

**MASTER OF SCIENCE  
IN  
SYSTEMS TECHNOLOGY**

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## MASTER OF SCIENCE IN SYSTEMS TECHNOLOGY

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### **OPERATIONAL ASSESSMENT OF SPACE BASED SITUATIONAL AWARENESS**

**Steven M. Arvanitas-Lieutenant, United States Navy**

**B.A., University of Utah, 1990**

**Master of Science in Systems Technology (Space Systems Operations)-September 1996**

**Advisor: Dan C. Boger, Command, Control, and Communications Academic Group**

**Second Reader: William Clifton, Space Systems Academic Group**

Situational awareness is the comprehension of one's position at a given time and point in space. Space-based situational awareness is a concept that makes use of the Global Positioning System (GPS) to report the positions of all friendly units in a given area. This information is rapidly broadcast to all friendly units in order to prevent fratricide and enhance command and control. It can also assist pilots in maintaining aircraft separation. This capability can be installed on any platform irrespective of unit type (SEAL team, SH-60B, tank, etc.), service, or nationality making joint operations more effective.

This thesis explores the application and acquisition of space-based situational awareness for the U.S. military. It details the Situational Awareness Beacon with Reply (SABER) system currently being fielded by the Space and Naval Warfare Systems ComEwadsworthmand. This system is currently an Advanced Concept Technology Demonstration (ACTD) program, and this assessment will focus on the overall operational concept of the prototype beacon system. Key features of the SABER system are detailed to give the reader an understanding of how situational awareness will be accomplished. An assessment of SABER's performance during an operational deployment with the 22nd Marine Expeditionary Unit and SABER integration issues in naval helicopters is also included.

### **TASK STRUCTURE AND SCENARIO DESIGN**

**Michael C. Berigan-Captain, United States Marine Corps**

**B. A., University of Florida, May 1989**

**Master of Science in Systems Technology-June 1996**

**Advisors: William G. Kemple, Command, Control, and Communications Academic Group**

**Kishore Sengupta, Department of Systems Management**

The Adaptive Architectures for Command and Control (A2C2) project is a four-year effort sponsored by the Office of Naval Research to explore adaptation in command and control structures. The project's first experiment involves studying interaction between task structure and organization structure. Although the organization structure dimension of interest was clear, not enough was known of the dimensions of task structure to determine the dimension of interest without further study. This thesis describes a process for developing military operational scenarios within a task structure context. First, the author conducts a literature review, defines the dimensions of task structure applicable to this project, develops a grading scale for each dimension, gives examples of the dimensions and grades each example, and describes how changes in one dimension might affect other dimensions. Then a method for developing scenarios in accordance with a predetermined structure and visualizing tasks is described, including a task structure diagram and a description of a task design process using the diagram and the dimensions previously delineated. The author then applies the task design process by developing two scenarios for the first A2C2 experiment that differ across one dimension of task structure, *coordination requirements*. Finally, a description of the experiment is given, including discussion of operationalization of the scenarios and organization structures, and lessons learned from the experiment with regard to scenario design.

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### ANALYSIS OF DIGITAL CELLULAR STANDARDS

**Rachel L. Pruitt-Billingsley-Lieutenant, United States Navy**

**B.S., Prairie View A&M University, 1987**

**Master of Science in Systems Technology-June 1996**

**Advisors: Dan C. Boger, Command, Control, and Communications Academic Group**

**Vicente Garcia, Department of Electrical and Computer Engineering**

Cellular communications has become one of the fastest growing segments in the telecommunications industry. The demand for cellular services has risen beyond all expectations. With the current growth of the analog cellular network, a strain has been put on the existing system and available spectrum. Cellular providers have been forced to use the existing bandwidth more efficiently by converting to digital technology. Four major digital cellular techniques are competing for marketplace dominance and each has the ability to expand the capacity of the cellular networks. The four systems are Global System for Mobile Communications (GSM), the Pan-European standard that utilizes FDMA/TDMA, using 25 MHz bandwidth channels, and operates in the radio frequency bands of 890-915 MHz for the uplink and 935-960 in the downlink; Digital Advanced Mobile Phone System (D-AMPS), the North American Digital Standard which is backwards compatible with the existing AMPS system; IS-95 manufactured by Qualcomm Inc. which utilizes the newest of the technologies CDMA, and finally Personal Digital Cellular (PDC), Japan's alternative which also uses TDMA technology. It is uncertain which system will become the standard, but it is certain that the ability to get to the marketplace, dominate it, and secure a stronghold in the market will be the successful standard.

### NAVAL THEATER BALLISTIC MISSILE DEFENSE (TBMD) DEVELOPMENT OF THE INFORMATION EXCHANGE REQUIREMENTS

**Daniel M. Brintzinghoffer-Lieutenant, United States Navy**

**B.A., The George Washington University, 1990**

**Master of Science in Systems Technology-June 1996**

**Advisors: Orin Marvel, Command, Control, and Communications Academic Group**

**John Osmundson, Command, Control, and Communications Academic Group**

As the United States moves into the next century one of the biggest threats facing her national interests is the proliferation of Theater Ballistic Missile (TBM) Systems, with their potential for carrying Weapons of Mass Destruction (WMD). In order for the United States to "project power", the Navy must play a large role in the protection of friendly assets from TBM attacks. Thus, the Navy is continuing to develop new systems and technologies as it attempts to migrate older weapons systems to fulfill this mission into its initial ballistic missile defense concept, Navy Area Defense (NAD). This thesis looks at the differences between the current "as is" physical/information architectures for the Anti-Air Warfare Commander and the future "to be" physical/information architectures for Theater Ballistic Missile Defense Commander.

The conventional anti-air warfare and TBM defense information requirements, on an Aegis, are developed using IDEF 0 Diagrams. These information requirement differences must be used as drivers for future system acquisition and development. Also, the potential problem areas associated with adding TBMD as an additional responsibility for the Air Warfare Commander (AWC) onboard and AEGIS platform, are covered.

The results of this thesis represent the initial plan (road map) for changes needed to support the evolving mission (Navy Area Defense) in the fleet.

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### **DIPHONE-BASED SPEECH RECOGNITION USING NEURAL NETWORKS**

**Mark E. Cantrell-Major, United States Marine Corps  
B.S., Oregon State University, 1982**

**Master of Science in Systems Technology-June 1996**

**Master of Science in Computer Science-June 1996**

**Advisors: Dan C. Boger, Command, Control, and Communications Academic Group  
Robert B. McGhee, Department of Computer Science**

Speaker-independent automatic speech recognition (ASR) is a problem of long-standing interest to the Department of Defense. Unfortunately, existing systems are still too limited in capability for many military purposes. Most large-vocabulary systems use phonemes (individual speech sounds, including vowels and consonants) as recognition units. This research explores the use of diphones (pairings of phonemes) as recognition units. Diphones are acoustically easier to recognize because co-articulation effects between the diphone's phonemes become recognition features, rather than confounding variables as in phoneme recognition. Also, diphones carry more information than phonemes, giving the lexical analyzer two chances to detect every phoneme in the word. Research results confirm these theoretical advantages. In testing with 4490 speech samples from 163 speakers, 70.2% of 157 test diphones were correctly identified by one trained neural network. In the same tests, the correct diphone was one of the top three outputs 89.0% of the time. During word recognition tests, the correct word was detected 85% of the time in continuous speech. Of those detections, the correct diphone was ranked first 41.6% of the time and among the top six 74% of the time. In addition, new methods of pitch-based frequency normalization and network feedback-based time alignment are introduced. Both of these techniques improved recognition accuracy on male and female speech samples from all eight dialect regions in the U.S. In one test set, frequency normalization reduced errors by 34%. Similarly, feedback-based time alignment reduced another network's test set errors from 32.8% to 11.0%.

### **A GLOBAL BROADCAST SERVICE FOR THE USER ON THE MOVE**

**Robert S. Carlisle-Lieutenant, United States Navy  
B.S., United States Naval Academy, 1988**

**Master of Science in Systems Technology (Space Systems Operations)-June 1996**

**Advisor: Paul Moose, Department of Electrical and Computer Engineering**

**Second Reader: Donald v. Z. Wadsworth, Department of Electrical and Computer Engineering**

In an effort to increase the amount of bandwidth available to ships and other disadvantaged users, the Department of Defense has initiated the Global Broadcast Service. This service uses commercial Direct Broadcast Satellite technology to broadcast video and data at high data rates to small and affordable terminals. The evolution of this technology, its commercial applications, and the Department of Defense's strategy for implementation of the Global Broadcast Service are summarized to illustrate the feasibility of providing this service to an on the move user. A satellite downlink budget from an actual demonstration involving the broadcast of Global Broadcast Service products to moving platforms is analyzed to highlight the limitations and further development required to provide this service to a user on the move. Several examples are given of how such a service to an on the move user could benefit military operations. Finally, several recommendations are provided concerning the future use and development of a Global Broadcast Service for the user on the move.

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### **AIR DEFENSE ANALYSIS FOR FRATRICIDE PREVENTION**

**Jeffrey W. Chlebowski-Captain, United States Marine Corps**

**B.S., The Pennsylvania State University, 1988**

**Master of Science in Systems Technology-June 1996**

**Advisor: Wayne P. Hughes, Jr., Department of Operations Research**

**William G. Kemple, Department of Operations Research**

In order to improve and develop tactics, techniques, and procedures (TTP) for the prevention of fratricide, joint air defense *processes* must be analyzed, not just the outcomes (i.e., fratricides themselves). Fratricide does not occur as an isolated incident but as a result of a series of events and processes—a chain of technical or procedural failures and errors—which must be investigated in great detail in order to effectively understand the true cause. Thus, the causes and implications of fratricide are reviewed, as well as the general measures to prevent it. A detailed description of key events and processes which characterize joint air defense is presented. A synopsis of the Joint Air Defense Operations/ Joint Engagement Zone (JADO/JEZ) Test Program is included to illustrate past attempts to improve and/or develop TTP and to outline the evolution of joint air defense analysis. Specific reasons *why* experimental methods of analysis are not entirely appropriate for analyzing joint air defense are included. The role of measures of effectiveness is discussed at length; operational considerations and field test constraints are also discussed. The effects of human factors are considered, including the cognitive limitations of human beings in stressful, information-intensive circumstances; environmental variables which affect human performance; and the role of morale, leadership, and esprit de corps. Significant conclusions are summarized and suggestions for improving joint air defense analysis are delineated.

### **THERMAL IMAGERY SPECTRAL ANALYSIS**

**Brian Harris Collins-Captain, United States Marine Corps**

**B.S., Rice University, 1990**

**Master of Science in Systems Technology-September 1996**

**Advisor: R. C. Olsen, Department of Physics**

**Second Reader: D. Cleary, Department of Physics**

The first thermal imagery from the Spatially Enhanced Broadband Array Spectrograph System (SEBASS) was analyzed for target detection purposes. Data were acquired during Exercise WESTERN RAINBOW in October of 1995 with Aerospace Corporation's new instrument. SEBASS is a thermal infrared spectral imaging system which collects data in 128 wavelength bands from 7.8 to 13.4  $\mu\text{m}$ . The system has 128 spatial pixels and a ground sample distance of 2.5 feet under the operating conditions of the exercise. The data reduction process included thermal calibration using on-board calibration sources, atmospheric correction through the use of in-scene data, and derivation of thermal emissivity. Analysis of the data was performed using techniques adopted from hyperspectral imagery. The application of the principal components transformation, the spectral angle mapper, and a spectral matched filter showed substantial enhancement of target detection capabilities when compared to the analysis of standard infrared imagery.

### **WIRELESS APPLICATIONS FOR MARINE AIR GROUND TASK FORCES**

**David A. Duff-Captain, United States Marine Corps**

**B.S., United States Naval Academy, 1990**

**Master of Science in Systems Technology-June 1996**

**Advisors: William G. Kemple, Command, Control, and Communications Academic Group**

**Carl R. Jones, Command, Control, and Communications Academic Group**

Wireless telecommunications have a place in the Marine Corps' future. The challenge is finding ways to match Marine Corps needs with current and future digital wireless technologies. The advanced command and coordination concepts envisioned for future expeditionary operations mesh well with technologies explored in this study. These include cellular networks, wireless data networks, mobile satellite services, and personal communication services. Careful application of these technologies will improve Marine command and coordination efforts in dynamic environments.

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Instead of physical connections offering information exchange from place-to-place, wireless models offer true “person-to-person” information exchange, regardless of location. On the chaotic, unstructured battlefields of the next ten to twenty years, getting key information to specific people, as opposed to places, will be even more important than it is now. There are a number of Marine personnel, processes, and applications at the MAGTF that could benefit from commercially available wireless technologies.

### **ATTACKING THE INFRASTRUCTURE: EXPLORING POTENTIAL USES OF OFFENSIVE INFORMATION WARFARE**

**Donald E. Elam-Lieutenant, United States Navy**

**B.S., United States Naval Academy, 1990**

**Master of Science in Systems Technology-June 1996**

**Advisors: Dan Boger, Command, Control, and Communications Academic Group**

**Vicente Garcia, Department of Electrical and Computer Engineering**

The world has entered the Third Wave; it has entered the Information Age. One of the fundamentals of this paradigm shift is the fact that information is power. The side that controls information more effectively will be victorious. Thus, countries and militaries must change their mentality in order to survive. A new form of conflict, Information Warfare, has been born. This new discipline is large, dynamic, and complex.

The need exists for education among military officers and other concerned professionals throughout the country. This thesis helps to bridge the education gap. It presents a snapshot of Information Warfare today, exploring many different avenues and possibilities along the way. The first half of the document is focused on Information Warfare in general, and the second half deals specifically with the offensive side.

The purpose of this thesis is not to present an all-encompassing view of Offensive Information War or even of Information Warfare in general. The field of Information Warfare is too big for any one individual or organization to fully comprehend all of its intricacies. Indeed, due to the dynamic nature of this discipline, chances are that some, or maybe even all, of the material contained herein will be obsolescent upon publication. The goal of the thesis is to present one view of Information Warfare, as seen through the eyes of many. The hope is that some benefit will be garnered by the reader, even if it only sparks an idea or helps to understand the importance of this growing warfare dimension.

### **UTILITY OF A LONG DWELL IMAGING (LDI) CAPABILITY TO ARMY OPERATIONS**

**Patrick F. Frakes-Captain, United States Army**

**B.S., College of William and Mary, 1986**

**M.S., Central Michigan University, 1995**

**Master of Science in Systems Technology (Space Systems Operations)-September 1996**

**Advisors: Dan C. Boger, Department of Systems Management**

**Carl R. Jones, Department of Systems Management**

In response to imagery support shortfalls identified as a result of Operation Desert Storm and imagery related requirements specified in Mission Need Statements, the Central Imagery Office (CIO), the National Reconnaissance Office (NRO) and the Defense Airborne Reconnaissance Office (DARO) are currently studying a new capability to add to the United States Imagery System (USIS). This new capability is called Long Dwell Imaging (LDI). The concept involves the ability of a system of sensors to image a given area over an extended period of time. This new capability represents a temporal shift from reconnaissance to surveillance.

The purpose of this study is to: (1) examine the utility of an LDI capability to Army operations as a function of current and future doctrine and the results of field research, and (2) subsequently suggest a baseline architecture which meets the needs of Army warfighters.

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This thesis presents a view of the utility of Long Dwell Imaging to Army operations from a doctrinal and operational standpoint. It is intended to serve as a link between the national level intelligence community and the Army warfighter at the corps level and below. Over 15 organizations/commands were visited and more than 30 individuals participated in interviews/discussions. Additionally, the author participated in the CIO sponsored LDIA Assessment (LDIA) Expert Panel Session and the LDIA Community Assessment Conference.

### **AN ANALYSIS OF THE ARMY'S TACTICAL PACKET NETWORK**

**Earnest E. Hansley-Captain, United States Army**

**B.S., Fort Valley State College, 1985**

**Master of Science in Systems Technology-June 1996**

**Advisors: Gilbert M. Lundy, Department of Computer Science**

**Orin E. Marvel, Command, Control, and Communications Academic Group**

This thesis represents an analysis of the U.S. Army's Tactical Communications System with particular emphasis on the Tactical Packet Network (TPN). It is a study of the Army's TPN and the proposed upgrade solutions. The U.S. Army awarded GTE a contract to replace the TPN Exterior Gateway Protocol with the Border Gateway Protocol. Additionally, the U.S. Army intends to upgrade the bandwidth of the Small Extension Node Switch and the Node Center Switch. The goal of both upgrades is to enhance the TPN.

One cannot look at TPN without looking at the overall infrastructure or the Army Tactical Command and Control System (ATCCS). Even this view is shortsighted. The ATCCS continues to evolve to meet the information requirements of the warfighter. Thus, a fair study must include our current capabilities and our future intentions for C4I. This thesis analyzes both.

### **AN ANALYSIS OF COMMERCIAL LOW EARTH ORBIT AND MEDIUM EARTH ORBIT MOBILE SATELLITE SYSTEMS AND THEIR POTENTIAL FOR MILITARY USE**

**Dana L. Haskell-Major, United States Marine Corps**

**B.S., University of Maine at Orono, 1984**

**Master of Science in Systems Technology (Space Systems Operations)-September 1996**

**Advisor: Brij Agrawal, Department of Aeronautics and Astronautics**

**Second Reader: Dan C. Boger, Command, Control, and Communications Academic Group**

In recent years the United States military has been employed in more and more non-traditional roles as well as maintaining the ability to respond to crises throughout the entire spectrum of conflict. These missions can range from assisting civilian authorities providing disaster relief to responding to a major regional contingency. Often times these operations take place in remote or war torn regions of the world with little or no communications infrastructure. Additionally, today's emphasis on rapid deployment and maneuver warfare has resulted in our surpassing the capabilities of current military communications equipment. Expensive military satellite programs as well as the decline in defense spending has shifted our focus to more cost effective means of satisfying these requirements. Commercial mobile satellite systems (MSSs) such as Motorola's Iridium, Loral/Qualcomm's Globalstar, and TRW's Odyssey offer a possible solution. This thesis analyzes these three commercial MSSs, expected to have initial operational capabilities before the turn of the century, and their ability to satisfy current and anticipated DoD operational requirements. Each of these systems is examined in terms of their capabilities, vulnerabilities, and cost. Based on this analysis, a determination is made as to their potential for military use.

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### THE WARFIGHTERS' FUTURE LINK TO INFORMATION

Christopher B. Henderson-Lieutenant, United States Navy  
B.S., Mathematics, Auburn University 1988

Master of Science in Systems Technology (Command, Control, and Communications Systems)-June 1996

Advisors: Dan C. Boger, Command, Control, and Communications Academic Group

Rex A. Buddenberg, Department of Systems Management

The purpose of this thesis is to introduce the concept of having a jointly integrated networking schema to better enhance battlefield communications and the dissemination of information using a smart push/pull concept from the highest commander down to the individual soldier. The concept of having a robust and dynamic network could provide the United States Armed Forces a better way of integrating the individual soldier's performance into higher level units. Current systems in the armed forces inventory are not truly interoperable, and not everyone has the capability to receive the information that these systems carry. A networked battlefield would allow everyone on the network to receive data carried by all systems.

With smart integration and design using commercially tested standards, the network can be built for all battlefield components. Each component would bring its equipment into the battlefield and become part of the network. Their systems would be able to plug and play with all other systems in the battlefield. The liberal use of COTS and GOTS networking equipment will reduce the cost of the network and would ensure compatibility among the battlefield components. Using OSI layers in the design of the system would ensure compatibility. DoD would need to make a concerted effort by having all of the services agree to make the battlefield network a top priority.

### SATELLITE ON-ORBIT REFUELING: A COST EFFECTIVENESS ANALYSIS

Rustie L. Hibbard-Commander, United States Navy  
B.S., Jacksonville University, 1979

Master of Science in Systems Technology (Space Systems Operations)-September 1996

Advisor: Dan C. Boger, Command, Control, and Communications Academic Group

Second Reader: William Clifton, Military Instructor

With the ever-shrinking military budget constraints facing military and civilian contractors, the ability to extend the operational life of any system for minimal cost compared to a replacement is desirable. This fact has never been more true than in today's space industry. This thesis addresses the possibility of extending satellite life through the use of on-orbit refueling. Through compilation and analysis of satellite operational life span data, it is shown that maneuvering fuel depletion has a significant impact on satellite operations in geosynchronous orbit. If these satellites could be refueled economically this would prove not only cost-effective but also improve satellite tactical employment for space support to the warfighter. Through the manipulation of satellite data, launch/design costs, on-orbit refueling vehicle design/construction costs, and on-orbit operational requirements, it can be shown that on-orbit refueling can be done cost effectively. Single versus multiple satellite refueling operations were evaluated to determine the concept's viability.

### THE DDD-III: A RESEARCH PARADIGM FOR ABSTRACTING JOINT C3 SCENARIOS FOR TIER-1 EXPERIMENTS

Gregory S. Higgins-Lieutenant Commander, United States Navy  
B.E.E., Villanova University, 1985

Master of Science in Systems Technology (Space Operations)-June 1996

Advisor: David Kleinman, Command, Control, and Communications Academic Group

Second Reader: William Kemple, Command, Control, and Communications Academic Group

Advances in communications technology and computers have made possible tremendous leaps forward in real-time Command and Control (C2). This revolution in C2 capability will provide decision makers (DMs) in the Joint military organization with an unparalleled tactical and strategic picture of the battlefield ("Global Awareness"). The ways in

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which DMs having Global Awareness coordinate their information, resources and activities to fulfill the organization's mission is the focus of the Adaptive Architectures for Command and Control (A2C2) project. In order to examine these command and control issues empirically, the A2C2 project required a multi-player real-time simulation environment. A new computer model was needed to abstract "real world" problems into a controlled laboratory environment. The result was the Distributed Dynamic Decisionmaking (DDD-III) paradigm. The phase one experiment of the A2C2 project was designed to validate the 000-III paradigm, with emphasis on the manipulation of organizational variables. This document reviews the project objectives, 000-III capabilities, experiment one scenarios and scenario development issues. The scenario generator users guide and players tutorial, developed during phase one, are provided. The intent of this document is to link the phase one experiment to the next, more advanced phase of the A2C2 project.

### **ES-3A EXPLOITATION OF NATIONAL RECONNAISSANCE ASSETS**

**John M. Hood-Lieutenant, United States Navy**

**B.A., University of Florida, 1989**

**Master of Science in Systems Technology (Space Systems Operations)-September 1996**

**Advisors: Kyle T. Alfriend, Space Systems Academic Group**

**Vicente C. Garcia, Department of Electrical and Computer Engineering**

Integrating national and tactical intelligence systems is an important priority in our National Security Strategy. Until recently though, national and tactical sensors operated separately. National systems focused on strategic priorities with little thought given to the needs of warfighters. But as Desert Storm demonstrated, national and tactical reconnaissance platforms, operating jointly, are critical in providing threat warning and precision targeting. Operating individually, national and tactical platforms suffer various limitations. When integrated, a synergy is achieved allowing the full potential of each component to be realized. In accordance with this warfighting trend, the ES-3A tactical signals intelligence aircraft will soon be equipped with the capability to directly receive intelligence from national assets. Little thought has been given as to what this new capability implies, especially in terms of how it will change the way the ES-3A is employed. Therefore, this thesis will discuss the kinds of intelligence the ES-3A mission commander can expect to receive from national systems, how that data will be delivered to the aircraft, how it is fused with intelligence derived from on-board sensors, and finally how this fused product can be used to accomplish mission tasks.

### **THE USE OF HÉNON BINARY SEQUENCES FOR DIRECT SEQUENCE SPREAD SPECTRUM CODE GENERATION**

**Linda M. Hunter-Lieutenant Commander, United States Navy**

**B.S., United States Naval Academy, 1987**

**Master of Science in Systems Technology (Space Systems Operations)-September 1996**

**Master of Science in Applied Mathematics-September 1996**

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

**Harold M. Fredricksen, Department of Mathematics**

In this thesis, the generation of secure codes using chaotic pseudo-random sequences and a generalized Geffe generator is investigated. These codes are tested for cryptographic security and applicability for use in a spread spectrum communications system. It is shown that the codes appear to be cryptographically sound and suitable for use in a multi-user environment, but do not significantly enhance the security of the spread spectrum system. Further simulation of the spread spectrum system is utilized to investigate the effect of errors in receiver spreading codes.

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### **VULNERABILITY STUDY OF THE SITUATIONAL AWARENESS BEACON WITH REPLY**

**Sandra M. Jamshidi-Lieutenant, United States Navy**

**B.S., United States Naval Academy, 1988**

**Master of Science in Systems Technology, (Space Systems Operations)-September 1996**

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

**Vicente C. Garcia, Jr., Department of Electrical and Computer Engineering**

**Second Reader: Raymond F. Bernstein, Jr., Department of Electrical and Computer Engineering**

This thesis is an evaluation of the vulnerabilities of the Situational Awareness Beacon with Reply (SABER) System from the perspective of an enemy force. The system design is described to provide the understanding necessary to evaluate the vulnerabilities. It provides the background of SABER's development and information on the concept of operations and system requirements. It includes a description of the fundamentals and definitions associated with the general vulnerabilities common to all communications systems which can be exploited by enemy forces. After establishing the methodology from which the system is viewed, the external vulnerabilities of the Global Positioning System (GPS) and UHF satellite communications (SATCOM) are discussed. It provides details on the extent of the vulnerabilities specific to SABER which could be exploited by a "technically feasible" enemy. The vulnerabilities are summarized on the basis of a nodal analysis. Recognizing that vulnerabilities must be considered in conjunction with threats, risks, and the impact to operational readiness, it provides some discussion on steps which must follow the vulnerability analysis. Recommendations for the SABER I production level model are provided with a list of potential areas for future research.

### **OBJECT ORIENTED DESIGN OF TACTICAL TIC-TAC-TOE C4I SIMULATION**

**Todd L. Lennon-Lieutenant, United States Navy**

**B.B.A., Texas A&M University, 1988**

**Master of Science in Systems Technology-June 1996**

**Advisors: Gary Porter, Command, Control, and Communications Academic Group**

**Michael Sovereign, Command, Control, and Communications Academic Group**

The purpose of this thesis is to redesign the Tactical Tic-Tac-Toe (T4) game using object-oriented design. T4 is a C4I simulation developed by Professor Gary Porter that is based on the traditional Tic-Tac-Toe game. It allows players to play against other players or against the computer. Various board sizes, multi-board games, delayed intelligence, team play, and limited communications are used to model real world C4I problems. The game allows for data collection for later analysis of game configurations and results. The goal of this thesis is to redesign the original program written in Macintosh HyperTalk language by using the Booch object-oriented design method and the C++ programming language for porting the program to a Unix or Windows environment with the ultimate goal of having a networked game that can be played remotely using a WWW browser type interface.

This design used requirements analysis and domain analysis to create class, operation, and attribute definition. Class association, aggregation, and inheritance are also specified. This design is ready to begin control class definition, access control definition, and operation algorithm development in preparation for coding an executable release.

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### FROM VISION TO INTEROPERABILITY: AN ANALYSIS OF DEPARTMENT OF DEFENSE AND SERVICE INITIATIVES

**Joseph M. Maiorana-Captain, United States Army**

**B.S., Clarion University of Pennsylvania, 1986**

**Master of Science in Systems Technology-June 1996**

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

**Dan C. Boger, Command, Control, and Communications Academic Group**

This paper is an assessment of Department of Defense (DoD) and service initiatives to ensure joint interoperability of Command, Control, Communications, Computers, and Intelligence (C4I) systems. Using a consolidated initiative matrix, visions and actions are reviewed to identify intent, and existing documents used by C4I system planners, designers, and developers are assessed against essential system development criteria and required baseline actions to achieve interoperability. Findings reveal that interoperability development guidance and tools do not address mission-specific parameters of C4I systems. Not all C4I systems are the same. Mission-specific requirements dictate whether a system is interoperable or not. The current interoperability definition is quite vague for mission-specific systems, and existing DoD and service initiatives only address general guidance to focus system development. Common mission-specific cases are provided and demonstrate that achieving interoperability is more than general guidance and more than the ability to pass data or information through seamless interfaces to ensure that systems are functional. Interoperability must be further defined by analyzing a C4I system's unique mission. Finally, to guide C4I system design, a framework to establish quantifiable thresholds is developed and presented using existing joint doctrine.

### THE MAE UAV: A ROLE IN THEATER MISSILE DEFENSE ATTACK OPERATIONS

**Michael Vincent McDonald-Major, United States Marine Corps**

**B.S., University of Central Florida, 1990**

**Master of Science in Systems Technology-September 1996**

**Advisor: Dan C. Boger, Chairman Command, Control, and Communications Academic Group**

**Second Reader: Michael G. Sovereign, Command, Control, and Communications Academic Group**

The changing nature of modern warfare and the rapid proliferation of theater ballistic missiles throughout the world have created a need for the development of operational concepts which address countering current theater missile (TM) threats. Destruction or disruption of an enemy's ability to successfully launch theater missiles will depend highly upon a near-real time intelligence dissemination process. Unmanned Aerial Vehicles (UAVs) may possess capabilities that allow them to assist counter-TM efforts as part of that process.

The thrust of this thesis is to draw conclusions regarding the Predator UAV's ability to assist counter-TM efforts in attack operations. The primary focus is locating and facilitating the destruction of mobile TM launchers through rapid dissemination of imagery to appropriate targeting systems. An historical discussion of U.S. theater missile defense (TMD) efforts and the use of UAVs in modern warfare is followed by a detailed description of the Predator system and a discussion of its vulnerability to exploitation. Finally, conclusions concerning Predator's ability to assist in such operations are made. Conclusions are based upon a wide range of exercise and demonstration documents that characterize Predator's operational performance.

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### **TACTICAL DMS: A GLOBAL BROADCAST SERVICE OPTION**

**Jose I. Morales-Lieutenant, United States Navy**

**B.S., United States Naval Academy, 1989**

**Master of Science in Systems Technology-June 1996**

**Advisors: Donald Wadsworth, Department of Electrical and Computer Engineering**

**Rex Buddenberg, Department of Systems Management**

**Carl Jones, Department of Systems Management**

This thesis presents one possible method of integrating the DMS and GBS systems. This effort is undertaken in order to explore how the DMS messaging capability can be extended to the mobile, tactical user via a new, more robust broadcast subsystem. The Navy's current Fleet Broadcast subsystem is not prepared to handle the increased traffic load expected from the conversion to DMS-based messaging. The application of GBS as a "next generation" Fleet Broadcast offers an expansive leap in tactical broadcast communication capability.

DMS broadcast to the tactical environment via GBS is achieved through the application of relatively new, commercially developed network addressing and mobile-user routing protocols. Adaptation of a broadcast messaging capability into the DMS is also incorporated. Incompatibility issues are resolved at the transport and network layers instead of higher-layer data format conversion. The proposed communications architecture provides for a high data-rate message broadcast system, capable of carrying DMS traffic to mobile units.

### **INTERNETWORKING: TECHNICAL STRATEGY FOR IMPLEMENTING THE NEXT GENERATION INTERNET PROTOCOL (IPV6) IN THE MARINE CORPS TACTICAL DATA NETWORK**

**James E. Nierle-Captain, United States Marine Corps**

**B.S., University of Southern California, 1985**

**Master of Science in Systems Technology-June 1996**

**Advisors: Dan Boger, Command, Control, and Communications Academic Group**

**Don Brutzman, Undersea Warfare Academic Group**

The Marine Corps must architect a tactical internet based on a software technology that is in transition—the Internet Protocol (IP). Development of the Marine Corps' tactical internetworking system (Tactical Data Network or TDN) is progressing concurrently with the global Internet community's development of the Next Generation Internet Protocol (IPv6). Current (IPv4) and next generation (IPv6) versions of the Internet Protocol can together meet the tactical internetworking needs of the Marine Corps.

IPv4 provides universal interoperability with other networking technologies and support for a wide range of services now, but without enhancements IPv4 cannot meet the long-term needs of evolving tactical applications. IPv6 is needed to meet emerging requirements (such as secure mobility) but is not yet ready for implementation in the Tactical Data Network. Therefore the Marine Corps must build the tactical internet architecture using IPv4 and incorporate IPv6 improvements when transition is possible.

Marine Corps commitment to IP is essential to ensure universal interoperability and hardware-independent evolution of tactical applications and networking technology. This work presents a tactical IP addressing plan for TDN that works with IPv4 and also facilitates smooth transition to IPv6. In concert with the other military services, the Marine Corps must develop a strategy for migrating the joint tactical internet to IPv6. The future viability of the Tactical Data Network depends on the Internet Protocol.

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### **SINGLE SOURCE ERROR ELLIPSE COMBINATION**

**Joseph R Orechovesky-Lieutenant, United States Navy**

**B.S., University of South Carolina, 1989**

**Master of Science in Systems Technology (Space Systems Operations)-September 1996**

**Advisor: Vicente Garcia, Department of Electrical and Computer Engineering**

**Second Reader: Gerry Baumgartner, NRaD**

There are a number of military applications in which the geographic location of a signal of interest is of prime importance to the ability of a unit to fulfill its mission. The accuracy of the geographic fix provided to the warfighter can directly affect the success or failure of a mission. One method to improve the accuracy of existing systems is to use the weighted average of a number of intercepts. Each intercept is manifested as an error ellipse comprised of a latitude, longitude, semi-axes, heading and a related Chi-squared distributed probability. Individual error ellipses can be viewed as a quadratic surface perpendicular to the x,y plane of a bivariate normal distribution, the z-axis intersection of which corresponds to a Chi-squared value. By transforming the individual error ellipses to their related location covariance matrices, Gaussian statistics may be used to produce a single location ellipse that combines information from several two-dimensional target location ellipses. By providing a means to fuse data from a given source the warfighter or analyst will be able to more accurately assess a threat and respond.

### **NEAR REAL TIME HUMAN INTELLIGENCE COMMUNICATIONS IN TIME CRITICAL TARGET EXPLOITATION**

**William R. Poppert-Lieutenant, United States Navy**

**B.A., The George Washington University, 1989**

**Master of Science in Systems Technology-September 1996**

**Advisor: Dan Boger, Command, Control, and Communications Academic Group**

**Second Reader: Terry Johnson, Department of National Security Affairs**

The proliferation of weapons of mass destruction (WMDs) and the rapid pace of modern warfare has increased the need of the Joint Force Commander (JFC) to focus on time-critical targets (TCTs). Human intelligence (HUMINT) has had a long history of support to military targeting, but in recent years has often lacked the timeliness necessary to prosecute TCTs. Advanced communication technologies and innovative architectures are improving HUMINT's timeliness, and they promise to make HUMINT a much more valuable tool to the JFC.

The objective of this thesis is to provide an understanding of the capabilities and limitations of HUMINT in a tactical environment, and to show how, through the application of modern technology and proper organization, HUMINT can be made as responsive, if not more so, than national technical means of collection.

### **THE DISADVANTAGE OF DIGITAL TECHNOLOGY**

**Richard E. Scott-Lieutenant, United States Navy**

**B.S., United States Naval Academy, 1988**

**Master of Science in Systems Technology (Space Systems Operations)-September 1996**

**Advisor: Herschel H. Loomis, Department of Electrical and Computer Engineering**

**Vicente C. Garcia, Department of Electrical and Computer Engineering**

Digital communications have been growing in popularity since the early 1970s. They offer many advantages over analog technology including improved signal quality, efficiency, interoperability, and lower cost. With this increase in popularity, the United States Intelligence Community is faced with a challenge. Collection against digital signals of interest is more difficult than that of their analog counterparts.

These challenges can be separated into three broad categories: scenario geometry, signal processing and limitations of current receiver capabilities. Scenario geometry refers to target access. Many signals are difficult to exploit simply because it is difficult to put collection assets in a position that permits access. The next challenge is processing. By its nature, digital signal processing is more complex and asset intensive than analog. Finally, any exploitation

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equipment has physical limitations. As targets gain more advanced technology, the limits of intercept equipment will be exceeded. New equipment will always be needed to match the growing threat. This paper discusses these difficulties in detail and makes recommendations for improved asset utilization and acquisition of future assets.

### **FUTURE INTELLIGENCE DISSEMINATION ARCHITECTURE**

**James Kirkwood Selkirk, Jr.-Lieutenant, United States Navy**

**B.S., United States Naval Academy 1989**

**Master of Science in Systems Technology-June 1996**

**Advisors: Dan C. Boger, Command, Control, and Communications Academic Group**

**Carl R. Jones, Department of Systems Management**

Joint task force commanders rely on intelligence to provide insight into an uncertain world. To fill this need, there are several Department of Defense (DoD) mechanisms to gather and display a wide variety of information. For Signals Intelligence (SIGINT) dissemination there are three primary systems: the TRAP Data Dissemination System (TDDS) operated by the Navy, the Tactical Information Broadcast Service (TIBS) operated by the Air Force, and the Tactical Reconnaissance Intelligence Exchange System (TRIXS) operated by the Army. In the Intelligence Authorization Act for Fiscal Year 1996, the House Select Committee on Intelligence threatened to freeze 75% of the DoD's intelligence budget until a comprehensive plan to unify intelligence broadcasts was completed. In response the Integrated Broadcast Service (IBS) plan was published by the Office of the Assistant Secretary of Defense for C3I. This thesis addresses the proposed IBS migration plan, the challenges ahead for the IBS program, the requirements for an ideal intelligence dissemination architecture, provides an assessment of the IBS with respect to the ideal system and makes recommendations for future intelligence dissemination. Two appendices are included: an example of the use of optical links in space-based information networks and a catalog of the satellite constellations operated by the National Reconnaissance Office (NRO). This thesis concludes that all intelligence dissemination should be carried on a global dissemination network for complete support to the warfighter.

### **AN OVERVIEW OF THE PETITE AMATEUR NAVY SATELLITE (PANSAT) PROJECT**

**Fred J. Severson-Lieutenant, United States Navy**

**B.S., United States Naval Academy, 1988**

**Master of Science in Systems Technology (Space Systems Operations)-December 1995**

**Advisor: I. Michael Ross, Department of Aeronautics and Astronautics**

The main thrust of this thesis is to present a manageable document that accurately portrays the current state of PANSAT and its supporting infrastructure. Research efforts involved investigating a variety of aspects of the PANSAT program including chronology, design, decision processes, and operations. The program objectives include the role of the PANSAT project as an educational tool for officer students and as a proof of concept for a small, digital store-and-forward communications satellite. An extensive list of external agency documentation requirements is also included. Scholastic institutions conducting similar projects could use this thesis as a design guideline as well as to spearhead their documentation efforts. This thesis is meant to be a comprehensive document as well as a suitable starting point for information concerning the PANSAT program.

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### A COMPUTER NETWORK SIMULATION TUTORIAL FOR COMNET III

**Jeffrey Edward Sullivan-Lieutenant, United States Navy**

**B.S., University of Missouri - Rolla, December 1988**

**Master of Science in System Technology-June 1996**

**Advisors: Suresh Sridhar, Department of Systems Management**

**Dan Boger, Command, Control, and Communications Academic Group**

The military is heavily reliant on the transfer of information among various networks in its day-to-day operations. With fewer defense dollars available for the development of new systems, the use of commercial-off-the-shelf (COTS) hardware to build military information networks is becoming commonplace. The critical nature of much of this information requires that knowledge of the performance characteristics of the networks through which this information travels be known. These characteristics allow network managers and designers to plan for future growth of the network, analyze network reliability, and plan for the construction of new networks.

One method to determine the performance characteristics of a network is through the use of modeling and simulation. COMNET III release 1.1n is a COTS network simulation application which may be used to model and simulate both local and wide area networks. This thesis provides a tutorial to explain the theory used in the application for the modeling and simulation of networks. Each chapter presents the theory of several objects which may be used in the application, states a network problem which is to be analyzed, provides step-by-step instructions to build a model to analyze the network problem, and presents the results of the network simulation.

### INFORMATION WARFARE: IMPLICATIONS FOR FORGING THE TOOLS

**Roger Dean Thrasher-Captain, United States Air Force**

**B.S., United States Air Force Academy, 1986**

**Master of Science in Systems Technology (C3 Systems)-June 1996**

**Advisors: Dan C. Boger, Command, Control, and Communications Academic Group**

**Carl R. Jones, Department of Systems Management**

One part of the modern Revolution in Military Affairs (RMA) is the possibility of a new form of warfare—often called information warfare. Development of information warfare depends on technological advances, systems development and adaptation of operational approaches and organizational structures. This thesis assesses the implications of information warfare for the technology and systems development areas, with the underlying motivation of ensuring the military is postured to “win the information warfare RMA” through effective research, development and acquisition. This assessment takes place primarily through a “Delphi” process designed to generate discussion between selected information warfare experts about the impacts of information warfare. This thesis concludes that information warfare is largely dependent on commercial information technology. This dependence means the military should rely on the commercial sector for most technological advances and products—with government research funds focused on military-unique research areas. Use of commercial items, coupled with DoD standard architectures, may enable a decentralization of information warfare acquisition to the user level. Finally, this dependence means the acquisition system should focus on architecture development, technology insertion, systems integration and on managing functions and services of systems—primarily through development of operational software to run on mostly commercial hardware.

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### **A TWO-CUBED EXPERIMENT TO EXAMINE THE EFFECTS OF INFORMATION COMPLETENESS, WORK LOAD, AND FAST PATROL BOAT COMMAND AND CONTROL IN THE LITTORALS UTILIZING THE WARGAME SIMULATION: *BATMAN & ROBIN***

**Nicholas K. Vodantis-Lieutenant, United States Navy**

**B.S., The Pennsylvania State University, 1987**

**Master of Science in Systems Technology-June 1996**

**Advisors: Gary R. Porter, Command, Control, and Communications Academic Group**

**William G. Kemple, Command, Control, and Communications Academic Group**

Fast Patrol Boats were considered a negligible threat when the U.S. Navy focused on blue water operations away from shore. Now that the Navy's focus has shifted to the littorals, where these ships patrol, the Fast Patrol Boat's potential as a credible adversary is gaining acceptance. Moreover, the threat may be greatly enhanced if Fast Patrol Boats employ Commercial Off-The-Shelf Command and Control equipment to coordinate their efforts. This paper presents the design and results of a wargaming experiment conducted with *Batman & Robin* at the Naval Postgraduate School to examine this issue.

The research question is how would U.S. Navy Surface Action Groups perform against Fast Patrol Boats equipped with Commercial Off-The-Shelf Command and Control equipment which enables these comparatively unsophisticated ships to conduct coordinated attacks. The experiment also looked at two other factors: Surface Action Group work load, which might exacerbate the offensive capability of Fast Patrol Boats conducting coordinated attacks with advanced Command and Control; and the quality of information our Surface Action Groups are provided which could likewise play a pivotal role in a confrontation or engagement.

A two-cubed factorial experiment was conducted to test seven hypotheses. Data were collected on ten performance measures for 128 trials total. Significant results were obtained for three factors and three interactions. Operational explanations are provided.

### **NAVY TACTICS, DOCTRINE, AND TRAINING REQUIREMENTS FOR LITTORAL WARFARE**

**John F.G. Wade-Lieutenant, United States Navy**

**B.S., United States Naval Academy, 1990**

**Master of Science in Systems Technology-June 1996**

**Advisors: Wayne P. Hughes Jr., Command, Control, and Communications Academic Group**

**William G. Kemple, Command, Control, and Communications Academic Group**

The White Papers "...From the Sea" and "Forward...From the Sea" have shifted the focus of U.S. maritime strategy from open-ocean (blue-water) operations to near land (littoral) operations. U.S. naval strength lies in the capability to conduct sustained operations on the high seas, but the littoral environment and the potential enemy which may be encountered there impose new demands on our naval forces. It is imprudent to assume that the U.S. Navy can transfer their open-ocean proficiency into the littoral unmodified. This thesis evaluates the U.S. Navy's ability to conduct operations within this environment through its Littoral Warfare tactics, doctrine, and training. Then corrective actions for building littoral tactics and doctrine are recommended. It is intended that the recommendations will initiate a tactical debate to better prepare U.S. naval forces for operations within littoral regions throughout the world.

### **THE HAE UAV AND DYNAMIC RETASKING BY TACTICAL COMMANDERS**

**Howard Todd Waller-First Lieutenant, United States Air Force**

**B.S., United States Air Force Academy, 1992**

**Master of Science in Systems Technology-June 1996**

**Advisor: Michael G. Sovereign, Command, Control, and Communications Academic Group**

Advancing technology and the changing nature and tempo of modern warfare has created many challenges. Desert Storm reiterated the need for Near-Real Time (NRT) imagery of the battlefield. History shows that Unmanned Aerial

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Vehicles (UAV) have the capability to meet some of these challenges. The Defense Airborne Reconnaissance Office (DARO) is directing a program to develop a family of UAVs that will meet the future NRT imagery needs of operational commanders. The High Altitude Endurance (HAE) UAV is part of this family of UAVs that will serve to provide sustained, broad area coverage for those commanders with time critical needs.

The thrust of this thesis is to define a process by which the time-critical Reconnaissance Surveillance and Target Acquisition (RSTA) imagery needs of the tactical commander on the battlefield can be met through effective dynamic retasking of the HAE UAV. This thesis examines HAE UAV capabilities, the intelligence cycle, and collection management procedures. Prohibitors of timely intelligence are highlighted. A process is described through which the HAE UAV may be dynamically retasked to meet the ground force commander's real-time collection requirements. The appropriateness of the HAE UAV to be used to satisfy the ground force commander's dynamic requirements is discussed.

### **NAVAL DOCTRINE: AN ANALYSIS OF THE EFFECTIVENESS OF NDP 1 AND NDP 6**

**Anne Laura Westerfield-Commander, United States Navy  
B.A., Ball State University, May 1980**

**Master of Science in System Technology-June 1996**

**Advisors: Wayne P. Hughes, Jr., Department of Operations Research  
William G. Kemple, Department of Operations Research**

The purpose of doctrine is to unite beliefs and actions. The Armed Forces are not always successful in achieving true interoperability; one cause for the disconnection between them is that, while the Services develop forces, they do not employ them. The Combatant commands employ what the Services provide. Accordingly, one of doctrine's most valuable roles is assuring the integration of developer and operator. This thesis examines the successfulness of Naval and Joint Warfare and Command and Control doctrine at the interface of development and employment.

The thesis concludes that Joint Publication 1, *Joint Warfare of the US Armed Forces*, and Joint Publication 6, *Doctrine for Command, Control, Communications, and Computer (C4) Systems*, present an integrated, focused framework. The ties to (and between) the corresponding Naval Doctrine Publications are weaker. Naval Doctrine Publication 1, *Naval Warfare*, the Naval Doctrine Command's first attempt at issuing doctrine, contains several weaknesses that detract from its stated purpose of establishing a framework for more detailed doctrine. Naval Doctrine Publication 6, *Naval Command and Control*, does meet its purpose and is a much stronger document, but could be further strengthened by incorporating a discussion of how Naval Command, Control, Communications, Computers, and Intelligence systems will be employed to support Naval Command and Control.

### **ORBITAL DEBRIS: COST IMPACT ON SETTING POLICY**

**William S. Wolfner-Commander, United States Navy  
B.S., Embry Riddle Aeronautical University, 1980**

**Master of Science in Systems Technology-June 1996**

**Advisor: K. Terry Alfriend, Space Systems Academic Group  
Carl R. Jones, Department of Systems Management**

As the exploration of space increases, the problems associated with orbital debris also increase. Orbital debris continues to grow at a linear rate with an ever increasing possibility of a shift to an exponential rate. If this point is achieved, space travel will, at best, be extremely hazardous and at worst, unusable. When mitigating orbital debris, cost and policy issues must be addressed. Currently, no policy exists that makes the mitigation of orbital debris mandatory but it only strongly recommends mitigation if it is cost effective. This thesis addresses the cost impact of alternative spacecraft design options for orbital debris mitigation. The cost impact is shown by developing generic satellite characteristics, considering two different altitudes, and using alternative design options.