

# MASTER OF SCIENCE IN SYSTEMS ENGINEERING

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## **FACILITATING SECURE MAIL IN A HIGH ASSURANCE LOCAL AREA NETWORK**

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Currently, almost all DoD systems are operated at a single level, classified or unclassified. The problems encountered on these single level systems with mail exchange, its storage, and manipulation are the multiple networks and workstations required to handle different security levels of data as well as the high cost of maintaining them. The Naval Postgraduate School Multilevel Secure Local Area Network (MLS LAN) project supports a high assurance server. This LAN is COTS-driven (commercial-off-the-shelf) and enforces a mandatory security policy while permitting users to employ standard office productivity tools on standard workstations. Initially, there was no means for multilevel mail exchange between clients of the system.

This research was to implement the simple mail transfer protocol (SMTP) server, Sendmail, on the Wang Federal XTS 300 as a multilevel server. A port of a UNIX version of Sendmail 8.9.3 was made to the XTS 300. Modifications to Sendmail were required so that it could be supported by the UNIX-like XTS 300 STOP 4.4.2 operating system. Sendmail proved to be a successful mail server for exchange of mail between system clients. Tests demonstrated successful transmission of simple mail and mail with attachments.

**DoD KEY TECHNOLOGY AREA:** Computing and Software

**KEYWORDS:** Multilevel Security (MLS), MLS Local Area Network (LAN), High Assurance, Sendmail, Commercial-off-the-Shelf (COTS), Platform, Server, Client, Trusted Path, Trusted Computing Base (TCB), Wang Federal XTS 300

## **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.

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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 (SINGGARS) and the Ultra-Wideband Radio Frequency Vest Antenna comparison to the standard SINGGARS manpack whip antenna.

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

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

### MODELING INFLUENCES AFFECTING INDIA'S USE OF NUCLEAR WEAPONS

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Since India and Pakistan became nuclear weapon states, the threat of a nuclear confrontation in South Asia has increased. Continuous fighting between the two countries for over fifty years involving the Kashmir region has raised the question of whether or not nuclear weapons will be used to settle their differences. Both countries have demonstrated the ability to produce or acquire nuclear weapons and the means to deliver them. Crossing of the Line of Control in Kashmir by either India or Pakistan and the possibility of escalation associated with conventional war has increased the chance of a nuclear war.

Utilizing a computer program known as Situational Influence Assessment Module (SIAM), an influence net model is constructed to ascertain the likelihood of India using nuclear weapons. The model is then validated by theater intelligence agencies. SIAM is used to identify critical influences known as pressure points, which may be vulnerable to manipulation as part of an Information Operations (IO) plan. This manipulation could affect India's decision to use nuclear weapons.

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

**KEYWORDS:** India, Nuclear Weapons, Modeling and Simulation, SIAM, Information Warfare, Perception Management

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

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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.

**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

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

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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

**EVALUATION OF TACTICAL DECISION AID PROGRAMS FOR PREDICTION OF FIELD  
PERFORMANCE OF INFRARED SENSORS**

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The diversity of infrared system performance prediction models currently used by different services conflict with the concept of 'joint operations' where all services must share the common resources to survive. In this respect this study presents an analysis and a comparison of two operational performance models, the U.S. Army's ACQUIRE and the infrared module of the Navy/Air Force Tactical Decision Aid (TDA), WinEOTDA. Differences in the modeling of underlying physical principles, input parameters, and treatments are analyzed. A comparison of the predicted detection ranges is made using a data set collected in the Gulf of Oman as the meteorological input. Suggestions are sought for the modification of the codes that will lead to the same outputs. Finally the possibility of adopting one of the codes as a standard TDA is analyzed. For the same scenario inputs and with a user-defined sensor model WinEOTDA predicted longer ranges for 100% of the time. WinEOTDA was observed to be more accurate in predicting detection ranges than ACQUIRE because of the improved target modeling.

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**DoD KEY TECHNOLOGY AREAS:** Sensors, Modeling and Simulation, Battlespace Environment

**KEYWORDS:** Tactical Decision Aids, FLIR92, SeaRad, ACQUIRE, WinEOTDA, TAWS

### **COMPUTER MODELING OF JAMMING EFFECTS ON ROLL STABILIZED MISSILES**

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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 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

### **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

**ANALYSIS OF THE POSITIONAL ACCURACY OF A RANGE DIFFERENCE MISSILE  
POSITION MEASURING SYSTEM**

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The Telemetry (TM) Tracker system is designed to determine time, space, and position information (TSPI) of an airborne missile by detecting its telemetry signal at a number of receiver sites. Doppler frequency measurements are converted to range differences between the missile and receiver sites, whose locations are known in three dimensions. An algorithm then utilizes these range differences to obtain missile TSPI with 1-meter accuracy. The TM Tracker was fielded during live missile firings and measurements indicated that the desired TSPI accuracy was not attained.

This thesis examines system requirements and limitations of the TM Tracker to obtain TSPI with 1-meter accuracy. The theory of operation and components of the TM Tracker are introduced. Algorithms used in computing position of a radiating source from range differences are analyzed. MATLAB simulations are conducted with missile trajectory data to determine the required measurement precision and signal-to-noise ratio (SNR) at the receiver sites to obtain 1-meter TSPI. The receivers' 45-degree, 3-dB beam widths are then implemented to observe their effects on TSPI accuracy. Simulations reveal that the TM Tracker system is capable of producing TSPI with 1-meter accuracy provided that precise frequency measurements and adequate SNR values are available at the receiver sites.

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

**KEYWORDS:** Telemetry (TM) Tracker, TSPI, Range Difference, Time Difference of Arrival (TDOA), Frequency Difference of Arrival (FDOA)

**EVALUATION OF LOW COST NETWORK INTRUSION DETECTION SOFTWARE FOR THE  
NETWORK CENTRIC NAVY**

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Network intrusion continues to be a viable threat to the Department of the Navy's (DON's) information infrastructure. As the U.S. Navy advances toward a knowledge-based infrastructure we are now vulnerable in new ways previously unknown, mainly due to the independent operation of all the emergent IT systems. As follow-on systems develop into a network-centric infrastructure, DOD has made intrusion into a classified system possible by linking from unclassified sites, a very real and serious problem. As a result of budget limitations and the accelerated pace required to catch up, emphasis is being placed on acquiring commercial off-the-shelf (COTS) products, many of which were never intended to completely meet the security demands of the military. To best protect our systems the development of a defense-in-depth layered security concept consisting of awareness, enforced policies, and firewalls, directly supports Presidential Decision Directive 63. This approach must be adopted since no single product provides total security. One element of the layered solution is a COTS network intrusion detection software system which will alert a network administrator to unauthorized intrusion. "NetProwler", a network intrusion detection system produced by Axent Technologies, is evaluated for naval use as a solution to multi-level network security.

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

**KEYWORDS:** Information Warfare, Information Systems Technology, Command Systems Technology, CNA/D/E, Intrusion Detection

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

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**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

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

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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.

**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

**COTS SOFTWARE DECISION SUPPORT MODELS FOR USPACOM'S THEATER  
ENGAGEMENT PLAN (TEP)**

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As part of the process of achieving national security objectives, the mission of United States Pacific Command (USPACOM) is to enhance security and promote peaceful development in the Asia region by deterring aggression, responding to crises and fighting to win. USPACOM's Theater Engagement Plan (TEP) contributes to the accomplishment of this mission by planning, coordinating, and implementing peacetime military activities to shape the region's security environment. USPACOM, J56 (Future Plans and Operations, Engagement) has a requirement to assess the effectiveness of engagement activities proposed, planned and conducted within its Area of Responsibility. USPACOM's goals and objectives for the engagement process have been formally defined, but no process exists to link engagement activities to goals and objectives. Consequently, there is no way to comparatively assess the value of one engagement activity versus another. This research focuses on the basics of Multi-Attribute Utility Theory (MAUT) and Analytical Hierarchy Process (AHP) techniques for alternative selection following a literature review, which addresses some of the issues in decision support, traditional modeling techniques, and some of the traditional methodologies for quantifying subjective judgments. Additionally, this research illustrates the usefulness of currently available COTS decision support software in assisting the decision-maker in this endeavor.

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

**KEYWORDS:** Decision Support, Decision Analysis, Multi-Attribute Utility Theory, Analytical Hierarchy Process

