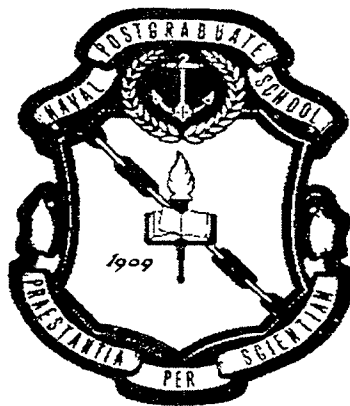


Naval Postgraduate School
Monterey, California 93943-5138

NPS-09-02-011



***SUMMARY
OF
RESEARCH
2000***



**Department of Electrical and Computer
Engineering**

**Jeffrey B. Knorr
Chair**

**Murali Tummala
Associate Chair for Research**

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Monterey, California

Rear Admiral David R. Ellison, USN
Superintendent

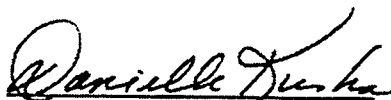
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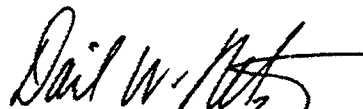
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THE NAVAL POSTGRADUATE SCHOOL MISSION

Increase the combat effectiveness of the U.S. and allied forces and enhance the security of the U.S.A. through advanced education and research programs focused on the technical, analytical, and managerial tools needed to confront defense related challenges of the future.



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PREFACE

Research at the Naval Postgraduate School is carried out by faculty in the four graduate schools (School of International Graduate Studies, Graduate School of Operations and Information Sciences, Graduate School of Engineering and Applied Sciences, and Graduate School of Business and Public Policy) and three Research Institutes (The Modeling, Virtual Environments, and Simulation (MOVES) Institute, Institute for Information Superiority and Innovation (I2SI), and Institute for Defense System Engineering and Analysis (IDSEA). This volume contains research summaries for the projects undertaken by faculty in the Department of Electrical and Computer Engineering during 2000. The summary also contains thesis abstracts for those students advised by Electrical and Computer Engineering faculty during 2000.

Questions about particular projects may be directed to the faculty Principal Investigator listed, the Department Chair, or the Department Associate Chair for Research. Questions may also be directed to the Office of the Associate Provost and Dean of Research. General questions about the Naval Postgraduate School Research Program should be directed to the Office of the Associate Provost and Dean of Research at (831) 656-2099 (voice) or research@nps.navy.mil (e-mail). Additional information is also available at the RESEARCH AT NPS website, <http://web.nps.navy.mil/~code09/>

Additional published information on the Naval Postgraduate School Research Program can be found in:

- *Compilation of Theses Abstracts*: A quarterly publication containing the abstracts of all unclassified theses by Naval Postgraduate School students.
- *Naval Postgraduate School Research*: A tri-annual (February, June, October) newsletter highlighting Naval Postgraduate School faculty and student research.
- *Summary of Research*: An annual publication containing research summaries for projects undertaken by the faculty of the Naval Postgraduate School.

This publication and those mentioned above can be found on-line at:
<http://web.nps.navy.mil/~code09/publications.html>.

INTRODUCTION

The research program at the Naval Postgraduate School exists to support the graduate education of our students. It does so by providing military relevant thesis topics that address issues from the current needs of the Fleet and Joint Forces to the science and technology that is required to sustain the long-term superiority of the Navy/DoD. It keeps our faculty current on Navy/DoD issues, to maintain the content of the upper division courses at the cutting edge of their disciplines. At the same time, the students and faculty together provide a very unique capability within the DoD for addressing warfighting problems. Our officers must be able to think innovatively and have the knowledge and skills that will let them apply technologies that are being rapidly developed in both the commercial and military sectors. Their unique knowledge of the operational Navy, when combined with a challenging thesis project that requires them to apply their focused graduate education, is one of the most effective methods for both solving Fleet problems and instilling the life-long capability for applying basic principles to the creative solution of complex problems.

The research program at the Naval Postgraduate School consists of both reimbursable (sponsored) and institutionally funded research. The research varies from very fundamental to very applied, from unclassified to all levels of classification.

- **Reimbursable (Sponsored) Program:** This program includes those projects externally funded on the basis of proposals submitted to outside sponsors by the School's faculty. These funds allow the faculty to interact closely with RDT&E program managers and high-level policymakers throughout the Navy, DoD, and other government agencies as well as with the private sector in defense-related technologies. The sponsored program utilizes Cooperative Research and Development Agreements (CRADAs) with private industry, participates in consortia with government laboratories and universities, provides off-campus courses either on-site at the recipient command, by VTC, or web-based, and provides short courses for technology updates.
- **Naval Postgraduate School Institutionally Funded Research (NIFR) Program:** The institutionally funded research program has several purposes: (1) to provide the initial support required for new faculty to establish a Navy/DoD relevant research area, (2) to provide support for major new initiatives that address near-term Fleet and OPNAV needs, (3) to enhance productive research that is reimbursably sponsored, and (4) to cost-share the support of a strong post-doctoral program.

In 2000, the level of research effort overall at the Naval Postgraduate School was 137 faculty work years and exceeded \$43 million. The reimbursable program has grown steadily to provide the faculty and staff support that is required to sustain a strong and viable graduate school in times of reduced budgets. In FY2000, over 93% of the research program was externally supported. A profile of the sponsorship of the Naval Postgraduate School Research Program in FY2000 is provided in Figure 1.

INTRODUCTION

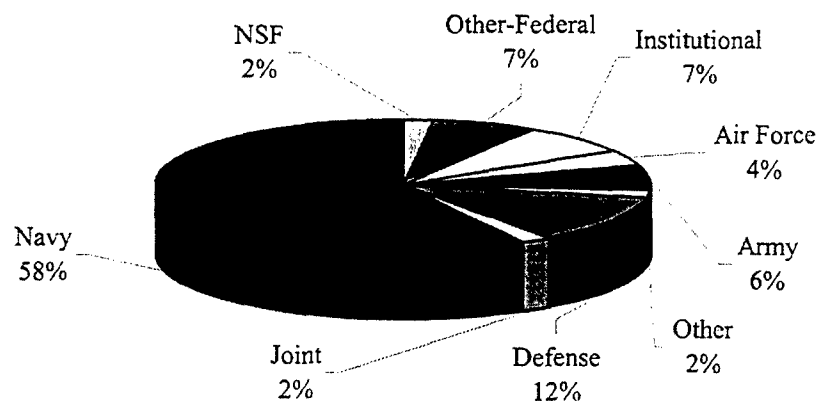


Figure 1. Profile of NPS Research and Sponsored Programs (\$43M)

The Office of Naval Research is the largest Navy external sponsor. The Naval Postgraduate School also supports the Systems Commands, Warfare Centers, Navy Labs and other Navy agencies. A profile of external Navy sponsorship for FY2000 is provided in Figure 2.

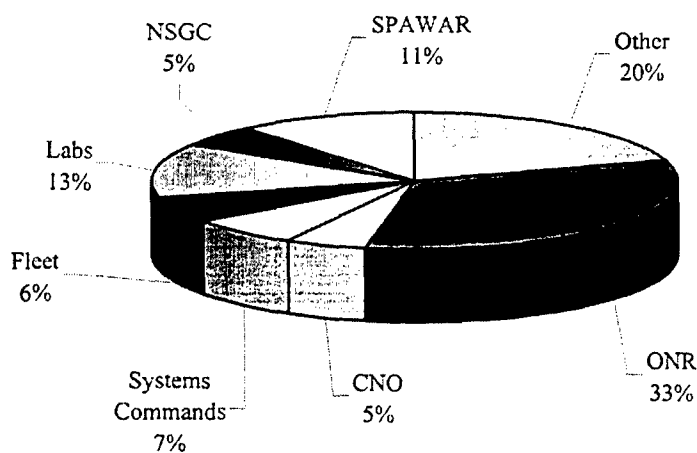


Figure 2. Navy External Sponsors of NPS Research and Sponsored Programs (\$25M)

These are both challenging and exciting times at the Naval Postgraduate School and the research program exists to help ensure that we remain unique in our ability to provide education for the warfighter.

DAVID W. NETZER
Associate Provost and Dean of Research

December 2001

**DEPARTMENT OF
ELECTRICAL AND COMPUTER
ENGINEERING**

**JEFFREY B. KNORR
CHAIR**

DEPARTMENT SUMMARY

OVERVIEW:

The Department of Electrical and Computer Engineering (ECE) has a broad research program, reflecting the variety of skills and interests of the faculty. ECE faculty research projects are supported by systems commands, warfare centers, the services, basic research agencies, other universities, and industry. These research projects can be grouped into ten major research thrust areas that support the curricula serviced by the Department as well as the several DoD Plans. Unique to the Department and the Naval Postgraduate School is the ability of faculty and students to perform military relevant classified research at all levels. The Department's research program ensures that our graduate students will have a creative meaningful thesis experience, that our curricula and courses will remain at the cutting edge, that we can recruit and retain quality faculty, and that we can provide our sponsors with cutting edge solutions to their problems.

CURRICULA SERVED:

- Electronic Systems Engineering
- Information Warfare
- Electronic Warfare
- Space Systems Operations
- Space Systems Engineering
- Undersea Warfare
- Joint C4I Systems
- Information Technology Management
- Aeronautical Engineering

DEGREES GRANTED:

- Master of Science in Electrical Engineering
- Master of Science in Engineering Science
- Master of Science in Computer Engineering
- Electrical Engineer
- Doctor of Philosophy

RESEARCH THRUSTS:

- Communication Systems:
Professor Tri Ha, Professor R. Clark Robertson
- Communication Networks:
Assistant Professor John McEachen, Professor Murali Tummala, Military Assistant Professor Robert Ives, Associate Professor Xiaoping Yun
- Computer/Information Systems:
Professor Jon Butler, Associate Professor Douglas Fouts, Professor Herschel Loomis, Visiting Instructor Randy Wight
- Electromagnetic Systems:
Professor Jeffrey Knorr, Research Associate Professor Richard Adler, Professor Ramakrishma Janaswamy, Associate Professor David Jenn, Professor Michael Morgan, Research Associate Andrew Parker, Research Associate Professor Ray Vincent, Military Assistant Professor J. Scott Tyo, Visiting Associate Professor Jovan Lebaric
- Infra-Red and Electro-Optics:
Distinguished Professor John Powers, Professor Phillip Pace, Visiting Associate Professor Ron Pieper
- Guidance, Control and Navigation Systems:
Associate Professor Roberto Cristi, Associate Professor Gary Hutchins, Associate Professor Xiaoping Yun

DEPARTMENT SUMMARY

- Power Electronics, Electric Machines and Distribution:
Associate Professor Robert Ashton, Associate Professor John Ciezki
- Radar, Surveillance and Information Warfare Systems:
Professor Jeffrey Knorr, Professor Phillip Pace, Research Associate Professor Lonnie Wilson, Professor R. Clark Robertson
- Signal Processing/Acoustic Systems:
Military Assistant Professor Bob Barasanti, Associate Professor Roberto Cristi, Associate Professor Monique Fargues, Associate Professor Ralph Hippenstiel, Professor Charles Therrien, Professor Murali Tummala, Professor Lawrence Ziomek
- Signals Intelligence/Space Systems:
Associate Professor Douglas Fouts, Professor Tri Ha, Associate Professor Ralph Hippenstiel, Professor Herschel Loomis, Assistant Professor John McEachen, Associate Professor Sherif Michael, Assistant Professor Todd Weatherford
- Solid State Microelectronics:
Associate Professor Douglas Fouts, Associate Professor Sherif Michael, Assistant Professor Todd Weatherford

RESEARCH FACILITIES:

- Signal Enhancement Lab
- Power Electronics Lab
- Digital Signal Processing Lab
- Electronics (Analog VLSI/Radiation Hardening) Lab
- Electronic Warfare Lab
- Electromagnetic Scattering Lab
- Digital Systems Lab
- Radar Lab
- Microwave and Antennas Lab
- Optical Electronics Lab
- Robotics Lab
- Advanced Networking Lab
- VLSI Lab
- Computer and Network Research Lab
- Secure Computing Lab

RESEARCH CENTERS:

- Center for Electronic Warfare Simulation and Modeling
- Center for Reconnaissance Research
- Center for Signal Processing
- Cryptologic Research Center

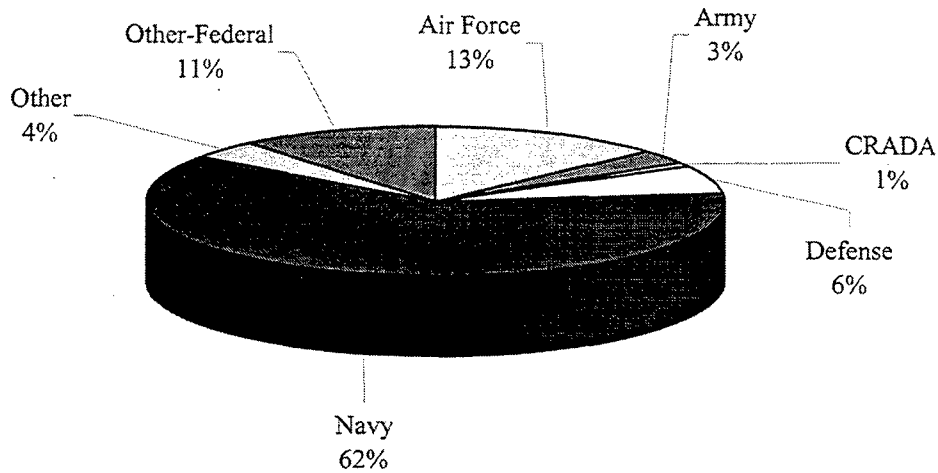
RESEARCH CHAIR:

- National Security Agency Cryptologic Chair

DEPARTMENT SUMMARY

RESEARCH PROGRAM-FY2000:

The Naval Postgraduate School's research program exceeded \$43 million in FY2000. Over 93% of the Naval Postgraduate School Research Program is externally funded. A profile of the external research sponsors for the Department of Electrical and Computer Engineering is provided below along with the size of the FY2000 externally funded program.



Size of Program: - \$2884K

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PROJECT SUMMARIES

SIGNAL-TO-NOISE ENHANCEMENT PROGRAM (SNEP) RESEARCH AND SUPPORT

R.W. Adler, Research Associate Professor

W.R. Vincent, Research Associate Professor

A.A. Parker, Research Associate

Department of Electrical and Computer Engineering

Sponsor: Naval Security Group Command

OBJECTIVE: Continued research and development in techniques to improve the signal-to-noise ratio at Navy receiving sites and at Regional System Operational Centers (RSOCs) worldwide.

SUMMARY: Development of techniques and methodology for identifying and locating radio noise sources and sources of interference to data processing and computer systems at NSG sites worldwide continued. Support was provided to NSG via review of pre-survey planning documentation, mitigation plans and authoring "Quick Look" and final site survey reports. Students and NSG site personnel were trained as part of the NSG support. A two-day HF Technical Review of Factors that Affect Performance of Naval Receiving Sites was organized and held in Monterey in October.

DoD KEY TECHNOLOGY AREAS: Sensors, Environmental Quality

KEY WORDS: Electromagnetic Environmental Effects, Communication Systems, Man-Made Noise, Antennas

FIELD SITE AND RSOC RESEARCH AND SUPPORT

R.W. Adler, Research Associate Professor

W.R. Vincent, Research Associate Professor

A.A. Parker, Research Associate

Department of Electrical and Computer Engineering

Sponsor: U. S. Army Information and Security Command

OBJECTIVE: Continued research and development in techniques to improve the signal-to-noise ratio at Regional System Operational Centers and at field sites.

SUMMARY: Development of techniques and methodology for identifying and locating data noise sources and sources of interference to data processing and computer systems and location of radio noise and interference sources at remote and local field sites. Support was provided to USA INSCOM via review of pre-survey planning documentation, mitigation plans, and authoring a "Quick Look" and a final site survey report. Students and RSOC site personnel were trained as a part of the INSCOM support.

DoD KEY TECHNOLOGY AREAS: Sensors, Environmental Quality

KEYWORDS: Electromagnetic Environmental Effects, Communication Systems, Man-Made Noise, Antennas

LOW PROBABILITY OF INTERCEPT SYSTEM EVALUATION

R.W. Adler, Research Associate Professor

W.R. Vincent, Research Associate Professor

A.A. Parker, Research Associate

Department of Electrical and Computer Engineering

Sponsor: Space and Naval Warfare Systems Center-San Diego

OBJECTIVE: Determine the probability of intercept of a candidate LPI system under development at SPAWWAR SYSCEN.

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SUMMARY: NPS conducted field tests of the system in an urban field environment and showed the effects of different antenna systems on the ability to detect the presence of the LPI signal. The impact of noise on the reception of the PLI signal was demonstrated.

DoD KEY TECHNOLOGY AREAS: Sensors, Environmental Quality

KEYWORDS: Electromagnetic Environmental Effects, Communication System, Man-Made Noise, Antennas

INTEGRATED FIGHT-THROUGH POWER AND ADVANCED POWER CONVERTER MODULES

Robert Ashton, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Surface Warfare Center-Philadelphia

OBJECTIVE: This research involves the engineering design of advanced power conversion modules under current Navy development. This task will require the investigation of available power converter design options. Additionally, assistance in the design and development of advanced reconfigurable zonal electric distribution system hardware will be provided in the form of testing, debugging and documentation. Support includes conducting appropriate tests, analyzing/evaluating technical documentation/data, and providing comments. The principal investigator shall attend technical meetings, as required, and provide monthly status reports. Travel to CDNSWC-SSES Philadelphia shall be required to implement the above objectives.

SUMMARY: This research concentrated on specific issues surrounding the Land Based Engineering Site (LBES) in Philadelphia. The investigator was tasked with the evaluation of data from test runs for a number of Power Converter Modules (PCM) ranging from 250kW to 19MW. Test results were analyzed and used by the investigator to aid in making recommendations for future PCMs. In addition, three specific failure events took place on the 19MW PWM electric drive unit. Each event was analyzed using the available data including forensics on the components. Reports and presentations were made in Philadelphia and Rugby, England. The results of the investigator have been utilized in redesign efforts by the vendor.

DoD KEY TECHNOLOGY AREA: Electronics

KEYWORDS: Power System, Auxiliary Resonant Commutated Pole Inverter, Electronic Devices, Energy Conversion

DEVELOPMENT OF ALGORITHMS SUPPORTING HARDWARE-IN-THE-LOOP CONTROL OF SYNCHRONOUS MACHINES

Robert Ashton, Associate Professor
John G. Ciezki, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Surface Warfare Center-Philadelphia

OBJECTIVE: The Navy's revitalized interest in electric drive and employing variable-speed drives in place of current fixed-frequency drives has motivated the need to study competing motor control strategies and motor drive topologies. The focus of this research was to develop a DSP platform for testing motor control algorithms. The platform is intended to have hardware-in-the-loop capability so that actual amplifiers and motors can be studied. Though interest has been expressed in studying propulsion motor applications, the platform should be generic enough to handle proof-of-concept studies for any number of types of motors or drives. Initially, the unit should be demonstrated on a 30-HP permanent-magnet synchronous machine driven by three H-bridge current amplifiers. Deliverables include an operational platform, the investigation of several open-loop and closed-loop synchronous machine speed-control

PROJECT SUMMARIES

algorithms, the implementation of said algorithms using dSPACE, and studies documenting the performance of the drive.

SUMMARY: The platform consisted of three H-bridge current amplifiers provided by NPS. The amplifiers, since they were internally grounded, had to be coupled to a three-phase load through transformers. The commanded machine current was generated by a dSPACE hardware-in-the-loop processor/software package. A convenient input/output panel for the dSPACE card and a host personal computer were also mounted in the 19-inch standard cabinet. Algorithms were developed by Dr. Ciezki and tested by LCDR Govier using ACSL and dSPACE at NPS. The algorithms were then transferred to Philadelphia and load into the unit there. Tests were originally executed open loop while nuances involving the position encoder were resolved. The 30-HP PM motor was then controlled in closed-loop mode using field-oriented vector control. Upon resolving some filtering issues, the unit was demonstrated to run properly at no-load and while loaded. Furthermore, more complex algorithms using speed and position information were tested and confirmed in the laboratory. The Philadelphia sponsor received a thesis as a deliverable and three conference papers.

PRESENTATIONS:

Ciezki, J.G., Ashton, R.W., and Fikse, T., "A Survey of AC Drive Propulsion Options," presented at the 3rd Naval Symposium on Electric Machines, Philadelphia, PA, 4-7 December 2000.

Ciezki, J.G., Ashton, R.W., and Govier, C., "Algorithms for a Reduced-Scale Permanent-Magnet Synchronous Machine Propulsion Drive," presented at the 3rd Naval Symposium on Electric Machines, Philadelphia, PA, 4-7 December 2000.

Ashton, R.W., Ciezki, J.G., and Lewis, T., "The Development of a Motor Controller Evaluation Platform," presented at the 3rd Naval Symposium on Electric Machines, Philadelphia, PA, 4-7 December 2000.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Other (Power System Enhancement)

KEYWORDS: PWM Inverter, Synchronous Machine, Vector Control, DSP

DESIGN ALGORITHMS FOR SUM-OF-PRODUCTS EXPRESSIONS OF FUNCTIONS WITH BI-COMPOSITIONS

Jon T. Butler, Professor

**Department of Electrical and Computer Engineering
Tsutomu Sasao, Kyushu Institute of Technology, Japan**

Sponsor: Unfunded

OBJECTIVE: To produce efficient design techniques for functions with bi-decompositions.

SUMMARY: A function $f(X, Y)$ has an AND bi-decomposition if it can be expressed as $f(X, Y) = g(X)h(Y)$, and X and Y are disjoint sets of variables. Many benchmark functions have AND (and other types, e.g., OR and exclusive OR) bi-decompositions. Since benchmark functions are representative of functions found in practical logic applications, there is significant interest in bi-decompositions. The goal of this research is to find efficient algorithms for producing minimal circuits for functions with bi-decompositions. One approach for functions with AND bi-decompositions is to minimize the two sub functions, $g(X)$ and $h(Y)$ separately, then AND their minimal forms together. Since the best-known algorithm for finding minimal forms is exponential in the number of variables, this "divide-and-conquer" technique produces significant reduction in computation time. However, it has been known (for about 10 years) that this will not always produce the minimal form for $f(X, Y)$. The goal of our research is to understand the extent to which this degrades minimization. For example, while this divide-and-conquer technique may not always produce a minimal form, it may be close to minimal. It is an open question as to what extent such a technique produces minimal or near-minimal realizations. We have shown a whole class of functions where the divide-and-conquer algorithm fails to find a minimal circuit and where the circuit found is significantly

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larger than the minimal form (the size difference is exponential in the number of variables). Another goal is to quantify the set of functions for which the divide-and-conquer technique always produces a minimal form. We have shown that a class of functions, called orthodox functions, has this property.

PRESENTATION:

Sasao, T. and Butler, J.T., "On the Minimization of SOPs for Bi-Decomposable Functions," Asian South Pacific Design Automation Conference (ASP-DAC), Yokohama, Japan, February 2001.

DoD KEY TECHNOLOGY AREAS: Computing and Software

KEYWORDS: Digital Systems, Compact Circuits, Computer-Aided Design Tools, Sum-of-Products Expressions, Bi-Decompositions

REED-MULLER CANONICAL EXPANSIONS OF LOGIC FUNCTIONS

Jon T. Butler, Professor

Department of Electrical and Computer Engineering

G.W. Dueck, University of New Brunswick, Canada

V.P. Shmerko, Technical University, Szczecin, Poland

S.V. Yanushkevich, Technical University, Szczecin, Poland

Sponsor: Unfunded

OBJECTIVE: To improve synthesis techniques for the Reed-Muller canonical representation of logic function.

SUMMARY: The Reed-Muller canonical expansion of a logic function uses the Exclusive OR of product terms. It has been shown that this representation requires fewer product terms, on the average, than standard sum-of-products expressions. We have developed a technique for designing Reed-Muller expansions for symmetric functions using the transeunt triangle. It is faster and requires less storage than the next best technique. We are now applying this to partially symmetric functions, which are more general than symmetric functions. We are also extending our results to include "mixed" polarity implementations, which enlarge the forms in which functions can be expressed. The advantage to this is that more compact circuits are possible.

PUBLICATIONS:

Butler, J.T., Dueck, G.W., Shmerko, V.P., and Yanushkevich, S.N., "Comments on 'Fast Exact Minimization of Fixed Polarity Reed-Muller Expansion for Symmetric Functions,'" *IEEE Transactions on Computer-Aided Design*, Vol. 19, No. 11, November 2000, pp. 1386-1388.

Yanushkevich, S.V., Butler, J.T., Dueck, G.W., and Shmerko, V., "Experiments on FPRM Expressions for Partially Symmetric Logic Functions," *Proceedings 30th International Symposium on Multiple-Valued Logic*, May 2000, pp. 141-146.

Butler, J.T., Dueck, G.W., Yanushkevich, S.N., and Shmerko, V.P., "On the Number of Generators for Transeunt Triangles," *Discrete Applied Mathematics* (accepted).

DoD KEY TECHNOLOGY AREAS: Computing and Software

KEYWORDS: Digital Systems, Compact Circuits, Computer-Aided Design Tools, Exclusive OR Sum-of-Products Expressions, Reed-Muller Canonical Expressions

PROJECT SUMMARIES

POWER FET AND SCHOTTKY DIODE DOSE RATE TEST DEVELOPMENT

John G. Ciezki, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Surface Warfare Center-Crane

OBJECTIVE: The survivability and effectiveness of many weapons systems and space-based applications are contingent on the reliability of the power supplies. In a nuclear environment, such systems are subject to failures due to total dose, dose rate and single-event upsets. Since the power supply has the potential to be the weak link in the system hardening chain, it is critical that designers ensure that the supply recovers quickly enough to guarantee mission completion. The power supply design must address the maintenance of the input and output power rails during large changes in the load photocurrent requirements and must ensure that the control loop is fast enough to ride through the event.

The work effort was modified by the sponsor to focus primarily on the testing and characterization of the dose-rate responses of commercially available rad-hard power devices. In particular, power FETs were investigated in both the on state and the off-state and Schottky diodes were investigated in the off state. All testing was performed at the NSWC Crane, Indiana facilities and was coordinated by Jeff Titus. CAPT Gerald Bloomfield's thesis was predicated on collection of the data, comparing the data against theoretical predictions, and analyzing failure modes.

SUMMARY: Upon obtaining device samples from Intersil and International Rectifier, a test rig was fabricated and a test plan established. The off-state 20-nsec transient responses of rad-hard power MOSFETs manufactured by IR, using devices of three different voltage ratings and three different die sizes, were measured over a wide range of dose rates and drain bias conditions. Similarly, components from Intersil, including p-channel and n-channel power MOSFETs of differing rated voltages and die sizes, were subjected to similar testing. The prompt photocurrent response of several reverse-biased Schottky diodes during exposure to 20-nsec 40-MeV electron pulses were recorded over a wide range of beam intensities. Devices were observed to catastrophically fail. The test data was assimilated and summarized in a thesis report and three conference papers. Mechanisms for device failures were discussed, motivating the need for further modeling and simulation to confirm hypotheses.

PUBLICATIONS:

Ciezki, J., Titus, J.L., Skinner, S., Bloomfield, G., and Smith, J.E., "Off-State Dose-Rate Responses of Power MOSFETs," to appear as a poster paper at the Hardened Electronics and Radiation Technology (HEART) Conference, San Antonio, TX, 7 March 2001.

Titus, J.L., Skinner, S., Bloomfield, G., Ciezki, J., and Smith, J.E., "Dose-Rate Responses of Reverse-Biased Power Schottky Diodes," to appear as a poster paper at the Hardened Electronics and Radiation Technology (HEART) Conference, San Antonio, TX, 7 March 2001.

Titus, J.L., Skinner, S., Bloomfield, G., Gillberg, J., Burton, D., Wheatley, C.F., and Ciezki, J., "Dose-Rate Responses of Commercial Rad-Hard Power MOSFETs Biased in an Off-State Condition," to appear as a poster paper at the Hardened Electronics and Radiation Technology (HEART) Conference, San Antonio, TX, 7 March 2001.

DoD KEY TECHNOLOGY AREAS: Electronics

KEYWORDS: Power FET, Schottky Diode, Dose Rate, Operate Through, Electronic Devices

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COMPONENT MODELING AND SIMULATION EFFORTS FOR A PROPOSED LHD-8 AC ZONAL DISTRIBUTION SYSTEM

John G. Ciezki, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Surface Warfare Center-Philadelphia

OBJECTIVE: The LHD-8 craft is planned to employ an AC zonal electric distribution system. The operation of the system requires study using computer models. Studies of interest include balanced faults, transient stability, and load sharing. Models required include 3-phase delta-delta transformers, three-phase wye-connected synchronous machines driven by diesel engines, and any additional connection software required to merge the models with current transmission line, circuit breaker, and load models. All models will be developed in ACSL and the appropriate field excitation and governor controls derived for baseline components. Deliverables include ACSL models, interconnection software, control algorithms, and assistance in running system studies.

SUMMARY: The work is ongoing. Models for the transformer and synchronous machine have been developed. A literature search on diesel engine modeling has been performed and various dynamic models uncovered. The controls for the diesel governor and the synchronous machine exciter were developed with the help of MATLAB and ACSL simulation. Some ACSL development has been slowed by virtue of difficulty getting the ACSL software renewed and difficulty getting the update for the FORTRAN compilers. No thesis is currently supporting this effort.

DoD KEY TECHNOLOGY AREAS: Surface/Under Surface Vehicles-Ships and Watercraft, Modeling and Simulation

KEYWORDS: AC Zonal Distribution, Diesel Generators, Transformers, ACSL Simulation

FEATURE EXTRACTION FOR SIGNAL CHARACTERIZATION IN CLASSIFICATION APPLICATIONS; APPLICATIONS TO COMMUNICATION MODULATIONS

Monique P. Fargues, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Center for Reconnaissance Research

OBJECTIVES: The goal of this on-going study is to extend a dimension reduction scheme considered in previous work. First, we investigated the scheme application to the classification of communication modulation schemes, and next we considered the application of higher-order statistics as class features for specific digital types of modulations specified by the sponsor.

SUMMARY: In a previous study we proposed a dimension reduction scheme to reduce the dimension of the feature space generated to characterize signal classes and use the resulting information for classification applications. The proposed scheme belongs to the class of projection pursuit algorithms and consists of an iterative scheme, which maximized the projected mean between two classes of data. The proposed scheme was tested both on synthetic and real-world underwater data. Results show similar or better in performance to those obtained using more classical classifiers (such as CART or back-propagation neural networks). During the first part of the CY2000 study we considered the spread of the projected data to improve on previous work. Results showed no significant improvements for variants of the original scheme. During the second part of the study we considered high-order statistic parameters as class features and specific types of communication schemes, as requested by the sponsor. Modulation types considered are: 2-8PSK, 2-8FSK, and 16-64-256QAM. Robustness due to additive white Gaussian noise and multipath environments are considered. The proposed classification scheme combines neural networks and equalization schemes to differentiate all specified modulation types.

PRESENTATION:

Fargues, M., "Feature Extraction and Dimension Reduction Issues: Applications to Classification," CRR

PROJECT SUMMARIES

Research Briefings, Monterey, CA, February and September 2000.

THESIS DIRECTED:

San Pedro, M., "Signal Classification Using the Mean Separator Neural Network," Masters Thesis, Naval Postgraduate School, March 2000.

DoD KEY TECHNOLOGY AREAS: Electronics, Computing and Software

KEYWORDS: Classification, Projection Pursuit, Dimension Reduction, Higher-Order Statistics

CEPXS/SPICE AUTOMATED SOFTWARE INTERFACE DEVELOPMENT

Douglas J. Fouts, Associate Professor

Department of Electrical and Computer Engineering and

Space Systems Academic Group

Sponsor: Lockheed Martin Space and Missile Systems and Naval Postgraduate School

OBJECTIVE: The purpose of this research is to create an automated software interface to allow the circuit simulation program known as SPICE to directly read and utilize the output of the radiation effects simulation program known as CEPXS.

SUMMARY: The Coupled Electron/Proton Transport Simulator (CEPXS) is used to quantify the amount of energy that is absorbed in each layer of a multi-layer stack of materials when the stack is exposed to nuclear radiation. Typically, the stack of materials represents a transistor that is part of an integrated circuit (IC) in an IC package on a printed circuit board in an enclosure. Thus, the output of CEPXS can be used to determine the amount of energy actually absorbed by a transistor. However, to determine the effects this absorbed energy has on the operation of the transistor and on the electronic circuit, the output of CEPXS must be analyzed by hand, many calculations must be made, and then the data can be input into the circuit simulation program SPICE (Simulation Program with Integrated Circuit Emphasis).

This project was successfully completed during the calendar year 2000. The software that was developed by this research provides a complete, fully automated interface between CEPXS and SPICE. This allows accurate simulations of the effects of nuclear radiation on very large circuits with many transistors, something that could not be done previously because of the slow, cumbersome, manual interface. At this point in time, the software has been delivered to the research sponsor, Lockheed Martin Missiles and Space. Both the source code and a compiled and ready to run version were provided. The first draft of an MSEE thesis that documents the program in detail is currently being reviewed by the sponsor. The final version of the thesis will soon be finished.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Modeling and Simulation, Electronics, Materials Processes, and Structures

KEYWORDS: Radiation Effects on Microelectronics, Modeling and Simulation, Space Electronics

NSA/K51 CRYPTOLOGIC RESEARCH LABORATORY AND THESIS RESEARCH SUPPORT

Tri T. Ha, Professor

Department of Electrical and Computer Engineering

Sponsor: National Security Agency

OBJECTIVE: Support for the Cryptologic Research Lab at the Naval Postgraduate School wherein graduate students perform research in support of K51.

SUMMARY: The Cryptologic Research Laboratory, sponsored by the National Security Agency's K51, is a valuable resource which provides a cost effective, viable and robust research platform for NPS graduate

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students and faculty in Electrical Engineering, Information Warfare, and Computer Science and related curricula. It offers an unclassified environment wherein graduate students can develop an in-depth understanding of Cryptology and related disciplines by researching capabilities, limitations, design, and operations of digital signal processing and exploitation techniques, satellite communications technologies, cellular technologies, wireless communications and other analogous cryptologic areas.

THESIS DIRECTED:

Cadenazzi, M., "Performance Analysis of the Higher Order Cyclostationary Based Classifier," Masters Thesis, Naval Postgraduate School, March 2000.

DoD KEY TECHNOLOGY AREAS: Other (Electrical Engineering, Information Operations)

KEYWORDS: Cryptology, Exploitation, Wireless

PROCESSING OF RADAR SIGNATURES USING CORRELATION AND WAVELET BASED CONCEPTS

Ralph D. Hippenstiel, Associate Professor

Monique P. Fargues, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Center for Reconnaissance Center

OBJECTIVE: The objective of this research is to simulate a typical modern radar signature exhibiting frequency agility and a variable PRF and to perform the correlation-wavelet-based estimation to obtain some system parameters. As a by-product radar status information might be obtained.

SUMMARY: The work investigates the detection of pulses and the extraction of modulation parameters of different types of time-limited chirp signals, as may be found in pulse-compression radars. The first part discusses detection and pulse start and stop time estimation. Three-time correlation function (TCF) based schemes and an envelope detection algorithm are compared. Results show that none of the pulse detection schemes considered are clearly superior for the SNR range considered. The specific selection will be a function of desirable characteristics to be optimized, such as P_{FA} or P_D . The second part focuses on the extraction of modulation parameters from linear and hyperbolic chirp modulation. Results show that time-frequency transformations lead to better focused images when dealing with noisy signals than wavelet-based decompositions. Better images allow more robust modulation estimation schemes.

PUBLICATION:

Hippenstiel, R., Fargues, M., Moraitakis, I., and Williams, C., "Detection and Parameter Estimation of Chirped Radar Signals," Naval Postgraduate School Technical Report, NPS-EC-00-001, January 2000.

THESIS DIRECTED:

Moraitakis, I., "Feature Extraction of Intra-Pulse Modulated Radar Signals Using Time-Frequency Analysis," Masters Thesis, Naval Postgraduate School, September 1999.

DoD KEY TECHNOLOGY AREAS: Electronic Devices

KEYWORDS: Radar Signals, Signal Detection/Classification, Wavelet-Based Decomposition

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IMPROVEMENT OF THE TIME DIFFERENCE ARRIVAL ESTIMATION OF GSM SIGNALS USING WAVELETS

Ralph D. Hippenstiel, Associate Professor

Tri T. Ha, Professor

Department of Electrical and Computer Engineering

Sponsor: Navy Tactical Exploitation of National Capabilities (TENCAP) Office

OBJECTIVE: To simulate typical GSM signals at an intermediate frequency (IF), as may be obtained from two spatially separated surveillance receivers. Use wavelet based de-noising to enhance the time difference of arrival (TDOA) estimation.

SUMMARY: Using the Hewlett-Packard Advanced Design System (HP-ADS), GSM data cuts (signatures) at an IF frequency are obtained. Typical electronic signatures are simulated at various signal-to-noise (SNR) levels using MATLAB. A method based on the approximation of the modified maximum likelihood technique and on a fourth order moment are demonstrated. Improvement in the mean square error (MSE) is obtained as a function of data parameters. The improvement is shown to be a function of SNR, data length, and spectral position relative to the sampling rate.

PUBLICATION:

Hippenstiel, R., Haney, T., and Ha, T.T., "Improvement of the Time Difference of Arrival (TDOA) Estimation of GSM Signals Using Wavelets," Naval Postgraduate School Technical Report, NPS-EC-00-008, June 2000.

THESIS DIRECTED:

Haney, T., "Generation of GSM Signals and Their Time Difference of Arrival (TDOA) Estimation," Masters Thesis, Naval Postgraduate School, June 2000.

DoD KEY TECHNOLOGY AREAS: Electronics

KEYWORDS: Geo-Location, Wavelet Processing, Signal Processing, Time Difference of Arrival (TDOA) Estimation

THEATER BALLISTIC MISSILE DEFENSE – MULTI-SENSOR FUSION, TRACKING, AND TARGETING TECHNIQUES

Robert G. Hutchins, Associate Professor

Hal Titus, Emeritus Professor

Department of Electrical and Computer Engineering

Sponsor: Navy Tactical Exploitation of National Capabilities (TENCAP) Office

OBJECTIVE: Our ultimate goal is to assess the feasibility of algorithms employing both strategic and theater sensors to detect, track and engage theater ballistic missiles during boost and/or early ballistic missile flight, destroying the missile over the territory of the aggressor.

SUMMARY: Our present space sensor devices have the potential to provide the shooter with much earlier ballistic missile launch detection and location information. However, all too often each sensor system will sequentially observe the target until a firm track is established, and then transfer the track information to the shooter. This method incurs significant time lag penalties between detection and launch of an interceptor. We focused on algorithms that would provide the earliest possible detection and tracking information by fusing information at the earliest possible time, by alerting the shooter with detection data and imprecise location information at the earliest possible time, and by tracking after data fusion for more accurate and faster target location and identification. Such an approach can bring to bear all sensor assets available to cover a threatened launch area, including space, shipboard, aircraft and UAV sensors, and to fuse these observations as quickly as they are obtained at a central site. This allows the shooter to launch at

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the earliest possible time, including instances of high suspected threat when a launch-before-track strategy may be acceptable.

The thrust of this research was to assess the feasibility of detection queuing of an AEGIS platform from a space-based system. Such a mechanism will initiate an active AEGIS track at the earliest space-based detection of launch prior to a complete track being developed by the spaceborne sensor system. Since the AEGIS system has a much faster revisit schedule to an area of interest than does a space-based sensor, this will permit much faster localization and tracking using the full three-dimensional capabilities (range, azimuth and elevation) of the AEGIS tracking system.

Past work has led to a Kalman-based interactive multiple model design for boost and transition phase tracking of a TBM. Research during last year focused on spacecraft-to-AEGIS hand-off issues and on backfitting algorithms to determine TBM launch locations in the shortest possible time. We developed simulations to test our sensor fusion and tracking algorithms, and we used classified missile trajectory data for more realistic algorithm tests. Testing and algorithm development focused on AEGIS-specific measurement and data acquisition capabilities.

DoD KEY TECHNOLOGY AREAS: Sensors, Modeling and Simulation

KEYWORDS: Theater Ballistic Missiles, Sensors, Extended Kalman Filters, Data Association, Target Tracking

ASSESSMENT OF OCEAN SURFACE ROUGHNESS ON EM PROPAGATION

R. Janaswamy, Professor

Department of Electrical and Computer Engineering

Sponsor: Space and Naval Warfare Systems Center-San Diego

OBJECTIVE: To develop theoretical model for assessing the effect of ocean surface roughness on long-range propagation.

SUMMARY: A theoretical formulation to include roughness-induced immittance within the framework of the split-step algorithm of the parabolic equation was developed. The present form of the split-step algorithm is capable of incorporating angle-dependent surface losses arising from roughness and is also applicable to underwater sound propagation over irregular ocean bed. The formulation was validated by considering several examples of radio propagation over wind-driven ocean surface under various ducting conditions. Frequencies from HF through microwave for both wave polarizations were considered in the validations.

PUBLICATION:

Janaswamy, R., "Radiowave Propagation Over a Non-Constant Immittance Plane," to appear in *Radio Science*, 2001.

PRESENTATION:

Janaswamy, R., "Rigorous Propagation Modeling Over Rough Sea Surface by the Parabolic Equation," paper # F2-9, 2001 URSI Meeting, University of Colorado, Boulder, CO, January 2001.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments

KEYWORDS: Surface Roughness, Parabolic Equation

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3D SITE SPECIFIC PROPAGATION STUDIES FOR WIRELESS COMMUNICATIONS

R. Janaswamy, Professor
Department of Electrical and Computer Engineering
Sponsor: U. S. Army Research Office

OBJECTIVE: To develop a 3-D propagation prediction model for wireless communications in outdoor environments. This is a 3-year project continuing on until July 2002.

SUMMARY: A parabolic equation based Fourier algorithm of solving 3D wave propagation in an urban environment comprised of vertical buildings of polygonal cross sections lying on flat ground was developed. The algorithm neglects depolarization and backscattering of waves, but includes several important propagation mechanisms such as reflections and diffractions by building rooftops, building sides, and ground. The algorithm was demonstrated for perfectly reflecting 2D and 3D buildings and was shown to be effective for implementation on a PC for obstacles scattered in a layout size as large as 0.6 km × 0.6 km at 1 GHz. Work is ongoing on extending the algorithm to non-perfectly reflecting obstacles.

PRESENTATION:

Janaswamy, R., "A 2.5D Hybrid Parabolic Equation/Ray Tracing Approach for Modeling Path Loss in Urban Environments," Paper No. C3-2, 2001 URSI Meeting, University of Colorado, Boulder, CO, January 2001.

DoD KEY TECHNOLOGY AREAS: Other (Tactical Battlespace Communications)

KEYWORDS: Wireless Propagation, Parabolic Equation

RADAR REMOTE SENSING

Jeffrey B. Knorr, Professor
Department of Electrical and Computer Engineering
Bob Bluth, Research Associate
Center for Interdisciplinary Remotely Piloted Aircraft Studies
Sponsor: Office of Naval Research

OBJECTIVE: The objective of this project is to acquire and modify two military radars for meteorological research.

SUMMARY: An Army AN/MPQ-64 Sentinel radar was acquired in the spring of 1999 and was brought to operational status during the fall of 1999 and the winter of 2000. An SBIR project N01-035, Weather Processor for Rapid Scanning Tactical Radars, was initiated with ProSensing, Amherst, MA to add a Doppler processor to the radar for severe storm research. During 2000 steps were also taken to obtain an Army AN/TPQ-37 Fire finder radar and delivery is expected in April 2001. This radar is similar to the AN/SPY-1 radar installed on the Navy's Aegis cruisers and destroyers. A project is planned to add a weather processor to this radar so it can be used as a test bed for investigation of AN/SPY-1 algorithms to extract meteorological data. The long-term objective of this project is to develop radar remote sensing capabilities that will provide meteorological data that can be used to describe weather phenomena, particularly in support of air operations in the fleet battle space.

PUBLICATION:

Knorr, J.B., "Analysis of the AN/SPY-1 and AN/TPQ-37 Radars (U)," SECRET working paper prepared for the Office of Naval Research, December 2000, 9 pp.

PROJECT SUMMARIES

PRESENTATION:

Knorr, J.B., "AN/MPQ-64 Radar Application to Severe Storm Research," presented at Ground Based Mobile Instrumentation Workshop, National Center for Atmospheric Research, Boulder, CO, 22-24 February 2000.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Sensors

KEYWORDS: Remote Sensing, Radar Meteorology

PRELIMINARY DESIGN OF LOW FREQUENCY EIGEN-ANTENNA FOR EA-6B

Jovan Lebaric, Visiting Associate Professor
Richard Adler, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Air Systems Command

OBJECTIVE: The objective is to design a wideband eigen-antenna to extend the range of transmitter/receiver operation to lower frequencies for which conventional antennas would be too large to implement on an EA-6B.

SUMMARY: The objective would be accomplished by one or more electrically small eigen antennas using near-field coupling to the platform (EA-6B aircraft), electromagnetic eigen-modes (resonant modes) to increase their radiation/reception effectiveness. This phase of research involves the eigen-mode mapping for the EA-6B aircraft, identification of suitable eigen-modes for the desired polarization (vertical) and far-field pattern (omnidirectional in azimuth), selection of optimal location(s) for the eigen-antenna(s), and preliminary computer verification of the eigen -antenna design. This is considered phase 1 of a larger research effort to result in a verified EA-6B eigen-antenna design for the user-specified frequency range.

Previously, electrical performance (input impedance, radiation patterns, overall efficiency, etc.) of a number of different antennas at several available locations on the EA6-B aircraft have been estimated using computational electromagnetic software in order to determine the location, type and size/shape of the optimum antenna.

THESIS DIRECTED:

Ertel, T.M., "Ultra-Wideband, Low Profile, Vertically Polarized Antenna Designs for Military Applications," MastersThesis, Naval Postgraduate School, September 2000.

DoD KEY TECHNOLOGY AREAS: Sensors

KEYWORDS: Antennas, Computational Electromagnetics

SSN UNIVERSAL MODULAR MAST (UMM) ANTENNA DESIGN AND PROTOTYPING

Jovan Lebaric, Visiting Associate Professor
Richard Adler, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Engineering Logistics Office

OBJECTIVE: Optimization of the computer model and building a prototype to verify the model of the UMM antenna designed by the NPS in FY99.

SUMMARY: The new attack submarine universal modular mast wideband antennas were designed by the NPS in FY99. The NPS will optimize the computer model and then build a prototype to verify the model created using computer electromagnetic simulation software (GNEC). The NPS will provide the data and a

PROJECT SUMMARIES

prototype to the program manager as an aid in determining and evaluating the design for the antenna system.

PRESENTATION:

Lebaric, J., Silva, M., Adler, R., and Cutsumbis, P., "RATTLE-1: A Compact, Broadband Directional UHF Communications Antenna," presented at the International Symposium on Antennas and Propagation 2000 (ISAP2000), Fukuoka, Japan.

Silva, M., Lebaric, J., Adler, R., and Cutsumbis, P., "The Antenna Comparison Technique (ACT)," presented at the International Symposium on Antennas and Propagation 2000 (ISAP2000), Fukuoka, Japan.

Silva, M., Lebaric, J., Adler, R., and Cutsumbis, P., "A Method of Obtaining Antenna Overall Efficiency from Antenna Computer Simulations," presented at the International Symposium on Antennas and Propagation 2000 (ISAP2000), Fukuoka, Japan.

THESES DIRECTED:

Cutsumbis, P.M., "Design, Prototyping and Measurement of a Cavity-Backed Conical Spiral Wideband Antenna for Submarine Applications," Masters Thesis, Naval Postgraduate School, June 2000.

Silva, M.M., "Design of an Ultra-Wideband Directional Antenna for a Given Set of Dimension Constraints," Masters Thesis, Naval Postgraduate School, September 2000.

DoD KEY TECHNOLOGY AREAS: Environmental Quality

KEYWORDS: Antennas, Computational Electromagnetics

DESIGN AND PROTOTYPING OF WIDEBAND USQ-113 ANTENNA FOR EA-6B

Jovan Lebaric, Visiting Associate Professor

Richard Adler, Research Associate Professor

Andrew Parker, Research Associate

Department of Electrical and Computer Engineering

Sponsor: Naval Air Systems Command

OBJECTIVE: Design and prototype two wideband antennas for the USQ-113 system onboard EA-6B aircraft.

SUMMARY: One of the proposed antennas is an evolution (reduced size) of the "bell" antenna design tested at NPS earlier in FY99, while the other is a new low-profile design conformal to the aircraft "skin." The research included computer modeling and simulation, prototyping, and electrical performance verification via measurements.

THESIS DIRECTED:

Al-Habsi, R.M., "An Ultra Wideband Antenna with Size Constraints," Masters Thesis, Naval Postgraduate School, March 2000.

DoD KEY TECHNOLOGY AREAS: Sensors

KEYWORDS: Antennas, Computational Electromagnetics

PROJECT SUMMARIES

JOINT TACTICAL RADIO (JTR) COMBAT WEAR INTEGRATED (COMWIN) VHF AND UHF ANTENNA DEVELOPMENT

Jovan Lebaric, Visiting Associate Professor

Richard Adler, Research Associate Professor

Andrew Parker, Research Associate

Department of Electrical and Computer Engineering

Sponsor: Space and Naval Warfare Systems Center-San Diego

OBJECTIVE: The preliminary design of two (VHF and UHF) Combat Wear Integrated (COMWIN) Antennas for the Man-Portable Joint Tactical Radio (JTR).

SUMMARY: Investigated designs of lightweight antennas devoid of any visual signature with frequency coverage from 30MHz to 2,000 MHz. The concept is based on the integration of several antennas (each covering a section of the JTR frequency range) with the items of combat wear of a dismounted soldier, such as the (kevlar) helmet and the flak vest.

PRESENTATIONS:

Gainor, T., Lebaric, J., Adler, R., "Ultra - Wideband VHF/UHF Radio Frequency Vest Antenna for Man-Portable Implementation of the Joint Tactical Radio System (JTRS)," MILCOM 2000, Los Angeles, CA.

Gainor, T., Lebaric, J., Adler, R., "Ultra-Wideband RF Helmet Antenna," MILCOM 2000, Los Angeles, CA.

Lebaric, J., Tan, A., Adler, R., "An Ultra-Wideband UHF Helmet Antenna for Man-Portable Implementation of the Joint Tactical Radio System (JTRS)," JWWG Meeting, SPAWAR System Center, San Diego, CA.

THESES DIRECTED:

Tan, A.T., "Design of an Ultra-Wideband Low Profile Vertically Polarized UHF Antenna for the U.S. Ground Troop Helmet," Masters Thesis, Naval Postgraduate School, March 2000.

Gainor, T., "Ultra-wideband Radio Frequency Vest Antenna Design," Masters Thesis, Naval Postgraduate School, September 2000

Limbert, M.E., "Ultra-wideband Combat Wearable Integrated (COMWIN) Antenna Design for the Joint Technical Radio System (JTRS)," Masters Thesis, Naval Postgraduate School, September 2000.

Emo, T., "Low-Profile Man-Portable HF Antenna Design," Masters Thesis, Naval Postgraduate School, December 2000.

DoD KEY TECHNOLOGY AREAS: Sensors

KEYWORDS: Antennas, Computational Electromagnetics

ADVANCED PROCESSOR AND MEMORY RESEARCH

H. H. Loomis, Jr., Professor

Department of Electrical and Computer Engineering

Sponsor: NPS Foundation, Inc.

OBJECTIVE: The objective in this task is to design two key very large-scale integrated circuits (VLSI) for a vector pipelined processor architecture. The first chip performs the function of interfacing baked memories using permutation-based decoding to a bus. The second chip is a pipelined vector processor that performs Radix-R Butterfly operations, complex vector addition and multiplication.

PROJECT SUMMARIES

DoD KEY TECHNOLOGY AREAS: Computing and Software

KEYWORDS: Vector Processor, Pipelining, Fast Fourier Transform, Digital Signal Processing

CRYPTOLOGIC COMMUNICATIONS SYSTEMS LABORATORY DEVELOPMENT

H. H. Loomis, Jr., Professor

Department of Electrical and Computer Engineering

Sponsor: Center for Reconnaissance Research

OBJECTIVE: Perform design, implementation and documentation of new cryptologic communications laboratory for wireless simulation, generation and reception for use by students studying in various aspects of Information Operation/Information Warfare.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications

KEYWORDS: Signal Intelligence, Information Warfare, Engineering, Communications Systems, Technical Education

JOINT IO/IW RESEARCH INITIATIVE BETWEEN

NPS/NSA CRYPTOLOGIC

CHAIR AND AFIWC

H. H. Loomis, Jr., Professor

Department of Electrical and Computer Engineering

Sponsor: U. S. Air Force Information Warfare Center

OBJECTIVE: Promote innovative Information Operations Research by NPS academia to support AFIWC mission.

DoD KEY TECHNOLOGY AREAS: Electronics

KEYWORDS: Communications, Signal Processing, Computers, Network Security

NRL SUPPORT FOR NPS STUDENT THESIS RESEARCH ON VSAT EXPLORATION

H. H. Loomis, Jr., Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Research Laboratory

OBJECTIVE: Promote innovative VSAT research by NPS students in support of the NRL mission

DoD KEY TECHNOLOGY AREAS: Other (Cryptology)

KEYWORDS: Communications, Signal Processing, VSAT, Collection, Radio Frequency

PROJECT SUMMARIES

PROJECT GUSTY ORIOLE

H. H. Loomis, Jr., Professor

Department of Electrical and Computer Engineering and Space Systems Academic Group

RADM Thomas C. Betterton, USN (Ret.)

Naval Space Technology Chair Professor of Space Systems

Alan Ross, Navy Tactical Exploitation of National Capabilities (TENCAP) Chair Professor

Sponsor: National Reconnaissance Office

OBJECTIVE: To conduct research into architectures and algorithms for the acquisition, processing, and communication of tactical information. To provide support for the course Space Systems 3001, Military Applications of Space and for SS4051, Military Space Systems and Technologies.

SUMMARY: Completed work on the following tasks: a) developed plans for a Satellite Communications System, which has been transitioned to a CRADA with Hughes Space and Communications Company (since acquired by Boeing Space Systems); b) completed triple-modular redundancy computer test bed for development of single-event-upset tolerant space-based computers from COTS computers. Entering test phase of this project now; c) analyzed data from Fleet Battle Experiment Echo supporting development of data fusion algorithms for Maritime Situational Awareness; and d) supported courses SS3001, SS4041, and SS4051 by the development of geolocation material and the arrangement of field trips to visit contractor sites.

THESES DIRECTED:

Summers, D., "Design and Construction of a Fault-Tolerant Computer," Masters Degree, Naval Postgraduate School, July 2000.

Hofheintz, D., "Development of a Fault-Tolerant Computer for Space Applications," Masters Thesis, Naval Postgraduate School, July 2000.

Martin, S.G., "Space-Based Computer Network Operations (CNO)," Masters Thesis, Naval Postgraduate School, September 2000.

Racinez, R., "Transitioning to the Unified Cryptologic Architecture," Masters Thesis, Naval Postgraduate School, September 2000

Wagonner, W.R., "Integration of Maritime Shipping Technical Data into a Common Database for Use in a Graphical Display," Masters Thesis, Naval Postgraduate School, September 2000.

Ziegler, W., "The Roles and Required Capabilities of Future National SIGINT Systems (U)," Masters Thesis, Naval Postgraduate School, September 2000.

DoD KEY TECHNOLOGY AREAS: Space Vehicles

KEYWORDS: Spaceborne Computers, Space Communications

GEOLOCATION WORKBENCH

H. H. Loomis, Jr., Professor

Department of Electrical and Computer Engineering and Space Systems Academic Group

Sponsor: Center for Reconnaissance Research

OBJECTIVE: To develop a software workbench in the MATLAB environment to facilitate the development and testing of algorithms related to the geopositioning of electromagnetic emitters from various types of observation platforms.

PROJECT SUMMARIES

SUMMARY: Concluded the project after the departure of Professor Shimeall in April 1999. The workbench now supports:

- The conversion of pre-detected IF sampled signal files from a variety of standard formats to an internal standard compatible with the CPEG program files;
- Routines for writing and reading internal standard PDW data files;
- The inclusion of several demonstration signal processing routines;
- The inclusion of several demonstration signal display routines;
- The inclusion of a 2-dimensional TDOA based Newton-Raphson geolocation algorithm for pedagogical purposes.

The software runs under MATLAB Version 5.x. It has been distributed to a contractor of the NRO for coordination with operational geolocation software.

PRESENTATION:

Loomis, H.H., Jr., "The Geolocation Workbench," presentation and demonstration to the Geolocation Workshop, National Reconnaissance Office, Chantilly, VA, March 2000.

OTHER:

Loomis, H.H., Jr., "Geolocation Workbench," Version 1.0, Department of Electrical and Computer Engineering, Naval Postgraduate School, January 2001. (MATLAB 5.x software)

DoD KEY TECHNOLOGY AREAS: Computing and Software

KEYWORDS: Geolocation

IT-21 WAN VULNERABILITY ASSESSMENT

John McEachen, Assistant Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Engineering Logistics Office

OBJECTIVE: Develop models and simulations of IT-21 specific standards-based digital communications networks using MIL3's OPNET network modeling software environment. Determine infrastructure constraints and vulnerabilities based on simulated results. Initiate a new focus on SS7 networks and their interface with IP networks such as IT-21. This work is part of a continuing project with NELO.

SUMMARY: The project has yielded several significant findings related to vulnerabilities of WAN routing protocols and has proposed several solutions to protecting IT-21 networks. Specifically, the project identified and reported a significant vulnerability in the Open Shortest Path First (OSPF) link state routing protocol and the Multiprotocol Label Switching (MPLS) label distribution protocol. The project also continues to investigate vulnerabilities in ATM's PNNI routing protocol. High-fidelity simulations of the SS7 network for testing and analysis of SS7/IP integration were developed. Several aspects of this project are classified. This project is in its third year of funding.

PUBLICATIONS:

McEachen, J.C. and Cay, A., "Masking Compressed Video Connection Utilization in ATM Networks," to appear in the *Proceedings of the 2001 IEEE International Symposium on Circuits and Systems (ISCAS 2001)*, Sydney, May 2001.

McEachen, J.C., Ow, K.C., and Lim C. T., "A System Level Description and Model of Signaling System No. 7," to appear in the *Proceedings of the 2001 IEEE International Symposium on Circuits and Systems (ISCAS 2001)*, Sydney, May 2001.

PROJECT SUMMARIES

McEachen, J.C. and Chesser, R.C., "Vulnerabilities in the Open Shortest Path First Routing Protocol," *Proceedings of the 2000 IEEE Military Communications International Symposium (MILCOM 2000)*, Los Angeles, CA, October 2000.

McEachen, J.C., Ow, K.C. and Lim C. T., "A Modeling Architecture For Standards-based Simulation of Signaling System No. 7," *Proceedings of OPNETWORK2000*, Washington, D.C., August 2000.

Cay, A. and McEachen, J.C., "Spectral Analysis of Connection Utilization Masking in ATM Networks," *Proceedings 25th IEEE International Conference on Acoustic, Speech and Signal Processing (ICASSP 2000)*, Istanbul, 3-5 June 2000.

PRESENTATIONS:

McEachen, J.C., "Vulnerabilities in the Open Shortest Path First Routing Protocol," 2000 IEEE Military Communications International Symposium (MILCOM 2000), 24 October 2000.

McEachen, J.C., "A Modeling Architecture For Standards-based Simulation of Signaling System No. 7," OPNETWORK2000, Washington, D.C., 1 September 2000.

McEachen, J. C., "Modeling Satellite Communications," OPNETWORK 2000, Washington, D.C., 31 August 2000.

THESES DIRECTED:

Chesser, R.L., "Vulnerabilities in the Open Shortest Path First Routing Protocol," Masters Thesis, Naval Postgraduate School, March 2000.

Ow, K.C., "OPNET Simulation of Signaling System No. 7 (SS7) Network Interfaces," Masters Thesis, Naval Postgraduate School, March 2000.

Lim, C.T., "Simulation of Signaling System No. 7 (SS7) Message Transfer Part 2 (MTP-2)," Masters Thesis, Naval Postgraduate School, March 2000.

Dixon, G.L., "Dynamics of Private Network-to-Network Interface (PNNI) Routing In ATM Vulnerability Assessments," Masters Thesis, Naval Postgraduate School, September 2000.

Stone, G.N., "Path-based Network Policy Language," Doctor of Philosophy, Naval Postgraduate School, September 2000.

MacRitchie, J.R., "An Examination of Possible Attacks on Cisco's IPSec-based VPN Gateways," Masters Thesis, Naval Postgraduate School, December 2000.

Lam, W., "Meeting SIGINT Constraints in IP Telephony," Masters Thesis, Naval Postgraduate School, March 2001.

Mullin, S., "Vulnerabilities in Multiprotocol Label Switching," Masters Thesis, Naval Postgraduate School, March 2001.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Modeling and Simulation, Computing and Software

KEYWORDS: Information Operations, Asynchronous Transfer Mode (ATM), ATM Traffic Modeling, SONET

PROJECT SUMMARIES

SECURITY VULNERABILITIES OF WIRELESS PROTOCOLS

John McEachen, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Engineering Logistics Office

OBJECTIVE: Perform research into the internal protocols of wireless computer networks and identify vulnerabilities associated with their standard implementation. Examine use of cellular-based protocols such as Mobitex and CDPD for data communications. Begin investigation into the interface of wireless networks with landline IP networks in the interest of examining upcoming technologies such as WAP and IP telephony.

SUMMARY: Interest in portable, high-bandwidth digital communications methods spans the world and presents a formidable challenge to the Defense Department of the United States. While anxious to use new communications equipment, the armed services are wary of the vulnerabilities they expose. This project examines the vulnerability of wireless local area networks (WLANs) when used by tactical units in an urban setting. Work on this project began in December 2000. This project already has identified several denial of service issues in the IEEE 802.11 control and management functions.

PUBLICATION:

McEachen, J.C. and Braswell, B., "Vulnerabilities in Control and Management Functions of IEEE 802.11 Wireless LANs," Naval Postgraduate School Technical Report, NPS-EC-01-001, February 2001.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Modeling and Simulation, Computing and Software

KEYWORDS: 802.11, ATM, Wireless, LAN, High Speed Networking, Ad-hoc Networking

COMPUTER MODELING OF HIGH-SPEED WIRELESS LOCAL AREA NETWORKS (WLAN)

John McEachen, Assistant Professor
Department of Electrical and Computer Engineering
Sponsor: National Security Agency

OBJECTIVE: Develop models for the assessment of high-speed wireless LAN performance over non-standard distances. Provide guidance and consultation on future initiatives in wireless LAN research.

SUMMARY: This project uses the OPNET Modeler network simulation tool to perform computer simulation of radio frequency (RF) environments where wireless LANs may be implemented. The most significant result of this project has been the development of a high-fidelity model of the IEEE 802.11a high-speed WLAN. This model will be release to the public in March 2001. Issues relating to receiver sensitivity and performance in noisy environments were also examined. Modeling includes analysis of Ad-hoc networks as well.

PUBLICATION:

Tope, M.A. and McEachen, J.C., "Performance Evaluation of Synthetic Waveguide Communication in a Nakagami M-Fading Environment," *Proceedings 2000 IEEE Military Communications International Symposium (MILCOM 2000)*, Los Angeles, CA, October 2000.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Modeling and Simulation, Computing and Software

KEYWORDS: 802.11, ATM, Wireless, LAN, High Speed Networking, Ad-hoc Networking

PROJECT SUMMARIES

RADIATION HARDENED SPACE BASED ELECTRONIC DEVICES AND SOLAR CELLS

Sherif Michael, Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Research Laboratory

OBJECTIVE: To study the Space radiation effects on state-of-the-art solar cells including GaAs, InP and Multi-junction cells. To investigate annealing methods for the recovery of radiation degraded performance of advanced space cells. And develop radiation hardened Analog VLSI circuits for space applications.

SUMMARY: Continuation of the ongoing research on Photovoltaic Power Technology. Research tasks include optimizing current annealing methods previously developed for GaAs cells. The tasks also include investigating of the new Laser annealing technique on GaAs and InP solar cells. Irradiating solar cells using NPS Linear Accelerator, and measuring their characteristics using the newly developed Solar Simulator Facilities. Other tasks are to investigate radiation effects on different electronic devices. Radiation testing of Analog VLSI chips previously designed and fabricated, using the NPS Linear Accelerator. Major research thrusts are annealing of radiation-damaged solar cells, investigating of laser annealing techniques for radiation-damaged solar cells, and radiation tolerant ASIC and analog IC design, implementation, and testing.

PUBLICATIONS:

Pieper, R. and Michael, S., "Circuit Modeling to Predict the Performance of Forced Cooled Plate Structure," *Proceedings 1999 IEEE International Symposium on Circuits and Systems*, Orlando, FL, June, 1999.

Pieper, R. and Michael, S., "A Robust Algorithm for Predicting Freezeout and Exhaustion Under Equilibrium Conditions," *Proceedings 2nd International Conference on Modeling and Simulation of Microsystems*, San Juan, PR, April 1999.

THESES DIRECTED:

Lee, R.D., "The Design, Simulation, and Fabrication of a VLSI Digitally Programmable GIC Filter," Masters Thesis, Naval Postgraduate School, December 2000.

DoD KEY TECHNOLOGY AREAS: Electronics, Environmental Quality

KEYWORDS: Space Radiation Effects, Satellites, Annealing, Radiation Hardened, Computer Modeling

NULKA FOT&E TEST PLAN DEVELOPMENT AND TECHNICAL SUPPORT

Phillip E. Pace, Associate Professor
Department of Electrical and Computer Engineering
Kenneth Davidson, Professor
Department of Meteorology
Sponsor: Commander Operational Test and Evaluation Force

OBJECTIVE: In order to evaluate the EW effectiveness of the Nulka/MK53 decoy launch system, Follow-On Test and Evaluation (FOT&E) exercises at sea must be conducted using captive-carry seekers, and test ships conducting both live NULKA firings as well as hovering the NULKA rocket with the use of a helicopter. Command Operational Test and Evaluation Force (COMOPTEVFOR) is the Navy's independent test agent responsible for developing the test requirements and test procedures. They also perform the analysis of the field test data to determine the degree of the NULKA's effectiveness. This technical support contract enabled consultation with COMOPTEVFOR to aid in the design of the test requirements and procedures as well as guide the decision for the necessary tools needed for the post-test analysis.

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SUMMARY: Through several meetings at COMOPTEVFOR, the group was able to lay down a specific test plan that exercised the NULKA's EW capability. The test involved multiple ships at sea, several NULKA rounds for live fire, several captive-carry threat seekers (NRL's P-3) and plans for a helicopter to hover the rocket at various positions.

DoD KEY TECHNOLOGY AREAS: Electronic Warfare, Sensors, Electronics

KEYWORDS: Nulka/MK53, Decoy Launch System

AN OPTIMUM SENSOR NETWORK CONFIGURATION

Phillip E. Pace, Associate Professor

Department of Electrical and Computer Engineering

Sponsors: Naval Air Systems Command and Johns Hopkins University

OBJECTIVE: This project provides support to the Airborne Electronic Attack (AEA) Analysis of Alternatives (AoA) Modeling and Simulation effort in the area of sensitivity analysis of the solutions evolved by NRL's Airborne Reactive Electronic Warfare Simulation (ARES). This network-centric analysis is to determine the robustness in the derived measures of effectiveness or sensitivity to system failures or variances in performance parameters. In addition, a sensitivity analysis is performed to test the vulnerability of solutions to the environment (e.g., threat intensity, terrain, IADS, etc.).

SUMMARY: This work continues the investigation of using the ARES to determine an optimum sensor/jammer network configuration for the suppression of enemy air defense (SEAD) using the classified RT4, RT2 scenarios. This involves evaluating the sensitivity of the Measures of Effectiveness (MOEs) to small perturbations in the optimal solution (as derived by the genetic algorithm in ARES). For example, a trade space for RT4, RT2 might involve four EA-6Bs, two Global Hawk unmanned aerial vehicles (UAVs), and six Miniature Air Launched Jammers (MALJs). After the ARES genetic simulation, the optimum answer could be: three EA-6Bs with ICAP 3 receivers but with an increase in sensitivity (e.g., by 10 dB), two Global Hawks with receivers having -90 dBm sensitivity and a MALJ with a specific X-band jammer onboard. The derived measures of effectiveness (MOE) might be for example: total tracking time by early warning radars = 20 s and total Surface-to-Air Missile (SAM) engagements = 20. A perturbation of the solution (e.g., no Global Hawk UAVs) is prepared and several vignettes are run for both RT2, RT4 to investigate the effect on the MOEs. This in turn will demonstrate the robustness of the MOEs to perturbations from the optimal solution. The tasks involved with this effort include running the RT4, RT2 distributed scenarios with conventional ARES (no genetic algorithms) to verify solutions and corresponding MOEs and then changing one or more parameters in the scenario solution and rerunning ARES to investigate the sensitivity of the derived MOEs to these changes.

DoD KEY TECHNOLOGY AREAS: Electronic Warfare, Sensors, Electronics

KEYWORDS: Network-Centric, Analysis of Alternatives, Airborne Electronic Attack, EA-6B, Unmanned Aerial Vehicles, Suppression of Enemy Air Defense

NAVY SURFACE ANTI-SHIP CRUISE MISSILE THREAT SIMULATOR VALIDATION WORKING GROUP

Phillip E. Pace, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Research Laboratory

OBJECTIVE: The objective of this proposal is to provide technical leadership to the Navy Surface Anti-Ship Cruise Missile Threat Simulator Validation Working Group. Three types of simulations are currently being validated by the SVWG for use in test and evaluation. These include (a) radio frequency missile hardware simulators, (b) infrared missile hardware simulators and (c) computer models of missile seekers and related electronics.

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SUMMARY: To insure that each ASCM simulator accurately represents the associated threat missile, OPNAV (N912) established the Navy-Unique ASCM Simulator Validation Working Group (SVWG). Three types of simulations are currently being addressed by the SVWG for use in EW test and evaluation (OPEVAL). These include (a) radio frequency hardware simulators, (b) infrared hardware simulators and (c) computer models. The duties for the SVWG chairman include coordinating with the Navy's Simulator Validation Coordinator, the NRL ENEWS Program Manager and other Navy commands (e.g., Commander, Operational Test and Evaluation Force) to prioritize the simulator validations for N912 approval. Additional responsibilities include coordinating with the Office of Naval Intelligence for threat data review and convening the SVWG as an independent and unbiased reviewer for all of the validation reports.

PUBLICATIONS:

Pace, P.E., Nash, M.D., Zulaica, D.P., Di Mattesa, A.A., and Hosmer, A., "A Relative Targeting Architecture for Captive-Carry Missile Simulator Experiments," *IEEE Transactions on Aerospace and Electronic Systems*, to be published.

Pace, P.E. and Zulaica, D.P., "A Relative Targeting Architecture for Test Range Visualization in Captive-Carry Missile Simulator Experiments: USS Peterson-Nulka Test Results (July 9, 1998)," Naval Postgraduate School Technical Report, NPS-EC-00-006, 3 May 2000.

PRESENTATIONS:

Pace, P.E., "SVWG Organizational Chart and Validation Plan," presented at the N9 Threat ASCM Simulator Validation Working Group, Naval Research Laboratory, 1 February 2000.

Pace, P.E., "The SVWG Charter - A Proposal," presented at the N9 Threat ASCM Simulator Validation Working Group, Naval Research Laboratory, 1 February 2000.

DoD KEY TECHNOLOGY AREAS: Electronic Warfare, Sensors, Electronics

KEYWORDS: Hardware-in-the-Loop, Threat Missile Simulators, Infrared, Computer Missile Simulation

DIGITAL TARGET IMAGING ARCHITECTURES

Phillip E. Pace, Associate Professor

Douglas J. Fouts, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Office of Naval Research

OBJECTIVE: The technical objective of this research is twofold. The *first* objective is to quantify the system-level implementation tradeoffs of a digital, programmable imaging architecture to generate realistic false target signatures against high resolution imaging radars, including synthetic aperture radar (SAR) and inverse SAR (ISAR), using all-digital techniques and modern digital radio frequency memory (DRFM) technology. The *second* objective is to design, fabricate and test an all digital target-imaging device capable of generating *large* false targets using wideband chirp signals of any duration to provide a new, superior radio frequency (RF) decoy capability.

SUMMARY: To generate the target and its motion, the user will program the *target extent*, the *amplitude* characteristics and the *motion profile* of each scatterer within the image on a pulse-to-pulse basis. The imaging device will reduce both the noise of the repeated signal and the size of such a system over prior analog technology with a significant cost reduction. The all-digital design will permit real-time alteration of operating parameters, permitting rapid and adaptive shifting among different types of large targets. It is expected that the device will be transitioned into the AN/SLY-2 (AIEWS) Increment-2 in order to generate structured false targets including any target motion or movement required for time-critical platform protection. In this first year we investigate the system-level tradeoffs and design a new programmable

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imaging architecture able to generate high-fidelity target images that have a realistic size (e.g., 512 range bins).

PUBLICATIONS:

Pace, P.E., Ekestorm, S., Karow, C., and Fouts, D., "An All-Digital Image Synthesizer for Countering High-Resolution Imaging Radars," Naval Postgraduate School Technical Report, NPS-EC-00-005, 24 February 2000.

Pace, P.E., Fouts, D.J., Ekestorm, S., and Karow, C., "Digital Image Synthesizers for Countering High-Resolution Imaging Radar," *IEEE Transactions on Aerospace and Electronic Systems*, in review.

PRESENTATIONS:

Pace, P.E., Ekestorm, S., Karow, C., Fouts, D., "All-Digital Image Synthesizer for Countering High Resolution Imaging Radars -- Progress Report FY99/00," presented at the TTCP-Technical Program 3, Naval Research Laboratory, Washington, D.C., 12 January 2000.

Pace, P.E., Ekestorm, S., Karow, C., Fouts, D., "All-Digital Image Synthesizer for Countering High Resolution Imaging Radars - Progress Report FY99/00," presented at Code 5740 - Ships Self-Defense, Naval Research Laboratory, Washington, D.C., 13 January 2000.

DoD KEY TECHNOLOGY AREAS: Electronic Warfare, Sensors, Electronics

KEYWORDS: Imaging Decoys, Inverse Synthetic Aperture Radar, Counter-Targeting, Counter-Terminal, Digital Radio Frequency Memories, DRFM

ROBUST SYMMETRICAL NUMBER SYSTEMS

Phillip E. Pace, Associate Professor

David C. Jenn, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Postgraduate School

OBJECTIVE: The objective of this research is to investigate new symmetrical number systems and their application to electronic engineering systems.

SUMMARY: Both an optimum symmetrical number system (OSNS) and a robust symmetrical number system (RSNS) have been investigated. The RSNS has an inherent performance advantage over the OSNS design since the encoding errors due to several comparators changing at one time is eliminated (Gray code properties). Applications investigated include high-speed folding analog-to-digital converters (ADCs) and phase-sampled direction finding antenna architectures. Symmetrical number system preprocessing is used to decompose the amplitude analyzing (folding ADC) or spatial filtering (DF antenna) operation into a number of parallel sub-operations (moduli) that are of smaller computational complexity. A much higher resolution is provided after the N different moduli are used and the results of these low precision sub-operations are recombined. By incorporating the OSNS or RSNS preprocessing concept, the performance of the system can be analyzed exactly. The OSNS gives the maximum dynamic range while the RSNS reduces considerably, the number of possible encoding errors. Simulation results for an RSNS ADC are reported as well as experimental results for a prototype OSNS and RSNS direction finding system.

PUBLICATIONS:

Pace, P.E., Styer, D., and Akin, I.A., "A Folding ADC Preprocessing Architecture Employing a Robust Symmetrical Number System with Gray-Code Properties," *IEEE Transactions on Circuits and Systems--II: Analog and Digital Signal Processing*, Vol. 47, No. 5, May 2000, pp. 462-467.

PROJECT SUMMARIES

Pace, P.E., Styer, D., and Ringer, W.D., "An Optimum SNS-to-Binary Conversion Algorithm and Pipelined Field Programmable Logic Design," *IEEE Transactions on Circuits and Systems—II: Analog and Digital Processing*, Vol. 47, No. 8, Aug. 2000, pp. 736-745.

Pace, P.E., Wickersham, D., Jenn, D., York, N., "High-Resolution Phase Sampled Interferometry Using Symmetrical Number Systems," *IEEE Transactions on Antennas and Propagation*, to be published.

Wickersham, D.J., Pace, P.E., Styer, D., Jenn, D.C., Vitale, R., and York, N.S., "High-Resolution DF Architectures Using a Robust Symmetrical Number System Encoding," *Proceedings of the IEEE International Conference on Phased Array Systems and Technology*, Dana Point, CA, 22 May 2000, pp. 169-172.

PATENT:

Pace, P.E., Styer, D., "Wideband Undersampling Digital Receiver," Naval Postgraduate School, U.S. Patent 6,031,879, 29 February 2000.

DoD KEY TECHNOLOGY AREAS: Electronic Warfare, Sensors, Electronics

KEYWORDS: Asymmetrical Number System, Direction Finding Antennas, Folding Analog-to-Digital Converter, Gray Code Property

PHOTONIC SAMPLING ARCHITECTURES FOR MICROWAVE SIGNAL COLLECTION AND ANALYSIS

Phillip E. Pace, Associate Professor

John P. Powers, Distinguished Professor

Department of Electrical and Computer Engineering

Sponsors: Defense Advanced Research Projects Agency and Naval Postgraduate School

OBJECTIVE: The objective of this research is the experimental investigation of a photonic sigma-delta architecture for high-speed sampling and digitization of RF and microwave signals. Our photonic sigma-delta ADC uses a mode-locked laser to oversample an input signal at two Mach-Zehnder interferometers. A fiber lattice accumulator is embedded within a feedback loop around a single-bit quantizer to spectrally shape the quantization noise to fall outside the signal band of interest. Decimation filtering is applied to the quantizer output to construct the input signal with high resolution.

SUMMARY: A single-bit, first-order, electro-optical sigma-delta modulator for use in wideband digital antennas was designed, constructed and experimentally tested. The construction and experimentation of the modulator was in two parts: the signal oversampling subsystem and the fiber lattice accumulator. A pulsed 1550-nm laser diode source was used to optically sample the RF antenna waveform. Performance characteristics of this subsystem were compared with the results of a computer simulation. A comparator circuit was designed and constructed in order to drive the signal accumulation in the fiber lattice in the proper direction. Before constructing the fiber lattice, the phase modulator and the semiconductor optical amplifier were characterized. The results of the characterization of the phase modulator determined the appropriate output voltage required by the comparator circuit. The characterization test of the optical amplifier established the correct operating range required for a monotonic linear response of the fiber lattice accumulator. Finally, a 4-port fiber lattice accumulator was constructed using a phase modulator, a semi-conductor optical amplifier, a pair of variable-ratio directional couplers and a delay loop equal to the pulse repetition interval of the sampling laser. The directional coupler coupling coefficients were matched with the gain of the optical amplifier to produce a monotonic response of the fiber lattice accumulator. Experimental results for the sigma-delta architecture were taken. Correct accumulation in the fiber lattice was not achieved since the linewidth of the laser diode was too broad. In addition, the need for a piezo-electric transducer for adaptively adjusting the optical cavity length was identified.

PROJECT SUMMARIES

PUBLICATION:

Pace, P.E., Bewley, S.A., and Powers, J.D., "Fiber Lattice Accumulator Design Considerations for Optical Sigma-Delta Analog-to-Digital Converters," *Optical Engineering*, Vol. 39, No. 6, June 2000, pp. 1517-1526.

PRESENTATION:

Gillespie, W.U., Powers, J.P., and Pace, P.E., "Design and Experimental Evaluation of an Integrated Optical Sigma-Delta Modulator for Wideband Digital Antennas," presented at the DARPA/MTO 2000 RF Lightwave Integrated Circuits, Cincinnati, OH, 16 October 2000.

DoD KEY TECHNOLOGY AREAS: Sensors

KEYWORDS: Sensors, Sigma-Delta, Sampling, Electro-Optic, Photonics, Electronics

ELECTRONIC WARFARE ADVANCED TECHNOLOGY STUDIES

R. Clark Robertson, Professor

Ron Pieper, Visiting Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Air Warfare Center-Aircraft Division and Naval Postgraduate School

OBJECTIVE: The objective of this project was to determine the conditions for which the aim-point of an infrared (IR) missile on a "hot" aircraft is on a location other than the hot metal parts of the engine and the effect this variation in aim-point has on IR countermeasures (IRCM) effectiveness.

SUMMARY: Aircraft survivability under conditions of a missile attack depends to a large extent on the tracking performance of the missile. Because the missile tends to track on and aims for the "hottest" part of the target within the unobscured field-of-view (FOV), tracking performance depends on the angle of the attack. Missiles characterized by having a spatially discriminating detection system, typically based on reticule detection technology, automatically introduce aim-point sensitivity into the tracking process. The aim-point of a missile threat on a targeted aircraft changes as functions of both the aspect of attack and the FOV of the missile detection system. This raises a practical point of query. Under what conditions, if any, will the aim point move from the rear hot metal parts and plume to, for example, the nose of the plane, and what is the effect of this change in aim-point on the optimum employment of IRCM? This information is relevant to the design of effective flare countermeasures. The effectiveness of flare countermeasures depends on a number of factors, including the aim-point of the missile on the target and the relationship of the aim-point to the deployment location of IRCM.

PRESENTATION:

DeLeo, N.C., Pieper, R., and Robertson, C., "Infrared Missile Aim-Point Modeling and Flare Countermeasure Effectiveness," presented at PMA-272, Patuxent River, MD, 6 June 2000.

THESIS DIRECTED:

DeLeo, N.C., "Infrared Missile Aim-Point Modeling and Flare Countermeasure Effectiveness," Masters Thesis, Naval Postgraduate School, June 2000.

DoD KEY TECHNOLOGY AREAS: Electronic Warfare

KEYWORDS: Electronic Countermeasures, IR Countermeasures, IR Signature Reduction, IR Sensors

PROJECT SUMMARIES

MISSILE AIM-POINT SENSITIVITY

R. Clark Robertson, Professor

Ron Pieper, Visiting Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Air Warfare Center-Aircraft Division and Naval Postgraduate School

OBJECTIVE: The objective of this study is to continue and elaborate on the aim-point study previously performed on the F15E using the F/A-18-E/F as a platform. The behavior of the aim-point of an IR missile can be simulated using a program developed by SAIC for the F15E aim-point study. Various questions addressed in the previous aim-point study will again be addressed, but the focus in this study will be on the F/A-18-E/F aircraft.

SUMMARY: Aircraft survivability under conditions of a missile attack depends to a large extent on the tracking performance of the missile. Through the use of computer programs such as MOSAIC and SPIRITS, various aspect dependent scenarios will be studied. The SPIRITS package allows for full imaging information at the seeker. The dependence of the aim-point on conditions such as aspect and aircraft signature levels, both with and without IRCM, will be examined. At least three surface-to-air missile threats, the Stinger Basic, the SA16, and the SA18, will be tested with the F/A-18-E/F. In addition, selected air-to-air missiles will also be tested with the F/A-18-E/F. A check will be made to determine if the aim-point is sensitive to the aspect angle between missile and aircraft and the effect of IRCM as a function of aim-point. A preselected combination of ranges and aspects will be used to define the initial experiment under typical operating conditions taken between minimum rated thrust and afterburner without IRCM. The aim-point during the flyout and chase scenario will be monitored as well as the aim-point for the initial lock-on. We will then examine the effectiveness of IRCM for various dispense locations. For example, if IRCM is dispensed with the intent of defeating a missile aimed at the engine or plume, but the missile is actually aimed at the aircraft nose, what is the effect on IRCM as compared with IRCM designed to be in the field-of-view (FOV) of the missile aim-point? Also examined will be missile range effects as a function of the threat FOV.

This project is new for FY01, but is likely to be canceled prior to completion due to the lack of support for this research by the IW curriculum.

DoD KEY TECHNOLOGY AREAS: Electronic Warfare

KEYWORDS: Electronic Countermeasures, IR Countermeasures, IR Signature Reduction, IR Sensors

EVALUATION OF CLASSIFICATION ALGORITHMS

Charles W. Therrien, Professor

Tri T. Ha, Professor

Department of Electrical and Computer Engineering

Sponsor: National Security Agency

OBJECTIVE: Develop methodology for testing of signal classification algorithms.

SUMMARY: This work continued in 2000 with the focus on testing the Higher-Order Cyclostationary-Based Classifier (HBC). One student performed comprehensive testing on the classification performance of several types of digital modulated signals. A follow-on student focused on a particular problem area (BPSK) and performed further testing and analysis.

THESES DIRECTED:

Cadenazzi, M.P., "Performance Analysis of the Higher-Order Cyclostationary-Based Classifier," Masters Thesis, Naval Postgraduate School, March 2000.

Bailey, B.K., "Performance and Space Borne Application Analysis of the Higher-Order Cyclostationary-Based Classifier," Masters Thesis, Naval Postgraduate School, December 2000.

PROJECT SUMMARIES

DoD KEY TECHNOLOGY AREAS: Other (Signal Processing)

KEYWORDS: Signal Classification, Higher Order Cyclostationarity

BEARTRAP POST-MISSION ANALYSIS SYSTEM

Murali Tummala, Professor

Charles W. Therrien, Professor

LCDR Robert Barsanti, USN, Military Instructor

Department of Electrical and Computer Engineering

Sponsor: Air Anti-Submarine Warfare Systems Program Office (PMA-264D)

OBJECTIVE: To design and develop a signal processing system capable of implementing narrowband frequency tracking, multi-target tracking, wideband and related processing, time-domain analysis, and data fusion for Beartrap post-mission analysis. The system is known as S2K (for System 2000).

SUMMARY: Focus this year was on delivering a final product to the sponsor. A beta-zero version of S2K was delivered to the sites this year. We expect to phase out the project in year 2001 with the final delivery of the system. During 2000, an HTML help system was developed to provide online help for the S2K system. In a software engineering effort, the EMST tracker was redesigned at a schematic level to develop an object-oriented architecture. The focus of this effort was to provide a means for compensating the tracker solution for biases introduced by drifting sonobuoy sensors. Towards this goal, a model of the expected sensor motion was developed and the parameters of this model were estimated using the same Maximum A-Prior (MAP) algorithm that estimates the target motion. Further studies on the estimation and discrimination of time delay of arrival were undertaken.

PUBLICATIONS:

Barsanti, R., Tummala, M., and Therrien, C., "Enhanced Multi-Segment Tracker," Naval Postgraduate School Technical Report, NPS-EC-00-009, 3 July 2000.

Barsanti, R. and Tummala, M., "Passive Target Tracking with Uncertain Sensor Positions," *Proceedings 34th Asilomar Conference on Signals, Systems, and Computers*, Pacific Grove, CA, 29 October-1 November 2000.

THESES DIRECTED:

Tidwell, B.S., "Toward an Object Oriented Architecture for the Enhanced Multi-Segment Tracker (EMST)," Masters Thesis, Naval Postgraduate School, March 2000.

McCabe, E.D. and Stone, C.D., "Development of the Beartrap Post Mission Processing System 2000 (S2K) HTML Help Project," Masters Thesis, Naval Postgraduate School, June 2000.

Bennett, G.H., "Acoustic Transient TDOA Estimation and Discrimination," Masters Thesis, Naval Postgraduate School, September 2000.

OTHER:

A beta version of the software was delivered to multiple Beartrap sites in Summer 2000 and Version 1.0 of the software is scheduled for release during the Spring quarter of 2001.

DoD KEY TECHNOLOGY AREAS: Sensors, Computing and Software, Human Systems Interface, Other (Signal Processing)

KEYWORDS: Signal Processor Design, Acoustic Signal Processing, Graphical User Interface Design

PROJECT SUMMARIES

WIRELESS NETWORKS FOR MOBILE AD HOC ENVIRONMENTS

Murali Tummala, Professor

Department of Electrical and Computer Engineering

Sponsor: Space and Naval Warfare Systems Command

OBJECTIVE: To develop graduate level course materials for wireless networks with emphasis on software defined radio principles and in support of the digital modular radio program. As part of the work, also investigate the mobile ad hoc routing protocols for use in the DMR program.

SUMMARY: The effort to develop materials for a course on wireless networks and software-defined radio is ongoing. There are no textbooks available. Also, the materials are spread among several areas of specialty: wireless engineering, networking, software engineering, radio engineering, and signal processing. During the course of development of the course materials, we investigated the routing protocols for mobile ad hoc networks: zone routing protocol and adaptive on-demand distance vector protocol.

PUBLICATION:

Shea, K.M., Ives, R., and Tummala, M., "Performance Evaluation of the Zone Routing Protocol for Tactical Wireless Networks," Proceedings 34th Asilomar Conference on Signals, Systems and Computers, Pacific Grove, CA, November 2000.

THESES DIRECTED:

Shea, K.M., "Simulation and Performance analysis of the Zone Routing Protocol for Tactical Mobile Ad Hoc Networks," Masters Thesis, Naval Postgraduate School, September 2000.

Theriot, T.P., "Simulation and Performance Analysis of the Ad Hoc On-demand Distance Vector Routing Protocol for Tactical Mobile Ad Hoc Networks," Masters Thesis, Naval Postgraduate School, December 2000.

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications, Computing and Software

KEY WORDS: Ad-hoc Wireless Networks, Software Defined Radio, Joint Tactical Radio System, Digital Modular Radio

ULTRA WIDEBAND ELECTROMAGNETIC MEASUREMENTS/

ULTRA WIDEBAND ANTENNA DEVELOPMENT

Capt J. Scott Tyo, USAF, Military Instructor

Department of Electrical and Computer Engineering

Sponsor: Air Force Research Laboratory

OBJECTIVE: To develop sensors and measurement strategies for use in ultra-wideband (UWB) microwave measurements, and to develop antennas for transmitting short-pulse signals.

SUMMARY: UWB electromagnetics involves the generation and radiation of electromagnetic transients on the order of 100 picoseconds in duration. These signals have instantaneous bandwidths of more than two decades. Conventional sensors and deconvolution strategies do not work with such large bandwidth signals. Under this project, several novel sensors were developed that minimize the need for deconvolution. These sensors work by optimizing their responses in the time domain, ignoring late-time effects that occur after the measurement of interest is over. In this way, the sensor can be used with almost no correction for short times. To help with the development of sensors and antennas for these applications, a study of the effect of aperture shape on antenna performance was also conducted.

PROJECT SUMMARIES

PRESENTATIONS:

Tyo, J.S., "Optimal Feeds for 4-Arm IRAs, Ultra-Wideband, Short-Pulse Electromagnetics," presented at EUROEM 2000, Edinburgh, Scotland, 1-3 June 2000.

Tyo, J.S. and Buchenauer, C.J., "Compact Sensors for Time-Domain Measurements," presented at EUROEM 2000, Edinburgh, Scotland, 1-3 June 2000.

DoD KEY TECHNOLOGY AREAS: Sensors, Directed Energy Weapons

KEYWORDS: Ultra-Wideband Electromagnetics, UWB Metrology

ULTRA-WIDEBAND ANTENNA ARRAY ANALYSIS

Capt J. Scott Tyo, USAF, Military Instructor

Department of Electrical and Computer Engineering

Sponsor: Center for Reconnaissance Research

OBJECTIVE: Investigate the design of ultra-wideband (UWB) array antennas for use in time-domain and broadband CW applications, including the development of concepts for dual-polarization capable UWB arrays. Validate modeling studies with experimental analysis of prototype arrays

SUMMARY: The initial phase of the investigation involved numerical analysis of candidate UWB array elements for beam shape characteristics. The analysis was completed using the finite-difference time domain computational electromagnetics method and the results compared favorably with experimental studies conducted previously. Small arrays of TEM horns were analyzed both numerically and experimentally, and the performance of the elements in and out of arrays was comparable. The steer ability of timed arrays was experimentally demonstrated in receiving mode for small collections of elements. Future work in this effort will include analysis of dual-polarization elements, time-domain beam forming, and element-to-element interactions.

THESIS DIRECTED:

Rutherford, S., "Combat Systems, Use of UWB Radar for Human Heart and Respiration Rate Localization," Masters Thesis, Naval Postgraduate School, June 2001.

DoD KEY TECHNOLOGY AREAS: Sensors, Directed Energy Weapons

KEYWORDS: Ultra-Wideband Array Antenna, UWB, Dual Polarization

POLARIMETRIC IMAGERY FOR REMOTE SENSING

Capt J. Scott Tyo, USAF, Military Instructor

Department of Electrical and Computer Engineering

Sponsor: Unfunded

OBJECTIVE: To improve the design of optical imaging polarimeters by maximizing SNR and minimizing the effect of experimental uncertainty.

SUMMARY: Imaging polarimetry requires simultaneous measurement of polarimetric information at as many as 10^6 pixels across a scene. The fewer measurements that are necessary to reconstruct the angle, degree, and ellipticity of polarization, the more suitable the method is for real-time applications. However, making fewer measurements increases susceptibility to detection noise and systematic errors associated with optical element misalignment and miscalibration.

The optimal polarimeter configurations for rotating compensator and variable retardance polarimetry were derived under this project. By choosing appropriate measurement strategies, SNR in reconstructed

PROJECT SUMMARIES

images could be improved by as much as 15 dB without improving the quality of the optics used to make the measurement. Additionally, the effect of element misalignment was quantified, and strategies to mitigate these effects were developed.

PUBLICATIONS:

Tyo, J.S., "Noise Equalization in Stokes Parameter Images Obtained Using Variable Retardance Polarimetry," *Optical Letter* 25, pp. 1198-1200 (2000).

Tyo, J.S., "Improvement of the Point-Spread Function in Scattering Media by Polarization Difference Imaging," *Journal of the Optical Society of America* 17, pp.1-10 (2000).

Tyo, J.S., "Considerations in Polarimeter Design," *SPIE* Vol. 4133 Polarization Measurement and Analysis III, D.B. Chenault, M.J. Duggin, W.G. Egan, and D.H. Goldstein, eds., pp. 65-74, *SPIE*, Bellingham, WA, 2000.

DoD KEY TECHNOLOGY AREAS: Sensors

KEYWORDS: Polarimetry, Polarimetric Imagery, Remote Sensing

SILVACO TOOLS DEVELOPMENT FOR RADIATION EFFECTS

Todd Weatherford, Assistant Professor

Andrew Parker, Research Associate

Department of Electrical and Computer Engineering

Sponsor: Naval Surface Warfare Center-Crane

OBJECTIVE: To develop semiconductor simulation tools to improve modeling of radiation effects in semiconductor devices.

SUMMARY: Work in 2000 has focused on modeling recombination effects in Metal-Oxide-Semiconductor structures and charge trapping in buried oxides. Results in the MOS structure simulations correlated to charge yield in oxide layers, but correlation was poor for recombination in silicon regions. Buried oxide simulations continued to model multi-edge SOI MOSFETs for back channel leakage. Effort discovered limitations in the oxide transport models which was later corrected.

THESES DIRECTED:

Gaskey, G., "Transient Response to Single Event Upset in Silicon-on-Insulator Field Effect Transistors," Masters Thesis, Naval Postgraduate School, March 2000.

Lake, V., "Modeling Total Dose Radiation Effects in a Multi-Edge SOI MOSFET," Masters Thesis, Naval Postgraduate School, December 2000.

DoD KEY TECHNOLOGY AREAS: Electronics, Materials, Processes and Structures, Modeling and Simulation, Other (Silicon-on-Insulator)

KEYWORDS: Solid-State Electronics, Semiconductors, Radiation Hardening

PROJECT SUMMARIES

TIME RESOLVED SINGLE EVENT EFFECT STUDIES IN SOI

Todd Weatherford, Assistant Professor

Andrew Parker, Research Associate

Department of Electrical and Computer Engineering

Sponsor: Air Force Research Laboratory

OBJECTIVE: To measure single event transients in very high speed digital circuits fabricated with silicon on insulator (SOI) technologies with ion and laser facilities. The picosecond transients will be compared to circuit and device simulations.

SUMMARY: SOI circuits fabricated in MIT Lincoln Laboratory's 0.25um and 0.11um semiconductor process were measured at University of Michigan's Center for Ultrafast Science utilizing their in-situ photoconductive probe and lasers. These results are the first sub nanosecond charge collection measurements on silicon MOSFET devices utilizing photoconductive sampling measurements. Measurements have been limited to discrete devices due to difficulty obtaining specific circuit designs to measurement signals within integrated circuits. Circuit simulations were performed to predict temporal measurements.

PUBLICATION:

Weatherford, T.R., Whitaker, J.F., and Keast, C., "In-situ Time-Resolved Voltage Transients Measured in CMOS/SOI Inverters," submitted to the IEEE Natural Space and Radiation Effects Conference, July 2001.

DoD KEY TECHNOLOGY AREAS: Electronics, Modeling and Simulation, Space Vehicles

KEYWORDS: Silicon-on-Insulator, Single Event Upsets, Picosecond Transients, SOI, SEU

NEUTRON SINGLE EVENT EFFECT STUDIES

Todd Weatherford, Assistant Professor

Andrew Parker, Research Associate

Department of Electrical and Computer Engineering

Sponsors: Navy Strategic Systems Program Office

OBJECTIVE: Initially to examine semiconductor device degradation effects related to neutron irradiation, redirected to study radiation effects on photo detectors.

SUMMARY: Investigated the variance in photo detector responsivity in InGaAs diodes to displacement damage. Radiation tests were performed at UCB's cyclotron and NPS' LINAC. Results showed the commercially available photo detectors were unacceptable for mission requirements. Device modeling, simulation and destructive analysis was performed to understand the failure mechanisms.

THESIS DIRECTED:

Kalowsky, J., "Radiation Effects in InGaAs P-I-N Photodiodes," Masters Thesis, Naval Postgraduate School, December 2000.

DoD KEY TECHNOLOGY AREAS: Electronics, Materials, Processes and Structures, Modeling and Simulation

KEYWORDS: Semiconductors, Opto-Electronics, Radiation Effects, Indium Gallium Arsenide

PROJECT SUMMARIES

HIGH PERFORMANCE SEI DEMONSTRATION Lonnie A. Wilson, Research Associate Professor Department of Electrical and Computer Engineering Sponsor: National Reconnaissance Office

OBJECTIVE: To support Specific Emitter Identification (SEI) data collection and initiate software code development using SEI DSP algorithms for the High Performance SEI Processor Demonstration.

SUMMARY: Key MOP (Modulation On Pulse) SEI deficiencies were identified. In an unclassified form, current SEI deficiencies include:

- Limited performance against radars with modern modulations. Current techniques cannot handle important emitters that contain small MOP signals from fundamental accuracy limitations, SNR limitations and other factors.
- Average SEI rate ~ XX% (unsatisfactory!) and requires high SNR conditions and pulse averaging for even conventional radars.
- SEI not performed at low SNR conditions.
- Current SEI Database limited by signal -selection, signal fidelity and data processing accuracy, and contains mostly navigation radars with few modern modulation radars. Also, database transportability, from platform to platform, is an issue.
- Current SEI system uses architecture and design developed 20 years ago with some technology improvements.
- Tonal interferences (internal and external) strictly limit current SEI system performance.
- A SEI system based on precision parameter measurements of conventional Radar parameters will not handle Modern Modulation Radars because of agile parameter conditions. Emitter ambiguities and ID errors cannot be resolved with these conventional techniques.

Enemy radar systems and targeting systems utilize coherent radars with modern modulations (frequency agility, PRF agility and other), that our ELINT systems need to defeat or neutralize in conventional military and peacekeeping missions. High Performance SEI techniques must effectively process these radar emitters on a single pulse basis. Also, unambiguous ID of radars associated with civil targets is an increasingly important element of counter-terrorism.

Emitters with modern modulations (agile frequency, agile PRF or PRI, nearly identical classical parameters, frequency coded, phase coded, etc.) are not effectively processed by current techniques. In particular, ELINT systems utilizing classical parameters for sorting and SEI/ID functions are very successful against radars with fixed classical parameters, but have limited success against radar emitters with modern modulations.

Navy EW and ELINT systems have known SEI performance limitations. For example, the Navy JETS Program has identified critical performance limitations, which include ambiguities and SEI/ID deficiencies, as well as problems with unacceptable incidents of fratricide, poor ID performance at low SNRs, lower than desired platform survivability, and operating range performance limitations.

The proposed High Performance SEI Processor will overcome key SEI problems and have the following characteristics:

- Uniquely identify modern radar systems with complex modulations and agile parameter variations that cannot be handled with current SEI techniques.
- Improve SEI rates at lower SNR conditions and use single pulse processing. Tonal interferences will not significantly degrade performance.

PROJECT SUMMARIES

- Provide unambiguous ID of civil platform radars of high interest.
- SEI Database is transportable from platform to platform.
- SEI cards will utilize, as much as possible, economical COTS hardware and software technologies.
- Reduce friendly fratricide incidents for a variety of peacetime and wartime scenarios.

SEI technical performance demonstrations were performed using radar emitter collected by the Naval Research Laboratory. DSP algorithms and software were developed for SEI processing and to establish ground truth on the contaminated NRL database. SEI assessments were performed.

In an unclassified summary, DSP SEI results were above 90% correct ID and exceeded SNR performance expectations by at least 3 dB. All project performance goals were exceeded. The sponsor is continuing this work in FY01 for ELINT deinterleavers.

THESIS DIRECTED:

Free, M., "Performance Assessment of an Intrapulse Technique to Identify and Deinterleave Radar Signals," Master's Thesis, Naval Postgraduate School, December 2000.

DoD KEY TECHNOLOGY AREAS: Sensors, Other (Targeting)

KEYWORDS: SEI, ID, RF Receiver, MOP Signal Extraction, Parameter Extraction

**CURRENT AND PROPOSED DATALINKS FOR
NAVAL AVIATION TIME CRITICAL STRIKE
Lonnie A. Wilson, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Chief of Naval Operations (N88)**

OBJECTIVE: The objective is to survey and assess current and proposed datalinks for Naval aviation time critical strike.

SUMMARY: Network Centric Warfare requires target information and data flow from sensors to command and control centers for decisions and then target information and data flow to shooters in a timely fashion for successful military strike operations. Datalinks can provide RTIC (Real Time Information to the Cockpit) strike information and paths for target information and data flow capabilities between sensor platforms, command platforms and shooter platforms. Broadcast modes, if implemented, can shorten RTIC time line.

Datalink capabilities, limitations (to include data throughput and transmission ranges), availability and deficiencies will be determined for Navy assets (surveillance, maritime patrol and fighter aircraft, ship and unmanned aircraft), joint assets, and national assets. Current and proposed datalinks considered are:

1. Air to ship data links – for E-2C, EA-6B, F/A-18, F-14, P-3, S-3, EP-3, unmanned aircraft, UAVs, ships and others
2. Air to air data links – between air platforms
3. Joint data links – between air and surface platforms
4. National data links – overhead to surface and air platforms
5. Link 16 / JTIDS for all of the above.

Datalink information is obtained from Navy / contractor product developers. Link 16 / JTIDS, as well as, Link 11, Link 4, CEC, CDL, TCDL, AWW-13, IDM Modem, FTI and other new datalinks are being considered.

PROJECT SUMMARIES

Link-16 Datalink information was summarized in a "handbook" format for reference use. Link-16 Datalink information was submitted for sponsor review in December 2000. Other datalink information will be added to the handbook in FY01.

DoD KEY TECHNOLOGY AREAS: Other (Communications)

KEYWORDS: Sensors, Datalinks, IW, Command and Control Centers, Shooters and Network Centric Warfare, Strike, Surveillance, Communications

AEA AIRCHITECTURE AND PLATFORM MIXES

Lonnie A. Wilson, Research Associate Professor
Department of Electrical and Computer Engineering
Sponsor: Naval Air Systems Command

OBJECTIVE: The objective is to perform top-level analysis of AEA (Advanced Electronic Attack) Architecture and Platform Mixes and identify key capabilities and needs to support the OSD AEA EA-6B follow-on studies.

SUMMARY: Expected EA-6B service life is through 2015 – 2020 requiring a follow-on platform or platform mix to the ICAP III upgrade expected to IOC in 2004. These efforts will use the EA-6B ICAP III as a baseline to build a future Electronic Attack (EA) capability to accomplish the SEAD role and other Information Operation missions. This core tactical capability includes radar jamming, communication jamming, hard-kill capabilities, and connectivity to ISR and off board assets. The expected result will be a platform mix utilizing available technology to develop a system of systems to provide future EA capabilities.

AEA candidate air vehicles can be manned or unmanned, performing either the dedicated AEA role or having AEA capability as part of their multi-mission capability. The nature of AEA support requires detailed knowledge of the supported air, ground and sea forces and emerging warfighter concepts in Information Operations (IO).

The fundamental goal of the AEA is to find the most mission capable, cost effective solution to tactical aviation requirements for electronic warfare (EW) support. The initial requirement is driven by the necessity to replace an aging EA-6B airframe.

The architecture and preliminary design were completed for a digital ES (Electronic Support) receiver and processor for the AEA application. Technical performance improvements and new operational performance capabilities were identified. The AEA Technical Working Group has agreed to develop the digital EC receiver along with high performance DSP with Specific Emitter Identification. NPS participated and supported the AEA Technical Working Group, the Digital Receiver Focus Group and the SEI Focus Group.

A new digital match filter concept was developed and demonstrated for the high performance detection and processing of LPI radar signals. This new LPI Receiver and DSP processing gain exceeded 36 dB for an LPI signal with 38 dB. Conventional EW receivers would have little or no capability against this LPI emitter.

THESIS DIRECTED:

Christie, K., "Low Probability of Intercept Radar Detection Techniques for Advanced Electronic Support Systems," Masters Thesis, Naval Postgraduate School, September 2000.

DoD KEY TECHNOLOGY AREAS: Electronic Warfare

KEYWORDS: EW, EA, Architecture, F-18G, UAV, UCAV, IW, Radar, Strike, and Surveillance

PROJECT SUMMARIES

WIRELESS DAMAGE CONTROL COMPUTER NETWORKS

Xiaoping Yun, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Sea Systems Command

OBJECTIVE: To test and evaluate data rate, range, and interoperability of IEEE 802.11b compliant wireless LAN product components for submarine damage control communications.

SUMMARY: Wireless LAN components rated at 2 Mbps were used in the Memphis test conducted in August 1999. Since the Memphis test, wireless LAN components rated at 11 Mbps were made available by Lucent and Aironet in the fourth quarter of 1999. This project conducted testing of 11 Mbps WLAN components on the campus at the Naval Postgraduate School (NPS) in Monterey, California. The actual measured throughput of both the Lucent Technologies WaveLAN Turbo and the Aironet Turbo DS components rated at 11 Mbps was 2.0 to 4.5 Mbps depending on test condition. Even though the actual data rates were discouraging when compared to the specification rates of 11 Mbps, there is a more than 100% increase in data rates when compared to the previous generation of products rated at 2 Mbps. The actual range measurements were in line with those specified by vendors.

THESIS DIRECTED:

McConnell, R.J., "Testing and Evaluation of Shipboard Wireless Network Components," Masters Thesis, Naval Postgraduate School, March 2000.

OTHER:

Yun, X., "Test and Evaluation of 11 Mbps Wireless LAN Components," project report submitted to NAVSEA PMS450T2, March 2000.

Yun, X., "Submarine Wireless LAN (SWLAN) Project Overview," presented to Commander Submarine Force, U.S. Atlantic Fleet, Norfolk, VA, April 2000.

Yun, X., "Software Prototyping for DC Communication Applications," project report submitted to NAVSEA PMS450T2, September 2000.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications

KEYWORDS: Damage Control, Wireless Computer Networks

MOTION TRACKING USING INERTIAL SENSORS

Xiaoping Yun, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Chief of Naval Operations (N6) and U. S. Army Research Office

OBJECTIVE: To develop a hybrid inertial/magnetic body tracking system for use in a networked virtual environment.

SUMMARY: As an off-shoot of our previous effort on autonomous underwater (AUV) inertial navigation system research, a hybrid inertial/magnetic body tracking system for use in a networked virtual environment was initiated. Toward this goal, a quaternion-based attitude filter based upon Gauss-Newton iteration and an orthogonal quaternion theorem was developed. This filter continuously corrects for drift and tracks without singularities. Simple, but effective algorithms for calculating sensor null points and scale factors and for determining the limb segment/sensor offsets have also been devised. These offsets allow efficient animation of a human model using world reference orientation data in quaternion form. Differential weighting of sensor data reduces the effects of magnetic field disturbances. In experiments, arms, legs, and the human torso have been tracked in real-time using an inertial/magnetic body tracking

PROJECT SUMMARIES

system, which includes three prototype MARG sensors. Preliminary simulation work has also been completed on a reduced order Kalman filter designed for body tracking.

PUBLICATION:

Yun, X., Backmann, E.R., and Arslan, S., "An Inertial Navigation System for Small Autonomous Underwater Vehicles," *Proceedings of 2000 IEEE International Conference on Robotics and Automation*, San Francisco, CA, 24-28 April 2000, pp. 1781-1786.

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DoD KEY TECHNOLOGY AREAS: Sensors

KEYWORDS: INS, GPS, AUV, Navigation Kalman Filter

REDUCED CREW SIZE METEROLOGY USING WIRELESS LANs AND WEARABLE PCs

Xiaoping Yun, Associate Professor

Department of Electrical and Computer Engineering

Sponsor: Naval Warfare Assessment Center

OBJECTIVE: To investigate the Reduced Crew Size (RCS) Metrology using WLANs and wearable computers.

SUMMARY: Working with the Measurement Science Directorate (MSD) of the Naval Warfare Assessment Station (NWS), feasibility of developing a general-purpose calibration system using wearable computers and wireless LANs was studied. In particular, a prototype of pressure calibration system has been developed. The prototype system was demonstrated at NAVSEA Philadelphia on 19-21 September 2000 and was well received by the NAVSEA Philadelphia staff.

DoD KEY TECHNOLOGY AREAS: Sensors

KEYWORDS: Metrology, Wireless LAN, Wearable Computer

EVALUATION OF DEINTERLEAVER ALGORITHMS

Lawrence J. Ziomek, Professor

Department of Electrical and Computer Engineering

Sponsor: National Security Agency

OBJECTIVE: In order for the Naval Postgraduate School (NPS) Cryptologic Research Laboratory (CRL) to create it's own "generic testing environment" so that it can independently evaluate the effectiveness of various pulse-train deinterleaver algorithms, it is necessary to develop mathematical models and computer simulations of waveforms that are due to the superposition (interleaving) of N different, transmitted pulse trains at a receiver. The capability to model and generate computer simulated data is very important because it will provide the NPS CRL with the "correct answers" necessary to evaluate various pulse-train deinterleaver algorithms, and to gain insight as to which currently existing measures of effectiveness (MOE) are best, or if new MOE need to be formulated.

PROJECT SUMMARIES

SUMMARY: General time-domain and frequency-domain mathematical models for N different transmitted pulse trains have been derived. Each pulse train is allowed to have its own number of pulses, carrier frequency, and total duration. In addition, each pulse within a given pulse train is allowed to have different amplitude scaling factors, amplitude-modulating and angle-modulating functions, and pulse lengths if desired. Furthermore, the pulse-repetition interval (PRI) for a given pulse train may be equal to a constant or it may vary according to some equation. General time-domain and frequency-domain mathematical models for the random received signal have also been derived. The received signal is modeled as being equal to the superposition (interleaving) of N different, transmitted pulse trains. Each individual pulse within a given received pulse train is allowed to have its own time delay, Doppler shift, random amplitude, and random phase. Work also began on studying in detail two new pulse-train deinterleaver algorithms that appeared very recently in the open literature. The first algorithm computes what I refer to as the interleaved-pulse-train (IPT) time-of-arrival (TOA) spectrum and the second algorithm computes what I refer to as the interleaved-pulse-train (IPT) cross-correlation detector (CCD) function. Both algorithms claim to be able to provide estimates of the total number of emitters (individually transmitted pulse trains) present in an IPT measured at a receiver, and estimates of the corresponding PRIs by only processing the time-of-arrivals (TOAs) of the individual pulses. Both algorithms claim to be able to handle staggered as well as uniform pulse trains. Four FORTRAN computer programs were also written. The first program generates computer simulated time-series data corresponding to an IPT measured at a receiver. The second program can generate either TOA data only, corresponding to each pulse in an IPT measured at a receiver, or pulse parameter vectors (pulse descriptor words) for an IPT measured at a receiver. At present, each pulse parameter vector contains the following information: 1) type of amplitude modulation used, 2) type of angle modulation used, 3) center frequency, 4) pulse amplitude, 5) TOA, 6) pulse length, 7) phase shift (if PSK is used), 8) frequency shift (if FSK is used), 9) swept bandwidth (if LFM is used), and 10) either up-chirp or down-chirp information (if LFM is used). The third and fourth computer programs compute the IPT TOA spectrum and the IPT CCD function, respectively, by processing TOA data.

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Ziomek, L.J., "A Mathematical Model of Interleaved Pulse Trains," Naval Postgraduate School, ECE Department, Cryptologic Research Laboratory, 3 March 2000, 24 pp.

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Ziomek, L.J., "An Initial Review of the Interleaved-Pulse-Train Cross-Correlation Detector Function," Naval Postgraduate School, ECE Department, Cryptologic Research Laboratory, 26 September 2000, 13 pp.

Four FORTRAN computer programs were written

DoD KEY TECHNOLOGY AREAS: Electronic Warfare, Modeling and Simulation

KEYWORDS: Interleaved Pulse Trains, Pulse-Train Deinterleaver Algorithms, Measures of Effectiveness

**DEPARTMENT OF
ELECTRICAL AND COMPUTER
ENGINEERING**

**2000
Faculty Publications
and Presentations**

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McEachen, J.C., OPNET SS7 message transfer part simulation models.

McEachen, J.C., Online.ECE WWW Course Portal: Established a consolidated course portal for EC web-based learning initiatives sponsored by COMSPAWARSYSCOM. This course provided a focal point for electronic course materials developed within the EC department. The development of the site was briefed to CINCPACFLT (ADM Clemens), COMSPAWARSYSCOM (ADM Gauss) and CNET (VADM Craine).

McEachen, J.C., NSA Distance Learning Remote Computer Facility: Installed and configured a system for Distance Learning students at the NSA to run EC computer assignments (MATLAB and OPNET) from their remote work center desktop by leveraging off research facilities locally. Facility included a WWW site for dissemination of class assignments, instructions, lecture notes, and software. To date the facility had been successfully used by students in EC4960 and EC3850. This was done at no cost to the government.

McEachen, J.C., EC4960 Course Materials WWW Server (<http://web.nps.navy.mil/~mceachen/ec4800/>): A resource containing complete collection of lecture notes, computer assignments, homework solutions, test keys, and software help manuals used to facilitate the instruction of EC4800. This was done at no cost to the government.

PUBLICATIONS/PRESENTATIONS

McEachen, J.C., EC3850 Course Materials WWW Server (<http://web.nps.navy.mil/~mceachen/ec3850/>): A resource containing complete collection of lecture notes, computer assignments, homework solutions, test keys, and software help manuals used to facilitate the instruction of EC3850. This was done at no cost to the government.

McEachen, J.C., EO3513 Course Materials WWW Server (<http://web.nps.navy.mil/~mceachen/eo3513/>): A resource containing complete collection of lecture notes, computer assignments, MATLAB code, frequently asked questions, homework solutions, test keys, and software help manuals used to facilitate the instruction of EO3513. This was done at no cost to the government.

McEachen, J.C., EC2010 Course Materials WWW Server (<http://web.nps.navy.mil/~mceachen/ec2010/>): A resource containing lecture notes, computer assignments, homework solutions, and test keys used to facilitate the instruction of EC2010. This was done at no cost to the government.

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Ziomek, L.J., "An Initial Review of the Interleaved-Pulse-Train Cross-Correlation Detector Function," Naval Postgraduate School, ECE Department, Cryptologic Research Laboratory, 26 September 2000, 13 pp.

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**DEPARTMENT OF
ELECTRICAL AND COMPUTER
ENGINEERING**

Thesis Abstracts

THESIS ABSTRACTS

TRANSIENT FIELD VISUALIZATION FOR ULTRA-WIDEBAND ANTENNA DESIGN

David V. Adamiak-Major, United States Marine Corps

B.S., United States Naval Academy, 1985

Master of Science in Electrical Engineering-December 1999

Advisor: Michael A. Morgan, Department of Electrical and Computer Engineering

Second Reader: R. Clark Robertson, Department of Electrical and Computer Engineering

Impulse antennas are specifically designed to transmit and/or receive very short bursts of electromagnetic energy. By their very nature, these short time-duration bursts (impulses) require ultra-wideband transmitting and receiving antennas. This thesis investigates a number of UWB antenna designs to determine their feasibility in receiving an impulse having a 1000:1 bandwidth (10 MHz to 10 GHz) with virtually no distortion.

As a tool in aiding the design of such an antenna, this thesis presents original software that was developed to visualize an impulse propagating in the near-field region of the antenna being considered. Such software will significantly reduce the workload and time required for antenna design and provide unique capabilities for heuristic understanding of the physics involved.

DoD KEY TECHNOLOGY AREA: Electronic Warfare

KEYWORDS: Impulse Antenna, Wideband Antenna, Ultra-Wideband, Near-Field, Software

AN ULTRA WIDEBAND ANTENNA WITH SIZE CONSTRAINTS

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Master of Science in Electrical Engineering-March 2000

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Second Reader: Richard Adler, Department of Electrical and Computer Engineering

Aircraft antennas for the low VHF frequency range are large and adversely affect aircraft aerodynamics. In order to reduce antenna size dielectric or ferrite cladding may be considered. Recent work on the properties of dielectric loaded antennas has suggested that some improvement in performance or reduction in size of an antenna can be achieved by coating it with a high-permittivity dielectric material. The objective here is to design a high power, ultra-wideband aircraft antenna operating in the frequency range from 30 MHz to 500 MHz with vertical polarization and omni-directional azimuth radiation pattern by employing dielectric cladding of metal antennas. An additional constraint is that the antenna's aerodynamic drag should be as low as possible. A number of antennas were successfully designed and simulated. The computer-predicted performance of these new designs surpasses the performance of the current antenna. The three best designs (occupying a larger volume than the current antenna) have VSWR less than 3 (relative to 50 ohms) from about 50 MHz to more than 500 MHz with the average VSWR of less than 1.5. In comparison, the current antenna can operate from about 140 MHz to 500 MHz with the VSWR < 3 and the average VSWR of about 1.9.

DoD KEY TECHNOLOGY AREAS: Air Vehicles, Sensors, Modeling and Simulation

KEYWORDS: Antennas, High Frequency Structure Simulator (HFSS)

THESIS ABSTRACTS

AMPLITUDE AND TEMPORAL JITTER ASSOCIATED WITH THE NPS ACTIVE MODE-LOCKED SIGMA LASER

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Master of Science in Applied Physics-June 2000

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Electro-optic techniques for analog-to-digital conversion (ADC) are being developed for wideband signal collection and analysis. They have the capability of being used for direct signal reception and ADC at an antenna. A fundamental requirement for these designs is a high-frequency optical pulse train with uniform amplitude and pulse spacing. A mode-locked fiber laser can provide pulse rates and pulsewidths suitable for these high bandwidth applications. In this thesis an accurate method for calculating and characterizing both the amplitude and timing jitters of the NPS active mode-locked sigma laser was designed and demonstrated. The method utilizes a wide bandwidth photodetector and a microwave spectrum analyzer to obtain data for analysis. Labview 4.0 software was used to extract and store the data displayed on the spectrum analyzer. Matlab 5.1 software was then used to analyze the Labview data and to perform calculations for the amplitude and temporal jitter. Measurements were made for a microwave sweep oscillator and a cw generator, then again with the fiber laser operating with each signal source. Final measurements were taken with variable laser diode pump powers by varying the controller currents. Results show that the calculation of the laser jitter is not dependent on the upper limit of the noise power integral calculation above 10 kHz; however, the jitter is highly dependent on the value of the lower frequency limit and decreases dramatically as the lower limit is increased. Laser amplitude jitter was found to decrease by 30% and timing jitter by 0.85 ps when the laser was operated with the cw generator instead of the sweep oscillator. Also, it was found that as pump power was increased, laser timing jitter decreased.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Mode-Locked Laser, Sigma Laser, Amplitude Jitter, Temporal Jitter

PROBABILITY OF SYMBOL ERROR FOR COHERENT AND NON-COHERENT DETECTION OF M-ARY FREQUENCY-SHIFT KEYED (MFSK) SIGNALS AFFECTED BY CO-CHANNEL INTERFERENCE AND ADDITIVE WHITE GAUSSIAN NOISE (AWGN) IN A FADING CHANNEL

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The probability of symbol error for coherent and non-coherent detection of M-ary frequency-shift keyed (MFSK) signals affected by other interfering MFSK signals (co-channel interference) and additive white Gaussian noise (AWGN) in a fading channel (Rayleigh and Rician models) is quantified in this thesis. First, theoretical expressions are derived for the symbol error probability as a function of the signal-to-noise ratio SNR and the signal-to-interference/jamming ratio SJR. Next, using SIMULINK and the MATLAB/SIMULINK Communications Toolbox, we develop models to determine the symbol error probability for Monte Carlo type simulations. Finally, we compare the theoretical symbol error probabilities with the simulation's results and identify the differences and their possible causes.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Computing and Software, Electronics Warfare, Modeling and Simulation

KEYWORDS: Communications, MFSK Coherent - Non-coherent Detection, Interference, AWGN, Fading Channel, Simulink

THESIS ABSTRACTS

TESTING AND EVALUATION OF THE SMALL AUTONOMOUS UNDERWATER VEHICLE (AUV) NAVIGATION SYSTEM (SANS)

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Master of Science in Electrical Engineering-March 2000

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Eric R. Bachmann, Department of Computer Science

At the Naval Postgraduate School (NPS), a small AUV navigation system (SANS) was developed for research in support of shallow-water mine countermeasures and coastal environmental monitoring. The objective of this thesis is to test and evaluate the SANS performance after tuning the filter gains through a series of testing procedures.

The new version of SANS (SANS III) used new hardware components which were smaller, cheaper, and more reliable. A PC/104 computer provided more computing power and, increased the reliability and compatibility of the system.

Implementing an asynchronous Kalman filter in the position and velocity estimation part of the navigation subsystem improved the navigation accuracy significantly. To determine and evaluate the overall system performance, ground vehicle testing was conducted. Test results showed that the SANS III was able to navigate within ± 15 feet of global positioning track with no global positioning update for three minutes.

DoD KEY TECHNOLOGY AREAS: Sensors, Surface/Under Surface Vehicles - Ships and Watercraft

KEYWORDS: INS, GPS, AUV, SANS, Navigation, Kalman Filter

ANALYSIS AND SIMULATION OF THE ADVANCED AMPHIBIOUS ASSAULT VEHICLE (AAAV) ELECTRICAL SYSTEM ARCHITECTURE

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The Advanced Amphibious Assault Vehicle (AAAV) is a high water speed amphibious armored personnel carrier that will replace the current family of Marine Corps amphibious assault vehicles. The AAAV is currently in Phase I of the DOD Acquisition Process. During this phase-extensive development, testing is being conducted and prototypes are being constructed. Ongoing tests of the current electrical system architecture are revealing problems and issues that need to be addressed. Present testing is also revealing the need for a troubleshooting tool that can be used to simulate and test proposed solutions.

A distributive computing effort is being conducted with Purdue University in order to provide the Marine Corps a tool where by it can test and evaluate the entire AAAV electrical system architecture. This document provides a general system description of the AAAV, an electrical system architecture overview, and a candidate electrical system description. Testing, modeling, and computer simulation efforts applied to the NBC (Nuclear, Biological, and Chemical) fan/filter motor drive and battery banks are described and the resulting data analyzed. Current research is investigating an issue regarding energy being forced back into the high power distribution bus due to regeneration from sudden impacts on the vehicle turret. An ultra capacitor bank may be incorporated in the AAAV electrical system in an effort to mitigate the effect of this regenerative energy. Therefore, testing, modeling, and computer simulation of an ultra capacitor is also reported.

DoD KEY TECHNOLOGY AREAS: Ground Vehicles, Modeling and Simulation

KEYWORDS: Advanced Amphibious Assault Vehicle (AAAV), ACSL, Simulation, Brushless DC Machine, Distributed Computing, Ultra-Capacitor

THESIS ABSTRACTS

EVALUATION OF RADIATION INDUCED HOLE TRAPPING MODEL FOR SIMULATING BACK-CHANNEL LEAKAGE CURRENT IN AN EDGELESS SOI nMOSFET

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Second Reader: Douglas J. Fouts, Department of Electrical and Computer Engineering

This thesis is part of a larger project that is attempting to address the decline of foundries producing radiation-hardened electronics for military space applications. The principal aim is to improve the radiation tolerance of commercial-off-the-shelf (COTS) electronics by developing wafer substrate designs that contain an SiO₂ isolation layer for Complementary Metal Oxide Semiconductor (CMOS) fabrication processes. It has been shown that this layer reduces single-event and dose-rate sensitivity. A manufacturer could then build radiation-tolerant commercial devices on these wafer substrates with little or no changes in the manufacturing process. This thesis contributes to the overall goal of substrate development by evaluating the performance of the Technology Computer Aided Design (TCAD) base hole trapping simulation in modeling back-channel leakage current caused by total dose irradiation after the addition of an initial charge density in the buried oxide (BOX).

DoD KEY TECHNOLOGY AREAS: Electronics, Modeling and Simulation, Other (Silicon-on-Insulator, Radiation Hardened)

KEYWORDS: Electronics, Silicon-on-Insulator, Modeling and Simulation, Radiation Hardened

ACOUSTIC TRANSIENT TDOA ESTIMATION AND DISCRIMINATION

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Master of Science in Electrical Engineering-September 2000

Master of Science in Engineering Acoustics-September 2000

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Murali Tummala, Department of Electrical and Computer Engineering

Kevin B. Smith, Department of Physics

This thesis examines acoustic transient discrimination and Time Difference of Arrival (TDOA) estimation for the purposes of estimating the position of a submarine in a sonabuoy field. Transient discrimination, for this thesis, is the process of telling different transients apart. Two algorithms are evaluated. One method is based on higher order statistics while the other is based on signal subspace techniques. Extensive simulations using synthetic transients were conducted to establish the performance of each algorithm in terms of discrimination and TDOA estimation. It was found that the bispectral algorithm gave better TDOA estimation at low SNRs while the subspace algorithm gave better TDOA estimation at high SNRs. For discrimination, it was found that the subspace algorithm gave constant false alarm rates at all SNRs while the false alarm rate for the bispectral algorithm grew with increasing SNR.

DoD KEY TECHNOLOGY AREAS: Sensors, Surface/Under Surface Vehicles - Ships and Watercraft, Modeling and Simulation

KEYWORDS: Transient, TDOA, Discrimination, Bispectrum, Subspace

THESIS ABSTRACTS

DOSE RATE RESPONSE OF COMMERCIAL-OFF-THE-SHELF RADIATION-HARDENED POWER MOSFETS AND SCHOTTKY DIODES

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Robert W. Ashton, Department of Electrical and Computer Engineering

Second Reader: Jeffrey L. Titus, Naval Surface Warfare Center-Crane

The off-state, dose rate response of several commercial-off-the-shelf radiation-hardened power MOSFETs manufactured by two corporations are reported over a wide range of operating voltages and dose rates. Data are presented for n-channel devices having different die sizes and devices having different rated breakdown voltages. The prompt photocurrent response of each MOSFET was recorded during exposure to a 20-ns radiation pulse of electrons from a linear accelerator at dose rates ranging from $1e8$ Rad(Si)/s to $4e11$ Rad(Si)/s. Tabulated agreement up to dose rates of $1e10$ Rad(Si)/s. Burnout was observed during the radiation pulse or shortly thereafter. The transient responses of several reverse-biased power Schottky diodes are also reported at similar dose rates. The experimentally measured photocurrent is found to be lower than anticipated. At high beam intensities on the order of 1×10^{11} Rad(Si)/s, several of the Schottky diodes are shown to exhibit catastrophic failure. Raw data waveforms of a power MOSFET are documented illustrating variations in the photocurrent pulses and failure modes.

DoD KEY TECHNOLOGY AREA: Radiation and Dose Rate Testing

KEYWORDS: Photocurrent, Dose Rate, Schottky

RECOVERY OF UNKNOWN CONSTRAINT LENGTH AND ENCODER POLYNOMIALS FOR RATE $\frac{1}{2}$ LINEAR CONVOLUTIONAL ENCODER

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It is sometimes useful to recover convolutionally encoded data without knowing the encoder parameters. The necessary first step is to recover these parameters so that a suitable decoder can be selected. In this study an attempt is made to recover the unknown constraint length K and the convolutional code polynomials for a feedback-free rate $\frac{1}{2}$ encoder from a received data stream. It will be shown that the output of such an encoder uniquely characterizes it and permits unambiguous identification of both K and the polynomials if the input data stream is sufficiently exciting and if the received encoded stream is both abundant and is free of transmission error.

The encoder output can be collected and collated in a manner that permits synthesis of an impulse response. Even though such an impulse input has not occurred, from the synthesized sequence one may derive the encoder parameters. The application of this synthetic impulse response algorithm with noisy data is then explored, and directions for further research are identified.

DoD KEY TECHNOLOGY AREA: Electronics

KEYWORDS: Encoder Parameters, Convolutional Code Polynomials

THESIS ABSTRACTS

A METHOD OF INCREASING THE KINEMATIC BOUNDARY OF AIR-TO-AIR MISSILES USING AN OPTIMAL CONTROL APPROACH

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Electrical Engineer-September 2000

Master of Science in Electrical Engineering-September 2000

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Current missile guidance laws are generally based on one of several forms of proportional navigation (PN). While PN laws are robust, analytically tractable, and computationally simple, they are only optimal in a narrow operating regime. Consequently, they may not optimize engagement range, time to intercept, or endgame kinetic energy. The advent of miniaturized high-speed computers has made it possible to compute optimal trajectories for missiles using command mid-course guidance as well as autonomous onboard guidance. This thesis employs a simplified six degree of freedom (6DOF) flight model and a full aerodynamic 6DOF flight model to analyze the performance of both PN and optimal guidance laws in a realistic simulation environment which accounts for the effects of drag and control system time constants on the missile's performance. Analysis of the missile's kinematic boundary is used as the basis of comparison. This analysis is immediately recognizable to the warfighter as an engagement envelope. The guidance laws are tested against non-maneuvering and maneuvering aircraft targets and against a simulation of a cruise missile threat. An application of the 6DOF model for a theater ballistic missile interceptor is presented.

DoD KEY TECHNOLOGY AREA: Aerospace Propulsion and Power

KEYWORDS: Missile Guidance Laws, Proportional Navigation, Optimal Control, Kinematic Boundary

TEST AND PERFORMANCE VERIFICATION FOR COMBAT WEAR INTEGRATED (COMWIN) COMMUNICATIONS ANTENNA

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Second Reader: Richard W. Adler, Department of Electrical and Computer Engineering

The Ultra-Wideband Radio Frequency Vest Antenna is the result of the research efforts to develop an antenna system to support the Joint Tactical Radio System (JTRS) currently being procured by the United States Department of Defense. The JTRS is an Ultra-Wideband radio system that is expected to operate in the 2 MHz to 2000 MHz frequency range. It is a frequency agile system that requires an equally responsive antenna system. Prior research conducted at the NPS has determined that the JTRS frequency range for a man-portable radio can be accommodated through the use of three separate antennas. The proposed frequency division: 2 to 30 MHz, 30 to 500 MHz, and 500 to 2000 MHz. This thesis concentrates on the performance of the Ultra-Wideband Radio Frequency Vest Antenna when operated with the AN/PRC-119A/D/F manpack radio (SINCGARS) and the Ultra-Wideband Radio Frequency Vest Antenna comparison to the standard SINCGARS manpack whip antenna.

DoD KEY TECHNOLOGY AREAS: Command Control and Communications, Electronics, Human Systems Interface

KEYWORDS: Antennas, Antenna Testing, COMbat Wear INtegration (COMWIN), SINCGARS Manpack Radio

THESIS ABSTRACTS

PERFORMANCE ANALYSIS OF THE HIGHER ORDER CYCLOSTATIONARY BASED CLASSIFIER

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Testing of the Higher Order Cyclostationary Based Classifier (HBC) is conducted to evaluate system operational performance. Utilizing Higher Order Cyclostationary (HOCS) analysis techniques the HBC is designed to automatically detect and classify communications and radar signals contained in input signal samples. While test results utilizing earlier data show a very effective system, a more rigorous test utilizing Agilent Inc.'s Advanced Design System (ADS) is herein carried out. Numerous modulation type samples were input with a variety of signal generation parameters. The results of the HBC analysis reveal a system which experiences difficulty in performing modulation detection and classification of the input data at moderate to high signal to noise ratios. Substantial improvement to the algorithm and interface appears to be required before operational implementation of this system is practical.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Cyclostationary, Cyclostationarity, Digital Signals, Signal Classification, Signals Intelligence (SIGINT)

INDOOR PROPAGATION SIMULATION SOFTWARE

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Computer simulation can be used to predict the signal strength in complex indoor environments. Signal propagation prediction is essential for determining the coverage of WLANs (Wireless Local Area Networks). Increasing use of WLANs within infrastructures that have been built prior to the installation of the wireless networks requires measurements, semi-empirical models, or computer simulations to determine the number and location of access points for optimum coverage. In cases where the infrastructure has yet to be built (as in a new class of ships) the simulation may be the only option for WLAN coverage prediction. In such a case blueprints may be used in conjunction with the computer indoor propagation simulation software in order to predict the best places to install the access points. The indoor propagation simulation software differs from the outdoor propagation software used for the cellular networks because of the differences in the characteristics of indoor and outdoor propagation channels.

This thesis explains the characteristics and structure of a Wireless Local Area Network and presents the computer simulation results the 2.4 GHz wireless signal propagation inside an enclosed space. A building at the Naval Postgraduate School, where some previous physical measurements have been conducted, was selected for the indoor propagation simulation.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Simulation of Signal Propagation, Wireless Local Area Network

THESIS ABSTRACTS

COMPUTER-AIDED RECOGNITION OF MAN-MADE STRUCTURES IN AERIAL PHOTOGRAPHS

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Second Readers: Robert B. McGhee, Department of Computer Science

Roberto Cristi, Department of Electrical and Computer Engineering

Aerial image acquisition systems are producing more data than can be analyzed by human experts. Most of the images produced by remote sensing satellites, including military ones, never get seen or inspected. In this work, automated detection and recognition of buildings in aerial photos is explored. Connectivity analysis is performed on graphs derived from line segment representations of the original images, obtained with the use of the Radon Transform. The model is experimentally validated using 2-meter panchromatic aerial photographs from the National Aerial Photography Program (NAPP), which is a marginally adequate resolution for the recognition of small buildings.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Computing and Software

KEYWORDS: Aerial Photograph Analysis, Pattern Recognition, Imagery Intelligence

CONNECTION UTILIZATION MASKING IN ATM NETWORKS

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A technique for connection utilization masking in ATM networks is presented, modeled and analyzed. Specifically, a cell injection mechanism is modeled with a two-state Markov Modulated Poisson Process (MMPP) to study its autocorrelation and power spectral density properties and the queue response to the arrival process. The Cruz bound is used to determine injection source traffic parameters. Cell injection is implemented on a permanent virtual channel with a bursty Variable Bit Rate (VBR) source. The result is also VBR traffic having a new set of user-defined statistics. Traffic traces representing before and after injection scenarios are collected and further processed to define autocorrelation and power spectrum density functions. The results are used to compare and justify analytical results. The cell-injected stream shows strong correlation over a long duration, an indication of the removal of burstiness. Cell Transfer Delay, Cell Loss Rate, and Cell Inter-arrival time statistics are collected to evaluate the injection's effects on Quality of Service (QoS) parameters. Cell injection causes more mid- and high-frequency traffic power to be shifted towards the low frequency region in the frequency spectrum, representing an increase in the mean arrival rate.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Other (High Speed Computer Networks)

KEYWORDS: Asynchronous Transfer Mode, ATM, Cell Injection, Cruz Bound, MMPP, AX/4000

THESIS ABSTRACTS

RESOLVING FREQUENCY AMBIGUITIES IN STEP FREQUENCY WIDEBAND COMPRESSIVE RECEIVERS

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Advisors: Curtis D. Schleher, Information Warfare Academic Group

David C. Jenn, Department of Electrical and Computer Engineering

Present compressive receiver implementations are limited due to their analog implementation and the necessity for digital processing of the serial output data. Previous research has shown that a stepped-frequency digital design using sub-Nyquist sampling mitigates many of the limitations. An algorithm that implements the Chinese Remainder Theorem to solve the frequency ambiguities that occur in the design due to sub-Nyquist sampling with high resolutions is investigated. Different resolutions, a different number of sampling frequencies, and sampling frequency pairs and triples with various differences are simulated for one to five signals that overlap in the time domain. Predictions for the best achievable resolution, the minimum number of sampling frequencies needed, and the difference required between the sampling frequencies are made according to the comparison of simulation results.

DoD KEY TECHNOLOGY AREAS: Electronics, Electronic Warfare

KEYWORDS: Wideband Digital Compressive Receivers, Resolving Frequency Ambiguities, Chinese Remainder Theorem

VULNERABILITIES IN THE OPEN SHORTEST PATH FIRST ROUTING PROTOCOL

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Second Reader: Vicente C. Garcia, National Security Agency Cryptologic Chair

In order to reduce the number of successful attacks against the U.S. Government's computer networks, resources must be invested not only in to implementing known fixes and security measures but also in to the identification and correction of vulnerabilities before adversaries can exploit them. This thesis identifies one such vulnerability in the Open Shortest Path First (OSPF) Interior Gateway Protocol. This protocol is responsible for deciding which route network traffic will take, assuming multiple routes exist, in an autonomous system. This vulnerability manipulates routers running OSPF into altering the route that certain traffic takes without introducing abnormalities that would alert system administrators. In addition, this manipulation can be reversed without alerting administrators or extended indefinitely.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Other (Internetworking)

KEYWORDS: Open Shortest Path First, OSPF, Vulnerabilities, Exploits, Routing Protocol, Interior Routing Protocol, Interior Gateway Protocol

THESIS ABSTRACTS

LOW PROBABILITY OF INTERCEPT RADAR DETECTION TECHNIQUES FOR ADVANCED ELECTRONIC SUPPORT SYSTEMS

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CAPT James R. Powell, USN, Information Warfare Academic Group

LPI radar detection poses one of the last remaining unsolved problems for ES and ELINT systems at operationally significant ranges. This thesis research investigates two LPI radar detection and processing techniques. First, the adaptive analog correlation LPI radar detector is assembled and tested. It effectively detects and processes low-power LPI radar signals for ideal laboratory conditions, but several major technical limitations are quantified including its poor performance in the presence of pulsed interference signals. Secondly, the digital matched filter LPI radar detector is developed and evaluated. Digital matched filters are formed from captured signals and software-generated signals. Quantitative assessments revealed no major performance limitations. This technique achieves LPI signal detection and SNR improvements to near-theoretical limits, while operating in the presence of high-power, high-density pulsed interference signals. The digital matched filter technique is identified as the clear choice for solution of the LPI radar detection problem, and can be employed to detect and process all complex modulation signals. It is also fully compatible with the next generation of digital ES receivers.

DoD KEY TECHNOLOGY AREA: Electronic Warfare

KEYWORDS: LPI Radar, Low Probability of Intercept Radar Detector, Digital Matched Filter, Pulse Compression, Advanced Digital ES System

PERFORMANCE ANALYSIS OF IRTOOL AND COMPARISON TO LWKD MARINE BOUNDARY LAYER PROGRAM

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This thesis evaluates the ability of the IRTOOL computer simulation program to predict mirages. Using identical input conditions taken from the MAPTIP experiment database, predicted Minimum Mirage Range (MMR) and Maximum Intervisitation Range (MIVR) from both the IRTOOL and IRBLEM models were extracted and compared with the measurements recorded in the database. By comparison of the algorithms it was found that discrepancies in IRTOOL mirage prediction could be ascribed to the input function for significant ocean wave height, which gave values much greater than measured or used in IRBLEM. For a significant wave height close to the measured value the IRTOOL predictions were in very close agreement with observation and with IRBLEM. IRTOOL predictions were in all cases within 2.7 km and in most cases within 1.3 km of the measurements for all ranges varying from about 7-26 km. The strong temperature gradient predicted by the model within a few meters of the water surface, uncertainties in the measured range, and the variation of 0.8 to 2°C in Air Sea Temperature Difference are sufficient to account for the observed deviations. Differences between predictions of different models are discussed.

DoD KEY TECHNOLOGY AREAS: Sensors, Modeling and Simulation

KEYWORDS: Refraction, Marine Boundary Layer, Atmosphere, IRTOOL, IRBLEM, Mirage, MAPTIP

THESIS ABSTRACTS

COMPUTER NETWORK PROTOCOL ANALYSIS (U)

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and

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Abstract is classified.

DoD KEY TECHNOLOGY AREAS: Computers and Software, Other (Cyber Warfare)

KEYWORDS: Signals Intelligence, Protocol Analysis, Internet Telephony, Voice Over IP

DESIGN, PROTOTYPING AND MEASUREMENTS OF CAVITY-BACKED CONICAL SPIRAL WIDEBAND ANTENNA FOR SUBMARINE APPLICATIONS

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Second Reader: Richard W. Adler, Department of Electrical and Computer Engineering

Currently, submarines contain wideband receive and several narrowband transmit antennas. Due to the limited space available for antennas on submarines, wideband transmit antennas that fulfill new mission requirements are needed. RATTLE-1 is a wide band antenna covering the 300 MHz to 3 GHz frequency range. The design was subject to user-specified physical constraints on antenna installation as well as operational constraints including of transmitting one kilowatt of power. The antenna is a two-arm conical Archimedean spiral backed by a hemispherical cavity. This thesis develops a physical prototype for the antenna, tests the basic design, models the antenna in an operational environment and performs limited testing in an operational environment. The results for prototype measurements show that RATTLE-1 operates with a 60 to 70 degree beamwidth, a main beam gain of 0 to 15 dB and a front to back ratio of 7 to 25 dB within the desired frequency range. Computer simulations were performed, using the Numerical Electromagnetics Code (NEC), and the antenna was tested on an outdoor antenna range to determine the effects of seawater on the antenna performance.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Electronics, Electronic Warfare, Sensors, Modeling and Simulation

KEYWORDS: Command, Control, and Communications, Electronics, Electronic Warfare, Sensors, Modeling and Simulation, Wideband Communications Antenna, Conical Spiral Antenna

DESIGN AND DEVELOPMENT OF THE EER MODULE FOR BEARTRAP POST MISSION PROCESSING SYSTEM 2000

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Master of Science in Electrical Engineering-December 1999

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Murali Tummala, Department of Electrical and Computer Engineering

This work is intended to support an Extended Echo Ranging (EER) addition to the BEARTRAP post mission Processing System 2000 (S2K). S2K is an analysis tool programmed using Microsoft Visual C++ and residing in a Microsoft Windows NT environment. Both BEARTRAP and EER missions are Anti-

THESIS ABSTRACTS

Submarine Warfare (ASW) missions and are able to be analyzed on the same hardware system due to the use of the same recording media. This thesis develops a design framework for the S2K EER module, which is the software support needed to perform post mission processing for the EER mission. Two submodules of the design are also developed. First is the Virtual Buoy Repositioning submodule, which uses acoustic data to correct errors in sonobuoy locations that are caused by aircraft navigational errors. Second is the Detection and Classification submodule, which processes the acoustic data to identify signal returns from the target. A preliminary analysis of incoming signals is performed using current techniques and exploring a new technique for signal classification.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Sensors

KEYWORDS: Acoustics, BEARTRAP, EER, DSP, ASW

INFRARED MISSILE AIM-POINT MODELING AND FLARE COUNTERMEASURE EFFECTIVENESS (U)

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Master of Science in Systems Technology-June 2000

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In today's battlefield environment, infrared surface-to-air missiles (IR SAMs) pose a significant threat to modern tactical aircraft. Every effort must be made to more successfully combat such threats through the use of flare countermeasures. The Modeling System for Advanced Investigation of Countermeasures (MOSAIC) is a simulation tool that models countermeasure effectiveness vs. different missile-threat situations. This research first compares the three different aircraft source models used by MOSAIC (area, ellipse, and SPIRITS source models). These source models are compared to each other as well as to actual field test results in order to draw conclusions on model accuracy. Second, the effectiveness of flare countermeasures is investigated based on release timing relative to missile aim-point. The aircraft, missile, and countermeasures used in this analysis are the F-15E, the Stinger Basic missile, and the MJU 27 and MJU 8 A/B flares.

DoD KEY TECHNOLOGY AREAS: Air Vehicles, Computing and Software, Modeling and Simulation

KEYWORDS: MOSAIC, SPIRITS, Infrared Countermeasures (IRCM), Modeling, Simulation, Stinger, F-15E, Aim-point

DESIGN OF ADVANCED ANALYSIS SOFTWARE FOR IT-21 COMPLIANT NETWORKS

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Master of Science in Electrical Engineering-December 1999

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The cornerstone to achieving battlefield dominance, as defined by Joint Vision 2010, is establishing and maintaining information superiority. This new paradigm of network centric warfare has shifted computer networking from an administrative support system to a tactical necessity. Recognizing this critical requirement for interoperable networking, the Department of the Navy promulgated the Information Technology for the Twenty-First Century (IT-21) computing standards. This thesis investigates the synergetic interactions between application software, the WindowsTM NT operating system, and the underlying networks. The insight gained is then exploited to develop performance analysis software in C++. The resulting application provides a valuable asset for examining, troubleshooting, and optimizing IT-21 information systems.

THESIS ABSTRACTS

DoD KEY TECHNOLOGY AREA: Other (High Speed Computer Networks)

KEYWORDS: Asynchronous Transfer Mode, ATM, IT-21, Winsock

EFFECTS OF SHIPBOARD COMPARTMENT FUEL FIRE AND FIRE EXTINGUISHING ON RF SIGNAL PROPAGATION IN THE 2.4 GHz ISM BAND

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Master of Science in Applied Physics-June 2000

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and**

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The objective of this research was to quantify the effects of fuel fire and the follow-on fire extinguishing actions on wireless shipboard communications in the 2.4 GHz ISM band. Directional and non-directional antennas with horizontal and vertical polarization, and a PC-controlled scalar network analyzer, were used onboard ex-USS SHADWELL to measure the attenuation of 2.4 - 2.485 GHz signals transmitted through diesel and heptane fire, water mist created by the fire extinguishing system, and subsequently developed steam. A MATLAB code has been used to analyze the data statistically.

The attenuation for directional antennas exhibits relatively small variations with time and frequency, but fire and the follow-on fire-extinguishing phases create severe non-stationary frequency selective fading for non-directional antennas. Therefore standard communication techniques effective against frequency selective fading (non-stationary but slowly varying with time) are recommended for use with communication systems intended for shipboard indoors use. Even in normal conditions, without fire, water mist, or steam, it was determined that frequency selective fading would be a problem for non-directional antennas used in shipboard compartments and thus a system with anti-fading capability should be considered for shipboard use.

DoD KEY TECHNOLOGY AREA: Other (Shipboard Wireless Communications)

KEYWORDS: Instrumentation Scientific Medical (ISM) Band, Radio Frequency (RF) Propagation, Attenuation, Fire Extinguishing System, Plasma, MATLAB

DYNAMICS OF PRIVATE NETWORK-TO-NETWORK INTERFACE (PNNI) ROUTING IN ATM VULNERABILITY ASSESSMENT

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To reduce the number of successful attacks against the U.S. Government's computer networks, resources must be invested not only into implementing known fixes and security measures, but also into the identification and correction of vulnerabilities before adversaries can exploit them. This thesis establishes a procedure for observing and analyzing the Private Network-to-Network Interface (PNNI) Routing Protocol. This protocol is responsible for deciding which route network traffic will take, assuming that multiple routes exist, in an autonomous system. Measurements of line utilization, cell delay and interarrival rate of the PNNI channel are taken into account for characterizing a normal PNNI exchange. Finally, potential vulnerabilities related to PNNI dynamics are discussed.

THESIS ABSTRACTS

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Asynchronous Transfer Mode, ATM, PNNI, Network Vulnerabilities, Exploits, Routing Protocol, Cell Injection, AX/4000, Internetworking, High Speed Computer Networks

IPSec-BASED VIRTUAL PRIVATE NETWORK VULNERABILITY ASSESSMENT

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Master of Science in Information Technology Management-March 2000

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Virtual Private Networks (VPNs) are an emerging security solution for computer networks in both the government and corporate arena. IPSec, the current standard for VPNs, offers a robust, standards based, and cryptographically effective solution for VPN implementation. Because of the immense complexity of IPSec, effective analysis is difficult. In an environment where Information Warfare in general, and computer network attack in particular, are becoming more pervasive, it is necessary develop a critical, independent evaluation of IPSec from a security perspective.

In order to develop an effective evaluation of IPSec VPNs, it is necessary to first develop a framework with which to analyze the various elements of VPN implementation. This framework can be extended for use as a tool to develop methodologies for VPN attack and exploitation, as well as protection. A Cisco Systems VPN router network is an example of how this framework can be applied to a real-world example.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Computing and Software

KEYWORDS: Virtual Private Networks, Computer Network Attack, Computer Security, Network Security

AN ALL-DIGITAL IMAGE SYNTHESIZER FOR COUNTERING HIGH-RESOLUTION IMAGING RADARS

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and

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Master of Science in Systems Engineering-September 2000

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Second Reader: Robert E. Surratt, Naval Research Laboratory

The subject of this thesis is a digital image synthesizer (DIS), which is especially useful as a counter-targeting signal repeater, i.e., for synthesizing the characteristic echo signature of a pre-selected target. The DIS has a digital radio frequency memory (DRFM) and associated circuitry, including digital tapped delay lines and a modulator in each delay line to impose both amplitude and frequency modulation in each line. A unique property of the digital image synthesizer is its ability to synthesize false targets using wideband chirp signals of any duration. The *system-on-a-chip* uses a scalable CMOS technology that increases the bandwidth and sensitivity of such a repeater over prior analog-based systems. The application-specific integrated-circuit reduces the noise of the repeated signal, reduces the size and cost of such a system and permits real-time alteration of operating parameters, permitting rapid and adaptive shifting among different types of targets to be synthesized.

THESIS ABSTRACTS

DoD KEY TECHNOLOGY AREAS: Electronics, Electronic Warfare

KEYWORDS: Inverse Synthetic Aperture Radars, ISAR, Countermeasure, Digital Radio Frequency Memory, DRFM, Image Synthesizer, Field Programmable Gate Array, FPGA, Application Specific Integrated Circuit, ASIC, Chip Design

ULTRA-WIDEBAND, LOW PROFILE, VERTICALLY POLARIZED ANTENNA DESIGNS FOR MILITARY APPLICATIONS

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The emerging need to operate ultra-wideband communication and electronic warfare systems in tactical environments will require efficient, omni-directional broadband antennas. In the case of the Grumman EA-6B, the candidate antenna should ideally operate from 30-500 MHz with a voltage standing-wave ratio (VSWR) less than three across the entire band. Additionally, it must be vertically polarized, it must be constrained in size, and it must have minimal aerodynamic effects while offering structural stability. In this thesis, an antenna was designed that is capable of operating in the frequency range of 72-500+ MHz, a 70 MHz improvement over the existing configuration. The antenna performance was optimized for its design restrictions and takes advantage of dielectric loading to minimize antenna size relative to the operating wavelengths. The antenna was designed and its performance predicted using Ansoft's High Frequency Structure Simulator (HFSS). HFSS is based on the finite element method (FEM). As well, it assigns material properties to a structure enabling more realistic antenna designs to be simulated. Several aerodynamic versions of the base design were modeled and simulated and a comparison of their performance is presented. As well, alternative antenna applications other than the Grumman EA-6B were suggested.

DoD KEY TECHNOLOGY AREAS: Air Vehicles, Electronic Warfare, Surface/Under Surface Vehicles-Ships and Watercraft, Ground Vehicles, Modeling and Simulation

KEYWORDS: Ultra-Wideband Antenna, Omni-Directional, Low Profile, Vertically Polarized, Ansoft High Frequency Structure Simulator (HFSS), Dielectric Loading

ULTRA-WIDEBAND RADIO FREQUENCY VEST ANTENNA

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The Ultra-Wideband Radio Frequency Vest Antenna is the result of the research efforts to develop an antenna system to support the Joint Tactical Radio System (JTRS) currently being procured by the United States Department of Defense. The JTRS is an Ultra-Wideband radio system that is expected to operate in the two Megahertz to two thousand Megahertz frequency range. It is a frequency agile system that requires an equally responsive antenna system. The operating spectrum of the radio has been determined to be effectively covered through the use of three separate antennas. The frequency divisions are two to thirty Megahertz, thirty to five hundred Megahertz, and five hundred to two thousand Megahertz. This thesis focuses on the thirty to five hundred Megahertz frequency range in support of the dismounted Marine or soldier in all combat environments.

THESIS ABSTRACTS

soldier in all combat environments.

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications, Electronics, Modeling and Simulation

KEYWORD: Antennas, Numerical Electromagnetics Code (NEC), Method of Moments, Wire Grid Modeling, Loop/Dipole, Man-portable, COMbat Wear INtegration (COMWIN)

GRAPHICAL USER INTERFACE FOR A PHYSICAL OPTICS RADAR CROSS SECTION PREDICTION CODE

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Second Reader: D. Curtis Schleher, Information Warfare Academic Group

This implementation of the physical optics approximation method for predicting the radar cross section (RCS) of complex objects utilizes the scientific computational features of MATLAB and its Graphical User Interface (GUI) functions to provide an error-free encoding of input parameters and efficient calculation. The POFACETS GUI provides a convenient tool for both students and electromagnetic professionals to design complex models by representing its component parts as triangular facets and offers options for defining the surface roughness of the scattering object. The GUI calculates the monostatic or bistatic radar cross section of the modeled object based on certain radar frequencies and parameters of interest, creates a variety of plots for the model geometry and its RCS measurement, and provides additional functionalities to enhance visualization of the object and check for accuracy of data. Various help windows and messages are available to the user to serve as guide in the efficient use of the GUI. The simplicity of the GUI design does not require the user to have a detailed understanding of the various steps involved in the RCS calculation.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Modeling and Simulation, Electronic Warfare

KEYWORDS: Physical Optics, Radar Cross-Section, Monostatic, Bistatic, Electromagnetic Scattering, Graphical User Interface

TRANSIENT RESPONSE TO SINGLE EVENT UPSET IN SILICON-ON-INSULATOR FIELD EFFECT TRANSISTORS

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Master of Science in Electrical Engineering-March 2000

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Second Reader: Douglas Fouts, Department of Electrical and Computer Engineering

Silicon-on-Insulator (SOI) technology provides promising radiation hardening characteristics but the effect of microdose issues are not understood. As transistors shrink, trapping of small amounts of charge in a gate oxide can cause threshold voltage shifts in Metal Oxide Semiconductor Field Effect Transistors (MOSFETs). This thesis examines the effects of enacting a microdose single event effect (SEE) upon a thick gate oxide of an SOI MOS capacitor in order to determine the degree of damage to the device and the recombination yield curve. Based on simulation data from the Silvaco software suite, a recombination yield curve is explored which can provide simulation data that can be used to design future SOI devices for DOD. Simulation results are compared to previously published, Single Event Upset (SEU) test data provided by the U.S. Army's Harry Diamond Laboratories to verify validity.

THESIS ABSTRACTS

DoD KEY TECHNOLOGY AREA: Electronics

KEYWORDS: Electronics, SOI, Radiation Hardened

PERMANENT-MAGNET SYNCHRONOUS MACHINE CONTROL STRATEGIES FOR ELECTRIC DRIVE

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Master of Science in Electrical Engineering-September 2000

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The United States Navy has committed to employing an Integrated Power System (IPS) on DD-21, the next generation land-attack destroyer. The IPS is embodied by two revolutionary concepts: the DC Zonal Electric Distribution System and the Electric Drive. Electric Drive propulsion offers numerous advantages over conventional drives including reduced overall weight, size, and maintenance requirements, improved flexibility of arrangement, and enhanced fault tolerance and controllability.

Since solid-state power converters drive the propulsion motor, it will be infinitely controllable throughout its speed range. This offers the capability to achieve a smooth torque on the ship's propeller. Of key interest is an algorithm to control the current and voltage wave-shapes of the propulsion motor. This thesis develops an algorithm based on field-oriented vector control that will be applied to a proof-of-concept 30 horsepower permanent-magnet synchronous machine currently under study. Two supervisory control architectures are analyzed consisting of two inner current loops and one outer speed loop. The selection of the controller gains is documented and validation simulation studies are presented. The thesis also outlines a hardware-in-the-loop testing strategy to be implemented with the dSPACE DS1103 Controller Board, a hardware and software package designed for real-time digital controller evaluation.

DoD KEY TECHNOLOGY AREAS: Surface/Under Surface Vehicles-Ships and Watercraft, Modeling and Simulation

KEYWORDS: Permanent-Magnet Synchronous Machine, Vector Control, Hardware-in-the-Loop, Electric Drive, Integrated Power System

DESIGN OF A LOW POWER EMBEDDED MICROPROCESSOR FOR A HANDS-EYES-EARS- FREE PERSONAL NAVIGATION AND COMMUNICATION SYSTEM

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Master of Science in Electrical Engineering-June 2000

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Second Reader: Randy L. Wight, Department of Electrical and Computer Engineering**

This thesis details the engineering design of a personal, computer-based system, which is intended to support a hands-eyes-ears-free Personal Navigational and Communication System (PNCS). This computer-based system is designed to be used with COTS devices, such as, (1) a GPS receiver, (2) a laptop or desktop computer, (3) a rechargeable, long-life battery pack, and (4) a wearable tactile communications vest. The vest is currently under development by the Naval Aerospace Medical Research Lab (NAMRL) and together with this computer-based system can provide a complete hands-free personal navigational and communication system. The intent of the navigation system is to satisfy both commercial and military uses for land-based pedestrian and vehicular travel.

DoD KEY TECHNOLOGY AREAS: Biomedical, Clothing, Textiles and Food, Command, Control, and Communications, Computing and Software, Electronics, Human Systems Interface, Sensors

KEYWORDS: GPS, Navigation, Embedded Design, Low Power, Microprocessor, Tactor

THESIS ABSTRACTS

GENERATION OF GLOBAL SYSTEM FOR MOBILE (GSM) SIGNALS AND THEIR TIME DIFFERENCE OF ARRIVAL (TDOA) ESTIMATION

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Master of Science in Electrical Engineering-June 2000

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Tri T. Ha, Department of Electrical and Computer Engineering**

Emitter localization is a very important communications tool that will be extremely valuable to a multitude of different military as well as civilian applications. In many parts of the world, GSM is the preferred method of modulation used in mobile phone traffic. This thesis addresses the time difference of arrival estimation applied to GSM type signals using wavelet-based techniques. Signals are generated using the Hewlett-Packard Advanced Design System software and processed using algorithms based on Matlab. The results of this thesis prove improvement can be made upon the localization of a GSM emitter through the use of wavelet-based denoising techniques.

DoD KEY TECHNOLOGY AREA: Other (Emitter Localization)

KEYWORDS: Global System for Mobile, Time Difference of Arrival, Wavelet Denoising, Emitter Localization

ANALYSIS, SIMULATION, AND FABRICATION OF CURRENT MODE CONTROLLED DC-DC POWER CONVERTERS

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Master of Science in Electrical Engineering-December 1999

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A modular DC Zonal Electrical Distribution System (DC ZEDS) offers advantages in both cost and weight over traditional radial shipboard distribution. In order to equip the next class of surface combatant with DC ZEDS, preparation research includes the design of autonomous DC-DC power converter modules having robust load sharing capability. This thesis examines the utility of current-mode switch control applied to high-voltage DC-DC power converters. A state-space representation for a current-mode controlled buck converter is developed. The system is modeled dynamically using the Advanced Continuous Simulation Language (ACSL). System stability and frequency response is modeled using MATLAB. A hardware controller is fabricated to implement current-mode control using available laboratory equipment.

DoD KEY TECHNOLOGY AREAS: Electronics, Modeling and Simulation, Other (Power Conversion)

KEYWORDS: DC-to-DC Buck Converter, Current-Mode, ACSL

ACOUSTIC LOCALIZATION OF TRANSIENT CAVITATION EVENTS WITHIN THE VOLUME OF A SUBMARINE PROPULSOR USING A CROSSED-LINE ARRAY

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Master of Science in Engineering Acoustics-December 1999

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The development of a computer program that is capable of localizing transient cavitation events within a scale-model submarine propulsor, for the Naval Surface Warfare Center Acoustic Research Detachment, is presented. The program focuses a 21-element, crossed-line array, by applying exact phase weights in the

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frequency domain and evaluating the resultant coherence across all of the sensors in the time domain. Localization is determined by a comparison of normalized coherent summations from many different points within a volume enclosing the source.

The program is general, in that the method used is capable of conducting near-field localization using any array, provided the sensor locations are well-known. The source is assumed to be a spherical spreading source with a direct path to the array. A method of rejecting portions of the time series that are contaminated by reflected paths is incorporated. An evaluation of the method using synthetic data is included.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Surface/Under Surface Vehicles - Ships and Watercraft, Other (Submarine Stealth)

KEYWORDS: Acoustic Localization, Array Focusing, Submarine Transient Cavitation, Transient Localization

ELECTRIC PROPULSION FOR MILITARY GEOSYNCHRONOUS SATELLITES

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Second Reader: Sherif Michael, Department of Electrical and Computer Engineering

Revolutionary changes in the launch, delivery, and operation of satellites over the next decade will directly impact life-cycle costs by providing a capability to place larger payload mass in space at less cost. The cost reducing delivery systems under development for large LEO constellations can be combined with electric propulsion (EP) upper stages to offer dramatic reduction in payload cost per kilogram for MEO and GEO applications. Higher energy-density solar arrays coupled to electric *primary* propulsion systems will offer significantly increased payload mass fractions on orbit, greater flexibility in relocating satellites, longer satellite lifetimes, and less penalty for de-orbiting expired satellites. By coupling low-thrust propagation algorithms with comparative mass-fraction equations, this thesis provides a systematic design approach for meeting on-orbit payload and power requirements. Stationkeeping, orbit insertion, GEO rephasing and deorbiting requirements are addressed. Two types of EP thrusters are investigated: electron bombardment ion thrusters and Hall-Effect thrusters. Electric propulsion parameters are derived and integrated into mission-specific mass fraction equations. This allows for determination of the optimal thruster type and operating point for each mission. Total mass savings using EP is ultimately translated to a required LEO insertion mass for a given payload and transfer time.

DoD KEY TECHNOLOGY AREAS: Aerospace Propulsion and Power, Space Vehicles

KEYWORDS: Electric Propulsion, Ion Thrusters, Hall-effect Thrusters, Orbit Transfer, Satellite Propulsion, Low-thrust Satellite Maneuvers, Stationkeeping, Geosynchronous Rephasing

COMPUTER MODELING OF JAMMING EFFECTS ON ROLL STABILIZED MISSILES

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Second Reader: David C. Jenn, Department of Electrical and Computer Engineering

Development of countermeasures against infrared missiles is enhanced by an ability to quantify the effects of the countermeasure. Analysts must be capable of accurately determining the attitude of the missile throughout its flight. This thesis describes the use of micro-miniature technologies to measure the rates experienced by a missile and the model required to effectively determine the missile's attitude.

The Applied Technology Associates ARS-04E and the Tokin America CG-16D sensors were

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evaluated for use as rate sensors and the Honeywell, SSEC, HMC1002 was evaluated for use as a roll sensor. Of these sensors, the CG-16D proved its ability to perform in this application. The ARS-04E was ineffective in this application.

A Simulink model is presented that performs the tasks of demodulating the sensors, performing coordinate transformation, and providing animation of the missile attitude for analysis. The model was evaluated for its ability to accurately determine the attitude of the missile based on input from the IMU packages. Sensor data was obtained from testing performed on a CARCO table flight motion simulator, and compared to the ground truth data provided by the CARCO table. Through testing, the model was capable of providing solutions within the 2 degrees RMS requirement.

DoD KEY TECHNOLOGY AREAS: Air Vehicles, Computing and Software, Sensors, Modeling and Simulation

KEYWORDS: Simulink, Inertial Measuring Unit, Euler Rotation, Animation

GLOBALSTAR: A NATIONAL SECURITY PERSPECTIVE

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Gerry Baumgartner, Space and Naval Warfare Systems Center-San Diego

It is expected that LEO-based satellite mobile telephony will thrive in the global marketplace of the 21st century. There are large portions of the world that could reap significant benefit from a satellite communication system such as the GLOBALSTAR. The worldwide communication services of the GLOBALSTAR provide a means to enhance the command and control capabilities of government and military leadership throughout the world. The application of the GLOBALSTAR to U.S. National Security issues deals with the impact of satellite mobile telephony upon the communication structure of U.S. National and foreign entities. Analysis of the GLOBALSTAR and its impact to U.S. National Security provide insight into what modifications need to be implemented to the existing Command, Control, Computers, Communications, Surveillance and Reconnaissance (C4ISR) Systems of the United States to accommodate emerging technologies that have the potential to revolutionize the way the world communicates.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Sensors, Space Vehicles

KEYWORDS: Satellite Mobile Telephony, Satellite Communications

ASYNCHRONOUS TRANSFER MODE AND LOCAL AREA NETWORK EMULATION STANDARDS, PROTOCOLS, AND SECURITY IMPLICATIONS

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Master of Science in Electrical Engineering-December 1999

Advisor: John C. McEachen, Department of Electrical and Computer Engineering

Second Reader: Murali Tummala, Department of Electrical and Computer Engineering

A complex networking technology called Asynchronous Transfer Mode (ATM) and a networking protocol called Local Area Network Emulation (LANE) are integrated into many naval networks without any security-driven naval configuration guidelines. No single publication is available that describes security issues of data delivery and signaling relating to the transition of Ethernet to LANE and ATM. This thesis provides: (1) an overview and security analysis of standardized protocols relating to ATM and LANE; (2) an overview and security analysis associated with integrating a Fore Systems Inc., LANE-based ATM network, with an accredited Cisco Systems Inc., Ethernet Virtual LAN (VLAN) network; and (3) associated security-related

THESIS ABSTRACTS

suggestions for network design and configurations. This thesis identifies possible negative security-related capabilities associated with ATM- and LANE-related protocols; however, many are mitigated using the identified network design guidelines. Qualitative analysis suggests that the introduction of an ATM/LANE backbone into an existing TCP/IP network does not increase the probability of incorrect destinations receiving and processing corrupted frames. It is hoped that this seminal document will assist in the development of standard security-driven implementation guidelines associated with ATM/LANE-based networks, as well as inform those required to prepare, and review associated network Risk Assessments.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Command, Control, and Communications, Other (High Speed Computer Networks)

KEYWORDS: Asynchronous Transfer Mode, ATM LAN Emulation, LANE, Emulated LAN, ELAN, Security, Private Network Network Interface, PNNI, User Network Interface, UNI

VULNERABILITY AND IMPACT ANALYSIS OF RADIO FREQUENCY INTERFERENCE ON MILITARY ULTRA HIGH FREQUENCY SATELLITE COMMUNICATIONS

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Second Reader: CDR Susan L. Higgins, USN, Space Systems Academic Group

As the U.S. military focuses more attention on information warfare and obtaining knowledge superiority on the battlefield, communications capabilities are becoming a critical element to military readiness. Ultra High Frequency Satellite Communications (UHF SATCOM) provides the military with unique capabilities that communication systems operating in other spectrum bands cannot. UHF SATCOM is the primary means of interoperability with Allies. Not only are these systems inexpensive and light enough to be man-portable but they can also operate through weather and foliage. Unfortunately, UHF SATCOM systems are extremely susceptible to radio frequency interference (RFI). The military's vulnerability to UHF SATCOM RFI is caused by technical, regulatory and operational factors.

This vulnerability manifests itself in terms of impact of RFI on UHF SATCOM and corresponding degradation of military operations. RFI is responsible for an approximately 25% decrease in UHF channel availability. Consequently, users often experience intermittent or complete circuit outages. Unfortunately, there is a severe deficiency in the services' ability to identify, geolocate and resolve RFI sources. When the factors and operational costs are analyzed together and reviewed as a whole, the vulnerability of our military's UHF SATCOM to RFI cannot be underestimated. This thesis provides recommendations for mitigating the military's vulnerability, eliminating deficiencies in resolution capability, thereby decreasing the impact of RFI on military readiness.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Command, Control and Communications, Electronic Warfare, Space Vehicles

KEYWORDS: Military Satellite Communications, Radio Frequency Interference, Ultra High Frequency Communications

THESIS ABSTRACTS

DARK CURRENT ANALYSIS AND COMPUTER SIMULATION OF TRIPLE-JUNCTION SOLAR CELLS

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Master of Science in Astronautical Engineering-December 1999

Master of Science in Electrical Engineering-December 1999

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Oscar Biblarz, Department of Aeronautics and Astronautics

Todd Weatherford, Department of Electrical and Computer Engineering

This thesis reports the steps taken to characterize the semiconductor properties of triple-junction solar cells. Chemically etching the solar cells exposes each of the three energy producing junctions, InGaP, GaAs and Ge, to probes. Dark current measurements reveal the diode ideality factors of each junction, and these results are compared to current theories on diodes and solar cells. Calculations performed on experimentally obtained values from previous studies and measured values from this research for individual junctions show an expected diode ideality factor for the entire solar cell of 6.2 to 6.4, which is close to the actual production cell value of 5.9. Silvaco International's semiconductor simulation software was used to model the solar cell under dark and illuminated conditions. The simulated dark current yields an ideality factor of 3.45—lower than expected. A spectral analysis equating wavelength of light to current production for each junction within the solar cell is presented, and methods to better match the current produced from each junction are investigated. A current-versus-voltage-curve comparison equates simulated results to actual manufactured cell performance under illumination conditions; simulated values were within 10% for V_{OC} and 15% for I_{SS} in the better performing junctions.

DoD KEY TECHNOLOGY AREA: Space Vehicles

KEYWORDS: Solar Cell, Multijunction, Tunneling, Software Simulation, Dark Current, GaAs, InGaP, GaInP, Ge

SIMULATION OF SIGNALING SYSTEM NO.7 MESSAGE TRANSFER PART 2

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B. Eng., National University of Singapore, 1994

Master of Science in Electrical Engineering-March 2000

Advisor: John McEachen, Department of Electrical and Computer Engineering

Second Reader: Murali Tummala, Department of Electrical and Computer Engineering

The objective of this work is to perform simulation modeling of the Signaling System No.7 (SS7) network with particular emphasis on modeling of the Message Transfer Part (MTP) Level 2. The basics of common channel signaling using Signaling System No. 7 is initially outlined and discussed with reference to the ITU-T Q.7xx-Series Recommendations. This includes the protocol stack, signaling points, signaling links and typical network structure. In particular, the functionality of the Message Transfer Part, which provides the main mechanism to convey signaling messages, is discussed in detail.

Subsequently the modeling of the Message Transfer Part, in particular MTP level 2, using the simulation tool OPNET from MIL3. Inc. is presented. The model uses a multi-layer modular approach, with each layer corresponding to the SS7 layer it is modeling. The functional blocks within each layer are thought of as processes. With their buffers and processors, these processes form a complex interlinked queuing model that is complicated to analyze but is readily simulated.

In order to illustrate the use of the simulation model, the basic linkset delay between two signaling points under a heavy traffic load is simulated and compared with analysis based on M/G/1 queuing models.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Modeling and Simulation

KEYWORDS: Signaling System No. 7, Link Delay

THESIS ABSTRACTS

AN INVESTIGATION AND ASSESSMENT OF LINUX IPCHAINS AND ITS VULNERABILITIES WITH RESPECT TO NETWORK SECURITY

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B.A., University of New Mexico, 1990

M.S., Troy State University, 1992

Master of Science in Electrical Engineering-June 2000

Advisors: Raymond F. Bernstein, Jr., Department of Electrical and Computer Engineering

Vicente C. Garcia, Jr., National Security Agency Cryptologic Chair Professor

This research thesis formulates a survey of network security and IPChains, the Linux firewall. It provides a detailed description of prominent network security procedures in use today. This paper falls directly in line with the goals of Executive Order 13010, the President's Critical Infrastructure Protection Plan, supports the goals of the National Security Agency's SIGINT Business Plan and the goals of both the Unified and Maritime Cryptologic Architecture. It will aid in the development of the problem solving efforts of the national cryptologic organization and be used to provide critical intelligence support to the Operational command and the national intelligence community.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Information Warfare, Command, Control and Communications

KEYWORDS: Linux, Network Security, IPChains

INVESTIGATION AND APPLICATION OF RECENT WEB-BASED TECHNOLOGIES TO THE TEACHING OF ELECTRICAL ENGINEERING COURSES

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Master of Science in Electrical Engineering-March 2000

Advisor: Jon T. Butler, Department of Electrical and Computer Engineering

Second Reader: Herschel H. Loomis, Jr., Department of Electrical and Computer Engineering

This thesis is part of an effort by the Department of Electrical and Computer (ECE) Engineering to implement distributed learning to better serve its students. Distributed learning is especially useful for a modern technologically-oriented military, which is geographically distributed. The goal of this thesis is to develop a prototype web-based course, specifically, EC2820 - Digital Logic Design. A primary sub-goal is to quantify time required and to understand the tradeoffs involved. A secondary sub-goal is to evaluate web page tools.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Web-Based Learning, Multimedia, On-Line Course

AN EXTENDED KALMAN FILTER FOR QUATERNION-BASED ATTITUDE ESTIMATION

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Electrical Engineer-September 2000

Master of Science in Electrical Engineering-September 2000

Advisors: Xiaoping Yun, Department of Electrical and Computer Engineering

Eric R. Bachmann, Department of Computer Science

Robert G. Hutchins, Department of Electrical and Computer Engineering

This thesis develops an extended Kalman filter for real-time estimation of rigid body motion attitude. The filter represents rotations using quaternions rather than Euler angles, which eliminates the long-standing problem of singularities associated with those angles. The process model converts angular rates into quaternion rates, which are in turn integrated to obtain quaternions. Gauss-Newton iteration is utilized to

THESIS ABSTRACTS

find the quaternion that best relates the values of linear accelerations and earth magnetic field in the body coordinate frame and the earth coordinate frame. The quaternion obtained from the optimization algorithm is used as part of the observations for the Kalman filter. As a result, measurement equations become linear. The computational requirements related to the extended Kalman filter developed using this approach are significantly reduced, making it possible to estimate attitude in real-time. Extensive static and dynamic simulation of the filter using Matlab proved it to be robust. Test cases included the presence of large initial errors as well as high noise levels. In all cases the filter was able to converge and accurately track attitude.

DoD KEY TECHNOLOGY AREAS: Human Systems Interface, Sensors, Modeling and Simulation

KEYWORDS: Inertial Navigation, Extended Kalman Filter, Quaternion

SPACE-BASED COMPUTER NETWORK OPERATIONS (CNO)

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Master of Science in Space Systems Operations-September 2000

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CAPT James R. Powell, USN, Information Warfare Academic Group

This abstract is classified.

DoD KEY TECHNOLOGY AREAS: Space Vehicles, Computing and Software

KEYWORDS: Internet, Satellite Operations, Computer Network Operations, Space-based Computer Network Operations

ANALYSIS OF RADIO FREQUENCY COMPONENTS FOR SHIPBOARD WIRELESS NETWORKS

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Master of Science in Electrical Engineering-December 1999

Advisor: Xiaoping Yun, Department of Electrical and Computer Engineering

Second Reader: John C. McEachen, Department of Electrical and Computer Engineering

Computers and computer networks are generally viewed as tools that allow personnel to increase productivity. However, due to the limitations of traditional local area networks (LANs), the Navy has not been able to efficiently leverage commercial computer technology for general shipboard applications. Recent advances in wireless LANs (WLANs) now permit mobile users to employ network applications to manage and share information. Mobile computers can be used by the crew to supplement damage control reports and reduce the strain on the over-taxed voice circuits. Watchstanders can make log entries into a central database that utilizes automated data trend analysis algorithms to detect deteriorating components and schedule maintenance to correct the problem prior to component failure. The advantages to using WLANs onboard naval vessels are nearly endless.

This thesis evaluates commercially available wireless networking components for use onboard naval vessels. Installing such equipment would enable mobile watchstanders to access services provided on LANs. The theories and principles governing the operation of WLANs are discussed. Then, current commercially available components are evaluated in a laboratory setting. Finally, the most promising component evaluated is tested in the hangarbay of an aircraft carrier and throughout the inhabitable compartments of a Los Angeles class submarine.

THESIS ABSTRACTS

DoD KEY TECHNOLOGY AREAS: Computing and Software, Command, Control and Communications, Other (Wireless Communications)

KEYWORDS: Wireless Local Area Networks, Spread Spectrum, Mobile Computers

DEVELOPMENT OF THE BEARTRAP POST MISSION PROCESSING SYSTEM 2000 (S2K) HTML HELP PROJECT

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Master of Science in Systems Technology-June 2000
and

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B.S., United States Naval Academy, 1994
Master of Science in Systems Technology-June 2000

Advisors: Murali Tummala, Department of Electrical and Computer Engineering
Gary R. Porter, Command, Control, Communications, Computers, and
Intelligence Academic Group

Second Reader: Michael K. Shields, M.K. Shields Company

This work is part of an ongoing effort to integrate the separate BEARTRAP post mission analysis tools into an application operating in a Microsoft Windows environment. This new integrated system will contain software modules designed to replace the array of diverse processing systems currently being used for BEARTRAP post mission analysis. This thesis develops the HTML Help features to support users of the BEARTRAP Post Mission Processing System 2000 (S2K) software application. This application allows an analyst to gather context sensitive HTML Help to support procedural use of the BEARTRAP Post Mission Processing System as well as background information on related fields of study. This document describes the background and development of the HTML Help project with particular emphasis on critical areas fundamental to the HTML Help project development and aspects requiring further research and development.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: HTML Help, BEARTRAP, S2K

TESTING AND EVALUATION OF SHIPBOARD WIRELESS NETWORK COMPONENTS

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Advisor: Xiaoping Yun, Department of Electrical and Computer Engineering

Second Reader: Herschel H. Loomis, Jr., Department of Electrical and Computer Engineering

Fundamental challenges facing program managers and information technology decision makers today are the identification of architectures and technologies that reduce the cost of maintaining computer networks while simultaneously increasing worker productivity. Advances in wireless communications and subsequently, wireless local area networks (WLANs) permit mobile users to share information without being hardwired to a network. These mobile devices will enable shipboard personnel to submit damage control reports, update equipment logs, view technical manuals and order repair parts, without being confined by the limitations of a wired network. The advantages of WLANs are virtually endless, ranging from the uses previously discussed, to communications between the ship and its small boats, to automated data transfer of degaussing results, and even direct parts ordering from a pier-side supply center.

This thesis provides a hardware analysis and discusses coverage limitations of commercially available WLAN components for use onboard naval vessels. Utilization of this mobile equipment will improve DC communications and watchstander productivity. With remote access to the wired network backbone, personnel can conduct transactions instantaneously whenever and wherever the need arises. A discussion

THESIS ABSTRACTS

of the theories and principles governing the operation of WLANs is presented, followed by a laboratory evaluation of current, commercially available components.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Command, Control, and Communications, Other (Wireless Communications)

KEYWORDS: Wireless Local Area Networks

TARGET TRACKING IN THE AUTOMATIC QUICK LOOK SYSTEM

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Second Reader: Michael K. Shields, M.K. Shields Company

This work is part of an ongoing effort to implement the Automatic Quick Look (AQL) system and integrate the separate BEARTRAP post mission analysis tools into a single desktop system residing in a Microsoft Windows environment. This new integrated system will contain software modules designed to replace and enhance the diverse array of processing systems which comprise the AQL system. This thesis examines the target tracking module which provides an estimated target track solution based on received acoustic data from a known sonobuoy pattern. Output from the target tracking module provides essential target aspect information for further sound pressure level (SPL) analysis. This work presents the development and conversion of the Enhanced Multi-Segment Tracking (EMST) algorithm from the original FORTRAN environment to a MATLAB environment. The MATLAB module will provide a development and testing platform for future implementation using Microsoft Visual C++.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Sensors, Modeling and Simulation

KEYWORDS: DSP, Narrowband, BEARTRAP

STEPPED FREQUENCY IMAGING RADAR SIMULATION

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Second Reader: Jeffrey B. Knorr, Department of Electrical and Computer Engineering

In this thesis, a technique involving Stepped Frequency and Inverse Synthetic Aperture Radar (ISAR) processing have been employed to develop two-dimensional radar images, for example, for an aircraft target. Radar returns from prominent scatterers of various parts of the target will be processed and displayed. The processing is a combination of two high-resolution processes: development of a high-range resolution (HRR) profile in slant range using the stepped frequency waveform, and the development of a high-resolution profile in cross-range using the ISAR technique. With these two techniques complementing each other, images of targets' dominant scatterers can be extracted, processed and displayed. With intelligence databases built over time, precise recognition of target type can be identified.

DoD KEY TECHNOLOGY AREA: Other (Radar Imaging Techniques)

KEYWORDS: Imaging, Radar, Stepped Frequency, Inverse Synthetic Aperture, Fast Fourier Transform

THESIS ABSTRACTS

EA-6B FOLLOW-ON STUDY: UAVS AND UCAVS

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The DoD's only air-based EA jamming capability is provided by 123 EA-6B Prowlers. It is projected that these 123 aircraft will no longer adequately support required Airborne Electronic Attack (AEA) missions beyond the year 2010 due to attrition and airframe life limits. In order to maintain the tactical advantage over enemy air defenses, the DoD must augment and ultimately replace its aging and diminishing fleet of EA-6B aircraft with an equal or better AEA capability. Integrated Product Teams (IPT) are conducting an Analysis of Alternatives (AOA) to define operational requirements that address the DoD's AEA needs. The principal contribution of this thesis is to identify those unmanned aerial vehicles (UAVs) and unmanned combat aerial vehicles (UCAVs) that can be utilized in the future for AEA. UAV Electronic Warfare (EW) payloads and smart weapons that could help in this area are presented as well. While much has already been written concerning UAVs, few resources exist that discuss the feasibility of UAV programs in the realm of EW. Even fewer resources discuss how these unmanned platforms must be linked in the future to conduct network-centric warfare. This thesis attempts to bridge that gap.

DoD KEY TECHNOLOGY AREAS: Air Vehicles, Electronic Warfare, Other (Airborne Electronic Attack)

KEYWORDS: Airborne Electronic Attack, EA-6B, Electronic Attack, Electronic Warfare, Jamming, Network Centric Warfare, Payloads, Precision Guided Weapons, Smart Weapons, UAV, UCAV

OPNET SIMULATION OF SIGNALING SYSTEM NO.7 (SS7) NETWORK INTERFACES

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B.Eng., National University of Singapore, 1989

Master of Science in Electrical Engineering-March 2000

Advisor: John C. McEachen, Department of Electrical and Computer Engineering

Second Reader: Murali Tummala, Department of Electrical and Computer Engineering

This thesis presents an OPNET model and simulation of the Signaling System No.7 (SS7) network, which is dubbed the world's largest data communications network. The main focus of the study is to model one of its levels, the Message Transfer Part Level 3, in accordance with the ITU-T Recommendation Q.704. An overview of SS7 that includes the evolution and basics of SS7 architecture is provided to familiarize the reader with the topic. This includes the protocol stack, signaling points, signaling links and a typical SS7 network structure. This is followed by a more detailed discussion about the functions of the various parts of the protocol, in particular, the functionality of the Message Transfer Parts. The OPNET modeling of the Message Transfer Part level 3, in particular the signaling message handling aspect, is presented. The simulation model presented uses a hierarchical approach, with each level corresponding to the SS7 level it is modeling. Simulation results of different scenarios using varying parameters, such as packet transmission time, packet length, and load sharing, for a typical SS7 network are also presented.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Modeling and Simulation

KEYWORDS: Signaling, Signaling System No.7 Kernel, Message Transfer Part, OPNET, Message Signaling Units

THESIS ABSTRACTS

SPACECRAFT INTEGRATED DESIGN TOOLS

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Master of Science in Astronautical Engineering-December 1999

Aeronautical and Astronautical Engineer-December 1999

Advisors: Brij N. Agrawal, Department of Aeronautics and Astronautics

Herschel H. Loomis, Jr., Department of Electrical and Computer Engineering

The thesis surveys current software tools to design satellites and develops an integrated spreadsheet-based tool for preliminary spacecraft design. First, several existing and future design tools - both commercially available and company proprietary - are discussed and evaluated. Second, a spreadsheet-based design tool, which is generally applicable to any earth-orbiting satellite, is developed. Preliminary design of all satellite subsystems is performed on separate sheets of the Excel workbook. Based on user-entered orbital data, propellant and mass budgets are also calculated. The design technique and spreadsheet implementation is presented along with the underlying "first principles" theory and equations.

DoD KEY TECHNOLOGY AREAS: Space Vehicles, Computing and Software

KEYWORDS: Spacecraft, Satellites, Design Tools, Concurrent Engineering

SIGNAL CLASSIFICATION USING THE MEAN SEPARATOR NEURAL NETWORK

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Master of Science in Electrical Engineering-March 2000

Advisors: Monique P. Fargues, Department of Electrical and Computer Engineering

Ralph D. Hippenstiel, Department of Electrical and Computer Engineering

The explosion of digital technology provides the warrior with the potential to exploit the battlespace in ways previously unknown. Unfortunately, this godsend is a two-edge sword. Although it promises the military commander greater situational awareness, the resulting tidal wave of data impairs his decision-making capacity. More data is not needed; enhanced information and knowledge are essential.

This study built upon the Mean Separator Neural Network (MSNN) signal classification tool originally proposed by Duzenli (1998) and modified it for increased robustness. MSNN variants were developed and investigated. One modification involved input data preconditioning prior to neural network processing. A second modification incorporated projection space variance in a re-defined performance parameter and in a newly defined training termination criterion. These alternative MSNN architectures were measured against the standard MSNN, a single-layer perceptron, and a statistical classifier using data of varying input dimensionality and noise power. Classification simulations performed using these techniques measured the accuracy in categorizing data objects composed of artificial features and features extracted from synthetic communication signals. The projection space modification variant exceeded all classifiers under noise-free conditions and performed comparably to the standard MSNN in noisy environments. The preconditioned input method produced a poorer response under most situations.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Computing and Software, Electronics, Electronic Warfare

KEYWORDS: Signal Classification, Neural Networks, Mean Separator Neural Network, Single Layer Perceptron, Statistical (Quadratic) Classifier

THESIS ABSTRACTS

DESIGN AND IMPLEMENTATION OF A HUMAN PRESENCE DETECTION SENSOR FOR USE WITH AUTONOMOUS MOBILE ROBOTS

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B.S., United States Naval Academy, 1995**

Master of Science in Electrical Engineering-June 2000

Advisor: Xiaoping Yun, Department of Electrical and Computer Engineering

Second Reader: Richard Harkins, Department of Physics

This thesis investigates the feasibility of designing a human presence detection sensor for implementation with an autonomous mobile robot. Current technology does not offer a low cost and readily realizable method for an autonomous vehicle to accurately identify the presence of human beings. Cameras, which require high-level image processing, have proven effective in identifying human faces. However, this sensing system would cost more than the autonomous mobile robots themselves, rendering the system cost inefficient. Also, active multi-array microwave systems and passive infrared systems have proven to be competent motion detection sensors, but not human presence detectors.

In this thesis, a type of sensor to identify an inherent commonality among all humans, infrared energy, is explored as well as a method of extracting this commonality from the rest of the environment. Finally, a proof of concept system is developed in various environments. Testing results demonstrate that a low-cost, high-performance human detection and tracking system for use with mobile robots is achievable using infrared sensors and digital signal processing. Additionally, recommendations are provided to enhance the current design using a more capable micro-controller for future system improvements. This thesis work is the first part of an ongoing project that implements a presence sensor that allows a mobile robot to identify and follow a human being.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Infrared, Motion Detector, Presence Sensor

TRANSITIONING TO THE UNIFIED CRYPTOLOGIC ARCHITECTURE

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Herschel H. Loomis, Jr., Department of Electrical and Computer Engineering

The National Security Agency/Central Security Service (NSA/CSS) is the nation's center for excellence for signals intelligence (SIGINT) and information assurance products and services. To sustain the nation's SIGINT capabilities, the NSA/CSS has begun a period of rapid change that will transform the way it performs the SIGINT mission to cope with the exploding information technology of today and tomorrow. One of the documents that chart the course for the NSA/CSS is the Unified Cryptologic Architecture. This thesis investigates both the systems engineering approach used in the Unified Cryptologic Architecture and the documents that detail the NSA/CSS transformation in order to postulate recommendations to support the transformation process.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Cryptologic Architecture, Business Plan, Signals Intelligence, Access Providers, Technology Forecast

THESIS ABSTRACTS

EVALUATION OF THE STATISTICS OF TARGET SPECTRA IN HYPERSPECTRAL IMAGERY (HSI)

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B.S., United States Naval Academy, 1994

Master of Science in Systems Engineering-September 2000

Advisor: Capt J. Scott Tyo, USAF, Department of Electrical and Computer Engineering

Second Reader: Richard. C. Olsen, Department of Physics

The majority of spectral imagery classifiers make a decision based on information from a particular spectrum, often the mean, which best represents the spectral signature of a particular target. It is known, however, that the spectral signature of a target can vary significantly due to differences in illumination conditions, target shape, and target material composition. Furthermore, many targets of interest are inherently mixed, as is the case with camouflaged military vehicles, leading to even greater variability.

In this thesis, a detailed statistical analysis is performed on HYDICE imagery of Davis Monthan Air Force Base. Several hundred pixels are identified as belonging to one of eight target classes and the distribution of spectral radiance within each group is studied. It has been found that simple normal statistics do not adequately model either the total radiance or the single band spectral radiance distributions, both of which can have highly skewed histograms even when the spectral radiance is high. Goodness of fit tests are performed for maximum likelihood normal, lognormal, gamma, and Weibull distributions. It was discovered that lognormal statistics can model the total radiance and many single-band distributions reasonably well, possibly indicative of multiplicative noise features in remotely sensed spectral imagery.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Spectral Imagery, Hyperspectral Imagery, Scene Statistics in Spectral Imagery

A 3D SPATIAL CHANNEL MODEL FOR CELLULAR RADIO

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Master of Science in Electrical Engineering-September 2000

Advisor: Ramakrishna Janaswamy, Department of Electrical and Computer Engineering

Second Reader: Tri T. Ha, Department of Electrical and Computer Engineering

This thesis provides closed form expressions for the angular distribution in azimuth and elevation planes for a geometrically based single bounce spheroid model. The geometry of the spheroid is defined by the semi-major axis a and the semi-minor axis b . The other parameter of interest in the model is the distance D between the base station and the mobile station. The latter is assumed to be at the center of the spheroid. The mobile station is assumed to be the transmitter, while the base station is the receiver. This thesis investigates the effects of the above parameters on the angular distribution of the received waves. Important parameters such as the R.M.S. angle spread in azimuth and elevation plane are calculated from the P.D.F. expressions derived. The behavior of these R.M.S. angle spreads versus the ratio a/D or b/D respectively is also investigated.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Battlespace Environments

KEYWORDS: Spatial Channel Model, Joint TOA/AOA PDF, AOA Marginal PDF in Azimuth Plane, AOA Marginal PDF in Elevation Plane, R.M.S. Angle Spread

THESIS ABSTRACTS

DAMAGE CONTROL AND LOG TAKING JAVA APPLICATIONS FOR SHIPBOARD WIRELESS LANs

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B.S., Turkish Army Academy, August 1992**

Master of Science in Electrical Engineering-December 1999

Advisor: Xiaoping Yun, Department of Electrical and Computer Engineering

Second Reader: C. Thomas Wu, Department of Computer Science

Damage control communications and watchstander log taking practices onboard submarines and ships need to be improved. Currently, damage control relies on a slow, error prone process involving sound powered telephone talkers and a grease pencil annotated white board. Also log taking practice suffers from similar problems. Logs are taken on paper forms, collected daily, and filed in cabinets. Wireless network and mobile computing devices can be a solution to improve the efficiency of these practices.

In this thesis, a distributed Java prototype software is developed to utilize the benefit of an onboard Intranet consisting of wireless LANs and pen-based handheld computers. For both practice areas, data could be entered into a handheld computer and then wirelessly transmitted to a database server. Those data can be processed by powerful main platforms and different supervisors can review them any time in parallel. An applet and a servlet program module are created to provide small, user friendly, platform independent electronic forms. Since handheld computers have some limitations like screen dimensions, computing power, and Java Virtual Machine, features of these software approaches are tested on a few different handheld computers to find the best software approach and computer product.

DoD KEY TECHNOLOGY AREAS: Surface/Under Surface Vehicles - Ships and Watercraft, Computing and Software

KEYWORDS: Wireless Local Area Network, Mobile Computing, Java, Pen-Based Computing

COMBAT IDENTIFICATION WITHIN THE JOINT AIR-TO-GROUND ENVIRONMENT

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Master of Science in Information Technology Management-September 2000

**Advisors: John S. Osmundson, Command, Control, Communications, Computers, and Intelligence
Academic Group**

Maj David V. Adamiak, USMC, Department of Electrical and Computer Engineering

Combat Identification (CID) has tremendous impact on joint warfighting and is critical to success on the battlefield. Numerous CID systems are being fielded by each Service to improve Situational Awareness (SA) and Target Identification (TI) capabilities in an effort to reduce fratricide while simultaneously improving combat effectiveness. Many of these systems are not interoperable and thus cannot exchange critical information with one another. Recently published joint vision statements emphasize that joint missions will continue to predominate in the future strategic environment. If this is truly the case, achieving an acceptable degree of interoperability among Theater Commander-In-Chiefs, Services, and Agencies (C/S/As) is paramount - particularly in the area of CID. This thesis examines the nature of CID in the joint environment focusing on Close Air Support (CAS) within the Air-to-Ground (A-G) mission area. This thesis then explores interoperability problems associated with CID systems, seeks to elucidate the sources of these problems, examines recent Department of Defense (DoD) efforts to address these problems, and makes recommendations to improve interoperability within the CID warfighting area.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Combat Identification, Fratricide, Interoperability, Close Air Support

THESIS ABSTRACTS

DIGITAL COMMUNICATIONS JAMMING

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Master of Science in Electrical Engineering-September 2000

Advisors: Rasler W. Smith, Department of Electrical and Computer Engineering

Jovan E. Lebaric, Department of Electrical and Computer Engineering

Second Reader: Maj David V. Adamiak, USMC, Department of Electrical and Computer Engineering

The objective of this thesis is to obtain a computer-based prediction of noise and jamming (barrage, pulsed and tone) effects on the probability-of-error for coherently detected BFSK, BPSK, QPSK, and noncoherently detected BFSK communication systems. To accomplish this, several models were developed using MATLAB Communications Toolbox and Simulink.

As observed from the simulation results, different types of jamming affect each digital modulation technique differently. We determined that in attempting to disrupt digital communications, it is often advantageous to concentrate the jamming energy in short pulses. Pulsed jamming can cause a substantial increase in the bit error rate relative to the rate caused by continuous jamming with the same average power. By comparing the effects of different jammer types used in the simulation, we observed that AM-modulated jammers caused more damage to digital communication systems than FM-modulated jammers.

The performance of the models has been verified by comparing the simulation results and the theoretical results for the bit error probability for the case of a signal in the presence of AWGN. The experimental results approach to the theoretical results after one million transmitted symbols. The difference in bit-error-rate was found to be between 0.64% and 1.25%, thus, the theoretical and numerical values of bit-error-rate are in reasonable agreement.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: MATLAB Communications Toolbox, Simulink, Jamming, Bit-Error Rate, BFSK, BPSK, and QPSK

ANALYSIS OF THE F/A-18G AS THE MANNED TACTICAL AIRBORNE ELECTRONIC ATTACK (AEA) PLATFORM

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Master of Science in Systems Engineering-September 2000

Advisors: CAPT James R. Powell, USN, Information Warfare Academic Group

Lonnie Wilson, Department of Electrical and Computer Engineering

The F/A-18G has minor shortcomings relative to the EA-6B ICAP-III baseline of the Advanced Electronic Attack (AEA) Analysis of Alternatives study being conducted by Naval Air Systems Command. By incorporating alterations, such as inclusion of a digital receiver system, complete communications electronic attack system, and routable network information system, this valid core can become a viable force for the future.

The mission radius and time on station figures with typical air defense suppression loads are nearly identical. AEA system components designed for the EA-6B ICAP-III are easily adaptable for use in the F/A-18G. An initial study of the electro-magnetic interference susceptibility for the F/A-18G was concluded with favorable results. Although the LR-700 can be adapted for use in this airframe, a digital implementation revolutionizes electronic surveillance with low probability of intercept radar and complex modulation waveform detection, coherent jamming capability, active cancellation look through, and specific emitter identification. An internet protocol routable network approach is introduced as a possible means to seamless connectivity and fully integrated data picture. The multi-role capability of the F/A-18G will provide synergistic strike and survivability advantages as well as training and readiness challenges. A quantification of overall effectiveness demonstrates the F/A-18G is a viable EA-6B follow-on and AEA platform.

THESIS ABSTRACTS

DoD KEY TECHNOLOGY AREAS: Air Vehicles, Electronic Warfare/Electronic Attack, Command, Control and Communications

KEYWORDS: EA-6B Prowler, F/A-18E/F/G Hornet, Airborne Electronic Attack (AEA), Wireless LAN, Digital Receivers

SIMULATION AND PERFORMANCE ANALYSIS OF THE ZONE ROUTING PROTOCOL FOR TACTICAL MOBILE AD HOC NETWORKS

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Masters of Science in Electrical Engineering-September 2000

Advisor: Murali Tummala, Department of Electrical and Computer Engineering

Second Reader: Robert Ives, Department of Electrical and Computer Engineering

This thesis presents a simulation and analysis of the Zone Routing Protocol (ZRP) for mobile ad hoc network (MANET) environments using the OPNET simulation tool. ZRP is being suggested for possible implementation in the Joint Tactical Radio System (JTRS) for the United States military. Utilizing a ZRP OPNET model that was developed at Cornell University, the analysis focuses on key performance parameters that include overhead generation, network adaptation, efficiency, and routing zone optimization. The ZRP model's traffic monitoring has been enhanced for this work to identify the engineering tradeoffs between efficiency and performance. The results of this thesis provide valuable insight into the analysis and performance with varying zone routing radius, node velocity, and node density. Critical MANET environmental and simulation parameters required for JTRS implementation into the military battlespace have been studied.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: MANET, PROTOCOL, BRP, DMR, IARP, IERP, JTRS, OPNET, ZRP

DESIGN OF AN ULTRA-WIDEBAND DIRECTIONAL ANTENNA FOR A GIVEN SET OF DIMENSION CONSTRAINTS

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This research encompasses the preliminary and detailed design phases of a directional high-power UHF antenna that fits within a restrictive cylinder. The antenna design was limited to a free-space situation.

In the preliminary design phase, various antenna configurations were evaluated through simulation using the Numerical Electromagnetics Code (GNEC) to determine the optimum design. The optimization process was divided into consecutive steps. The best antenna from one step was further developed in the next step, and so on, until the final preliminary design, the RATTLE-1 antenna, was obtained. The Antenna Comparison Technique (ACT), a procedure that compares normalized grades evaluated for each antenna, was used to choose the optimum antenna configuration.

The detailed design phase concentrated on solving the impedance matching problem between the antenna and the transmission line. The final solution entailed the use of a tapered coaxial line balun. The performance of the RATTLE-1 integrated balun was evaluated through simulations using the High-Frequency Structure Simulator (HFSS) and prototype measurements.

THESIS ABSTRACTS

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Antenna Simulation, Antenna Optimization, Conical Spiral Antenna, Broadband UHF Antennas, Tapered Coaxial Line Balun

A SURVEY AND ANALYSIS OF GEOLOCATION PROCESSORS

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Donald v. Z. Wadsworth, Department of Electrical and Computer Engineering

Geolocation of electromagnetic emitters is a processing intensive endeavor. Numerous signal data processing systems have been developed to accomplish this difficult task. These systems utilize different hardware configurations, software tools, and processing algorithms, with each system possessing varying capabilities and limitations. Many current programs and projects require the employment of these processing suites, necessitating the selection and possible modification of the most suitable system. This thesis document provides a survey and analysis of the currently available signal processing systems and discusses in depth the associated deployment, hardware, software, algorithm and development issues. The analysis provides a unique resource, heretofore lacking, for interested parties to utilize when tasked with the selection of a processing system that will meet their mission specific requirements.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Geolocation, Signal Processing

IPSEC VIRTUAL PRIVATE NETWORKS

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In the Information Age, information itself is a weapon due to the speed of transmitting data. However, to be usable, the information must be accurate, timely, and relevant. To ensure these three basic tenets, we must have strong Information Assurance.

Internet Protocol Security Virtual Private Networks offer a standards-based solution to the problems of transmitting sensitive data across an open source extranet such as the Internet. As a security solution for computer networks, they offer a strong method for encryption and authentication. However, due to the complexity of the technology, effective implementation requires detailed understanding of the setup process and painstaking attention to detail during the setup process.

Due to the threats that abound in today's world, the overall approach to the management of the Navy's Information Technology systems must be restructured. To have a consistent and standard policy is of utmost importance, as is the training of those that must install and maintain the systems and policies.

Cisco System routers offer the hardware required to fulfill the Virtual Private Networking requirements. The framework needed to develop an overall plan for consistently employing the Information Technology systems used today can be found in the Navy Nuclear Power program.

THESIS ABSTRACTS

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Command, Control, and Communications, Computing and Software, Electronics, Electronic Warfare, Human Systems Interface, Manpower, Personnel, and Training

KEYWORDS: Information Age, Information Assurance, Virtual Private Networks, Internet Protocol Security, Firewalls, Information Technology, Information Technology Management, Cisco Routers

DC CHARACTERIZATION OF EFETs GROWN ON BULK GaAs AND OVER BUFFER LAYERS OF LOW TEMPERATURE GROWN GaAs(Be)

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This thesis is part of a larger project that is attempting to address the drastic decline of foundries producing radiation hardened electronics for mil-aerospace applications. Wafer substrates containing certain buffer layers are known to improve the radiation tolerance of circuits built on them. Manufacturers potentially can use these substrates to build radiation tolerant devices with minimal or no changes to the design of a COTS device. This research documents the *DC* characteristics of standard Vitesse *EFETs*. Using a computer model built with Silvaco software, predictions for the *DC* operation of Vitesse *EFETs* built on a substrate with layers of *AlGaAs* over *LT GaAs(Be)* are made. Finally, an equation expressing the fermi level as a function of *Be* doping in *LT GaAs(Be)* is developed.

DoD KEY TECHNOLOGY AREAS: Electronics, Other (Radiation Effects)

KEYWORDS: Electronics, Radiation Hardened Electronics, Gallium Arsenide

DETECTION OF SHORT TRANSIENTS IN COLORED NOISE BY MULTI-RESOLUTION ANALYSIS

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Detecting short transients is a signal processing application that has a wide range of military uses. To be specific in Undersea Warfare, sensitive signal detection schemes can increase the effective range of active and passive sonar operations. Current research is being done to improve the capability of detecting short signals buried within background noise, particularly in Littoral waters. Starting with a colored noise model, this thesis will introduce two denoising methods based on multi-resolution analysis and compare the results to current transient detection techniques. The goal of this thesis is not necessarily to replace current detection schemes, but rather to enhance them and thereby making the procedure more robust.

DoD KEY TECHNOLOGY AREAS: Sensors, Surface/Under Surface Vehicles - Ships and Watercraft, Modeling and Simulation

KEYWORDS: Wavelets, Filter Banks, Multi-resolution Analysis, Transient Signals

THESIS ABSTRACTS

A PATH-BASED NETWORK POLICY LANGUAGE

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Network policies are "traffic regulations" for the networks which make up the Internet. These are necessary for managing the flow of data, for access control to the network, and for managing the network to achieve other types of quality of service goals. However, with the myriad of different policies and networks, all with varying needs, conflicts can arise between network policies. Detecting and correcting these conflicts can be quite difficult for human administrators. Thus, there is a need for a theoretically sound method for specifying policy and for automatically detecting policy conflicts.

This dissertation presents a path-based policy language that is more comprehensive than earlier languages for describing network policy. The Path-Based Policy Language (PPL) is a formal language for constructing models of Internet service and access control. This path-based language is extensible and allows for an unambiguous representation of network policies based on both the static and dynamic attributes of today's networks. To support this language, both a compiler and policy conflict tester were developed. These tools accept network policies specified in PPL, translate them into formal logic, and using a theorem prover to test for policy conflicts. PPL allows for the efficient representation of large networks with its abbreviated path format. This path format allows multiple paths to be represented with one statement.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Policy Language, Path-Based, Network Management, Conflict Detection, Conflict Resolution

IMPLEMENTATION OF A FAULT TOLERANT COMPUTING TESTBED: A TOOL FOR THE ANALYSIS OF HARDWARE AND SOFTWARE FAULT HANDLING TECHNIQUES

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With spacecraft designs placing more emphasis on reduced cost, faster design time, and higher performance, it is easy to understand why more commercial-off-the-shelf (COTS) devices are being used in space based applications. The COTS devices offer spacecraft designers shorter design-to-orbit times, lower system costs, orders of magnitude better performance, and a much better software availability than their radiation hardened (radhard) counterparts. The major drawback to using COTS devices in space is their increased susceptibility to the effects of radiation, single event upsets (SEUs) in particular.

This thesis will focus on the implementation of a fault tolerant computer system. The hardware design presented here has two different benefits. First, the system can act as a software testbed, which allows testing of software fault tolerant techniques in the presence of radiation induced SEUs. This allows the testing of the software algorithms in the environment they were designed to operate in without the expense of being placed in orbit. Additionally, the design can be used as a hybrid fault tolerant computer system. By combining the masking ability of the hardware with supporting software, the system can mask out and reset processor errors in real time. The design layout will be presented using OrCAD® schematics.

THESIS ABSTRACTS

DoD KEY TECHNOLOGY AREAS: Space Vehicles, Computing and Software, Electronics

KEYWORDS: Fault Tolerant Computing, Triple Modular Redundancy (TMR), Commercial-off-the-Shelf (COTS) Devices, Single Event Upsets (SEU)

MISSILE TERMINAL GUIDANCE AND CONTROL AGAINST EVASIVE TARGETS

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The ability of a missile to intercept a target in its flight is greatly determined by the guidance law employed in the guidance processing of the missile. Two main types of guidance laws are employed in the majority of missiles, namely proportional navigation (PN) and command to line-of-sight (CLOS). The effectiveness of CLOS however is limited to shorter ranges of up to about 6km, due to its sensitivity to angular tracking errors between the ground station and the target. PN is probably the most widely used homing guidance law, which seeks to null the line-of-sight (LOS) angle rate by making the missile turn rate be directly proportional to the LOS rate. PN does not suffer from the range limitation encountered by CLOS because it is self-homing and relies on an onboard seeker that provides target's LOS information directly. We modeled the two-dimensioned missile-target intercept geometry with CLOS and PN guidance laws using Matlab[®] Simulink[™]. The engagement results for a non-maneuvering target were first established as a benchmark and subsequently compared for the case of a target with a 9-g evasive maneuver. While conventional PN was shown to be effective against a non-maneuvering target, it has to be modified to improve its performance against a maneuvering target. Simulations for a proportional navigation strategy incorporating bang-bang control was carried out and analyzed. The performance of this strategy is also presented.

DoD KEY TECHNOLOGY AREA: Other (Missile Guidance Laws)

KEYWORDS: Missile Guidance Laws, Proportional Navigation, Command to Line-of-Sight

DESIGN OF AN ULTRA-WIDEBAND LOW PROFILE VERTICALLY POLARIZED UHF ANTENNA FOR THE U.S. GROUND TROOP HELMET

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The Joint Tactical Radio System (JTRS), which will operate from 2-2000 MHz, will meet emerging needs for ultra-wideband radios for the tactical battle space. Conventional antennas for tactical radios are capable of operating in a narrow band of frequencies. In addition, they have large visual profiles that expose the radioman's position. The COMbat Wear INtegration (COMWIN) antenna system developed at NPS incorporates wideband antennas into the soldier's combat wear to meet the above-mentioned challenges. In this thesis, a helmet-mounted antenna was designed to operate from 500-2000 MHz. Its performance was predicted through simulation. A prototype was built and its performance measured. The antenna is conformal to the shape of the soldier's helmet. It uses copper polyester to provide an antenna that is easily incorporated into the helmet. Measurements on the prototype showed good fit with theoretical predictions. The antenna's VSWR was less than 3:1 between 500 and 2000 MHz, except for an isolated band around 900 MHz. The presence of an operator wearing the helmet improved the VSWR. Simulation results at 500 MHz, 1000 MHz and 2000 MHz showed that the radiation patterns were omnidirectional and concentrated in the sector from the horizon to 60° elevation.

THESIS ABSTRACTS

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Ultra-Wideband UHF Helmet Antenna, Conformal Antenna, VSWR, Lightweight, Low Profile, Vertically Polarized, Omnidirectional, Prototype Antenna

TOWARD AN OBJECT-ORIENTED ARCHITECTURE FOR THE ENHANCED MULTI-SEGMENT TRACKER (EMST)

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This work is part of an ongoing effort to integrate the separate BEARTRAP post-mission analysis tools into an application operating in a Microsoft Windows environment. The new integrated system will replace the array of diverse processing systems currently being used for BEARTRAP post mission analysis. This thesis is the initial effort toward reengineering the Enhanced Multi-Segment Tracker (EMST) module to incorporate object-oriented capabilities and architecture. The module is an algorithm implemented in the C++ programming language for reconstructing a submarine's track through the water based on analysis of collected magnetic and acoustic data.

The first step requires reverse engineering the existing source code in order to understand the module. The hypothesis is that by reverse engineering the EMST source code, the attributes, behaviors and relationships that characterize the system can be identified, which will enable the future construction of objects for reengineering the system into an object-oriented architecture. The thesis describes the reverse engineering tasks performed on the existing EMST source code and presents methods for determining the attributes, behaviors and relationships that characterize the algorithm.

DoD KEY TECHNOLOGY AREA: Computing and Software

KEYWORDS: Software Engineering, Software Reverse Engineering, Software Re-Engineering, Object-Oriented Technology, Unified Modeling Language, BEARTRAP

EVALUATION OF RANGE COMPENSATION IN THERMAL IMAGING OF SHIPS USING THE EOPACE DATA BASE

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An ever-present problem in analyzing thermal images for target signatures is the influence of atmospheric effects in the signature observed at significant range. The compensation for these effects, mostly atmospheric absorption and scattering and path radiance requires accurate knowledge of the meteorological parameters for the area involved at the time of the measurements.

Based both on infrared image files taken during the Electro-Optical Propagation Assessment in Coastal Environments (EOPACE) experiment together with the EOPACE environmental data base and on the SeaRad propagation code to generate radiance, a range compensation algorithm is proposed in this thesis. Applying SeaRad output adjusted for the sky path radiance, an 11 by 11 matrix of the apparent sea temperatures is constructed in which each row corresponds to a different zenith angle and therefore range, and each column to a different sea apparent black body temperature. By interpolation all sea pixels in the image are range compensated. The ship pixels are range compensated by imposing continuity in the sea ship interface. The magnitude of scene temperature correction required is of the order of -2.3 ± 1.7 °C which is comparable to the precision of the recorded data.

THESIS ABSTRACTS

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Sensors, Modeling and Simulation

KEYWORDS: Infrared Radiation, Radiance, Atmospheric Propagation, Range Compensation, Thermal Imaging

ATTITUDE DETERMINATION OF A THREE-AXIS STABILIZED SPACECRAFT USING STAR SENSORS

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The purpose of this thesis is to investigate the application of a six-state discrete Kalman filter for estimates of angular rates based solely on star sensor data. The satellite is in a Molnyia orbit where orbital angular velocity and orbital angular acceleration are predetermined and stored in the on-board computer; such that they will be available each time a star observation is made. A two-axis star sensor will provide two angles to the estimator whereupon the third "unsensed" angle will be predicted; the rates about all three axes are then estimated. The results show that the rate estimates are accurate to within 10^{-7} r/s, which is equivalent to the data produced by gyroscopes.

DoD KEY TECHNOLOGY AREA: Space Vehicles

KEYWORDS: Kalman, Molnyia, MATLAB, Spacecraft, Satellite, Star Sensor, Star Tracker, Estimation, Rate, Gyroscope

INTEGRATION OF MARITIME SHIPPING TECHNICAL DATA INTO A COMMON DATABASE FOR USE IN A GRAPHICAL DISPLAY

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Master of Science in Space Systems Operations-September 2000

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Maritime Situational Awareness has been an important part of the overall shipping picture since the beginning of high seas exploration. Both military and civilian professionals have desired the knowledge of what ships are in their vicinity and what ships will be in their vicinity in the near and distant future. A common database will enhance the integration of multiple data sources into an accurate display of past, present, and future shipping tracks. In the past, shipping professionals relied on one or two sources to provide them with a picture of the maritime situation. Advancing technologies of the present and future allow and will allow for an increased number of data options to assist in providing a display of the shipping picture. This thesis will describe the generation, integration, and correlation of multiple sources of maritime shipping data into a common database. Examples presented show the application of the database and the display to the ship-tracking problem.

DoD KEY TECHNOLOGY AREAS: Space Vehicles, Sensors

KEYWORDS: Maritime Situational Awareness, Database, Graphical Display

THESIS ABSTRACTS

DETECTION OF WIRELESS LOCAL AREA NETWORKS IN AN URBAN TACTICAL ENVIRONMENT

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Second Reader: Vicente C. Garcia, National Security Agency Cryptologic Chair

Interest in portable, high-bandwidth digital communications methods spans the world and presents a formidable challenge to the Defense Department of the United States. While anxious to use new communications equipment, the armed services are wary of the vulnerabilities they expose. This thesis examines the vulnerability of wireless local area networks (WLANs) when used by tactical units in an urban setting.

The U. S. Marine Corps experimented with WLANs during Exercises Urban Warrior '99 and Kernel Blitz '99. Samples of exercise transmissions were collected and recorded in support of this thesis. Two direct sequence spread spectrum (DSSS) WLAN detectors were designed and implemented to analyze the data. One is an optimal detector and the other is non-optimal. This thesis details the design of the detectors and presents an analysis of the performance of the non-optimal detector.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Battle Space Environments, Other (High Speed Computer Networks)

KEYWORDS: Wireless Local Area Networks, WLAN, 802.11, Detection and Estimation, Computer Networks

A STUDY OF THE FEASIBILITY AND APPLICABILITY OF SHAPE CONTROLLED SPACE BASED INFLATABLE MEMBRANE STRUCTURES

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Inflatable structures used for space applications offer mass, volume, and cost savings to spacecraft programs, allowing larger space structures to be built. For certain space applications, there are advantages to using large structures. For example, antennas achieve higher gains when they are increased in size. Higher gains equate to higher data throughputs. Therefore, inflatable structures offer improvements in performance to certain types of spacecraft components.

Environmental factors induce surface errors on large inflatable structures. This degrades performance, especially for inflatable antennas. To reduce this degradation, active and passive control systems can be used to sense errors and control the shape of the antenna. One method of applying an active and passive control system is by using piezoelectric films that are either attached to or are part of the inflatable structure.

The research performed for this thesis explored the theoretical performance of a large inflatable space-based antenna via spreadsheet analysis and the physical performance of a piezoelectric film via laboratory experimentation. For the laboratory experiment, the film was attached to a drum and varying internal pressures and voltages were applied. Also, in order to validate the experimental results, an analytical model was created using MSC/PATRAN and MSC/NASTRAN software.

DoD KEY TECHNOLOGY AREAS: Space Vehicles

KEYWORDS: Piezoelectric Film, Inflatable Structure, Antennas, Communications, Satellite Development

THESIS ABSTRACTS

APPLICATION OF THE ROBUST SYMMETRICAL NUMBER SYSTEM TO HIGH RESOLUTION DIRECTION FINDING INTERFEROMETRY

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To reduce the number of phase sampling comparators in a direction finding (DF) interferometer antenna, a new array based on a robust symmetrical number system (RSNS) is described. The RSNS is used to decompose the spatial filtering operation into a number of parallel sub-operations that are of smaller computational complexity. Each sub-operation (interferometer) symmetrically folds the phase with folding period equal to $2Nm_i$, where N is the number of channels that are used and m_i is the channel modulus. A small comparator ladder mid-level quantizes each folded phase response. Each sub-operation only requires a precision in accordance with that modulus. A much higher DF resolution is achieved after the N different RSNS moduli are used and the results of these low precision sub-operations are recombined. The parallel use of phase waveforms increases the antenna resolution without increasing the folding rate of the system. The new antenna is constructed and tested in an anechoic chamber, and the results are compared with the experimental results of a previously tested optimum symmetrical number system (OSNS) array. Although the dynamic range of the RSNS is somewhat less than the OSNS, the inherent Gray code properties make it attractive for error control in phase sampling interferometry.

DoD KEY TECHNOLOGY AREAS: Sensors, Electronic Warfare

KEYWORDS: Robust Symmetrical Number Systems, Optimum Symmetrical Number Systems, Phase Sampling Interferometry, Direction Finding, Ambiguity Resolution

THE ROLES AND REQUIRED CAPABILITIES OF FUTURE NATIONAL SIGINT SYSTEMS

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National systems provide critical signals intelligence (SIGINT) support to both military commanders and national-level decisionmakers during peacetime, wartime, and contingency operations. This thesis explores how changes in the global technological environment are necessitating changes in the roles and required collection capabilities of future national SIGINT systems. It is imperative that future national SIGINT systems be tailored to the future signals environment, and be developed in the context of the overall SIGINT effort of multiple access providers detailed in the *Unified Cryptologic Architecture*. This thesis provides an estimate of the future SIGINT environment from a technological point of view, analyzes the roles that should be assigned to national systems, and develops collection-related requirements for the future national SIGINT architecture. Furthermore, this thesis briefly describes currently projected national SIGINT systems, focusing on collection-related shortcomings relative to future requirements. Finally, a brief outline is provided of possible evolutionary changes that have the potential to meet the future SIGINT collection requirements.

DoD KEY TECHNOLOGY AREAS: Electronic Warfare, Sensors, Other (Intelligence)

KEYWORDS: Signals Intelligence, Electronic Intelligence, Collection Requirements, Access Providers, Technology Forecast, National Systems

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