MATHEMATICS DEPARTMENT
RESEARCH SUMMARIES AY 2002

CARLOS F. BORGES – *Associate Professor*

Research Project Summary
Total Least Squares Fitting of Ordered Data with Polynomial Splines
C. F. Borges, Associate Professor of Applied Mathematics
Sponsor: Unfunded

Objective: To develop fast and numerically stable algorithms for fitting polynomial splines to ordered data with minimal error in the total least-squares sense.

Summary: This unfunded effort is a continuing research project. The idea is to fit parametric polynomial spline curves to ordered data to get the best possible fit. Unlike traditional least-squares methods we assume that errors may occur in both the x and y directions. Moreover, we allow the data to be completely general - in particular, it does not have to be functional in nature, it may overlap itself or change directions without restriction. All that is required is an ordered set of points in the plane. I have investigated a variety of different approaches and have developed some very fast and robust algorithms for solving the problem for a single Bezier curve. I have extended these algorithms to work with B-spline curves with general knot sequences.

Publications:

- C.F. Borges and T.A. Pastva, *Total Least Squares Fitting of Bezier and B-Spline Curves to Ordered Data*, **Computer Aided Geometric Design**, Volume 19, Number 4, 2002, pages 275-289.

Keywords: Curve Fitting, Data Compression, and Approximation Theory.

Research Project Summary
Modeling the Spread of Biological Infections in a Functioning Military Unit
C. F. Borges, Associate Professor of Applied Mathematics
Sponsor: Unfunded

Objective: To develop models that can be used to study the spread of biological infections in functioning military units. To use these models to better understand the implications of a bio-warfare attack on a forward operating military unit, and to develop strategies for minimizing the effects of such attacks.

Summary: This unfunded effort is a continuing research project. I am very proud of my work with CAPT Ryan Paterson, USMC. His master's thesis work centered on various methods I have been investigating for modeling the spread of biological infections in

functioning military units. He implemented a computer model that allows one to investigate the impact of a biological warfare attack on a single Marine battalion operating in a combat area. This model is quite general and we used it to further investigate vaccination and quarantine strategies and other aspects critical to operating in a bio-warfare environment where the specific agents can generate contagious illnesses (secondary infections). This is the first model of its kind.

Publications:

- Ryan Paterson, *Modeling Man-made Epidemics*, Masters Thesis, Naval Postgraduate School, Monterey, CA; Springfield, VA: Available from National Technical Information Service, 2002.

Keywords: Biological Warfare, Biological Terrorism.

DAVID CANRIGHT – *Associate Professor*

Research Project Summary
THERMOCAPILLARY EFFECTS IN WELDING
D. Canright, Associate Professor of Applied Mathematics
Sponsor: Unfunded

Objective: To analyze the thermocapillary feedback mechanism in the "cold corner" region of weld pools, and to develop an accurate model of this process for numerical simulation of welding.

Summary: This unfunded project extends previously funded work. At the edge of a weld pool, where hot liquid meets relatively cool solid, thermocapillary effects may locally dominate the flow of fluid and of heat, which can affect the quality of the resulting weld. In this case, the length scales of this concentrated flow are extremely small relative to the pool size, imposing severe resolution constraints for numerical simulations. The current work uses our earlier scaling analysis to develop a boundary-layer model that exploits the even smaller length scales of viscous boundary layers in the corner. The resulting corner model compares well with careful numerical simulations, and can be integrated into a global simulation to relieve the severe resolution constraints. This year resulted in one journal article and two conference presentations.

Publications:

D. Canright and M. Huber 2002 "A Boundary-Layer Model of Thermocapillary Flow in a Cold Corner," *Physics of Fluids* **14(9)**:3272-3279.

Presentations:

D. Canright and M. Huber "Boundary-Layer Model for Thermocapillary Feedback Near a Cold Wall," SIAM 50th Anniversary and 2002 Annual Meeting, Philadelphia, Pennsylvania, 8-12 July 2002.

D. Canright and M. Huber "Thermocapillary Feedback Near a Cold Wall: A Boundary-Layer Model," 55th Annual Meeting of the Division of Fluid Dynamics of the American Physical Society, Dallas TX, 24-26 November 2002. (Abstract published in *Bulletin of the American Physical Society* **47(10)**:197, 2002.)

Keywords: Thermocapillary Flow, Materials Processing, Boundary-Layer Theory.

DONALD A. DANIELSON – *Professor*

Research Project Summary
Buckling of Ship Grillages with Bulb Flat Stiffeners
Donald A. Danielson, Professor
Sponsor: Naval Surface Warfare Center

Objective: In earlier work, analytical formulas and finite element models have been developed for predicting the buckling loads of commonly used plate structures having thin-walled stiffeners. Now there is great interest in bulb flat stiffeners, whose unique shape distributes steel to maximize the resistance to buckling.

Summary: In 2002, Professor Danielson extended earlier analytical formulas to apply to stiffeners of arbitrary cross section. As part of his PhD thesis work, LTC Archie Wilmer developed analytical models for needed cross section properties, and compared the predictions with a finite element code.

Keywords: Structure, Ship, Grillage, Stiffener, Buckling

FARIBA FAHROO – *Associate Professor*

Research Project Summary
Trajectory Guidance Using a Spectral Method
Fariba Fahroo, Associate Professor of Applied Mathematics
Sponsor: Draper Labs

Objective: To develop a real-time non-linear guidance algorithm based on the pseudo-spectral methods for reusable launch vehicles.

Summary: This research project is the continuation of a multi-year contract with Draper labs on developing and analysis of algorithms for solving complex trajectory optimization problems. The ultimate goal is to develop solutions methods for the inner (fast) and outer (slow) guidance loops for launch vehicles. In conjunction with developing efficient and accurate solution technique based on pseudo-spectral numerical methods for the outer loop, a guidance algorithm based on the pseudo-spectral methods was developed. This algorithm solved the main boundary-value problem in an efficient manner and was tested on a Low Thrust Orbit Transfer Problem. Currently the goal is to extend the result to guidance for a re-entry launch vehicle.

Publications:

- F. Fahroo and I. M. Ross, Direct trajectory Optimization by a Chebyshev Pseudo-spectral Method, Journal of Guidance, Control and Dynamics, Vol. 25,
- No. 1, (2002), pp. 160-166.

- I.M. Ross, J. Rea, and F. Fahroo, Exploiting Higher-Order Derivatives in Computational Optimal Control, the proceedings of the 2002 IEEE Mediterranean Conference, July 2002, Lisbon, Portugal.

- I.M. Ross and F. Fahroo, A Direct Method for Solving Nonsmooth Optimal Control Problems, the proceedings of the 2002 IFAC World Conference, Barcelona, Spain, July 2002.

- H. Yan, F. Fahroo, and I. M. Ross, Real-Time Computation of Neighboring Optimal Guidance, the proceedings of the AIAA Guidance, Navigation and Control Conference, Monterey, CA August 5-8, 2002.

- J. Strizzi, I. M. Ross, and F. Fahroo, Towards Real-Time Computation of Optimal Controls for Nonlinear Systems, the proceedings of the AIAA Guidance, Navigation and Control Conference, Monterey, CA August 5-8, 2002.

- I.M. Ross, J. T. King, and F. Fahroo, Designing Optimal Spacecraft Formations, the proceedings of the AIAA/AAS Astrodynamics Conference, Monterey, CA August 5-8, 2002.

- I.M. Ross and F. Fahroo, A Perspective on Methods for Trajectory Optimization, the proceedings of the AIAA/AAS Astrodynamics Conference, Monterey, CA August 5-8, 2002.

- I.M. Ross and F. Fahroo, Pseudo-spectral Methods for Optimal Motion Planning of Differentially Flat Systems, the proceedings of the 41st Conference on Decision and Control, Las Vegas, NV, December 2002.

Keywords: Trajectory Optimization, Guidance, Pseudo-spectral methods.

Research Project Summary
Guidance and Control Algorithms for Hypersonic and Reusable Launch Vehicles
Fariba Fahroo, Associate Professor of Applied Mathematics
Sponsor: AFRL

Objective: To develop a fast and accurate methods for determining the largest reachable set (footprint) for a reusable launch vehicle.

Summary: The ultimate goals of this research are to develop advanced guidance and control algorithms for hypersonic and reusable launch vehicles. One application is in the area of determining reachable regions by a reentry or un-powered hypersonic vehicle experiencing control effector failures. This problem was formulated as a parameter dependent optimal control problem and was solved using a numerical package developed at NPS by (Mike Ross and the PI). Future goals of the project will involve designing an adaptive reconfigurable control system for the X-40A vehicle to support a flight-test demonstration of an integrated adaptive guidance and control system.

Publications: 2 conference papers were submitted (1 to the 2003 IEEE aerospace conference (March 2003) and the other to the 2003 American Conference in Control (June 2003)). They are both accepted to appear in 2003.

HAL FREDRICKSEN – *Professor*

Research Project Summary
Visiting Professor at U. S. Military Academy
H.M. Fredricksen, Professor of Applied Mathematics
Sponsor: U. S. Military Academy

Objective: To continue the relationship which exists between the Mathematics Departments at USMA and NPS and to find areas for future development.

Summary: The Mathematics Department at USMA sponsors a Visiting Professor activity to provide an enrichment environment for their (primarily) military faculty. This is accomplished by bringing in senior faculty to interact, conduct research and teach cadets. Experiences shared will provide benefit to the individual and his home University, as well as that enjoyed by the faculty at USMA. Ultimately, the relationships between the two institutions will be enhanced and continued student enrollments at NPS will be the natural result.

Keywords: Education

CHRIS FRENZEN – *Associate Professor*

Research Project Summary
Aspects of the Statistical Theory of Shape
C.L. Frenzen, Associate Professor of Applied Mathematics
Sponsor: Unfunded

Objective: Representing the shape of a data set as a point on a manifold allows shape to be studied in a manner susceptible to mathematical and statistical analysis. This is key to comparing data sets. A central problem of shape theory is that it is not possible to represent the full range of shapes of an object in a Euclidean space without losing the ability to distinguish quantitatively between different shapes. This forces one to consider real and complex projective manifolds as shape spaces. The objective here is to understand and describe the topological and geometric properties of these new shape spaces, so that classical statistical methods can be adapted to work on them.

Summary: When information in a data set about its location, scale, and orientation is removed, what remains is called the shape of the data. In the last two decades, it has been known that shapes could be represented as points in a so-called shape manifold. To compare shapes we must define a metric, and this metric defines a geometric structure on the manifold. These geometric structures are difficult to interpret and visualize, and finding concrete and simple representations for them is an important goal. Some preliminary results have been obtained along these lines.

Keywords: Shape, statistical analysis

WILLIAM B. GRAGG – *Professor*

Research Project Summary
Convergence of the Shifted QR Algorithm for unitary Hessenberg matrices
William B. Gragg, Professor of Applied Mathematics
Sponsor: Unfunded

Objective: To establish the global, and the cubic speed of, convergence of the unitary Hessenberg QR algorithm with Wilkinson's shift. The process is a fast, O(n^2), process for solving such problems, which are of fundamental importance for signal processing.

Summary: This paper shows that for unitary Hessenberg matrices the QR algorithm with the Wilkinson shift gives global convergence. Moreover the asymptotic rate of convergence is at least cubic, higher than that which is only quadratic for Hermitian tridiagonal matrices. A general mixed shift strategy with global convergence and cubic rate is also presented.

Publications:

- Tai-Lin Wang and William B Gragg, *Convergence of the shifted QR algorithm for unitary Hessenberg matrices*, **Mathematics of Computation**, Volume 71, Number 240, 2002, pages 1473-1496.

Research Project Summary
Convergence of the Unitary QR Algorithm with a Unimodular Wilkinson Shift
William B. Gragg, Professor of Applied Mathematics
Sponsor: Unfunded

Objective: To find a better shift strategy for the uhqr algorithm, one that makes the algorithm practically faster and more numerically stable.

Summary: In applying the QR algorithm to compute the eigenvalues of a unitary Hessenberg matrix, a projected Wilkinson shift of unit modulus is proposed and proved to give global convergence with (at least) a quadratic asymptotic rate for the QR iteration. Experimental testing demonstrates that the unimodular shift produces more efficient numerical convergence.

Publications:

- William B Gragg, *Convergence of the unitary QR algorithm with a unimodular Wilkinson shift*, **Mathematics of Computation**, Volume 72, Number 241, 2003, Published electronically on June 25, 2002.

TOKE JAYACHANDRAN – *Professor*

Research Project Summary
Analysis of Data from the Multi-center Validation Project
Toke Jayachandran, Professor of Applied Mathematics
Sponsor: Defense Intelligence Agency Central MASINT Organization

Objective: To perform statistical analyses of data collected by the Armed Forces Institute of Pathology (AFIP) on behalf of the Central MASINT organization. The goal was to assess the effectiveness of the RAPID thermal cycler in detecting the presence of biological/chemical agents such as anthrax and other agents, and to set standards and guidelines for laboratory analyses of samples containing suspect material.

Summary: AFIP provided the raw data collected from the primary experiment using synthesized samples contaminated with differing levels of anthrax and analyzed at seven different laboratories. After several extensive discussions with the scientists at AFIP, the data was reformatted so as to be amenable to statistical analyses. Several statistical procedures were applied to determine the threshold level of the contaminant that has high probability of detection and also to identify the performance differences in the laboratories participating in the experiment. AFIP suggested that it would be useful to generate ROC curves for the data (Receiver Operating Characteristic Curves); ROC curves are often used by drug companies in support of new drugs for which FDA approval is being sought. Relevant information on the procedure for generating ROC curves was collected through an Internet search and applied to the AFIP data. Because of the fact that the data did not report any false positive results (necessary for generating a meaningful ROC curve) the resulting graphs turned out to be straight lines, primarily.

An informal report on the results of the analysis was submitted to both AFIP and the sponsor. AFIP is continuing the experiment with several other chemical/biological threat agents and agreed to provide me the new data in a format ready for statistical analysis; the project has been on hold pending the arrival of the data.

Publications:

- "Statistical Analysis of AFIP Data", an informal report sent to AFIP and the sponsor.

WEI KANG – *Associate Professor*

Research Project Summary
Integrated Cooperative Control of Satellite Formations
Wei Kang, Associate Professor of Applied Mathematics
Sponsor: AFRL

Objective: The objectives of the project are (a) Coordinated formation control in the presence of J2 and other disturbances. (b) Attitude control when a satellite flies on an orbit under J2 and other disturbances. (c) Coordination strategy in an integrated controller with both relative attitude control and relative position control. (d) Simulations to test the proposed feedback design.

Summary: Attitude tracking with almost disturbance decoupling is developed for rigid bodies. For multi-satellite systems, the multiple tracking controllers are integrated together in a perceptive frame to track a moving target. The coordinated controller does

not assume the desired attitude as a priori information. Instead, the on-line sensor information of the satellite and the target position are used to control the attitude. As a result, the controller is robust under orbital uncertainties such as J2 perturbation in a multi-satellite system.

Publications:

- W. Kang and H. -H. Yeh, *Coordinated Attitude Control of Multi-Satellite Systems*, **International Journal of Robust and Nonlinear Control**, Vol. 12, (2002), 185-205.

- W. Kang and F. A. Papoulias, *Bifurcation and Control of Submersible Vehicles with Dive Plane Reversal*, **Latin American Applied Research-An International Journal**, to appear.

- B. Hamzi, W. Kang and J.-P. Barbot, *Analysis and Control of Hopf Bifurcations*, **SIAM Journal on Control and Optimization**, to appear.

- A.J. Krener, W. Kang and D. Chang, *Control Bifurcations*, **IEEE Transactions on Automatic Control**, to appear.

- A.J. Krener and W. Kang, *Locally Convergent Nonlinear Observers*, **SIAM Journal on Control and Optimization**, to appear.

- B. Hamzi and W. Kang, Resonant Terms and Bifurcations of Nonlinear Control Systems with One Uncontrollable Mode, Systems and Control Letters, to appear.

- W. Kang and A. Sparks, *Coordinated attitude and formation Control of multi-Satellite systems*, **Proceedings of the AIAA Guidance, Navigation, and Control Conference**, Monterey, California, August, 2002.

- W. Kang, N. Xi, Y. Zhao, J. Tan, Y. Wang, *Formation control of multiple autonomous vehicles: theory and experimentation*, **Proceedings of the IFAC World Congress**, Barcelona, Spain, July, 2002.

- W. Kang and M. Xiao, *Controllable or Uncontrollable? - A Bifurcation Point of View*, **Proceedings of the IEEE Conference on Decision and Control**, Las Vegas, Nevada, December, 2002.

Keywords: Formation control, Satellites, Bifurcation control.

Research Project Summary

New Trends in Nonlinear Dynamics and Control, and Their Applications

Wei Kang, Associate Professor of Applied Mathematics
Carlos F. Borges, Associate Professor of Applied Mathematics

Sponsor: AFOSR

Objective: To organize a two-day symposium ``New Trends in Nonlinear Dynamics and Control, and Their Applications" at NPS.

Summary: The Symposium on New Trends in Nonlinear Dynamics and Control, and their Applications was held October 18-19, 2002, at the Naval Postgraduate School (NPS) in Monterey, California. The symposium was organized in conjunction with the 60th birthday of Professor Arthur J. Krener, a pioneer in nonlinear control theory and its applications for the last three decades. Leading researchers in nonlinear control attended the conference.

Publications: Articles about the conference have been published in the Newsletters of UC Davis, NPS, SIU, and will appear in IEEE Control Magazine. Springer will publish a book based on the conference proceedings.

Keywords: Nonlinear Dynamics, Control Theory.

BARD MANSAGER – *Senior Lecturer*

BENY NETA– *Professor*

Research Project Summary
Galerkin Spectral Synthesis Methods
Beny Neta, Professor of Applied Mathematics
Sponsor: Unfunded

Objective: To develop existence and uniqueness theory for the energy dependent, steady state neutron diffusion equation with inhomogeneous oblique boundary conditions imposed. Also develop a convergence theory for the Galerkin Spectral Synthesis Approximations.

Summary: An existence and uniqueness theory is developed for the energy dependent, steady state neutron diffusion equation with inhomogeneous oblique boundary conditions imposed. Also, a convergence theory is developed for the Galerkin Spectral Synthesis Approximations, which arise when trial functions depending only on energy are utilized. The diffusion coefficient, the total and scattering cross-sectional data are all assumed to be both spatially and energy dependent. Interior interfaces defined by spatial discontinuities in the cross-section data are assumed present. Our estimates are in a Sobolev-type norm, and our results show that the spectral synthesis approximations are optimal in the sense of being of the same order as the error generated by the best approximation to the actual solution from the subspace to which the spectral synthesis approximations belong.

Publications:

- B. Neta, S. Reich, and H. D. Victory**,** *Galerkin Spectral Synthesis Methods for Diffusion Equations with General Boundary Conditions***, Annals of Nuclear Energy,** Volume 29, 2002, 913-927.

Keywords: Galerkin, Spectral Synthesis, Diffusion.

Research Project Summary

A Study of Lateral Boundary Conditions for The NRL's Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS)

Beny Neta, Professor of Applied Mathematics

Sponsor: ONR

Objective: The treatment of lateral boundaries in regional models has been a perennial problem since the early days of numerical weather prediction. In a limited-area model the lateral edges are not physical boundaries of the flow but constitute artificial constraints imposed by computational considerations. Hence they do not have a physical counterpart. We must impose conditions at these artificial boundaries in order to solve the problem in an efficient and accurate manner.
We propose here to continue our work on high order non-reflecting boundary conditions for the dispersive Klein-Gordon equation. We intend to extend our new schemes to the nonlinear shallow water equations.

Publications:

- D. Givoli, B. Neta, High-Order Higdon Non-Reflecting Boundary Conditions for the Shallow Water Equations, NPS--MA--02-001, Technical Report Naval Postgraduate School, Monterey, CA, 2002.

- D. Givoli, B. Neta, High-Order Non-Reflecting Boundary Conditions for Dispersive Waves, Wave Motion, accepted for publication.

- D. Givoli, B. Neta, High-Order Non-Reflecting Boundary Scheme for Time-Dependent Waves, J. Computational Physics, accepted for publication.

- D. Givoli, B. Neta, and Igor Patlashenko, Finite Element Analysis of Time-Dependent Semi-Infinite Wave-Guides with High-Order Boundary Treatment, accepted for publication.

- D. Givoli and B. Neta, High-Order Non-Reflecting Boundary Conditions for Dispersive Wave Problems, Proceeding of the International Conference on Computational and Mathematical Methods in Science and Engineering, Alicante, Spain, 20-25 September 2002.

- D. Givoli and B. Neta, High-Order Non-Reflecting Boundary Conditions for Dispersive Wave Problems, J. Computational and Applied Mathematics, accepted for publication.

- V. van Joolen, B. Neta, D. Givoli, High-Order Non-Reflecting Boundary Conditions for Dispersive Wave Problems in Stratified Media, Proceedings of 2003 Coastal Engineering, Cadiz, Spain, 23-26 June 2003, accepted for publication.

Keywords: Mesoscale, limited-area model, perfectly matched layers, COAMPS.

GUILLERMO OWEN – *Professor*

Research Project Summary
Stability in Situations of Shifting Balance of Power
Guillermo Owen, Professor of Applied Mathematics
Gordon McCormick, Professor of Defense Analysis
Sponsor: Special Operations Command

Objective: To study the way in which a shifting balance of power will cause instability in international relations.

Summary: We have developed models that show how the shifting balance of power can lead both to preventive wars and to wars of adjustment. Regions of stability and instability, depending both on the current balance of power and on the speed with which this balance is shifting, have been mapped.

Under a previous portion of this contract, methods of bargaining between states and sub-state entities were developed.

Publications: An article (jointly with G. McCormick), Factionalism, Bargaining, and Violence in Civil Wars, was submitted for publication. Another article, War and the Shifting Distribution of Power (also with McCormick) is almost ready for publication.

Keywords: bargaining, conflict, terrorism, preventive war

Research Project Summary
Models of Endogenous Formation of Coalitions
Guillermo Owen, Professor of Applied Mathematics
Sponsor: Unfunded

Objective: To develop models of coalition formation and the corresponding power and payoffs.

Summary: In this project I have been studying attractive models of coalition formation. A study of coalitions within the European Union (European Parliament, European Central Bank, Council of Ministers) is underway.

Publications:

- Gambarelli, G., and G. Owen. "Power in Political and Business Structures," in Power and Fairness, ed. M. J. Holler, H. Kliemt, D. Schmidtchen, and M. E. Streit, Jahrbuch für neue politische Ökonomie, Mohr Siebeck, Tübingen, 2002, 57-68.

Keywords: Bargaining, coalitions, power indices

CRAIG RASMUSSEN – *Associate Professor*

Research Project Summary
Information System Certifier Education
Cynthia E. Irvine, Associate Professor of Computer Science
Craig Rasmussen, Associate Professor of Applied Mathematics
Sponsor: SPAWAR

Objective: Develop a curriculum for the purpose of educating U.S. Navy information system certifiers, and prepare introductory materials to facilitate familiarization of certifiers-to-be with the requisite knowledge and skills.

Summary: This is an ongoing project. The Navy has a critical shortage of information system certifiers in uniform, and the NPS Cebrowski Institute is uniquely well qualified to address this problem. Under contract to PMW161, we are developing an educational program for new certifiers. An outline for the course and a bibliography of applicable Government documents were developed, and development of the course material was initiated. Students in the program will be of two types: short course students and resident graduate students. Short course students will be individuals who may already be working in the area of certification and accreditation or those who are moving into this field. The short Certifier Education program students will spend approximately eight weeks in formal courses over a period of from eighteen months to two years. The courses will be of short duration and high intensity; with eight hours devoted to class and laboratory exercises each day. The intervening periods between visits to school will be spent in the field, where students acquire essential experience. Resident students will include certifier courses as electives as part of their graduate program, which depending upon student background, validation of prerequisites, and other factors can last between 12 and 24 months. A prerequisite for all students is an undergraduate degree in computer science or closely related engineering field. With

two exceptions, the curriculum comprises courses already in the catalogue. The exceptions are the newly designed CS4680 (Introduction to Certification and Accreditation) and CS4685 (Case Studies in Certification).

We have also prepared a CD-ROM containing an overview of the Certification and Accreditation process specifically targeted at students entering the program. Because of unusual attributes of Naval systems and procedures, PMW161 requested an introduction that was Navy-specific. Accordingly, we digested dozens of DoD and DoN documents on certification and accreditation, and met with personnel from PMW161, the result being a product that would introduce the prospective Navy certifier to the responsibilities, skill sets, and requisite knowledge associated with the job.

Presentations:

- Dinolt, G., "The Navy Certifier Program", Cebrowski Institute Symposium, Monterey, CA, July 30, 2002.
- Rasmussen, C., "A Program for Education in Certification and Accreditation", WISE 3 / WECS 5, Monterey, CA, June 26-28, 2003.

Other: "The System Certification and Accreditation Process", a CD-ROM introduction to certification and accreditation for prospective Navy certifiers.

Keywords: Information Assurance, Computer Security, Certification and Accreditation.

CLYDE SCANDRETT – *Professor*

Research Project Summary
Acoustic Radiation and Scattering from Submerged Structures
C. Scandrett, Professor of Applied Mathematics
Sponsor: IHPC Singapore

Objective: To analyze and numerically model the effects of applying active and passive acoustic layers for the purpose of reducing radiated and scattered signals from fluid-loaded structures.

Summary: The final report on this project was delivered to the sponsors that included summaries of the work that had been conducted over the past few years. Topics included numerical modeling (using FDM and FEM) of layered materials. Structures considered were, Alberich coatings, multi-layered elastic/visco-elastic coatings, and piezo-electric layers. The final report included applications of the T-matrix method for use in decomposing more complicated structures in an effort to ascertain their acoustic properties. Subsequently, there were over this year a number of revisions made on a paper submitted to the Journal of Sound and Vibration that is expected to be accepted for publication in 2003.

Publications:

C. Scandrett “Scattering and active acoustic control from a submerged spherical shell”, J. Acoustical Soc. Am, **111(2)** 893-907, 2002

C. Scandrett, Y. S. Shin, K. C. Hung, M. S. Khan, C. K. Lim, and C. C. Lilian “Cancellation techniques in underwater scattering of Acoustic Signals”, revisions of the paper sent to J. Sound & Vibration.

Keywords: Acoustic scattering, active acoustic control, and underwater acoustics

Research Project Summary

NPS Mine and Undersea Warfare Program

C. Scandrett, Professor of Applied Mathematics

Sponsor: Program Executive Office, Mine and Undersea Warfare

Objective: Oversee the work done by the Mine Warfare Chair, and assist where necessary in the performance of his/her duties. The general requirements of the Mine Warfare Chair include: 1) facilitating student visits to mine warfare commands and research activities; 2) planning and executing mine warfare workshops and symposia; 3) serving as curator of the Menneken Lecture Series on Mine Warfare, and 4) being the liaison between the PEO, NPS, and Navy Labs. .

Summary: Some of the accomplishments that occurred this past year include:

1. Set up of the Undersea Warfare Research Center with 20 NPS faculty
2. Hosted the 5th International Symposium on Technology and the Mine Problem, held at NPS In April. Three hundred scientists, engineers, military and civilian deminers, and program sponsors from the international communities in Europe and the Pacific and from the US Army, US Marine Corps, and US Navy met in Monterey to share recent results and advances in the technologies that support future countermeasures systems development
3. Hosted a conference entitled "The enemy is still below: the global diffusion of submarines and related technology", sponsored by Lawrence Livermore National Labs in May.
4. Initiated a program through ONR's National Naval Responsibility Program (NNRP) that brings Navy Lab civilians to NPS for a one-year masters program. Two students are currently on-board from CSS and NUWC.
5. Managed to get NPS as the spring site for the NDIA conference for 2003.

Publication:

Proceedings of the Fifth International Symposium have been produced, and will be distributed in 2003.

Presentations:

Several Presentations were made to Fleet Admirals including RADM Ellison, RADM Slaught, RADM Sullivan (N77 – sponsor of the UW curriculum), and many others.

Keywords: Mines, Mining, Undersea Warfare

Research Project Summary

Finite Element Modeling of High Frequency Acoustics

C. Scandrett, Professor of Applied Mathematics

Sponsor: ONR

Objective: Perform research and development of the FE code ProPHLEX for use in numerical modeling of acoustic propagation in ocean sediments. The work includes collaboration with researchers at SACLANTCEN, and members of an experimental research team working on SAX04 in FY04.

Summary: This project was started late this past year. The 80K funded was used primarily for the purchase of a perpetual license of the ProPHLEX code (75K) and for a single trip to SACLANTCEN to collaborate with researchers there currently using the code. An additional trip to the Acoustical Society meeting in December was a venue for participants in the upcoming SAX04 experiments and research to plan on the upcoming collaborative project.

Keywords: Acoustic scattering, underwater acoustics, sediment acoustics