended by personnel from other Navy labs and from French Navy labs. Some additional progress was made in studying the effects of the delamination of the rubber coating son the vibrational modes of the DT-276 hydrophone.

Publications: B. Hamonic, Proceedings of the Mini-Workshop on ATILA Applications," NPS61-89-005, December, 1988.

B. Hamonic, Edited by O.B. Wilson, "Introductory Manual for the Finite-Elements Code ATILA," December, 1988.

Conference
Presentations: B.F. Hamonic, O.B. Wilson, and S.R. Baker, "Coupling Finite Elements and Helmoholtz Integral Equations for Solving Radiation and Scattering Problems," Presented to the Joint Meeting of the Acoustical Society of America and The Acoustical Society of Japan, Honolulu, HI., November, 1988.

Title:	Computational Models of Ion Beam Etching
Investigator:	D.E. Harrison, Prof. of Physics and R. Smith, Research Associate
Sponsor:	Office of Naval Research
Objective:	To model surface damage using non-linear wave, Monte-Carlo and Molecular Dynamics Models of Surfaces subjecting to bombarding ions.

Summary: An investigation of surface damage on materials subjected to bombardment by ion beams has been investigated using three different models and visual color computer graphics on a desk top computer. Faster integration algorithms have been investigated and applied. It has been found that as the energy of the bombarding beam increases, the damage occurs as a result of fewer and fewer events which give large yields. Comparison between different crystal faces has been carried out and the results are qualitatively in line with experiments conducted using the scanning tunneling microscope.

Publications: I.V. Katardjiev, G. Carter, M.J. Nobes, and R. Smith, "Precision Modeling of Mask-Substrate Evolution During Ion Beam Etching," Journal of Vacuum Science and Technology A6 (4), pp. 2443-2550, 1988.

R. Smith and J.M. Walls, "Ion Erosion in Surface Analysis," Chapter 2 in Methods of Surface Analysis, J.M. Walls (ed), 1988, CUP.

R. Smith, A.H. Osbaldestin, G. Carter, I.V. Katardjiev, and M.J. Nobes, "Simple Statistical Models for Erosion and Growth," In Materials Modification by High Fluence Beams, R. Kelly (ed), Martinus Nijhoff, Dordrecht, 1988.

Conference Presentations: R. Smith, "Computational Models of Ion Beam Etching," Invited Paper presented at the European Vacuum Conference Salford University, U.K., 1988.

R. Smith and D.E. Harrison, "surface Damage on the (010) and (3111) Faces of Cu Due to Bombardment by Ar Ions," Presented at the Gordon Research Conference on Atomic Collisions in Solids, Plymouth, New Hampshire, July, 1988.

External
Seminar:

R. Smith, "Models of Surface Erosion," Department of Chemistry, Penn State University, October, 1988.

Title:	Atomic Relaxation and Vacancy-Interstitial Recombination in Sr and Zr3Al
Investigators:	D.E. Harrison, Prof. of Physics; R. Smith, Research Associate; and D.F. Pedraza, Oak Ridge National Laboratory
Sponsor:	Direct Funding
Objective:	To simulate the relaxation around defects and the recombination of vacancies and interstitials in important alloy materials used in the nuclear industry.

Summary:	Two problems associated with crystalline defects in the materials Zr and Zr3Al have been investigated by means of molecular dynamics computer simulations. In the first problem, the relaxed configuration around a single vacancy, a di-vacancy, and a tri-vacancy have been computed by introducing the defect into a perfect lattice and dynamically relaxing the crystal until it attains equilibrium. The results show qualitative agreement with static studies, but show clearly that the first and second neighbors of the defect have different relaxed states depending on their configuration with respect to the vacancy. The recombination studies have shown that a vacancy-interstitial pair quickly relaxes to the perfect crystal if the interstitial is within an adjacent crystalline cell.

Thesis Directed:	V.M. Menzella, Atomic Relaxation and Vacancy-Interstitial Recombination in Zr and Zr3Al." M.S. Thesis, December, 1988.

Title:	Molecular Dynamics Simulations of Liquids and Sputtering of Liquids Under Ion Bombardment
Investigators:	D.E. Harrison, Prof. of Physics; R. Smith, Research Associate; M.L. Fisher, Lt. U.S. Coastguard; and R. de Jesus Rodriquez, Lt. U.S. Navy
Sponsor:	Direct Funding
Objective:	To provide a good computer model of a liquid and to compare the sputtering data with that from solid targets.

Summary: A dynamical simulation of liquid Cu has been carried out by using a computer model which warms a solid crystal target in two ways. First by assigning thermal displacements and secondly by assigning thermal velocities to atoms in Cu crystal and allowing the target to equilibrate. The radial distribution was compared to neutron diffraction data and the energy distribution to that of the Maxwell-Boltzmann distribution, with excellent agreement. Sputtering yields from these targets have been calculated using an embedded atom potential model and also using pair potentials. The yields show an increase of between 15% and 40% compared to those of the solid crystal.

Title:	Flash X-Ray Facility, Part I
Investigator:	X.K. Maruyama, Prof. of Physics
Sponsor:	NPS Research Council
Objective:	To install, make operational and instrument the Pulserad 112A Flash x-ray machine at Bldg. 216 of the Naval Postgraduate School.

Summary: The Pulserad 112A laboratory has been refurbished. The flash x-ray machine (FXR) has been delivered to NPS form Physics International in San Leandro, CA. The FXR has been made operational. Instrumentation is proceeding. A screen room has been installed and dosimetry measurement equipment has been acquired. Electron-photon transport code, ITS, has been made operational at NPS. Characterization of the accelerator is proceeding.

Conference
Presentation: X.K. Maruyama et al., "Measurement of Off-Axis Energy Deposition form 100 MeV Electrons Traversing Water and Liquid Nitrogen," 25th Nuclear and Space Radiation Effects Conference, Portland, OR., July, 1988.

Theses
Directed: D.C. Jensen, "Monte Carlo Calculation of Electron Multiple Scattering in Thin Foils," M.S. Thesis, June, 1988.

H.B. Luna, "Radiation Effects on Rare-Earth Permanent Magnets," M.S. Thesis, June, 1988.

Title:	Measurement of EM Radiation from High Current Electron Beams
Investigators:	J.R. Neighbours, Prof. of Physics; F.R. Buskirk, Prof. of Physics; and X.K. Maruyama, Prof. of Physics
Objective:	Measurement of electromagnetic signatures from electron beams.
Publications:	J.R. Neighbours, "Cerenkov and Sub-Cerenkov Radiation form a Charged Particle Beam," Journal of Applied Physics 61, pp. 2741, 1987.
	X.K. Maruyama, "Optical Transition Radiation as a Real-Time, On-Line Diagnostic for Free Electron Laser Systems," Nuclear Instruments and Methods A272, 237, 1988.
Conference Presentations:	X.K. Maruyama, "Optical Transition Radiation as a Real-Time, On-Line Diagnostic for Free Electron Laser Systems," 9th International Free Electron Laser Conference, Williamsburgh, VA., October, 1987.
	X.K. Maruyama, "Optical Transition Radiation as a Beam Monitor for CW Electron Accelerators," APS Meeting, Santa Fe, NM, October, 1988.
Theses Directed:	Y.M. Lee, "Diffraction Transition Radiation from Periodic Electron Bunches," M.S. Thesis, December, 1987.
	J.E. Joynson, "A Transition Radiation Experiment to Measure the Electron Beam Modulation Induced by the Free Electron Laser, A Design Study," M.S. Thesis, December, 1987.
	W. Longstaff, "Three-Dimensional Analysis of Optical Transition Radiation," M.S. Thesis, December, 1988.
	K.B. Wee, "Radiation Signatures from an External Relativistic Electron Beam," M.S. Thesis, December, 1988.

Title:	Plasma Heating at the Plasmapause
Investigators:	R.C. Olsen, Associate Prof. of Physics and S. Gnanalingam, Adjunct Prof. of Physics
Sponsor:	Office of Naval Research
Objective:	Analyze satellite data relevant to plasma heating processes near the plasmapause, near the magnetic equator. This is a continuing program.

Summary: The majority of the analysis activity during the last year has been associated with the goal of establishing conclusively the existence of a local minimum in the total plasma (electron) density at the magnetic equator, as a function of latitude. This density minimum is nominally associated with the plasma heating processes which have been under study. Four clear cases have been found where suitable data exist to determine the total density, and the contributions of the hot and cold ion populations. The work is continuing. A parallel activity which has been nurtured under this project has been a study of a pulsation event observed on the SCATHA satellite, in the PC5 frequency range. This event appears to demonstrate the resonance of magnetic "L-Shells."

Thesis
Directed: J.W. Patterson, "Observations of Hydromagnetic Wave in the Earth's Magnetosphere," M.S. Thesis, December, 1988.

Title:	Satellite Charge Control with Electron and Ion Sources
Investigators:	R.C. Olsen, Associate Prof. of Physics and S. Gnanalignam, Adjunct Prof. of Physics
Sponsor:	NPS Research Council
Objective:	Establish a program in satellite charge control, with data analysis and experimental facilities, analyze data relevant to satellite charging, and from experiments in active charge control. Develop laboratory plasma devices in preparation for flight experiments.

Summary: A minicomputer based analysis system was developed, for the purpose of analyzing data from satellite and sounding rocket experiments. This system was used to address charging data from the Air Force P78-2 (SACTHA) satellite, during natural and induced charging events. Floating potentials were studied for ion and electron beam experiments, with the discovery that substantial current limiting occurred because of beam 'blow-up.' Return ion fluxes were found to be generated on the satellite surface, caused by sputtering of surface material by ambient energetic hydrogen and oxygen. Plasma wave studies showed substantial electromagnetic wave power was generated in the electron cyclotron frequency range by electron beam experiments.

Theses
Directed:

D.R. Lowery, "Survey of the Air Force P78-2 (SACTHA) Satellite Plasma Wave Data During Electron Gun Operations," M.S. Thesis, December, 1987.

L.E. Weddle, "Ion Gun Generated Electromagnetic Interference on the SACTHA Satellite," M.S. Thesis, December, 1987.

P.W. Werner, "Ion Gun Operations at High Altitudes," M.S. Thesis, June, 1988.

C.W. Norwood, "Ions Generated on or Near Satellite Surfaces," M.S. Thesis, June, 1988.

Title: Plasma Contactor Flight Test Definition

Investigator: R.C. Olsen, Associate Prof. of Physics

Sponsor: NASA Lewis Research Center

Objective: Define and begin design for a sounding rocket
                        experiment to test basic processes in current
                        emission/absorption for a body in space.

Summary: The problem of emitting or collecting up to
                        1 ampere of electrons from the ambient
                        ionosphere to a satellite or rocket has been
                        the topic of ongoing studies funded by NASA-
                        LeRC. A sounding rocket mission to study the
                        important processes was defined, utilizing
                        hollow cathode plasma sources to enhance the
                        electrical connection between the vehicle and
                        the ambient plasma.   The necessary
                        instrumentation was defined, with design work
                        as necessary.   In particular, the ion
                        spectrometer was modified to include mass
                        separation ~~~~ ~r~ ite to the problem of
                        studying a xenon source in the $H+/O+$
                        ionosphere. Estimates were made of the
                        floating potentials of the two ends for the
                        tethered, mother-daughter sounding rocket
                        payload.

Conference
Presentations: S.I. Yoon, "Definition Study and Model for
                        a Tethered Sounding Rocket," M.S. Thesis,
                        December, 1988.

Title:	Validation of Air Force Flow and Dispersion hazard Assessment Capabilities
Investigators:	G.E. Schacher, Prof. and Dean of Science and Engineering; R.F. Kamada, Adjunct Research Prof. of Physics; and C.E. Skupniewicz, Research Associate in Physics
Sponsor:	Air Force Space Division
Objective:	(a) To assemble a meteorology and plume hazard assessment handbook for Vandenberg AFB, (b) compare Vandenberg windflow models against plume tracer field studies, (c) conduct field studies of the Marine inversion in Vandenberg complex terrain under seabreeze conditions.

Summary: The Vandenberg AFB Meteorology and Plume Dispersion Handbook was completed. This 450 page reference describes typical and hazardous windflow types, toxic hazard assessment protocols, dispersion, modeling results, and pertinent regulatory and modeling issues. Results from the WOCSS/RIMPUFF and LIMCOM/RIMPUFF flow/puff models are being compared with Vandenberg's Mt. Iron plume tracer experiments. An inversion height algorithm has been developed and is being tested against inversion height data from our field study. Humidity, pressure, temperature, and turbulence fields from these experiments are also being compared with similarity theory predictions.

Publications: C.E. Skupniewicz, R.F. Kamada, G.E. Schacher, "Turbulence Intensity within the Energy Producing Frequencies of the Horizontal Velocity Spectra," Bound, Layer Meteorol., no. 87-110 LU.

R.F. Kamada, A Fractal Interfacial Entrainment Model for Dry Convection Boundary Layers, Part I: Model Description," J. of Atmos. Sci., 45, 17, pp. 2365-2374, 1988.

R.F. Kamada, "A Fractal Interfacial Entrainment Model for Dry Convective Boundary Layers, Part III; Discussion of Model Behavior and Comparison with Other Models," J. Atmos. Sci., 45, 17, pp. 2375-2383, 1988.

Conference
Presentations:

C.E. Skupniewicz and G.E. Schacher, "Modification of Sea Breeze Surface Layer Winds near Pt. Arguello, Ca. due to Easterly flow above the Marine Boundary Layer," 4th Conference Meteorol. and Oceano. Coastal Zone, Anaheim, CA., February 3-5, 1988.

R.F. Kamada, C.E. Skupniewicz, J.W. Glendening, G.E. Schacher, I. Troen, T. Mikkelsen, S. Thykier-Nielsen, A.F. DeBaas, and S. Larsen, "A Hazard Assessment Technique in Complex Terrain," Proc. 3rd JANAFF Symp., Monterey, CA., May 26-30, 1988.

T. Mikkelsen, S. Thykier-Nielsen, I. Troen, A.F. De Baas, S.E. Larsen, R.F. Kamada, C.E. Skupniewicz, and G.E. Schacher, "A Hazard Assessment Model for Complex Terrain," Proc. 8th Symp. on Turb. and Diff., San Diego, CA., April 25-29, 1988.

S. Thykier-Nielsen, T. Mikkelsen, S.E. Larsen, I. Troen, A.F. De Baas, R. Kamada, C. Skupniewicz, and G. Schacher, "A Model for Accidental Releases in Complex Terrain," Proc. 17th NATO/CCMS ITM, Cambridge, (UK), September 19-22, 1988.

Title:	Unipolar Arcing, A Basic Laser Damage Mechanism
Investigator:	F.R. Schwirzke, Prof. of Physics
Sponsor:	Office of Naval Research
Objective:	Investigate the discharge physics of laser induced breakdown and unipolar arcing on conducting and nonconducting surfaces.

| Summary: | Laser beams interact with surfaces by a variety of thermal impulse and electrical effects. Unipolar arcing is the primary electrical plasma-surface interaction process once breakdown occurs. Without any external voltage applies, many electrical micro-arcs burn between the surface and the laser heated plasma, driven by local variations of the sheath potential with the surface acting as both the cathode and anode. Energy and momentum coupling to conducting target materials will be investigated to determine what unipolar arcing has on the coupling process. |

Publications:	F. ¯Schwirzke, "Initial Vacuum Breakdown by Unipolar Arcing," Bull. Am. Phys. Soc. 33, 1951, October, 1988.
Conference Presentations:	F. Schwirzke, "Laser-Plasma-Surface Interactions," 8th International Workshop on Laser Interaction and Related Plasma Phenomena," Monterey, CA., October 26-30, 1987.
	F. Schwirzke, "Initial Vacuum Breakdown by Unipolar Arcing," 30th Annual Meeting of the Division of Plasma Physics, Hollywood, FL., October 31 November 4, 1988.
	F. Schwirzke, "Unipolar Arcing," Workshop on Transient Induced Insulator Flashover in Vacuum," Lawrence Livermore National Laboratory, CA., August 24-25, 1988.
Theses Directed:	D.H. Curtiss, "Theoretical Model of the Cathode Spot in an Unipolar Arc," M.S. Thesis, December, 1988.

A.R. Wojtowich, "Background Gas Pressure Dependence of Unipolar Arcing on Soda Lime Glass and Plastic Induced by a CO2 Pulsed Laser," M.S. Thesis, June, 1988.

R.M. Harkins, "Target Voltage Response in Reaction to Laser Radiation," M.S. Thesis, December, 1988.

Title:	Microscopic Model and Scaling Laws for a Plasma Opening Switch
Investigator:	F.R. Schwirzke, Prof. of Physics
Sponsor:	Naval Research Laboratory
Objective:	Investigate the discharge physics and the microscopic surface effects of plasma opening switches.

Summary: The most critical aspect of inductive energy storage is the opening switch. A large voltage pulse is induced when a conducting plasma switch is rapidly opened in an inductive system. How to reduce the electron current through the plasma in the presence of an increasing voltage is the paramount problem. Electron emission from the cathode provides the electron current when the switch is closed. The reduction of the electron flow in a sheath near the cathode opens the switch. Scaling laws indicate that the induced, increasing voltage does not interfere with the opening process of the switch once the electron Larmor radius become smaller that the sheath width. Switch performance as function of electron emission form the cathode, plasma production by ionization of absorbed neutral atoms, and the plasma dynamics near the cathode sheath have been investigated.

Publications: F. Schwirzke, "The Influence of the Sheath Electric Field on Electron Emission from Cathode Spots," Bull. Am. Phys. Soc. 32, 1943, October, 1987.

F. Schwirzke, "Plasma Formation on Surfaces by Microexplosion and Unipolar Arcing," Conference Record, 1988 IEEE International Conference on Plasma Science, p. 30, 1988.

Conference Presentations: F. Schwirzke, "The Influence of the Sheath Electric Field on Electron Emission from Cathode Spots," 29th Annual Meeting of the Division of Plasma Physics, San Diego, CA., November 2-7, 1988.

F. Schwirzke, "Plasma Formation on Surfaces by Microexplosions and Unipolar Arcing," 1988 International Conference on Plasma Science, Seattle WA., June 6-8, 1988.

Thesis
Directed: S. Evans, "The Influence of Ionization within
                   a   Plasma   Opening   Switch,"   M.S.   Thesis,
                   December, 1987.

Title: Atmospheric Optical Turbulence Measurements for RME

Investigator: D. L. Walters

Sponsor: Air Force Weapons Laboratory

Objective: To collect a climatological set of Atmospheric mutual coherence length and isoplanatic angle measurements at the ground based, Relay Mirror Experiment Site, Kihei Hawaii.

Summary: A set of 6 measurements were collected every two months during FY 88 for the Relay Mirror Project. These measurements were needed to quantify the site conditions, before launch, of the Relay Mirror Satellite. Measurements were conducted on schedule during August, October, December of 1987 and February, April and July of 1988. The tentative results were delivered to the sponsor as soon as possible after the measurements. And a thesis of the compiled optical measurements has been delivered. A key accomplishment was that NPS implemented the collection of rawinsonde meteorological balloon launches to support the optical measurements for these measurements. This was a major accomplishment, to be able to transport all the optical and meteorological equipment to a remote site, six times during the year and reliably conduct the measurement program. A key scientific result was the assessment of the 4-5 degree C maritime boundary layer inversion and its affect on the optical measurements. We found that 50-70 % of the optical turbulence along a ground to space vertical path is confined to this 100-200 m layer. In addition were successfully able to extract, optical turbulence C_t^2 data directly from the high resolution rawinsonde temperature data. This is a major accomplishment that reduces the cost of these measurements by a factor of ten over previous investigators.

Publications: NPS Technical Report 61-88-002 (see below)

Thesis   D. H. Nelson, "Atmospheric Turbulence Effects the
Directed: Relay Mirror Experiment," Masters Thesis and NPS Technical Report, June 1988.

Title: Atmospheric Optical Turbulence Summary

Investigator: D. L. Walters

Sponsor: Strategic Defense Initiative Office in conjunction
                with the Office of Naval Research and the Naval
                Research Laboratory.

Objective: To summarize the NPS atmospheric research findings
                with respect to optical turbulence and optical
                site selection.

Summary: NPS presented five years of research findings to a
                joint,   NASA,   ONR,   NRL,   Naval Observatory,
                University of California at Berkeley, audience on
                28 October. This was a well received meeting that
                is altering the course of the US Navy program for
                high resolution optical interferometry.   This
                meeting spanned an immediate set of measurements
                that were conducted in Vieques Puerto Rico, during
                16-28 December 1989. This meeting set the ground
                work for the FY 89 NPS, ONR, NRL program that is
                being conducted.

Conference   D. L. Walters, "Atmospheric Optical Turbulence
                measurements along   the Pacific   Coast,   Jet
                Propulsion Laboratory, 28 October, 1988.

Title: Mountain Boundary Layer Measurements   using a High
                    Resolution Acoustic Profiler

Investigator: D. L. Walters

Sponsor: Space and Naval Warafare Systems Command

Objective: The Pacific coastal mountains provide sites with
                    very low optical turbulence degradations.   A
                    pronounced increase in the amount of turbulence
                    occurs around midnight.   The source of this and
                    the altitude dependence must be determined.

Summary: The funding for this project was severely cut back
                    to about 1/3 of the original effort.   We focused
                    our   efforts   on   collecting acoustic sounder
                    measurements at Anderson Peak, the Air Force-
                    Vandenberg optical   tracking site, during the
                    summer of 1988.   The weather patterns during the
                    summer were   abnormal with   a persistent low
                    pressure off the Pacific Coast rather that the
                    expected Pacific High.   This pattern altered the
                    weather   over   the   entire   Unites   States,
                    parsicularly the mid-west.   The low pressure
                    introduced a new weather category into our data
                    base.   Two, one-week field trips were conducted,
                    but the weather patterns did not produce the
                    desired conditions.   We were able to enhance,
                    substantially the accuracy, display technique and
                    overall performance of the hardware and software
                    during this time.

Publications: NPS Technical Report NPS 61-89-003 (see below)

Thesis   M. R. Ohlmstead, "Development of a Differential
Directed: Temperature   Probe   for   the   Measurement   of
                    Atmospheric Turbulence at All Levels", Master's
                    Thesis and NPS Technical Report, December, 1988.

Title: Remote Atmospheric Optical Turbulence Systems

Investigators: D. L. Walters, Associate Professor of Physics

Sponsor: Air Force Weapons Laboratory

Objective: To provide measurements and assessment of atmospheric distortions for Strategic Defense Initiative programs at Kirtland Air Force Base, and other locations world wide.

Summary: Measurements were performed at Kirtland Air Force Base, and at another location, the Mohave site three times in order to assess their suitability for major DoD optical programs. NPS has developed all of the measurements that are used in these measurements. Instruments have been developed for the atmospheric modulation transfer function, the isoplanatic angle, high resolution, quantitative acoustic sounders and real time meterological rawinsonde systems.

Publications: T. H. Moore, and D. L. Walters, "Observations on centrosymmetric and asymmetric scattering in barium titanate," Journal of the Optical Society of America B, Vol. 5, 1806-1809, August, 1988.

Thesis   R. R. Holland, "Refractive Turbulence Profiling
Directed: Via Binary Source Intensity Scintillation Correlation," Masters Thesis, June 1988.

                D. P. Davison, "An investigation into backscattered Cross Section Calibration of an Acoustic Sounder Used for Analysis of Lower Atmospheric Turbulence", Masters Thesis, December 1988

Title:	Transducers Performance Monitoring and Array Performance Prediction
Investigators:	O.B. Wilson, Prof. of Physics; S.R. Baker, Assistant Prof. of Physics; and E. Kuntsal, Adjunct Research Prof. of Physics
Sponsor:	Naval Sea Systems Command

Objective: The primary objective are, first, to take advantage of the state-of-the-art, computer controlled measuring instruments to help improve the quality of the in-service measurements conducted in the field by Navy technicians on transducers used in the ANBQR-7 and ANBQQ-5 sonar systems. These procedures could act as an aid in the making of maintenance decision. A second objective is to use the power of small computers to provide the technician in the field the capability to estimate sonar transducer array performance when some of the elements are degraded. This is a continuing program.

Summary: A major part of the progress towards both objectives work has been accomplished by students as part of their thesis research. Application of the so-called Delta-Z reciprocity calibration method has been made to individual TR-317 transducers in a free-field. Studies are now directed toward developing this method for elements in an array. Work was continued on array performance algorithms development. A software package has been completed. In-board phasing techniques were developed and one has become a standard field test procedure.

Theses
Directed: J.L. Knecht, "Validation of Automated In-Service Sonar Transducer Performance Monitoring Techniques for the AN/BQQ-5 Spherical Array," M.S. Thesis, December, 1987.

L. Hall, "Micro-Computer Modeling of Active Array Performance in the AN/BQQ-5 Sonar," M.S. Thesis, December, 1987.

A. Wilson, "Development of a Transient Inboard Wiring Test for the AN/BQR-7 Array," M.S. Thesis, December, 1987.

M.D. Patton, "Reciprocity Calibration of an In-Service Transducer by the Delta-Z Method, M.S. Thesis, September, 1988.

Title:	Application of Automated Transducer Performance Monitoring Procedures at the AN/BQQ-6 Sonar
Investigators:	O.B. Wilson Prof. of Physics; S.R. Baker, Assistant, Prof. of Physics; and E. Kuntsal, Adjunct Prof. of Physics
Sponsor:	Naval Undersea Warfare Engineering Station
Objective:	To apply the transducers monitoring techniques developed for the AN/BAR-7 and AN/BQQ-5 sonar systems to the AN/BQQ-6 sonar system on Trident Submarines.
Summary:	The complex Immittance Measurement (CIM) System was adapted to the DT-574 hydrophone in the AN/BQQ-6 sonar by LT Harvey. Laboratory and field measurements were made. A preliminary attempt was made to apply the Delta-Z reciprocity calibration method to the laboratory data on the DT-574, with very encouraging results. As a result, we proceeded with the use of these procedures to diagnose the state of health of the hydrophone on the USS Ohio, which are presently scheduled for wholesale replacement in about a year. LT Vazquez has collected impedance measurements of almost all of the hydrophones aboard the USS Ohio. Together with laboratory measurements on some new hydrophones, an empirical procedure was developed for using the Delta-Z method for estimating the absolute in-service sensitivity of the hydrophones. As a results, we believe we have the best estimate of the absolute sensitivity of each hydrophone.
Thesis Directed:	K.J. Harvey, "A Performance Monitoring System for the AN/BQQ-6 Sonar System Spherical and Line Arrays," M.S. Thesis, March, 1988.

DEPARTMENT
OF
ELECTRICAL AND
COMPUTER ENGINEERING

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INTRODUCTION

The research program of the Department of Electrical and Computer Engineering involves projects in the following areas: signal processing, systems and controls, electromagnetics, radar and electronic warfare, communications, computer engineering and underwater acoustics.   Some research projects span one or more of these areas, although they are listed below in only one catagory.   Graduate students are involved in most efforts and the titles of published theses are listed with the project descriptions.

SIGNAL PROCESSING

Non-stationary spectral parameter estimation methods were developed by Professor R.D. Hippenstiel using the Wigner-Ville distribution, a model based approach and instantaneous power spectrum.

Professor Murali Tummala expanded his investigation of adaptive algorithms for lattice filters using the Gray-Markel type IIR model, the companion ARMA model and the generalized Mullis-Roberts criterion.   Simulations have been conducted to study convergence properties.

Professor Daniel Bukofzer initiated a new research effort devoted to analyzing, evaluating, summarizing, and projecting trends in Soviet digital signal processing work. The goal is to be able to identify areas of emphasis, areas of applications, and application trends that could impact on the Soviet technology that enhances their war fighting effort.

Professor John Powers continued a joint project with the Aeronautics Department to develop techniques for obtaining quantitative particle size data within the combuster and across the exhaust nozzle of solid propellent rocket motors.   Various methods are being considered such as holography and forward scattered light measurements.

Professor Michael Morgan investigated parameter estimation algorithms originated by Cadzow-Solomon and Kumaresan-Tufts for identifying the aspect independent natural resonances of radar targets.   Validations were performed using noise polluted synthetic signals, time-domain integral equation scattering responses and transient scattering signatures from scale model aircraft.

Professors Therrien and Tummala considered the LMS and RLS methods of adaptive filtering for 2-D signal and image processing. These methods were applied to image processing for noise removal, debluring, coding and target detection.

SYSTEMS AND CONTROLS

Professor Jeff Burl began a project directed towards advancing the theory, practice, and application of the control of distributed parameter systems. Reduced order models generated both by the physics of the problem and empirically have been found to be intimately linked with the control problem.

Professors Roberto Cristi and Sherif Michael continued the development of a parallel processor based upon switched capacitor techniques for adaptive control applications. This controller has the capability for self-adjustment to parameter changes, using parameter identification performed by a systolic array.

Professor Michael continued his research into photovoltaic power technology. Tasks included the implementation of a microprocessor based system, the investigation of photovoltaic current annealing processes and other related topics of radiation effects on GaAs and Si devices.

Professor R. Panholzer headed the continuation of a multi-disciplinary project directed towards design refinement and concept assessment for a small, low cost, full capability general purpose satellite - the Orion.

Professor Hal Titus worked on a variety of attitude control systems for the Orion satellite. An original synthesis for nonlinear feedback control was developed.

Professor Titus also investigated the enhancement of a Kalman filter torpedo tracking program using a smoothing algorithm. The development has been completed on an IBM PC compatible computer. Additional uses of the enhanced algorithm are possible, such as in collision avoidance.

ELECTROMAGNETICS

A new generalized potential formulation for electromagnetic fields in inhomogeneous media was developed by Professor Morgan. This formulation has been tested and is being implemented via the numerical finite element method to solve for scattering from complex material objects.

Navy HF long-distance communication antennas are very site sensitive with respect to low-angle (critical) coverage. Professor Richard Adler is quantifying the effects on low-angle performance of ground conditions near the antenna.

Professor Harry Atwater is developing transmission and discontinuity parameter information for suspended-substrate striplines which are used in microwave integrated circuits.

Computer modeling results from the Numerical Electromagnetic Code are being validated by Professor James Breakall using experimental measurements on a full-size and complicated antenna structure which has important relevance to Army and government HF communication systems.

Professor Rama Janaswamy developed an analytical-computational model for the radiation characteristics of a millimeter wave planar antenna. The model is based on the method of moments for solving an electric field integral equation for the unknown surface curent. The model overcomes a shortcoming of an earlier theory and leads to better antenna designs.

Professor Hung-Mou Lee continued his investigation into the excitation of cavity resonance modes by an incident wave. This research considers both theoretical and experimental approaches using the tubular cylinder as a model.

Professor H-M. Lee also continued to investigate the effects of ducting and the curvature of Earth on sea clutter up to the vicinity of the radar horizon. A theoretical framework has to be developed so that the propagation of radio waves up to the vicinity of the radar horizon can be accurately and conveniently formulated and solved.

Professor Powers continued work on a linear systems approach to the modeling of propagation of pulsed and transient ultrasound waves in lossless and lossy media. The technique, which employs spatial frequency domain techniques, allows the application of computer-efficient FFT algorithms in lieu of methods involving complicated line integral evaluations.

RADAR AND ELECTRONIC WARFARE

Professor Michael Morgan investigated the viability of obtaining narrow pulse signatures radar targets using measured random noise scattering. This has the potential of providing a low-cost wideband laboratory tool for scattering experiments as well as offering high resolution, but passive, radar sensors for use in hostile situations.

Professor Stephen Jauregui continued work to improve SIGINT acquisition and DF systems used aboard ships. The objective is to research new techniques and developments, working both on test plans and the actual testing.

Professors Therrien and Moose developed and evaluated a 2-D target detection algorithm using adaptive filtering. This algorithm was evaluated for detection of small targets in very low signal-to-noise ratio environments. A tracking algorithm was also implemented for use in successive frames of IR data.

Professor Titus developed a simulation to provide optimal placement of chaff and subsequent ship manuever to maximixe missile to ship miss distance.

COMMUNICATIONS

Professor Paul Moose developed a phase modulated spread spectrum packet communication technique and identified the channel parameters of an acoustic link for the packets required for a critical Naval application.

Professor Jauregui continued involvement in a program to enhance signals and decrease noise at US Navy HFDF and aquisition sites. This is accomplished by collecting data on site and determining a variety of mitigating techniques.

Professor Bukofzer continued his study of the performance of digital communication receivers operating in the presence of jamming. Because of the many different receivers that can be considered (depending on the modulation used, channel, interference, use of spread spectrum modulation, forward error control coding, etc.) the analysis is quite extensive.

Professor Tri Ha performed a detailed analysis of the throughput and delay of unslotted "Aloha" with variable length packets and its variants. The analysis also incorporates data link control protocols into the random access strategies where the feedback channel operates in the time-domain multiplex mode.

Professor Glen Myers has developed a new realization of a Delta modulation digital filter. An algorithm was developed for rapid simulation of any design (lowpass, highpass, matched, etc.) as well as simple hardware realization of the specified filter response. This approach uses digital technology, requires no multipliers and operates in real time.

An investigation of cyclic spectral analysis algorithms and computational structures was conducted by Professor H.H. Loomis for the purposes of detection and classification of spread spectrum signals in noise and interference.

Professor Loomis also investigated algorithms and architectures of systems for the production, distribution and analysis of tactical information, including architectures of spaceborne computer systems. He also considered operational problems concerned with the employment of tactical information for decision making and targeting.

COMPUTER ENGINEERING

A knowledge based expert system for image identification was developed by Professor Chin-Hwa Lee.   This is being used to promote the usage of topographic information stored in DTED and DFAD together with the updated information from satellite imagery to recognize or classify area.

Professor C-H. Lee also continued his efforts in the design of special purpose hardware to process tactical image data. Image processing algorithms such as correlations are being implemented in systems with special architecture using available VHSIC chips.

Professor Jon Butler developed new synthesis techniques, under NSF support, for multi-valued CCD logic circuits which can provide specified functions as a computer-aided design (CAD) tool.   In a separate NATO project multiple-valued CCD/CMOS devices were considered for synthesis of programmable logic arrays.

Professor Loomis investigated advanced computer aided design techniques such as silicon compilers to provide rapid production of complex VLSI chips from system descriptions. The testing and design for test of VLSI circuits was also considered.

In this recently initiated project, Professor Chyan Yang considered the implementation of a CAD tool for rapid timing verification of VLSI chip designs at the switch level.   This effort will not only save fabrication costs caused by design flaws but will also give designers rapid feedback for discovering the critical path of circuits.

UNDERWATER ACOUSTICS

The development of a time-invariant, space-variant, random transfer function of the ocean volume and its corresponding coherence function were derived by Professor Lawrence Ziomek based upon 3-D ray acoustics.   New expressions for the amplitude, eikonal and phase along a ray were obtained.

Various digital image processing techniques were considered in the work of Professor Therrien, as directed towards enhancing video images of underwater objects during recovery in turbid water.   Methods were explored for performing the image processing on a small computer and in real time.

Professor James Miller intitiated two projects in acoustic tomography. One of these has the goal of monitoring Monterey Bay with an acoustic tomography system. This system would provide 3-D sound speed and current maps of the Bay for use by Oceanographers and other ocean researchers. A second project will develop and test a tomographic system to analyze the effects on long-range acoustic propagation of ocean surface waves, internal waves, and complex 3-dimensional bathymetry.

Title: Low Angle HF Communication Antenna Prediction and
                  Validation

Investigator: R. W. Adler, Adjunct Professor of Electrical and
                  Computer Engineering

Sponsor: Naval Security Group Support Activity

Objective: Validate existing numerical models of HF antennas
                  and develop additional modeling capability to
                  include site terrain effects.

Summary: Navy HF long-distance communication antennas are
                  very site sensitive with respect to low-angle
                  (critical) coverage. This project will establish
                  the magnitude of the effects on low-angle
                  performance of ground conditions near the antenna.
                  Analysis and measurements of ground constants will
                  establish a fly-by full-scale measurement of
                  radiation patterns in FY91. This year, validation
                  methods for ground constant measurements are being
                  conducted.

Publication: R.W. Adler, "A Numerical Model of a Conical
                  Monopole/Rotatable Log-Periodic Array," Naval
                  Postgraduate School Report, March 1988.

Theses
Directed: "Analysis of a High-Frequency Conical
                  Monopole/Rotatable Log Periodic Array Using the
                  Numerical Electromagnetics Code", E.R. Abbrogast,
                  M.S. Thesis, Dec 1988.

Title: Microwave Integrated Circuit Element Designs

Investigator: H. A. Atwater, Adjunct Professor of Electrical and
                Computer Engineering

Sponsor: Naval Ocean Systems Center

Objective: The objective of this research is to supply
                transmission and discontinuity parameter
                information for suspended-substrate striplines.

Summary: Research is being conducted to evaluate design
                parameters of passive microwave circuit elements,
                for inclusion in microwave integrated circuit
                design. This work is conducted in support of
                ongoing development of system components at the
                Microwave Circuits Laboratory of NOSC. The
                Laboratory is interested in waveguide filter
                construction using suspended-substrate stripline
                transmission format. Only limited design data for
                this format is available in the literature,
                particularly for the line-discontinuities needed
                in filter construction.   This research, which
                was initiated in Fall term, AY88, is still in
                progress.

Publications: H. A. Atwater, "Tests of Microstrip Dispersion
                Formulas," IEEE Transactions on Microwave Theory
                and Techniques, Vol. MTT-36, pp. 619-621 (Mar 88).

                A. Gopinath, H. A. Atwater, "Simulation of GaAs
                p-i-n Diodes," IEEE Transactions on Electron
                Devices, Vol. ED-35, pp. 414-417 (Apr 88).

                H. A. Atwater, "Simplified Design Equations for
                Microstrip Line Parameters," submitted for
                publication Dec 88 (now under consideration)

Title: The NEC3 Verification at HF for Antenna
                    Applications

Investigator: J. K. Breakall, Associate Professor of Electrical
                    and Computer Engineering, and R. W. Adler, Adjunct
                    Professor of Electrical and Computer Engineering.

Sponsor: US Army Information Systems Engineering Center,
                    Ft. Huachuca, AZ.

Objective: To compare computer modeling results from the
                    Numerical Electromagnetic Code (NEC) with
                    experimental measurements on a full-size and
                    complicated antenna structure which has important
                    relevance to Army and government HF communication
                    systems.

Summary: There has been a need to thoroughly test several
                    of the modeling features of the Numerical
                    Electromagnetics Code (NEC), an antenna analysis
                    computer program in use at NPS, on a very
                    important antenna, the Spiracone, in use by the
                    Army and other government agencies. NEC computer
                    modeling results were obtained and compared with
                    experimental measurements on a full-size antenna
                    over the High-·Frequency (HF) band, 2-30 MHz. The
                    electrical parameters of impedance, gain, and
                    radiation pattern shape were investigated. This
                    data was used to validate NEC and provide modeling
                    guidelines for future computer analysis of other
                    complicated antennas. Furthermore, additional
                    performance characteristics were obtained for the
                    Spiracone antenna. These results are very
                    important to DoD since more of these antennas
                    could possibly be procured in the future.

Thesis   A. Z. Siregar, "A Computer Investigation of the
Directed: Spiracone Antenna," M.S. Thesis, Dec. 1988.

Title: Jamming Techniques in Conventional and Spread
Spectrum Digital Communication Systems

Investigator: Daniel Bukofzer, Assistant Professor of Electrical
and Computer Engineering

Sponsor: Space and Naval Warfare Systems Command

Objective: This study is part of a continuing program dealing
with the performance of digital communication
receivers operating in the presence of jamming.
Because of the many different receivers that can
be considered (depending on the modulation used,
channel, interference, use of spread spectrum
modulation, forward error control coding, etc.)
the analysis is quite extensive. The basic
objective is a determination of how a receiver is
affected by some generalized form of jamming.
Jamming must also be properly modeled. Depending
on the jammer model used, such as filtered random
noise, modulated noise, multiple but
deterministic] tones, etc., it influences the
receivers to be analyzed). Once the performance
has been determined, it is usually desireable to
attempt to determine what specific form of jamming
may result in maximum receiver performance
degradation. Then, this specific jamming form can
be used to evaluate receiver performance in the
presence of such jamming. Thereby determining the
vulnerability of such system to "optimized"
jamming.

Summary: Based on the background information given in the
objective section, receivers were analyzed in
terms of false alarm rates and probability of miss
in order to determine receiver error rates.
Systems not employing spread spectrum modulation
were considered and for certain classes of
receivers it was demonstrated that optimized
jamming spectra can be identified, and such
jamming has the capability of producing severe
performance degradations at relatively low jamming
to signal ratios.

Conference   Solutions to the Radar Signal Return Masking
Presentation: Problem, International Conference, Radar `87,
London, England, Oct 1987.

Thesis   Performance of Radar Receivers Under Various
Directed: Signal Masking Techniques, P. Mavropoulos, MS
Thesis, Dec 1988.

Title: An Evaluation of Digital Signal Processing
                    Methodologies

Investigator: Daniel Bukofzer, Assistant Professor of Electrical
                    and Computer Engineering

Sponsor: U. S. Army Foreign Science & Technology Center

Objective: This is a new research effort devoted to
                    analyzing, evaluating, summarizing, and projecting
                    trends in Soviet digital signal processing work.
                    The goal is to be able to identify areas of
                    emphasis, areas of applications, and application
                    trends that could impact on the Soviet technology
                    that enhances their war fighting effort.

Summary: In this initial research phase, the project has
                    been scaled down to analyzing Soviet work on Walsh
                    functions. Based on abstracts (classified and
                    unclassified) and wherever possible on full length
                    publications, an assessment of Soviet work on
                    Walsh functions has been initiated, so as to
                    identify application areas (approximately 7 such
                    areas have been identified). Further assessments
                    are being made by relating activities of various
                    researchers to specific Soviet organizations in
                    order to determine trends and applications to
                    Soviet military equipment.

Title:	Distributed Parameter System Control Using Reduced Order Modeling
Investigator:	J. B. Burl, Assistant Professor of Electrical and Computer Engineering
Sponsor:	NPS Research Council

Objective: Advancement of the theory, practice, and application of the control of distributed parameter systems is the ultimate objective of this research. Reduced order models generated both by the physics of the problem and empirically (system identification), have been found to be intimately linked with the control problem. Therefore additional objectives are: Evaluate the control performance resulting from the use of various reduced order models. Generate algorithms for the identification of a reduced order model that describes the dynamics of a general distributed paremeter system. Emphasis was placed on generating models of sufficiently low order that they can be used with practical control algorithms and generating algorithms that require a reasonable amount of computation.

Summary: The research encompassed both theory development in reduced order modeling (ROM) and the application of ROM techniques to specific problems: the control of large space structures and image processing. The theory development focused on enumerating the properties of a particular ROM scheme involving the Karhunen-Loeve expansion. The application portion focused on using computer simulation for the evaluation of various ROM schemes used in the control of large space structures. In addition, the ROM approach was employed on image models and found to yield a novel method for filtering of moving images.

Publications: J. B. Burl, "Estimating the Basis Functions of the Karhunen-Loeve Transform," IEEE Trans on Acoustics, Speech, and Signal Processing, Vol. 37, no. 1, pp. 99-105, 1989 (forthcoming).

J. B. Burl, "Application of the Karhunen-Loeve Expansion to the Reduced Order Control of Distributed Parameter Systems," Control and Computers, Vol. 16, no. 1, pp. 12-15, 1988.

J. B. Burl, "Distributed Parameter System Identification Using Spatial Filtering and Karhunen-Loeve Modes," Proc. 26th IEEE Conference on Decision and Control, vol. 3, pp. 2326-2330, 1987.

Conference Presentations:	J. B. Burl, T. M. Grogan, and W. J. Preston, "Effects of Reduced Order Modeling on the Control of a Space Station," 1989 IEEE International Conference on Control and Applications, 1989, (forthcoming)
	J. B. Burl, "Reduced Order Kalman Filtering of Moving Images," The Twenty-Second Annual Asilomar Conference on Signals, Systems, and Computers, Pacific Grove, California, 1988.
	J. B. Burl, "Distributed Parameter System Identification Using Spatial Filtering and the Karhunen-Loeve Modes," The 26th IEEE Conference on Decision and Control, Los Angeles, 1987.
Theses Directed:	W. J. Preston, "Effects of Reduced Order Modeling on the Control of Large Space Structures," M.S. Thesis, Sep. 1988.
	B. M. Jackson, "Utilization of a Kalman Observer with Large Space Structures," M.S. Thesis, Dec. 1988.
	T. M. Grogan, "Reduced Order Modeling of Large Space Structures Using the Karhunen-Loeve Modes," M.S. Thesis, in progress.

Title: Development of CAD Multiple-Valued Circuits

Investigator: J. T. Butler, Professor of Electrical and Computer
                Engineering

Sponsor: National Science Foundation

Objective: To develop synthesis techniques and CAD (computer-
                aided design) tools for multiple-valued DC
                (charged-coupled devices) circuits. This project
                augments (provides salary and additional travel) a
                NATO grant on a similar topic.

Summary: A CAD tool was developed for multiple-valued CCD
                PLA's (programmable logic arrays) [4]. In
                addition, an analysis was performed on heuristic
                PLA minimization techniques [6-7]. This showed
                that there is surprisingly little difference in
                the three techniques analyzed. Two performed
                almost equally well on the average, although there
                was significant variability on specific functions.
                We made progress in the understanding of the
                costtable techniques for synthesizing functions
                [2-3, 5].

Publications: [1] J. T. Butler and H. G. Kerkhoff, "Multiple-
                Valued CCD Circuits," Computer, Vol. 21, No. 24,
                pp. 58-69, April 1988.

                [2] J. T. Butler, H. G. Kerkhoff, and S. Onneweer,
                "A Comparative Analysis of Techniques for the
                Minimization of Function Cost Using the Costtable
                Approach," submitted.

                [3] J. T. Butler and K. A. Schueller, "on the
                Equivalence of Cost Functions in the Design of
                Circuits by Costtables," forthcoming in IEEE
                Trans. on Comp.

                [4] H. G. Kerkhoff and J. T. Butler, "A Module
                Compiler for High-Radix CCD-PLA's," submitted.

                [5] K. A. Schueller and J. T. Butler, "Minimal
                Costtable Realization Problem is NP-Complete,"
                submitted.

                [6] P. P. Tirumalai and J. T. Butler, "Analysis of
                Minimization Algorithms for Multiple-Valued
                Programmable Logic Arrays," Proceedings of the
                18th Intl. Symp. on Multiple-Valued Logic, May
                1988, pp. 226-236.

                [7] P. P. Tirumalai and J. T. Butler,
                "Minimization Algorithms for Multiple-Valued
                Programmable Logic Arrays," submitted.

[8] P. P. Tirumalai and J. T. Butler, "Prime and Nonprime Implicants in the Minimization of Multiple-Valued Logic Functions," submitted.

Conference Presentation:	P. P. Tirumalai, "Analysis of Minimization algorithms for Multiple-Valued Programmable Logic Arrays," 18th Intl. Symp., Palma de Majorca, Spain, 24-26 May 1988.
Thesis Directed:	P. P. Tirumalai, "Design and Analysis of Multiple-valued Programmable Logic Arrays," Ph.D. thesis, June 1989, Northwestern University (all requirements satisfied Nov 1988).

Title:	On the Design of Multiple-Valued CCD/CMOS VLSI Circuits

Title: On the Design of Multiple-Valued CCD/CMOS VLSI
                Circuits

Investigators: J. T. Butler, Professor of Electrical and Computer
                Engineering, and H. G. Kerkhoff, Lecturer,
                Department of Electrical Engineering, University
                of Twente, Enschede, The Netherlands.

Sponsor: North Atlantic Treaty Organization

Objective: To develop multiple-valued CCD/CMOS devices and to
                develop efficient synthesis algorithms for
                programmable logic arrays using the SUM operator.

Summary: Under this grant, we developed a costtable
                approach to the design of multiple-valued CMOS
                circuits. The design approach is based on a
                library lookup approach. A CAD (computer-aided
                design) tool based on this was developed [6]. We
                made several fundamental discoveries on the
                costtable approach [3-4, 7-8], including a
                demonstration that design by costtable is an NP-
                complete problem [7]. We also analyzed the
                advantage of a "preprocessing" of functions before
                a costtable synthesis is applied [3] showing the
                relative merits of various techniques. An
                analysis of functions realized by multiple-valued
                PLA's (programmable logic arrays) produced an
                interesting result for commercially available
                binary PLA's. All but one such PLA is incorrectly
                designed [1].

Publications: [1] E. A. Bender and J. T. Butler, "On the Size of
                PLA's Required to Realize Binary and Multiple-
                Valued Functions," IEEE Trans. on Comp., Vol. 38,
                No. 1, pp. 82-89, Jan 1989.

                [2] J. T. Butler and H. G. Kerkhoff, "Multiple-
                Valued CCD Circuits," Computer, Vol. 21, No. 24,
                pp. 58-69, April 1988.

                [3] J. T. Butler, H. G. Kerkhoff, and S. Onneweer,
                "A Comparitive Analysis of Techniques for the
                Minimization of Function Cost Using the Costtable
                Approach," submitted.

                [4] J. T. Butler and K. A. Schueller, "On the
                Equivalence of Cost Functions in the Design of
                Circuits by Costtables," forthcoming in IEEE
                Trans. on Comp.

                [5] H. G. Kerkhoff and J. T. Butler, "A Module
                Compiler for High-Radix CCD-PLA's," submitted.

[6] S. Onneweer, H. G. Kerkhoff, and J. T. Butler, "Structural Computer-Aided Design of Current-Mode CMOS Logic Circuits," Proc. of the 18th Intl. Symp. on Multiple-Valued Logic, May 1988, pp. 21-30.

[7] K. A. Schueller and J. T. Butler, "Minimal Costtable Realization Problem is NP-Complete," submitted.

[8] K. A. Schueller and J. T. Butler, "Minimal and Near-Minimal Costtables for Use in the Design of Multiple-Valued Circuits," submitted.

[9] P. P. Tirumalai and J. T. Butler, "Analysis of Minimization Algorithms for Multiple-Valued Programmable Logic Arrays," Proc. of the 18th Intl. Symp. on Multiple-Valued Logic, May 1988, pp. 226-236.

[10] P. P. Tirumalai and J. T. Butler, "Minimization Algorithms for Multiple-Valued Programmable Logic Arrays," submitted.

[11] P. P. Tirumalai and J. T. Butler, "Prime and Nonprime Implicants in the Minimization of Multiple-Valued Logic Functions," submitted.

Conference Presentation: S. Onneweer, "Structural Computer-Aided Design of Current-Mode CMOS Logic Circuits," 18th Intl. Symp. on Multiple-Valued Logic, Palma de Majorca, Spain, 24-26 May 1988.

Title:	Computer-Aided-Design Tools for Multiple-Valued Current-Mode CMOS VLSI
Investigator:	J. T. Butler, Professor of Electrical and Computer Engineering
Sponsor:	NPS Foundation
Objective:	To develop synthesis techniques for a new multiple-valued logic technology, current mode CMOS.

Summary: A computer-aided design (CAD) tool has been developed for multiple-valued current mode CMOS PLA's (programmable logic arrays). It accepts a function specification, applies one or two heuristic minimization algorithms, and then generates a layout. A substantial part of the effort was devoted to the design of the PLA cell. Various designs were created and simulated and the best chosen. The CAD tool is installed on the Department of Electrical and Computer Engineering VAX11-785 with other existing design packages.

Publications: K. A. Schueller and J. T. Butler, "Minimal Costtable Realization Problem is NP-Complete," submitted.

P. P. Tirumalai and J. T. Butler, "Minimization Algorithms for Multiple-Valued Programmable Logic Arrays," submitted.

P. P. Tirumalai and J. T. Butler, "Prime and Nonprime Implicants in the Minimization of Multiple-Valued Logic Functions," submitted.

Theses Directed: Hoon-Soep Lee, "A CAD Tool for Current-Mode Multiple-Valued CMOS Circuits," Master's Thesis, Dec 1988.

Yong-Ha Ko, "Design of Multiple-Valued Programmable Logic Arrays," Master's Thesis, Dec 1988.

Title:	Parallel Processing and Systolic Array Techniques in Adaptive Control
Investigators:	Roberto Cristi and Sherif Michael, Associate Professors of Electrical and Computer Engineering
Sponsor:	Naval Ocean Systems Center
Objective:	To develop an adaptive control system based on parallel processing and switched capacitor techniques.

Summary: This project addresses the design of algorithms for on-line identification and adaptive control for linear systems, implementable on systolic arrays. As a result of this research, the proposed adaptive controller has the capability of self-adjusting to parameter changes, based on the parameter identification performed by the systolic array. An algorithm has been developed in order to estimate the parameters of a transfer function using a network of simple, interconnected computing cells. A major advantage of this approach is that the parallelism allows computational speeds which are constant, regardless of the number of parameters to be estimated. The identified parameters can be used to adjust the gains of an analog controller, based on switched capacitors, thus leading to an adaptive controller implementable on modern VLSI technology.

Publications: R. Cristi, "Parallel Processing in the Adaptive Control of Linear Systems," SIAM Journal on Matrix Analysis and Applications, Vol. 9, No. 1, January 1988. Also in Linear Algebra in Signals, Systems and Control, by B. N. Datta et al (Editors), SIAM, Philadelphia 1988.

Theses P. A. Willis, "Adaptive Identification by Systolic Directed: Arrays," M.S. Thesis, Dec 1987.

M. Tumc, "A Systolic Array Implementation for Adaptive Control Systems," M.S. Thesis, Dec 1988.

Conference R. Cristi, S. Michael, "Hybrid Adaptive Control of Presentation: Linear Systems by Parallel Processing and Switched Capacitor Techniques," Proceedings of the International Symposium on Circuits and Systems (ISCAS), Helsinki, Finland, June 1988.

Title:	Variable Length Packet Communications with Noisy Feedback Channel
Investigator:	T. T. Ha, Associate Professor of Electrical and Computer Engineering
Sponsor:	NPS Research Council
Objective:	This research effort is intended to provide a unified approach to delay-throughput analysis of unslotted aloha, selective-repeat aloha, go-back-n aloha, and ARQ strategies with variable length packets and noisy return path.
Summary:	A detailed analysis has been performed for the throughput and delay of unslotted aloha with variable length packets and its variants, the selective-repeat aloha and go-back-n aloha. The analysis also incorporates data link control protocols into the random access strategies where the feedback channel operates in the TDM mode. Also studied are various ARQ strategies suitable for mobile communications and satellite communications via very small aperture terminal (VSAT). Analysis of major random access strategies with fixed length packets such as unslotted aloha, slotted aloha, CSMA, and CSMA/CD in a power capture environment is also conducted. The throughput and stability are developed and numerical results are given.
Publications:	T.T. Ha, "Personal Computer Communications Via VSAT Networks," IEEE Journal on Selected Areas in Communications, Special Issue on Personal Computers, April 1989.
Conference Presentations:	R.L. Borchardt and T.T. Ha, "Throughtput of Slotted Aloha Networks with Random Multiple Signal Levels," 22nd Annual Conference on Information Sciences and Systems, March 16-18, 1988, pp. 87-91.
	R.L. Borchardt and T.T. Ha, "Power Capture Aloha," MILCOM '88, October 23-26, 1988, pp. 703-707.
Thesis Directed:	"Peformance Analysis of Aloha Networks Utilizing Multiple Signal Power Levels", R.L. Borchardt, Engineers Thesis, June 1988.

Title: Spectral Estimation of Non-Stationary Processes

Investigator: R. D. Hippenstiel, Assistant Professor of
                  Electrical and Computer Engineering

Sponsor: Naval Ocean System Center

Objective: To investigate ways to extract spectral
                  information from data having non-stationary
                  charactristics. This is part of a continuing
                  effort.

Summary: Current techniques for handling non-stationary
                  spectral estimation were investigated. In
                  particular the Wigner-Ville distribution, a model
                  based approach and the instantaneous power
                  spectrum (IPS) were examined. An improved version
                  of IPS was presented and some of its
                  characteristics were derived. Several cases were
                  examined.

Conference   R. D. Hippenstiel and P. M. Oliviera,
Presentation: "Instantaneous Power Spectrum," 22nd Asilomar
                  Conference on Signals, Systems and Computers,
                  November 1988.

Thesis   P. M. Oliviera, "Non-Stationary Spectral
Directed: Estimation," Engineer's Thesis, In progress.

Title: Signal to Noise Enhancement Research and Support

Investigators: S. Jauregui and R.W. Adler, Adjunct Professors of
                Electrical and Computer Engineering

Sponsor: SPAWAR PMW-144

Objective: To develop a program to enhance signals and
                decrease noise at US Navy HFDF and aquisition
                sites. This is accomplished by collecting data on
                site and determine a variety of mitigating
                techniques. This is a continuing program started
                and led by the NPS for about 12 years.

Summary: The following activities were visited from Oct
                1987 to Dec 1987 to make site surveys:

                1. NSGA - Northwest VA - Dec 1987
                2. NSGA - Skaggs Island CA - Mar 1988
                3. NSGA - Adak Alaska - Apr 1988
                4. Naval Commsta - Guam - Apr 1988
                5. NSG Activity - Misawa Japan - Jun 1988
                6. Naval Commsta - Rota Spain - Sep 1988

                (A Fixup was made at NSGA Skaggs in July of 1988)

                Surveys are typically 7 to 10 days long. Fixup
                trips are typically 4 weeks long with NPS normally
                there for the first and last week to record the
                before and after results and to do the site
                improvement analysis. The NSGA Northwest visit
                was unusual in that it was a site survey to
                determine the reduction in noise caused by a
                $3,000,000 powerline repair job done by Virginia
                Power on recommendation of the NPS SNEP group.

Contributions: As indicated above, this is a continuing effort
                over the past 12 years. NPS has developed a
                number of noise mitigating techniques which are
                currently being incorporated into the Navy HF
                acquisition and HFDF sites. The Barrier Theory
                has been applied to cabinets and chassis level as
                well as improved grounding techniques. The NPS
                SNEP team has given briefing on these techniques
                at operational sites and a variety of
                headquarters. This noise suppression progress has
                been fed back into the HF techniques courses and
                the SIGINT courses.

Title:	Diffraction by a Half-Plane Lying on an M-Layered Medium
Investigator:	Ramakrishna Janaswamy, Assistant Professor of Electrical and Computer Engineering
Sponsor:	NPS Research Council
Objective:	To develop an analytical/computational model for the radiation characteristics of a millimeter wave planar antenna.

Summary: A rigorous model for the design of the Tapered Slot Antenna was developed. The model was based on the method of moments for solving the Electric Field Integral Equation for the unknown surface curent. The model overcomes a shortcoming of an earlier theory and leads to better antenna designs. The planar antenna finds a number of applications in imaging systems, jamming systems, and in phased arrays. A computer code was developed with the capability to calculate the current distribution, the input impedance, and the radiation pattern for a given set of electrical and physical parameters of the tapered slot antenna. Experiments were performed to check the validity of the model.

Publications: R. Janaswamy, ``An Accurate Moment Method Model for the Tapered Slot Antenna,'' to appear in IEEE Transactions on Antennas and Propagation, 1989.

Thesis Directed: T. P. Kelly, "Design Data for the Tapered Slot Antenna," M.S. Thesis, December 1988.

Title: SIGINT, SIGSEC, and C3CM Research and Support

Investigators: S. Jauregui and R.W. Adler, Adjunct Professors of
                  Electrical and Computer Engineering

Sponsor: SPAWAR PMW-143

Objective: This is a continuing program which has been active
                  for 15 years. The work has to do largely with
                  SIGINT acquisition and DF systems used aboard
                  ship. The objective is to research new techniques
                  and developments, work on test plans and assist in
                  the testing.

Summary: This year the work was accomplished in three
                  areas:

                  1. Precision frequency measurement for
                  differential doppler
                  2. Digital wide band techniques versus
                  compressive techniques
                  3. Parallel versus sequential HFDF techniques

                  The precision frequency measurement technique will
                  field five systems in 1989. Three of these will
                  be shore tested and two will be used aboard ship.
                  In 1988 NPS developed a communications interface
                  to utilize the current comms system on an almost
                  transparent basis. A number of briefings were
                  given at various field stations and headquarters
                  on this technique and how it will improve anti-air
                  defenses. The combat DF system uses a compressive
                  wide band HF receiver in its acquisition system.
                  A follow-on program will use an FFT device to
                  replace the compressive system. NPS was involved
                  in some side by side factory testing of the two
                  systems. The combat DF system has used sequential
                  sampling in the HFDF area. It has recently
                  developed a parallel sampling system which has
                  involved NPS in both testing and analysis of side
                  by side results.

Contributions: This year a communications interface box between
                  the differential doppler generation box and the
                  Bullseye communications system was developed on a
                  not to interfer basis with the communications
                  system. These interfaces will be used in the Fall
                  of 1989 overseas testing.
                  Data was gathered on the new and old CDF
                  techniques. An analysis and thesis report was
                  written on the results in FY88 with the hope of
                  deriving a new accuracy confirming algorithm in
                  FY89. All of this work is fed back into my SIGINT
                  and HF courses.

Title:	Signal to Noise Enhancement Research and Support
Investigators:	S. Jauregui and R. Adler, Adjunct Professors of Electrical and Computer Engineering
Sponsor:	SPAWAR PMW-144
Objective:	To develop a program to enhance signals and decrease noise at US Navy HFDF and acquisition sites. This is accomplished by collecting data on site and determining a variety of mitigating techniques. This is a continuing program started and led by the NPS for about 12 years.
Summary:	The following activities were visited from Oct 1987 to Dec 1987 to make site surveys:

    1.   NSGA - Northwest VA - Dec 1987
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    4.   Naval Commsta - Guam - Apr 1988
    5.   NSG Activity - Misawa Japan - Jun 1988
    6.   Naval Commsta - Rota Spain - Sep 1988
(A Fixup was made at NSGA Skaggs in July of 1988)

Surveys are typically 7 to 10 days long. Fixup trips are typically 4 weeks long with NPS normally there for the first and last week to record the before and after results and to do the site improvement analysis. The NSGA Northwest visit was unusual in that it was a site survey to determine the reduction in noise caused by a $3,000,000 powerline repair job done by Virginia Power on recommendation of the NPS SNEP group.

Publications:	A number of quick look reports presented to each commanding officer before leaving site after a survey or fixup.
Theses	"Strategies in the Topological Approach to Electromagnetic Interface," V.D. Ingram, M.S. Thesis, Dec 1987.
	"The Reduction of High Frequency Intermodulation Products via Terrain Shielding", B.A. Alexander, M.S. Thesis, Dec 1988.
Presentations:	1. At each command an outbriefing was given to various groups normally including: The CO, interested officers, and chiefs on the results of the survey or fixup. In addition to the briefings, hands on instructions were given to the mat personnel.

2.   In Jan 1988, a day SNEP presentation was given to approximately 40 installers and designers for NESSEC, Washington D.C.

3.   In Dec 1988, presentations were given to the CNSG EMO personnel for all of the Pacific and all of the Atlantic in two half day sessions on the SNEP program and the progress made.

Title: SIGINT, SIGSEC, and C3CM Research and Support

Investigators: S. Jauregui and R.W. Adler, Adjunct Professors of
                    Electrical and Computer Engineering

Sponsor: SPAWAR PMW-143

Objective: This is a continuing program which has been active
                    for 15 years. The work has to do largely with
                    SIGINT acquisition and DF systems used aboard
                    ship. The objective is to research new techniques
                    and developments, work on test plans and assist in
                    the testing.

Summary: This year the work was accomplished in three
                    areas:

                          1.   Precision frequency measurement for
                          differential doppler
                          2.   Digital wide band techniques versus
                          compressive techniques
                          3.   Parallel   versus   sequential   HFDF
                          techniques

                    The precision frequency measurement technique will
                    field five systems in 1989. Three of these will
                    be shore tested and two will be used aboard ship.
                    In 1988 NPS developed a communications interface
                    to utilize the current comms system on an almost
                    transparent basis. A number of briefings were
                    given at various field stations and headquarters
                    on this technique and how it will improve anti-air
                    defenses. The combat DF system uses a compressive
                    wide band HF receiver in its acquisition system.
                    A follow-on program will use an FFT device to
                    replace the compressive system. NPS was involved
                    in some side by side factory testing of the two
                    systems. The combat DF system has used sequential
                    sampling in the HFDF area. It has recently
                    developed a parallel sampling system which has
                    involved NPS in both testing and analysis of side
                    by side results.

Conference   Bullseye users group: a one hour presentation on
Presentations: past results using differential doppler and test
                    goals in the current system.

                    CINCUSNAVEUR N-8: a presentation of differential
                    doppler goals and expected field anti-air
                    improvements. NSGA Edzell and NSGD Rota: same
                    presentation as given to CINCUSNAVEUR.

Theses: "Baseline Performance of Combat DF Direction
                    Finding System Using Classic Outboard as Control,"
                    J. James, M.S. Thesis, Sep 1988.

"Interfacing an Existing Communication System to an Independent Computer Controlled Network on a Non-Interference Basis," M.J. Marbach, <u>Engineers Thesis</u>, Dec 1988.

Title:	Silicon Bread-Boarding with Gate Array for Tactical Image Processing
Investigator:	Chin-Hwa Lee, Associate Professor of Electrical and Computer Engineering
Sponsor:	Naval Ocean System Center
Objective:	To design special purpose hardware to process tactical image data. Image processing algorithms such as correlations are implemented in systems with special architecture using available VHSIC chips.

Summary: It is necessary to consider facts concerning the controller to coordinator processing activities in the system. One approach is to integrate the controller circuit into a single semicustom circuit chip. In this study, we found out that two available approaches to implement a controller are not preferred. The first such approach uses Gate Array Technology. This technology is more suitable for a large volume production environment. The initial costs for fabrication per chip is around $50K. This approach was not taken in the project. The second approach is using macro-cells in the design. This can cut down the design effort but the turn around time is about six months or more. We have found that a new approach, using programmable logic devices (PLD), is more suitable. This has both short turn around time and small initial costs. But, the complexity of the controller has to be limited to about 5,000 transistors. Presently, we are orientating ourselves to employ this technology. We have established the design tool environment for using the PLD this year. Next year we will implement a single design of the system.

Publication:	"Simulation of Systolic Array in Graphics," Proc. of the 2nd Annual Parallel Processing Symp., April 1988.
Conference Presentation:	"Simulation of Systolic Array in Graphics," 2nd Annual Parallel Processing Sysmposium, April 1988.
Thesis Directed:	"Modeling with VHDL," LT L.T. Directed: Hsu, M.S. Thesis, completion in 1989.

Title:	Rule-Based Image Processing System for Object Recognition
Investigator:	Chin-Hwa Lee, Associate Professor of Electrical and Computer Engineering
Sponsor:	Army Space Program Office
Objective:	Promote the usage of topographic information stored in DTED and DFAD together with the updated information from satellite imagery to recognize or classify area.
Summary:	Usually battlefield planning is done with topographical maps and collateral intelligence. We want to investigate the possibilities of using Landsat data to provide more timely information of the ground conditions for the involved area. The features of interest are ground gradients for heavy vehicles, dependence of line of sight on ground vegetation and forestry, and possible concealment for covert activities, etc. The LAS system will be used to prepare these overlays. The nonparametric classification methods will also be used in the experiment to identify similar category of ground coverage in the overlays.
Publications:	"Incremental Extraction of Houses and Buildings from Aerial Photographs," (with H. J. Lee), Journal of Information Science and Engineering, Aug 1988.
	"House and Building Extraction from Aerial Photographs," (with H. J. Lee), submitted to Journal of Pattern Recognition and Artificial Intelligence for review on April 1988.
	"Partial Matching of Two-Dimensional Shapes," (with G. P. Quek), submitted to IEEE Trans. on Pattern Analysis and Machine Inteligence for review on 10 July 1988.
Conference Presentation:	"Partial Matching of Two-Dimensional Shapes Using Random Coding," (with G. P. Quek), Proc. of the 9th Intl. Conf. on Pattern Recognition, Nov 1988.
	"Model-Based Building Verification in Aerial Photographs," Proc. of IEEE Workshop on Computer Vision, Nov 1987, pp. 271-273.
	"Knowledge-Based System for Verifying Building in Aerial Photographs," (with H. J. Lee), Proc. of Intl. Computer Symp., Dec 1987.

Title:	Ray-Mode Coupling
Investigator:	Hung-Mou Lee, Associate Professor of Electrical and Computer Engineering
Sponsor:	Office of Naval Research
Objective:	To understand the excitation of internal resonance mode of a cavity by an incident plane wave.
Summary:	Understanding the excitation of bound states (cavity resonance modes) by an incident wave (a field in the continuous spectrum) is essential for vulnerability analysis of complex systems. This research investigates this problem both theoretically and experimentally using the tubular cylinder as a model. Some analytical results on the scarrering of a tubuler cylinder of finite length have been obtained by the investigator which compare favorably with experimental data. It demonstrates that the tubular cylinder is a useful model and the analytical technique pioneered by the investigator is promising.
Publications:	H-M. Lee, "Rise and Fall of Directed Transient: Use of Mellin Transformation in Time Domain Problems," Radio Science, 22, (6), pp. 1102-1108, Nov 1987. H-M. Lee, "Spectral Analysis of Complex-Source Pulsed Beams: Comment," Journal of the Optical Society of America, A5, (5), p. 756, May 1988.

Title: Navy Anti-Air Warfare Studies

Investigator: Hung-Mou Lee, Associate Professor of Electrical
                  and Computer Engineering

Sponsor: Office of the Chief of Naval Operations

Objective: To investigate the effects of ducting and the
                  curvature of Earth on sea clutter up to the
                  vicinity of radar horizon.

Summary: A theoretical framework has to be developed so
                  that the propagation of radio waves up to the
                  vicinity of the radar horizon can be accurately
                  and conveniently formulated and solved. This
                  formulation should allow easy extension to include
                  surface roughness of the ocean. An approximation
                  technique conceived recently appears to offer such
                  utility.

                  Since there does not appear to be any clutter data
                  with environmental parameters clearly specified,
                  it is desirable that new data sets be collected.
                  They can be analyzed both for building a
                  phenomenological models and for checking
                  theoretical projections. An experimentation radar
                  set will be assembled to take rf propagation and
                  sea clutter data. Later on, this setup can be
                  utilized as a flexible radar system for both
                  teching and research.

Publications:

                  H-M. Lee, "Sommerfeld Type Integrals for the
                  Radiation of a Dipole Above a Spherical Earth,"
                  submitted to Radio Science.

Conference
Presentations: H-M. Lee, "Radio Wave Propagation in the
                  Intermediate Region," Proc. of the Intl. Symp. on
                  Radio Propagation," Beijing, China, 1988, pp. 231-
                  234, International Information Exchange Service
                  Company, Kowlon, Hong Kong, April 1988.

                  H-M. Lee, "EM Propagation to the Ocean Horizon,"
                  to appear in Proc. of the Conf. on Marine Boundary
                  Layer, 1988.

                  H-M. Lee, "Short Range Propagation Above L Band -
                  A Quasi Cylindrical Approximation," to appear in
                  the Abstracts of the National Radio Science
                  Meeting, 1989.

H-M. Lee, "Propagation in the Presence of Evaporation Duct - A New Formulation," accepted for presentation and publication in the Proc. of the Intl. Symp. on Antennas and EM Theory, 1989.

Theses
Directed:
"Engineering Design of a Digital MTI System for Short Range AAW" by Lt. Larry T. Scalzitti, <u>M.S. Thesis</u>, Mar 1988.

"Sea Spike Modeling" by It. Chin-Chuan Kuo, <u>M.S. Thesis</u>, Dec 1988.

Title: Classification and Estimation of Signals using Cyclic Spectrum Analysis Techniques.

Investigator: H. H. Loomis, Jr., Professor of Electrical and Computer Engineering.

Sponsor: SPAWAR 004-4

Summary: Investigated Implementations and performance of Spread spectrum detection algorithms based on spectral correlation methods.

Publications: W. Brown, III and H. H. Loomis, Jr., "Digital Implementations of Cyclic Spectrum Analyzers," Proceedings, Fourth Annual ASSP Workshop on Spectrum Estimation and Modeling, August 1988, pp. 264-270.

H. H. Loomis, Jr. and W. A. Gardner, "Design of a Covert Communications Technique (U)," Naval Post-graduate School Report \#62-88-03, November 1988.

Gardner, W. A., "Detection, Classification, and Estimation of Spread-Spectrum Signals in Noise and Interference--Continuation II," Final report on continuation II of contract 85-3363, June 1988.

Theses Directed: "Cyclic Spectral Analysis Architectures," Curtis Mitchell, LCDR USN, M.S. Thesis, December 1987.

"Design and Analysis of a Covert Communications System," Richard Lockowitz, LT USN, M.S. Thesis Sep 1988.

Title: Advanced Signal Processing Techniques

Investigator: H. H. Loomis, Jr., Professor of Electrical and
                    Computer Engineering.

Sponsor: Assistant Secretary of the Air Force

Summary: Investigating advanced signal processing
                    algorithms and architectures for the detection and
                    characterization of broadband communications sig-
                    nals in noise and interference.

Theses   "Microcomputer Implementations of Spectral
Directed: Correlation Algorithms," Thomas V. Cole, LT USN,
                    M.S. Thesis, Sep. 1988.

                    "VLSI Implementation of Pipeline Digital Fil-
                    ters," Venus Jangsri, LT Royal Thai Navy, M.S.
                    Thesis, Sep. 1988.

                    "Geolocation of Direct Sequence Spread Spectrum
                    Signals," Michael Loomis, LT USN, M.S. Thesis,
                    Dec. 1988.

Title: Project GUSTY ORIOLE

Investigator: H. H. Loomis, Jr., Professor of Electrical and
                Computer Engineering.

Sponsor: SPAWAR 004-54

Summary: Investigated Algorithms and architectures of sys-
                tems for the production, distribution and analysis
                of tactical information. Investigated architec-
                tures of spaceborne computer systems. Investi-
                gated operational problems concerned with the em-
                ployment of tactical information for decision
                making and targeting.

Theses   "Vulnerability Analysis of NAS Sigonella to Hos-
Directed: tile Intelligence Collection Efforts," Wendy
                Chiado, LT USN, M.S. Thesis, Sep 1988.

                "An Integrated Systems Approach utilizing
                National Systems and Organic Assets for Tactical
                Indications and Warning," Craig E. French, LT
                USN, M.S. Thesis, Sep 1988.

                "The Soviet Military Space Program: A Strategic
                Assessment," John Mahony, Cpt USA, M.S. Thesis,
                Sep 1988 (C).

                "User Tasking Architecture Design Considerations
                for Space Based Radar," Mark B. Segal, LT USN,
                M.S. Thesis, Sep 1988.

                "The Tactical Contribution of PAWS/TRE to the
                Surface Fleet's Major Mission Areas," Kenneth V.
                Spiro, LT USN, M.S. Thesis, Sep 1988.

                "A Tactical Doctrine for the Fleet Application of
                PAWS", Roderick Trice, LCDR USN, M.S. Thesis,
                Sep 1988.

Title:	Automated Design of VLSI Devices for Navy Space Applications
Investigator:	H. H. Loomis, Jr., Professor of Electrical and Computer Engineering.
Sponsor:	SPAWAR 004-51

Summary:	Investigated advanced computer aided design techniques such as silicon compilers to the rapid production of complex VLSI chips from system descriptions. Also investigated testing and design for test of VLSI circuits. Investigated custom chip architectures for portions of Spaceborne processor being developed for SPAWAR.

Theses Directed:	"XOR Structure Simulation with Mossim II," Kent Irwin, LT USN, M.S. Thesis, March 1988, (C).
	"An Improved Router for the Monterey Silicon Compiler," Carlos Rexach, LT USN, M.S. Thesis, March 1988, (C).
	"Transistor Sizing in Static CMOS Logic Design with an Application to the Technology Upgrade of a Silicon Compiler," Gordon Steele, Capt USMC, M.S. Thesis, March 1988, (C).
	"Automated Design of a Microprogrammed Controller for a Finite State Machine," James Harmon, LCDR USN, M.S. Thesis, June 1988, (C).
	"VLSI Design using the GENESIL Silicon Compiler," Robert Settle, Lt Col USMC, M.S. Thesis, Sep 1988.
	"Silicon Compiler Implementation of a Kalman Filter Algorithm as an ASIC," Randall Rockey, Capt USMC, M.S. Thesis, Dec 1988.

Title:	An Autonomous System for the Evaluation of Radiation Effects and Annealing of Photovoltaic Devices
Investigator:	Sherif Michael, Associate Professor of Electrical and Computer Engineering
Sponsor:	SPAWAR

Summary: This is a continuation of the ongoing research on Photovoltaic Power Technology. Research tasks include the implementation of the microprocessor based system proposed in FY 87 research, the investigation of Photovoltaic current annealing processes and other related topics of radiation effects on GaAs and Si devices.

Publications: "ORION: A Small, Full Capbility, General Purpose, Low Earth Orbit Satellite Bus," Proceedings of 25th Space Congress, Cocoa Beach, FL, April 1988 (with A. Fuhs, and M. Mosier).

"On-Orbit Annealing of Satellite Solar Panels," Proceedings of the 2nd Annual AIAA/USU Conference on Small Sattelites, Logan, Utah, September 1988. (with R. S. Sommers).

Theses
Directed: "Construction of Gallium Arsenide Solar Concentrator for Space Use," M.S. Thesis, Chris L. Hudec, March 1988.

"A Microprocessor-Based, Solar Cell Parameter Measurement System," M.S. Thesis, LT Robert R. Oxborrow, June 1988.

Title:	Imaging Monterey Bay with Acoustic Tomography
Investigators:	J. H. Miller, Assistant Professor of Electrical and Computer Engineering, T. P. Stanton, Adjunct Research Professor of Oceanography, E. B. Thornton, Professor of Oceanography, and L. J. Ziomek, Associate Professor of Electrical and Computer Engineering.
Sponsor:	Monterey Bay Aquarium Research Institute
Objective:	The goal of this research is a long-term (5 year) monitoring of Monterey Bay with an acoustic tomography system. This system would provide 3-D sound speed and current maps of the Bay for use by Oceanographers and other ocean researchers.
Summary:	This is the first year of a joint effort by the Electrical and Computer Engineering Department and the Oceanography Department to develop an ocean acoustic tomography (OAT) system in Monterey Bay. It is envisioned that the Bay would be surrounded by shore-linked acoustic transceivers that would transmit and receive coded acoustic signals. This is the ocean acoustic analog to medical X-ray computer-assisted tomography (CAT). Whereas CAT uses the X-ray intensity fluctuations measured at a number of angles through the imaged tissue, OAT uses the fluctuations of measured travel times from a number of acoustic multipaths though an ocean body. These fluctuations are then "inverted" to provide an estimate of the intervening sound speed structure (and hence density) and current structure. In this reporting period, preliminary analyses were conducted to verify the feasibility of tomography in Monterey Bay. These analyses included 2-dimensional ray traces and normal mode modeling given historical oceanographic conditions in the Bay. We are just beginning a very sophisticated 3-dimensional acoustic ray trace analysis. This analysis will take into account the complicated bathymetry in Monterey Bay including the Submarine Canyon.
Theses Directed:	Frederic Strohm, "On the Use of Matched Field Processing for Full Wave Inversions of Ocean Acoustic Tomography Signals," M.S. Thesis, June 1989. Co-advising with Professor Robert Bourke. Peter Lynch, "On the Use of Gold Codes for Ocean Acoustic Tomography," M.S. Thesis, June 1989. David Pierce, "Sub-Space Methods in Matched Field Processing," Ph.D. Thesis, June 1980. Co-advising with Professor Charles Therrien.

Rod Scott, "Using Transputers for 3-D Acoustic Ray Tracing,"<u>M.S.</u> <u>Thesis</u>, Sep 1989.

Title: Engineering Development and Test of Surface Wave/
                  Internal Wave Tomography

Investigator: J. H. Miller, Assistant Professor of Electrical
                  and Computer Engineering

Sponsor: NPS Research Council

Objective: The objectives of this research were to develop
                  and test a tomographic system to analyze the
                  effects on long-range acoustic propagation of
                  ocean surface waves, internal waves, and complex
                  3-dimensional bathymetry.

Summary: Ocean acoustic tomography (OAT) is the ocean
                  acoustic analog to medical X-ray computer-assisted
                  tomography (CAT). Whereas CAT uses the X-ray
                  intensity fluctuations measured at a number of
                  angles through the imaged tissue, OAT uses the
                  fluctuations of measured travel times from a
                  number of acoustic multipaths though an ocean
                  body. These fluctuations are then "inverted" to
                  provide an information on surface waves, internal
                  waves, density structure, etc. In the past year,
                  a system was developed to test some of the above
                  ideas. A successful experiment was held during
                  the week of December 12, 1988 in cooperation with
                  the Woods Hole Oceanographic Institution. An
                  acoustic source with a center frequency of 224 Hz
                  was placed on a minor seamount 20 miles off Point
                  Sur. Modified sonobuoys (with anchor, bottom-
                  mounted hyrdophone, large capacity battery, and
                  large float) were placed in Monterey Bay to
                  receive the acoustic signals from the source. The
                  sonobuoy RF signals were received and recorded
                  ashore. A preliminary analysis of the data shows
                  very exciting results.

Theses   Theresa Rowan, "Monterey Bay Acoustic Tomography:
Directed: Ray Tracing and Environmental Assessment,"
                  M.S. Thesis, Sep 1988.

                  Kevin Schaaff, "Tomographic Signal Demodulation
                  and Decoding Techniques," M.S. Thesis, Sep
                  1989.

                  Robert Dees, "Monterey Bay Acoustic Tomography:
                  Inversion for Sea Surface and Internal Wave
                  Spectra," M.S. Thesis, June 1989.

Title:	Finite Element Computation of Electromagnetic Scattering
Investigator:	Michael A. Morgan, Professor of Electrical and Computer Engineering
Sponsor:	Office of Naval Technology
Objective:	To develop CAD type computer programs for use in the analysis and design of complex electromagnetic scattering structures.
Summary:	A new computational procedure is being investigated for using the finite element method to evaluate scattering by complex objects. The scattering solution is effected by partitioning the physical structure into solution modules. The complete solution is then assembled using flow-diagram based matrix feedback control theory, where the individua modules are represented using matrix transfer functions.
Publications:	M.A. Morgan and T.B. Welch, "Field Feedback Computation of Scattering by Inhomogeneous Penetrable Cylinders of Arbitrary Cross Section," In preparation for submission: IEEE Transactions on Antennas and Propagation,
Conference Presentation:	M.A. Morgan, "Scattering Validations for the Field Feedback Formulation," 1988 URSI Radio Science Meeting, Syracuse University, June 1988.
Thesis	T.B. Welch, "Electromagnetic Scattering from Two-Dimensional Objects using the Field Feedback Formulation," Engineers Thesis, March 1989.

Title: Radome Induced Antenna Pattern Aberrations

Investigator: Michael A. Morgan, Professor of Electrical and
                Computer Engineering

Sponsor: Naval Weapons Center

Objective: Computational algorithms are being developed
                for assessing the changes induced in the patterns
                of gimbal mounted Navy missile antennas due to
                radome enclosures.

Summary: Navy surface-to-air and air-to-air missiles, which
                employ aerodynamically shaped radomes, are highly
                susceptible to radome induced boresight tracking
                errors.   This research is directed towards the
                development of a unique finite-element computer
                program for the resonance region evaluation of the
                effects of radome structures on Navy missile
                seeker antenna patterns.   This computer program
                will be developed in stages, over a multiple year
                period, with each step resulting in new
                enhancements which increase the range of
                applicability and the resultant accuracy of the
                computations.

Publications: M.A. Morgan, "Generalized Coupled Potentials for
                Electromagnetic Fields in Inhomogeneous Media,"
                IEEE Transactions on Antennas and Propagation,
                Vol. AP-36, Dec. 1988, pp. 1735-1743.

Conference   M.A. Morgan, "Generalized Coupled Azimuthal
Presentation   Potentials for Electromagnetic Fields in
                Inhomogeneous Media," 1988 URSI National Radio
                Science Meeting, Univ. of Colorado, Jan. 1988.

Thesis   E. Connolly, "Finite Element Electromagnetic
Directed: Scattering: An Interactive Microcomputer
                Program," M.S. Thesis, June 1988.

Title:	Target Identification Using Resonance Annihilation Filtering
Investigator:	Michael A. Morgan, Professor of Electrical and Computer Engineering
Sponsor:	DARPA Tactical Technology Office
Objective:	To develop optimized algorithms for utilizing natural resonances of radar targets for aspect independent identification in the real world.
Summary:	Aspect invariant natural resonant cancellation is being investigated using specially designed resonance annihilation digital filters. Considerations are given to classification accuracy versus signal to noise ratio and signal bandwidth for scale model tactical aircraft models.
Publications:	M.A. Morgan, "Scatterer Discrimination Based Upon Natural Resonance Annihilation," Journal of Electromagnetic Waves and Applications, Vol. 2, No. 5/6, 1988, pp. 481-502. P.J. Moser, H. Uberall and M.A. Morgan, "Finite Element Computation of Complex Resonant Frequencies for Penetrable Axisymmetric Bodies", Journal of Electromagnetic Waves and Applications, Vol. 3, No. 2, 1989, pp. 129-143. Special Issue on Differential Methods in Electromagnetics, Edited by M.A. Morgan.
Conference Presentation:	M.A. Morgan and P.J. Moser, "Finite Element Evaluation of Complex Natural Resonant Frequencies", 1988 National Radio Science Meeting, University of Colorado, Jan. 1988.
Theses Directed:	S.A. Norton, "Identification of Radar Targets from the Poles of their System Function," Engineers Thesis, March 1988.

Title: High-Resolution Transient Scattering
                  Measurements Using a Broadband Noise Source

Investigator: Michael A. Morgan, Professor of Electrical and
                  Computer Engineering

Sponsor: DARPA Aerospace Technology Office

Objective: To investigate the viability of synthesizing
                  narrow pulse signatures of radar targets using
                  measured random noise scattering.

Summary: In this unique effort, narrow pulse responses of
                  scattering targets are synthesized from
                  experimental measurements of the cross-correlation
                  of broadband random noise incident upon and
                  scattered from objects. A dual-channel coherent
                  sampling oscilloscope is used as a correlation
                  receiver.

Publication: M.A. Morgan and B.W. McDaniel, "Transient
                  Electromagnetic Scattering: Data Acquisition and
                  Signal Processing," IEEE Transactions on
                  Instrumentation and Measurement, Vol. 37, No. 2,
                  June 1988, pp. 263-268.

Theses   S. Somapee, "A Computer Algorithm for Automated
Directed: Transient Scattering Measurements," M.S. Thesis,
                  June 1988.

                  D.I. Lee, "Impulse Scattering Responses Using
                  Noise Illumination,", M.S. Thesis, March 1988

Title: Research in Digital Signal Processing:
                    Communications Digital Signal Processing

Investigator: Paul H. Moose, Associate Professor of Electrical
                    and Computer Engineering

Sponsor: NOSC, Mr. Darrell Marsch; Direct Funding

Objective: To develop a phase modulated spread spectrum
                    packet communication technique and to identify the
                    channel parameters of an acoustic link for the
                    packets required for a critical Naval application.

Summary: Conventional computer-to-computer communications
                    links employ external modems, and band-shifters to
                    interface the computers to the physical link. The
                    physical link may be wire, fiber, an RF link or in
                    the case of underwater communications, an acoustic
                    link. In this research, we are experimenting with
                    signal packets encoded in the frequency domain and
                    established directly in the time domain as
                    spreadspectrum signals using an inverse FFT
                    embedded within the host computer. The computer
                    receiving the packets performs the inverse
                    operation for decoding and error correction.
                    Redundancy in either time or frequency, frequency
                    hopping, and other techniques to provide jam
                    resistance are simply introduced in the software
                    driven encoding process.

                    Our first application for this technique is in an
                    acoustic link. Before a final signal design can
                    be established, more specific information is
                    required about the phase and amplitude properties ·
                    of the acoustic channel to be employed. We plan
                    to measure the properties of a typical channel
                    during 1989 using a suite of spread spectrum
                    signals with different time and frequency
                    resolution capabilities. We also plan to develop
                    a receiver with adaptive synchronization
                    capabilities in a second host computer. (The host
                    computers for our communications terminals are
                    PC/ATs.)

Thesis   "High Speed Output Interface for a Multifrequency
Directed: Quaternary Phase Shift Keying Signal Generated on
                    an Industry Standard Computer," R.D. Childs,
                    M.S. Thesis, Dec 1988.

Reports: "Signal Design of MFQPSK Signals for an Acoustic
                    Link," P.H. Moose, Memo 88-1, 4 Feb 1988.

                    "SNR and BER's for MFQPSK Signals," P.H. Moose,
                    Memo 88-2, 20 Feb 1988.

Title:	The Design of Digital Filters Using Delta Modulation
Investigator:	Glen A. Myers, Associate Professor of Electrical and Computer Engineering
Sponsor:	SPAWAR
Objective:	To develop a a hardware efficient design of digital filters

Summary: Nonrecursive digital filters with weighted delays use n bits to represent sample values at each tap, m bits for weight storage, and perform n x m bit binary multiplication at each tap. For large order systems there is considerable hardware and wiring complexity and a penalty in filter performance capabilities.

A new form of digital filter has resulted from this effort during the past year. Delta modulation is used to represent the input signal and also the filter characteristic. An algorithm was developed for rapid simulation of any design (lowpass, highpass, matched, etc.) as well as simple hardware realization of the specified filter response. This approach uses digital technology, requires no multipliers and operates in real time. Continuing work to be done includes a sensitivity analysis with respect to system parameters, noise performance analysis, prototype filter construction and consideration of applications.

Dissertation Directed   "Description, Analysis and Simulation of a New Realization of Digital Filters," Ahmed Fahmy Amin Mahrous, Ph.D. Dissertation, Sep 1987.

Title: Propagation of Scalar Acoustic Waves

Investigator: John Powers, Professor of Electrical and
                Computer Engineering

Sponsor: Office of Naval Research

Objective: To apply spatial frequency domain techniques to
                modeling the propagation of pulsed and transient
                ultrasound waves in lossless and lossy media. The
                technique would allow the application of computer-
                efficient FFT algorithms to problems that have
                previously used complicated line integrals for
                evaluation.

Summary: Work continues to apply the spatial transform
                approach to lossy media. Models for media with a
                quadratic dependence of the attenuation
                coefficient fit the Stoke's equation. Approximate
                solutions have been found and are being explored
                via mathematical modeling. Models for media with
                an attenuation coefficient that varies linearly
                with frequency reduce to the Klein-Gordon
                equation. We are in the process of trying to fit
                data reported in the literature for tissue
                propagation to find the best fit in values of the
                two model coefficients for use in numerical
                models. coefficients

Publications: "Transient wave propagation in an attenuating
                medium with a quadratic frequency dependence" (in
                preparation)

Title: Solid Propellant Combustion/Automated Data
                    Retrieval from Holograms

Investigators: David Netzer, Professor of Aeronautics, and John
                    Powers, Professor of Electrical and Computer
                    Engineering

Sponsor: Air Force Rocket Astronautical Laboratory

Objective: To develop techniques to obtain particle size data
                    within the combustor and across the exhaust nozzle
                    of solid propellant rocket motors.

Summary: This continuing investigation consists of two
                    main studies: (1) experimentally measuring
                    particulate sizes using measurements of forward
                    scattered light, holography, high speed motion
                    pictures and SEM evaluation of residue collected
                    in an exhaust probe; and (2) development of
                    techniques for computer-aided automatic retrieval
                    of particle size data from holograms. The former
                    effort is summarized in the report from Professor
                    D.W. Netzer.

                    The speckle reduction filters implemented in last
                    year's work were compared against scene averaging.
                    The best combination appears was shown to be
                    recording the image off of the rotating mylar disk
                    to use camera tube averaging and them to apply the
                    geometric filter to reduce speckle.

                    Feature identification and counting was speeded up
                    through the reprogramming of our algorithms into
                    the C language. Speed improvements of two were
                    achieved. Memory limitations imposed by DOS in the
                    Fortran programs limited some processing to
                    partial images. These memory limitations were
                    removed by the dynamic memory allocation
                    techniques that C allows. Additionally the
                    processing had to be done with sequential Fortran
                    programs due to limited memory. Now all operations
                    are done in one program on full screen images.

Publications: S. Orguc, T.E. Pruitt, T.D. Edwards, E.D.
                    Youngborg, J.P. Powers, and D.W. Netzer,
                    "Measurement of particulate size in solid
                    propellant rocket motors", Proceedings of the 24th
                    JANNAF Solid Combustion Meeting, CPIA Pub. 476,
                    Chemical Propulsion Information Agency, Johns
                    Hopkins University, pp. 165--182

T.D. Edwards, R.K. Harris, K.G. Horton, M.G. Keith, A. Ketadidjaja, Y.S. Lee, D.N. Redman, J.S. Rosa, J.B. Rubin, S.C. Yoon, J.P. Powers, and L.W. Netzer, "Measurements of pariculates in solid propellant rocket motors (U)", Air Force Astronautics Laboratory Technical Report, AFAL--TR--87--029, Edwards Air Force Base, California, October 1987

Conference presentation: "Measurement of particulates in solid propellant motors", Presented at 24th JANNAF Combustion Meeting, Monterey, CA, October 1987

Theses Directed: "Automatic data retrieval from rocket motor holograms", LTJG E.S. Orguc, Turkish Navy, MSEE, Dec 1987

"Code optimization of speckle reduction algorithms for image processing of rocket motor holograms", LCDR D.S. Kaeser, USN, Dec 1988

"Automatic measurement of particles from holograms taken in the combustion chamber of a rocket motor", MAJ D.J.G. Carrier, Canadian Armed Forces, MSEE, Dec 1988

Title:	Fixed Distributed Systems: Environmental Acoustics and Fiber Optic Communications
Investigators:	Calvin Dunlap, Adjunct Professor of Oceanography, and John Powers, Professor of Electrical and Computer Engineering
Sponsor:	Space and Naval Warfare Systems Command
Objective:	To investigate the environmental effects on fixed distributed acoustic systems by study of a sample system to be installed in Monterey Bay. Additional study is on the use of fiber optic cables for transmitting the data. This report is on the fiber optic telemetry portion of this project.

Summary: A fiber optic telemetry unit used to monitor the operating voltage of a long-life seawater battery was redesigned for longer distance transmission using single mode fiber. A laser diode power unit was designed and laboratory tested through 10 km of actual fiber plus 60 km of simulated fiber successfully for this application.

Design efforts continued on a multi-channel fiber optic data link from undersea experiments to shore. Three approaches were investigated. The first is an analog link using FM optical carrier modulation to allow multiple analog channels to be frequency division multiplexed and transmitted over the fiber. A set of active filters separate and detect the channels. The second approach uses a high-speed A/D converter to digitize the data. A microprocessor controls the digitization, time-domain multiplexing, and frame synchronization. The clock-encoded data stream is received and demodulated at the receiving end. The third approach studied the use of code division multiplexing to all several channels of information to be transmitted simultaneously.

I study on reliability of long wavelength lasers was undertaken. lasers of InGaAsP should have adequate reliability for short term applications (on the order of a year) and for most long term applications. A survey of manufacturer's showed a wide variation of test conditions and definitions of end of useful life. Government specifications need to carefully prescribe the method of lifetime prediction and techniques used to extrapolate lifetimes from accelerated aging test conditions.

Theses Directed:	"Long haul underwater fiber-optic communications", LT J.G. Gallagher, USN, MSEE, Dec 1987

"Multichannel data transmission through a fiber optic cable", LT F. Hatzidakis, Hellenic Navy, MSEE, Dec 1987

"Reliability of state-of-the-art long wavelength semiconductor lasers", LT R.G. Bowdish, USN, Mar 1988

"Unidirectional Manchester encoded data transfer via a fiber optic link", LT R.G. Ragsdale, Jr., USN MSEE, Mar 1988

"Microprocessor control of a fast analog-to-digital converter for an underwater fiber optic data link", LT G.L. Schlecte, USCG, Mar 1988

"Long haul underwater fiber optic link", LCDR F.A. DeNap, USN, MSEE, Mar 1988

"Semiconductor laser diodes and the design of a D.C. powered laser diode drive unit", LT J.C. Cappuccio, Jr., USN, June 1988

Title: Digital Processing for Enhancement of Images of
                    Underwater Objects

Investigator: C. W. Therrien, Associate Professor of Electrical
                    and Comuter Engineering, A. Keiyu, Adjunct
                    Research Professor, and Professor J. S. Lim,
                    Consultant

Sponsor: Naval Underwater Warfare Engineering Station

Objective: To determine if digital image processing methods
                    can prove useful in enhancing video images during
                    underwater object recovery operations.

Summary: Various image processing techniques were applied
                    to underwater video images of objects in turbid
                    water to enhance these images. Methods were
                    explored for performing the image processing on a
                    small computer and in real time using special
                    purpose hardware. A computational analysis of the
                    various options was carried out. Research is
                    continuing with emphasis on implementing a
                    combination of real time and non real time methods
                    in an operational setting.

Report: "Study on Image processing for Turbid Water
                    Viewing," J. Lim and C. W. Therrien, Naval
                    Postgraduate School Report NPS62-87-013, June
                    1987.

Theses
Directed: "Enhancement of Video Images Degraded by Turbid
                    Water," J. Franco, M.S. Thesis, Dec 1986.

                    "Architecture for Near Real Time Enhancement of
                    Video Underwater Images," R. Ventura, M.S. Thesis,
                    Mar 1988.

Title:	Research in Multidimensional Signal Processing
Investigator:	C. W. Therrien, Associate Professor of Electrical and Computer Engineering and M. Tummala, Assistant Professor of Electrical and Computer Engineering
Sponsor:	Office of Naval Research
Objective:	To develop methods for adaptive signal processing in two dimensions.

Summary: The LMS method of adaptive filtering was explored for 2-D signal and image processing. A version of the RLS method and a separate `fast RLS' method was also developed for 2-D. These methods were applied to image processing for noise removal, debluring, and coding, and target detection.

Theses
Directed:
S. Wilstrup, "Adaptive Algorithms for 2-D Filtering," S. L. Wilstrup, M.S. Thesis, Sep 1988.

A. Sequeira, "Two-Dimensional Adaptive Algorithms," Engineers Thesis, to be completed March 1989.

Title: Analysis of Multichannel Image Data

Investigators: C. W. Therrien and P. H. Moose, Associate
                Professors of Electrical and Computer Engineering

Sponsor: Naval Ocean Systems Center

Objective: To explore object detection and tracking for
                multichannel IR and other related coincident data
                on targets of interest.

Summary: A two dimensional target detection algorithm based
                on 2-D adaptive filtering concepts was implemented
                and evaluated for detection of small point targets
                in very low signal to noise ratio environments. A
                target tracking algorithm was also developed for
                use with the detection algorithm to track targets
                through successive frames of IR data.

Publications: C. W. Therrien and T. V. DeMars, "New Algorithms
                for Detection and Tracking of Targets in Images,"
                proc. 22nd Annual Asilomar Conf. on Signals,
                Systems, and Computers, 31 October - 2 November
                1986, Pacific Grove, CA.

Theses
Directed: "Adaptive Dim Point Target Detection and Tracking
                in Infrared Images," T. V. DeMars, M.S. Thesis,
                Dec 1988.

Title:	Chaff Defense Against The ASCM
Investigator:	Hal Titus, Professor of Electrical and Computer Engineering
Sponsor:	NAVSEA
Objective:	To develop tactics for the use of chaff against the ASCM.

Summary: A simulation was developed to provide the optimal placement of chaff, and subsequent ship maneuver to maximize the missile to ship miss distance at CPA. The operator may also choose his own placement and maneuver to see if he can beat the computer's solution. The operator inputs the geometry and parameters of the attack, and the game is played out. Knowledge of how the threat missile centroids the ship and chaff return inside the range and angle gates is the critical intelligence parameter. The program may suggest new tactics, and is also good training for the ship's officers.

Thesis Directed: C. Nygard,"Optimal Chaff Defense and Maneuver Against The ASCM," M.S. Thesis, Dec 1988

Title: Attitude Control For Spacecraft

Investigator: Hal Titus, Professor of Electrical and Computer
                Engineering

Sponsor: SPAWAR-004

Objective: To design a variety of attitude control systems
                for the Orion Spacecraft.

Summary: The Orion Spacecraft happens to be a system
                without a payload. Therefore, to design a
                control, we must consider many possible
                alternatives. The first design was for three axis
                stabilization using thrusters. The theory is well
                known, but the synthesis into a nonlinear feedback
                control is rather original. Optimal minimum
                fuel/time cost functions were investigated.
                Mimimum fuel limit cycle motion was developed as
                well as response to large disturbances.

Publications: H. Titus, S. Dee, J. Cunningham, "Minimum
                Fuel/Time Controls Via Pontryagin Revisited"
                to appear in the IEEE International Conference
                on Control and Applications, April,1989

Thesis   S. Dee, "Three Axis Stabilization for the
Directed: Orion Spacecraft," M.S. Thesis, Dec 1988

Title:	Kalman Filter Smoothing
Investigator:	Hal Titus, Professsor of Electrical and Computer Engineering
Sponsor:	NUWES
Objective:	To add a smoothing algorithm to an existing Kalman Filter torpedo tracking program.

Summary: In the past year we have attempted to program a Kalman Filter for use on a IBM PC compatible to handle the torpedo tracking problem. This program has been run using real data containing observations from several arrays concurrently. This program now works quite satisfactorily.

In addition we have added to this program a smoothing algorithm which also processes the data backwards in negative time. Thus, each point in time has an estimate of track containing the data observed on both sides (in time). This program now also is working on real data supplied by Keyport which Professor Bob Read obtained. This program may be of use in post test analysis.

The forward time Kalman Filter Tracker may be of use in real time range operations. For instance, it can easily be adapted for collision avoidance in range safety. Hopefully the smoothing algorithm may be used to give smooth track as the torpedo passes from one array to the next.

Thesis Directed: R.C. Nicklas, "Kalman Filter Smoothing For Torpedo Tracking," M.S Thesis, March 1989

Title:	Adaptive Algorithms for Normalized IIR Lattice Filters
Sponsor:	NPS Research Council
Investigator:	Murali Tummala

Summary:	This is a continuing research effort of the work done during the Summer of 1987. The research involved developing adaptive algorithms for Gray-Markel type IIR lattice filters --- both normalized and one--multiplier versions are considered. The companion problem of ARMA modeling is also investigated. The algorithms are based on the least mean square criterion. Algorithms for the normalized case recursively updated a trigonometric function as against a reflection coefficient. This new approach assures the filter stability by forcing the poles of the transfer function to lie with in the unit circle. Algorithms for the one--multiplier case followed the traditional way of updating the reflection coefficients directly. The normalized algorithms exhibited faster convergence where as the one--multiplier algorithms are computationally quite economical. Simulation runs have been carried out to study the convergence behavior of both types of algorithms. Additionally, we have also developed adaptive algorithms for IIR filtering based on an approach known as generalized Mullis--Roberts criterion. The algorithms developed here have potential applications in array processing (sonar or radar) and modeling one--dimensional signals.

Publication:	M. Tummala, "New Adaptive Normalized Lattice Algorithm for Recursive Filters," Electronics Letters, Vol. 24, pp. 659-661, May 1988.
Conference Presentation:	D. W. Mennecke and M. Tummala, "Adaptive ARMA Lattice Based on Generalized Mullis--Roberts Criterion," in Proc. Twenty Second Asilomar Conf. on Signals, Systems, and Computers (Pacific Grove, CA), IEEE Computer Society Press, November 1988.
Theses	D. W. Mennecke, "Adaptive ARMA Lattice Filter Directed: Based on Generalized Mullis--Roberts Criterion," M. S. Thesis, June 1988.
	W. A. Dicken, "A Split--Levinson Approach to Autoregressive Filtering," M.S. Thesis, June 1988.
	P. S. Dal Santo, "System Identification by ARMA Modeling," M.S. Thesis, Sep 1988.

Title:	Timing Verification for VLSI Designs
Investigator:	Chyan Yang, Assistant Professor of Electrical and Computer Engineering
Sponsor:	NPS Research Council

Objective: In military applications it often requires architectural explorations with rapid prototyping. The purpose of this research is to provide the rapid timing verification for VLSI chip designs. The designers will not fabricate a chip that violates the timing or machine cycle requirement. This will not only save the fabrication costs due to the design flaws and also give the designers a rapid feedback on discovering the critical path of the circuits. This research is to design a CAD tool to assist the digital designers in rapidly performing the timing verification at the switch level.

Summary: This project started in October 1988 and is now in progress. Most existing timing verifiers solve the problem by formulating it into a graph theoretic problem of finding the longest or shortest paths. Crystal is a timing verifier developed at UC Berkeley and can be considered as a plain depth-first search program. In reality, the Crystal cannot handle big circuit, e.g., a 32-bit microprocessor. The designers need a rapid feedback to verify their designs. Obviously, with pruning, the technique that can cut off part of search tree, we can save some computation time.

We propose two possible areas for research: (1) hierarchical and pruning techniques and (2) parallel processing. The former will be considered a primary area that tremendous development effort and computer time are required. The latter will be considered as a secondary area and depends on that if there is any competent student who is interested in doing it. Besides, some extension from the previous project, see attachment I.1, will be studied during this period: testing and chip generation. Explanation can be found in the following section (Thesis Directed).

Conferences Attended: C. Yang, R. Scott, and D. Johnson, "Optimal Topologies for Small Scale Multiprocessor Workfarms," in preparation, Abstract submitted to Annual Symposium on Parallel Processing.

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T. Hsu and C. Yang, "Object Recognition by Hashing Techniques," Intl. Computer Symp., Dec 1988.

Theses Directed: "Channel and Switchbox Routing Using a Greedy Channel Algorithm with Outward Scanning Technique," M. Roderick, <u>M.S.</u> <u>Thesis</u>, Dec 1988.

"A Pad Frame Generator with Automatic Channel Routing for VLSI Chip Assembly," David Carlton, <u>M.S.</u> <u>Thesis</u>, Dec 1988.

"Design of Multible-Valued Programmable Logic Arrays," Y.H. Ko, <u>M.S.</u> <u>Thesis</u>, Dec 1988.

"A CAD Tool for Current-Mode Multiple-Valued CMOS Circuits," H.S. Lee, <u>M.S.</u> <u>Thesis</u>, Dec 1988.

Title: Underwater Acoustic Propagation and Scattering in a Random Ocean - A Linear Systems Theory Approach

Investigator: Lawrence J. Ziomek, Associate Professor of Electrical and Computer Engineering

Sponsor: Office of Naval Research

Objective: To develop both a mathematical and a numerical ocean acoustic propagation model based on the principles of linear, time-variant, space-variant, random filter theory and the physics of wave propagation in random media.

Summary: Both a random, time-invariant, space-variant transfer function of the ocean volume and its corresponding coherence function were derived based on three-dimensional ray acoustics. New expressions for the amplitude, eikonal, and phase along a ray path were derived. Comparisons between the transfer function approach and both the path-integral technique and the Rytov method for weak fluctuations were made. It was shown that the transfer function approach was analogous in concept with the path-integral technique, although the transfer function approach is more general. The transfer function approach was also shown to be in agreement with the Rytov method for weak fluctuations. In addition, a transfer function of a Pekeris waveguide was also derived. Preliminary computer code implementing the transfer function of a Pekeris waveguide has been written and partially validated. Computer code implementing the transfer function of the ociean volume based on the WKB approximation is in progress.

Publications: L. J. Ziomek and R. J. Blount, Jr., "Underwater Acoustic Model-Based Signal Processing," IEEE Transactions on Acoustics, Speech, and Signal Processing, Vol. ASSP-35, No. 12, pp. 1670-1683, Dec 1987.

L. J. Ziomek and C. D. Behrle, "Localization of Multiple Broadband Targets Via Frequency Domain Adaptive Beamforming for Planar Arrays," accepted for publication by the <u>Journal</u> <u>of</u> <u>the</u> <u>Acoustical</u> <u>Society</u> <u>of</u> <u>America</u>, to appear in the February or March 1989 issue.

L. J. Ziomek, "Linear Time-Invariant Space-Variant Filters and Three-Dimensional Ray Acoustics," in review by the <u>IEEE</u> <u>Transactions</u> <u>on</u> <u>Oceanic</u> <u>Engineering</u>.

Conferences
Presentations:
L. J. Ziomek and C. D. Behrle, "Localization of Multiple Broadband Targets Via Frequency Domain Adaptive Beamforming for Planar Arrays," Conference Record Twenty-first Asilomar Conference on Signals, Systems, and Computers, pp. 411-415, 2-4 Nov 1987, Pacific Grove, Calif.

L. J. Ziomek, L. A. Souza, and P. R. Campbell, "Pulse Propagation in a Ramdom Ocean-A Linear Systems Theory Approach," submitted to Oceans `89, an international conference, 18-21 Sept 1989, Seattle, Wash.

Theses
Directed:
M. D. Budney, "Target Localization in an Inhomogeneous Medium," <u>M.S.</u> <u>Thesis</u>, Dec 1987.

C. D. Behrle, "Computer Simulation Studies of Multiple Broadband Target Localization Via Frequency Domain Adaptive Beamforming for Planar Arrays," <u>M.S.</u> <u>Thesis</u>, Mar 1988.

N. V. Nikitakos, "A Comparison of Two Frequency Domain Adaptive Beamforming Algorithms for Sonar Signal Processing," <u>M.S.</u> <u>Thesis</u>, Dec 1988.

DEPARTMENT
OF
METEOROLOGY

DEPARTMENT OF METEOROLOGY

The research program in the department of Meteorology continues in several areas: 1) numerical air/ocean modeling and prediction, 2) dynamics of fronts and flow over and around mountains, 3) analysis and dynamics of tropical weather systems, 4) atmospheric boundary layers over the sea and ice, 5) regional weather studies and 6) remote sensing. A number of related investigations have been pursued by various faculty members under each of these headings.

NUMERICAL MODELING AND PREDICTION

R.T. Williams is developing and testing numerical procedures for global and regional weather prediction. He is investigating various finite element formulations with respect to treatment of small-scale flow fields. He is also applying the techniques to the prediction on air flow cyclogenesis. R.T. Williams, C.P. Chang, and M.S. Peng are investigating the "Mei-Yu" front over eastern asia with a dynamical front model.

M.A. Rennick and R.L. Haney have completed their study of large-scale air-sea interaction in the tropics using coupled numerical models. The study produced an analytic solution for the transient response of a closed equatorial ocean basin to a specified atmospheric wind anomaly, and it also showed the effects that various upper ocean thermal processes (such as vertical mixing, horizontal advection, etc.) have on the stability of the coupled ocean-atmosphere system relevant to El Nino.

R.L. Elsberry and L.K. Shay are using a three-dimensional ocean model to simulate the response to passage of a hurricane. The present focus is on comparing the predicted response to recent observations of currents and temperature in the ocean after hurricane passage.

Numerical-observational studies of rapid maritime cyclogenesis events are being pursued by R.L. Elsberry, C.-S. Liou, W.A. Nuss and C.H. Wash. Diagnostic studies of analyses and predictions by the Naval Operational Regional Atmospheric Prediction System (NORAPS) are used to evaluate physical processes that occur during rapid cyclogenesis. R.L. Elsberry and C.-S. Liou are also investigating methods to improve NORAPS performance in analyzing and predicting cyclogenesis.

J.W. Glendening is developing a finite-element model for the atmospheric boundary layer, using second-order closure to predict turbulence production and transport. This model will aid analysis of boundary layer structure and its temporal and spatial variation in the arctic marginal ice zone. In addition, he is employing large-eddy closure techniques to study boundary layer development in a strongly baroclinic zone and also as a test of the parameterizations of his second-order closure model.

Our modeling efforts include 1) a marine atmospheric boundary layer model for predicting (6-12 hours) properties that affect radar and optical propagation within the boundary layer, and those factors (radiation and boundary fluxes) that affect the upper part of the ocean, directed by K.L. Davidson, and 2) a numerical investigation of the dynamics and prediction of synoptic-scale variability in the coastal ocean off California, led by R.L. Haney.

DYNAMICS OF FRONTS AND FLOW OVER AND AROUND MOUNTAINS

R.T. Williams is studying the conditions that determine whether or not the air will flow over or around a long mountain range. The formation of cyclones in the lee of mountain complexes is being investigated. Also, R.T. Williams and M.S. Peng are studying the interactions of fronts with topography.

ANALYSIS AND DYNAMICS OF TROPICAL WEATHER SYSTEMS

C.-P. Chang, R.T. Williams, C.-S. Liou and M.S. Peng continue to investigate various aspects of the dynamics of tropical weather systems, the dynamics of tropical synoptic and planetary motions and lateral interactions. The diagnostic analysis of East Asian monsoon circulations is being pursued by C.-P. Chang, C. S. Liou, and M.S. Peng.

A multi-year basic research program to understand the dynamics of tropical cyclone motion has begun. R.L. Elsberry serves as the Technical Director of the overall research initiative at the Office of Naval Research. R.T. Williams and M.S. Peng are developed analytical and numerical models of tropical cyclone motion, and the 1988 research Chair incumbent, G.J. Holland, has also been involved in this research program. R.L. Elsberry and associates continue applied research efforts to improve tropical cyclone prediction via statistical evaluations and expert systems.

ATMOSPHERIC BOUNDARY LAYERS OVER THE SEA AND ICE

Research in this area includes several interdisciplinary shipboard and land-based observational and theoretical projects involving K.L. Davidson, W.J. Shaw, P.S. Guest, and a Ph. D. Student. Recent observational projects have occurred in the Marginal Ice Zone of the East Greenland Sea and across an ocean front in the Northwest Atlantic Ocean. The marginal ice zone experiment was conducted in March and April 1987 and included measurements from three ships. The ocean front experiment was performed in February 1986, and analyses are being performed on the multi-platform data set. Objectives of the individual projects are 1) to evaluate and formulate models that relate changes in the depth and structure of the atmospheric boundary layer to surface fluxes and sky conditions, 2) to evaluate and formulate models for equilibrium marine aerosol distributions, 3) to establish synoptic-scale descriptions of the magnitude and height variations of optical turbulence, and 4) to evaluate synoptic-scale forcing on the boundary layer processes and evolutions in the marginal ice

zone.

W.J. Shaw continued investigations of mesoscale variability in the coastal and marine atmospheric boundary layers. Aircraft data collected aboard the NSAR Electra research aircraft in the Sargasso Sea are being analyzed to determine the mechanisms involved in the response of the atmosphere to an open-ocean front. W.J. Shaw, K.L. Davidson, and P.A. Durkee executed a measurements program with NEPRF and NOAA's Wave Propagation Laboratory in the sea-breeze circulation in the Salinas Valley, California. This study involved acoustic sounder, surface measurements, rawinsondes, and doppler lidar in one of the most extensive sea-breeze measurements experiments that has been undertaken.

J.W. Glendening and K.L. Davidson are modeling atmospheric boundary layer development over the marginal ice zone, using a second-order turbulence closure model to predict both spatial and temporal changes of temperature, wind and turbulence. This model will operate in conjunction with measured profiles to allow analysis of mechanisms producing the observed boundary layer structure.

REGIONAL WEATHER STUDIES

F.R. Williams and R.J. Renard are continuing the development of Forecaster's Handbook for Central America and adjacent ocean areas that will include sections on climatology, air/ocean circulations and thermal features that are important to Naval air/sea operations. The handbook will contain case studies of hurricanes striking Central America during 1988--the first to do so since 1980.

R.J. Renard and staff associates continue the development of statistical forecasting techniques applied to Antarctic operational weather parameters, especially visibility in the vicinity of McMurdo, Antarctica.

REMOTE SENSING

K.L. Davidson is involved in experimental verification on mechanisms responsible for scatterometer and synthetic aperture radar (SAR) images of the ocean surfaces. Analyses were completed on surface stress data from a tower off the California Coast, near San Diego and were collected in conjunction with aircraft and tower radar measurements. Another experiment performed in an area off the coast of Norway related surface stress to information gathered by ship and airborne SAR and scatterometers. This was a high wind and high sea-state experiment. P.A. Durkee is examining the relationship between satellite-detected visible and infrared radiance and extinction by aerosols. C.H. Wash and P.A. Durkee are applying interactive computer techniques to GOES and NOAA visual, infrared and other radiometric data to specify cloud and precipitation patterns using the NEPRF Satellite Processing and Acquisition System and the NPS Interactive Digital Environmental

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Analysis Laboratory. An automated satellite cloud and precipitation analysis algorithm was delivered to NEPRF to be part of the Tactical Environmental Support System (TESS). C.H. Wash is using high resolution Space Shuttle photography to better understand mesoscale cloud structure in NASA and DMSP imagery.

Title:	Tropical and Monsoon Studies
Investigators:	C.-P. Chang, Professor of Meteorology R.T. Williams, Professor of Meteorology
Sponsor:	National Science Foundation
Objective:	To study the structure and dynamics of large-scale motions in the tropics and monsoon regions.
Summary:	This project includes three major components in the study of tropical and monsoon dynamics: 1) theoretical studies of planetary scale motion forced by tropical heating; 2) observational studies of planetary and synoptic scale motions related to tropical forcing and midlatitude-tropical interactions, and 3) numerical simulation of the Mei-Yu system of the East Asian summer monsoon and the effect of topography on fronts.
Publications:	C.-P. Chang and H. Lim, "Kelvin Wave-CISK; A Possible Mechanism for the 30-50 Day Oscillations," Journal of Atmospheric Science, 45, pp. 1709-1720, June, 1988.
	C.-P. Chang, "Dynamics of Winter Monsoon Cold Surges," 2nd WMO/MOSTE Proceedings Regional Workshop on Asian Winter Monsoon, SMO Tropical Meteorology Research Program Report, 30, 1-7, June, 1988.
	C.-P. Chang, M.S. Peng, and J.S. Boyle, "Interannual Variations of Tropical Divergence at 200 mb during Northern Winter," Proceedings of the International Symposium on TOGA and Air-Sea Interaction over the Western Pacific, December, 1988.

Title:	Wind Analysis Over Tropical Oceans During TOGA
Investigators:	C.-P. Chang, Professor of Meteorology M.S. Peng, Adjunct Professor of Meteorology
Sponsor:	NOAA
Objectives:	To study the feasibility of using satellite cloud-derived winds to enhance surface analysis over the tropical Pacific during the Tropical Ocean and Global Atmosphere Experiment, and to study the effect of tropical sea-surface temperature on global circulations.
Summary:	FNOC Tropical Global Band data are being used for two different studies. The first is to enhance the tropical marine wind analysis using the low-level cloud drift winds and numerical weather prediction wind shear. This scheme has been tested for a few cased and is being expanded to a longer period. In addition, the 200 mb data stream function and velocity potential are analyzed to study the possible effect of tropical convection on the teleconnection pattern over the North Pacific during winter.
Publication:	C.-P. Chang, M.S. Peng, and J.S. Boyle, "Interannual variations of Tropical Divergence at 200 mb during Northern Winder," Proceedings of the International Symposium on TOGA and Air-Sea Interaction over the Western Pacific, December, 1988.

Title:	Meteorological Studies of Arctic Regions
Investigators:	K.L. Davidson, Professor of Meteorology; W.J. Shaw, Associate Professor of Meteorology; J.W. Glendening, Adjunct Professor, and P.S. Guest, Meteorologist
Sponsor:	Office of Naval Research (ONR-1125-AR,1244)

Objective: Current objective of continuing Arctic Meteorology studies were to make progress on analyses/interpretations of meteorological data collected in two Marginal Ice Zone Experiments (MIZEX-84 and -87) and to prepare for and perform measurements in the Coordinated Eastern Arctic Experiment (CEAREX).

Summary: FY 87-88 analyses/interpretations yielded results which show that procedures adapted for ship board and ice flow collection of the surface stress data in the MIZEX's have proven successful (e.g. Guest and Davidson, JGR, 1987). More recent interpretations have been made from summer MIZEX's (83 and 84) radiation (Francis et al., JOC, 1989) and rawinsonde (Willis, NPS Thesis, 1987) results.

Considerable analysis effort in FY88 was directed toward data collected in the winter-spring experiment (MIZEX-87). MIZEX-87 included data collection from 3 ships, aircraft remote sensing and satellites. Initial studies of these data were of synoptic and mesoscale atmospheric feature which occurred (Shultz, 1987 and Dinkler, 1988, NPS MS Theses). The next studies were of refractive conditions obtained from rawinsonde profiles (Groters, NPS Thesis, 1988; Shaw et al., 1988).

Meteorological instrumentation including radiation sensors, a rawinsonde system, a SODAR and profile mast in addition to that for standard parameters were on R/V Polarbjorn in September 1988 when she departed Tromso No for the CEAREX drift phase. Near continuous data collection of all but ice floe (SODAR Profile Mast) data occurred through December even with abrupt ending (due to floe break-ups) of the planned drift experiment in the third week of November.

Publications: P.S. Guest and K.L. Davidson, "MIZEX 87 Meteorology Atlas," NPS-63-88-004 February, 1988, p. 137.

P.S. Guest, K.L. Davidson, and C.A. Vaucher, "Atmospheric Boundary Layer Features Observed in the Spring Marginal Ice Zone," Proceedings of the 2nd AMS Conference on Polar Meteorology and Oceanography, Madison, WI., March 29-31, pp. 73-74, 1988.

K.L. Davidson, R.R. Schultz, and R.W. Fett, "Observations of Fram Strait Ice Edge Westward Propagating Wave," Proceedings Second AMS Conference on Polar Meteorology and Oceanography, Madison, WI., March 1988. p. 15.

K.L. Davidson and J.E. Overland, "Boundary Layer Processes in the Seasonal Ice Zone," Proceedings Second AMS Conference on Polar Meteorology and Oceanography, Madison, WI., March, 1988. p. 56.

Conference
Presentations: K.L. Davidson and P.S. Guest, "Wind Stress Observation in the Spring Arctic Marginal Ice Zone," AGU Ocean Sciences Meeting, New Orleans, LA., January 18-22, 1988.

K.L. Davidson, "Meteorological Instrumentation and Measurement," MTS/IEEE/OES Workshop on Instrumentation and Measurements in the Polar Regions, Monterey, CA., January 27-29, 1988.

K.L. Davidson, R.R. Schultz, and R.W. Fett, "Observations of Fram Strait Ice Edge Westward Propagating Wave," Second AMS Conference on Polar Meteorology and Oceanography, Madison, WI., March 29-31, 1988.

K.L. Davidson and J.W. Overland, "Boundary Layer Processes in the Seasonal Ice Zone," Second AMS Conference on Polar Meteorology and Oceanography, Madison, WI., March 29-31, 1988.

W.J. Shaw, K.L. Davidson, Z. Willis, and D. Groters, "Horizontal Variability of Mean Refractive Structure in the Arctic," Conference on Microwave Propagation in the Marine Boundary Layer, (Naval Env. Pred. Res. Fac.) Monterey, CA. September, 1988.

Theses
Directed:

D.J. Groters, "Temporal and Spatial Variability of the Marine Atmospheric Boundary Layer and its Effect on Electromagnetic Propagation in and Around the Greenland Sea Marginal Ice Zone," NPS Master's Thesis, June, 1988.

K.L. Dinkler, "The Variability of the Marine Atmospheric Boundary Layer in the Greenland Sea Marginal Ice Zone: A Case Study," NPS Master's Thesis, December, 1988.

Title:	Remote Sensing and Air Sea Interaction
Investigators:	K.L. Davidson, Professor of Meteorology; P. Durkee, Associate Professor of Meteorology, and C. Skupniewicz, Physical Scientist
Sponsor:	Office of Naval Research (ONR-112D1)
Objective:	Current objective in these continuing studies were to: 1) Interpret tower/shipboard obtained wind stress value collected in the TOWARD/FASINEX experiments with regard to the influence of local SST and wave feature and to combine them with radar obtained results and to 2) collect and perform preliminary analyses on surface wind stress obtained from a ship and a buoy in NORCSEX (March-April, 1988) and from a tower and a buoy in the SAXON (September-October, 1988) experiment.

Summary: FY 88 accomplishments were as follows for the different experiments:

TOWARD: Analyses and interpretation of TOWARD surface wind stress values were completed and results described in Geernaert (JGR, 1988). The tower obtained mean drag coefficients for this coastal location were sightly less than open ocean values.

FASINEX: Comparison and interpretation were made of variation across a SST from of wind stress and radar backscatter and described by LI et al (JPO, 1989). The backscatter and stress values decreased, with the same percentage, from the warm to cold side.

NORCSEX: Continuous measurements were made of surface layer mean vector wind, temperature, humidity and turbulent wind were made in the MORCSEX region (Haltenbaken) from the R/V Haakon Mosby from March 3-27, 1988 and from a buoy for a 40 hour period from March 8-10, 1988. Friction velocity and ship mounted scatterometer (X, C, and L band) backscatter values have a best fit relation with tow linear segments with subgroups corresponding to wind speeds less than 6 m/s and greater than 8 m/s.

SAXON: Sonic anemometer, hot-film and supporting surface layer meteorology data were collected for 300 hours from the Chesapeake Light Tower in September and

October, 1988.

Publications: G.L. Geernaert, G.L. Davidson, S.E. Larsen, and T.M. Mikkelson, 1988; "Wind Stress Measurements during the Tower Ocean and Radar Dependence Experiment," Journal Geophysical Research, 93, pp. 13913-13924, November, 1988.

Title:	Aerosol Properties of the Marine Atmospheric Boundary Layer
Investigators:	K.L. Davidson, Professor of Meteorology; P.A. Durkee, Associate Professor of Meteorology, and W.J. Shaw, Associate Professor of Meteorology
Sponsor:	Naval Ocean Systems Center
Objective:	Current objectives of analyses/ interpretations and data collection in these continuing studies were to verity or formulate equilibrium marine aerosol models for, a) vertical variation in overwater regimes of mid and subtropical regions and b) surface layer as influence by advection in Marginal Ice Zone (MIZ) region.

Summary: Primary analyses/interpretation efforts were with MIZEX-84 and SNI-87 surface and rawinsonde data sets to establish general conditions (Willis 1987, Mineart 1988, and Starck 1988, NPS MS Theses). The examinations are especially being directed toward the role of entrainment and advection on features in the boundary layer. Guest et al. (1988) and Hanson et al. (1988) *describe the wind range* of data and the complex nature of the boundary layer in the vicinity of San Nicolas Island (SNI), California during July 1987 (SNI). These are the results of ship/aircraft/island measurements of boundary layer structure and aerosol properties made in SNI-87.

Progress on analysis of aerosol data from aircraft in the West North Atlantic Frontal Air-Sea Interation Experiment (FASINEX) and from ship in SNI-87 did progress as far as surface and mixed-layer data associated with it. The FASINEX aircraft aerosol data were obtained from other groups participating with the NCAR Electra and the NOAA P-3.

The SNI-87 R/V Point Sur aerosol data have been coupled with the shipboard meteorological data but examinations of the combined set have not been performed. Further evaluations of the vertical aerosol model (NOVAM) have been performed (de Leeuw and Davidson 1989) incorporating profile properties of aerosol as well as temperature and humidity derived from continuing

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analyses.

Publications:

P.S. Guest, C.A. Vaucher, S.R. Fellbaum and K.L. Davidson, "A Near Surface Wind Maximum of the Southern California Coast, "Proceedings Fourth AMS Conference on Meteorology and Oceanography of the Coastal Zone, Anaheim, CA., February 1-3, 1988. pp. 21-23.

G.L/ Geernaert, K.L. Davidson and P.S. Guest, "Observed Short-term Characteristics of the Marginal Ice Zone Planetary Boundary Layer and its Impact on Elevated EM Ducting," Radio Science, 1988.

Conference
Presentations:

P.S. Guest, C.A. Vaucher, S.R. Fellbaum, and K.L. Davidson, "A Near Surface Wind Maximum of the Southern California Coast," Proceedings Fourth AMS Conference on Meteorology and Oceanography of the Coastal Zone, Anaheim, CA. February 1-3, 1988.

H.P. Hanson, K.L. Davidson, H. Gerber, S. Khalsa, K.A. Kloesel, R. Sschwiesow, J.B. Snider, D.M. Wielicki, and D.P. Wylie, "FIRE Aircraft/Island/Ship/Satellite Intercomparison: Preliminary Results for July 16, FSET Workshop, Vail, CO., July 6-8, 1988.

Publications:

G.M. Mineart, "Multispectral Satellite Analysis of Marine Stratocumulus Cloud Microphysics," NPS MS Thesis, March, 1988.

S. Smolinski, "Marine Boundary Layer Depth and Relative Humidity Estimates Using Multi-Spectral Satellite Measurements," NPS MS Thesis, March, 1988.

D.E. Starck, "Assessment of Regional Refractive Conditions Using Rawinsonde and Satellite Imagery Data," NPS MS Thesis, September, 1988.

Title: Atmospheric Forcing in Ocean-Atmosphere Mixed Layer Processes and Humidity Transfer

Investigators: K.L. Davidson, Professor of Meteorology, W.J. Shaw, Associate Professor of Meteorology and P.J. Boyle, Meteorologist

Objectives: Current objectives in these continuing studies are to complete coordinated (with other platform groups) analyses and interpretation of atmospheric surface and boundary layer data obtained in the Frontal Air Sea Interaction Experiment (FASINEX) and in the Humidity Exchange main Experiment (HEXMAX).

Summary: FASINEX results pertain to the shipboard measured influence of the SST on surface and mixed layer properties. Rawinsonde measured boundary layer profiles indicate that for the FASINEX period advective (synoptic scale) influence ont eh mixed layer were dominant over SST influences. Spatial and temporal descriptions from the long and uninterrupted ship program are necessary to establish the relative role of advection and SST influence. The combined aircraft scatterometer/wind stress and shipboard wind stress results described by Li et al. (1989) show dynamic variation across an SST front better than any previous results.

HEXMAX results pertain to shipboard (R/V Frederick Russell) measured influence of and location, relative to proximity to a coastal located tower (MPS - with 15 meters water depth), and storm fronts on the surface wind stress (drag coefficient). Initial coordinated HEXMAX analyses showed higher than expected drag coefficients from dissipation and covariance methods on MPN. Examinations of ship value when it was near MPN to those when it was at a location, with 18 meter water depths, 60-65 KM West Southwest of MPN revealed no significant difference between the two locations. However, MPN values were to 15 to 20% higher than the ship values when the ship was near it.

Publications:	S.R. Fellbaum and K.L. Davidson, et al. "Frontal Air-Sea Interaction Experiment (FASINEX) Shipboard Meteorology Data and Weather Atlas," NPS-63-88-002, January, 1988. p 98.
	K.L. Davidson, W.J. Shaw, and W.G. Large, 1988b "Wind Stress Results from Multi-Platform and Multi-Sensor Measurements in FASINEX," Proceedings 7th AMS Conference on Air-Sea Interactions, Anaheim, Ca,. pp. 132-136, February, 1988.
	K.L. Davidson, P.J. Boyle, S.R. Fellbaum, and J. Mundy, 1988a:"Atmospheric Surface and Mixed Layer Properties Observed from Ships in FASINEX," Proceedings 7th AMS Conference on Air-Sea Interactions, Anaheim, CA., pp. 161-165, February, 1988.
	K.L. Davidson, S.A. Fellbaum, C.E. Skupniewicz, and D.E. Speil, "Naval Postgraduate School Turbulent Flux Results from the RRS Frederick Russell," Proceedings of NATO Advanced Workshop on Humidity Exchange over the Sea, Dellenhoven, Epe, Netherlands, April 25-29, 1988. pp. 129-135.
Conference Presentations:	K.L. Davidson, W.J. Shaw, and W.G. Large, 1988b: "Wind Stress Results from Multi-Platform and Multi-Sensor Measurements in FASINEX," 7th AMS Conference on Air-Sea Interaction, Anaheim, CA., February 1-3, 1988.
	K.L. Davidson, P.J. Boyle, S.R. Fellbaum and J. Mundy, 1988a: "Atmospheric Surface and Mixed Layer Properties Observed from Ships in FASINEX," 7th AMS Conference on Air-Sea Interaction, Anaheim, CA., February 1-3, 1988.
	K.L. Davidson, S.A. Fellbaum, C.E. Skupniewicz, and D.E. Spiel," Naval Postgraduate School Turbulent Flux Results from the RRS Frederick Russell," NATO Advanced Workshop on Humidity Exchange Over the Sea Dellenhoven, Epe, Netherlands, April 25-29, 1988.

Title:	Satellite Detection of Marine Atmospheric Boundary Layer (MABL) Characteristics
Investigator:	P.A. Durkee, Associate Professor of Meteorology
Sponsor:	NPS Direct Funded - ONR Sponsored
Objective:	To investigate new techniques for detecting characteristics of the marine atmospheric boundary layer. The program of study was to include participation in field experiments and theoretical radiative transfer calculations to provide physical basis for the observations.
Summary:	This project was designed as a three-year effort that began in FY85. The major accomplishment so far has been the quantization of the effect of aerosol particles above the marine boundary layer on the various techniques for boundary layer characterization. Also, development was begun on a technique designed to estimate boundary layer thickness and relative humidity from satellite measurements of optical depth and total water vapor. The technique uses data from only on satellite sensor, but at various wavelengths. The techniques is computationally efficient and will provide estimated over wide areas of cloud-free ocean.
Conference Presentations:	P.A. Durkee, R. Kren, and S. Smolinski, 1988: Marine Boundary Layer Depth and Humidity Estimations from Satellite Measured Optical Depth and Total Water Content, 3rd Conference on Satellite Meteorology and Oceanography, American Meteorological Society, January 31 - February 5, 1988. Anaheim, CA.
	P.A. Durkee and G.M. Mineart, 1988: "Aerosol and Cloud Microphysical Effects on Marine Stratocumulus Reflectance from Multi-Spectral Satellite Measurements," Presented at International Radiation Symposium, Lille, France, August 18-24, 1988.

P.A. Durkee, J.G. Hudson, and G.M. Mineart, 1988: "Aerosol effect on Marine Stratocumulus Development Observed from Multi-spectral satellite measurements, Presented at the 12th International Conference on Atmospheric Aerosols and Nucleation, Vienna, Austria, August 22-27, 1988.

Theses
Directed:

LT G. Mineart, "multi-spectral Satellite Analysis of Marine Stratocumulus Cloud Microphysics, MS Thesis, March, 1988.

LCDR S. Smolinski, "Marine Boundary Layer Depth and Relative Humidity Estimates using Multispectral Satellite Measurements," MS Thesis, March, 1988.

LT S. Morehead, "Ship Track Cloud Analysis for the North Pacific Area," MS Thesis, June, 1988.

Title:	Electronic Weapon System Satellite Support
Investigator:	P.A. Durkee, Associate Professor of Meteorology
Sponsor:	NPS Direct Funded - NEPRF Sponsored
Objective:	To develop a method to estimate visibility from satellite measurements of upwelling radiance. Also to evaluate the Defense Meteorological Satellite Program Operational Linescan System (DMSP OLS) and the NOAA Advanced Very High Resolution Radiometer (AVHRR) for their ability to provide input to the visibility estimation scheme.

Summary:	The DMSP and AVHRR sensors were evaluated for their potential for visibility estimations. The DMSP system was found to have severe limitations due to a low signal noise ratio and to ambiguities in the upwelling radiance from the ocean rface. The AVHRR system has considerable high signal to noise and the spectral response limits the ocean surface contribution to upwelling radiance. The AVHRR system also is able to measure radiance at multiple wavelengths which provides indications of the vertical distribution of aerosol particles. Four radiative transfer approximations were tested for their suitability in a visibility estimation scheme. Fortunately the simplest and the most easily inverted approach provides accuracy within our current ability to measure aerosol optical depth from satellites. Therefore, the first version of a visibility estimation technique will be simple and easy to evaluate. The project is continuing and is expected to begin producing visibility climatologies of various ocean basins.

Theses Directed:	LT Ed Frost, "Global Estimates of Aerosol Particle Characteristics," MS Thesis, December, 1988. LCDR R. Shema, "Correlation of Satellite-Detected Aerosol Characteristics and Oceanic Dimethyl Sulfide (DMS), MS Thesis, December, 1988.

Title:	Tropical Cyclone Prediction Studies
Investigator:	R.L. Elsberry, Professor of Meteorology
Sponsor:	Naval Environmental Prediction Research Facility
Objective:	To improve the accuracy of the tropical cyclone forecast guidance to the fleet. One goal of this continuing project is to produce a more objective approach to the tropical cyclone prediction. New technology such as decision-tree algorithms and expert systems offer potential for future improvements in forecasts.

Summary: An objective technique for forecasting 24, 48, and 72 h intensity of Western North Pacific tropical cyclones has been developed (elsberry, Weniger, and Measnor, 1988). Environmental wind information is included via empirical orthogonal functions of operationally-analyzed wind fields. Based on dependent sample verifications, the regression equations stratified by storm intensity appear to offer improvements relative to the official forecasts at 48h and 72h.

Relative vorticity fields calculated from operational wind analyses are shown to be a useful diagnostic tool to anticipate tropical cyclone turning motions (Sherman, 1988; Elsberry, 1988). In a number of case studies, the development of specific deformations of the vorticity patterns seem to offer guidance to the forecasters to anticipate turning motions. Further testing by operational forecasters is suggested.

A prototype expert system has been developed to forecast typhoon conditions at Cubi Point, Philippines (Hagaman, 1988). One set of rules modifies the storm position and strength forecast to account for terrain interactions while crossing the Philippines. A second set estimates the local winds given the modified storm position and intensity. A conservative strategy of using worst-case wind gust estimates contributes to an over-prediction of the local winds. Never-the-less, the prototype indicates the potential of expert systems for local wind event predictions.

Publications: R.L. Elsberry, E.L. Weniger, and D.H. Meanor, "A Statistical Tropical Cyclone Intensity Forecast Technique Incorporating Wind and Vertical Wind Shear Information," Monthly Weather Review, 116, pp. 2142-2154, November, 1988.

Conference
Presentations: R.L. Elsberry, "Recent Cyclone Research at the Naval Postgraduate School," Proceedings, Environmental Group U.S. Pacific Command Tropical Cyclone Conference, Guam, pp. 286-287, February 9-12, 1988.

Theses
Directed: B.T. Sherman, "Synoptic Patterns Related to Tropical Cyclone Recurvature," MS Thesis, March, 1988.

                             B.M. Hagaman, "A Prototype Expert System Typhoon Condition at Cubi Point, Philippines," MS Thesis, September, 1988.

Title:	Tropical Cyclone Motion Studies
Investigator:	R.L. Elsberry, Professor of Meteorology
Sponsor:	Office of Naval Research
Objective:	To improve basic understanding of tropical cyclone motion. The primary focus is on understanding the role of tropical cyclone structure. The ultimate goal in this five-year program is the development of improved methods of forecasting the track of tropical cyclones,which pose one of the primary peacetime threats to the safety of fleet operating units.

Some aspects of tropical cyclone structure on tropical cyclone motion have been examined with a nondivergent, barotropic numerical model with no basic current (Fiorin and Elsberry, 1988a). Vortex translation associated with the beta effect depends sensitively on the strength of the flow between 300 and 1000 km form the center. The dynamics of this beta-drift is studied via decomposition into symmetric and asymmetric circulations. The asymmetric circulation is dominated by an azimuthal wavenumber ohe circulation with a nearly uniform board scale ventilation flow between an anticyclone gyre to the East and cyclonic gyre to the West. The linear beta term is responsible for the initial formation of the asymmetric gyres. Nonlinear advection of the asymmetric circulation by the symmetric vortex flow twists the interior region between the gyres and orients the ventilation flow toward the Northwest rather than toward the North.

A two-dimensional Fourier decomposition procedure is used to isolate small, medium, and large scale components of some typical tangential wind profiles used in theoretical studies of tropical cyclone motion (Fiorino and Elsberry, 1988b). The vortex that projects into the largest scales. The medium and small scales have a significant effect on the direction of motion by influencing the rotation of the asymmetric gyres that are induced primarily by the largest scales.

Two technical reports on the progress and plans for the ONR Accelerated Research Initiative have been produced. First,

Elsberry (1988a) describes a workshop that reviewed the first-year progress, the future research issues and the tentative hypotheses for the field experiment. The second report (elsberry 1988b) summarizes additional progress and refines the primary issues to be addressed. Planning for the field experiment was begun with a series of working groups.

Publications:
R.L. Elsberry, "ONR Tropical Cyclone Motion Research Initiative: First-year Review, Discussion and Tentative Hypotheses," NPS-63-88-003, 1988. p. 86.

R.L. Elsberry, "ONR Tropical Cyclone Motion Research Initiative: Mid-year Review, Discussion and Working Group Reports," NPS-63-88-005, 1988. p. 103.

Conference
Presentations:
R.L. Elsberry, "Update on the Navy (ONR) Tropical Cyclone Motion Initiative," Proceedings, 42nd Interdepartmental Hurricane Conference, Homestead AFB, FL. A-23, January 12-15, 1988.

M. Fioring and R.L. Elsberry, "Role of Vortex Structure in Tropical Cyclone Motion," International Conference on Tropical Meteorology," Brisbane, Australia, July 4-8, 1988.

R.L. Elsberry and R.F. Abbey, "Tropical Cyclone Motion -- A Basic Research Initiative," International Conference on Tropical Meteorology, Brisbane, Australia, July 4-8, 1988.

R.L. Elsberry, "Recent Tropical Cyclone Motion Research," 21st Session of Typhoon Committee, Manila, Philippines, November 22-28, 1988.

Title:	Ocean Responses to Strong Atmospheric Forcing
Investigators:	R.L. Elsberry, Professor of Meteorology; L.K. Shay, Adjunct Research Professor
Sponsor:	Office of Naval Research
Objective:	The current research task addresses the ocean current response to strong atmospheric forcing events (hurricanes, low-level atmospheric jets, etc.) within the context of near inertial wave dynamics that is linked to vertical current shear and mixing events in the upper ocean.

Summary:	To isolate dominant forcing mechanisms or processes, observations acquired during atmospheric forcing events are analyzed and modeled using simple linear models or primitive numerical models. A linear model capable of simulating the near-inertial response is predominantly baroclinic, a small, but detectable, barotropic component is found in the near-inertial wave band. The simulated mesoscale features from the linear model agree fairly well with observations acquired in Hurricanes Nobert and Frederic. A Joint NAVY/NOAA aircraft based, air-sea interaction experiment was conducted during the passage of Hurricane Gilbert (September 14-19, 1988). A total of 82 Airborne expendable Current Profilers (AXCP's) were successfully deployed by the NOAA WP-3's on five research flights in the Gulf of Mexico prior, during the subsequent to Gilbert. The Sea Surface Temperature (SST) response measured by AXCP's in the wake of Gilbert is being compared with satellite-driven SST's from the Advanced very High Resolution Radiometer (AVHRR), the NOAA operational analyses and from downward-looking radiometer observations on-board the NOAA WP-3 aircraft.

Publications:	L.K. Shay, R.L. Elsberry and P.G. Black, "Vertical Structure of the Ocean Current Response to Hurricane Norbert," EOS 69 (16) p. 385, 1988. L.K. Shay, S.W. Chang, and R.L. Elsberry, "Free-surface Effects on the Ocean Current Response to Hurricanes, Part II: Comparison with Observation," EOS 69 (16), P. 381, 1988.

Conference
Presentations:
L.K. Shay, R.L. Elsberry and P.G. Black, "Mesoscale Ocean Current and Temperature Patterns Induced by Hurricanes," 17th Conference on Hurricanes and Tropical Meteorology, American Meteorological Society, Miami, FL.

L.K. Shay, R.L. Elsberry, and P.G. Black, "Vertical Structure of the Ocean Current Response to Hurricane Nobert, American Geophysical Union, Spring Meeting, Baltimore, MD., 1988.

L.K. Shay, S.W. Chang, and R.L. Elsberry, "Free-surface Effects on the Ocean Current Response to Hurricanes, Part II: Comparison with Observations, American Geophysical Union, Spring Meeting, Baltimore, MD, 1988.

Title: Observational-numerical Studies of Severe
                       Synoptic Weather Phenomena

Investigators: R.L. Elsberry and C.-S. Liou

Sponsor: Naval Environmental Prediction Research
                       Facility

Objective: To improve the accuracy of the forecast
                       guidance to the fleet on synoptic space and
                       time scales.

Summary: Combined observational and numerical studies
                       of severe synoptic systems such as tropical
                       cyclones and rapidly developing extratropical
                       cyclones to improve the accuracy of the
                       forecast guidance to the fleet on synoptic
                       space and time scales. A global Optimum
                       Interpolation (OI) analysis model is
                       adapted/modified to improve the regional
                       analysis and forecast of rapid cyclogenesis
                       events that occur in GALE OIP-2 and IOP-9.
                       I have developed computer software to
                       reformat the extra data observed in GALE dan
                       to merge them with the operational data set
                       so that the enhanced data set can be read by
                       Naval Operational Regional Atmospheric
                       Prediction Systems (NORAPS) to better analyze
                       and forecast the cyclogenesis events.

Conference
Presentations: C.-S. Liou, S.M. Heikkinen, C.H. Wash, W.A.
                       Nuss, and R.L. Elsberry: "Toward Improvement
                       in Predicting GALE IOP-2 and GALE IOP-9
                       Cases," Presented at GALE/CASP Workshop at
                       Val Morin, Canada, October, 1988.

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Title:	Eddy Generation Mechanisms in Eastern Boundary Current Regions
Investigator:	R.L. Haney, Professor of Meteorology
Sponsor:	Office of Naval Research
Objective:	The scientific objective of this research task is to use a multi-level primitive equation ocean model, along with specific data set collected in the Coastal Transition Zone (CTZ) program, to examine the role of winds and variable bottom topography in influencing jets and eddies in the California Current.
Summary:	Hydrographic (CTD) and current profiles (ADCP) data from the 1988 CTZ program will be used to form a composite description of the coastal jet off California, and the evolution of this composite jet over variable topography, with and without wind forcing, will be studies using a recently developed primitive equation model. The CTZ field data (repeated hydrographic stations during summer 1988) will also be used to perform data assimilation and model hindcast studies with the primitive equation model.
Presentations:	R.L. Haney, "Modeling Coastal Transition Zone (CTZ) Jets and Eddies," Fall Annual Meeting of the American Geophysical Union, San Francisco, December 5-9, 1988.
Thesis Directed:	C.D. Johnson, "Numerical Ocean Prediction in the California Coastal Region Using a High-Resolution Primitive Equation Model," MS Thesis, June, 1988.

Title:	Large-Scale Atmosphere Ocean Coupling
Investigators:	R.L. Haney, Professor of Meteorology and M.A. Rennick, Adjunct Professor of Meteorology
Sponsor:	National Science Foundation
Objective:	To improve our understanding of the physical basis of El Nino-Southern Oscillation (ENSO).

Summary: An analytic investigation of unstable air-sea interaction in a coupled reduced gravity ocean-atmosphere of the equatorial region has been completed. The results demonstrate the extreme sensitivity of the coupled air ocean system to processes that affect the ocean surface temperature. Numerical calculations using the nonlinear version of our model substantiate the basic conclusion of the analytic study, and provide further insight into processes that affect the sea surface temperature during the early phase of an ENSO event.

Publications: M.A. Rennick and R.L. Haney, "Solutions to the Shallow Water Equations in an Ocean Basin Forced by Unsteady Winds," NPS-63-88-006, October, 1988.

W.L. Benedict and R.L. Haney, "Contribution of Tropical Winds to Subseasonal Fluctuations in Atmospheric Angular Momentum and Length of Day," Journal of Geophys. Res., 93(D12), pp. 15,973-15,978, 1988.

Conference
Presentations: R.L. Haney and W.L. Benedict, "Contribution of Tropical Winds to Subseasonal Fluctuations in Global Angular Momentum and Length of Day," Fall Annual Meeting of the American Geophysical Union, San Francisco, December 5-9, 1988.

Thesis
Directed: W.L. Benedict, "Atmospheric Angular Momentum and Length of Day," M.S. Thesis, March, 1988.

Title: Aircraft Measurements in the Frontal Air-Sea
                        Interaction Experiment

Investigator: W.J. Shaw

Sponsor: National Science Foundation (NSF)

Objective: To collect data during FASINEX using the NCAR
                        Electra aircraft to use them to deduce the
                        atmospheric boundary layer's response to an
                        ocean front.

Summary: The NCAR Electra flew six mission near 70W
                        and 28N in February, 1986. The first year
                        of analysis was spent in determining
                        necessary standard corrections to the
                        Electra's mean wind velocity measurements,
                        humidity measurements, and sea-surface
                        temperature measurements and in developing
                        a preliminary assessment of the atmospheric
                        boundary layer's mesoscale variability in
                        relation to the ocean front. These have been
                        completed. Work on renavigation of the
                        Electra for wind correction has led NOAA to
                        procure LORAN-C navigational aids for the P-
                        3 Orion research aircraft based in Miami.

                        Emerging scientific results indicate that the
                        front does indeed leave a substantial imprint
                        in the flux fields of the ABL. Surface
                        stresses change by as much as a factor of 3
                        from one side of the front to the other.
                        Additionally, cooperative work with other
                        scientists, who made scatterometer
                        measurements coordinated with the turbulence
                        measurements of the Electra, indicates that
                        the scatterometer reflects surface stress
                        rather than neutral surface wind. This
                        result addresses what has been a
                        controversial question in the surface stress
                        measurement community for many years. The
                        final year of the project will be devoted to
                        developing the physical balances necessary
                        to explain the atmosphere-ocean interaction
                        near the front.

Conference
Presentations: W.J. Shaw and G.T. Vaucher, "Atmospheric
                        Surface Layer Balances in the Presence of a
                        Subtropical Ocean Front," 7th Conference on
                        Ocean-Atmospheric International (Am. Met.
                        Soc.), Anaheim, CA. February, 1988.

Title:	Analysis of Data from LASBEX
Investigator:	W.J. Shaw, Associate Professor of Meteorology, (principle investigator), P.A. Durkee, Assoc. Professor of Meteorology, K.L. Davidson, Professor of Meteorology
Sponsor:	Naval Environmental Prediction Research Facility (Direct Funding)
Objective:	To continue and expand the analysis of data collected during the Land/Sea Breeze Experiment (LASBEX) that was carried out in the Salinas Valley during September, 1987.

Summary:

LASBEX, jointly sponsored by the National Oceanographic and Atmospheric Administration (NOAA) and the Naval Environmental Prediction Research Facility (NEPRF), is a cooperative effort to investigate the structure of the coastal atmospheric boundary layer and to simultaneously evaluate performance of the 10.6-micron doppler lidar system under development by NOAA's Wave Propagation Laboratory (WPL).

The filed phase of LASBEX occurred during the period of September 15-10, 1987 in the Salinas Valley near Castroville, California and provided one of the most extensive observations of the coastal sea breeze circulation ever obtained. In addition to the lidar data, the filed measurement program provided excellent data from aerosol probes and rawinsondes over Monterey Bay, from radiosondes over the Salinas Valley, form doppler acoustic sounders, and rom a network of surface meteorology stations. These data are being combined with satellite AVHHR imagery and with surface data from routinely reporting stations in the Salinas Valley and the Monterey Bay area.

Conference
Presentations:

W.J. Shaw and M. Fagan, "Observations of the Land/Sea Breeze Circulation in Central California: Preliminary Results from LASBEX," Am. Geophys. Union Fall Meeting, San Francisco, December, 1988.

Title:	Aircraft Measurements of the Atmospheric Boundary Layer in CEAREX
Investigator:	W.J. Shaw, Associate Professor; K.L. Davidson, Professor of Meteorology
Sponsor:	Office of Naval Research (Direct Funding)

Objective: The objectives of this project are 1) to investigate the physical balances of the arctic atmospheric boundary layer (energy, momentum, etc.) particularly in the vicinity of the seasonal sea ice zone (SSIZ); 2) to investigate atmospheric boundary layer variability across the SSIZ and to interpret its role in secondary circulations that may be present through mechanisms such as stress cure and roughness-induced divergence; and 3) to investigate characteristics of the turbulence statistics themselves as they relate to ABL mean structure and to the spatial variability of the SSIZ.

Summary: This year's support is for participation in the Coordinated Eastern Arctic Experiment (CEAREX) using NOAA's P-3 Orion research Aircraft. Measurements of the mesoscale and microscale structure of the atmospheric boundary layer over the seasonal sea ice zone near Spitzbergen, Norway will be made in March, 1989 and an analysis initiated. Work will be done in conjunction with investigators from NOSS's Pacific Marine Environmental Laboratory.

Title:	Optical Turbulence in the Marine Boundary Layer

Investigators:	W.J. Shaw, Associate Professor of Meteorology, (principle investigator), K.L. Davidson, Professor of Meteorology

Sponsor:	NEPRF (Direct Funded Project)

Objective:	This is a continuation of the data analysis form project FIRE collected aboard the R/N Point Sur in July 1987. Atmospheric boundary layer structure that affects the propagation of infrared and visible radiation will be examined using acoustic sounder, rawinsonde, and other data.

Summary:

During July of 1987, the Naval Postgraduate School participated in the First ISCCP Regional Experiment (FIRE) using the R/V Pt. Sur in the vicinity of San Nicolas Island off the Southern California coast. (ISCCP is an acronym for the International Satellite Cloud Climatology Project). Investigators from numerous other universities and laboratories also participated in this filed measurement program. Its general purpose was to provide as complete a set of ground truth as is currently possible for satellite cloud measurements of marine stratocumulus.

During the past year, all the data collected by NPS aboard the R/V Pt. Sur have been reduced and archived. Surface fluxes have been calculated from measurements of shipboard mean values and are available for incorporation into further studies. In addition, we have discovered the presence of a persistent low-level wind maximum which occurs below the primary capping inversion, contrary to assumptions of most models of the atmospheric boundary layer.

Title:	Satellite Applications for TESS
Investigators:	C.H. Wash, Associate Professor of Meteorology; P.H. Durkee, Associate Professor of Meteorology
Sponsor:	To provide NEPRF with satellite applications for the TESS 3.0 system. To prepare applications which best fit within the constraints of available data sources, available computer resources and fleet operational importance.

Summary:	A cloud and precipitation classification program, designed for geostationary satellite data, was applied to various cases of polar orbiting satellite data. To improve polar orbiter applications, a navigation routine was developed which will provide accurate location of the image data. Also, study was begun on the application of AVHRR multichannel data to the cloud classification algorithms. Variations in marine stratus cloud systems was emphasized in this study.

Publications:	C.H. Wash and C. Motell, "Rain Estimation for Infrared and visible GOES Satellite Data," Journal of Application Meteor., 1988.
Conference Presentations:	R. Allen, P.A. Durkee, and C.H. Wash, 1988: Automated Satellite Cloud Analysis: A multispectral Approach to the Problem of Low Cloud Discrimination," Presented at Fourth Satellite Conference at Los Angeles, CA., February, 1988.
Theses Directed:	J.P. Baron, "An Objective Method of Discrimination between Cloud and Sea Ice Utilizing Satellite Imagery," MS Thesis, December, 1987.
	W. Bethke, "Accuracy of Satellite Data Navigation," MS Thesis, March, 1988.
	D. Owen, "Three-dimensional Analysis of Synoptic Satellite and Conventional Meteorological Observations," MS Thesis, March, 1988.
	S. Morehead, "Ship Track Cloud Analysis of the North Pacific Area," MS Thesis, June, 1989.

T. Sheridan, "Microwave, Visual-infrared Estimates of Precipitation for a Rapidly Developing Eastern North Pacific Ocean Cyclone," MS Thesis, December, 1988.

Title:	Observational Numerical Study of Maritime Extratropical Cyclones using FGGE Data
Investigators:	C.H. Wash, Associate Professor of Meteorology, R.L. Elsberry, Professor of Meteorology
Sponsor:	National Aeronautics and Space Administration
Objective:	To better understand the development, maturation and decay of maritime extratropical cyclones using a combined observational and numerical modeling approach.
Summary:	Diagnostic studies of collections of rapid and slow developing cyclones were completed with FGGE data using potential vorticity and other diagnostic quantities. The recent thesis of Eric Wright illustrated that the rapid and slow development can be explained by different intensities in the upper level forcing mechanisms.
Publications:	C.H. Wash, J. Peak, W. Calland, and W. Cook, 1987: "diagnostic Study of Explosive Cyclogenesis during FGGE," Mon. Weather Review, 109, pp. 1531-1552, February, 1988.

R.L. Elsberry and P.J. Kirchoffer, "Studies of Explosive Cyclogenesis over the Ocean Based Operationally Analyzed Fields," Weather and Forecasting, 3, September, 1988. pp. 205-215. |
| Thesis Directed: | E. Wright, "Study of Explosive and Non-explosive Cyclogenesis," M.S. Thesis, December, 1988. |

Title:	Rapid Maritime Cyclogenesis Studies
Investigators:	C.H. Wash, Associate Professor of Meteorology; R.L. Elsberry, Professor Meteorology; C.-S. Liou, Adjunct Professor of Meteorology; W.A. Nuss, Adjunct Professor of Meteorology
Sponsor:	Office of Naval Research-Marine Meteorology (Direct Funded Project)
Objective:	To understand the physical processes that lead to rapid cyclogenesis at sea using of Genesis of Atlantic Lows Experiment (GALE) and Experiment on Rapidly Intensifying Cyclones over the Atlantic (ERICA) data.

Summary:

New analyses incorporating GALE data using 12 h data assimilation cycle was completed for GALE IOP-2 and IOP-9 Diagnostic studies using these revised analysis were initiated.

Improved gridded data has been used to analyze surface heat and moisture fluxes in GALE IOP-9. The contribution of theses fluxes near the strong warm front to the rapid development has been assessed by determining the condition of moist, symmetric stability near the warm front.

Conference
Presentations:

W.A. Nuss, C.-S. Liou, S. Heikkinen, C.H. Wash, and R.L. Elsberry, "Cyclone Development and Modeling in GALE IOP-9," Presented at Cyclone Workshop, October 18-21, 1988, Philadelphia, PA.

C.-S. Liou, S. Heikkinen, C. Wash, W. Nuss, and R.L. Elsberry, "Toward Improvement in Predicting GALE IOP-2 and IOP-9 Cases," Presented at GALE/CASP Workshop, October 2-6, 1988, Montreal, Canada.

W.A. Nuss, "Air-Sea Interaction Influences on Marine Cyclones," AMS Annual Meeting Air/Sea Interaction Conference, Anaheim, CA., January, 1988.

Theses
Directed:

J. Carson, "A Study of a Rapid Cyclogenesis Event," MS Thesis, June, 1988.

J. Atangan, "Satellite Signatures of Rapid Cyclogenesis," M.S. Thesis, September, 1988.

K.L. Davidson, W.J. Shaw, and W. Large, 1988,
"Wind Stress Results from Multi-platform and
Multi-sensor Measurements in FASINEX," 7th
Conference on Ocean-Atmospheric International
(Am. Met. Soc.), Anaheim, CA., February,
1988.

Title:	Air Flow over Large Scale Topography
Investigators:	R.T. Williams, Professor of Meteorology; M.A. Rennick, Adjunct Professor of Meteorology; and M.S. Peng, Adjunct Professor of Meteorology
Sponsor:	National Science Foundation
Objective:	To utilize observational results from ALPEX with theoretical and numerical studies to investigate the interaction between air flow and large scale topography. This is a continuing project.
Summary:	The foundation of cyclones in the lee of a mountain range was studied with numerical models. The problem of flow over and around a long mountain models. Frontal collapse was studied with a small numerical model. The effect of topography on fronts was studied with tow dimensional numerical model. Also the fronted solution were compared with an advected scalar when there was no forcing.
Publications:	R.L. Gall, R.T. Williams, and T.L. Clark, "Gravity Waves Generated During Frontogenesis," Journal of the Atmospheric Sciences, 45, 2204-2219, August 1, 1988.
Conference Presentations:	R.T. Williams and M.S. Peng, "Effects of Topography on Fronts in a Vertically Sheared Flow," Annual Meeting of the Pacific Division of the American Association for the Advancement, June 18-22, 1988, Corvallis, OR.

Title:	Numerical Modeling of Unique Atmospheric Phenomena
Investigators:	R.T. Williams, Professor of Meteorology; M.S. Peng, Adjunct Professor Meteorology
Sponsor:	Office of Naval Research
Objective:	Develop and test better numerical techniques for use in Navy weather forecasting models. This is a continuing project.

Summary: The interaction of planetary waves with synoptic waves was carried out with the normal mode technique developed by Errico. Daily initial data from the FNOC model over a three-month period were used. The analysis was split into different vertical modes with the equivalent depth decreasing with increasing mode number. For the first of barotropic mode it was found that the synoptic scale waves forced the planetary waves on the average. The reverse was found the next two baroclinic modes. Thus the synoptic scale interaction with the planetary waves are similar to the interaction with the zonal flow. Flow over steep mountains were carried out with two and three dimensional numerical models. For sufficiently steep mountain hydraulic jumps were found on the lee side of the mountain. Two dimensional studies on fronts moving over topography were carried out. Frontal solutions with no forcing were compared with the scalar advection theory of Blumen and Gross.

Publications: R.L. Gall, R.T. Williams, and T.L. Clark, "Gravity Waves Generated during Frontogenesis," Journal of the Atmospheric Sciences, 45, pp. 2204-2219, August 1, 1988.

Conference
Presentations: R.T. Williams, and M.S. Peng, "effects of Topography on Fronts in a Vertically Sheared Flow," Annual Meeting of the Pacific Division of the American Association of the Advancement of Science, June 18-22, 1988, Corvallis, OR.

Thesis
Directed: M.D. McAtee, "Interaction between Synoptic and Planetary Scales of Motion Doctoral Dissertation, December, 1987.

Title:	Theory of Tropical Cyclone Motion
Investigators:	R.T. Williams, Professor of Meteorology and M.S. Peng, Adjunct Professor of Meteorology
Sponsor:	Office of Naval Research
Objective:	To understand the physical processes which control the motion of tropical cyclones. This is a continuing project.

Summary:

An analytic model was developed in a frame of reference moving with the vortex, and the vorticity equation was linearized. We solved numerically both the steady state and the time-dependent forms of equation. The time-dependent solution showed very convergence, although approximate balance was achieved within a moderate period of time. The steady state solution had unrealistically large amplitudes. This behavior was found to be related to barotropic instability of the vortex. The full numerical model was also integrated with tow basic environmental wind fields: 1) linear, 2) parabolic. Both of these wind fields lead to modifications in the beta drift process. A further study examined the linear stability of disturbances in a $1/r$ vortex. It was found that smooth initial disturbances were strongly damped by the continuous spectrum modes. The results strongly suggest that tropical cyclones and typhoons are made nearly circular by this process.

Conference
Presentations:

R.T. Williams, M.S. Peng, and J.C.-L. Chan, "Study of the Beta-Effect in Tropical Cyclone Motion," International Conference on Tropical Meteorology, Brisbane, Australia, July 4-8, 1988.

Publications:	R.E. Newton and A.L. Schoenstadt, "Performance Comparisons for Two Versions of the Staniforth-Mitchell Barotropic Numerical Weather Prediction Code. Naval Postgraduate School, 69-88-006, July 1988, p. 5.
Conference Presentations:	B. Neta, "The Effect of Spatial Discretization on the Steady State Solution of the Shallow Water Equations," International Conference on Computational Methods in Flow Analysis, September 5-8, 1988, Okayama, Japan.
Thesis Directed:	T.I. Pertoliagis, "Studies of Barotropic Flow Over Topography using a Galerkin Finite Element Model," M.S. Thesis, March, 1988.

Title:	Development of a Finite Element Prediction Model
Investigators:	R.T. Williams, Professor of Meteorology; A.L. Schoenstadt, Professor of Mathematics; B. Neta, Associate Professor Mathematics; and R.E. Newton, Professor of Mechanical Engineering
Sponsor:	Office of Naval Research
Objective:	To develop and test a finite element atmospheric prediction model. This is a continuing project.

Rossby waves in the shallow water equations were analyzed with various numerical schemes. These included unstaggered vorticity-divergence formulations with finite difference and finite elements, and primitive equation finite difference schemes being the best. The research on vertical finite element schemes used the linearized baroclinic vorticity-divergence equations for a single horizontal spectral mode. Three finite difference schemes were compared with the three finite element schemes, which had model points corresponding to grid points 'in the finite difference schemes. These numerical schemes were applied to a baroclinic instability situation with linear an hyperbolic wind profiles. The previously developed shallow water finite element was tested with various bottom topography configurations. In the first series of experiments the topography had no variation along the channel. The numerical solutions were compared with approximate analytic solutions. The model was also tested with small scale flow over topography in cases where hydraulic jumps can form. The results compared well with the jump-no-jump theory developed by Houghton and Kasahara. A semi-Lagrangian scheme was developed for the nonlinear advection equation. Near the time of discontinuity formation the scheme was much better than finite difference and tau spectral formulations. Additional effort was applied to improve the solvers which are needed with the finite element method.

Title:	Regional Synoptic Forecasting: Central America Surrounding Caribbean Sea/North Pacific Ocean Areas
Investigators:	F.R. Williams, Adjunct Professor Meteorology; R.J. Renard, Professor and Chairman of the Meteorology Dept.
Sponsor:	Naval Environmental Prediction Research Facility
Objective:	Publication of a regional forecaster handbook.
Summary:	Following site visits in FY 1986 and real-time data collection (i.e., satellite imagery, concurrent Navy and National Meteorological Center analyses, etc.) in FY 1987, the current FY 1988 work has included the compilation of 250 pages of the forecasters handbook. The material completed includes: climatologies of the "rainy season" and "dry Season" of the seven countries, coastal oceanographic influences, rainy season, "case studies", and appendices concerning 1) tropical analysis, 2) ceiling and visibility statistics and 3) tracks of North Atlantic tropical cyclones. Publication is anticipated after January 1989 following completion of dry season (winter) case studies and an additional hurricane case study.

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DEFENSE RESOURCES MANAGEMENT EDUCATION CENTER

Defense Resources Management Education Center

The Defense Resources Management Education Center (DRMEC) is a DoD sponsored tenant activity located at the Naval Postgraduate School. The mission of the Center is to conduct resources management short courses for mid to senior level officers and civilians from the U.S. and allied nations. Since 1965, over 16,000 U.S. and 5,000 international participants have attended DRMEC courses.

The faculty of the Center are faculty of NPS and, as such, engage in a wide variety of research programs in support of the DoD mission. Current areas of faculty research include: Soviet Public Expenditure Decisions (Professor Earl Brubaker); Integrating Manpower Concerns in the Acquisition Process (Associate Professor Boynton); The Impact of Defense Expenditures on Economic Growth (Professor Peter Frederiksen and C. J. LaCivita); Economic Development of Third World Countries (Professor Peter Frederiksen); Applying the Theory of Differential Games to Model Bi-lateral US/USSR Defense Expenditures (Associate Professor Francois Melese); The Structure of the Defense Industry (Assistant Professor Robert Pirog); Systemic and Demographic Approach to Federal Budgeting (Professor John Dawson); Development of Outlay Forecasting Models for DoD Planning and Budgeting (Associate Professor Kent Wall and Associate Professor LaCivita); Underlying Trends in American Alignments (Associate Professor Darnell Whitt); Strategic Planning Forecasting System for the JCS (Professor Robert von Pagenhardt); Evolution and consequences of Trust and Betrayal in Organizations (Associate Professor James Morris); DoD Manpower Issues (Professor James Blandin).

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Title: Soviet   Decision-Making   for   Public
                    Expenditures.

Investigator: Earl R. Brubaker

Objective: To add to our understanding of Soviet
                    decision-making for public expenditures in
                    general and for national security programs in
                    particular.   To learn: (1) who participates
                    and the form of participation, (2) how
                    objectives are defined, (3) what criteria are
                    used, (4) how economic and budgetary doctrine
                    relate to the process, (5) how the process
                    might be modeled, (6) how understanding the
                    process can facilitate explanation and/or
                    prediction of Soviet public expenditure
                    changes in response to changing
                    circumstances.

Summary: Collection, survey, and analysis of relevant
                    materials, Soviet and Western, has continued.
                    A preliminary report has been drafted and is
                    being revised.

Title:	FORECASTS System
Investigators:	Principal Investigator: Robert von Pagenhardt
	Others: Francois Melese, Thomas Adler, James Blandin, Donald Bonsper, James Channon, John Dawson, Nazli Choucri, Olaf Helmer, C.J. LaCivita, Dana Meadows, Dennis Meadows, Robert North, Robert Pirog, Kent Wall.
Sponsor:	OJCS; JDSSC/DCA
Objective:	To update, enhance, and make more useful the FORECASTS System of the Joint Staff in order that J-5 and others may (1) wisely anticipate trends, developments and challenges affecting the U.S. and the world twenty years hence, and (2) better consider alternative long-range strategies to deal with dangers and/or opportunities.
Summary:	I was responsible for the review and evaluation of the Policy Sciences section of the FORECASTS model. In the course of my studies in this area, I co-wrote with Philippe Michel an extension of the Richardson model which the Chief Scientist (Dr. Mesarovich) has decided to include in the "models base" of the FORECASTS System.

DEPARTMENT
OF
AERONAUTICS

DEPARTMENT OF AERONAUTICS AND ASTRONAUTICS

During the reporting period, Aeronautics/Astronautics faculty have been active in the following major research areas:

Aircraft Combat Survivability

Professor Ball continued his studies of aircraft combat survivability by conducting research in the following areas: (1) standard missile warhead; (2) air defense gun effectiveness; (3) computer graphics and the Endgame; (4) battle damage repair of advanced composite airframes; (5) vulnerability of advanced composite airframes; (6) P-3 defensive air combat maneuvering; (7) CBR survivability; and (8) the influence of aircraft signatures and performance upon survivability.

Helicopter-Ship Interface

Professor Val Healey continued his wind tunnel experimental investigations of the helicopter-ship interface problem in which he is exploring the ship's aerodynamic environment as it affects helicopter operation to and from the ship. It was discovered that, in the stationary mode, the primary variable influencing the airwake is the ship's yaw angle and that pitch and roll have only minor influence. Experiments were conducted for the flight deck of the DD-963. Relative areas exposed to fairly uniform flow were measured as a function of yaw angle.

Boundary Layer Studies

Professor Howard continued his research to explore wing boundary layer response to a high frequency single-event turbulent disturbance at conditions near separation. The first studies have been performed on attached flows. Results indicate that a stabilizing mechanism takes place during part of the disturbance passage cycle. Further studies will treat the case of flows of incipient separation.

Flight Test Research for Unmanned Air Vehicles

Professor Howard has initiated a flight test research program of Unmanned Air Vehicles for Navy Applications. In FY88 a 1/4 scale (7-ft span) trainer UAV1 and a 1/2-scale Pioneer-type UAV were constructed/acquired; a 2/3-scale Pioneer-type UAV was designed on which construction was begun; a rate sensor package was designed; and development proceeded on design and construction of an engine torque stand and wind-tunnel thrust stand for engine power and propeller efficiency testing.

Finite Element Analysis of Thick Composite Structures

Professor Kolar in the first phase of this work developed a finite element analysis using biquadratic Lagrangian interpolation functions of C-O continuity for plate bending. Transverse shears were accounted for by using Mindlin plate assumptions. Results were obtained for static loading for different thicknesses, fiber-resin combinations, and number of layers. Extension of the theory to obtain buckling loads is explored.

Energy Conservation in Steam Distribution Systems

Professor Miller continued his work with the Steam Heat Distribution Program that allows public works engineering staff to exploit its management and maintenance potentialities. Field tests of the Steam Heat Distribution Program were carried out at a number of facilities. At Pensacola, it was revealed that the steam distribution system had a very poor pressure distribution which might be alleviated through minor operating changes. Potential savings of 19% were forecast for a system that has a total operating cost of nearly $2000 per hour.

Particle Behavior in Exhaust Nozzles of Rocket Motors

Professor Netzer continued his research on solid propellant rocket motors. The investigation successfully characterized for the first time the behavior of ZrC (a stability additive) within the motor and exhaust nozzle of a small solid propellant rocket motor. Light diffraction measurements, high speed motion pictures, pulsed holography and scanning electron microscope analysis of collected combustion products were used. In a second area of research, that of emission reductions for gas turbine combustors and test cell augmentors, significant progress was made during the year with a number of major findings reported.

High Alpha Low Speed Aerodynamics Research

Work in this area is being primarily done under the auspices of the NPS-NASA Joint Institute. Professor Platzer reports that among the accomplishments during this reporting period was the development of a new capability for the department. A "Fiber Optic Laser Sheet Visualization System" was developed for the NPS Low Speed Wind Tunnel. It is the subject of a paper to be presented in August at the 4th Asian Fluid Mechanics Conference to be held in Hong Kong. Title of the paper is, "Flow Visualization by Laser Sheet".

High Angle of Attack Aerodynamics

Professors Platzer and Chandrasekhara continued their program to establish a center for high angle of attack unsteady aerodynamics to support the Navy's next generation super-maneuverability fighter aircraft program. In support of this, a unique

Compressible Dynamic Stall Facility (CDSF) to oscillate an air-foil at helicopter flight conditions was built with design and fabrication support from NASA Ames Research Center. The facility was installed in the Fluid Mechanics Indraft Wind Tunnel at NASA Ames.

Compressor Aerodynamics

Professor Shreeve continued experimental investigations of compressor cascade flows and of the tip clearance effects in a three-stage low-speed axial flow compressor. The goal of this research is to come up with modifications to present design procedures which ignore the gap. To carry out the experimental work, a 36-inch O.D., low-speed, three-stage axial compressor has been reassembled which has a 7.2-inch cylindrical flow path.

Higher Harmonic Control for Helicopters

Higher Harmonic Control (HHC) is a new active control concept for helicopters that promises major breakthroughs in helicopter vibrations and performance. Flight tests of an HHC-equipped OH-6A helicopter on a NASA/Army sponsored program have demonstrated A 90% reduction in vibration levels and up to a 30% reduction in power required. In ongoing work at NPS under Professors Wood and Kolar, flight test data from this program are being researched by two Ph.D. students. In addition, a radio-controlled helicopter is being purchased and instrumented for future flight testing.

Composite Materials Research

Professor Wu continued research on the aging characterization of composite materials. As a result of his efforts, the Naval Postgraduate School now has a well-equipped laboratory that makes it possible to establish stress aging for fibers and composites. Results of continuous ongoing tests provide an independent and uninterrupted data base for DOD needs. Among the work being done in the laboratory is that of developing a proof-test methodology for advanced composite materials.

Title:	Naval Postgraduate School Survivability Support
Investigator:	Professor Robert E. Ball Department of Aeronautics & Astronautics
Sponsor:	Naval Air Systems Command Air Combat Survivability Branch, AIR-5164
Objective:	To provide technical support to the Air Combat Survivability Branch by conducting research and developing methodology in the following areas of aircraft combat survivability: a. STANDARD Missile Warhead effectiveness b. Air Defense Gun Effectiveness c. Computer Graphics and the Endgame d. Battle Damage Repair of Advanced Composite Airframes e. Vulnerability of Advanced Composite Airframes f. P-3 Defensive Air Combat Maneuvering (DACM) g. CBR Survivability h. The Influence of Aircraft Signatures and Performance upon Survivability

Summary:	This project was a study of the lethality of several STANDARD missile HE warheads, including the current warhead, earlier versions, and a proposed design. This project continued the development of a computer program for determining the effectiveness of air defense guns against targets using random, realistic flight paths. In particular, the proximity fuzed, high explosive warhead was added to the program. This project consisted of the development of a computer graphics program that shows the zones around an aircraft within which a detonation by a proximity fuzed HE warhead would result in fragment hits on the aircraft. This project consisted of a study of the status of the technology and techniques for battle damage repair of advanced composite structures in the field or on a carrier.

This project examined the vulnerability of advanced composite airframe structures to ballistic impact and design techniques to improve battle damage tolerance.

This project consisted of the preparation of material to be used in a training manual developed by VP-31, Moffett Field, for P-3 ASW crews for defensive air combat maneuvering.

This project initiated a study of the integration of chemical and biological threats into the conventional survivability discipline. In particular, the terms and definitions used in CBR defense were replaced by similar terms used in the conventional survivability discipline.

This project consisted of the examination of the relative effects of performance, signature reduction, and threat warning upon the susceptibility of high performance aircraft.

Title:	Compressibility Effects on the Dynamic Stall of Oscillating Airfoils
Investigators:	M.S. Chandrasekhara, Adjunct Research Professor, Department of Aeronautics and Astronautics, Professor M.F. Platzer, Department of Aeronautics and Astronautics
Sponsor:	U.S. Army Research Office
Objective:	To study the effects of compressibility on the dynamic stall of oscillating airfoils with application to helicopters. This information will be useful in extending the flight envelope of future helicopter systems. On-going program since March 1986.

| Summary: | During the reporting period, a unique Compressible Dynamic Stall Facility (CDSF) to oscillate an airfoil at helicopter flight conditions was built with design and fabrication support from NASA Ames Research Center. The facility was installed in the Fluid Mechanics Laboratory Indraft Wind Tunnel. Also, a stroboscopic schlieren system was developed for the purpose of flow visualization studies. The results of the study showed the presence of a large dynamic stall vortex for all flow conditions. Compressibility effects began at a Mach number of 0.3 and decreased the angle at which dynamic stall process was initiated. However, increasing the oscillation frequency or the degree of unsteadiness had the effect of delaying this process, even at high Mach numbers. |

| Conference Presentations: | M.S. Chandrasekhara, J.A. Ekaterinaris and L.W. Carr, "Experimental and Computational Tracking of Dynamic Stall Vortex", at the 41st Annual Meeting of the Fluid Dynamics Division of the American Physical Society, Buffalo, November 20-22, 1988. |

Title:	Compressibility Effects on the Dynamic Stall of Airfoils Undergoing Rapid Ramp Type Motion
Investigators:	M.S. Chandrasekhara, Adjunct Research Professor, Department of Aeronautics and Astronautics and M.F. Platzer, Professor, Department of Aeronautics and Astronautics
Sponsor:	U.S. Air Force Office of Scientific Research
Objective:	To study the effects of compressibility on the dynamic stall of an airfoil undergoing a rapid ramp type pitching motion with applications to supermaneuverability of fighter aircraft. On-going project since October 1986.
Summary:	During the reporting period, the choice of a drive system to rapidly pitch an airfoil at rates as high as 3600 /sec was finalized. After considering several options, a hydraulic drive with an accumulator, servo-value and feed back system was decided to be the best for the application. The design of the system was completed and its fabrication was started. Simulations of the feed back system response were carried out that included the leakage flow through the cylinder and valves. The design required pushing the limits of technology and custom fabrication of several components. This project shares the instrumentation and other facilities being used in the ARO project.

Title: High Alpha High Speed Aerodynamics Research

Investigators: M.S. Chandrasekhara, Adjunct Research Professor, Department of Aeronautics and Astronautics and M.F. Platzer, Professor, Department of Aeronautics and Astronautics, Late S. Bodapati, Adjunct Research Professor, Department of Aeronautics and Astronautics

Sponsor: Naval Air Systems Command

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

Summary: This project complements the research being carried out under funding from AFOSR. For the reporting period, some LDV instrumentation components were acquired. Also, an extensive software package for acquisition of Laser Doppler Velocimentry data in unsteady flows was developed and tested. This involved integrating several instruments with the computer and synchronising the data acquisition with an unsteady random event, namely, the LDV signal. Since the data consists of both continuous and random signals, necessary hardware to latch the continuous data when the unsteady data becomes available was also developed.

Title:	High Alpha Low Speed Aerodynamics Research
Investigators:	M.S. Chandrasekhara, Adjunct Research Professor, Department of Aeronautics and Astronautics, M.F. Platzer, Professor, Department of Aeronautics and Astronautics, S.K. Hebbar, Adjunct Research Professor, Department of Aeronautics and Astronautics, Late S. Bodapati, Adjunct Research Professor, Department of Aeronautics and Astronautics
Sponsor:	Naval Air Systems Command
Objective:	To conduct high alpha, low speed unsteady aerodynamics research and to complement the high speed research activities in the Navy-NASA Joint Institute on aircraft supermaneuverability and agility.

Summary:	During the reporting period, a new capability was added to the instrumentation depth of the Department of Aeronautics and Astronautics. This was the development of a "Fiber Optic Laser Sheet Flow Visualization System" for the NPS Low Speed Wind Tunnel. This was designed nd fabricated as part of a thesis by a Master's student. Subsequently, flow visualization studies were carried out on a YF-17 model for various flow conditions, including at high angles of attack. The laser sheet allowed the visuali\ation of the strong, asymmetric, vortical flow over the aircraft.

Conference Presentation:	S.K. Hebbar, M.S. Chandrasekhara, J.S. Chlebanowski, "Flow Visualization by Laser Sheet", To be presented at the 4th Asian Fluid Mechanics Conference, Hong Kong, August 19-23, 1989
Thesis Directed:	J.S. Chlebanowski, Jr. "Flow Visualization by Laser Sheet", Master's Thesis, March 1988.

Title:	Ship Airwake Analysis
Sponsor:	Naval Air Systems Command
Investigator:	Healey, J V
Objective:	Long-term - to measure, and scale up to full size, the pertinent paramenters ofthe flowfield in the wake of model ship for scaling to full-suze and use in simulation of the landing of helicopters on ships. For this period - to investigate by flow visualization the wake of the Tarawa and the DD-963.

This is an on-going project. Initially, a sheared turbulent flow that simulates the flow of a neutral atmosphere over rough sea was established in the smoke tunnel at NPS. Then this sheared turbulent flow around simple blocks and ship-like structures was studied via flow-visualization. This year's contribution was to study the flow around models of the U.S.S. Tarawa and the DD-963. The purpose of the flow-viz work is to identify the approximate flow direction along certain landing paths. This information is necessary because the 3-d hot-wire probe can measure accuratley only when the flow approaches within a certain cone angle from the probe axis. |

| Summary: | It was discovered that, in the stationary mode, the pitch and roll have minor influence on the airwake and that the primary variable is the yaw angle (the angle that the ship's axis makes with relative wind). The attention was focused largely on the flight deck of the DD-963 and the relative areas exposed to fairly uniform flow noted as a function of yaw angle. The pattern of the flow the "recirculating" zone of the deck was found to very complex. The airflow passing high over the hangar flowed down a curved slope and aft avoiding the deck. At levels just above the hangar "roof" the air flowed in a downward curve forming a stagnation point on the deck, then splitting, some flowing aft and the remainder forward and upwards towards the hangar face where it formed another stagnation point and it then split and moved towards the sides of the |

ship. As the latter stream flowed back toward the hangar face, it was joined at levels just above the deck by air flowing in from both sides of the hangar. Both streams merged, flowed upwards to about the level of the hangar roof and then streamed aft in two streams roughly from the aft-top corners of the hangar.

Publications:

Healey, J V, "The Prospects for Simulating the Helicopter/Ship Interface," Naval Engineers Journal, vol. 99, no. 2, 1987.

Johns, M K and Healey, J V, "The Airwake of a DD-963 Class Destroyer," to be published in the Naval Engineer's Journal.

Theses
Directed:

J.L. Biskadouris, "Flow Visualization of the airwake of an oscillating generic ship model," December, 1987.

T.A. Cahill, "Visualization of the Flowfield Around and Oscillating Model of the USS Enterprise in a Simulated Atmospheric Boundary Layer, March, 1988.

W.H. Daley III, "Flow Visualization of the Airwake of a model of a Tarawa Class LHA in a Simulated Atmospheric Boundary Layer, June, 1988.

M.K. Johns, "Flow Visualization of the Airwake Around a Model of a Spruance Class Destroyer in a Simulated Atmospheric Boundary Layer, September, 1988.

Title:	High Alpha Low Speed Aerodynamics Research
Investigators:	S.K. Hebbar, Adjunct Professor of Aeronautics and Astronautics, and M.F. Platzer, Professor of Aeronautics and Astronautics
Sponsor:	Naval Air Systems Command
Objective:	This is a multi-year program aimed at establishing a state-of-the-art research center for high angle-of-attack unsteady aerodynamic studies at the Navy-NASA Joint Institute of Aeronautics.

Summary: A low speed experimental program on high alpha unsteady aerodynamics was initiated at the Naval Postgraduate School to carry out the investigations related to highly maneuverable fighter aircraft. During the period under review the following major tasks were accomplished: (a) A technique for flow visualization by laser sheet was developed, refined, validated and integrated with the NPS 32"x45" low speed wind tunnel to permit qualitative diagnostics of complex flow fields around aircraft models at high angles-of-attack. (b) A systematic program of high alpha low speed experimental investigations of a 3% YF-17 fighter aircraft model in the wind tunnel was initiated with laser sheet flow visualization studies of the flow field and force balance measurements on the model. (c) A 15"x20"x60" horizontal flow visualization water tunnel, specifically designed for high alpha research, with capabilities for pitching and yawing a model and for dye-injection was installed. A 1/48th scale F-18 fighter aircraft model fitted with several dye-injection ports was procured for initiating exploratory water tunnel flow visualization studies.

Publications: S.K Hebbar, M.S. Chandrasekhara, and J.S. Chlebanowski, "A Laser Sheet Flow Visualization System for Qualitative Flow Analysis," Experiments in Fluids, in progress.

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Conference Presentations:	S.K. Hebbar, M.S. Chandrasekhara, and J.S. Chlebanowski, "Flow Visualization by Laser Sheet," Accepted for presentation at the Fourth Asian Congress of Fluid Mechanics, Hong Kong, August 21-25, 1989.
Thesis Directed:	J.S. Chlebanowski, Jr., "Flow Visualization by Laser Sheet," Master's Thesis, March 1988. D.H. Leedy, "An Experimental Investigation of a Fighter Aircraft Model at High Angles of Attack," Master's Thesis, September 1988.

Title:	A Flight Test Research Program For Navy Unmanned Air Vehicles
Investigator:	R.M. Howard, Assistant Professor of Aeronautics and Astronautics
Sponsor:	Unfunded for FY88; NAVAIR, Aircraft Division, Research and Technology, for FY89
Objective:	To develop a research program for small unmanned flight vehicles, for the purposes of sensor development and performance and flying-quality research and testing.

Summary: A research program has been initiated for the flight testing of Unmanned Air Vehicles (UAVs) for Navy Applications. The purposes are to provide flight platforms to conduct aerodynamic, performance, and flying quality research on low Reynolds number vehicles, and to devise a generic flight test program to accurately measure UAV performance with onboard sensors. In FY88 a 1/4-scale (7-ft. span) trainer UAV and a 1/2-scale Pioneer UAV were constructed/acquired, a 2/3-scale Pioneer-type UAV was designed on which construction was begun, a rate sensor package was designed, and development proceeded on design and construction of a engine torque stand and wind-tunnel thrust stand for engine power and propeller efficiency testing. Flights have begun at the time of writing. This program will also contribute to the Flight Test Engineering course.

Thesis Directed:	H.K. Parker, "The Design and Initial Construction of a Composite RPV for Flight Research Applications," Master's Thesis, September 1988.

Title:	Effects of the Launch Environment on a Vertically-Launched Missile
Investigator:	R.M. Howard, Assistant Professor of Aeronautics and Astronautics
Sponsor:	Unfunded for FY88; Standard Missile Program Office, Naval Surface Warfare Center, for FY89
Objective:	To experimental study the effects of flowfield turbulence on the formation and existence of asymmetric vortices, which can induce significant unwanted side forces on the sharp noses of missiles and aircraft.

Summary:

A vertical launch capability for Navy surface-to-air missiles was recently introduced. Launching a missile vertically can expose it to significant crosswinds and flowfield disturbances from ship airwake turbulence. A wind tunnel study of a 1/7-scale Navy surface-to-air missile is being conducted at high angles of attack at various levels of generated flowfield turbulence. The work for FY88 involved making force and moment measurements to characterize the effects of the turbulence and the strake-tail configuration on the formation of nose-generated asymmetric vortices and the resultant side force. It was found that a strong induced side force continues to exist at high turbulence levels, which is increased at turbulence length scales corresponding to the vortex scale (about 60% of the missile diameter).

Publications:

R.M. Howard, M.P. Rabang, and D.P. Roane, "Aerodynamic Effects of a Turbulent Flowfield on a Vertically Launched Missile," accepted for AIAA Aerospaces Conference, Jan. 1989 (AIAA Paper 89-0329); submitted to the Journal of Spacecraft and Rockets.

Theses
Directed:

D.P. Roane, "The Effect of a Turbulent Airstream on a Vertically-Launched Missile at High Angles of Attack," Master's Thesis, December 1987.

M.P. Rabang, "Turbulence Effects on the High Angle of Attack Aerodynamics of a Vertically Launched Missile," Master's Thesis, June 1988.

Theses
Directed:
 (Cont.)   M.H. Lung, "Flowfield Measurements in the
                            Vortex Wake of a Missile at High Angle of
                            Attack in Turbulence," Master's Thesis,
                            December 1988.

Title:	Boundary Layer Response to An Unsteady Turbulent Environment
Investigator:	R.M. Howard, Assistant Professor of Aeronautics and Astronautics
Sponsor:	NAVAIR, Aircraft Division, Research and Technology
Objective:	To study the wing boundary layer response to a high frequency single-event turbulent disturbance at conditions near separation. This work applies to a supermaneuverable aircraft in or near the post-stall flight regime, and relates to the NAVAIR Enhanced Fighter Maneuverability Program.

| Summary: | In many situations the boundary layer on a lifting surface can be sensitive to time-dependent disturbances in the flow environment. One important case relates to dynamic maneuvering for increased fighter agility. The possibility of immersion of a lifting surface in the separated turbulent wake of a second surface or body raises the question of the likelihood of loss of control should the flow over that surface be adversely affected. Initial studies have been performed to consider the boundary layer response to a periodic turbulent freestreamer disturbance, in order to study in a statistical manner the results from a single-event disturbance. The first studies have been performed on attached flows. The results indicate a stabilizing mechanism to take place during part of the distrubance passage cycle. Further studies will treat the case of flows of incipient separation. |

| Publication: | R.M. Howard and R.W. Renound, "Wing Boundary Layer Response to an Unsteady Turbulent Flowfield," submitted to the AIAA Applied Aerodynamics Conference, Seattle, WA, August 1989.

S.J. Miley, R.M. Howard, and B.J. Holmes, "Wing Laminar Boundary Layer in the Presence of a Propeller Slipstream," Journal of Aircraft, Vol. 25, No. 7, July 1988, pp. 606-611. |

R.M. Howard and S.J. Miley, "Time-Dependent Boundary Layer Response in a Propeller Slipstream," Journal of Aircraft, forthcoming.

D.K. Johnson, R.M. Howard, and P. Ilacqua, "Data Analysis for Time-Dependent Turbulence Measurements," to be submitted to the AIAA Journal, in progress.

Theses
Directed:

R.W. Renoud, "Boundary Layer Response to An Unsteady Turbulent Environment," Master's Thesis, December 1988.

D.K. Johnson, "A Data Analysis System for Unsteady Turbulence Measurements, "Master's Thesis, September 1988.

Title:	Boundary Layer Studies of a Wortmann Airfoil in a Turbulent Environment
Investigator:	R.M. Howard, Assistant Professor of Aeronautics and Astronautics
Sponsor:	Naval Postgraduate School Research Council
Objective:	To study the behavior of a wing boundary layer at low Reynolds numbers subjected to high levels of free-stream turbulence. This work is applicable to the environment of a remotely piloted vehicle during recovery onboard a battleship, such as that for the Navy Pioneer RPV currently in operation. This project is a continuation of one that began in FY87, when the PI joined NPS.

| Summary: | An experimental study of the behavior of an airfoil at low Reynolds numbers in a turbulent environment was conducted. The study is applicable to the situation of a Navy Remotely Piloted Vehicle (RPV) or Unmanned Air Vehicle (UAV) upon onboard retrieval at sea, where the flight environment is subject to turbulence from the oceanic atmospheric boundary layer and from ship airwake turbulence. Airfoil boundary layers were measured with hot-wire anemometry with grid-generated turbulence. It was found that all levels of free stream turbulence, from 0.5 to 3.8% intensity, tended to move the point of transition closer to the leading edge. But it was also found that only the smallest level of increase, which corresponds to a turbulence scale on the order of the boundary layer size, tended to cause a increase in growth in the boundary layer thickness over the ambient turbulence case. The higher turbulence levels (corresponding to turbulence scales an order of magnitude larger than the boundary layer thickness) failed to have an effect on the boundary layer growth. |

| Publications: | NPS Report, in progress. Technical Note to submit to the Journal of Aircraft, in progress. |
| Thesis Directed: | D.W. Kindelspire, "The Effects of Freestream Turbulence on Airfoil Boundary Layer Behavior at Low Reynolds Numbers," Master's Thesis, September 1988. |

Title: Analysis of Thick Composite Structures

Investigator: R. Kolar, Assistant Professor, Aeronautics
                          and Astronautics Department

Sponsor: David Taylor Research Center

Objectives: The failure of structures made of advanced
                          composite materials is an important concern
                          in the design.   Particular concerns are
                          structures that are classified as thick
                          plates an/or shells, where thin plate
                          theories are not applicable or yield
                          unacceptable results. The objectives, then,
                          was to develop new finite elements to be able
                          to predict the behavior of such thick plates.

Summary: As a first phase in this direction, a finite
                          element using biquadratic lagrangian
                          interpolation functions of C-0 continuity for
                          plate bending was developed.   Transverse
                          shears were accounted by using Mindlin-plate
                          assumptions. Results are obtained for static
                          loading for different thicknesses, fiber-
                          resin combinations, and number of layers.
                          Ectension of the theory to obtain the
                          bucklink loads, either by a complete
                          nonlinear approach or linearized buckling
                          using eigen-problem formulation is being
                          looked into.

                          A second finite element, based on tri-cubic
                          interpolation functions based on three-
                          dimensional elasticity theory is also
                          developed.   Presently, the results are
                          obtained for isotropic case and extension to
                          obtain the results for advanced composite
                          plates is being pursued.

Title:	Testing of Advanced Composite Structures at Elevated Temperatures
Investigator:	R. Kolar, Assistant Professor, Aeronautics and Astronautics Department
Sponsor:	Research Council (FY88) and Naval Weapons Center, China Lake (FY89)
Objectives:	To develop facilities to determine strength of advanced composites at elevated temperatures and test for strength the composite coupons supplied by the NWC, China Lake.
Summary:	A data-acquisition system, comprising a system controller, strain gage scanners, temperature scanners, temperature, and power controllers were put together and integrated into the MTS Testing machine. A special purpose infrared heated oven was installed on the MTS to heat the specimens (Range of the oven: up to 2000 F). Series of tests on coupons obtained from NWC were tested successfully over the desired range of 100-450 F for strength and stiffness. Different lay-up designs and fiber-resin combinations were employed. These are candidate materials for advanced tactical missile air-frames conceived at NWC, China Lake.
Publications:	In preparation, to be presented in a forth coming conference.

Title:	Energy Conservation in Steam Distribution Systems
Investigator:	James A. Miller, Department of Aeronautics and Astronautics
Sponsor:	Naval Facilities Engineering Command, Naval Civil Engineering Laboratory
Objectives:	Complete field testing, code revisions and a complete field service manual for activity level use of the Steam Heat Distribution Program allowing public works engineering staff to exploit its management and maintenance potentialities.

Summary: Field tests of the Steam Heat Distribution Program were carried out at the Naval Supply School, Athens, Georgia and Pensacola Naval Air Station. At the Naval Supply School results demonstrated that savings of about 12% of summer heating costs could be realized by shutting down a portion of the system not in use during summer months and reduction of system operating pressure. At Pensacola, it was revealed that the steam distribution system also had a very poor pressure distribution which might be alleviated through minor operating changes and that the lack of a viable condensate return system resulted in a net loss of 10% of the heat input and that steam trap losses resulted in about 9% of total system losses. With a total cost of nearly $2000 per hour the potential savings are not insignificant. Following field testing and the removal of several program bugs and the incorporation of additional computed output information, a comprehensive users manual was drafted which has proven successful in its goal of permitting public works level engineering staff to make full use of the Steam Heat Distribution Program. Success of the program is evidenced by the wide use of the Steam Heat Distribution Program both in the military and civilian communities. Current users include all divisions of the Naval Facilities Engineering Command, the U.S. Army, Pacific Gas and Electric Company and Public Service Company of Colorado. Additional requests for user information has been received from ASEA Brown Boueri in Sweden and Denmark and Linkopings District Heating Authority of Sweden.

Summary:
(Cont.)

This unanticipated demand has required a reprinting of the Users Manual.

Additionally, the Steam Heat Distribution Program is expected to become a part of a district heating evaluation program, HEATPLAN, currently funded by a consortium of the Department of the Navy, the City of Chicago, the City of New York and the Swedish District Heating Association and coordinated by the Washington State Energy Office.

Publications:
Steam Heat Distribution Program Users Manual, TM-M73-87-20, Naval Civil Engineering Laboratory, Port Hueneme, California, 1988.

Conference
Presentations:
Research Planning Meeting, Tri-Service Underground Heat Distribution Committee, Monterey, California, November 15-17, 1988.

Title:	Particle Behavior in Exhaust Nozzles of Solid Porpellant Rocket Motors
Investigators:	David W. Netzer John P. Powers
Sponsor:	Air Force Astronautics Laboratory
Objectives:	Utilize high speed motion pictures, collected combustion products, scanning electron microscope analysis, measurements of diffractively scattered light and pulsed holography to characaterize the behavior of particulates from the propellant surface into the exhaust plume of a small solid propellant rocket motor.

Summary: The investigation sucessfully characterized for the first time the behavior of ZrC (a stability additive) within the motor and exhaust nozzle of a small solid propellant rocket motor. Light diffraction measurements, high speed motion pictures, pulsed holography and scanning electron microscope analysis of collected combustion products were used. ZrC was found to react to form ZrO_2 on or near the propellant surface. The behavior of the particulates were characterized through the motor and exhaust nozzle as a function of operating pressure and nozzle exit Mach number. In addition, often used assumptions to characterize exhaust plumes (monomodal distributions) were shown to be often incorrect. The results have provided new data for validation of performance (SPD), plume flowfield (SPF-2) and infrared radiation (SIRRM-2) calculations.

Publications: (1) "Measurements of Particulates in Solid Propellant Rocket Motors", T.D. Edwards, R.K. Harris, K.G. Horton, M.G. Keith, A. Kertadidjaja, Y.S. Lee, D.N. Redman, J.S. Rosa, J.B. Rubin, S.C. Yoon, J.P. Powers and D.W. Netzer, Air Force Astronautics Laboratory Report, AFAL TR-87-029, Oct. 1987.

(2) "Light Diffraction Particle Size Measurements in Small Solid Propellant Rocket Motors", E.D. Youngborg, T.E. Pruitt, M.J. Smith and D.W. Netzer, Accepted for publication in J. Propulsion and Power.

(3) "Measurement of Particulate Size in Solid Propellant Rocket Motors", S. Orguc, T.E. Pruitt, T.D. Edwards, E.D. Youngborg, J.P. Powers and D.W. Netzer, 24th JANNAF Combustion Meeting, Monterey, CA, CPIA Publication 476, Vol. 1, Oct. 1987, pp 165-182.

Conference
Presentations: (1) See Publication (3)

Theses Directed: (1) "Application of Laser Diffraction Techniques to Particle Sizing in Solid Propellant Rocket Motors", E.D. Youngborg, M.S.A.E., Dec 1987.

(2) "An Experimental Investigation of the Behavior of Metallized Solid Propellants", M.J. Smith, M.S.E.S., In progress.

(3) "Holographic Investigation of Solid Propellant Combustion", A.G. Butler, M.S.E.S., In progress.

(4) "Laser Light Diffraction Particle Sizing in Solid Propellant Rocket Motors", D. Hovland, A.E., In progress.

Title: Emission Reductions for Gas Turbine
                  Combustors and Test Cell Augmentors

Investigator: David W. Netzer

Sponsor: Direct Funded (Naval Air Propulsion Center)

Objective: Evaluate the effects of fuel composition,
                  smoke suppressant fuel additives and
                  combustor air inlet temperature on the soot
                  size and concentration both within the
                  combustor and across the augmentor tube.

Summary: The major findings of the investigation were
                  as follows:

                  (1) Fuel-air ratio had little effect on D32
                  values (.31-.41 microns for NAPC fuel #1)
                  within the combustor.
                  (2) Decreased fuel hydrogen content (NAPC
                  fuel #7) resulted in larger D32 (.49-.58
                  microns) in the combustor but no significant
                  effect at the entrance to the exhaust nozzle.
                  (3) Significant soot agglomeration occurred
                  across the exhaust nozzle-augmentor tube
                  combination (D32 increased by factors of 2-
                  3).
                  (4) At the same fuel-air ratio, increased
                  combustor air inlet temperature slightly
                  increased D32 at the nozzle entrance, but
                  decreased D32 at the augmentor tube exhaust.
                  Soot agglomeration appeared to be slowed in
                  the presence of higher temperatures.
                  (5) Ferrocence concentrations of 8 ml/gal of
                  fuel were not effective in reducing opacity.
                  (6) For the concentrations and test
                  conditions employed, ferrocene (1)
                  significantly increased D 32 within the
                  combustor with only small decreases in
                  concentration and (2) had no significant
                  effect on concentration at the nozzle
                  entrance, but increased D 32 at low fuel-air
                  ratios.
                  (7) Ferrocene significantly reduced the
                  particle size at the augmentor exit.
                  (8) Raising combustor air inlet temperature
                  increased the ability of ferrocene to reduce
                  D32 at the augmentor tube exhaust.
                  (9) Soot particle concentrations wee
                  estimated to be 0.3 mgm/1 at the nozzle
                  entrance and 1-2 mgm/1 in the combustor.
                  These results have shown that fuel type can
                  effect soot size and concentation within the
                  combustor, but time at temperature

Summary
(Cont.)

significantly negates these effects at the nozzle entrance. Lower power settings should result in larger soot particles in the test cell exhaust stack. Ferrocene appears to enhance agglomeration within the combustor but inhibits agglomeration with the augmentor tube, and it is more effective at higher temperatures.

Publications:

(1)"Measurements of Gas Turbine Combustor and Engine Augmentor Tube Soot Characteristics", M.F. Young, T.A. Grafton, H. Conner and D.W. Netzer, Naval Postgraduate Report NPS67-88-002), July 1988.

Thesis Directed:

(1)"An Experimental Investigation of Sooting Characteristics of a Gas Turbine Combustor and Augmentor Tube", '.H. Lindsay, M.S.A.E., Sept. 1988.

Title: Combustion Behavior of Solid Fuel Ramjets

Investigator: David W. Netzer

Sponsor: Direct Funded (Naval Weapons Center)

Objectives: Utilize holography and measurements of
                        scattered laser light to examine the effects
                        of metallized fuel composition and test
                        conditions on the particulate behavior within
                        the combustor of a solid fuel ramjet. Design
                        and install test apparatus for evaluation of
                        dual-mode and supersonic combustion solid
                        fuel ramjets.

Summary: The combustion behavior of boron carbide,
                        silicon and aluminum based fuels were
                        investigated using a windowed, two-
                        dimensional motor together with a pulsed ruby
                        laser and holocamera. A mass flux of 0.35
                        lbm/in2 sec was employed and chamber pressure
                        were varied from 100 to 140 psia with an
                        average air inlet temperature of 1150 R.
                        Diffuse illumination holograms were required
                        in order to permit the burning particles to
                        be recorded without the severe schlieren
                        effects which are characteristic of
                        collimated light holograms in this situation.
                        With the resulting speckle and the presence
                        of large amounts of very small particles, the
                        resolution was limited to between 15 and 25
                        microns. B4C was found to produce a small
                        amount of very fine post fire residue whereas
                        the silicon and aluminum based fuels produced
                        large amounts of very coarse residue. The
                        holograms were successful in showing the
                        large flakes which are shed from the surface
                        and which had been previously observed near
                        the viewing window using high speed motion
                        pictures. The most important finding was
                        that practically all of the particles in the
                        boundary layer region are smaller than 25
                        microns, irrespective of the fuel
                        composition. This implies that very good
                        combustion efficiency should be obtainable if
                        the particles can be made to ignite near the
                        fuel surface. Light scattering measurements
                        will be required to det.rmine the particle
                        size distributions within the solid fuel
                        ramjet and this investigation has been
                        initiated.

Title:	Investigation of Propulsive Flow and Aircraft Agility Problems
Investigator:	Max F. Platzer, Professor of Aeronautics and Astronautics
Co-investigator:	Professor T. Cebeci, Professor M.A. Badrinarayanan, Dr. J.A. Ekaterinaris
Sponsor:	Naval Air Systems Command

Objective: The objective of the proposed investigation is twofold:

a) To continue the development of computational methods for the analysis of steady and unsteady viscous flow effects in turbomachinery blade rows and to continue the experimental development of a new jet excitation mechanism

b) To start the analysis of enhanced aircraft maneuverability and agility due to short-duration fully stalled flight.

Summary: a) A numerical method for calculating unsteady two-dimensional boundary layers in incompressible laminar and turbulent flows was developed and applied to a single airfoil changing its incidence angle in time. The solution procedure adopts a first order panel method to solve for the inviscid part of the flow, and an implicit finite difference method for the viscous part of the flow. Results were obtained for flows over oscillating and rapidly pitching airfoils.

b) Also, Navier-Stokes codes were used to obtain solutions for incompressible and compressible flows over oscillating and rapidly pitching airfoils.

c) A new jet excitation method was developed using a bi-vane system and an exploratory investigation of the effectiveness of this scheme to increase the jet's secondary flow entrainment capability was completed.

d) Volume II of the AGARD Manual on Aeroelasticity in Axial-Flow Turbomachines was completed and published in September 1988.

Publications: "Numerical Investigation of Unsteady Compressible Flow through Nozzles and Cascades", Proc. of the Fourth International Symposium on Unsteady Aerodynamics and Aeroelasticity of Turbomachines and Propellers, Aachen, Germany, February 1988, pp. 335-356 (with A. Boelcs, T.H. Fransson).

"The Mixing Mechanism by Organized Turbulence Structures in a Plane Jet Excited by a Novel Method", Proc. of the IUTAM Symposium on Turbulence Management and Relaminarisation, Bangalore, India, 1988, pp. 471-484 (with M.A. Badrinarayanan) "Numerical Simulation of Inviscid Transonic Flow through Nozzles with Fluctuating Back Pressure", ASME Gas Turbine and Aeroengine Congress, Amsterdam, Netherlands, Paper No. 88-GT-287, June 1988, (with A. Boelcs, T.H. Fransson)

"Transition Modeling Effects on Viscous/Inviscid Interaction Analysis of Low Reynolds Number Airfoils Flows Involving Laminar Separation Bubbles", ASME Gas Turbine and Aeroengine Congress, Amsterdam, Netherlands, Paper No. 88-GT-32, June 1988, (with G.J. Walker, P.H. Subroto).

"AGARD Manual on Aeroelasticity in Axial Flow Turbomachines, Volume 2, Structural Dynamics and Aeroelasticity" AGARDograph No. 298, June 1988 (edited with F.O. Carta).

Theses Directed: L.J. Cowles, MSAE Thesis, "High Reynolds Number, Low Mach Number, Steady Flow Field Calculations over a NACA 0012 Airfoil Using Navier-Stokes and Interactive Boundary Layer Theory", December 1987 E. Pagenkopf, MSAE Thesis, "Dynamic Stall Calculations Using a Navier-Stokes Code", March 1988

J.H. Conroyd, MSAE Thesis, "Dynamic Stall Calculations Using a Zonal Navier-Stokes Code", March 1988

A. Kreniski, MSES Thesis, "The Use of Seaplanes as an Advanced Weapon System" September 1988

Title: Unsteady Heat Transfer in Turbine Cascades

Investigator: M.F. Platzer, Professor of Aeronautics and Astronautics

Co-Investigator: Professor T. Cebeci, California State University, Long Beach

Sponsor: NASA Lewis Research Center

Objective: Develop a general method for the numerical prediction of temperature and velocity in the two-dimensional flow field past a linear cascade which is exposed to an arbitrary gust.

Summary: A method for computing the heat transfer in the stagnation region of turbine blades was developed for incompressible flows and evaluated for two model problems involving laminar flows. Also, a numerical code was developed to solve for the potential flow for two airfoils executing unsteady motions in an inviscid incompressible medium and a numerical method for computing unsteady two-dimensional boundary layers on a single airfoil was developed. Sample calculations were completed on a NACA 0012 and on a Sikorsky airfoil demonstrating the influence of rapid pitch motion on the laminar and turbulent boundary layer development.

Publications: "Progress towards the Development of an Inviscid/Viscous Interaction Method for Unsteady Flows in Turbomachinery Cascades", Proc. of the Fourth International Symposium on Unsteady Aerodynamic's and Aeroelasticity of Turbomachines and Propellers, Aachen, Germany, Februray 1988, pp. 721-753 (with T. Cebeci, N.G. Teng, A. Krainer, R.J. Simoneau)

C.K. Pang, AE-Thesis, "A Computer Code for Unsteady Incompressible Flow past Two Airfoils" September 1988.

DEPARTMENT
OF
OCEANOGRAPHY

DEPARTMENT OF OCEANOGRAPHY

NEARSHORE STUDIES

Professors E.B. Thornton, C.S. Wu, and N. Dodd are studying the kinematics of breaking waves within the surf zone and their effect on beach erosion. Data have been acquired through participation in experiments in Southern California and North Carolina. Using these data, a model based on energy flux balance has been developed which describes the transformation of random wave heights and resulting along shore currents. The research sponsor for these studies is ONR and the State of California.

COASTAL OCEAN STUDIES

Prof. M.B. Batteen is using a primitive equation ocean model to understand the effects of wind forcing and topography on Eastern Boundary Currents. The technical sponsor for the work on the California Current is ONR and for the work on the Leeuwin Current is NSF.

Prof. S.R. Ramp has been a participant in two projects. The purpose of the "Coastal Transition Zone" project is to improve our understanding of the formation of cold filaments which extend offshore from coastal upwelling regions. Prof. Ramp organized several cruises to the study region and supervised the collection of hydrographic data, Prof. Ramp also began a project to study the currents on the shelf and slope off Pt. Sur. The technical sponsor for this work is ONR.

Prof. C.R. Dunlap completed his studies of the acoustic environment off Monterey. Prof. J.A. Nystuen continued efforts to develop an ocean drifting buoy samples oceanographic, meteorologic and acoustic parameters and telemeters this information ashore via the ARGOS satellite data relay system. The technical sponsor for this research was ONR.

Prof. C.A. Collins began studies of the kinematics of the currents across the continental margin off Pt. Sur using velocity sounding techniques. The sponsor for this study was ONR.

OPEN OCEAN STUDIES

Under sponsorship of the NSF, Prof. A.J. Sentner, Jr., completed a numerical simulation of global ocean circulation with mesoscale resolution. This calculation has established the feasibility of ocean prediction using modern large-scale computers. A new calculation with time-varying forcing is underway.

Prof. D.C. Smith, IV, carried out a study to understand the circulation under which rings coalesce with the Gulf Steam. A Regional two-layer numerical model of the ocean was used. This study was sponsored by .;SF.

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Prof. T.P. Stanton and Prof. E.B. Thornton are studying the properties of velocity shears and density gradients in the upper ocean. A towed package and coherent and incoherent doppler velocimeters have been developed to measure finescale shear and turbulent microstructure. Observations were collected during tow cruises. The research is sponsored by ONR.

Prof. C.A. Collins conducted an investigation of the mesoscale circulation of Mindanao using drifting buoys and an AXBT survey. The technical sponsor for this project was ONR.

Prof. R.W. Garwood and Prof. P. Chu are sponsored by the NPS Research Foundation, ONR and NSF to investigate the thermodynamic and dynamic coupling between the oceanic atmospheric turbulent boundary layer properties and a better understanding of atmosphere ocean exchanges.

Prof. R.W. Garwood and Prof. P. Chu began studies of seamount-induced vertical circulation and mixing. Current meter moorings that were deployed on SE Hancock seamount were recovered and data are being analyzed. The technical sponsor for this work was ONR.

ARCTIC STUDIES

Prof. R.H. Bourke and R.G. Paquette are involved in studies of the frontal and finestructure phenomena associated with the ice edges of the Atlantic and Pacific Oceans as well as studies of Arctic sea ice. These studies have applications for environmental acoustics and under-ice submarine operations. The sponsor is the Arctic Submarine Laboratory.

Prof. D.C. Smith, IV, completed a numerical study of the interaction of an ocean eddy with the marginal ice zone. This study was sponsored by ONR.

Prof. A.J. Semtner, Jr., completed studies of the atmospheric forcing and sea-ice response in a coupled ice-ocean model. These studies were sponsored by the NPS Foundations.

ENVIRONMENTAL ACOUST S

Prof. J.A. Nystuen is developing techniques for measuring rainfall at sea through ambient sound measurements. He carried on a study of precipitation generated ambient sound in winter storms off the Coast of Nova Scotia. His research is technically sponsored by ONR.

Prof. C.R. Dunlap and Prof. R.H. Bourke completed studies on the performance of vertical line arrays. The sponsor is the Naval Avionics Center and the Naval Air Systems Command.

Prof. R.H. Bourke continued studies of the ambient noise generated in arctic ice-covered waters based on noise measurements acquired by drifting buoys. The sponsor is the Arctic submarine

laboratory.

MARINE OPERATIONS

Prof. C.A. Collins and Mrs. N.A. McGhee provided shipboard support for NPS at-sea research projects of the Central California coast. Sixty days of operations were carried out on the R/V Pt. Sur and 17 on the USNS DeSteiger; students and faculty participating included the Department of Oceanography Meteorology, and Physics. The sponsor for this project is the Commander, Naval Oceanography Command.

Prof. R.W. Garwood, S.R. Ramp, and C.A. Collins continued the development of a Physical Oceanographic Observation Laboratory through the acquisition of current meters and acoustic released. The technical sponsor for the research part of this project is ONR.

Title:	Modeling Studies of the Eastern Boundary Flow off Western Australia
Investigator:	M.L. Batteen, Assistant Professor of Oceanography
Sponsor:	National Science Foundation, September, 1988-1900
Objective:	The objectives of this project are to investigate 1) why the Eastern boundary flow off Western Australia (W.A.) is generally poleward rather than equatorward, and 2) why mesoscale eddies are present in this region. To accomplish these goals, we propose to 1) adapt an existing primitive equation (PE) ocean model presently being used in the Eastern boundary flow region off California to the Eastern boundary flow region of W.A.; 2) incorporate different initial condition appropriate for the W.A. region into the model; and 3) run a series of numerical model experiments using the different initial condition. Analysis of the results from each experiment should determine under what conditions a poleward flow (called the Leeuwin Current) and/or mesoscale eddies are generated. The ultimate goal is to provide the physical understanding necessary for high resolution ocean prediction in this region.

| Summary: | Since funding for this project began in September, 1988, we have run two numerical experiments with the same initial conditions of poleward surface jet overlying an equatorward undercurrent, one run made on an f-plane and the other on a beta-plane. In both cases mesoscale eddies were generated. Analysis of the results are presently being made. |

Title:	Wind Forcing Effects on Eddies and Jets in the CCS
Investigator:	M.L. Batteen, Assistant Professor of Oceanography
Sponsor:	Direct Funded Sponsor: Office of Naval Research

Objective: The objective of this project is to understand the role of wind forcing in eddy and jet formations in the CCS (California Current System). To accomplish these goals, we proposed to 1) incorporate wind forcing into an existing primitive equation (PE) model of the California Current, 2) vary the type of wind forcing and 3) compare the results with observations.

Summary: Wind forcing has been incorporated into the model with the additional model development of inc?uding surface heating to prevent continuous cooling nearshore when coastal upwelling occurs. The effects of wind forcing have been analyzed by varying the type of wind forcing. In particular, we have focused on cases of steady, scuthward winds, with and without the curl, in a flat bottom ocean. Preliminary results show the development of eddies and jets. Model improvements in these studies are to incorporate time-dependent wind data and finer horizontal resolution (to look at fronts).

Publications: M.L. Batteen, "A Numerical Study of Wind Forcing of Eddies and Jets in the California Current System," Transactions of the American Geophysical Union, 69, 1249, 1988.

C.R. Johnson, M.L. Batteen, and R.L. Haney, "Ocean Prediction in the California Coastal Region Using a High Resolution Primitive Equation Model," NPS68-88-007, 1988. p. 43.

T.A. Tielking and M.L. Batteen, "Wind Forcing of Eddies and Jets in the California Current System," NPS68-88-006, 1988. p. 107.

M.L. Batteen, "On the Use of Sigma Coordinate in Large-Scale Ocean Circulation Modeling," Ocean Modelling, 77 3-5, 1988.

M.L. Batteen, "Modeling Studies and Sampling Sensitivity of Mesoscale Processes in the California Current System," WMO/JSC Working Group on Numerical Experimentation, 10, 8.34--8.35, 1987.

Conference
Presentations:

M.L. Batteen, "A Numerical Study of Wind Forcing of Eddies and Jets in the California Current System," Am. Geophys. Union, AGU Fall Meeting, San Francisco, CA., December 5-9, 1988.

M.L. Batteen, "Modeling Studies of the Central California Current System," Minutes of the 35th Eastern Pacific Oceanic Conference, Lake Arrowhead, CA., November, 1988.

M.L. Batteen, "Modeling studies of Mesoscale Processes in the California Current System (CCS)," Transactions of the American Geophysical Union, 68, 1330, AGU Fall Meeting, December, 1987, San Francisco, CA.

M.L. Batteen, "Modeling of Eddies and Jets in the California Current System," Minutes of the 34th Eastern Pacific Oceanic Conference, October, 1987, Tiburon, CA.

Theses
Directed:

T.A. Tielking, "Wind Forcing of Eddies and Jets in the California Current System." M.S. Thesis, June, 1988.

C.D. Johnson, "Feasibility of Ocean Forecasting in the California Coastal Region Using a High Resolution Primitive Equation Model," M.S. Thesis, June, 1988.

M.E. Beasley, "Changes in the California Current System Observed off Northern California during July-August, 1986," M.S. Thesis, December, 1987.

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Title:	Marginal Sea-Ice Zone Studies 1988
Investigators:	R.H. Bourke, Professor of Oceanography and R.G. Paquette, Emeritus Professor of Oceanography
Sponsor:	Arctic Submarine Laboratory
Objective:	Carry out physical oceanographic research, including field measurements, in the marginal sea-ice zone of the Bering, Chukchi, and Greenland Seas. This work has the long-term applied objective of facilitating the operation of submarines under ice. It is part of the continuing MIZPAC and MIZLANT programs.

| Summary: | This is an ongoing program to study the frontal and fine structure phenomena associated with the ice edges of the Atlantic and Pacific Oceans. Measurements, primarily CTD lowering, have been carried out from ice breakers sine 1971 and include observations both in summer and winter. During FY88, we have completed the analysis of the 1986 cruise to Nares Strait. An M.S. thesis, a data report, and a journal article resulted from this work. Preparations for a summer cruise to the Greenland Sea in 1989 as part of the Greenland Sea Project are underway. Analysis of under ice ambient noise from the Eurasian Basing and Greenland Sea has been . completed. An M.S. thesis, a data report, and two journal articles have been published on this data. Analysis of ice thickness data from five floes in the Beaufort Sea has been completed. Two journal articles were written on this work. Work is continuing on ambient noise studies in the Beaufort Sea and transmission loss in the Greenland Sea MIZ. Dr. T.O. Manley from Lamont Doherty Geological Observatory collaborated with Prof. Bourke on a study of the potential energy field in Fram Strait with the objective to characterize the potential for baroclinic and barotropic eddy generation. |

| Publications: | R.H. Bourke, A.M. Weigel, and R.G. Paquette, "The Westward Turning Branch of the West Spitzbergen Current," J. of Geophys, Res. 93 (C11): pp. 14065-14077, 1988. |

R.H. Bourke, R.G. Paquette, and V.G. Addison, "MIZLANT 86 Data Report: Results of an Oceanographic Cruise to Northern Bafflin Bay and Nares Strait in September, 1986," NPS68-88-004, April, 1988.

D.L. Poffenberger and R.H. Bourke, "Arctic Ambient Noise Measured From Drifting Buoys in the Greenland Sea and Eurasian Basin: Data Summary," NPS68-87-006, December, 1987.

Conference
Presentations:

R.H. Bourke, "Winter Oceanographic, Sea Ice and Acoustic Conditions Near Svalbard," Seminar War Game, Naval Surface Weapons Center, Silver Spring, MD., October 5-6, 1988.

R.H. Bourke, "Impact of the Ocean Environment on Arctic ASW Operations," Fall Meeting American Defense Preparedness Association, Plenary Session, Monterey, CA., October 12-15, 1987.

R.H. Bourke, "Environmental Influence on Naval Operations in the Arctic," Annual Meeting Board of Advisors for Univ. of Colorado, URI, Boulder, CO., October 28-29, 1987.

R.H. Bourke, R.G. Paquette, and W.B. Tucker, "Measurements of Sea-Ice Thickness, Freeboard, and Draft," Annual Fall Meeting American Geophysical Union, San Francisco, CA., December 9-10, 1987. Also Abstract in EOS, Trans, Am. Geophys, Un, 68(44): 1316, 1987.

V.G. Addison, R.H. Bourke, and R.G. Paquette, "Oceanographic Observations in Baffin Bay Nares Strait," Annual Fall Meeting American Geophysical Union, San Francisco, CA., December 9-10, 1987. Also Abstract in EOS, Trans. Am. Geophys, Un, 68(44): 1317, 1987.

R.H. Bourke, "Arctic Acoustics," 56th MORS Conference, Monterey, CA., June 28-30, 1988.

Theses
Directed:

V.G. Addison, "The Physical Oceanography of Baffin Bay and Nares Strait, M.S. Thesis and Tech. Report (68-87-008), December, 1987.

D.L. Poffenberger, "Analysis of Ambient Noise Measured from Drifting Buoys in the Greenland Sea and Eurasian Basin," M.S. Thesis and Tech. Report (68-88-005), December, 1987.

Title:	Chair in Arctic Marine Science
Investigator:	R.H. Bourke, Professor of Oceanography
Sponsor:	Office of Naval Research
Objective:	To foster oceanographic research in the Arctic acquaint Naval officer students with Arctic problems, reduce results of pure research to operational usage, and publicize Navy interest in the Arctic.

Summary: Prof. Bourke served as administrator of the Chair handling such details as selecting Chair candidates, writing IPS's, proposals, and setting up visits and seminars for the Chair incumbent. Dr. R.S. Pritchard, President of IceCasting, Inc., was the Chair incumbent during FY88. He had a productive year providing seminars, lectures, writing papers, and attending conferences. He developed an ambient noise measuring and data logging system for use in the CEAREX Project. He served as thesis advisor for a M.S. student working on ambient noise due to shearing of the boundary layer under sea ice. He made extensive progress toward formulating and underice ambient noise prediction model forced by various processes.

Title: Marine Operations

Investigators: C.A. Collins, Professor and Chairman of
                       Oceanography

Sponsor: Naval Oceanography Command

Objective: To provide administrative and logistical
                       support for shipboard operations and
                       education.

Summary: The Naval Postgraduate School Marine
                       operations program carried out a total of 78
                       days at sea in FY88. Studies included the
                       disciplines of physics, physical
                       oceanography, and meteorology. Activities
                       included spring and fall cruises as part of
                       the Operational Oceanography/Meteorology
                       course (OC/MR 3570), investigation of the
                       effect of ocean current on vertical
                       hydrophone arrays, sea surface microbubble
                       measurements, surveys of the density and
                       velocity structure of Point Sur, mapping
                       hydrographic fields of the coastal transition
                       zone off Pt. Arena, and instrumentation
                       tests.

Title:	California Undercurrent Study
Investigators:	C.A. Collins, Professor and Chairman of Oceanography
Sponsor:	Office of Naval Research
Objective:	To develop a better understanding of the kinematics and dynamics of the California Undercurrent.

Summary:

We have initiated our studies of the velocity field across the continental margin off Point Sur using an autonomous acoustically tracked velocity profiler called "Pegasus." Research cruises have been carried out as follows: April 15 - May 2, USNS DeSteiger; August 3 - 8, R/V Pt. Sur; September 22-27, R/V Pt. Sur; and November 14 - 19, R/V Pt. Sur. On the first cruise we set and surveyed ten pairs of transducers. Seven of these are located along 36-20N between 122-15W and 123W and the others are located at CALCOFI stations farther offshore and to the North. Inertial period currents were stronger than expected so that we now sample stations a half an inertial period apart. Data from the first three cruises indicated that organized poleward flow occurred across the continental shelf and slope to about 123W and above 800m. Transport was estimated at about 2.5 Sverdrups.

We will continue this series of bimonthly cruises for another year to resolve the seasonal pattern of the circulations. We will also acquire an updated version of Pegasus which can be tracked more accurately.

Conference
Presentations:

C.A. Collins, "Velocity Measurements of the California Undercurrent," 35th Annual Meeting of the Eastern Pacific Oceanic Conference, Lake Arrowhead, CA., November 9, 1988.

Publications:

T.A. Rago, C.A. Collins, and F. CHAVEZ, "Hydrographic Measurements off Point Sur," Transaction, Am. Geoph. Union, 69(44), pp. 1249, 1988.

Title:	Mindanao Eddy Study
Investigator:	C.A. Collins, Professor and Chairman of Oceanography
Sponsor:	Office of Naval Research
Objective:	Determine the mesoscale structure associated with the Southward retroflection of the North Equatorial Current of Mindanao.

Summary:

A synoptic view of the upper ocean temperature field was obtained by means of aircraft survey from July 11-14 for the region to East Mindanao. The region adjacent to Mindanao from 3N to 7-40N and from 125-45E to 128-50E was sampled with 15 n. mile spacing and the region North of Halmahera from 1-25N to 6-23N and from 129-04E to 129-45E was sampled with 25 n. mile spacing. At the same time the velocity structure of the region was sampled with six surface-drogued drifting buoys. The drifting buoys were launched across the Southward flowing |Mindanao current 7N and 8N. This project was carried out in conjunction with WEPOCS III and related U.S. TOGA experiments.

The data provide a consistent picture of a narrow, strong, equatorward Western boundary current---the Mindanao Current---which flows into the Celebes Sea. One drifter yielded an averaged daily speed of about three knots while in the Mindanao Current. Return flow into the Pacific was observed form the Molucca Sea. The drifting buoys recirculate in eddies both to the East mindanao as well as to the Northeast of Halmahera. The pattern of flow observed by drifters agrees well with that inferred from temperature measurements.

Conference
Presentations:

N.L. McGee, C.A. Collins, and G.H. Carpenter, "An AXBT Survey off Mindanao and Halmahera," Transactions Am. Geoph. Union, 69 (44), pp. 1227, 1988.

P.L. Richardson and C.A. Collins, "Preliminary Results from WEPOCS Drifters," Transactions, Am. Geoph. Union, 69 (44), pp. 1227, 1988.

Title:	Topographic Interaction ARI: Mixing and Nutrient Enhancement Near an Isolated Seamount
Principal Investigator:	R.W. Garwood, Jr., Professor
Co-Investigator:	P. Chu, Adj. Res. Professor
Sponsor:	Office of Naval Research
Objective:	To predict the effect of seamounts on upper ocean mixing and circulation attributable to mixing.
Summary:	We have participated in all the planning meetings for this new ONR accelerated research initiative and understand the effect of topography on the semi-geostrophic flow.
Publications:	P.R. Bannon and P.C. Chu, "Anelastic Semigeostrophic Flow Over a Mountain Ridge, Journal of Atmosphere Science, pp. 1020-1029, 1988.
	S.C. Raugust, R.E. Brainard, and R.W. Garwood, Jr., "Bottom Moored Current Meter Data From the Southeast Hancock Seamount in April 1987," NPS68-88-008, pp. 84, 1987.

Title:	The Equatorial Mixed Layer
Principal Investigator:	R.W. Garwood, Professor
Associate Investigator:	P. Chu, Adj. Res. Professor
Sponsor:	National Science Foundation
Objective:	To develcp a comprehensive understanding of the dynamics of the equatorial turbulent boundary layer.

Summary: An intensive examination of a new feedback mechanism between the clouds and the oceanic mixed layer has been undertaken. It is found that cloud reduce the solar radiation at the ocean surface by scattering and absorption, which cools the ocean surface layer by increasing entrainment. The cooling of the ocean mixed layer lowers the evaporation rate, which will diminish the cloud. This is a negative feedback mechanism. On the other hand, precipitation dilutes the surface salinity, stabilizing the upper ocean and reducing mixed layer deepening. The reduction in the mixed layer depth will increase the sea surface temperature by concentrating the net radiation plus heat fluxes downward across the sea surface into a thinner layer. The increase of sea surface temperature augments the surface evaporation, which in turn produces more cloud. This is positive feedback mechanism.

Publications: P.C. Chu and R.W. Garwood, Jr., "Thermodynamic Feedback Between Summer Monsoon and Ocean Temperature and Salinity, IUGG Proc., I 166, 1987.

P.C. Chu, "An Instability Theory of Air-Sea Interaction for Coastal Upwelling," Advanced Atmos. Sci., 5, Springer-Verlag, New York, pp. 277-285, 1988.

Conference Presentations: P.C. Chu and R.W. Garwood, Jr., "Thermodynamical Feedback Between Summer Monsoon and Ocean Temperature and Salinity, IUGG, Vancouver, Canada, 1987.

Thesis
Directed: H.J. Ries, "The Climatological Seasonal
                                  Response of the Ocean Mixed Layer in the
                                  Equatorial and Tropical Pacific Ocean, M.S.
                                  Thesis, March, 1988.

Title:	Coupled Oceanic and Atmospheric Boundary Layers
Sponsor:	NPS Direct Funds
Investigators:	R.W. Garwood, Jr., Professor, (principle investigator); P. Chu, Adj. Res. Professor
Objective:	To provide a theoretical basis for ice drift prediction.

Summary:

A intensive survey of the feedback mechanism among three components (air, ice, and ocean) in the marginal ice zone is made. Thermally generated surface wind, blowing from ice to water (ice breeze) with some deflection due to the earth rotation, forces the ice drift and ocean currents near the MIZ. By changing the surface temperature gradient, the ice motion and ocean currents feed back on the surface winds. A coupled air-ice-ocean model is developed to predict the ice-drift pattern, the ice divergence/convergence criterion, the ice edge upwelling, ice edge banding, and the polynya formation.

Publications:

P.C. Chu, "Generation of Unstable Modes of the Iceward Attenuation Swell by Icebreeze," Journal of Phys. Oceanogr., 17, pp. 828-832, 1987.

P.C. Chu, "An Instability Theory of Ice-air Interaction for the Formation of Ice-edge Bands," Journal of Geophys. Res., 92, pp. 6966-6970, 1987.

P.C. Chu, "An Icebreeze Mechanism for an Ice Divergence - Convergence Criterion in the Marginal ice Zone," Journal of Phys. Oceanogr., 17, pp. 1627-1632, 1987.

P.C. Chu, "An Air-sea Feedback Mechanism for Quasi-geostrophic Water Movement Near a Fast Shelf-ice Edge with a Small Curvature," Chinese Journal of Atmosphere Science, 11, Allerton Press, New York, pp. 31-42, 1987.

P.C. Chu, "An Air-Ice-Ocean Feedback Mechanism in the Marginal Ice Zone," IUGG PROC., III, 862, 1987.

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P.C. Chu, "A Seabreeze Mechanism for Ice Edge Upwelling," Chinese Journal of Atmosphere Science, 11, Allerton Press, New York, pp. 163-181, 1988.

P.C. Chu, "A Mesoscale Air-Ice-Ocean Feedback Mechanism for the Drift in the Marginal Ice Zone," OMAE (IV), pp. 83-90, 1988.

P.C. Chu and R.W. Garwood, Jr., "Comments on a Coupled Dynamic-Thermodynamic Model of an Ice-Ocean System in the Marginal Ice Zone," Journal of Geophys. Res., 93, pp. 5155-5156, 1988.

Conference
Presentations:

P.C. Chu, "An Air-Ice-Ocean Feedback Mechanism in the Marginal Ice Zone," IUGG 1987, Vancouver, Canada.

P.C. Chu, "A Meso-Scale Air-Ice-Ocean Feedback Mechanism for the Ice Drift in the Marginal Ice Zone," OMAE, Houston, 1988.

Theses
Directed:

A. Turker, "Evaporation Effects on the Mediterranean Sea Mixed Layer," M.S. Thesis, September, 1988.

M.S. Livezy, "Discrete Precipitation Effects on Seasonal Mixed Layer Dynamics in the North Pacific Ocean," M.S. Thesis, September, 1988.

Title:	Imaging Monterey Bay with Acoustic Tomography
Investigators:	J.H. Miller, Assistant Professor of Electrical and Computer Engineering; T.P. Stanton, Adjunct Research Professor of Oceanography; E.B. Thornton, Professor of Oceanography; and L.J. Ziomek, Associate Professor of Electrical and Computer Engineering
Sponsor:	Monterey Bay Aquarium Research Institute
Objective:	The goal of this research is a long-term (5 year) monitoring of Monterey Bay with an acoustic tomography system. This system would provide 3-D sound speed and current maps of the Bay for use by oceanographers and other ocean researchers.

Summary:	This is the first year of a joint effort by the Electrical and Computer Engineering Department and the Oceanography Department to develop an ocean acoustic tomography (OAT) system in Monterey Bay. It is envisioned that the Bay would be surrounded by shore-linked acoustic transceivers that would transmit and receive coded acoustic signals. This is the ocean acoustic analog to medical X-ray computer-assisted tomography signals. This is the ocean acoustic analog to medical X-ray computer assisted tomography (CAT). Whereas CAT uses the S-ray intensify fluctuations measured at a number of angles through the imaged tissue, OAT uses the fluctuations of measure travel times from a number of acoustic multipaths through an ocean body. These fluctuations are then "inverted" to provide an estimate of the intervening sound speed structure (and hence density) and current structure. In this reporting period, preliminary analyses were conducted to verify the feasibility of tomography in Monterey Bay. These analyses included 2-dimensional ray traces and normal mode modeling given historical oceanographic conditions in the Bay. We are just beginning a very sophisticated 3-dimensional acoustic ray trace analysis. The analysis will take into account the complicated bathymetry in Monterey Bay including the Submarine Canyon.

Title: NPS Ambient Noise Drifter System (NADS)

Investigator: J.A. Nystuen, Assistant Professor of Oceanography

Sponsor: Direct Funding - CNOC Review

Objective: To access the ability to predict geophysical quantities from a remote ambient sound drifting buoy. The environmental data collected will be compared with simultaneous satellite data (SSM/I).

Summary: This is a new project. Hydrophone components have been ordered. A satellite data link to the IDEA lab from ENOC is being established. The drifting buoy platform has been identified (Tri-Star) and the preliminary design discusses.

Title:	Rainfall Measurements Using Underwater Ambient Sound
Investigator:	J.A. Nystuen, Assistant Professor of Oceanography
Sponsor:	Direct Funding - ONR Review
Objective:	To explore the feasibility of monitoring oceanic rainfall by passively measuring the ambient sound generated.

Summary: An analysis of ocean ambient sound data set together with extensive environmental measurements was conducted. The conclusion include that precipitation can be detected acoustically even in high wind and wave conditions. Rainfall rate measurements were not possible with our current understanding of the physics. Ambient bubble populations were estimated acoustically and for this data set not in agreement with optically derived populations.

A laboratory tank has been set up (in H. Medwin's Lab) to begin an investigation of the role of drop size and impact angle on the two principle mechanisms for sound production by a single drop impact. Preliminary data has been recorded.

The numerical work has concentrated on modeling the acoustic source strength directly rather than monitoring the pressure below drop. A new description of the physics was developed and presented at the Fall Meeting of the Acoustical Society of America.

Acoustic measurements of wind and rain depend on the interaction of theses phenomena. Part of this interaction is the attenuation of surface gravity waves by rain. An extensive review of literature was performed and numerical model of the problem has been set up. Dr. F. Harlow of the Los Alamos National Lab has been consulted and is ready to apply his transport of turbulent energy density theory to the problem.

Publications: J.A. Nystuen and D.M. Farmer, "The Sound Generated by Precipitation Striking the Ocean Surface," Sea and Surface Sound, ed. B. Kerman, pp. 485-500, Kluwer, 1988.

Conference
Presentations: J.A. Nystuen, "Observations of Ocean Surface
                      Phenomena Using Underwater Ambient Sound,"
                      Fall Meeting, AGU, San Francisco, December,
                      1987.

                      J.A. Nystuen, "Hydroacoustic of Drop Impact,"
                      Soc. Am., Honolulu, November, 1988.

Title: The Physical Oceanography Observation
                Laboratory (POOL)

Investigators: S.R. Ramp, Assistant Professor; C.A. Collins,
                Professor; and R.W. Garwood, Professor, (all
                Department of Oceanography).

Sponsor: Naval Postgraduate School Direct Funding

Objective: To develop and maintain the capability to
                make state of the art measurements of current
                speed and direction, temperature
                conductivity, and pressure in the ocean,
                using both shipboard and moored autonomous
                instrumentation.

Summary: The primary thrust of the POOL group thus far
                has been to develop the ability to
                successfully moor and recover current meters
                in the ocean. This effort included acquiring
                the necessary personnel, and transferring
                technology to new and existing personnel.
                Equipment acquired included 19 Aanderaa RCM8
                current meter, two R.D. Instruments self-
                contained ADCPs, 9 EG&G BACS model 8242
                acoustic releases, and all the mooring
                hardware necessary to deploy this equipment
                in the ocean at four sites on the continental
                slope off Point Sur (see the POST project
                summary). Dr. Dale Phillsbury occupied the
                CNOC chair during summer 1988, and with other
                members of this staff at Oregon State
                University, helped NPS personnel prepare and
                deploy our first mooring on the 800 m isobath
                off Point Sur. This mooring will be
                recovered and redeployed during March, 1989.
                Deployment of the full array depends on
                hiring additional manpower, which has been
                the greatest problem for the POOL group so
                far. Future POOL projects include six
                moorings in support of the ONR seamount ARI,
                and continued measurements along the Point
                Sur Transect.

Title:	The Point Sur Transect (POST) Program
Investigators:	S.R. Ramp, Assistant Professor and P.F. Jessen, Oceanographer, both Department of Oceanography
Sponsor:	ONR, Direct Funding
Objective:	To resolve the physical and biological variability of the California Current System off Point Sur, California, at seasonal and longer time scales, using both shipboard and moored measurements maintained for a period of at least 5 years.

Summary: The Naval Postgraduate School has begun repeat occupations of an oceanographic transect across the California Current System (CCS) near Point Sur, CA., consisting of moored current measurements of the shelf and slope (this program), Lagrangian current measurements using the PEGASUS system (see project summary by C. Collins) and repeated hydrographic sections along the line (both programs). We are cooperating with investigators at the Monterey Bay Aquarium Research Institute (MBARI) who are collecting related biological and chemical data along the same section. Two problems of particular interest are the kinematics and dynamics of the California Undercurrent and the resolution of El Nino/Southern Oscillation (ENSO) Events.

The first mooring was deployed during August 1988 and will be recovered and redeployed during March 1989. Two years of hydrographic data have now been obtained and archived on the NPS student cruises. Analysis of the data for low frequency signals is just beginning.

Title:	The Coastal Transition Zone (CTZ) Program
Investigators:	S.R. Ramp, Assistant Professor, and P.F. Jessen, Oceanographer. There are approximately two dozen other principle investigators involved in this program.
Sponsor:	Naval Postgraduate School Direct Funding. Office of Naval Research
Objective:	To enhance our understanding of the kinematics and dynamics of the cold filaments which are often observed in the satellite AVHRR and CZCS imagery of the central California coast, and to assess the impact of these structures on the across-shelf transport and the biological productivity of the region.

Summary: The CTZ program is a 5-year ONR Accelerated Research Initiative (ARI) whose objective is stated above. We carried out tow cruises in 1987 and 1988 as part of the large scale mapping group. The 1987 data (previously described) has now been processed through the data report stage and is being analyzed and utilized by students for thesis work.

The main field effort for the CTZ program took place during the summer of 1988. Six maps were made of the physical and biological variables in a cold filament off Point Sur Arena California. Our NPS group obtained maps 3 and 4. The maps were made using a skewed 100 x 120 nm grid of hydrographic stations supplemented by ADCP velocity, meteorology, and continuous underway sampling systems. Everything worked very well and an excellent data set was obtained. A total of 34 clear, useful AVHRR satellite images of the study region were also obtained during the cruise. The preparation of data reports and further analyses of the 1988 data are underway.

Conference
Presentations: S.R. Ramp, "Preliminary Results from the CTZ Pilot Study, March and June, 1987," Presented at the Eastern Pacific Oceanic Conference, Tiburon, CA., October, 1987.

S.R. Ramp and P.F. Jessen, "Preliminary Results from the Coastal Transition Zone (CTZ) Program Study: June 1987," AGU Fall Meeting, San Francisco, CA., December, 1988.

P.F. Jessen and S.R. Ramp, "Oceanographic Conditions in the Coastal Transition Zone (CTZ) Off Central California during March 1987," AGU Fall Meeting, San Francisco, CA., December, 1987.

S.R. Ramp, "Results from CTZ Large Scale Survey Grids 3 and 4 during July 1988," CTZ Principle Investigators Meeting, La Jolla, CA., November, 1988.

S.R. Ramp and P.F. Jessen, "Preliminary Results from the Coastal Transition Zone (CTZ) Mapping Cruises during July 1988.

P.F. Jessen and S.R. Ramp, "Velocity Structure Associated with a Cold Filament Off Point Arena, California during July, 1988," AGU Fall Meeting, San Francisco, CA., December, 1988.

Theses Directed:

R.L. Snow, "Sea Surface Temperature and Salinity Structure of Cold Upwelling Filaments Near Point Arena as Observed Using Continuous Underway Sampling Systems," M.S. Thesis, June, 1988.

Title: Interannual Variability of the Tropical
                        Pacific Ocean

Investigators: A.J. Semtner, Professor Oceanography

Sponsor: National Science Foundation

Objective: The objectives of this project are (I) to
                        carry out multi-year simulations of the
                        tropical Pacific Ocean using a comprehensive
                        numerical ocean model, with surface forcing
                        data from an NCAR atmospheric general
                        circulation model; (II) to compare results
                        with observed record of El Nino Events; (III)
                        to analyze the physical causes of the
                        interannual variability of the tropical
                        pacific; and (IV) to examine the sensitivity
                        of the simulations to degradation of the
                        surface forcing through time and/or space
                        averaging.

Summary: The ocean model for the proposed work has
                        been modified over the preceding 12 months
                        to conform closely to the configurations
                        suggested by the reviewers of the original
                        proposal. The end result is an ocean model
                        for all the tropical and subtropical oceans
                        of the globe between latitudes 3 0 s and 40
                        N.   The grid resolution is 0.5 degrees in
                        both latitude and longitude. Up to twenty
                        vertical levels in the vertical are stacked
                        downward from the surface to the observed
                        bottom depth at each horizontal gridpoint.
                        Open boundary conditions from a previous 20-
                        year global integration with the same grid
                        structure are prescribed at the open Northern
                        and Southern boundaries of the model. Sponge
                        layers ten degrees of latitude in width
                        provide the transition between the tropical
                        oceans and the open boundaries.   The open
                        boundaries with sponge layers have been
                        tested in extended (multi-month) integrations
                        and found to behave properly. The model as
                        presently configured is probably the only
                        model of the entire tropical ocean (Pacific,
                        Atlantic, and Indian sectors) and the only
                        one with boundary condition specified from
                        a high resolution global ocean model.   No
                        problems are evident at the open boundaries,
                        and the internal circulation is only slightly
                        modified due to the introduction of sponge
                        layers.

Title:	Development of a Global Eddy-Resolving Thermodynamic Ocean Model for the 1990's
Investigator:	A.J. Semtner, Professor of Oceanography
Sponsor:	National Science Foundation
Objective:	The objectives of this project are (I) to develop and test advanced numerical and physical algorithms within a global ocean model which is already capable of utilizing supercomputer of the 1990's to the fullest; (II) to carry out a global one-third degree eddy resolving ocean calculation for a simulated time span of a decade, and (III) to develop further methods for analysis of the predicted fields and comparison with existing results of earlier one-degree and half-degree global simulations from the same model.

| Summary: | The proposed work has only begun, but already a paper on the results of a global eddy-resolving ocean calculation with 1/2 degree grid spacing and 20 vertical levels has been accepted for publication in the December 1988 color issue of the Journal of Geophysical Research (OCEANS). Also, the mean and eddy fields of global temperature at a depth of 160 meters were featured as a cover illustration on the November 1988 issue of OCEANOGRAPHY magazine. Extensions of the work are in progress. |

Title:	Support for Commander, Naval Oceanography Command Chair in Oceanography
Investigators:	A.J. Semtner, Professor of Oceanography
Sponsor:	Naval Postgraduate School
Objective:	This projects supports the Commander, Naval Oceanography Command Chair in Oceanography.

Summary: Funding of the CNOC Chair for FY 1988 has been used to support ten total man-months of extended visits by four university-based oceanographers to allow collaborations in Navy-relevant areas of interest. Dr. T. Manley of the Lamont-Doherty Laboratory of Columbia University has been engaged in a continuing effort with Prof. Bourke of NPS to combine and interpret their individual datasets on the East Greenland Current regime, in order to understand the dynamics and predictability of ice edge eddies and the effect of double-diffusive mixing on the East Greenland Polar Front.

Three additional visitors were on hand during the summer of 1988 to augment the nps Oceanography Department's growing program in studying the strategically important region of the Northeast Pacific, including the California Current System. These visitors augmented the Physical Oceanography Observational Laboratory (POOL), which involves Professors Collins, Ramp, and other member of the staff. Two of the visitors are observationalists from Oregon State University, i.e. Prof. D. Pillsbury and J. Bottero. Additional material on their backgrounds and planned activities is available from the OPI agreement excerpts. The final visitor was theoretical - modeling oceanographer from Nova University, Prof. J. McCreary. His main interest is Eastern boundary circulations; and as such he has been able to contribute to the theoretical considerations in POOL experiment design and to the California Current modeling efforts being carried out by Profs. Batteen and Smith.

Title:	The Interaction of an Isolated Eddy with a Marginal Ice Zone
Investigator:	D.C. Smith, IV
Sponsor:	Office of Naval Research, Arctic Programs

Summary:

The interaction of mesoscale ocean eddies with a free-drift marginal ice zone has been studies using a coupled air-ice-ocean numerical model. The results aid understanding of physical processes in the MIZ. Emphasis has been on processes in the East Greenland Current region. Processes in the East Greenland Current region. Processes studies to data include wind effects on existing eddies, the effect of topography on eddy decay and ice edge distortions caused by eddy ice-edge ocean frontal interaction. Recent observation indicate that the ocean eddies are most likely advected into the area from the West Sptizbergen Current. The eddies then interact with the East Greenland Current and the marginal ice zone. Results indicate that the interaction of an eddy with the East Greenland Current can provide a mechanism for ice exports towards the open ocean. This mechanism also results in dipole formation in the upper ocean, providing a possible explanation for recent observations of ocean dipoles. The effect of an ocean jet has also been found to lead to multiple ice edges as is also consistent with recent published results.

Publications:

D.C. Smith, IV, A.A. Bird, and W.P. Budgell, "A Numerical Study of Mesoscale Ocean Eddy Interaction with a Marginal Ice Zone," Journal of Geophysical Research, 93, pp. 12461-12475, 1988.

Conference Presentations:

D.C. Smith, IV and A.A. Bird, "A Numerical Study of Isolated Eddy Interaction with a Marginal Ice Zone: Wind Driven Simulation," Spring Meeting AGU, New Orleans, 1988.

W.P. Budgell, D.C. Smith, IV, and A.A. Bird, "Internal Ice Stress Effects in a Coupled Marginal Ice Zone/Ocean Model," Fall Meeting AGU San Francisco, 1988.

D.C. Smith, IV, A.A. Bird, and W.P. Budgell, "The Interaction of an Ocean Eddy with a Marginal Ice Zone Ocean Front," Fall Meeting AGU San Francisco, 1988.

Thesis
Directed:

J.L. Barker, "The Effects of Time Dependent Winds and Ocean Eddies on Ice Motion in a Marginal Ice Zone, M.S. Thesis, December, 1987.

Title: Eddy Interaction with Topography and Coastal
                          Jets in an Eastern Boundary Current Regime

Investigator: D.C. Smith, IV, Professor

Objective: To understand the range of mesoscale eddy
                          dynamics which occur in Eastern boundary
                          currents. Processes studied to date include
                          the instability and associated Rossby wave
                          radiation form a nonzonal coastal jet and the
                          interaction of an existing ocean eddy with
                          an open ocean jet.

Summary: The interaction of an ocean eddy with an
                          ocean jet has been studies using a process
                          oriented two-layer regional numerical ocean
                          model.   The results   illustrate motion
                          induced in eddies associated with eddy-jet
                          interaction.   The experiments lead to a
                          better   understanding   of   ring-stream
                          interactions, a precedent to prediction of
                          the Gulf Stream system. Process studies of
                          filament formation in the California Current
                          region have been conducted. Eddy-jet, eddy-
                          topography   and   baroclinic   instability
                          mechanisms were studies numerically. Rossby
                          wave radiation form a unstable nonzonal jet
                          was   found   to   exhibit   many   of   the
                          characteristics of the observed filaments.

Conference
Presentations: D.C. Smith, IV, and D.A. Oliver, "filament
                          Formation   as   Related   to   Baroclinic
                          Instability in the California Current System
                          Near Cape Mendocino," Fall Meeting AGU San
                          Francisco, 1987.

                          D.C.   Smith,   IV,   and   G.P.   Davis,   "The
                          Interaction of an Isolated Eddy with an Ocean
                          Jet," Presented at the 20th International
                          Symposium on Ocean Hydrodynamics, University
                          of Liege, Belgium, 1988.

Thesis
Directed: D.A. Oliver, "Simulation of the California
                          Current: Filament Formation as Related to
                          Baroclinic   Instability,"   M.S.   Thesis,
                          September, 1987.

                          G.P.   Davis,   "A   Numerical   Study   of   Eddy
                          Interactions with a Barotropic Oceanic Jet,"
                          M.S. Thesis, June, 1988.

Title:	Mixing in the Upper Ocean Due to Fine Scale Shear and Wave Breaking
Investigators:	T.P. Stanton and E.B. Thornton
Sponsor:	ONR Oceanography
Objective:	Acoustic doppler techniques are being developed to investigate mixing processes associated with surface waves, internal waves and boundary layer flows. Two unique doppler profilers have been implemented to non-invasively measure three component velocity fields from 10 m down to sub-cm scales in open ocean conditions. These instruments are being used in on-going programs including CAREX and SAXON, which exploit the high temporal and spatial resolution of measurements to study the velocity structure of turbulence processes down to dissipation scales.
Summary:	(a) Three-component velocity profiles below open ocean surface gravity waves have been measured to allow Reynolds stresses to be directly estimated in the presence of the large irrotational orbital velocity field. A bistatic geometry coherent acoustic doppler profiler was deployed for 10 days at a depth of 5 m during SAXON from a lighthouse tower 15 km off Chesapeake Bay in September, 1988. The doppler profiler had a four element pressure slope array co-located with it to provide an estimate of the directional field. The bistatic profiler measured three-component current velocities every 8 cm in a 3 degree width ensonified volume extending to the wave surface.
	(b) The sub-ice turbulent boundary layer will be measured during the 1989 CAREX program in the Arctic to provide a high resolution view of the turbulence field over a range of mean ice velocities, ice topologies and stratification conditions. Heat fluxes and the near-surface internal wave field will be simultaneously measured to a depth of 100 m using a recently completed microstructure-resolving acoustic doppler profiler.
Publications:	T.P. Stanton, "Recent Advances in Oceanic Velocity Measurements Using Acoustic Doppler Techniques," Center for Water Research Seminar, February, 1988.

Title: Mixing Processes in Upwelling Filaments

Investigator: T.P. Stanton

Sponsor: ONR Oceanography (Coastal Transition Zone (ARI)

Objective: a) To estimate the mixing rates associated with fronts and intrusion in the upwelling region off Point Arena. b) To participate in mapping the current and thermohaline field of the Coastal Transition Zone Measurement domain to define the evolution of the persistent offshore jet under varying wind forcing conditions.

Summary: a) Over 500 km of towyo CTD, micro-conductivity, optical properties, and ADCP data were gathered during a series of transects across a filament West of Point Arena in July 1986. The towyo data provides fine-scale optical and thermohaline structure and thermal microstructure estimates form 5 to 130 m depth with approximately 500 m horizontal resolution. This data set was gathered in collaboration with Libe Washburn, and our analysis is directed toward defining the relationship between the widely observed intrusions and the filament, and estimating the isopcnal and diapycnal mixing rates inside and outside the filament.

b) During the 1988 CTZ field program, the fifth of six consecutive mappings of a standardized grip spanning an upwelling filament off Point Arena was made from the R/V POINT SUR. The CTZ grid was occupied between 21 and 28 July and calibration and processing of the CTD station data, underway atmospheric forcing, and acoustic doppler data has been completed. All the data fields can be readily mapped into a regular grid using objective analysis techniques to facilitate intercomparison of mapped fields and assimilation into models. This cruise spanned a period of light winds and significant surface heating in contrast to the strong upwelling favorable winds which dominated the previous four weeks. These conditions provided and opportunity to observe the relaxation of the domain after upwelling ceased. On-going analysis is focused on the distribution of thermohaline and optical properties associated with the

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intrusion and surface flows.

Publications: J. Stockel and T.P. Stanton, "Preliminary Results of a CTD/ADCP Survey in the CTZ Domain during 21-27 July, 1988," Coastal Transition Zone Newsletter, 3, 4, 1988.

T.P. Stanton and J. Stockel, "Relaxation of the CTZ 88 Domain," Trans, Am. Geophysical Union, 69, pp. 1260, 1988.

Title:	Nearshore Wave Processes
Investigators:	E.B. Thornton, Prof. 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. The specific objectives of the proposed research are: 1) determine breaking criterion as a function of depth, beach slope and wave frequency and 2) determine the transformation of waves and longshore currents across the surf zone due to energy conversion and dissipation in the breaking processes.

Summary:	Research this past year continued analysis of the results of the major field experiments at Torrey Pines, California and Santa Barbara, California, the SUPERDUCK experiment at Duck, North Carolina and the development of predictive models. A model describing the transformation of random wave heights and resulting longshore currents over arbitrary bathymetry was developed based on energy flux balance. Dissipation is considered due to wave breaking and bed friction. Wave breaking is characterized after periodic bores. The random nature of the wave heights is described by the Rayleigh distribution. The model is able to predict the increase in averaged wave height due to shoaling and subsequent decrease due to wave breaking. Twenty-five M.S. theses have resulted from this research program.

Publications:	D.E. Martens and E.B. Thornton, "Nearshore Zone Monitoring System," Proc. of Coastal Hydrodynamics Conference, ASCE, pp. 579-588, 1987.
	S.M. Abdelrahman and E.B. Thornton, "Changes in the Short Wave Amplitude and Wavenumber due to the Presence of Infragravity Waves," Proc. of Coastal Hydrodynamics Conference, ASCE, pp. 458-478, 1987.
	D.J. Whitford and E.B. Thornton, "Measuring Wind and Wave Forcing of Longshore Currents during SUPERDUCK - A Preliminary Analysis," Proc. of Coastal Hydrodynamics Conference, ASCE, pp. 589-602, 1987.

Title: Test and Evaluation of Sea, Swell, and Surf
                        Programs (SSSP)

Investigator: E.B. Thornton, Prof. of Oceanography

Sponsor: NEPRF

Objective: The FORTRAN code for the Sea, Swell, and Surf
                        Program (SSSP) is being converged to a BASIC
                        code to run on a Hewlett-Packard 9845b-275
                        mini-computer. Test and evaluation will be
                        performed on the model using extensive
                        available wave and surf data form La Jolla,
                        CA., Santa Barbara, CA., and Duck, North
                        Carolina. These Field Experiments cover a
                        wide variety of wave and surf conditions.

Summary: A sea, swell, and surf program was improved,
                        tested, and evaluated on a micro-computer
                        (HP-9845B). Sea swell is calculated by a two
                        dimensional spectral model. The energy
                        balance equation is tested for different
                        cases of wind velocities and water depths.

                        Wave transformation is described by one
                        dimensional random wave model in which the
                        wave heights are described using the Rayleigh
                        distribution. The obtained solution of the
                        random wave field is used to predict the
                        longshore currents. The model outputs of
                        wave height and current are compared with
                        data acquired from a wave tank and natural
                        beaches. The model is found to accurately
                        forecast wave heights, breaker location,
                        breaker type and longshore currents for
                        several set of conditions. Two M.S. theses
                        resulted from this research.

Title:	Modeling of Wave Transformation in Monterey Bay
Investigators:	E.B. Thornton, Prof. of Oceanography and C.S. Wu, Adjunct Research Professor
Sponsor:	Department of Boating and Waterways, State of California
Objective:	This proposal is to perform numerical modeling of waves in Monterey Bay. The investigation is for continuation of the modeling efforts on refraction and diffraction of ocean waves of Monterey Submarine Canyon. The model is developed and being tested for various cases. An integrated data base of bathymetry is proposed for running wave transformation processes. The U.S. Army WIS deep water directional spectra will be refracted to obtain coastal waves at different locations around the Bay. The shallow water waves could be used for studies of littoral processes, wave forces, and coastal planning.
Summary:	A parabolic ray model was developed and tested for the plane beach case and a two-dimensional sinusoidal contour. The model solves wave number explicitly (Wu and Thornton, 1986) and produces superfast wave field solutions. The refraction model is used as a basis for the modified refraction model, which includes diffraction across the ray. The modified ray model was run on different topographies and under different wave attack. The ray refraction model is found not sensitive to small changes in offshore approach angle. One M.S. thesis was directed under this research.

DEPARTMENT
OF
MECHANICAL
ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

The primary thrust of the research program in Mechanical Engineering continues to advance the state of knowledge in areas important to the U.S. Navy, more specifically, those involving solid mechanics, shock and vibration, dynamic systems and control, heat transfer, fluid mechanics and hydrodynamics, and materials science.

In addition to the research activities of seventeen permanent faculty and eight visiting and adjunct faculty, the Department hosts the work of the ONT Chaired Professor in Surface Ship Technology. This position was filled by during the reporting period by Professor E. Wilson from the University of California, Berkeley who worked on PC Based Finite Element Methods for Thermal Stress Analysis of Navy Boiler Superheater Headers.

Research results are published in the student theses, project reports, and in papers which are both presented at national and international conferences and published in the scientific and technical journals.

SOLID MECHANICS, SHOCK AND VIBRATION (SSV)

Professor Cantin has continued his work on the thermal stress analysis of Boiler Components that was started with DTRC sponsorship and continued with the collaboration of Professor E. Wilson, ONT Chair Professor in Surface Ship Technology. The long term objective of this work is to assist NAVSEA in the solution of the premature failure of high temperature boiler components.

Professor Shin has been active in Underwater Shock and Vibration studies. Funded by the Defense Nuclear Agency, he has initiated work into the understanding of stiffened tripping characteristics. Several carefully planned UNDEX tests were conducted comparing Z, wide flange and narrow flange T stiffeners. The results will aid in the formulation of mathematical models to predict the ultimate strength of submarine structures in resisting underwater shock. Additionally, funded by David Taylor Naval Ship Research and Development Center, Professor Shin, together with Adjunct Professor K.S. Kim, has been actively investigating the vibration damping characteristics of bolted and welded connections for structural plates and shells. These elements transmit machinery generated noise, and joint damping can help to minimize this effect. Professor Shin, in continued work with material damping properties, has developed techniques for the measurement of damping behavior of selected high damping alloys and initiated work in the structural analysis of highly flexible light weight members for use in the U.S. Navy's N-ROSS (Remote Ocean Sensing Satellite) system.

DYNAMIC SYSTEMS AND CONTROL (DSC)

During this reporting period (FY87) Professor Smith continued

work with NSWC/WOL in the development of the robotic firefighter. The main focus is to apply linear optimum control theory to the design of continuous controllers for the robotic arm used to direct fire extinguishant to a shipboard aircraft fire. The procedure used at present is for a human operator to approach the burning aircraft, drill an entrance hole in the skin and insert extinguishant. The robot device will use low power from the water main source and be designated to perform the same task. In addition, Professor Smith has continued with his work on dynamic modelling of a small gas turbine engine plant for the purpose of developing advanced control schemes.

In related work sponsored by the NPS Foundation, the simulation of manipulator dynamics has been accomplished including important nonlinearities and avoiding problems of singularity. Also, work is underway to exploit the power of a microcomputer controller for providing control of the hardware.

Professor L.W. Chang has initiated work sponsored by the NPS Foundation dealing with control algorithms for light weight flexible manipulator arms such as those needed for space applications or for high speed industrial robots. A physical experimental arm having a very flexible link with hydraulic actuation has been built. The computer simulation and the experimental validation have been conducted for the single-link manipulator. An improved model was developed to reduce the discrepancies between the experimental results and the simulation results. A control algorithm has been developed to control a partial-actuated system. The research is continuing.

Professor Healey has lead a joint Computer Science, Electrical and Mechanical Engineering research program in the Planning, Navigation, Dynamics and Control of Autonomous Underwater Vehicles. This project has performed simulations of a typical Swimmer Delivery Vehicle under rapid maneuvering and is pursuing both experimental and simulated investigations into the design and development of advanced control systems that will be required for the Navy's use of autonomous vehicles.

HEAT TRANSFER, FLUID MECHANICS AND HYDRODYNAMICS (HTFMH)

In this area, Professors Nunn and Kelleher have continued ongoing work sponsored by NWC at China Lake in the modelling of heat transfer and thermodynamics of airfoils immersed in rocket nozzle exhaust gas. The purpose of the work is to predict the temperature transients within the airfoil as it is used for thrust vector control. This year the PHOENICS code has been installed and used to predict the heat transfer characteristics. Additionally, IR thermography methods have been developed for measurement of heat transfer rates in bodies of complex shapes. The work is ongoing.

Professor Salinas is developing a simulation model for flows within the interior of jet engine test cells for NCEL, Port Hueneme. The Navy is planning a redesign of all such test

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facilities and Professor Salinas' model will be used to determine pressure and velocity fields as an aid in the redesign process. The results of a two-dimensional analysis have been obtained. This project is ongoing.

Distinguished Professor Marto, joined by adjunct Professor Wanniarachchi, continued their work on Nucleate Boiling Behavior of Refrigerant R-114 from various surfaces funded by David Taylor Research Center. This work, aimed at enhancing heat transfer in evaporation units is hoped to lead to a reduction in the size and weight of shipboard power plants. The effects of oil in the mixture and surface configuration have been investigated--showing that the enhanced heat transfer tubes can improve coefficients by up to a factor of ten. The work is continuing using other tube configurations including tube bundles for which a new test apparatus will be constructed.

Additionally, with Professor J.W. Rose from Queen Mary College, London University, they are working on steam condensation problems in horizontal tubes, funded by NSF.

Professor Pucci is also conducting research in cooling but related to the reduction of IR signatures in gas turbine ship exhaust stacks. Sponsored by Naval Sea System Command, he has continued a program in the testing of three basic designs of exhaust gas eductors. These systems mix cool ambient gas with hot exhaust gas resulting in reduced temperature emissions. Data relative to flow, pressure drop, and temperature lowering, including IR imaging and thermographic results, have been obtained. As a second project, again funded by Naval Sea Systems Command, Professor Pucci is supervising student thesis work aimed at generating a computer model for the design of inlet air and exhaust gas ducting for Naval gas turbing installations.

Professor Kelleher continued his work on the modelling of fluid/thermal phenomena following initiation of a fire. Fire control is a major problem onboard ship. This model will help to explain the results of full size tests conducted by the Navy.

Professor Kelleher and Professor Ligrani have been working on the Laminar to Turbulent transition for boundary layers in a Curved Channel. In these situations, secondary flows are induced causing changes in the boundary layer thickness and impacting local heat transfer capabilities. This work is funded by NASA Lewis Research Center. Professor Ligrani has been funded by NASA Ames Research Center in a separate effort to develop subminiature multisensor Hot-Wire Probes for Improved turbulence measurements, and also by the Air Force Wright-Patterson Aeronautical Laboratories to further the understanding of heat transfer anomalies in film cooled boundary layers when embedded vortices are present. The latter work has an impact on the cooling of gas turbine engine blades as turbine inlet temperatures are increased.

Professor Joshi has initiated work in cooling of electronic components by liquid immersion techniques with Professor Kelleher.

The work is sponsored by NWSC Crane, and is beginning to develop a research activity in fluid-thermal processes relating to the welding of new Navy HSLA steels.

Distinguished Professor Sarpkaya has been continuing theoretical and experimental studies in the area of Hydrodynamics and Time Dependent Flows to determine the rise and demise of trailing vortices and the inception of interfacial disturbances in homogeneous and density stratified media. This series of efforts is sponsored by the Office of Naval Research and leads to the ability to infer details concerning submarine characteristics from observed disturbances in the ocean. In another project ongoing with NSF funds, Professor Sarpkaya and his students are working on time dependent flow about bluff bodies (smooth and rough cylinders) to obtain more refined predictive capability of the fluid-structure interaction. In addition, Professor Sarpkaya has undertaken an extensive theoretical and experimental work on the determination of the causes of parachute collapse. This work is sponsored by the Sandia National Laboratories and was the subject of a Ph.D. dissertation by COL S. Mostafa, working under the direction of Prof. Sarpkaya. All of these projects are continuing along both theoretical and experimental lines.

MATERIALS SCIENCE (MS)

Research in Materials Science has been undertaken by Professor McNelley, Perkins and Challenger. The main thrust of the NPS program is to integrate the mechanical properties of metals or metal composite materials to their microstructural characteristics. Professor Perkins, sponsored by David Taylor Research Center, is working on the Damping Properties of Quiet Metal Alloys. The alloys, such as Cu-Mn, have a high internal damping capability which depends on mechanical processing history, and can be useful in machinery quieting. Professor McNelley in conjunction with Adjunct Professor S. Hales, have been pursuing research in the Superplastic Forming of Aluminum Alloys. Supported by Naval Air Systems Command, this work is leading to the ability to manufacture parts with complex geometries in an inexpensive way. Additionally, sponsored by Wright-Patterson Aeronautical Laboratories, Professor McNelley has been studying porosity influences on M-50 bearing steel properties and especially rolling contact fatigue resistance. Professor Challenger, prior to his leaving initiated work on welding of HSLA steels which was sponsored by DTRC and continued under the guidance of Adjunct Professors Losz and Saboury.

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Title:	Stress Analysis of Boiler Components
Investigator:	G. Cantin
Sponsor:	NSRDC, Direct Funding
Objective:	The long term objective is to assist the Naval Ship Engineering community with a recurring premature failure problem in Boiler Components subject to a very high temperature and pressure environment. The short term objectives is to adapt the ADINA code to these types of problems. A preliminary study was completed using a PC code indicating the a 3-dimensional study should be made to answer the many unanswered questions. The coding system should also have a thermal analysis system besides the usual Finite Element code. One student is going to continue this project when his course work allows him to do so.

Summary:	The present phase of the study was based on the use of the ADINA system from M.I.T. It was received previously for use on the VAX/780 of the Computer Science Department. One student completed his thesis with that system. Use of the same code was extended to the Joint AERO/MECHANICAL CAD/CAE system and the system was exchanged for one that would work on the new machines. During our intercessional of 1988, a number of procedures were developed to facilitate the use of that system by students. A complete set of specifications were developed and an emulator for the PLOT10 system was written for our system. In the mean time, a new version of the system was made available that would correct all the shortcomings of the previous system. A demand to the foundation was approved and the new version received and installed.

Thesis Directed:	D.R. Kitchin, "2-Dimensional Axisymmetric and 3-Dimensional Finite Element Stress Analysis of the LHA-1 Class Superheater Header," M.S. Thesis, March, 1988.

Title: Attitude Control of the Orion Satellite

Investigator: L.W. Chang, Assistant Professor of Mechanical
                    Engineering

Sponsor: NPS Direct Fund

Summary: The idea that drives the Orion satellite
                    design is an eduction by which the research
                    team at the NPS can learn to design and build
                    an affordable, general purpose satellite.
                    At a stage without knowing the payloads, the
                    attitude control options of the Orion
                    satellite was investigated. The comparison
                    of control options were studied.

Title: Dynamic Models and Motion Controls of High
                  Performance Industrial Robots

Investigator: L.W. Chang, Assistant Professor of Mechanical
                  Engineering

Sponsor: NPS Research Council

Summary: This project was to develop a flexible-body
                  control for both lightweight manipulators and
                  the PUMA robot. A nonlinear control system
                  for a flexible-single-link minipulator was
                  designed   and   implemented   with   a   micro-
                  computer.   The   dynamic   behavior   of   the
                  lightweight manipulator was studied for point
                  to point control as well as tracking control.
                  The structural flexibility of the PUMA robot
                  was   identified   and   incorporated   into   the
                  dynamic model. A nonlinear control is being
                  developed and studied.

Thesis
Directed: M. Kirkland, "Implementation of a Dynamic
                  Control of a Single-Link Flexible Army Using
                  a General Micro-Computer," MS, September,
                  1988.

Title: Planning, Navigation, Dynamics, and Control of Autonomous Underwater Vehicles

Investigators: A.J. Healey, Principal Investigator, D.L. Smith, Associate Investigator, F.A. Papoulias, Associate Investigator, R. Cristi, Associate Investigator, R.B. McGhee, Associate Investigator, and S.H. Kwak, Associate Investigator

Sponsor: Naval Surface Warfare Center

Objectives: The long term objective of this on-going research program is to investigate the basic sensing and control issues, including higher level intelligent processing requirements for future AUV's.

The design, building, and testing of a series of model vehicles is an integral part of this objective, which will be met by demonstration of the controlled behavior performance of AUV's for various mission scenarios.

Summary: During FY88, progress has been made on four fronts: global planning, navigation system modelling, local path planning and obstacle avoidance, and vehicle dynamics and control.

The feasibility of using an Artificial. Intelligence approach to the Hierarchical control of Global Planning functions for AUVs has been demonstrated in the thesis work of D.L. MacPherson. The system developed was based on using a KEY expert system shell to provide a Mouse-driven user interface on a TI-Explorer Lisp Machine. Lisp code needed to achieve AUV path planning and control also was hosted on this machine. The simplified dynamics and autopilot level of control, as well as the simulation of the environment, were accomplished on a Silicon Graphics IRIS Workstation. The results of this simulation were entirely satisfactory and established the validity of the approach.

Due to the lack of distinguishing landmarks at sea, ship navigation has always posed a challenge to available technology. While stellar navigation and chronometers largely solved this problem for surface vessels, at least to the point of permitting navigation

to a recognizable landfall, such external position reference are generally denied to underwater vehicles. Instead, in the absence of any absolute position information, submersibles such as ROV's are either tethered to surface vessels for short distance travel, or they depend upon Inertial Navigation Systems (INS) or some other form of dead reckoning to determine their position at sea.

The purpose of this research is to investigate how several information sources can be integrated in order to provide correcting capabilities in the INS. In this particular research will be proceeding along two parallel lines: a) the use of adaptive techniques for estimation of drifts of the INS signals, and b) the development of an image processing system as a covert aid to navigation.

From the image processing point of view, the investigator is actively working on algorithms for filtering and segmentation of images in noisy environments (Cristi, 1985). In particular, research work based on an estimation theoretic approach seems to yield promising results for the detection of objects in turbid water, thus providing a way of locating targets in low visibility conditions.

Research through September 1988 included the integration of adaptive estimation and control techniques with the inertial navigation system. As a consequence of the desire to develop a relatively low cost system for navigation and guidance, an investigation into the feasibility of using noisy gyros measurements has been done. Roll rate, pitch rate, and directional gyros have been ordered, which will be used in the prototype vehicle.

Conference
Presentations:

A.J. Healey, NSWC, White Oak Labs, Project progress presentation to Sponsors, August, 1988.

R.B. Mcghee, NSWC, White Oak Labs, Progress presentations to Sponsors, July, 1988.

D.L. Smith,"Dive-Plane Path Planning for an Autonomous Underwater Vehicle," Presented at ASME Winter Annual Meeting, Chicago, November, 1988.

A.J. Healey, "Model-Based Maneuvering Controls for Autonomous Underwater Vehicles," Presented at ASME Winter Annual Meeting, Chicago, November, 1988.

Theses Directed: G.M. Brunner, "Experimental Verification of AUV Performance, ME, March, 1988.

S.W. Delaplane, "Preliminary Design and Cycle Verification of Digital Autopilot for Autonomous Underwater Vehicles, MS, March, 1988.

M. Farren, "Some Experiments with Acoustic Returns Relative to Obstacle Identification for AUV Operations, MS, March, 1988.

D.W. Sanders, "A Feasibility Study in Path Planning Using Optimization Techniques, December, 1988.

V. Squitier, "A Kalman Filtering Approach to the Estimation of Gyro Drifts in an Inertial Navigation System, MS, March, 1988.

D.L. MacPherson, "Computer Simulation Study of Rule-Based Control of an Autonomous Underwater Vehicle," MS, March, 1988.

W. Smith, "Local Path Planning Using Optimal Control Techniques, MS, June, 1988.

K.P. Larsen, "Reduced Hydrodynamic Modelling for a Submersible Vehicle," MS, September, 1988.

G.J. Reina, "AUV Dive Control Development Including Sensor Bias Compensation and Parameter Estimation, MS, December,1988.

Title:	Heat Transfer and Fluid Flow in Fusion Welding
Sponsor:	National Science Foundation
Investigator:	Y. Joshi
Objective:	An experimental and compucational investigation of thermo-fluid processes associated with fusion welding. Cooling rates during gas tungsten arc welding (GTA) process will be measured using intrusive, as well as non-instrusive techniques. Computations will involve the examination of convection within the weldpool, as well as the conduction in the surrounding material. Results will be obtained for various materials.

Summary:	A three-dimensional transient heat conduction model was made of the GTA process. This included effects of variable material properties and latent heats associated with melting, as well as phase transformation. The model used varying grid sizes to provide good resolution in regions of large temperature gradients and yet minimize the total number of grid points. A new computational technique involving a semi discrete procedure was developed. Computational predictions of cooling rates, once quasi-steady conditions were achieved were made with available measurements.

Thesis Directed:	L.R. Walker, "Two Dimensional Computations of Heat Transfer in Fusion Welding," M.S. Thesis, September, 1988.

Title:	A Study of Heat Transfer and Fluid Flow in Fusion Welding
Investigator:	Y. Joshi
Sponsor:	David Taylor Research Center
Objective:	To investigate the changes in surface temperature profiles due to imperfections during fusion welding processes. Both computational and experimental studies will be undertaken to investigate signatures of common defects such as torch misalignment and inclusion of impurities.

Summary: The three-dimensional computational code developed for GTA weldings was modified to study the effects of misalignments and inclusions. Feasibility of using non-contact sensors to detect the resulting surface temperature changes was examined. Based on the computations, a correlation was developed to relate the flaw size to the resulting change in surface temperature. In conjunction with theses computations, an experimental facility for the measurement of surface temperatures during fusion welding was also developed. An existing infra-red thermography system was enhanced for non-contact surface temperature. A new non-contact surface temperature measurement probe was also developed for welding applications.

Title:	Liquid Immersion Natural Convection Cooling of Electronic Equipment
Investigator:	Y. Joshi
Sponsor:	Naval Weapons Support Center
Objective:	To examine flow and heat transfer characteristics during natural convection from electronic components immersed in dielectric liquids. Both computational and experimental investigations are in progress. Current experiments are focussing on two different geometrical configurations. This work will be later extended to other geometries.

Summary:	Natural convection flow and heat transfer from a three by three array of simulated components in a rectangular enclosure filled with a dielectric fluid was studied experimentally. Several different power levels were examined for two component orientation and three different enclosure widths. The resulting component surface temperature measurements were used in obtaining non-dimensional heat transfer correlations. The effects of the enclosure boundary conditions on the heat transfer from the components were also examined. A new experimental setup was designed which will employ actual semi-conductor packages in liquid immersion cooling.

Conference Presentations:	Y. Joshi, M.D. Kelleher, and T.J. Benedict, "Natural Convection Immersion Cooling of an Array of Simulated Chips in an Enclosure Filled with Dielectric Fluid," Presented at the XXth International Symposium of the International Center for Heat and Mass Transfer, August, 1988.
Thesis Directed:	T.J. Benedict, "An Advanced Study of Natural Convection Immersion Cooling of a 3 by 3 Array of Simulated Components in a Enclosure Filled with Dielectric Liquid," M.S. Thesis, June, 1988.

E.I. Torres, "Natural Convection Liquid Immersion Cooling of Discrete Heat Sources in an Enclosure: Effects of Boundary Conditions and Component Orientation," M.S. Thesis, December, 1988.

Title:	Transient Buoyancy Induced and Mixed Convection Flows
Investigator:	Y. Joshi
Sponsor:	NPS Research Council
Objective:	To develop a fundamental understanding of buoyancy induced and mixed convection flows. Specific applications of these processes to current problems in the area of electronic packaging technology are to be examined. This effort is a continuation of a program started in FY86.

Summary:	Natural convection liquid cooling of arrays of discrete heat sources was examined experimentally. In the first set of experiments transport was investigated from a single column of protruding elements mounted on a vertical surface in water. The effect of a parallel shroud on heat transfer was also studied. A heat transfer correlation was developed for this configuration. In the single column of flush mounted discrete heating elements on a vertical surface was examined, both with and without a shroud. A heat transfer correlation was obtained based on the temperature measurements.

Theses Directed:	T.D. Wilson, "A Study of Natural Convection Cooling of Multiple Discrete Heat Sources in a Vertical Channel," M.S. Thesis, June, 1988.
	D.L. Knight, "Natural Convection Liquid Immersion Cooling of a Column of Discrete Heat Sources in a Vertical Channel," M.S. Thesis, September, 1988.

Title: Modeling of the Spread of Fire and Smoke in
                 Confined Spaces

Investigators: Matthew D. Kelleher,
               Professor of Mechanical Engineering

Sponsor: Naval Research Laboratory

Objective: To develop a finite difference numerical model
                 for the realistic determination of the time-
                 dependent fire and smoke spread in confined
                 spaces. The model is to be used to simulate
                 various fire scenarios in submarines and
                 surface ships for fire safety and design
                 considerations.

Summary: The initial finite difference models have been
                 extended to include the actual cylindrical-
                 spherical geometry of the FIRE-I research
                 vessel at the Naval Research Lab. The effects
                 of surface radiation heat transfer between
                 walls of the vessel has also been introduced
                 into the model. Refinements to the ad-hoc heat
                 input model to represent the heat release due
                 the combustion process have been developed.
                 Extensive computer runs have been carried out
                 to compare the model predictions with the
                 experimental results from FIRE-I. These model
                 predictions are totally consistent with the
                 experimental results. The model dramatically
                 illustrates the need for improves measurement
                 of the fuel burn rate to allow more accurate
                 input data for the model simulations.

Publications: M.D. Kelleher, J. Raycraft, K.T. Yang and H.Q.
                Yang, "Fire Spread in a Three-Dimensional
                Pressure Vessel with Radiation Exchange and
                Wall Heat Losses", NPS Report, NPS-69-88-008,
                submitted for publication in the International
                Journal of Mathematical and Computer Modeling.

Thesis   J. Raycraft, "Numerical Field Model Simulation
Directed: of Full Scale Fire Tests in a Closed Spherical/
                Cylindrical Vessel", MS & Mech Engr, Dec. 1987.

                R. Houck, "Numerical Field Model Simulation of
                Full-Scale Fire Tests in a Closed Spherical/
                Cylindrical Vessel with Internal Ventilation",
                MS Sept. 1988.

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Title:	Naval Postgraduate School Mini-Satellite (ORION)
Sponsor:	Air Force Technical Application Center, Patrick AFB, FL
Investigators:	K.S. Kim and R. Panholzer
Objective:	To design and build a small satellite (ORION). The ORION is a Mini-Satellite bus which will support a 50-100 pound payload and has attitude control, propulsion, electrical power, on-board payload and has control, propulsion, electrical power, on board microprocessor and data storage, telemetry and all other capabilities normally found in larger satellites.
Summary:	The preliminary design of the Mini-Satellite assumed the launch of the satellite from the GAS Canister of the Space Shuttle and the single spin attitude stabilization and consists of a long cylindrical shape body and four long flexible radial booms. The stability of the simple spinning motion of the satellite about the axial axis of symmetry is investigated analytically.
Publications:	K.S. Kim and Y.S. Shin, "Investigation of the Spin Stability of the NPS Mini-Satellite (ORION)," Progress Report, NPS 69-88-011, December, 1987.

Title:	Effects of Unsteadiness on Laminar-Turbulent Transition in Straight Channel Flow
Investigator:	P.M. Ligrani and C.S. Subramanian, Adjunct Research Professor
Sponsor:	Office of Naval Research via NPS Direct Funding
Objective:	To investigate the effects of unsteadiness on transition in straight channel flow.

Summary:

Results from this study will elucidate fundamental mechanisms operative in the laminar-turbulent transition process as it is affected by mean flow unsteadiness. Information will be obtained on: (1) parameters governing the unsteady flow, (2) events occurring during the onset and development of transition, (3) the interaction between organized induced unsteadiness and transition, and (4) how heat transfer in transitioning channel flow is affected by unsteadiness. Straight channel flow is employed to provide a well defined test case for complex transitioning flow.

This work is important to DoN and DoD because unsteadiness affects flows in a variety of ways. One important example are the gusts of wind which pass over airfoil surfaces as an aircraft is taking off from an aircraft carrier.

Publications:

P.M. Ligrani and C.S. Subramanian, "Progress Report on the Project Effects of Unsteadiness on Laminar Turbulent Transition in Straight Channel Flow," NPS Internal Report, January 1989.

C.S. Subramanian, J. Green and P.M. Ligrani, "Crossed Hot-Wire Sensor M e a s u r e m e n t Procedures," NPS Internal Report, January 1989.

Conference
Presentations: None

<u>Theses</u>
<u>Directed</u>:   1.   Effects of Unsteadiness on Laminar-
Turbulent Transition in Straight Channel Flow
(J. Longest), Naval Postgraduate School, Code
69, June 1989, MS Degree.

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<u>Title</u>:	Laminar/Turbulent Transition in a Curved Channel with Heat Transfer
<u>Investigator</u>:	P.M. Ligrani, Associate Professor and C.S. Subramanian, Adjunct Research Professor
<u>Sponsor</u>:	AVSCOM, U.S. Army Aviation Research and Technology Activity via the NASA-Lewis Research Center
<u>Objective</u>:	To obtain a better understanding of laminar/turbulent transition in a curved channel from experimentation. Of particular importance are the influences of Dean vortices and their effects on local heat transfer distributions and flow structural characteristics including mean vorticity distributions. Flow visualization, wall heat flux measurement, and detailed probing will be used to obtain information about the flow.

<u>Summary</u>: In flow in curved channels having large aspect ratio (width to height), secondary flow such as Dean vortices are present. These cause significant variations in local wall heat transfer, and are also expected to change the way in which transition from laminar to turbulent flow occurs. This flow is investigated using flow visualization techniques, and subminiature, hot-wire probes. Wall heat transfer measurements will also be made. Mean velocity measurements will be made using a specially designed five-hole pressure probe, the results of which will also be used to determine mean vorticity distributions.

This work is important to DoN and DoD because of the influences of concave curvature which is the source of centrifugal instabilities leading to the formation of pairs of counter-rotating Dean vortices. Concave curvature is present near airfoils, turbine blades, heat exchangers, and internal cooling passages.

<u>Publications</u>: P.M. Ligrani and R.D. Niver, "Flow Visualization of Dean Vortices in a Curved Channel with 40 to 1 Aspect Ratio," <u>Physics of Fluids</u>, Vol. 31, No. 12, pp. 3605-3617, December 1988.

P.M. Ligrani, B.A. Singer and L.R. Baun, "Spatial Resolution and Downwash Velocity Corrections for Multiple-Hole Pressure Probes in Complex Flows," accepted for publication in Experiments in Fluids, 1989.

P.M. Ligrani, R.V. Westphal and F.R. Lemos, "Fabrication and Testing of Subminiature Multi-Sensor Hot-Wire Probes," accepted for publication in Journal of Physics E - Scientific Instruments, 1989.

P.M. Ligrani, B.A. Singer and L.R. Baun, "Miniature Five-Hole Pressure Probe for Measurements of Three Mean Velocity Components in Low Speed Flow," submitted to Journal of Physics E - Scientific Instruments, 1988.

P.M. Ligrani and L.R. Baun, "Structure and Development of Dean Vortices in a Curved Rectangular Channel with 40 to 1 Aspect Ratio, in preparation for Journal of Fluid Mechanics, 1988.

Conference
Presentations: P.M. Ligrani, L.R. Baun and B.A. Singer, "Development and Structure of Dean Vortices in a Curved Channel with 40:1 Aspect Ratio," American Physical Society Division of Fluid Dynamics Forty-First Annual Meeting, Buffalo, November 1988.

Theses
Directed: 1.   A Flow Visualization Study of Laminar/Turbulent Transition in a Curved Channel (M.A. Siedband), Naval Postgraduate School, Code 69, March 1987, MS Degree.

2. Structural Characteristics of Dean Vortices in a Curved Channel (R.D. Niver), Naval Postgraduate School, Code 69, June 1987, MS Degree.

3.   The Development and Structural Characteristics of Dean Vortices in a Curved Rectangular Channel (L.R. Baun), Naval Postgraduate School, Code 69, September 1988, ME Degree.

4.   Flow   Visualization   of   Time-Varying
Structural Characteristics of Dean Vortices in
a   Curved   Channel   (D.W.   Bella),   Naval
Postgraduate School, Code 69, December 1990, MS
Degree.

Title:	"Effects of an Embedded Vortex on Injection from a Single Film-Cooling Hole in a Turbulent Boundary Layer."
Investigator:	P.M. Ligrani
Sponsor:	Wright Aeronautical Laboratories, Wright Patterson Air Force Base
Objective:	To Study the effects of intense secondary flows, especially embedded vortices, on heat transfer and the cooling schemes used for end-wall surfaces in the first turbine stage of gas turbine engines.

Summary: Many fluid mechanics phenomena, such as vortices, secondary flows, and separation, exist near end-walls in the first stage of turbines. Because of high heat loads to metal parts, the understanding of these phenomena is vital for the design of effective cooling systems to maintain metal surface temperatures at acceptable levels. One such cooling techniques is film cooling, used to give a "blanket" of cool air between hot gas and metal surfaces. However, with secondary flows, in particular, with vortices embedded in boundary layers, the protection from film cooling may be reduced, drastically in some cases. In one project, an experimental investigation of the interaction of film cooling jets (or a single jet), and a boundary layer embedded vortex is to be undertaken. In additional projects, the effects of other types of secondary flows will be examined. Measurements will be made of surface temperatures, wall heat flux, and heat transfer coefficients as different parameters are varied. Flow visualization and surface temperature visualization will also be employed.

This work is important to DoN and DoD because of its application to the types of gas turbines used on high performance aircraft such as ones which land on aircraft carriers.

Publications: P.M. Ligrani, A. Ortiz, S.L. Joseph, and D.L. Evans, "Effects of Embedded Vortices on Film-Cooled Turbulent Boundary Layers," ASME transaction - Journal of Turbomachinery, January, 1989.

P.M. Ligrani, S.L. Joseph, A. Ortiz, and D.L. Evans, "Heat Transfer in Film-Cooled Turbulent Boundary Layers at Different Blowing Ratios as Affected by Longitudinal Vortices," Experimental Thermal and Fluid Science, Vol. 1, No. 4, pp. 347-362, 1988.

P.M. Ligrani and W. Williams, "Effects of an Embedded Vortex on Injection from a Single Film Cooling Hole in a Turbulent Boundary Layer," submitted to ASME Transactions - Journal of Turbomachinery, 1989.

Conference Presentation: P.M. Ligrani, A. Ortiz, S.L. Joseph and D.L. Evans, "Effects of Embedded Vortices on Film-Cooled Turbulent Boundary Layers," ASME 33rd International Gas Turbine and Aeroengine Conference and Exposition, Amsterdam, June 1988.

P.M. Ligrani, W. Williams, "Effects of an Embedded Vortex on Injection from a Single Film Cooling Hole in a Turbulent Boundary Layer," ASME 34th International Gas Turbine and Aeroengine Conference and Exposition, Toronto, June 1989.

Theses Directed: 1. Effects of Embedded Vortices on Heat Transfer in Film-Cooled Turbulent Boundary Layers (S.L. Joseph), Naval Postgraduate School, Code 69, December 1986, ME Degree.

2. Study of Vortices Embedded in Boundary Layers with Film Cooling (D.L. Evans), Naval Postgraduate School, Code 69, March 1987, MS Degree.

3. The Thermal Behavior of Film-Cooled Turbulent Boundary Layers as Affected by Longitudinal Vortices (A. Ortiz), Naval Postgraduate School, Code 6ɔ, September 1987, ME Degree.

4. Effects of an Embedded Vortex on a Single Film Cooling Jet in a Turbulent Boundary Layer (W. Williams), Naval Postgraduate School, Code 69, June 1988, MS Degree

Title:	The Effect of Welding Process on the Microstructure and Properties of HY-130 Weldments
Investigators:	J.M.B. Losz and S. Saboury
Sponsor:	David Taylor Naval Ship Research and Development Center (DTNSRDC)
Objective:	To examine the relationship between structure and properties in HY-130 steel weldments produced by submerged-arc-welding (SAW) and gas-metal-arc welding (GMAW) processes.

Summary:	HY-130 is a high-strength, low-carbon steel used in the quenched and tempered condition. It is designed for high performance and marine applications where good weldability is the major requirement. Optimum welding parameters are currently under investigation. In this study, 1/2 inch (12.7 mm) HY-130 steel weldments produced by submerged arc welding (SAW) and gas metal arc welding (GMAW) process were compared by means of systematic microstructural characterization of the base metal, weld metal, and heat affected zone (HAZ). The microstructures were characterized by optical and electron microscopy and microhardness measurements were performed in the weld metal and across the HAZ to relate the microstructure with the microhardness profiles. The weld metal microstructure of both weldments showed a predominantly martensitic structure. The GNAW weld metal has a defined lath martensite structure and contained more retained austenite and twinned martensite. The SAW weld metal has a less defined lath structure which was more bianitic. The microhardness values were higher in the GMAW weld metal. No significant differences in microstructure and hardness were observed in the HAZ of the two weldments.

Thesis Directed:	"The Effect of Welding Process on the Microstructure of HY-130 Steel Weldments," M.S. Thesis by T.M. McNutt, December, 1988.

Title: The Effect of Filler Metal Composition on the
                          Microstructure of HY-130 GMAW Weldments

Investigators: J.M.B. Losz and S. Saboury

Sponsor: David Taylor Naval Ship Research and
                          Development Center (DTNSRDC)

Objective: To study the effect of heat input and
                          electrode chemical composition on the weld
                          metal microstructures in thin section HY-130
                          steel weldments produced by multipass gas-
                          metal-arc welding (GMAW) process.

Summary: Thin section HY-130 is being considered by
                          the US Navy for use desks and foundations in
                          the SSN-21 design as weight saving measure
                          Optimum welding procedures for thin section
                          HY-130 do no currently exist, but they are
                          being developed by DTNSRDC. In this study,
                          the effect of heat input and electrode
                          composition on the weld microstructures and
                          mechanical properties of four 12.7 mm thick
                          HY-130 steel weldments produced by the GMAW
                          process were reported. Microstructures were
                          fully characterized by light and electron
                          microscopy. Mechanical property results were
                          correlated with the microstructure.   The
                          lower heat input produced microstructural
                          refinement and more uniform hardness.   The
                          higher carbon content electrode lowered the
                          M/S temperature and stabilized the austenite.
                          A microduplex structure of lath martensite
                          and thin film interlath retained austenite
                          produced a good combination of strength and
                          toughness.

Thesis
Directed: "The Effect of Heat Input and Composition on
                          Weld Metal Microstructures in this Section
                          HY-130 GMAW Weldments," M.S. Thesis by D.M.
                          Pedersen, December, 1988.

Title: Advanced Cooling of Electric Motors

Investigators: P.J. Marto, Distinguished Professor
                 A.S. Wanniarachchi, Adjunct Professor

Sponsor: David W. Taylor Naval Ship Research and
                 Development Center

Objective: This work is part of a continuing program to
                 identify more effective heat transfer
                 techniques for cooling electric motors on board
                 naval vessels compared to existing forced-
                 convection cooling of air. The use of forced
                 convection liquid cooling as well as rotating
                 heat pipes have been studied.

Summary: Analytical calculations have been performed to
                 study the effectiveness of using heat pipe
                 cooling in comparison with liquid cooling of
                 rotors in large electric motors. Rotating,
                 off-axis heat pipes have been designed and
                 fabricated for testing at DTNSRDC. In
                 addition, technical guidance on experimental
                 data gathered at DTNSRDC has been provided for
                 liquid cooling when using either oil or water.

Publications: A.S. Wanniarachchi and P.J. Marto, "Heat Pipe
                 Cooling of Large Electric Motors: Project
                 Report for the Period 1 October 1987 - 30
                 September 1988," Naval Postgraduate School
                 Report NP69-88-002PR, December 1988.

Title: Enhanced Boiling and Condensation of R-114

Investigators: P.J. Marto, Distinguished Professor
A.S. Wanniarachchi, Adjunct Professor

Sponsor: David W. Taylor Naval Ship Research and Development Center

Objective: This work is part of a continuing program to determine the best boiling and condensing surfaces to utilize in Naval R-114 refrigeration plants.

Summary: A tube bundle apparatus has been constructed to simulate a portion of an operating refrigeration plant evaporator and condenser. During the past year, while Professor Marto was on Sabbatical Leave, there was an unavailability of thesis students to work on this project until April 1988. At that time, work commenced to modify the apparatus to insure proper operation and to instrument it for accurate measurements. Lt. B. Mabrey integrated all support systems into the apparatus and developed an interactive computer program for data acquisition and reduction. Preliminary condensation data were obtained for smooth and finned tubes. However, during operation, an unexpected contamination of the condensing surfaces occurred, making accurate measurements impossible to obtain. The contamination was found to be caused by thermal decomposition of the refrigerant at the electric cartridge heaters in the evaporator. More precise power control of the evaporator heaters has been established to eliminate or minimize this problem.

Publications: P.J. Marto and A.S. Wanniarachchi, "Enhanced Boiling and Condensation of R-114: Project Report for the Period 1 October 1987 - 30 September 1988," Naval Postgraduate School Report NPS69-88-001PR, December 1988.

Thesis
Directed: B.D. Mabrey, "Condensation of Refrigerants on Small Tube Bundles," Master's Thesis, December 1988.

Title: Film Condensation Heat Transfer Enhancement on
                      Horizontal Finned Tubes

Investigators: P.J. Marto, Distinguished Professor
                   A.S. Wanniarachchi, Adjunct Professor
                   J.W. Rose, University of London (Consultant).

Sponsor: National Science Foundation

Objective: This work is part of a continuing program to
                      determine the optimum finned tube configuration
                      that will produce maximum condensation heat
                      transfer for a given fluid and under given
                      operating conditions.

Summary: An experimental apparatus has been in operation
                      that will permit accurate condensation heat
                      transfer coefficient data to be obtained.
                      Numerous finned tubes have been tested using
                      steam, Freon-113 and ethylene glycol. During
                      the past year, the apparatus has been modified
                      to accept different diameter tubes and to allow
                      high vapor velocities (up to 30 m/s) to occur.
                      Experimental results show that the optimum fin
                      spacing may not be affected by tube diameter.
                      Vapor velocity has a smaller effect on finned
                      tubes than on smooth tubes.

Publications: P.J. Marto, "An Evaluation of Film Condensation
                      on Horizontal Integral-Fin Tubes," Journal of
                      Heat Transfer, Special Anniversary Issue, Vol.
                      110, No. 5, (November 1988), pp. 1287-1305.

                      P.J. Marto, D. Zebrowski, A.S. Wanniarachchi
                      and J.W. Rose, "Film Condensation of R-113 on
                      HOrizontal Finned Tubes," ASME Proceedings of
                      the 1988 National Heat Transfer Conference,
                      Vol. 2, pp. 583-592, edited by H.R. Jacobs,
                      Houston: American Society of Mechanical
                      Engineers, 1988.

                      P.J. Marto, O. Cakan, A.S. Wanniarachchi and
                      J.W. Rose, "Enhancement of Steam Condensation
                      on a Horizontal Finned Tube by Using Drainage
                      Strips," Proceedings of the 2nd U.K. National
                      Heat Transfer Conference, Glasgow, Scotland,
                      1988.

<u>Conference</u>
<u>Presentations</u>: See Above

<u>Theses</u>
<u>Directed</u>:   T.L. Van Petten, "Filmwise Condensation on Low
                Integral-Fin Tubes of Different Diameter,
                <u>Master's Thesis</u>, December 1988.

                C.L. Hopkins, "Effect of Vapor Velocity During
                Condensation on Horizontal Finned Tubes,"
                <u>Master's Thesis</u>, December 1988.

Title:	Investigation of the Influence of Microporosity on the Behavior of M-50 Bearing Steel
Investigator:	T.R. McNelley, Professor
Objective:	To determine the effect of microporosity on the rollins contract fatigue resistance of M-50 steel and the effectiveness of hot isostatic pressing (HIP) in closing the microporosity.
Summary:	Microporosity, originally documented in this laboratory, has been confirmed by other laboratories to exist in many heats of M-50 steel. The microporosity may be closed by HIP at temperatures below the normal austenitizing temperature for M-50 (lower temperature is necessary to avoid grain growth) but then the microporosity has been observed to reappear upon subsequent final hardening of the steel. Testing in progress will determine whether the HIP cycle and subsequent reduction in extent of microporosity results in improvement of rolling contact fatigue behavior of M-50 steel. Also, microanalytical methods including energy dispersive analysis will be employed to determine the nature of the carbides near which micropores form.
Publications:	A. Garg, T.R. McNelley, and J.L. Perry, "Analysis of Microporosity Associated with Insoluble Carbides in VIM-VAR AISI M-50 Steel," Metallography, vol. 20, pp. 89-98, 1987.

Title: Ultra-Fine Grained Superplastic Al-Mg and Al-Mg-Li Alloys: Thermomechanical Processing and Microstructural Development.

Investigator: T.R. McNelley, Professor

Sponsor: Naval Air Systems Command (Navy Block Funding)

Objective: To develope refined microstructures of approximately 1.0 micron grain size in wrought Al-based alloys, including Al-Mg, Al-Mg-Li, 2090 and 7475 materials, to facilitate warm temperature, cavitation-free superplasticity.

Summary: Research on Al-Mg alloys has been conducted in this laboratory and it has been demonstrated that refined microstructures of grain size as small as 1.0 micron may be attained by thermomechanical processing (TMP). The TMP methods include warm rolling and controlled reheating between consecutive rolling passes. The mechanism of grain refinement has been determined to consist of recovery of dislocations to evolving subgrain boundaries, resulting in gradual increase in boundary misorientation until a conversion of the boundary structure takes place and grain boundaries capable of sustaining superplastic deformation mechanisms are attained. Thus, the mechanism may be classified as continuous recrystallization during the course of TMP. By means of this processing, duclitities in excess of 1000 pct have been attained in Al-Mg-Li alloys when testing is conducted at 300°C and strain rates above 10^{-2} s^{-1}. Similar microstructural evolution can be induced in 2090 (Al-Cu-Li-Mg) alloys with resultant enhancement of ductility anticipated as well.

Publications: H.C. Heikkenen and T.R. McNelley, (editors), Superplasticity in Aerospace, The Metals and Materials Society of AIME, Warrendale, PA, 1988.

E.W. Lee and T.R. McNelley, "Superplastic Al-Mg Alloys," Journal of Metals (Materials Forum), Vol. 39, No. 11, p. 57, 1987.

S.J. Hales and T.R. McNelley, "Microstructure Evolution by Continuous Recrystallization in a Superplastic Al-Mg Alloy," Acta Metallargica, Vol. 36, pp. 1229-1239, 1988.

S.J. Hales and T.R. McNelley, "Fine Grained Superplasticity at 300°C in a Wrought Al-Mg Alloy," in Superplasticity in Aerospace, H.C. Heikkenen and T.R. McNelley (editors), TMS-AIME, Warrendale, PA, 1988, pp. 61-76.

R. Crooks, S.J. Hales and T.R. McNelley, "Microstructural Refinement via Continuous Recrystallization in a Superplastic Aluminum Alloys," in Proceedings of the International Conference on Superplasticity and Superplastic Forming, H.C. Hamilton and N.E. Paton (editors), TMS-AIME, Warrendale, PA, in press.

G. Avramovic-Cingara, H.J. McQueen, A. Salama and T.R. McNelley, "Hot Working and Resultant 300°C Ductility of Al-Fe and Al-Fe-Co Alloys," Scripta Metallurgia, in press.

S.J. Hales, I.G. Munro and T.R. McNelley, "Superplasticity in an Al-Mg-Li-Zr Alloy at Elevated Temperatures," in preparation for Scripta Metallurgia.

S.J. Hales and T.R. McNelley, "On Recrystallization and Superplasticity at 300°C in Al-Mg Alloys: I-Experimental Evidence," Metallurgical Transactions, in preparation.

S.J. Hales, T.R. McNelley and H.J. McQueen, "On Recrystallization and Superplasticity at 300°C in Al-Mg Alloys: II-A Qualitative Model," Metallurgical Transactions, in preparation.

Presentations: S.J. Hales and T.R. McNelley, "fine-Grained Superplasticity at 300°C in a Wrought Al-Mg Alloy," in the Symposium on Superplasticity in Aerospace, 117th Annual Meeting of AIME, Phoenix, Arizona, January 25-28, 1988.

T.R. McNelley and S.J. Hales, "Microstructure Refinement by Continuous Recrystallization During Processing of Superplastic Aluminum Alloys," WESTEC-88, Los Angles, California, March 21-24, 1988.

R. Crooks, S.J. Hales and T.R. McNelley, "Microstructural Refinement via Continuous Recrystallization in a Superplastic Aluminum Alloy," International Conference on Superplasticity and Superplastic Forming, Blaine, Washington, August 3-7, 1988.

G. Avramovic-Cingara, H.J. McQueen, A. Salama and T.R. McNelley, "Hot Working and Resultant 300°C Mechanical Behavior of Al-Fe and Al-FE-Co Alloys," The Eighth International Conference on Strength of Metals and Alloys (ICSMA-8), Tampere, Finland, August 23-27, 1988.

G. Avramovic-Cingara, H.J. McQueen, A. Salama and T.R. McNelley, "Hot Working and Non-Superplastic Behavior of Al-Fe and Al-Fe-Co Alloys," Annual Fall Meeting of the American Society for Metals and The Materials Society of AIME, Chicago, IL, September 25-29, 1988.

Theses
Directed:

A.A. Salama, "Analysis of Grain Refinement and Superplasticity in Al-Mg Alloys," Ph.D. December, 1987.

W.F. Ferris, "The Age Hardening Response of Thermomechanically Processed Al-Mg-Li Alloys," MSAE, December, 1987.

I.G. Munro, "Optimizing Superplastic Response in Lithium-Containing Al-Mg Alloys," MSME, December, 1987.

P.T. Spiropoulous, "Thermomechanical Processing of Aluminum Alloy 2090 for Superplasticity," MSME, December, 1987.

G.J. Kuhnert, "The Influence of Warm Rolling Parameters on the Superplastic Response of Al-Mg Alloy," MSME, June 1988.

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H.C. Regis, "Processing of Aluminum Alloy 2090 for Superplasticity," MSME, June, 1988.

G.E. Groh, "Processing and Superplasticity in Aluminum Alloy 2090," MSME, September, 1988.

Patent: E.W. Lee, S.J. Hales and T.R. McNelley, "Method and Composition for Producing Superplastic Aluminum Alloys," Patent Application Filed October, 1988, Navy Case No. 70397.

Title: Damping Properties and Applications of Quiet
                  Metal Alloys

Investigators: J. Perkins

Sponsor: David Taylor Research Center, Annapolis, MD

Objective: To characterize the damping properties and
                  delineate the damping mechanisms in a variety
                  of "quiet metal" alloys, including Cu-Mn, Fe-
                  Cr, Ti-Ni, Cu-Zn-Al and Cu-Al-Ni.

Summary: Specific damping capacity as a function of
                  cyclic strain and temperature has been
                  evaluated in detail for alloys based on Cu-Mn,
                  Fe-Cr and Ti-Ni. This has been done for alloys
                  in a variety of heat treated conditions in
                  order to discover and model the features which
                  lead to optimum damping behavior. All the
                  alloys display a threshold strain, above which
                  particular mechanisms are activated. They also
                  all display a saturation effect above a certain
                  level of strain. Microstructural features have
                  been studied via temperature-stage transmission
                  electron microscopy, and transformation
                  Kinetics have been monitored via calorimetry
                  and diletometry.

Publications: K. Adachi, J. Perkins and C.M. Wayman, "The
                  Crystallography and Boundary Structure of
                  Inter-Plate Group Combinations of 18R
                  Martensite Variants in Cu-Zn-Al Shape Memory
                  Alloys," Acta Metallurgica 36 (1988) pp. 1343-
                  1365.

                  J. Perkins, L.L. Mayes and T. Yamashita,
                  "Flickering Contrast in TEM Images of Tweed
                  Microstructures in an Aged Cu-Mn-Al Alloy,"
                  Scripta Metallurgica 22 (1988) pp. 887-892.

                  J. Perkins, L.L. Mayes and T. Yamashita,
                  "Effects of Aging on the Morphology of
                  Flickering Contrast in Tweed Microstructures of
                  Cu-Mn-Based Alloys," Scripta Metallurgica 22
                  (1988) pp. 1137-1142.

                  J. Perkins, L.L. Mayes, T. Yamashita, M.H. Wu
                  and J. Reskusich, "Pre-Martensitic Transitions
                  in Aged Cu-Mn Alloys," Proceedings of the MRS

International Meeting on Advanced Materials (Tokyo, 30 May-3 June 1988), Symposium on Shape Memory Materials (K. Shimizu and K. Otsuka, eds.), Materials Research Society, Pittsburgh, 1988.

J. Perkins, M.H. Wu and K. Adachi, "Interfaces and Substructures in Copper-Based Shape Memory Alloys," Invited Paper, Proceedings of the 1988 Electron Microscopy Society of America 46th Annual Meeting (Milwaukee, 7-12 August 1988)(G.W. Bailey, editor), San Francisco Press, San Francisco, 1988, pp. 786-787.

J. Perkins, K. Adachi, M.H. Wu and T. Yamashita, "TEM Studies of Transformation Interfaces and Substructures in Some Copper-Based Shape Memory Alloys," Invited Paper, Proceedings of the Symposium on the Use of TEM in the Study of Phase Transformations, Ultramicroscopy, (in press, 1988).

J. Perkins, "The Two-Way Shape Memory Effect," Invited Paper, Proceedings of the Symposium and Workshop on Engineering Aspects of Shape Memory, (Michigan State Univ., 15-17 August 1988), The Metallurgical Society, 1988.

M.H. Wu, J. Perkins and C.M. Wayman, "Antiphase Domain Structures in Cu-Zn-Al α_1 Bainite Plates," Invited Paper, Proceedings of the International Conference on Bainite (Chicago, 26-27 September 1988), American Society for Metals, 1988.

J. Perkins, K. Adachi, T.B. Massalski, T. Yamashita, M.H. Wu, L.L. Mayes, J.P. Heil, D.M. Farkas and J. Reskusich, "Tweed Contrast and 'Flickering' Features due to FCC-to-FCT Lattice Instability in Aged Cu-Mn Alloys", 1988 Fall Meeting of The Metallurgical Society, Chicago, Illinois, September 1988.

Conference
Presentations: J. Perkins, L.L. Mayes, T. Yamashita, M.H. Wu and J. Reskusich, "Pre-Martensitic Transitions in Aged Cu-Mn Alloys," Proceedings of the MRS International Meeting on Advanced Materials (Tokyo, 30 May-3 June 1988), Symposium on Shape

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Memory Materials (K. Shimizu and K. Otsuka, eds.), Materials Research Society, Pittsburgh, 1988.

J. Perkins, M.H. Wu and K. Adachi, "Interfaces and Substructures in Copper-Based Shape Memory Alloys," Invited Paper, <u>Proceedings of the 1988 Electron Microscopy Society of America 46th Annual Meeting</u> (Milwaukee, 7-12 August 1988)(G.W. Bailey, editor), San Francisco Press, San Francisco, 1988, pp. 786-787.

J. Perkins, "The Two-Way Shape Memory Effect," Invited Paper, <u>Proceedings of the Symposium and Workshop on Engineering Aspects of Shape Memory</u>, (Michigan State Univ., 15-17 August 1988), The Metallurgical Society, 1988.

Theses
Directed:

James L. Childs, MSME, 12.87, "The Effect of Heat Treatment and Cyclic Strain Amplitude on the Damping Properties of Fe-Cr-Based Alloys".

Thomas O'Laughlin, MSME, 12/87, "Determination of Tafel Constants in Non-Linear Polarization Curves from High Damping and Other Naval Alloys".

Larry L. Mayes, MSMS, 3/88, "An Electron Microscopic Study of Tweed Microstructure and Premartensitic Effects in High Damping 53Cu-45Mn-2Al Alloy".

Joseph P. Heil, MSME, 6/88, "Damping and Microstructures of Copper-Manganese-Based High Damping Alloys".

Title: Turbomachinery Rotor Blade Balancing

Investigator: Paul F. Pucci, Professor of Mechanical
                Engineering

Sponsor: Unfunded

Objective: The assembly of blades of different masses in a
                turbomachinery rotor may result in an unbalanced
                force acting on the rotor during rotation. There
                exists a blade sequence for which a minimum
                unbalance exists.

Summary: During the period 01 October 1987 and 31 December
                1988 an algorithm was devised and a computer
                program written to execute it to determine the
                sequence of blade insertions resulting in a
                minimum unbalanced force.

Publication: A. R. Yardimoglu, "A Computer Program for the
                Installation of Blading in a Turbomachinery Rotor
                Resulting in Minimum Unbalance", M.S.M.E. Thesis,
                December 1988.

Title: Analytic Model of Gas Turbine Flow Systems
                    Part I

Investigator: Paul F. Pucci, Professor of Mechanical
                    Engineering

Sponsor: Naval Sea Systems Command, Code 05R3

Objective: An exhaust gas diffuser of a proposed gas
                    turbine engine is modelled by a commercially
                    available three-dimensional, finite-volume
                    numerical computer code for the solution of
                    fluid mechanics and heat transfer problems.

Summary: The commercial fluid mechanics code PHOENICS was
                    used to model one of two proposed engine exhaust
                    gas diffusers. A parallel physical model test
                    program, one fifth scale, is being conducted at
                    DTRC Annapolis. The computer will simulate the
                    physical model so that results of the computer
                    model and physical model may be compared.

                    During the period 01 October 1987 and 31 December
                    1988, one geometry was computer simulated and one
                    operating point computed.

Publications: K. M. Griffin, "Numerical Simulation of the Fluid
                    Flow Through a Gas Turbine Engine Exhaust
                    Diffuser", M.S.M.E. and Mechanical Engineer
                    Thesis, NPS, June 1988.

Title: Analytic Model of Gas Turbine Flow Systems
                    Part II

Investigator: Paul F. Pucci, Professor of Mechanical
                    Engineering

Sponsor: Naval Sea Systems Command, Code 05R3

Objective: The pressure drop that occurs in the inlet air
                    and exhaust gas systems of gas turbine engine
                    installations on naval ships affects the
                    performance of the engine. A computer code which
                    allows the designer to select intake and exhaust
                    system components and to calculate the pressure
                    drops and their effect on the engine performance
                    is developed.

Summary: A computer code developed at NPS which allows a
                    designer to select inlet air and exhaust gas
                    system components for a gas turbine engine
                    installation on a naval ship and integrates the
                    effect of the pressure drops in the systems on
                    the performance of an LM 2500 marine gas turbine
                    engine.

                    During the period 01 October 1987 and 31 December
                    1988, the computer code was revised to
                    incorporate a single reference for the
                    calculation of pressure drops.

Publication: A. Harris, "Pressure Drop Prediction Through an
                    Intake and Exhaust System Using the GE-LM 2500
                    Gas Turbine Engine," M.S.M.E. Thesis, December
                    1988.

Title: Gas Turbine Installations on the DDG-51

Investigator: Paul F. Pucci, Professor of Mechanical
                Engineering

Sponsor: Naval Sea Systems Command, Code 400D

Objective: Monitor the design and model testing of the
                intake air and exhaust gas systems of the gas
                turbine engine installations on the DDG-51.

Summary: During the period 01 October 1987 and 31 December
                1988, the principal investigator travelled to
                NAVSEA Washington, DC, to the contracted ship
                designer, Gibbs and Cox, in New York, NY, and to
                NAVSSES Philadelphia, location of the Land Based
                Test Site, to discuss the design of the inlet air
                and exhaust gas systems for the gas turbine
                engines on the DDG-51.

Title:	Stress Relief Embrittlement in HSLA-100 Weldments
Investigators:	S. Saboury and J.M.B. Losz
Sponsor:	David Taylor Naval Ship Research and Development Center
Objective:	To study the susceptibility of HSLA-1000 steel weldments to stress relief cracking.

Summary: The US Navy is currently developing an new family of high-strength, low alloy steels which derive a significant portion of their strength from copper precipitation. These highly weldable steels require little or no preheat, resulting in substantial cost savings. The first of these steels, HSLA-80, has been certified for ship construction, but recent studies have indicated some susceptibility to stress relief cracking in weldments.

HSLA-100, a modification of HSLA-80, is now being considered for several higher-strength Naval structures. Stress-relief cracking has not been studied previously in this steel and is the subject of investigation in this work. The steel weldments were loaded below their yield strength, heated to temperatures of 550*-650* C, and permitted to stress relieve for one hour. At all temperatures, the steel exhibited susceptibility to stress relief cracking in certain stress ranges. Optical and canning electron microscopy exhibited intergranular cracking which always traversed the coarse-grained region of the heat-affected zone. Auger and transmission electron microscopy indicated high concentrations of alloying elements at the grain boundaries. Stress-relief cracking was associated with the diffusion of alloying elements to the prior austenite grain boundaries.

Thesis Directed:	"Stress Relief Cracking in Copper-Precipitation Strengthened HSLA-100 Steel," M.S. Thesis by S.A. McNutt, December, 1988.

Title: The Effect of Aging Treatment on the Structure and Properties of HSLA-100 Steel

Investigators: S. Saboury and J.M.B. Losz

Sponsor: David Taylor Naval Ship Research and Development Center

Objective: To study the structural property relationships of HSLA-100 steel after various aging treatments.

Summary: The high strength low alloy (HLSA) steels which are being developed as replacements for the HY family of steels are low carbon steels which derive their strength in part due to the precipitation of fine coherent copper particles formed during a quench and aging heat treatments. HSLA-100 is being developed to meet the strength and toughness requirements of HY-100, but can easily welded without preheat, thereby reducing fabrication costs. The project uses light and electron microscopy for microstructural characterization while tensile, Charpy, and hardness tests are relied upon for the mechanical properties. The microstructure and mechanical characteristics of HSLA-100 after aging at several different temperatures was correlated. A high ductility and the required 100 ksi yield strength was observed after aging at 675 C, although this temperature was found to be close to the low eutectoid temperature displayed by HSLA-100. Splitting was observed in the tensile fracture surfaces, but the mechanical properties were not adversely affected.

Thesis
Directed: "The Effect of Aging Treatment of the Microstructure and Properties of Copper-Precipitation Strengthen HSLA Steel," M.S. Thesis by M.H. Heinze, December, 1988.

Title:	Three-Dimensional Modeling of Flows within Gas Turbine Engine Test Cells
Sponsor:	Naval Civil Engineering Laboratory, China Lake, CA.
Investigators:	D. Salinas
Other Investigators:	LT. R. Braxton, LT. CMDR. E.A. Nicolaus, LT. CMDR. M. Meaker, and T. A. Maraoui

Summary:

NAVAIR has initiated a program for the modernization of existing test cell facilities and the design of new test cell facilities. The overall cost of the project is estimated at $700 million, with R&DT at $22 million. One part of the project is to determine the feasibility of using a CFD (computational fluid dynamics) code to assist in the design of test cells. NPS is assisting the Naval Civil Engineering Laboratory in this determination. Several student thesis projects have analyzed existing test cells. These investigations show that the use of a CFD code can be an effective tool in the design of test cell facilities. This investigator is analyzing the Cubi Point test cell facility.

Publications:

D. Salinas and C. Kodres, "Modeling the Aerothermal Characteristics of Jet Engine Test Cells," Proceedings of the 2nd International Phoenics User Conference.

Title:	Separation Points on a Cylinder in Harmonic Flow
Investigator:	T. Sarpkaya, Dis. Prof., Mechanical Engineering
Sponsor:	The Chief of Naval Research, Direct Funding
Objective:	To determine the excursion of the separation points on smooth and rough circular cylinders in multi-frequency harmonic flows (e.g., ocean waves which are composed of many amplitudes and frequencies). The unsteady flow used in this investigation is a generalization of a more special mono-harmonic flow. The latter is the subject of another investigation.
Summary:	Extensive experiments have been carried out in a U-shaped water tunnel. The desired time-dependent flow is generated through the use of a Gaussain wave generator. The results will serve several purposed: (i) they will be compared with those obtained in the ocean environment; (ii) they will enhance our knowledge of the most general separated oscillating flow about bluff bodies; and (iii) they will help to devise methods to minimize the consequences of separation on bodies immersed in the ocean environment where the flow is not only omnidirectional, but also composed of many frequencies. The investigation is continuing through the use of several methods of separation-point identification (differential pressure probe, hot-film probe, and flow visualization) and through the use of several smooth and sand-roughened circular cylinders.
Publications:	T. Sarpkaya and W.H. Butterworth, Jr., "Separation Points on a Cylinder in Oscillating Flow," NPS-69-89-01, 1988.
Thesis Directed:	W.H. Butterworth, "Separation in Time-Dependent Flow," M.S. Thesis, September, 1988.

Title:	Separation Points on a Cylinder in Sinusoidally-Oscillating Flow
Investigator:	T. Sarpkaya, Dist. Prof., Mechanical Engineering
Sponsor:	National Science Foundation
Objective:	The purpose of this investigation is to determine the excursion of the separation points on a smooth circular cylinder in a sinusoidally oscillating flow. The unsteady flow used in this investigation is a special case of a more general harmonic flow composed of many frequencies. The latter is the subject of another investigation.

Summary:	Experiments have been carried out in a U-shaped water tunnel at various Reynolds numbers and Keulegan-Carpenter numbers, using a wave of constant frequency. The motion of the separation point on a smooth circular cylinder has been determined as a function of a normalized time for various Keulegan-Carpenter numbers. The results will serve several purposed: (i) they will be compared with those obtained numerically thorough the use of the discrete vortex analysis to guide and complement the analysis; (ii) they will enhance our basic understanding of separation thorough the use of a relatively idealized time-dependent flow about bluff bodies; and (iii) they will help to devise methods to delay the occurrence of separation. It must be emphasized that very little is known about the motion of separation points in un-steady flows. A parallel investigation will extended the results obtained with the mono-harmonic flow to the more general case of multi-frequency harmonic oscillations about smooth and rough cylinders.

Publications:	T. Sarpkaya, "Oscillating Flow About Smooth and Rough Cylinders," Journal of Offshore Mechanics and Arctic Engineering, Trans, ASME, vol. 2, pp. 113-121, 1987.

Title:	Interaction of Underwater Vortices with a Free Surface
Investigator:	T. Sarpkaya, Dist. Prof. of Mechanical Engineering
Sponsor:	The Chief of Naval Research, Direct Funded
Objective:	To relate the free-surface scars and striations generated by the motion of surface ships and submerged bodies to the motion and characteristics of the generating bodies for the purpose of SAR tracking and non-acoustic detection of target vehicles.

Summary: Numerous experiments have been carried out in a large towing tank with various lifting surfaces and submerged bodies in homogeneous and density-stratified medium. In addition, experiments with two dimensional vortex pairs have been conducted in a large water basin using both stratified and homogeneous medium. The characteristics of the resulting surface scars have been evaluated in terms of the governing parameters thorough the use of Motion Analysis System and a Sun computer. Extensive numerical analysis have been performed and computer code has been developed to predict numerically the characteristics of the surface disturbances. Experiments and analysis are continuing towards the evaluation of the behavior of the scars in terms of the prevailing Froude numbers, Atwood number and the Vaisala-Brundt frequencies.

Publications: T. Sarpkaya, J. Elnitsky II, and R.E. Leeker, "Wake of a Vortex Pair on the Free Surface," Proceedings of the 17th Symposium on Naval Hydrodynamics, vol. 1, pp. 47-54, 1988.

Theses
Directed: R.E. Leeker, "Free Surface Scars due to a Vortex Pair," M.S. Thesis, March, 1988.

M.D. Petersen-Overton, "The Interaction of a Fluid Interface with a Vortex Pair," M.S. Thesis, June, 1988.

Title:	Computational Methods with Vortices
Investigator:	T. Sarpkaya, Dist. Prof. of Mechanical Engineering
Sponsor:	ASME Freeman Scholar Program
Objective:	As part of the Freeman Scholar Award, to write a comprehensive review of the computational methods based upon Helmholtz's concepts of vortex dynamics, making use of Lagrangian or mixed Lagrangian-Eulerian schemes, the Boit-Savart law or the Vortex in Cell methods.

Summary:

The review is organized around two major sections: Theoretical Foundations and practical applications of vortex methods. The first covers topics such as vorticity and laws of transportation, evolution equations for vortex sheet, real vortices and instabilities, Biot-Savart law, smoothing techniques (cutoff schemes, amalgamation of vortices, subvortex methods), cloud-in-cell or vortex-in-cell methods, body representation (Routh's rule, surface singularity distribution), operator splitting and the random walk method (description and convergence), and asymmetry introduction. The next section covers contra flowing streams, vortical flows in aerodynamics (vortex sheet; roll up; slender body; two-vortex; multi-discrete vortex; and segment or panel methods; three-dimensional flow models; and vortex lattice methods), separated flow about cylindrical bodies, (circular cylinder, sharp-edged bodies, arbitrarily-shaped bodies), general three-dimensional flows (vortex rings, turbulent spots, temporally, and spatially-growing shear layers), and other applications (vortex-blade interactions, combustion phenomena, acoustics, contour dynamics, interaction of line vortices, chaos, and turbulence). The review is concluded with a brief comparison of these methods with others used in computational fluid dynamics and a personal view of their future prospects.

Title: Wake Profile of Bow Planes

Investigator: T. Sarpkaya, Dist. Prof. of Mechanical Engineering

Sponsor: Defence Advanced Research Projects Agency

Objective: The understanding of the internal waves and the Bernoulli humps generated by the control planes and the body of SSN-21.

Summary: Extensive measurements were made through the use of an SSN-21 model in a towing tank to determine its wake characteristics. These were related to the dimensionaless parameters such as the Reynolds number, Froude number, Brunt-Vaisala frequency, the angle of attack of the body and the bow planes, and the parameters characterizing the body shape. The investigation delineated the range of the angle of attack of the bow planes for which the vortex migration is limited to certain depths. The characteristics of the surface flow patterns resulting from the interaction of the internal waves with the free surface have been evaluated. Furthermore, means, have been discovered to modify the shape of the fixed stability planes to practically eliminate the wake generated by them.

Publications: T. Sarpkaya, S.K. Johnson, W.E. Gray, and J.J. Daly, "Vortex Motion in Homogeneous and Stratified Media," Naval Research Reviews, vol. 39, pp. 3-8, 1987.

Title:	Unsteady Flow About Cambered Plates
Investigator:	T. Sarpkaya, Dist. Prof. of Mechanical Engineering
Sponsor:	Sandia National Laboratories
Objective:	To develop theoretical and experimental methods to explain the reasons leading to the collapse of large parachutes and to devise methods to prevent it.

Summary:
Large parachutes, delivered by low flying, high speed aircraft, collapse shortly after the onset of deceleration. A fundamental investigation was undertaken through the use of the discrete vortex method. Extensive computer studies have shown that the cause of the collapse is the development of large vortices and their backward motion during the rapid deceleration of the parachute. In addition, extensive tests were carried out in a vertical water tunnel. The measured forces and the flow kinematics agreed surprisingly well with those predicted numerically. The investigation has been extended to include the effect of porosity through the use of boundary-fitted vortices.

Publications: T. Sarpkaya, S.I.M. Mostafa, and P. Munz, "Unsteady Flow About Cambered Plates," NPS-69-87-012.

Thesis
Directed: P.J. Lindsey, "Unsteady Flow About Porous Cambered Plates," M.S. Thesis, June, 1988.

Title:	Data Acquisition, Reduction and Analysis of Underwater Shock Testing Using Super Microcomputer
Investigator:	Y.S. Shin, Associate Professor of Mechanical Engineering and K.S. Kim, Adjunct Research Professor
Objective:	To develop data Acquisition and Real time analysis system to process the underwater explosion shock and vibration signatures using super microcomputer.

Summary:

The advent of small, portable super microcomputer has enabled the rapid analysis of extremely high mechanical signals. Their capabilities have expanded to allow real time analysis. Data Acquisition Modules with 16 analog signal channels can easily fit inside portable desk top super microcomputer. Fast 32 bit processors, small high volume hard disk drive and large RAM capacities complete the package, enabling the use of a super microcomputer for the data acquisition and field analysis in the area of underwater explosion shock testing. The combination of the acquisition and analysis capabilities in the same device eliminates the requirement to record the data to an intermediate device prior to analysis. The maximum sampling rate is 1-mega Hz. The underwater shock signal processing program was developed with various types of underwater shock in mind as a long range program. This program will be used to verify the validity of the data acquisition and real time analysis in 1989 Underwater Shock Testing Program at NPS. This approach will eliminate the process of data acquisition of FM Wideband Tape Recorder and will be able to make a complete review of the test results and real time analysis on the test site. This approach will eventually replace the state-of-the-art (classical) method. This research is a definite and significant contribution to underwater explosion testing for DoD application in Weapons development. This development is also implemented in ME4525, "Naval Ship Shock Design and Analysis" in NPS.

Publications: H.L. Budweg and Y.S. Shin, "Experimental
                                 Studies on the Tripping Behavior of Narrow
                                 T-Stiffened Flat Plates Subjected to
                                 Hydrostatic Pressure and Underwater Shock,"
                                 Proceedings of the 58th Shock and Vibration
                                 Symposium, NASA 2488, vol. 1, pp. 61-95.
                                 Huntsville, AL., October, 1987. This paper
                                 was also presented at the Conference.

Thesis
Directed: G.E. Monteith, "Shipboard Vibrational Effects
                                 on the Navy's High Energy Laser," M.S.
                                 Thesis, December, 1987.

Title: Vibration Damping: Design, Analysis, and
                        Testing

Investigator: Y.S. Shin, Associate Professor of Mechanical
                        Engineering

Sponsor: David Taylor Research Center

Objective: To develop passive vibration control schemes
                        of Naval components in the form of energy
                        dissipation, isolation, and absorbing
                        devices.

Summary: The control of the vibration of a mechanical
                        system is usally accomplished by both active
                        and passive devices or treatment to the
                        structures. In this continuing project, the
                        passive device and treatment to the system
                        have been a concern to control the vibration
                        in the form of energy dissipation, isolation,
                        and absorbing devices. The current research
                        project include (1) friction and joint
                        damping of build up structure, (2)
                        constrained layered viscoelastic damping, and
                        (3)-the waveguide absorber.

Title:	Vibration Damping: Design, Analysis and Testing
Sponsor:	David Taylor Research Center, Bethesda, MD.
Investigators:	Y.S. Shin and K.S. Kim
Objective:	To study and develop various passive vibration control methods for ship and submarine silencing.

Summary: A long standing concern of the Navy has been the reduction of structural vibration in ships and submarines. Various passive vibration control methods are studied analytically and experimentally: (1) Damping enhancement at structural joints. (2) Constrained layer damping, and (3) Wave Guide Absorbers. A generic model consisting of four plates and two cylindrical shells is used for the joint damping and the constrained layer damping studies. Visocoelastic circular plate wave guide absorbers are studied.

Publications: K.S. Kim, and Y.S. Shin, and G.G. Lee, "Impedance Prediction of Beam Wave Guide Absorbers Using High-Order Beam Theories," In Shock and Wave Propagation, ASME-PVP, vol. 134, pp. 19-26, June, 1988.

Theses
Directed: "Analytical and Experimental Studies of Beam Wave Guide Absorbers for Structural Damping," M.S. Thesis by G.G. Lee, March, 1988.

Title: Vibration Damping: Design, Analysis and Testing

Principal Investigator: Young S. Shin, Associate Professor of Mechanical Engineering

Sponsor: David Taylor Research Center

Objective: To develop passive vibration control schemes of naval components in the form of energy dissipation, isolation and absorbing devices.

Summary: The control of the vibration of a mechanical system is usually accomplished by both active and passive devices or treatment to the structures. In this continuing project, the passive device and treatment to the system have been a concern to control the vibration in the form of energy dissipation, isolation and absorbing devices. The current research projects include (1) friction and joint damping of buildup structure, (2) constrained layered viscoelastic damping, and (3) the waveguide absorber. Experimental studies were extensively performed to understand the damping benefit of bolted connection of plate and shell type structure. The bolt preload and joint damp treatment were significant factors to control the resonant vibration amplitudes and frequencies of the system. Constrained layered viscoelastic damped plate and shell type structure was designed and analyzed using Modal Strain Energy Method. The results were compared with the experiment and problem areas were clearly identified. Viscoelastic and constrained layered beam and plate type waveguide absorbers were studied. Theory was developed and energy dissipation schemes were evaluated. The results were also compared with experiments.

Publications: K.S. Kim, Y.S. Shin and G. Lee, "Impedance Prediction of Beam Waveguide Absorber Using Higher-Order Beam Theories," Proceeding ASME PVP-Vol. 134, pp. 19-26, Pittsburgh, June, 1988. Also submitted for publication at Journal of Sound and Vibration.

Y.S. Shin, P.F. Milster and S.T. Knouse, "Parametric Studies on the Measurement of Damping Quantities," Proceedings of <u>6th International Conference of Pressure Vessel Technology</u>, Beijing, China, Sept. 11-16, 1988.

G. Knot, Y.S. Shin and M. Chargin, "A Modal Analysis of the Violin," Proceedings of <u>MSC/NASTRAN World Users Conference</u>, Los Angeles, March 1988.

Y.S. Shin, K.S. Kim and J.C. Iverson, "Analytical and Experimental Investigations of the Damping Characteristics of Bolted and Welded Structural Connections for Plates and Shells," Naval Postgraduate School Technical Report, NPS 69-86-011, December, 1987.

Conference Presentation: conferences.

The first three papers listed in the above publications were presented at the

Thesis Directed:

1. G. J. Maurer, "Vibration Responses of Constrained Viscoelastically Damped Plates: Analysis and Experiments," <u>Master's thesis</u> in Mechanical Engineering, December 1987.

2. R.W. Durham, "Experimental Investigation of the Effects of Underwater Exposure on the Damping Characteristics of Bolted Structural Connections for Plate and Shells," <u>Master's thesis</u> in Mechanical Engineering, March 1988.

3. G. Lee, "Analytical and Experimental Studies of Beam Waveguide Absorbers for Structural Damping," <u>Master's thesis</u> in Mechanical Engineering, March 1988.

4. C.D. Hettera, "The Modelling of Viscoelastic Circular Plates for Use as Waveguide Absorbers," <u>Master's thesis</u> in Mechanical Engineering, September 1988.

5. C.T. Horne, III, "Experimental Investigation into the Structural Damping of a Flat Plate with Waveguide Absorbers Attached," <u>Master's thesis</u> in Mechanical Engineering, September 1988.

6.   J.R. Nault, "Analytical and Experimental
Investigation of Constrained Viscoelastic
Layer Damping of Plates and Shells," <u>Master's
thesis</u> in Mechanical Engineering, September
1988.

Title:	Application of Modern Control to a Marine Gas Turbine
Investigator:	D.L. Smith
Sponsor:	Naval Sea Systems Command
Objective:	To conduct modeling, testing, and control design feasibility studies which will form part of a critical design technology base for advanced marine gas turbine controllers.

Summary: A cause-and-effect model of the NPS test bed marine gas turbine equipment has been completed. A linear controller design model has developed and verified. A comprehensive nonlinear test bed simulation program for a digital computer has been written and verified to model test bed dynamic responses to proposed controller candiates. A comparative study of a classical controller and a modern controller has been completed showing the merits of each for the test bed under simulated sea conditions. An advanced expert system controller for compressor stall has been designed and is now being investigated.

Publications: V.A. Stammetti, and D.L. Smith, "Survey and Analysis of Marine Gas Turbine Contol after 1975," NPS Report, NPS69-88-002, April, 1988.

J.A. Davitt, and D.L. Smith, "An Evaluation of the Potential for Expert System Application to Marine Gas Turbine Control, NPS Progress Report, NPS69-99-006.

Conference
Presentations: D.L. Smith, "Linear Modeling of a Marine Gas Turbine Power Plant," ASME Gas Turbine and Aeroengine Congress, Amsterdam, June 6-9, 1988.

Thesis
Directed: V.A. Stammetti, "Comparative Controller Design for a Marine Gas Turbine Propulsion Plant," MSME, September, 1988.

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