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Monterey, California; Naval Postgraduate School

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# COMPILATION OF ABSTRACTS

Unrestricted Dissertations,  
Theses, and Final Projects

NPS Class of June 2016



Office of the Vice President and Dean of Research

NAVAL POSTGRADUATE SCHOOL

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## PREFACE

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This publication, *Compilation of Abstracts*, contains abstracts of unrestricted dissertations, theses, and capstone project reports submitted for the doctor of philosophy, master of arts, master of business administration, and master of science degrees for the Naval Postgraduate School's June 2016 graduating class. A digital copy of this publication can be found at <https://calhoun.nps.edu/handle/10945/49904> while the corresponding metadata for June 2016 abstracts can be found at <https://calhoun.nps.edu/handle/10945/49530>.

This compilation is published to acquaint those interested in the fields represented with the nature and substance of Naval Postgraduate School student research, which covers a wide range of defense-related topics. An online copy of this and previous editions can be found at <https://calhoun.nps.edu/handle/10945/27474>. Calhoun, the institutional archive of NPS, provides a convenient way to search the content of unrestricted theses. Search for specific full-text theses and dissertations by author, advisor, branch of service, date issued, degree, department, or type at <http://calhoun.nps.edu/handle/10945/16>.

Guidelines for obtaining printed copies of unrestricted dissertations, theses, and capstone project reports are outlined on the last page of this volume. Restricted theses are available for viewing on the NPS SIPRNet and through the Defense Technical Information Center at <http://www.dtic.mil/dtic/>.

### **Additional Information on NPS Research and Academic Programs**

*Summary of Research*, an annual compilation of research projects and publications, is also available online at <https://calhoun.nps.edu/handle/10945/13736>. "Research," a monthly newsletter highlighting some of the newest developments in NPS research, can be found at <https://calhoun.nps.edu/handle/10945/7839>.

For other inquiries about student and faculty research at NPS, please contact the Dean of Research, Jeffrey Paduan:

Naval Postgraduate School  
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For details on degree programs at NPS, please contact the director of admissions at (831) 656-3093 or [grad-ed@nps.edu](mailto:grad-ed@nps.edu). The NPS academic catalog is available at <http://www.nps.edu/Academics/GeneralCatalog/Layout.html>. The admissions website is at <http://www.nps.edu/Academics/Admissions/Index.html>.



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# INTRODUCTION

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The Naval Postgraduate School is pleased to present the dissertation, thesis, and capstone project report abstracts for unrestricted research completed in June 2016 by the graduating class.

## MISSION

The Naval Postgraduate School (NPS) was established to serve the advanced educational needs of the Navy. The broad responsibility of NPS is reflected in its stated mission:

*To increase the combat effectiveness of commissioned officers of the naval service to enhance the security of the United States. In support of the foregoing, and to sustain academic excellence, fosters and encourages a program of relevant and meritorious research which both supports the needs of the Navy and Department of Defense (DOD) while building the intellectual capital of the Naval Postgraduate School faculty.*

To fulfill its mission, the Naval Postgraduate School advances innovation in the Navy and prepares officers for employing new technologies. The research program at NPS supports the mission of graduate education. Research at NPS

- advances knowledge in a wide range of disciplines relevant to DON/DOD;
- maintains upper-division course content and cutting-edge programs;
- provides the opportunity for students to demonstrate independent graduate-level scholarship in their areas of study;

- challenges students with creative problem solving experiences on DOD-relevant issues;
- solves warfare problems; and
- attracts and retains quality faculty with state-of-the-art expertise.

To meet its educational requirements, the Navy has developed a unique academic institution at NPS and via distance learning (DL) through specially tailored academic programs and a distinctive educational experience tying academic disciplines to naval and joint warfighting applications. NPS has aligned its education and research programs to achieve three major goals:

1. nationally recognized academic programs that support the operations of the Navy and Marine Corps, our sister services, and our allies;
2. research programs that focus on the integration of education and research in support of current and emerging national security technologies and operations; and
3. executive and continuing education programs that support sustained intellectual innovation and growth throughout an officer's career.

## ACADEMIC PROGRAMS

### School of International Graduate Studies (SIGS)

*The unique programs and faculty expertise within SIGS seek to identify and address current and emerging security challenges and strengthen multilateral and bilateral defense cooperation between the United States and other nations. Areas of expertise range from nuclear nonproliferation to counterterrorism; from the history of war to emerging biological and cyber threats; and from the security aspects of political economy to international law.*

- Civil-Military Relations
- Combating Terrorism Strategy and Policy
- Defense Decision Making and Planning
- Homeland Security and Defense
- Security Studies
- Stabilization and Reconstruction
- National Security and Intelligence, Regional Studies:
  - Middle East, South Asia, Sub-Saharan Africa
  - Far East, Southeast Asia, the Pacific
  - Europe and Eurasia
  - Western Hemisphere

## **Graduate School of Business and Public Policy (GSBPP)**

*GSBPP reflects the management side of national defense in support of operational requirements, with programs open to the U.S. uniformed services, DOD employees and contractors, federal employees, and international military and government employees. An integrated civilian and military faculty focuses on defense organizations, system applications, and instruction supported by extensive defense-oriented research.*

- Acquisition and Contract Management
- Advanced Acquisition Program
- Contract Management (DL)
- Defense Business Management
- Defense Systems Analysis
- Defense Systems Management
- Executive MBA (DL)
- Financial Management
- Information Systems Management
- Material Logistics Support
- Manpower Systems Analysis
- Program Management (DL)
- Supply-Chain Management
- Systems Acquisition Management
- Transportation Management

## **Graduate School of Engineering and Applied Sciences (GSEAS)**

*GSEAS provides advanced education in engineering and applied sciences while developing technological advances with strict application to DOD needs, thus setting it apart from civilian graduate schools of engineering. It is focused on preparing the next generation of U.S. and international leaders, military and civilian alike, for the uncertainties and challenges of a rapidly changing technological world.*

- Applied Mathematics
- Combat Systems Sciences and Technology
- Electronic Systems Engineering (residential and DL)
- Mechanical Engineering for Nuclear-trained Officers (DL)
- Meteorology and Oceanography
- Meteorology
- Naval/Mechanical Engineering
- Oceanography
- Operational Oceanography
- Reactors–Mechanical/Electrical Engineering (DL)
- Space Systems Engineering
- Space Systems Operations (residential and DL)
- Systems Engineering (residential and DL)
- Systems Engineering Management (DL)
- Undersea Warfare
- Underwater Acoustic Systems (DL)

## **Graduate School of Operational and Information Sciences (GSOIS)**

*GSOIS delivers graduate-level education and conducts cutting-edge research in four non-traditional knowledge domains responsive to U.S. military needs: information science and technology, military computer science, military operations analysis and research, and special operations and related defense analysis.*

- Applied Cyber Operations
- Computer Science (residential and DL)
- Computing Technology (DL)
- Cyber Systems and Operations
- Cost Estimating and Analysis (DL)
- Electronic Warfare Systems (International)
- Human Systems Integration
- Identity Management and Cyber Security (residential and DL)
- Information Sciences
- Information Systems and Operations
- Information Systems and Technology
- Information Warfare
- Joint C4I Systems
- Joint Information Operations
- Joint Operational Logistics
- Modeling, Virtual Environments, and Simulation
- Operations Analysis
- Remote Sensing
- Software Engineering (residential and DL)
- Special Operations
- Systems Analysis (DL)

## **Office of the Provost**

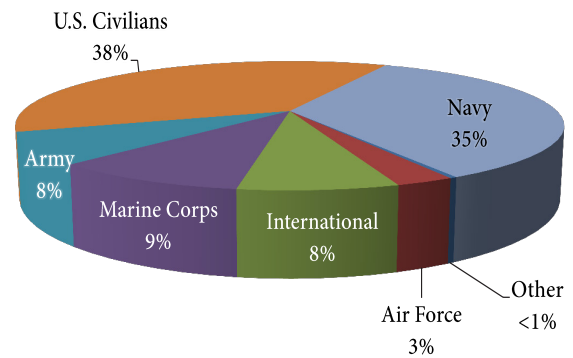
*The Office of the Provost provides oversight to a specialized degree program that leads to a master of science in systems engineering analysis. Students benefit from cross-disciplinary course offerings and research opportunities found in GSEAS systems engineering and GSOIS systems and operational analysis curricula.*

- Systems Engineering Analysis

## STUDENT POPULATION

The student body consists of U.S. officers from all branches of the uniformed services, civilian employees of the federal government, and international military officers and government civilians. The student population distribution for June 2016 is shown in Figure 1.

*Figure 1: Total enrollment by student type for the third quarter of 2016 (2,654 total). Source: NPS Academic Affairs Quarterly Enrollment Report, AY2016/Quarter 3.*



## STUDENT RESEARCH

Independent scholarly work in the form of a dissertation (PhD), thesis (master's/engineer), or capstone project is required for most academic programs. Student research projects address issues ranging from the current needs of the fleet and joint forces to the science and technology required to sustain long-term superiority of the Navy and DOD. Guided by faculty advisors, NPS students represent a vital resource within the DOD for addressing war-fighting problems and maintaining cutting-edge expertise, particularly in a time when technology and information operations are changing rapidly. Naval Postgraduate School alumni think innovatively and possess the knowledge and skills to apply nascent technologies in the commercial and military sectors. Their firsthand grasp of operations, when combined with challenging projects that require them to apply their focused graduate coursework, is one of the most effective elements in solving fleet, joint-force, and regional problems. NPS graduate education encourages a lifelong capacity for applying basic principles and creative solutions to complex problems. NPS is also unique in its ability to conduct classified research. Classified these are available on the NPS SIPRNet.



*Source: Naval Postgraduate School Public Affairs Office*

## DEGREES OFFERED

Curricula meet defense requirements within the traditional degree framework through residential or distance-learning status. All curricula lead to a master of science or art or a master of business administration; additional study may yield an engineer or doctoral degree. Below is a listing of degrees offered at the Naval Postgraduate School.

### Doctor of Philosophy

- Applied Mathematics
- Applied Physics
- Astronautical Engineering
- Computer Science
- Electrical Engineering
- Engineering Acoustics
- Information Sciences
- Mechanical Engineering
- Meteorology
- Modeling, Virtual Environments, and Simulation
- Operations Research
- Physical Oceanography
- Physics
- Security Studies
- Software Engineering
- Systems Engineering
- Systems Engineering Analysis

### Engineer

- Astronautical
- Electrical
- Mechanical

### Master of Arts

- Identity Management and Cyber Security
- Security Studies

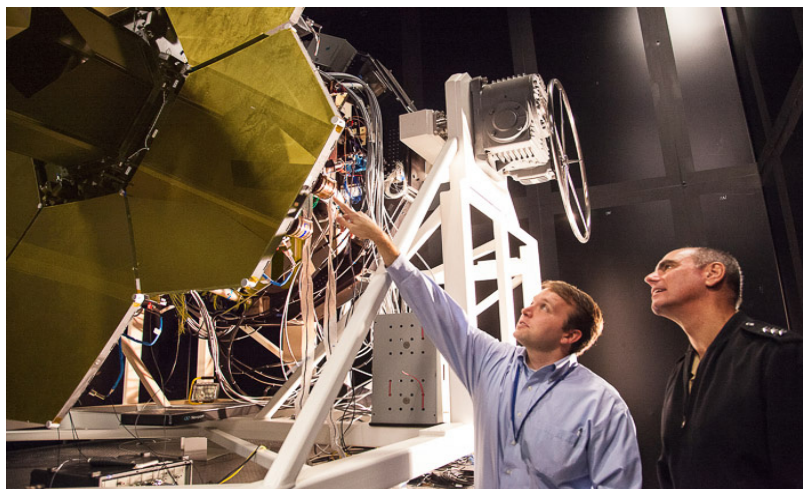
### Master of Business Administration



Source: NPS Public Affairs Office

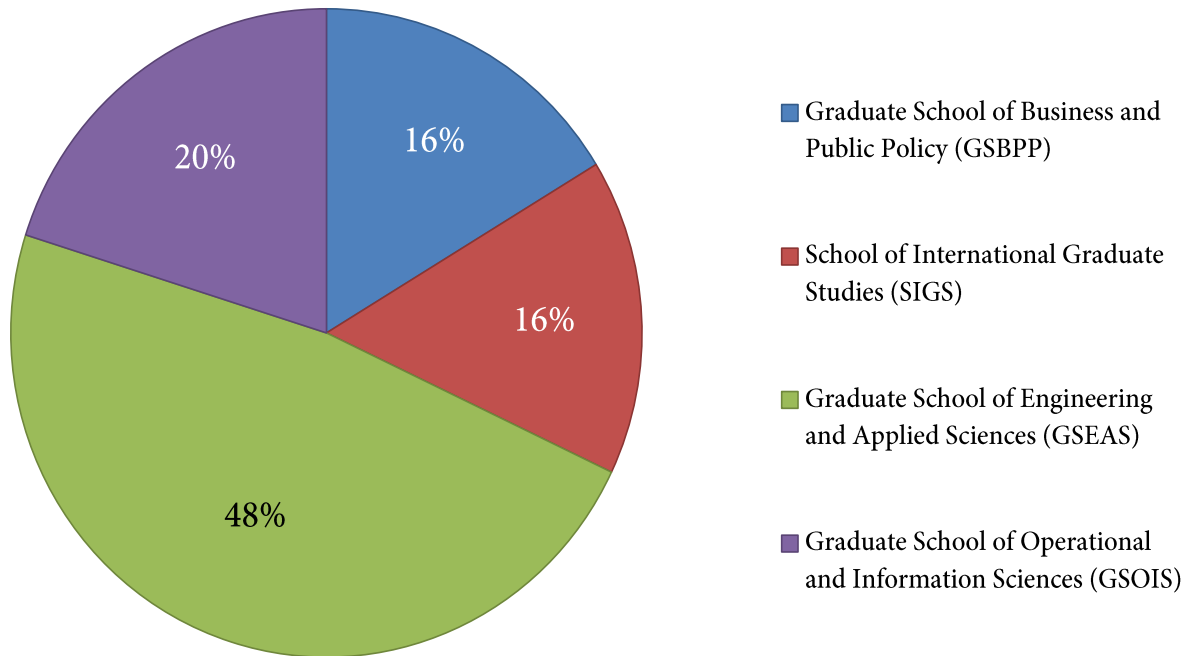
### Master of Science

- Applied Cyber Operations
- Applied Mathematics
- Applied Physics
- Applied Science
- Astronautical Engineering
- Combat Systems Technology
- Computer Engineering
- Computer Science
- Computing Technology
- Contract Management
- Cyber Systems and Operations
- Defense Analysis
- Electrical Engineering
- Electronic Warfare Systems Engineering
- Engineering Acoustics
- Engineering Science
- Engineering Systems
- Human Systems Integration
- Information Operations
- Information Systems and Operations
- Information Technology Management
- Information Warfare Systems Engineering
- Management
- Mechanical Engineering
- Meteorology
- Meteorology and Physical Oceanography
- Modeling, Virtual Environments, and Simulation
- Operations Research
- Physical Oceanography
- Physics
- Product Development
- Program Management
- Remote-Sensing Intelligence
- Software Engineering
- Space Systems Operations
- Systems Analysis
- Systems Engineering
- Systems Engineering Analysis
- Systems Engineering Management
- Systems Technology

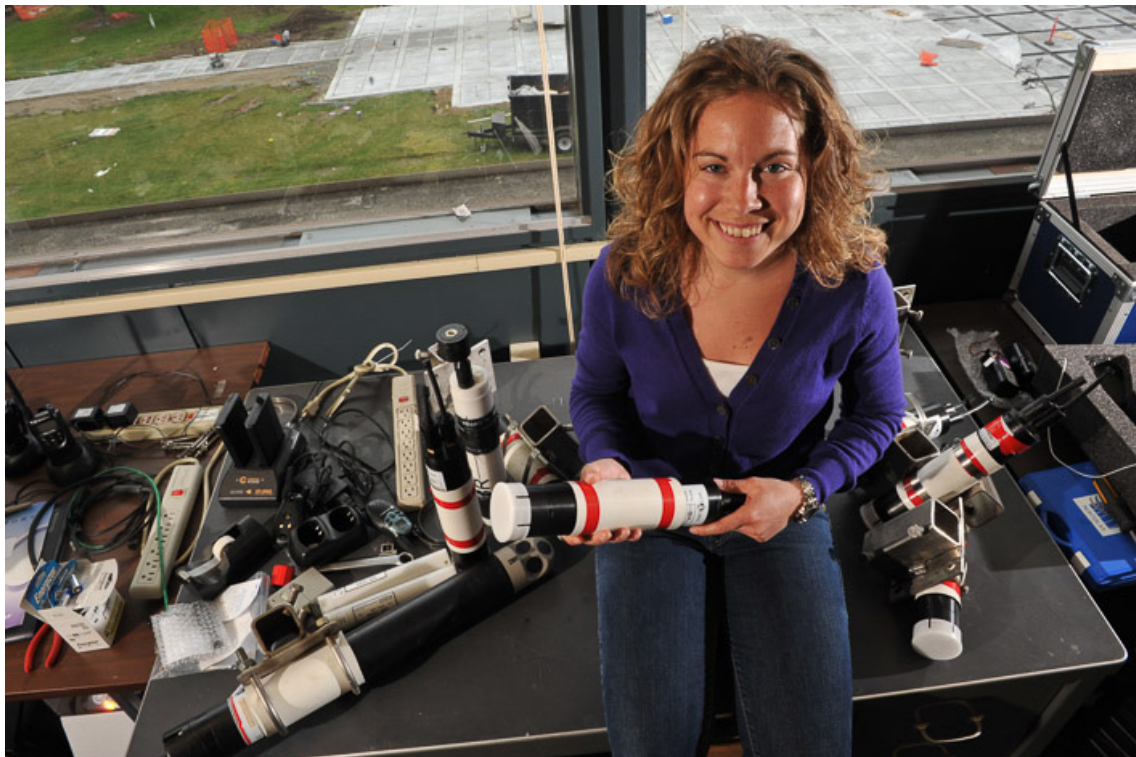


## JUNE 2016 DEGREES CONFERRED

The June 2016 graduating class produced 179 unrestricted dissertations, theses, and capstone project reports as part of the graduation requirement. Figure 2 indicates the distribution of degrees awarded by academic school.



*Figure 2. Distribution of degrees conferred by academic school, June 2016 (unrestricted theses)*



*Source: NPS Public Affairs Office*



## ACADEMIC AWARDS ANNOUNCED JUNE 2016

Many departments honor graduating students for the quality and contributions made by their dissertations, theses, or capstone reports. The following listing recognizes students selected by NPS faculty and military associations for superior academic achievement and outstanding theses.

### Campus-wide Awards

- Monterey Council Navy League Award for Highest Academic Achievement: Major Michael J. Kansteiner, USMC—Outstanding Thesis: *Mitigating Risk to DOD Information Networks by Improving Network Security in Third-Party Information Networks*
- Naval Postgraduate School Outstanding Academic Achievement Award for Department of Defense Student: Ms. Catherine Stevens, Graduate School of Business and Public Policy
- Naval Postgraduate School Outstanding Academic Achievement Award for International Students: Captain Muhammet Tekin, Turkish Army
- Association of the United States Army, General Joseph W. Stilwell Chapter, Award for Outstanding Army Student: Major Kyle Greenheck, USA, and Captain Ryan E. Miller, USA
- NPS Foundation/U.S. Naval Institute Annual Essay Contest Award: Captain Christopher Bartos, USMC

### Graduate School of Business and Public Policy (GSBPP)

- The Graduate School of Business and Public Policy Faculty Outstanding International Student Award: Lieutenant Ioannis Kanlis, Hellenic Navy—Outstanding Thesis: *Possibilities and Limitations of Flexible Work Arrangements in the Military*
- Department of the Navy Award for Academic Excellence in Financial Management: Lieutenant Charles Fuehrer, USN
- Rear Admiral Donald R. Eaton Logistics Award for Outstanding Achievement: Lieutenant Wagner Correia de Souza, Brazilian Navy—Outstanding Thesis: *Demand Forecasting: An Evaluation of DOD's Accuracy Metric and Navy's Procedures*
- The Army Acquisition Corps Award for Scholastic Achievement: Major Dustin Gray, USA
- Naval Supply Systems Command Award for Academic Excellence: Lieutenant Commander Michael Rigoni, USN—Outstanding Thesis: *Demand Forecasting: An Evaluation of DOD's Accuracy Metric and Navy's Procedures*
- Commander Philip A. Murphy-Sweet Memorial Award for Excellence in Acquisition: Lieutenant David Odom, USN
- Rear Admiral Thomas R. McClellan Award for Academic Excellence in the Graduate School of Business and Public Policy: Lieutenant Commander Brandon Gill, USN
- Conrad Scholar Award for Distinguished Academic Achievement in Financial Management: Lieutenant Commander Adam Heil, USN, and LCDR Patrick Imhoff, USN

### Graduate School of Engineering and Applied Sciences (GSEAS)

- The Surface Navy Association's Award for Excellence in Surface Warfare Research: Lieutenant Commander Clay Johnson, USN, and LT Travis Harlow, USN
- Space Systems Operations Award for Academic Excellence: Captain James P. Connolly, USMC
- Naval Sea Systems Command Award for Excellence in Systems Engineering: Lieutenant Paul Schmitz, USCG
- Meyer Award for Outstanding Student in Systems Engineering (Distance Learning): Mr. Vicente A. Gonzales and Mr. Christopher Mermagent
- Admiral William Adger Moffett Space Systems Award: Major Erika Teichert, USMC
- The Warren Randolph Church Award for Excellence in Mathematics Jr. Member Scholarship Committee: Captain Ryan Miller, USA—Outstanding Thesis: *Purpose-driven Communities in Multiplex Networks: Thresholding User-Engaged Layer Aggregation*
- Space and Naval Warfare Systems Command Award in Electronic Systems Engineering: Lieutenant Commander Aaron D. Coudray, USN
- Naval Sea Systems Command Award for Excellence in Combat Systems: Lieutenant Joon Kim, USN, and Lieutenant David Armandt, USN
- Naval Sea Systems Command Award in Naval/Mechanical Engineering: Lieutenant Commander Derek Fletcher, USN

## Graduate School of Operational and Information Sciences (GSOIS)

- AFCEA John McReynolds Wozencraft Award for Academic Excellence in Joint C4I: Major Eric H. Larsen, USMC
- AFCEA John McReynolds Wozencraft Electrical and Computer Engineering Academic Honor Award: Major Adam E. Foushee, USMC
- Rear Admiral Grace Murray Hopper Computer Science Award: Captain Anthony Collier, USMC—Outstanding Thesis: *Automated Network Mapping and Topology Verification*
- Military Operations Research Society Stephen A. Tisdale Graduate Research Award: Captain Greg Zerr, USMC—Outstanding Thesis: *Optimization of USMC Hornet Inventory*
- Army Chief of Staff Award for Excellence in Operations Research: Major Glenn Darrow, USA
- Joint Chiefs of Staff Command, Control and Communications Award for Academic Achievement: Captain Matthew Zach, USMC—Outstanding Thesis: *Unmanned Tactical Autonomous Control and Collaboration Coactive Design*
- Commander George L. Phillips Modeling, Virtual Environments, and Simulation Award: Lieutenant Junior Grade Ali Opcin, Turkish Navy

## School of International Graduate Studies (SIGS)

- The Louis D. Liskin Award for Excellence in Regional Security Studies: Major James F. Beal, USMC—Outstanding Thesis: *Mission Accomplished? Rebuilding the Iraqi and Afghan Armies*—and Lieutenant Breanna Strand, USN—Outstanding Thesis: *Explaining Sectarian Violence in the Middle East: A Comparative Study of Bahrain and Yemen*
- The International Student Award for Excellence in Regional or Security Studies: Lieutenant Colonel Holger Oswald, German Air Force—Outstanding Thesis: *Ukraine Crisis and Transatlantic Security Relations: Causes for Reassessment of Strategy and Partnership*
- The Outstanding United States Air Force Graduate Award, Department of National Security Affairs: Captain Vinamra Pande, USAF
- Foreign Area Officer Association Award for Excellence in International Affairs: Major Amy Roznowski, USMC

## Outstanding Thesis Recognition

- Major Jesse T. Attig, USMC: *Proof-of-Concept Part Task Trainer for Close Air Support Procedures*
- Major Jacob W. Capps, USA: *Radiation Detection and Classification of Heavy Oxide Inorganic Scintillator Crystals for Detection of Fast Neutrons*
- Major Travis D. Carlson, USMC: *Can Subjects Be Guided to Optimal Decisions? The Use of a Real-Time Training Intervention Model*
- Lieutenant Tzu-Lun Chen, Taiwan Navy: *Rebuilding Public Trust in the Taiwan Military: A Systems Approach*
- Major Nicholas R. Dubaz, USA: *Bringing the Meaning Back in: Exploring Existentially Motivated Terrorism*
- Major Brandon M. Fulton, USA: *Determining Market Categorization of United States ZIP Codes for Purposes of Army Recruiting*
- Ensign Jeremiah J. Fulton, USN: *Wing-Embedded, Cross-Flow-Fan, Vertical Takeoff and Landing Air Vehicle*
- Captain Karoline Hood, USA: *Modeling Storm Surges Using Discontinuous Galerkin Methods*
- Captain Ben E. McCaleb III, USMC: *Identifying U.S. Marine Corps Recruit Characteristics That Correspond to Success in Specific Occupational Fields*
- Captain David Miller, USMC: *Hierarchical Task Network Prototyping in Unity3D*
- Captain Stephen K. Phillips, USMC: *Creating Feedback Channels with Optical Communications for Information Operations*
- Lieutenant Taylor J. South, USN: *Fluid-Structure Interaction in a Fluid-filled Composite Structure Subjected to Low Velocity Impact*
- Major Derek L. Swenningsen, USMC: *Automatic Inference of Cryptographic Key Length Based on Analysis of Proof Tightness*
- First Lieutenant Yusuf Z. Temiz, Turkish Army: *Artillery Survivability Model*
- Lieutenant Jacob D. Thompson, USN: *Nonlinear Effects in Transformation Optics-based Metamaterial Shields for Counter Directed Energy Weapon Defense*



## **ADVANCED DEGREES**

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Doctor of Philosophy  
Mechanical Engineer



# DOCTOR OF PHILOSOPHY

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## **THERMAL CREEP FORCE: ANALYSIS AND APPLICATION**

**David Wolfe—Commander, United States Navy**

**Doctor of Philosophy in Applied Physics**

**Advisor: Andres Larraza, Department of Physics**

The existence of two motive forces on a Crookes radiometer has complicated the investigation of either force independently. The thermal creep shear force, in particular, has been subject to differing interpretations of the direction in which it acts and its order of magnitude. A horizontal vane radiometer design is provided, which isolates the thermal creep shear force. The horizontal vane radiometer is explored through experiment, kinetic theory, and the Direct Simulation Monte Carlo method. The qualitative agreement between the three methods of investigation is good. The quantitative agreement between the three methods of investigation is better than an order of magnitude in the cases examined. The thermal creep force is found to act from the hot side to the cold side of the vane. The peak in the radiometer's angular speed as a function of pressure is found to be explained as much by the behavior of the drag force as by the behavior of the thermal creep force. In addition, this dissertation provides scaling laws between millimeter-scale and micron-scale horizontal vane radiometers, a design of a microelectromechanical system (MEMS) horizontal vane radiometer, and conceptual designs of two-MEMS energy harvesting devices that exploit the thermal creep force. [Full Text](#)

Keywords: rarefied gas flows, kinetic theory, numerical methods

## **TRI-LEVEL OPTIMIZATION ALGORITHMS FOR SOLVING DEFENDER-ATTACKER-DEFENDER NETWORK MODELS**

**Gary Lazzaro—Commander, United States Navy**

**Doctor of Philosophy in Operations Research**

**Advisor: W. Matthew Carlyle, Department of Operations Research**

The optimal defense and operation of networks against worst-case attack is an important problem for military analysts. We review development of existing solutions for the Defender-Attacker-Defender (DAD) tri-level optimization model and investigate new applications and solution procedures. We develop an implicit enumeration algorithm that incorporates the addition of new defenses as an alternative solution method for the DAD model. Our testing demonstrates that implicit enumeration can efficiently generate all equivalent optimal or near-optimal solutions for DAD problems. When budgets for network defense or attack are uncertain, decision makers usually prioritize defenses in nested lists. We quantify the costs of various strategies for nesting of defenses. We design a parametric programming formulation of the DAD model to find nested defenses that have the smallest cost difference from optimal non-nested solutions. We create new solution procedures for the DAD-constrained shortest path problem. We merge the attacker model with Lagrangian relaxation of the operator model into a single formulation that can obtain fast heuristic solutions. We combine our heuristic algorithm with traditional methods to obtain provably optimal or near-optimal solutions. We test our algo-

rithms on medium and large networks, and our results show that our innovations can significantly outperform traditional nested decomposition. [Full Text](#)

Keywords: defender-attacker-defender, network optimization, tri-level optimization, implicit enumeration, nested defense, prioritized lists, constrained shortest path, minimum cost flow, algorithms, network defense, network interdiction, network modeling, system defense

**A MODEL-BASED SYSTEMS ENGINEERING METHODOLOGY FOR  
EMPLOYING ARCHITECTURE IN SYSTEM ANALYSIS: DEVELOPING  
SIMULATION MODELS USING SYSTEMS MODELING LANGUAGE  
PRODUCTS TO LINK ARCHITECTURE AND ANALYSIS**

**Paul Beery–Civilian, Naval Postgraduate School**

**Doctor of Philosophy in Systems Engineering**

**Advisor: Eugene Paulo, Department of Systems Engineering**

This dissertation contributes to model-based systems engineering (MBSE) by formally defining an MBSE methodology for employing architecture in system analysis (MEASA) that presents a comprehensive framework detailing the relationship between system architecture products and external models and simulations used to analyze system performance and feasibility. Specifically, the research combines the use of Systems Modeling Language products and operational simulation models to support assessment of system requirements for systems engineering. The MBSE MEASA transforms operational needs into preferred system configurations through the analysis of detailed simulation models. The research does this by using designed experiments to generate architecture tradespace visualizations that highlight the impact that system design parameters, system-environment interactions, system operational implementation, and system component interactions have on system performance. The research demonstrates a procedure for iterations of the methodology when analysis suggests potentially impactful design, operational, or environmental variables (as well as potential interactions between those variables). The research develops and analyzes notional architecture products and simulation models of U.S. Navy mine warfare systems to demonstrate an application of the MBSE MEASA. [Full Text](#)

Keywords: model-based systems engineering, Systems Modeling Language, system architecture, system analysis, modeling and simulation, mine warfare, MCM-1 Avenger, Littoral Combat Ship

**THE SYSTEM OF SYSTEMS ARCHITECTURE FEASIBILITY ASSESSMENT MODEL**

**Stephen Gillespie–Captain, United States Army**

**Doctor of Philosophy in Systems Engineering**

**Advisor: Eugene Paulo, Department of Systems Engineering**

This research presents the system of systems (SoS) tradespace definition methodology (SoS-TDM) and SoS architecture feasibility assessment model (SoS-AFAM). Together, these extend current model-based systems engineering (MBSE) and SoS engineering (SoSE) methodologies. In particular, they extend the methods of tradespace exploration to considerations of multiple perspectives of an SoS— physical, process, and organization. In considering multiple perspectives of an SoS, one better defines the SoS and is more likely to correctly represent its performance in an analysis model. The SoS-TDM defines an SoS tradespace by progressively winnowing the design space with increasingly strict definitions of feasibility and then exhaustively analyzing the remaining points. The SoS-AFAM defines and assesses SoS architecture feasibility through a variety of tests that consider the aforementioned aspects of an SoS. Together, these methods may be integrated with existing MBSE and SoSE methodologies to extend their utility. [Full Text](#)

Keywords: model-based systems engineering, system of systems, systems architecting, systems analysis

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# MECHANICAL ENGINEER

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## CFD ANALYSIS OF THE SBXC GLIDER AIRFRAME

Alejandro Garcia Aguilar–Lieutenant Junior Grade, Mexican Navy

Mechanical Engineer and Master of Science in Mechanical Engineering

Advisor: Kevin Jones, Department of Mechanical and Aerospace Engineering

Co-Advisor: Vladimir Dobrokhodov, Department of Mechanical and Aerospace Engineering

Second Reader: Isaac Kaminer, Department of Mechanical and Aerospace Engineering

The research of this thesis develops and implements a computational model of the SBXC Glider utilized in the Tactical Long-Endurance Unmanned Aerial System (TaLEUAS) project in order to simulate the aerodynamic performance of the airframe and compare it with real flight data. The broader goals are, first, to provide a methodology for simulating a glider design with the intention to develop an optimization process or to evaluate a new design using computational tools, and second, to allow students to follow an easy process in which to undertake similar aerodynamic analyses. The fluid behavior is studied using computer software such as Ansys CFX, which is based mathematically on finite element methods. To validate and verify the methodology developed, a mathematical comparison was made with the previous research data obtaining a similar region for best flying behavior. Recommendations are given to increase the accuracy of the flying performance for velocities greater than 15 m/s. [Full Text](#)

Keywords: finite element method, computational fluid dynamics, Y Plus, mesh element quality, aerodynamic data, fluid domain, Solidworks/ANSYS, 3D modeling and simulation

## CORROSION AND THERMAL PROCESSING IN COLD GAS DYNAMIC SPRAY DEPOSITED AUSTENITIC STAINLESS STEEL COATINGS

John Luhn–Lieutenant, United States Navy

Mechanical Engineer and Master of Science in Mechanical Engineering

Advisor: Sarath Menon, Department of Mechanical and Aerospace Engineering

Co-Advisor: Luke Brewer, Department of Mechanical and Aerospace Engineering

This thesis presents research on the corrosion properties and effects of heat treatment on austenitic stainless steel coatings produced by the cold gas dynamic spray process on 316L stainless steel substrates. Previous work on the use of the low-pressure cold spray process to spray austenitic stainless steel was reproduced and validated. Heat treatment of the coatings was found to reduce porosity and evidence was found of recrystallization of the coatings. No significant changes in elemental distribution were found to occur during heat treatment. Corrosion testing was conducted by salt fog testing and anodic polarization. Coatings in the as-sprayed condition were found to be less corrosion resistant than bulk 316L stainless steel. Heat treated samples were observed to show corrosion resistance even worse than as-sprayed coatings. In fact, all heat treated samples exhibited little or no passivation behavior. Grain boundary sensitization is suspected as a probable cause for poor corrosion resistance in some samples, and the presence of ferrite in the powder and coatings may also be a cause of corrosion resistance that is worse than the fully austenitic substrate. [Full Text](#)

Keywords: cold spray, stainless steel, salt fog testing, potentiostatic testing





# MASTER OF ARTS

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Security Studies



# MASTER OF ARTS IN SECURITY STUDIES

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## **STYLES OF INTERNATIONAL MEDIATION IN PEACE PROCESSES BETWEEN STATES AND TERRORIST ORGANIZATIONS**

**Santiago Arca Henon—Civilian, Uruguay**

**Master of Arts in Security Studies (Combating Terrorism: Policy & Strategy)**

**Advisor: Carolyn Halladay, Center for Civil-Military Relations**

**Co-Advisor: Rodrigo Nieto-Gomez, Department of National Security Affairs**

As a conflict management strategy, mediation has offered a way to abate or resolve conflicts, and it is a solid alternative to escalating hostilities. Most academic works analyze mediation by studying the mediators' roles and behavior, and such study is facilitated by the use of categories or typologies. This thesis seeks to identify an additional method known as the styles of mediation. Because international mediation has been used in terrorism conflicts, this thesis explores the styles of international mediation that have been employed in peace processes between states and terrorist organizations, and uses the Israeli-Palestinian, Northern Ireland, and Sri Lankan peace processes as case studies. Two specific styles of mediation are suggested: personalistic mediation and institutionalized mediation, both strongly linked to the frameworks under which the mediation is exercised. Personalistic mediation is a framework of mediation that develops and establishes itself as the mediation unfolds, largely due to the mediators' own work and determination. Institutionalized mediation takes place when an institution created in a peace process adopts a mediation strategy and exercises it under its institutional umbrella. The proposed styles may not only help analysts define frameworks in future mediations, but also compare mediation, and in some cases even predict—to an extent—patterns and results of mediation. [Full Text](#)

Keywords: conflict management, conflict resolution, mediation, styles of mediation, personalistic mediation, institutionalized mediation, peace process, terrorism, counterterrorism, Northern Ireland, Israel, Palestine, Sri Lanka, Irish Republican Army, Palestine Liberation Organization, Liberation Tigers of Tamil Eelam

## **THE PORT SECURITY GRANT PROGRAM: GOOD ENOUGH, OR CAN IT BE MADE BETTER?**

**Paul Arnett—Captain, United States Coast Guard**

**Master of Arts in Security Studies (Homeland Security and Defense)**

**Advisor: Rudy Darken, Department of Computer Science**

**Second Reader: Ryan Ellis, Northeastern University**

For almost a decade and a half since the terrorist attacks of September 11, 2001, the Port Security Grant Program (PSGP) has provided funding to project proposals for improving the security and resiliency posture of the nation's ports and waterways. The United States has over 360 coastal and inland ports through which over \$1.3 trillion in cargo moves annually; a safe, secure, and efficient marine transportation system is critical to national security. The PSGP is intended to enhance port security and resiliency by funding proposals to provide increased risk management, measures to mitigate disruptions and facilitate port recovery, and maritime domain awareness capabilities to prevent, respond to, and recover from attacks. The PSGP has matured to include funding for all hazards threatening the ports—natural, accidental, and intentional. This thesis seeks

to evaluate how well the PSGP has met those goals and if it should be improved, reorganized, or eliminated. [Full Text](#)

Keywords: Port Security Grant Program, Maritime Transportation Security Act, Area Maritime Security Committee

**MISSION ACCOMPLISHED? REBUILDING THE IRAQI AND AFGHAN ARMIES**

*The following paper has been recognized as outstanding by its department*

**James Beal—Major, United States Marine Corps**

**Master of Arts in Security Studies (Middle East, South Asia, Sub-Saharan Africa)**

**Advisor: James Russell, Department of National Security Affairs**

**Second Reader: Daniel Moran, Department of National Security Affairs**

The two wars in Iraq and Afghanistan have demonstrated that the U.S. military must be prepared to conduct foreign security force assistance missions as a major element of the U.S. national security strategy. This thesis is a study of the United States' attempt to build strong central armies in Iraq and Afghanistan in the midst of larger nation-building efforts. Following the collapse of the Taliban and Saddam Hussein regimes, the U.S. military was tasked to rebuild the national armies of Afghanistan and Iraq. Since the departure of U.S. forces from Iraq in 2011 and the withdrawal of combat advisors from Afghanistan in 2014, the Islamic State has gained control of significant territory in Iraq including Mosul, Iraq's second largest city, while the Taliban and the Islamic State of Iraq and the Levant-Khorasan control 30 percent of Afghan districts. The purpose of this thesis is to explain why, despite \$60 billion and more than a decade of military advisory efforts, the Iraqi and Afghan national armies are not unified, sustainable forces loyal to the central government and capable of defending their territories from internal and external threats. There are four key premises as to why the Iraqi and Afghan armies have not met the expectations of a sustainable and legitimate central army: failure to achieve legitimacy of governance, lack of motivation and will to fight, creation of an army in the Western image rather than an army that meets the needs of Iraq and Afghanistan, and the lack of a long-term U.S. strategy and commitment. [Full Text](#)

Keywords: Iraq, Afghanistan, Iraqi Army, Afghanistan National Army, ANA, ISF, IA, counterinsurgency, COIN, military advisor, legitimacy, nation-building

**MILITARY LEGISLATION: EXPLAINING MILITARY OFFICERS' WRITING DEFICIENCIES**

**Andrii Borysov—Civilian, Ukraine**

**Master of Arts in Security Studies (Strategic Studies)**

**Advisor: Carolyn Halladay, Center for Civil-Military Relations**

**Co-Advisor: Sandra Leavitt, Director, Graduate Writing Center**

In performing jobs related to national security and defense, personnel must comply with rules and decisions communicated in the form of written legislation, which includes directives, memos, instructions, manuals, standard operating procedures, and reports. Incorrect understanding of legislative provisions may lead to disastrous consequences, making clear communication through these documents paramount. The vast majority of military officers write legislation using academic writing skills developed at military and civilian universities. However, academic writing skills do not enable officers to write legislative acts efficiently. Using theories of learning and teaching, the thesis examines the reasons why an academic writing style, everyday military writing, and general writing are inappropriate for preparing officers to write legislation. It identifies the similarities and differences between academic and legislative writing to reveal the skills necessary for both. It then investigates if academic and everyday writing and reading can produce the knowledge required for legislative drafting. Concluding that they cannot, it then explores how multiple environments favor or impede officers

in developing legislative drafting skills. It concludes that audience, academic norms, and other environments diminish legislative writing skills. Recommendations are offered for how to teach officers legislative drafting and organize the process of writing legislative documents at military units. [Full Text](#)

Keywords: academic writing, legislative drafting, academic paper, legislative document, manual, writing skills

**GERMANY'S ANSCHLUSS WITH AUSTRIA AND RUSSIA'S  
ANNEXATION OF CRIMEA: AN ANALYTICAL COMPARISON**

**Peter Church—Lieutenant, United States Navy**

**Master of Arts in Security Studies (Europe and Eurasia)**

**Advisor: David Yost, Department of National Security Affairs**

**Co-Advisor: Donald Abenheim, Department of National Security Affairs**

This thesis compares the irredentist and revanchist actions of Nazi Germany and the contemporary Russian Federation with regard to violent and coercive changes of borders as an element of statecraft. It presents an analytical comparison of Nazi Germany's 1938 Anschluss with Austria and Russia's 2014 annexation of Crimea with regard to nationalist sentiment and geopolitical aims. Although the revanchist moves share striking similarities, the nationalist movements, political goals, and methods of annexation differ significantly. The Hitler comparison is a frequently used political mechanism to simplify issues and galvanize support. However, using the comparison for Vladimir Putin's behavior impedes serious strategic analysis and frustrates diplomatic dialogues. Such hasty and ill-founded analogies should be avoided in the interests of analytical clarity and the formulation of effective responses and solutions. [Full Text](#)

Keywords: annexation, Anschluss, Austria, Crimea, Hitler, irredentism, Nazi Germany, Putin, revanchism, Russia

**BIG MISSILES AND BIG DECKS: THE VIABILITY OF  
AIRCRAFT CARRIERS IN AN A2/AD WORLD**

**Robert Coffman—Lieutenant, United States Navy**

**Master of Arts in Security Studies (Strategic Studies)**

**Advisor: Erik Dahl, Department of National Security Affairs**

**Second Reader: Daniel Moran, Department of National Security Affairs**

This thesis analyzes the implications of modern anti-access/area denial (A2/AD) capabilities on the use of aircraft carriers in executing U.S. maritime strategy. The objective is to determine if there are historical lessons from previous U.S. experiences with A2/AD capabilities that bear on the current debate. Additionally, it analyzes several proposed alternatives to the aircraft carrier. It argues that there are several relevant lessons from previous A2/AD challenges with aircraft carriers and the United States' ability to conduct sea control and power projection, and that none of the aircraft carrier alternatives can sufficiently provide the necessary capabilities across a range of military operations. It concludes that incorporating innovative employment of carrier strike groups in an A2/AD environment, while also pursuing advancements in the air wing's operating range, provides a viable solution to redressing the A2/AD threat. [Full Text](#)

Keywords: anti-access, area denial, A2/AD, maritime strategy, aircraft carrier, ASBM, air wing, sea control, power projection, technology, innovation, operational experimentation, haystack, uptick

**U.S. NAVY BLOODHOUNDS: ESTABLISHING A NEW  
MARITIME SECURITY COMBATANT**

**Ryan Donohue—Lieutenant, United States Navy**

**Master of Arts in Security Studies (Homeland Security and Defense)**

**Advisor: Erik Dahl, Department of National Security Affairs**

**Co-Advisor: Rodrigo Nieto-Gomez, Department of National Security Affairs**

To protect the United States' 4.5 million miles of Economic Exclusion Zone, maritime forces are directed to conduct homeland defense missions and support civil authorities as far from U.S. shorelines as possible to protect the country from transnational threats. In order to protect the United States from transnational organized crime regimes and their continued maritime narcotics trafficking, the U.S. Navy requires a surface combatant to fulfill these interdiction missions. Therefore, with the Navy's decommissioning of its patrol frigates, should the Navy plan development of a new vessel, rebuild the Oliver Hazard Perry class frigates, or refocus the Littoral Combat Ship (LCS) program to replace the current frigate's capabilities in combating narcotic trafficking? In turn, the Oliver Hazard Perry class was a sound platform that performed well, the LCS is a troubled program facing severe financial, stability, and lethality issues, while the design and construction of a new frigate is entirely too costly and time consuming. With these considerations in mind, this thesis proposes the reconstruction of the Oliver Hazard Perry class frigate for maritime security operations, as a result of its illustrious multirole career, survivability, and relatively cheaper price point than the increasingly expensive and unproven LCS ship class. [Full Text](#)

Keywords: Navy, Coast Guard, maritime security, counternarcotic, drug interdiction, frigate, Littoral Combat Ship, Homeland Security, law enforcement

**HAS DEMOCRACY DESTABILIZED EAST ASIA?**

**Zachary Elkin—Lieutenant, United States Navy**

**Master of Arts in Security Studies (Far East, Southeast Asia, the Pacific)**

**Advisor: Robert Weiner, Department of National Security Affairs**

**Second Reader: Christopher Twomey, Department of National Security Affairs**

Japan and South Korea share many similarities. Both have experienced periods of extraordinary growth, both have advanced market economies, and both have recently experienced the first transition between parties that control its executive branch. In each case, scholars have blamed the new parties for instability. The Democratic Party of Japan's rule witnessed base issues that exacerbated U.S.-Japan relations, the 3/11 disaster, and the nationalization of the Senkaku Islands, an action that increased tension with China over the disputed territory. In South Korea, Kim Dae-jung and Roh Moo-hyun presided over the desecuritization of the North Korean threat, heated anti-American protests, and a near conflict with Tokyo over the disputed Dokdo Islands. These were all tense scenarios for new leaders. But were they tense because of these administrations' policies and actions; that is, do political parties in Tokyo and Seoul actually matter? Or would these outcomes have occurred regardless? It is the conclusion of this research that the administrations did contribute to the instability within East Asia; however, their impact on regional stability was transitory. Each administration attempted significant policy changes and each had differing degrees of failure because of international and domestic constraints that tended to reinforce the status quo. [Full Text](#)

Keywords: Japan, Korea, democracy, Asia, stability

**BOLIVIA'S "LEFT TURN" TOWARD RENTIER PLURINATIONALISM  
AND ITS EFFECTS ON ETHNIC TENSIONS AND SOLIDARITY**

**Christopher Euans—Lieutenant, United States Navy**

**Master of Arts in Security Studies (Western Hemisphere)**

**Advisor: Anne Clunan, Department of National Security Affairs**

**Co-Advisor: Diego Esparza, Department of National Security Affairs**

This thesis examines the establishment of plurinationalism in Bolivia and its relationship with a rentier economy based in extractive energy resources. In the early 2000s, Bolivia became part of a Leftist shift in governments across South America. With the election of Bolivia's first indigenous president, Evo Morales, Bolivia cast aside neo-liberal economic policies and nationalized many of its industries, the largest being the hydrocarbon and oil industry. Utilizing strong cultural and historical symbols, Morales gained overwhelming support from the mestizo and indigenous communities. The promise of self-determination and autonomy for self-identifying indigenous groups propelled Bolivian plurinationalism forward as the answer for change in a government that finally represented the traditionally repressed majority. Energy rents supported universal pensions, education, and maternal-infant health care; these programs became the primary tools for populist-style redistribution. This thesis analyzes the effectiveness of these social programs in establishing national cohesion and identity among the Bolivian population. A historical comparison of Bolivia before plurinationalism, announced in 2005, and during the establishment of plurinationalism, from 2005-2013, is utilized to gauge the effectiveness of the new government policy in creating national cohesion. The primary finding of this thesis is that the effective impact of social programs on national cohesion is minimal. Instead of greater Bolivian national cohesion, the primary outcome of these programs is the reinforcement of the social divide between the Morales government supporters in the western highlands and autonomy-seeking groups in the eastern lowlands. [Full Text](#)

Keywords: plurinationalism, indigeneity, ethnicity, nationalism, identity, rentier

**WITH STRINGS ATTACHED: CHINA'S ECONOMIC POLICY IN THE SOUTH CHINA SEA**

**Jarrold Fiecoat—Lieutenant, United States Navy**

**Master of Arts in Security Studies (Far East, Southeast Asia, the Pacific)**

**Advisor: Naazneen Barma, Department of National Security Affairs**

**Second Reader: David Anderson, Department of National Security Affairs**

How has China used economic policy to create leverage in its relationships with its Asian neighbors? Through comparative case studies of China's political and economic relationship with the Philippines and its political and economic relationship with Cambodia, this thesis supports the notion that China uses cooperative economic policy to entice political support from its poorer, lesser developed neighbors while using coercive economic policy to extract political concessions from its more advanced, emerging neighbors. In short, China uses coercive economic policy to extract concessions from Manila while it uses cooperative economic policy to woo Cambodian support in those very disputes. [Full Text](#)

Keywords: People's Republic of China, PRC, South China Sea, political economy, coercive economics, soft power



**MARITIME CYBERSECURITY: THE FUTURE OF NATIONAL SECURITY**

**Christopher Hayes—Lieutenant, United States Navy**

**Master of Arts in Security Studies (Homeland Security and Defense)**

**Advisor: Erik Dahl, Department of National Security Affairs**

**Second Reader: Wade Huntley, Department of National Security Affairs**

Cybersecurity in the 21st century is constantly evolving and changing in order to meet today's threats. The maritime industry in the United States is no different than any other organization that can fall under a cyber-attack. Currently, no major cyber threat has threatened the maritime community in the United States or national security. Recent attempts to disrupt the flow of the maritime industry, however, legitimize fears over maritime cyber-attacks. The United States has significant shortfalls in maritime cybersecurity. This thesis evaluates U.S. ports and strategies against those of the European Union to examine the impact of cyber issues on the United States and its national security. The maritime community is not cyber resilient and has no specific guidelines or responses in place to deter or prevent a major cyber-attack on the United States. For the United States to maintain its cyber resilience and normal operations at its ports, the global maritime community must address the issues together to maintain global maritime dominance. [Full Text](#)

Keywords: maritime, maritime cybersecurity, national security, ports, terminals, coast guard

**A SOUTH CHINA SEA ADIZ—VIETNAM'S NEXT CHALLENGE**

**Duc Ho—Major, United States Air Force**

**Master of Arts in Security Studies (Far East, Southeast Asia, the Pacific)**

**Advisor: Michael Malley, Department of National Security Affairs**

**Second Reader: Robert Weiner, Department of National Security Affairs**

When China declared its East China Sea (ECS) Air Defense Identification Zone (ADIZ) in November 2013, the declaration sparked fears that it would soon implement similar zones over the South China Sea (SCS), further exacerbating tensions in the region. Since Vietnam is projected to be the country most affected by China's SCS ADIZ, this thesis focuses on how Vietnam's leaders might respond. To do so, this thesis reviews reactions from Japan, South Korea, and Taiwan during the 2013 ECS ADIZ crisis to identify a range of possible responses for Vietnam. It then explores how Vietnam has responded to past territorial disputes from China—both land and maritime—to identify similar challenges that an ADIZ might pose. Finally, it analyzes the range of responses within the context of Vietnam's current strategies toward China. Research reveals that Vietnam has four major policy options: bilateral diplomacy, multilateralization/arbitration, complete defiance, and a mixture of civilian appeasement and military nonrecognition. The policy option Vietnam chooses will depend largely on its leadership preferences as well as domestic and geopolitical factors. [Full Text](#)

Keywords: ADIZ, SCS ADIZ, ECS ADIZ, South China Sea, East China Sea, Vietnam

**SOCIAL MEDIA'S IMPACT ON CIVIC ENGAGEMENT IN MEXICO**

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Since the advent of the Internet, Mexico has embraced and utilized social media at a dramatically increasing rate. Today, 54 million Mexican citizens collaborate via online communities more avidly than those in some developed countries. But has the increase in social media activity fostered civic engagement in Mexico? This thesis argues that it predominately has. Specifically, social media has increased civic awareness, broadened collective action, and strengthened political activism in Mexico. However, one aspect of civic engagement

social media has yet to change is Mexico's collective identity. This thesis analyzes the 1968 Tlatelolco student movement and the 1985 Mexico City earthquake's social mobilizations as catalyst events for the birth of civil society. Society rallied to establish a myriad of social and political organizations built to foster citizenry and community. The Internet revolution in the early 1990s further opened platforms for activists to engage in and campaign on issues important to them. The success of Twitter movements #NoteAnules, #InternetNecesario, and #AyotzinapaSomosTodos instilled confidence in the effectiveness of social media as a tool for activism. Through understanding of social media, engaged e-citizens can continue to make informed political decisions, increase social capital of the nation, and bring Mexico closer to being a liberal democratic nation. [Full Text](#)

Keywords: social media, civic engagement, Mexico, civic awareness, collective action, collective identity, political activism, social movement, civic society, digital revolution, Twitter, Tlatelolco

**GRANTING CONCESSIONS AND PAYING RANSOMS TO TERRORISTS: A POLICY  
OPTIONS ANALYSIS OF THE U.S. POLICY ON HOSTAGE RECOVERY**

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**Co-Advisor: John Rollins, Center for Homeland Defense and Security**

Nations around the world, including the United States, have been battling terrorist hostage-takings by instituting no-concessions policies. The hope is that denying terrorists their demands will remove all incentives for hostage-taking, thereby eliminating its practice. However, since this policy has been in existence, research has shown that hostage-takings have increased. Considering the recent, highly publicized beheadings of hostages held by the Islamic State, is there a better policy option that would protect U.S. citizens who are being held hostage? To answer this question, this thesis conducted a policy options analysis. Criteria were developed from the literature, and the current U.S. policy was compared to two other policy options. The research found that current U.S. policy does not effectively achieve its goals and, as such, does not offer the best protection to U.S. citizens. As a result, the thesis concluded that the United States would be better served by removing the no-concessions rule and focusing on a policy that punishes terrorists who participate in hostage-taking. [Full Text](#)

Keywords: terrorism, terrorist, hostage, negotiating, concessions, policy, ransom

**RISING SUN OVER AFRICA: JAPAN'S NEW FRONTIER  
FOR MILITARY NORMALIZATION**

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Japan's current military operations in Africa, little known and underreported, have challenged its established security doctrine and led it to a more normal military that employs its self-defense forces in ever-greater roles. By examining Japan's Self-Defense Force (JSDF) missions in the Gulf of Aden and South Sudan against a backdrop of Japan's greater strategic approach to Africa, this thesis uncovers the unexpected impact that these missions have had in Japanese policy-making at home. Whereas the lack of a constrained institutional framework in the Gulf of Aden mission naturally enables revisionists to push for unprecedented security reforms to meet evolving mission requirements, the mission in South Sudan has also contributed unexpectedly to impactful security reforms to meet its own evolving mission requirements within the construct of the United Nations (UN). Mission success in increasingly challenging and dangerous roles in Africa has allowed the JSDF

to not only become an integral part of Japan's comprehensive development efforts on the continent, but has also influenced the ability of Japan's revisionists to chart a new course in the post-Cold War world. [Full Text](#)

Keywords: Japan, Africa, normalization, Japan Self-Defense Force (JSDF), Gulf of Aden, Djibouti, South Sudan

**THE LONGUE DURÉE: INDONESIA'S RESPONSE TO THE  
THREAT OF JIHADIST TERRORISM 1998–2016**

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This thesis studies the evolution of the Indonesian government's response to the threat of transnational jihadism and addresses the debate over the effectiveness of its counterterrorism policy. It poses the question: has Indonesian policy on transnational terrorism been effective in combating the mobilization of radical Islamic groups? By examining the three periods since Indonesia's transition to democracy—1998–2001, 2002–2008, and 2009–present—the prominent political and social issues considered by politicians and counterterrorist specialists can be seen through the lenses of the threats facing Indonesia and the state's response. Through these means, the evolution and effectiveness of Indonesian counterterrorism may be further measured against the context and interplay of three factors: counterterrorism policies chosen, changing nature and evolution of the jihadist groups, and public opinion. These factors enabled state capacity and the implementation of a criminal justice counterterrorism approach effectively implementing “hard” and “soft” methods. With continued implementation of this approach, Indonesia may be positioned to combat the re-emergent transnationally influenced jihadist threats. The findings and lessons learned identified in this thesis may assist countries like Indonesia in their counterterrorist strategy development, capacity building, and application. [Full Text](#)

Keywords: Indonesia, counterterrorism, transnational terrorism, Detachment-88, foreign fighters, al-Qaeda, Jemaah Islamiyah, jihadists, Islamic State, Southeast Asia

**SOVEREIGNTY UNDER SIEGE: DRUG TRAFFICKING AND STATE  
CAPACITY IN THE CARIBBEAN AND CENTRAL AMERICA**

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Drug trafficking organizations have increased their prominence throughout the Caribbean and Central America. These organizations undermine the rule of law, increase levels of violence and corruption, and hamper development, all of which can weaken a state. Weak or failing states become domestic and regional burdens that spill over into neighboring countries and cause secondary and tertiary problems. This thesis examines causes for different state capacities in the Caribbean and Central America through case study comparisons between Haiti, the Bahamas, Nicaragua, and Guatemala. The varying state capacities' interaction with similar drug trafficking pressures accounts for different state legitimacy statuses. Haiti's institutional and ideological influences account for its low state capacity (SC) as compared to the Bahamas. Policy decisions to improve security forces' (SECFOR) state capacity and cooperate with U.S. counternarcotic operations result in the Bahamas' higher SC. Nicaragua and Guatemala's transitions to democracy have resulted in different SECFOR capacities. Nicaragua chose to improve its SECFOR and currently receives assistance from the United States to combat drug trafficking. In contrast, Guatemala institutionalized a corrupt and ineffective SECFOR during its transition to peace. Both regional comparisons prove that SC is a choice. Understanding this relationship

can guide domestic and international policy incentives or directives to assist countries in a narco- or under siege–state legitimacy status. [Full Text](#)

Keywords: vulnerable states, stable states, narco-state, under siege, state capacity, drug trafficking pressures, drug trafficking organizations (DTO), state legitimacy, impacts, Caribbean, Central America, Haiti, Bahamas, Nicaragua, Guatemala

**SIDELINING DEMOCRACY?: EXPLAINING THE UNITED STATES’  
RESPONSE TO THAILAND’S 2006 AND 2014 COUPS D’ÉTAT**

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Second Reader: Tristan Mabry, Department of National Security Affairs**

To explain the United States’ relatively mild response to Thailand’s 2006 and 2014 coups d’état, this research analyzed the economic, security, and diplomatic conditions that existed before and after those regime-changing events. Shifts in bilateral relations were assessed using balance of power, alliance, and democratization theories. Thailand’s most recent adventures with military rule, after nearly 15 years of democracy, affected U.S.-Thai relations but not in ways democratization theory would predict. More specifically, the United States took into consideration Thailand’s stability and options with China, Russia, and regional partners. Therefore, balance of power theory offered the most convincing explanation in the security realm. The United States appeared to sideline its advocacy for democratization and took measured approaches to judiciously maintain its alliance with Thailand to preserve its strategic hegemonic influence in Southeast Asia. In the long run, a strong U.S.-Thailand relationship will maintain the United States’ influence in Southeast Asia to counterbalance emerging economic, security, and diplomatic threats. [Full Text](#)

Keywords: coup d’état, Thailand, U.S.-Thailand relations, regime change, democratization, balance of power, alliance theory, U.S.-Thailand alliance, Cobra Gold, International Military Education and Training, IMET, Foreign Military Sales, FMS, International Law Enforcement Academy, ILEA, Southeast Asia, Prem Tinsulanonda, Thaksin Shinawatra, Yingluck Shinawatra, Prayuth Chan-ocha

**UNDERSTANDING WHERE AMERICA’S PUBLIC DISCUSSION TAKES PLACE IN  
TODAY’S SOCIETY: CASE STUDIES OF CONCEALED WEAPONS CARRY REFORM**

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Co-Advisor: Anshu Chatterjee, Department of National Security Affairs**

Ideally, in America’s democratic society, lawmakers pass laws based on the will of the people. The passage of concealed-carry laws across the country would then suggest that there is a significant movement that has pushed these bills through. However, the traditional media has failed to cover this aspect of the changing societal demand. What does this observation suggest about traditional media, which is considered an important medium of public discussion in a democracy? Has another medium for public discussion replaced the Fourth Estate? A case-study approach is used to single out instances in which states that passed concealed-weapons laws did so despite the lack of traditional media coverage. First, this thesis identifies traditional media trends at the state and national levels within the time period surrounding the passage of handgun reforms. Second, the media trend is compared to the passage of gun legislation and concealed-carry laws to establish the breadth, depth, and reach of traditional media’s role in the public sphere. Third, alternative modes of information are compared to identify the presence and impact of other media sources on the public discourse. This research compares and contrasts the roles and importance of traditional and social media in the public sphere today, as

evidenced by the coverage of concealed-carry laws and related stories. The research suggests that traditional news media is no longer the main forum for discussions regarding gun regulations in the public sphere. Social media's growing influence in the public has led to its emergence as an alternative to traditional media. [Full Text](#)

Keywords: concealed carry, handgun laws, right to carry, traditional media, mainstream media, alternative media, social media

**UKRAINE CRISIS AND TRANSATLANTIC SECURITY RELATIONS:  
CAUSES FOR REASSESSMENT OF STRATEGY AND PARTNERSHIP**

*The following paper has been recognized as outstanding by its department*

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The Ukraine Crisis marks a substantial change in German and European Union approaches toward Russia and poses questions about European security architecture after the end of the Cold War. The conflict also has a significant transatlantic dimension, characterized by a resurgent Russia, and has challenged durability in the Euro-Atlantic security order. The thesis explores the transatlantic community's strength in the present European security crisis, the common challenges of an enlarged transatlantic security zone, and the concerned regions' ability and mutual willingness to maintain and renew relations to keep up with security challenges. Although the research reveals that the transatlantic security community's lead nations, Germany and the United States, cooperated to counter Russian aggression and avert further crisis escalation, they could not prevent Russia's de facto annexation of Crimea and the ensuing destabilization of Ukraine. The thesis concludes that neither U.S. exceptionalism nor European strategic independence could lead to more stable conditions for peace in the transatlantic area. The Ukraine Crisis' lessons present essential considerations for adapting strategy and partnership across the Euro-Atlantic community. [Full Text](#)

Keywords: Ukraine, Russia, United States, Germany, Europe, transatlantic relations, NATO, European Union, strategic culture, U.S. foreign policy, German foreign policy

**THE POLITICAL ECONOMY OF INDIA'S ECONOMIC  
REFORMS: THREE PERIODS FROM 1947–2016**

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**Co-Advisor: Anshu Chatterjee, Department of National Security Affairs**

India's economic policies have evolved significantly since its independence in 1947. The evolution of the policies can be assessed by the unique domestic and international environment that existed during the most pivotal parts of India's economic history. This research explores some of the most notable parts of India's political economy and analyzes the domestic and international factors during that time. The research concludes that India's political economy is undoubtedly influenced by both types of factors. More surprisingly, the relative weight of domestic versus international factors has been gradually shifting in the past six decades. The changing dynamic of how India's economic policies are made is useful in understanding what shapes public policy in the world's largest democracy, and how both Indian and international actors can best seek to impact the country's economic policies. [Full Text](#)

Keywords: Indian political economy, green revolution, middle-class poverty

**WHAT EXPLAINS THE PATTERNS OF DIVERSIFICATION  
IN DRUG TRAFFICKING ORGANIZATIONS?**

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**Second Reader: Thomas Bruneau, Department of National Security Affairs**

The purpose of this thesis is to identify the factors that influence drug trafficking organizations' motivations to diversify their operations. With that in mind, the thesis seeks to answer the question: What explains the patterns of drug trafficking organizations' diversification? For this thesis, I have used sources found on corporate diversification, in addition to sources that I have found for three Mexican drug trafficking organizations (DTOs): the Sinaloa, Los Zetas, and Tijuana, to highlight the similarities and the differences in patterns among the three. The thesis concludes that various factors allow the DTOs to diversify into new businesses. First, as is the case in Mexico, the state has to be weak to provide opportunities for the clandestine organizations to diversify. Second, DTOs find opportunities through economic globalization and abundance of organizational resources that they use to motivate themselves to diversify. Moreover, to acclimate to the ever-changing clandestine landscape, DTOs require a decentralized internal structure. DTOs diversify to maximize their ability to cross-subsidize their revenue to combat state suppression. Rather than using hard power to cripple the DTOs, the Mexican government needs to understand their operation to hit them where it hurts, in their profits. [Full Text](#)

Keywords: drug trafficking organization (DTO), transnational criminal organization (TCO), Sinaloa, Los Zetas, Tijuana, diversification, conglomerate power, clandestine, cross-subsidization

**ENERGY SECURITY STRATEGIES: AN ANALYSIS OF TANZANIA AND MOZAMBIQUE**

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Energy security is increasingly becoming a major focus in the world today. For developing countries, energy security is limited by lack of access to resources and critical infrastructure. Recent natural gas discoveries in Sub-Saharan Africa are creating energy development opportunities. At the same time, increased global interest is forcing developing countries to choose an energy strategy that either prioritizes domestic consumption or export of energy resources. The strategy a government chooses affects the overall energy security of that country. This thesis seeks to explain why countries pursue energy strategies that focus on domestic consumption of indigenous energy resources instead of export. To answer this question, case studies of the energy sectors of Tanzania and Mozambique analyze the factors influencing the choice of energy strategy. This thesis finds that the primary factors influencing energy strategy choice are political party competition, the country's economic strategy, and international relationships. Analysis of the case studies indicates that the combination of political elite cohesion, economic reforms that favor the domestic energy market, and structuring the influence of international actors in policy development enables the development of the domestic energy sector. [Full Text](#)

Keywords: energy security, energy strategy, energy sector, natural gas, programmatic elites, political elites, technocrats, developing countries, Tanzania, Mozambique, energy resources

**GETTING THE MESSAGE ACROSS: AN ANALYSIS OF FOODBORNE OUTBREAK COMMUNICATIONS BETWEEN FEDERAL, STATE, AND LOCAL HEALTH AGENCIES**

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To assure coordination of emergency response across multiple areas of responsibility, clear methods of communication between public health agencies need to be defined before responding to foodborne outbreaks. Such capacity is essential to assure the United States can satisfy its goal of achieving an Integrated Food Safety System, as mandated under the 2011 Food Safety Modernization Act. With this in mind, a comparative analysis was conducted of 21 states' general operating procedures to ascertain lines and modes of communication related to foodborne outbreaks, evaluate for procedural commonalities and best practices, identify potential barriers to effective communication, and make recommendations to enhance multi-directional coordinated information exchanges among health agencies. The analysis identified that while all states included recognize the value of a prompt response in disease identification, investigation, and control, coordinated communication strategies within and between affected public health agencies is less robust. Many protocols are vague in establishing parameters for what information can be shared with other agencies, and under which circumstances. A multitude of electronic portals exist for collaborative purposes; however, these resources are not centralized. Recommendations for systemic improvement include expanding the current food protection rapid-response teams to all 50 states, assuring that formalized inter- and intra-agency communication plans exist in every outbreak response protocol, assuring the Incident Command System is explicitly stipulated in every regulatory outbreak response plan, and establishing funding opportunities for county and local health agencies related to communication training and system enhancements for collaborations in the midst of an outbreak. [Full Text](#)

Keywords: food safety, food defense, food terrorism, emergency response, outbreaks, communication, FSMA, IFSS, public health, ICS

**CHINESE AND RUSSIAN POLICIES ON CLIMATE CHANGE:  
IMPLICATIONS FOR U.S. NATIONAL SECURITY POLICY**

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Since the conclusion of the 1997 Kyoto Protocol negotiations, the Chinese government has been steadily increasing measures for the reduction of its greenhouse gases (GHG) emissions. Meanwhile, the Russian government has been extremely hesitant to even acknowledge humanity's role in climate change. This thesis investigates why China and Russia have chosen to take such divergent paths regarding climate change after compliance obligations were established at Kyoto. The factors considered include shifts in national public opinion regarding climate change, economics, demographics, expected future effects of global warming, resources, and the Kyoto Protocol itself. The case studies of Chinese and Russian climate change policies and programs highlight three significant factors in the divergence: 1) the Kyoto Protocol, which set the initial policy baselines for both countries; 2) geography and demography, which forced China to take actions to combat climate change since it is half the size of Russia but has roughly ten times as many people; and 3) the lengthy and continuous leadership of Russia's current president, Vladimir Putin, who has held the position of either president or prime minister since 1999 and has taken virtually no action to combat climate change. [Full Text](#)

Keywords: climate change, China, Russia, U.S. National Security Policy

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**CYBERSECURITY “LANES IN THE ROAD” FOR THE  
DEPARTMENT OF HOMELAND SECURITY**

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**Second Reader: Wade Huntley, Department of National Security Affairs**

The roles and responsibilities for cybersecurity within the national government are not clearly delineated. This thesis asks if the current allocations of cybersecurity responsibilities to DHS are optimal for achieving national cybersecurity objectives. To answer this question, the evolution of cybersecurity policies within the United States is evaluated, looking specifically at DHS. Additionally, FBI, NSA/DOD, and DNI cybersecurity roles are identified. The Sony Pictures Entertainment cyber-attack is examined as a case study for how a real-world event is handled, and to determine the pros and cons of the current allocation of responsibilities. The evidence from the Sony cyber-attack suggests that the Secret Service, under DHS, is not ready to conduct a proper investigation for a cyber-attack but that the FBI is. This thesis identifies numerous responsibility allocation changes that would streamline cybersecurity at the national level. The main recommendations are that DHS should be the lead agency for improving and strengthening cybersecurity, while the FBI should be the lead agency for investigating cyber-attacks, unless the attack is against one of the people that the Secret Service protects, in which case they should become the lead investigator with direct support from the FBI. [Full Text](#)

Keywords: Department of Homeland Security, DHS, cyber, cybersecurity, Sony cyber-attack

**EXPLAINING SECTARIAN VIOLENCE IN THE MIDDLE EAST:  
A COMPARATIVE STUDY OF BAHRAIN AND YEMEN**

*The following paper has been recognized as outstanding by its department*

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Sectarian violence in the Middle East has continued to rise amid regional turmoil and transition. Though violence perpetuated along sectarian identities has occurred at times during the Middle East’s long history, it is not a constant or normal state of events. This thesis explains the rise in contemporary sectarian violence through comparative analysis and literature on Middle Eastern sectarianism and ethnic violence theory. This thesis has identified four primary independent variables as contributing factors to the dependent variable of sectarian violence. Three primary independent variables heightened the saliency of sectarian identity and regional sectarian tensions: identity group grievances, elite instrumentalization, and the regional context of the proxy war between Saudi Arabia and Iran. State collapse, the fourth and most critical variable, then transforms sectarian tensions into sectarian violence due to the political, economic, and security vacuums created. This conclusion is demonstrated by comparing sectarian violence in Bahrain and Yemen. Though Bahrain and Yemen share the first three variables (grievances, instrumentalization, and regional context), they diverge on the fourth variable, state collapse. As a result, Yemen, which has experienced state collapse, has escalating sectarian violence, while Bahrain has failed to experience sectarian violence due to a robust and capable state apparatus. [Full Text](#)

Keywords: sectarian violence, sectarianism, Middle East, Yemen, Bahrain, state collapse, Saudi Arabia, Iran, proxy war, grievances, instrumentalization, Government of Yemen, Government of Bahrain



**FACILITATING THE MEDICAL RESPONSE INTO AN ACTIVE SHOOTER HOT ZONE**  
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**Co-Advisor: Patrick Miller, Center for Homeland Defense and Security**

The response to active shooter attacks is not as effective as it could be. People die before receiving care because most jurisdictions have a policy in place that stipulates emergency medical services (EMS) wait to enter a scene until law enforcement (LE) announces that the scene is clear or secure. Since this can take some time, life-saving care is not immediately available to the people who most need it, and consequently, there can be a greater loss of life. How can a combined LE and EMS response, based on combat medical care, be effective in saving lives during an active shooter incident? Utilizing 10 historic active shooter cases ranging from the Texas tower shooting in 1966 and concluding with the Sandy Hook school shooting in 2012, I analyzed the responses to consider the response times of the responders, time of access to the victims, and transport time to medical facilities. The basis for the responses utilized data collected by the U.S. military from combat injuries sustained from World War II through the current conflicts in the Middle East. From these analyses, I am able to show that fast field intervention based on training, policy, and operational planning with the Incident Command System component, which includes both law enforcement and fire/EMS entry teams, will provide better patient viability prior to hospital care. This will not be a critique of right and wrong, as the responders did what was needed at the time; however, in current-day hindsight, there are points that can be noted for future response growth. [Full Text](#)

Keywords: active shooter, emergency medical service (EMS), fire, Incident Command System (ICS), law enforcement, Multi-Assault Counter-Terrorism Action Capabilities (MACTAC), Newtown, National Incident Management System (NIMS), swarming, rescue task force, Tactical Emergency Casualty Care (TECC), Tactical Emergency Medical Service (TEMS), Texas tower, Columbine, Virginia Tech

**THE MANNED PENETRATING BOMBER: TIME TO RECONSIDER?**

**Shawn Toenyes—Major, United States Army**  
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**Co-Advisor: James Russell, Department of National Security Affairs**

During the Cold War, the United States constructed a nuclear triad, which consists of three components: strategic bombers, intercontinental ballistic missiles (ICBMs), and submarine-launched ballistic missiles (SLBMs). The triad's mission was to ensure that the U.S. nuclear force would not be crippled or destroyed should an enemy attempt a first strike attack against the United States. This, in turn, offered a credible threat of a U.S.-launched second strike, enhancing the overall effectiveness of our deterrent strategy. This thesis challenges a central tenet of traditional U.S. nuclear doctrine by asking whether the Triad is still needed. Although some in the Air Force, along with various government personnel and those outside of the National Capital Region, have questioned the continued reliance on the bomber, there has been insufficient debate about either the bomber's deterrence value or second-strike launch capability in the event that nuclear deterrence collapses. This research examines the historic and contemporary reasons for maintaining bombers as part of the Triad. This thesis concludes that the strategic bomber should be removed from the Triad and the financial savings be redistributed to the remaining legs of the newly formed nuclear dyad. [Full Text](#)

Keywords: triad, deterrence, bombers

**MASTER  
OF  
BUSINESS ADMINISTRATION**

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# MASTER OF BUSINESS ADMINISTRATION

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## **COST ESTIMATES OF CONCENTRATED PHOTOVOLTAIC HEAT SINK PRODUCTION**

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**Master of Business Administration**

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The focus of the thesis is the formulation of a credible, reasonable, and professionally developed cost analysis of adding optimized cooling technologies to concentrated photovoltaic (CPV) systems. Current CPV systems use basic heat sink designs to increase efficiency. Modern heat sink design can achieve greater overall efficiencies of electricity generation. As the CPV market has matured, production costs have come down to near flat-panel photovoltaic (PV) production costs. CPV units outperform flat-panel PV units in areas of high direct normal irradiance (DNI) in terms of electricity generation efficiency and power produced per square meter. Gains in efficiency should shorten payback periods for CPV systems, if they are not prohibited by high upfront costs of manufacturing and installation. Ultimately, a better understanding of cost drivers in CPV unit production will help in the making of a more informed selection of optimal technology for Department of Defense/Department of the Navy self-sufficient solar power for our bases. This research will help further U.S. Navy energy goals by increasing alternative energy ashore and its use across the Navy. [Full Text](#)

Keywords: capital expenditure (CAPEX), cost analysis, concentrated photovoltaic (CPV), Department of the Navy (DON), direct normal irradiance (DNI), Secretary of the Navy (SECNAV), payback, photovoltaic (PV), return on investment (ROI)

## **LPTA VERSUS TRADEOFF: ANALYSIS OF CONTRACT SOURCE SELECTION STRATEGIES AND PERFORMANCE OUTCOMES**

**Jacob Baker—Lieutenant Commander, United States Navy**

**Michael Bono—Lieutenant Commander, United States Navy**

**Justin DeVoe—Lieutenant Commander, United States Navy**

**Master of Business Administration**

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**Co-Advisor: Rene Rendon, Graduate School of Business and Public Policy**

The Department of Defense (DOD) spends hundreds of billions of dollars annually to procure highly complex weapon systems, supplies, and services. Due to recent budget constraints, DOD stakeholders are closely examining the strategies and methodologies contracting professionals employ to acquire what the DOD needs. Contracting professionals may use lowest price technically acceptable (LPTA) and tradeoff strategies to procure requirements to maximize the overall best value to the government. The purpose of this research is to determine if a relationship exists between the contract source selection strategy employed, either LPTA or tradeoff, and the contract pre-award and post-award performance metrics. Data were collected from contract files located at Naval Sea Systems Command to determine the potential relationship between LPTA and tradeoff performance metrics. The findings of this research suggest that not enough data were collected to answer the research questions. However, the data contained in this report will be incorporated into a pool of data

gathered from previous research efforts to provide adequate statistical power to answer the research questions. The report concludes with recommendations for further research. [Full Text](#)

Keywords: contracting, contract management process, source selection, lowest price technically acceptable, tradeoff

**UTILIZATION OF SMALL BUSINESSES IN NAVY SUBCONTRACTING**

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**Second Reader: Keith Snider, Graduate School of Business and Public Policy**

While the Department of Defense met its FY2012 small-business subcontracting goal, the Department of the Navy (DON) is quite possibly leaving behind the potential for more small-business participation in the area of subcontracting. The DON utilizes many large prime contractors, especially when it comes to ships and complex weapons systems. Most of these large primes are obligated to subcontract work to small firms. Further, the DON is obligated by law to maximize small-business participation in contracting. This report will evaluate and determine whether opportunities for fuller utilization of small businesses in DON subcontracting exist. Also, the study will address to what extent individual commands within DON utilize small-business subcontracting and the effect of common methods for increasing small-business participation. Factors such as subcontracting plans, goals achievement, and incentives will be studied. [Full Text](#)

Keywords: Department of the Navy, small business, subcontracting

**DEADLINE TIGHTNESS AND PERFORMANCE IN  
OPERATIONAL AND LOGISTICS CONTEXTS**

**Jason Blanchard–Lieutenant Commander, United States Navy**

**Paul Kloepping–Lieutenant, United States Navy**

**Derek Vogt–Lieutenant Commander, United States Navy**

**Master of Business Administration**

**Advisor: Ken Doerr, Graduate School of Business and Public Policy**

**Co-Advisor: David Nembhard, The Pennsylvania State University**

**Co-Advisor: Jelle de Vries, Vrije University Amsterdam, Amsterdam, Netherlands**

The purpose of this research is to better understand the relationships among regulatory focus (dispositional factor), inventory record accuracy (an operational context), and deadline tightness (a parameter under management control) against performance. Participant performance was measured by the amount of defects identified and the cumulative times to complete the given tasks. Two conditions placed on the participants were a high and low inventory-record accuracy and a loose or tight deadline, and prevention and promotion focused were measured on a regulatory focus scale. We analyzed, through statistical tools such as regression and a t test, the significance between performance, conditions, and regulatory focus. The anticipated outcome is to validate our assumption that tighter deadlines will lead to lower performance and that inventory record accuracy results in higher levels of performance. These findings may have practical applications for organizations such as DLA, NAVSUP, and other agencies or organizations that perform warehouse tasking when assigning or hiring individuals to perform such functions. [Full Text](#)

Keywords: regulatory focus, deadlines, inventory record accuracy, throughput rate, defect rate

**TWO-BIN KANBAN: ORDERING IMPACT AT NAVY MEDICAL CENTER SAN DIEGO**

**Audrey Carter–Lieutenant, United States Navy**

**Master of Business Administration**

**Advisor: Geraldo Ferrer, Graduate School of Business and Public Policy**

**Co-Advisor: Mie-Sophia Augier, Global Public Policy Academic Group**

One of the most important aspects of hospital administration is the medical consumable inventory process. The Navy Bureau of Medicine and Surgery (BUMED) hopes to improve the medical inventory process across the Navy Medicine enterprise with a new lean medical inventory system called two-bin Kanban. In 2014, BUMED implemented two-bin Kanban inventory systems in 22 Navy military treatment facilities (MTFs). This project analyzes the efficiency and effectiveness of the two-bin Kanban inventory system in three departments at Navy Medical Center San Diego (NMCS D). In this evaluation, over 163,000 medical consumable transactions worth a net value of \$1.6 million were analyzed across two years (2013 and 2015). Inventory ordering patterns, cost savings/avoidance, and cost per relative value unit (RVU) are a few of the analyses that were conducted to determine what impact, if any, two-bin Kanban had on the Gastroenterology, Urology, and Oral Maxillofacial Surgery (OMFS) departments at NMCS D. The data is statistically significant in 2015 when compared to 2013. Procurement order costs decreased and procurement order efficiency improved across all departments. However, given the nature of the observations and the existence of other process-improvement efforts, this research is unable to confirm if the two-bin Kanban was the cause for the performance improvements. [Full Text](#)

Keywords: supply-chain, two-bin Kanban, cost-analysis, hospital

**AN ANALYSIS OF WHEN OFFICERS SHOULD ENTER  
THE ARMY CONTRACTING CAREER FIELD**

**Jose Crespo–Major, United States Army**

**Master of Business Administration**

**Advisor: Ryan Sullivan, Defense Resources Management Institute**

**Co-Advisor: Amilcar Menichini, Graduate School of Business and Public Policy**

The purpose of this MBA project is to determine when active duty officers should be allowed to enter into the Army Acquisition Corps' Contracting Career Field. Contracting is a highly specialized career field that requires a technically proficient workforce with extensive contracting experience. Given the existing career timeline format, contracting military occupational specialty officers may only have approximately six years of experience working in contracting-related assignments, including staff positions, prior to being eligible for promotion to lieutenant colonel. In order to improve officers' technical proficiency before their promotion to contracting leadership positions as lieutenant colonels and colonels, the Army Acquisition Corps may need to admit officers into the career field earlier. Officers would then be afforded more contracting assignments, thus obtaining more experience prior to receiving contracting leadership positions. This project examines several courses of action that the Army Acquisition Corps can utilize to establish the most cost-efficient period for officers to join the Contracting Career Field. [Full Text](#)

Keywords: Army Acquisition Corps, contract career field, contract management officers

**A BASELINE ANALYSIS OF COMBAT LOGISTICS FORCE SCHEDULING EFFICIENCY**

**Michael Cribbs–Lieutenant, United States Navy**

**Master of Business Administration**

**Advisor: Daniel Nussbaum, Department of Operations Research**

**Second Reader: Bryan Hudgens, Graduate School of Business and Public Policy**

Combatant ships in the Fifth Fleet sphere of operations depend upon Military Sealift Command (MSC) to supply stores and fuel while they are underway. Scheduling the delivery of supplies has predominately been customer driven, which has led to inefficiencies in the utilization of MSC resources. The introduction of Replenishment at Sea Planner (RASP) in 2013 provided a new tool that is expected to increase efficiency of scheduling operations by reducing scheduling errors and manpower needed for fulfillment. The purpose of this research is to analyze data from Fifth Fleet collected before and after RASP with a goal of establishing a baseline efficiency in Combat Logistics Force (CLF) ship utilization. Supply and demand models were built over the data sets, presenting an interesting view of the disproportion of available commodities available to customers. Efficiencies were compared before and after RASP, resulting in a recommendation that the Fast Combat Support Ship (AOE) be the ship of choice due to better efficiency and cost to deliver commodities to the warships in the Fifth Fleet area of responsibility. The trends from the data were mostly inconclusive, however; as a result, this paper recommends expanding the research years for further data analysis to include 2011, 2012, 2014, and 2016. [Full Text](#)

Keywords: logistics, Military Sealift Command, efficiency, freight rates, Combat Logistics Force, replenishment at sea, replenishment at sea planner, coalition support, supply and demand

**A COST–BENEFIT ANALYSIS BETWEEN THE CURRENT NAVAL OFFICER  
RETENTION BONUS PLAN AND THE ENLISTED RETENTION BONUS PLAN**

**Donald Freeman–Commander, United States Navy**

**Nicholas Zerler–Lieutenant Commander, United States Navy**

**Master of Business Administration**

**Advisor: Amilcar Menichini, Graduate School of Business and Public Policy**

**Co-Advisor: Bryan Hudgens, Graduate School of Business and Public Policy**

The current fiscal constraints and increased operational tempo over the last decade have placed a strain on the U.S. Navy and the potential retention of sailors. On September 12, 2014, in an interview with the U.S. Naval Institute, Vice ADM Bill Moran, Deputy Chief of Naval Operations for Manpower, Personnel, Training, and Education, stated that he has seen signs of a looming sailor exodus. The exodus could be as bad as the post-Cold War period and just before the terrorist attacks of September 11, 2001. This project is a cost–benefit analysis between the current officer-retention bonus plan and the enlisted-retention bonus plan. To aid in the improvement of retention-targeted bonuses across the Navy, our research focuses on the retention rates and effectiveness of current bonus structures, the timing of those bonuses, and internal and external factors affecting retention. [Full Text](#)

Keywords: Retention, bonus

**DEPARTMENT OF DEFENSE'S 2015 RETIREMENT PLAN COST ANALYSIS**

**James Hanlon—Lieutenant Commander, United States Navy**

**Kedish Hemmings—Lieutenant, United States Navy**

**Charles Fuehrer—Lieutenant, United States Navy**

**Master of Business Administration**

**Advisor: Amilcar Menichini, Graduate School of Business and Public Policy**

**Second Reader: Jesse Cunha, Graduate School of Business and Public Policy**

The new military retirement system is advertised to significantly reduce the Department of Defense's (DOD) monetary outlays over the short and long term. These savings are generated through a variety of assumptions outside of the department's control. The variables that have the greatest impact over cost savings are controlled by service members' (SM) actions, choices, and federal interest rates. Critical analysis of these variables could potentially affect future cost savings and is key in budget preparation and future spending plans. This MBA report presents a sensitivity analysis on three separate variables that have a significant impact on retirement costs. Realistic manipulation of these independent variables will show short-term versus long-term cost savings. Additionally, a high-cost and low-cost scenario is explored. With cost scenarios differing up to \$321 billion, DOD needs to be aware of the potential effects of future outlays. It is recommended that DOD conduct additional economic research and acquire further data on the preferences of current SMs in order to provide a more narrow range of cost savings. [Full Text](#)

Keywords: Department of Defense, OSD, MCRMC, November 2015 new retirement plan, military retirement

**RISK-ADJUSTED VALUATION OF THE CURRENT MILITARY  
RETIREMENT AND THE CY2018 RETIREMENT SYSTEM**

**Adam Heil—Lieutenant Commander, United States Navy**

**Master of Business Administration**

**Advisor: Amilcar Menichini, Graduate School of Business and Public Policy**

**Second Reader: Robert Eger, Graduate School of Business and Public Policy**

This paper analyzes the U.S. military's choice to transition to the blended retirement system in 2018. All service members will be grandfathered into the current system but those with less than 12 years of service will be able to change from the legacy cliff-vested annuity to a pension that includes a reduced annuity, a 401(k)-type matched investment, and a career continuation bonus. The method used to value the two systems leverages the assumptions made by the Military Compensation and Retirement Modernization Commission and RAND. However, it also incorporates risk into the calculation when valuing the annuity and continuation bonus portions of the retirement systems by using historical Department of Defense retention curves. All military members who do not intend to complete 20 years of service should switch to the blended system to derive at least some retirement value from their time in the military. Of the remaining population intending to complete at least 20 years of service, all service members—save for enlisted members with six or more years of service—benefit from the change to the new blended pension. [Full Text](#)

Keywords: military retirement, retirement reform, blended retirement



**CONTRACT SOURCE SELECTION: AN ANALYSIS OF LOWEST PRICE  
TECHNICALLY ACCEPTABLE AND TRADEOFF STRATEGIES**

**David Hill–Lieutenant, United States Navy**

**David Odom–Lieutenant, United States Navy**

**Jamal Osman–Lieutenant Commander, United States Navy**

**Wesley Paulk–Lieutenant, United States Navy**

**Master of Business Administration**

**Advisor: Rene Rendon, Graduate School of Business and Public Policy**

**Co-Advisor: Karen Landale, Graduate School of Business and Public Policy**

Source selection planning is an important step within the acquisition process. Use of an appropriate source selection strategy is key to minimizing risk and ensuring best value for all stakeholders. On the basis of thorough market research, acquisition professionals must decide at an early stage which source selection strategy (lowest price technically acceptable or tradeoff) to utilize in order to achieve a best value contract award. This research attempts to determine if a relationship exists between contract outcomes (e.g., procurement administrative lead-time, Contractor Performance Assessment Reporting System ratings, and earned value management assessments) and source selection strategy. This research is part of an ongoing research stream. Our research incorporates new data extracted from a large sample of contracts at the Space and Naval Warfare Systems Command and Naval Supply Systems Command. The results suggest there is a relationship between source selection strategy and procurement administrative lead-time. However, there is not yet sufficient data to confirm if a relationship exists between source selection strategy and Contractor Performance Assessment Reporting System ratings, or between source selection strategy and federal supply codes at different systems commands. Future research should focus on gathering more empirical data to assess these relationships. [Full Text](#)

Keywords: contract outcomes tradeoff, lowest price technically acceptable, best value contract management process, source selection strategy

**THE IMPACT OF COMMERCIAL AVIATION ON NAVAL AVIATION**

**Patrick Imhoff–Lieutenant Commander, United States Navy**

**Master of Business Administration**

**Advisor: Amilcar Menichini, Graduate School of Business and Public Policy**

**Second Reader: Robert Eger, Graduate School of Business and Public Policy**

For the first time in over 15 years, commercial airlines are hiring large numbers of pilots and threatening retention rates for naval aviation. One major concern for Navy leadership is if there is a major difference in compensation for aviators who transition to the airlines after 10 years when compared to aviators who make that transition after retirement. The other concern is how the new blended retirement plan will impact compensation and ultimately retention. Using net present value, this research discounted career earnings back to the point at which a naval aviator chooses to stay in the service or seek commercial employment. It was revealed that aviators who decide to leave the service after 10 years stand to earn significantly more money than those who remain until retirement. Aviation Career Continuation Pay was analyzed and alternate payment plans were studied to provide options for the Navy to shrink the gap in compensation. Ultimately, if the Navy is willing to spend more money on compensation, they can close the compensation gap and hopefully prevent future retention problems. [Full Text](#)

Keywords: naval aviation, commercial aviation, aviation career continuation pay, military retirement

**POSSIBILITIES AND LIMITATIONS OF FLEXIBLE WORK  
ARRANGEMENTS IN THE MILITARY**

*The following paper has been recognized as outstanding by its department*

**Ioannis Kanlis–Lieutenant, Hellenic Navy**

**Master of Business Administration**

**Advisor: Ryan Sullivan, Defense Resources Management Institute**

**Co-Advisor: Jesse Cunha, Graduate School of Business and Public Policy**

Employers widely utilize flexible work arrangements (FWAs) both to improve employee work-life balance and to increase organizational effectiveness. To date, the private sector has embraced FWA to a much larger extent than has the military. In this project, I outline the underpinnings of workplace flexibility and describe how it can potentially improve the military labor market. First, I outline a conceptual framework that addresses the work environment's dynamics and complexities while assessing the most common benefits and challenges found in FWAs. Second, I outline a military-centered five-phase process that facilitates the implementation of FWAs in the military work environment. The model is not a panacea, but is instead a comprehensive starting point to help management understand the importance of workplace flexibility, the positive effects from the organizations' and defense members' perspectives, and the elements of an implementation plan. [Full Text](#)

Keywords: workplace flexibility, flexible work arrangements, military work environment, flextime, telework, telecommuting

**ECONOMIC ANALYSIS SUPPORTING THE INCREASE OF THE  
UNSPECIFIED MINOR MILITARY CONSTRUCTION THRESHOLD**

**Clifford Kelsey–Lieutenant Commander, United States Navy**

**Master of Business Administration**

**Advisor: Philip Candreva, Graduate School of Business and Public Policy**

**Co-Advisor: Amilcar Menichini, Graduate School of Business and Public Policy**

This report analyzes the economical, technological, and environmental challenges U.S. Navy engineers face in constructing quality, usable facilities while meeting the constraints of the Unspecified Minor Military Construction (UMMC) threshold. By examining the Department of the Navy's Minor and Military Construction programs, conducting a comparative analysis of DD Form 1391s from past projects to evaluate cost escalation factors and analyzing construction escalation indices, this report supports the recent increase of the UMMC threshold from \$750K to \$1M and provides recommendations for future threshold determination. [Full Text](#)

Keywords: UMMC, MINCON, MILCON, OSD, DON, NAVFAC, construction, escalation

**PROPOSING A RESEARCH METHODOLOGY TO EVALUATE THE RELATION  
BETWEEN TRAINING NEEDS ASSESSMENT AND EMPLOYEE PERFORMANCE**

**Naeem Malik–Lieutenant Colonel, Pakistan Army**

**Mohamed Alobaidli–Captain, Royal Bahraini Air Force**

**Master of Business Administration**

**Advisor: Robert Looney, Department of National Security Affairs**

**Co-Advisor: Becky Jones, Graduate School of Business and Public Policy**

Training needs assessment (TNA) is utilized effectively as an evaluation tool by organizations in various countries to determine if training is the best solution to their problems. These organizations have benefited greatly by identifying the weak links and finding suitable solutions, thus optimizing their efficiency. The effectiveness and advantage of a TNA evaluation process, however, has been neither properly understood nor implemented in Arab culture. It is felt that organizations in countries like Bahrain have tremendous potential to enhance

their efficiency and contribute more positively to economic growth at the national level. Therefore, an effort is being made to propose a research methodology to describe the degree to which TNA affects positive employee performance, specifically in Bahrain. Based on the proposed methodology, separate organizations in Bahrain could be surveyed later, by future researchers, to determine the comprehensiveness of their TNA and employee performance after training. [Full Text](#)

Keywords: training needs assessments, human resources, TNA, Likert scale analysis, LSA

**DELIBERATING A CONTRACT-TYPE BASED RISK MITIGATION  
STRATEGY FOR SOUTH AFRICAN DEFENSE ACQUISITIONS**

**Thomas Mkhaliphi—Civilian, Armscor**

**Master of Business Administration**

**Advisor: Robert Mortlock, Graduate School of Business and Public Policy**

**Co-Advisor: Matthew Kremer, Graduate School of Business and Public Policy**

This project explores the possibility of applying a contract-type based strategy to manage acquisition program costs and schedule risks for the South African (SA) Department of Defense (DOD). The hypothesis proposes a strategy that consists of the wide variety of contract types for use within the acquisition process. The emphasis is on the application of incentive fees and award fees. The study analyzed three past programs and one current program from the SA DOD to establish a rationale for considering the application of the incentives and award fee for contract types as a risk mitigation plan. An analysis of three similar U.S. DOD programs that also implemented incentives and award fees based on contract type indicated that from a risk management perspective, the application of contract type is not inconsequential but the risks are manageable. In order to facilitate the application of this strategy, we find it is necessary to adapt regulations such as Preferential Procurement Policy Framework Act (PPPFA) and Public Financial Management Act (PFMA) and directive documents such as A-PRAC-1034. We further recommend that Earned Value Management (EVM) should be considered by the SA DOD to tie deviations between technical, cost, and schedule performance. [Full Text](#)

Keywords: acquisition process, defense acquisition, contract-type, risk management

**STRATEGIC FORESIGHT PROCESS—IMPROVEMENTS FOR  
THE HUNGARIAN MINISTRY OF DEFENSE**

**Bence Németh—Civilian, Ministry of Defense, Hungary**

**Master of Business Administration**

**Advisor: Mie-Sophia Augier, Global Public Policy Academic Group**

**Co-Advisor: Nicholas Dew, Graduate School of Business and Public Policy**

In 2013-2014, the Hungarian Ministry of Defense (HUN MoD) engaged in its first structured Strategic Foresight process, a process designed to examine events that might affect Hungary until 2030. While it achieved success, the process also had shortcomings. Namely, the Strategic Analysis Group accurately predicted two events, Russia's use of military force and the migration crisis worsening, yet they neither foresaw how fast Russian aggression would result in military conflict nor did they believe in their findings enough to appropriately prepare for the migration crisis. This thesis introduces the evolution and main concepts of Futures Studies and Foresight. It describes the Hungarian Strategic Foresight process and results, explains how the Hungarian experts contemplated the crises before they started, and compares their considerations to the actual events. It also uses the diagnostic tools inherent in Voros's generic Foresight framework to analyze the HUN MoD's Strategic Foresight process, confirming those findings with Popper's methods categories. The thesis concludes that the Foresight process had relevant flaws caused by being unprepared regarding Foresight methodology and also by being intelligence-focused rather than leaving room for alternative future possibilities and out-of-the-box thinking. The thesis recommends improving Strategic Foresight methodology, building Foresight

capacity, and raising awareness about the relationship between intelligence and Foresight work in the HUN MoD. [Full Text](#)

Keywords: strategic Foresight, strategic management, Hungary, Hungarian Ministry of Defense, migration, Russia

**AN ANALYSIS OF VIABLE FINANCIAL NEGOTIATIONS PROCESSES AND RELATED INTERNAL CONTROLS FOR PROCUREMENT IN PAKISTAN**

**Abdul Rafique–Commander, Pakistan Navy**

**Muhammad Malik–Major, Pakistan Army**

**Muhammad Salman–Lieutenant Commander, Pakistan Navy**

**Master of Business Administration**

**Advisor: Juanita Rendon, Graduate School of Business and Public Policy**

**Co-Advisor: Karen Landale, Graduate School of Business and Public Policy**

In Pakistan, the process of public procurement procedure standardization started in 2002 with the establishment of the Pakistan Public Procurement Regulatory Authority (PPRA), based on the 1994 United Nations Commission on International Trade Law (UNCITRAL) Model Law. PPRA rules allow four types of procurement procedures but limit the ability to conduct financial negotiations. PPRA rules are aimed at implementing a unified procurement regime for federal and provincial organizations to ensure a transparent procurement system in Pakistan. The U.S. procurement model and the UK procurement model categorize negotiated procurement procedures under competitive procurement processes. The UNCITRAL Model Law also recommended financial negotiations in 2011. The purpose of this research study is to analyze the financial negotiations process for public procurement in the United States, the United Kingdom, and the United Nations along with the associated internal controls in order to develop a guide for Pakistan defense contracting. This research study focuses on the analysis of the negotiation processes of contemporary procurement models and the Committee of Sponsoring Organizations internal control policy guidelines to guide the financial negotiations process for defense procurement in Pakistan. This research study recommends a financial negotiations process and related internal control procedures for the Pakistan PPRA. [Full Text](#)

Keywords: Pakistan, procurement, PPRA, financial negotiations, UNCITRAL, COSO, internal controls

**DEMAND FORECASTING: AN EVALUATION OF DOD'S ACCURACY METRIC AND NAVY'S PROCEDURES**

*The following paper has been recognized as outstanding by its department*

**Michael Rigoni–Lieutenant Commander, United States Navy**

**Wagner Correia de Souza–Captain Lieutenant, Brazilian Navy**

**Master of Business Administration**

**Advisor: Geraldo Ferrer, Graduate School of Business and Public Policy**

**Co-Advisor: Kenneth Doerr, Graduate School of Business and Public Policy**

In 2013, the Department of Defense (DOD) implemented an accuracy metric to monitor how well the services and Defense Logistics Agency were forecasting demand for inventory items. After three years, results were still poor. DOD uses a metric derived from the Mean of Absolute Percentage Error, yet it differs in significant ways, such as including unit cost to enable the aggregation of data pertaining to all items. In this study, we analyze how unit cost and other parameters affect the validity of DOD metric results. Our research included a review of academic literature on forecast accuracy measurement that uncovered an alternative metric, Mean of Absolute Scaled Errors (MASE), which we tested against the DOD metric. We found the DOD metric produced non-intuitive results and was adversely affected by unit cost and demand volume, while MASE avoided these errors. We utilized MASE to compare six forecasting methods and found that flexibility in choice of

forecasting method produced better results than the naive method when coefficient of variation (CV) is below 2.0. We recommend that the DOD and Navy adopt MASE for aggregation and item-level forecast accuracy evaluation. We recommend that Navy utilize flexibility in choice of forecast method for individual items with CV below 2.0. [Full Text](#)

Keywords: comprehensive inventory management improvement plan, mean of absolute scaled error, lead time adjusted squared error, forecast accuracy, benchmarking, naive method, coefficient of variation

**STRATEGY TO ACHIEVE ENERGY AND WATER SUSTAINABILITY IN LATIN AMERICA THROUGH HUMANITARIAN ASSISTANCE AND DISASTER RELIEF OPERATIONS**

**William Romps–Lieutenant, United States Navy**

**Master of Business Administration**

**Advisor: Deborah Gibbons, Graduate School of Business and Public Policy**

**Second Reader: Mie-Sophia Augier, Global Public Policy Academic Group**

The United States is a leader in humanitarian assistance and disaster relief, and the Department of Defense is called upon by Department of Defense Directive 5105.65 to lead efforts to assist nations in need of education support, health support, disaster preparedness, and basic infrastructure. Latin America is a strategic neighbor of the United States and is susceptible to man-made and natural disasters. Many of the countries that make up Latin America lack access to clean water, proper sanitation, and sources of electricity. The purpose of this thesis is to explore the capabilities of a technology that provides sanitation and water treatment services, the byproduct of which is drinkable water, electric power, and construction-grade ash, and then relay this technology to a humanitarian assistance and disaster relief role in Latin America. This thesis also discusses the rule of law index, influence on host nation governments, population makeup, and area characteristics to consider when determining whether to proceed with a humanitarian assistance or disaster relief project that incorporates water-sanitation-power combined technology. [Full Text](#)

Keywords: humanitarian assistance, disaster relief, renewable energy, sanitation, biomass, waste-to-energy, energy strategy

**A COST ANALYSIS OF DIRECT CASH COMPENSATION IN LIEU OF OPERATING MILITARY COMMISSARY STORES**

**Christopher Smith–Lieutenant Commander, United States Navy**

**Master of Business Administration**

**Advisor: Amilcar Menichini, Graduate School of Business and Public Policy**

**Second Reader: Jesse Cunha, Graduate School of Business and Public Policy**

The Defense Commissary Agency (DeCA) provides groceries at cost (cost consists of the purchase price, a 1 percent markup on select grocery items to cover the cost of inventory loss during normal operations, and the cost of transportation to the store, not including overseas transportation) plus a 5 percent surcharge to military families worldwide. DeCA relies on appropriated funding to operate, and significant budget cuts by the Department of Defense (DOD) threaten the current operation model. This thesis will evaluate whether direct cash compensation to service members would reduce costs to the DOD while still providing the current benefit that DeCA provides them. This thesis will also provide an estimate of the monetary value of the commissary benefit to service members and the monetary value of the commissary benefit in remote locations. The research will incorporate data extracted from financial statements from DeCA and from military demographic data. This thesis finds that it would be less expensive over time to continue operating the com-

missary system as is, rather than offer direct cash compensation to military service members, for at least the next twenty years. [Full Text](#)

Keywords: commissaries, commissary, shopping benefit, military benefit, military stores, DeCA, budget cuts, savings, cost cut, eligible patron, groceries, food, remote military bases, value of benefit, value of commissary, cash compensation



## MASTER OF SCIENCE

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Applied Mathematics  
Applied Physics  
Astronautical Engineering  
Computer Science  
Contract Management  
Cyber Systems and Operations  
Defense Analysis  
Electrical Engineering  
Engineering Acoustics  
Information Strategy and Political Warfare  
Information Warfare Systems Engineering  
Management  
Mechanical Engineering  
Meteorology and Physical Oceanography  
Modeling, Virtual Environments, and Simulation  
Operations Research  
Physical Oceanography  
Physics  
Space Systems Operations  
Systems Engineering  
Systems Technology





# MASTER OF SCIENCE IN APPLIED MATHEMATICS

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## MODELING STORM SURGES USING DISCONTINUOUS GALERKIN METHODS

*The following paper has been recognized as outstanding by its department*

**Karoline Hood—Captain, United States Army**

**Master of Science in Applied Mathematics**

**Advisor: Frank Giraldo, Department of Applied Mathematics**

**Second Reader: Simone Marras, Stanford University**

Storm surges have a devastating impact on coastlines throughout the United States. In order to accurately understand the impacts of storm surges, there needs to be an effective model. One of the governing systems of equations used to model storm surges' effects is the Shallow Water Equations (SWE). In this thesis, we solve the SWE numerically by means of a discontinuous Galerkin (DG) method. The DG method provides high-order accuracy and geometric flexibility on unstructured grids. To run the model, we used both implicit and explicit time integration for solving the SWE. Using explicit time integration as our fundamental truth, we found the error norm of the implicit method to be minimal. This study focuses on the impacts of a simulated storm surge in La Push, Washington, which had undergone a beach restoration project. The beach restoration involved altering the bathymetry along the shoreline to prevent overtopping waves from breaching the mainland. To validate the simulations, we ran three benchmark tests. Real bathymetry was used along with real storm and tidal data. We measured the momentum flux of a wave on the existing bathymetry and the new bathymetry to determine if the new bathymetry had less momentum flux. Our results showed there was less momentum flux with the new bathymetry, and therefore the new bathymetry was more resistant to storm surges. After running the model at a high resolution, we modified the grid resolution to vary throughout the domain with a focus on high resolution closer to the shoreline. In our simulation, we also learned of the effects spurious waves can have on the results. Due to boundary conditions, a spurious wave can reflect back into a model and impact the velocity and momentum flux. [Full Text](#)

Keywords: storm surges, Discontinuous Galerkin method (DG), GMSH, Shallow Water Equations (SWE), implicit and explicit time integrators, momentum flux, beach restoration, spurious waves

## PURPOSE-DRIVEN COMMUNITIES IN MULTIPLEX NETWORKS: THRESHOLDING USER-ENGAGED LAYER AGGREGATION

*The following paper has been recognized as outstanding by its department*

**Ryan Miller—Captain, United States Army**

**Master of Science in Applied Mathematics**

**Advisor: Ralucca Gera, Department of Applied Mathematics**

**Second Reader: Gerry Baumgartner, Laboratory for Telecommunication Sciences**

**Second Reader: W. Matthew Carlyle, Department of Operations Research**

Discovering true and meaningful communities in dark networks is a non-trivial yet useful task. Because terrorists work hard to hide their relationships/network, analysts have an incomplete picture of their strategy;

even worse, the degree of incompleteness is unknown. To better protect our nation, analysts would benefit from a tool that helps them identify meaningful terrorist communities. [Full Text](#)

Keywords: community detection, network science, layer aggregation, dark networks, conductance, cluster adequacy, modularity, Louvain method, shortest path interdiction

**PARTIAL INFORMATION COMMUNITY DETECTION IN A MULTILAYER NETWORK**

**Scott Warnke—Captain, United States Army**

**Master of Science in Applied Mathematics**

**Advisor: Raluca Gera, Department of Applied Mathematics**

**Second Reader: Gerry Baumgartner, Laboratory for Telecommunication Sciences**

Identifying communities in a dark network is a potentially difficult task. The nature of dark networks, and their characteristic of concealing connections within the network, makes community detection an enterprise based on operations and decisions with only partial information. We take this concept of operation with only partial information, and extend it to our work by identifying communities within a dark network using only a single layer from the full multilayer network. Additionally, the concept of identification of terrorist networks within civilian populations is one of ever-increasing importance in our world today. We create a large multilayer synthetic network, and embed a known terrorist network in the larger synthetic network. We construct our synthetic network in a manner to ensure that our terrorist network is not unique, in order to make discovery of the terrorist network difficult. In this portion of our work we are concerned with identifying the entire terrorist network, not just a community within the terrorist network. We use known discovery algorithms to discover the terrorist network, and compare the results to modified algorithms introduced in this thesis and their ability to discover the terrorist network as quickly as possible. [Full Text](#)

Keywords: multilayer networks, partial information, network discovery, synthetic network construction, community detection, dark networks

# MASTER OF SCIENCE IN APPLIED PHYSICS

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## CONTROLLING ROBOTIC SWARM BEHAVIOR UTILIZING REAL-TIME KINEMATICS AND ARTIFICIAL PHYSICS

David Armandt–Lieutenant, United States Navy

Master of Science in Applied Physics

Advisor: Richard Harkins, Department of Physics

Second Reader: Brian Bingham, Department of Mechanical and Aerospace Engineering

Recent commercial developments in small, low cost real-time kinematic GPS sensors enable position realization for light, mobile platforms with centimeter-level accuracy. With a high degree of positional confidence, we explore the feasibility of close-proximity operations of cooperative autonomous agents in an outdoor, GPS-enabled environment. A computer-simulated Hookean spring force is used to control a swarm of robotic agents, a technique called artificial physics. The computer model applies a proportional spring constant based on position information, and the resultant force is applied to each agent respectively. We validate the model by comparing it to analytic solutions, then further refine the model by comparing it to field testing data. With an accurate model of the system, user-defined tasks are tested in simulations and the same algorithm then controls the behavior of the robotic swarm in an outdoor environment. [Full Text](#)

Keywords: multiple robot coordination, robotic swarm, robotic swarm behavior, real-time Kinematic GPS, Robot Operating System

## RADIATION DETECTION AND CLASSIFICATION OF HEAVY OXIDE INORGANIC SCINTILLATOR CRYSTALS FOR DETECTION OF FAST NEUTRONS

*The following paper has been recognized as outstanding by its department*

Jacob Capps–Major, United States Army

Master of Science in Applied Physics

Advisor: Craig Smith, Department of Physics

Co-Advisor: Fabio Alves, Department of Physics

Improved detection of fast neutrons can help prevent illicit nuclear materials from being trafficked and potentially used on American soil. To detect fast neutrons, most current systems use a multi-step process of thermalizing the neutrons, providing a medium or material for neutron capture or other interaction, and then detecting the resultant gamma radiation signal. Heavy inorganic oxide scintillators can detect fast neutrons without thermalization. Simplifying the complex, multi-step detection process into a single interaction and detection medium reduces the detection system's complexity while improving efficiency, compactness, and cost effectiveness. To understand how such scintillators respond to gamma and neutron radiation, we exposed selected scintillators to different gamma and neutron sources and measured the resulting emission responses with photomultiplier tubes and photonic devices. The resultant emission responses were found to depend on a variety of factors including temperature, crystal fabrication, and structure. In addition to considering these factors, the target material's relationship of response to the effective atomic number,  $Z_{eff}$ , was characterized.

Follow-on work is recommended to further characterize fast neutrons' spectral response to irradiation. [Full Text](#)

Keywords: heavy oxide inorganic scintillators, detection of fast neutrons, spectroscopy, gamma induced scintillation, neutron induced scintillation, spectral response, diffuse source, collimated source

**CENTRIFUGAL TENSIONED METASTABLE FLUID DETECTORS  
FOR TRACE RADIATION SOURCES: EXPERIMENTAL  
VERIFICATION AND MILITARY EMPLOYMENT**

**Dominic Chiaverotti—Captain, United States Marine Corps**

**Master of Science in Applied Physics**

**Advisor: Craig Smith, Department of Physics**

**Co-Advisor: Anthony Pollman, Department of Mechanical and Aerospace Engineering**

Centrifugal tensioned metastable fluid detectors (CTMFDs) promise a compact, easy to use, highly sensitive, robust, discriminatory, mobile sensor platform that could detect the presence of special nuclear materials in real time. CTMFDs could help in the detection of fast neutrons or alpha particles that are telltale signs of nuclear material, while remaining blind to gamma radiation that could otherwise interfere with the desired measurement. CTMFDs have a simple, easy-to-use equipment string that costs on the order of hundreds of dollars compared with traditional detectors with similar capabilities, which cost on the order of thousands of dollars. This study involved laboratory testing comparing the CTMFD's capabilities of actinide spectroscopy and neutron detection against other detection systems with similar capabilities. The CTMFD was found to have a comparable neutron detection efficiency, and was found to be much more effective at discriminating between highly diluted actinide solutions using alpha particle spectroscopy. Employment of the proper CTMFD setup could involve use at military checkpoints, or aiding in determining origins of a nuclear weapon in a post-detonation analysis scenario. [Full Text](#)

Keywords: TMFD, neutron radiation, alpha radiation, gamma radiation, metastable fluids, detection efficiency, neutron detection

**AN IMPROVED THERMAL BLOOMING MODEL FOR THE  
LASER PERFORMANCE CODE ANCHOR**

**Joseph Collins—Lieutenant, United States Navy**

**Master of Science in Applied Physics**

**Advisor: Keith Cohn, Department of Physics**

**Second Reader: Joseph Blau, Department of Physics**

Laser weapon systems, unlike conventional weapons, are heavily dependent upon the ever-changing atmospheric conditions in their employment theater. In order to understand the operational effectiveness of a laser weapon, the performance limits due to atmospheric conditions need to be understood. ANCHOR, a laser performance scaling code developed at the Naval Postgraduate School, is one such code used to model a laser's effectiveness for a variety of atmospheric conditions. This thesis focuses on the calibration of ANCHOR's thermal blooming model. In the absence of turbulence, thermal blooming is generally well understood and the thermal blooming Strehl ratio is well defined. When turbulence is coupled with thermal blooming, however, the thermal blooming Strehl ratio is exceedingly difficult to quantify using scaling codes. This thesis calibrates ANCHOR's thermal blooming model using the full wave propagation code TBWaveCalc by adjusting the co-

efficients of an analytical formula to best fit the TBWaveCalc results over a wide variety of initial conditions. [Full Text](#)

Keywords: thermal blooming, atmospheric propagation, laser, scaling code, Strehl ratio, ANCHOR, COAMPS, NAVSLaM, LEEDR

**EFFECTS OF RELATIVE PLATFORM AND TARGET MOTION  
ON PROPAGATION OF HIGH ENERGY LASERS**

**Hayati Emir–Lieutenant Junior Grade, Turkish Navy**

**Master of Science in Applied Physics**

**Advisor: Joseph Blau, Department of Physics**

**Co-Advisor: Keith Cohn, Department of Physics**

To facilitate the study of engagement scenarios with high energy lasers, the Directed Energy Physics Group at the Naval Postgraduate School developed a laser performance code called Atmospheric NPS Code for HEL Optical pRopagation (ANCHOR). This code uses well-known analytical scaling laws and a scriptable user interface to allow the quick exploration of multi-dimensional parameter studies. Recently, a new capability was added that incorporates relative platform/target motion. This study demonstrates this new capability, and compares ANCHOR results with those obtained with the full diffraction code built into WaveTrain. [Full Text](#)

Keywords: directed energy weapons, high energy lasers, atmospheric propagation, relative platform, target motion

**MEMS TERAHERTZ FOCAL PLANE ARRAY WITH OPTICAL READOUT**

**Hugo Gonzalez–Captain, United States Marine Corps**

**Master of Science in Astronautical Engineering and Master of Science in Applied Physics**

**Advisor: Gamani Karunasiri, Department of Physics**

**Co-Advisor: Fabio Alves, Department of Physics**

**Second Reader: Jae Jun Kim, Department of Mechanical and Aerospace Engineering**

The terahertz (THz) spectral range remains a relatively untapped portion of the electromagnetic spectrum. THz radiation's unique ability to penetrate non-metallic materials presents an exciting opportunity for many imaging applications. The purpose of this research is to investigate a unique imaging method using a THz radiation source and metamaterial absorber. By using a metamaterial absorber, the THz detection frequency of interest can be tuned by controlling geometrical parameters with nearly 100% absorption. THz sensing can be achieved by integrating a metamaterial absorber with bi-material legs to form a sensor. Moveable mirror-like surfaces on the backside of the metamaterial under THz absorption can cause a deflection of visible light and from it, the original image can be reconstructed using an optical readout system. In this thesis, the construction of the optical readout system for characterization of sensor pixels as well as THz imaging is described. [Full Text](#)

Keywords: THz, terahertz, QCL, metamaterial, imaging, optical readout

**IMPROVED DENSITY-FUNCTIONAL TIGHT BINDING  
POTENTIALS FOR METALLOID ALUMINUM CLUSTERS**

**Joon Kim–Lieutenant, United States Navy**

**Master of Science in Applied Physics**

**Advisor: Joseph Hooper, Department of Physics**

In this thesis, we study the feasibility of improving aluminum-carbon repulsive potentials for use in density-functional tight binding (DFTB) simulations of low-valence aluminum metalloid clusters. These systems are under consideration for use as novel fuels with rapid metal combustion kinetics, and contain an unusual mix of low-valence metal/metal bonds as well as organometallic components. We show that current DFTB parametrizations of the repulsive potential for Al/C interactions do not provide an adequate treatment of the bonding in these clusters. We performed a re-parametrization of the Al-C repulsive potential via comparison to high-level density functional theory (DFT) results that are known to give accurate thermochemistry for these clusters. We found that the reparametrized system solves the most egregious issues, particularly those associated with an unphysical distortion of the  $\sim 5$  Al/cyclopentadienyl bond. DFTB molecular dynamics simulations of the oxidation of  $\text{Al}_4\text{Cp}^*_4$  show reasonable comparison with a DFT-based Car-Parrinello method, including correct prediction of hydride transfers from  $\text{Cp}^*$  to the metal centers during the reaction. [Full Text](#)

Keywords: improved, density, functional, tight, binding, potentials, metalloid, aluminum clusters

**INVESTIGATION OF THE EMISSIVITY AND SUITABILITY OF A  
CARBON THIN FILM FOR TERAHERTZ ABSORBERS**

**Naomi Sullivan–Lieutenant, United States Navy**

**Master of Science in Applied Physics**

**Advisor: Dragoslav Grbovic, Department of Physics**

**Co-Advisor: Fabio Alves, Department of Physics**

The main goal of this work is to optimize the emissivity of terahertz (THz) thermal sensors by deposition of a carbon thin film. Previously, these thermal sensors were designed to detect THz radiation utilizing metamaterials in a complicated optical probing scheme. We have repurposed them to absorb terahertz radiation, convert the radiation to heat, and convey that surface temperature as an infrared image, essentially mapping the terahertz domain. This design has the potential to be used for optical applications such as an attachable lens that would convert any IR (infrared) camera into a THz camera. Additionally, by using this technique, we show that carbon thin films produce sufficient spectral emissivity for IR-based readout. We ascertained that to deposit a carbon thin film an iron catalyst is needed; pure aluminum cannot be used as a catalyst for chemical vapor deposition (CVD) of carbon. Overall, this study provides a viable method to fabricate thin carbon films at low temperatures for IR-based readout. [Full Text](#)

Keywords: MEMS, etching, EDS

**POWER AND ENERGY STORAGE REQUIREMENTS FOR SHIP  
INTEGRATION OF SOLID-STATE LASERS ON NAVAL PLATFORMS**

**Joshua Valiani–Lieutenant, United States Navy**

**Master of Science in Applied Physics**

**Advisor: Joseph Blau, Department of Physics**

**Co-Advisor: Keith Cohn, Department of Physics**

The U.S. Navy's interest in high-energy lasers (HELs) dictates the need for further study into the propagation of laser light through different atmospheric conditions. Due to the amount of energy required to power these laser weapons systems and the limited amount of available energy onboard ships, different energy storage

systems need to be explored. For this research, two locations were studied: the coast of Cuba and the coast of Russia. These two locations were studied during moderate winter conditions for varying laser output power: 150 kW, 500 kW, and 1 MW. The laser performance code ANCHOR was used to estimate the number of successful HEL engagements that can proceed against a certain target using various configurations of energy storage as the laser output power is varied. [Full Text](#)

Keywords: energy storage, lithium-ion batteries, lead acid batteries, atmospheric propagation, laser, ANCHOR





# MASTER OF SCIENCE IN ASTRONAUTICAL ENGINEERING

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## EVOLVED DESIGN, INTEGRATION, AND TEST OF A MODULAR, MULTI-LINK, SPACECRAFT-BASED ROBOTIC MANIPULATOR

Jerry Drew—Captain, United States Army

Master of Science in Astronautical Engineering

Advisor: Marcello Romano, Department of Mechanical and Aerospace Engineering

Second Reader: Josep Virgili-Llop, National Research Council

This thesis reports on the evolved design, test, and integration of a robotic manipulator consisting of multiple modular links, which enable the reconfiguration of the manipulator system for differing mission requirements without constructing unique hardware for each experimental campaign. The evolved design replaced custom components with commercial components to improve performance, standardize hardware, and reduce assembly time. Additional links were constructed and assembled into a four-link manipulator capable of moving its end-effector without imparting motion to the base spacecraft. Each joint can be controlled independently and provides unique telemetry data via Wi-Fi. A mathematical model of the system was implemented, and the kinematic and dynamic behaviors calibrated, resulting in confirmation of the validity of the modular link manipulator concept. A software code based on this model, the Spacecraft Robotics Toolkit (SPART), was published as an open-source kinematics/dynamics and control framework for use by the spacecraft robotics community. Future research will investigate further upgrades, manipulator control and use in operational scenarios. [Full Text](#)

Keywords: spacecraft, robotics, kinematics, dynamics, multi-body mechanics

## MEMS TERAHERTZ FOCAL PLANE ARRAY WITH OPTICAL READOUT

Hugo Gonzalez—Captain, United States Marine Corps

Master of Science in Astronautical Engineering and Master of Science in Applied Physics

Advisor: Gamani Karunasiri, Department of Physics

Co-Advisor: Fabio Alves, Department of Physics

Second Reader: Jae Jun Kim, Department of Mechanical and Aerospace Engineering

The terahertz (THz) spectral range remains a relatively untapped portion of the electromagnetic spectrum. THz radiation's unique ability to penetrate non-metallic materials presents an exciting opportunity for many imaging applications. The purpose of this research is to investigate a unique imaging method using a THz radiation source and metamaterial absorber. By using a metamaterial absorber, the THz detection frequency of interest can be tuned by controlling geometrical parameters with nearly 100% absorption. THz sensing can be achieved by integrating a metamaterial absorber with bi-material legs to form a sensor. Moveable mirror-like surfaces on the backside of the metamaterial under THz absorption can cause a deflection of visible light and from it, the original image can be reconstructed using an optical readout system. In this thesis, the construction of the optical readout system for characterization of sensor pixels as well as THz imaging is described. [Full Text](#)

Keywords: THz, terahertz, QCL, metamaterial, imaging, optical readout

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# MASTER OF SCIENCE IN COMPUTER SCIENCE

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## **AUTOMATED NETWORK MAPPING AND TOPOLOGY VERIFICATION**

*The following paper has been recognized as outstanding by its department*

**Anthony Collier—Captain, United States Marine Corps**

**Master of Science in Computer Science**

**Advisor: Gurminder Singh, Department of Computer Science**

**Co-Advisor: John Gibson, Department of Computer Science**

The current military reliance on computer networks for operational missions and administrative duties makes network stability and security a high priority for military units. The rapid rate at which technology changes means that constant and continued training is required for the skilled professionals who maintain and secure these computer networks. Current training methods are insufficient at representing the complex nature of the typical modern military computer network and the continually evolving nature of the attacks to networks. The Mapping, Awareness, and Virtualization Network Administrator Training Tool (MAVNATT) is a proposed system designed to replicate operational computer networks, through virtualization, providing a stable, accurate, and safely partitioned training environment that can closely mimic the configuration and functionality of any operational network. This research provides a solution for the mapping module of the MAVNATT system in the form of an application. During testing, we successfully developed network plans, visualized and verified those plans, scanned live networks for comparison and validation against those plans, and exported the network configurations for import by the MAVNATT awareness and virtualization modules. The mapping application was developed on a foundational framework that facilitates expansion and increased functionality during future research. [Full Text](#)

Keywords: network mapping, network verification, network topology, network administrator training, MAVNATT, MAST, tactical network

## **A FRAMEWORK FOR FAULT TOLERANCE IN VIRTUALIZED SERVERS**

**Kadir Elmas—Lieutenant Junior Grade, Turkish Navy**

**Master of Science in Computer Science**

**Advisor: Man-Tak Shing, Department of Computer Science**

**Co-Advisor: Arijit Das, Department of Computer Science**

In modern naval platforms, most of the critical operations are done with the help of automated systems. Specifically, operational decisions and actions are finalized using command and control systems (C2 systems). A wide variety of sensors, radars, communication devices, and weapons are connected to C2 systems. Generally speaking, C2 systems receive data from their respective sensors and radar and process that data. Officers then rely on C2 output to make sound decisions by using their technical knowledge combined with detailed scientific information. A modern approach to ensuring the robustness of these systems is to have multiple systems (or servers) running at the same time that back up one another. Since that approach is expensive, this thesis attempts to solve that problem or find an alternative solution with a fault-tolerant, virtual server-based

system framework. Our goal is to overcome shortcomings with a cost- and space-efficient and user-friendly approach. [Full Text](#)

Keywords: fault tolerance, databases, data guard, switchover, failover

**CONSTRUCTING SOCIAL NETWORKS FROM SECONDARY  
STORAGE WITH BULK ANALYSIS TOOLS**

**Janina Green–Captain, United States Army  
Master of Science in Computer Science**

**Advisor: Michael McCarrin, Department of Computer Science  
Co-Advisor: Raluca Gera, Department of Applied Mathematics**

Intelligence analysts depend on the ability to understand the social networks of suspects and adversaries. We develop a novel method for automatically discovering this information from digital storage media by analyzing byte-offset proximity between digital artifacts on the raw media. We show that this method can be used to group email addresses that indicate real communication between users and those that do not. Furthermore, in the case where addresses do represent communication between users, our analysis indicates that classic measures of centrality are effective for identifying important nodes and close associates, and that further study of modularity classes may be a promising method of partitioning complex components. Finally, in support of the above work, we also created a tagged dataset of graphs for which ground truth was determined by interviews with the owners, and which can be used for future study in this area. Two objectives motivated this thesis, both of which serve the greater goal of making analysts more efficient. The first was to reduce the time digital analysts consume sorting through the results, in order to complete cases in a timely manner. The second was to eliminate data that was not relevant to discovering social networks, in order to achieve the ultimate goal of eventually paving the way for an automated process that identifies social structures. [Full Text](#)

Keywords: social network analysis, social network structure, digital forensics, digital fingerprinting, bulk data analysis, visualization, email address analysis

**DISTRIBUTED EMULATION IN SUPPORT OF LARGE NETWORKS**

**Brian Greunke–Captain, United States Marine Corps  
Master of Science in Computer Science**

**Advisor: Robert Beverly, Department of Computer Science  
Second Reader: Justin Rohrer, Department of Computer Science**

Network emulation is a valuable, though potentially resource intensive, method for virtualizing networks for analysis or testing. Though high-powered servers are becoming increasingly accessible, the size and complexity of physical networks have increased in a similar fashion, thereby limiting the type and size of networks that can be emulated on a single physical machine. In this thesis, we present a tool that allows the developers of ground truth topologies to distribute the emulation requirements across multiple physical machines, thereby increasing the size of networks that can be emulated. First, we reexamine existing tools to discover current methods for emulating synthetic and physical networks. Then we modify an existing platform to enable execution on multiple machines, while increasing flexibility for future extensions. We then develop methods for efficiently distributing the topology among the available resources in order to maximize the potential scale. Finally, we run a series of scenarios simulating real world events, such as a Border Gateway Protocol (BGP) hijack attack, in order to demonstrate the utility and efficiency of the system. [Full Text](#)

Keywords: distributed emulation, network emulation, linear program, BGP hijack

**INTEGRATION OF EXPERIENCE API INTO CDET'S E-LEARNING**

**Clayton MacAloney—Major, United States Marine Corps**

**Master of Science in Computer Science**

**Advisor: Man-Tak Shing, Department of Computer Science**

**Co-Advisor: Arijit Das, Department of Computer Science**

The increased availability and use of online devices has the Marine Corps College of Distance Education and Training (CDET) looking at Experience API (xAPI) for ways to improve the accessibility, effectiveness, and efficiency of the educational instruction they provide. This thesis recommends a way for CDET to incorporate xAPI into the courseware currently delivered by their learning management system (LMS), MarineNet. Research was conducted into how learning objectives, online assessments, and xAPI can create a learning objective performance value (a measurement of a student's proficiency in a specific learning objective). A prototype system consisting of a LMS, Learning Record Store (LRS), and xAPI courseware was developed, and learning experiences linking course assessment questions to learning objectives were extracted to the LRS. The learning experiences were then analyzed to calculate learning objective performance values, which provide the ability to determine students' strengths and weaknesses in specific subject areas. This enables tailored curriculums that allow time and resources to be spent in subject areas that most benefit the student and the Marine Corps, while maximizing the effectiveness and efficiency of their e-learning courseware. [Full Text](#)

Keywords: Experience API, e-learning, learning objectives, online assessments, learning record store, learning management system, MarineNet

**SERVER-BASED AND SERVER-LESS BYOD SOLUTIONS  
TO SUPPORT ELECTRONIC LEARNING**

**Brian McCarthy—Captain, United States Marine Corps**

**Joshua Benson—Captain, United States Marine Corps**

**Master of Science in Computer Science**

**Advisor: Man-Tak Shing, Department of Computer Science**

**Co-Advisor: Arijit Das, Department of Computer Science**

Over the past 10 years, bring your own device has become an emerging practice across the commercial landscape and has empowered employees to conduct work-related business from the comfort of their own phone, tablet, or other personal electronic device. Currently in the Department of Defense, and specifically the Department of the Navy, no viable solution exists for the delivery of eLearning content to a service member's personal device that satisfies existing policies. The purpose of this thesis is to explore two potential solutions: a server-based method and a server-less method, both of which would allow Marines and Sailors to access eLearning course material by way of their personal devices. This thesis will test the feasibility and functionality of our server-based and server-less solutions by implementing a basic proof of concept for each. The intent is to provide a baseline from which further research and development can be conducted, and to demonstrate how these solutions present a low-risk environment that preserves government network security while still serving as a professional military education force multiplier. Both solutions, while demonstrated with limited prototypes, have the potential to finally introduce bring your own device into the Department of the Navy's eLearning realm. [Full Text](#)

Keywords: bring your own device, personal electronic device, server-based, server-less, untethered, eLearning

**AUTOMATIC INFERENCE OF CRYPTOGRAPHIC KEY LENGTH  
BASED ON ANALYSIS OF PROOF TIGHTNESS**

*The following paper has been recognized as outstanding by its department*

**Derek Swenningsen–Major, United States Marine Corps**

**Master of Science in Computer Science**

**Advisor: Mark Gondree, Department of Computer Science**

**Second Reader: George Dinolt, Department of Computer Science**

Currently, reasoning about key lengths within a security scheme involves utilizing generalized recommendations or conducting lengthy manual analyses of how security parameters relate to the security of the scheme. In this paper, we provide the tools necessary for automating reasoning about key lengths and effective security within a security scheme. We first formalize the reasoning about cryptographic proofs within an attack tree structure, then expand attack tree methodology to include cryptographic reductions. We then provide the algorithms for maintaining and automatically reasoning about these expanded attack trees. We provide a software tool that utilizes machine-readable proof and attack metadata and the attack tree methodology to provide rapid and precise answers regarding security parameters and effective security. This eliminates the need to rely on generalized recommendations and provides timely reanalysis when newfound attacks or proofs surface. We validate our software tool within the Schnorr public-key signature scheme as a case study. [Full Text](#)

Keywords: keylength analysis, automated reasoning, attack tree, attack tree analysis, cryptographic reasoning

**DETECTING MALICIOUS TWEETS IN TWITTER USING RUNTIME  
MONITORING WITH HIDDEN INFORMATION**

**Abdullah Yilmaz–Captain, Turkish Armed Forces, Army**

**Master of Science in Computer Science**

**Advisor: Doron Drusinsky, Department of Computer Science**

**Second Reader: Man-Tak Shing, Department of Computer Science**

Although there is voluminous data flow in social media, it is still possible to create an effective system that can detect malicious activities within a shorter time and provide situational awareness. This thesis developed patterns for a probabilistic approach to identify malicious behavior by monitoring big data. We collected twenty-two thousand tweets from publicly available Twitter data and used them in our testing and validation processes. We combined deterministic and nondeterministic approaches to monitor and verify the system. In the deterministic part, we determined assertions by using natural language (NL) and associated formal specifications. We then specified visible and hidden parameters, which are used for subsequent identification of hidden parameters in Hidden Markov Model (HMM) techniques. In the nondeterministic part, we used probabilistic formal specifications with visible and hidden parameters, used in HMM, to monitor and verify the system. An important contribution of the work is that we specified some event patterns indicating malicious activities. Based on these patterns, we obtained output to indicate the possibility of each tweet being malicious. [Full Text](#)

Keywords: formal specifications, hidden Markov model, hidden data, twitter, runtime verification, runtime monitoring, statechart assertions

# MASTER OF SCIENCE IN CONTRACT MANAGEMENT

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## THE DILEMMA OF DEPARTMENT OF DEFENSE BUSINESS SYSTEM MODERNIZATION EFFORTS: WHY INTENDED OUTCOMES HAVE NOT BEEN FULLY MET AND WHAT NEEDS TO CHANGE

**Pamela Coleman–Civilian, Department of the Navy**

**Jodus Hortin–Civilian, Department of the Navy**

**Lauren Pascioni–Civilian, Department of the Navy**

**Master of Science in Contract Management**

**Advisor: E. Cory Yoder, Graduate School of Business and Public Policy**

**Co-Advisor: Laurie Patton, Naval Facilities Engineering Command, Headquarters, Acquisition**

Over the last twenty years, the Government Accountability Office (GAO) has repeatedly found that the Department of Defense's (DOD) business systems have little continuity and that many systems perform similar taskings and were classified as high risk. Despite this designation being made over twenty years ago, the DOD has made little progress implementing the GAO's recommendations. The intent of this joint applied project is not to merely discuss prior recommendations and findings regarding the DOD's business system modernization program from the GAO and other stakeholders, but to identify and thoroughly discuss root cause(s) that have prohibited the DOD from achieving full-implementation over the past twenty years. The goal of this research is to expand upon data and information that is available through published literature and other sources by applying the unique work experiences of the authors as DOD Contract Specialists, as well as the authors' academic perspectives resulting from knowledge obtained through the Contract Management cohort at Naval Postgraduate School. Based on the authors' experience and familiarity, the emphasis of this research was on the DOD contract writing systems. This JAP seeks to report on the progress of DOD business system modernization efforts and develop a better way forward based on the findings to the following primary research questions: 1) What was the catalyst for the DOD's recent business systems modernization efforts, and what is the current nature of that need? 2) Why has the DOD failed to fully meet its business systems modernization objectives in a timely manner? 3) What additional action is needed for the DOD to fully achieve intended outcomes of its business system modernization objectives? 4) Are there other potential outcomes of DOD's business systems modernization efforts that have not been previously accounted for, or particular focus areas that may yield better results? [Full Text](#)

Keywords: DOD business system modernization, contract writing systems (CWS), Standard Procurement System (SPS), SeaPort Enhanced (SeaPort-e), Procurement Automated Data and Document System (PADDS) legacy systems



### **USMC CONTINGENCY CONTRACTING FORCE: AN ANALYSIS OF TRANSIENT OFFICERS IN A RAPIDLY CHANGING ACQUISITION ENVIRONMENT**

**Adam Harrison—Captain, United States Marine Corps**

**Craig Warner—Captain, United States Marine Corps**

**Dylan Armknecht—Captain, United States Marine Corps**

**Master of Science in Contract Management**

**Advisor: Raymond Jones, Graduate School of Business and Public Policy**

**Co-Advisor: Stephanie King, United States Marine Corps**

This research explores the transient nature of Marine Corps officers serving in the Contingency Contracting Force and the potential link to an inability to efficiently execute mission requirements. Through an analysis of recent manpower structure realignment actions, this research assesses training, career path, and manpower deficiency considerations that pertain to officers serving in contracting. The reader is walked through this analysis via literature review discoveries, Department of Defense Inspector General findings, and survey feedback from senior leaders within the Marine Corps contracting community. These results are then analyzed through the lens of personnel, protocol, and platform organizational pillars using the Three Integrated Pillars of Success Model. The research effectively achieves the results desired by the established research objective, identifying potential root causes to problems felt within the Marine Corps Contingency Contracting Force officer corps that represent critical vulnerabilities within the overall contracting structure. The top five recommendations for the Marine Corps to increase the health of its contracting officer corps are presented. Additionally, future research considerations are presented that have the potential to further increase the Contingency Contracting Force's ability to efficiently execute its mission requirements. [Full Text](#)

Keywords: manpower, Contingency Contracting Force, 3006, Three Integrated Pillars of Success Model

### **AN ANALYSIS OF ETHICS LAWS, COMPLIANCE WITH ETHICAL STANDARDS, AND ETHICAL CORE COMPETENCY WITHIN THE DEPARTMENT OF THE ARMY**

**Nancy Lyons—Civilian, Department of the Army**

**Nathan Wienhoff—Civilian, Department of the Army**

**Master of Science in Contract Management**

**Advisor: Thomas Bagwell, Deputy Program Executive Officer,**

**Program Executive Office, Ground Combat Systems**

**Co-Advisor: Patricia Cook, Graduate School of Business and Public Policy**

This project examines the Department of the Army (DA) ethics laws, compliance with ethical standards, and ethics training core competency requirement to address Acquisition Research Program Topic #T15-013: Ethics--Can it be taught? What changes are needed in civilian and military leadership training to address recent ethical violations and to ensure that future leaders are well grounded in their ethical responsibilities and standards of conduct? This research explores the disparities between the DA ethics training objectives versus the subjectivity involved in applying ethical principles to decision-making. We analyze the DA ethics training courses, policies, and procedures. The project explores the distinctions between ethics, values, integrity, standards of conduct, and morality as they relate to clearly defined ethics rules and scenarios where ethical laws or policies may be ambiguous or absent. The research methodology includes a comparative analysis of the Joint Ethics Regulation (JER), the Federal Acquisition Regulation (FAR), and DA ethics training objectives. We also provide an analysis of adjudicated cases involving ethical failures to address changes needed in DA training to ensure that future leaders understand their ethical responsibilities and standards of conduct. [Full Text](#)

Keywords: ethics laws, annual ethics training, compliance with ethical standards, ethical core competency, Department of the Army, ethical violations, ethical decision-making, values-based decision-making, compliance-based decision-making, moral courage, integrity, Joint Ethics Regulation, standards of conduct

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## CONTRACT MANAGEMENT

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### **AN ANALYSIS OF THE ARMY SERVICE ACQUISITION REVIEW REQUIREMENTS AND THE PERCEIVED EFFECTIVENESS ON INTENDED IMPROVEMENTS**

**Roxanne Moss—Civilian, Naval Facilities Engineering Command, Marianas**

**Michael Vukovich—Civilian, Naval Surface Warfare Center, Carderock**

**Megan Weidner—Civilian, Army Contracting Command, Orlando**

**Master of Science in Contract Management**

**Advisor: Charles Pickar, Graduate School of Business and Public Policy**

**Co-Advisor: Lesley Sullivan, Policy Chief Army Contracting Command - Orlando**

In 2009, the Office of the Under Secretary of Defense Acquisition, Technology and Logistics (USD[AT&L]) established oversight requirements for service acquisitions upon realizing that services contracting accounted for half of the Department of Defense's annual obligations. This led to the enactment of stricter policies for services contracting within the Department of the Army. This project reviews the policies and procedures that led to the Army Service Acquisition Strategy Review Requirements, analyzes their intent, and assesses progress. The objective is to identify potential improvements to the review processes and provide better value for Army service acquisitions. To accomplish this objective, a survey was created to target individuals who have submitted requirements packages through the Army Services Strategy Panel (ASSP) process. The intent of the survey is to assess the perceived effectiveness of these policy changes to determine whether intended improvements are being achieved. Research suggests that the Army may benefit from issuing a similar survey and should assess feedback to determine whether resources are being properly utilized. The Army should take measures to ensure lessons learned throughout the review process are captured to maximize potential value. Lastly, the Army should consider setting specific program metrics to track throughout the ASSP process.

[Full Text](#)

Keywords: Department of Defense, service acquisition, policy, Army service acquisition, Defense Procurement and Acquisition Policy (DPAP), Deputy Assistant Secretary of the Army for Procurement, DASA(P)

### **AN ANALYSIS OF THE DEPARTMENT OF DEFENSE'S USE OF OTHER TRANSACTION AUTHORITY (10 U.S.C. 2371)**

**Catherine Stevens—Civilian, Department of Defense**

**Master of Science in Contract Management**

**Advisor: E. Cory Yoder, Graduate School of Business and Public Policy**

**Co-Advisor: Linda Allen, Retired, GSA, Senior Executive Service**

This research provides an analysis of the Department of Defense's historical and current use of Other Transaction (OT) authority as codified in Section 10 of United States Code (U.S.C.) 2371. The 2016 National Defense Authorization Act made the OT for prototype authority permanent. Methodology includes reviews of available literature such as Government Accountability Office (GAO) audit reports, DOD Inspector General reports, and studies by the Congressional Research Service, research by the RAND institution, and Senate and House testimony. Interviews with three OT subject-matter experts provide valuable insight into the creation of the original language as well as legislative changes to OT authority. OT authority has allowed the DOD greater flexibility in working with commercial companies that have traditionally not worked with the federal government in research and development (R&D) efforts. OTs are not subject to the same laws and regulations that govern standard procurement contracts, grants, and cooperative agreements. Research shows that OTs can be a powerful instrument in advancing technology and innovation in R&D. It is imperative that the DOD continue to promote understanding of this unique authority in order to remain on the cutting edge of state-of-the-art technologies. [Full Text](#)

Keywords: Other Transactions, research and development, prototype

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## CONTRACT MANAGEMENT

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### **FLAWED EXECUTION: A CASE STUDY ON OPERATIONAL CONTRACT SUPPORT**

**Scott Taggart—Captain, United States Marine Corps**  
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Contracting for supplies and services within a contingency and deployed operational environment has become a vital necessity. Despite the last decade and a half of armed conflict, the military services as a whole have done a poor job of teaching their leaders how to effectively plan for and manage operational contract support, starting with requirements generation and continuing to post-award contract management. The objective of this research is to develop a case study for use in Joint Professional Military Education schools that examines the far-reaching strategic, operational, and tactical effects of operational contract support (OCS). This case study will examine the use of OCS in a deployed environment, and the positive and negative impacts of OCS decisions on the tactical, operational, and larger strategic military mission. We also consider the long-term effects of the requirement and subsequent contract action—fiscally, politically, and locally. The case study is meant to spur discussion on how second-, third-, and fourth-order OCS effects impact the United States' military mission and general interests. [Full Text](#)

Keywords: operational contract support, contracting, theater support, contingency, Marine Corps, joint

### **AN ANALYSIS OF CYBERSECURITY AND HOW IT IS AFFECTING A CONTRACT WRITING SYSTEM, SEAPORT**

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The purpose of this paper is to research cybersecurity and whether it creates inefficiencies and ineffective business support for the DOD—specifically, the contract writing system SeaPort. Is cybersecurity becoming too restrictive, making the ability to support the programs and warfighters inefficient and ineffective? What business practices could be put in place to protect the DOD without hindering contract and business support to the warfighter? This research topic came about due to the underperformance of SeaPort when used by NAVSEA contract specialists at Dahlgren. The research begins with a brief overview of the Internet, cybersecurity, and SeaPort contract writing system. The literature review describes the private and public sectors with regard to cybersecurity as well as any policies related to cybersecurity. Sixteen (16) SeaPort users were surveyed in order to gain an understanding of the issues surrounding SeaPort. We discovered that SeaPort, indeed, was having issues regarding PDF generation, FPDS-NG reporting, and overall latency. A direct correlation between cybersecurity and SeaPort efficiency could not be proven; however, theoretically, cybersecurity can be attributed. Recommendations include adding more servers to existing SeaPort network infrastructure and further research conducted by cyberexperts within the government with the authority to access direct cyber-reports on the system. [Full Text](#)

Keywords: SeaPort, cyber security, help desk, speed, cyber threat, cyber attack

# MASTER OF SCIENCE IN CYBER SYSTEMS AND OPERATIONS

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## **A MODEL FOR REAL-TIME DATA REPUTATION VIA CYBER TELEMETRY**

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The federal government faces a monumental task of protecting national security information, advanced warfighting capabilities and the personal information entrusted by hundreds of millions of American citizens. Each federal agency has now identified High Value Assets (HVA) as defined by information sets that our adversaries most typically target. The Continuous Diagnostic and Mitigation initiative aims to establish a unified security posture across the federal space with a specific focus on HVAs. This work examines federal cybersecurity initiatives and proposes how data reputation and telemetry can enhance the federal security posture, increase the costs of computer network attack of our adversaries, and improve the ability of defenders to drive down the time between when malicious code is observed and when protections are put in place. [Full Text](#)

Keywords: data reputation, federal government, end point protection, telemetry

## **CYBERSPACE ACTIONS IN A COUNTERINSURGENCY**

*The following paper has been recognized as outstanding by its department*

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This work addresses the insufficiency of United States Department of Defense joint doctrine for incorporating cyberspace operations into counterinsurgency (COIN) campaigns. This insufficiency is addressed through the use of a matrix, which aligns the cyberspace actions described in joint cyberspace doctrine against the COIN tenets outlined in joint COIN doctrine. Each intersection of cyberspace actions and COIN tenets is explored, first by listing the effects that the cyberspace action can produce in support of the COIN tenet. Each list of effects is then evaluated to determine the degree to which these effects are accounted for by current doctrine, whether these effects have been seen in actual COINs, and how significantly these effects contribute to a COIN campaign. To facilitate open discussion, we draw only from unclassified sources. We find that existing doctrine does not address many types of missions and operations that can produce effects in support of the COIN tenets. The intersections with effects that contribute most significantly to a COIN campaign, but are least accounted for by current doctrine, are prioritized; we then propose additions to current doctrine that account for the insufficient guidance. We conclude by addressing the limitations of this mapping and suggesting future research. [Full Text](#)

Keywords: counterinsurgency, cyber, doctrine



# MASTER OF SCIENCE IN DEFENSE ANALYSIS

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## **HARBINGERS OF THE CALIPHATE: ISLAMIC STATE REVOLUTIONARY ACTIONS 2011–2014**

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At the time of the U.S. forces' withdrawal from Iraq at the end of 2011, the Islamic State was on the brink of defeat. With roughly 700 members remaining, the movement initiated a well-designed and rigorously executed revolutionary campaign, first in Iraq and then Syria. By June of 2014, a movement once dismissed as junior varsity was dominating eastern Syria and routing divisions of the Iraqi Army. This thesis develops a model of revolutionary growth and employs it as a tool to evaluate the Islamic State's campaign from 2011 through 2014. This evaluation reveals the significance and logic of Islamic State car bomb attacks against the Iraqi Security Forces and Shia civilians. The analysis explains how and why the Islamic State forges alliances and eliminates rival movements and tribal organizations. This evaluation illuminates the Islamic State's internal structure and methodology for governing territory to support further growth. This thesis allows the reader to form a better understanding of the integrated strategy of the Islamic State, so as to be better prepared to contribute to current efforts to combat the movement in Iraq, Syria, and other troubled nations. [Full Text](#)

Keywords: Islamic State, Iraq, Syria, insurgency, terrorism, counter-terrorism, counter-insurgency, revolutions, unconventional warfare, jihadist movements

## **WATCH OUT FOR THE CHILDREN: ARMY POLICY AND CHILD SOLDIERS**

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According to the United Nations, there are over 300,000 child soldiers operating throughout the world, and the potential that U.S. soldiers will interact with child soldiers remains significant. Military doctrine, policy, and training have been updated to take the current operational environment into consideration. The same cannot be said for the interaction with child soldiers. This thesis will begin to identify and address gaps in the current Army policy and doctrine concerning child soldiers. Additionally, this thesis will begin to identify ways to bridge the gaps identified in order to address how U.S. soldiers can best be prepared when they confront child soldiers on the battlefield. This research identifies that there is a rising issue concerning child soldiers, but that the U.S. Army has failed to implement the necessary changes to support its soldiers in dealing with this when they deploy. The Army references international treaties that the United States is not a party to in order to provide guidance to soldiers concerning child soldiers. This guidance needs to be codified, implemented, and distributed to support soldiers who might be faced with the choice about whether to take the life of a child. [Full Text](#)

Keywords: child soldiers, International Humanitarian Law, Army policy and doctrine

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**PEACEFUL PROTEST, POLITICAL REGIMES, AND THE SOCIAL MEDIA CHALLENGE**

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Information and communication technologies (ICT) have transformed with the advent of the Internet and the diffusion of cellular-based communications. Previous research has examined the effects of horizontal ICT on collective violence, but the effects on non-violent expressions are not well understood. Using social conflict data from Africa and Latin America between 1990 and 2011, this study employs negative binomial regression models to explore the distinct effects of the spread of social media on peaceful protests within democratic, anocratic, and autocratic regimes. Multiple regression models find strong statistical evidence in support of a positive relationship between social media and peaceful protest in anocratic regimes. Autocratic and anocratic states will thus increasingly find themselves in a social media challenge—repress horizontal ICT or embrace it and its effects—as their populations seek democratization. [Full Text](#)

Keywords: information and communications technology (ICT), authoritarian, autocratic, anocratic, civil conflict, collective action, peaceful protest, social media index (SMI)

**PERCEPTION IS REALITY: SPECIAL OPERATIONS FORCES IN THE GRAY ZONE**

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As conflicts increasingly fall within the Gray Zone—that is, outside the traditional peace-or-war construct—the U.S. military must understand how to succeed in this ambiguous environment and counter its threats. A key challenge is understanding how to employ the tools available in the Gray Zone—the primary tool being Special Operation Forces (SOF). This research finds that policymakers and others outside of SOF have often misapplied this tool, due to limited understanding of SOF roles and competencies. This limited understanding or misperception of SOF may have a detrimental effect on the ability of the United States to reach its foreign policy goals. This research analyzes U.S. SOF employment in the Gray Zone, breaking down constituent components and identifying those of greater importance. Characteristics of the Gray Zone and irregular warfare are considered, and a holistic approach to the use of irregular warfare in the Gray Zone is proposed. Graham Allison and Morton Halperin's bureaucratic politics model is used to discern the factors that shape the perception of SOF. Two historical cases are viewed through the lens of the bureaucratic politics model to show how SOF capabilities must be well understood and properly employed to achieve desired U.S. policy goals. [Full Text](#)

Keywords: Special Operations Forces, Gray Zone, irregular warfare, U.S. policy, bureaucratic politics model, Somalia, Philippines, Operation Enduring Freedom-Philippines (OEF-P)

**BRINGING THE MEANING BACK IN: EXPLORING  
EXISTENTIALLY MOTIVATED TERRORISM**

*The following paper has been recognized as outstanding by its department*

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Radicalization and political violence are traditionally explained as rational, instrumental choices motivated by grievances, deprivation, oppression, and other factors external to the individual. This explanatory model, however, is dangerously incomplete; many radicalized individuals appear to be internally motivated toward violence as a way to bring meaning to their lives. Western philosophy, and the existentialist school in particular, has long recognized the centrality of meaning to human existence. Psychology and sociology have more recently empirically demonstrated meaning-in-life's close connection to happiness, psychological well-being, and even physical health. This thesis examines both the philosophy and science of meaning-in-life, demonstrating the process through which it is produced and terrorism's unique ability to do so. Finally, this thesis examines four case studies across time, place, and ideological basis to establish the influence of existential motives in the history of terrorism. Understanding and accounting for the importance of meaning-in-life and its role in terrorism will help develop effective counter-radicalization and counter-violent extremism programs that account for more than rational, instrumental motives. [Full Text](#)

Keywords: terrorism, political violence, positive psychology, existentialism, philosophy, rational choice, radicalization, Red Army Faction, ETA, ISIS, counter-violent extremism, counter-terrorism

**COOPERATION AMONG NATIONS: UNDERSTANDING THE  
COUNTER NUCLEAR SMUGGLING NETWORK IN EUROPE**

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**Co-Advisor: Zachary Davis, Department of National Security Affairs**

This research identifies and characterizes a U.S.-centric counter nuclear smuggling network in Europe, and recommends ways to improve its cooperation and effectiveness. The purpose is to provide United States Special Operations Command (USSOCOM), North Atlantic Treaty Organization Special Operations Headquarters (NSHQ), and the larger counterproliferation (CP) community with an understanding of how the current network functions, its strengths and weaknesses, and how it can be improved. The research starts by examining prominent theories of international relations to understand cooperation within the network. Afterward, social network analysis (SNA) is used to define the Counter Nuclear Smuggling-Europe (CNS-E) network and characterize its structure. Lastly, the function of the network is assessed using realistic vignettes based upon current threats in Europe. The results of this research indicate that the CNS-E network is highly decentralized and dense. Cooperation is abundant, though not sufficiently strong to ensure that information is shared. This research concludes by making the following recommendations: 1) The U.S. government should focus on strengthening existing relations, not creating new relations; 2) The network should centralize capabilities and information in regional hubs; 3) USSOCOM and NSHQ should establish strong relationships with law enforcement agencies; 4) USSOCOM and NSHQ can contribute to nonproliferation efforts by conducting threat assessments of European chemical biological radiological nuclear (CBRN) facilities. [Full Text](#)

Keywords: weapons of mass destruction, counterproliferation, nonproliferation, social network analysis, nuclear smuggling, Europe, counter-terrorism

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**BY FORCE OR BY FRAUD: OPTIMIZING U.S. INFORMATION  
STRATEGY WITH DECEPTION**

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Military deception (MILDEC) operations have a long and illustrious place in America's battlefield history. To great effect, MILDEC has enabled countless victories in every U.S. conflict since the Revolutionary War. However, the United States has allowed its deception capability to atrophy. Possible explanations for our MILDEC divestiture range from structural insufficiencies to an ethical framework that emphasizes truth and transparency. Simultaneously, the onset of the Information Age has leveled the playing field between state and non-state actors and proved that lasting victory cannot be achieved by force alone. Yet, due in part to the difficulty involved in quantifiably measuring information strategy, the contemporary military's acceptance and understanding of information warfare has been limited. This necessitates the re-examination of U.S. information strategy formulation to address more effectively the challenges and complexities encountered in the human domain. To overcome this impediment, this thesis examines the intangible aspects of information warfare and proposes a structured decision-making tool capable of generating precise computations of optimal information strategies. *By Force or by Fraud* is a quantitative assessment of MILDEC's utility on the modern battlefield that is qualitatively tested against historic cases of information warfare. [Full Text](#)

Keywords: deception, MILDEC, influence, psychological operations, PSYOP, MISO, information operations, IO, counterinsurgency, special operations forces, game theory, analytical hierarchy process, non-state actors, human domain, Dhofar Rebellion, Irish War of Independence, Israel-Lebanon Conflict, Vietnam War, information age, information strategy

**CIVIL WARS HIJACKED: A CASE STUDY OF THE LEBANESE CIVIL WAR**

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The United States continues to be drawn into complex conflict environments where multiple internal and external state and non-state actors (NSAs) compete for influence. This thesis seeks to address how an external state actor can establish influence in a civil war environment through effective support of non-state actors. The research question is addressed through an in-depth analysis of the Lebanese Civil War from 1975 to 1990, using both qualitative and social network analysis to assess the strategies of three state actors in that conflict: Israel, Syria, and Iran. This study suggests that external state actors can increase their influence in a civil war environment through a variety of strategies. However, the most dominant state actors are typically those that pursue a limited objective through a combination of direct and indirect support to a heterogeneous coalition of non-state actors employing a combination of violent and non-violent techniques. The lessons obtained from this analysis may provide valuable insights to planners tasked with the development of influence within a civil war through external support to NSAs. [Full Text](#)

Keywords: Lebanon, Syria, Iran, Israel, non-state actor, surrogate warfare, proxy warfare, longitudinal social network analysis, civil war

**MARITIME SOF IN THE LITTORALS: THEORETICAL PRINCIPLES  
FOR SUCCESSFUL LITTORAL SPECIAL OPERATIONS**

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This thesis uses past experiences to help develop a theoretical framework for maritime special operations forces (SOF) to succeed in the littorals. The theoretical framework defines six principles important to special operations in littoral spaces: deliberate planning, tailored force, specified mobility, joint support, cover/concealment, and innovation. Five historical case studies, followed by a vignette, show the importance of these theoretical principles for planning and executing successful special operations in this complex environment. These principles should be considered for incorporation into any future SOF doctrine or concepts designed for this environment. For more than a decade of deployment in Afghanistan and Iraq, maritime SOF focused on land warfare. However, most maritime and amphibious forces are currently refocusing their efforts to their core capabilities. General statistics indicate that, because of population growth, urbanization, and half the world's population living no more than 120 miles from a coast, future conflicts and humanitarian disasters will likely take place in the littorals. Littoral operations are vastly different from land-locked or open-water operations. Maritime SOF units must prepare for future operations in the littorals. [Full Text](#)

Keywords: SOF, littorals, maritime special operations, principles of war, doctrine

**COMBAT STORIES MAP: A HISTORICAL REPOSITORY AND AFTER  
ACTION TOOL FOR CAPTURING, STORING, AND ANALYZING  
GEOREFERENCED INDIVIDUAL COMBAT NARRATIVES**

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Despite the proliferation of technology and near-global Internet accessibility, a web-based program incorporating interactive maps to record personal combat experiences does not exist. The Combat Stories Map addresses this deficiency. The Combat Stories Map is a web-based Geographic Information System specifically designed to collect and store U.S. service members' georeferenced combat stories. The stories are immediately available for after action analysis, and they are maintained in an easily searchable database for future research. The Combat Stories Map uses powerful, cloud-based mapping software to provide near-global access and almost infinite expansion while leveraging innate mental characteristics to provide an interface that facilitates easy input and analysis. Its analytical tools enable the comparison of individual narratives to official histories of battles. This project demonstrated the tool's use by collecting combat experiences from Iraq and Afghanistan for after action purposes. By validating Fallujah veterans' narratives with the official history of the Second Battle of Fallujah, this project illustrated the tool's worth in capturing and maintaining individual combat stories. With further development, the Combat Stories Map could become a valuable system for after action combat analysis, and for historical archiving and research purposes. [Full Text](#)

Keywords: combat stories, geospatial information system, validation, after action, lessons learned, narratives, Second Battle of Fallujah, story maps, georeferenced

**PREPARING TO BE UNPREPARED: GROUND FORCE COMMANDER DECISION MAKING IN A VOLATILE, UNCERTAIN, COMPLEX, AND AMBIGUOUS WORLD**

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What are the characteristics of effective ground force commander (GFC) decision making? What commonalities do we see? What are best practices for pre-mission preparation and mission execution? This thesis focuses on GFC decision making in order to investigate how to better prepare leaders for the current operating environment. It examines tactical-level decision making under conditions of uncertainty. It does so by drawing on interviews with combat-experienced commanders. An examination of their thought processes while leading tactical combat elements reveals that mental preparation, vicarious experience, and complex, repetitive training are key components of effective GFC decision making. The thesis concludes with recommendations about how to enhance GFC decision making for future volatile, uncertain, complex, and ambiguous (VUCA) environments. [Full Text](#)

Keywords: decision making, VUCA, training, combat, leadership

**MOVING FORWARD BY LOOKING IN THE REARVIEW MIRROR**

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The U.S. military remains a premier conventional fighting force, but success in counterinsurgency has proved to be beyond its grasp on numerous occasions. Consequently, this research investigates preconditions that could increase the likelihood of success for a U.S.-supported counterinsurgency. The selected factors include the host government's level of legitimacy, its capacity and willingness to deny sanctuary, and whether it shares key objectives with the United States. In all four cases of this comparative analysis, the United States functioned as the external supporter to the counterinsurgency forces. The cases include conflicts in the Philippines (2002–2014), El Salvador (1981–1992), Afghanistan (2001–2009), and Iraq (2003–2006). In the cases of the Philippines and El Salvador, both governments demonstrated a degree of legitimacy, the capacity and willingness to deny sanctuary, and shared critical objectives with the United States. In the cases of Iraq and Afghanistan, both governments were relatively illegitimate and lacked the willingness and capacity to deny sanctuary. Moreover, while the host governments shared some objectives with the United States, the local populations did not embrace these ideals. Arguably, the Philippine and El Salvador cases reached acceptable outcomes, while the conflicts in Iraq and Afghanistan have not. Therefore, this thesis recommends that the United States should not commit significant military support unless all three pre-conditions are satisfied. [Full Text](#)

Keywords: Afghanistan, counterinsurgency, El Salvador, insurgency, Iraq, irregular warfare, Philippines

**MEGACITIES AND THE PROPOSED URBAN INTERVENTION MODEL**

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As of 2016, 12 percent of the world's population lives in 36 megacities. By 2030, experts estimate that 17 mega regions, hosting 60 percent of the world's population, will account for 75 percent of global GDP. Megacities come with several unique challenges for governance and the provision of services to their populations, as well as for military intervention in the wake of natural or manmade disasters. This thesis asks the question: What do Geographic Combatant Commands (GCCs) and Theater Special Operation Commands (TSOCs) need to know about megacities, and how can they improve the planning process to more rapidly assess, synchronize, and guide military interventions in megacities? The thesis proposes a four-part model—the Urban Intervention Model (UIM)—that allows military leaders to conduct a rapid assessment and plan for military intervention into a megacity in the wake of natural or manmade disasters. It then applies the UIM to a hypothetical case study, the megacity of Cairene following an earthquake, to demonstrate how planning staffs can use the model to plan for military intervention. [Full Text](#)

Keywords: megacity, urbanization, Urban Intervention Model, Analytical Hierarchy Process, Experiential Learning Model, Joint Operation Planning Process, force ratio

**BROKEN MIRRORS: TRACING ISSUES IN BUILDING PARTNER CAPACITY**

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Recent U.S. military engagements in fragile states have focused on building security institutions that match Western military and police models. These operations, however, have highlighted the need to reevaluate how we build host-nation security institutions from the ground up in conflict areas with varying social, religious, and ethnic concentrations. The interaction between the environment, doctrine, and technology (EDT) provided by U.S. government agencies has complicated the issue by locking the host-nation's success to ongoing U.S. support. This research uses process-tracing to examine EDT factors in two case studies: U.S. advisory missions in Vietnam from 1954–1965, and in Afghanistan from 2001 to the present. These cases are used to analyze past and current U.S. efforts aimed at building a partner's capacity to secure their own sovereign territory. Because the current U.S. model for fighting internal threats maintains a military structured for fighting external threats, a foreign partner's security structure will likely collapse without continuing U.S. advisory presence and materiel support. [Full Text](#)

Keywords: building partner capacity, security force assistance, military assistance

**THE INFLUENCE OF TAMIL DIASPORA ON STABILITY IN SRI LANKA**

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Although the Sinhalese and Tamil ethnic problem is deep-rooted and of long-standing origins, in the early 1980s, it turned into an armed conflict under the leadership of Velupillai Prabhakaran, who had formed the Liberation Tigers of Tamil Eelam (LTTE). The military defeat of the LTTE in 2009 did not end the Sri Lankan ethnic problem. Pro-LTTE Tamils, who have migrated and settled in many parts of the world, have created many diasporic Tamil organizations to continue their fight for a separate state. The LTTE uses the actions of the Transnational Government of Tamil Eelam, the Global Tamil Forum, and the British Tamil Forum indirectly to achieve its political goal—a Tamil homeland. The Tamil Eelam People's Assembly as well as ex-combatant and intelligence groups continue to adhere to radical ideas of a re-emerging LTTE insurgency. Also, the Tamil diaspora is manipulating the Tamil National Alliance and Sri Lankan Tamils to achieve its goals. Presently, the UNHCR resolution on alleged war crimes by the Sri Lankan military is a major issue among the members of the diaspora, who wish to discredit Sri Lanka's government and military. Since Sri Lanka's independence in 1948, all successive governments have failed to find a solution for the demands of the Tamils. The government should encourage all ethnic groups to think of Sri Lanka as one nation for the promotion of peaceful coexistence. [Full Text](#)

Keywords: Sri Lanka, LTTE, Tamil diaspora, re-emergence of terrorism

**A REMEDY TO CRISES: DANISH SPECIAL OPERATIONS FORCES IN  
WHOLE-OF-GOVERNMENT STABILIZATION ENGAGEMENTS**

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In 2013, the Danish government crafted a policy to guide its integrated stabilization efforts in fragile and conflict-affected states, emphasizing the prevention of violent conflict. This capstone project provides recommendations and guidelines for Danish politicians and the Danish defense command to operationalize this policy and define the supportive role that Danish special operations forces (DANSOF) can play. The capstone draws from a rich body of stabilization literature to provide working definitions for a whole-of-government approach; goals, measures of success, and risk assessment; capacity- and state-building strategies; and the incorporation of intelligence and information operations. This research also considers DANSOF capabilities and recent involvement in Afghanistan to identify the various roles DANSOF can play in stabilization operations. To increase the chances of successful stabilization efforts, it is essential that international efforts be well coordinated, including goals, ways, and means. This capstone recommends that DANSOF can support these efforts in roles such as prevention, reconnaissance, intelligence gathering and assessment, security, capacity building, support to national and international agencies, and liaison with international agencies and local authorities. [Full Text](#)

Keywords: fragile states, conflict-affected states, whole-of-government, stabilization, prevention, special operations forces, capacity building, state building

**MY BROTHER'S KEEPER: FORGING SOF OPERATORS  
THROUGH DEVELOPMENTAL RELATIONSHIPS**

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Personal and professional development is paramount to the growth and success of individuals and the organizations they comprise. The United States military's special operations forces (SOF) are elite small teams that work in austere situations globally. SOF operators are expected to be competent and capable at all times. They must rely on their team members for personal and professional development. This paper sought to assess the characteristics and outcomes of developmental relationships within SOF teams. Through interviews with SOF operators from the Army Special Forces, Navy SEALs, and Marine Raiders, the findings reinforce the necessity of development within teams. Numerous viewpoints emerged regarding the importance of team dynamics, leadership cohesion, and strong personal traits. SOF development providers' and recipients' insights helped paint a picture of developmental relationships within SOF teams--specifically, how and why development is initiated, what is provided, and how it benefits operators. The qualitative interview process exposed numerous implications for SOF operators, team leaders, and the greater SOF community regarding the importance of proactive and meaningful development. [Full Text](#)

Keywords: Navy SEALs, Army Special Forces (Green Berets), Marine Raiders, Special Operations Forces, SOF, personal development, professional development, team building, leadership, mentoring, mentorship

**IN SILENCE TOWARD THE UNKNOWN: PRINCIPLES OF  
SPECIAL RECONNAISSANCE AND SURVEILLANCE**

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**Second Reader: Laura Adame, Department of Defense Analysis**

Recently, the debate surrounding special operations has neglected one of its core activities: special reconnaissance and surveillance (SR). The application of advanced technology capacities has overtaken the more traditional intelligence collection. Therefore, SR may become a lost art and science, and certain principles need to be considered to support SR missions. The purpose of this thesis is to identify principles and a theory for SR missions. The thesis asserts that there is a threshold called relative certainty (sufficient actionable intelligence), where a decision maker can make an informed decision based on the intelligence presented. The chosen approach is a qualitative comparative analysis of historical SR missions, including in the South Atlantic War of 1982 and the Inchon landing of 1950. Also, this study suggests special operations forces can improve mission success with the use of the suggested principles of SR: coordination, review, cover, reporting, and exploitation. Finally, this study asserts that there is a distinction between theories that support special operations in achieving the aim and theories explaining the unique utility of special operations, that is, theories for special operations and theories of special operations. Ultimately, special operations engage a unique set of principles to accomplish successful missions. [Full Text](#)

Keywords: Special Operations Forces, special reconnaissance and surveillance, principles, theory

**SPECIAL WARFARE: RESTRUCTURING FOR THE FUTURE**

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**Advisor: Anna Simons, Department of Defense Analysis**

**Second Reader: William Fox, Department of Defense Analysis**

The special forces operational detachment-alpha (SFODA) has remained virtually unchanged since its inception in 1956. However, throughout its history, the SFODA has frequently been augmented with various assets, particularly civil affairs. The purpose of this thesis is to analyze the SFODA in its current form and make recommendations for its future composition and focusing of resources. Throughout its history, the SFODA has been augmented to accomplish its missions during conflicts. Particularly frequent has been augmentation by civil affairs and psychological warfare personnel. As special forces play an important, if not leading, role in low-intensity conflict, they will continue to rely upon these assets. This thesis approaches the challenge of restructuring the SFODA by examining three cases in which special forces, or special operations forces, were used: World War II (the Jedburghs and Detachment 101), Vietnam (special forces), and Afghanistan (special forces). Based on an examination of these cases, this thesis offers recommendations on force structure, recruiting, and training for the future. [Full Text](#)

Keywords: special forces, SOF, unconventional warfare, low-intensity conflict, irregular warfare, civil affairs, psychological operations, special forces operational detachment-alpha, SFODA

# MASTER OF SCIENCE IN ELECTRICAL ENGINEERING

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## DATA MINING OF EXTREMELY LARGE AD HOC DATA SETS TO PRODUCE INVERTED INDICES

Aaron Coudray—Lieutenant Commander, United States Navy  
Master of Science in Electrical Engineering

Advisor: Frank Kragh, Department of Electrical and Computer Engineering  
Co-Advisor: Jim Scrofani, Department of Electrical and Computer Engineering

The purpose of this study is to leverage existing Internet-sized ad hoc data sets by creating an inverted index that will enable a robust search capability. In particular, this study is focused on the Common Crawl web corpus. This involves exploring the tools and techniques necessary to effectively traverse this data set, as well as producing the tools to create an inverted index relationship between the terms and websites found within web archive files. The primary tools utilized in this process are Apache Hadoop, Apache MapReduce, Amazon Web Services, and Java. Additionally, methods to enhance this relationship with other information of interest are investigated in this thesis. Specifically, an index was developed that contains the added component of term relative location. This inverted index relationship is an essential component of—and the first step in—creating a robust search capability for a very large ad hoc data set. [Full Text](#)

Keywords: big data, Common Crawl, Hadoop, inverted index, inverted indices, Java, MapReduce

## USING POSTURE ESTIMATION TO ENHANCE PERSONAL INERTIAL TRACKING

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Advisor: Xiaoping Yun, Department of Electrical and Computer Engineering  
Co-Advisor: Zachary Staples, Department of Electrical and Computer Engineering  
Second Reader: James Calusdian, Department of Electrical and Computer Engineering

In close quarters combat, the lack of situational awareness can cause confusion, limit tempo of operations, and lead to fratricide. One approach to enhance the small-unit leader's situational awareness is to develop a network capable of mapping friendly positions. Current techniques for tracking the individual rifleman rely heavily on GPS, which does not work well indoors where satellite coverage is limited or even non-existent. One solution is to use inertial navigation systems to augment tracking during periods without GPS coverage. The goal of this research is to improve the current personal inertial navigation system by reducing or eliminating drift errors that are prevalent in this technology. The posture-tracking algorithm uses the YEI 3-space Data-Logging sensors to compute the posture of the individual rifleman. By tracking posture, stationary periods can be detected, and drift errors in the inertial navigation system are reduced. In the testing phase, the posture estimation algorithm was integrated with the personal navigation system, which is currently under development by concurrent research at the Naval Postgraduate School. Increased accuracy for inertial navigation systems that include posture tracking are demonstrated by the results of this thesis. [Full Text](#)

Keywords: personal navigation system, rotation matrix, geometry of fire, situational awareness, close quarters combat, orientation, coordinate system, reference frame, quaternion, Euler angles, YEI, posture tracking, human pose



**COMPARISON OF TWO RAILGUN POWER SUPPLY ARCHITECTURES TO QUANTIFY  
THE ENERGY DISSIPATED AFTER THE PROJECTILE LEAVES THE RAILGUN**

**Mitchell Stewart—Lieutenant, United States Navy  
Master of Science in Electrical Engineering**

**Advisor: Alexander Julian, Department of Electrical and Computer Engineering  
Co-Advisor: Giovanna Oriti, Department of Electrical and Computer Engineering**

Railgun muzzle flash, or post-fire arcing, is a major concern to the Navy because of the potential associated thermal stresses. In this thesis, we compared two railgun power supplies in Matlab Simulink to quantify their associated post-fire energy. When the armature exits the rails, a finite energy from the railgun pulsed-power supply is inductively stored in the rails and discharges at the muzzle. This energy, which is due to the loss of the low-voltage electrical contact that is ordinarily between the armature and the rail, is forced by the system inductance to flow as an electrical discharge, creating a muzzle flash. Quantification of this post-fire rail energy in our simulation from both the existing railgun power supply and the proposed power supply—a thyristor-based power supply versus a buck-boost converter, respectively—reveals that the buck-boost converter topology is better suited for the railgun, particularly at minimizing the post-fire muzzle energy. The minimization of the post-fire energy allows for an extended rail life and potentially longer usage. [Full Text](#)

Keywords: railgun, power supply, post-fire energy

# MASTER OF SCIENCE IN ENGINEERING ACOUSTICS

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## RESOLUTION OF PORT/STARBOARD AMBIGUITY USING A LINEAR ARRAY OF TRIPLETS AND A TWIN-LINE PLANAR ARRAY

Stilson Veras Cardoso—Civilian, Brazilian Navy  
Master of Science in Engineering Acoustics

Advisor: Lawrence Ziomek, Department of Electrical and Computer Engineering  
Second Reader: Monique Fargues, Department of Electrical and Computer Engineering

This thesis is a study on the ability of towed sonar arrays to resolve the PS (port/starboard) ambiguity problem, and focuses on a twin-line planar array and a linear array of triplets. A twin-line planar array is commonly employed in underwater warfare. The goal is to offer the reader a comprehensive understanding of the method used for the solution of the PS ambiguity problem, concerning the beamformer's complex weights, operating frequency, and limit on beam steering. Initially, the basic characteristics and functional blocks, technical, and operational peculiarities of towed linear sonar arrays are presented, and then a single triplet, a linear array of triplets, and a twin-line planar array are respectively examined in detail. The research consists of mathematical modeling of the elements and the arrays, calculation of beam patterns for study cases, and signal processing simulations programmed in MATLAB. The simulations make use of a signal generator, designed to assess the performance of the twin-line planar array. The generator provides the reader with a systems view of the array operation, taking into account the characteristics of the target and medium. [Full Text](#)

Keywords: towed sonar array, port/starboard ambiguity problem, single triplet, linear array of triplets, twin-line planar array

## LOW FREQUENCY ACOUSTIC INTENSITY PROPAGATION MODELING IN SHALLOW WATER WAVEGUIDES

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Master of Science in Engineering Acoustics

Advisor: Kevin Smith, Department of Physics  
Co-Advisor: Thomas Howarth, Naval Undersea Warfare Center Division, Newport, RI

Three popular numerical techniques are employed to examine the acoustic pressure and intensity features present in several environments of interest. Free field propagation and analytically tractable planar interfacial two-fluid transmission and reflection are used to benchmark the commercial software package COMSOL. Canonical Pekeris-type waveguides are used as initial points of comparison to illustrate COMSOL's ability to capture all pertinent physics. Additional environments with non-trivial bathymetry and varying sound speed profiles are then used to examine the rich feature set anticipated in experimental data. Predictions of recently estimated and experimentally verified physical phenomena serve as further proof of the accuracy of implementation of the Finite Element Method. Guidelines and recommendations are provided for future studies using

COMSOL, along with circumstances under which traditional treatment of the air-water interface is appropriate and when an explicit full-physics model is required. [Full Text](#)

Keywords: wave propagation, normal modes, parabolic equation, finite element method, acoustic intensity, linear acoustics, PACS codes, 43.20.-f general linear acoustics, 43.20.Mv waveguides, wave propagation in tubes and ducts, 43.30.Bp normal mode propagation of sound in water, 43.30.Gv backscattering, echoes, and reverberation in water due to combinations of boundaries

# MASTER OF SCIENCE IN INFORMATION STRATEGY AND POLITICAL WARFARE

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## **KIDS AT THE BORDER: UNACCOMPANIED CHILD MIGRATION FROM THE NORTHERN TRIANGLE AND MEXICO**

**David Carattini–Major, United States Army**

**Master of Science in Information Strategy and Political Warfare**

**Advisor: Marcos Berger, Department of Defense Analysis**

**Second Reader: Robert Burks, Department of Defense Analysis**

In the United States, the issue of immigration, particularly illegal immigration, has had significant implications for national security, the political landscape, culture, and the U.S. economy. Current U.S. regulations and enforcement practices are clearly ineffective to meet the challenges surrounding the ending or containment of illegal immigration. Meanwhile, the issue of illegal immigration attracts even more attention and demonstrates the United States' apparent inability to deal effectively with the problem. In 2011, a surge of unaccompanied children (under age 18) coming illegally from Mexico, Guatemala, El Salvador, and Honduras were apprehended by U.S. immigration agencies at the U.S.-Mexico border. This thesis takes a two-part approach to focus on the ongoing rise in unaccompanied children, starting with a brief explanation of why children leave their home countries and how they get to the U.S.-Mexico border, following with the United States' reaction to the recent surge in unaccompanied children. We ask if the United States is doing enough to address the problem of rising numbers of unaccompanied children in the context of changes and continuities in the Department of Homeland Security's wider approach to illegal immigration. The solution requires policy reform that properly addresses socio-economic and security conditions in the region. This is done in an effort to produce a viable set of policy recommendations that lay out why the United States needs to do more, and what it needs to do in order to have an impact on the issue of unaccompanied children specifically and illegal immigration more generally. [Full Text](#)

Keywords: unaccompanied child migration, Northern Triangle, Mexico, Department of Homeland Security, Border Patrol, Customs and Border Protection, TOPSIS, transnational criminal organization (TCO), U.S.-Mexico border, unaccompanied alien children (UAC)

## **PEACEFUL PROTEST, POLITICAL REGIMES, AND THE SOCIAL MEDIA CHALLENGE**

**Geoffrey Childs–Major, United States Army**

**Randolph Fleming–Major, United States Army**

**Master of Science in Information Strategy and Political Warfare**

**and Master of Science in Defense Analysis**

**Advisor: T. Camber Warren, Department of Defense Analysis**

**Second Reader: Robert Burks, Department of Defense Analysis**

Information and communication technologies (ICT) have transformed with the advent of the Internet and the diffusion of cellular-based communications. Previous research has examined the effects of horizontal ICT on collective violence, but the effects on non-violent expressions are not well understood. Using social conflict data from Africa and Latin America between 1990 and 2011, this study employs negative binomial regression models to explore the distinct effects of the spread of social media on peaceful protests within democratic, anocratic, and autocratic regimes. Multiple regression models find strong statistical evidence in support of a positive relationship between social media and peaceful protest in anocratic regimes. Autocratic and anocratic

states will thus increasingly find themselves in a social media challenge—repress horizontal ICT or embrace it and its effects—as their populations seek democratization. [Full Text](#)

Keywords: information and communications technology (ICT), authoritarian, autocratic, anocratic, civil conflict, collective action, peaceful protest, social media index (SMI)

**TERRORIST GROUP BRANDS: UNDERSTANDING TERRORIST  
GROUP STRATEGIES THROUGH BRAND EXPOSURE**

**Bradley Greaver—Major, United States Army**

**Master of Science in Information Strategy and Political Warfare**

**Advisor: T. Camber Warren, Department of Defense Analysis**

**Second Reader: George Lober, Department of Defense Analysis**

Much as commercial firms do, terrorist groups use branding to increase support and thus their capacity to conduct operations. This thesis introduces the new concept of terrorist brand exposure as a reflection of effective brand management strategies and communications among terrorist groups. In that regard, this thesis seeks to merge two vastly different theories, brand theory and terrorism studies, into one package. The research involves a quantitative analysis of the terrorist brand exposure of Al Qaeda and the Islamic State in the news media published on the Internet between April 1, 2013, and December 31, 2015. The results of this thesis validate that terrorist groups can influence their brand exposure through violent terrorist actions and manage their brand strategies to differentiate themselves from other groups in the global competition for resources. [Full Text](#)

Keywords: branding, brand exposure, brand management, terrorist groups, terrorism, Al Qaeda, Islamic State, ISIS, mass-mediated terrorism

# MASTER OF SCIENCE IN INFORMATION WARFARE SYSTEMS ENGINEERING

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## EMPIRICAL ANALYSIS OF USING ERASURE CODING IN OUTSOURCING DATA STORAGE WITH PROVABLE SECURITY

Abdallah Bakir—First Lieutenant, Tunisian Army

Master of Science in Information Warfare Systems Engineering

Advisor: Mark Gondree, Department of Computer Science

Second Reader: Raymond Buettner, Department of Information Sciences

Proof of retrievability (POR) and proof of data possession (PDP) are cryptographic tools for auditing big data on a storage server or in the cloud. Their goals are to verify that the server is storing data and, in case of data alteration, recovering this data. These tools provide probabilistic guarantees that the server is storing information, without accessing the entire file and providing the capability to recover the original data under certain limits. In this work, we study maximum distance separable (MDS) codes as the underlying tools providing recoverability for POR. We survey MDS codes and select Reed-Solomon and Cauchy Reed-Solomon MDS codes to be implemented into a prototype POR library. We use the `liberasurecode` library to evaluate multiple error-correcting code (ECC) backend implementations for these codes. We enhance the `libpdp` library, an open source PDP library that implements some PDP schemes, to interface with `liberasurecode` to measure the real-world cost of integrating erasure coding in POR implementations. [Full Text](#)

Keywords: proof of retrievability, proof of data possession, erasure codes, error correcting code, cloud storage, data integrity

## REBUILDING PUBLIC TRUST IN THE TAIWAN MILITARY: A SYSTEMS APPROACH

*The following paper has been recognized as outstanding by its department*

Tzu-Lun Chen—Lieutenant, Taiwan Navy

Master of Science in Information Warfare Systems Engineering

Advisor: Steven Iatrou, Department of Information Sciences

Co-Advisor: Edward Fisher, Department of Information Sciences

This thesis focuses on how the Taiwan military can improve public perception by changing its posting strategies on the Taiwanese Ministry of Defense Facebook page. By enhancing public trust through social media, the military would be better positioned to increase recruitment, funding, and morale. First, the research analyzes the application of Facebook and use of the Like button as an indicator of public trust levels. Then it employs content analysis methods to evaluate which posting formats and writing approaches would lead to various trust levels. The findings reveal that the Taiwan military can improve public perception through its use of Facebook by publicizing cultural events such as the Lunar New Year, creating surprising content for followers, managing the trust-building process, and using Facebook's text and picture format with a proactive content strategy. [Full Text](#)

Keywords: image building, image restoration, emotional outreach, image display, groupies, public trust, marketing, crisis management

### MITIGATING RISK TO DOD INFORMATION NETWORKS BY IMPROVING NETWORK SECURITY IN THIRD-PARTY INFORMATION NETWORKS

*The following paper has been recognized as outstanding by its department*

**Michael Kansteiner–Major, United States Marine Corps**

**Master of Science in Information Warfare Systems Engineering**

**Advisor: Raymond Buettner, Department of Information Sciences**

**Second Reader: Ramsey Meyer, Department of Information Sciences**

Poorly defended third-party information networks can act as an attack vector for cyber attackers to successfully breach larger and more robustly defended information networks. Therefore, third-party networks connecting to Department of Defense (DOD) information networks may pose a significant risk to the DOD. The DOD has attempted to alleviate this risk to its networks by requiring covered defense contractors to meet certain network security standards and by initiating a cyber threat information sharing program: the DOD Defense Industrial Base (DIB) Cyber Security/Information Assurance (CS/IA) Program. However, these DOD actions are not aggressive enough to adequately mitigate this risk to DOD networks. To adequately address this problem, an expanded and more aggressive incentive-based program is required. Existing federal government, incentive-based programs were analyzed as potential exemplars from which to build a new incentive-based network security program. The Department of Homeland Security's (DHS's) Safety Act Program was ultimately chosen as the primary exemplar. Using this model, an Enhanced DOD CS/IA Program was designed to offer the DOD a system that can influence the improvement of third-party network security through a structure of synchronized network security controls and incentives. By implementing the proposed DOD Enhanced CS/IA Program to improve the network security of third-party networks that connect to DOD networks, the DOD can better mitigate the risk of cyber attacks to its own networks. [Full Text](#)

Keywords: network security, information networks, third-party networks, incentives, DODIN

### CREATING FEEDBACK CHANNELS WITH OPTICAL COMMUNICATIONS FOR INFORMATION OPERATIONS

*The following paper has been recognized as outstanding by its department*

**Stephen Phillips–Captain, United States Marine Corps**

**Master of Science in Information Warfare Systems Engineering**

**Advisor: Don Brutzman, Department of Information Sciences**

**Co-Advisor: Ed Fisher, Department of Information Sciences**

Current efforts within Information Operations (IO) to effectively measure the influence and performance of products used to message primarily human target audiences lack the benefits that web-based analytic technologies can provide. This thesis adapts previous research dedicated to optical communications through Quick Response (QR) codes as a messaging platform to provide a feedback channel for IO messaging efforts through optical communications technology. First, these concepts are applied to show covert amphibious operations. Optical communications technologies, direct marketing principles, and current IO shortfalls are explored to determine whether optical communications technologies can provide feedback channels for IO. The results are an integration of the analytic techniques used by Internet advertising campaigns incorporated into the continuous Observe, Orient, Decide, Act (OODA) loop decision-making process of IO practitioners. Integration of cyber-related analytic techniques offers IO practitioners a larger set of tools to measure message delivery accuracy and gain feedback on product effects directly from target audiences. This research recommends exploration of applications of cyber-related capabilities associated with QR code scanning to provide empirical proof of concept feasibility. The benefit of cyber-related analytic tools is an increase in ability to accurately measure effectiveness and performance for Information Operations. [Full Text](#)

Keywords: Information Operations, IO, QR code, optical communications, direct marketing, measure of effectiveness, MOE, measure of performance, MOP, enhanced MOP, feedback, feedback channels, OODA loop

# MASTER OF SCIENCE IN MANAGEMENT

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## **SUSPENDED DRAFT: EFFECTS ON THE COMPOSITION AND QUALITY OF THE MILITARY WORKFORCE IN THE GERMAN ARMED FORCES**

**Stefan Koenigsmark—Commander, Junior Grade, German Navy  
Master of Science in Management**

**Advisor: Marigee Bacolod, Graduate School of Business and Public Policy**

**Co-Advisor: Latika Hartmann, Graduate School of Business and Public Policy**

In 2011, the German Armed Forces became an all-volunteer force (AVF) for the first time since 1955. Less than one year after first proposed, the end to mandatory conscription became official, giving insufficient time to consider the consequences that such a drastic change in military manning methods might have on the overall effectiveness of German national security. To date, five years later, little research exists regarding what effects the switch has had on quality of the recruit population. The thesis first considers global reasoning regarding ending conscription, especially that technological innovations in modern warfare have forever altered how we fight. Then it examines specific results of ending conscription in other countries, namely the United States. It carefully analyzes data from the German General Social Survey and German Micro Census to estimate difference-in-differences effects of AVF introduction on the quality and quantity of recruits as well as on the overall perception of the importance of national security among the German population. The thesis finds that, while the educational level of recruits increased, the perceived importance of national security dropped. The author recommends further data analysis as well as an information campaign, both of which would better ensure—nationally and globally—the effectiveness and strength of German national security. [Full Text](#)

Keywords: German Armed Forces, draft, conscription, All-Volunteer Force, recruits, quality, composition, workforce

## **ROLE OF SOCIAL NETWORKS IN RESILIENCE OF NAVAL RECRUITS: A QUANTITATIVE ANALYSIS**

**Andrea Watling—Lieutenant, United States Navy  
Master of Science in Management**

**Advisor: Edward Powley, Graduate School of Business and Public Policy**

**Co-Advisor: Frank Barrett, Graduate School of Business and Public Policy**

The overall purpose of this study is to make a connection between the positive energy levels of Navy recruits and their resilience. We also want to understand the patterns of social networks that might help identify and improve resilience. This study hypothesizes that groups receiving positively framed resilience interventions were more likely to show higher levels of resilience than control groups. Data for this project comes from the Navy's Recruit Training Command in Great Lakes and comprises 1,297 total surveys from a total of eight divisions of recruits at two different time periods. Quantitative analyses using surveys and network data examine the effects of positive energy on recruit resilience within the social networks. The findings of this research suggest that there is a relationship between positive energy networks and resilience. This research serves as a foundation for future research on social networks in the U.S. Navy and provides some recommendations for future work to extend the study on resilience. [Full Text](#)

Keywords: resilience, cohesion, density, procedural justice

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# MASTER OF SCIENCE IN MECHANICAL ENGINEERING

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## **FLUID-STRUCTURE INTERACTION OF CHANNEL DRIVEN CAVITY FLOW**

**Stephen Arceneaux–Ensign, United States Navy**

**Master of Science in Mechanical Engineering**

**Advisor: Young Kwon, Department of Mechanical and Aerospace Engineering**

**Second Reader: Jarema Didoszak, Department of Mechanical and Aerospace Engineering**

An experimental setup was developed for channel driven cavity flow in order to study the fluid-structure interaction and provide benchmark data for validation of numerical fluid-structure interaction models. The channel driven cavity flow is a modification from lid-driven cavity flow. To examine the fluid-structure interaction, the bottom side of the cavity is a deformable flat plate. All other boundaries are rigid. The fluid-structure interaction inside the cavity is driven by flow through a thin channel topside of the cavity. Water is used as the fluid. Fluid-structure interaction for different deformable plates during constant flow is quantified using a variety of strain and displacement measurement techniques. To establish suitable boundary conditions for numerical analysis of the experiment, the inlet velocity of the channel driven cavity flow is known. Outlet pressure is constant atmospheric. Numerical results are obtained using ANSYS's CFX and structure analysis. [Full Text](#)

Keywords: fluid-structure interaction, channel driven cavity flow, lid-driven cavity flow

## **TERMINAL HOMING FOR AUTONOMOUS UNDERWATER VEHICLE DOCKING**

**Eric Bermudez–Ensign, United States Navy**

**Master of Science in Mechanical Engineering**

**Advisor: Douglas Horner, Department of Mechanical and Aerospace Engineering**

**Second Reader: Noel Du Toit, Department of Mechanical and Aerospace Engineering**

The use of docking stations for autonomous underwater vehicles (AUV) provides the ability to keep a vehicle on station, conducting missions for extended periods of time, with limited human interaction. However, the use of a docking station brings about challenges associated with terminal homing, position estimation, and vehicle control. A traditional single propeller-driven AUV must dock at a high relative approach velocity to maintain controllability, which can lead to serious damage to the AUV and the docking station. Alternatively, equipping an AUV with forward and aft pairs of horizontal and vertical cross-tunnel thrusters enables a hovering capability and allows for a slower, more deliberate approach that can help reduce potential damage during the terminal homing phase. Additionally, the commonly used ultra-short baseline (USBL) acoustic transponder attached to the docking station, which provides bearing and range measurements, can be asynchronous and sparse. The integration of these measurements into an optimal position estimation filter can potentially produce inaccuracies that are detrimental during docking operations. This thesis discusses the development of a hydrodynamic model and a filtering algorithm for position estimation for a cross tunnel thruster-enabled REMUS 100 AUV. The hydrodynamic model provides the capability of simulating vehicle docking with variable environmental effects. The filtering algorithm looks to provide an integrated solution of inertial navigation measurements and USBL measurements to provide a more accurate vehicle location during docking operations. [Full Text](#)

Keywords: terminal homing, REMUS 100, USBL, UKF, hydrodynamic model, position estimation filtering

**RADIATION EFFECTS IN DUAL HEAT SINKS FOR COOLING  
OF CONCENTRATED PHOTOVOLTAICS**

**Mark Brandau–Lieutenant, United States Navy  
Master of Science in Mechanical Engineering**

**Advisor: Garth Hobson, Department of Mechanical and Aerospace Engineering  
Co-Advisor: Anthony Gannon, Department of Mechanical and Aerospace Engineering**

This thesis experimentally and numerically examined the effectiveness of improving the cooling of concentrated photovoltaics (CPV) through the use of dual heat sinks. The intent was to improve heat transfer by radiation to lower the operating temperature of the CPV system, and therefore increase the power output. Experimental and numerical results were obtained for multiple configurations to determine the effect of increased emissivity of the sink to reject heat to a ground-based sink and the effect of lowering ground temperature. Experimental results indicated that a properly constructed pin-fin sink could improve heat transfer and lower operating temperature at near horizontal angles of inclination of the CPV panel. However, numerical modeling with conditions more closely matching the intended application indicates that dual heat sinks interfere with natural convection sufficiently to reduce cooling and therefore efficiency. Evaluation of these results will provide insight to improve the cooling of CPV systems and improve the power output. [Full Text](#)

Keywords: heat sinks, pin-fin, thermal radiation, CPV

**CHARACTERIZATION OF PARTICLES CREATED BY LASER-  
DRIVEN HYDROTHERMAL PROCESSING**

**Andres Camargo–Lieutenant Commander, United States Coast Guard  
Master of Science in Mechanical Engineering**

**Advisor: Sarath Menon, Department of Mechanical and Aerospace Engineering  
Co-Advisor: Claudia Luhrs, Department of Mechanical and Aerospace Engineering  
Second Reader: Raymond Mariella, Lawrence Livermore National Laboratory**

This study examined particles created by laser-driven hydrothermal processing, an innovative technique used for the ablation of submerged materials. Two naturally occurring materials, obsidian and tektite, were used as targets for this technique. Characterization of sample materials before and after laser processing was conducted through multiple techniques such as optical microscopy, X-ray diffraction, scanning electron microscopy, transmission electron microscopy, and energy dispersive X-ray spectroscopy. Examination of the untreated base material, in bulk and crushed form, established a baseline for comparison to particles created by laser processing of the same material. Characterization methods provided data of micron- and nano-sized particles, including their crystal structure, microstructure, and chemical composition. The bulk and crushed obsidian and tektite samples contained inclusions and particles rich in several transition elements, most notably iron and titanium. Analysis of liquid media collected after laser processing of bulk obsidian and tektite samples revealed fine particles rich in the same elements. Evidence suggests laser-driven hydrothermal processing separates heavy elements from the mostly amorphous silica matrix encountered in the materials examined. [Full Text](#)

Keywords: laser-driven hydrothermal processing, characterization, obsidian, tektite, natural glass

**NOVEL NATURAL CONVECTION HEAT SINK DESIGN  
CONCEPTS FROM FIRST PRINCIPLES**

**Derek Fletcher—Lieutenant Commander, United States Navy  
Master of Science in Mechanical Engineering**

**Advisor: Garth Hobson, Department of Mechanical and Aerospace Engineering  
Second Reader: Joshua Gordis, Department of Mechanical and Aerospace Engineering**

This was a two-part numerical study using ANSYS Fluent to develop novel heat sink concepts from first principles. The objective of this research was to highlight geometric structures that incorporate the principles of the stack effect to improve the heat transfer capability of a heat sink under natural convection. The first part investigated the heat transfer/fluid flow characteristics of vertically aligned tubes. The gaps between tubes break up the thermal and velocity boundary layers and the moving fluid within a tube entrains the cooler ambient air surrounding the gap, thus increasing mass flow rate and average Nusselt number through each tube. The optimal gap-to-length ratio varies depending on the number of tubes in the system. The second part built upon the insight gained to develop heat sinks to compare to pin-fin heat sinks. A tube system heat sink provides a significant improvement in the heat transfer capability over a circular pin-fin arrangement, demonstrated by an increase in both the overall heat transferred and average heat transfer coefficient. The principles discussed in this study have the potential to expand the capability of natural convective heat transfer. [Full Text](#)

Keywords: natural convection, free convection, passive cooling, heat sink, tube system, pin-fin, hollow pin-fin, heat sink design

**WING-EMBEDDED, CROSS-FLOW-FAN, VERTICAL  
TAKEOFF AND LANDING AIR VEHICLE**

*The following paper has been recognized as outstanding by its department*

**Jeremiah Fulton—Ensign, United States Navy  
Master of Science in Mechanical Engineering**

**Advisor: Garth Hobson, Department of Mechanical and Aerospace Engineering  
Co-Advisor: Anthony Gannon, Department of Mechanical and Aerospace Engineering**

This research demonstrated that a vertical takeoff and landing aircraft capable of transitioning to conventional flight using cross-flow fans is possible. In particular, the design and manufacture of a wing-embedded cross-flow fan airfoil, and its implementation into an aircraft, was conducted. The design was developed based on the Gottingen 570 airfoil and generated lift coefficients of four—greater than the sum of the parts—due to the fundamental coupling between the wing and cross-flow fan. The wing was characterized with Ansys' CFX solver over tip-speed ratios of zero (hover) to infinity (glide), and predicted a hover angle of  $36\frac{1}{4}$  with 56% of the lift coming from the airfoil. This meant that a full  $90\frac{1}{4}$  rotation was not required to go from hover to forward flight; additionally, even while hovering, more than half of the lift was generated by the airfoil. The airfoil was manufactured from pre-impregnated carbon fiber using a mold produced by 3D printing. Printer filament selection was based on glass transition temperature and printability. ABS filament was chosen due to its high temperature resistance and relative ease of 3D printing. The aircraft was configured with all the wing assemblies facing the same direction to favor faster forward flight. This differed from previous designs, which used symmetry to increase stability. Controlled untethered flight was successful. [Full Text](#)

Keywords: heavy lifting aircraft, air vehicle, propulsive wing, wing embedded, cross-flow fan (CFF), vertical takeoff and landing (VTOL), horizontal takeoff and landing, 3D print mold, additive material manufacture, prepreg carbon fiber layup, pre-impregnated, controller stabilized

### **CFD ANALYSIS OF THE SBXC GLIDER AIRFRAME**

**Alejandro Garcia Aguilar–Lieutenant Junior Grade, Mexican Navy**

**Mechanical Engineer and Master of Science in Mechanical Engineering**

**Advisor: Kevin Jones, Department of Mechanical and Aerospace Engineering**

**Co-Advisor: Vladimir Dobrokhodov, Department of Mechanical and Aerospace Engineering**

**Second Reader: Isaac Kaminer, Department of Mechanical and Aerospace Engineering**

The research of this thesis develops and implements a computational model of the SBXC Glider utilized in the Tactical Long-Endurance Unmanned Aerial System (TaLEUAS) project in order to simulate the aerodynamic performance of the airframe and compare it with real flight data. The broader goals are, first, to provide a methodology for simulating a glider design with the intention to develop an optimization process or to evaluate a new design using computational tools, and second, to allow students to follow an easy process in which to undertake similar aerodynamic analyses. The fluid behavior is studied using computer software such as Ansys CFX, which is based mathematically on finite element methods. To validate and verify the methodology developed, a mathematical comparison was made with the previous research data obtaining a similar region for best flying behavior. Recommendations are given to increase the accuracy of the flying performance for velocities greater than 15 m/s. [Full Text](#)

Keywords: finite element method, computational fluid dynamics, Y Plus, mesh element quality, aerodynamic data, fluid domain, Solidworks/ANSYS, 3D modeling and simulation

### **WATER TUNNEL STUDIES OF DYNAMIC WING FLAP EFFECTS**

**Edgar E. Gonzalez–Lieutenant Commander, Mexican Navy**

**Master of Science in Mechanical Engineering**

**Advisor: M. S. Chandrasekhara, Mechanical and Aerospace Engineering**

**Second Reader: Kevin Jones, Department of Mechanical and Aerospace Engineering**

The flow features developing over a two-element NACA 0012 airfoil, with the rear portion serving as a trailing edge flap, were investigated using dye flow visualization in the NPS water tunnel. The original motivation for the work arose from a need to identify any potential to enhance maneuverability of aircraft to enable smoother landing under adverse flight situations. The flap portion was maneuvered in two different unsteady motion histories by a drive mechanism: a constant pitch rate motion and a sinusoidal oscillatory motion, at Reynolds numbers of 7,500 and 37,500. Comparisons were also drawn with steady flow features under similar conditions. In both unsteady cases, features of dynamic stall flow were observed. Unlike standard airfoil dynamic stall, the unsteady flow over a dynamic flap develops in the wake of the airfoil main element. This introduces many flow complexities such as reversed flows at low flap (deflection) angles of attack, dynamic stall developing from the wrap-around trailing edge flow that also interacts with main element boundary layer flow, unusual behavior for the main element, and flap clearance gap flow. However, since dynamic stall was observed at such flap deflections, it indicates that by differentially oscillating the flaps, it might be possible to develop differential lift on the two sides of a flight vehicle, which may provide better control authority than seen in steady flows. The results could be applied to unmanned air vehicles as well. [Full Text](#)

Keywords: unsteady aerodynamics, oscillatory flap, 2D-unsteady flows

### **MICROGRID CONTROL STRATEGY UTILIZING THERMAL ENERGY STORAGE WITH RENEWABLE SOLAR AND WIND POWER GENERATION**

**Kevin Hawxhurst–Ensign, United States Navy  
Master of Science in Mechanical Engineering**

**Advisor: Anthony Gannon, Department of Mechanical and Aerospace Engineering**

**Co-Advisor: Andrea Holmes, Department of Physics**

As part of the Department of Defense’s exploration into alternative energy solutions, this research focused on developing and implementing a control strategy for a microgrid system that was developed using a multi-physics energy approach. The objective was to demonstrate a microgrid system that more effectively uses renewable energy based on the end-use application of energy. The NPS Integrated Multi-Physics Renewable Energy Laboratory microgrid system was designed primarily for heating and cooling applications and utilizes thermal storage capabilities. A novel control strategy was also implemented to decrease the need for backup electrical power. The control strategy matches load demand from a chiller and heater to power generation from renewable solar and wind resources. Energy is stored as ice for cooling applications and in high temperature ceramic bricks for heating applications. A controller was designed using MATLAB and successfully implemented the desired control strategy. This was challenging as communication between the controller, the microgrid, the loads, and the thermal storage devices had to be established across multiple architectures. Using MATLAB, the controller operated nearly continuously for six months, collecting data for analysis. This research proves that the end-use energy design concept works by putting in place a working demonstration plant. [Full Text](#)

Keywords: microgrid, control strategy, renewable energy, thermal storage, multi-physics, end-use energy

### **IMPACT OF UNDERWATER EXPLOSIONS ON CONCRETE BRIDGE FOUNDATIONS**

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Master of Science in Mechanical Engineering**

**Advisor: Jarema Didoszak, Department of Mechanical and Aerospace Engineering**

**Co-Advisor: Young Kwon, Department of Mechanical and Aerospace Engineering**

In the event an underwater improvised explosive device (IED) were placed near a bridge, Explosive Ordnance Disposal (EOD) units would typically mitigate the threat by conducting a controlled detonation of the bomb. The controlled detonation must be executed a safe distance from any critical infrastructure to ensure the survivability of the structure. This thesis implements the Dynamic System Mechanics Advanced Simulation to characterize a safe detonation distance by determining the critical scenario contributing toward bridge failure. Efforts were also made to determine the parameters critical to modeling bridge foundations. To characterize the most critical scenario, trinitrotoluene was detonated at varying horizontal standoff distances and at varying water depths. The interaction of the underwater explosion (UNDEX) with a bridge foundation modeled from an actual bridge was observed. Intermediate depths were the most damaging to the foundation when the bomb was detonated near the surface of the water and when the bomb was located at the sand-water interface. Subsequently, EOD units should aim for controlled detonations in shallow or deep water. Two parameters, load and rebar reinforcement volume fraction, were varied to observe their impact on the foundation’s response to an UNDEX. The damage to the foundation was minimal as the load fluctuated, indicating that these loads do not need to be properly modeled. When the reinforcement was placed entirely in the X-, Y-, or Z- dimension, the rebar perpendicular to the shockwave proved to be the most critical. Changes in reinforcement volume fraction are also not important in short simulations. As the simulation is extended, the dependence of the damage on the volume fraction increases. As such, foundation models do not need to accurately model the load, but must properly model the reinforcement perpendicular to the shockwave and the volume fraction, if the simulation is long. Understanding which foundational components are critical to

its survivability allow bridge foundations to be grouped based on these components, such as reinforcement volume fraction. [Full Text](#)

Keywords: UNDEX, DYSMAS, DYNA, Gemini, infrastructure, bridge, Eulerian, Lagrangian

**CORROSION AND THERMAL PROCESSING IN COLD GAS DYNAMIC  
SPRAY DEPOSITED AUSTENITIC STAINLESS STEEL COATINGS**

**John Luhn–Lieutenant, United States Navy**

**Mechanical Engineer and Master of Science in Mechanical Engineering**

**Advisor: Sarath Menon, Department of Mechanical and Aerospace Engineering**

**Co-Advisor: Luke Brewer, Department of Mechanical and Aerospace Engineering**

This thesis presents research on the corrosion properties and effects of heat treatment on austenitic stainless steel coatings produced by the cold gas dynamic spray process on 316L stainless steel substrates. Previous work on the use of the low-pressure cold spray process to spray austenitic stainless steel was reproduced and validated. Heat treatment of the coatings was found to reduce porosity and evidence was found of recrystallization of the coatings. No significant changes in elemental distribution were found to occur during heat treatment. Corrosion testing was conducted by salt fog testing and anodic polarization. Coatings in the as-sprayed condition were found to be less corrosion resistant than bulk 316L stainless steel. Heat treated samples were observed to show corrosion resistance even worse than as-sprayed coatings. In fact, all heat treated samples exhibited little or no passivation behavior. Grain boundary sensitization is suspected as a probable cause for poor corrosion resistance in some samples, and the presence of ferrite in the powder and coatings may also be a cause of corrosion resistance that is worse than the fully austenitic substrate. [Full Text](#)

Keywords: cold spray, stainless steel, salt fog testing, potentiostatic testing

**FLUID–STRUCTURE INTERACTION IN A FLUID-FILLED COMPOSITE  
STRUCTURE SUBJECTED TO LOW VELOCITY IMPACT**

*The following paper has been recognized as outstanding by its department*

**Taylor South–Lieutenant, United States Navy**

**Master of Science in Mechanical Engineering**

**Advisor: Young Kwon, Department of Mechanical and Aerospace Engineering**

**Second Reader: Jarema Didoszak, Department of Mechanical and Aerospace Engineering**

The effects of fluid structure interaction in a fluid-filled cubic composite structure subjected to low velocity impact are the focus of this study. A fabrication technique was developed for creating an E-glass composite cubic structure and a pendulum was designed and built to provide a repeatable low velocity impact. The behavior of the composite structure was studied at various fluid fill levels and impact velocities. The fluid level inside the structure was varied incrementally from empty (0% fill) to full (100% fill). With impact load measurements, strain measurements on each side, and high-speed video, the behavior for each test case was analyzed and compared. Two types of baffles were designed and fabricated out of dense foam material. The behavior of the structure with and without a baffle was compared. The results showed the effect of fluid structure interaction in the composite was significant and varied with the fluid fill level. In addition, the effect of a baffle varied between the sides of the structure with the most notable effect being on the front and back sides. The baffle provided the greatest strain reduction at the high fill levels. [Full Text](#)

Keywords: glass fiber composite, fluid structure interaction, low velocity impact, partially filled fluid container

### **EVALUATION OF COMPOSITE-HULL SHIPS OPERATING IN ARCTIC ICE**

**Ryan Tran–Ensign, United States Navy**

**Master of Science in Mechanical Engineering**

**Advisor: Young Kwon, Department of Mechanical and Aerospace Engineering**

**Co-Advisor: Jarema Didoszak, Department of Mechanical and Aerospace Engineering**

As ocean temperatures rise, naval exploration around the Arctic Ocean is increasing due to the rapidly melting ice caps. Extensive research is thus being conducted to determine the interaction between ice and steel hulls in anticipation of opening sea lanes. While the majority of the research focuses on traditional steel-hull ships, limited research has been conducted on composite-hull ships to determine how this material will respond in Arctic waters. Therefore, the purpose of this study is to evaluate how composite materials interact with free-floating ice. The program, DYSMAS, conducted a computational parametric analysis to determine how increasing ship velocity, expanding ice block size, adding ice blocks, and changing the hull shape (vertical, tumblehome, and flared) affected the ship's performance. The numerical tests reveal that the ice block position has the greatest influence on the effective stress for the ship. Additionally, a second component of this thesis was to design and build a wave generating system. The system was designed and partially built, but an unexpected closure prevented the completion of construction. This project provides the foundation for both experimental and computational research relevant to composite-hull ships transiting through ice fields. [Full Text](#)

Keywords: composite, ships, Arctic, sea ice, DYSMAS, wave generator, plunger

### **DEVELOPMENT OF IMPROVED DESIGN AND 3D PRINTING MANUFACTURE OF CROSS-FLOW FAN ROTOR**

**Timothy Waterman–Ensign, United States Navy**

**Master of Science in Mechanical Engineering**

**Advisor: Garth Hobson, Department of Mechanical and Aerospace Engineering**

**Co-Advisor: Anthony Gannon, Department of Mechanical and Aerospace Engineering**

This study determined the optimum blade stagger angle for a cross-flow fan rotor and evaluated the performance of a 3D printed rotor. Using ANSYS-CFX and SolidWorks, the cross-flow fan was modeled computationally and tested at 8,000 rpm. A parametric study determined optimum blade stagger angle using thrust, power, and thrust-to-power ratio as desired output variables. A MarkForged Mark One 3D printer was used to print components of a carbon-fiber composite cross-flow fan rotor. These pieces were assembled and the thrust, power, and thrust-to-power ratio of the 3D printed rotor were measured. These performance characteristics were compared to a rotor of the same geometry previously manufactured from traditional carbon fiber components. The optimum stagger angle for the current 26-bladed, 101.6 mm (4 inch) diameter rotor was determined to be 10° forward of its previous position. The 3D printed rotor was found to produce less thrust, but also required less power. This was thought to be caused by the outward deflection of the rotor blades due to centripetal force in conjunction with the surface roughness of the blades. The rotor did have a similar thrust-to-power ratio as the current cross-flow fan rotor at speeds of up to 8,000 rpm. [Full Text](#)

Keywords: cross-flow fan, vertical take-off and landing, 3D printing, computational fluid dynamics, VTOL, CFD





# MASTER OF SCIENCE IN METEOROLOGY AND PHYSICAL OCEANOGRAPHY

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## QUANTIFYING SEASONAL SKILL IN COUPLED SEA ICE MODELS USING FREEBOARD MEASUREMENTS FROM SPACEBORNE LASER ALTIMETERS

**Kristine Bench–Lieutenant, United States Navy**

**Master of Science in Meteorology and Physical Oceanography**

**Advisor: Andrew Roberts, Department of Oceanography**

**Second Reader: Wieslaw Maslowski, Department of Oceanography**

Satellites and several specially equipped scientific aircraft provide basin-wide altimetric measurements of sea ice freeboard, from which sea ice thickness can be estimated. Up to now, few methods have been developed to use these measurements to quantitatively assess the skill of predictive models of sea ice for the Arctic. This thesis addresses this problem, using measured freeboard from Ice, Cloud, and land Elevation Satellite (ICESat) and Operation IceBridge (OIB). Output from the Regional Arctic System Model (RASM) is used to demonstrate applicability of both variance- and correlation-weighted skill scores of freeboard that quantify model skill and take measurement error into account. The techniques are demonstrated using two different RASM configurations, one using Elastic-Viscous-Plastic (EVP) ice mechanics, the other using the Elastic-Anisotropic-Plastic (EAP) rheology, both simulated for 2004 and 2007, during which ICESat was in operation. RASM variance skill scores ranged from 0.712 to 0.824 and correlation skill scores were between 0.319 and 0.511. The skill scores were calculated for monthly periods and require little adaption to be applicable for monthly to decadal Navy forecasts of the Arctic. This will help improve sea ice prediction by quantifying model limitations and thus maximize the usefulness of ICESat-2 freeboard measurements after that satellite is launched next year. [Full Text](#)

Keywords: Arctic, climate change, Regional Arctic System Model, altimetry measurements, sea ice, sea ice thickness, freeboard, ICESat, ICESat-2, climate model, coupled model, Operation IceBridge

## INFLUENCE OF MOMENTUM EXCESS ON THE PATTERN AND DYNAMICS OF INTERMEDIATE-RANGE STRATIFIED WAKES

**Michael Martin–Lieutenant, United States Navy**

**Master of Science in Meteorology and Physical Oceanography**

**Advisor: Timour Radko, Department of Oceanography**

**Second Reader: Peter Chu, Department of Oceanography**

Submerged bodies propagating in stratified fluids frequently create disturbances in temperature, salinity, and momentum that are detectable at the air-sea interface. This project includes the addition of momentum excess in order to model the fundamental differences between signatures generated by towed and self-propelled bodies in various ocean states. In cases where the body forces, form drag, and thrust were balanced, fewer and less expansive surface signatures were observed. In cases where the balance was disturbed by either lack or excess of self-propulsion, a greater perturbation was achieved, particularly in the ocean interior. Discovering the significance of the internal, intermediate-range wakes has transformed the focus of the entire study. With the increasing employment of unmanned underwater vehicles, it is equally imperative to research the internal ocean dynamics as it is to study the physics at the surface. This study was focused on direct numerical simulations. However, the data collected in this investigation have produced new insights into the dynamics

of stratified wakes, which can be used on the operational level for developing and improving algorithms for non-acoustic signature prediction and detection. [Full Text](#)

Keywords: stratified wakes, direct numerical simulations, momentum excess, dimensional analysis, surface thermal signatures, internal velocity signatures

### **ICE STORMS IN A CHANGING CLIMATE**

**Jennifer McNitt–Lieutenant Commander, United States Navy**  
**Master of Science in Meteorology and Physical Oceanography**  
**Advisor: Wendell Nuss, Department of Meteorology**  
**Co-Advisor: David Titley, Pennsylvania State University**

Ice storms can cause billions of dollars' worth of damage to energy infrastructure, towers, surrounding trees (that could further damage electrical structures), and transportation, and can cause death either due to exposure to subfreezing temperatures or vehicular accidents. An increase in global temperatures, due to climate change, could affect the frequency, intensity, and geographic location of ice storms. Three known ice storm case studies were chosen to build, test, and adjust an algorithm that could predict freezing precipitation events. Once the algorithm was deemed satisfactory, it was used on four different ice storm seasons to analyze how well it identified and verified significant differences among the seasons. This research suggests that the algorithm could continue to be adjusted for better output and tested over several ice storm seasons. Other present weather parameters could be predicted by building another algorithm, using a similar approach. [Full Text](#)

Keywords: ice storms, climate change, algorithm, mean jet stream, climatology, ice storm seasons, verified

### **IN-SITU OBSERVATION OF UNDISTURBED SURFACE LAYER SCALAR PROFILES FOR CHARACTERIZING EVAPORATIVE DUCT PROPERTIES**

**Richard Rainer–Lieutenant, United States Navy**  
**Master of Science in Meteorology and Physical Oceanography**  
**Advisor: Qing Wang, Department of Meteorology**  
**Second Reader: Wendell Nuss, Department of Meteorology**

Understanding the vertical variations of temperature and humidity in the marine atmospheric surface layer (MASL) is extremely important for naval and civilian applications. In particular, such variations affect the propagation of electromagnetic waves (EM) by forming an evaporation duct. However, direct measurements of these profiles have been difficult from a large ship because of the disturbance introduced by the platform. In this thesis, the design, deployment, and initial data analyses of a marine atmospheric profiling system (MAPS) is introduced. The MAPS is developed as part of the Coupled Air Sea Process and EM ducting Research (CASPER) project. It is capable of making repeated measurements of the lowest tens of meters of the MASL from a small Rigid Hull Inflatable Boat (RHIB), or a small work boat, equipped with a tethered profiling system and a small meteorological mast. For each profiling set at a given location, 10-15 profiles were made to allow sufficient samples to derive the mean profile. This thesis discusses the methods for controlling data quality and obtaining the mean profiles from the scattered profiling data. Evaporation duct height and strength are derived and compared to those generated from an evaporation duct model using various input from measurements. [Full Text](#)

Keywords: evaporative duct, CASPER, maritime atmospheric surface layer, air-sea interaction, vertical profile

**INTER-ANNUAL VARIABILITY OF THE CALIFORNIA CURRENT SYSTEM AND  
ASSOCIATED BIOCHEMICAL CHARACTERISTICS FROM PROLONGED DATA SERIES**

**DyAnna Rodriguez–Lieutenant, United States Navy**

**Master of Science in Meteorology and Physical Oceanography**

**Advisor: Peter Chu, Department of Oceanography**

**Co-Advisor: Tetyana Margolina, Department of Oceanography**

This research investigates the California Current System (CCS) utilizing Synoptic Monthly Gridded World Ocean database (SMG-WOD) for temperature and salinity profiles, MODIS-A for surface chlorophyll-a (Chl-a) concentration, and climatological indices El Nino Modoki Index (EMI) and Multivariate El Nino Southern Oscillation Index (MEI), to compare inter-annual variations. The SMG- WOD produces 3D gridded fields with  $1^{\circ}\times 1^{\circ}$  horizontal resolution and 28 vertical layers. The area of interest was  $0^{\circ}$ - $54^{\circ}$ N,  $165^{\circ}$ W- $105^{\circ}$ W from January 1945-December 2014. Because processes within 50 km of the coast are not well resolved by SMG-WOD, Chl-a data from MODIS-A with a 4.6 km resolution was used from July 2002-December 2014. Acceleration potential at the isopycnal surface of  $\sigma_{\theta} = 26.9 \text{ kg/ m}^3$  relative to the 1000 dbar was calculated from the SMG-WOD. Composite and Empirical Orthogonal Function (EOF) analysis was conducted to identify patterns of maximum variance. Correlation coefficients were calculated to determine connections between inter-annual variability and EMI/MEI. Acceleration potential had small seasonal variability, while Chl-a concentration demonstrated large seasonal variability. When Principal Component (PC) 1 is positive, EMI index will be negative, resulting in an increased geostrophic flow in the CCS. For positive PC2, MEI is negative resulting in an offshore flow and thus enhanced coastal upwelling in the CCS. Positive PC1 correspond to negative EMI/MEI and elevated surface Chl-a concentration in the CCS. [Full Text](#)

Keywords: California Current, inter-annual variability, acceleration potential, World Ocean Database (WOD), synoptic monthly gridded WOD (SMG-WOD), optimal spectral decomposition (OSD), composite analysis, empirical orthogonal function (EOF), climatological indices, El Nino Modoki Index (EMI), multivariate ENSO Index (MEI), MODIS-A, surface chlorophyll-a concentration



# MASTER OF SCIENCE IN MODELING, VIRTUAL ENVIRONMENTS, AND SIMULATION

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## PROOF-OF-CONCEPT PART TASK TRAINER FOR CLOSE AIR SUPPORT PROCEDURES

*The following paper has been recognized as outstanding by its department*

**Jesse Attig–Major, United States Marine Corps**

**Master of Science in Modeling, Virtual Environments, and Simulation**

**Advisor: Amela Sadagic, MOVES Institute**

**Second Reader: Joe Sullivan, MOVES Institute**

Transitioning between two training phases of the close air support (CAS) syllabus can be difficult for pilots under instruction (PUIs). The level and variety of skills needed for each stage may not be acquired in the previous step, which makes it difficult for the pilot to take the most value from the current stage of training. By providing PUIs with supplemental training solutions that aim to bridge those training gaps, it may be possible to increase the value of the ultimate, but time-limited, training opportunities like simulator and actual flight events. This research prototyped a supplemental training solution that offers a context-relevant, immersive virtual environment that removes the need to fly or operate the aircraft system, thus enabling the trainee to focus only on improving the skills related to problem schema (communication, decision making, and CAS procedures). The resulting system enables repetitive, individual training of CAS communication and procedure skills similar to chair flying combined with tactically correct examples of CAS missions used during chalk talks. An informal user study indicated this approach has the potential to make the transition to the simulator or aircraft much easier and could offer a viable training solution in an increasingly fiscally constrained environment. [Full Text](#)

Keywords: part-task trainer, close air support, virtual environment, aviation

## CAN SUBJECTS BE GUIDED TO OPTIMAL DECISIONS? THE USE OF A REAL-TIME TRAINING INTERVENTION MODEL

*The following paper has been recognized as outstanding by its department*

**Travis Carlson–Major, United States Marine Corps**

**Master of Science in Modeling, Virtual Environments, and Simulation**

**Advisor: Quinn Kennedy, Department of Operations Research**

**Co-Advisor: Lee Sciarini, Department of Operations Research**

Effective decision-making is a hallmark of military leadership, and development of decision makers is critical to military strategy. The Cognitive Alignment with Performance-Targeted Training Intervention Model (CAPTTIM) was developed to aid training of optimal decision-making. Cognitive state suggests a subject is exploring the decision environment as opposed to exploiting it, and decision performance classifies whether a subject is making optimal decisions. Using a color-coded structure combining cognitive state and decision performance, CAPTTIM indicates whether those factors are aligned for optimal decision-making—exploiting the environment and making optimal decisions—or not. The focus of this thesis was to identify each subject's CAPTTIM status in real time and, when decision performance was misaligned, provide feedback to influence the subject's future decisions. Through a human-subject experiment ( $n = 34$ ), we classified decision-makers' CAPTTIM status in real time. We randomly assigned 17 subjects to receive tailored feedback during execution of a decision task (feedback group), and trend analysis reveals the feedback group to be more likely to reach optimal decisions than a control group. These results imply that training systems could be tailored to

the individual and that methods used to instruct effective decision-making may expand to include real-time understanding and intervention. [Full Text](#)

Keywords: decision making, optimal decision making, training, real-time data capture, intervention

### **DISCRETE EVENT SIMULATION MODEL OF THE POLARIS 2.1 GAMMA RAY IMAGING RADIATION DETECTION DEVICE**

**Andres Juarez—Captain, United States Marine Corps**

**Master of Science in Modeling, Virtual Environments, and Simulation**

**Advisor: Arnold Buss, MOVES Institute**

**Second Reader: Steve Mullins, Department of Information Sciences**

The nuclear threat remains a top priority for the United States government; there are many agencies whose sole focus is thwarting terrorist actions. As layer upon layer of both passive and active defensive measures are employed, the research community continues to bear new tools to aid in detection of radiological material. Incorporating and developing tactics, techniques, and procedures (TTPs) for those devices becomes a challenge in and of itself. For this thesis, the Polaris 2.1 Gamma Ray Imaging Radiation Detection Device (Polaris) was selected as the technology to be modeled. The platform, Simkit, was utilized to create a discrete event simulation (DES) model of the Polaris. After carefully constructing the DES, multiple simulations were run measuring the time to detect all radiation sources in the simulated environment. Then, all data and parameters from the simulation were used for statistical analysis to determine significant factors in the DES—for example, not only was the strength of the radiation source significant, but so was the amount of variance introduced into the DES. These results are non-intuitive and pave a path for further research to enhance the DES and find the optimal TTPs for this device from both the tactical and operational perspectives. [Full Text](#)

Keywords: discrete event simulation model, radiation detection, factor analysis

### **HIERARCHICAL TASK NETWORK PROTOTYPING IN UNITY3D**

*The following paper has been recognized as outstanding by its department*

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**Advisor: Imre Balogh, MOVES Institute**

**Second Reader: David Reeves, MOVES Institute**

The Combined Arms Analysis Tool for the 21st Century, or COMBATXXI, is the primary analytical combat simulation model in use by the Marine Corps' Operations Analysis Division (OAD) and the Army's Training and Doctrine (TRADOC) Analysis Center for weapon system and force effectiveness analysis. The bottleneck in the COMBATXXI scenario production process is the behavior development process. Analytically useful scenarios demand complex and dynamic behaviors that react to the unique circumstances of the simulation's current state. Hierarchical Task Networks (HTN) are the state-of-the-art methodology in COMBATXXI used to describe dynamic behaviors. Although HTNs decrease the scenario development time, they are difficult to conceptualize, validate, and troubleshoot. The long iteration cycle is due, in part, to the complex development environment, the necessity of a large simulated infrastructure to test behaviors, and an inability to visually debug. Here we present a solution for prototyping HTNs by extending an existing commercial implementation of Behavior Trees within the Unity3D game engine prior to building the HTN in COMBATXXI. Existing HTNs were emulated within this prototyping environment to test transferability of the behaviors, and new HTNs were prototyped in Unity3d prior to being built in COMBATXXI as a proof of concept. Prototyping HTNs in a 3D development environment may prove useful by reducing the iteration time and improving the

overall quality of the behaviors. The interactive nature of Unity3d reduces the iteration time, and the ability to rapidly test many different cases improves the quality of the behaviors. [Full Text](#)

Keywords: hierarchical task network, HTN, dynamic behaviors, behavior prototyping, agent-based simulation, entity-level combat model, game engine, discrete event simulation, virtual environments

### **MODELING ANTI-AIR WARFARE WITH DISCRETE EVENT SIMULATION AND ANALYZING NAVAL CONVOY OPERATIONS**

**Ali Opcin—Lieutenant Junior Grade, Turkish Navy**  
**Master of Science in Modeling, Virtual Environments, and Simulation**  
**and Master of Science in Operations Research**  
**Advisor: Arnold Buss, MOVES Institute**  
**Co-Advisor: Thomas Lucas, Department of Operations Research**  
**Second Reader: Paul Sanchez, Department of Operations Research**

Anti-air warfare (AAW) is a primary naval warfare area. Using AAW tactics and concepts of operations, this research explores the most critical success factors of convoy operations. In this study, a discrete event simulation (DES) was built by modeling ships, and their sensors and weapons, to simulate convoy operations under air threat. Where classified data was unavailable, assumptions were made and approximations were used in constructing the ships, weapons, and sensors. The model was used to simulate over 1.5 million naval battles varying 99 input variables using sophisticated and systematically created data combinations. To select the input settings over a specific range of input variables, a nearly orthogonal nearly balanced (NOB) Latin hypercube design was used. The effects of these input changes on the outputs were analyzed using partition trees and nominal logistic regression. The primary response variable was the survival of the High Value Unit (HVU) as a binary outcome. According to the analysis, in a convoy operation under air threat, the surface-to-air missile (SAM) specifications of the screen ships, the staying power of the HVU, and the anti-ship missile (ASM) specifications of the enemy ships had the most significant effect on the survival of the HVU. [Full Text](#)

Keywords: discrete event simulation, modeling anti-air warfare, Simkit, component based approach, layered defense systems, formation movements, design of experiments, simulation output analysis

### **EARLY SYNTHETIC PROTOTYPING: THE USE OF VIDEO AFTER-ACTION REPORTS FOR HARVESTING USEFUL FEEDBACK IN EARLY DESIGN**

**Matthew Provost—Lieutenant Colonel, United States Army**  
**Master of Science in Modeling, Virtual Environments, and Simulation**  
**Advisor: Rudolph Darken, Department of Computer Science**  
**Second Reader: Brian Vogt, United States Army**

Early Synthetic Prototyping (ESP) is a new concept in which capability and material developers use an online game to crowdsource ideas from online players in order to increase viable synthetic prototypes. In entertainment games, players often create videos of their game play to share with other players to demonstrate how to complete a segment of a game. This thesis explores similar self-recorded videos of ESP game play and determines if they provide useful data to capability and material developers that can influence the early design process, or if the videos affect the ESP process itself. The study shows that user videos affect player behavior as well as increase engagement and entertainment for the players, which serves to maintain a large player population essential to ESP success. The exact reasons for increased engagement and entertainment are unclear and are topics for further investigation. These results are important to ESP developers because if ESP game developers can increase the engagement and fun in playing their games, it will increase participation and willing-



ness to contribute ideas and strategies with other players. The increase in contributions and participation will then lead to an increase in the number of early prototypes that can be analyzed and potentially used. [Full Text](#)

Keywords: Early Synthetic Prototyping, video games, science and technology, game environment, online game communities, innovation, military acquisition

### **INFLUENCING GAMEPLAY IN SUPPORT OF EARLY SYNTHETIC PROTOTYPING STUDIES**

**Douglas Ross—Major, United States Army**

**Master of Science in Modeling, Virtual Environments, and Simulation**

**Advisor: Rudolph Darken, Department of Computer Science**

**Co-Advisor: Brian Vogt, Army Capabilities Integration Center (ARCIC)**

Early Synthetic Prototyping (ESP) is a concept being developed by the Army Capabilities Integration Center (ARCIC) to utilize a game environment and crowdsourcing techniques to receive end-user feedback on proposed acquisition programs early in the concept development stage. To be effective, ESP will need soldiers to participate, both to produce data and to interact with the game environment in such a way that the data is meaningful. This study proposed a methodology for creating scoring algorithms and examined its ability to influence player behavior and enjoyment. A group of students and faculty from the Naval Postgraduate School executed two scenarios in a Virtual Battlespace 3 game environment. A scoring algorithm was applied to one scenario and data collected to determine the effect on player behavior and motivation. The study found qualitative evidence that scoring mechanisms enhanced enjoyment and could influence desired behavior. However, quantitative data was not statistically significant to demonstrate a corresponding effect on gameplay. The results of this preliminary work can be used to support future studies on how to utilize scoring algorithms to support ESP research. [Full Text](#)

Keywords: Early Synthetic Prototyping, acquisition, video games, crowdsourcing, Engineering Resilient Systems, science and technology, game environment

### **ARTILLERY SURVIVABILITY MODEL**

*The following paper has been recognized as outstanding by its department*

**Yusuf Temiz—First Lieutenant, Turkish Army**

**Master of Science in Modeling, Virtual Environments, and Simulation**

**Advisor: Christian Darken, Department of Computer Science**

**Second Reader: Michael Guerrero, MOVES Institute**

This work investigates the use of modern simulation techniques for evaluating artillery movement doctrine. A simulation called the Artillery Survivability Model was created as a proof of principle. The simulation incorporates the most salient features relating to artillery survivability according to our small-scale survey of expert opinion on this subject. It consists of a 3D agent-based simulation that incorporates AI technology that is novel to this domain, including terrain analysis, advanced movement planning, and GPU-based particle filters to represent enemy anticipation of friendly artillery behavior. The simulation has been created with the popular game engine Unity 3D, and has two different modes. The first is the experiment mode, which is executed from command line without rendering any image, and runs up to 50 times faster than the real-time simulation. Therefore, it is a suitable platform to perform multiple runs for experimenting. The experiment mode also enables users to set their own design of experiment by manipulating an editable CSV file. The second one is a real-time mode that renders a 3D virtual environment of a restricted battlefield where the survivability move-

ments of an artillery company are visualized. This mode provides detailed visualization of the simulation and enables future experimental uses of the simulation as a training tool. [Full Text](#)

Keywords: survivability, artillery, GPGPU, AI, agent-based, simulation, 3D, Unity, experiment, fast-forward

### **TOWARDS A GAME-BASED PERISCOPE SIMULATOR FOR SUBMARINE OFFICERS TACTICAL TRAINING**

**Rodrigo da Silva Vieira–Lieutenant Commander, Brazilian Navy  
Master of Science in Modeling, Virtual Environments, and Simulation  
Advisor: Lee Sciarini, Department of Operations Research  
Co-Advisor: Perry McDowell, MOVES Institute**

Early in their career, submarine officers must develop and maintain many skills to qualify as periscope operators. This critical position comprises complex tasks, requiring precise steps, accurate mental calculations, and celerity of actions and thoughts, while obeying specific rules to ensure the safety of the submarine and its crew. Currently, gaps in training exist between the professional courses a submarine officer attends over a career to learn and practice these skills. Following an instructional system design process, this thesis developed a 3D, game-based periscope tactical training prototype. This part-task training solution can provide feedback on predetermined performance measures, either automated, real-time, or post-hoc. The second part of this thesis used the prototype environment to investigate the impact of feedback type on performance. Results indicated that participants receiving real-time feedback had significantly better performance than those who received post-hoc feedback during an initial trial. Performance for both groups significantly improved for subsequent trials; by the third trial, however, significant differences were not observed for feedback type. Additionally, results of an exploratory analysis showed feedback type affected performance by age, time in service, and gaming experience. Results of this thesis support the use of game-based simulation as training tools and that feedback type could be tailored to individuals based on factors such as age and experience to optimize training outcomes. [Full Text](#)

Keywords: training simulations, game-based training system, periscope simulator, submarines, training, part-task training, Brazilian Navy, Unity, feedback



# MASTER OF SCIENCE IN OPERATIONS RESEARCH

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## AN EVOLVING ASYMMETRIC GAME FOR MODELING INTERDICTOR-SMUGGLER PROBLEMS

Richard Allain–Major, United States Marine Corps  
Master of Science in Operations Research

Advisor: David Alderson, Department of Operations Research

Second Reader: W. Matthew Carlyle, Department of Operations Research

We propose a novel network interdiction model that reconciles many operational realities identified by military literature. Specifically, we conduct network interdiction within a dynamic network under partial information, using incomplete feedback and allowing two-sided adaptive play. Combining these aspects in an evolving game, we use optimization, simulation, and stochastic models to achieve a hybrid model. Modeling some currently underrepresented martial problems in this way makes it possible to highlight otherwise obscure relationships between policy and outcome, and to discover emergent effects, such as deterrence. As an example of this class of problems, we consider the struggle between a smuggler and interdictor. The smuggler seeks to maximize the amount of forces and materiel infiltrated from an origin to destination. The interdictor seeks to minimize this smuggler flow. Using two simple examples of an illicit-trafficking network, we demonstrate how to use these quantitative models within such an interdictor-smuggler context to (1) evaluate the value of seizures as a proxy for smuggled materiel, (2) assess the value of exploration, and (3) provide decision makers with practical ways to better allocate resources and increase effectiveness. [Full Text](#)

Keywords: dynamic network interdiction, smuggling, evolutionary games, incomplete and asymmetric information, online learning, dynamic stochastic programming, adaptive risk management

## IED PATTERN RECOGNITION USING SINUSOIDAL MODELS

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Master of Science in Operations Research

Advisor: Michael Atkinson, Department of Operations Research

Second Reader: Connor McLemore, Operations Analysis Program Office

More than half of all U.S. casualties in Iraq and Afghanistan were caused by improvised explosive devices (IEDs). Despite the spending of over \$75 billion to combat this threat, intelligence analysts still lack efficient tools to conduct IED pattern analysis. This thesis evaluates sinusoidal models for effectiveness in assisting in the identification of IED patterns. We formulate three models to test against IED patterns encountered in Iraq and Afghanistan: the Hawkes point process, the non-linear optimization of a sine function, and discrete Fourier transforms (DFT). Non-linear optimization and DFT models both out-perform a mean inter-arrival model when applied to representative IED patterns. We also applied these models against portions of an Iraq IED dataset using a rolling horizon forecast. Lastly, we test model performance when applied to patterns identified from the Iraq dataset. We conclude that although there is not a silver bullet for IED pattern detection, the use of these models in IED environments has the potential to reduce the amount of time and effort

intelligence analysts expend when identifying IED patterns. We recommend incorporating these models into a graphic user interface usable by intelligence analysts responsible for IED pattern recognition. [Full Text](#)

Keywords: improvised explosive device, IED, Hawkes point process, discrete Fourier transforms, pattern recognition, rolling horizon forecast

### **OPTIMAL REPAIR AND REPLACEMENT POLICY FOR A SYSTEM WITH MULTIPLE COMPONENTS**

**Jan-Wilhelm Bredecke–Major, German Army**

**Master of Science in Operations Research**

**Advisor: David Alderson, Department of Operations Research**

**Co-Advisor: Kyle Lin, Department of Operations Research**

**Second Reader: Michael Atkinson, Department of Operations Research**

This thesis formulates and solves a Markov decision problem to find the optimal repair and replacement policy for a system of multiple components whose failure rates are age-dependent. We assume that the failure rate for an old component is higher than for that of a new component. When a component fails, it can either be replaced, making it new, or repaired, making it functional but old. An old component can also be replaced proactively. We formulate the model for a single component as a linear program, and perform parametric analysis on the transition probabilities and system rewards to understand when different policies are optimal. We extend the model to include multiple, independent components, and apply the model to a notional infrastructure network whose performance depends on the state of its network links. [Full Text](#)

Keywords: failure, repair, replace, multiple component models, maintenance models, Markov decision process

### **A PREDICTIVE ANALYSIS OF THE DEPARTMENT OF DEFENSE DISTRIBUTION SYSTEM UTILIZING RANDOM FORESTS**

**Amber Coleman–Major, United States Marine Corps**

**Master of Science in Operations Research**

**Advisor: Samuel Buttrey, Department of Operations Research**

**Second Reader: Jonathan Alt, Department of Operations Research**

This thesis develops machine-learning models capable of predicting Department of Defense distribution system performance of United States Marine Corps ocean requisitions to the United States Pacific Command area of operations. We use historical data to develop a model for each sub-segment of the Transporter leg within the distribution pipeline and develop two different models to predict the ocean transit sub-segment based on Hawaii and non-Hawaii destinations. We develop a linear regression, regression tree, and random forest model for each sub-segment and find that the weekday and month in which requisitions begin the Transporter segment are among the most significant drivers in variability. United States Transportation Command currently uses the average performance per sub-segment to estimate Transporter length, and our models, when applied to the test set, perform considerably better than the average. We conclude that the random forest models provide the best and most robust results for most sub-segments. However, we encounter several issues concerning missing values within our dataset, which we suspect artificially inflate the significance of some of our predictor variables. We recommend refining data collection processes in order to collect observations that are more accurate and applying the same methodologies in the future. [Full Text](#)

Keywords: Department of Defense (DOD) distribution, linear regression, regression trees, random forests, machine learning, ocean shipments, predictive models, United States Transportation Command (USTRANSCOM), Marine Corps Logistics Command (MARCORLOGCOM)

**A NEW APPROACH TO SITE DEMAND-BASED LEVEL INVENTORY OPTIMIZATION**

**Tacettin Ersoz—Lieutenant Junior Grade, Turkish Navy**

**Master of Science in Operations Research**

**Advisor: Javier Salmeron, Department of Operations Research**

**Second Reader: Emily Craparo, Department of Operations Research**

Naval Supply Systems Command (NAVSUP) supports Navy, Marine Corps, Joint, and Allied Forces with their inventory of more than 430,000 items worth \$21 billion using several distribution sites. Choosing the optimum order-point and order-quantity for each item is important to meet the stochastic demand while satisfying multiple restrictions such as budget and maximum number of orders. The Site Demand-Based Level Inventory Optimization Model (SIOM) is a mixed-integer, linear program developed at the Naval Postgraduate School to provide NAVSUP planners with guidance on this complex problem. Ongoing tests have been successful, but SIOM's computational run times are long. This thesis introduces a new, faster reformulation (SIOMsQ) that approximates the solution of the same problem by reducing the possible candidate sets of order-points and order-quantities for each item. We find that the solutions suggested by SIOMsQ are better than or very close to those of SIOM in test cases provided by NAVSUP, with substantially shorter computational times. Therefore, we recommend using SIOMsQ versus SIOM. [Full Text](#)

Keywords: inventory management, inventory optimization, order points, order quantities, Naval Supply Systems Command, demand based item, mixed-integer linear problem

**THE ISLAMIC STATE BATTLE PLAN: PRESS RELEASE**

**NATURAL LANGUAGE PROCESSING**

**James Friedlein—Major, United States Marine Corps**

**Master of Science in Operations Research**

**Advisor: Lyn Whitaker, Department of Operations Research**

**Second Reader: Craig Whiteside, Naval War College**

The purpose of this study is to develop methods to accelerate and enhance the analysis of Islamic State Movement text documents. We analyze a unique database collected by Dr. Craig Whiteside, which consists of nearly 3,000 open-source translated press releases from 2003-2014. Using Natural Language Processing tools, the text data is aggregated into a corpus and processed based on document term structure and frequency. In order to reduce analyst workload, we validate Whiteside's manual analysis and construct cross-validated generalized linear models to automatically classify documents into one of seven types. A cascade classification model outperforms all other models with a mean cross-validated misclassification rate of 5.71 percent. Islamic State Movement operational summaries are classified as type Celebrate. We develop a layered algorithm based on regular expressions and location searches to extract critical information from each attack event and display the details on a map using a web-based interactive R Shiny application. With the ability to automatically classify Islamic State Movement text documents and visually interact with the data contained within those classified as type Celebrate, analysts and decision makers are able to process and understand large amounts of text data more quickly and effectively. [Full Text](#)

Keywords: Islamic State Movement, Islamic State of Iraq, ISIS, Islamic State, Natural Language Processing, text mining, corpus, generalized linear model, cascade, R Shiny, leaflet, data visualization

**DETERMINING MARKET CATEGORIZATION OF UNITED STATES  
ZIP CODES FOR PURPOSES OF ARMY RECRUITING**

*The following paper has been recognized as outstanding by its department*

**Brandon Fulton—Major, United States Army**

**Master of Science in Operations Research**

**Advisor: Lyn Whitaker, Department of Operations Research**

**Second Reader: Jeffrey House, Department of Operations Research**

The U.S. Army relies on Zone Improvement Plan (ZIP) codes to assign recruiters and to track recruit production. ZIP codes have different densities of potential recruits; the Army uses commercial market segmentation data to analyze markets and past accessions to assign recruiters and quotas to maximize production. We use 347 variables from publicly available United States government agencies for each of 34,007 ZIP codes to cluster ZIP codes into similar groups. We use between two and 18 clusters for each of five categories of data, using three dissimilarity calculation methods, and three clustering algorithms. Using national recruiting leads as a proxy for market potential, we find the best cluster assignment by fitting Poisson regressions predicting leads from ZIP code cluster membership. Economic cluster assignments predict leads with a pseudo R-squared value of 0.69, reducing the need for United States Army Recruiting Command to rely on proprietary data with 66 market segments per ZIP code for market analysis and predicting recruiting potential. These 18 clusters provide an easier tool for recruiting commanders. Additionally, these clusters offer a new method of identifying potentially high-production ZIP codes without using previous accessions and the highly correlated number of recruiters assigned as predictor variables. [Full Text](#)

Keywords: recruiting, tree clusters, unsupervised

**OPTIMIZING MAINTENANCE MANPOWER FOR USMC F/A-18 SQUADRONS**

**Kevin Goodwin—Major, United States Marine Corps**

**Master of Science in Operations Research**

**Advisor: W. Matthew Carlyle, Department of Operations Research**

**Co-Advisor: Robert Dell, Department of Operations Research**

**Second Reader: Jeffrey Hyink, Department of Operations Research**

United States Marine Corps F/A-18 squadrons face increasing maintenance requirements to keep their aging aircraft operationally ready. Each squadron maintenance department has six production work centers (WCs) that specialize in different maintenance activities. Each Marine in one of the six production WCs belongs to one of three categories of experience level, with some maintenance actions requiring certification by a member of the most experienced category before an aircraft can fly. This thesis formulates the Manpower Validation Planner (MVP), an integer linear program that daily assigns tasks to available Marines from each WC and experience level to a squadron's maintenance actions, with the requirement to keep a standard number of aircraft operationally ready. We demonstrate the MVP using two years of daily maintenance and manning data from five F/A-18 squadrons to calculate the number of used, unused, and deficit hours of work. Our baseline analysis shows the majority of WCs in an F/A-18 maintenance department have sufficient manpower available, but that two WCs are overtasked. Additional analysis shows the impossibility of keeping the required number of aircraft operationally ready given the time available to fix aircraft and evaluates mitigation strategies. [Full Text](#)

Keywords: optimizing, maintenance manpower, F/A-18, manpower validation planner, RBA

**TOWARD A MORE RESPONSIVE CONSUMABLE MATERIEL SUPPLY CHAIN:  
LEVERAGING NEW METRICS TO IDENTIFY AND CLASSIFY ITEMS OF CONCERN**

**Andrew Haley—Lieutenant Commander, Supply Corps, United States Navy  
Master of Science in Operations Research**

**Advisor: Robert Koyak, Department of Operations Research**

**Second Reader: Peter Ward, Department of Operations Research**

We develop a classification system for U.S. Navy consumable items to give the Naval Supply Systems Command (NAVSUP) a better position for advocacy regarding these assets. The Defense Logistics Agency (DLA) is responsible for the procurement, storage, and distribution of the Navy's consumable assets. Its inventory system is highly dynamic, and items may be requisitioned for long periods without undue delay followed by sudden, unexpected shortages that directly affect Navy combat readiness. We propose a new metric, customer time limit (CTL), which normalizes the requisition fulfillment time according to priority level and the physical location of the customer. Using this metric, we essentially classify inventory items as problematical with respect to two different criteria: whether the median CTL exceeds a nominal threshold, and whether CTL exhibits an increasing trend. To apply this classification, nonparametric statistical methods are used based on consumable requisition data for calendar years 2013 through 2015, resulting in three categories: NSNs at Risk, Bad Actors, or Bad Actors with Trend. Collectively, we find that NSNs at Risk and Bad Actors with Trend constitute approximately one percent in both U.S. Navy consumable item population and annual consumable expenditure (\$19 million out of \$1.9 billion purchased), and that Bad Actors comprise approximately two percent of U.S. Navy consumable item population and 7% of annual consumable expenditure (\$140 million out of \$1.9 billion purchased). [Full Text](#)

Keywords: Defense Logistics Agency (DLA), Naval Supply Systems Command (NAVSUP), logistics, inventory, consumable, NSNs at Risk, Bad Actors, Bad Actors with Trend, items of concern, customer time limit (CTL), coefficient of variation (CV), Spearman rank correlation test

**APPLICATIONS OF TEXT ANALYTICS IN THE INTELLIGENCE COMMUNITY**

**Daniel Hall—Captain, United States Marine Corps  
Master of Science in Operations Research**

**Advisor: Johannes Royset, Department of Operations Research**

**Second Reader: Jon Alt, Department of Operations Research**

We evaluate Anseri, a commercial text analytics software, and its ability to assist a military intelligence analyst in the planning phase of major operations. The intelligence cycle involves extensive, timely, and detailed analysis of the operating environment. This requires a lot of reading by intelligence analysts to fully analyze the content. Tools that automate the initial summarization of the topic themes in a large body of text reduce the amount of time spent reading the material and focus the analyst's research efforts by providing a method to prioritize documents based on their relevance to the research topic. Anseri's utility is tested on a corpus of Islamic State press releases to demonstrate the analyst's ability to quickly gain a basic understanding of the thematic nature of the corpus and prioritize deeper research. [Full Text](#)

Keywords: topic analysis, intelligence, text analytics, Islamic State



### **ANALYSIS OF ERROR PROPAGATION WITHIN HIERARCHICAL AIR COMBAT MODELS**

**Salih Ilaslan—Captain, Turkish Air Forces**

**Master of Science in Operations Research**

**Advisor: Thomas Lucas, Department of Operations Research**

**Second Reader: Jeffrey Appleget, Department of Operations Research**

Operations research analysts often use a hierarchy of combat models to provide insight to military decision makers. Briefly, lower-level, higher-resolution models provide input to higher-level, lower-resolution models. This allows analysts to explore how engineering and tactics changes can affect campaign effectiveness. This thesis builds upon previous research and examines various methods for employing distributions of engagement-level model outputs as input to campaign-level models, instead of just using the average. We contrast methods for linking the engagement-level model to the campaign-level model. Previous research indicates that when expected values alone are propagated through layers of combat models, the final results will likely be biased, and risk underestimated. An air-to-air engagement model is developed to generate a data library that is used as input in a stochastic Lanchester campaign model. A variety of sampling methods are employed to sample from the engagement model's output data library to provide input to the campaign model. The results indicate that the manner in which the engagement and campaign models are linked has substantial impact on the estimates of operational effectiveness and risk. Additionally, our research illustrates how running a designed experiment on the engagement-level model, to generate a library of data that can be linked to the campaign-level model, can support robust decision making. [Full Text](#)

Keywords: hierarchical combat modeling, air combat modeling, campaign analysis, mean and variance analysis, sampling methods, metamodeling, error propagation, Lanchester equations, agent-based simulation, design of experiments, simulation output analysis

### **EVALUATING EFFECTIVENESS OF A FRIGATE IN AN ANTI-AIR WARFARE (AAW) ENVIRONMENT**

**Serif Kaya—Lieutenant Junior Grade, Turkish Navy**

**Master of Science in Operations Research**

**Advisor: Jeffrey Kline, Department of Operations Research**

**Second Reader: Thomas Lucas, Department of Operations Research**

Designing naval ship capabilities for shipbuilding is a challenging process requiring comprehensive technical and tactical studies. Technical studies involve ship design characteristics such as engineering, weapon, and support systems. Tactical studies include the anticipated area of operation, expected threat, the capabilities of the enemy, and potential missions to accomplish. Both studies are used in ship design to determine the ship's required combat capabilities before finalizing the hull design. This research uses the agent-based modeling tool Map Aware Non-Uniform Automata (MANA) to explore the best combat capabilities for a frigate in an anti-air warfare (AAW) environment. Regression and partition trees are used to analyze factors that influence the measures of the friendly frigate's survivability and number of enemy casualties. This study also investigates the use of a prospective ship-based unmanned aerial vehicle (UAV) in AAW operations. We find that the inclusion of Point Defense Missile Systems with long and medium range surface-to-air missiles has the most positive effects on ship survivability. By contrast, we find inclusion of a UAV in this mission has little effect. [Full Text](#)

Keywords: agent-based modeling, anti-air warfare (AAW), weapon selection, unmanned aerial vehicle, simulation, design of experiments, combat systems

**OPTIMIZATION OF MARINE FORCES RESERVE EQUIPMENT REDISTRIBUTION**

**Nicolas Martinez–Major, United States Marine Corps**

**Master of Science in Operations Research**

**Advisor: Javier Salmeron, Department of Operations Research**

**Second Reader: Robert McGuiness, Marine Forces Reserve**

This research creates the Marine Corps Equipment Redistribution Model (MCERM). MCERM is a mathematical optimization model that can be used as a decision-support prototype to guide Marine Forces Reserve (MARFORRES) in planning asset redistribution to satisfy subordinate units' training and equipping requirements. MCERM implements a mixed-integer, linear program that selects sets of equipment transfers between units in order to raise overall readiness for priority units. MCERM optimally minimizes both (a) a function of transit distance and equipment size to transfer equipment to a unit (used as a surrogate for actual transfer cost), and (b) inventory shortages. MCERM allows planners to influence recommended transfers by (a) placing a weighted penalty on transfers that cross between commands, and (b) increasing the shortage penalty over the transfer penalty. It also enables the use of substitute equipment at an additional penalty. A realistic test case analyzes all equipment to unit ownerships reported by MARFORRES on April 22, 2016. From the results, MCERM's recommended transfers decreased the overall shortage penalty by a large margin while incurring a relatively low transfer penalty. This prototype enables planners to review the entire MARFORRES equipment redistribution problem, select optimized solutions, and perform fast sensitivity analysis on the competing objectives. [Full Text](#)

Keywords: optimization, Marine Forces Reserve, redistribution, reallocation, equipment supply, logistics

**IDENTIFYING U.S. MARINE CORPS RECRUIT CHARACTERISTICS THAT  
CORRESPOND TO SUCCESS IN SPECIFIC OCCUPATIONAL FIELDS**

*The following paper has been recognized as outstanding by its department*

**Ben McCaleb–Captain, United States Marine Corps**

**Master of Science in Operations Research**

**Advisor: Robert Koyak, Department of Operations Research**

**Second Reader: Chad Seagren, Graduate School of Business and Public Policy**

This thesis investigates how Marine recruit information available at entry can be used to predict which occupational field (OCCFLD) is best suited to an individual and if a Marine will successfully complete the first term of enlistment. Multinomial regression models are developed to calculate estimated probabilities that a given recruit will attain United States Marine Corps (USMC) Computed Reenlistment Tiers I, II, III, or IV in a particular OCCFLD. Optimization of OCCFLD assignment based on the developed models illustrates the potential value of insight gained from recruit information available prior to enlistment. The relationship of recruit characteristics available prior to enlistment and the USMC Computed Tier Score assigned in the last year of a Marine's first enlistment is dependent upon the OCCFLD assigned. We recommend identifying OCCFLDs with the highest estimated probabilities of Tier I or Tier II attainment at the recruitment phase. Providing recruits and recruiters a tool that provides estimated probabilities of attaining Tier I or Tier II in descending order for each OCCFLD during initial assignment has the potential to increase the caliber of Marines across all OCCFLDs and to aid in assessing the current OCCFLD assignment practices. [Full Text](#)

Keywords: assignment, ASVAB, first term enlistment, MOS, Multinomial Elastinet Regression, OCCFLD

**ANALYSIS OF REGIONAL EFFECTS ON MARKET SEGMENT PRODUCTION**

**James Moffitt—Captain, United States Army**

**Master of Science in Operations Research**

**Advisor: Lyn Whitaker, Department of Operations Research**

**Co-Advisor: Jonathan Alt, Department of Operations Research**

**Second Reader: Jeffrey House, Department of Operations Research**

This thesis develops a data-driven statistical model capable of identifying regional factors that affect the number of United States Army Recruiting Command (USAREC) accessions in Potential Rating Index Zip Code Market New Evolution (PRIZM NE) market segments. This model will aid USAREC G2 analysts involved in conducting recruiting market intelligence. Market intelligence helps the commander visualize the performance of subordinate units within their market and provides recommendations for use and expansion. This thesis first attempts to establish that a single high-assessing PRIZM NE market segment, Segment 32, does not access recruits at the same rate across regions. This thesis then develops general linear regression and gradient boosted decision tree models to determine the regional factors that contribute to the variance of recruit production. In particular, the gradient boosted decision tree delivers predictive results that allow analysts to identify regions that have underperforming accession rates compared to the national average. The recommendation of this thesis is that the USAREC implement the gradient boosted decision trees for use in G2 market analysis. [Full Text](#)

Keywords: recruiting, market segmentation, PRIZM NE, Poisson regression, gradient boosted decision tree

**MODELING ANTI-AIR WARFARE WITH DISCRETE EVENT  
SIMULATION AND ANALYZING NAVAL CONVOY OPERATIONS**

**Ali Opcin—Lieutenant Junior Grade, Turkish Navy**

**Master of Science in Modeling, Virtual Environments, and Simulation  
and Master of Science in Operations Research**

**Advisor: Arnold Buss, MOVES Institute**

**Co-Advisor: Thomas Lucas, Department of Operations Research**

**Second Reader: Paul Sanchez, Department of Operations Research**

Anti-air warfare (AAW) is a primary naval warfare area. Using AAW tactics and concepts of operations, this research explores the most critical success factors of convoy operations. In this study, a discrete event simulation (DES) was built by modeling ships, and their sensors and weapons, to simulate convoy operations under air threat. Where classified data was unavailable, assumptions were made and approximations were used in constructing the ships, weapons, and sensors. The model was used to simulate over 1.5 million naval battles varying 99 input variables using sophisticated and systematically created data combinations. To select the input settings over a specific range of input variables, a nearly orthogonal nearly balanced (NOB) Latin hypercube design was used. The effects of these input changes on the outputs were analyzed using partition trees and nominal logistic regression. The primary response variable was the survival of the High Value Unit (HVU) as a binary outcome. According to the analysis, in a convoy operation under air threat, the surface-to-air missile (SAM) specifications of the screen ships, the staying power of the HVU, and the anti-ship missile (ASM) specifications of the enemy ships had the most significant effect on the survival of the HVU. [Full Text](#)

Keywords: discrete event simulation, modeling anti-air warfare, Simkit, component based approach, layered defense systems, formation movements, design of experiments, simulation output analysis

**USING DISCRETE-EVENT SIMULATION TO ANALYZE PERSONNEL REQUIREMENTS  
FOR THE MALAYSIAN ARMY'S NEW UTILITY HELICOPTER FLEET**

**Hasnan bin Mohamad Rais—Major, Malaysian Army  
Master of Science in Operations Research**

**Advisor: Dashi Singham, Department of Operations Research**

**Co-Advisor: Jeffrey House, Department of Operations Research**

**Second Reader: Connor McLemore, Operations Analysis Program Office**

This thesis describes the analysis used to determine personnel requirements for the Malaysian Army's S61A-4 utility helicopter fleet. We use discrete-event simulation (DES) to model maintenance activities in the Malaysian Army Aviation (MAA) fleet in order to evaluate the impact of maintenance crew resources on helicopter availability. Our model simulates the normal daily operating activities in the MAA environment and includes the size of the fleet, fleet flying operations, and maintenance activities including daily inspection, rectification, and scheduled maintenance. A ranking and selection (R&S) method is used to select the best system or a subset that contains the best system design from the competing alternatives. The outputs of this paper provide the Malaysian Army Human Resource department an ability to allocate the appropriate number of personnel for the new fleet. [Full Text](#)

Keywords: discrete-event simulation, Malaysian Army Aviation, MAA, helicopter fleet, maintenance, personnel requirements, ranking and selection, subsets

**DUAL APPROACH TO SUPERQUANTILE ESTIMATION  
AND APPLICATIONS TO DENSITY FITTING**

**John Sabol—Captain, United States Marine Corps  
Master of Science in Operations Research**

**Advisor: Johannes Royset, Department of Operations Research**

**Second Reader: Samuel Buttrey, Department of Operations Research**

Analysts often concern themselves with the tail regions of distributions, sometimes called extreme events, in order to measure or predict risk. One risk metric, the superquantile, possesses several properties that make it particularly well-suited for risk quantification. Observable data, however, often lack information on extreme events due to various resource constraints, resulting in sample superquantile estimates that often undervalue the true level of risk. By leveraging the dual relationship between superquantiles and superexpectations, we apply constrained optimization on second-order epi-splines to arrive at incrementally better approximations of superquantile values. With these improved estimates, we incorporate additional constraints to improve the fidelity of density estimates in tail regions. We limit our investigation to data with heavy tails, where risk quantification is typically the most difficult. Demonstrations are provided in the form of a known distributional benchmark, historical financial data, and a fluid dynamics model used in the development of a high-speed naval vessel. Results show that accurate quantile and superquantile constraint implementation, in conjunction with empirical statistics and distributional knowledge, can improve tail density estimates by up to 15% for small samples of various heavy-tailed distributions. [Full Text](#)

Keywords: probability density estimation, epi-splines, optimization, risk quantification, superquantiles, non-parametric statistics

### **A SPATIAL ANALYSIS AND GAME THEORETICAL APPROACH OVER THE DISPUTED ISLANDS IN THE AEGEAN SEA**

**Samet Salin–Lieutenant Junior Grade, Turkish Naval Forces**

**Master of Science in Operations Research**

**Advisor: Kyle Lin, Department of Operations Research**

**Second Reader: Lyn Whitaker, Department of Operations Research**

Throughout history, the Aegean Sea has been a sea of crisis. Today, Turkey and Greece--the two countries surrounding the Aegean Sea--continue to dispute several issues regarding the Aegean. The most significant dispute is over the sovereignty of several islands. This research presents a method to produce an arbitration solution to allocate these disputed islands between the two countries. We identify 39 disputed islands and six important attributes for each island, including perimeter, area, population, distance to Greece, distance to Turkey, and territorial water area. After applying spatial analysis to two open-source maps, we apply utility theory, the Analytical Hierarchy Process, and the Nash arbitration scheme to propose an arbitration solution. The arbitration solution tends to allocate to Turkey those islands with larger areas of territorial waters and greater proximity to the Turkish mainland, and allocate to Greece those islands with larger population and greater proximity to the Greek mainland. [Full Text](#)

Keywords: spatial analysis, game theory, Nash arbitration scheme, Aegean, disputed islands, territorial waters, utilization, Turkey, Greece, bargaining problem, analytical hierarchy process

### **ANALYSIS OF PROTECTION MEASURES FOR NAVAL VESSELS BERTHED AT HARBOR AGAINST TERRORIST ATTACKS**

**Raja Sikandar–Lieutenant Commander, Pakistan Navy**

**Master of Science in Operations Research**

**Advisor: Thomas Lucas, Department of Operations Research**

**Second Reader: Jeffrey Kline, Department of Operations Research**

The defense of a naval ship berthed in a harbor is a complex task affected by many factors. These include the fishing vessel density close to the ship and the challenge of discriminating neutral vessels from threats. A naval vessel berthed at harbor is more susceptible to attack than a vessel in open seas. The chances of detecting and countering a terrorist boat vary widely depending on several factors, including early identification of the attack and weapons available. This research uses modeling in Map Aware Non-uniform Automata (MANA) to analyze the protection measures adopted by naval vessels against terrorist boats. The experiments were designed to efficiently generate data, which was then replicated using high-performance computing, to address a wide range of possibilities and outcomes. The data generated were analyzed using a variety of techniques. The study concluded that lethality of Blue weapons is the most important factor in determining Blue's ability to counter a Red suicide boat attack. Additionally, the tactic of firing a warning shot followed by disabling shots within the exclusion zone decreases Blue's success probability. Finally, an exclusion zone of at least 60 meters that is enforced with a patrol boat is recommended. [Full Text](#)

Keywords: simulation, agent-based, design of experiments, force protection, ship self-defense

**NEW PERSPECTIVES ON INTELLIGENCE COLLECTION AND PROCESSING**

**Muhammet Tekin—Captain, Turkish Army**

**Master of Science in Operations Research**

**Advisor: Roberto Szechtman, Department of Operations Research**

**Second Reader: Michael Atkinson, Department of Operations Research**

Intelligence-production activities are typically viewed as part of an intelligence cycle, consisting of planning, collection, processing, analysis, and dissemination stages. Once a request for information is issued, the intelligence agencies mostly deal with the collection and processing activities of the cycle. However, in most situations, there is an enormous amount of data to be collected. This overabundance of information requires methods that select only the useful data, to prevent intelligence personnel from wasting time and effort on non-relevant data. Online learning is an area of research that has gained attention in recent years with applications in areas such as web advertising, classification, and decision making. In this thesis, we develop a model aimed at the collection and processing phases of the intelligence cycle, applicable in situations where the data is obtained sequentially, so that learning algorithms are realistic. We analyze the performance of a modified Thompson Sampling algorithm, to help intelligence analysts make good decisions, regarding the sources from which to collect/process as well as the collection/processing capacity and its allocation over time, in order to bind the risk of missing valuable information below a certain threshold. [Full Text](#)

Keywords: online learning, Thompson Sampling, intelligence collection

**IMPROVING DEPARTMENT OF DEFENSE GLOBAL DISTRIBUTION  
PERFORMANCE THROUGH NETWORK ANALYSIS**

**Justin Thompson—Captain, United States Army**

**Master of Science in Operations Research**

**Advisor: Samuel Buttrey, Department of Operations Research**

**Co-Advisor: Jonathan Alt, Department of Operations Research**

**Second Reader: Jeffrey House, Department of Operations Research**

In October 2015, the United States Transportation Command (USTRANSCOM) implemented a new global shipping performance assessment method. USTRANSCOM assesses shipping lane performance by analyzing the distribution of the start-to-finish shipping time for all requisitions during a given time period and comparing the 85th quantile to an established time standard for the lane. The command assesses overall network performance using the total number of shipping lanes that perform better than the standard. Previously, USTRANSCOM grouped shipping lanes according to shipping method and destination with no consideration given the origin. The new method includes the origin information. Using parametric and non-parametric statistical tests and data analysis techniques, we show that the addition of requisition origin information enables more accurate analysis of the shipping network. Optimization provides node improvement recommendations. We find that focusing improvement on commercial air and military air shipments provide the greatest overall network performance increase. [Full Text](#)

Keywords: supply chain metrics, distribution networks, requisition shipping time, strategic distribution database, nonparametric analysis, linear optimization

**OPTIMIZATION OF USMC HORNET INVENTORY**

*The following paper has been recognized as outstanding by its department*

**Gregory Zerr—Captain, United States Marine Corps**

**Master of Science in Operations Research**

**Advisor: W. Matthew Carlyle, Department of Operations Research**

**Co-Advisor: Robert Dell, Department of Operations Research**

The 2016 United States Marine Corps (USMC) Aviation Plan establishes the timeline to transition all F/A-18 Hornet squadrons to the F-35 Joint Strike Fighter. Ensuring Hornets can continue to support operational requirements during this transition is a challenge. In this thesis we address the management of the USMC Hornet inventory by developing, implementing, and testing an integer linear program called Hornet Assignment Sundown Model (HASM). HASM prescribes each individual Hornet's monthly squadron assignment, utilization, maintenance, storage, and retirement over its remaining service life while ensuring each squadron satisfies (to the extent possible) monthly flight hour requirements. To test HASM, this thesis develops forecasts of monthly squadron flight hour requirements and readiness rates from randomly and uniformly generated values using median performance with noise as inputs. Computational analysis using unclassified information on the USMC Hornet inventory demonstrates HASM's ability to illustrate the impact of management strategies on meeting future requirements. This thesis identifies future shortfalls and assesses requirement reductions to mitigate them so that resources can be applied to efficiently and effectively preserve the combat capability of the Marine Corps Air Ground Task Force. [Full Text](#)

Keywords: F/A-18 Hornet, integer linear programming, optimization, cascade, rolling horizon, aircraft maintenance, inventory management

# MASTER OF SCIENCE IN PHYSICAL OCEANOGRAPHY

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## AN ANALYSIS OF THE BEAUFORT SEA THERMOHALINE STRUCTURE AND VARIABILITY, AND ITS EFFECTS ON ACOUSTIC PROPAGATION

Annalise Pearson—Lieutenant Commander, Royal Australian Navy

Master of Science in Physical Oceanography

Advisor: John Colosi, Department of Oceanography

Second Reader: John Joseph, Department of Oceanography

This thesis provides an analysis of spatial and temporal thermohaline variations of the Canada Basin in the Western Arctic and examines how these variations affect sound speed fields and acoustic propagation. In recent decades, changes in the Arctic water column have been underway as a result of climate change, including reduced sea ice and changes in transports between the Pacific and Atlantic oceans. These changes were studied and analyzed using observational data collected from the Canada Basin Acoustic Propagation Experiment (CANAPE), conducted in the summer of 2015. The thermohaline sound speed structure was examined by computing isopycnal displacements, which allowed separation of internal waves and eddies from intrusive thermohaline structure or spice. Temporal structure of these processes was estimated using spectral analysis, and vertical structure was examined by computing the rms variation of the various processes as a function of depth. Observations were compared to climatology. Acoustic propagation simulations using a ray-based model termed Bellhop were used to estimate the acoustic sensitivity to the observed ocean structure. It was found that internal waves were weak compared to the Garret Munk spectrum and that spice is surprisingly strong in the ocean structure with dominance in the upper 100m. The acoustic analysis revealed that a greater variability in transmission loss in the CTD CANAPE data was evident compared to climatology and previous observations, particularly at greater frequencies and range. The presence of a sub-surface sound speed duct existed with an axis at  $\sim 120\text{m}$  and accommodated an environment with increased travel distance for acoustic energy and lower transmission loss for depths between 100–200m. [Full Text](#)

Keywords: polar oceanography, Beaufort Sea, thermohaline sound speed structure, climate change, Arctic sea ice extent, acoustic propagation, Arctic acoustics





# MASTER OF SCIENCE IN PHYSICS

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## NONLINEAR EFFECTS IN TRANSFORMATION OPTICS-BASED METAMATERIAL SHIELDS FOR COUNTER DIRECTED ENERGY WEAPON DEFENSE

*The following paper has been recognized as outstanding by its department*

**Jacob Thompson—Lieutenant, United States Navy**

**Master of Science in Physics**

**Advisor: James Luscombe, Department of Physics**

**Co-Advisor: Brett Borden, Department of Physics**

Transformation optics is the current method used to design metamaterial structures that manipulate the path of electromagnetic radiation. This approach, however, relies upon a completely linear response of the polarization and magnetization fields with respect to incident electromagnetic field intensities. As those field intensities rise, such as from a hypothetical directed energy weapon, nonlinear effects, which are unaccounted for in a completely linear theory, are observed. In order to investigate the behavior of a transformation optics-derived structure in such a high-field intensity regime, we propose to employ an iterative solution to the Maxwell equations for such a structure, and compare these results to those of the purely linear transformation optics model. Examining the first-order results of this approach, we observe a strong dependence of response field amplitude upon the wavelength of incident radiation. [Full Text](#)

Keywords: transformation optics, counter-directed energy weapons, metamaterials, electrodynamics, coordinate transformations



# MASTER OF SCIENCE IN SPACE SYSTEMS OPERATIONS

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## **TECHNIQUE FOR GEOLOCATION OF EMI EMITTERS BY O3B SATELLITES**

**James Connolly—Captain, United States Marine Corps**

**Master of Science in Space Systems Operations**

**Advisor: Charles Racoosin, Space Systems Academic Group**

**Second Reader: Herschel Loomis, Department of Electrical and Computer Engineering**

This thesis investigates how and to what effectiveness the O3b commercial satellite constellation could be used for geolocation of Ka-band EMI sources in support of the Department of Defense (DOD). Review of commonly used geolocation techniques for suitability and comparison of those with the O3b constellation characteristics shows that a new method of geolocation is necessary and possible. A method using the Doppler effect with frequency data from a single antenna was then created that is compatible with O3b. This method uses the received frequency of the jammer over time to detect the base frequency, and then compares the received frequency to that of simulated emitters at known locations in order to provide a geolocation for EMI emitters. This was modeled to be accurate within 16 km throughout O3b's service area. This level of accuracy would provide the ability to mitigate the interference or decrease a search area for assets with higher capabilities in order to increase their efficiency of tasking/use. This method is of further benefit to the DOD due to its potential to be low cost, be maintained as an organic capability by the units, and decrease the time necessary to reach a conclusion when working through the Joint Spectrum Interference Resolution process. [Full Text](#)

Keywords: geolocation, interference, SATCOM, O3b



# MASTER OF SCIENCE IN SYSTEMS ENGINEERING

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The following theses and capstone project reports were produced by residential or distance-learning students in the systems-engineering curriculum. The degrees awarded include Masters of Science in Systems Engineering, Systems Engineering Management, and Engineering Systems.

## **EXPLORING THE INTEGRATION OF COSYSMO WITH A MODEL-BASED SYSTEMS ENGINEERING METHODOLOGY IN EARLY TRADE SPACE ANALYTICS AND DECISIONS**

**Dennis Edwards—Captain, United States Army**

**Master of Science in Systems Engineering**

**Advisor: Raymond Madachy, Department of Systems Engineering**

**Second Reader: John Green, Department of Systems Engineering**

This research explores the integration of the Constructive Systems Engineering Cost Model (COSYSMO) into early modeling efforts for the Department of Defense (DOD). Initial acquisition decisions influence the analysis and design of systems engineers, who face an increasingly complex and dynamic environment with significant impact on system life-cycle decisions and cost. This work utilizes a model-based systems engineering (MBSE) approach and the systems modeling language (SysML) to highlight the sharing of system model data with COSYSMO to provide an estimate of systems engineering costs. The document highlights the proposed methods compliance to cost estimation techniques, adherence and support to pre-Milestone A requirements of the DOD acquisitions process, and links to the Department of Defense Architectural Framework (DODAF). Application and documentation of the author's methods include a commonly used humanitarian aid effort scenario that incorporates traditional systems functional analysis of a single water distiller. The work's results demonstrate an ability for automated and semi-automated integration with COSYSMO from the system model in a web-based tool, conclude with challenges associated with external cost model integration, and suggest future areas of continued refinement and extensions. A starting point for an ensemble of models to enhance DOD cost estimation practices results from the techniques. [Full Text](#)

Keywords: COSYSMO, DODAF, MBSE, SysML

## **CONCEPTUAL AND PRELIMINARY DESIGN OF A LOW- COST PRECISION AERIAL DELIVERY SYSTEM**

**Andrew Hall—Commander, United States Navy**

**Master of Science in Systems Engineering**

**Advisor: Oleg Yakimenko, Department of Systems Engineering**

**Second Reader: Fotis Papoulias, Department of Systems Engineering**

The U.S. Army and U.S. Air Force have interest in the development of a Joint Precision Aerial Delivery System (JPADS) that could remotely and accurately resupply dispersed and geographically isolated ground forces. The Marine Corps has requested options that offer increased accuracy, lighter payloads, greater stand-off distances and reduced cost. To date, most research has resulted in a series of large, expensive and platform-specific solutions, which do not capitalize on the enhanced range and capability afforded by existing and commercially available unmanned aerial system technology. The systems engineering processes contained in the conceptual

and preliminary design phases are utilized to investigate and develop a potentially low-cost alternative to existing systems. Using an Agile methodology, individual components are designed and incorporated into an integrated aerial system that utilizes an autonomously guided and controlled ram-air parachute delivered from an unmanned aerial platform. Employment of the low-cost micro-light weight class of JPADS has the potential to provide all services with a near-term platform to remotely deliver diverse logistical and sensor payloads while minimizing risk to forces. [Full Text](#)

Keywords: conceptual design, preliminary design, Agile methodology, autonomous navigation, precision aerial delivery, parachute, control

### **SYSTEM ARCHITECTURE FOR LOGISTICS OF A DISTRIBUTED NAVAL SURFACE FORCE**

**Travis Harlow—Lieutenant, United States Navy**

**Master of Science in Systems Engineering**

**Advisor: Eugene Paulo, Department of Systems Engineering**

**Co-Advisor: Paul Beery, Department of Systems Engineering**

The U.S. Navy is committed to conducting offensive operations via a new warfighting concept known as Distributed Lethality. Several articles, blogs, conferences, and task forces provide varying opinions on how one should define Distributed Lethality. This thesis examines the logistical component of Distributed Lethality and provides structure to the concept via the creation of an architectural framework. The methodology for creating this architecture includes portions of the traditional systems engineering process along with model based systems engineering (MBSE) and the Department of Defense Architectural Framework (DODAF) v2.0 schema. Requirements are derived from the stakeholder analysis and then connected to the necessary capabilities to fulfill those requirements. From the capabilities, a variety of operational vignettes—focused on logistical support—are used to identify the necessary operational architecture to support a distributed force. Finally, the operational architecture is decomposed to the underwriting functions that are connected to components and performers for mission execution. In conclusion, the stakeholder is provided with a fully traceable, flexible, and scalable architecture to aid in codifying the Distributed Lethality concept. Recommendations for follow-on research are to focus on identifying the measures of performance and effectiveness of the architecture by linking it to a model for simulation. [Full Text](#)

Keywords: model based systems engineering, Department of Defense Architectural Framework, system architecture, distributed lethality, adaptive force package, aircraft carrier, littoral combat ship, guided missile destroyer, oiler

### **A SYSTEMS ARCHITECTURE FOR OPERATIONAL DISTRIBUTED LETHALITY**

**Clay Johnson—Lieutenant Commander, United States Navy**

**Master of Science in Systems Engineering**

**Advisor: Eugene Paulo, Department of Systems Engineering**

**Second Reader: Paul Beery, Department of Systems Engineering**

Distributed Lethality is a new concept in Surface Warfare that involves using small groups of surface combatants to go on the offensive against the enemy. This new concept requires structure and definition, and building a systems architecture for it is an effective way to provide both. This thesis investigates and defines the core requirements of Distributed Lethality and the capabilities that are necessary to meet these requirements. It builds an example mission flow for a Distributed Lethality scenario, and then defines the functions necessary to implement this flow. Finally, the model includes the components that perform the identified functions. The systems architecture for operational Distributed Lethality clearly demonstrates the connections and relationships between each element of the model, allowing for clear traceability from the smallest component to the

originating requirement. This systems architecture for operational Distributed Lethality builds the foundation for future Distributed Lethality research and will power operational simulations and wargames. [Full Text](#)

Keywords: Distributed Lethality, systems architecture, model based systems engineering, Surface Warfare

### **SYSTEM BEHAVIOR MODELS: A SURVEY OF APPROACHES**

**Scott Ruppel–Civilian, Department of the Navy**

**Master of Science in Systems Engineering Management**

**Advisor: Kristin Giammarco, Department of Systems Engineering**

**Second Reader: John Green, Department of Systems Engineering**

Human-designed systems are growing in complexity, with increasing numbers of components and behavior combinations, resulting in more emergent and unintended behaviors evident in operations. This thesis explores various behavior modeling approaches and their potential for exposing emergent behaviors, highlighting trends and modeling approaches. The report defines key concepts and provides a context for a comparative analysis of approaches. In particular, this report assesses a relatively new approach to behavior and architecture modeling, Monterey Phoenix (MP), and compares it with Petri nets, a well-established method. The comparison involves a simple communication process between two components, which is modeled and compared to an equivalent Petri net model. Shared outcomes involve a successful communication between the components and failure modes of the components not receiving or processing data. The models produce identical state space results. The combined state space graph of the Petri model allowed a quick assessment of all potential states but was more cumbersome to build than the MP model. A comparison of approaches charts the modeling methods against the key concepts, revealing the differences among methods, contrasted with the aspects of MP. [Full Text](#)

Keywords: Monterey Phoenix, Petri nets, behavior modeling, model-based systems engineering, modeling approaches, modeling survey

### **A SEAKEEPING PERFORMANCE AND AFFORDABILITY TRADEOFF STUDY FOR THE COAST GUARD OFFSHORE PATROL CUTTER**

**Paul Schmitz–Lieutenant, United States Coast Guard**

**Master of Science in Systems Engineering**

**Advisor: Fotis Papoulias, Department of Systems Engineering**

**Second Reader: Clifford Whitcomb, Department of Systems Engineering**

The United States Coast Guard Offshore Patrol Cutter program requires a method to analyze trades made between performance and affordability. Models of seakeeping performance were developed using linear seakeeping analysis, and a cost model was adopted from previous research. Both models were integrated into a decision support tool. Entering a notional Offshore Patrol Cutter design into the tool revealed that the program would likely perform well but could have a high cost risk. The decision support tool connects the two competing ideas of seakeeping performance and system affordability for program managers, while allowing different designs to be tested. Additional research into this topic should consider using more accurate seakeeping analysis techniques to create more accurate seakeeping performance prediction models. [Full Text](#)

Keywords: seakeeping, U.S. Coast Guard, Offshore Patrol Cutter



**A FEASIBILITY ASSESSMENT OF 6LOWPAN FOR SECURE  
COMMUNICATIONS IN THE U.S. ARMY**

**Alan Stephens—Major, United States Army  
Master of Science in Systems Engineering**

**Advisor: Gregory Miller, Department of Systems Engineering**

**Co-Advisor: Preetha Thulasiraman, Department of Electrical and Computer Engineering**

This thesis uses systems engineering techniques to assess the feasibility for the United States Army to use IPv6 securely over an IEEE standard 802.15.4 (6LoWPAN) network in both an operational and a support role. The methods used include assessing the limitations and security mechanisms of 6LoWPAN, assessing wireless security concerns, small battery capacity and duration, and the remaining potential for use in both environments. The same model could apply to other protocols or capabilities given operational requirements. Expected operational situations aid in identification of requirements. The two operational scenarios examined in this thesis indicate 6LoWPAN could provide value and meet technical requirements in a support environment such as a combat hospital, but analysis of a tactical situation such as replacing an AN/PRC-154A radio for Nett Warrior backhaul indicates its implementation would be problematic. Specifically, in the generalized tactical role, 6LoWPAN devices with a standard AAA rechargeable battery exhibit a lifetime of 11.7 hours or 15.3 hours with a standard AA rechargeable battery and 2.45-inch device length transmitting at -2 dBm. The required encryption standards and layered protocol stack headers result in message payload limits, the worst-case being 45 bytes of data. Reliable voice communications are not feasible over 6LoWPAN's limited bandwidth. [Full Text](#)

Keywords: LoWPAN, 6LoWPAN, 802.15.4, energy, security, feasibility, wireless, networks, range, duration, wireless security, BFT, systems engineering, requirements, Army

**UNMANNED SYSTEMS IN INTEGRATING CROSS-DOMAIN NAVAL FIRES**

**Systems Engineering Analysis, Cohort 23**

**Master of Science in Systems Engineering Analysis**

**Advisor: Fotis Papoulias, Department of Systems Engineering**

**Co-Advisor: Michael Atkinson, Department of Operations Research**

The ability to communicate and transmit targeting data via the electromagnetic spectrum is crucial to the U.S. Navy's ability to fight. However, in recent years, potential adversaries have significantly advanced their electronic warfare capabilities, obtaining an ability to interfere with the Navy's use of the electromagnetic spectrum during operations in contested environments. SEA23 investigates concepts of operation focusing on future potential electromagnetic-spectrum warfighting capabilities in the 2025–2030 timeframe. Specifically, we explore these capabilities using modular unmanned and manned platforms capable of carrying communications and data suites to enable cross-domain targeting information in support of tactical offensive operations in a contested, denied, degraded, intermittent, and limited-bandwidth environment. This project focuses on developing a system-of-systems architecture and analyzing alternatives to provide potential solutions while developing the associated concepts of operation. We recommend an architecture based on Link 16 and organic rotary-wing unmanned aerial vehicles to transfer sensor to shooter data in demanding and contested environments. [Full Text](#)

Keywords: unmanned systems, cross domain, unmanned aerial vehicles, naval fires, targeting, distributed lethality, anti-access, area denial; denied, disrupted, degraded, low-bandwidth environment

# MASTER OF SCIENCE IN SYSTEMS TECHNOLOGY

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## **BUILDING A FOUNDATION FOR THE IMPLEMENTATION OF AN ENTERPRISE ARCHITECTURE FOR THE ARGENTINIAN ARMY**

**Andres Orabona–Lieutenant Colonel, Argentinian Army**

**Master of Science in Systems Technology (Command, Control and Communications)**

**Advisor: Glenn Cook, Department of Information Sciences**

**Second Reader: Steve Iatrou, Department of Information Sciences**

Every organization has four layers that connect its vision, goals, scopes, and ideals to their execution through the data, processes, applications, and technology used. In recent years, technology has been considered as the answer to every problem. For every problem, technology could find a particular solution. Different results, however, have been obtained by many organizations. Many enterprises that initially were successful failed to maintain the pace; others managed to thrive in an increasingly competitive environment made up of an increasingly demanding public. Recently, some methodologies have been developed to assess how an organization can improve its overall performance and gain capabilities. In this way, an organization is less flexible but stronger and more agile. This can be done by getting a holistic view of the organization and achieving a blueprint, in order to align the four layers that compose an organization. The purpose of this thesis is to explore how these methodologies can be implemented in the Argentinian Army, what benefits can be obtained from them, and how they would impact the organization. The Argentinian Army wants to be a modern organization. Implementing modern organizational methodologies is a way to achieve the desired final state. [Full Text](#)

Keywords: enterprise architecture, Argentinian Army, operational model, foundation for execution, information technology, chief information officer, public administration

## **UNMANNED TACTICAL AUTONOMOUS CONTROL AND COLLABORATION COACTIVE DESIGN**

*The following paper has been recognized as outstanding by its department*

**Matthew Zach–Captain, United States Marine Corps**

**Master of Science in Systems Technology (Command, Control and Communications)**

**Advisor: Dan Boger, Department of Information Sciences**

**Second Reader: Scot Miller, Department of Information Sciences**

Unmanned tactical autonomous control and collaboration (UTACC) is a Marine Corps experimental research initiative with the overarching aim of developing a collaborative human-robotic system of systems (SoS). This thesis analyzed the results of the existing UTACC concept development and incorporated them into an emergent human-robotic system development method, Coactive Design. An advantage to using this method is that it includes the human and his or her internal processes when modeling the system. As such, the focus is shifted to supplementing team capacities vice developing autonomy. The two aims of this thesis are (1) to provide a recommendation for incorporating the Coactive Design method into the systems' development life cycle and (2) to provide a list of design requirements for a resilient UTACC SoS. Resilience is realized by designing for flexibility. A teamwork infrastructure built on many interdependent relationships provides this flexibility. These interdependent relationships can be grouped into three areas: observability, predictability, and directability. Counter to conventional practices within the robotics industry, Coactive Design focuses on managing these interdependencies rather than focusing on autonomy. Coactive Design also provides a

cost-benefit analysis of development choices, which assists with developing efficiencies during the design and development of the system. [Full Text](#)

Keywords: UTACC, autonomy, coactive design, joint teaming, human-machine collaboration, information and data exchange requirements, observability, predictability, directability





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