MASTER OF SCIENCE
IN
SYSTEMS TECHNOLOGY

OPNET PERFORMANCE SIMULATION OF NETWORK SECURITY SERVICES

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This thesis conducts a performance simulation of Asynchronous Transfer Mode (ATM) and Kerberos security solutions. Specifically, the study will build a working modeling framework of the Kerberos security service and the CellCase ATM encryption service. The model will be used to look at how these services will affect throughput by inserting waiting times in a series of queues in a small sized network.

The result of algorithms for calculating cryptographic delay are then inserted in an OPNET model and examined against a control model for validation. These models assume a linear relationship between the cryptographic service time and the throughput. Further relationships between service time and throughput are suggested for use in other security systems.

This thesis concludes that the modeling framework presented is viable for creating higher fidelity performance simulations of network security services. The area of Public Key Infrastructure (PKI) is a key area where the research may be utilized.

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

KEYWORDS: Joint Command, Control, Communications, Computers and Intelligence (C^4I), Optimized Network Evaluation Tool (OPNET), Kerberos, Asynchronous Transfer Mode (ATM)

JOINT SPECTRUM ACQUISITION AND MANAGEMENT FOR THE 21ST CENTURY

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Radio frequency (RF) spectrum is a limited, reusable resource. The next century's ownership of this resource, and the policies which guide its usage, are being determined today. The spectrum requirements needed for the realization of *Joint Vision* 2010 are in direct competition with similar commercial needs worldwide. This thesis outlines the fundamental agencies, regulations, and policies that govern the acquisition and management of the radio frequency (RF) spectrum. An understanding of Department of Defense (DoD), national, and international procedures for frequency management is critical to military acquisition professionals involved in the planning of future systems.

This thesis will assist students and researchers at the Naval Postgraduate School in developing an understanding of spectrum management and acquisition policies as they relate to United States joint military command, control, and communications (C3) systems.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Communications, Frequency Management, Radio, Spectrum

(Classified Title)

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Information Operations is being executed at many levels in today's world. Operations in the Command, Control, Communications, Computer, and Intelligence (C4I) area has to be dealt with in many realms. The integration of information and telecommunication technologies is reaching throughout the world, providing a solution to the need for reliable communications. The advantage in the global exchange of data has increased the volume of information in the commercial, government, and military. In the late 1970s, VSAT networks were introduced to support low data rate communication over large geographic areas. The rapid development of communications technologies has put less industrialized nations on the same level as the United States and Western Europe in information technology. By the year 2000, over 700,000 VSAT terminals are expected to be in operation worldwide. Nations that are developing and growing at rapid rates will most likely be a potential adversary for the United States in the future. National Security may be faced with VSAT issues that will need to be dealt with, and the vast quantity and variety of networks carrying an overwhelming amount of data world wide makes finding targets of intelligence interest difficult. In order to support SPAWARSYSCEN San Diego project RADIANT SAPPHIRE. This research looks into a potential adversary's VSAT architecture and defines how it is utilized. The overall product will be a technical intelligence estimate of VSAT capabilities for a specific nation.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Very Small Aperture Terminal (VSAT), RADIANT SAPPHIRE, Signals Intelligence, Satellite Communications

COMMAND AND CONTROL IN THE SYSTEMS TECHNOLOGY BATTLE LAB

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Joint Vision 2010 introduces the emerging operational concepts of Dominant Maneuver, Precision Engagement, Focused Logistics, and Full-Dimensional Protection enabled by Information Superiority. Information Superiority is gained through operational architectures that closely couple the capabilities of sensors, C2, and "shooters." This architecture of future warfare can be characterized as "Network Centric Warfare." The Navy's response to adapt and develop new operational concepts in support of Network Centric Warfare is Information Technology for the Twenty First Century (IT-21). IT-21 is a reprioritization of existing Command, Control, Communications, Computers, and Intelligence (C4I) programs of record focused on accelerating the transition to a personal computer (PC)-based tactical and support warfighting network. Battle Labs exist Service-wide to aide in this growth process. Battle labs are focused organizations created to explore new technology, concepts, doctrine, or tactics, techniques, and procedures to improve the efficiency and combat power of the forces. The Systems Technology Battle Lab (STBL) was established to inject an academic viewpoint into experiments and research sponsored by the MBC and Commander, Third Fleet (COMTHIRDFLT). Currently, the documentation on the systems installed and how they work together to provide a centralized forum for experimentation and research is inadequate. The

purpose of this thesis is to provide the STBL user with a guide describing the capabilities of the STBL and an example of its utilization in an integrated form.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Command, Control, C2, Process, Systems

A PROPOSED FIRE SUPPORT COMMUNICATION ARCHITECTURE FOR EXTENDING THE LITTORAL BATTLESPACE (ELB) ADVANCED CONCEPT TECHNOLOGY DEMONSTRATION (ACTD) '01

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Extending the littoral battlespace (ELB) is vital to the United States Navy and Marine Corps. Fast, accurate, and reliable fire support will continue to be essential to the execution of Operational Maneuver From The Sea (OMFTS) and Ship-To-Objective Maneuver (STOM). The emergence of new technology has made these concepts possible. Technology will allow Marines to reach their objectives faster and farther then ever before. Information gathering, dissemination, and targeting will be key factors to the success of these new concepts.

The development of low earth orbiting satellites that provide a seamless Command, Control, Communications, and Computers, and Intelligence (C4I) network will be necessary for ELB. This network will provide worldwide coverage, emphasize light forces with the ability to connect to larger forces and have a near zero footprint. The emerging communication architectures must have the capacity for voice, data, and video handling from high to narrow banwidth. Developing a "light" communications architecture that supports these emerging concepts will allow ELB to be responsive for joint operations in the twenty-first century.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Extending the Littoral Battlespace, Operational Manuever From The Sea, Ship-To-Objective Manuever, Low Earth Orbiting Satellites

ANALYSIS OF OPERATIONAL LEVEL COMMAND, CONTROL, COMMUNICATIONS, COMPUTERS AND INTELLIGENCE (C^4I) SYSTEMS ON TAIWAN (U)

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This study offers a comprehensive analysis of operational level command, control, communications, computers, and intelligence (C^4I) systems used by Taiwan for national defense. Review of open and intelligence sources has identified a significant lack of information for United States military planners on the architecture and systems employed by Taiwan. This study is intended to form the basis for continued research and analysis to fill this void.

This analysis summarizes briefly the historical and current geopolitical issues affecting U.S. relations with Taiwan and China. Taiwan's command, control, communications, computers, and intelligence (C^4I) system is then examined, evaluating its ability to observe, orient, decide, and act upon relevant tactical

information. The E-2T HAWKEYE is also analyzed for its role in air defense operations. The study concludes with an examination of Taiwan's potential C^4I vulnerabilities, and implications for possible U.S. military actions in the region.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Taiwan, Command and Control, C^4I, Air Defense, E-2T

A SCENARIO-BASED ANALYSIS OF THE MOBILE SATELLITE SERVICES

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This thesis examines the recent trend towards using commercial satellite technology to augment military satellite communications (MILSATCOM) systems. The use of commercial communications technology is necessary because current and future military systems are vulnerable to bandwidth limitations. Additional reasons for this use include difficulties in military procurement and acquisition strategies due to the military's inability to keep pace with rapidly changing technologies and standards. The use of commercial Mobile Satellite Services (MSS) will resolve current and future bandwidth limitations and will accommodate the timetables of the procurement and acquisition processes. Military use of commercial MSS systems is dependent on technical understanding and vendor capability evaluations. This thesis provides in-depth background information on three MSS architectures that are currently available, and relevant technical issues that need to be addressed prior to their integration into military communications. This discussion is followed by an evaluation of these systems against three operationally representative scenarios which were derived from MSS requirements documents. The evaluation highlights salient features of each system, and provides a basis for an objective understanding of each system's capabilities and limitations. Conclusions from each scenario are presented, followed by recommendations for future implementations of MSS technology.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Communications, LEO Communications, Mobile Satellite Services

A FUTURE C4 ARCHITECTURE FOR MILITARY OPERATIONS ON URBANIZED TERRAIN

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Military Operations on Urbanized Terrain (MOUT) are becoming increasingly likely as city populations worldwide continue to rise dramatically. The need for U.S. forces to operate in urban areas was evident in Somalia, Haiti, and Bosnia and the evidence suggests this trend will continue. Since urban operations represent one of the most physically and mentally challenging battlefields U.S. forces must be prepared for the rigors of urban combat. New warfighting philosophies and concepts will give the U.S. a qualitative edge if we are able to employ them. The U.S. must understand the C2 challenges associated with urban warfare. Furthermore new technologies will give the U.S. the capability to dominate the battlefield with superior situational awareness and decision making. But unless these new technologies are integrated into a robust, redundant, reliable, and secure C4 architecture the U.S. advantage may disappear. First the author explores the nature of urban warfare, second the nature of buildings and cities are considered, third the challenges of command and control on the urban battlefield are examined and finally the behavior of electromagnetic energy is discussed along with specific technologies that may be components of a future

C4 architecture. The result provides the C4 planner with an overview of C2 and a feasible C4 architecture for MOUT.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: MOUT, Command and Control, C4

THE EXPEDITIONARY AEROSPACE FORCE AND DISTRIBUTED OPERATIONS FOR COMMAND AND CONTROL

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In the latter part of 1998, the United States Air Force began to institutionalize its post-Cold War expeditionary nature by ushering in its “Expeditionary Aerospace Force” (EAF) concept. A critical component of this concept is a “lean” force which calls for a reduction of the Air Force’s forward-deployed footprint of both personnel and equipment. This reduction is supported by and relies on advances in information and communications technologies. These technological advances allow the Air Force to conduct operations from multiple, independent nodes in a teaming manner. This approach, also known as “distributed operations,” is becoming standard throughout the U.S. Armed Forces. It allows many personnel to remain geographically separated from the forward-deployed forces which "reach back" to rear locations for required support.

The Air Force's transition to an expeditionary aerospace force and corresponding reliance on "distributed operations" poses new challenges to command and control. This thesis examines the changes the Air Force is undertaking to meet the challenges associated with implementing the EAF concept. These changes fit into the three pillars of command and control – personnel, processes, and technology.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Expeditionary Aerospace Force, Command and Control, Distributed Operations

TACTICAL DISTRIBUTION OF SATELLITE POSITION DATA FOR THE AIRBORNE LASER

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The Airborne Laser will conduct defensive operations in 2006 against theater ballistic missiles by applying laser energy to the attacking missile in boost phase. When ABL engages a missile there is a risk of damage to on-orbit satellites behind the target by the laser. U.S. Space Command’s SPADOC computer system in the Space Control Center in Cheyenne Mountain provides ground-based laser operators safe firing windows to protect orbiting objects near the laser emission. ABL requires the same functionality and the satellite position information on-board the aircraft. This thesis proposes a Commercial-Off-the-Shelf-based solution to deliver the satellite position data to ABL, and describes the operational, system and technical architectures of the Distributive Predictive Avoidance (DPA) communication link. The operational architecture includes a description of the Airborne Laser mission and the role of DPA. The system architecture will outline the components necessary to establish the communications link from Cheyenne Mountain to the aircraft, and the technical architecture will describe the communication waveform that will be used as the data link, Ultra High Frequency Demand Assigned Multiple Access.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Airborne Laser, Ultra High Frequency Demand Assigned Multiple Access

(CLASSIFIED TITLE)

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The integration of information and telecommunication technologies is reaching into the four corners of the world, providing a solution to the need for reliable communications. The advantages inherent in the global exchange of data are widely accepted and the volume of information in the commercial, government, and military spheres continues to increase. In the 1980s, very small aperture terminal VSAT networks were introduced to support low data rate communications over large geographic areas. Currently, their usage has expanded to broadcast and distribution services for data, image, audio and video, collection and monitoring for data, two-way interactive services such as reservation and banking systems, database applications, and voice communications. The rapid development of communications technologies has catapulted less industrialized nations into the Information Age, placing them on par with the United States and Western Europe in several areas. By the year 2000, over 700,000 VSAT terminals are expected to be in operation worldwide. Nations that are developing and growing at rapid rates will most likely be a concern for the United States to face in the future. As countries take advantage of the available technology, obtaining information from targets of interest to national security will be more challenging.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Very Small Aperture Terminal, RADIANT SAPPHIRE

AN INTEGRATION OF MARTES AND THE EP-3E SIGINT COLLECTION PLATFORM (U)

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The ability of the EP-3E electronic warfare configured naval reconnaissance aircraft to collect, process, and exploit signals of tactical and strategic interest is of vital importance to our national defense. Standard operating procedures require unidentified and high priority signals of interest to be recorded for further analysis. This recording process is antiquated and often inefficient. The EP-3E utilizes medium bandwidth, reel-to-reel analog tapes for recording. These tapes are sent to Yokosuka, Japan for initial analysis, then they are forwarded to the National Security Agency, Fort Meade, Maryland for final analysis. The time involved from signal recording to final analysis is 3-6 months. This process is less than optimum and does not fulfill joint, near real-time intelligence needs.

This thesis will analyze and evaluate the potential of increasing the efficiency of the EP-3E SIGINT collection, recording, and analysis process utilizing the MARTES signal processing system.

MARTES is a signal processing system that uses software to aid in producing near-real time post-flight analysis of digitally recorded signals.

DoD KEY TECHNOLOGY AREAS: Air Vehicles, Battlespace Environments, Command, Control, and Communications, Computing and Software, Electronics, Electronic Warfare, Human System Interface, Manpower, Personnel, and Training, Sensors, Manufacturing Science and Technology

KEYWORDS: MARTES, EP-3E, SIGINT, COMINT, ELINT, Digital

PERFORMANCE ASSESSMENT OF THE TACTICAL NETWORK ANALYSIS AND PLANNING SYSTEM PLUS (TNAPS+) AUTOMATED PLANNING TOOL FOR COMMAND, CONTROL, COMMUNICATIONS, COMPUTER, AND INTELLIGENCE (C^4I) SYSTEMS

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The Joint Staff established the Tactical Network Analysis and Planning System Plus (TNAPS+) as the interim joint communications planning and management system. The Marines Command and Control Systems Course and the Army's Joint Task Force System Planning Course both utilize TNAPS+ to conduct tactical C4I network planning in their course requirements. This thesis is a Naval Postgraduate School C4I curriculum practical application of TNAPS+ in an expeditionary Joint Task Force environment, focusing on planning tactical C4I system networks based on a case study of Exercise Tandem Thrust in Australia. In addition to manual tools and historical precedents, automation software enables the C4I system integration planner to rapidly plan networks to meet user requirements during deliberate or crisis action planning efforts. System architecture products derived from TNAPS+ planning can be used at the network or nodal level and exported to Annex K Communications planning documents. This thesis presents an overview of the TNAPS+ software product, implementation and performance and reveals areas for improved performance as well as identifying other network planning tools that can be used in concert with TNAPS+.

DoD KEY TECHNOLOGY AREA: Command, Control, and Communications

KEYWORDS: Command and Control Systems, Network Planning, Command, Control, Communications, Computers and Itelligence, Tactical Network Analysis and Planning System Plus (TNAPS+)