COMPILATION OF ABSTRACTS

Unrestricted Dissertations, Theses, and Final Projects

NPS Class of September 2016
This publication, *Compilation of Abstracts*, contains abstracts of unrestricted dissertations, theses, and capstone project reports submitted for the doctor of philosophy, master of arts, master of business administration, and master of science degrees for the Naval Postgraduate School’s September 2016 graduating class. A digital copy of this publication can be found at https://calhoun.nps.edu/handle/10945/51418 while the corresponding metadata for September 2016 abstracts can be found at http://calhoun.nps.edu/handle/10945/50610.

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

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

Additional Information on NPS Research and Academic Programs

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

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

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

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

MISSION

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

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

To fulfill its mission, the Naval Postgraduate School advances innovation in the Navy and prepares officers for employing new technologies. The research program at NPS supports the mission of graduate education. Research at NPS
• advances knowledge in a wide range of disciplines relevant to DON/DOD;
• maintains upper-division course content and cutting-edge programs;
• provides the opportunity for students to demonstrate independent graduate-level scholarship in their areas of study;
• challenges students with creative problem solving experiences on DOD-relevant issues;
• solves warfare problems; and
• attracts and retains quality faculty with state-of-the-art expertise.

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

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

ACADEMIC PROGRAMS

School of International Graduate Studies (SIGS)

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

• Civil-Military Relations
• Combating Terrorism Strategy and Policy
• Defense Decision Making and Planning
• Homeland Security and Defense
• Security Studies
• Stabilization and Reconstruction

• National Security and Intelligence, Regional Studies:
  - Middle East, South Asia, Sub-Saharan Africa
  - Far East, Southeast Asia, the Pacific
  - Europe and Eurasia
  - Western Hemisphere
Graduate School of Business and Public Policy (GSBPP)

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

- Acquisition and Contract Management
- Advanced Acquisition Program
- Contract Management (DL)
- Defense Business Management
- Defense Systems Analysis
- Defense Systems Management
- Executive MBA (DL)
- Financial Management

- Information Systems Management
- Material Logistics Support
- Manpower Systems Analysis
- Program Management (DL)
- Supply-Chain Management
- Systems Acquisition Management
- Transportation Management

Graduate School of Engineering and Applied Sciences (GSEAS)

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

- Applied Mathematics
- Combat Systems Sciences and Technology
- Electronic Systems Engineering (residential and DL)
- Mechanical Engineering for Nuclear-trained Officers (DL)
- Meteorology and Oceanography
- Meteorology
- Naval/Mechanical Engineering
- Oceanography

- Operational Oceanography
- Reactors–Mechanical/Electrical Engineering (DL)
- Space Systems Engineering
- Space Systems Operations (residential and DL)
- Systems Engineering (residential and DL)
- Systems Engineering Management (DL)
- Undersea Warfare
- Underwater Acoustic Systems (DL)

Graduate School of Operational and Information Sciences (GSOIS)

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

- Applied Cyber Operations
- Computer Science (residential and DL)
- Computing Technology (DL)
- Cyber Systems and Operations
- Cost Estimating and Analysis (DL)
- Electronic Warfare Systems (International)
- Human Systems Integration
- Identity Management and Cyber Security (residential and DL)
- Information Sciences
- Information Systems and Operations
- Information Systems and Technology

- Information Warfare
- Joint C4I Systems
- Joint Information Operations
- Joint Operational Logistics
- Modeling, Virtual Environments, and Simulation
- Operations Analysis
- Remote Sensing
- Software Engineering (residential and DL)
- Special Operations
- Systems Analysis (DL)

Office of the Provost

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

- Systems Engineering Analysis
STUDENT POPULATION

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

*Figure 1: Total enrollment by student type for the fourth quarter of 2016 (2,743 total). Source: NPS Academic Affairs Quarterly Enrollment Report, AY2016/Quarter 4.*

STUDENT RESEARCH

Independent scholarly work in the form of a dissertation (PhD), thesis (master’s/engineer), or capstone project is required for most academic programs. Student research projects address issues ranging from the current needs of the fleet and joint forces to the science and technology required to sustain long-term superiority of the Navy and DOD. Guided by faculty advisors, NPS students represent a vital resource within the DOD for addressing war-fighting problems and maintaining cutting-edge expertise, particularly in a time when technology and information operations are changing rapidly. Naval Postgraduate School alumni think innovatively and possess the knowledge and skills to apply nascent technologies in the commercial and military sectors. Their firsthand grasp of operations, when combined with challenging projects that require them to apply their focused graduate coursework, is one of the most effective elements in solving fleet, joint-force, and regional problems. NPS graduate education encourages a lifelong capacity for applying basic principles and creative solutions to complex problems. NPS is also unique in its ability to conduct classified research. Classified theses are available on the NPS SIPRNet.
DEGREES OFFERED
Curricula meet defense requirements within the traditional degree framework through residential or distance-learning status. All curricula lead to a master of science or art or a master of business administration; additional study may yield an engineer or doctoral degree. Below is a listing of degrees offered at the Naval Postgraduate School.

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

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

**Engineer**
- Astronautical
- Electrical
- Mechanical

**Master of Arts**
- Identity Management and Cyber Security
- Security Studies

**Master of Business Administration**

*Source: NPS Public Affairs Office*
SEPTEMBER 2016 DEGREES CONFERRED
The September 2016 graduating class produced 150 unrestricted dissertations, theses, and capstone project reports as part of the graduation requirement. Figure 2 indicates the distribution of degrees awarded by academic school.

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

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

**Campus-wide Awards**
- Monterey Council Navy League Award for Highest Academic Achievement: Captain Kiel A. Reese, USMC
- Naval Postgraduate School Outstanding Academic Achievement Award for Department of Defense Student: Ms. Beth Anne Sammoos
- Naval Postgraduate School Outstanding Academic Achievement Award for International Students: Captain Roey Ben Yoash, Israeli Army—Outstanding Thesis: *Anti-Submarine Warfare Search Models*
- Association of the United States Army, General Joseph W. Stilwell Chapter, Award for Outstanding Army Student: Second Lieutenant Thomas J. Knuth, USA

**Graduate School of Business and Public Policy (GSBPP)**
- The Louis D. Liskin Award for Excellence in Management: Lieutenant Commander Kevin Chlan, USN

**Graduate School of Engineering and Applied Sciences (GSEAS)**
- The Surface Navy Association’s Award for Excellence in Surface Warfare Research: Lieutenant Kristen Eriksen, USN
- Space and Naval Warfare Systems Command Award in Electronic Systems Engineering: Lieutenant Junior Grade (Eng) Anastasios Antoniou, Hellenic Navy
- Chief of Naval Operations Undersea Warfare Award: Lieutenant Zachary Lukens, USN
- Submarine Force Undersea Warfare Curriculum Award: Lieutenant Shawn Stelzel, USN
- Meyer Award for Outstanding Student in Systems Engineering (Distance Learning): Ms. Kathi H. Dubar, Mr. Justin Ryan Berrier, and Ms. Kristie Jo Wilkerson
- Naval Sea Systems Command Award in Naval/Mechanical Engineering: Lieutenant Commander Matthew O’Brian, USN
- Oceanographer of the Navy Award for Outstanding Academic Performance in Meteorology and Oceanography: Lieutenant Thomas Freimuth, USN

**Graduate School of Operational and Information Sciences (GSOIS)**
- Military Operations Research Society Stephen A. Tisdale Graduate Research Award: Captain Roey ben Yoash, Israeli Army
- AFCEA John McReynolds Wozencraft Electrical and Computer Engineering Academic Honor Award: Mr. Chee Kiong Ong, Singapore and ME6 Chew Kung Tan, Singapore Navy
- Rear Admiral Grace Murray Hopper Information Technology Management Award: Major Kyle Opel, USMC
- The Hans Jones Award for Excellence in Thesis Research in Special Operations and Irregular Warfare or Security, Stabilization, Transition and Reconstruction (SSTR): Major William Holloway, USA
- Chief of Naval Operations Award for Excellence in Operations Research: Commander Kevin Williams, USN

**School of International Graduate Studies (SIGS)**
- The Louis D. Liskin Award for Excellence in Regional Security Studies: Lieutenant Z’hra M. Ghavam, USN
- The International Student Award for Excellence in Regional or Security Studies: Captain Yildirim Isik, Turkish Army
- The Outstanding United States Air Force Graduate Award, Department of National Security Affairs: Major Ellen M. Canup, USAF—Outstanding Thesis: *Entrepreneurs and Informal Finance in Kenya*
- The Curtis H. “Butch” Straub Achievement Award: Assistant Chief John Flynn, Yonkers Fire Department, NY
Outstanding Thesis Recognition

- Captain Hichem ben Abdallah, Tunisian Army: Convolutional Neural Networks as Feature Extractors for Data-Scarce Visual Searches
- Major Chun Chieh Cheng, Singapore Armed Forces, Army: A Brownian Bridge Movement Model to Track Mobile Targets
- Lieutenant David W. Courtney, USN: Implementation of Secure 6LoWPAN Communications for Tactical Wireless Sensor Networks
- Lieutenant Matthew L. R. Fillmore, USN: Italy, the European Union, and Mediterranean Migrants: Opportunity from Crisis?
- Ramón A. García, Civilian, Naval Undersea Warfare Center Division, Newport, RI: Evaluation of Model-based Systems Engineering Processes for Integration into Rapid Acquisition Programs
- Lieutenant Stephen J. Klingseis, USN: Syrian Refugees: Are They a Non-Traditional Threat to Water Supplies in Lebanon and Jordan?
- Kum Leong Lee, Civilian, Defence Science Organisation National Laboratories: Model for Atmospheric Propagation of Spatially Combined Laser Beams
- Michael B. Revill, Civilian, Department of the Navy: UAV Swarm Behavior Modeling for Early Exposure of Failure Modes
- Captain Jeremy F. Thomas, USMC: Exploring the Impact of Fuel Data Acquisition Technology on the USMC Expeditionary Energy Command and Control System
- Michelle Tonelli, Attorney-Advisor, Office of General Counsel, Department of Homeland Security: Your Criminal FICO Score
- Lieutenant Commander Christopher J. Wasek, USN: Cloud Fingerprinting: Using Clock Skews to Determine Co-Location of Virtual Machines
ADVANCED DEGREES

Doctor of Philosophy
Electrical Engineer
DOCTOR OF PHILOSOPHY

UNSCENTED SAMPLING TECHNIQUES FOR EVOLUTIONARY COMPUTATION
WITH APPLICATIONS TO ASTRODYNAMIC OPTIMIZATION
Christopher McGrath—Captain, United States Air Force
Doctor of Philosophy in Astronautical Engineering
Dissertation Supervisor: I. Michael Ross, Department of Mechanical and Aerospace Engineering

This dissertation investigates several innovative approaches to evolutionary optimization that are relevant to numerous applications in astronautical engineering. The challenges and shortfalls associated with evolutionary algorithms are translated into three overarching goals that directly motivate the research and innovations of this dissertation. The first goal is to investigate and employ techniques that enable evolutionary algorithms to effectively handle constraints in a way that allows for feasible solutions to constrained optimization problems. The second goal is to improve computation times and efficiencies associated with evolutionary algorithms. The last goal is to enhance the evolutionary algorithm’s robustness and ability to consistently find accurate solutions within a finite number of iterations. Novel techniques involving the application of unscented sampling, parallel computation, and various forms of exact penalty functions are developed and applied to both genetic algorithms and evolution strategies to achieve these goals. The results of this research offer a promising new set of modified evolutionary algorithms that outperform state-of-the-art techniques on a number of challenging multimodal optimization problems. In addition, these new methods are shown to be very effective in solving a minimum-propellant lunar lander optimal control problem, representing a class of problems that are historically difficult to solve using evolutionary algorithms. Full Text

Keywords: evolutionary algorithm, evolution strategy, genetic algorithm, parallel computation, parallel processing, unscented sampling

NONLINEAR ESTIMATION WITH SPARSE TEMPORAL MEASUREMENTS
Paul Frontera—Commander, United States Navy
Doctor of Philosophy in Mechanical Engineering
Dissertation Supervisor: I. Michael Ross, Department of Mechanical and Aerospace Engineering

Nonlinear estimators based on the Kalman filter, the extended Kalman filter (EKF) and unscented Kalman filter (UKF) are commonly used in practical application. The Kalman filter is an optimal estimator for linear systems; the EKF and UKF are sub-optimal approximations of the Kalman filter. The EKF uses a first-order Taylor series approximation to linearize nonlinear models; the UKF uses an approximation of the states’ joint probability distribution. Long measurement intervals exacerbate approximation error in each approach, particularly in covariance estimation. EKF and UKF performance under varied measurement frequency is studied through two problems, a single dimension falling body and a simple pendulum. The EKF is shown more sensitive to measurement frequency than the UKF in the falling body problem. However, both estimators display insensitivity to measurement frequency in the simple pendulum problem. The literature’s lack of consensus as to whether the EKF or UKF is the superior nonlinear estimator may be explained through covariance approximation error. Tools are presented to analyze EKF and UKF measurement frequency sensitivity. Covariance is propagated forward using the approximations of the EKF and UKF. Each propagated covariance is compared for similarity with a Monte Carlo propagation. The similarity of the covariance matrices is shown to predict filter performance. Portions of the state trajectory susceptible to EKF divergence are found
using the Frobenius norm of the Jacobian matrix, limiting the need to consider covariance propagation along the entire state trajectory. Long measurement intervals also reveal a commonly overlooked challenge in UKF application: sigma point selection methods may produce sigma point vectors that violate physical state constraints. Although the UKF can function under this condition over short measurement intervals, unexpected failure may occur without consideration of physical constraints. A novel constrained UKF, using the scaled unscented transform, is proposed to address this issue. Full Text

Keywords: nonlinear estimation, measurement, frequency, EKF, UKF, constrained

EVOLUTION OF A WESTERN ARCTIC ICE-OCEAN BOUNDARY LAYER AND MIXED LAYER ACROSS A DEVELOPING THERMODYNAMICALLY FORCED MARGINAL ICE ZONE
Shawn Gallaher–Commander, United States Navy
Doctor of Philosophy in Physical Oceanography
Dissertation Supervisor: Timothy Stanton, Department of Oceanography

A comprehensive set of autonomous ice-ocean measurements were collected across the Canada Basin to study the summer evolution of the ice-ocean boundary layer (IOBL) and ocean mixed layer (OML). Evaluation of local heat and freshwater balances and associated turbulent forcing reveals that melt ponds strongly influence the summer IOBL-OML evolution. The areal expansion and drainage of melt ponds resulted in a substantial increase in upper ocean heat storage (39 MJm⁻²) and development of the summer mixed layer and near-surface temperature maximum (NSTM). 1-D boundary layer model results show that melt pond drainage provided sufficient buoyancy to the summer halocline to prevent subsequent wind events from mixing out the NSTM. Ice Camp observations captured the development of a second shallower NSTM in late summer; however, meltwater contributions were inadequate to sustain this feature when winds increased. In the marginal ice zone (MIZ), thermal heterogeneities in the upper ocean led to large ocean-to-ice heat fluxes (100–200 Wm⁻²) and enhanced basal ice melt (3–6 cm-day⁻¹). Calculation of the upper ocean heat budget shows that the extensive area of deteriorating sea ice observed away from the ice edge during the 2014 season, termed the thermodynamically forced MIZ, was driven primarily by local solar radiative heat input. Full Text

Keywords: ice-ocean boundary layer processes, thermodynamic evolution of the upper ocean, ephemeral pycnocline, Local Turbulence Closure model, Thermodynamic Marginal Ice Zone, turbulent heat partitioning, melt pond drainage, through-ice radiative transmission, near-surface temperature maximum, summer halocline, summer mixed layer

EXECUTABLE BEHAVIORAL MODELING OF SYSTEM- AND SOFTWARE-ARCHITECTURE SPECIFICATIONS TO INFORM RESOURCING DECISIONS
Monica Farah-Stapleton–Civilian, Office of the Secretary of Defense
Doctor of Philosophy in Software Engineering
Dissertation Supervisor: Mikhail Auguston, Department of Computer Science

The size, cost, and slow rate of change of Department of Defense (DOD) Information Technology (IT) systems make introducing new capabilities challenging. Without considering the whole system and its environment, design decisions may result in unintended operational and financial impacts, often not visible until later testing. These complex systems and their interactions are not cheap to maintain, impacting intellectual, programmatic, and organizational resources. Precise behavioral modeling offers a way to assess architectural design decisions prior to, during, and after implementation to mitigate the impacts of complexity, but this modeling cannot estimate those design decisions’ effort and cost. This research introduces a methodology to extract Unadjusted Function Point (UFP) counts from architectural behavioral models utilizing a framework called Monterey Phoenix (MP), lightweight formal methods, and high-level pseudocode for use in cost esti-
information models such as COCOMO II. Additionally, integration test estimates are informed by extracts of MP model event traces. These unambiguous, executable architecture models and their views can be inspected and revised in order to facilitate communication with stakeholders, reduce the potential for software failure, and lower implementation costs. Full Text

Keywords: architecture, behavioral modeling, cost estimates, unadjusted function point, test cases, views

METHODOLOGY FOR THE SYSTEM INTEGRATION OF ADAPTIVE RESILIENCE IN ARMOR
Joseph Cannon–Major, United States Army
Doctor of Philosophy in Systems Engineering
Dissertation Supervisor: Eugene Paulo, Department of Systems Engineering

This dissertation introduces a novel augmentation to system-engineering methodology based on the integration of adaptive capacity, which produces enhanced resilience in technological systems that operate in complex operating environments. The implementation of this methodology enhances system resistance to top-level function failure or accelerates the system's functional recovery in the event of a top-level function failure due to functional requirement shift, evolutions, or perturbations. Specifically, the dissertation defines and proposes a methodology to integrate adaptive resilience and demonstrates its implementation in a relevant armor system case study. The conceptual validity of the methodology is proven through a physical comparative test and evaluation of the system described in the case study. The research and resulting methodology supplements and enhances traditional system-engineering processes by offering systems designers the opportunity to integrate adaptive capacity into systems, enhancing systems' resilient resistance or recovery to top-level function failure in complex operating environments. The research expands traditional and contemporary systems engineering, design, and integration methodologies, which currently do not explicitly address system adaptation and resilience. The methodology accomplishes this objective by defining adaptive design considerations, identifying controllable adaptive performance factors, characterizing adaptive performance factors and configurations, mapping and integrating adaptive components, and verifying and validating the adaptive components and configurations that achieve system requirements and adaptive design considerations. The utility of this research and methodology is demonstrated through development of an adaptive resilient armor system called the mechanically adaptive armor linkage (MAAL), which was designed, developed, and validated using the methodology for the system integration of adaptive resilience (MSIAR). Full Text

Keywords: adaptive resilience, adaptive capacity, adaptability, resilient, complex operating environment, systems engineering, system integration, engineering resilience, resilience theory
For an Energy Management System (EMS)-controlled microgrid that uses a single-phase voltage source inverter (VSI) configuration to supply power for AC loads from DC energy storage devices, the DC link connecting the VSI to the DC energy storage devices experiences a voltage ripple that is a second-order harmonic of the AC frequency. When the EMS has a battery bank as the only DC energy storage device, the DC link voltage ripple causes a second-order harmonic ripple in battery current that leads to a reduction in battery life. Supercapacitors (SCs), which are capable of operating through many more cycles than batteries, can be added to the EMS to form a battery and SC Hybrid Energy Storage System (HESS). The EMS can then be used to filter out the second-order harmonic ripple in battery bank current and provide this current solely from the SC bank, extending battery life and reducing system operating costs. The design of a computer simulation of an EMS providing power to a microgrid is discussed in this thesis. Simulations provide theoretical results and laboratory results compare well with the theoretical results, showing that SCs can be used to remove the second-order harmonic current ripple from the battery bank. Full Text

Keywords: Energy Management System (EMS), peak shaving, Voltage Source Inverters (VSI), Hybrid Energy Storage System (HESS), supercapacitor (SC), ultracapacitor (UC), power electronics, microgrid (MG), bidirectional dc/dc converters, battery life extension
This thesis explores the links that exist between human beings and how the presence or absence of connectivity within a person's social network impacts one's health and well-being. Through the analysis of both the social and clinical sciences, this research explores the question: What role do social relationships, and their associated networks, play in the lives of high healthcare utilizers? This thesis studies the origins of human connection and presents the science of social network analysis to demonstrate how interconnected relationships influence the well-being of networked individuals. The findings indicate that the quality of an individual's social network can have a positive or negative effect on the individual's health. Those who are socially isolated in their community often have difficulty managing complex health conditions and navigating the fractured national healthcare system. Deficits in community healthcare and social support networks cause these individuals to frequently utilize expensive and finite public safety and hospital emergency department resources for primary healthcare services. This research presents four recommendations to promote improved healthcare system navigation for high healthcare utilizers by understanding not only the patients' social networks but also the healthcare provider network. **Full Text**

Keywords: superuser, healthcare, fire service, emergency medical services, social network analysis

**MERIDA INITIATIVE: INSIGHT INTO U.S.-MEXICO RELATIONS**  
Andrew Bartholomeaux–Lieutenant, United States Navy  
Master of Arts in Security Studies (Western Hemisphere)  
Advisor: Erik Dahl, Department of National Security Affairs  
Second Reader: Rodrigo Nieto-Gomez, Department of National Security Affairs

In 2007, the United States and Mexico agreed to a bilateral anti-drug policy known as the Mérida Initiative, with the intent of disrupting organized crime and drug trafficking in Mexico. The initiative has persisted through multiple administrations on both sides of the border and has been criticized by scholars for its oversimplification of the problem. Did funding and allocation of resources of the Mérida Initiative address the underlying issues that contributed to the drug trade in Mexico? Analyzing the historical foundations that supported the rise of organized crime in Mexico, combined with the factors that drive the drug trade, reveals an anti-drug policy focused on military operations and not on addressing the factors set forth in the initiative. This thesis exposes the underlying issues and analyzes allocation of resources to pinpoint where the focus is, and where it should be placed. This thesis concludes that resources are allocated to security operations when they would be better suited to training the judicial branch in Mexico, improving the border, and improving
the community to provide opportunities outside organized crime. Furthermore, the United States has steps to take to fulfil its shared responsibility. **Full Text**

Keywords: United States, Mexico, Mérida Initiative, anti-drug policy, organized crime, border security, arms trafficking, money laundering, Plan Colombia, failed state, militarization

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**CIVIL-MILITARY RELATIONS AND SEXUAL ASSAULT**

**Brandi Bluhm—Civilian, Department of the Navy**  
**Master of Arts in Security Studies (Civil-Military Relations)**  
**Advisor: Carolyn Halladay, Center for Civil-Military Relations**  
**Co-Advisor: Cristiana Matei, Center for Civil-Military Relations**

The Bureau of Justice Statistics' Criminal Victimization Survey reported that there were 284,350 rapes or sexual assaults in the United States in 2014. In the same year, the Department of Defense (DOD) Sexual Assault Prevention and Response Office (SAPRO) estimated that 18,900 sexual assaults occurred in the military. In recent years, Congress has been increasing pressure on the military to improve sexual assault prevention and response; some efforts to resolve the sexual assault problem in the military have included proposals to alter the military justice system to resemble its civilian counterpart. Yet, as the numbers suggest, the civilian justice system may not be doing such a good job either. Civil-military relations revolve around who controls what. This thesis addresses the role of civil-military relations in regard to sexual assault prevention and response. Through official statistics, documents from the state of California and the Department of Defense, scholarly research, and reports from the media, this paper describes the experience of the victim as he or she navigates through either system. The comparison of the systems side by side reveals that, if the civilian and military communities work together to capitalize on learning from each other, real progress can occur in serving victims of sexual assault. The focus must shift from “Who is doing a worse job?” to “How can both systems learn from each other to improve and best serve the victims of these horrible crimes?” **Full Text**

Keywords: sexual assault, law, justice system, civil–military relations, rape, victim, legal

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**ENHANCING THE NFL’S COUNTER-TERRORISM EFFORTS: IS THE LEAGUE’S SECURITY SCHEME ABLE TO EFFECTIVELY THWART TERRORIST ATTACKS?**

**Jeffrey Bolstad—Lieutenant, United States Navy**  
**Master of Arts in Security Studies (Homeland Security and Defense)**  
**Advisor: Carolyn Halladay, Center for Civil-Military Relations**  
**Second Reader: James Moltz, Department of National Security Affairs**

The National Football League (NFL) has become the unofficial national pastime in the United States due to its massive popularity in terms of game attendance, television viewership, and annual revenues. Because the league is far and away the most popular professional sports league in the world, there exists a risk that its games will be targeted by terrorists seeking either to announce their agenda or simply to inflict as many casualties as possible. My thesis answers the following questions: How adequate is security at non-Super Bowl NFL games against potential terrorist attacks? And how can the government and the league best manage this interface of public and private issues and secure major-league regular-season football games and their tailgates effectively and in a manner that does not scare away the fan base? Additionally, the thesis draws comparative lessons from the security programs at U.S. international airports and the English Premier League. It concludes that the
NFL has largely succeeded in its protective efforts but must yet improve security in tailgating areas, especially in surrounding private lots. Full Text

Keywords: 9/11 (September 11, 2001), airport security, aviation security, Department of Homeland Security (DHS), English Premier League (EPL), football, mass gatherings, National Football League (NFL), safety manuals, soccer, sports security, soccer, terrorism, terrorist, Transportation Security Administration (TSA)

**ENTREPRENEURS AND INFORMAL FINANCE IN KENYA**

*This paper has been recognized as outstanding by its department.*

Ellen Canup–Major, United States Air Force

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

Advisor: Robert Looney, Department of National Security Affairs

Second Reader: Rachel Sigman, Department of National Security Affairs

The future of a country is closely tied to its economy, and entrepreneurs have a direct impact on that future. Many Kenyans are underserved by formal financial institutions, despite Kenya's relatively robust banking structure when compared to those of other African nations. Kenyan entrepreneurs can, however, turn to alternative finance options like microfinance institutions (MFIs) and rotating savings and credit associations (ROSCAs). In this paper, the success of these two alternative finance institution types is judged in terms of their respective abilities to create economic growth and improve individual welfare. In general, while MFIs targeted toward entrepreneurs, like the Kenya Women's Finance Trust (KWFT), present a more direct causal link to business growth, ROSCAs are more prevalent and are in a better position to increase individual welfare. In the future, MFIs should adapt their lending practices to leverage some of the cultural aspects of group-centered lending that are firmly embedded in ROSCAs. By doing so, MFIs will lower their transaction costs and ensure they are better able to operate in the future. Similarly, as new financial technologies like mobile phone-based banking emerge, MFIs and ROSCAs must adapt to remain competitive. Full Text

Keywords: Kenya, microfinance, rotating savings and credit associations, economy, economic growth, welfare outcomes

**REMOVED EFFECTIVELY: UNMANNED AERIAL VEHICLES, THE INFORMATION REVOLUTION IN MILITARY AFFAIRS, AND THE RISE OF THE DRONE IN SOUTHEAST ASIA**

Grant Cassingham–Lieutenant, United States Navy

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

Advisor: Erik Dahl, Department of National Security Affairs

Co-Advisor: Michael Malley, Department of National Security Affairs

The information revolution in military affairs (IRMA) has changed the way that wars are fought and won. Exploiting the revolution’s core principles enables a net-centric, informationalized force to outmaneuver and defeat its adversaries. Unmanned aerial vehicles (UAV) represent a critical advancement in intelligence collection capability, but are they as revolutionary a technology as one might expect? Is UAV acquisition without IRMA exploitation the equivalent of purchasing surface-to-air missiles without their radars? This thesis argues that IRMA exploitation is a necessary precondition for effective UAV employment, especially in the maritime domain. By examining the maritime UAV use of several countries across the IRMA exploitation spectrum, one can see that UAV deployment without an underlying information architecture undermines the utility of an unmanned asset. Southeast Asia is the world’s fastest growing UAV market. While analysts have predicted that UAVs will disrupt the regional balance of power, this analysis finds that due to a lack of IRMA exploitation, the chances of disruption are extremely remote. This thesis identifies the IRMA-related deficien-
cies of future UAV users, and provides recommendations for increasing the chance of effective UAV use and ultimately, combat efficiency. Full Text

Keywords: unmanned aerial vehicle, UAV, information revolution in military affairs, revolution in military affairs, Southeast Asia, Malaysia, Singapore, Philippines, Vietnam, Indonesia, China, United States, Iran, effectiveness, drone, intelligence, sensors, command and control, situational awareness, maritime domain awareness, net-centric warfare

SECURING HEALTHCARE’S QUANTIFIED-SELF DATA: A COMPARATIVE ANALYSIS VERSUS PERSONAL FINANCIAL ACCOUNT AGGREGATORS BASED ON PORTER'S FIVE FORCES FRAMEWORK FOR COMPETITIVE FORCES

Catherine Chiang–Management Program Analyst, United States Citizenship and Immigration Services
Master of Arts in Security Studies (Homeland Security and Defense)
Advisor: Rodrigo Nieto-Gomez, Department of National Security Affairs
Co-Advisor: John Rollins, Center for Homeland Defense and Security

This thesis explores possible solutions to secure the aggregation and sharing of healthcare’s quantified-self data, based on lessons from the personal financial industry. To address this concern, Porter's Five Forces Framework is used to understand how consumers are impacted by the two sectors’ differences in legislation, technology, and security. The analysis in this thesis indicates that consumers of financial account aggregators benefit from more secure and interoperable services. In contrast, users of healthcare aggregators are negatively affected by the healthcare industry’s higher threat of new entrants and the bargaining power of suppliers. Therefore, healthcare leaders should improve consumer benefits by transforming their industry’s competitive forces to mimic those of the financial services industry. To accomplish this goal, industry leaders could focus on filling the gap in the Health Insurance Portability and Accountability Act (HIPAA) for self-generated data, improving security innovations, and attracting third-party developers to secure data interoperability. Full Text

Keywords: quantified-self movement, data aggregation, data sharing, account aggregators, screen scraping, healthcare, personal finance, Porter’s Five Forces, competitive forces, information security, privacy, data security and interoperability

AFRICAN GOVERNMENTS’ RESPONSE TO INSURGENCY

Jared Cordell–Major, United States Air Force
Master of Arts in Security Studies (Middle East, South Asia, Sub-Saharan Africa)
Advisor: Jessica Piombo, Department of National Security Affairs
Second Reader: Anna Simons, Department of Defense Analysis

Why would an otherwise-capable African government permit an insurgency to persist within its borders for an extended period of time while possessing the means to address it? Through a comparative approach, drawing on academic research on Uganda and the Lord’s Resistance Army and Nigeria and Boko Haram, this thesis seeks to explain why some insurgencies persist for extended periods of time with minimal government intervention. The research suggests that in the case studies analyzed, Uganda and Nigeria have permitted the insurgencies to continue due to the economic and political benefits that they are able to derive from the ongoing conflict. African governments may at times exploit insurgency and internal conflict to meet political objectives. U.S. policy makers should strongly consider this possibility when deciding upon economic and
military aid packages to countries involved in ongoing conflict, to avoid inadvertently facilitating ongoing conflict. Full Text

Keywords: insurgency, Lord's Resistance Army, LRA, Uganda, Nigeria, Boko Haram, war economy, ethnic marginalization, counterinsurgency, COIN, African politics

REDUCING THE USE OF FORCE: DE-ESCALATION TRAINING FOR POLICE OFFICERS

Eric Dayley–Captain, Idaho State Police
Master of Arts in Security Studies (Homeland Security and Defense)
Advisor: Thomas Housel, Department of Information Sciences
Co-Advisor: Patrick Miller, Center for Homeland Defense and Security

The use of force by police officers has captured the attention of society. Allegations of inappropriate or misapplied force happen with regularity. This thesis conducted a survey of the members of the International Association of Directors of Law Enforcement Standards and Training to determine the number of training hours dedicated to firearms and force versus de-escalation topics. It analyzes the results through the framework of the Recognition-Primed Decision model, which asserts that in rapidly evolving, time-limited incidents, individuals make decisions based on prior experiences. This thesis hypothesizes that officers are primed to use force rather than de-escalation options due to an overemphasis on force during training sessions. The survey results showed an 8.9 to 1 ratio of training hours on force versus de-escalation. It recommends that police trainers strive to achieve parity in training hours dedicated to force and de-escalation topics. It also recommends that scenario-based training be emphasized to provide experiences to draw upon, and that the scenarios mirror real-world probabilities. Positioning Theory, Crisis Intervention Team principles, and de-escalation strategies of other countries are also examined for methods that could be implemented to reduce the occurrences of inappropriate use of force by police officers. Full Text

Keywords: police, use of force, de-escalation, Recognition-Primed Decision, Positioning Theory, Crisis Intervention Teams, warrior versus guardian

HUMAN TRAFFICKING AND U.S. GOVERNMENT RESPONSES POST- 9/11

Kevin DeCeoursty–Lieutenant, United States Navy
Master of Arts in Security Studies (Homeland Security and Defense)
Advisor: Carolyn Halladay, Center for Civil-Military Relations
Co-Advisor: Robert Looney, Department of National Security Affairs

The thesis examines the effectiveness of U.S. government anti-human trafficking efforts in the post- 9/11 environment. The body of human trafficking literature has revealed four common themes: human agency, labor rights, the sex industry, and crime control. The thesis examines five federal departments that were selected based on their relative experience, expertise, and operational mandates. Open source statistical data and other information gleaned from documents, articles, and reports determine how each department’s efforts to combat human trafficking correlate to the four main human trafficking themes. The thesis illuminates that through experience and initiative, the applicable federal departments can properly identify and balance the external and internal aspects of human trafficking. The current state of federal efforts to combat human trafficking are encouraging, as they provide sufficient remedies to trafficking victims who are marginalized, disenfranchised, or subjugated, and provide some trafficking disincentives. These efforts are steps toward the global paradigm shift required to eliminate the exploitation of vulnerable populations and individuals. Full Text

Keywords: human trafficking, human smuggling, labor trafficking, sex trafficking, trafficking in persons, counter-terrorism
SECURITY STUDIES

THE U.S. RESPONSE TO NEOs: AVOIDING A BLACK SWAN EVENT
Candice Dixon—Civilian, Department of the Navy
Master of Arts in Security Studies (Homeland Security and Defense)
Advisor: Erik Dahl, Department of National Security Affairs
Co-Advisor: Clay Moltz, Department of National Security Affairs

Near Earth Objects (NEOs) present one of the greatest threats to Earth, but currently there is no U.S. or international response and mitigation strategy in place for a NEO impact. This thesis examines case studies from two other high impact low probability (HILP) events—earthquakes and volcanoes—with the intent of applying lessons learned to the formulation of a NEO mitigation strategy. The case studies include domestic and international examples, offering insights into the critical areas of education and training, infrastructure, and communications. Considering the destructiveness of the threat, it would be in the best interests of global leaders to develop a NEO strategy that uses best response practices from these other events. This thesis recommends the use of an early warning system, greater involvement of leadership, and crowdsourcing ideas beyond the public sector. Full Text

Keywords: Near Earth Object, NEO, HILP, mitigation

THE SUCCESSES AND FAILURES OF DEMOCRACY IN THE POST-SOVIET REPUBLICS
Allison Dolby—Captain, United States Marine Corps
Master of Arts in Security Studies (Europe and Eurasia)
Advisor: Mikhail Tsypkin, Department of National Security Affairs
Co-Advisor: David Yost, Department of National Security Affairs

The purpose of this thesis is to answer the question of what factors contribute to the differing levels of democratic success in the post-Soviet republics. The thesis draws on political theory and historical approaches to examine all 15 of the post-Soviet republics as a group in order to identify common trends, and then investigates two particular case studies—Russia and Kyrgyzstan—for further insight. Using the Freedom House scores to measure levels of democratic development, the thesis focuses on two important factors that contribute to democratic success: the balance of power among the elites at the moment of transition and the nature of the initial constitutional framework. The first theory posits that the power dynamics of leadership between the democrats and those supporting the ancien régime are crucial in determining the level of democratic development. The second theory concentrates on the impact for democracy of the type of constitutional framework adopted—whether parliamentary, presidential, or some mixture of the two. The thesis examines the merits of these two variables and concludes that an analysis combining them offers the most useful explanation of what contributes to the differing levels of democratic success. Full Text

Keywords: democratization, post-Soviet, constitutional frameworks, parliamentary, presidential, semi-presidential, democratic development, Russia, Kyrgyzstan, leadership, balance of power, leadership dynamics, democratic transition

POTENTIAL EFFECTS OF PERMANENT NEUTRALITY ON MONGOLIA'S DEFENSE FOREIGN COOPERATION
Myagmarjav Dorj—Lieutenant Colonel, Mongolian Armed Forces
Master of Arts in Security Studies (Strategic Studies)
Advisor: James Russell, Department of National Security Affairs
Co-Advisor: Scott Jasper, Center for Civil-Military Relations

The Mongolians have debated a potential declaration of permanent neutrality since September 2015. These debates have contained little or no consideration of the potential effects on Mongolia’s defense cooperation.
with foreign militaries. Mongolia has developed defense cooperation with Russia, China, and other countries in order to enhance military capability and interoperability. The country’s defense cooperation allows Mongolia to contribute to global peace and stability activities as a vital foreign policy tool of the country. This thesis analyzes the potential effects of permanent neutrality on foreign defense cooperation. This analysis is based on the study of the concept of neutrality and the benefits and limitations of the permanent neutrality policies; the examination of the defense cooperation experiences of neutral countries such as Switzerland, Finland, Sweden, Austria, and Turkmenistan; and the evaluation of current foreign cooperation of Mongolia’s defense. If Mongolia became permanently neutral, it would likely cause defense cooperation challenges, such as discouraging current partners, and potentially disengaging current cooperation. Since Mongolia has limited military capacity, foreign cooperation for defense is crucial. Such cooperation enhances Mongolia’s defense capacity and enables it to participate in global stability affairs. This thesis assesses that the permanent neutrality policy is not suitable for Mongolia’s defense foreign cooperation. **Full Text**

Keywords: permanent neutrality status, Mongolia’s defense cooperation, defense relations, peacekeeping capacity, Mongolia’s defense capability, military interoperability

### THE CARRIER STRIKE GROUP: EXAMINING APPROACHES TO FORWARD PRESENCE

**Christopher Elliott–Lieutenant Commander, United States Navy**  
**Master of Arts in Security Studies (Strategic Studies)**  
**Advisor: Daniel Moran, Department of National Security Affairs**  
**Second Reader: James Russell, Department of National Security Affairs**

With carriers reduced to their lowest number since 1942, maintaining forward presence in regions of U.S. national interest has proven difficult. The current carrier operating concept has resulted in unprecedented deployment lengths, shorter home-cycles and increasing strain on crew members and their families. By examining the Carrier Strike Group (CSG) deployment models and the various techniques for optimizing forward presence, a more efficient approach may be developed. This thesis answers the following question: How will the carrier’s ability to protect U.S. national interests through a global strategy centered on forward presence and flexible response be accomplished in the future? The goal is to maximize forward presence based on current and forecast ship-building budgets and resources by identifying the CSG’s utility and role in forward presence while assessing various techniques. The predicted carrier force structure of 11 is assumed while determining which technique or combination of techniques produces the appropriate level of forward presence and crisis response to deter current and future global threats. A combined approach incorporating a proportional crew swap concept with the potential to increase overseas-based CSGs will offer more options to policy-makers and leadership and increased flexibility in employing the CSG in pursuit of U.S. national interests. **Full Text**

Keywords: Carrier Strike Group, CSG, carrier, forward presence, extended deployments, overseas-basing, crew rotation, crew swap, Optimized-Fleet Response Plan

### ITALY, THE EUROPEAN UNION, AND MEDITERRANEAN MIGRANTS: OPPORTUNITY FROM CRISIS?

**Matthew Fillmore–Lieutenant, United States Navy**  
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Since 2013, civil and interstate wars have roiled North Africa and the Middle East. These conflicts, along with poverty in both regions, have led to the largest migration to Europe since the end of World War II. This thesis considers the effects of mass migration on Italy and the European Union (EU). It examines Italian and EU
military responses to the migrant crisis, as well as possible means to dedicate greater resources to aid in security endeavors. This thesis also explores the impacts that the migrant crisis has had on the Italian economic and political life. It analyzes the Italian immigration system, along with how it interfaces with the EU’s immigration system, and explores ways in which both can promote more effective migrant and refugee economic integration. This thesis concludes that current EU and Italian efforts to address the Mediterranean migrant crisis are falling short of effectively managing the migrant and refugee influx. This thesis recommends NATO involvement concerning the security and flow management aspects of this challenge, and also argues that better economic integration of the migrants and refugees may hold the key to economic renewal in various EU member states, notably Italy. Full Text

Keywords: European migrant crisis, Italy, European Union, economic migrants, refugees, operation Sophia, Mare Nostrum, Mediterranean Sea

MINDFULNESS TRAINING: WORTHWHILE AS A MEANS TO ENHANCE FIRST-RESPONDER CRISIS DECISION MAKING?
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This thesis identified a need for improvement in first-responder crisis decision making. The primary research question was, would mindfulness training be worthwhile as a means to enhance first-responder crisis decision making? Qualitative research methods (primarily a thematic analysis of the literature) were utilized to explore the areas of first responder operations, crisis decision making, and mindfulness training to identify key categories in the data relevant to the primary and sub-research questions. Evidence uncovered during this research supports a conclusion that mindfulness training may be one way in which first responders can improve their capacity to make effective decisions during a crisis. It was demonstrated that these improvements to crisis decision making resulting from mindfulness training could very well culminate in significant improvement of outcomes during future emergencies and disasters at which mindful first responders are present. Despite identifying significant implementation challenges, systematic analysis of the literature revealed sufficient evidence to warrant serious consideration for further study and application of this theory in the field, including potential implementation of discipline-specific and culturally relevant mindfulness training systems within first responder organizations. Full Text

Keywords: mindful, mindfulness, meditation, decision making, crisis decision making, situational awareness, sensemaking, attentional control, attentional training, cognitive bias, self-awareness, meta-awareness, neuroplasticity, neuroscience, organic technology, working memory capacity, first responder, focus, stress management, non-reactivity, mindfulness-based resilience training, mindfulness-based stress reduction, mindfulness-based attention training, mindfulness-based mind fitness training, strength training for attention and resilience in ROTC cadets
Many areas of the cyber domain of American citizens are under attack: critical infrastructure, electrical grids, banks, businesses, government, and personally identifiable information (identity theft, medical records, child exploitation, etc.). Although the focus of recent cybersecurity legislation has provided additional authorities to federal agencies, a key concern for state, local, tribal and territorial (SLTT) government entities is this: What is the best way to protect computer networks at the state and local level? State and local governments have the responsibility to protect dams, freeway systems, power and water plants, emergency communications, personal identifiable information, health care records, educational institutions, and banking systems. The array of responsibilities and the cybersecurity threat landscape make state- and local-level computer networks fertile ground for the cyber adversary. This research focuses on the threat to SLTT computer networks and how to leverage information-sharing initiatives, cybersecurity policies and state and local fusion centers to prevent, mitigate, and deter cyber threats targeted at SLTT computer networks. Full Text

Keywords: cybersecurity, cyber security, DHS, fusion, fusion center, information sharing, intelligence, NCCIC, NSA, NTOC, team, cyber threat, cyber mission

The advent of cyberspace has created a new, unregulated dimension of warfare, which the North Atlantic Treaty Organization (NATO) has striven to manage. This thesis raises the following question: To what extent is NATO cybernetically, politically, militarily, and economically prepared to respond to a major act of cyberwar against one or more of its members? The thesis evaluates NATO’s level of preparedness across seven areas: cyber strategy, cyber cooperation, decision making, political will, crisis management, defense spending, and defense policy prioritization. The thesis concludes that NATO is moderately prepared to respond effectively to a major act of cyberwar launched against one or more of the allies. NATO’s implementation of its cyber policies and cooperative partnerships probably make it cybernetically prepared to address major acts of cyberwar; however, challenges with decision making, public support, crisis management, defense spending, and defense policies could make NATO less than optimally effective in responding with force to acts of cyber aggression that rise to the level of a conventional armed attack. The thesis recommends that NATO enhance its efforts in cyber strategy development, cyber cooperation, decisional delegation, strategic messaging, and defense spending to address challenges resulting from the evolving complexity and heterogeneity of cyber incidents. Full Text

Keywords: North Atlantic Treaty Organization, NATO, Washington Treaty, North Atlantic Treaty, Article 5, collective defense, consensus, cyber, cyber attack, cyberwar, cybersecurity, hybrid, cyber readiness, conventional armed attack, kinetic attack, Wales Summit, Warsaw Summit
Since the formation of the Islamic State of Iraq and the Levant (ISIL) and its so-called Caliphate, the terrorist organization has demonstrated its capability and willingness to project force beyond its immediate area of operations in the Middle East, extending to Western countries. Rather than solely dispatching trained foreign fighters, in the United States, ISIL’s strategy has involved homegrown violent extremists (HVEs) with a limited range of connectivity to the group. This thesis explores the threat posed by a subgroup of HVEs identified as redirected radicals, aspiring foreign fighters who, when prevented by counterterrorism actions from traveling overseas, decided instead to alter their targeting trajectory and commit violence in their home countries.

Through an extensive comparative case study analysis of recent ISIL-related violent incidents and plots in the United States, Canada, and Australia, common trends identified the prevalence of redirected radicals. This thesis found that policy responses to this phenomenon differed significantly across these three nations, using an array of legal authorities including undercover investigations, passport revocation, and preventative detention with varying degrees of effectiveness. Ultimately, this thesis determined that investigations involving potential redirected radicals offer unique opportunities for counterterrorism authorities to effectively decrease the likelihood of a domestic attack. Full Text

Keywords: Islamic State of Iraq and the Levant, ISIS, ISIL, Al-Qaeda, Iraq, Syria, homegrown violent extremist(s), redirected radicals, aspiring foreign fighters, United States, Australia, Canada, terrorism, counterterrorism

As China continues its comprehensive military modernization program, the 2015 Annual Report to Congress on Military and Security Developments Involving the PRC, published by the Office of the Secretary of Defense, has expressed concerns that China’s military modernization has the potential to reduce core U.S. military technological advantages. In order to put this concern into a broader context, this thesis asks: how does China’s navy compare to navies of existing powers? With China’s naval expansion in mind, this thesis compares the People’s Liberation Army (Navy) (PLAN) to other modern naval powers to determine if China’s force structure resembles a regional navy that is built primarily for power projection, sea denial, or sea line of communications (SLOC) defense. Comparative case studies are used to contextualize China’s naval modernization by identifying characteristics of archetypal navies built for sea denial, power projection, and SLOC defense. The Royal Swedish Navy is analyzed as a navy that specializes in sea denial, the French Navy is analyzed as a navy that specializes in power projection, and the Japanese Maritime Self Defense Force is analyzed as a navy that specializes in SLOC defense. This thesis finds that China is primarily pursuing a maritime strategy centered on SLOC defense, but is also capable of employing a sea denial strategy in its near seas. Full Text

Keywords: Chinese naval modernization, People’s Liberation Army (Navy), sea denial, power projection, SLOC defense, maritime strategy, Royal Swedish Navy, French Navy, Japanese Maritime Self-Defense Force
Are Vietnam and the Philippines trending more toward conflict or cooperation with China over disputed territories and resource claims in the South China Sea? This thesis investigates realist and liberal international relations theories applied to three states involved in South China Sea disputes. It reviews the history of South China Sea disputes between China, Vietnam, and the Philippines since 1988 and reviews the states' growing economic interconnectedness to determine whether they have trended toward armed conflict or if economic interdependence has led the states toward cooperation to manage their overlapping claims. This thesis concludes that China, Vietnam, and the Philippines have trended neither toward armed conflict nor cooperation to manage their South China Sea territory and resource disputes. Despite increasing tensions over the competition for territory and resources, the states have managed their disputes peacefully and have avoided armed conflict since 1988. Furthermore, despite increasing asymmetric economic interdependence between the smaller states and China correlating to the period of relative peace in the South China Sea, the states have rarely cooperated with one another to manage their disputes. Asymmetric economic interdependence between the smaller states and China, however, has contributed to the relative peace in the South China Sea. Full Text

Keywords: South China Sea, China, Vietnam, the Philippines, economic interdependence, territory and resource disputes

The United States Intelligence Community is tasked with providing the intelligence necessary to protect the homeland and U.S. interests abroad. Technology acts as a force multiplier for intelligence analysts, but that advantage also comes with substantial risk. The risk lies in our reliance on technology and processes; the tradecraft of intelligence analysis and critical thinking appears to be losing relevance. During the intelligence analysis process, weak signals are often identified and then dismissed. In hindsight, these weak signals are realized as missed opportunities that could have allowed the Intelligence Community to mitigate the threat. This research examines cognitive bias from multiple perspectives and affirms that cognitive bias does influence intelligence analysis, and intelligence analysts need to understand the effects of cognitive bias. This research presents a recent case study and determines the negative influences those biases on decisions that were ultimately made in error. As a result of this research and analysis, several mitigation strategies are identified and included as recommendations to the Intelligence Community. These strategies present the United States with an opportunity to decrease the influence of cognitive bias on intelligence analysis, leading to a more effective and resilient Intelligence Community. Full Text

Keywords: cognitive bias, intelligence cycle, intelligence analysis, Intelligence Community, decision making, intuitive thinking, analytical thinking, Benghazi
SAUDI ARABIA’S NUCLEAR POSTURE: IS HEDGING THE FUTURE?
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The Joint Comprehensive Plan of Action (JCPOA) leaves Iran with residual capabilities that position it for the rapid development of nuclear weapons should it abandon the deal. This thesis examines how the JCPOA affects Saudi Arabia and what actions the Saudis are likely to take. The Saudi premise of “whatever they have, we’ll have” in regard to Iran leans toward a Saudi Arabian nuclear hedging strategy, but is it feasible? This thesis proposes a model that explores the interaction of threat, domestic factors, and current international nonproliferation regimes and how they drive a nation toward nuclear hedging. The model is applied to the cases of Pakistan, a nuclear proliferation state, and Japan, the archetypical hedging state, and later to Saudi Arabia. This comparative case study finds that despite its national will, technological factors—such as an impoverished scientific community—make Saudi Arabia’s nuclear hedging untenable at this time. In addition to technical capability, the presence or absence of strong alliances factor into the national decision to hedge or proliferate. This thesis concludes by offering insight into when the United States should reexamine the Saudi Arabian case and what it should consider if the Saudis consider nuclear optionality. Full Text

Keywords: Saudi Arabia, Nuclear, Hedging, Pakistan, Japan

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This thesis focuses on examining the enemy during the 2013–2014 Ukraine Crisis and providing context to the headlines regarding the politics of the conflict. It examines both the external enemy and the internal enemy, as characterized by the Russian press. The external enemy chapter focuses on NATO and five key propagandized myths that were popularized around the time of the Ukraine Crisis. The internal enemy chapter focuses on gender, examining the roles masculinity, femininity, and sexual orientation has in politics. Examining the propaganda helps to dissect the tactics used by the Russian government and media. The success of those tactics could have a direct effect on whether they are recycled in another conflict with another country, such as Moldova, Romania, or Poland, in the future. This thesis conducted a comparative analysis of the propaganda in the Ukraine Crisis concerning gender, WWI/WWII, Russian culture, and the enemy against historical Soviet and post-Soviet propaganda. Full Text

Keywords: Russia, Ukraine, feminism, masculinity, LGBT, NATO, myth, propaganda
The roles and missions of militaries around the world are expanding into new areas. This inevitably affects the existing concepts of civil–military relations and forces us to rethink those concepts in light of new roles and missions for the military. These issues are pertinent particularly to recently democratized countries such as Turkey. Since its path to democratization in 1946, Turkey has endeavored to develop democratic civil–military relations. Starting in the 1980s, Turkey’s civil–military relations have been particularly influenced by an internal security threat—the Partiya Karkerên Kurdistan (PKK). The Turkish governments have utilized a concerted action of the police and gendarmerie forces, affiliated under the Ministry of the Interior, and the Turkish Armed Forces (TAF) against this terrorist organization, with TAF as the leading actor. This thesis assesses the effects of the non-traditional roles and missions assigned to TAF within this context on democratic civilian control. Even though there have been minor changes at the institutional level, TAF’s intense involvement in the fight against the PKK has created a cultural shift from confrontation to cooperation between civilians and soldiers, and thus has increased the level of cooperation. This harmony has provided the actors with an opportunity to lay firm foundations for democratic civilian control without provoking TAF, and increased military effectiveness without creating a sense of threat over civilians still being haunted by memories of past coups. 

Keywords: civil-military relations, democratic civilian control, military effectiveness, Turkey, PKK, counter-terrorism

The purpose of this thesis is to ask if microfinance institutions (MFIs) facilitate poverty reduction in Bangladesh. The research begins with an overview of the historical, institutional, and political underpinnings of poverty in Bangladesh and then surveys quantitative findings to determine the extent to which the rural poor’s income can be augmented. Resources furnishing this analysis include panel data drawn from MFI borrowers in randomly selected villages that have branches serviced by Grameen Bank, Association for Social Advancement (ASA), and Bangladesh Rural Advancement Committee (BRAC). In addition, by addressing development indicators, microcredit’s non-economic outcomes—or spillover effects—are also measured, including literacy and infant mortality. In order to address MFIs’ more difficult-to-measure spillover effects, this thesis also treats the notions of civil society and women’s empowerment as relevant areas that pertain to poverty mitigation.

Keywords: microcredit, microfinance, poverty reduction, Bangladesh, property rights, women’s empowerment, social trust, rural poverty
SYRIAN REFUGEES: ARE THEY A NON-TRADITIONAL THREAT TO WATER SUPPLIES IN LEBANON AND JORDAN?

This paper has been recognized as outstanding by its department.
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Second Reader: Naazneen Barma, Department of National Security Affairs

Water scarcity is a critical problem facing the Middle East, more so than any other region of the world. Countries in the area have devoted vast resources to coping with the decreasing availability of water. Methods from cloud seeding to underground pipelines of desalinated water from the sea are prevalent in government discussions on the issue. These projects have had marginal impacts due to the massive humanitarian crisis caused by the Syrian civil war. With Syrians migrating to other Middle Eastern countries by the millions, the water-stressed states of the region cannot cope with the additional demand on their fragile and failing hydrological systems. This thesis examines Lebanon and Jordan as comparative case studies to explore the effects of Syrian refugees on the water supplies of each country as a non-traditional security threat. Political stability is the ultimate goal of each state; however, the effects of millions of refugees on available water has a significant impact on civil society and the perceptions of the host populations, which may undermine the desired goal of stability for each regime. Full Text

Keywords: water, refugee, non-traditional, Jordan, Lebanon, infrastructure, state capacity, Syrian refugees

DEVELOPING A SHARED SERVICE UNMANNED AERIAL VEHICLE CAPABILITY FOR REGIONAL EMERGENCY SERVICES

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At the scenes of emergencies across the nation, unmanned aerial vehicles (UAVs) have proven their worth to rescue crews; however, this expensive asset is not necessarily a tool that every emergency service would use routinely. This research explored three shared service models, determined their best attributes, and then applied those characteristics to the development of a regional UAV asset that would avoid duplication of resources. The study addressed relevant issues including assumption of risk and liability, public privacy concerns, and federal legislation. Findings led to the following recommendations in the creation of a regional UAV asset: 1) conduct a response evaluation to support a shared service UAV; 2) organize the asset under local government nonprofit oversight; 3) take advantage of grant funding for initial asset purchase; 4) define sustainable funding for maintenance and repair; 5) investigate further revenue generation, housing at least one asset within a large organization; 6) research applicable state law for managing risk; 7) develop privacy and organizational policy consistent with community standards; and 8) define the roles and responsibilities of the organization and the administration. Full Text

Keywords: unmanned aerial vehicles, regional shared services, emergency service UAV, UAV shared service.
TB ANYWHERE IS TB EVERYWHERE: THE INTERSECTION OF U.S. IMMIGRATION ENFORCEMENT POLICY AND TB
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Tuberculosis (TB) is a significant health issue for both the general public and the officers who enforce our nation's immigration laws. Current immigration enforcement policies increase the likelihood that immigration officers will encounter people with TB. Should the United States alter its immigration enforcement policies to address more directly the threat that tuberculosis poses to public health? This thesis reviews this question through the lens of the Advisory Council on Tuberculosis's recommendation that the priority is to identify and treat all cases of active TB. This thesis provides a policy options analysis examining the status quo and three options suggested in the literature on TB: cure TB before removal, increase international cooperation in treating TB, and increase TB testing. This policy analysis identifies gaps in the Department of Homeland Security's (DHS) ability to identify and treat active TB in the aliens encountered through the immigration enforcement process. Additionally, it recommends that the DHS require that all detained aliens be screened for active TB by use of a chest X-ray. It further recommends that the DHS completely cure all aliens found to have active TB, whether detained or released from detention, prior to their removal from the United States. Full Text

Keywords: tuberculosis (TB), multidrug-resistant tuberculosis (MDR-TB), latent tuberculosis infection (LTBI), extensively drug-resistant tuberculosis (XDR-TB), immigration enforcement, U.S. Customs and Immigration, borders, detention facility, immigration policies, public health, Alternatives to Detention

TERRORISM-RELATED LOSS OF CITIZENSHIP—A POLICY REVIEW
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Since September 11, 2001, a collection of bills has been submitted to Congress proposing to amend section 349 of the Immigration and Nationality Act to provide that an individual may lose U.S. citizenship for joining a terrorist organization, or engaging in or supporting terrorism. Although several of our allies, including the United Kingdom, Australia, and France, have considered and in some instances passed similar legislation during the same period, Congress has not given these proposals serious consideration. This thesis provides a policy analysis, assessing the viability of terrorism-related loss of citizenship under U.S. law. Following a review of the history of acquisition and loss of citizenship in the United States, including key laws and precedent decisions, and a comparative analysis of legislation considered and either passed or rejected by the U.K., Australia, and France, it provides a critical review of terrorism-related loss of citizenship bills submitted to Congress since 9/11. This thesis demonstrates that viable terrorism-related loss of citizenship legislation may be possible, but that bills submitted to date have been largely symbolic, rather than serious, efforts. This thesis provides drafting recommendations to legislators but raises questions about the practical utility and necessity of such laws. Full Text

Keywords: expatriation, expatriate, renunciation, citizenship, citizen, national, naturalization, denaturalization, nationality, terrorism, terrorist, loss of citizenship, loss of nationality, United Kingdom, Australia, France, voluntariness, intent, deprivation, withdrawal, statelessness, material support, designated terrorist organization, Immigration and Nationality Act
Islamist militant organizations appear to be evolving from traditional disassociated networks, al-Qaeda’s model, into centralized regional powers with the intent of developing into national governments. This thesis presents a comparative case study of five mainstream Islamist militant organizations, the Islamic State, Jabhat Fatah al-Sham, al-Shabaab, the Afghan Taliban, and Hezbollah, to determine how close they have come to statehood and how such a change may affect U.S. homeland security. The criteria used to analyze the case studies were primarily derived from the Montevideo Convention on the Rights and Duties of States, which describes a state as an entity with a permanent population, defined borders, an ability to conduct governance, and an ability to enter into relations with other national governments. Additional criteria were used to determine the organizations’ propensity to threaten the United States in their governmental capacity. This thesis found that none of the Islamist militant organizations in the case studies currently fit all the criteria for statehood; however, none fit al-Qaeda’s disassociated model, either. Therefore, the international community should consider defining and more accurately classifying these groups as militant states. Full Text

Keywords: ISIS, IS, ISIL, Taliban, Hezbollah, al-Shabaab, governance, Montevideo, Islamic State, terrorism, statehood, insurgency, Syria, Somalia, Afghanistan, al-Qaeda, ideology, caliphate

Many public health and safety education interventions have failed because practitioners did not apply effective methods of influence to alter individuals’ actions. Identification of successful methods has been complicated by the lack of a theory to describe the factors that cause individuals to perform recommended practices. This thesis investigated the methods responsible for success in individual-level public health and safety interventions. A comparative case study was conducted on a set of interventions that encouraged seat belt use, bicycle helmet wearing, and alcohol moderation. Each intervention was analyzed using a four-model approach encompassing rational choice, reasoned behavior, and both intuitive and reflective interpretations of behavioral economics in order to detect methods that might have influenced individuals to change their actions. Comparative analysis between case analyses permitted identification of the intervention methods correlated with successful health and safety programs in general. The social forces of injunctive pressure and public commitment were found to be correlated with effective programs of influence. This thesis concludes that future public health and safety education interventions may achieve success by leveraging peer pressure and public commitments to elicit compliance with desired practices. Full Text

Keywords: public health and safety, fire and life safety education, smoke alarm, intervention, influence, rational choice, reasoned behavior, behavioral economics, heuristic, decision making, behavior, choice architecture
VENEZUELA'S CORRUPTION ON THE RISE: FOURTEEN YEARS OF CHÁVISMO
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This thesis seeks to answer two related questions regarding corruption and Chávismo. First, what factors contributed to the rise in Venezuela's Corruption Perception Index from 2000–2014? Second, what does Venezuela need to do to reverse that trend? The thesis examines Hugo Chávez's populist policies as well as two leading factors for the rise of corruption—weak governance and oil over-dependence practices—and analyzes the Resource Curse theory and Cháveznomics. Chávez's populist policies created neo-patrimonial networks, increasing the intensity of corrupt practices between specific sectors of citizens and political elites. Cháveznomics policies also created a mismanagement of windfall oil rents, establishing a Rentier State for Venezuela. The Rentier State established corrupt patronage networks with state industries that remained intact under the high oil prices during 2000–2014. The thesis also conducts theoretical analysis of anti-corruption methods while considering Venezuelan societal elements of culture, political will, and international integration. State-center anti-corruption strategies prove to be an appropriate method for Venezuela's societal elements and unique corruption environment. The proposed state-center strategies incorporate a three-prong anti-corruption approach, including political, economic, and social accountability reforms with market-friendly social democratic policies that build political will and civic engagement. Full Text

Keywords: Venezuela, Mexico, Brazil, Hugo Chávez, corruption, Resource Curse, oil, populism, anti-corruption, state-center anti-corruption

RESCUING TOMORROW TODAY: FIXING TRAINING AND DEVELOPMENT FOR DHS LEADERS
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Leadership is an essential quality that all homeland security professionals should possess. Unfortunately, the nature, scope, importance, and complexity of protecting the United States has overshadowed the fact that Department of Homeland Security (DHS) employees are not receiving the proper leadership training. Furthermore, lack of adequate training tools within the department is making it increasingly difficult to deliver the limited amount of available leadership training education. Personnel surveys reveal that the quality of leadership within the department is not getting better, and in some cases, is perceived as worsening. As the first generation of homeland security leaders and managers depart the organization, DHS has a responsibility to its future generation of employees to identify leadership training and education deficiencies and provide individuals with the proper leadership tools for individual and departmental success. This thesis proposes that senior DHS leaders admit to the leadership training deficiencies, create programs to fill leadership training gaps in an integrated manner throughout the organization, develop accountability measures, and utilize portions of effective training and development programs from Department of Defense and civilian corporations alike. Full Text

Keywords: homeland security, Department of Defense, leadership, management, training, personnel development, mentorship, e-learning, blended learning solutions, Hurricane Katrina
Since the declaration of the Islamic State (IS) in 2014, men and women have been recruited to join the Caliphate in numbers surpassing those recruited by al Qaida. This variance in recruitment volume is likely attributable to the online propaganda campaign, Brand Caliphate. This thesis looks at the recruitment of women and asks if Brand Caliphate specifically targets females with its messaging, and if so, is the messaging effective? Based on a textual analysis of Brand Caliphate’s propaganda, it appears IS tried to deliver messaging targeted toward females. However, six case studies of radicalized females suggests the recruitment of these women does not appear to be directly attributable to the targeted messaging. There is, however, evidence that most of the female recruits studied linked to online radicalization and Brand Caliphate’s broader messaging. All of the women studied initially looked online for information regarding IS. This initial outreach served to identify them as targets for radicalization by IS recruiters, who continued to persuade the females through direct online communication. Ultimately, a sense of belonging to a community, even if it exists online, served as a more powerful draw to potential recruits than the targeted messaging of Brand Caliphate. 

Keywords: terrorism, recruitment, radicalization, propaganda, discourse analysis, textual analysis
PREVENTING STRESS DISORDERS FOR LAW ENFORCEMENT OFFICERS EXPOSED TO DISTURBING MEDIA
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The law enforcement officer’s job is both physically and mentally challenging. In an instant, officers can be thrown into extremely stressful situations. Officers and intelligence analysts continually view disturbing images during their time in the unit—some must watch child pornography, and others prison torture, as part of their daily duties. This thesis explores how law enforcement departments can prevent secondary traumatic stress disorder (STSD) among officers. Although limited in part by the police culture, the research examined several currently utilized programs that teach coping mechanisms, including SHIFT, peer support officer programs, and critical incident stress management. The research also examined approaches being utilized by the military to treat returning soldiers suffering from post-traumatic stress disorder (PTSD), including group therapy, cognitive behavioral therapy, and service dogs. Further research should be conducted to discover law enforcement programs that proactively treat the mental health and wellness of all their officers, not only those exposed to disturbing media. Full Text

Keywords: post-traumatic stress disorder (PTSD), secondary traumatic stress disorder (STSD), law enforcement, Psychological First Aid (PFA), Critical Incident Stress Debriefing (CISD), cognitive behavioral therapy (CBT), Internet Crimes Against Children (ICAC), Supporting Heroes In metal health Foundation Training (SHIFT), peer support officer, Police Organization Providing Peer Assistance (POPPA), child pornography, child exploitation, group therapy, counterintelligence analyst, computer forensics, forensic examiner

HACKING YOUR RIDE: IS WEB 2.0 CREATING VULNERABILITIES TO SURFACE TRANSPORTATION?
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The purpose of this thesis is to determine the threats that social media and social navigation (SMSN) pose to the surface transportation system. The research catalogs the types of threats and SMSN’s vulnerabilities, and uncovers terrorists’ malign use of social media for intelligence gathering. Academic researchers have already discovered threats in social navigation platforms such as Waze and Google Maps; Sybil and man-in-the-middle attacks allow malicious actors to create traffic congestion and alternate vehicle routing. While this has not yet caused an attributable security concern to the vehicle surface transportation system, in the hands of malicious actors, these vulnerabilities could be exploited to orchestrate an attack that devastates infrastructure and risks human lives. Full Text

Keywords: social media, social navigation, Web 2.0, surface transportation security, vehicle transportation security, Waze, Google Maps, traffic congestion, traffic management security, transportation security vulnerabilities, transportation security threats
ASSESSING RESILIENCE: HOW PLANS, STRATEGIES, AND AFTER ACTION REPORTS CAN IMPROVE OUR UNDERSTANDING OF ORGANIZATIONAL PREPAREDNESS
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Co-Advisor: Glen Woodbury, Department of National Security Affairs

Resilience has emerged as a prominent term throughout homeland security and emergency preparedness doctrine. The National Preparedness Goal, the Department of Homeland Security’s (DHS) guiding strategic document, defines success as having a secure and resilient nation. The homeland security enterprise promotes resilience, yet there is little literature on resilience at the organizational level in public safety agencies, organizations that are key to the homeland security enterprise. This thesis sought to answer two questions. First, how can existing public safety doctrine contribute to an understanding of the organizational resilience of public safety agencies? Second, how can after action reports (AARs) and their resultant learning process contribute to an understanding of adaptive capacity? To answer the research questions, this thesis applied New Zealand’s resilience management framework to public safety agency doctrine. The research found that public safety agencies are engaged in activities that contribute to understanding their organizational resilience. It also found that the New Zealand framework can provide a working construct for understanding resilience within U.S. public safety agencies. Recommendations include standardizing AARs with federal guidance and making them publicly available to further contribute to understanding organizational resilience. Full Text

Keywords: resilience, organizations, public safety agencies, resilience management framework

A SYSTEMIC ANALYSIS OF THE CHALLENGES OF POLICING SENEGAL: THE ROLE OF THE POLICE IN DEMOCRACY
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Second Reader: Jessica Piombo, Department of National Security Affairs

Little is known about the role of the police in Africa, and even less about the police in francophone African countries. Intrastate conflicts and peace-building after the Cold War tied policing to personal security, democracy, and sustainable development. Senegal has a stable democracy and police forces that were established prior to Senegalese independence in 1960, but it is still uncertain if they can become a police force that contributes to national and personal security capable of dealing with human and narcotic trafficking, transnational crimes, and international terrorism. This study investigates the challenges facing the Senegalese police forces and their impact on the Senegalese national and personal security environment. The primary police services face challenges with resources, capacity, terrorism, and transnational crime. The major finding is that the centralized structure of the Senegalese police, controlled by a semi-authoritarian president and the political elites, prevents the police from becoming a public safety institution able to address matters of personal security. This dynamic isolates the police from the Senegalese citizens and atrophies their ability to combat crime, preventing their development into a public safety institution. Full Text

Keywords: policing, democratic policing, African police, post-conflict policing, police, democratic development
This thesis examines the potential advantages for Finland and Sweden in pursuing closer cooperation with the North Atlantic Treaty Organization (NATO) and possible membership. The security policy objectives of Finland and Sweden have largely been defensive in nature: to ensure national survival and protection of sovereignty. With the exception of Finland’s opposition to the Soviet Union’s aggression in 1939–1940 and 1941–1944 to defend its national independence, both countries have remained neutral in foreign and security policies. Sweden’s geopolitical situation is advantageous in that the Baltic Sea hinders invasion and the country has positive relations with its immediate neighbors. In contrast, Finland shares a lengthy border with Russia and has a complex history of relations with Moscow. In 2009, Sweden pledged a Declaration of Solidarity that protects its neighboring Nordic states as well as European Union (EU) member states in an effort to strengthen and preserve peaceful relations and stability. The thesis concludes that the benefits of closer cooperation with the Alliance and possible membership, notably collective defense protection under Article 5 of the North Atlantic Treaty, are substantial. Russia’s recent aggressive behavior may lead Finland and Sweden to seek closer cooperation with NATO and to give greater attention to the option of membership.

Keywords: NATO, EU, Finland, Sweden, Russia, defense cooperation, collective defense, deterrence, solidarity, security, neutrality, non-alignment, membership, expansion, SFNTG, EDA, PfP, EMU, OSCE, NOR-DAC, NORDCAPS, NORDEFCO, A2/AD, CSDP, CFSP, FCMA, USSR, EDA, EEZ, DDoS, CIS, CCD-COE, C4I, ISR, EU BG, EC, SECGEN, economic interdependence, Lisbon Treaty, Article 42.7, Article 5

This is a proof-of-concept project for an online law enforcement learning organization dedicated to combating violent extremism (CVE), specifically, counter-radicalization techniques to be implemented by state, local, and tribal law enforcement agencies. Although there are many different forms of violent extremism, examples in this paper reflect those threats from Islamic violent extremism. Even so, this proposed law enforcement learning organization model could be used to facilitate countermeasures against all forms of violent extremism. The paper proposes utilizing an asynchronous online discussion format for state, local, and tribal law enforcement agencies to enter into dialogue about counter radicalization as well as to provide resources for law enforcement training cadre and command staff. This learning model concept will augment current CVE counter-radicalization strategies in the United States, allowing for greater dialogue, information, and idea sharing. Additionally, two curriculum options are presented to augment the learning organization concept. The project’s foundation is within the online asynchronous discussion and related instructional design body of research.

Keywords: combating violent extremism (CVE), counter radicalization, online asynchronous discussion, computer mediated communication, collaboration, strategic thinking, learning organizations, law enforcement partners
NORMATIVE FACTORS IN U.S. NUCLEAR POLICY
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Master of Arts in Security Studies (Strategic Studies)
Advisor: Wade Huntley, Department of National Security Affairs
Second Reader: Daniel Moran, Department of National Security Affairs

This thesis explores the relative value that norms have on U.S. nuclear policies, particularly on their constraining effect on nuclear weapon use and possession. Contemporary academic literature explores how norms constrain the use of nuclear arms, but further research is needed to determine how norms affect policies of possession. Using case studies from the Cold War, this thesis presents research indicating that norms have had inconsistent constraining effects on nuclear use and possession policies. Upon applying four leading theories on how norms affect U.S. nuclear policymaking, it becomes clear that no single theory dominated policymaker decisions throughout the Cold War. Instead, differing circumstances created vast inconsistencies as to the constraining effects that norms had on nuclear strategies. Today’s policymakers must understand the constraining role that norms have on nuclear policy, and that these norms differ in their constraining effects when nuclear policies are broadened beyond just those of nuclear use. Nuclear policies regarding the possession of nuclear weapons are also influenced by norms, but not necessarily in the same way as they are for nuclear use. Full Text

Keywords: nuclear policy, norms, logic-of-consequences, logic-of-appropriateness, tradition of non-use, military utility, cold war, nuclear taboo

BEACHES OF THE FUTURE: ANALYZING TERRITORIAL DISPUTES IN SOUTH AMERICA
Vanessa Rigoroso–Lieutenant Commander, United States Navy
Master of Arts in Security Studies (Western Hemisphere)
Advisor: Diego Esparza, Department of National Security Affairs
Second Reader: Rodrigo Nieto-Gomez, Department of National Security Affairs

Territorial and border disputes have long been a foundation for conflicts in the international arena, but in Latin America, gaps in literature still remain. Analyzing cases in this region can equip the international community to understand sources of conflict, formulate improved foreign policy with U.S. allied partners, and achieve steps toward peace and stability. The general application theory is still being sought: What factors cause dispute resolutions in Latin America? Chile has been able to resolve disputes with other countries with shared borders but has yet to yield to Bolivia’s aspirations for sovereign access to the sea. This thesis examines three case studies of territorial or boundary disputes utilizing Chile as the nexus: the Beagle Channel dispute between Chile and Argentina, the Chile-Peru Maritime Boundary Dispute, and Bolivia’s pursuit of sovereign access to the Pacific Ocean. Through analysis of dyadic attempts at resolution via an international relations lens, this research finds that nations in dispute are likely to terminate conflict with the presence of an international resolution body, a desired mutual peace, and leaders that promote favorable discourse toward settlement. Full Text

Keywords: Latin America, South America, Chile, Bolivia, Argentina, Peru, maritime, border, territorial dispute, international relations, realism, liberalism, constructivism
U.S. AND NATO NAVAL ENGAGEMENT WITH RUSSIA IN THE BLACK SEA: HISTORICAL PATTERNS AND CURRENT PROSPECTS

Alex Schneider–Lieutenant, United States Navy
Master of Arts in Security Studies (Europe and Eurasia)
Advisor: David Yost, Department of National Security Affairs
Second Reader: Mikhail Tsypkin, Department of National Security Affairs

Since Russia's annexation of Crimea in March 2014, the United States and its NATO Allies have increased their military presence and exercises in the Black Sea focused on deterring Russian aggression or coercion. Russia has also increased the number and magnitude of its exercises in the region. In some interactions in this region, Russia has acted in an unprofessional manner and has engaged in provocative conduct against U.S. and NATO military units to an extent that has placed future U.S.–Russian and NATO–Russian relations into question. This thesis analyzes how Russia’s ambitious military maneuvers and the subsequent U.S.–NATO responses have resulted in a security dilemma in the Black Sea region. Russia’s Black Sea Fleet buildup and modernization program will generate new economic and security concerns that the United States and NATO will confront as Russia’s military capabilities expand in the region. Despite the NATO Allies’ attempts to establish cooperation and open dialogue with Russia, Moscow seems unwilling to reciprocate. Until Russia engages in cooperation and open dialogue with the NATO Allies, the security dilemma will persist, and it may result in a possible flashpoint in the Black Sea region.

Keywords: North Atlantic Treaty Organization, European Union, Russia, military exercises and interactions, Black Sea Fleet, Black Sea

SOVEREIGN CITIZEN MOVEMENT: AN EMPIRICAL STUDY ON THE RISE IN ACTIVITY, EXPLANATIONS OF GROWTH, AND POLICY PRESCRIPTIONS

Brian Slater–Captain, United States Air Force
Master of Arts in Security Studies (Homeland Security and Defense)
Advisor: Carolyn Halladay, Center for Civil-Military Relations
Second Reader: Tristan Mabry, Department of National Security Affairs

The United States faces a domestic threat that is largely ignored by counterterrorism practitioners and policy: the Sovereign Citizens Movement. The adherents of this antigovernment movement have committed violent, even terroristic, acts and employed paper terrorism tactics. The group clogs courts and harasses government officials, but a paucity of hard data on the Sovereigns has stymied any concerted or unified response. Law enforcement officials have yet to determine how many Sovereigns are active in the United States, where they are concentrated, or whether the movement is gaining adherents. This thesis addresses the dearth of information on the Sovereign Citizens Movement. It relies on both quantitative and qualitative research, providing a detailed analysis of 548 court cases. The assessment of the group’s targets, related court vulnerabilities, and relevant statewide statistics can be harnessed into quality policy decisions. This work proves the increasing trend in Sovereign Citizen activities, exposes the gaps in the present literature and domestic terrorism policy, and provides recommendations for prescriptive policy changes across the spectrum of agencies responsible for countering domestic terrorist threats.

Keywords: sovereign citizen, social movements, political polarization, rising activity, paper terrorism, quantitative study, qualitative study, domestic terrorism
GPS: PUBLIC UTILITY OR SOFTWARE PLATFORM?
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Master of Arts in Security Studies (Homeland Security and Defense)
Advisor: Rodrigo Nieto-Gomez, Department of National Security Affairs
Second Reader: Lauren Wollman, Center for Homeland Defense and Security

The Global Positioning System (GPS), a satellite navigation system, is critical to the United States' national and homeland security. The United States has made GPS resilient to interruption by flying more satellites than required, dispersing its infrastructure, and increasing its signals. Despite these efforts, there is concern that the United States may not be able to overcome disturbances in GPS's operations. Limitations in GPS data and the policy literature prevent the full quantification of exactly how vulnerable GPS is to service interruption. This thesis used constant comparison analysis to examine how a shift in conceptual lens from viewing GPS as a public utility to viewing it as a software platform has changed our understanding of its criticality, resilience, and vulnerability. This methodology overcomes research limitations by using GPS system design, operations, and policies as its data sources. The public utility lens reveals that the United States has increased GPS resilience through system design and redundancies. The software platform lens shows that the United States further increased GPS resilience by adding navigation signals. Together, the lenses indicate that manufacturers, application developers, and users constrain GPS's increasing resilience. Additional data, models, and research are required to inform policies and decisions to further improve GPS's resilience. Full Text

Keywords: Global Positioning System (GPS), Global Navigation Satellite Systems (GNSS), Positioning Navigation and Timing (PNT), global utility, public utility, software platform, GPS resilience, GPS augmentation system, disruption of GPS

NATIONAL SECURITY AND INSTITUTIONAL PATHOLOGIES: A PATH DEPENDENT ANALYSIS OF U.S. INTERVENTIONS IN IRAN, GUATEMALA, CUBA, AND IRAQ
Matthew Thompson–Major, United States Army
Master of Arts in Security Studies (Western Hemisphere)
Advisor: Diego Esparza, Department of National Security Affairs
Co-Advisor: Thomas Bruneau, Department of National Security Affairs

Covert U.S. interventions in Iran (1953), Guatemala (1954), and Cuba (1961) represent one path-dependent event sequence whereby institutions adopted pathological characteristics that carried the U.S. national security apparatus into the failed invasion of Cuba at the Bay of Pigs. Likewise, the overt U.S. intervention in Iraq (2003) represents a similar institutionally driven event sequence that carried the United States to war with Iraq under dubious justification. Through analyzing systemic factors that influenced policy formulation prior to and during the Eisenhower and Bush administrations, I argue that sufficient evidence exists to suggest that institutions developed based largely on ideologically driven threat perceptions of communism and terrorism negatively influenced policy formulation and contributed to undesirable outcomes in both event chains. Agency-driven shifts in national security institutions to achieve ideologically based objectives during each administration drove U.S. foreign policy outside of previously institutionalized procedures by seizing upon opportunity structures created during periods of national fear stemming from salient political environments plagued with excessive communist and terrorist threat perceptions and rhetoric. Understanding how institutional path-dependent factors converged in each of these cases may shed light on how to prevent such foreign policy missteps in the future. Full Text

Keywords: communism, Cuba 1961, institutions, Iran 1953, Iraq 2003, Guatemala 1954, economic nationalism, Latin American studies, national security affairs, path dependence, national security strategy, terrorism, Western Hemisphere
YOUR CRIMINAL FICO SCORE

Michelle Tonelli—Attorney-Advisor, Office of General Counsel, Department of Homeland Security
Master of Arts in Security Studies (Homeland Security and Defense)
Advisor: Rodrigo Nieto-Gomez, Department of National Security Affairs
Co-Advisor: John Rollins, Center for Homeland Defense and Security

One of the more contentious uses of big data analytics in homeland security is predictive policing, which harnesses big data to allocate police resources, decrease crime, and increase public safety. While predictive analytics has long been in use to forecast human behavior, the framework has not proved to be a flawless undertaking. In an effort to improve outcomes of predictive policing, this thesis assesses two high-profile programs—the nation’s most popular credit-scoring system and a federal flight-risk program—to determine the greatest pitfalls inherent to programs using predictive analytics. The programs are assessed using what is commonly known in big data as the four Vs—volume, velocity, variety, veracity—but with an added component of the author’s creation: verification. Through this framework, it became apparent that the hardest Vs for any predictive policing program to fulfill are veracity and verification. As the field of predictive policing expands, programs face the challenge of ensuring that data used for analysis is accurate and remains accurate, and that the metrics used to verify risk assessments are sound. Full Text

Keywords: predictive policing, predictive analytics, FICO, Secure Flight, Five Vs, risk assessments, big data

TACTICAL FIREFIGHTER TEAMS: PIVOTING TOWARD THE FIRE SERVICE’S EVOLVING HOMELAND SECURITY MISSION

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Master of Arts in Security Studies (Homeland Security and Defense)
Advisor: Lauren Wollman, Center for Homeland Defense and Security
Co-Advisor: Rodrigo Nieto-Gomez, Department of National Security Affairs

Firefighters and police officers are increasingly called upon to work in each other’s spaces but are neither trained nor equipped to do so; consequently, they are limited in their ability to enter one another’s high-threat areas. Fire complicates the police’s ability to respond to hostile incidents by creating visibility issues and thermal injuries as the burning building deteriorates. Firefighters are equally ill-prepared to enter an environment in which fire and firearms are present while victims are trapped within the hazard zone. As a result, first responders consistently lack the capability to accomplish combined missions when multiple threats are present. This thesis investigates the best way to fill this operational gap, first by examining the merits and limitations of several models related to the role of firefighters during hostile events. It then documents and analyzes the field tests of a fourth model piloted by the Houston Fire Department that would deploy cross-trained firefighting strike teams into hot zones with both incendiary and ballistic hazards. Full Text

Keywords: tactical firefighter teams, fire as a weapon, fire service, Mumbai attack, active shooter, Houston Fire Department, pilot study, hostile event
On the one hand, it is readily assumed that the government must keep some information secret for the security of the state and the safety of people; on the other, as the ultimate sovereign, the people require access to information through government transparency. One area where this tension between secrecy and transparency is highly pertinent is continuity of operations plans. Continuity plans contain highly sensitive information that, if not protected from disclosure under open records laws, may reveal vulnerabilities for potential exploitation by malicious actors. How can confidentiality and disclosure needs for government information in continuity of operations plans be reconciled? Using a hybrid method that includes historical, legal, political, and disciplinary research and contextual analysis, this thesis investigates the tension between the meaning and goals of secrecy and transparency in the political context, analyzes exposures in the current legal and practical frameworks, and considers approaches for balancing the legitimate interests of secrecy and transparency in achieving security and accountability. Based on analysis and application, this thesis proposes a practical solution in the form of a uniform protective security approach for confidentiality and disclosure through a modified understanding of risk and a specific responsive risk-balancing model.

Keywords: continuity of operations plans (COOP), business continuity, secrecy, confidentiality, transparency, mediated transparency, accountability, open government, open records, freedom of information, Freedom of Information Act (FOIA), protective security, risk management, Presidential Policy Directive 21 (PPD-21), National Security Presidential Directive 51 (NSPD-51)

Drought, melting Arctic ice, ocean acidification, and sea-level rise are all subsectors of climate change. I have identified these as slow-onset disasters. The purpose of this thesis is to determine whether slow-onset disasters are adequately addressed in the homeland security discipline. Risk assessments were performed to determine the level of risk these types of disasters pose to homeland security. The critical infrastructure life-line sectors—Energy, Communications, Transportation Systems, and Water and Wastewater Systems—were chosen for these assessments because of their identified criticality to national security. The assessments reveal that slow-onset disasters pose varying degrees of risk to these sectors. Policy analyses were conducted on the components of the nation’s coordinated approach to homeland security. These reveal that the homeland security discipline does not adequately address slow-onset disasters because of internal contradictions. The contradictions are the result of two of the frameworks used in the development of homeland security policies—continuity heuristic and probabilistic thinking. These frameworks lead disaster-consequence planners to consider the probability and magnitude of a disaster based on a retro-focused approach. Based upon my findings, I recommend that possibilistic reasoning (anticipating the worst that could happen), coupled with a
future-focused approach, be used to develop homeland security policies that will fully address the emerging threats posed by slow-onset disasters. Full Text

Keywords: slow-onset disaster, climate change, critical infrastructure sectors, continuity heuristic, frameworks, homeland security, emergency management, disaster preparedness, disaster response, disaster recovery, hazard mitigation, protection mission area, sea level rise, ocean acidification, melting arctic ice, drought
This report conducts a cost-benefit analysis of the policy implemented to scrutinize non-DOD conference attendance at the Naval Postgraduate School. Using historical conference travel data from FY12 to FY15, this analysis assesses the strengths and challenges associated with the current policy compared with the conventional process prior to the travel restrictions. The findings of the cost-benefit analysis identify the resource and labor expenses resulting from the increase in processing requirements. This report recommends an abridged process to improve the efficiency of processing non-DOD conference requests. Full Text

Keywords: travel, conference travel, non-DOD conference, cost benefit analysis, DTS, JTR, activity-based accounting
MASTER OF SCIENCE

Applied Mathematics
Applied Physics
Combat Systems Technology
Computer Science
Cyber Systems and Operations
Defense Analysis
Electrical Engineering
Engineering Acoustics
Information Technology Management
Mechanical Engineering
Meteorology and Physical Oceanography
Modeling, Virtual Environments, and Simulation
Operations Research
Physical Oceanography
Program Management
Systems Engineering
MASTER OF SCIENCE
IN
APPLIED MATHEMATICS

AERIAL LOGISTICS MANAGEMENT FOR CARRIER ONBOARD DELIVERY
Samuel Chen–Lieutenant, United States Navy
Master of Science in Operations Research and Master of Science in Applied Mathematics
Advisor: Kyle Lin, Department of Operations Research
Co-Advisor: Wei Kang, Department of Applied Mathematics
Second Reader: Michael Atkinson, Department of Operations Research

Carrier onboard delivery (COD) is the use of aircraft to transport people and cargo from a forward logistics site (FLS) to a carrier strike group (CSG). The goal of this thesis is to study how the real-time cargo tracking capability can reduce the delay of high-priority cargo while increasing that of low-priority cargo. To do so, we analyze data from COD operations between 2010 and 2015 to develop a simulation model, and use those data to infer model parameters. Our simulation results indicate that, with two C-2A aircraft currently used by the Navy, real-time cargo tracking can reduce the delay of high-priority cargo by more than 50%, while increasing that of low-priority cargo by about 25%. The Navy plans to replace C-2A with a variant of V-22 Osprey for COD operations in the near future, and is conducting cargo space studies to facilitate this transition. By testing a few different model parameters based on studies available for V-22, our simulation results indicate a similar observation of delay tradeoff between high-priority cargo and low-priority cargo, although the tradeoff is less pronounced, mainly because three V-22 will be stationed at the FLS. Full Text

Keywords: carrier onboard delivery (COD), C-2A Greyhound, CMV-22B Osprey, carrier strike group (CSG), forward logistics site (FLS), sea base, discrete event simulation (DES), stochastic

NONQUADRATIC VARIATION OF THE BLUM-BLUM-SHUB PSEUDORANDOM NUMBER GENERATOR
Thomas Knuth–Second Lieutenant, United States Army
Master of Science in Applied Mathematics
Second Reader: Thor Martinsen, Department of Applied Mathematics

Cryptography is essential for secure online communications. Many different types of ciphers are implemented in modern-day cryptography, but they all have one common factor. All ciphers require a source of randomness, which makes them unpredictable. One such source of this randomness is a random number generator. This thesis focuses on Pseudorandom Number Generators (PRNG), specifically, a PRNG called Blum-Blum-Shub (BBS). In this thesis, we make two modifications to BBS, and test our modified generators for randomness using the National Institute of Standards and Technology (NIST) tests. The original BBS is a quadratic generator that generates bits based on the output of squaring terms in a sequence. The first modification replaces the quadratic generator with a cubic generator. The second modification generates bits faster by using more bits per iteration. Data collected in this thesis suggests that the cubic modification performs just as well as the original generator. In addition, data from this thesis suggests that taking more bits per iteration can speed up this process while retaining randomness. In addition, we propose a new cryptosystem based upon the modification of the BBS PRNG introduced in this thesis. Full Text

Keywords: Pseudorandom Number Generator, Blum-Blum-Shub
Search and detection theory encapsulates a broad range of scenarios, from searching for lost car keys in a parking lot to prosecuting a submarine in the South China Sea. This research draws on oceanographic properties to develop a search radii for two surface ships, searching for a submarine at various speeds, utilizing one of three search patterns: in-line spiral search, in-line ladder search, and a multi-path ladder search. Analysis reveals which parameters yield the highest probability of detection in a 14nm by 14nm search area based on the oceanographic properties at 21N 119E. Full Text

Keywords: search theory, undersea warfare, South China Sea, anti-submarine warfare

MULTIPRIME BLUM-BLUM-SHUB PSEUDORANDOM NUMBER GENERATOR
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Advisor: Pantelimon Stanica, Department of Applied Mathematics
Co-Advisor: Thor Martinsen, Department of Applied Mathematics

Blum-Blum-Shub (BBS) is a (probabilistically) secure pseudorandom bit/number generator which outputs a sequence by repeatedly reducing squares modulo the product of two Blum-primes. Our goal for this thesis is to modify the algorithm by using a modulus which is the product of three Blum-primes. We evaluate the effect of this modification using the suite of tests from National Institute of Standards and Technology (NIST). Previous research has evaluated the limit on the number of least important bits that can be extracted per iteration of the BBS algorithm while still maintaining the pseudorandom properties. In this paper, we go beyond the proposed limit and compare the modified BBS with the original BBS using the NIST tests. This paper also discusses the cryptosystem based on the modified BBS as well as the original BBS. We use three metrics for the comparison of performance: the type of tests, the overall performance of sequences against NIST tests, and the time to generate sequences. Our test data shows that both versions performed in a similar manner when subjected to NIST tests. Furthermore, bit generation is significantly faster for sequences generated by taking the last 50 bits or more, while still maintaining pseudorandom properties. Full Text

Keywords: pseudorandom number generator, pseudorandom bit generator, Blum-Blum-Shub, cryptography, National Institute of Standards and Technology tests
MASTER OF SCIENCE IN APPLIED PHYSICS

MODELING OF A MICRO-ELECTRONIC-MECHANICAL SYSTEMS (MEMS) DEFORMABLE MIRROR FOR SIMULATION AND CHARACTERIZATION

Mark Mueller—Lieutenant, United States Navy
Master of Science in Applied Physics
Advisor: Fabio Alves, Department of Physics
Co-Advisor: Andres Larraza, Department of Physics

Development of a model that can simulate the wavefront-altering effects of a micro-electro-mechanical system (MEMS) mirror has many potential research benefits. Without the need to purchase costly lab equipment and/or wait for mirror fabrication, the use of model simulation would allow users to optimize various parameters of a device before fabrication. Research focused on developing models for two of the most common types of MEMS mirrors: segmented and continuous face sheet devices. Models for these devices were first constructed in MATLAB and then experimentally verified in order to characterize and compare the differences in behavior between model and measured results. The models developed displayed similar results when compared to interferometric readings taken from an actual MEMS mirror. The models were able to reduce the wavefront error of a notional distorted wave. The corrected wavefront of the notional wave compared well with experimental data collected indicating that the models were good representations compared to actual devices of their specific type. Full Text

Keywords: adaptive optics, deformable mirror, MEMS
MASTER OF SCIENCE
IN
COMBAT SYSTEMS TECHNOLOGY

MODEL FOR ATMOSPHERIC PROPAGATION OF SPATIALLY COMBINED LASER BEAMS

This paper has been recognized as outstanding by its department.

Kum Leong Lee—Civilian, Defence Science Organisation National Laboratories
Master of Science in Combat Systems Technology
Advisor: Joseph Blau, Department of Physics
Co-Advisor: Keith Cohn, Department of Physics

This thesis developed a propagation model that can be used to investigate the performance of coherent and incoherent beam configurations subjected to diffraction and thermal blooming effects. The propagation model also provides an additional damage assessment parameter—power-in-the-bucket—as well as the irradiance in the target plane for any laser wavelength. The propagation model results have target irradiance patterns similar to those obtained from WaveTrain, although the peak irradiance differs by ~ 30% due to differences in thermal blooming modeling. In addition, the propagation model can optimize certain beamlet configurations’ peak irradiance using a genetic algorithm. Based on all the simulation results, a 13-beamlet configuration is deemed to have highest peak irradiance and power-in-the-bucket of all the tested multiple beam configurations. Full Text

Keywords: directed energy weapons, spatially combined laser beams
Email addresses extracted from secondary storage devices are important to a forensic analyst when conducting an investigation. They can provide insight into the user’s social network and help identify other potential persons of interest. However, a large portion of the email addresses from any given device are artifacts of installed software and are of no interest to the analyst. We propose a method for discovering relevant email addresses by creating graphs consisting of extracted email addresses along with their byte-offset location in storage. We compute certain global attributes of these graphs to construct feature vectors, which we use to classify graphs into useful and not useful categories. This process filters out the majority of uninteresting email addresses. We show that using the network topological measures on the dataset tested, Naïve Bayes and SVM were successful in identifying 100% and 95.5%, respectively, of all graphs that contained useful email addresses both with areas under the curve above .97 and F1 scores at .80 and .90 for Naïve Bayes and SVM, respectively. Our results show that using network science metrics as attributes to classify graphs of email addresses based on the graph’s topology could be an effective and efficient tool for automatically delivering evidence to an analyst.

Keywords: digital forensics, network science, graph theory, machine learning

De-identification methods have helped government organizations provide the public with useful information, promoting transparency and accountability while also protecting the individual privacy of the data subjects. However, due to the recent massive increase in data collection and improved methods of analysis, de-identification has become a more difficult task. This work outlines challenges and discusses procedures for making a potentially sensitive data set available to extramural researchers and institutions without significant risk to human subject privacy. We provide a detailed explanation of personally identifiable information to help us understand what forms of personally identifiable information can cause the most harm. Furthermore, we discuss the legality and ethics behind working with personally identifiable information to illustrate the importance of protecting privacy. We then offer a taxonomy of threats, vulnerabilities, and impacts and describe how these determine risk. Based on this taxonomy, we develop a framework to assess risk on the Real Data Corpus, a collection of forensic disk images containing personally identifiable information. In addition, we analyze de-identification methods such as pseudonymization and anonymization, and consider re-identification risks.
Finally, we apply our framework and methodology to a real-world scenario to determine the risk of data disclosure to an extramural researcher. Full Text

Keywords: de-identification, risk management and assessment, Real Data Corpus, digital forensics, big data, personally identifiable information

HORIZON DETECTION IN THE VISIBLE SPECTRUM
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Master of Science in Computer Science
Advisor: Mathias Kolsch, Department of Computer Science
Second Reader: Daniel Bursch, Space Systems Academic Group

In the last few decades, machine learning and computer vision techniques have enabled precise and repeatable image recognition. Computer vision techniques can also recognize star patterns in star trackers for satellite attitude determination. Horizon detection in the visible spectrum was largely discarded for attitude determination in favor of thermal imagery, due to the greater consistency of the earth's thermal radiation. This thesis examines computer vision and machine learning techniques to develop a horizon detection algorithm for the visible spectrum. By examining different features of visual imagery, machine learning techniques were evaluated on the ability to detect a visible horizon and determine its orientation. An empirical analysis of visual imagery from low-earth orbit was conducted to develop a horizon brightness transition model, which allows for consistent and adjustable determination of the horizon’s location. The final result is a horizon detection and orientation determination algorithm that successfully indicates if a horizon is present in an image with 96% precision and 92% recall. The brightness model correctly identifies the location of the horizon in 85% of the tested image set. Full Text

Keywords: attitude determination, machine learning, image classification, earth horizon sensor, computer vision, line detection, visible horizon, visible spectrum imagery, horizon detection

SOFTWARE ARCHITECTURE FOR ANTI-SUBMARINE WARFARE UNMANNED SURFACE VEHICLES
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Master of Science in Computer Science
Advisor: Luqi, Department of Computer Science
Second Reader: Winford Ellis, Undersea Warfare Academic Group

The U.S. Navy seeks to reduce costs associated with anti-submarine warfare (ASW) operations by exploring the use of unmanned surface vehicles (USVs). Currently, the process of finding submarines tends to be tedious and manpower-intensive due to the high volume of acoustic data with limited means to filter for valuable information. Therefore, innovative software frameworks are required to transition from a one-to-many to a many-to-one USV/ human interaction model. By examining potential software frameworks, this thesis addresses many of the benefits and challenges inherent to using USVs in dynamic maritime environments. Furthermore, this evaluation provides a building block for the continued development of USV software systems. Full Text

Keywords: USV, ASW, autonomous systems, artificial intelligence, software architecture, unmanned systems
The unique principles of quantum mechanics may one day enable computers to perform operations that would be impossible on a classical computer. Although no one knows whether it will be possible to build a large-scale, functional, and stable quantum computer, researchers can study quantum-mechanical systems and develop algorithms and circuits by simulating quantum systems in software. Performance and memory bottlenecks prevent most current quantum computer simulators from being able to simulate quantum systems that are large enough to be useful. In this thesis, we develop a matrix-free sequential quantum computer simulator to vastly improve both time and memory performance of sequential code on a single processor. Next, we distribute the matrix-free algorithm over multiple parallel processors using the Message Passing Interface in order to simulate quantum systems that are too large to reside wholly within the memory of a single processor. Finally, we simulate various quantum circuits using the Hamming high-performance computing cluster in order to conduct algorithmic analysis. 

Keywords: quantum computing, quantum computer simulation, parallel computing

In contrast to traditional networks, Software Defined Networking (SDN) allows the programming of network functions via an Application Programming Interface (API). The ability to implement the APIs in software is advantageous for traffic manipulation in SDN. With automated logic being programmed into a centralized component of the SDN, network operators are presented with new and scalable methods for traffic manipulation. Enterprises and internet service providers of all sizes can implement these techniques to great effect. Of particular concern are large, state-owned providers. A motivation for this thesis came from a case study on China’s Great Cannon and how the operators redirect benign traffic via content injection. In a technically similar fashion, we implemented targeted redirection on a software-defined network. Our experimentation demonstrates how an owner of the network can use man-in-the-middle (MiTM) techniques to redirect the traffic of unknowing users. To enable these techniques, we wrote a MiTM application to redirect targeted users to a malicious server. Within a multi-switch test bed, our experimental results show that forcing our MiTM application to pass the injected response packet on a directed path to the switch closest to the targeted destination reduces the overall response time. In addition to testing for a route that would reduce overall HTTP response times, we illustrate the technical requirements of the attack in our MiTM taxonomy.

Keywords: software-defined networking, man in the middle, iframe injection, openflow, Ryu, mininet
A recent enhancement to Transmission Control Protocol (TCP) is Multipath TCP (TCP), a new transport layer protocol that enhances TCP to be capable of communicating over multiple paths by establishing several “subflow” connections between endpoints. Each subflow behaves in the same way that a traditional, single-path TCP connection would. Previous work has demonstrated that adversaries can perform cross-path data fragmentation to evade Network Intrusion Detection System (NIDS) when the NIDS is unable to integrate related subflows into a single MPTCP data stream. We present a general solution to enable current penetration testing tools to perform MPTCP cross-path fragmentation attacks. On the defensive side, we demonstrate that existing transport layer proxies can be used in conjunction with an MPTCP kernel to transparently convert a multipath connection into a single-path connection that can be analyzed by a NIDS. We also investigate extending Snort to perform MPTCP stream reassembly and create a prototype Snort plugin for accomplishing this functionality. 

Keywords: MPTCP, multipath PCP, Intrusion, Detection, Cross-path fragmentation, networking, IDS, session-making, Snort, proxy

SECURE CLOUD COMPUTING IMPLEMENTATION STUDY FOR SINGAPORE MILITARY OPERATIONS
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Master of Science in Computer Science
Advisor: John Fulp, Department of Computer Science
Co-Advisor: Gurminder Singh, Department of Computer Science

Cloud computing benefits organizations in many ways. With characteristics such as resource pooling, broad network access, on-demand self-service, and rapid elasticity, an organization’s overall IT management can be significantly reduced (in terms of labor, software, and hardware) and its work processes made more efficient. However, is cloud computing suitable for the Singapore Armed Forces (SAF)? How can the SAF migrate its traditional system to cloud-based services in a safe and secure manner? In this thesis, cloud computing was shown to increase cost-effectiveness in the healthcare and business sectors. In addition, from the military perspective, the benefits of cloud computing were analyzed from a study of the Department of Defense. Then, using cloud computing–related documents from the United States, a list of recommended policy statements were developed for the SAF to consider for guidance as it migrates to greater adoption of cloud-based computing in support of its operations. These policy statements encompass the various aspects of information security deemed most important to the SAF’s adoption of a cloud-based computing environment.

Keywords: military cloud computing, could computing military features, military cloud computing framework
FREE SPACE OPTICAL COMMUNICATION FOR TACTICAL OPERATIONS
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Master of Science in Computer Science
Advisor: John Gibson, Department of Computer Science
Co-Advisor: Gurminder Singh, Department of Computer Science

The increasing demand for data bandwidth is a present and relevant issue for communications. Military communications further require secure connections for data transfer. The Free Space Optical (FSO) communication system, with its ability to connect at a high data rate, offers an appealing solution to the current need. Using laser technology and transmitting at a wavelength invisible to the human eye, FSO is difficult to detect and intercept, providing a highly secure means of communication. However, it faces the limitation of being a strictly line-of-sight communication technology and is known to be greatly affected by atmospheric attenuation. This thesis documents three experiments involving FSO technology, including the process of the experiment preparations, laser-related hazard assessment, and implementation of a standard procedure to mitigate any possible risk. The contribution of this thesis is the acknowledgment that this proposed process is feasible. Experiments were conducted on an SA Photonics NEXUS 3 FSO Communications System. From the gathered results, the system was assessed to provide high throughput and low frame loss. Our work also ascertains that FSO is a technology that can become the next-generation means of military communications. Specifically, our findings indicate that the NEXUS has potential and merits further testing and development for military communications. Full Text

Keywords: free space optics, communications, computer science, networking, laser communications

TRANSITIONING CLIENT-BASED NALCOMIS TO A MULTI-FUNCTION WEB-BASED APPLICATION
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Master of Science in Computer Science
Advisor: Man-Tak Shing, Department of Computer Science
Co-Advisor: Arijit Das, Department of Computer Science

Navy and Marine Corps aviation utilizes a software suite to manage logistics known as NTCSS, and one of its primary applications is NALCOMIS. NALCOMIS has two configurations that are used by organizational and intermediate level maintenance activities, Optimized Organizational Maintenance Activity (OOMA) and Optimized Intermediate Maintenance Activity (OIMA). These configurations communicate with each other when co-located with a local client server. If a squadron departs its home station for a deployment or exercise, the OOMA server is disconnected from OIMA and lines of communication are lost. All data that needs to be shared between systems must be manually entered and updated. Manual data entry can lead to errors, resulting in inventory discrepancies that can amount to millions of dollars. This research examines technologies that lead to the design of a system that seamlessly integrates the two configurations of NALCOMIS and moves from a local client server model to a web server accessed through a secure web application. A proof of concept was developed to demonstrate the viability and utility of the proposed web-based application. Our analysis of the system load on the existing NALCOMIS servers shows that, with a minimum investment in hardware, a Marine Corps wide NALCOMIS-WEB could be implemented to create a fully interconnected Marine Aviation Logistics Squadron (MALS) network. Full Text

Keywords: NALCOMIS, database, web server, JDBC, web application, multi-tier architecture, aviation logistics
AN APPROACH FOR DETECTING MALICIOUS EMAILS USING RUNTIME MONITORING WITH HIDDEN DATA
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Master of Science in Computer Science
Advisor: Doron Drusinsky, Department of Computer Science
Second Reader: Man-Tak Shing, Department of Computer Science

Computer systems continue to be at risk of attack by malicious software attached to email. Email has been determined to be the cause of 80% of computer virus infections. Millions of dollars are lost yearly due to the damage brought by malicious emails. Popular approaches toward the defense against malicious emails are antivirus scanners and server-based filters. Further, state-of-the-art methods are being employed to enhance security against malicious programs. However, despite efforts to protect personal information in emails, malicious programs continue to pose a significant threat. This thesis presents the application of a hybrid of Runtime Monitoring and Machine Learning for monitoring patterns of malicious emails. The system is designed in a way that it gathers malicious emails to determine whether they are suspicious, unknown, or benign. The application of runtime monitoring helps reduce the chance that suspicious emails are spread and lowers the likelihood that users will be threatened. Patterns were developed in Rules4business.com to facilitate the detection of threats and apply rules to the identified rules validation, while at the same time tracking them. The runtime monitoring application system entails the detection of the malicious emails by assessing the pattern in which they are sent and qualifying them into different states identified as suspicious, unknown, or benign. Through the application of the system, it would be possible to eliminate threats posed to private individuals and corporations emanating from the malicious emails. We performed deterministic runtime monitoring, built a Hidden Markov Model (HMM), and performed runtime monitoring with hidden data. It is the reasoning about the patterns of malicious emails with hidden artifacts that provides the potential of providing improved classification. Full Text

Keywords: malicious emails, runtime monitoring, statechart assertions, formal specifications, Hidden Markov Model

CLOUD FINGERPRINTING: USING CLOCK SKEWS TO DETERMINE CO-LOCATION OF VIRTUAL MACHINES
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Master of Science in Computer Science
Advisor: Geoffrey Xie, Department of Computer Science
Co-Advisor: Mathias Kolsch, Department of Computer Science

Cloud computing has quickly revolutionized computing practices of organizations, including the Department of Defense. However, security concerns over co-location attacks have arisen from the consolidation inherent in virtualization and from physical hardware hosting virtual machines for multiple businesses and organizations. Current cloud security methods, such as Amazon’s Virtual Private Cloud, have evolved defenses against most of the well-known fingerprinting and mapping methods in order to prevent malicious users from determining virtual machine co-location on the same hardware. Our solution to co-locating virtual machines unhindered was to derive their clock skews, or the temporal deviation of the system clock over time. Capturing normal TCP traffic to analyze timestamps from a virtual machine in the cloud, our results were inconclusive in demonstrating that co-located virtual machines will have similar clock skews due to large, inconsistent packet delays. Our research demonstrates a potential vulnerability in cloud defenses so that cloud users and providers can take appropriate steps to prevent malicious co-location attacks. Full Text

Keywords: cloud, TCP timestamps, clock skews, side-channel attacks, virtual machines, VM co-location, finger-printing
There are multiple applications for pseudorandom number generators, notably in simulation and cryptography. A bad pseudorandom number generator can cause misleading results in simulations or loss of security and attacks against implementations of cryptographic systems with low-entropy sequences. Pseudorandom number generator test suites provide insight and metrics for security-critical system components. This thesis added multi-threading to an existing test-suite, known as Dieharder, to significantly speed up pseudorandom number generator testing on multi-core systems. Evaluations were conducted on the original Dieharder, a threaded version of Dieharder using a POSIX-compliant thread pool (Dieharder-T), and a threaded version of Dieharder-T using OpenMP with static and dynamic scheduling. The results show that Dieharder-T with OpenMP, two threads and static scheduling completes in about half the time of the single-threaded Dieharder-T. The run-time is not halved again when the number of threads is increased to four, due to inefficient scheduling of tasks to threads. A hybrid scheduling solution is proposed to improve the performance of the multi-threaded pseudorandom number generator test suite. Full Text

Keywords: pseudorandom number generator, statistical test suite, multi-threading, Dieharder
Insider threat is a significant problem for both governmental and private organizations. Individuals can do immense harm with their trusted accesses. To combat this threat, organizations have created departments with trained analysts whose sole purpose is to deter, detect, and mitigate the insider threat. These analysts monitor employees and analyze activities to detect dangerous practices, whether witting or unwitting, and report these actions to supervisors for mitigation. When organizations share insider threat information among one another, it can improve all organizations’ abilities to deter, detect, or mitigate the insider threat. The challenge lies in merging external and existing data with as little human interaction as possible. This thesis examines the work that takes place in an insider threat department and identifies requirements for a solution that would allow for information sharing between organizations. Full Text

Keywords: insider threat, data sharing, hub operations, heterogeneous data
How can Norwegian Special Operations Forces (NORSOF) improve its capabilities for military assistance (MA) in order to increase the strategic utility of both NORSOF and MA? After examining and analyzing the broader literature, a more specific body of literature about NORSOF, the results of an already existing survey of NORSOF personnel, and comments contained within both the respective literature and the survey results, we recommend establishing a national SOF doctrine to strengthen NORSOF niches in the global SOF network, seek synergy between national tasks and MA, increase NORSOF vertical implementation in operations, use the MA capability in support of the Ministry of Foreign Affairs, and establish an MA Network of Practice across NORSOF units. This capstone concludes with three new courses of action that demonstrate how NORSOF’s enhanced MA capabilities can be pursued in order to achieve strategic objectives for Norway in the realms of deterrence, reassurance, and conflict resolution. Full Text

Keywords: Norwegian Special Operations Forces, military assistance, capability development, foreign internal defense, security force assistance, security sector reform, global SOF network, deterrence, reassurance, negotiations

OPERATION EXODUS: THE MASSACRE OF 44 PHILIPPINE POLICE COMMANDOS IN MAMASAPANO CLASH
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Master of Science in Defense Analysis
Advisor: William Fox, Department of Defense Analysis
Co-Advisor: Robert Burks, Department of Defense Analysis

The Mamasapano case (also known as OPLAN: Exodus) is a controversial special operations mission that was executed in January 25, 2015, by Philippine National Police commandos to neutralize high-value terrorist leaders. During the last phase of their operation, these commandos were swarmed by different armed groups in the area of operation. This thesis analyzes the factors that led to the failure of OPLAN: Exodus through a unique perspective—the point of view of a special operator—to study how the operation's structure affected the culture, the environment, the leadership, and the men. The study assesses the leaders’ criteria through the science of strategic thinking, utilizing Game Theory and Multi-Attribute Decision Making; the combination of these two dynamic tools is used to evaluate their potential usefulness in special operations decision making. Finally, this thesis proposes criteria and an organizational solution that can be useful for special operations
units like the Philippine National Police Special Action Forces to avoid tragedies and loss of human life, especially in the special operations community. Full Text

Keywords: Philippines, Philippine National Police, Special Action Force, OPLAN: Exodus, terrorism, Moro Islamic Liberation Front, Bangsamoro Freedom Fighters, counterterrorism, Special Operations, Mindanao, Mamasapano
The ability to securely disseminate data in a timely manner is critical to military missions in a hostile environment. Tactical wireless sensor networks (WSN) consist of power-constrained devices spread throughout a region-of-interest to provide data extraction in real time. In this thesis, we develop cyber security mechanisms to be implemented on a tactical WSN using the 6LoWPAN protocol for use by the United States Marine Corps (USMC). Specifically, we develop an architectural framework for tactical WSNs by studying cyber security gaps and vulnerabilities within the 6LoWPAN security sublayer, which is based on the IEEE 802.15.4 standard. We develop a key management scheme and a centralized routing mechanism that is non-broadcast but feasible in an operational scenario. In addition, we modify the 6LoWPAN enabled IEEE 802.15.4 frame structure to facilitate the newly developed keying and centralized routing mechanisms. Methods to aid in deployment planning are also discussed. The tactical WSN architecture was tested against a variety of well-known network attacks. The attacks simulated were spoofing, man-in-the-middle, and denial-of-service. Through MATLAB simulations, we showed the effectiveness and efficiency of the developed cyber security mechanisms to provide integrity and reliability to a deployed tactical WSN.

Full Text

Keywords: wireless sensor networks (WSN), sensor nodes, 6LoWPAN, IEEE 802.15.4, energy constrained node, centralized routing, keying mechanism, network attacks, denial of service (DOS), man-in-the-middle (MITM), spoofing

CHARACTERIZATION AND RELIABILITY OF VERTICAL N-TYPE GALLIUM NITRIDE SCHOTTKY CONTACTS

Silicon- and silicon carbide-based power devices have dominated the power electronics industry. For many emerging high-current and high-power applications, vertical transport gallium nitride (GaN)-based devices are more desirable. In this study, a series of reduced-defect, vertical n-type GaN Schottky contacts were fabricated and subjected to high-current density accelerated lifetime tests to understand the physics of contact degradation and compare the reliability of different metallization types and process cleans. Tested Schottky metals included molybdenum, molybdenum-gold, and chromium-gold. Process cleans compared were a piranha etch and a hydrofluoric acid etch. Pre-stress electrical characterization confirmed functioning Schottky contacts and determined device electrical performance parameters. Using a stress-measure-stress system, we obtained results of high-current density accelerated lifetime testing of 170 hours at current densities of 2.3 kAcm⁻² that showed both catastrophic and non-catastrophic failures across all metallization types and process
cleans. While comparative analysis showed that molybdenum was the most reliable, identified experimental testing and non-ideal fabrication issues limited the conclusivity of the results. The identified constraints and initial comparative results serve to inform future Schottky contact structural design and fabrication for future optimized testing Full Text

Keywords: accelerated lifetime testing, Schottky barrier height inhomogeneity, gallium nitride, vertical transport, power electronics, high current density, semiconductor reliability

REMOVAL OF DIRECT CURRENT LINK HARMONIC RIPPLE IN SINGLE-PHASE VOLTAGE SOURCE INVERTER SYSTEMS USING SUPERCAPACITORS

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Electrical Engineer and Master of Science in Electrical Engineering
Advisor: Giovanna Oriti, Department of Electrical and Computer Engineering
Co-Advisor: Alexander Julian, Department of Electrical and Computer Engineering
Second Reader: Roberto Cristi, Department of Electrical and Computer Engineering

For an Energy Management System (EMS)-controlled microgrid that uses a single-phase voltage source inverter (VSI) configuration to supply power for AC loads from DC energy storage devices, the DC link connecting the VSI to the DC energy storage devices experiences a voltage ripple that is a second-order harmonic of the AC frequency. When the EMS has a battery bank as the only DC energy storage device, the DC link voltage ripple causes a second-order harmonic ripple in battery current that leads to a reduction in battery life. Supercapacitors (SCs), which are capable of operating through many more cycles than batteries, can be added to the EMS to form a battery and SC Hybrid Energy Storage System (HESS). The EMS can then be used to filter out the second-order harmonic ripple in battery bank current and provide this current solely from the SC bank, extending battery life and reducing system operating costs. The design of a computer simulation of an EMS providing power to a microgrid is discussed in this thesis. Simulations provide theoretical results and laboratory results compare well with the theoretical results, showing that SCs can be used to remove the second-order harmonic current ripple from the battery bank. Full Text

Keywords: Energy Management System (EMS), peak shaving, Voltage Source Inverters (VSI), Hybrid Energy Storage System (HESS), supercapacitor (SC), ultracapacitor (UC), power electronics, microgrid (MG), bidirectional dc/dc converters, battery life extension

PHASED ARRAY EXCITATIONS FOR EFFICIENT NEAR-FIELD WIRELESS POWER TRANSMISSION

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Master of Science in Electrical Engineering
Advisor: David Jenn, Department of Electrical and Computer Engineering
Second Reader: Roberto Cristi, Department of Electrical and Computer Engineering

This thesis is a continuation of an NPS project relating to the improvement of wireless-power transfer (WPT) in the near field. Improvement to power reception in the near field requires that excitation correction methods be applied to the transmitter antenna. The emphasis of this thesis is a parametric study of two correction methods to focus the transmitter array beam to the receiver array. Quadratic-phase correction and complex-conjugate matching methods were investigated using Matlab and Savant to implement a simulation. Array size, frequency of operation, and distance between arrays were parameters used to gauge the improvement of power reception. Both methods demonstrated improvement over the uniform case at certain distances in the
near field, with the complex-conjugate matching method proving to be the better option at very close ranges. Analysis and discussions of the advantages and disadvantages of each method are presented. Full Text

Keywords: wireless power transmission, Matlab, Savant, near field, phase correction

DETECTING A MULTI-HOMED DEVICE USING CLOCK SKEW
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Master of Science in Electrical Engineering
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Co-Advisor: John McEachen, Department of Electrical and Computer Engineering

The aim of this thesis was to determine the feasibility of identifying a device connected to the Internet through multiple interfaces (i.e., multi-homed) using only the information provided by passively observing network traffic. Since multi-homed hosts allow an alternate means for outside entities to circumvent the security of a firewall and gain access to a network, it is important for a network's security to be able to detect and remove such devices. In this work, the idea of using clock skew—which is the difference in perceived time between two system clocks—as a unique signature is utilized to identify hosts on a network that are potentially multi-homed. Testing was done on a software-defined network that contained a multi-homed host. After traffic between hosts was collected and analyzed, analysis of the confidence intervals of the device's clock skew was conducted to determine if IP addresses originating from the same host could be successfully detected solely from network traffic. Testing confirmed that the proposed scheme provided a valid means of detecting a multi-homed device on a network. This scheme was repeated on multiple hosts and on a device with multiple connections to the network. Full Text

Keywords: software defined network, multi-homed host, network monitoring, network fingerprinting

MICROWAVE-PHOTONIC ARCHITECTURE FOR DIRECTION FINDING OF LPI EMITTERS: POST-PROCESSING FOR ANGLE OF ARRIVAL ESTIMATION
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Direction finding (DF) systems are fundamental electronic support measures for electronic warfare. A number of DF techniques have been developed over the years; however, these systems are limited in bandwidth and resolution and suffer from a complex design for frequency down-conversion. An innovative design of a microwave-photonic direction finding technique for the detection and direction finding of low probability of intercept (LPI) signals is investigated in this thesis. Key advantages of this design include a small baseline, wide bandwidth, high resolution, and minimal space, weight, and power requirements. A unique phase encoding method is used to resolve the ambiguities over the entire field-of-view with high accuracy. Experimental tests using frequency-modulated continuous wave (FMCW) and continuous wave (CW) P4 modulated signals were conducted in an anechoic chamber to verify the system design. Test results showed that the microwave-photonic DF system has a sensitivity of –62.96 dBm and is capable of measuring the angle-of-arrival (AOA) of the LPI signals with <1° resolution over a 180° field-of-view. For an FMCW signal, it was demonstrated that the system is capable of estimating the AOA with a root-mean-square (RMS) error of 0.29° at <1° resolution. For a P4 coded signal, the RMS error in estimating the AOA is 0.32° at 1° resolution. Full Text

Keywords: direction finding, DF, LPI signals, minimum Euclidean distance detection, photonics, Mach Zehnder modulator, MZM, angle of arrival, AOA
A SITUATIONAL-AWARENESS SYSTEM FOR NETWORKED INFANTRY INCLUDING AN ACCELEROMETER-BASED SHOT-IDENTIFICATION ALGORITHM FOR DIRECT-FIRE WEAPONS

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Co-Advisor: Xiaoping Yun, Department of Electrical and Computer Engineering

Combat effectiveness is increased by decreasing uncertainty through shared situational awareness (SA) at all levels of command. A system that provides immediate knowledge of subordinates’ locations and azimuths of fire when engaging the enemy increases the small-unit leader’s SA, facilitating his coordination and execution of a course of action. In this thesis, such a system was prototyped using commercial-off-the-shelf components related to the system’s functional areas of shot identification, orientation, localization, data processing, and mapping. The primary focus of this project was the development of a shot-identification algorithm utilizing data collected from inertial sensors attached to Armalite Rifle 15 (AR15) variant weapons. In spite of under-sampling limitations, the shot-identification algorithm was successful in classifying shots taken with three different AR15 rifles by six different shooters using a variety of stances and multiple engagement techniques. The full system was tested successfully with two rifle nodes passing localization and firing azimuth data in response to a simulated shot. This information passed over the Naval Postgraduate School network to a separate command operations center node where it was mapped in Google Earth. Full Text

Keywords: situational awareness, networked infantrymen, direct-fire weapons, AR15-variant weapons, shot identification, accelerometer, digital sampling, under sampling, Euler angles, firing azimuth, YEI, GPS, Google Earth, mapping

MICROWAVE-PHOTONIC ARCHITECTURE FOR DIRECTION FINDING OF LPI EMITTERS: FRONT-END ANALOG CIRCUIT DESIGN AND COMPONENT CHARACTERIZATION

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Direction finding (DF) systems are critical components in electronic warfare intercept receivers. Many existing radio frequency DF techniques use a non-linear frequency down-conversion process that generates spurious frequencies that can hide the signals-of-interest. In addition, these systems suffer from a limited bandwidth and poor resolution (e.g., > 2°). To overcome these limitations, a miniature microwave-photonic phase-sampling DF technique is investigated in this thesis. This front-end design uses a combination of integrated optical Mach-Zehnder phase detectors to measure the emitter’s phase difference with the largest baseline being 23 cm. The front-end components were characterized to ensure accuracy in the resolved angle-of-arrival (AOA). The front-end design was constructed to be modular in order to facilitate testing and verification of analog components accuracy. Signal processing with a class IV laser required particular attention to ensure that any stray radiation or leakage was isolated. Testing with low probability of intercept (LPI) waveform modulation consisted of using a linear frequency-modulated continuous wave (FMCW) and a phase coded P4 modulation, both at 2.4 GHz, in an anechoic chamber. Measurements were taken to quantify the DF receiver sensitivity was $\delta_R = -62.96\,\text{dBm}$. It was demonstrated that the system was capable of estimating the AOA for the FMCW signal with a root-mean square (RMS) error of $0.29^\circ$ at < 1° resolution and a P4 modulation RMS error of $0.32^\circ$ at <1° resolution. Full Text

Keywords: direction finding, DF, 1dB compression, photonics, DE-MZM, Mach-Zehnder, direction of arrival, AOA
As the demand for a more robust and reliable electrical grid continues to grow, the United States Navy is determined to find effective energy solutions. The use of energy management systems (EMS) and uninterruptible power systems (UPS) can be seen both ashore and afloat. Most UPS and EMS are comprised of power inverters. These inverters must comply with the military standards for conducted emissions. In this thesis, two different modulation strategies, bipolar and unipolar, are explored. The primary goal is to understand the effects each modulation strategy has on the conducted electromagnetic interference (EMI) and then try to eliminate that EMI in the common and differential mode paths. In order to accomplish this, a laboratory experiment on an EMS using both modulation strategies was performed. The EMS was in grid-connected mode. Once the differential and common mode currents and voltages were obtained, Simulink was used to model the laboratory EMS. Once there was confidence in the model's ability to predict the laboratory behavior, a line impedance stabilization network (LISN) was added to the design. Comparing the LISN voltage to the MIL-STD showed that the current model was not within limits. The addition of a passive filter proved to minimize the conducted EMI for a single-phase grid-tied inverter. 

Keywords: single-phase inverter, conducted emissions
AN INVESTIGATION OF THE PERFORMANCE OF A RIBBON AND SMALL PLANAR MAGNETIC TRANSDUCER, MADE FOR USE IN AIR, AS AN UNDERWATER ACOUSTIC VELOCITY SENSOR

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Master of Science in Engineering Acoustics
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Co-Advisor: Steven Baker, Department of Physics

The use of vector sensors in sonar receiving array applications is an area of active investigation by the U.S. Navy. A vector sensor combines the outputs of a monopolar (pressure) sensor co-located with one or more orthogonal dipolar (velocity or, more commonly, pressure-gradient) sensors to achieve a modest (5–6 dB) amount of directivity at a single point. The directivity of an array formed using such sensors is also modestly improved by the same amount. More importantly, though, the azimuthal angle ambiguity that occurs in the beam pattern of a line array of point pressure sensors is removed by employing vector sensors instead. This thesis describes an investigation into the underwater use of a pressure-gradient transducer technology that has been employed in airborne acoustic applications for many years (mostly as a source), but, to our knowledge, has heretofore never been employed under water. The devices examined include planar-magnetic and true ribbon transducers. The planar-magnetic transducer is very closely related to what was developed first (i.e., the true magnetic ribbon transducer). The same as an ordinary magnetic loudspeaker or microphone, both the planar-magnetic and true ribbon transducers employ a mutually orthogonal electrical conductor, magnetic field, and axis of motion of a diaphragm. We present the results of measurements made both in air and water of the transmitting and receiving responses of a planar-magnetic and a true ribbon transducer. We also present a procedure for the free-field reciprocity calibration of a pressure-gradient transducer. Full Text

Keywords: vector sensor, monopolar, dipolar, pressure transducer, pressure gradient transducers, planar magnetic, magnetic ribbon, free-field.

EXTENDING THE CALIBRATION IN THE UNDERWATER SOUND REFERENCE DIVISION (USRD) RECIPROCITY COUPLER TO INCORPORATE PHASE

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Master of Science in Engineering Acoustics
Advisor: Steven Baker, Department of Physics

Co-Advisor: Steven Crocker, Naval Undersea Warfare Center Division Newport

In this report, a phase measurement is added to the Underwater Sound Reference Division (USRD) reciprocity coupler primary calibration procedure for an H48 reference hydrophone. Data acquisition equipment is added to record time-series data from the hydrophone under test and from the reciprocal transducers. The complex-valued hydrophone sensitivity is calculated. The sensitivity magnitude is compared to measurements from the standard coupler calibration procedure, and the complex sensitivity data are also fitted to a simple high-pass circuit model. The model is used to estimate the low-frequency cutoff of H48 hydrophone SN4. The low-frequency cutoff measured in this report is about 0.2 Hz higher than that originally measured and specified when the H48 hydrophones were first built. The new results show significant roll-off in phase below 10-20 Hz,
a range where the phase is typically assumed flat during the standard calibration. By 1 Hz the phase roll-off is about 20°. The error analysis of the original coupler is summarized and error and uncertainty due to new data acquisition equipment and phase measurement added. Some errors due to simplifications in the acoustics of the coupler are left to future work. Full Text

Keywords: acoustic, calibration, coupler, reciprocity, phase, uncertainty, complex uncertainty, H48, hydrophone, Under-water Sound Reference Division, USRD
MarineNet offers distance learning (DL) training and education (T&E) opportunities to all Marines. For active duty Marines, government-provided desktops and laptops (GPDLs) typically support DL T&E or learning resource centers (LRCs) located inside many military installations. In contrast, Marine Forces Reserve (MFR) personnel have a unique challenge: most MFR units are located in home training centers (HTCs) away from military installations. Consequently, reserve Marines do not have GPDLs or LRCs to access DL T&E. The current alternative is for MFR personnel to use personal devices outside of the Nonsecure Internet Protocol Router Network (NIPRNET). This alternative assumes MFR personnel will purchase or already have their own devices. In addition, devices outside of the NIPRNET tend to experience compatibility issues when accessing some MarineNet courseware. This research tested equipment, software, and virtual machine (VM) architectures to find a technologically efficient alternative to GPDLs and LRCs that can support the unique needs of MFR. The emphasis is on researching mature technologies and leveraging free Internet options currently available in the United States. An efficient alternative is proposed to provide reserve personnel with a device to access the Internet, offering free Wi-Fi at the HTCs, and deploying VMs based on the VMware architecture. Full Text

Keywords: distance learning, virtual machine, Marine Forces Reserve, learning resource centers
layer from which to extract features, and minimum number of training samples to be considered to obtain the best classification results with our approach. **Full Text**

Keywords: convolutional Neural Networks, k-Nearest Neighbors, image classification, data scarcity, transfer learning, activation codes, high-dimensional space, cosine similarity, Euclidean distance, t-SNE

### MARINE AIR-GROUND TASK FORCE DISTRIBUTION IN THE BATTLESPACE
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Margaret Snyder—Captain, United States Marine Corps  
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**Co-Advisor:** Magdi Kamel, Department of Information Sciences  
**Second Reader:** Sharon Runde, Computer and Information Programs Program Office

This thesis applies a systems thinking methodology to produce a proof of principle decision support dashboard that integrates relevant Marine air-ground task force (MAGTF) logistics systems to assist the tactical level commander to better manage ground and air transportation assets. For this thesis, the researchers define the MAGTF system in terms of three components: 1) organization design, 2) IT systems, and 3) feedback control. The researchers looked at the existing Log IT systems supporting the current MAGTF organization and assessed how well our application design can use and access existing logistics databases to improve logistics decision-making. The researchers discovered that effective application design depends on selecting the appropriate organizational level of war the application is designed to support: 1) strategic, 2) operational, or 3) tactical. By developing a proof of principle application that accesses existing databases and applying a systems thinking methodology, the researchers demonstrate how information can be used to enhance the MAGTF commander’s decision making for more efficient and effective employment of transportation assets in the battlespace. The potential benefit of this research is a proposed systemic structure with an associated web application that provides the MAGTF commander with critical information for supporting operations. **Full Text**

Keywords: MAGTF, TCPT, TBMCS, GCSS-MC, Oracle, organization design

### COUNTERMEASURES TO INSIDER CYBER THREATS FOR TURKISH GENERAL COMMAND OF GENDARMERIE
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**Master of Science in Information Technology Management**  
**Advisor:** Shelley Gallup, Department of Information Sciences  
**Second Reader:** Thomas Anderson, USACE ERDC CRREL

Insider threats expose every nation, state, and business entity to danger; however, most organizations do not realize this, or choose to ignore it. Since most studies and technical solutions for insider threats originate from the United States, a good starting point for organizations such as the Turkish General Command of Gendarmerie (TGCG) would be to analyze lessons learned from U.S. examples to try to find ways to adapt countermeasures, considering cultural constraints. This thesis provides background information about attributes of insider threats, summarizes malicious insiders’ characteristics and motivations, and reviews documents (e.g., presidential memorandums, directives, best practices, mitigation strategies) published in the United States for countering insider threats in the United States. Then, technical and non-technical key practices for TGCG are explained. These practices are analyzed in terms of the effects of Turkish culture by using Geert Hofstede’s di-
dimensions of national cultures. Finally, recommendations for conceptual implementations of countermeasures to TGCG are presented. Full Text

Keywords: insider, insider threat, cyber threat, transfer of technology, cultural constraints, national cultural dimensions, socio-technical systems, Turkish gendarmerie, Turkish general command of gendarmerie.

COMMERCIAL MOBILE DEVICE TECHNOLOGY IMPLEMENTATION IMPLICATIONS IN UNITED STATES MARINE CORPS PROCESSES: A CASE STUDY APPROACH
Buddy Ellis–Major, United States Marine Corps
Master of Science in Information Technology Management
Advisor: Glenn Cook, Department of Information Sciences
Second Reader: Thomas Housel, Department of Information Sciences

The United States Marine Corps is operating in an increasingly resource-limited and fiscally constrained environment while simultaneously becoming more dependent on information technology systems to efficiently train and operate. Balancing budget and mission requires innovative solutions to current problems. One such innovation that could potentially save the Marine Corps money, while increasing its ability to prepare for and conduct its mission, is the use of commercial mobile devices. This research used case study methodology to describe three processes that could benefit from the implementation of commercial mobile devices in the Marine Corps. Each independent case study was presented with three courses of action with implementation strategy variations. Socio-technical systems theory was used to analyze the intersection between the proposed new technology and the user. The technology acceptance model was used to analyze the likelihood of actual usage based on implementation strategy used. Finally, each course of action was analyzed with regard to confidentiality, integrity, and availability of organizational data. The conclusion of this research is that no one-size-fits-all implementation strategy of these devices will minimize risks and maximize benefits in all processes. This is likely due to the variations in confidentiality, integrity, and availability requirements of each process. Full Text

Keywords: commercial mobile device, bring your own device, BYOD, change management, application-based access, United States Marine Corps, USMC, confidentiality, integrity, availability, technology acceptance, sociotechnical systems theory

UNMANNED TACTICAL AUTONOMOUS CONTROL AND COLLABORATION MEASURES OF PERFORMANCE AND MEASURES OF EFFECTIVENESS
Timothy Kirkpatrick–Captain, United States Marine Corps
Edward Rushing–Major, United States Marine Corps
Master of Science in Information Technology Management
Advisor: Dan Boger, Department of Information Sciences
Co-Advisor: Scot Miller, Department of Information Sciences

As the technological capabilities of the world’s combat systems grow at a breathtaking pace, the reins with which people regulate and direct these instruments of destruction must keep pace. Unmanned Tactical Autonomous Collaboration and Control (UTACC) is a system of systems that will reduce the cognitive load of the warfighter while enhancing mission effectiveness. As with any emerging concept, testing and development of UTACC are critical underpinnings of successful deployment to operating forces. This thesis sought to determine which measures of performance and measures of effectiveness (MOP/MOE) are most critical to the development of UTACC. The MOP/MOE development process involved establishing a baseline layer of the Marine Corps Troop Leading Steps. The authors aligned the appropriate troop-leading step with phases in the context of a reconnaissance scenario. The next layer consisted of previously developed Coactive Design tasks and Individual Training Standards from the Marine Corps Task List associated with reconnaissance. The final product addresses both technical and tactical tasks required for efficient and effective mission accomplish-
ment for any unit integrated with UTACC, but the effort is far from finished. Follow-on efforts should refine and expand the list to include different mission sets, tactical tasks and unit composition. Full Text

Keywords: UTACC, robotics, autonomy, reconnaissance, Marine Corps task list, metrics, measures of effectiveness, measures of performance

UNMANNED TACTICAL AUTONOMOUS CONTROL AND COLLABORATION (UTACC) CAMPAIGN OF EXPERIMENTATION
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Master of Science in Information Technology Management
Advisor: Dan Boger, Department of Information Sciences
Co-Advisor: Scot Miller, Department of Information Sciences

This thesis defines a campaign of experimentation to guide Unmanned Tactical Autonomous Collaboration and Control (UTACC) development from concept to reality. It also applies design methodologies to reduce costs and increase the quality, effectiveness, and speed of UTACC's development. UTACC is a system of systems that teams Marines with unmanned robotic systems to reduce the Marine's cognitive load and enhance mission accomplishment. Bringing UTACC from concept to reality requires extensive experimentation, but prior to this thesis no experimentation plan has existed. A series of UTACC theses have been written starting with a Concept of Operations (CONOPS). Then theses red-celled the CONOPS, explored Coactive Design methodology, analyzed unmanned aerial vehicle alternatives, and generated measures of effectiveness and performance for the system. Using information from the previous theses, the campaign of experimentation described in this thesis identifies key developmental relationships, associates measures with them, and organizes them in an incremental order. This thesis also emphasizes Coactive Design and Model Driven Software Development to reduce cost and improve the quality and flexibility of the system. The goal of the campaign is to provide a plan to develop a robust, cost-efficient system that Marines can use as a part of their team to increase victory on the battlefield. Full Text

Keywords: UTACC, autonomy, campaign of experimentation, measure of effectiveness, measure of performance, coactive design, model driven software development

MEASURING THE IMPACT OF MOTIVATION ON ACHIEVEMENT AND COURSE COMPLETION RATES IN MARINENET DISTANCE EDUCATION
Timothy Lindshield–Captain, United States Marine Corps
Master of Science in Information Technology Management
Advisor: Robert Eger, Graduate School of Business and Public Policy
Second Reader: Steven Iatrou, Department of Information Sciences

The Marine Corps Distance Learning Network (MarineNet) is the primary source for distance education (DE) and online training for the Marine Corps. This research applies the learning theory of human motivation to archival MarineNet data to determine if motivation factors impact academic performance and course completion. The literature on motivation divides this variable into multiple types of intrinsic and extrinsic motivations. Each type of motivation has a different effect on human learning and course outcomes. To test this theory, archival data from the MarineNet was analyzed. MarineNet courses were divided into five categories based on the type of extrinsic or intrinsic motivation required for enrollment. The exam scores, failure rates, and completion rates were then calculated for each course category. The results indicate that exam scores and failure rates follow the expected trend in the literature on motivation. The results for completion rates oppose the existing literature. The results demonstrate the similarities and dissimilarities that exist between civilian
and Marine Corps DE programs as well as the gap in knowledge on human learning within the Marine Corps. Several recommendations are made for bridging the gap. Full Text

Keywords: MarineNet distance education, motivation, course completion, pass rates, completion rates

EXPLORING THE IMPACT OF FUEL DATA ACQUISITION TECHNOLOGY ON THE USMC EXPEDITIONARY ENERGY COMMAND AND CONTROL SYSTEM

This paper has been recognized as outstanding by its department.
Jeremy Thomas—Captain, United States Marine Corps
Master of Science in Information Technology Management
Advisor: Glenn Cook, Department of Information Sciences
Co-Advisor: Kathryn Aten, Graduate School of Business and Public Policy

Marine Corps commanders have inadequate tools for energy awareness on the battlefield. The purpose of this study is to explore how vehicle telematics could impact operational reach through improving awareness of fuel stocks from hours to near-real time. The research uses an exploratory sequential mixed methods design to establish how current practices may change with the introduction of telematics. The first-phase qualitative findings suggest that the tactical fuel supply chain is inherently unstable due to information delays and information processing distortion. The second phase tests the hypothesis that telematics has a positive effect on operational reach. This is accomplished through a supply chain simulation that compares the current process against a reengineered solution with telematics. Between the two models, the reengineered supply chain produced the opportunity for higher tempo, more agile combat units, and increased system stability. While these are desirable effects, operational reach was reduced by 7% as fuel was more available to combat units. In addition to fuel-saving initiatives that telematics may inform, there may be long-term benefits that warrant the full integration of fuel telematics throughout the military supply chain. Full Text

Keywords: systems thinking, systems dynamics, feedback loops, supply chain management, data acquisition technology

THE LEAN ACQUISITION STRATEGY BEHIND THE DOD’S 2015 ELECTRONIC HEALTH RECORD SYSTEM

Stanley Wong—Lieutenant Commander, United States Navy
Master of Science in Information Technology Management
Advisor: Mark Nissen, Department of Information Sciences
Co-Advisor: Mark Krause, Space and Naval Warfare Systems Command (SPAWAR)

The Department of Defense (DOD) failed in its previous attempt to acquire an enterprise electronic health record (EHR) system. The earlier program was plagued with schedule delays and cost overruns, which caused its failure. In July 2015, the DOD’s Program Executive Office awarded a $4.3 billion contract for a new EHR system that was below cost and ahead of schedule. The objective of this research is to investigate the key reasons why the DOD has succeeded in acquiring its most recent EHR. This study interviewed nine members of the Program Management Office (PMO) team for their opinions on and experiences with their acquisition and management strategies used during the procurement. The research showed that members from the program management to the program executive level shared commonalities in management styles that led to the successful acquisition of the DOD’s newest EHR system. The research identified several factors key to the program’s success: a tailored acquisition plan that allowed the PMO to directly report to the Under Secretary
of Defense for Acquisition, Technology and Logistics; a separation between the medical communities and the acquisition team; an engagement with industry early in the process; and a motivated leadership. Full Text

Keywords: electronic health record (EHR) system, Defense Healthcare Management System (DHMSM), health information technology acquisition, Integrated Electronic Health Record (iEHR), Veterans Information Systems and Technology Architecture (VISTA), acquisition management
This research explores a novel repair technique to reverse the sensitization of aluminum magnesium (Al-Mg) alloys. Al-Mg alloys can become sensitized when magnesium comes out of solution as a second phase, $\text{Al}_3\text{Mg}_2$, on the grain boundaries, eventually forming a continuous network and increasing susceptibility to intergranular stress corrosion cracking (SCC). Sensitized 5456 Al-Mg alloy samples removed from active Navy ships were metallographically characterized. These were compared to similar samples that were heat treated in order to reverse the sensitization effect. Both of these were also compared to as wrought 5456 aluminum. All samples were also tested for tensile strength and degree of sensitization using the ASTM G67 Nitric Acid Mass Loss Test (NAMLT). Two heat treatment profiles were compared. Both of these profiles successfully reversed the sensitization effect, with similar performance. Heat treatment may have affected the tensile properties and negatively degraded the resulting microstructure by annealing the material. Therefore, more research is necessary to prove this technique’s suitability for shipboard repair.

Keywords: reverse sensitizing 5456 aluminum alloy

A method for predicting the accuracy of unguided artillery projectiles is presented in this thesis. The goal was to develop a standalone program that would estimate accuracy without the need for a large database of weapon trajectory data. The presented method uses a simplified version of the modified point mass trajectory model and error computation models to predict error metrics that are particularly useful in predicting damage effects on various types of targets using the Joint Weaponeering System (JWS). The developed program is coded in Visual Basic, and the error metrics can typically be computed in less than 30 seconds for most ranges, in the computation precision specified in this thesis. The program was verified by comparing it against the FT 155-AM-02 firing table for the M107(HE) 155mm artillery projectile. The verification results demonstrate that the developed trajectory model closely matches the basic trajectory data to within 2% and ballistic partials to within 7% for most ranges of interest. Accuracy metrics derived from the ballistic partials generated from the developed program are within 10% of those derived from the firing table’s ballistic partials for typical firing ranges. The model is able to take into account wind effects and varying levels of meteorological data staleness. The developed program is named the Indirect Fire Delivery Accuracy Program (IFDAP), and it can be used...
to predict accuracies for any unguided projectile given the required aerodynamic coefficients, physical properties, and error budgets. Full Text

Keywords: accuracy, error, artillery, unguided, modified point mass, indirect fire

WIND ASSESSMENT FOR AERIAL PAYLOAD DELIVERY SYSTEMS USING GPS AND IMU SENSORS
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Master of Science in Mechanical Engineering
Advisor: Oleg Yakimenko, Department of Systems Engineering
Second Reader: Fotis Papoulias, Department of Systems Engineering

Numerous organizations within the Department of Defense have requested research and development efforts to create a lightweight Joint Precision Airdrop System (JPADS) capable of covertly distributing items to austere or contested locations. This mission has many critical challenges, with meteorological estimation near the top of the list due to a ram-air parachute’s high susceptibility to environmental forces. Computer-based modeling of environmental conditions is extremely difficult due to the chaotic and often unpredictable interactions of environmental factors and the surrounding topography, so bench tests, flight tests, and the post-processing of the resultant test data were the research methods used in development of this thesis. Ultimately, this thesis presents two models for winds aloft prediction capable of presenting an increased fidelity solution. Both methods were field tested and could be used in JPADS guidance, navigation, and control algorithms. Full Text

Keywords: JPADS, aerial delivery, commercial off-the-shelf, parachute control, wind estimation, quaternions, dynamic equations, kinematic equations, MATLAB

ASSEMBLY AND DESIGN MINIATURIZATION OF FLOATING SPACECRAFT SIMULATOR AND ITS MAGNETIC DOCKING INTERFACE
Jonathan Park–Lieutenant, United States Navy
Master of Science in Mechanical Engineering
Advisor: Marcello Romano, Department of Mechanical and Aerospace Engineering
Second Reader: Josep Virgili-Llop, Department of Mechanical and Aerospace Engineering

A detailed description of the assembly procedure of the Floating Spacecraft Simulator (FSS) has been produced for the Naval Postgraduate School’s Spacecraft Robotics Laboratory. This procedure has been used to assemble an additional FSS, resulting in a total of three operational units. The second part of the research effort was devoted to the design of a miniaturized version of the FSS. Due to the finite size of the testbed, it was desirable to reduce the footprint of the FSS to increase the available space. The preliminary, yet detailed, design of the miniaturized FSS reduced its footprint by nearly 70%, from 729cm² to 225cm². The components for the design were selected from commercial-off-the-shelf sources to standardize hardware and reduce cost. A new magnetic docking interface for the miniaturized FSS has also been designed. The main features of the docking interface include an electromagnet for docking and undocking, a spring-loaded connector, and an air connection used to transfer air. Future research will build a prototype of the miniaturized simulator and its docking interface, test its capabilities, and apply upgrades as new and improved components become available. Full Text

Keywords: spacecraft, robotics, miniaturization, docking, interface, mechanism, simulator
With the increased use of Unmanned Aerial Vehicles (UAVs) in military operations, their role in a missile defense operation is not well defined. The simulation program discussed in this thesis studies the feasibility of utilizing UAVs to patrol a potential Intercontinental Ballistic Missile (ICBM) launch area using a single or multiple Counter Unmanned Aerial Vehicles (CUAVs), detecting the launch event and tracking an ICBM using the CUAVs’ onboard optical sensors. The ultimate goal is to assess the parameters of ICBM ascent and provide target information to bring the attacking UAVs onto the anti-missile launch course to reliably intercept the threat. This thesis explores the challenges in creating a simulation program to process video footage from an unstable platform and the limitations of using background subtraction method to detect the missile motion. Although the simulation program test results showed that it is unable to consistently detect a missile launch and track its trajectory for all the test videos, the developed algorithms allowed a surveillance UAV to detect a missile launch for most of the videos and also track its trajectory with an accuracy that is sufficient for targeting purposes. This thesis is limited to using the simulation program to detect a launch event offline and is based on the amateur rocket launch data gathered during the launch trials at Mojave Desert in May of 2016. Full Text

Keywords: missile launch detection, missile trajectory tracking, computer vision, ORB (Oriented FAST and Rotated BRIEF)
This research investigates the inter-annual acoustic variability in the Yellow Sea identified from the Synoptic Monthly Gridded-World Ocean Database (SMG-WOD) as compared with the Navy’s Global Digital Environmental Model (GDEM). The SMG-WOD has a horizontal resolution of 1˚, 28 vertical levels from the surface to 3000 m depth and one-month temporal increments allowing individual years of acoustic data to be analyzed, whereas GDEM is a climatological database with a horizontal resolution of 1/4˚ and 78 vertical levels. The Yellow Sea is a semi-enclosed basin located between China and Korea with a mean depth of 40m; acoustics are driven by shallow water dynamics and interaction with the bottom. Seven distinct locations were selected for acoustic comparison based on various depths and bottom types. Composite analysis of the sound speed profiles reveals evident inter-annual variability at all locations, superimposed into a strong seasonal variability. Overall, SMG-WOD produces longer propagation ranges than GDEM in the winter, while ranges in the summer are similar within the two datasets, as modeled in BELLHOP. The most reflective bottom sediment (gravel) produced the longest ranges in both summer and winter, in contrast to other locations, which presented higher attenuation values and produced extremely limited ranges in the summer. Inter-annual variability, as expressed by extended acoustic ranges in SMG-WOD, indicates the need for a dataset with temporal resolution but optimally with higher vertical and horizontal resolution. Full Text

Keywords: Yellow Sea, inter-annual variability, shallow water acoustics, GDEM, Synoptic Monthly Gridded (SMG)-WOD, BELLHOP
Marine Corps Installation and Logistics Command is seeking assistance to improve operations within Marine Corps Maintenance Production plants. The problem addressed in this thesis deals with production lines: there must be a proper balance of parts on hand and inventory costs to ensure optimal production output. This problem becomes increasingly difficult to solve as production-line complexity increases and overall budget flexibility decreases. As the Marine Corps enters a time of fiscal austerity and reduced overseas combat operations, it is critical to optimize its processes so major end items are refurbished in the quickest and most cost-effective manner, thereby ensuring maximum combat effectiveness. This research focuses on developing a proof of concept analytical tool to better facilitate order management of repair parts. This tool integrates optimization and discrete-event simulation. This construct can potentially provide an effective means in improving order management decisions. However, the effectiveness of the tool is contingent on accurate vehicle condition history, parts order history, and/or future estimated parts shipping dates. Information derived from the analysis can be used to make recommendations for reorder policy, enable future model development, and improve the overall maintenance production process. 

Keywords: optimization, discrete event simulation, inventory management, Marine Depot Maintenance Command
The ability of unmanned aerial vehicles to execute intelligence, surveillance, reconnaissance, and targeting and strike missions creates a trade-space decision for naval aviation programmatic decision makers. In the military’s current fiscal climate, manned and unmanned aircraft compete for limited funding. This study takes a simulation approach using the simulation modeling framework based on intelligent objects (SIMIO) environment to model a fast attack craft/fast inshore attack craft anti-surface warfare expanded kill chain. It tests and analyzes multiple manned and unmanned aircraft configurations. In the evaluation of unclassified concepts of operation and use of unclassified data sources, results indicate that aircraft attrition due to hostile weapon engagements is the dominant factor in the determination of concept of operation efficiency. Based on the operational environment, low-cost and less capable unmanned aircraft provide an alternative to the increased survivability of manned aircraft or more capable and higher-cost unmanned aircraft. We provide quantifiable metrics that enable the efficient and effective selection of aircraft to execute fast attack craft/fast inshore attack craft anti-surface warfare kill chains.

Keywords: unmanned aerial vehicles, manned aircraft, kill chain, surveillance, detection, SIMIO

U.S. statutory policy requires the armed services to continuously balance manpower inventory with congressionally authorized requirements. Inaccurate forecasts put the Navy’s budget at risk and degrade overall mission readiness. Navy policymakers must be able to rely on accurate inventory forecasts to develop necessary manpower plans that steer inventory to match planned authorizations. Strength planners, in turn, rely on forecasting models like the Officer Strategic Analysis Model (OSAM) in an attempt to accurately predict future inventory levels. This study utilizes applications of data farming to OSAM to simulate Unrestricted Line Officer (URL) inventory over a seven-year period. Additionally, the research utilizes applications of Design of Experiments (DOE) to project Surface Warfare Officer (SWO) inventory across a variety of assumptions, including a proposed Enhanced Probationary Officer Continuation and Re-designation (EPOCR) policy. Analysis finds that current policy will reduce FY2016 URL inventory by 8% over a seven-year period, and over-execute SWO inventory authorizations by 40%. We find that EPOCR reduces operating strength deviation (OSD) in total SWO inventory strength by 12% by FY2022. Additionally, implementing a low accession
plan and a high transfer plan is the most robust in correcting OSD. When implemented correctly, EPOCR has the potential to decrease OSD to modest levels with minimal risk of under-execution. Full Text

Keywords: manpower, end strength, design of experiments, simulation, Officer Strategic Analysis Model (OSAM), inventory projection, data farming, robust analysis, meta-modeling

ANTI-SUBMARINE WARFARE SEARCH MODELS
This paper has been recognized as outstanding by its department.
Roey ben Yoash–Captain, Israel Defense Forces
Master of Science in Operations Research
Advisor: Moshe Kress, Department of Operations Research
Co-Advisor: Michael Atkinson, Department of Operations Research
Second Reader: Roberto Szechtman, Department of Operations Research

Stealth and high endurance make submarines ideally suited to a variety of missions, and finding ways to detect, track, and, if necessary, acquire and attack them has long been a topic of research. In this thesis, we study effective ways to operate an MH-60R helicopter in anti-submarine warfare (ASW) missions. Following an initial cue given by an external source indicating the presence of a possible submarine target, a helicopter is sent to detect, follow, acquire, and attack the submarine. To perform its mission, the helicopter can carry various payloads of sensors and torpedoes. The first part of the thesis focuses on a helicopter equipped with dipping sonar and develops a model that optimizes the operation of the helicopter and measures its effectiveness. We analyze the effect of the different input parameters, such as helicopter speed, submarine speed, sensor detection radius, and travel time to the point of detection on the optimal dipping pattern and the probability of mission success, and show that arrival time is the most important parameter. We also address the optimization problem associated with the payload of a helicopter on an ASW mission and determine the best mix of fuel, sensors, and weapons for a helicopter on such a mission. Full Text

Keywords: anti-submarine warfare, search and detection

AERIAL LOGISTICS MANAGEMENT FOR CARRIER ONBOARD DELIVERY
Samuel Chen–Lieutenant, United States Navy
Master of Science in Operations Research and Master of Science in Applied Mathematics
Advisor: Kyle Lin, Department of Operations Research
Co-Advisor: Wei Kang, Department of Applied Mathematics
Second Reader: Michael Atkinson, Department of Operations Research

Carrier onboard delivery (COD) is the use of aircraft to transport people and cargo from a forward logistics site (FLS) to a carrier strike group (CSG). The goal of this thesis is to study how the real-time cargo tracking capability can reduce the delay of high-priority cargo while increasing that of low-priority cargo. To do so, we analyze data from COD operations between 2010 and 2015 to develop a simulation model, and use those data to infer model parameters. Our simulation results indicate that, with two C-2A aircraft currently used by the Navy, real-time cargo tracking can reduce the delay of high-priority cargo by more than 50%, while increasing that of low-priority cargo by about 25%. The Navy plans to replace C-2A with a variant of V-22 Osprey for COD operations in the near future, and is conducting cargo space studies to facilitate this transition. By testing a few different model parameters based on studies available for V-22, our simulation results indicate a similar observation of delay tradeoff between high-priority cargo and low-priority cargo, although the tradeoff is less pronounced, mainly because three V-22 will be stationed at the FLS. Full Text

Keywords: carrier onboard delivery (COD), C-2A Greyhound, CMV-22B Osprey, carrier strike group (CSG), forward logistics site (FLS), sea base, discrete event simulation (DES), stochastic
A BROWNIAN BRIDGE MOVEMENT MODEL TO TRACK MOBILE TARGETS

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Master of Science in Operations Research
Advisor: Dashi Singham, Department of Operations Research
Second Reader: Michael Atkinson, Department of Operations Research

The Brownian bridge movement model (BBMM) models target movement between two known points as a Brownian bridge. This thesis extended the BBMM to account for multiple starting and ending points and to account for intelligence inputs midway through the target movement. The BBMM is applied to a military scenario where U.S. forces are conducting surveillance to monitor the breakout of Chinese forces in the South China Sea. Probability heat maps, depicting the probability of a target location at discrete times, are generated through simulations in MATLAB. Using the heat maps, this thesis developed an algorithm to automate the placement of sensors to detect the target. This thesis focused on the use of a network of unmanned sensors as the means for target detection. The relationship between the sensors’ attributes and the probability of detection is explored through a meta-experiment. The experiment utilizes a three-stage algorithm that generates heat maps, deploys sensors and randomizes intelligence inputs, and measures the probability of detection. A trade-off analysis was conducted and showed that to achieve a higher probability of detection, it is more effective to have sensors cover a wider area at fewer discrete points in time than to have a greater number of discrete looks using sensors covering smaller areas. Full Text

Keywords: Brownian bridge movement models, unmanned sensors, probability of detection, search and detection, simulations

NAVY OPERATIONAL PLANNER - UNDERSEA WARFARE MODULE

Guy Molina–Lieutenant, United States Navy
Master of Science in Operations Research
Advisor: W. Matthew Carlyle, Department of Operations Research
Second Reader: Jeffrey Kline, Department of Operations Research

Joint maritime operational planning is the difficult task of assigning various platforms to accomplish a multitude of missions in several areas of operations. The task becomes more difficult as resources are limited, mission requirements evolve, and platform capabilities vary. Emerging threats and technology in the undersea domain have created renewed interest and increased the priority of undersea warfare (USW) planning. This thesis develops and provides a proof-of-concept for a decision-support tool to aid operational planning in a USW environment. Specifically, it provides an optimization model with an optimal solution that maximizes multi-mission achievement in a theater USW environment through the scheduling of surface, sub-surface, and air assets over a non-fixed time horizon. Tactics and their mathematical representation are an input to our model. This makes the model easily adapted to any USW scenario and other warfare areas where mission achievement can be measured quantitatively. Full Text

Keywords: optimization, integer programming, binary integer programming, navy operational planner, maritime operational planning tool, decision aid, navy logistics, navy mission planner, NMP, NOP, USW, ASW, MIW
ESTIMATING THE DEPTH OF THE NAVY RECRUITING MARKET
Emilie Monaghan—Captain, United States Marine Corps
Master of Science in Operations Research
Advisor: Lyn Whitaker, Department of Operations Research
Second Reader: Jonathan Alt, Department of Operations Research

This research develops a statistical model for predicting the number of leads, as an indicator of market depth, that a ZIP code will produce for Navy Recruiting Command (NRC). The U.S. Navy recruits from all over the country, using previous accessions in a recruiting district to assign recruiters and goals. This research develops statistical models to determine the key drivers of the number of leads at the ZIP code level. This research develops a Poisson regression model to predict the number of leads using factors such as IRS-estimated population size and five cluster membership factors constructed from publicly available data sources. We recommend that NRC make use of the Poisson regression model in order to determine high-yield ZIP codes for market depth. Full Text

Keywords: Navy Recruiting Command, NRC, recruiting, data analysis, clusters, generalized linear regression, leads, Poisson regression

ANALYZING PREDICTORS OF HIGH OPIOID USE IN THE U.S. NAVY
Francis Tam—Lieutenant Commander, United States Navy
Master of Science in Operations Research
Advisor: Lyn Whitaker, Department of Operations Research
Second Reader: Andrew Anglemyer, Department of Operations Research

This study analyzes data from a select group of active duty (AD) service members enrolled to the Puget Sound area Navy military treatment facilities (MTF) in order to develop a model that identifies the risk that opioid users will become high opioid users, as defined by Navy Bureau of Medicine and Surgery (BUMED). The analysis examines the relationship between the response variable—high opioid user—as a function of a number of explanatory variables, including patient age, deployment history, sources of prescription and medical diagnoses. Logistic regression and machine learning models are used for data analysis. The study concludes that a simple, executable model that consolidates the variables to two explanatory factors performs as well, if not better than, the more complicated machine learning models. The two highly influential factors are the number of prescription sources for opioid medications and the total number of diagnoses. This logistic regression model has the potential to benefit Navy Medicine to make important decisions for their opioid-prescribed patients. With the ability to identify the risk that an opioid user becomes a high user, healthcare leaders can better manage resources to focus on the prevention and treatment for higher-risk patients. This concentrated coordination can result in improved patient care for this sub-population, reduced long-term cost for the military healthcare system and, overall, a more medically ready military force. Full Text

Keywords: opioids, statistical analysis, logistic regression, active duty military
This research investigates the ability of epi-splines to improve upon current methods of creating empirical semivariograms for use in optimal spatial estimation (OSE). Models utilizing traditional methods of curve fitting for semivariograms (spherical, exponential, and Matérn) used in the spatial estimation process are compared to a proposed model that employs an epi-spline for curve fitting. The resulting semivariograms are then used for kriging to produce spatial estimation using a sparse number of measurements. The epi-spline model improves upon the mean absolute error, mean standard error, and range of errors when compared to traditional methods. However, the comparisons indicate that goodness of fit does not drastically improve the resultant spatial estimation. The benefit of epi-splines, in addition to their ability to more accurately depict the relationship between data points, is their ability to incorporate soft information in the form of constraints and the tighter variance of estimates resulting from their use. Full Text

Keywords: epi-splines, terrain aided navigation, semivariograms, kriging, optimal spatial estimation
MASTER OF SCIENCE
IN
PHYSICAL OCEANOGRAPHY

SHORT-RANGE ACOUSTIC PROPAGATION UNDER ARCTIC ICE COVER DURING ICEX-16
Mitchell Nelson–Lieutenant, United States Navy
Master of Science in Physical Oceanography
Advisor: John Joseph, Department of Oceanography
Co-Advisor: Ben Reeder, Department of Oceanography

During the Arctic Submarine Lab–hosted 2016 Ice Exercise, short-range acoustic propagation under ice cover was evaluated. Sound speed profiles were measured and a series of acoustic signals at depths of 25, 50, and 183 meters and frequencies of 950, 2800, and 4050 hertz, respectively, were transmitted from the ice camp. Remotely located vertical line arrays at ranges of approximately 1.5 and 3 kilometers recorded the transmissions. The sound speed profile data obtained at the ice camp were used to model ray paths and transmission loss in the observed frequency, range, and depth combinations. The received signals were processed and analyzed to determine observed variability and transmission loss, which was then compared to the models. A key finding was the presence of a highly variable layer at 50 meters, which was characterized by its effects on sound signals and the sound speed profile. Observations also highlighted variability during transmissions and between trials while finding significant weaknesses in the modeling software’s ability to accurately predict the acoustic environment in the region. Full Text

Keywords: Arctic, Beaufort Sea, acoustic propagation, transmission loss, sound speed profile, bellhop, modeling

EFFECTS OF INTERNAL WAVES ON SOUND PROPAGATION IN THE SHALLOW WATERS OF THE CONTINENTAL SHELVES
Ming Yi Ong–Military Expert 6, Republic of Singapore Navy
Master of Science in Physical Oceanography
Second Reader: Tetyana Margolina, Department of Oceanography

Sound waves propagating through the oceans are refracted by internal waves. In the shallow waters of the continental shelves, an additional downward refraction of sound waves due to internal waves can cause them to interact more often with the seabed, resulting in additional energy from the sound waves being dissipated into the seabed. This study investigates how internal waves affect sound propagation on the continental shelves. It first quantified the types of internal waves on the continental shelf of California, near Point Sal, using data collected from a field experiment. Next, the effects that these internal waves have on sound propagation were quantified via simulations using a ray theory acoustic model. The results showed that internal waves in the experiment area were largely generated by tidal forcing. Compared to simulations without internal waves, simulations accounting for the effects of internal waves resulted in higher sound energy loss, as internal waves tend to cause sound waves to strike the seabed at steeper angles and over shorter distances. Thus, to enable a more accurate assessment of underwater acoustic system performance, the effects of internal waves on sound propagation in shallow waters need to be accounted for. Full Text

Keywords: internal waves, shallow water, sound propagation, continental shelves
In order to improve morale and raise the level of workforce productivity, it is critical to understand trends in an individual's motivational factors. We developed a closed-loop survey instrument and analysis methodology to identify distinct generational workforce motivational factors. Nine United States Army Research Development and Engineering Command (RDECOM) supervisory engineers, General Schedule (GS) 14 and 15, reviewed the survey instrument for relevancy, consistency, and applicability to meet the objective. Through the 108 comments received, the instrument was refined for transition to the Human Resources directorate in RDECOM. Subsequently, we developed a plan to provide recommendations within the current government compensation and workplace environment structure to motivate the target generational workforce demographic to improve productivity. The deliverables from this project include a comprehensive motivational factors survey and approach to qualitative analysis techniques. In addition, we recommend a phased approach for broad-level survey dissemination and performance of responses analyses by RDECOM to affect workforce policy change implementation. In conclusion, through utilization of a survey instrument, RDECOM will be able to recognize generational motivational factors, translate that knowledge into historically successful and new or novel methods of rewards, introduce workplace environment changes, and award high achievers in order to retain the engineering workforce.

Keywords: job characteristics model, motivation, workforce, generational, productivity, survey, career path, dimensions of culture, job satisfaction

RECENT ACQUISITION REFORM THROUGH TECHNOLOGY AND WORKFORCE IMPROVEMENTS
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Mark Marchioli–Civilian, Department of the Army
Master of Science in Program Management
Advisor: Brad Naegle, Graduate School of Business and Public Policy
Co-Advisor: Sean Murphy, United States Army

Research conducted for this joint applied project attempted to determine which policies should be put in place to further acquisition reform, based on a review of previous reforms enacted through technology and workforce improvements and their consequent outcomes. The objectives of the project were to examine the various acquisition reform initiatives that have been enacted recently, in order to determine what reforms have proven successful in producing the intended outcome, and what reforms have not been effective in changing the acquisition process to accomplish the initial goal. We found that the various reforms instituted over the previous twenty-five years have attempted to address how acquisitions can be streamlined within the Department of
Defense (DOD) to create efficiencies and improve cost and schedule for major programs. The major finding of this research is that there is overlap in the reforms that have been initiated and the changes they seek to implement. This makes it difficult to determine what reforms are driving successes and failures of acquisition reform policy and which will allow policy makers to adjust and drive positive change to the DOD acquisition process based upon verifiable data collection. This lack of data can only be fixed by resetting the acquisition reform process. It is our recommendation that a fifteen-year suspension be placed on acquisition reforms to stabilize the system and reset the data collection. Once stabilization has occurred, a new acquisition reform should be enacted, and a second suspension of fifteen years should be implemented to ensure data can be collected and the reform can be analyzed in isolation. This strategy would ensure that the data collected solely represents the effects of the latest reform over the course of an acquisition’s life cycle.

Keywords: acquisition reform

WORKFORCE RETENTION STUDY IN SUPPORT OF THE U.S. ARMY ABERDEEN TEST CENTER HUMAN CAPITAL MANAGEMENT STRATEGY

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Kristi Sanchez-Vahamonde–Civilian, Department of the Army
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Master of Science in Program Management

Advisor: Charles Pickar, Graduate School of Business and Public Policy
Co-Advisor: Heather Hilton, U.S. Army Aberdeen Test Center

In Fiscal Year 2015, the U.S. Army Aberdeen Test Center (ATC) experienced an attrition rate of 10.4% of its civilian workforce. Without mitigation, the current employee turnover could result in a loss of organizational knowledge, reduction in the number of highly skilled test center employees, and a failure for ATC to meet mission objectives, namely the execution of rigorous testing to support Department of Defense acquisition programs. A Workforce Retention Study (WRS) was conducted to analyze and address current ATC attrition trends and to provide recommendations on strategies to improve retention. To determine the most suitable recommendations, the WRS Research Team conducted a comprehensive literature review and collected data from existing sources. In addition, surveys were designed and deployed to current and former ATC employees to collect data regarding job satisfaction, motivation, demographics, leadership, suggestions for improvement, and future plans. The WRS identified that, in general, ATC civilian employees stay employed at ATC because of the organization’s meaningful mission, work/life balance, and effective supervisor-to-employee relationships. Factors contributing to employee dissatisfaction include a lack of career growth opportunities and competitive pay, inefficient organizational processes, ineffective leadership, lack of a flexible telework program, and poor facility/work conditions. In order to retain high-performing employees, the WRS Research Team recommends ATC increase career growth opportunities; streamline and simplify organizational processes; improve leadership training, accountability, and empowerment; implement a more flexible telework program; and prioritize infrastructure improvement.

Keywords: retention, attrition, civilian, workforce, Aberdeen Test Center, job satisfaction
AN ANALYSIS OF THE GPS R&D PROGRAM AS A CASE STUDY ILLUSTRATING DOD R&D AND ITS ASSOCIATED SUCCESSES TO JUSTIFY THE CONTINUED INVESTMENTS INTO AND SUSTAINMENT OF DOD R&D BUDGETS

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Michael Livaudais–Civilian, Department of the Navy
Master of Science in Program Management
Advisor: Brad Naegle, Graduate School of Business and Public Policy
Co-Advisor: Joshua Gomer, SPAWAR Systems Center Atlantic

The purpose of this joint applied project is to examine the trends in funding the Department of Defense (DOD), assess the importance of robust research and development investment on national security and warfighters’ capabilities, and justify continued devotion to funding DOD research and development (R&D). This research looks at the history of DOD R&D budgets and examines R&D spending trends and the importance of R&D to warfighters and humanity. An evaluation of the DOD’s R&D infrastructure and the impacts that drive future funding decisions is also part of this research. The case study of GPS is the primary example to defend the importance of R&D. The case study ranges from the history of its discovery, how it applies to the military, the associated compounded benefits to other discoveries, and technological improvements due to the maturation of GPS, to the associated benefits to the U.S. economy. Maintaining the proper level of DOD R&D funding in each fiscal year is imperative to allow DOD agencies to pursue R&D projects that enhance the warfighter’s future competencies and well-being in combat and in disaster-relief circumstances. Appropriate R&D funding also provides for accelerating mature technology solutions to be deployed with the current fighting force. Full Text

Keywords: DOD, R&D, GPS, budgets, military, funding

EVOLUTION OF THE OPERATIONAL ENERGY STRATEGY AND ITS CONSIDERATION IN THE DEFENSE ACQUISITION PROCESS

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Robert Rodgers–Civilian, Department of the Army
Master of Science in Program Management
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Co-Advisor: Robert Sheibley, Program Executive Office - Aviation, ITE/FVL Project Office

Our team looked at the DOD Operational Energy Strategy evolution and how it applies to new and modified weapon systems, considering the three-legged table of the acquisition system: 1) acquisition, 2) requirements and 3) planning, programming, budgeting, and execution (PPBE). We looked at the evolution of the operational energy area initiatives (executive orders, Defense Science Board studies, strategy and policy documents) with a focus on practical ways to gain traction or improve promulgation of key guidance and documentation for new-starts and/or upgrades to weapon system acquisition programs. Additionally, we highlight a few of the in-service initiatives and process improvements underway to reduce fuel consumption. Full Text

Keywords: operational energy, DOD acquisition system
IMPACTS OF TRANSITIONING FROM FIRM FIXED PRICE TO FIXED PRICE INCENTIVE FIRM TARGET CONTRACTS IN PEO MISSILES AND SPACE

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Brandi Ricketts—Civilian, Department of the Army
Shannon Tidwell—Civilian, Department of the Army
Master of Science in Program Management

Advisor: Charles Pickar, Graduate School of Business and Public Policy
Second Reader: Brad Naegle, Graduate School of Business and Public Policy

The objective of this project is to analyze the impacts to major weapon systems programs in Program Executive Office (PEO) Missiles and Space as a result of transitioning from firm fixed price (FFP) contracts to fixed price incentive firm target (FPIF) contracts. This project presents an in-depth examination of FFP and FPIF contract types, including definitions, profit mechanisms, and advantages and disadvantages associated with each type. This project reviews three iterations of Better Buying Power, with a specific focus on profitability and the use of FPIF contracts. The project presents and analyzes data collected through interviews with PEO Missiles and Space program management and contracting personnel who support programs that have transitioned from FFP to FPIF. The project also examines defense industry profitability and considers the perspective of defense contractors regarding Department of Defense profit policy. The analysis results indicate that the PEO is appropriately applying guidance for choosing FPIF contracts in follow-on production, and that there are both benefits and challenges associated with FPIF contracts. Recommendations include continuing to assess FPIF use for production programs, obtaining actual cost data, and improving incentive contracting workforce training. Further research on the longer-term effects of transitioning to FPIF is recommended.

Full Text

Keywords: firm fixed price, FFP, fixed price incentive firm target, FPIF, incentive, Better Buying Power

AN ANALYSIS OF ARMY CONTRACT ADMINISTRATION WITH REGARD TO CONTRACTING OFFICER'S REPRESENTATIVES

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Master of Science in Program Management

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

This research project examines Army contract administration procedures in the Continental United States (CONUS) and Outside Continental United States (OCONUS) performed by Contracting Officer’s Representatives (CORs) for service contracts. We analyze COR roles, responsibilities, education/training, communication, staff levels, oversight, and leadership support by comparing and contrasting Army COR contract administration processes from a CONUS and OCONUS perspective. The results inform Army Contracting leadership about differences and discrepancies that exist in the training of CORs and in the processes followed. Using regulatory documents, audit reports, and interviews with CONUS and OCONUS CORs and supervisors, leaders, and commanders of CORs, we found gaps and challenges that affect the completion of COR duties relating to Army service contracts. We identified five common COR issues that need to be addressed: education/training, communication, staff levels, oversight, and leadership support. We found that COR training differs in CONUS and OCONUS environments. Additionally, lessons learned revealed that COR training remains inadequate, communication among contracting personnel and CORs requires improvement, staff levels need to be increased to support contract administration, managers nominate CORs who
lack technical knowledge and experience, and commanders and leaders neither understand the requirements
needed to support contract administration requirements nor COR roles and responsibilities. Full Text

Keywords: contract administration, contracting officer's representative (COR), COR roles and responsibilities, COR training requirements.

WHY ARMY PROGRAM MANAGERS STRUGGLE AS LIFE CYCLE MANAGERS: A STUDY OF THE PM'S ROLES, RESPONSIBILITIES, AND BARRIERS IN THE EXECUTION OF OPERATIONS AND SUPPORT

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Co-Advisor: Brad Naegle, Graduate School of Business and Public Policy

Department of the Army program managers (PMs) have encountered difficulty in effectively managing the life cycle sustainment plan (LCSP) after transition into the Operations and Support (O&S) phase. Due to concerns with the M 777 Howitzer program, Program Executive Office Ammunition (PEO-Ammo) requested a review of the perceived lack of PM control during the O&S phase. This lack of control is focused on the LCSP funding, which PEO-Ammo believes has jeopardized the success of several of their programs beyond the production and deployment (P&D) portions of the system life cycle. For this reason, the PM's transition and execution of the O&S phase of a system after final production is the primary focus of this paper. An evaluation of the PM’s environment was conducted by analyzing PM and key stakeholder roles, responsibilities, resources, processes, and expectations. A gap analysis was performed and identified the loss of control perceived by the PM to be centered on the lack of LCSP funding control and visibility by the acquisition chain of command. The authors recommend a revision to Army Regulation 700-127 and DA PAM 700-127 in order to clarify the accountability of the PM and the Life Cycle Management Commands. Full Text

Keywords: program manager, PM, Operations and Support, O&S, life cycle

AN ANALYSIS OF THE ORGANIZATIONAL STRUCTURE OF REDSTONE TEST CENTER'S ENVIRONMENT AND COMPONENTS TEST DIRECTORATE WITH REGARD TO INSTRUMENTATION DESIGN CAPABILITIES

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Master of Science in Program Management
Advisor: Raymond Jones, Graduate School of Business and Public Policy
Co-Advisor: Brett Boren, Department of the Army

This research provides an analysis of the organizational structure of Redstone Test Center's Environment and Components Test Directorate, with specific regard to its instrumentation design and development capabilities, for the purpose of identifying opportunities to improve communication, standardization, and efficiency. Redstone Test Center (RTC) is one of the U.S. Army Test and Evaluation Command's test centers and is responsible for testing a variety of missiles, sensors, and Army aviation platforms. To accomplish this testing and provide value for customers, it is often necessary to build customized engineering design solutions to command and control the systems under test, to acquire test data, or to simulate real-world operation. RTC has a cadre of technically savvy engineers tasked with designing and developing these innovative test solutions. However, these engineers are isolated from each other organizationally, such that communication and collaboration are not common. Inefficiency is rife, and standardization of processes and procedures is almost nonexistent. This research found that these problems could be corrected through organizational changes, grouping the instru-
mentation design engineers together. The research also found that creating a leadership position tasked with promoting communication, efficiency, and standardization is also necessary to achieve these goals. Full Text

Keywords: organizational analysis, organizational structure, formal and informal networks

CASE ANALYSIS OF THE JOINT HIGH-SPEED VESSEL PROGRAM: DEFENSE ACQUISITION
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Master of Science in Program Management
Advisor: Charles Pickar, Graduate School of Business and Public Policy
Co-Advisor: Brad Naegle, Graduate School of Business and Public Policy

In response to a shifting National Military Strategy that renewed the focus of combat operations on smaller, projectable, and dynamic joint fight entities, both the Army and Navy reviewed requirements to address capability shortfalls in either their force structure or operational warfighting concepts, or both. Both services’ initial capability reviews resulted in a series of Advanced Concept Technology Demonstrations (ACTD) designed to explore the military utility of converted commercial, high-speed, shallow-draft vessels as a materiel solution. This case study investigates the use of the ACTD to support the requirements generation and validation processes, the extent to which Army transformational and mobility factors drove the requirements process, whether or not changes in logistic support plans for Joint High-Speed Vessel (JHSV) impacted Army mission capabilities, and ultimately if these considerations led to a successful joint service acquisition of the JHSV. For both services, the ACTD supported the requirements process but it also presented new challenges in the approach to a joint materiel solution that would satisfy operational needs. That approach prioritized, validated, and incorporated competing operational requirements into a final and unique materiel solution for a system capability that is fielded. Full Text

Keywords: Advanced Concept and Technology Demonstration (ACTD); Department of Defense (DOD), Theater Support Vessel (TSV), command, control, communications, computers, Intelligence Surveillance and Reconnaissance (C4ISR), Joint High-Speed Vessel (JHSV), Global War on Terrorism (GWOT), Civilian Mariners (CIVMAR), Contract Mariners (CONMAR), Military Sealift Command (MSC), Joint Capability Integration and Development System (JCIDS), Program Executive Office (PEO), Reception Staging Onward Movement and Integration (RSOI)

EFFECTS OF DEPARTMENT OF DEFENSE INSTRUCTION 5000.02 ON JOINT PROGRAM EXECUTIVE OFFICE–CHEMICAL BIOLOGICAL DEFENSE EFFECTIVENESS
Emily Whaley–Civilian, Department of the Army
Master of Science in Program Management
Advisor: Michael Boudreau, Graduate School of Business and Public Policy
Co-Advisor: Kate Ong, Joint Program Executive Office for Chemical and Biological Defense (JPEO-CBD)

This project provides an analysis on the expected effects of the most recent guidance that seeks to reform Department of Defense acquisition. Specifically, it researches and analyzes the effects of other acquisition reform items on the Joint Program Executive Office for Chemical and Biological Defense portfolio, and the expected trend of the newest guidance toward achieving greater effectiveness in acquisition. Methodology includes a comparative analysis of items that may indicate effectiveness, such as project schedules and number of documents required. Data and analysis indicate that Department of Defense Instruction 5000.02 may not have increased acquisition efficiency throughout the military services. Additional data collection specific to
smaller acquisition programs, as well as targeting study of leading rather than lagging indicators, may provide greater insight into the effects of recent acquisition reforms. Full Text

Keywords: Department of Defense Instruction (DoDI) 5000.02, better buying power, initiative, reform
MASTER OF SCIENCE
IN
SYSTEMS ENGINEERING

The following theses and capstone project reports were produced by residential or distance-learning students in the systems-engineering curriculum. The degrees awarded include Masters of Science in Systems Engineering, Systems Engineering Management, and Engineering Systems.

OPERATIONAL ENERGY CAPABILITY PORTFOLIO ANALYSIS FOR PROTECTION OF MARITIME FORCES AGAINST SMALL BOAT SWARMS
Whye Kin Melvin Cheang–Lieutenant Colonel, Republic of Singapore Navy
Master of Science in Systems Engineering
Advisor: Alejandro Hernandez, Department of Systems Engineering
Co-Advisor: Susan Sanchez, Department of Operations Research
Second Reader: Matthew Boensel, Department of Systems Engineering

This research examines the requirements of a capability portfolio for protecting a maritime force against a conventional small boat swarm attack. It provides decision makers with insights gleaned from exploring the trade space between weapon consumption, fuel consumption, and cost against the need to protect the force. Such an attack can deplete a force's resources and create risk to overall mission accomplishment. In this research, the Iranian training attack on a mock U.S. aircraft carrier in the Strait of Hormuz in February 2015 is the basis for the modeled scenario. A notional U.S. carrier group forms the baseline capability. An agent-based simulation scenario models the effectiveness of various capability options added to the baseline. These options include maturing developments such as the littoral combat ship (LCS) with modified Hellfire missiles, Spike LR missiles adapted onto autonomous 11-m unmanned surface vessels (USV), and advanced precision kill weapon system II missiles carried by Fire Scout tactical unmanned aerial vehicles (TUAV). A nearly orthogonal and balanced design, with 512 design points, yields broad insights and ensures an efficient experiment. Partition tree analysis, a non-parametric regression technique, identifies the presence and strength of influential factors. Efficient mixes of LCS, USVs, or TUAVs prove to be critical elements of protecting the maritime force while preserving its capabilities to accomplish the overall mission. Full Text

Keywords: small boat swarm, small boat threat, tradeoff studies, operational energy, weapon consumption, fuel consumption, cost, agent-based simulation, agent-based modeling, MANA

SHORT-TERM CYBER-ATTACKS WITH LONG-TERM EFFECTS AND DEGRADATION OF SUPPLY CHAIN CAPABILITY
Jose Lamberty–Lieutenant Commander, United States Navy
Master of Science in Systems Engineering
Advisor: Gary Langford, Department of Systems Engineering

Historically, cyber-attacks targeting computer networks have sometimes favored the attacker over the defender, resulting in great loss of information or denial of service. This thesis investigates the possibility that short-term cyber-attacks on network supply chains may conceal more sinister plans to destroy the long-term operational effectiveness for supplying goods during periods of critical needs. Using a life-cycle approach,
 quantifiable metrics were used to compare short-term risks with long-term risks in a network supply chain to establish the existenc of black swan events. Full Text

Keywords: cybersecurity, supply chain risk management, vulnerability analysis, short-term, long-term, black swan, quantifiable supply chain metrics

SYSTEMS ENGINEERING APPROACH TO DEVELOP GUIDANCE, NAVIGATION AND CONTROL ALGORITHMS FOR UNMANNED GROUND VEHICLE

This paper has been recognized as outstanding by its department.

Eng Soon Lim–Major, Republic of Singapore Army
Master of Science in Systems Engineering
Advisor: Oleg Yakimenko, Department of Systems Engineering
Second Reader: Fotis Papoulis, Department of Systems Engineering

Despite the growing popularity of unmanned systems being deployed in the military domain, limited research efforts have been dedicated to the progress of ground system developments. Dedicated efforts for unmanned ground vehicles (UGV) focused largely on operations in continental environments, places where vegetation is relatively sparse compared to a tropical jungle or plantation estate commonly found in Asia. This research explores methods for the development of an UGV that would be capable of operating autonomously in a densely cluttered environment such as that found in Asia. This thesis adopted a systems engineering approach to understand the pertinent parameters affecting the performance of the UGV in order to evaluate, design and develop the necessary guidance, navigation and control algorithms for the UGV. The thesis uses methodologies such as the pure pursuit method for path following and the vector field histogram method for obstacle avoidance as the main guidance and control algorithm governing the movement of the UGV. The thesis then considers the use of the feature recognition method of image processing to form the basis of the target identification and tracking algorithm. Full Text

Keywords: unmanned ground vehicles, pure pursuit, vector field histogram, feature recognition

THE SYSTEMS TEST ARCHITECT: ENABLING THE LEAP FROM TESTABLE TO TESTED

Javier Rinaldi–Civilian, Department of the Navy
Master of Science in Systems Engineering
Advisor: Oleg Yakimenko, Department of Systems Engineering
Second Reader: Kristin Giammarco, Department of Systems Engineering

Test and evaluation is one of the cornerstones of the systems engineering process. Not only is it the main vehicle to obtain information about the adequacy of a system design, but it positively influences design decisions and the systems engineering process, if used from the earliest life-cycle stages. Based on its value, the Department of Defense (DOD) and industry both have placed an emphasis on a shift-left mentality approach in recent years. Despite this, little guidance or policy is available on how to achieve this mentality within the scope of the systems engineering process. Through the analysis of the documented roles of test and evaluation in systems engineering, this thesis examines the concept that test and evaluation, based on its desired early involvement in the system engineering process, is a stakeholder in that process. In order to participate in that process, test and evaluation as an activity requires a proxy, which this work refers to as the systems test architect. The conclusion is that the Systems Test Architect will positively influence the systems engineering process by becoming the proxy stakeholder for test and evaluation. Full Text

Keywords: test and evaluation, test architect
ACHIEVING SHIP’S MISSION FLEXIBILITY THROUGH DESIGNING, PRINTING AND OPERATING UNMANNED SYSTEMS WITH ADDITIVE MANUFACTURING AND DELAYED DIFFERENTIATION

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Master of Science in Systems Engineering
Advisor: Ronald Giachetti, Department of Systems Engineering
Second Reader: Christopher Adams, Department of Mechanical and Aerospace Engineering

The design, print and operate (DPO) concept of operations (CONOPS) is proposed in this thesis as a new means of equipping ships with the appropriate capabilities. A companion concept of delayed differentiation is also introduced. In coupling the two concepts, additive manufacturing of capabilities in-situ becomes a possibility through the equipping of operational units with three building blocks: additive manufacturing systems and their raw materials, commercial off-the-shelf items and field programmable gate arrays. A concept of operations on uses of additive manufacturing was developed to illustrate the flexibility that the nexus of DPO CONOPS and delayed differentiation can engender. A tactical unmanned aerial vehicle (UAV) was used as an illustration to contextualize the concept of operations to enhance the littoral combat ship’s survivability when operating in the littorals. Assessments were then made on the feasibility of DPO CONOPS for shipboard uses. A tactical UAV was used as it was assessed to be operationally relevant and significant. Analytical models that could be iterated to achieve the specific-to-mission requirements were developed to analyze and assess the implementation approach. The models focused on the UAV’s reliability in fulfilling the mission as well as the build-time of the UAV. Full Text

Keywords: design, print and operate, DPO, unmanned aerial vehicle, UAV, concept of operations, CONOPS

APPLYING FAILURE MODES, EFFECTS, AND CRITICALITY ANALYSIS AND HUMAN RELIABILITY ANALYSIS TECHNIQUES TO IMPROVE SAFETY DESIGN OF WORK PROCESS IN SINGAPORE ARMED FORCES

Weihao Soon—Captain, Singapore Army
Master of Science in Systems Engineering
Advisor: Karen Holness, Department of Systems Engineering
Second Reader: Lawrence Shattuck, Department of Operations Research

The Singapore Armed Forces (SAF) has an instituted safety program that utilizes a generic risk assessment technique called the Risk Assessment Worksheet (RAW), which has several shortcomings including vague categorization to guide task decomposition, a generic 5-M factor hazard identification method, and insufficient resolution to prioritize risks. This thesis studies two alternative risk assessment techniques: Process Failure Modes, Effects, and Criticality Analysis (PFMECA) and Human Error Assessment and Reduction Technique (HEART), to determine their suitability for use by SAF. To compare the three techniques in assessing the risks associated with a specific work process, this thesis uses the activity of replacing the track on one side of an armored fighting vehicle in the workshop. Both PFMECA and HEART analyses were more effective than RAW. In addition, PFMECA and HEART were equally effective at identifying the top risks, as shown through side-by-side comparison and a case study. Furthermore, SAF personnel can easily learn and apply the PFMECA technique because SAF is already using a similar technique, the FMECA technique, for technical system analysis. Full Text

Keywords: FMECA, PFMECA, HRA, HEART
ENHANCING AUTONOMY OF AERIAL SYSTEMS VIA INTEGRATION OF VISUAL SENSORS INTO THEIR AVIONICS SUITE
Kenny Teo—Captain, Singapore Army
Master of Science in Systems Engineering
Advisor: Oleg Yakimenko, Department of Systems Engineering
Second Reader: Fotis Papoulias, Department of Systems Engineering

Autonomous aerial systems have started to gain much traction in the military intelligence, surveillance and reconnaissance domain. The remotely piloted systems, such as the Predator, are already successful unmanned systems; the next step forward is to use autonomous systems to overcome high manning requirements. These systems are scalable and serve as excellent force multipliers, but there are other technological issues to overcome to qualify an autonomous aerial system, such as navigation and collision avoidance. This thesis explores autonomous system capabilities using quadrotors in the context of the Singapore Armed Forces. It first applies a systems engineering approach to analyze stakeholders’ needs, then translates the needs to functional requirements, and concludes with the development of a possible system architecture for an autonomous quadrotor system. The author then conducted indoor flight experiments to validate the capabilities of waypoint navigations and collision avoidance. The results were highly encouraging and qualified the aerial platform for subsequent visual sensor integration. Full Text

Keywords: autonomous system, quadrotors, direct method, inverse dynamics, virtual domain

SYSTEMS ENGINEERING APPROACH TO GROUND COMBAT VEHICLE SURVIVABILITY IN URBAN OPERATIONS
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Master of Science in Systems Engineering
Advisor: Christopher Adams, Department of Mechanical and Aerospace Engineering
Co-Advisor: Fotis Papoulias, Department of Systems Engineering
Second Reader: Joseph Klamo, Department of Systems Engineering

Ground combat vehicles (GCV) traditionally rely on passive armor to reduce their vulnerability against threats. This is insufficient now, given the increasing gap between threat lethality and passive armor capability and the change in threat scenario from relatively open terrain to urban terrain. This thesis provides an overview of system survivability and discusses the conventional approach to GCV survivability. This thesis then uses a systems engineering approach to guide the subsequent study, which identifies likely threats to GCVs in an urban environment and discusses potential susceptibility reduction techniques and technologies that can counter the threats. This thesis then develops a survivability assessment model (using Imagine That’s Extend-Sim), which quantifies the different survivability characteristics of a GCV and determines the sets of survivability characteristics to meet the defined survivability requirement. Finally, this thesis demonstrates the use of a decision-making methodology (multi-attribute decision-making) to manage the capability conflicts that arise between survivability and other key platform capabilities. Therefore, this author hopes to help military planners and engineers design more robust, holistic and balanced survivability solutions for GCVs, to provide more flexibility against different types of threats and threat scenarios. Full Text

Keywords: ground combat vehicle, survivability, susceptibility, vulnerability, urban operations
MODELING OF ENGINE PARAMETERS FOR CONDITION-BASED MAINTENANCE OF THE MTU SERIES 2000 DIESEL ENGINE
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Master of Science in Systems Engineering
Advisor: Robert Koyak, Department of Operations Research
Co-Advisor: Fotis Papoulias, Department of Systems Engineering
Second Reader: Mark Rhoades, Department of Systems Engineering

Condition-based maintenance (CBM) entails performing maintenance only when needed to save on resources and cost. Formulating a model that reflects the behavior of the marine diesel engine in its normal operating conditions would aid in making predictions of the behavior of a condition monitoring parameter. Modeling for CBM is a data-dependent process. Data acquisition, processing, and analysis are required for modeling the behavior of the normal operating conditions of the diesel engine. This thesis leverages on existing data collected through sensors on a diesel engine to describe these conditions using regression analysis. The proposed data selection criteria ensure that data used for modeling are suitable. To model the behavior of the engine, an autoregressive distributed lag (ARDL) time series model of engine speed and exhaust gas temperature is derived. The lag length for ARDL is determined by whitening of residuals using the autocorrelation function. Due to non-normality of the residuals, a nonparametric quantile regression approach is adopted, and the derived model allows us to predict the parameter (exhaust gas temperature) that we consider. Full Text

Keywords: condition-based maintenance, regression, autoregressive distributed lag, marine diesel engine, modeling, prediction, nonparametric

OPTIMIZATION CASE STUDY: ISR ALLOCATION IN THE GLOBAL FORCE MANAGEMENT PROCESS
Guillermo Carrillo—Lieutenant Commander, United States Navy
Master of Science in Systems Engineering Management
Advisor: Walter Owen, Department of Systems Engineering
Co-Advisor: Paul Ewing, Department of Operations Research

Global Force Management (GFM) is a force-allocation, process-driven system that distributes military forces across the globe to meet Combatant Commander objectives. The goal is to match military capabilities provided by the military services to Geographic Combatant Commander requirements. This thesis is a proof of concept for an optimization model that maximizes the distribution of a finite number of full motion video intelligence, surveillance, and reconnaissance (ISR) assets to a prioritized list of requirements to meet national security objectives. This thesis examines the ISR GFM process. With the insight gained to the process, the model applies a mixed integer linear programming formulation to provide an optimized force allocation recommendation. The model's objective function managed the trade-off between FADM priority and platform consideration, which optimized the allocation 902 hours per day of full motion video to meet 1902 hours per day of 20 CCDR requirements. The research, methodology, and analyses presented in this thesis is a successful proof of concept proving that this optimization model will objectively inform senior decision makers in the Department of Defense for intelligence surveillance reconnaissance Global Force Management allocation. Full Text

Keywords: GFM, global force, allocation, ISR, optimization, requirements, force provider, mixed integer linear program
This thesis describes a framework upon which programs, particularly those identified as engaging in rapid acquisition, can compare themselves to determine if the adoption of a Model-Based Systems Engineering (MBSE) approach might be feasible. The research was established as a case study of several defense acquisition programs that are using MBSE as part of their software development process by providing a background for those programs being evaluated, then delving into their individual MBSE processes to identify the principal elements that added the most value in terms of delivering a suitable and effective product expediently. After completing the characterization of the MBSE approaches, an assessment of a sample target program was conducted, exercising the framework developed. The research indicates that while the implementation of MBSE can require additional effort during the initial development stages, the demonstrated benefits typically outweigh the extra upfront burden by reducing the overall design cycle time and improving the validation and verification activities. An in-depth mapping of the upfront MBSE work required would provide additional engineering rationale to justify the programmatic investment for implementing an MBSE approach.

Keywords: MBSE, rapid acquisition, software development process, analysis framework, evaluation guidelines
LOW-IMPACT SPACE WEATHER SENSORS AND THE U.S. NATIONAL SECURITY SPACECRAFT

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Advisor: Mark Rhoades, Department of Systems Engineering
Second Reader: Steve Tackett, Space Systems Academic Group

Incorporating inexpensive low-impact targeted surface charging (plasma) and total ionizing dose (radiation) sensors onto national security spacecraft to monitor real-time environments local to each spacecraft will close a gap in the U.S. space weather observation network. Evaluation of the current space weather monitoring architecture identified key stakeholders and their needs, as well as a gap in targeted data. This paper outlines a solution to improve national security spacecraft anomaly resolution and resiliency while decreasing system life-cycle cost. A technical assessment of available products found that low-cost, low-impact spacecraft charging and radiation sensors exist that meet stakeholder needs. However, upon evaluating the acquisition process, weaknesses in the Joint Capabilities Integration and Development System (JCIDS) prevented the stakeholder's requirements from being met. Physical modifications essential for the current space weather observation network to meet the stakeholder's needs were identified in an IDEF0 model that represented the functional decomposition for integrated and proliferated targeted sensors using ViTech© CORE system architecting software. A risk assessment for sensor integration during each phase of the acquisition process resulted in a recommendation for national security space enterprise leadership to bypass the JCIDS process and require all national security space systems integrate low-impact space weather sensors prior to Milestone-C. Full Text

Keywords: space weather, space weather forecasting, space situational awareness, space environment sensors, dosimetry, dosimeter, space particles, radiation detector, solar proton event, plasma environment, radiation environment, spacecraft charging, total ionizing dose, national security

FACTORS THAT INFLUENCE HUMAN BEHAVIOR AND NEGATIVELY AFFECT ENERGY CONSUMPTION IN USMC GROUND UNITS DURING OPERATIONS

John Peters–Civilian, Department of the Navy
Master of Science in Systems Engineering Management
Advisor: Eugene Paulo, Department of Systems Engineering
Second Reader: Paul Beery, Department of Systems Engineering

The energy required to employ today’s technologies on the battlefield is a logistical burden and a potential vulnerability. The thirst for energy is jeopardizing the self-sufficiency and security of the deployed warfighter. Improvements to equipment and the employment of renewable energy systems fail to address the impact that human behavior has on energy consumption and overlooks a tremendous opportunity. The Marine Corps’ return to its expeditionary posture as a fast, austere and lethal force requires that it come to terms with energy consumption. The data and analysis presented in this thesis identifies behavioral trends and indicates that significant energy savings can be obtained through a concerted effort and behavior-change strategy that includes training and education, policy and planning, leadership and communication to improve individual and organizational awareness of the importance of efficient and effective use of energy. In particular, opportunities are available for significant improvement in the use and employment of generators, environmental control units and vehicles. Energy-related behavior changes within the operational environment can have a positive impact in several areas to include improved energy security, greater self-sufficiency, increased operational reach and fewer casualties from force protection of fuel resupply convoys. Full Text

Keywords: energy security, operational energy, human behavior, vehicle idling, energy strategy, energy behavior, energy reductions, behavior change
SYSTEMS ENGINEERING

SYSTEM OF SYSTEMS ENGINEERING AND INTEGRATION PROCESS FOR NETWORK TRANSPORT ASSESSMENT

Matthew Rambo–Civilian, Department of the Navy
Master of Science in Systems Engineering Management
Advisor: Warren Vaneman, Department of Systems Engineering
Co-Advisor: Anthony Russell, Space and Naval Warfare Systems Command (SPAWAR)

This thesis proposes a system of systems (SoS) engineering and integration (SoSE&I) process and provides a use case for a network transport analysis that is tailored to an information technology (IT) network. The purpose of the process is to identify the capabilities required for the transport and provide a framework for analysis, test, and implementation to ensure that the network IT system supports the user requirements for the overall SoS. The thesis then details a Navy use case through the steps of the proposed process and provides example steps and criteria for the assessment. Prior research on SoS architectures was leveraged in developing the proposed process and tailored to support IT network challenges. The thesis makes recommendations to prioritize capabilities, to implement capability-based quality of service (QoS), to have a detailed understanding of applications for the correlation of application to capability, to continuously monitor IT networks to ensure satisfactory performance with new applications or user behavior, and to ensure governance is applied through the process to ensure oversight of design and tradeoff decisions for network throughput analyses. Full Text

Keywords: network transport, SoS architecture, SoS testing, SoSE&I

A SYSTEM ENGINEERING STUDY AND CONCEPT DEVELOPMENT FOR A HUMANITARIAN AID AND DISASTER RELIEF OPERATIONS MANAGEMENT PLATFORM

Julie Reed–Captain, United States Air Force
Master of Science in Systems Engineering Management
Advisor: Eugene Paulo, Department of Systems Engineering
Second Reader: Bonnie Young, Department of Systems Engineering

This thesis develops a concept and initial system definition of a Humanitarian Aid and Disaster Relief (HADR) Operations Management Platform (OMP) that supports various stakeholders involved in time critical humanitarian response efforts. The concept for the OMP explores the various functions necessary to manage HADR operations to include facilitation of information exchange, collaboration among disaster responders, and a common operating picture (COP) that informs decision makers of the operational environment. The development of the OMP uses system engineering methodologies and a tailored development process to identify the requirements, functions, and architecture necessary to support the platform. The OMP concept also includes multiple data sources for near real-time information and support tools for assessments, planning, implementation, execution, and evaluation. This thesis also assesses advances in technology and applications to more effectively support and manage HADR efforts. As such, the OMP takes into consideration how current HADR operations are conducted today, and the role of virtual volunteers in supporting the platform. These virtual volunteers support the HADR effort by conducting tasks virtually via their computers and an internet connection anywhere in the world. Full Text

Keywords: humanitarian aid, disaster relief, systems engineering, concept development, platform

Full Text
Over the past decade, the Department of Defense has placed a great amount of attention on the advancements of unmanned aerial vehicles (UAVs), and more specifically on employing a large number of autonomous UAVs into swarms. These swarms form an organized cluster of vehicles to act out multifaceted operations as a group. Despite the benefits offered by UAV swarms, there are hurdles that engineering teams must grapple with while designing a UAV swarm system. One key area is creating and understanding the swarming behavior and revealing all potential failure scenarios that may impact the desired mission. This research uses Monterey Phoenix (MP) to model system behaviors by grouping them into distinct, reusable agent-like models of possible actor behaviors and modeling actor interactions as separate constraints. This approach affords the ability to compute every possible variation of actor behaviors with every other possible actor behavior from these models, which generates an exhaustive set of possible scenarios or event traces. Through manual inspection or semi-automated assertion checking of these event traces, the discovery of unwanted and undesirable behaviors and failure modes is achievable, which allows mission planners to then counteract these unsolicited instances with necessary failsafe behaviors.

Keywords: swarm, search and rescue, behavior modeling, UAV, Monterey Phoenix, failure modes, failsafe behaviors

This thesis presents a detailed process and model describing how public sector organizations can implement a research and development (R&D) portfolio optimization strategy to maximize the cost-adjusted benefit metric of a portfolio while simultaneously seeking to maintain and improve a national strategic technologic advantage. The model is applied to an R&D dataset from the FY 17 Naval Research Program (NRP) at the Naval Postgraduate School. The process presented follows a framework incorporating proposal filtering for initial selectivity, proposal weighting based on defined criteria and alignment with the organization’s mission and purpose, proposal value and risk determinations, and concludes with portfolio optimization. The optimization’s objective function sought to maximize the sum of a portfolio’s cost-adjusted benefit calculation, subject to remaining within the NRP’s research and development budget. The model effectively resulted in predominantly selecting proposals with medium, high and very high probabilities of success in the risk category and valuations predominantly in the medium, high and very high range. The completion of this thesis has provided a new perspective on R&D selection strategies for public sector investment and highlighted the challenges of placing a value on a public sector R&D proposal.

Keywords: research and development, R&D, portfolio optimization, public sector valuation
A META-ANALYSIS OF CORROSION STUDIES FOR MARITIME PATROL AND RECONNAISSANCE AIRCRAFT (MPRA)

Thomas Wilson—Civilian, Department of the Navy
Master of Science in Systems Engineering Management
Advisor: Walter Owen, Department of Systems Engineering
Second Reader: Ronald Carlson, Department of Systems Engineering

It is very important to find means and methods to reduce maritime patrol and reconnaissance aircraft (MPRA) corrosion costs. This thesis examines recent Department of Defense (DOD) and Government Accounting Office (GAO) corrosion studies to conduct meta-analysis and make recommendations based on correlated findings. The methods adopted for this thesis consist of a literature review, heuristic flow diagram, case study selections and meta-analysis. The conclusions are that the cost of MPRA corrosion treatment and prevention is detrimental in the consumption of manpower and resources, is a high readiness degrader, and diverts funding that could be used for future programs. Corrosion treatment and prevention processes of the past may not be environmentally acceptable today. This study recommends that hazardous material used to combat aircraft paint/corrosion be carefully monitored and reduced to a minimum as soon as possible. Further, man-hour reduction studies are needed to optimize a balance between corrosion prevention and treatment cost and man-hours. One recommendation is to establish an international naval corrosion working group to pool talent and resources with our naval allies toward developing common corrosion tactics. An additional recommendation is to fund a comprehensive MPRA wash interval optimization study to include all MPRA-type model series aircraft.

Keywords: Naval Aviation Logistics Command Management Information System (NALCOMIS), Optimized Organizational Maintenance Activity (OOMA), Department of Defense (DOD), Government Accounting Office (GAO)

A BENEFIT ANALYSIS OF USING A LOW-COST FLIGHT SIMULATOR FOR THE MH-60R

J. Gregory Zilai—Lieutenant, United States Navy
Master of Science in Systems Engineering Management
Advisor: Alejandro Hernandez, Department of Systems Engineering
Second Reader: Joseph Sweeney, Department of Systems Engineering

Tactical proficiency in the Helicopter Maritime Strike community is pivotal in the United States National Defense Strategy. In an increasingly tight fiscal environment, flight hours available for training have been diminishing and will continue to diminish, despite an ever-growing battery of tactical requirements. The existing flight simulator for the MH-60R is highly capable; however, each hour of use is expensive, and not every capability of the simulator is required for every training event conducted. This thesis examines eight different configurations of a low-cost trainer, and analyzes the impact of each configuration on the utilization rates of the existing simulators. It uses the throughput data from the MH-60R Fleet Replacement Squadron to compare the configurations, as the Fleet Replacement Squadron is the single largest user of the devices. This thesis does not aim to determine an optimal configuration. It provides analytical evidence that the introduction of a low-cost trainer has the ability to make the existing devices significantly more available for events that require a high level of fidelity.

Keywords: aviation, simulator, MH-60R, FRS, flight training, helicopter, HSM
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