

Naval Postgraduate School  
Monterey, California 93943-5138  
NPS-04-11-005



**Compilation of**

**THESIS ABSTRACTS**

**September 2011**



**Office of the Vice President and Dean of Research**  
**Naval Postgraduate School**

## PREFACE

This publication contains abstracts of unrestricted theses submitted for the degrees doctor of philosophy, master of business administration, master of science, and master of arts for the September 2011 graduation.

This compilation of abstracts of theses is published in order that those interested in the fields represented may have an opportunity to become acquainted with the nature and substance of the student research that has been undertaken. Copies of theses are available for those wishing more detailed information. The procedure for obtaining copies is outlined on the last page of this volume.

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Summary of Research, an annual compilation of research projects and publications, is also available online, at <http://www.nps.edu/Research/SummaryRes.html>. Research News, a monthly newsletter highlighting NPS research, can be found at <http://www.nps.edu/Research/Newsletters.html>.

# INTRODUCTION

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## Mission

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

Increase the combat effectiveness of U.S. and allied armed forces and enhance the security of the United States of America through advanced education and research programs focused on the technical, analytical, and managerial tools needed to confront defense-related challenges of the future.

To fulfill its mission, the Naval Postgraduate School strives to sustain excellence in the quality of its instructional programs, to be responsive to technological change and innovation in the Navy, and to prepare officers to introduce and utilize future technologies.

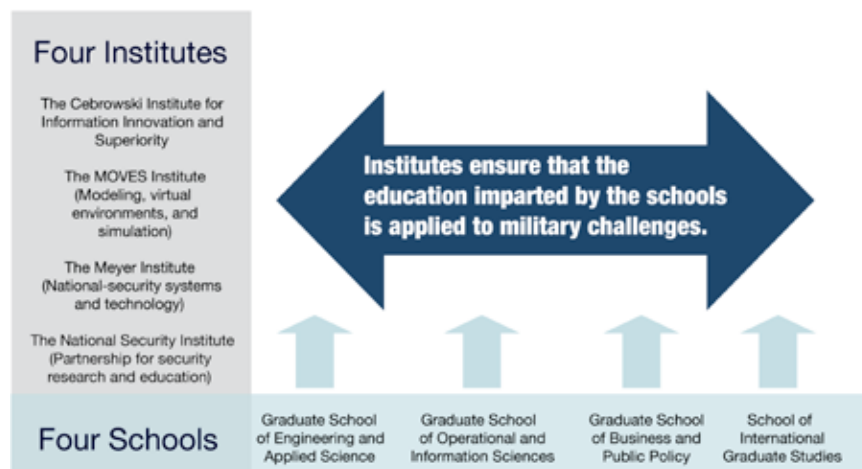
The research program at NPS exists to support the primary mission of graduate education. Research at NPS: maintains upper-division course content and programs at cutting edge; challenges students with creative problem solving experiences on DoD-relevant issues; advances DoN/DoD technology; solves warfare problems; and attracts and retains quality faculty.

## Academic Programs

To meet its educational requirements, the Navy has developed a unique academic institution at the Naval Postgraduate School through the use of specially tailored academic programs, and a distinctive organization tying academic disciplines to naval and joint warfighting applications.

The Naval Postgraduate School has aligned its education and supporting research programs to achieve three major goals: 1) academic programs that are nationally recognized and support the current and future 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 of

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## INTRODUCTION

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education and research in support of current and emerging national security technologies and operations, and 3) executive and continuing education programs that support continuous intellectual innovation and growth throughout an officer's career. Programs of graduate studies at NPS are grouped as follows:

### **Graduate School of Operational and Information Sciences**

- Computer Science
- Computer Technology
- Electronic Warfare Systems
- Human Systems Integration
- Information Sciences
- Information Systems and Operations
- Information Systems and Technology
- Information Warfare
- Joint C4I Systems
- Joint Information Operations
- Modeling, Virtual Environments, and Simulation
- Operations Analysis
- Operational Logistics, Joint
- Software Engineering
- Special Operations and Irregular Warfare
- Systems Analysis

### **Graduate School of Engineering and Applied Sciences**

- Applied Mathematics
- Combat Systems Science and Technology
- Electronic Systems Engineering
- Meteorology
- Meteorology and Oceanography
- Naval/Mechanical Engineering
- Oceanography
- Operational Oceanography
- Reactors–Mechanical/Electrical Engineering
- Space Systems Engineering
- Space Systems Operations
- Systems Engineering
- Systems Engineering Management
- Undersea Warfare
- Underwater Acoustic Systems

### **Graduate School of Business and Public Policy**

- Acquisition and Contract Management
- Contract Management
- Executive Management
- Executive Master of Business Administration
- Financial Management
- Information Systems Management
- Defense Business Management
- Defense Systems Analysis
- Defense Systems Management, International
- Material Logistics Support
- Manpower Systems Analysis
- Program Management
- Resource Planning and Management for International Defense
- Supply Chain Management
- Systems Acquisition Management
- Transportation Management

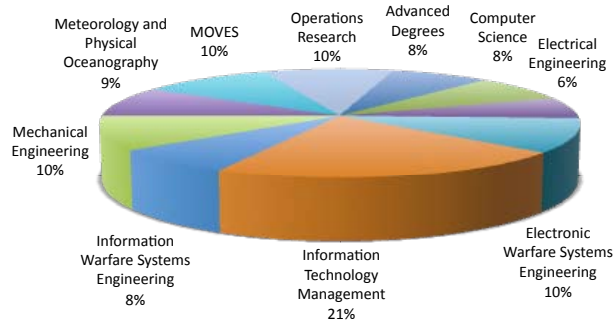
### **School of International Graduate Studies**

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

The student body consists of U.S. officers from all branches of the uniformed services, civilian employees of the federal government, and foreign military officers and government civilians. The resident degree/sub-specialty student population for September 2011 is shown in Figure 1 on the following page.

# INTRODUCTION

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*\*Army Reserve, Army Reserve National Guard, Coast Guard,  
National Oceanographic and Aeronautics Administration*

**Figure 1: Resident Degrees/Subspecialty Student Population for September 2011 (1,545 total)**

## Academic Degrees

Curricula meet defense requirements within the traditional degree framework. All curricula lead to a master's; additional study may yield an engineer's or doctoral degree. Below is a listing of the degrees offered at NPS:

### Master of Arts

- Security Studies

### Master of Business Administration

### Master of Science

- Applied Mathematics
- Applied Physics
- Applied Science
- Astronautical Engineering
- Combat Systems Technology
- Computer Science
- Computing Technology
- Contract Management
- Cost Estimation and Analysis
- 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

### Engineer

- Astronautical Engineer
- Electrical Engineer
- Mechanical Engineer

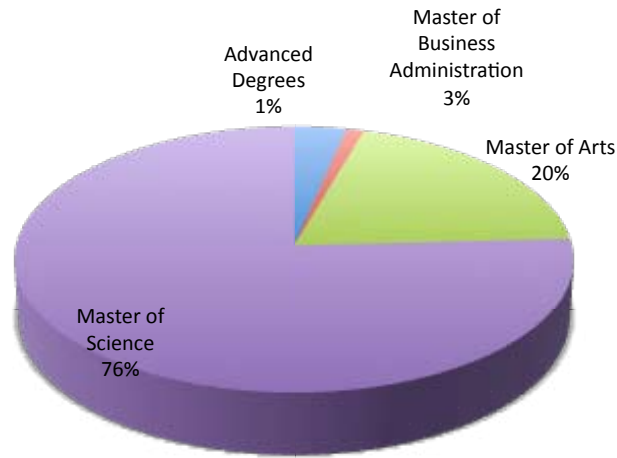
### Doctor of Philosophy

- 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

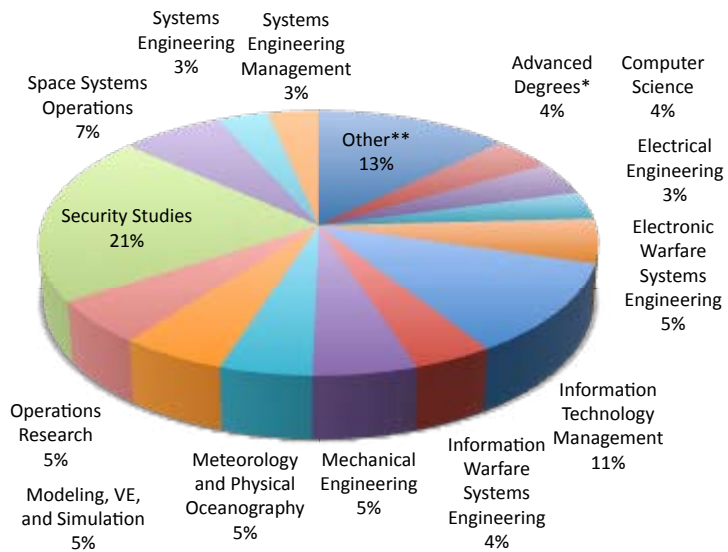
## INTRODUCTION

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In September 2011, 184 degrees were conferred. Figure 2 indicates distribution by type, Figure 3 by degree area.



**Figure 2. Distribution by Degree Type  
(184 Degrees Conferred)**



\* Advanced degrees: doctorate in mechanical engineering (1), meteorology (1), modeling, virtual environments and engineering (2), security studies (1); electrical engineer, mechanical engineer (1)

\*\*Other master's degrees: astronautical engineering (2), applied math (2), applied science (1), business administration (2), contract management (4), defense analysis (1), engineering acoustics (1), engineering science (1), information sciences (1), information systems and operations (1), meteorology and oceanography (2), physical oceanography (2), software engineering (4)

**Figure 3. Degrees Conferred in September 2011  
(184 Degrees Conferred)**

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## INTRODUCTION

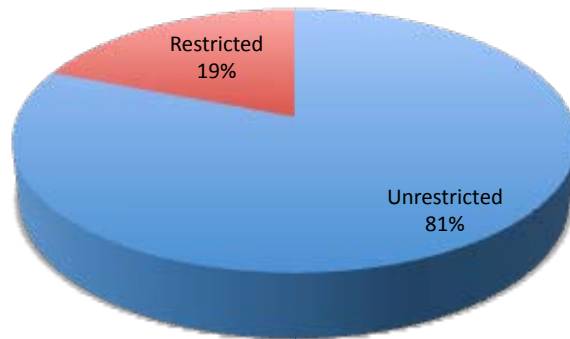
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### Theses

The thesis is the capstone of the student's academic endeavor at NPS. Thesis topics address issues ranging from the current needs of the fleet and joint forces to the science and technology that is required to sustain long-term superiority of the Navy/DoD.

Aided by faculty advisors, NPS students represent a vital resource within the DoD for addressing warfighting problems, one especially important at present, when technology in general, and information operations in particular, is changing rapidly. Our officers think innovatively and possess the knowledge and skill to apply nascent technologies in the commercial and military sectors. Their firsthand grasp of operations, when combined with a challenging thesis project that requires them to apply their focused graduate education, is one of the most effective elements in solving fleet/joint-force problems. NPS graduate education encourages a lifelong capacity for applying basic principles to the creative solution of complex problems.

NPS is unique in its ability to conduct classified research. Restricted theses are available on the NPS SIPRNET.



**Figure 4. Classification of Theses  
(184 Degrees Conferred)**



---

## TABLE OF CONTENTS

---

### ADVANCED DEGREES

#### Doctor of Philosophy

|   |   |
|---|---|
| The Effect of Time-Advance Mechanism in Modeling and Simulation.....                    | 3 |
| Ku Klux Rising: Toward an Understanding of American Right-Wing Terrorist Campaigns..... | 3 |
| A Quantitative Model for Assessing Visual Simulation Software Architecture.....         | 4 |
| Extracting Value from Ensembles for Cloud-Free Forecasting.....                         | 5 |

#### Engineer

|   |   |
|---|---|
| Adaptive Control of a Doubly-Fed Induction Generator for Wind Power ..... | 7 |
| Alternatives Impact in Combatant Ship Design .....                        | 7 |

### MASTER OF BUSINESS ADMINISTRATION

|  |   |
|--|---|
| Economics of Fishery Failure: The Fall of the King—Analysis of United States West Coast<br>Chinook Salmon ( <i>Oncorhynchus tshawytscha</i> )..... | 9 |
| France, Germany, Greece and the United Kingdom: An Analysis and Comparison of Budget<br>Deficits and Defense Spending.....                         | 9 |

### MASTER OF SCIENCE

#### Applied Mathematics

|  |    |
|--|----|
| Probabilistic Search on Optimized Graph Topologies .....                                       | 13 |
| Search Planning Under Incomplete Information Using Stochastic Optimization and Regression..... | 13 |

#### Applied Science

|  |    |
|--|----|
| Assessing Vulnerabilities in Interdependent Infrastructures Using Attacker-Defender Models ..... | 15 |
|--|----|

#### Computer Science

|  |    |
|--|----|
| Residual Network Data Structures in Android Devices.....   | 17 |
| A Registrar Administration System Requirements Analysis and Product Recommendation for<br>Marine Corps University, Quantico, Virginia..... | 17 |
| A Concept for Continuous Monitoring That Reduces Redundancy in Information Assurance Processes.....  | 18 |
| Mobile Security Enclaves .....   | 18 |
| Telecommunication Policy in the Caribbean: A Comparison of Telecommunications in the<br>Dominican Republic and Haiti .....                 | 19 |
| Onboard and Parts-based Object Detection from Aerial Imagery .....   | 19 |

#### Electrical Engineering

|   |    |
|---|----|
| TCAD Analysis of Heating and Maximum Current Density in Carbon Nanofiber Interconnects.....             | 21 |
| Highly Absorbing Metal Nanolaminates for Bimaterial THZ Sensors .....                                   | 21 |
| Extending the Unambiguous Range of CW Polyphase Radar Systems Using Number Theoretic<br>Transforms..... | 22 |
| Preconditioner Circuit Analysis .....   | 23 |
| Adaptive Control of a Doubly-Fed Induction Generator for Wind Power .....                               | 23 |

#### Electronic Warfare Systems Engineering

|   |    |
|---|----|
| Highly Absorbing Metal Nanolaminates for Bi-material Thz Sensors .....                | 25 |
| Extending the Dynamic Range of a Photonic RSNS ADC Using a Segmentation Approach..... | 25 |
| An Improved Rectenna for Wireless Power Transmission for Unmanned Air Vehicles.....   | 26 |

---

## TABLE OF CONTENTS

---

|  |    |
|--|----|
| Novel Node Capability Metric to Assess the Value of Networking in a General Command and Control Communication Topology .....   | 26 |
| A Comparative Analysis of Network Approaches for Tactical Wireless Communications, Validated by Joint Communication Simulation System (JCSS) Simulations: A Swedish Perspective..... | 27 |
| Optical Readout System for Bimaterial Terahertz Sensors.....   | 28 |
| Extending the Unambiguous Range of CW Polyphase Radar Systems Using Number Theoretic Transforms .....  | 28 |
| Localized Optimization and Effectiveness Analysis of Medium PRF Airborne Pulse Doppler Radars in the Turkish Air Force .....   | 29 |
| <b>Engineering Acoustics</b>   |    |
| Minesweeping for Pressure Actuated Mines by Air Injection into a Water Column.....   | 31 |
| <b>Engineering Science</b>   |    |
| A Software Assurance Framework for Mitigating the Risks of Malicious Software in Embedded Systems Used in Aircraft .....   | 33 |
| <b>Information Systems and Operations</b>  |    |
| Implementing the DoD Joint Operation Planning Process for Private-Industry Enterprise Security .....   | 35 |
| <b>Information Technology Management</b>   |    |
| A Comparative Analysis of the Snort and Suricata Intrusion-Detection Systems .....   | 37 |
| Web Applications and Thin Clients in the Navy .....  | 37 |
| Risk, Uncertainty and Open Architecture in the DoD Acquisition System .....  | 38 |
| Infrastructure Suitability Assessment Modeling for Cloud-Computing Solutions .....   | 38 |
| Transitioning the Tactical Marine Corps to IPv6.....   | 39 |
| Developing Information Storage and Retrieval Systems on the Internet: A Knowledge-Management Approach.....   | 39 |
| A Registrar Administration-System-Requirements Analysis and Product Recommendation for Marine Corps University, Quantico, Virginia.....  | 40 |
| Supporting Command and Control (C2) of an Embarked Commander: Tunneling SIPRNET Data Across an Unclassified Wireless LAN.....  | 40 |
| Leveraging an SNMP Agent in Terminal Equipment for Network Monitoring of U. S. Navy SATCOM.....  | 41 |
| Simple Messaging and Collaboration System for Heterogeneous Organizations Operating in Disaster Environments.....  | 41 |
| Virtual Cloud Computing: Effects and Application of Hastily Formed Networks (HFN) for Humanitarian Assistance/Disaster Relief (HA/DR) Missions .....                                 | 42 |
| Smart Fires: A COTS Approach to Tactical Fire Support Using a Smartphone.....  | 42 |
| Network Management System for Tactical Mobile Ad Hoc Network Segments .....  | 43 |
| Virtualization of Aegis: A Study of the Feasibility of Applying Open Architecture Technology to the Surface Navy's Most Complex Automated Weapon System .....                        | 43 |
| Organizational Use of a Framework for Innovation Adoption.....   | 44 |
| Analysis of Return on Investment in Industry Service-oriented Architecture Implementation .....  | 44 |
| An Adaptive Communication Solution: Applying Commercial, Off-the-Shelf Cellular Technology to Tactical-Communication Requirements .....  | 44 |
| <b>Information Warfare Systems Engineering</b>   |    |
| Developing a Software Model to Assess a Nation's Capability to Conduct Sustained, Offensive, Cyber Warfare.....  | 47 |
| Evaluation of HRI Payloads for Rapid Precision Target Localization to Provide Information to the Tactical Warfighter.....  | 48 |

---

## TABLE OF CONTENTS

---

|   |    |
|---|----|
| Comparative Analysis of Emergency Response Operations: Haiti Earthquake in January 2010 and Pakistan's Flood in 2010.....                       | 48 |
| Design Requirements for Weaponizing Man-Portable UAS in Support of Counter-Sniper Operations .....  | 49 |
| Using Voice-over-Internet Protocol to Create True End-to-End Security.....  | 49 |
| Initial Design and Concept of Operations for a Clandestine Data-Relay UUV to Circumvent Jungle-Canopy Effects on Satellite Communications ..... | 50 |
| <b>Mechanical Engineering</b>   |    |
| Low-Speed Wind-Tunnel-Flow Quality Determination.....   | 51 |
| Applying Massively Parallel Kinetic Monte Carlo Methods to Simulate Grain Growth and Sintering in Powdered Metals .....                         | 51 |
| Investigation of Transitional Flows on Compressor Blades in Cascade .....   | 52 |
| Development of Nanoporous Carbide-Derived Carbon Electrodes for High-Performance, Lithium-Ion Batteries.....                                    | 52 |
| Alternatives Impact in Combatant Ship Design .....  | 53 |
| Fluid-Structure-Interaction Effect on Sandwich Composite Structures .....   | 54 |
| Investigation of an Explicitly Modeled, Solid, Ocean Floor on a Shallow-Water Under Event .....   | 54 |
| Integration of Control Algorithms for Quadrotor UAVs Using an Indoor Sensor Environment .....   | 55 |
| <b>Meteorology and Oceanography</b>   |    |
| Measurements of the Air-Sea Interface from an Instrumented Small Buoy.....  | 57 |
| Evaluating Tropical-Cyclone Forecast Track Uncertainty Using a Grand Ensemble of Ensemble Prediction Systems.....                               | 57 |
| <b>Meteorology and Physical Oceanography</b>  |    |
| Climate and Weather Analysis of Afghanistan Thunderstorms .....   | 59 |
| Numerical Simulations, Mean-Field Theory and Modulational Stability Analysis of Thermohaline Intrusions .....                                   | 59 |
| Air-Ocean Characteristics During the Impact of Typhoons on the Ocean in the Pacific (ITOP) Program ..   | 60 |
| An Effective Noise-filtering Method for Mine Detection .....  | 60 |
| Modeling the Impacts of Intraseasonal to Interannual Climate Variations on Tropical Cyclone Formations in the Western North Pacific .....       | 61 |
| Derivation of River Bathymetry Using Imagery from Unmanned, Aerial Vehicles (UAVs).....   | 62 |
| The Use of Autonomous Vehicles for Spatially Measuring Mean Velocity Profiles in Rivers and Estuaries ..  | 62 |
| <b>Modeling, Virtual Environments, and Simulation</b>   |    |
| Improving Military Change Detection Skills in a Virtual Environment: The Effects of Time, Threat Level, and Tutorials.....                      | 63 |
| Design and Task Analysis for a Game-based Ship-Handling Simulator Using an Open Source Game Engine (Delta3D) .....                              | 63 |
| Identifying the Method for Effective Combat Marksmanship Using Site Optics and Packaged Sensor Feedback.....                                    | 64 |
| Comparison of Data-Development Tools for Populating Cognitive Models in Social Simulation .....   | 64 |
| Balancing Exploration and Exploitation in Agent Learning .....  | 65 |
| Representing Trust in Cognitive Social Simulations .....  | 65 |
| Evaluation of Modern Navies's Damage Control and Firefighting Training Using Simulator Platforms .....  | 66 |
| Onboard and Parts-based Object Detection from Aerial Imagery .....  | 66 |
| <b>Operations Research</b>  |    |
| Changing the Paradigm: Simulation, a Method of First Resort .....   | 69 |
| Adaptive Discrete-event Simulation for Analysis of Harpy Swarm Attack.....  | 69 |

---

## TABLE OF CONTENTS

---

|  |    |
|--|----|
| Robust Analysis of the Joint-Strike Fighter Integrated-Training-Center Pilot Scheduling .....            | 70 |
| Estimating the Fully Burdened Cost of Fuel Using an Input/Output Model: A Micro-Level Analysis.....      | 70 |
| Probabilistic Search on Optimized Graph Topologies .....   | 71 |
| Analytically Quantifying Gains in the Test and Evaluation Process Through Capabilities-Based Analysis .. | 71 |
| Free-Text Disease Classification.....  | 72 |
| Search Planning Under Incomplete Information Using Stochastic Optimization and Regression.....           | 72 |
| <br><b>Physical Oceanography</b>   |    |
| Mine-Burial Expert System for Change of MIW Doctrine.....  | 73 |
| Tuning, Validation, and Uncertainty Estimates for a Sound-Exposure Model .....                           | 73 |
| <br><b>Remote-Sensing Intelligence</b>   |    |
| Automating Identification of Roads and Trails Under Canopy Using Lidar.....                              | 75 |
| <br><b>Software Engineering</b>  |    |
| Infrastructure Suitability Assessment Modeling for Cloud-Computing Solutions .....                       | 77 |
| Model View Controller for Content Management on the Cloud .....  | 77 |
| <br><b>Space-Systems Operations</b>  |    |
| Evolved, Expendable, Launch Vehicle (EELV) Secondary-payload Adapter (ESPA)                              |    |
| Ring: Overcoming Challenges to Enable Responsive Space.....  | 79 |
| NPSSAT1 Mems 3-Axis Rate Sensor Suite Performance, Characterization, and                                 |    |
| Flight-Unit Acceptance Testing.....  | 79 |
| Operationally Responsive Tasking .....   | 80 |
| Application of the Terrestar Satellite Constellation to the Global Initiative for Tracking Special       |    |
| and Nonproliferation Material.....   | 80 |
| Mobile CubeSat Command and Control .....   | 81 |
| Automating Identification of Roads and Trails Under Canopy Using Lidar.....                              | 81 |
| Optimizing the Navy’s Investment in Space Professionals.....   | 82 |
| Mobile CubeSat Command and Control: Assembly and Lessons Learned.....                                    | 82 |
| Coastal Bathymetry Using Satellite Observation in Support of Intelligence Preparation                    |    |
| of the Environment.....  | 83 |
| Enabling the Commercial Space Transportation Industry at the Mid-Atlantic Regional Spaceport .....       | 83 |
| <br><b>Systems Engineering</b>   |    |
| A Simulation-based Analysis of U.S. Army Watercraft Capabilities in a 2022 Foreign                       |    |
| Humanitarian-assistance/Disaster-Relief Operation .....  | 85 |
| A Hybrid Approach to Tactical Vehicles .....   | 85 |
| A Model for Communications-Satellite-System Architecture Assessment .....                                | 86 |
| How the Degree of Accuracy of an Inertial Measurement Unit (IMU) Influences the                          |    |
| Miss Distance of a Gun-Launched Precision Munition.....  | 86 |
| Investigating the Link Between Combat System Capability and Ship Design .....                            | 87 |
| <br><b>Systems-Engineering Management</b>  |    |
| The Naval Enlisted Aviation Manpower System: Advancing Readiness Through Improved                        |    |
| Utilization of Intellectual Capital.....   | 89 |
| Multi-Year Optimization of the Space and Missile Systems Center (SMC) 2012–2017                          |    |
| Launch Mission Model .....   | 89 |
| Improving Health Care Delivery for Post-Traumatic-Stress Disorder: An Interrelated Approach .....        | 90 |
| Leveraging Systems Engineering and Optimization.....   | 90 |
| Applying the Art of Systems and Organizational Architecting in Order to Implement                        |    |
| Operational Design into Marine Corps Planning Doctrine .....   | 90 |

---

---

## TABLE OF CONTENTS

---

|   |    |
|---|----|
| Establishing a Product Baseline for Global-Positioning-System Satellites Through Functional and Physical-Configuration Audits ..... | 91 |
|---|----|

### MASTER OF ARTS

#### Security Studies

|  |     |
|--|-----|
| Management of the Severely Mentally Ill and Its Effects on Homeland Security .....   | 93  |
| Does the Dragon Soar Higher Than the Eagle? .....  | 93  |
| Contemporary Jus Ad Bellum on Use of Force in Self-defense by States Against Non-State Terrorist Groups—limitations, Evolutions and Alternatives .....     | 94  |
| An Intelligence-Sharing Continuum: Next Generation Requirements for U.S. Counterterrorism Efforts.....   | 94  |
| Organizational Leadership’s Impact on Emergent Behavior During Disaster Response and Recovery Operations.....  | 95  |
| Promoting Interagency Readiness Through Standardized Training and Education of Front-Line Responders .....   | 95  |
| New York City Fire Department Chief-Officer’s Evaluation of the Citywide Incident-Management System as It Pertains to Interagency Emergency Response ..... | 96  |
| No Failure of Imagination: Examining Foundational Flaws in America’s Homeland Security Enterprise.....   | 97  |
| Integration of Training Civilian and Military Disaster Responders .....  | 97  |
| The Influence of Culture on Strategic Decision-Making in Japan and China.....  | 98  |
| Homeland Security Strategic Plan for the Non-Major Local-Law-Enforcement Agency .....  | 98  |
| Two Missions, One Secret Service: The Value of the Investigative Mission.....  | 99  |
| Political Subculture: A Resilience Modifier.....   | 99  |
| Counter-Radicalization: Best Practices in the United States and Lessons Learned from Abroad.....   | 100 |
| The Vulnerability of Social Networking Media and the Insider Threat: New Eyes for Bad Guys.....  | 100 |
| Biosurveillance Technology: Providing Situational Awareness Through Increased Information Sharing .....  | 101 |
| Homeland Security Organizations: Design Contingencies in Complex Environments .....  | 101 |
| How Can Officers Be Better Prepared to Interact with Non-Governmental Organizations in a Post-Conflict Environment? .....                                  | 102 |
| Greek National-Security Concerns and the European Union’s Common Foreign and Security Policy: Consensus or Divergence? .....                               | 102 |
| Defense Sector Reform and Civilian Protection in the Democratic Republic of the Congo .....  | 103 |
| Composite Artistry Meets Facial-Recognition Technology: Exploring the Use of Facial-Recognition Technology to Identify Composite Images .....              | 103 |
| State and Local Homeland-Security Officials: Who Are They and What Do They Do?.....  | 104 |
| Harnessing the Power of Collaborative Relationships to Improve National Preparedness and Responsiveness.....   | 104 |
| A Regime-Legitimacy Explanation of African Peacekeeping.....   | 105 |
| Getting to One from Title 10 + Title 32: Unity of Effort in the Homeland .....   | 105 |
| Highway Security: Filling the Void.....  | 106 |
| Affecting Reform: Explaining the Kingdom of Cambodia’s Contributions to United Nations Peacekeeping Operations in Comparative Context .....                | 106 |
| The Domestic Security Command—the Evolution of U.S. Northern Command.....  | 107 |
| U.S. Maritime Security: Sustainability Challenges.....   | 107 |
| Risky Invasions: Decisions Made by the Argentine Junta Regarding Disputed Islands, 1978–1982.....  | 108 |
| Potential Standards and Methods for the National Guard’s Homeland-Response Force.....  | 108 |



## **ADVANCED DEGREES**

Doctor of Philosophy  
Engineer



# DOCTOR OF PHILOSOPHY

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## **THE EFFECT OF TIME-ADVANCE MECHANISM IN MODELING AND SIMULATION**

**Ahmed A. Alrowaei—Major, Royal Bahraini Air Force**

**B.S., Cranfield University, 1998**

**M.S., Naval Postgraduate School, September 2005**

**Doctor of Philosophy in Modeling, Virtual Environments, and Simulation—September 2011**

**Dissertation Supervisor: Arnold H. Buss, MOVES Institute**

As the discipline of Modeling and Simulation (M&S) becomes more complex, modelers are faced with mounting challenges to design and analyze simulations that effectively address difficult problems across military, industrial, and societal fields. Understanding the effects of time-advance mechanisms (TAMs) is essential to making advances in the design and use of M&S across a wide variety of domains. We perform a series of empirical studies to characterize and compare the influence of discrete event simulation (DES) and discrete time simulation (DTS) approaches, and describe the effects of changes in time “step” sizes across a number of vital simulation areas including queuing systems, combat systems, and human behavior representations of military significance. Our results illustrate that the choice of TAM can have a significant impact on the behavior of models, the output obtained from simulation tools, and the recommendations that are likely to result. We describe inconsistencies and the emergence of unintended behaviors resulting from the use of different TAM approaches and DTS time “steps.” We conclude that the DES approach is more likely to produce trustworthy simulation results for decision-making applications, and that the time step approach carries additional inherent risks that are often invisible to modelers of complex systems.

**KEYWORDS:** Time-advance Mechanism, Discrete Event Simulation, Discrete Time

## **KU KLUX RISING: TOWARD AN UNDERSTANDING OF AMERICAN RIGHT WING TERRORIST CAMPAIGNS**

**Paul D. Brister—Major, United States Air Force**

**B.S., U.S. Air Force Academy, 1998**

**M.S., Naval Postgraduate School, 2005**

**Doctor of Philosophy in Security Studies—September 2011**

**Dissertation Supervisor: Maria Rasmussen, Department of National Security Affairs**

Since 1866, the Ku Klux Klan has been able to muster three distinctive and sustained campaigns of terrorism, commonly referred to as the three “waves” of Klan violence. The first occurred between 1866 and 1871, the second between 1915 and 1928, and the third from roughly 1954 to the mid-1960s. Subsequent to the third wave, the Klan unsuccessfully attempted another resurgence in the mid-1970s/early 1980s but was snuffed out before a campaign could be triggered. By studying the three most successful Klan campaigns of the past (granting that each varied in scope, intensity and outcome) alongside the failed campaign attempt of the 1970–1980s, this dissertation will investigate which commonly cited factors and conditions were, in fact, associated with the rise of the KKK’s campaigns of terrorism.

This project differs from previous works on the Ku Klux Klan in that it systematically compares four different periods of time—three periods that represent campaigns of violent activity and one that does not. This will facilitate testing the most common explanations of right wing terrorism alongside one another. Numer-

ous detailed histories have been written about the Klan, but none has performed a systematic comparison in an effort to explain why, where, and when the Klan was capable of stringing together terrorist violence into a sustained campaign. This dissertation seeks to fill that void.

Ultimately, the dissertation finds that four factors—the presence of a safe haven, organizational structure, leadership, and recruitment techniques—are necessary and jointly sufficient to explain Klan campaign emergence. By combining these factors in a manner which better reflects their interplay, a model offering greater explanatory value emerges. The first significant set of correlates is the presence or absence of safe havens and their relation to the organizational structure chosen by Klan leadership. The second set of correlates is the ability of the Klan to downplay its core ideology and effectively frame a recruitment message which resonates with a pre-existing dominant social narrative—a narrative usually based on mythologized history or an unfalsifiable belief system. As will be explained in concluding chapters, the probabilistic model that emerges when these factors combine proves more effective in explaining and predicting campaigns of Klan terrorism than simply listing these factors as if they are not consciously combined for effect.

**KEYWORDS:** Terrorism, Domestic Terrorism, Right Wing Terrorism, Ku Klux Klan

**A QUANTITATIVE MODEL FOR ASSESSING VISUAL  
SIMULATION SOFTWARE ARCHITECTURE**

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**B.S., Oregon State University, 1998**

**M.S., Air Force Institute of Technology, June 2000**

**Doctor of Philosophy in Modeling, Virtual Environments, and Simulation—September 2011**

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

The U.S. military is the largest single user of simulation in the world, and our visual simulations can be software-intensive systems with a lifespan of many years. Managers of these simulations need tools to help them make better decisions at the architectural level. Currently, no such quantitative models with supporting metrics exist for this purpose. There are properties that are held as positive characteristics in visual simulation architectures. Visual simulation architectures can be distinguished from one another based on three characteristics: (1) openness, as defined by the use of standards, licensing, and support of innovation; (2) reuse, as defined by the potential of being used in subsequent projects; and (3) agility, as defined by the ease with which software can be integrated, reconfigured, or repurposed. In this research, we propose quantifiable models to measure openness, reuse, and agility, and claim that the models adequately distinguish visual simulation frameworks from one another. Furthermore, we claim that these models can enhance military acquisition decisions. The results show that application of the metrics offers a level of granularity that is useful in identifying key differences in simulation frameworks that could have profound downstream implications.

**KEYWORDS:** Software Metrics, Visual Simulation, Architecture, Frameworks, Openness, Reuse, Reusability, Agility, Components

**EXTRACTING VALUE FROM ENSEMBLES FOR CLOUD-FREE FORECASTING**

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**B.S., Florida State University, 1999**

**M.S., Naval Postgraduate School, 2005**

**Doctor of Philosophy in Meteorology–September 2011**

**Dissertation Supervisor: Joshua Hacker, Department of Meteorology**

**Dissertation Committee Chair: Patrick Harr, Department of Meteorology**

The Air Force Weather Agency (AFWA) is currently producing cloudfree forecasts for several agencies, but operational forecasts do not incorporate forecast uncertainty. Uncertainty can be forecasted via an ensemble created with perturbed initial conditions. We combine AFWA's global cloud analysis and cloud advection model with the National Centers for Environmental Prediction's global weather ensemble to study the potential for ensemble cloud-free forecasting in support of space-based image collection. A year of ensemble forecasts forms the evaluation dataset. The operationally relevant cloud-free forecast threshold (cloud cover less than 30%) is evaluated over sets of 24-km grid boxes in three climatologically different regions. The analyses and forecasts favor cloud-cover values near 0% and 100% cloud cover, making skill metrics that assume normal statistics mostly inappropriate. Thus we focus on contingency table metrics at the 30% threshold and argue that the odds ratio is most appropriate. Because costs of satellite image collection are largely unknown or classified, and typical cost/loss models may not apply, we also invoke utility theory to quantify operator benefits obtainable from the ensemble. Ensemble skill is apparent, and utility for risk-averse users in persistently clear, cloudy, and variable regions/seasons yields up to a 20% increase in operational efficiency.

**KEYWORDS:** ADVCLD, GACE, Cloud-Free Forecast, Value, Utility, WWMCA, GEFS



# ENGINEER

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## **ADAPTIVE CONTROL OF A DOUBLY-FED INDUCTION GENERATOR FOR WIND POWER**

**Stamatios Orfanos–Pepainas, Lieutenant, Hellenic Navy**

**B.S., Hellenic Naval Academy, June 2001**

**Electrical Engineer–September 2011**

**Master of Science in Electrical Engineering–September 2011**

**Advisor: Roberto Cristi, Department of Electrical and Computer Engineering**

**Second Advisor: Alexander L. Julian, Department of Electrical and Computer Engineering**

**Second Reader: Xiaoping Yun, Department of Electrical and Computer Engineering**

The use of doubly-fed induction generators (DFIG) for wind energy conversion is addressed in this thesis. It is well known that when the stator is connected to the electric grid, the rotor voltage can control both mechanical torque and reactive electric power.

To guarantee efficient wind energy conversion, it is important to research and design more advanced control schemes. In this thesis, we first review the basic theory behind DFIGs and Adaptive Control. Next we design an adaptive controller for a wind turbine using a DFIG and model and simulate the system. In order to create a valid assessment on the results of this method, we compare the system's performance with a standard control scheme based on proportional integral (PI) controllers as proposed in standard approaches.

**KEYWORDS:** Wind Energy, DFIG, Adaptive Control

## **ALTERNATIVES IMPACT IN COMBATANT SHIP DESIGN**

**Gerardo Sanabria Gaitan–Lieutenant, Colombian Navy**

**B.S., Colombian Naval Academy, 2009**

**Master of Science in Mechanical Engineering–September 2011**

**Mechanical Engineer–September 2011**

**Advisor: Fotis Papoulias, Department of Mechanical and Aerospace Engineering**

**Co-Advisor: Clifford Whitcomb, Department of Systems Engineering**

This thesis continues the development of a systems methodology for the conceptual design of a medium tonnage combatant ship for the Colombian navy. The purpose is to demonstrate the impact that different systems and operational capabilities have in the overall design. The objective is to demonstrate the ability to conduct ship trade-off studies based on capability, allowing ship design configuration decisions on the warfighting effectiveness over multiple missions, with explicit consideration of combat and weapon-system characteristics.

Once the mission capabilities that a ship must accomplish have been identified, a set of ship designs is created using a synthesis model, which are then formed into a multidimensional design space. Mission-effectiveness models are then used to simulate the how well each ship mission is accomplished in the context of warfighting scenarios.

The ship-design space and each mission-effectiveness space are formed using response surface designs created through a design of experiments methodology. The mission scenarios are a multiple-criteria decision space in which ship alternatives are assessed as solutions to the overall design problem. The combat-system design variables link the multiple response surfaces to form the relationships between mission capabilities and

ship characteristics. A statistical analysis tool, JMP, creates a graphical environment that decision makers can use to interactively analyze different ship alternatives and determine the most effective design from a warfighting perspective.

The thesis demonstrates an example of selecting conceptual designs that meet desired mission-effectiveness criteria for the medium-tonnage combatant for mission scenarios of interest to the Colombian navy.

**KEYWORDS:** Conceptual Ship Design, Combatant Ship, Ship Trade Off Studies, Design Of Experiments, Design Space, Model Based Systems Engineering, Capability Based Design.

# MASTER OF BUSINESS ADMINISTRATION

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## **ECONOMICS OF FISHERY FAILURE: THE FALL OF THE KING—ANALYSIS OF UNITED STATES WEST COAST CHINOOK SALMON (*ONCORHYNCUS TSHAWYTSCHA*)**

**Michael J. Hoshlyk—Commander, NOAA Commissioned Corps**

**B.S., University of Rochester, 1988**

**Master of Business Administration—September 2011**

**Advisor: William R. Gates, Graduate School of Business and Public Policy**

**Second Reader: Robert E. Looney, Department of National Security Affairs**

This study examines bio-economic trends within the West Coast wild salmon fishery, specifically the Chinook (King) salmon *Oncorhynchus Tshawytscha* species. This study will first review the historical management, policies, competing interests, and environment affecting the health of the wild Chinook that brought the fishery sector to its current status. It focuses on fisheries supply data derived from both farmed aquaculture and troll caught (wild) salmon off the West Coast of the United States (California, Oregon, Washington, and Alaska) from 1980–2007. The study will then describe the wild Chinook fishery market and assess the effect of the farmed fishery supply and the long-term implications of changes in consumer preferences in conjunction with a growing farmed fish market and declining regional fishery availability. The data of the declining West Coast stocks, growth of wild imports and global salmon aquaculture data reflect the supply changes that have occurred in the salmon market both prior to and during this period. The study further examines the long and short-term economic implications of the development of international commercially farmed salmon fisheries upon the wild salmon fishery.

Analysis of historical trends assesses the effects of status quo policy and management in the salmon fishery and resulting historical and current supply and demand curves as a means of forecasting future market pricing. The study will show how United States wild salmon stocks are vital to U.S. supply and competition in domestic and international salmon markets and how variability in that stock at low levels will most likely continue absent significant government policy revisions and will directly impact premium market pricing.

**KEYWORDS:** Chinook, West Coast Wild Chinook Salmon Fishery, Aquaculture, Bio-Economics, Supply and Demand, Farmed Salmon Imports, Management and Trends, Premium Market Pricing

## **FRANCE, GERMANY, GREECE AND THE UNITED KINGDOM: AN ANALYSIS AND COMPARISON OF BUDGET DEFICITS AND DEFENSE SPENDING**

**Friedrich Schoettelndreyer—Commander, German Navy**

**Diplom Ingenieur, Technical University of Hamburg-Harburg, Germany, March 2001**

**Master of Business Administration—September 2011**

**Advisor: Douglas A. Brook, Graduate School of Business and Public Policy**

**Second Reader: Jeremy Arkes, Graduate School of Business and Public Policy**

This thesis documents findings on the relationship of government budget deficits and defense spending for France, Germany, Greece, and the United Kingdom in detail and for NATO and OECD country collectives. The thesis topic is relevant, as many European countries are justifying their recent cuts in defense spending with high government budget deficits. The author looked at different data sources and metrics to graphically

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analyze the developments in government budget deficits and defense expenditures for the selected countries over a fifteen-year period and statistically analyze possible interactions between lagged budget deficits and defense expenditures for NATO and OECD country collectives. Six regression models were developed and applied to the country collectives with different time periods, from 1975 up to 2009. A fixed effects regression analysis was used to determine the significance levels and the standard errors of the independent variables. The research method consisted of four activities: review of related research, analysis of government budget spending levels, analysis of defense spending levels and graphical and statistical analysis of government budget deficit and defense spending relationship. The literature survey focused on data research, theories on government budget deficits and defense spending and the European Union's Stability and Growth Pact.

**KEYWORDS:** Government Budget Deficits, Defense Spending, Military Expenditures, Nato, Oecd, France, Greece, Germany, United Kingdom, Sgp, Edp, Fixed Effects Regression

# MASTER OF SCIENCE

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Applied Mathematics  
Applied Science  
Computer Science  
Electrical Engineering  
Electronic Warfare Systems Engineering  
Engineering Acoustics  
Engineering Science  
Information Systems and Operations  
Information Technology Management  
Information Warfare Systems Engineering  
Mechanical Engineering  
Meteorology and Oceanography  
Meteorology and Physical Oceanography  
Modeling, Virtual Environments, and Simulation  
Operations Research  
Physical Oceanography  
Remote Sensing Intelligence  
Software Engineering  
Space Systems Operations  
System Engineering  
Systems-Engineering Management



# MASTER OF SCIENCE IN APPLIED MATHEMATICS

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## **PROBABILISTIC SEARCH ON OPTIMIZED GRAPH TOPOLOGIES**

**Christian Klaus–Major, German Army**

**Diplom-Ingenieur in Information Engineering, Universität der Bundeswehr München, June 2002**

**Master of Science in Operations Research–September 2011**

**Master of Science in Applied Mathematics–September 2011**

**Co-Advisor: Timothy H. Chung, Department of Systems Engineering**

**Co-Advisor: Craig Rasmussen, Department of Applied Mathematics**

**Second Reader: Nedialko Dimitrov, Department of Operations Research**

**Second Reader: Raluca Gera, Department of Applied Mathematics**

This thesis investigates how the performance of a mobile searcher is affected by altering the search environment. We model the search environment as a simple connected, undirected graph. By adding new edges to the graph, we change the search environment. Our objective is to optimize search performance, that is, to minimize the (expected) time needed to find the target, in the context of probabilistic search. We first analyze two different methods to generate random connected graphs, then evaluate a number of methods to augment the graph, typically by considering the algebraic connectivity of the graph and its associated (Fiedler) eigenvector. Extensive simulation studies and resulting statistical and theoretical models show that adding a few wisely chosen edges to a sparse graph is sufficient to dramatically increase search performance. Further, we propose a novel method for incorporating prior information about the target's likely location by defining a subgraph on which the presented approach is performed, resulting in even greater improvements in search performance.

**KEYWORDS:** Search and Detection, Search Environment, Graph Laplacian, Algebraic Connectivity, Augmenting a Graph

## **SEARCH PLANNING UNDER INCOMPLETE INFORMATION USING STOCHASTIC OPTIMIZATION AND REGRESSION**

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**B.S., Portuguese Naval Academy, 2003**

**Master of Science in Operations Research–September 2011**

**Master of Science in Applied Mathematics–September 2011**

**Co-Advisor: Johannes O. Royset, Department of Operations Research**

**Co-Advisor: Carlos F. Borges, Department of Applied Mathematics**

**Second Reader: R. Tyrrell Rockafellar, University of Washington, Seattle**

This thesis deals with a type of stochastic optimization problem where the decision maker does not have complete information concerning the objective function. Specifically, we consider a discrete time-and-space search optimization problem where we seek to find a moving target in an area of operations. There are two sources of uncertainty: the target location and the sensor performance.

We formulate the objective function for this problem in terms of a risk measure of a parameterized random variable and consider three cases involving various degrees of knowledge about the sensor performance. In all cases, we consider both the expectation and superquantile risk measures. While the expectation results in an objective function representing the probability of missing the target, the superquantile gives rise to more conservative search plans that perform reasonably well even under exceptional circumstances.

In the case of incomplete information about the distribution of the sensor performance, we approximate the random variable using a nonstandard regression that minimizes the error induced in some sense. We examine the cases in a series of numerical examples.

**KEYWORDS:** Search Planning, Stochastic Optimization, Risk-tuned Regression Models, Uncertainty, Risk Measure, Superquantile.

# MASTER OF SCIENCE IN APPLIED SCIENCE

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## **ASSESSING VULNERABILITIES IN INTERDEPENDENT INFRASTRUCTURES USING ATTACKER-DEFENDER MODELS**

**Cory A. Dixon—Commander, United States Navy  
B.S., North Carolina State University, June 1993**

**Master of Science in Applied Science (Operations Research)—September 2011**

**Advisor: David L. Alderson, Department of Operations Research**

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

**Second Reader: Gerald G. Brown, Department of Operations Research**

Our economic and social welfare depend on certain “critical” infrastructures and key resources. Protecting these infrastructures is a challenge because they are complex, and as systems they are difficult to understand, predict and control. In addition, they do not operate in isolation, but are interdependent with other infrastructures. This presents a challenge for their modeling and analysis. Due to the complexity of modeling the operation of just a single infrastructure, most research to date has analyzed infrastructures in isolation. This thesis introduces a taxonomy of dependence relationships and incorporates these relationships into an attacker-defender model of interdependent infrastructure operation. We formulate and solve a sequence of models to illustrate how dependence relationships between infrastructures create vulnerabilities that are not apparent in single-infrastructure models, and we use the results to assess the consequences of disruptions to a system of infrastructures. We provide complete documentation for how to apply these techniques to real infrastructure problems and include a discussion of the necessary assumptions, as well as the pros and cons of our methods. Finally, we present examples of how to provide relevant, understandable results to help decision makers, such as where to make limited investments to increase resilience.

**KEYWORDS:** Infrastructure, Attacker-Defender, Dependence, Vulnerability, Operational Resilience, Interdiction, Worst-Case Analysis



# MASTER OF SCIENCE IN COMPUTER SCIENCE

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## **RESIDUAL NETWORK DATA STRUCTURES IN ANDROID DEVICES**

**Gregory S. Cardwell—Lieutenant Commander, United States Navy**

**B.S., College of the Ozarks, May 1999**

**Master of Science in Computer Science—September 2011**

**Co-Advisor: Robert Beverly, Department of Computer Science**

**Co-Advisor: Simson Garfinkel, Department of Computer Science**

The emergence and recent ubiquity of Smartphones present new opportunities and challenges to forensic examiners. Smartphones enable new mobile application and use paradigms by being constantly attached to the Internet via one of several physical communication media, e.g. cellular radio, WiFi, or Bluetooth. The Smartphone's storage medium represents a potential source of current and historical network metadata and records of prior data transfers. By using known ground truth data exchanges in a controlled experimental environment, this thesis identifies network metadata stored by the Android operating system that can be readily retrieved from the device's internal non-volatile storage. The identified network metadata can ascertain the identity of prior network access points to which the device associated. An important by-product of this research is a well-labeled Android Smartphone image corpus, allowing the mobile forensic community to perform repeatable, scientific experiments, and to test mobile forensic tools.

**KEYWORDS:** Android Operating System, Forensics, Smartphones, Network Data Structures, Network Forensics

## **A REGISTRAR ADMINISTRATION SYSTEM REQUIREMENTS ANALYSIS AND PRODUCT RECOMMENDATION FOR MARINE CORPS UNIVERSITY, QUANTICO, VIRGINIA**

**Daniel E. Good—Captain, United States Marine Corps**

**B.S., United States Naval Academy, May 2002**

**Master of Science in Computer Science—September 2011**

**Master of Science in Information Technology—September 2011**

**Co-Advisor: Luqi, Department of Computer Science**

**Co-Advisor: Karl Pfeiffer, Department of Information Sciences**

Marine Corps University (MCU) is a relatively young organization and continues to mature as it brings more academic functionality and oversight under centralized control, especially in the area of Information Technology (IT). Much of MCU's IT control and responsibility still remains decentralized down to the school and college level. This research focuses on a specific IT capability, a Registrar Administration System (RAS). A RAS may also be termed a Student Information System (SIS). This type of system performs many functions. Some of them typically include the ability to hold or access personal student and faculty information; correlating students to courses completed, grades received and when; providing faculty a portal to upload course grades; and providing the Registrar's office access to generate transcripts. It may also include functionality for registrar, course scheduling, or alumni needs. In this research, we conduct a requirements analysis (RA) to determine MCU's needs for this type of system.

After understanding MCU's requirements, we conduct a market analysis to learn about systems that are being employed at institutions similar to MCU. Next, product characteristics, or factors, to be considered and Likert rating scales are defined in preparation for an evaluation of each system. We conduct a product com-

parison based on our system evaluations and conclude by recommending the best system to MCU.

**KEYWORDS:** Usmc, Mcu, Student Information System, Iet Master Plan, Requirements Analysis, Software Engineering, Market Analysis, Product Comparison, Product Recommendation, Business Study

**A CONCEPT FOR CONTINUOUS MONITORING THAT REDUCES  
REDUNDANCY IN INFORMATION-ASSURANCE PROCESSES**

**Sophia Kostopoulos–DoD Civilian**

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**Master of Science in Computer Science–September 2011**

**Advisor: Karen L. Burke, Department of Computer Science**

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

This thesis analyzes the structure of a few of the Information Assurance (IA) processes currently being used in the United States government. The general structure of these processes is uncovered and used to create a Continuous Monitoring Process that can be used to create a tool to incorporate any process of similar structure. A proof-of-concept application is drafted to demonstrate the main aspects of the proposed tool. The possibilities and implications of the proof-of-concept application are explored, including the future work required to develop a fully functional and automated version of the proposed Continuous Monitoring tool.

Keywords: Information Assurance, Certification and Accreditation (C&A), Continuous Monitoring, DIA-CAP.

**MOBILE SECURITY ENCLAVES**

**Kevin J. LaFrenier–Captain, United States Marine Corps**

**B.S., United States Naval Academy, 2002**

**Master of Science in Computer Science–September 2011**

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

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

There are currently no access control methods to permit personnel, such as military members, government agencies, or first-responders, access to restricted resources and applications that are only available when certain conditions are satisfied. Such conditions include user authentication, authorized geographic locations, and connections to specific base transceiver stations or base station controllers. This work defines mobile security enclaves, which are designed to provide this access control, are adaptable and compatible with mobile cellular infrastructures, and can operate without being connected to a dedicated back-end network. The goal of this proposed architecture is to permit users who satisfy specific pre-conditions access to resources and applications to which they otherwise normally would not be granted access.

An example where this research is beneficial is during crisis response. Disasters require first responders the need to have immediate access to resources available in a specific location. Another example is agencies requiring mobile communication device use on classified networks or to access classified resources. These mobile security enclaves not only provide strict security by authenticating the user and device location, they also prevent access to networks or resources outside of authorized areas and restrict unauthorized users.

**KEYWORDS:** Mobile Communication Devices, Mobile Security, Mobile Enclaves, Security Applications, GSM Security Applications, Mobile Base Station Subsystems, Mobile Access Controls, Mobile Authentication, SIM Authentication

**TELECOMMUNICATION POLICY IN THE CARIBBEAN: A COMPARISON OF  
TELECOMMUNICATIONS IN THE DOMINICAN REPUBLIC AND HAITI**

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**B.S., Marquette University, May 2001**

**Master of Science in Computer Science—September 2011**

**Advisor: Bert Lundy, Department of Computer Science**

**Second Reader: Karl Pfeiffer, Department of Information Sciences**

Several factors affect the development of telecommunications policy in a country. These include government intervention, geography, alliances, and economic stability. By studying different countries, and comparing these factors and the rates of growth of each state, one can further understand the different levels of telecommunications development. This thesis will explore telecommunications policy, its success and failures, in the Dominican Republic and Haiti, where telecommunications has become a major source of jobs and economy due to foreign investments. Analysis of telecommunications policies, regulatory bodies, and agreements will be studied and compared to each country's rate of growth in the past ten years.

This thesis will provide recommendations for the successful implementation of regulatory policies in the named developing Caribbean nations. By examining the policies in these nations, this thesis will determine the effectiveness of the country's telecommunications policy. Additionally, the thesis will explore the influence of specific actors, such as corruption, nonenforcement of regulatory laws, lack of developed accounting and auditing systems, and the limitation of the government in developing policy.

**KEYWORDS:** Telecommunications, Wireless, Telephone, Cellular, Policy, Government Regulation, Caribbean, Dominican Republic, Haiti.

**ONBOARD AND PARTS-BASED OBJECT DETECTION FROM AERIAL IMAGERY**

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**B.S., United States Naval Academy, May 2004**

**Master of Science in Computer Science—September 2011**

**Master of Science in Modeling, Virtual Environments, and Engineering—September 2011**

**Co-Advisor: Mathias Kölsch, Department of Computer Science**

**Co-Advisor: Chris Darken, Department of Computer Science**

The almost endless amount of full-motion video (FMV) data collected by Unmanned Aerial Vehicles (UAV) and similar sources presents mounting challenges to human analysts, particularly to their sustained attention to detail despite the monotony of continuous review. This digital deluge of raw imagery also places unsustainable loads on the limited resource of network bandwidth. Automated analysis onboard the UAV allows transmitting only pertinent portions of the imagery, reducing bandwidth usage and mitigating operator fatigue. Further, target detection and tracking information that is immediately available to the UAV facilitates more autonomous operations, with reduced communication needs to the ground station. Experimental results proved the utility of our onboard detection system a) through bandwidth reduction by two orders of magnitude and b) through reduced operator workload.

Additionally, a novel parts-based detection method was developed. A whole-object detector is not well suited for deformable and articulated objects, and susceptible to failure due to partial occlusions. Parts detection with a subsequent structural model overcomes these difficulties, is potentially more computationally efficient (smaller resource footprint and able to be decomposed into a hierarchy), and permits reuse for multiple object types. Our parts-based vehicle detector achieved detection accuracy comparable to whole-object detection, yet exhibiting said advantages.

**KEYWORDS:** Onboard Object Detection, Parts Based Object Detection, Computer Vision, Machine Learning



# MASTER OF SCIENCE IN ELECTRICAL ENGINEERING

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## **TCAD ANALYSIS OF HEATING AND MAXIMUM CURRENT DENSITY IN CARBON NANOFIBER INTERCONNECTS**

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**Master of Science in Electrical Engineering–September 2011**

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**Second Reader: Sebastian Osswald, Departments of Physics  
and Mechanical and Aerospace Engineering**

As devices shrink, the current density through interconnects increases proportionally making new materials a necessity for industry growth. Carbon nanofiber (CNF) and carbon nanotube's (CNT) potential for high current density make them a possible replacement for metal contacts. Learning the limitations of CNFs and CNTs is important if they are to be used in next-generation electronics. As current density increases, heat is generated throughout the CNF structure. This heating eventually leads to breakdown as the temperature reaches the bonding energy of the carbon–carbon (C–C) bond, the bond between two carbon atoms. The resultant reaction is the vaporization of the carbon, eliminating electromigration problems common with metal interconnects.

The physics of breakdown of CNFs is poorly understood. The CNF interconnects' heating under a voltage sweep between two electrodes is modeled in this thesis. A working model was created with Silvaco ATLAS using experimental data provided by Santa Clara University (SCU). An analytical solution was found for the heat generation occurring within the device. The simulation does not show the breakdown occurring; instead, it accurately predicts the temperature and electrical characteristics of the device. This model will aid in the analysis of CNFs' reliability and potential future integration into the next-generation electronics.

**KEYWORDS:** Carbon Nanotube, CNT, Carbon Nanofiber, CNF, High Current Density, Breakdown, Interconnect, Silvaco ATLAS, Thermal Breakdown, Reliability, Modeling

## **HIGHLY ABSORBING METAL NANOLAMINATES FOR BI-MATERIAL THZ SENSORS**

**Karamitros Apostolos–Lieutenant Junior, Hellenic Navy**

**B.S, Greek Naval Academy, May 2004**

**Master of Science in Electronic Warfare Systems Engineering and**

**Master of Science in Electrical Engineering–September 2011**

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

**Co-Advisors: David Jenn, Department of Electrical and Computer Engineering**

**Dragoslav Grbovic, Department of Physics**

The terahertz (THz) region of the electromagnetic spectrum covers frequencies ranging from approximately 100 GHz to 10 THz. This region of the spectrum has not been fully utilized due to the lack of compact and efficient sources as well as detectors.

The aim of the present research is to explore the use of thin metal films as high THz absorbing materials and determine their absorbing characteristics in the THz range both analytically as well as experimentally. These films are to be used in bi-material-based suspended structures which sense minute changes in temperature due to THz absorption via difference in thermal expansion coefficients in materials used in the structures. Nickel thin films with thicknesses ranging from 3 to 50 nm were deposited on silicon substrates using e-beam

evaporation and were characterized using Fourier transform infrared (FTIR) spectroscopy extended to the THz range. Calculating Fresnel's transmission and reflection coefficient allowed us to theoretically predict the absorption of the films, which was found to agree well with the measurements.

Further numerical analysis of absorption as a function of Ni film thickness indicates that the maximum possible value of absorption is 50%. This is experimentally demonstrated using a 2.9 nm Ni film. In addition, it is found analytically that for a given conductivity there is a unique thickness that gives the highest possible absorption (50%). This is highly significant since it allows us to explore the use of other potential metal thin films as well as doped semiconductors as THz absorbers for integration into bi-material sensors.

**KEYWORDS:** Bi-material Structure, Nickel Thin Films, Terahertz Absorption, Fresnel's Equations, Ftir Spectroscopy, Maximizing the thz Absorption

### **EXTENDING THE UNAMBIGUOUS RANGE OF CW POLYPHASE RADAR SYSTEMS USING NUMBER THEORETIC TRANSFORMS**

**Nattaphum Paepolshiri—Lieutenant, Royal Thai Navy**

**B.S., Royal Thai Naval Academy, December 2005**

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

**Master of Science in Electrical Engineering—September 2011**

**Advisor: Phillip E. Pace, Department of Electrical and Computer Engineering**

**Co-Advisor: David C. Jenn, Department of Electrical and Computer Engineering**

Polyphase continuous waveform (CW) radar systems often use the popular Frank code and P4 code due to their linear time-frequency characteristics as well as their low periodic ambiguity sidelobes. The phase relationship of the Frank code corresponds to a sawtooth folding waveform. The phase relationship of the P4 code is symmetrical with a parabolic distribution. The radar system's unambiguous target detection range is limited by the number of subcodes within the code period (code length). Increasing the code length to extend the unambiguous range results in a larger range-Doppler correlation matrix processor in the receiver, a longer compression time and an increase in the receiver's bulk memory requirements. In addition, the entire code period may not be returned from the target due to a limited time-on-target resulting in significant correlation loss. To significantly extend the unambiguous range beyond a single code period, this thesis explores the relationship between the polyphase codes (Frank and P4) and the number theoretic transforms (NTT) where the residues exhibit the same distribution as the polyphase values. The unambiguous range is extended from the number of subcodes within a single code period to the dynamic range of the transform without requiring a large increase in correlation processing. The dynamic range of a NTT is defined as the greatest length of combined phase sequences that contain no ambiguities or repeated paired terms. By transmitting coprime code periods, the unambiguous range can be extended by considering the paired values from each sequence. A new Frank phase code formulation is derived as a function of the *residue number system* (RNS) where each residue corresponds to a phase value within the code period (modulus) sequence. Based on the symmetrical distribution of the P4 code, a new phase code expression is derived using both the *symmetrical number system* (SNS) and the *robust symmetrical number system* (RSNS). Here each phase value within the code period corresponds to a symmetrical residue. MATLAB simulations are used to verify the new expressions for the RNS, SNS and RSNS phase codes. Implementation considerations of the new approach are also addressed.

**KEYWORDS:** CW rAdar, Polyphase Sequence, Frank Code, P4 Code, Unambiguous Range, Pulse Compression, Residue Number System, Symmetrical Number System, Robust Symmetrical Number System.

**PRECONDITIONER CIRCUIT ANALYSIS**

**Matthew J. Nye–Lieutenant, United States Navy**

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Voltages up to 10,000 volts or higher must be attenuated and measured to provide control feedback for many applications like medium voltage generators or pulsed power systems. How these medium voltage signals can be conditioned so that they can be input to analog control circuits or analog-to-digital converters is the focus of this thesis. A preconditioner circuit takes as input a medium voltage signal and outputs a low voltage conditioned signal to an analog-to-digital converter. Each of the components of the preconditioner circuit, a voltage divider and an averaging circuit designed with an operational amplifier, contributes to the signal conditioning. The theoretical computations, simulations of the circuit, and experimental data were analyzed for congruence. The 3 dB bandwidth of the experiment's frequency response was significantly reduced compared to that of the simulation's frequency response because of parasitic capacitances in the circuit board.

**KEYWORDS:** Medium Voltage Generators, Pulsed Power Systems, Analog-to-digital Converter, Preconditioner Circuit, Voltage Divider, Averaging Circuit, Operational Amplifier

**ADAPTIVE CONTROL OF A DOUBLY-FED INDUCTION  
GENERATOR FOR WIND POWER**

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**Electrical Engineer–September 2011**

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The use of doubly-fed induction generators (DFIG) for wind energy conversion is addressed in this thesis. It is well known that when the stator is connected to the electric grid, the rotor voltage can control both mechanical torque and reactive electric power.

To guarantee efficient wind energy conversion, it is important to research and design more advanced control schemes. In this thesis, we first review the basic theory behind DFIGs and adaptive control. Next we design an adaptive controller for a wind turbine using a DFIG and model and simulate the system. In order to create a valid assessment on the results of this method, we compare the system's performance with a standard control scheme based on proportional integral (PI) controllers as proposed in standard approaches.

**KEYWORDS:** Wind Energy, DFIG, Adaptive Control



# MASTER OF SCIENCE IN ELECTRONIC WARFARE SYSTEMS ENGINEERING

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## **HIGHLY ABSORBING METAL NANOLAMINATES FOR BI-MATERIAL THZ SENSORS**

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**Master of Science in Electrical Engineering–September 2011**

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The terahertz (THz) region of the electromagnetic spectrum covers frequencies ranging from approximately 100 GHz to 10 THz. This region of the spectrum has not been fully utilized due to the lack of compact and efficient sources as well as detectors.

The aim of the present research is to explore the use of thin metal films as high THz absorbing materials and determine their absorbing characteristics in the THz range both analytically as well as experimentally. These films are to be used in bi-material-based suspended structures which sense minute changes in temperature due to THz absorption via difference in thermal expansion coefficients in materials used in the structures. Nickel thin films with thicknesses ranging from 3 to 50 nm were deposited on silicon substrates using e-beam evaporation and were characterized using Fourier transform infrared (FTIR) spectroscopy extended to the THz range. Calculating Fresnel's transmission and reflection coefficient allowed us to theoretically predict the absorption of the films, which was found to agree well with the measurements.

Further numerical analysis of absorption as a function of Ni film thickness indicates that the maximum possible value of absorption is 50%. This is experimentally demonstrated using a 2.9 nm Ni film. In addition, it is found analytically that for a given conductivity there is a unique thickness that gives the highest possible absorption (50%). This is highly significant since it allows us to explore the use of other potential metal thin films as well as doped semiconductors as THz absorbers for integration into bi-material sensors.

**KEYWORDS:** Bi-Material Structure, Nickel Thin Films, Terahertz Absorption, Fresnel's Equations, Ftir Spectroscopy, Maximizing the thz Absorption

## **EXTENDING THE DYNAMIC RANGE OF A PHOTONIC RSNS ADC USING A SEGMENTATION APPROACH**

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The trend in high-performance digital receivers is to configure the analog-to-digital converter (ADC) directly after the antenna and low noise amplifier. Direct digitization of wideband antenna signals can be realized using Mach-Zehnder interferometers (MZI) to efficiently fold the RF signal into the optical domain. The robust symmetrical number system (RSNS) is a modular scheme formed using integer sequences and insures that any two successive vectors or paired terms from all  $N$  sequences differ by only one integer (integer Gray

code property). A photonic ADC preprocessing architecture using the RSNS uses a modulus  $m_i$  number of comparators at the output of each MZI/photodetector. The total number of comparators with a logic “1” in each channel represents the integer values within each RSNS sequence. The dynamic range  $\widehat{M}$  is the greatest length of combined sequences that contain no ambiguities. In this thesis a novel photonic ADC approach is described in which the dynamic range is extended by including in  $\widehat{M}$ , the smaller sequence lengths without ambiguities that are adjacent to the  $\widehat{M}$  sequence. To demonstrate the concept, the input signal is applied to  $N = 3$  MZIs with comparators in each channel. To determine the correct sequence for the input signal, two additional comparators are used whose logical outputs control a RSNS-to-binary conversion algorithm in a field programmable gate array (FPGA). By including the two additional sequence lengths, the extended-RSNS preprocessing approach is able to increase the 7-bit design to a 8-bit design. Many of the preprocessing functions in the photonic design limited the performance of the ADC and were due to instabilities in the analog circuits. These limitations were also eliminated in this thesis by including in the FPGA, the DC bias necessary to phase align the MZI transfer functions, the post-detection low pass filtering, and the minimum and maximum signal level detections required to match the detected signal amplitude range to the range required by the comparators. Simulation results are shown to verify the feasibility of the concepts that are presented. Future efforts to be explored include optimization of the extended-RSNS FPGA control logic and experimental testing of the design using wideband components. Also to be investigated is the incorporation of more than two adjacent sequence lengths to further extend the dynamic range.

**KEYWORDS:** Robust Symmetrical Number System, Dynamic Range Extension, Half-Wave Voltage, Effective number of bits (ENOB), Signal-to-Noise Ratio (SNR)

### **AN IMPROVED RECTENNA FOR WIRELESS POWER TRANSMISSION FOR UNMANNED AIR VEHICLES**

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This thesis continues an NPS project related to wireless power transmission for micro air vehicles (MAVs). The conversion of radio-frequency (rf) power into usable direct-current (dc) power is performed by a rectifying antenna, or rectenna. The emphasis of this thesis is the simulation and experimental study of various rectenna designs to determine which best provides high efficiency, stable output power, and lightweight design. The analysis of rectenna design focuses on four subsystems: (1) the receiving antenna, (2) the matching sections, (3) the rectification, and (4) the post-rectification filter. Based on the findings of this research, the ultimate rectenna design implements a half-wave dipole antenna that performs full-wave rectification with two diodes. The post-rectification filter is implemented by a capacitor to obtain stable dc power. The final design achieved an efficiency of nearly 66% for input power in the range of 200 mW.

**KEYWORDS:** Rectenna, Wireless Power Transmission, Dipole Antenna, MAV.

### **NOVEL NODE CAPABILITY METRIC TO ASSESS THE VALUE OF NETWORKING IN A GENERAL COMMAND AND CONTROL COMMUNICATION TOPOLOGY**

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**Co-Advisor: Lt. Col. Terry E. Smith, USAF, Department of Information Sciences**

In order to quantify any node's capacity to support optimal information flow within a distributed command and control network, a novel node capability value calculation is developed from first principles. The expression for the node capability value is developed using three fundamental building blocks: data throughput, bandwidth efficiency, and the link margin. The data throughput depends on the average packet arrival rate, the probability of not dropping a packet and the probability of correct receiving a packet at the queue. The bandwidth efficiency depends on the node data rate and the transmission bandwidth, while the link margin is a function of the received and required energy per bit to noise power density. The generalized connectivity integrates the computed node capability value by considering all the distributed network connections scaled by their route length and estimating the characteristic tempo, which is the maximum information exchange rate. The generalized connectivity results reflect the amount and quality of detectable information that the nodes can process and transmit about the network. The results also show how the power and bandwidth efficiency of any specific node compares the power and bandwidth efficiency of all the other nodes. A four-node dynamic scenario is simulated and used to numerically evaluate the expression for the node capability value.

Command-and-control tradeoff issues facing battlespace managers and decision makers are examined by including the networks characteristic tempo into a single observe, orient, decide and act (OODA loop). Also, included in the OODA loop, are action tempos and the command and control speed. Consideration of the influence of three classic Sheridan levels of automation on decision making are used to model the operational impacts via three action tempo tiers: high, medium, and low-action. Input command and control information rates produced the strongest observed influences on aggregate network simulation outputs.

**KEYWORDS:** Node Capability, Network Centric Warfare, NCO, C2, Battlespace Managers, Decision Tempo

### **A COMPARATIVE ANALYSIS OF NETWORK APPROACHES FOR TACTICAL WIRELESS COMMUNICATIONS, VALIDATED BY JOINT COMMUNICATION SIMULATION SYSTEM (JCSS) SIMULATIONS: A SWEDISH PERSPECTIVE**

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**Co-Advisor: Lt. Col. Terry Smith, USAF, Department of Information Sciences**

This thesis project explores two approaches for military tactical wireless communications solutions in the context of being useful for the Swedish armed forces. The study's tactical perspective focuses on a force of battalion size. The two network approaches, ad hoc networking and infrastructure based, were analyzed and compared via simulation. As a baseline for this thesis project, research was initiated based on appropriate communication requirements for the tactical force. This was followed by background research into current technologies for ad hoc networking and infrastructure-based systems. In order to analyze and compare the two technology approaches, a model was developed using the software Joint Communication Simulation System (JCSS) and a battalion-sized network simulation using ad hoc and infrastructure-based technology.

This thesis project addressed tactical force requirements from the perspective of the basic Swedish armed forces principle for command and control, which is maneuver warfare. Evaluation of the technologies is discussed through the important perspectives of capacity, mobility, flexibility, robustness, interoperability, and cost. By analyzing the technology approaches from these perspectives, this thesis project attempts to provide the Swedish Armed Forces with more information and understanding, which in-turn will allow better-suited future developments of all tactical wireless communication systems.

**KEYWORDS:** Ad Hoc Networking, Infrastructure Based Systems, Tactical Communications, Software Defined Radio, JCSS, Modeling, Simulation

### OPTICAL READOUT SYSTEM FOR BIMATERIAL, TERAHERTZ SENSORS

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Master of Science in Electronic Warfare Systems Engineering—September 2009

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Associate Advisor: David C. Jenn, Department of Electrical and Computer Engineering

Second Reader: Fabio Durante Pereira Alves, National Research Council Research Associate

The objective of this work is to design, assemble, and characterize an optical readout for bi-material, MEMS-sensor arrays that can be integrated into a THz imaging system. All this effort is a contribution to the goals of the research conducted by the Naval Postgraduate School Sensor Research Laboratory on designing and fabricating THz-optimized, bi-material, MEMS-sensor arrays for THz imaging. Basic concepts of THz radiation and detection are presented. Several aspects of THz imaging and sensor-array readout possibilities are discussed in terms of the principle of operation for this type of sensor. An experimental optical readout was assembled during this research, and its configuration is shown, as well as all of its component details. The experimental setup was characterized following a method described in this work, and the obtained results are analyzed. Finally, one possibility of optical readout integration with THz imaging system is suggested.

**KEYWORDS:** Optical Readout, Terahertz, Sensor Array, Bi-Material MEMs, Imaging.

### EXTENDING THE UNAMBIGUOUS RANGE OF CW POLYPHASE RADAR SYSTEMS USING NUMBER THEORETIC TRANSFORMS

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Master of Science in Electronic Warfare Systems Engineering

Master of Science in Electrical Engineering—September 2011

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Polyphase, continuous-waveform (CW) radar systems often use the popular Frank code and P4 code due to their linear time-frequency characteristics as well as their low periodic ambiguity sidelobes. The phase relationship of the Frank code corresponds to a sawtooth folding waveform. The phase relationship of the P4 code is symmetrical with a parabolic distribution. The radar system's unambiguous target detection range is limited by the number of subcodes within the code period (code length). Increasing the code length to extend the unambiguous range results in a larger range-Doppler correlation matrix processor in the receiver, a longer compression time and an increase in the receiver's bulk memory requirements. In addition, the entire code period may not be returned from the target due to a limited time-on-target resulting in significant correlation loss. To significantly extend the unambiguous range beyond a single code period, this thesis explores the relationship between the polyphase codes (Frank and P4) and the number theoretic transforms (NTT) where the residues exhibit the same distribution as the polyphase values. The unambiguous range is extended from the number of subcodes within a single code period to the dynamic range of the transform without requiring a large increase in correlation processing. The dynamic range of a NTT is defined as the greatest length of combined phase sequences that contain no ambiguities or repeated paired terms. By transmitting coprime code periods, the unambiguous range can be extended by considering the paired values from each sequence. A new Frank phase code formulation is derived as a function of the *residue number system* (RNS) where each residue corresponds to a phase value within the code period (modulus) sequence. Based on the symmetrical distribution of the P4 code, a new phase code expression is derived using both the *symmetrical number system* (SNS) and the *robust symmetrical number system* (RSNS). Here each phase value within the code period corresponds to a symmetrical residue. MATLAB simulations are used to verify the new expressions for the RNS, SNS and RSNS phase codes. Implementation considerations of the new approach are also addressed.

**KEYWORDS:** CW radar, Polyphase sequence, Frank code, P4 code, Unambiguous range, Pulse compression, Residue Number System, Symmetrical Number System, Robust Symmetrical Number System.

### **LOCALIZED OPTIMIZATION AND EFFECTIVENESS ANALYSIS OF MEDIUM PRF AIRBORNE PULSE DOPPLER RADARS IN THE TURKISH AIR FORCE**

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**Master of Science in Electronic Warfare Systems Engineering—September 2011**

**Co-Advisor: Lt Col Terry Smith, USAF, Department of Information Sciences**

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

The use of different pulse repetition frequencies (PRFs) delivers significantly different behaviors to airborne radars. For instance, the main purpose for using low PRF is to obtain an unambiguous range measurement. However, the tradeoff when using a low PRF is that the measurement of the target's radial velocity is highly ambiguous and can result in missing some target detections. On the other hand, high PRF is used to reduce or eliminate ambiguities in the measurement of radial velocity. A high PRF, however, causes a highly ambiguous range measurement. The true range is resolved by transmitting multiple waveforms with different PRFs. A modified form of pulse Doppler radar that operates at a medium PRF has both range and Doppler shift ambiguities. However, medium PRF is potentially better for detecting aircraft with low closing speeds than high PRF pulse Doppler.

This thesis will focus on the effectiveness and localized optimization of medium PRF in airborne pulse Doppler radars, for the Turkish Air Force. This thesis will also present an analysis of medium PRF performance in a low altitude, air-to-air operating environment offering moderate range radar capability and also delivering acceptable range and Doppler resolution within that operating environment.

**KEYWORDS:** Airborne Pulse Doppler Radar, Pulse Repetition Frequency, Medium PRF, Clutter, Localized Optimization



# MASTER OF SCIENCE IN ENGINEERING ACOUSTICS

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## MINESWEEPING FOR PRESSURE-ACTUATED MINES BY AIR INJECTION INTO A WATER COLUMN

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B.S., United States Naval Academy, 2004

Master of Science in Engineering Acoustics—September 2011

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The U.S. Navy historically has not had an adequate means to remotely pressure-sweep for mines at reasonable speeds and cost, and this is still the case. The Navy has addressed such threats, but countermeasures are time consuming and considered to be very resource intensive. During this thesis two sets of data were collected in tow tank experiments using two different sizes of bubble squid apparatus. This thesis is a continuation of work already completed by LT Jeffery Murawski from December 2009. This continuation was able to extend the proof-of-concept with larger scale tow-tank testing at NPS. Further testing with the much larger three-meter bubble squid apparatus culminated in experiments conducted in March 2010 at the David Taylor Research Basin in Carderock, MD. The data that was collected and analyzed in this thesis will show that the bubble squid apparatus is a viable concept for solving the pressure influence minesweeping capability gap.

**KEYWORDS:** Bubbles, Pressure Actuated Mines, Minesweeping



# MASTER OF SCIENCE IN ENGINEERING SCIENCE

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## A SOFTWARE ASSURANCE FRAMEWORK FOR MITIGATING THE RISKS OF MALICIOUS SOFTWARE IN EMBEDDED SYSTEMS USED IN AIRCRAFT

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Master of Science in Engineering Science—May 1992

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Co-Advisor: Janet Gill, Naval Air Warfare Center

Malicious software represents a significant and growing threat to Department of Defense systems. Threats to airborne systems in particular can be characterized not by system vulnerability to internet based exploits but rather by the risk posed by malicious code already present in the system's software. Although there are software techniques to detect and prevent certain types of attacks, a Systems Engineer has access to system level information and system design techniques that can quantify and in many cases mitigate the risks posed by potential malicious code present in the system. These techniques are especially applicable to malicious code in embedded airborne system although they can be applied to other systems that share certain traits.

This thesis provides an overview of the types of threat involved; techniques that can be used to detect malicious code in individual aircraft weapons-replaceable assemblies (WRAs); risks and mitigation strategies related to a generic aircraft software development process; system level techniques to prevent embedded malicious software from causing harm in aircraft; and a technique for documenting software assurance (SwA) arguments being made about the system and the individual WRAs.

**KEYWORDS:** Systems Engineering, Software Assurance (SwA), Malicious Software, Malicious Code, Exploit, Mitigation Strategies, Software Custody Chain, Goal Structuring Notation (GSN)



# MASTER OF SCIENCE IN INFORMATION SYSTEMS AND OPERATIONS

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## IMPLEMENTING THE DOD JOINT OPERATION PLANNING PROCESS FOR PRIVATE-INDUSTRY ENTERPRISE SECURITY

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Master of Science in Information Systems and Operations—September 2011

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Second Reader: Karl D. Peiffer, Department of Information Sciences

The purpose of this research is to provide an analysis of the efficacy of the Joint Operation Planning Process (JOPP) to improve current enterprise security planning within the private industry. This report will investigate predominant frameworks used within private industry in order to define the purpose and weaknesses of each. The JOPP will be investigated to better understand what aspects may be viable for implementation into private industry enterprise security programs. This information will be used to develop a new process called the Enterprise Security Planning Process (ESPP) that will illustrate the potential use of the JOPP for private industry.

The conclusions derived through the research performed in this report are directed to the specific application of Department of Defense battle concepts into private industry security practices. The relevance of private industry's enterprise security programs to joint operation planning will be emphasized through the failures associated with the current business mindset of enterprise security operations. Private industry security operations will be illustrated as more closely related to military conflict than business-as-usual operations.

**KEYWORDS:** Enterprise Security Framework, Joint Operation Planning Process (JOPP), Enterprise Security Planning Process



# MASTER OF SCIENCE IN INFORMATION TECHNOLOGY MANAGEMENT

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## A COMPARATIVE ANALYSIS OF THE SNORT AND SURICATA INTRUSION-DETECTION SYSTEMS

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Master of Science in Information Technology Management–September 2011

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Second Reader: Rex Buddenberg, Department of Information Sciences

Our research focuses on comparing the performance of two open-source intrusion-detection systems, Snort and Suricata, for detecting malicious activity on computer networks. Snort, the de-facto industry standard open-source solution, is a mature product that has been available for over a decade. Suricata, released two years ago, offers a new approach to signature-based intrusion detection and takes advantage of current technology such as process multi-threading to improve processing speed. We ran each product on a multi-core computer and evaluated several hours of network traffic on the NPS backbone. We evaluated the speed, memory requirements, and accuracy of the detection engines in a variety of experiments. We conclude that Suricata will be able to handle larger volumes of traffic than Snort with similar accuracy, and thus recommend it for future needs at NPS since the Snort installation is approaching its bandwidth limits.

**KEYWORDS:** Intrusion-detection System (IDS), Snort, Suricata, Information Technology, Information Assurance, Network-Security Monitoring (NSM), Intrusion Prevention System (IPS)

## WEB APPLICATIONS AND THIN CLIENTS IN THE NAVY

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This thesis investigates the advantages and disadvantages of transitioning to Web applications and thin client-server architecture for U.S. Navy shore based Components. Thin clients and Web Technology have advanced significantly over the last few years and now more than ever, offer a multitude of cost efficient solutions. In the past, networking technology and bandwidth limitations made traditional personal computers or “fat clients” a more viable option for naval commands. The advancements in networking technology and Wi-Fi have significantly reduced these constraints. Moore’s law has held constant, advancing digital storage and processing capability far beyond the traditional Client-Server Architecture’s ability to take full advantage of these services. The proliferation of server and network technology continues to provide economies of scale that drive down the cost of hardware. The accessibility of these technologies enabled application and software developers to steadily increase the size and complexity of software and applications. The fat client’s proliferation led to most of this software and application development in the form of native applications. The cost of software and native applications written for fat-client platforms continues to increase while server utilization remains negligible. Decentralization due to the inherent local access precipitated by the use of fat client-server architectures and native applications creates surplus server capacity and redundant data centers. The Department of the Navy’s (DON) focus is shifting to thin clients and enterprise software licensing due to budgetary

constraints and the need for increased efficiencies. It is possible that thin client-server architecture and Web applications may be able to provide these cost savings and efficiencies.

**KEYWORDS:** Web Applications, Native Applications, Mobile Applications, Client Server Architecture, Thin Client Server Architecture, Fat Client, Thin Client, Smart Mobile Wireless Devices, Total Cost of Ownership, Energy Consumption

### **RISK, UNCERTAINTY AND OPEN ARCHITECTURE IN THE DOD ACQUISITION SYSTEM**

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**Second Reader: Frank Barrett, Graduate School of Business and Public Policy**

This thesis analyzes the impact of risk and uncertainty on the Department of Defense (DoD) Acquisitions System and the decision making process of modern program managers. A number of risks and uncertainties will be identified and a determination will be made if service-oriented architecture (SOA) and open architecture (OA) decreases or increases risks and uncertainty. In addition, it explores whether SOA and OA has achieved projected significant cost savings.

**KEYWORDS:** Open Architecture, DoD Acquisitions, Service Oriented Architecture, Risk, Uncertainty

### **INFRASTRUCTURE SUITABILITY ASSESSMENT MODELING FOR CLOUD COMPUTING SOLUTIONS**

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**E.E., Helmut-Schmidt University, 1992**

**Master of Science in Information Technology Management—September 2011**

**Master of Science in Software Engineering—September 2011**

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**Co-Advisor: Albert Barreto III, Department of Information Sciences**

Maturing virtualization in information technology systems have enabled increased implementations of the cloud computing paradigm, dissolving the need to co-locate user and computing power by providing desired services through the network. This thesis researches the support that current network modeling and simulation applications can provide to IT projects in planning, implementing and maintaining networks for cloud solutions. A problem-appropriate domain model and subsequent requirements are developed for the assessment of several network modeling and simulation tools, which leads to the identification of a capability gap precluding the use of such tools in early stages of cloud computing projects. Consequently a practical, modular designed methodology is proposed to measure the essential properties necessary for developing appropriate cloud computing network traffic models. The conducted proof-of-concept experiment applied to a virtual desktop environment finds the proposed methodology suitable and problem-appropriate, and results in recommended steps to close the identified capability gap.

**KEYWORDS:** Cloud Computing, Modeling, Simulation, Virtualization, Virtual Desktop Infrastructure, Network Emulator

**TRANSITIONING THE TACTICAL MARINE CORPS TO IPV6**

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**Master of Science in Information Technology Management—September 2011**

**Advisor: Alexander B. Bordetsky, Department of Information Sciences**

**Second Reader: Gildo D. Cabrera, United States Marine Corps**

As communication in tactical arenas continues to trend from serial to Internet Protocol (IP) based, the necessity for tactical programs of record to embrace IP communications becomes more and more imperative. While many Marine Corps tactical communications programs of record already recognize this trend and its significance, some are affected more heavily than others.

Numerous advantages exist for transitioning from Internet Protocol version 4 to Internet Protocol version 6, and a top-down transition makes most sense for deployed and deploying units; the Data Distribution System-Modular is the system best suited to take on this role.

The Naval Postgraduate School's Center for Network Innovation and Experimentation (CENETIX) and Tactical Network Topology (TNT) field experimentation program, along with the Marine Corps Tactical Systems Support Activity (MCTSSA), can take on this task of transitioning the Tactical Marine Corps to IPv6; the commonality of the Defense Research Engineering Network (DREN) will allow for collaboration and testing that will greatly benefit our war fighters.

**KEYWORDS:** IPv6, Transition, DDS-M, Tactical Networking

**DEVELOPING INFORMATION STORAGE AND RETRIEVAL SYSTEMS  
ON THE INTERNET: A KNOWLEDGE MANAGEMENT APPROACH**

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**Second Reader: Eleanor Uhlinger, Dudley Knox Library**

Search is becoming the primary way in which people get information. In 2010, global Internet usage was over two billion people, with 92% of online adults using search engines to find information. Most commercial search engines (Google, Yahoo, Bing, etc.) provide their indexing and search services at no cost. The DoD can achieve large gains at a small cost by making public documents available to search engines. This can be achieved through the utilization of important design components and effective knowledge management. This thesis examines methods for making information available to search engines at the Naval Postgraduate School (NPS) and the Defense Technical Information Center (DTIC). In a large-scale project, over 200,000 documents were organized on the website dodreports.com. The results of this research revealed improvement gains of 8-20% for finding reports through commercial search engines during the first six months of implementation.

**KEYWORDS:** Information Systems, Knowledge Based Systems, Knowledge Management, Technical Information Centers, Information Retrieval, Department of Defense

**A REGISTRAR ADMINISTRATION SYSTEM REQUIREMENTS ANALYSIS AND PRODUCT RECOMMENDATION FOR MARINE CORPS UNIVERSITY, QUANTICO, VIRGINIA**

**Daniel E. Good—Captain, United States Marine Corps**

**B.S., United States Naval Academy, May 2002**

**Master of Science in Computer Science—September 2011**

**Master of Science in Information Technology Management—September 2011**

**Co-Advisor: Luqi, Department of Computer Science**

**Co-Advisor: Karl Pfeiffer, Department of Information Sciences**

Marine Corps University (MCU) is a relatively young organization and continues to mature as it brings more academic functionality and oversight under centralized control, especially in the area of Information Technology (IT). Much of MCU's IT control and responsibility still remains decentralized down to the school and college level. This research focuses on a specific IT capability, a registrar administration system (RAS). A RAS may also be termed a student-information system (SIS). This type of system performs many functions. Some of them typically include the ability to hold or access personal student and faculty information; correlating students to courses completed, grades received and when; providing faculty a portal to upload course grades; and providing the Registrar's office access to generate transcripts. It may also include functionality for registrar, course scheduling, or alumni needs. In this research, we conduct a requirements analysis (RA) to determine MCU's needs for this type of system.

After understanding MCU's requirements, we conduct a market analysis to learn about systems that are being employed at institutions similar to MCU. Next, product characteristics, or factors, to be considered and Likert rating scales are defined in preparation for an evaluation of each system. We conduct a product comparison based on our system evaluations and conclude by recommending the best system to MCU.

**KEYWORDS:** USMC, MCU, Student Information System, Iet Master Plan, Requirements Analysis, Software Engineering, Market Analysis, Product Comparison, Product Recommendation, Business Study

**SUPPORTING COMMAND AND CONTROL (C2) OF AN EMBARKED COMMANDER:  
TUNNELING SIPRNET DATA ACROSS AN UNCLASSIFIED WIRELESS LAN**

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**Advisor: Douglas J. MacKinnon, Department of Information Sciences**

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

Command and Control (C2) by today's embarked commanders requires timely and reliable access to classified data systems at the C2 node provided by the ship. Most often, the ship's spaces provided to an embarked staff are inadequate to support the commander's C2 requirements. Often, there are not enough classified computers or classified Local Area Network (LAN) connections. To facilitate improved ability to exercise C2, a ship's company technicians typically place a hub on the network to provide extra connection points. This procedure takes time for the technicians to implement and requires physical connection to the wired network. A potential alternative may be to leverage current IEEE 802.11 technology to provide wireless connectivity for these clients, yet wireless technology alone will not address this problem. Coupling an 802.11 network with Secret Client Tunneling Device (SCTD)-enabled classified laptops can provide the access to classified data that is required by the embarked commander to exercise command and control of his assigned forces. This thesis examines the use of the KOV-26 Talon card and the KIV-54 cryptographic module, both NSA Type I encryptors, as a method of tunneling SIPRNet data across an afloat unclassified wireless Local Area Network (LAN).

**KEYWORDS:** Command Control (C2), Wireless Local Area Network (WLAN), 802.11, Data Tunneling

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### **LEVERAGING AN SNMP AGENT IN TERMINAL EQUIPMENT FOR NETWORK MONITORING OF U. S. NAVY SATCOM**

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**Master of Science in Information Technology Management–September 2011**

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This research describes and analyzes a United States Navy Satellite Communications (SATCOM) performance monitoring model in providing status information to a network monitoring console to support naval operations. The environment is characterized by potentially adverse conditions that affect satellite performance. Current SATCOM systems are unable to provide performance information to the network's performance monitor because they are not Simple Network Management Protocol (SNMP) enabled and not integrated into the routable network. A network monitoring model defined by sense, decide, and act is central to this study. It represents enhanced monitoring by the subscriber station's monitor console for naval shipboard operations. This model delivers operational and RF environmental information to the SNMP MIB environment so that commonly used SNMP agents can request and send information for sending proper messages to the network's performance monitoring system.

The proposed solution is explored through analysis of existing monitoring models together with observations of a tactical networking field experiment, in which equipment at the edge of the network and subscriber's SATCOM terminal is monitored for gathering critical performance details.

**KEYWORDS:** Satellite Communications, ADNS, Master Station, Base Station, Subscriber Station, Terminal, Modem, SNMP, MIB, Monitoring, Sensors, RF Environment, RF Interference, Routable Network, SNMP Agent, SNMP Manager, Fault Monitoring, Remote Monitoring (RMON), Tactical Network Topology (TNT), Maritime Interdiction Operations (MIO), 8th Layer

### **SIMPLE MESSAGING AND COLLABORATION SYSTEM FOR HETEROGENEOUS ORGANIZATIONS OPERATING IN DISASTER ENVIRONMENTS**

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A novel communication system for use by a wide variety of first responders in disaster response is described. The system is based primarily on SMS messaging technologies and either indigenous mobile phone service providers or mobile phone service brought in via cellular-on-wheels (COWs), UAV, rapidly deployed towers, etc. End users use either their own cell phones, running a native SMS application, or low cost phones that are distributed by a large NGO, such as UN OCHA. If a proprietary network is set up, SIM cards are distributed to end users to allow access to the network, or administrators will explicitly allow access via a phone's IMEI number or other access control methods.

**KEYWORDS:** Disaster Response, Relief, Communications, SMS, First Responders, NGO, Non-governmental Organizations, Collaboration, Communication, Open Source Software

**VIRTUAL CLOUD COMPUTING: EFFECTS AND APPLICATION OF HASTILY FORMED NETWORKS FOR HUMANITARIAN-ASSISTANCE/DISASTER-RELIEF MISSIONS**

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**Advisor: Douglas MacKinnon, Department of Information Sciences**

Catastrophic events occur throughout the earth and first responders can benefit from improved Command and Control (C2). Currently, military C2 capabilities, though adequate in some settings, can be enhanced using virtual applications. This thesis seeks as its goals to analyze and transform present Hastily Formed Network (HFN) capabilities into a virtual HFN system, controlling for technology. I will accomplish this through leveraging the Naval Postgraduate School (NPS) HFN and Virtualization and Cloud Computing labs. The independent variables will be defined as the current HFN architecture and Virtualization and Cloud Computing lab, and the dependent variables will be defined as cost and hardware.

Through this research effort, I seek to explore, and perhaps improve, HFN capabilities through available virtualization technologies. The additional technologies applied to the current HFN system may aid in the speed of connectivity to the World Wide Web and other mission critical resources, thus promoting an enhanced C2 capability, and in turn save lives during HA/DR missions. This research points the way for future researchers to continue leveraging virtualization technologies and cloud computing in HA/DR settings.

The thesis research conducted and distributed is in the area of networking and applied sciences in technology. The methodology and practices during the research utilized cutting-edge technology while testing performance capabilities of virtualized systems. The information gathering and research phase of this thesis directly applies elements of information systems analysis.

**KEYWORDS:** Hastily Formed Network, Virtualization Technology, Networking, Satellite Terminals, Command and Control

**SMART FIRES: A COTS APPROACH TO TACTICAL FIRE SUPPORT USING A SMARTPHONE**

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Communications in wartime are critical. The United States Marine Corps communicates well using a variety of radios, each for a specialized and limited purpose. However, the USMC could potentially benefit from the exploration of combining communication capabilities in a single device by leveraging commercial off-the-shelf software and expanding the existing network infrastructure. This thesis seeks to resolve this gap in capabilities by providing a fire support application prototype that serves as a proof-of-concept for rapidly developable applications that would have an immediate positive impact, providing enhanced warfighter capabilities. If successful, this application could be further developed and fielded, and thus improve warfighting capabilities and inform future efforts in an effort to accomplish improved network management and the efficient use of existing and future communication technologies.

**KEYWORDS:** AFATDS, Android Programming, Call for Fires, Cellular, Fire Support Coordination, Fire Support Team, Forward Observer, Future Systems, Joint Communications Battle-platform, Military Wireless Communication, Rapidly Developable Applications, Smartphone, Tactical Fire Support.

**NETWORK MANAGEMENT SYSTEM FOR TACTICAL  
MOBILE AD HOC NETWORK SEGMENTS**

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Mobile Ad Hoc Networking (MANET) technologies are highly desirable in tactical environments because they are able to communicate with neighboring devices over one or more hops in order to extend connectivity to areas where a fixed infrastructure is not available or is not possible. There are many factors which can influence the performance and reliability of a MANET. Communications links within the MANET are continuously fluctuating due to device location, power, or environmental factors. Devices within the MANET can enter the network and then disappear due to the devices losing connectivity because of their physical location relative to other nodes within the network. A network management system (NMS) that can provide for MANET administration in both simulation-based and real-time operational environments provides additional value for this network. The objectives for this network management system is to allow users to predict, monitor, and control network behavior; this specifically includes viewing and remotely managing variables such as node status, node location, attached equipment, channel selection, frequencies, error rates, and network utilization.

**KEYWORDS:** Network Management System, Tactical Mobile Adhoc Networks, Simple Network Management Protocol

**VIRTUALIZATION OF AEGIS: A STUDY OF THE FEASIBILITY OF  
APPLYING OPEN-ARCHITECTURE TECHNOLOGY TO THE SURFACE  
NAVY'S MOST COMPLEX AUTOMATED-WEAPON SYSTEM**

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Rising costs of proprietary equipment in legacy electronic applications are increasingly drawing resources from vital programs. Growing interest in evaluating open-architecture technology to replace closed systems is evidenced by publications on the subject. Researchers have approached this topic from various angles, including lifecycle management, risk simulation, total cost of ownership, and knowledge-value-added measures.

This exploratory study uses open architecture hardware employing virtualization technology to test the feasibility of replacing legacy components of military systems. Virtualization has the potential to provide significant cost savings in terms of procurement, daily operation, and maintenance. Additionally, virtualization provides functional benefits such as load-balancing, greater processor utilization and storage flexibility, streamlined scalability, and simplified disaster recovery strategies.

This thesis is original research in the form of a proof-of-concept study. It details performance results of a locally-constructed test platform, designed to simulate a portion of the U.S. Navy's AEGIS Weapon System. The scope of this work is to test the viability of using commodity-based hardware to achieve performance levels equal to, or greater than, current proprietary systems. Value-Added metrics are applied through cost comparisons between the test platform and typical AEGIS systems. While this study specifically targets AEGIS, the results can be generalized to non-military applications.

**KEYWORDS:** AEGIS; Virtualization; Open Architecture

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**KEYWORDS:** AEGIS; Virtualization; Open Architecture

**ORGANIZATIONAL USE OF A FRAMEWORK FOR INNOVATION ADOPTION**

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This research examines organizational theory to gain understanding about the tradeoffs organizations are required to make in order to adopt innovations. As a framework for identifying gaps in current processes, the eight practices identified by Denning and Dunham's *The Innovator's Way, Essential Practices For Successful Innovation* (2010) are introduced. The eight practices are also provided as a tool to improve communications, focus, and methods for achieving innovation adoption within an organization.

**KEYWORDS:** Innovation Adoption, Ambidextrous Organization, Exploration/Exploitation, Innovator's Way

**ANALYSIS OF RETURN ON INVESTMENT IN INDUSTRY SERVICE-ORIENTED ARCHITECTURE IMPLEMENTATION**

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The Department of Defense (DoD) is interested in acquiring systems that promote the use of open architecture (OA). Industry has implemented service-oriented architecture (SOA) in its processes and may provide a benchmark for cost savings as well as examples of best practices for the DoD. The basic research question guiding this thesis is, What are the industry cost-saving benchmarks when transitioning to SOA from a proprietary system? The research supports the argument that OA in the DoD is similar to SOA in industry. This comparison is essential for the application of this thesis because this allows the outcomes of industry SOA implementation to be translated into what the DoD can expect from its OA implementations. This research then answers the research question by analyzing 34 industry reports, 18 of which provided at least an overall ROI, and 10 of which broke out their ROI calculations into separate cost types. The reported costs were grouped into categories of cost savings, cost avoidance, or productivity improvements. The researcher concluded that the industry ROI for SOA implementation is 72%. Additionally, best practices in industry that are transferable to DoD were identified, including ensuring system flexibility and implementing SOA incrementally.

**KEYWORDS:** Service Oriented Architecture (SOA), Open Architecture (OA), Return on Investment (ROI), Modular Open Systems Approach (MOSA)

**AN ADAPTIVE COMMUNICATION SOLUTION: APPLYING COMMERCIAL, OFF-THE-SHELF (COTS) CELLULAR TECHNOLOGY TO TACTICAL-COMMUNICATION REQUIREMENTS**

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## INFORMATION TECHNOLOGY MANAGEMENT

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This thesis will research the availability and applicability of using commercial, off-the-shelf (COTS) cellular software, running on a Smartphone hardware platform to address communication requirements as identified in a 1st Marine Division Universal Needs Statement (UNS). Having only conducted introductory research in to this topic, preliminary results have shown that the majority of the research conducted in the past have centered on either COTS cellular software specific to an application, or on the utility of tactical communication devices as they are currently being employed. The intent of this research is discover if a bridge is possible and available for cellular COTS software running on a COTS Smartphone device to be leveraged, satisfying communication requirements of small unit leaders in a tactical environment.

Our hypothesis is that COTS technology can provide a number of viable options to address tactical communication shortfalls based on the fact that the communication shortfalls identified, are capabilities that the commercial industry currently exercise on a daily basis e.g., text, chat, voice, position location information, imagery and map viewing, streaming video, web browsing and e-mail. All of these identified communication capabilities are available in military command and control systems however, they reside primarily at the higher Headquarter levels, requiring large communication assets to establish those services. Furthermore, due to technology shortfalls and asset limitations, only a few of these capabilities are currently being extended down to the small unit level. Many small unit leaders are experiencing that these limitations in communication capabilities are needlessly placing undue risks on to the mission and their personnel. With COTS Smartphone technology and the advancements made in the commercial cellular industry, this research intends to advance the study towards discover a viable COTS solution that can satisfy tactical communication requirements for the small unit leader.

**KEYWORDS:** Commercial, Off-the-Shelf (COTS), Smartphone, Cellular, Wireless, Application, Technology, Small Unit Leader, Tactical, Network, Network Centric Warfare, Communication Requirements, Marine Corps, IA, STIG, UNS, UNP, EPLRS, IISR, THHR, AN/PRC-117G, JTRS



# MASTER OF SCIENCE IN INFORMATION WARFARE SYSTEMS ENGINEERING

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## DEVELOPING A SOFTWARE MODEL TO ASSESS A NATION'S CAPABILITY TO CONDUCT SUSTAINED, OFFENSIVE CYBER WARFARE

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Co-Advisor: Dorothy E. Denning, Department of Defense Analysis

This research provides a Situational Influence Assessment Module (SIAM) software model for assessing the capability of a country to conduct sustained, offensive cyber warfare. The SIAM Cyber Warfare Capability Model identifies a process to quantify the baseline information needed to evaluate a complex problem. The model is a tool and allows analysts to understand the reasoning behind the assessments made by the model. The SIAM Cyber Warfare Capability Model is meant to be used as a mechanism to examine in detail the factors that should indicate a country's cyber warfare capabilities.

The SIAM Cyber Warfare Capability Model is a four level, hierarchical model that relies on user-defined relationships (links) to inform and assess whether a country has the capability to conduct, sustained offensive cyber warfare. The model requires the user provide a confidence value for the information contained within the Initial Nodes at the lowest level, level four, which will propagate up through the model based on user defined link strengths. The model accounts for the cumulative effect that multiple inputs may have on a nation state's cyber warfare capability through Causal Strengths (CAST) Logic. The analyst is also able to alter the information contained in the level four nodes along with the strength of the links, as more information is made available. This provides for a readily updateable model that considers multiple indicators and relationships.

The SIAM Cyber Warfare Capability Model required 15,010 evaluations in its design once the four level structure was adopted. During the development of the model, we constrained ourselves to work within the data considerations provided by the sponsor. The model requires the user to decide the relative importance of pertinent considerations, as defined within the model, when defining the level four Initial Nodes. The model becomes easily expandable if the analyst determines there is a key consideration missing for an Initial Node it can be incorporated and documented. Furthermore, the model is readily transferrable. The models link strengths and reasoning are well documented allowing for it to be applied to a variety of nations and utilized by multiple organizations.

The SIAM Cyber Warfare Capability Model was delivered to the sponsor, who then shared the model with other members of the Intelligence Community (IC). The sponsor endorsed the approach in our model and felt it provided a solid foundation for future modeling efforts. The sponsor used the Cyber Warfare Capability Model to account for resources in a separate model that analyzes a state's cyber program by taking a capability equals sophistication times resources approach. We view this feedback and subsequent use of our model in a separate product as a validation of the methodology employed in the Cyber Warfare Capability Model.

**KEYWORDS:** Computer Network Operations (CNO), Computer Network Defense (CND), Computer Network Exploitation (CNE), Computer Network Attack (CNA), Cyber Situational Influence Assessment Module (SIAM), Influence Net

**EVALUATION OF HRI PAYLOADS FOR RAPID PRECISION TARGET LOCALIZATION  
TO PROVIDE INFORMATION TO THE TACTICAL WARFIGHTER**

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**Master of Science in Information Warfare Systems Engineering—September 2011**

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**Second Reader: Raymond R. Buettner, Jr., Department of Information Sciences**

High Resolution Imagery (HRI) with precise location and targeting data for the warfighter has become an integral part in today's asymmetric warfare environment. This thesis conducted practical testing of systems and employed qualitative research methods to evaluate HRI payloads for SUAS to provide rapid precision target localization to the warfighter. The research attempted to evaluate new HRI systems integration with the current SUAS's to produce accurate or reduced error images for intelligence and targeting data. The targeting solutions were to be evaluated against those calculated solutions achieved on a manned aircraft. This part of the evaluation was not completed due to the discovery of radio frequency noise interference induced by systems modifications required to fit the small confines of the SUAS platform. Targeting solution research was conducted using archival images from a manned flight mission. Once the system and technology is modified to eliminate the radio frequency noise there is a high probability of successfully proving the desired capability.

**KEYWORDS:** Unmanned Aerial Vehicles, High Resolution Payloads, Targeting, RF Noise

**COMPARATIVE ANALYSIS OF EMERGENCY RESPONSE OPERATIONS:  
HAITIAN EARTHQUAKE IN JANUARY 2010 AND PAKISTANI FLOOD IN 2010**

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This study explores HA/DR operations and the associated response of the international community during the recent earthquake in Haiti and flood in Pakistan in 2010. A powerful earthquake of magnitude 7.0 hit Haiti on January 12, causing great damage and mass casualties. The international community responded swiftly and took over relief efforts in the country saving a lot of lives. Handsome donations were also given and committed. Pakistan suffered heavy floods, which started in the end of July 2010 and affected nearly the entire country. Loss of life was not very great, but infrastructure damage and people subsequently affected surpassed the combined total of the 2004 Tsunami, Haiti earthquake and 2005 South Asia earthquake. During this disaster the international community, particularly volunteer technologists, were not mobilized the way they were in Haiti. Donations were made late and comparatively slow. No single country can handle a large-scale natural disaster like the two exemplar cases chosen for this thesis, and hence the role of the international community is very important. Such response has not been equitable in the past and it is the goal of this research to find ways to make it more equitable in the future.

**KEYWORDS:** Haiti, Earthquake, Pakistan, Flood, Emergency Response Operations, International Community, HA/DR, United Nations, FRC, NDMA, ICT

**DESIGN REQUIREMENTS FOR WEAPONIZING MAN-PORTABLE UNMANNED,  
AERIAL SYSTEMS IN SUPPORT OF COUNTER-SNIPER OPERATIONS**

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The sniper is a highly successful tool used by the enemy to create both physical and psychological effects on U.S. and Coalition forces. A single enemy sniper can pin down an entire company-sized element for an extended period of time, resulting in measurable disruptions in operations. This threat is as old as the rifle itself but has been somewhat shadowed by the proliferation of the improvised, explosive device (IED) over the past few years. Nevertheless, many resources are being dedicated to counter-sniper technology to include: permanently mounted radar systems, vehicle mounted systems, and shot detection systems worn by the individual Soldier to identify the point of origin of the small-arms fire and thus the location of the sniper.

This location is extremely helpful information, but knowledge of the sniper's location alone will not always be enough to regain freedom of maneuver. If the sniper is free to target, his target is not free to maneuver. This thesis explores the design requirements of weaponizing man-portable UAS at the tactical level in support of counter-sniper operations so that the sniper is not free to operate without risk. These systems are already commonly deployed on the battlefield and if a scalable weapons system capability can be provided it will immediately reduce the effectiveness of the adversary snipers.

**KEYWORDS:** Unmanned Aerial System, UAS, UAV, SUAS, MAV, RQ-11B Raven, RQ-151 Pointer, Puma AE, Wasp III, Quadrotor, Weaponized UAS, Counter-Sniper, Man-Portable, VTOL

**USING VOICE-OVER-INTERNET PROTOCOL TO  
CREATE TRUE END-TO-END SECURITY**

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In 2010, there were approximately 260,000 classified messages released to the general public via the website Wikileaks. The classified information was gathered by a "trusted" military member who had the right level of clearance to view the documents in question, but did not have a need to know. This easily illustrates the flaw in trusted enclaves and computing bases that secure the data lower than Layer 7 of the OSI Reference Model. Once a spy, hacker, or "trusted" member is inside the enclave, they have access to any and all information they wish to see.

The goal of this thesis is to convey the need for security solutions that are developed at Layer 7 of the OSI Reference Model. VOIP/SIP clients that use TLS and SRTP in conjunction with PKI will show that there are already solutions that exist at Layer 7. Additionally, clients that take advantage of ZRTP will provide the best examples of protecting data instead of just an infrastructure. Because only small amounts of source code will see unprotected data, thorough analysis of this code is achievable mitigating security vulnerabilities within the code.

**KEYWORDS:** VOIP, Voice Over Internet Protocol, RTP, SRTP, SIP, TLS, ZRTP, Session Initiation Protocol, End-to-End Security, Network Security, Software Engineering, SIP Server

INITIAL DESIGN AND CONCEPT OF OPERATIONS FOR A  
CLANDESTINE DATA-RELAY UUV TO CIRCUMVENT JUNGLE-  
CANOPY EFFECTS ON SATELLITE COMMUNICATIONS

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Communications within jungle environments has always been a difficult proposition. This is especially true of collection assets beneath triple canopy jungle that need to communicate with overhead national assets. The traditional methods of countering the negative effects of the canopy on EM signals have been to increase the power to offset the losses, or to utilize new, more canopy transparent portions of the EM spectrum. However, there are complications with both of these methods. Simply increasing transmitted power increases the drain on the system's power supply, thus lowering effective on-station time. Shifting to a different portion of the EM spectrum can negatively affect the transmission rate of the system and requires specialized equipment such as antennas and modulators.

This work addresses the issue by designing a semi-autonomous UUV, which will clandestinely relay data from the embedded jungle systems to overhead national assets. Rather than trying to punch through the canopy directly, the proposed UUV will take advantage of the fact that most jungle water ways have, at the very least, a thinner canopy overhead if not a clear view of the sky for less lossy satellite communications. This shifts the primary communications from an Earth-Sky problem to a lateral wave model where the communications travels parallel to the canopy. While the jungle is still not an ideal medium for communications, other methods can be used to address these losses.

The proposed UUV will be designed to be cheap and constructed from existing systems. It will also be small, and lightweight, enough to be delivered and deployed in theater via aircraft, boats, and operators on the ground. Additionally it will be capable of long on station times due to the ability recharge on station.

**KEYWORDS:** AUV, UUV, Jungle Operations, Data Relay, Clandestine Operations

# MASTER OF SCIENCE IN MECHANICAL ENGINEERING

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## **LOW-SPEED, WIND-TUNNEL FLOW QUALITY DETERMINATION**

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

Low-speed wind tunnel testing continues to be a fundamental tool in the study of fluid dynamics. Before utilizing the tunnel as a test platform, the flow characteristics within the test section must be examined to provide a picture of the quality and suitability of the wind tunnel for experimentation or demonstration purposes. Towards this goal, the NPS MAE wind tunnel was reinstalled and calibrated. In particular, the calibration process involves determining wind tunnel speed vs. the motor speed, the tunnel wall static pressure distribution, and static pressures across selected planes, the two-dimensionality of the velocity profile, using a pitot-static tube as well as a single component hot wire (CTA), the wall boundary layer characteristics consisting of the velocity profile, the streamwise turbulence intensity distribution, and the spectral characteristics of the flow at selected points, which were all completed.

Dedicated instrumentation consisting of pressure transducers attached to a pitot-static tube, wall static pressure taps, and a pressure rake; a hotwire anemometry system; a linear traverse system was assembled. It also included a data acquisition (DAQ) processor with high-speed analog to digital conversion and digital I/O boards, all of which were controlled by in-house developed LabVIEW software.

Results of the testing show an axial velocity range of 0-38 m/s, a maximum velocity which is 84% of the tunnel's rated speed. The 2-D flow uniformity was found to be within  $\pm 7\%$  using a pressure rake and  $\pm 3\%$  with a turbulence intensity  $\approx 0.11\%$  at full speed using a CTA, demonstrating the tunnel's viability as a demonstration platform. Power spectral density plots in the boundary layer exhibit typical behavior of fully developed turbulent flow, and future testing of a flat-plate wake defect is planned for verification.

**KEYWORDS:** National Instruments, LabVIEW, Virtual Instrument, Wind Tunnel, Data Acquisition, Plint, Microstar, Turbulence Intensity, Boundary Layer, Power Spectrum

## **APPLYING MASSIVELY PARALLEL KINETIC MONTE CARLO METHODS TO SIMULATE GRAIN GROWTH AND SINTERING IN POWDERED METALS**

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Kinetic Monte Carlo (KMC) simulation methods were utilized to study the grain growth and sintering of nanocrystalline metal compacts. Sintering is the process used to fabricate materials from powders by densifying the powder compact at elevated temperatures. Recently, experimental literature has demonstrated that nanoparticles ( $< 50$  nm) can be used to bond materials at dramatically lower temperatures and pressures while maintaining the mechanical properties of nanostructured materials. Despite these promising results, the grain growth and sintering mechanisms of nanostructures are not fully understood.

Simulations performed using KMC algorithms can be used to model nanoparticle grain growth and sintering. Sandia National Laboratories' new, massively-parallel, Stochastic Parallel Particle Kinetic Simulator (SPPARKS) code is capable of simulating large-scale problems of grain growth and sintering from the nanoscale to the microscale.

This thesis focused on setting up SPPARKS on the Naval Postgraduate School's high performance computing resources. The performance of SPPARKS was assessed for large-scale simulations of grain growth and sintering. Using SPPARKS, the ability to perform coupled grain growth and sintering was demonstrated while controlling variables such as temperature, porosity, and grain size. The results demonstrate the importance of the spatial distribution of porosity on the nanostructure evolution during grain growth and sintering.

**KEYWORDS:** Grain Growth, Sintering, Nanoparticles, Kinetic Monte Carlo, Stochastic Parallel Particle Kinetic Simulator, High Performance Computer Simulations

### **INVESTIGATION OF TRANSITIONAL FLOWS ON COMPRESSOR BLADES IN CASCADE**

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Flow around polished second-generation controlled-diffusion blades in cascade set at their design inlet flow angle was investigated at various Reynolds numbers using static pressure measurements, five-hole probe surveys, two-component laser Doppler velocimetry (LDV), computational fluid dynamics and flow visualization. A suction-side separation bubble formed at Reynolds number, based on chord length, of 203,000 and collapsed by a Reynolds number of 393,000. Five-hole probe surveys characterized the blade-row inlet and outlet flow and showed the loss coefficient had a maximum value of 0.030 at a Reynolds number of 203,000 and a minimum of 0.012 at a Reynolds number of 400,000. The suction-side separation bubble was completely documented with LDV. The boundary layer was found to undergo laminar separation at 55 percent axial chord, transitioned in the boundary layer and re-attached turbulent by 67 percent axial chord. A quasi three-dimensional, Reynolds-Averaged Navier-Stokes, computational fluid dynamics model was created and accurately predicted the suction-side separation bubble and boundary layer transition inside the bubble. Flow visualization verified the transitional behavior of the separation bubble and showed the separation point was steady while the reattachment point was turbulent.

**KEYWORDS:** Controlled-Diffusion, Cascade, Compressor, Separation, Laser Doppler Velocimetry, Computational Fluid Dynamics

### **DEVELOPMENT OF NANOPOROUS CARBIDE-DERIVED CARBON ELECTRODES FOR HIGH-PERFORMANCE LITHIUM-ION BATTERIES**

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**Master of Science in Mechanical Engineering—September 2011**

**Advisor: Sebastian Osswald, Department of Physics and Department of Mechanical and Aerospace Engineering**

**Second Reader: Joseph Farmer, Lawrence Livermore National Laboratory**

Lithium ion batteries are the state-of-the-art power sources for portable electronic devices and, due to their superior energy and power densities, are promising candidates for the demanding energy storage applications of the U.S. Navy and other branches of the military. While graphitic carbon is currently the most common anode material in lithium ion batteries, it suffers from low specific capacity ( $\sim 372$  mAh/g) and poor power

characteristics. In contrast, amorphous carbons allow for faster charge/discharge kinetics and were found to exhibit specific capacities of up to 1,000 mAh/g due to a different, and still unknown storage mechanism. This work examines the suitability of amorphous carbide-derived carbon (CDC) anodes for high-power and high-energy density lithium ion batteries. Using different material characterization techniques, such as Raman Spectroscopy, X-Ray Diffraction (XRD), and Scanning Electron Microscope (SEM), we aim to determine the relationship between the structural features of CDC to its electrochemical performance. Studies were conducted on three titanium carbide (TiC)-based CDC powders, synthesized at 600, 1,000, and 1,200 °C. Custom-made CDC anodes were fabricated, tested and cycled against commercial LiCoO<sub>2</sub> and lithium metal cathodes in button-type coin cell enclosures. Electrochemical testing revealed specific capacities approaching 300 mAh/g. While the observed specific energy is lower than that of a conventional graphite anodes, the results are promising and may provide deeper insights into the relatively unknown charge storage mechanism in amorphous carbons. Our results also indicate that CDCs allow for substantial improvements in power characteristics, but additional research is needed to verify the obtained results and further optimize the electrode fabrication process.

**KEYWORDS:** Lithium Ion Batteries, Nanoporous Carbon, Carbon Anode, Carbide-Derived Carbon, Raman Spectroscopy, Scanning Electron Microscope, X-Ray Diffraction

### **ALTERNATIVES IMPACT IN COMBATANT SHIP DESIGN**

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**B.S., Colombia Naval Academy, 2009**

**Master of Science in Mechanical Engineering–September 2011**

**Mechanical Engineer–September 2011**

**Advisor: Fotis Papoulias, Department of Mechanical and Aerospace Engineering**

**Co-Advisor: Clifford Whitcomb, Department of Systems Engineering**

This thesis continues the development of a systems methodology for the conceptual design of a medium tonnage combatant ship for the Colombian navy. The purpose is to demonstrate the impact that different systems and operational capabilities have in the overall design. The objective is to demonstrate the ability to conduct ship trade-off studies based on capability, allowing ship design configuration decisions on the warfighting effectiveness over multiple missions, with explicit consideration of combat and weapon-system characteristics. Once the mission capabilities that a ship must accomplish have been identified, a set of ship designs is created using a synthesis model, which are then formed into a multidimensional design space. Mission-effectiveness models are then used to simulate the how well each ship mission is accomplished in the context of warfighting scenarios.

The ship-design space and each mission-effectiveness space are formed using response surface designs created through a design of experiments methodology. The mission scenarios are a multiple-criteria decision space in which ship alternatives are assessed as solutions to the overall design problem. The combat-system design variables link the multiple response surfaces to form the relationships between mission capabilities and ship characteristics. A statistical analysis tool, JMP, creates a graphical environment that decision makers can use to interactively analyze different ship alternatives and determine the most effective design from a warfighting perspective.

The thesis demonstrates an example of selecting conceptual designs that meet desired mission-effectiveness criteria for the medium-tonnage combatant for mission scenarios of interest to the Colombian navy.

**KEYWORDS:** Conceptual Ship Design, Combatant Ship, Ship Trade-Off Studies, Design of Experiments, Design Space, Model Based Systems Engineering, Capability Based Design.

**FLUID-STRUCTURE-INTERACTION EFFECT ON  
SANDWICH-COMPOSITE STRUCTURES**

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B.S., Virginia Military Institute, 1998**

**Master of Science in Mechanical Engineering—September 2011**

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

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

The objective of this research is to examine the fluid structure interaction (FSI) effect on composite sandwich structures under a low velocity impact.

The primary sandwich composite used in this study was a 6.35 mm balsa core and a multi-ply symmetrical plain weave 6 oz E-glass skin. The specific geometry of the composite was a 305 mm by 305 mm square with clamped boundary conditions. Using a uniquely designed vertical drop-weight testing machine, there were three fluid conditions in which these experiments focused. The first of these conditions was completely dry (or air) surrounded testing. The second condition was completely water submerged. The final condition was a wet top/air-backed surrounded test. The tests were conducted progressively from a low to high drop height to best conclude the onset and spread of damage to the sandwich composite when impacted with the test machine. The measured output of these tests was force levels and multi-axis strain performance.

The collection and analysis of this data will help to increase the understanding of the study of sandwich composites, particularly in a marine environment.

**KEYWORDS:** Fluid Structure Interaction, FSI, composite, balsa, low velocity impact, sandwich composites, VARTM, Vacuum Assisted Resin Transfer Molding

**INVESTIGATION OF AN EXPLICITLY MODELED, SOLID, OCEAN FLOOR  
ON A SHALLOW-WATER UNDERWATER EXPLOSION EVENT**

**Adam P. Walters—Lieutenant, United States Navy**

**B.S., Purdue University, May 2005**

**Master of Science in Mechanical Engineering—September 2011**

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

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

Current practices for modeling the ocean floor in underwater explosion simulations call for application of an inviscid fluid with soil properties. A method for modeling the ocean floor as a Lagrangian solid, vice an Eulerian fluid, was developed in order to determine its effects on underwater explosions in shallow water using the DYSMAS solver. The Lagrangian solid bottom model utilized transmitting boundary segments, exterior nodal forces acting as constraints, and the application of prestress to minimize any distortions into the fluid domain. Elastic materials were used, though multiple constitutive soil models can be applied to improve the accuracy. This method is unable to account for soil cratering effects, however it provides the distinct advantage of modeling contoured ocean floors such as dredged channels and sloped bottoms absent in Eulerian formulations. The dynamic loading effects of the investigated bottom contours were found to be negligible in the analyzed cases as a result of the bulk cavitation zone which dominates the chosen fluid field and serves as a buffer to the target. In addition to its utility in bottom modeling, implementation of the non-reflecting boundary along with realistic material models can be used to drastically reduce the size of current fluid domains.

**KEYWORDS:** Underwater Explosion, Shallow Water, DYSMAS, Dyna\_N(3D), Gemini, Ocean Bottom Modeling, Transmitting Boundary

**INTEGRATION OF CONTROL ALGORITHMS FOR QUADROTOR  
UAVS USING AN INDOOR SENSOR ENVIRONMENT**

**Bryan D. Watts—Lieutenant, United States Coast Guard  
B.S., U.S. Coast Guard Academy, July 2005**

**Master of Science in Mechanical Engineering—September 2011**

**Advisor: Isaac Kaminer, Department of Mechanical and Aerospace Engineering**

**Second Reader: Vladimir Dobrokhodov, Department of Mechanical and Aerospace Engineering**

This thesis develops an architecture that facilitates the design and indoor testing of control algorithms implemented onboard quadrotor UAVs using an ultra-wideband (UWB) indoor positioning solution from Ubisense. Initially, details are provided on basic quadrotor dynamics, the setup of the indoor sensor environment, and the communication scheme. A thorough analysis is conducted on the accuracy and estimation lag of Ubisense UWB sensors for providing indoor position information to the quadrotor.

Once this framework is established, the focus is placed on design and experimental validation of the altitude hold control algorithm. The observer used is a discrete Kalman filter which minimizes the covariance of position and acceleration measurement inputs to produce a smooth estimation of states (position, velocity and acceleration). These estimated states are then fed into a modified P-D plus Integral controller to produce quadrotor thrust commands for given altitude step commands. Results indicate that the technology used is capable of maintaining a UAV's altitude within an error margin of  $\pm 13.3$  cm, but the relatively slow update rate of the Ubisense system limits the possibility of more complex and aggressive maneuvers.

**KEYWORDS:** UAV, Quadrotor, Autonomous, Control, UWB, RFID, RTLS, Ubisense, Kalman Filter, Altitude Hold, Vertical Channel



# MASTER OF SCIENCE IN METEOROLOGY AND OCEANOGRAPHY

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## MEASUREMENTS OF THE AIR–SEA INTERFACE FROM AN INSTRUMENTED SMALL BUOY

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B.A., Brigham Young University, 1999

Master of Science in Meteorology and Oceanography—September 2011

Advisor: Qing Wang, Department of Meteorology

Co-Advisor: Thomas Herbers, Department of Oceanography

An instrumented spar buoy, Met-on-a-Stick (MOAS), was designed, deployed, and validated for measuring the air sea interface processes at multiple levels. This system was deployed in June 2010 off the coast of California, and January and February 2011 in Monterey Bay. The system provides mean measurements of wind, temperature, and humidity at multiple levels within 3 m above the sea surface and measurements of sea surface temperature at three levels below ocean surface. It is small enough to be deployed and retrieved by two people. This thesis work introduces the design and the instrumentation of the system and evaluates the ability of the system for characterizing near-surface vertical variations of the marine boundary layer. The results indicate that the platform performance is as expected and is capable of providing measurements to characterize the fine variations close to the air–sea interface. We foresee a broad use of the MOAS in the future due to its low-cost and ease of deployment. Future improvements of the system include the use of better wind and GPS sensors to increase the quality of wind and wave measurements from the MOAS.

**KEYWORDS:** Monin-Obukholv, linear wave theory, surface flux, log linear profile, constant flux layer, meteorology instrument, oceanography instrument

## EVALUATING TROPICAL CYCLONE FORECAST TRACK UNCERTAINTY USING A GRAND ENSEMBLE OF ENSEMBLE PREDICTION SYSTEMS

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M.S., University of Southern Mississippi, August 2008

Master of Science in Meteorology and Oceanography—September 2011

Advisor: Patrick A. Harr, Department of Meteorology

CO-Advisor: Eva D. Regnier, Department of Operations Research

The skill of a combined grand ensemble (GE), which is constructed from three operational global ensemble prediction systems (EPS), is evaluated with respect to the probability forecast of a tropical cyclone (TC) being within a specified area. Anisotropic probability ellipses are defined from the GE to contain 68% of the ensemble members. Forecast reliability is based on whether the forecast verifying position is within the ellipse. A sharpness parameter is based on the size of the GE-based probability ellipse relative to other operational forecast probability ellipses. For the 2010 Atlantic TC season, results indicate that the GE ellipses exhibit a high degree of reliability whereas the operational probability circle tends to be over-dispersive. Additionally, the GE ellipse tends to be sharper than the operational product for forecast intervals beyond 48 hours. The size and shape of the GE ellipses varied with TC track types, which suggests that information about the physics of the flow-dependent system is retained whereas isotropic probability ellipses may not reflect

variability associated with track type. It is concluded that the GE probability ellipse demonstrates utility for combined EPS to enhance probabilistic forecasts for use as TC-related decision aids, as there is a potential for reducing the sizes of warning areas.

**KEYWORDS:** Grand Ensemble Operational Ensemble Prediction Systems, Tropical Cyclone, Spatial variability, Probability Ellipse, Flow dependent system.

# MASTER OF SCIENCE IN METEOROLOGY AND PHYSICAL OCEANOGRAPHY

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## CLIMATE AND WEATHER ANALYSIS OF AFGHANISTAN THUNDERSTORMS

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Master of Science in Meteorology and Physical Oceanography—September 2011

Advisor: Tom Murphree, Department of Meteorology

Co-Advisor: Paul Frederickson, Department of Meteorology

Thunderstorms are a significant factor in the planning and execution of Department of Defense (DoD) operations in Afghanistan, especially in the spring and summer. Skillful forecasting of Afghanistan thunderstorms has proven difficult, even at relatively short lead times of 24 hours or less. This has led to adverse effects on a wide range of DoD missions. One potential reason for the forecasting difficulties is a lack of understanding of the conditions that lead to static instability and thunderstorms in the elevated desert mountain environment that characterizes much of Afghanistan. Much of the thunderstorm forecasting for Afghanistan is based on forecasting methods developed for the contiguous U.S. (CONUS)—for example, the use of CONUS-based static stability indices as indicators of the potential for thunderstorm development. We have investigated methods for improving thunderstorm forecasting in and near Kabul, Afghanistan, by: (1) analyzing interannual to hourly variations in thunderstorm activity; and (2) analyzing the large-scale conditions that are favorable and unfavorable for thunderstorms. We used in-situ surface and radiosonde data to characterize the local conditions associated with thunderstorm variations. Our focus was on March–May, the period with the most thunderstorm activity in Kabul. We also used global reanalysis data to analyze the large-scale conditions that are favorable and unfavorable for thunderstorm development. We developed and tested two new static stability indices for use in Kabul. We also developed a large-scale circulation index to describe the regional factors that contribute to thunderstorm variations. Finally, we identified outgoing longwave radiation anomalies that occurred in specific tropical ocean basins as potential precursors for predicting thunderstorm and non-thunderstorm events at lead times of five to fifteen days.

**KEYWORDS:** Kabul, Afghanistan, Forecasting, Elevated Desert Mountain Environment, Thunderstorms, Static Stability, Indices, Climate, Climate Variations, Climate Analysis, Range Forecasting

## NUMERICAL SIMULATIONS, MEAN FIELD THEORY AND MODULATIONAL STABILITY ANALYSIS OF THERMOHALINE INTRUSIONS

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Master of Science in Meteorology and Physical Oceanography—September 2011

Advisor: Timour Radko, Department of Oceanography

Second Reader: Jason Flanagan, National Research Council Research Associate

Thermohaline intrusions are produced by lateral shear advection across thermal and haline fronts, self-driven via double-diffusion, and cause significant lateral fluxes. The primary goal of this thesis is to understand the mechanisms responsible for their development and equilibration. Previous theories (mean-field models) were limited by their reliance on the vertical flux laws, which still remain a great source of uncertainty and require

modelers to assume that intrusion development is uniquely determined by the background gradients. An alternative approach, based on the multiscale mechanics, views intrusions as modulational instability of the rapidly varying salt fingers. We present an exhaustive study on the effects of background parameters on the vertical and horizontal fluxes of temperature and salinity using two-dimensional numerical simulations. Specific experiments are designed to identify the most promising theoretical techniques for predicting intrusion evolution. Based on numerical results, the assessments of the two theoretical models are made and the mean field theory is found to be superior. Growth rates are calculated as a function of inclination of intrusions, which is used to determine the dominant modes by focusing on the fastest-growing instability. Equilibrium diffusivities are calculated to develop an explicit parameterization for the effects of thermohaline intrusions.

**KEYWORDS:** Salt Fingers, Double Diffusion, Double-Diffusive Convection, Heat Flux, Salt Flux, Prandtl Number, Prandtl, Diffusivity, Diffusivity Ratio, Growth Rate Balance, Salt Finger Growth Rate, Thermohaline, Diffusive Convection, Buoyancy, Ocean Circulation, Ocean Convection, Turbulent Mixing

### **AIR-OCEAN CHARACTERISTICS DURING THE IMPACT OF TYPHOONS ON THE OCEAN IN THE PACIFIC (ITOP) PROGRAM**

**Amy D. Heck—Lieutenant Commander, United States Navy  
B.S., United States Naval Academy, 2000**

**Master of Science in Meteorology and Physical Oceanography—September 2011**

**Advisor: Patrick A. Harr, Department of Meteorology**

**Second Reader: COL John L. Dumas, USA, Department of Meteorology**

Interactions between a tropical cyclone (TC) and the underlying ocean environment can have significant impacts on physical mechanisms during the formation and intensification of the storm. During the summer of 2010, the Impact of Typhoons on the Ocean in the Pacific (ITOP) program was conducted to examine interactions between the ocean and TCs using a variety of experimental approaches. Specific observational assets included an array of moored buoys, two WC-130J aircraft, and a U.S. research vessel (RV Revelle). Airborne-deployed sensors included dropwindsondes, airborne expendable bathythermographs (AXBTs), Lagrangian floats, and drifters.

In this thesis, AXBT observations were used to examine basic characteristics of the ocean environment during TCs that occurred during ITP. Observations were compared to the Naval Research Laboratory East Asian Seas Numerical Forecast System (NRL EASNS). For high ocean heat content (OHC), the model analyzed OHC was too low and for low OHC, the model analyses were too high. The largest analyzed and observed differences were found to occur in regions of TC-induced ocean changes. The significance of this comparison is the contribution to understanding the relationship between OHC and TC structure, with specific focus on the representation in the operational NRL EASNFS.

**KEYWORDS:** Tropical Cyclone, Air-Ocean Interaction, Ocean Heat Content, Typhoon

### **AN EFFECTIVE NOISE-FILTERING METHOD FOR MINE DETECTION**

**Bryan Y. Hong—Lieutenant, United States Navy  
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**Master of Science in Meteorology and Physical Oceanography—September 2011**

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

**Second Reader: Ronald E. Betsch, NAVO, Stennis Space Center, Mississippi**

Automatic detection of sea mines in coastal regions is difficult due to highly varying sea bottom conditions present in the underwater environment. Detection systems must be able to discriminate objects that vary in size, shape, and orientation from naturally occurring and man-made clutter. Additionally, these automated

systems must be computationally efficient to be incorporated into Unmanned Aerial Vehicle (UAV) sensor systems characterized by high sensor data-rates and limited processing abilities. Commonly used noise filters largely depend on the window (or neighborhood) size, which makes the mine detection ineffective. Using the bi-dimensional empirical mode decomposition (BEMD) analysis, an effective, robust sea mine detection system can be created. A family of decomposed images is generated and applied to optical lidar image data (ROAR) supplied by Naval Surface Warfare Center, Panama City. These decompositions project key image features, geometrically defined structures with orientations, and localized information into distinct orthogonal components or feature subspaces of the image. Application of the BEMD method to the analysis on side scan sonar data is also provided.

Accurate detection and classification of mines is time consuming and requires divers or AUVs in the water. The navy continues to pursue more expedient methods in mine countermeasures, and with airborne lidar, a surf zone and landing zone can be quickly surveyed for possible mines. In the near surf zone, all possible mines can be quickly neutralized by dropping guided munitions, eliminating the need to send divers or AUVs to verify contacts. Still, the need for improved methods of detection and classification is needed. BEMD, a relatively new method of signal analysis developed about fifteen years ago, was tested on lidar imagery from the ROAR experiment to look for any improvements in detecting and classifying mines.

KEYWORDS: Bi-Dimensional Empirical Mode Decomposition, Filter, Mine Detection, Lidar Survey

### **MODELING THE IMPACTS OF INTRASEASONAL TO INTERANNUAL CLIMATE VARIATIONS ON TROPICAL CYCLONE FORMATIONS IN THE WESTERN NORTH PACIFIC**

**Stephanie A. Johnson–Lieutenant, United States Navy**

**B.A., University of Washington, June 2006**

**Master of Science in Meteorology and Physical Oceanography–September 2011**

**Co-Advisor: Tom Murphree, Department of Meteorology**

**Co-Advisor: David W. Meyer, Department of Meteorology**

We have analyzed the modulation of TC formations in the western North Pacific (WNP) during July-October by El Niño (EN), La Niña (LN) and the Madden Julian Oscillation (MJO). This analysis was conducted from the perspective of several large scale environmental factors (LSEFs) that strongly influence tropical cyclone (TC) formation: sea surface temperature (SST), low level relative vorticity, vertical wind shear, and upper level divergence. We examined the variations in each LSEF associated with EN, LN, and MJO. We used composite LSEFs for EN, LN, and each of the eight MJO phases to force the Naval Postgraduate School (NPS) statistical model for calculating TC formation probabilities. We then compared the resulting probabilities to actual formations to determine how accurately the model represented ENLN and MJO related variations in TC formations.

The model based probabilities provide a realistic quantitative representation of how ENLN and MJO make TC formations more and less likely in the WNP. In particular, the model accurately represents: (1) the southeastward (northwestward) shift in conditions favorable for TC formation during EN (LN); and (2) the enhancement (suppression) of formation favorable conditions to the west and east of the Philippines during phases 4-7 (1-3, 8) of the MJO. For ENLN, the LSEF variations that appear to have the most direct impacts on the TC formation probability variations are those in SST, low level relative vorticity, and the zonal component of vertical wind shear. For MJO, the LSEF variations that appear to have the most direct impacts on the TC formation probability variations are those in low level relative vorticity, the zonal component of vertical wind shear, and upper level divergence. Our results should be useful in improving the education, training, and environmental situational awareness of TC forecasters. Our results also indicate that the NPS model has the potential to improve operational forecasting of TC formations in the WNP, if forced by skillful forecasts of the LSEFs. If so, the resulting forecasts would be useful in improving the planning of DoD and other operations in the WNP.

**KEYWORDS:** Tropical Cyclones, Western North Pacific, Long Range Forecasting, Large Scale Environmental Factors, El Niño, La Niña, Madden-Julian Oscillation

**DERIVATION OF RIVER BATHYMETRY USING IMAGERY  
FROM UNMANNED, AERIAL VEHICLES (UAVS)**

**Matthew Pawlenko—Lieutenant Commander, United States Navy**

**B.S., Purdue University, August 2002**

**Master of Science in Meteorology and Physical Oceanography—September 2011**

**Advisor: Philip A. Durkee, Department of Meteorology**

**Co-Advisor: K. Todd Holland, Naval Research Laboratory, Stennis Space Center**

In many places where U.S. forces operate, there is insufficient data regarding river-water depths, which is needed for safe operational planning. Satellite sensors and airborne manned platforms have been used for bathymetric derivation, but are not in abundance, nor do they have the spatial resolution required to examine smaller rivers. Using unmanned, aerial vehicles (UAVs), this research examines the feasibility of using a ratio method with digital imagery to derive water depths, as well as a simpler polynomial regression to create a look-up table for use in the field. The results show that the ratio method of red to blue had higher correlation than the red color band on its own, and simple polynomial regression using a ratio of red to blue had higher correlation than more widely accepted methods. However, both methods are limited by a maximum depth, defined as the point where color no longer changes with depth—all depths beyond this point appear as maximum depth. These findings show that using imagery from UAVs for bathymetric derivation could be a feasible alternative to accepted satellite imagery methods, but further research is needed to demonstrate operational utility.

**KEYWORDS:** Unmanned Aerial Vehicle, River Bathymetry, Remote Sensing, Bathymetric Derivation, Look-up Table, Beer's Law, Kootenai River, Trinity River

**THE USE OF AUTONOMOUS VEHICLES FOR SPATIALLY MEASURING  
MEAN VELOCITY PROFILES IN RIVERS AND ESTUARIES**

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**B.S., University of South Alabama, December 2003**

**Master of Science in Meteorology and Physical Oceanography—September 2011**

**Advisor: Jamie MacMahan, Department of Oceanography**

**Second Reader: Ed Thornton, Professor Emeritus**

Autonomous vehicles (AVs) are commonly used in oceanic and more recently estuarine and riverine environments because they are small, versatile, efficient, moving platforms equipped with a suite of instruments for measuring environmental conditions. However, moving vessel observations, particularly those associated with Acoustic Doppler Current Profiler (ADCP) measurements, can be problematic owing to instrument noise, flow fluctuations, and spatial variability. A range of ADCPs manufactured by different companies were integrated onto an Unmanned Surface Vehicle (USV), an Unmanned Underwater Vehicle (UUV), and some additional stationary platforms, and were deployed in a number of natural riverine and estuarine environments to evaluate the quality of the velocity profile over the depth, minimum averaging time interval requirements and AV mission planning considerations. An appropriate averaging window,  $T_*$ , was determined using the Kalman Algorithm with a Kalman gain equal to 1%.  $T_*$  was found to be independent of depth, flow velocity, and environment. There was no correlation ( $R^2=0.18$ ) for  $T_*$  between flow magnitude and direction. Results from all measurements had a similar  $T_*$  of approximately 3 minutes. Based on this, an averaging window of 4 minutes is conservatively suggested to obtain a statistically confident measure of the mean velocity profile.

**KEYWORDS:** Unmanned Surface Vehicle (USV), Unmanned Underwater Vehicle (UUV), Acoustic Doppler Current Profiler (ADCP), Velocity profile, Riverine, Estuarine

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

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## **IMPROVING MILITARY CHANGE DETECTION SKILLS IN A VIRTUAL ENVIRONMENT: THE EFFECTS OF TIME, THREAT LEVEL, AND TUTORIALS**

**Jason C. Caldwell—Major, United States Army**

**B.S., United States Military Academy, 1995**

**Michael K. Stinchfield—Major, United States Army**

**B.S., Troy State University, 2000**

**Master of Science in Modeling, Virtual Environments, and Simulations—September 2011**

**Advisor: Michael E. McCauley, MOVES Institute**

**Co-Advisor: Anthony Ciavarelli, MOVES Institute**

**Second Reader: Quinn Kennedy, Department of Operations Research**

The first one hundred days of combat are the most dangerous time for a Soldier due to uncertainty and unfamiliarity with his area of operations. Developing a desktop virtual trainer for change detection could reduce the threat to Soldiers by improving their ability to detect signals among the cluttered, noisy neighborhoods of the current operational environment. Building upon previous change detection and signal detection works, this thesis explores the use of Army Virtual Battlespace 2™ as a prototype-training tool for change detection. Leveraging an Army-owned distributable trainer would potentially benefit Soldiers prior to deployment. This research team conducted an experiment that tested fifteen participants over four weeks. Each participant explored the virtual environment twelve times. Researchers analyzed correct detections, false alarms, user confidence, threat levels, and tutorial group assignment. This first attempt at developing a military-oriented virtual trainer resulted in statistically significant improvement in detection percentages, user confidence, and decay of false alarm rates over time with p-values less than 0.01. The results showed no significance in the use of an in-simulation tutorial or target threat level. Future work should expand on this foundational research to determine whether the skills developed using this trainer transfer to real-world change detection.

**KEYWORDS:** Virtual Battlespace 2, Virtual Environment Training, Change Detection

## **DESIGN AND TASK ANALYSIS FOR A GAME-BASED SHIPHANDLING SIMULATOR USING AN OPEN SOURCE GAME ENGINE (DELTA3D)**

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**B.S., Brazilian Naval Academy, December 1998**

**Master of Science in Modeling, Virtual Environment, and Simulation—September 2011**

**Co-Advisor: Christian Darken, Department of Computer Science**

**Co-Advisor: Anthony Ciavarelli, MOVES Institute**

**Second Reader: Roberto de Beauclair, Pontifical Catholic University of Rio de Janeiro, Brazil**

This thesis addresses the need for a navigation and shiphandling game-based training system at naval academies. The Yard Patrol Simulator (YPSim) is an application designed to reduce the knowledge gap between classroom instruction and hands-on training onboard naval academy training boats (YPs). The goal was to

develop a proof-of-concept game-based simulator that uses 3D graphics to replicate basic tasks executed onboard the YPs. Two missions were selected for a brief task analysis study to determine the design of the respective game scenario and requirements. The design process involved in building user interface, physics model, 3D models, and artificial intelligence actors are described in this work. For thesis purposes, YPSim was designed using the Brazilian Naval Academy's YP as a training framework development environment. Using a sample of the final end user population, we conducted a user acceptance study of proof-of-concept version of YPSim (v0.14) at the Brazilian Naval Academy. The findings in this work can be generalized to any other naval academy or institution where basic navigation and shiphandling instruction is provided. Initial results from a prototype implementation of YPSim at the Brazilian Naval Academy provided insights into the potential use of this training system.

**KEYWORDS:** Simulator Design, Serious Games, Shiphandling Simulator, Training, Virtual Environments, Simulation, Open Source, Brazilian Navy

### **IDENTIFYING THE METHOD FOR EFFECTIVE COMBAT MARKSMANSHIP USING SITE OPTICS AND PACKAGED SENSOR FEEDBACK**

**Gabriel D. Diaz—Captain, United States Marine Corps**

**B.S., University of New Mexico, May 2005**

**Master of Science in Modeling Virtual Environments and Simulation—September 2011**

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**Co-Advisor: Anthony Ciavarelli, MOVES Institute**

**Second Reader: Christian Smith, Department of Operations Research**

The Marine Corps is assessing how shooters train for Combat Marksmanship. An implementation of the Rifle Combat Optics (RCO) has been introduced into the Annual Rifle Qualification requirement. The question now is how do coaches modify training to effectively instruct the shooters in firing with the RCO? This study provides feedback using the Split Shot Scope System as an aid in training doctrinal techniques for marksmanship on live fire ranges. The assessments, provided by current Marine Corps Marksmanship Instructors, highlight a necessity to using a device such as the Split Shot Scope System. In a post survey conducted in the study, responses provide a viable path to employing this diagnostic tool during live fire shooting and reporting the level of utility of this device. Added, in this study, is the use of a sensor package derived from concepts of the Indoor Simulated Marksmanship Trainer (ISMT), which will be discussed to provide the utility of such a device for improving and defining a useful technique for training shooters. While this may not be a complete fix to the dilemma, this study has provided an approach to understanding and deriving methods for effective marksmanship training and diagnosing fundamental problems more clearly.

**KEYWORDS:** Marksmanship, Optics, Remote Sensors, Shooting, Simulation, Rifle, Weapons, Training

### **COMPARISON OF DATA DEVELOPMENT TOOLS FOR POPULATING COGNITIVE MODELS IN SOCIAL SIMULATION**

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**B.S., United States Naval Academy, May 1996**

**Master of Science in Modeling, Virtual Environments, and Simulations—September 2011**

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

**Second Reader: LTC Jonathan K. Alt, USA, TRAC—Monterey**

The United States is engaged in a new type of warfare. Defeating the enemy is now predicated on winning over local populations. To win these groups, commanders need to know what responses to expect for various operations in particular locations. Social simulations are a promising means of modeling these reactions, and there are several current methods used to populate these simulations with agents representative of a specific society. These methods, however, often require the input of subject matter experts and are costly in price and

time. This thesis examines the simplification and automation of the agent instantiation process by conducting a usability study of two data development tools currently under consideration by the U.S. Army and TRAC–Monterey. The tools, a survey data case file generator developed at TRAC–Monterey and a text analysis tool (STANLEY) developed by Sandia National Laboratory, were examined in separate manners, and the results were encouraging. The survey tool was tested to validate in a practical manner its generated case files with respect to simulation output and real-world surveys. STANLEY was evaluated by scoring sentiment in a document corpus and attempting to correlate those scores to a real world issue. Results of the study indicate that the survey data tool generated case files of adequate quality to instantiate social simulations, potentially minimizing SME requirements and costs. Technical limitations precluded STANLEY from returning enough data for sufficient correlation comparison, although the results indicate the tool has potential.

**KEYWORDS:** Social Simulations, Survey Data, Cultural Geography, Text Analysis, Agent Instantiation, Irregular Warfare, Data Development Tool

### BALANCING EXPLORATION AND EXPLOITATION IN AGENT LEARNING

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**Master of Science in Modeling, Virtual Environments, and Simulation–September 2011**

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

**Second Reader: LTC Jonathan K. Alt, USA, TRAC–Monterey**

Controlling the ratio of exploration and exploitation in agent learning in dynamic environments is a continuing challenge in applying agent-learning techniques. Methods to control this ratio in a manner that mimics human behavior are required for use in the representation of human behavior in simulations, where the goal is to constrain agent-learning mechanisms in a manner similar to that observed in human cognition.

The Cultural Geography (CG) model, under development in TRAC Monterey, is an agent-based social simulation. It simulates a wide variety of situations and scenarios so that a dynamic ratio between exploration and exploitation makes the decisions more sensible. As part of an attempt to improve the model, this thesis investigates enhancements to the exploration-exploitation balance by using different techniques. The work includes design of experiments with a range of factors in multiple environments and statistical analysis related to these experiments. As a main finding from this research, for small environments and for short runs techniques based on subjective utility give better results, while for long runs techniques based on time obtain higher utilities than other techniques. In more complex and bigger environments, a combined technique performed better in long runs.

**KEYWORDS:** Cultural Geography, Social Simulations, Reinforcement Learning, Agent-Based Modeling, Exploration, and Exploitation.

### REPRESENTING TRUST IN COGNITIVE SOCIAL SIMULATIONS

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Trust plays a critical role in communications, strength of relationships, and information processing at the individual and group levels. Cognitive social simulations show promise in providing an experimental platform for the examination of social phenomena such as trust formation. This work is a novel attempt at trust

representation in a cognitive social simulation using reinforcement learning algorithms. Initial algorithm development was completed within a standalone social network simulation and tested using a public commodity game. Evaluation of the contributions and dividends within the public commodity game shows that many of the expected behaviors of human trust formation are present. Initial results show that reinforcement learning can accurately capture the core essentials of human trust formation. Following standalone testing, the trust algorithm was imported into the cultural-geography model for large-scale test and evaluation.

**KEYWORDS:** Cognition, Agent, Simulation, Trust, Reinforcement Learning, Machine Learning, Public Commodity, Experimental Economics

### **EVALUATION OF MODERN NAVIES'S DAMAGE CONTROL AND FIREFIGHTING TRAINING USING SIMULATOR PLATFORMS**

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**Master of Science in Modeling, Virtual Environments, and Simulation—September 2011**

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**Co-Advisor: Anthony Ciavarelli, MOVES Institute**

Modern navies have faced new roles and challenges during the last decade. From purely defensive responsibilities, modern navies have now taken on such multiple challenges in the worldwide theater, as peace keeping missions, humanitarian assistance, anti-piracy support, disaster assistance and others, both military and sociological in scope. Furthermore, the increasing complexity of these missions mandates a strong, constant operational readiness and a high level of performance in the full spectrum of a ship's activities. In order for these missions to be accomplished successfully, survivability is the foremost concern, and the cornerstone of survivability is damage control. Permanent, continuous and high-level damage control and firefighting training for all crewmembers of a navy ship is paramount. Hopefully, this training can be achieved safely, efficiently and economically by using simulation and training simulator platforms, which have dominated the training field in the last few decades. After participating in "damage control" and "firefighting" courses, investigating the main training system components, and administering surveys to instructors and students regarding subjective ratings and opinions about the training system, we found that the U.S. Navy damage control and firefighting training in San Diego is very effective, valuable, and beneficial to ship crews and the U.S. Navy.

**KEYWORDS:** Training, Evaluation, Damage Control, Firefighting, Simulator Platforms, Training Evaluation Model

### **ONBOARD AND PARTS-BASED OBJECT DETECTION FROM AERIAL IMAGERY**

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**Master of Science in Computer Science—September 2011**

**Master of Science in Modeling, Virtual Environments, and Engineering—September 2011**

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The almost endless amount of full-motion video (FMV) data collected by unmanned, aerial vehicles (UAV) and similar sources presents mounting challenges to human analysts, particularly to their sustained attention to detail despite the monotony of continuous review. This digital deluge of raw imagery also places unsustainable loads on the limited resource of network bandwidth. Automated analysis onboard the UAV allows transmitting only pertinent portions of the imagery, reducing bandwidth usage and mitigating operator fatigue. Further, target detection and tracking information that is immediately available to the UAV facilitates more autonomous operations, with reduced communication needs to the ground station. Experimental results

proved the utility of our onboard detection system a) through bandwidth reduction by two orders of magnitude and b) through reduced operator workload.

Additionally, a novel parts-based detection method was developed. A whole-object detector is not well suited for deformable and articulated objects, and susceptible to failure due to partial occlusions. Parts detection with a subsequent structural model overcomes these difficulties, is potentially more computationally efficient (smaller resource footprint and able to be decomposed into a hierarchy), and permits reuse for multiple object types. Our parts-based vehicle detector achieved detection accuracy comparable to whole-object detection, yet exhibiting said advantages.



# MASTER OF SCIENCE IN OPERATIONS RESEARCH

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## **CHANGING THE PARADIGM: SIMULATION, A METHOD OF FIRST RESORT**

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**Master of Science in Operations Research—September 2011**

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**Second Reader: Devaushi Singham, Department of Operations Research**

The computing capability to which Operations Research (OR) analysts have access today is over 1,000,000,000 times more powerful than the first simulation pioneers had sixty years ago, yet the concept that simulation is a “method of last resort” still plagues the OR community. Many real-world problems are complex, with properties such as high dimensionality, non-linear effects, stochastic elements, and dependence between variables. Solving these problems analytically often requires simplifying assumptions, running the risk of making a Type III error (i.e., getting the right answer to the wrong problem). This paper explores the development of computer simulation, and the key design principles that must be followed, to demonstrate how simulation is often the appropriate tool in understanding complex, real-world problems. Contrasting the results of a recently published analytical approach to the analysis of an airport check-in counter scheduling problem versus those of a simulation study of the same system, we demonstrate that simulation can quickly provide the same answers with any desired degree of precision and with no loss of insight. More importantly, simulation can easily use both empirical data and more realistic assumptions—which allows for the analyst to address the right problem. With current computational capabilities and methods, it is time to change the paradigm. Simulation is a method of first resort.

**KEYWORDS:** Simulation, Queuing Theory, Design of Experiments (DOE), Object Orienting Modeling, Computational Tractability, Airport Scheduling, Simio

## **ADAPTIVE DISCRETE-EVENT SIMULATION FOR ANALYSIS OF HARPY SWARM ATTACK**

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**Second Reader: Jeffrey E. Kline, Department of Operations Research**

Harpy swarm attacks are a new type of threat designed for suppression of enemy air defenses. Research into combating Harpy swarm attacks has been conducted but the simulation software used to date, the Naval Simulation System, is inadequate for future research. A new and mission-focused simulation tool is necessary to advance research in defensive tactics against Harpy and other unmanned aerial vehicle threats (UAV).

This research develops a simulation model for a Harpy swarm attack using Simkit to meet the need for a mission-specific analytical tool. The base model consists of a user-defined Harpy patrol area and a ship traversing the area on a course and speed also defined by the user. A total of sixteen parameters are defined and implemented. The model records the time any Harpy strikes the ship to provide data for the response variable, the number of Harpy hits on the ship.

Main effect and full factorial regressions were performed, as well as a partition tree to determine which

parameters had the most significance on the number of Harpies that hit the ship. These model characteristics and future enhancements will give researchers the ability to assess alternative anti-UAV swarm tactics.

**KEYWORDS:** Discrete Event Simulation, Simkit, Harpy Swarm, Counter UAV, Air Defense

**ROBUST ANALYSIS OF THE JOINT-STRIKE FIGHTER INTEGRATED-  
TRAINING-CENTER PILOT SCHEDULING**

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Master of Science in Operation Research—September 2011  
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This thesis focuses on analyzing factors that affect a student's time to train (TTT) as he completes the Joint Strike Fighters (JSF) pilot-training syllabus at the Integrated Training Center (ITC) on Eglin Air Force Base. It identifies the most robust course of action (COA), provides accurate TTT estimates, and identifies a watch list of factors that have the most effect on TTT. The results of this thesis provide a basis and a justification for procurement and resource decisions for the JSF. They also provide a means to ensure a proper flow of pilots to operational commands, reduce unnecessary flights, and enable the ITC to complete its mission while remaining within monthly flight time and airframe limits. It can also help predict the impact of future resource decisions and assist commanders in mitigating their operational effect.

The primary recommendation for reducing TTT is to have students work 11 hours per day and have the workday start at or after 0900. Increasing the number of full motion simulator (FMS), while reducing TTT, is not justified. Although a limited resource, airspace is not a potential bottleneck in the system and any change, short of elimination, has very little influence on TTT. Flight refly rates and aircraft failure rates above 12% and 13%, respectively, significantly increase TTT and must be carefully monitored.

**KEYWORDS:** Joint Strike Fighter, Integrated Training Center , Robust Analysis, Nearly Orthogonal Latin Hypercube, Design of Experiments, Simulation, Pilot Scheduling

**ESTIMATING THE FULLY BURDENED COST OF FUEL USING AN  
INPUT/OUTPUT MODEL: A MICRO-LEVEL ANALYSIS**

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In 2010, the Department of Defense (DoD) spent \$13.2 billion on fuel purchases, with over 3,000 lives lost in fuel-delivery operations between 2003 and 2007. To reduce both of these figures, the DoD is investing in technology to reduce fuel consumption, especially in expeditionary and forward operations. These reductions will cause cascading effects throughout the supply chain.

The tools of input-output analysis appear to be a natural fit for determining fuel costs throughout the supply chain and identifying the best ways to improve the efficiency of providing war-fighting capability. A model of the existing portion of the United States Marine Corps supply chain in Afghanistan was built as a proof of concept, along with six scenarios that explore different methods of reducing fuel consumption, to estimate the fuel multiplier for each component in the supply chain. This model was useful in providing insight and lower bound on the fully burdened cost of fuel within the Afghanistan supply chain. The results of this analysis

show that the impact of force protection fuel usage is not as large as previously believed. In some situations, fuel resupply through an airdrop could be a more efficient delivery method than ground transportation. Different methods of achieving reduced fuel consumption have different impacts on the fuel multiplier in the supply chain, thus affecting the short-term planning ability of the operational commander.

**PROBABILISTIC SEARCH ON OPTIMIZED GRAPH TOPOLOGIES**

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**Master of Science in Operations Research–September 2011**

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**Second Reader: Nedialko Dimitrov, Department of Operations Research**

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This thesis investigates how the performance of a mobile searcher is affected by altering the search environment. We model the search environment as a simple connected, undirected graph. By adding new edges to the graph, we change the search environment. Our objective is to optimize search performance, that is, to minimize the (expected) time needed to find the target, in the context of probabilistic search. We first analyze two different methods to generate random connected graphs, then evaluate a number of methods to augment the graph, typically by considering the algebraic connectivity of the graph and its associated (Fiedler) eigenvector. Extensive simulation studies and resulting statistical and theoretical models show that adding a few wisely chosen edges to a sparse graph is sufficient to dramatically increase search performance. Further, we propose a novel method for incorporating prior information about the target’s likely location by defining a subgraph on which the presented approach is performed, resulting in even greater improvements in search performance.

**KEYWORDS:** search and detection, search environment, graph Laplacian, algebraic connectivity, augmenting a graph

**ANALYTICALLY QUANTIFYING GAINS IN THE TEST AND EVALUATION  
PROCESS THROUGH CAPABILITIES-BASED ANALYSIS**

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**Second Reader: CDR Harrison C. Schramm, USN, Department of Operations Research**

Military operating environments are increasingly diverse and technically challenging. Fielding relevant weapons systems to meet the demands of this environment is increasingly difficult, prompting policy shifts that mandate a focus on systems capable of combating a wide threat range. The capabilities-based test and evaluation (CBT&E) construct is the Department of the Navy’s effort to concentrate on integrated system design with the objective of satisfying a particular operational response (capability) under a robust range of operating conditions. One aspect of CBT&E is the increased employment of advanced mathematical and statistical techniques in the test and evaluation (T&E) process. This study illustrates advantages of incorporating these invaluable techniques, like design of experiments (DOE) and modeling and simulation (M&S), within the T&E process. We also suggest a general methodology for approaching test plan design, presented via a notional scenario in which a complex system must defend a forward outpost. We found through statistical analysis that the application of DOE concepts to the system under test (SUT) throughout three primary phases of T&E quantifiably improved the accomplishment of the selected measure of effectiveness (MOE).

**KEYWORDS:** Test and Evaluation, Capabilities-Based Test and Evaluation (CBT&E), Design of Experiments, Modeling and Simulation, Mission-Based Test and Evaluation, Operational Test & Evaluation (OT&E), Developmental Test and Evaluation (DT&E), Integrated Test and Evaluation (IT&E), SASIO, Defense Acquisition, Factorial Design, Optimal Design

**FREE-TEXT DISEASE CLASSIFICATION**

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Modern medicine produces data with every patient interaction. While many data elements are easily captured and analyzed, the fundamental record of the patient/clinician interaction is captured in written, free text. This thesis provides the foundation for the military health system to begin building an auto classifier for ICD9 diagnostic codes, based on free-text clinician notes. Support-vector machine models are fit to approximately 84,000 free-text records, providing a means to predict ICD9 codes for other free-text records. While the research conducted in this thesis did not provide a consummate ICD9 classification model, it does provide the foundation required to further more detailed analysis.

**KEYWORDS:** Statistical Learning, ICD9 Auto Classification, Medical Data Mining

**SEARCH PLANNING UNDER INCOMPLETE INFORMATION  
USING STOCHASTIC OPTIMIZATION AND REGRESSION**

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**Master of Science in Operations Research—September 2011**

**Master of Science in Applied Mathematics—September 2011**

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**Second Reader: R. Tyrrell Rockafellar, University of Washington, Seattle**

This thesis deals with a type of stochastic optimization problem where the decision maker does not have complete information concerning the objective function. Specifically, we consider a discrete time-and-space search optimization problem where we seek to find a moving target in an area of operations. There are two sources of uncertainty: the target location and the sensor performance.

We formulate the objective function for this problem in terms of a risk measure of a parameterized random variable and consider three cases involving various degrees of knowledge about the sensor performance. In all cases, we consider both the expectation and superquantile risk measures. While the expectation results in an objective function representing the probability of missing the target, the superquantile gives rise to more conservative search plans that perform reasonably well even under exceptional circumstances.

In the case of incomplete information about the distribution of the sensor performance, we approximate the random variable using a nonstandard regression that minimizes the error induced in some sense. We examine the cases in a series of numerical examples.

**KEYWORDS:** Search Planning, Stochastic Optimization, Risk-Tuned Regression Models, Uncertainty

# MASTER OF SCIENCE IN PHYSICAL OCEANOGRAPHY

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## **MINE-BURIAL EXPERT SYSTEM FOR CHANGE OF MIW DOCTRINE**

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Mine-impact burial models such as IMPACT25, IMPACT28, and IMPACT35 have been used in the MIW community in an attempt to calculate the percentage of impact burial for sea mines. Until recently, the models have been deterministic, using parameters such as sediment type, air and sea trajectories, drop angle, and mine type to calculate the percentage of burial. These models have been relatively effective in calculating impact burial, but little attention has been given to the temporal effects on mine burial, known as scour burial. Another shortfall of the deterministic modeling approach is the inability to capture the stochastic nature of the input parameters. To address these issues the John Hopkins University–Applied Physics Laboratory (JHU-APL), in conjunction with the NRL, has developed the Mine-Burial Expert System (MBES).

The MBES is a Bayesian network of physics based, deterministic models, observational data, and expert opinion. It provides the opportunity to give input parameters as probability density tables (PD'Ts) and receive a burial percentage as an output distribution. This allows its user to capture the variability of input parameters and converge them into variability in the burial prediction, providing valuable risk data to the mine countermeasure (MCM) commander. The MBES has been incorporated into the Environmental Post Mission Analysis (EPMA) tool for Naval Oceanographic Office (NAVO), which could give the MCM planners an idea of the confidence level of its predictions. To understand how the variability and confidence levels can be used and how it may affect current doctrine, a series of tests have been run through the MBES. A thorough review of the results can have a significant effect on future use of the system and subsequent changes to MIW doctrine. In particular, current doctrinal sediment categories are not sufficient in capturing the resolution of the MBES predictions.

**KEYWORDS:** Mine Burial Expert System, stochastic model, mine burial prediction, physical oceanography

## **TUNING, VALIDATION, AND UNCERTAINTY ESTIMATES FOR A SOUND-EXPOSURE MODEL**

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**Co-Advisor: Ching-Sang Chiu, Department of Oceanography**

To tune and validate the performance of an acoustic model, sound signals were transmitted from a calibrated source, at various midrange frequencies, and received on a moored acoustic-recording package at the edge of Tanner Bank near the Southern California Anti-Submarine Warfare Range (SOAR). The acoustic monitoring package was constructed of three calibrated Acousonde recorders. Source levels (SL) were measured at 1.8 me-

## PHYSICAL OCEANOGRAPHY

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ters from the source using a bioacoustic probe. Signals recorded on the acousondes and the bioacoustic probe were processed to measure transmission loss (TL) and its variability. Measurements were compared with estimates of TL calculated from the Navy standard parabolic equation (NSPE) acoustic model using a first-guess geoacoustic bottom, based on the literature. Other model inputs included bathymetry from the U.S. Coastal Relief Model, and sound-speed profiles from expendable bathythermographs (XBT) and the Navy Coastal Ocean Model. Using data garnered from previous studies of the bottom sediment and sublayer near the Southern California Offshore Range, variations of a geoacoustic model were constructed and input into the NSPE model. TL from all model runs were then analyzed across all frequencies to determine the best fit geoacoustic model to use with NSPE when applying it near SCORE for acoustic predictions. Research was funded by the United States Navy Chief of Naval Operations, Environmental Readiness Division (CNO/N45)

**KEYWORDS:** Transmission Loss, Receive Level, Source Level, TL, RL, SL, Sound Exposure Model, Oceanography, NSPE, Tanner Bank, SCORE, SOAR, Parabolic Equation, Geoacoustic, Geoacoustic Inversion, Acousonde, G-34

# MASTER OF SCIENCE IN REMOTE-SENSING INTELLIGENCE

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## **AUTOMATING IDENTIFICATION OF ROADS AND TRAILS UNDER CANOPY USING LIDAR**

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**Master of Science in Space Systems Operations—September 2011**

**Master of Science in Remote-Sensing Intelligence—September 2011**

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Analysis techniques are developed to automatically extract roads and trails under thick forest canopy. LiDAR data were taken over the Swanton Pacific Ranch in the Santa Cruz Mountains from an airborne laser-mapping system, the Optech 3100, on March 9–10, 2010. Collected data were characterized by point densities of 5–10 m<sup>2</sup>. Point cloud data were reduced to digital surface models using ARCMAP (from ESRI). The DSM was calculated at 1 meter spacing. These surface models were analyzed using topographic tools in ENVI, allowing for calculation of curvature, slope, convexity, and shaded relief. A multilayer dataset was built and analyzed using spectral analysis tools in ENVI. The classification technique used was a combination of maximum likelihood classifier and a decision tree after use of erosion/dilation operators. Results are compared to ground truth collected in 2011. Classification resulted in 83.6% true positive rate, and the image-processing result reduced the false positive rate to 3.0%.

**KEYWORDS:** LiDAR, LADAR, Swanton Pacific Ranch, Feature Extraction



# MASTER OF SCIENCE IN SOFTWARE ENGINEERING

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## INFRASTRUCTURE SUITABILITY ASSESSMENT MODELING FOR CLOUD COMPUTING SOLUTIONS

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Maturing virtualization in information technology systems have enabled increased implementations of the cloud computing paradigm, dissolving the need to co-locate user and computing power by providing desired services through the network. This thesis researches the support that current network modeling and simulation applications can provide to IT projects in planning, implementing and maintaining networks for cloud solutions. A problem-appropriate domain model and subsequent requirements are developed for the assessment of several network modeling and simulation tools, which leads to the identification of a capability gap precluding the use of such tools in early stages of cloud computing projects. Consequently a practical, modular designed methodology is proposed to measure the essential properties necessary for developing appropriate cloud computing network traffic models. The conducted proof-of-concept experiment applied to a virtual desktop environment finds the proposed methodology suitable and problem-appropriate, and results in recommended steps to close the identified capability gap.

**KEYWORDS:** Cloud Computing, Modeling, Simulation, Virtualization, Desktop Infrastructure, Network Emulator

## MODEL VIEW CONTROLLER FOR CONTENT MANAGEMENT ON THE CLOUD

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Cloud computing portrays a new model for providing IT services over the Internet. In cloud computing, resources are accessed from the Internet through web-based tools. Although cloud computing offers reduced cost, increased storage, high automation, flexibility, mobility, and the ability of IT to shift focus, there are other concerns—such as the management, organization and structure of content on the cloud—that large organizations should consider before migrating to the cloud. This thesis presents an overview of Model View Controller (MVC) architectural pattern and describes how the pattern can be applied to the cloud for content management. The MVC architecture is proposed in this thesis because it divides the aspects of a document into three parts: a model, view and controller, thus allowing elasticity, portability, and interoperability for document objects. The thesis presents a case study to illustrate how MVC can be use to facilitate document collaboration and content management in the cloud, and examines existing document standards to assess their readiness in supporting the MVC document architecture.

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**KEYWORDS:** Cloud Computing, Model View Controller (MVC) Architectural Pattern, Document Collaboration, Content Management, Document Standards

# MASTER OF SCIENCE IN SPACE SYSTEMS OPERATIONS

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## **EVOLVED, EXPENDABLE, LAUNCH VEHICLE SECONDARY-PAYLOAD ADAPTER RING: OVERCOMING CHALLENGES TO ENABLE RESPONSIVE SPACE**

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**Master of Science in Space Systems Operations—September 2011**

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**Second Reader: William J. Welch, Department of Information Sciences**

Technology advancement is a primary goal for military space development. By staying ahead of the competition, space systems can offer unique battlefield capabilities. A number of space programs are increasingly behind schedule, over budget, and underperforming. This thesis explains the benefits the evolved, expendable, launch vehicle (EELV) secondary-payload adapter (ESPA) ring can offer programs experiencing technical immaturity or desiring responsive space. By understanding and adhering to the *ESPA Rideshare Users Guide* and the *Auxiliary Payload Interface Control* document, programs desiring a ride aboard an ESPA-configured EELV will achieve greater success and have fewer issues in the launch vehicle-to-satellite integration process.

The Government Accountability Office (GAO) has published many reports offering proven process requirements that will result in increasing the odds of program success. By studying the benefits an ESPA ring offers, many processes recommended by the GAO can be implemented resulting in better cost and schedule performance. The research performed involves launch vehicles and their current state, along with a description of rideshare integration. The analytical results, along with findings of successful and struggling space programs, are then used to show how the ESPA system can advance program readiness from the laboratory to the operational environment.

Keywords: Atlas V, Auxiliary Payloads, Delta IV, EELV Secondary Payload Adapter (ESPA), Evolved Expendable Launch Vehicle (EELV), Launch Vehicles, Mission Integration

## **NPSAT1 MEMS, 3-AXIS, RATE-SENSOR-SUITE PERFORMANCE, CHARACTERIZATION, AND FLIGHT-UNIT ACCEPTANCE TESTING**

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NPSAT1 is a small satellite providing education and hands-on experience to NPS students; it also serves as a platform for small satellite technology proof-of-concept demonstrations and experiments. One of these experiments is the MEMS rate sensor experiment. Comprising a triad of COTS MEMS devices, this experiment will use the MEMS rate sensors to measure angular rates for NPSAT1.

The NPSAT1 MEMS 3-Axis rate sensor was originally characterized and tested in 2007. Subsequently, the decision was made to fly the MEMS subsystem unpressurized. This new requirement, along with the replacement of a damaged sensor, necessitated the recalibration of the MEMS subsystem.

In addition, the rate compensation algorithm has been updated by determining the systematic errors of

the subsystem–bias, thermal and pressure in-run drift, scale factor errors, and nonorthogonality through thermal ramp tests and rate transfer tests. Furthermore, other inertial sensor error sources such as hysteresis, repeatability, run-to-run error, and noise have been investigated. Acceptance testing was also performed to investigate vibration sensitivity and screen for workmanship defects.

The performance and characterization results verify that the MEMS subsystem can meet the flight requirements for rates  $>0.1^\circ/\text{sec}$ , while the acceptance tests demonstrate the robustness and reliability of the unit.

**KEYWORDS:** NPSAT1, Small Satellites, Micro-Electro-Mechanical Systems, MEMS, COTS, Rate Sensors, Calibration, Sensor Errors

### **OPERATIONALLY RESPONSIVE TASKING**

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**Master of Science in Space Systems Operations–September 2011**

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This paper presents evidence that the United States military and intelligence communities have a history of focusing on hardware while neglecting the need to examine processes. It proceeds to illustrate that current ORS initiatives appear to be doing the same. A case study is presented highlighting the ramifications of neglecting processes when trying to improve operations. ISR tasking is examined, including the potential that politics exerts influences upon the process. The concept of Operationally Responsive Tasking is presented, not as a specific methodology for tasking satellites, but as a generalized model offering insight into the ramifications of certain tasking process design decisions. Specific constructs introduced include Tasking Depth, Tasking Breadth, Petitioner Tasking, and Supplicant Tasking. The model is shown to offer insight into tasking process modifications and their impacts. The potential for the Virtual Mission Operations Center software to implement the ability to modify a tasking process on-demand is discussed. VMOC is shown to be a sound platform for implementing the basic concepts of ORT, including reducing the expertise required to utilize ISR satellites through the use of ontologies. Responsiveness is shown to be a limited resource that is tied to the capacity of collection assets. Specific recommendations for further research into mathematical models to guide tasking process decisions are offered.

**KEYWORDS:** Space Tasking, ORS, Operationally Responsive Space, ORT, Operationally Responsive Tasking, Tasking Methodology, Triage, VMOC, Virtual Mission Operations Center

### **APPLICATION OF THE TERRESTAR SATELLITE CONSTELLATION TO THE GLOBAL INITIATIVE FOR TRACKING SPECIAL AND NONPROLIFERATION MATERIAL**

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In an era distinguished by innovative communication technologies capable of linking with geosynchronous satellites while small enough to fit into a pocket, the modern battlefield commander and warfighter can know the precise location of surrounding friendly forces. This concept of communication involving satellites provides for a new tier of situational awareness in combat and noncombat environments, dating as far back as

the Persian Gulf war. This tool altered the command and control element by improving the knowledge and certainty that this capability provided. Recent studies and experiments have demonstrated the applicability of these military systems to civil service as well. Space based situational awareness provide capabilities such as continuous over-the-horizon communications and position reporting of friendly assets. These capabilities have been available since the Persian Gulf war. System limitations include a lack of real-time image, terrain masking, and security.

Until recently, the devices used for friendly force tracking have been devices that rely on National Technical Means. However, the recent trend is to use commercially available technology to enable tracking of both friendly and enemy forces. This technology ranges from the use of GPS-equipped cell phones to satellites in LEO such as Iridium and GlobalStar. Terrestar is a new company specializing in space technology and wireless communication devices. Additionally, TerreStar wireless-communication devices are designed to use both cellular and satellite networks. This feature provides a redundant tracking method not otherwise available. This study includes an investigation into Terrestar tracking devices used to locate and monitor the position and movement of friendly forces.

**KEYWORDS:** TerreStar, Friendly Force Tracking, Blue Force Tracking, Geosynchronous Communications, Red Force Tracking, Nonproliferation

### **MOBILE CUBESAT COMMAND AND CONTROL**

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**Second Reader: James A. Horning, Space Systems Academic Group**

The Mobile CubeSat command-and-control (MC3) program will become the ground segment of the Colony II satellite program. The MC3 ground station contains commercial, off-the-shelf (COTS) hardware with government, off-the-shelf (GOTS) software making it an affordable option for government agencies and universities participating in the Colony II program. Further, the MC3 program provides educational opportunities to students and training to space professionals in satellite communications. This thesis analyzes the MC3 program from the program manager's point of view providing a concept of operations (CONOPS) of the program as well as initial analysis of MC3 ground-station locations. Also included in this thesis is a future cost analysis of the MC3 program as well as lessons learned from the NPS acquisition process.

**KEYWORDS:** Mobile CubeSat Command and Control, Colony II, Program Management, CONOPS, Education, Cost

### **AUTOMATING IDENTIFICATION OF ROADS AND TRAILS UNDER CANOPY USING LIDAR**

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**Master of Science in Space Systems Operations—September 2011**

**Master of Science in Remote Sensing Intelligence—September 2011**

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**Second Reader: Kristen Tsois, Department of Defense Analysis**

Analysis techniques are developed to automatically extract roads and trails under thick forest canopy. LiDAR data were taken over the Swanton Pacific Ranch in the Santa Cruz Mountains from an airborne laser mapping system, the Optech 3100, on March 9–10, 2010. Collected data were characterized by point densities of 5–10 m<sup>2</sup>. Point cloud data were reduced to digital surface models using ARCMAP (from ESRI). The DSM

was calculated at one-meter spacing. These surface models were analyzed using topographic tools in ENVI, allowing for calculation of curvature, slope, convexity, and shaded relief. A multilayer dataset was built and analyzed using spectral analysis tools in ENVI. The classification technique used was a combination of maximum likelihood classifier and a decision tree after use of erosion/dilation operators. Results are compared to ground truth collected in 2011. Classification resulted in 83.6% true positive rate, and the image processing result reduced the false positive rate to 3.0%.

**KEYWORDS:** LiDAR, LADAR, Swanton Pacific Ranch, Feature Extraction

### **OPTIMIZING THE NAVY'S INVESTMENT IN SPACE PROFESSIONALS**

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**Second Reader: Charles M. Racoosin, Space Systems Academic Group**

The U.S. Navy relies heavily on the capabilities and advantages provided by space assets. Today's Navy would face severe operational challenges without space-based communications, navigation and surveillance capabilities. A small group of space professionals within the Navy diligently works with other organizations and services to ensure these capabilities are continuously available. The origins of the Navy's involvement with space and rocketry dates back to pre-World War II, when rockets for use on aircraft were developed and tested at the U.S. Naval Academy. Since then, the Navy has had an undeniable need to ensure that space systems are available to support naval and joint operations. The Navy's collective knowledge of the space enterprise is therefore invaluable to current naval operations and must be preserved.

This study is a reassessment of the current Navy space cadre construct based on the implementation and effectiveness of the 2004 naval space cadre human capital strategy. Its purpose is to examine current and historical utilization rates of Navy space professionals, compare the Navy space personnel management construct to that of the other services, identify the current challenges and shortcomings of the Navy space cadre, and offer reasonable recommendations that could optimize the Navy's investment in space professionals.

**KEYWORDS:** Navy Space Cadre, Space Professional, DoD Space Cadre, Space Warfare Officer

### **MOBILE CUBESAT COMMAND AND CONTROL: ASSEMBLY AND LESSONS LEARNED**

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The Mobile CubeSat command-and-control (MC3) system provides ground support for the Colony II program. The combination of commercial, off-the-shelf hardware with government, off-the-shelf control software make for a low cost ground station solution. The Naval Postgraduate School will partner with select educational facilities to provide a world-wide footprint for Colony II satellite operations. To assist these partner facilities, the author created a detailed assembly and setup guide targeted to an average college student, a typical user for the MC3 ground station. This thesis captures the assembly process and documents lessons learned to help future operators of MC3 ground stations in their educational endeavors. Also included is an analysis and discussion of the Global Educational Network for Satellite Operations and its suitability for performing the Colony II ground segment mission and possibly supplementing the MC3 network.

**KEYWORDS:** Mobile CubeSat Command and Control, MC3, Ground Station, Lessons, Assembly Guide

**COASTAL BATHYMETRY USING SATELLITE OBSERVATION IN SUPPORT  
OF INTELLIGENCE PREPARATION OF THE ENVIRONMENT**

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Subaqueous beach profiles are obtained for littoral regions near Camp Pendleton, CA, using observations of wave motion. Imagery was acquired from WorldView2 Satellite on 24 March 2010. Two sequential images taken ten seconds apart are used for the analyses herein. Water depths were calculated using linear dispersion relationship for surface gravity waves. Depth profiles were established from shoreline out to one kilometer offshore and depths of up to fifteen meters. Comparisons with USGS DEM values show agreement within five percent in the surf zone (shoreline to wave breaking) and one percent outside the surf zone (offshore of wave breaking).

**KEYWORDS:** Bathymetry, Subaqueous Beach Profile, Satellite, Intelligence Preparation of the Environment, Remote Sensing, Linear Dispersion Relationship, Surface Gravity Waves, Wave Velocity Method, Wave Celerity Method, Linear Airy-wave.

**ENABLING THE COMMERCIAL SPACE-TRANSPORTATION  
INDUSTRY AT THE MID-ATLANTIC REGIONAL SPACEPORT**

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**Second Reader: Charles Racoosin, Space Systems Academic Group**

The focus of this paper is on how to energize the space industrial base as directed by the National Security Space Strategy of 2011. Using a case study of the Mid-Atlantic Regional Spaceport (MARS), an analysis of how to enable the commercial space transportation industry will be discussed. A look at previous government ventures that have been privatized, along with the history of commercial space transportation, sets the stage for evaluating the future of the industry. An in-depth analysis of FAA and NASA regulation was done to compare and contrast the advantages and disadvantages of each and provide insight on the future regulation of the industry. Past launches, government funding, and future plans are all studied to determine a forecast for demand. Recommendations are provided to the MARS on how to enable their commercial space transportation industry and conclusions are drawn on the importance of the commercial space transportation industry to National Security.

**KEYWORDS:** Enabling Commercial Space Flight, Transportation Industry, Mid-Atlantic Regional Spaceport, MARS, FAA, NASA, Regulation



# MASTER OF SCIENCE IN SYSTEMS ENGINEERING

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## **A SIMULATION-BASED ANALYSIS OF U.S. ARMY WATERCRAFT CAPABILITIES IN A 2022 FOREIGN HUMANITARIAN-ASSISTANCE/DISASTER-RELIEF OPERATION**

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**Second Reader: Jeffrey Appleget, Department of Operations Research**

This thesis utilizes the operational context established by Expeditionary Warrior 2010 (EW10), a United States Marine Corps operational level seminar planning game, to analyze a 2022 United States Army watercraft foreign humanitarian assistance/disaster relief (FHA/DR) Operation. The EW10 Wargame was conducted over four days, and in order to ensure complete analysis of the entire scenario within the time constraints, the composition of forces was explicitly defined. This thesis considers the full range of possible force compositions. A full functional and physical architecture is developed, using EW10 as an operational basis. Corresponding measures of outcome, measures of effectiveness, and measures of performance for U.S. Army watercraft FHA/DR operations are defined. The current U.S. Army watercraft master plan is used to develop a 2022 U.S. Army watercraft force structure, to include the integration of the Office of Naval Research's transformable craft (T-Craft). A discrete event simulation is developed using Imagine That's ExtendSim software to analyze the impact of variations in the projected force structure as well as the performance gains and losses associated with the introduction and removal of the T-Craft from the force structure. Simulation analysis indicates that, if the T-Craft is available in 2022, U.S. Army FHA/DR response forces should be defined by: eight or more T-Craft, 4 or more joint high-speed vessels (JHSV), and four or more logistics support vessels. In the absence of T-Craft, the response force should be defined by: seven or more JHSV and thirteen or more landing craft Utility 2000s.

**KEYWORDS:** Transformable Craft, Army Watercraft, Humanitarian Assistance/Disaster Relief, Extend-Sim, Efficient Experimental Design, Nearly Orthogonal Latin Hypercube, Discrete Event Simulation

## **A HYBRID APPROACH TO TACTICAL VEHICLES**

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**Co-Advisor: Joseph Bayer, DoD Contractor**

Combat operations are suffering from unnecessarily high fuel demand which degrades capability, exposes support operations to greater risk than necessary, and increases operations and support costs. This thesis describes the current suite of hybrid drivetrain technologies, evaluates their effectiveness in a tactical environment, and suggests an architecture that reduces fuel consumption while maintaining performance against mobility, transportability, survivability, and safety requirements. This thesis includes a comprehensive analysis of nine power sources and three general hybrid architectures against ten performance attributes using multiple criterion decision theory with considerations for selection criteria dependencies and vehicle duty cycles. The rating of selection criteria is not always a direct comparison of component performance parameters. In

some cases, capabilities are dependent on the general hybrid architecture and on the form of energy storage in others. In a fully burden cost of fuel context, the capability of hybrid drivetrains to improve fuel economy of vehicles by up to 20% translates to \$0.39-\$83.54 billion in annual savings across the Army's tactical wheeled vehicle fleet depending on the fuel delivery method. The recommended hybrid drivetrain architecture is a series hybrid with a diesel engine primary power source, flywheel secondary power source, and permanent magnet traction motors.

**KEYWORDS:** Drivetrain, flywheel, fuel cell, hybrid, microturbine, ultracapacitor, battery, series, parallel, mild hybrid, lithium ion, nickel metal hydride, lead acid, tactical vehicle, mobility, transportability, survivability, cycle life, power to weight ratio, operating range, specific power, specific energy, efficiency, decision theory, concept selection

### **A MODEL FOR COMMUNICATIONS SATELLITE SYSTEM ARCHITECTURE ASSESSMENT**

**Charlotte M. Gerhart—DoD Civilian**

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**Second Reader: Thomas V. Huynh, Department of Systems Engineering**

Communications satellite system architecture trades traditionally only consider the cost per unit of capacity provided. This selection method ignores the other requirements with which the system architectures were designed, and that are critical to providing a capability to the warfighter. A survey of communications satellite systems identified five common attributes that are incorporated in the design process: communications capacity, access, interoperability, commandability, and information assurance and protection. A mathematical model was implemented to enable the analysis of communications satellite system architectures based on multiple system attributes. Utilization of the model in a hypothetical test case demonstrated how variations in key performance attributes influences the choice of the preferred system in a selection process.

**KEYWORDS:** Communications Satellite Architecture, Satellite Architecture Trades, Communication Satellite Requirements

### **HOW THE DEGREE OF ACCURACY OF AN INERTIAL MEASUREMENT UNIT (IMU) INFLUENCES THE MISS DISTANCE OF A GUN-LAUNCHED PRECISION MUNITION**

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**Master of Science in Systems Engineering—September 2011**

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**Second Reader: Donald E. Carlucci, Picatinny Arsenal, U.S. Army**

Precision munition projectiles guide to an area to hit their target. The projectile must read position in-flight and measure deviations from the intended flight path. This allows the projectile to correct and maintain the intended trajectory. An Inertial Measurement Unit (IMU) device measures the relative movement of a projectile throughout flight and measures the deviation from the intended path, enabling the projectile to course correct. The purpose of this thesis is to understand the degree to which the precision of the IMU influences the delivery accuracy of a gun-launched munition. This research will model the influences of gyro bias stability and acceleration bias stability and quantify their effects.

**KEYWORDS:** Precision Munitions, Inertial Measurement Unit, Gun-launched Munition, Bias Stability

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**INVESTIGATING THE LINK BETWEEN COMBAT  
SYSTEM CAPABILITY AND SHIP DESIGN**

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**Master of Science in Systems Engineering—September 2011**

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**Second Reader: Eugene Paulo, Department of Systems Engineering**

The focus of this thesis is the examination of a method to supplement current combatant ship synthesis tools with combat system equipment and warfighting capability parameters. Current conceptual ship design tools lack an early integration of the naval architecture and the combat system aspects of a ship. Although the U.S. Navy's vision and the current Joint Capabilities Integration & Development System (JCIDS) process involve designing ships based on warfighting capability using measures of effectiveness, the current ship synthesis tools lack the appropriate combat system parameters that will allow design for capability.

This study specifically investigates a link between a combat system capability and a ship design by conducting research and analysis on an existing combat system, a shipborne air search radar. A mathematical relationship was obtained between the radars detection ranges and their respective system weights. This equation describing the relationship between a combat system capability (radar detection range) and a naval architecture parameter (weight) was used to supplement an existing Excel-based ship synthesis tool. By inserting this into the model, the ships synthesized were able to change based on a desired combat system capability input from the user. Additionally, by modeling the radar detection range in a warfighting scenario in ExtendSim, the impacts of the radar detection range on warfighting effectiveness were computed. Therefore, it was demonstrated that a ship synthesis model could produce designs based on a user's input of a stakeholder-desired combat capability.

Using a single combat system and its corresponding measure of effectiveness in a single warfare area, this thesis shows as a proof of concept that combat system capability can be integrated into ship design. It lays the groundwork for creating an improved ship synthesis tool that includes complete sensitivity to capabilities from all the combat systems on the ship and how these selected parameters impact mission performance in a large spectrum of warfare areas. With this new ship synthesis model, designers can directly address stakeholder concerns, and can conduct trade off analyses for decision makers that result in an optimal ship design.

**KEYWORDS:** Combat System Capability, Warfighting Effectiveness, Discrete Event Simulation, Ship Synthesis Tool, Naval Architecture Parameter, Naval Ship Design



# MASTER OF SCIENCE IN SYSTEMS ENGINEERING MANAGEMENT

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## **THE NAVAL ENLISTED AVIATION-MANPOWER SYSTEM: ADVANCING READINESS THROUGH IMPROVED UTILIZATION OF INTELLECTUAL CAPITAL**

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**Co-Advisor: Benjamin Roberts, Department of Systems Engineering**

Manpower within the Department of the Navy is a major consumer of valuable resources. Current manpower management strategies are not reinforced with sound system components that employ vital intellectual capital considerations.

The current metric in manpower, is referred to as readiness. In its current state it lacks true meaning, as the metric fails to capture the true costs expended to achieve it, and once it is achieved, there is no commitment to preserving it. In fact, the current system design decreases readiness while attempting to increase readiness elsewhere, with the same asset.

When dealing with manpower, there are always two perspectives that must be considered. The first is the perspective of the employer, and the second is that of the employee. The Navy's current system of manpower, while seeking a mutually beneficial arrangement, actually creates a great deal of instability for both employer and employee. This instability results in very high expenditures of limited resources, with in many cases, very poor returns.

This thesis examines present intellectual capital theory, and evaluates current enlisted aviation manpower system elements in terms of this theory. The research then turns to the employment of the science of systemology to help determine a definitive direction for an improved, efficient system for the 21<sup>st</sup> century.

**KEYWORDS:** Intellectual Capital, Human Capital, Social Capital, Organizational Capital, Manpower, Readiness, Enterprise

## **MULTI-YEAR OPTIMIZATION OF THE SPACE AND MISSILE SYSTEMS CENTER (SMC) 2012–2017-LAUNCH MISSION MODEL**

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**Second Reader: Nicholas P. Previsich, Space and Missile Systems Center, United States Air Force**

Air Force Space Command, Space and Missile Systems Center (SMC), Los Angeles Air Force Base in El Segundo, California is the preeminent Department of Defense (DoD) acquisition center for the nation's rocket launch vehicles and spacecraft. A particularly effective linear programming tool is the "Multi-Period Optimal Launch Vehicle Tool" (MPOLVT) to maximize payload lift performance with cost efficiency across the Air Force Mission Model forecast over several yearly periods. MPOLVT accounts for the dynamic nature of launch vehicle and spacecraft program offices' priorities and budgets with lift capability performance of the Atlas V and Delta IV launch families of vehicles. Using payload demand data for years 2012 through 2017, we observe that MPOLVT distributes launch vehicles to spacecraft according to future mission demand needs

and we note that the multi-period solution offers a more cost effective optimization than just modeling independent 12 month periods. This is due to cost savings realized in early production years while carrying inventory over later years.

Currently launch vehicle acquisition management relies on acquisition specifications and standards, professional opinions and judgments, and qualitative analysis. We expect MPOLVT to better inform launch vehicle acquisition management, which currently does not rely on quantitative analysis; rather, it utilizes qualitative based decision-making methods.

**KEYWORDS:** Space Command, AFSPC, Space & Missile Systems Center, SMC, Launch Vehicle, United Launch Alliance, SpaceX, Atlas V, Delta IV, Minotaur, Falcon, Production, Inventory, Booster Procurement, Multiyear Optimization, Time Phased Models, Linear Programming, Objective Function, Constraints, Integer Decision Variables, Binary Decision Variables, MPOLVT, GAMS, LEO, MEO, GEO, Satellites, Orbits, Space Debris, Booster, Upperstage, Mission Integration Model

### **IMPROVING HEALTH-CARE DELIVERY FOR POST-TRAUMATIC-STRESS DISORDER: AN INTERRELATED APPROACH LEVERAGING SYSTEMS ENGINEERING AND OPTIMIZATION**

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**Master of Science in Systems Engineering Management**

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**Co-Advisor: John Osmundson, Department of Information Sciences**

Post-traumatic stress (PTSD), major depression, anxiety disorders, and other post-deployment adjustment difficulties affect a significant number of veterans returning from Operation Iraq Freedom and Operation Enduring Freedom. To contend with this new influx of veterans suffering from the psychological aftermath of military combat, the VA has been proactive, including commissioning this study of their PTSD health care delivery system. Its objective is to provide the best care, in the most efficient manner possible to as many affected veterans as possible.

This study examines PTSD health care delivery from a systems engineering perspective. It employs state-of-the-art tools such as: ExtendSim modeling and simulation software, and JMP analysis software.

The resulting models produce a set of eight optimized system factors, which maximize the desirability of four system performance measures that define the efficiency, capacity, and timeliness of the system. We argue that these models can and should be used as a platform for future work in this area of study.

**KEYWORDS:** PTSD, Post-Traumatic-Stress Disorder, Systems Engineering, Optimization, ExtendSim, VDT Power, JMP, Excel, Health Care Delivery, Veteran's Affairs, VA

### **APPLYING THE ART OF SYSTEMS AND ORGANIZATIONAL ARCHITECTING IN ORDER TO IMPLEMENT OPERATIONAL DESIGN INTO MARINE CORPS PLANNING DOCTRINE**

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**Second Reader: Gary Langford, Department of Systems Engineering**

In 2010, the United States Marine Corps (USMC) changed its Marine Corps Planning Process (MCP) to include operational design in response to direction from the Commander of United States Joint Forces Command (USJFCOM). This updated process, however, has been misunderstood and fundamentally no different

from the previous edition based upon a classical decision-making model. This thesis therefore presents an alternative planning process for the USMC. This thesis uses the foundations of systems architecting to redefine operational design as operational architecting and presents a detailed operational architecting process that translates strategic guidance into an operational design. This operational design then becomes the starting point for the traditional military planning process. The alternative planning process describes operational architecting as a distinct activity from operational planning but provides for a seamless transition between both activities and for multiple iterations if needed. The thesis recommends this process as a baseline for further refinement and experimentation as the USMC further develops its planning theory and doctrine.

**KEYWORDS:** Marine Corps Planning Doctrine, Systems Architecting, Military Planning Process, Joint Operational Planning Process

### **ESTABLISHING A PRODUCT BASELINE FOR GLOBAL-POSITIONING SYSTEM SATELLITES THROUGH FUNCTIONAL AND PHYSICAL CONFIGURATION AUDITS**

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**Master of Science in Systems Engineering Management—September 2011**

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

Programs without a proper technical baseline will not be able to achieve cost, schedule, and/or performance objectives. The purpose of this thesis is to provide clear steps, methods, guidelines, and suggestions to mature the functional, allocated, and product baselines from the development baseline to the contract baseline for the acquisition of a global-positioning system (GPS) space segment. Implementation of these recommendations will reduce cost and/or schedule for programs such as GPS across the Space and Missile Systems Center (SMC). The thesis better defines, recommends updates, and suggests tailoring for relevant sections in standards such as MIL-STD-1521B and MIL-STD-973. It narrows some of the policies established in the DoD 5000.2 and other commonly used space acquisition regulations while satisfying the GPS Wing System Engineering Plan (SEP) requirement for the completion of a Functional and Physical Configuration Audit (FCA/PCA). It also identifies some characteristics of conducting appropriate and efficient audits for space segment acquisition programs in the GPS Wing that can be adapted and applied to similar programs across SMC. Ultimately, this thesis attempts to set the foundation for SMC and/or Wing level plans, policies, and instructions used to establish the product baseline for space systems acquired at SMC.

**KEYWORDS:** Functional and Physical Configuration Audit FCA/PCA, Space Systems Acquisition Baseline, Technical Review, Technical Baseline, Product Baseline, Allocated Baseline, Configuration Baseline, System Verification Review



# MASTER OF ARTS IN SECURITY STUDIES

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## **MANAGEMENT OF THE SEVERELY MENTALLY ILL AND ITS EFFECTS ON HOMELAND SECURITY**

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**Master of Arts in Security Studies—June 2011**

**Co-Advisor: David Brannan, DoD Contractor**

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As a result of the events of September 11, 2001, law enforcement agencies nationwide have been assigned a plethora of terrorism prevention and recovery related duties. Many federal documents outline and emphasize duties and responsibilities pertaining to local law enforcement. The prevention of acts of terrorism within communities has become a focal point of patrol activities for state and local police agencies. Simultaneously, local law enforcement is dealing with the unintended consequences of a policy change that in effect removed the daily care of our nation's severely mentally ill population from the medical community and placed it with the criminal justice system. This policy change has caused a spike in the frequency of arrests of severely mentally ill persons, prison and jail population and the homeless population. A nationwide survey of 2,406 senior law-enforcement officials conducted within this paper indicates that the deinstitutionalization of the severely mentally ill population has become a major consumer of law enforcement resources nationwide. This paper argues that highly cost-effective policy recommendations exist that would assist in correcting the current situation, which is needlessly draining law enforcement resources nationwide, thereby allowing sorely needed resources to be directed toward this nation's homeland security concerns.

**KEYWORDS:** Law enforcement, severe mental illness, homeland security, law enforcement resources, assisted out-patient treatment, homeless population, prison overcrowding, New Windsor Police Department

## **DOES THE DRAGON SOAR HIGHER THAN THE EAGLE?**

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Chinese economic penetration of Latin America has profoundly altered the economic and political relationships in the region. This thesis argues that while the growing relationship between China and Brazil has been beneficial for both countries, it is especially beneficial for China. While the Brazilian raw materials and agricultural industries have profited, the influx of finished Chinese products is making many Brazilian industries, especially textiles, uneconomical, and has raised fears that Brazil may contract the "Dutch disease"—reliance on a few industries for export income. However, China has offset the historic political influence of the United States in the region, and holds out the prospect of being a strong sponsor of Brazil's ambitions to become an international political player commensurate with its growing regional economic and political importance. Latin American states are finding various ways to expand lines of communication and to collaborate with the

Chinese, who are clearly set to play a major role in aid-giving worldwide. We must better understand our future competitor in order to develop our own strategy for engagement in Latin America.

**KEYWORDS:** BRIC, BRICS, Trade, Latin American Trade, Brazil, Brazilian Expansion, Brazilian Trade, Sino-Latin America, China, Chinese Trade, Chinese Expansion.

**CONTEMPORARY JUS AD BELLUM ON USE OF FORCE IN  
SELF-DEFENSE BY STATES AGAINST NON-STATE TERRORIST GROUPS—  
LIMITATIONS, EVOLUTIONS, AND ALTERNATIVES**

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International law is challenged to ensure the legal and legitimate use of force by states against non-state terrorist groups. Such groups evade easy classification as criminals or armed forces. Their organization, methods and targets are simultaneously local in application, but global in impact. They attack the foundations of state identity and legitimacy, including the monopoly on use of force, but are not state actors. Non-state actor threats are not unprecedented, but states and international law have never had to contend with non-state actors possessing global reach and force, resources and influence on par with some states, which creates a dilemma for contemporary states and jus ad bellum—to adhere to principles of international law and customs of legitimate state action, or to ensure the security of the state's citizens. The predicament is incompatible with the notion that, in the modern era, the use of force by states is to be limited, governed and made legitimate by the rule of law. State use of force without legal authorization creates severe issues of legitimacy, with politically and socially destabilizing effects. This paper examines these issues in full and identifies key trends and potential avenues for legal reform.

**KEYWORDS:** International Law, Just War, Non-State Actor, State Actor, Self-Defense, jus ad bellum, Sovereignty

**AN INTELLIGENCE-SHARING CONTINUUM: NEXT-GENERATION  
REQUIREMENTS FOR U.S. COUNTERTERRORISM EFFORTS**

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**Master of Arts in Security Studies—September 2011**

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**Second Reader: Pat Miller, DoD Contractor**

The September 11, 2001 terrorist attacks were a major catalyst for intelligence reform in the United States. Since this date, most government agencies have strived to evolve and advance in this capacity. One such way has been through the development of multi-agency, multi-disciplinary intelligence centers, such as the National Counterterrorism Center, the Interagency Threat Assessment and Coordination Group, and the 72 state and major urban area fusion centers established throughout the nation. However, despite the changes that have occurred throughout the U.S. intelligence and law enforcement communities, significant issues still remain that are impeding the creation and flow of actionable intelligence to support domestic counterterrorism efforts. This has been identified from research conducted on numerous sources. Several policy, technological, cultural and political challenges exist, all contributing to the less-than-perfect nature of the United States'

existing counterterrorism framework.

This thesis aims to identify potential solutions that leverage existing intelligence operations to promote an intelligence-sharing continuum across all tiers of U.S. government. The author provides an analysis of specific, priority issues that require fixing within our nation's counterterrorism system, and provides evidence-based recommendations to improve the capability and value of existing intelligence support structures and further-develop the desired intelligence-sharing continuum.

**KEYWORDS:** Fusion center, Interagency Threat Assessment and Coordination Group, intelligence requirements, information sharing, National Counterterrorism Center, Homeland Security, FBI

**ORGANIZATIONAL LEADERSHIP'S IMPACT ON EMERGENT BEHAVIOR  
DURING DISASTER RESPONSE AND RECOVERY OPERATIONS**

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Since the events of 9/11 and Hurricane Katrina, emergency management has put great efforts into formalizing response and recovery structures following natural and man-made disasters. However, these formalized structures are not often flexible enough to allow for the innovation that each different disaster may require to best meet the needs of the impacted citizens in the most effective and efficient way possible. As emergency management continues to become more complex, organizational leadership will be challenged to balance the need for standard operating procedures and policies against the ability to leverage emergent behavior that allows for innovation in addressing the specific problems brought on by each unique disaster.

This thesis focuses on identifying under what circumstances emergent behavior is desired within the context of emergency management, and how organizational leadership can impact the factors that enhance or inhibit emergence during response and recovery operations. Using participant observation methods over the course of many years of disaster leadership, eight different incidents were analyzed for the identification of leadership themes that impacted emergent behavior.

As a result of these findings, five themes emerged in which emergency management's organizational leadership can most effectively impact self-organizing behavior within its ranks. With an understanding of when emergence is desirable, and by developing the capacity and an organizational culture that supports the vacillation between structure and innovation, emergency management officials will be better able to lead effective responses to complex incidents.

**KEYWORDS:** Emergence, Self-organization, Emergency Management, Organizational Leadership, Complex Adaptive Systems, Incident Management

**PROMOTING INTERAGENCY READINESS THROUGH STANDARDIZED  
TRAINING AND EDUCATION OF FRONT-LINE RESPONDERS**

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The Department of Homeland Security continues to anticipate barriers between federal and state entities and

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continues to research new and innovative ways to break down these barriers in order to enable collaboration with states to build a trained emergency-response workforce. New Jersey must also anticipate these barriers and must develop a structured, coherent, and standardized approach to prevention, response, and recovery. This thesis proposes the implementation of a multidisciplinary homeland-security training and education system. This will enhance the capabilities of first responders and emergency managers with regard to the elements of uniformity, interoperability, and the capacity to train personnel to a high level of interchangeability. The primary principle necessary in the design of an effective multidisciplinary training and education system is the establishment of a curriculum that is standards driven.

The creation of this system will ensure that every first responder and emergency manager in New Jersey understands his mission as it relates to preventing, responding to, and recovering from terrorist attacks. By focusing on the front-line individual, the state can effectively enhance its overall preparedness.

**KEYWORDS:** Multidiscipline, preparedness, uniformity, interoperability, interchangeability, law enforcement, fire service, emergency management, standards, first responder training, homeland security education, New Jersey State Police

**NEW YORK CITY FIRE DEPARTMENT CHIEF-OFFICER'S EVALUATION  
OF THE CITYWIDE INCIDENT-MANAGEMENT SYSTEM AS IT  
PERTAINS TO INTERAGENCY EMERGENCY RESPONSE**

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A review of the events of September 11 in New York City shows that inadequate interagency coordination or interdisciplinary collaboration existed among the rescuers arriving at the World Trade Center in Lower Manhattan. The 9/11 Commission recommended and NIMS mandated better coordination between the several agencies, specifically the fire and police departments. In 2004, New York City created the Citywide Incident Management System (CIMS) to address these shortcomings.

The goal of this research is to provide an evaluation of CIMS several years after implementation; has it changed emergency response in New York City or are the same problems occurring? A survey of the FDNY chief officers was conducted and the results show that CIMS' policies are not consistently enacted.

The history and creation of CIMS shortly following the September 11 terrorist attacks is discussed along with a brief background on interagency emergency operations. The history of conflict between the FDNY and the New York City Police Department (NYPD) and its motives are not the subject of this thesis, although they are discussed briefly.

In closing, many of the same problems that plagued the emergency responders on September 11 still exist according to the survey results.

**KEYWORDS:** New York City, Citywide Incident Management System, CIMS, FDNY, NYPD, Inter-Agency Coordination, NIMS, Inter-Disciplinary Collaboration, September 11, 2001, Information Sharing

**NO FAILURE OF IMAGINATION: EXAMINING FOUNDATIONAL  
FLAWS IN AMERICA'S HOMELAND SECURITY ENTERPRISE**

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Current United States (U.S.) policy vis-à-vis the nation's homeland security enterprise is built on a fatally flawed foundation. It is based on a top-down, federal-centric model, rather than on a constitutional model that develops capability for resilience, response, protection and preparedness for crises.

The issues leading to this flawed foundation go back to the inherent constitutional tension between the federal and state governments. Historically, when confronted by national-level crises, the federal government has based its actions and mandates on flawed metapolicy addressing all possibly related issues, rather than directing effort at solving the major crisis at hand. In so doing, the preemption of power, and the coercion through funding and regulation have been results unto themselves.

The crisis that encapsulates homeland security today is as wide and amorphous as the crisis confronting America at the time of the Great Depression. Both crises involve constitutional, social, financial, and political issues of extreme complexity. In addition, both resulted in significant expansion of federal prerogatives.

This thesis seeks to examine the metapolicy behind the reaction to such severe and yet amorphous crises and to suggest courses of action that—within the bounds of existing political reality—can redirect today's homeland security enterprise in a more effective manner. The research looks at historical and legal concepts, and conducts an in-depth review of similarities between the New Deal era and the modern homeland-security era.

**KEYWORDS:** Homeland Security, Emergency Management, Risk; Metapolicy, Federalism, New Deal

**INTEGRATION OF TRAINING CIVILIAN AND MILITARY DISASTER RESPONDERS**

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In the years since the September 11 attacks of 2001 and following the Gulf Coast hurricanes and the earthquake in Haiti, research has shown that first responders and medical institutions remain insufficiently prepared to address the increased demands for emergency response during and following major disasters. The threat from terrorism and natural disasters is very real; thus, the medical “system” will face continual challenges. A brutal recent reminder of this was the international outbreak of the H1N1 virus that caused a worldwide pandemic in 2009, resulting in an increased demand for medical services.

In the wake of these disasters Homeland Security presidential directives (HSPD) were issued. Among these are HSPD 21, *Public Health and Medical Preparedness*, which requires the establishment of a realistic strategy at all levels of government and across all sectors in the medical response community to meet the demands of contemporary preparedness. Areas of concern include the education and training for future response. To meet these needs, joint training of responders may enhance the efficiency of currently established training methodologies for national disaster teams, civilian hospital personnel, and National Guard and Reserve military emergency medical personnel training in domestic emergency medical deployment and response.

The research questions to be answered is how can the national policy enterprises design an effective model

for the pre-event joint command and control training of disaster responders for both military and civilian operations? The conclusions reached in this research can be used to shape future national and local training policies and curriculum presented to response agency leaders from civil and military agencies.

**KEYWORDS:** Disaster Response, Emergency Medical Personnel, Military, Coordination, Collaborations, Training Integration, Defense Support to Civilian Authorities, National Response Framework, Homeland Security Presidential Directive 21, Civilian Hospital Personnel, Kilpatrick Model of Evaluation, Connecticut Department of Public Health, Public Health

**THE INFLUENCE OF CULTURE ON STRATEGIC  
DECISION-MAKING IN JAPAN AND CHINA**

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

This thesis considers in the influence of culture on strategic decision-making processes in Japan and China. It applies strategic culture and operational code analysis to two historical case studies, Japan in 1941 and China in 1954, and considers primary source documents from both cases. Through this analysis, the thesis assesses the strengths and weaknesses of both research perspectives and develops a composite view of decision-making for both Japan and China. It determines that elements of culture, manifested through strategic culture and operational code, had a significant influence on decision-making in both cases, but that it cannot entirely supplant structural theories of international relations in determining state behavior. It suggests some future research avenues that could improve understanding of these cases and decision-making research in general.

**KEYWORDS:** Culture; China; Japan; Strategic Culture; Operational Code; World War II; Geneva Conference; Decision-Making

**HOMELAND-SECURITY STRATEGIC PLAN FOR THE  
NON-MAJOR, LOCAL, LAW-ENFORCEMENT AGENCY**

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Effectively implementing a homeland security program within police agencies labeled “non-major” in the United States is a challenge that requires different approaches from those that the large, or “major” departments employ. This research provides critical analysis leading to recommendations on how this important implementation can be accomplished without increasing the budget or personnel requirements within a given agency. Using a rigorous policy analytical framework and a representative case study approach, the findings coordinate and suggest how this process can fit into an agency’s plan to protect and respond to a community while successfully merging new and existing homeland security programs. The research finds that within a non-major police agency, the critical nodes for implementing effective homeland security hinge on an integrated leadership, communication and data collection synergy that leaders of these non-major departments can be taught and implement. This research contributes to the growing literature seeking to merge traditional law enforcement responsibilities with emerging homeland security requirements more effectively.

**KEYWORDS:** Non-Major Law Enforcement Agencies, Meta-Leadership, SAR Reporting, Collaboration, Intelligence-Led Policing

**TWO MISSIONS, ONE SECRET SERVICE: THE VALUE  
OF THE INVESTIGATIVE MISSION**

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The dual missions of the United States Secret Service, investigations and protection, appear to be without relationship or value to the other, and as a result, support and attention for the investigative mission has waned. This lack of attention to investigations is dangerous for the secret service and for the country it serves. To make this argument, this thesis attempts to determine whether the investigative mission is actually important to the successful performance of its protective mission.

Through the use of a hybrid research methodology, with quantitative and qualitative aspects, this thesis argues that the types of investigations performed by the secret service are not as important as the experiential learning, respite from the hyper-vigilance of protection, and surge capacity provided by the investigative mission. Since the investigative mission supports the protective mission in these three important ways, the Secret Service requires a robust, well-funded, and substantial investigative mission to continue to properly provide protection to this nation's leaders.

**KEYWORDS:** Secret Service, Protection, Investigations, Law Enforcement, Department of Homeland Security

**POLITICAL SUBCULTURE: A RESILIENCE MODIFIER**

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With the number and severity of disasters seemingly on the rise, there is an increased call for enhancing resilience to mitigate the post-event costs. Resilience is widely understood to revolve around the demography, geography, sociology, and economy of the area under study. What is not known is what other factors have measurable effects on the overall resilience of communities. One potential factor in this equation is political subculture, Daniel Elazar's term for the cultural stance of a community with regards to views on government and politics and their role in the society. In seeking to discover whether political subculture affects the resilience of a community, the author used analysis of disaster case studies from three representative communities—each highlighting one of Elazar's three subcultures of traditional, individual and moral—to investigate whether pre-evaluated resilience values and predicted response to disaster coincided with actual event outcomes. By using the Social Vulnerability Index values established by Susan Cutter as a baseline metric for a quantifiable measure of resilience, the author found that political subculture affects resiliency and should be further researched as a potential planning factor of resilience and response.

**KEYWORDS:** Resilience, political subculture, Daniel Elazar, community, subcultures, Social Vulnerability Index, Hurricane Katrina, Colorado tornados, Midwest flooding.

**COUNTER-RADICALIZATION: BEST PRACTICES IN THE  
UNITED STATES AND LESSONS LEARNED FROM ABROAD**

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The proposed thesis analyzes the threat and impact of homegrown radicalization on members of Muslim communities, its development and process in the United States and Europe, as well as unified efforts to counter radicalization that emphasize the need for interagency coordination and interdisciplinary approaches among all levels of government. Examined are the effectiveness and impact of a number of currently implemented counter-radicalization strategies and community outreach programs in the United States, particularly by the New York City Police Department (NYPD) and the Los Angeles Sheriff's Department, as well as in countries abroad in the United Kingdom, Amsterdam and Scandinavia. Best practices recommendations for implementing effective community outreach programs and developing a multi-agency counter-radicalization policy throughout the United States that aim to counter-radicalization and prevent violent extremism are based on promising findings derived from the research literature, selected case examples from the UK and Amsterdam, and professional expertise in community affairs.

**KEYWORDS:** Homegrown Radicalization, Counter-Radicalization, Violent Extremism, Community Policing

**THE VULNERABILITY OF SOCIAL NETWORKING MEDIA AND  
THE INSIDER THREAT: NEW EYES FOR BAD GUYS**

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Social networking media introduces a new set of vulnerabilities to protecting an organization's sensitive information. Competitors and foreign adversaries are actively targeting U.S. industry to acquire trade secrets to undercut U.S. business in the marketplace. Of primary concern in this endeavor is an insider's betrayal of an organization, witting or unwitting, by providing sensitive information to a hostile outsider that negatively impact an organization. A common existing technique to enable this breach of sensitive information is social engineering—the attempt to elicit sensitive information by obscuring the true motivation and/or identity behind the request. Social engineering, when coupled with the new and widespread use of social networking media, becomes more effective by exploiting the wealth of information found on the social networking sites. This information allows for more selective targeting of individuals with access to critical information. This thesis identifies the vulnerabilities created by social networking media and proposes a mitigation and prevention strategy that couples training and awareness with active surveys and monitoring of critical persons within an organization.

**KEYWORDS:** Social networking media, social engineering, insider threat, Sarbanes-Oxley Act

**BIOSURVEILLANCE TECHNOLOGY: PROVIDING SITUATIONAL  
AWARENESS THROUGH INCREASED INFORMATION SHARING**

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This need for the public health and medical enterprise to share information, has increased over the last decade, due to events such as the Severe Acute Respiratory Syndrome (SARS) outbreak, natural disasters, such as Hurricane Katrina, the 2009 H1N1 influenza outbreak, and other naturally occurring outbreaks, such as the recent Shiga toxin-producing *E. coli* O104 (STEC O104:H4) infections occurring in and associated with travel to Germany.

This thesis explores the various ways that information sharing can be improved within the public health and medical enterprise. Through case studies and interviews, a conceptual framework, the LEAPS model, was developed to guide the process to improve information sharing. This model is based upon the establishment of a strong foundation in health information sharing and disease surveillance. This model is centered upon leadership, policy, and strategy. The LEAPS model framework is then expanded to offer specific ways for the public health and medical enterprise to improve information sharing within jurisdictions and sectors to rapidly detect and respond to naturally occurring or intentional disease outbreaks or exposures and to create better situational awareness and a common operating picture

**KEYWORDS:** public health, information sharing, biosurveillance, situational awareness, common operating picture, medical, disease surveillance, syndromic surveillance, disease reporting, bioterrorism, LEAPS model

**HOMELAND-SECURITY ORGANIZATIONS:  
DESIGN CONTINGENCIES IN COMPLEX ENVIRONMENTS**

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Protecting America from terrorism, natural disasters, and other threats has never been more important or as complex an endeavor as it is today. From asymmetrical warfare to economic meltdown, the environments are increasingly unstable, dynamic, and complex, yet many U.S. homeland security organizations are designed around a 19th century model created for the Industrial Age. Information Age challenges demand new ideas for organizational design. Traditional mechanistic and hierarchical bureaucracies must be re-examined.

This thesis explores case studies that include an intelligence organization fighting bioterrorism and a military unit battling insurgents in asymmetrical warfare. Case study research was selected to examine “how” and “why” questions related to organic organizational design in dynamic and complex environments.

Organic designs provide a better fit because they leverage three critical capabilities for these environments: communication dissemination, sense-making, and timely conversion of information to action. This fit is accomplished through elements, such as decentralized decision authority, emergent leadership, low specialization, low formalization, use of liaisons, and a reliance on performance controls, that in turn contribute to decentralized allocation of decision rights, unconstrained patterns of interaction, and broad distribution of information.

Organizations of the future will benefit from the insights that emerged from this research.

**KEYWORDS:** Mechanistic, Organic, Hierarchical, Network, Organizational Design, Complexity, Complex Adaptive Systems, Uncertainty, Dynamic, Unstable Environment, Organization and Management Theory, Contingency Theory, Intelligence Organization, Command

**HOW CAN OFFICERS BE BETTER PREPARED TO INTERACT WITH NON-GOVERNMENTAL ORGANIZATIONS IN A POST-CONFLICT ENVIRONMENT?**

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This thesis examines the state of relations between the military and non-governmental organizations (NGOs). Military-NGO relationship can be improved in specific ways. The involvement of the military in post-conflict reconstruction efforts is required due increasingly tenuous security situations and the need to achieve stabilization of the post-conflict society. I argue that an effective way for increasing cooperation/coordination is by improving the preparation of the military officer expected to operate in that cooperative environment.

This research investigates the effectiveness of the existing practices of preparing the military officer for NGO interaction and provides recommendations for improving the preparation through utilization of an anonymous survey provided to a cross-organizational audience. The lessons learned through this research will provide a foundation for military decision makers to properly allocate funding towards these efforts.

**KEYWORDS:** Civil-Military Relations, Non-Governmental Organizations, NGO, Post-Conflict Operations

**GREEK NATIONAL-SECURITY CONCERNS AND THE EUROPEAN UNION'S COMMON FOREIGN AND SECURITY POLICY: CONSENSUS OR DIVERGENCE?**

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One of the most important yet insufficiently researched dynamics of the European Union (EU) concerns its effectiveness in accommodating the security concerns of its members. With NATO dominating the collective security market of the old continent, the launch of the Common Security and Defense Policy (CSDP) in 1999 generated an interesting security option, and silently partitioned the NATO members of the EU into a “Euro-atlanticist” and a “Euro-continentalist” group, with the non-duplication of NATO being the point of contention. With Greece’s major security concern deriving from Turkey, a fellow NATO member, Athens holds a firm position in the latter group, seeking to turn the evolving European defense project into a counterweight to NATO in guaranteeing Greek national security. While Greek security priorities have remained remarkably consistent, the ambitious European defense project has undergone various fluctuations, reflecting the awkward development in its evolution. As a consequence, Greece’s anticipations of a CSDP commitment in its national security concerns have oscillated accordingly: periods of positive signs succeeded periods of disillusionment, and vice versa. Against this background, this paper attempts to elucidate Greek perceptions of its security providers and aims to give an answer to the following question: Are Greek security concerns reflected in the CSDP? In other words, is the EU an adequate security provider for Greece? This thesis argues that the territorial security concerns of the EU’s member-states, especially those of Greece, cannot be fully assuaged under the CSDP auspices. More specifically, the CSDP does not adequately address Greek national

interests, if defending these interests entails a European military response.

**KEYWORDS:** Greece, European Union (EU), Common Security and Defense Policy (CSDP), European Security and Defense Policy (ESDP), Frontex, Security, Defense, Foreign Policy, Turkey, Albania, FYROM, Immigration.

**DEFENSE-SECTOR REFORM AND CIVILIAN PROTECTION  
IN THE DEMOCRATIC REPUBLIC OF THE CONGO**

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**Sophal Ear, Department of National Security Affairs**

The United Nations organization mission in the Democratic Republic of the Congo (MONUC) was deployed as a multidimensional peacekeeping force in the Democratic Republic of the Congo (DRC) from 1999 until 2010. During this time, violence continued to plague the eastern part of the country. In response to continued civilian casualties, MONUC made civilian protection a core component of its mission. While MONUC never succeeded in adequately protecting civilians, a close examination of its mandate and operations reveals a continual process of adjustment ultimately leading to an attempt by MONUC to assist in defense sector reform. The evidence reveals that MONUC's adjustments had a slight effect on reducing ethnic violence from 2003-2007, but violence against civilians by the FARDC and rebels did not decrease from 2007-2010. This thesis attempts to explain why MONUC did not succeed in the end at increasing civilian protection. MONUC's actions to reform the FARDC were not efficacious because MONUC lacked capacity to fully carry through with its strategy combined with a lack of wholehearted Congolese Government support. The answers are important because they may help future civilian protection missions succeed.

**KEYWORDS:** Democratic Republic of the Congo, MONUC, UN Peacekeeping, Civilian Protection, Security Sector Reform, Defense Sector Reform

**COMPOSITE ARTISTRY MEETS FACIAL-RECOGNITION  
TECHNOLOGY: EXPLORING THE USE OF FACIAL-RECOGNITION  
TECHNOLOGY TO IDENTIFY COMPOSITE IMAGES**

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Forensic art has been used for decades as a tool for law enforcement. When crime witnesses can provide a suspect description, an artist can create a composite drawing in hopes that a member of the public will recognize the subject. In cases where a suspect is captured on film, that photograph can be submitted into a facial recognition program for comparison with millions of possible matches, offering abundant opportunities to identify the suspect. Because composite images are reliant on a chance opportunity for a member of the public to see and recognize the subject depicted, they are unable to leverage the robust number of comparative opportunities associated with facial recognition programs.

This research investigates the efficacy of combining composite forensic artistry with facial recognition technology to create a viable investigative tool to identify suspects, as well as better informing artists and program creators on how to improve the success of merging these technologies. This research ultimately re-

veals that while facial recognition programs can recognize composite renderings, they cannot achieve a level of accuracy that is useful to investigators. It also suggests opportunities to better design facial recognition programs to be more successful in the identification of composite images.

**KEYWORDS:** Composite Art, Forensic Art, Facial Recognition, Composite Imagery, Forensic Imagery, Composite Sketches

**STATE AND LOCAL HOMELAND-SECURITY OFFICIALS:  
WHO ARE THEY AND WHAT DO THEY DO?**

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Today, hundreds of colleges and universities throughout the United States of America are offering prospective students homeland security certificates, bachelor's and master's degrees to educate a new cadre of homeland-security officials. Yet, when asked, a practicing homeland-security professional will likely admit that he/she has little idea what these students will be able to do when they graduate. The problem is that homeland security, in its current form, is not clearly defined and few understand what homeland security officials actually do, especially at the state and local levels.

This research addresses this problem by asking state and local homeland-security officials about who they are and what they do. By conducting interviews with state and local homeland security officials in practice, this research provides insight into the world of nonfederal homeland-security officials, their activities and their backgrounds. It further provides a set of recommendations for developing educational, training and developmental programs that support homeland security officials at the state and local levels.

**KEYWORDS:** Homeland Security, State, Local, Government, Professionals, Discipline, Education, Degree

**HARNESSING THE POWER OF COLLABORATIVE RELATIONSHIPS TO  
IMPROVE NATIONAL PREPAREDNESS AND RESPONSIVENESS**

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**Second Reader: Marilyn Cobb Croach, U.S. Army Northern Command**

This thesis focuses on the activities of leading and the elements of partnerships to move a large bureaucratic organization to a higher level of fitness and remain reliable and relevant in keeping the nation prepared to respond to national emergencies and domestic events. The critical elements of leading and partnerships include a combination of building trust, sensemaking, and collaboration with all the activities of leading and partnerships that those elements encompass. This combination creates the basis for collaborative relationships that when used correctly can help organizations to work and lead across boundaries to tackle the wicked problems that face homeland security professionals today.

The research for this thesis is exploratory and used the methodology of grounded theory. In addition, a single case was studied through the methodology of participant observation to collect data, which was analyzed to test the theory of collaborative relationships. The analysis demonstrated the importance of relationships in creating collaborative efforts and partnership engagements among the many organizations that must work together during a national emergency. The findings also supported the theory of collaborative relation-

ships and offered examples of how to utilize such relationships in the complex world of homeland security and national preparedness.

**KEYWORDS:** Leadership, Leading, Partnerships, Relationships, Participant Observation, Ground Theory, and Collaboration

### **A REGIME-LEGITIMACY EXPLANATION OF AFRICAN PEACEKEEPING**

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**Advisor: Sophal Ear, Department of National Security Affairs**

The American military needs to understand what incentivizes some African nations to participate in peacekeeping in order to strengthen the incentive structure so that high levels of peacekeeping will continue. The main argument advanced in this thesis is that regimes that are attempting to increase their structural legitimacy are more likely to volunteer for peacekeeping missions to gain international political legitimacy, as well as domestic social and economic legitimacy. This hypothesis is based on a synthesis of constructivism and political economy. The constructivist perspective argues that regimes that govern societies with identities and norms based on protecting others can gain domestic legitimacy through benevolent external actions; this same argument holds true for increasing international legitimacy by following international norms. This hypothesis is also based on a political economy argument that the monetary benefits from peacekeeping are transmitted throughout the military and society, resulting in domestic legitimacy. Quantitative results show that a state's structural legitimacy is correlated to its level of peacekeeping in a U-shaped curve, meaning that states attempting to increase their legitimacy participate at a higher-than-expected level. Likewise, the case study of Rwanda's involvement in the United Nations African Union Mission in Darfur illustrates that the Rwandan Patriotic Front government reaps economic, social and political benefits from peacekeeping that strengthen that regime's legitimacy.

**KEYWORDS:** Sub Saharan Africa, Peacekeeping, Regime Legitimacy, Rwanda, UNAMID

### **GETTING TO ONE FROM TITLE 10 + TITLE 32: UNITY OF EFFORT IN THE HOMELAND**

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**Master of Arts in Security Studies—September 2011**

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**Co-Advisor: Stanley Supinski, DoD Contractor**

This thesis bridges the knowledge gap between Title 10 active duty and Title 32 National Guard in order to breakdown cultural barriers and reach unity of effort for response operations in the homeland. Regrettably, a unified response was missing among Title 10 active duty and Title 32 National Guard members following Hurricane Katrina. Since then, initiatives based in doctrine, statutes, and formal recommendations have been established to address unity of effort, however, a serious knowledge gap remains. Future threats, man made or natural, will require a unified response to save lives and mitigate suffering. Case studies on the Israeli Home Front Command and the Florida Division of Emergency Management help determine best practices to reach unity of effort between Title 10 active duty and Title 32 National Guard. Appreciating the varying perspectives, concerns and competing interests among state and federal stakeholders on command and control of military forces in the homeland is vital to moving forward. Understanding culture and context among Title 10 active duty and Title 32 National Guard will facilitate learning and resolve conflict. Progress is underway to

reach unity of effort through the Council of Governors on dual-status command and this thesis recommends next steps to enhance efforts.

**KEYWORDS:** Unity of Effort, Defense Support to Civil Authorities, Title 10 Active Duty, Title 32 National Guard, National Response Framework, Command and Control, Dual Status Command, USNORTHCOM

**HIGHWAY SECURITY: FILLING THE VOID**

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**Master of Arts in Security Studies—September 2011**

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In a society dependent upon our highways, protection from the destructive tactics of terrorists is critical. If successfully attacked and destroyed, these critical highway infrastructures could isolate a community, severely hamper the transportation of vital goods and services, and potentially kill motorists along the structure when the attack occurs. An explosive device detonated in heavy traffic during rush hour could cause deaths, significant injuries, and create a psychological impact reverberating around the entire country.

Our open roadway system not only provides us with the freedoms our forefathers intended, but also provides terrorists the ability to travel the highways of this country without government intervention. Unfortunately, this unencumbered freedom of movement also lends itself to exploitation by terrorists. Threat assessments consistently reveal the vulnerability of our highways and their critical infrastructure to terrorist attacks. Yet, the highways remain underprotected.

Law enforcement officers are the foot soldiers of the war on terror in the United States. It is a very small army with tremendous responsibility. Our public looks to the police to protect them against crime and criminals; terrorists are the new criminals and terrorism is the new crime. The strategies and tactics to make the public safe against terrorism on our highways are similar, and they are a natural extension of existing law enforcement highway safety strategies. No paradigm shift is necessary.

This thesis proposes strategies designed to take law enforcement's concept of highway safety and expand this paradigm to mesh with the threat environment of modern-day terrorism.

**KEYWORDS:** Homeland security, homeland security enterprise, transportation critical infrastructure, terrorism, improvised explosive devices, law enforcement, highway security strategies, public engagement, First Observer, See Something, Say Something, America's Waterway Watch, Prevent.

**AFFECTING REFORM: EXPLAINING THE KINGDOM OF CAMBODIA'S  
CONTRIBUTIONS TO UNITED NATIONS PEACEKEEPING  
OPERATIONS IN COMPARATIVE CONTEXT**

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**Master of Arts in Security Studies—September 2011**

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**Co-Advisor: Arturo Sotomayor, Department of National Security Affairs**

The Kingdom of Cambodia has recently begun to provide Royal Cambodian Armed Forces personnel to United Nations-led peacekeeping operations in Africa and the Middle East. This thesis draws on systemic, regional, and domestic level theories for why states contribute to international organizations in an attempt to explain participation in peacekeeping abroad. It argues that Cambodia's political and military elite promote peacekeeping as a means of inexpensively affecting military reform. This thesis will also provide a comparative

case study of the Republic of Indonesia. The Southeast Asian nation has significantly increased the number of personnel it provides to United Nations peacekeeping missions, from a few hundred in early 2001 to nearly eighteen hundred personnel in mid-2011.

**KEYWORDS:** Kingdom of Cambodia; Republic of Indonesia; United Nations; Peacekeeping.

**THE DOMESTIC SECURITY COMMAND: THE EVOLUTION  
OF U.S. NORTHERN COMMAND**

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**Master of Arts in Security Studies—September 2011**

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The United States lacks the capability to effectively achieve whole nation situational awareness and accomplish intergovernmental, interagency and multidisciplinary planning and response in the homeland. United States Northern Command (USNORTHCOM) and the Department of Homeland Security (DHS) were established in the post-911 environment to address this issue but should now be reevaluated to ascertain whether they truly provide the appropriate framework to facilitate the nation's needs within our Federalist framework. This thesis discovers that USNORTHCOM can provide the military component and form the basis of this unique capstone organization but should evolve significantly to become a coalition of those organizations that, together, truly facilitate a whole nation approach to defense and security. USNORTHCOM should evolve away from a traditional military-centric combatant command towards an integrated Homeland Defense and Security Command (DSC) that effectively melds Department of Defense (DoD) elements, selected Department of Homeland Security components and National Guard organizations while also providing for connectivity to states and their governors. The resultant DoD-DHS-NGB coalition organization would be better able to secure, defend and support the U.S. homeland.

**KEYWORDS:** USNORTHCOM, National Guard, Homeland Security, Integrated Planning, Situational Awareness, Unity of Effort

**U.S. MARITIME SECURITY: SUSTAINABILITY CHALLENGES**

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The U.S. maritime domain includes vast resources and enables transportation of goods and services across the globe. Similar to all critical infrastructures and key resources, the maritime domain can be exploited to cause harm to people and disrupt economic stability. The President's National Strategy for Maritime Security and the U.S. maritime security framework is designed to deter, prevent and respond to a broad range of threats and exploitations. The U.S. maritime security system has evolved over the past decade and faces significant challenges including severe budget reductions, gaps between national guidance and specific roles and responsibilities assigned to federal agencies, and lack of interoperability among disparate logistic, training processes and operational command centers within the Department of Homeland Security (DHS).

Within the DHS, the United States Coast Guard and Customs and Border Protection execute the preponderance of maritime security missions. They struggle with aging air and marine assets and continuous

interoperability challenges. The long-term solution includes a new alignment of air and marine resources and capabilities under one agency within the department, which will increase efficiency and reduce duplication of effort and costs, while maintaining a sustainable and layered maritime security posture in support of the President's strategy.

**KEYWORDS:** Maritime Security, United States Coast Guard, Customs and Border Protection, National Strategy for Maritime Security

**RISKY INVASIONS: DECISIONS MADE BY THE ARGENTINE  
JUNTA REGARDING DISPUTED ISLANDS, 1978–1982**

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In 1978, Argentina and Chile were poised at the brink of war over disputed possession of the Beagle Channel islands located near the southern tip of South America. Despite provocative military maneuvering and inflammatory rhetoric from both sides, Argentina's ruling military junta pulled back just short of attacking the territory occupied by Chile, and eventually both sides reached a peaceful settlement.

Only four years later, Argentina launched a surprise invasion of the British-held Falkland Islands in the South Atlantic. Why did Argentina choose to go to war with Britain in 1982, but not with Chile in 1978? What factors led to a grab for the Falklands instead of the Beagle Channel islands?

Prospect theory, borrowed from cognitive psychology, may hold the answer. This theory proposes that decision-makers tend to be more risk-averse when they are facing a potential gain and more willing to take risks when they are confronting a potential loss. Therefore, the junta refrained from invading the Beagle Channel islands because they were more secure in their political position and therefore facing a potential gain, but chose to invade the Falklands because they were insecure in their position and facing the loss of political power.

**KEYWORDS:** Argentina, Chile, Territorial Disputes, Beagle Channel, Falkland Islands, Malvinas, Junta, Governmental Decision Making, Prospect Theory

**POTENTIAL STANDARDS AND METHODS FOR THE NATIONAL  
GUARD'S HOMELAND-RESPONSE FORCE**

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In 2009, the Office of the Secretary of Defense directed the creation of ten National Guard Homeland Response Force (HRF) units to provide regional chemical biological radiological nuclear and explosive (CBRNE) and disaster response in each of the 10 FEMA regions beginning in September 2011. The HRF was selected to fill a regional CBRNE capability gap. The HRF concept is a 566-person National Guard unit tasked to provide command, CBRNE assessment, decontamination, casualty care, logistics, security, and rescue in support of civilian officials during a regional-level CBRNE event or disaster. With domestic response mission and overseas deployment requirements, the HRF faces the difficult challenge of meeting both civilian response and military battlefield standards. Although some DoD organizations have had similar domestic response missions,

no precedent for the HRF exists. The HRF reflects an evolution of military units with CBRNE and disaster related missions beginning in the 1990s. Government and private criticisms of these previous DoD CBRNE include wasted tax dollars, poor training strategies, and poor links to national planning scenarios. This thesis provides lessons learned from case studies of previous U.S. and Israeli CBRNE and disaster response organizations while recommending standards that the new HRF can use for improved implementation.

**KEYWORDS:** Civil Support Operations, Defense Support to Civil Authorities, Civil Support Teams, CBRNE Consequence Management Response Force, Chemical Biological Radiological Nuclear Explosive, CBRNE Enterprise, Weapons of Mass Destruction, National Guard, HRF, Homeland Response Force, CC-MRF, weapons of mass destruction

## STUDENT INDEX

---

### A

Actkinson, LT John I., USN 31  
Albin, LCDR Eugene A., USN 35  
Alrowaei, MAJ Ahmed A., Bahraini Air Force 3  
Anderson, LT Ben , USNL. 69  
Apostolos, LJG Karamitros, Hellenic Navy 21, 25  
Arslan, 1st LT Erdal, Turkish Army 25  
Atkins, Maj Robert M., USAF 79

### B

Badescu, Veronica V. 79  
Bass, Lt Col Aaron C., USAF 80  
Beery, Paul T. 85  
Beuligmann, LT Christopher M., USN 73  
Biasotti, Michael C. 93  
Bray, LT Erik K., USN 93  
Brister, MAJ Paul D., USAF 3  
Britt, LT Jeremy L., USN 35  
Brody, Michael H. 94  
Brunton, Jason A. 21

### C

Caldwell, MAJ Jason C., USA 63  
Camarena, LCDR Richard M., USN 80  
Carabin, David 94  
Cardwell, LCDR Gregory S., USN 17  
Carmody, LT Francis J., USN 73  
Casper, Nancy 95  
Cervi, LT Joseph J., USN 89  
Cheney, LCDR David J., USN 57  
Cobb, LT Brandon J., USN 69  
Cole, LT Scott F., USN 36  
Collins, Tristin J. 95  
Cummings, LT Brian, USND. 47

### D

Davidson, LCDR Pornchai, USN 70  
de Moraes, LCDR Claudio C., Brazilian Navy 63  
Diaz, Capt Gabrie, USMC I D. 64  
Dixon, CMDR Cory A., USN 15  
Dubbs, LCDR Sean R., USN 70

### E

Esposito, John M. 96

### F

Fehse, CDR Carsten, German Navy 77  
Fehse, CMDR Carsten, German Navy 36  
Fingerholz, Mark D. 85  
Fodera, Capt Christopher M., USMC 37  
Freed, Judson M. 97

Fulmer, LT Charles A., USN 37

### G

Gaitan, LT Gerardo Sanabria, Colombian Navy 7, 53  
Geis, LTJG Chad E., USN 59  
Gerhart, Charlotte M. 86  
Ginn, Robert C. 33  
Good, Capt Daniel E., USMC 17, 38  
Griffith, LT Robert C., USN 81  
Guercia, Jr., Leonard H. 97  
Guo, Jerry M. 98

### H

Halsey, Brad A. 98  
Harder, MAJ Robert W., USAF 4  
Harlow, Richard 99  
Harmon III, MAJ Charles F., USA 75, 81  
Harvey, LT Scott A., USN 51  
Hay, LCDR Aaron M., USN 51  
Hebert, LT Mark A., USN 59  
Heck, LCDR Amy, USND. 60  
Holihan, LT Michael L., USN 52  
Hong, LT Bryan Y., USN 60  
Hoshlyk, CMDR Michael J., NOAA 9  
Hunter, Maj Gordon S., USAF 99

### J

Johnson, LT Stephani, USN 61

### K

Klaus, MAJ Christian, USA 13, 71  
Kosseim, Amin G. 100  
Kostopoulos, Sophia 18

### L

LaFrenier, Capt Kevin , USMCJ. 18  
Lednicky, CDR Eric J., USN 71  
Lenkart, John J. 100  
Logsdon, Jasie K. 101

### M

Madia, James D. 101  
Magalhães, Lt Col Marcelo Vellozo, Brazilian Air Force 26  
Marshburn, CDR Erik R., USN 38  
Matvay, Jr., LCDR David M., USN 102  
Maxen, LTC Fredrik, Swedish Army 27  
Maxey, LT Craig A., USN 72  
McDougall, Francis G. 89

---

## STUDENT INDEX

---

- McGruder, Crystal A. 77  
McKaughan, LCDR Daniel , USNC. 64  
McKenzie, Scott A. 90  
McLaughlin, LCDR Robert D., USN 39  
Menychtas, LT Charalampos, Hellenic Navy 102  
Meyer, Ramsey 39  
Miller, LCDR Clint W., USN 82  
Miller, LT Glenn A., USN 48  
Mintz, LCDR Leslie A., USN 103  
Miranda, LT Sofia I., Portuguese Navy 13, 72  
Montagner, LTC Elison, Brazilian Air Force 28  
Montgomery, Tracy L. 103  
Morris, Capt Mark K., USMC 40  
Morrison, LCDR Gregory C., USN 82  
Myrick, LCDR Kenneth B., USN 83
- N**  
Nairn, Jason P. 104  
Niazi, LCDR Javed Iqbal Khan, Pakistani Navy 48  
Nye, LT Matthew J., USN 23
- O**  
Oregon, MAJ Rogelio S., USMC 40  
Orfanos, LT Stamatios, Hellenic Navy 23  
Orfanos-Pepainas, LT Stamatios, Hellenic Navy 7  
Ozcan, 1st Lt Ozkan, Turkish Air Force 65
- P**  
Paepolshiri, LT Nattaphum, Royal Thai Navy 22, 28  
Panhorst, David W. 86  
Pawlenko, LCDR Matth, USN 62  
Pearman, LT Douglas W., USN 57  
Pollock, LT Shawnoah, USN 65  
Poteete, Paul W. 45  
Prosch, Caroline Ross 105
- R**  
Reale, LTC Joseph D., USA 104  
Roberts, LT Erik S., USN 41  
Rogers, Maj Claiborne H., USMC 90  
Ross, 2nd Lt Matthew, USAF 105  
Russillo, Tracy S. 106  
Ryan, LT Michael D., USN 106
- S**  
Sakamoto, LT Kamryn M., USN 52  
Schoettelndreyer, CDR Friedrich,  
German Navy 9  
Shelstad, LTC Kristine L., USA 107  
Sifa, 1st Lt Haldun, Turkish Air Force 29  
Snyder, Maj Derek J., USMC 49  
Socias, LCDR Luis F., USN 19  
Starcovic, LT Philip J., USN 49  
Stubblefield, MAJ, Cedrick L., USAF 5
- T**  
Thompson, CDR Laura Jean, USCG 107  
Tuggle, LT Christopher K., USN 62  
Tyree, LT Michael G., USN 50
- U**  
Upp, LT Daniel G., USN 108
- V**  
Varelas, LCDR Georgios, Hellenic Navy 66  
Violette, LCDR Michael A., USN 54  
Voigts, Maj Scott Avery, USMC 42
- W**  
Walters, LT Adam P., USN 54  
Watts, LT Bryan D., USCG 55  
Welch, LT Savannah G., USN 87  
Willcox, Capt Travis G., USAF 91  
Winters, LCDR Nathan J., USN 83  
Wolff, Capt Russel G., USMC 42
- Y**  
Yang, Maj Keo S., USMC 42
- Z**  
Zaborowski, LT Robert M., USN 19
-

---

## FACULTY INDEX

---

### A

Alderson, David L. 15  
Alt, LTC Jonathan 64, 65  
Alves, Fabio Durante Pereira 28  
Anthony Ciavarelli 63  
Appleget, Jeffrey 85  
Apte, Aruna 39  
Arkes, Jeremy 9  
Augier, Mie 98  
Austin, William 97

### B

Bach, Robert 107  
Barreto, Albert 40  
Barrett, Frank 36  
Bayer, Joseph 85  
Beauchair, Roberto de 63  
Becker, William 64  
Bellavita, Christopher 95, 100, 101, 104  
Bergin, Richard 101, 103  
Betsch, Ronald E. 60, 73  
Beverly, Robert 17  
Boger, Dan 48  
Bordetsky, Alex 27, 37, 39, 80  
Borges, Carlos F. 13, 72  
Brannan, David 93, 98, 106  
Brewer, Luke 51  
Brook, Douglas A. 9  
Brown, Gerald G. 15  
Buddenberg, Rex 35, 49  
Buettner, Jr., Raymond R. 47, 48, 49, 50  
Burke, Karen L. 18  
Bursch, Daniel 83  
Buss, Arnold 3, 69  
Buttrey, Samuel E. 72

### C

Cabrera, Gildo D. 37  
Carlucci, Donald E. 86  
Carlyle, W. Matthew 15  
Chandrasekhara, Muguru S. 51  
Chiu, Ching-Sang 73  
Chung, Timothy H. 13, 71  
Chu, Peter C. 60, 73  
Ciavarelli, Anthony 63, 64, 66  
Clovis, Samuel 97, 99  
Cook, Glenn R. 35, 39  
Cristi, Roberto 7, 23  
Croach, Marilyn Cobb 104

### D

Dahl, Erik 99  
Darken, Christian 19, 63, 64, 65, 66  
Darken, Rudy 4  
David C. Jenn 28  
Denardo, Bruce 31  
Denning, Dorothy E. 47  
Dew, Nicholas 42  
Didoszak, Jarema 54  
Dimitrov, Nedialko 13, 71  
Dinolt, George W. 18  
Dobrokhodov, Vladimir 55  
Drusinsky, Doron 77  
Dumas, COL John L., USA 60  
Durkee, Philip A. 62

### E

Ear, Sopal 102, 103, 105, 106  
Eide, Kris 97  
Ewing, Lee P. 89

### F

Farmer, Joseph 52  
Fernandez, Lauren 99  
Fisher, Edward 29, 45  
Flanagan, Jason 59  
Fleischer, Peter 73  
Frederickson, Paul 59

### G

Gannon, Anthony J. 52  
Garfinkel, Simson 17  
Gates, William R. 9  
Gera, Raluca 13, 71  
Gibson, John H. 18, 38, 40, 42  
Gill, Janet 33  
Gordon, Ellen 95  
Grbovic, Dragoslav 21, 25

### H

Hacker, Joshua 5  
Halladay, Carolyn 102  
Harr, Patrick 5, 57, 60  
Herbers, Thomas 57  
Hobson, Garth V. 52  
Holland, K. Todd 62  
Horning, James A. 79, 81, 82  
Housel, Thomas 36, 42  
Huynh, Thomas V. 86

---

## FACULTY INDEX

---

### J

Jenn, David 21, 22, 25, 26, 28  
Jones, Kevin D. 48, 49, 51  
Josefek, Robert 100, 101, 103  
Joseph, John 73  
Julian, Alexander L. 7, 23

### K

Kaminer, Isaac 55  
Kapolka, Daphne 31  
Karunasiri, Gamani 21, 25  
Kennedy, Quinn 63  
Kline, Jeffrey E. 69  
Kölsch, Mathias 19, 66  
Kragelund, Sean 50  
Kwon, Young 51, 54

### L

Langford, Gary 90, 91  
Lawson, Letitia 103  
Liu, Chun-Yi 26  
Looney, Robert E. 9  
Lucas, Thomas W. 69, 70  
Lundy, Bert 19  
Luqi 17, 38

### M

MacKinnon, Doug 35, 38, 40, 42, 90  
MacMahan, Jamie 62., 83  
McCauley, Michael E. 63, 66  
McConnell, Bernd 107  
McGregor, Donald O. 49  
Meyer, David W. 61  
Miller, Pat 93, 94, 98, 99, 106  
Morag, Nadav 94, 96, 100, 105  
Mun, Johnathan 42  
Murphree, Tom 59, 61

### N

Newman, James H. 79, 81, 82  
Nissen, Mark E. 37  
Nussbaum, Daniel A. 70

### O

Olsen, Richard C. 75, 81, 83  
Olwell, David H. 85  
Osmundson, John 33, 42, 90  
Osswald, Sebastian 21, 52  
Owen, Walter 86, 89

### P

Pace, Phillip E. 22, 25, 26, 28  
Papoulias, Fotis 7, 53  
Paulo, Eugene 85, 87  
Peiffer, Karl D. 45  
Pelfrey Sr., William 104  
Pfeiffer, Karl 17, 19, 38  
Pickar, Charles 91  
Piombo, Jessica 105  
Porch, Douglas 108  
Porch, Ralph D. 93  
Previsich, Nicholas P. 89

### R

Racoosin, Charles 82, 83  
Radko, Timour 59  
Rasmussen, Craig 13, 71  
Rasmussen, Maria 3  
Regnier, Eva 57, 70  
Rhoades, Mark M. 79, 80  
Roberts, Benjamin 89  
Rockafellar, R. Tyrrell 13, 72  
Rogalski, Col Dirk, German Airforce 102  
Romero, Ric 26  
Rowe, Neil 35  
Royset, Johannes O. 13, 72

### S

Schramm, Harrison C. 71  
Scott, Al 80  
Scott, Alan D. 80, 82  
Seagren, Chad 70  
Shing, Man-Tak 36, 41, 77  
Silvestrini, Rachel T. 71  
Simeral, Robert 94, 108  
Singham, Devaushi 69  
Singh, Gurminder 18  
Smith, Lt Col Terry 26, 27, 29  
Smith, Paul 100  
Soos, Charles 95  
Sotomayor, Arturo 106  
Strindberg, Anders 96  
Supinski, Stanley 105, 107, 108

### T

Thornton, Ed 62  
Travis, LCDR Henry, USN 86  
Trinkunas, Harold 93  
Tsolis, Kristen 75, 81  
Twomey, Christopher 98

## FACULTY INDEX

---

### U

Uhlinger, Eleanor 37

### V

Velázquez, Arturo C. Sotomayor 108

Voigts, Scott Avery 42

### W

Wang, Qing 57

Watman, Kenneth 94

Weatherford, Todd R. 21

Webb, Natalie 102

Welch, William J. 79

Whitaker, Lyn R. 72

Whitcomb, Clifford 7, 53, 87

### Y

Yun, Xiaoping 7, 23

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