
THESIS ABSTRACTS

TRANSIENT FIELD VISUALIZATION FOR ULTRA-WIDEBAND ANTENNA DESIGN

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Master of Science in Electrical Engineering-December 1999

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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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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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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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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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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 Engineering Acoustics-September 2000

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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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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 $1x10^{11}$ 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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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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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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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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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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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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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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**Master of Science in Electrical Engineering-June 2000
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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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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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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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 Windows™ 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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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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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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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

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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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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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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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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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

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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 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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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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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

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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**

**Christopher D. Stone-Lieutenant, United States Navy
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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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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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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

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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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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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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

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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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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

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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

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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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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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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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Master of Science in Electrical Engineering-March 2000

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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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Master of Science in Applied Physics-December 1999

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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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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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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