

# MASTER OF SCIENCE IN OPERATIONS RESEARCH

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## CONCEPT FOR A SPECIAL OPERATIONS PLANNING AND ANALYSIS SYSTEM

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This thesis designed and partially implemented a platform independent mission planning and analysis system for the United States Special Operations Command (US SOCOM). The ability to move to platform independent technologies is particularly important for the special operations community since it cannot expect standardized computer planning and analysis systems for their joint, multi-national, and inter-agency operations. This thesis also investigates the ability to integrate legacy systems using an open architecture on an object web. In addition, this thesis incorporates operations research methods into this system to show their importance in planning and analysis. The system is developed in the Java programming language using loosely coupled components. The system involves an image component that contains a map with overlays. The use of common object request broker architecture (CORBA) for integrating legacy systems is discussed. To show the relevance of this system, a scenario involving joint and coalition forces is developed. The scenario demonstrates the usefulness and need for platform independent planning and analysis systems. Finally, this thesis recommends an architecture that USSOCOM should investigate for its future mission planning, analysis, rehearsal, and execution (MPARE) system.

**DoD KEY TECHNOLOGY AREA:** Command, Control, and Communications

**KEYWORDS:** Special Operations, Map-Based Planning, Java, Platform Independent, MPARE, Loosely Coupled Components

## AN ANALYTICAL APPROACH TO OPTIMAL AIMING FOR THE ARMY TACTICAL MISSILE SYSTEM

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After Desert Storm the Army Tactical Missile System's (ATACMS) range was increased from 165km to 300km. The increase in range was gained by reducing the total number of submunitions. To offset the loss of effectiveness, a global positioning system was added to the guidance unit to increase accuracy of the missile.

Further increases to the missile's effectiveness can be gained by optimizing the aimpoints at which the missile is fired. This can be accomplished by using an analytical function that predicts the probability of kill based on several parameters that are dependent on the type of target and missile. This function, through the use of a model such as the OpAimer model developed in this thesis, can then assure at least a locally optimal solution for the aimpoints. The parameters of the model include the target's location error, the accuracy of the missile and the shape of the distribution of a missile's bomblets about its center of impact.

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Optimization methods such as the OpAimer model must become part of the current fire direction systems. Their inclusion will ensure that the ATACMS missile is used effectively and limited assets are not unnecessarily wasted.

**DoD KEY TECHNOLOGY AREA:** Conventional Weapons, Computing and Software

**KEYWORDS:** Army Tactical Missile System, ATACMS, Optimal Aiming

### A COMPARISON OF ANALYSIS IN DISTRIBUTED INTERACTIVE SIMULATION AND HIGH LEVEL ARCHITECTURE

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As the Department of Defense (DoD) continually relies more on Modeling and Simulation (M&S) for testing, analyzing, and training, issues of interoperability have become one of the most important concerns. As such, DoD adopted the Distributed Interactive Simulation (DIS) protocol in 1991. Although successful in many aspects, DIS is limited by available information from models, memory and network requirements, and analytical tools available. Therefore, in 1996 the Defense Modeling and Simulation Office (DMSO) released the High Level Architecture (HLA), an object-oriented approach to interoperability.

This thesis compares these different approaches to analysis to determine functionality in terms of gathering, processing, and reporting on analytical questions in both environments. To compare DIS and HLA analysis, three simulation runs were conducted: Janus vs. Janus in DIS, HLA without an Analysis Federate, and HLA with an Analysis Federate. The Analysis Federate is an HLA-compliant software package that gathers and processes information for analysis requirements. The results of the three simulation runs and subsequent analysis demonstrated the techniques and approaches for each infrastructure. The resulting comparison between them show HLA with the Analysis Federate is the easiest and most functional tool.

The Analysis Federate fills an analysis void currently in HLA and by implementing it with the study question model tree methodology, an analyst will be more effective and be able to provide real-time feedback.

**DoD KEY TECHNOLOGY AREA:** Modeling and Simulation

**KEYWORDS:** Analysis Federate, Distributed Interactive Simulation (DIS), High Level Architecture (HLA), Federation Object Model (FOM), Simulation Object Model (SOM), Janus, Gateway, Study Question Model Tree, Federation, Run-Time Infrastructure (RTI), Protocol Data Unit (PDU), PDU Adapter Software System (PASS)

### ANALYSIS OF NAVY DELAYED ENTRY PROGRAM AND RECRUIT TRAINING CENTER ATTRITION

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Attrition from the Navy's Delayed Entry Program (DEP) and attrition from Bootcamp are costly phenomena. The Commander of Naval Recruiting (CNRC) and Center for Naval Analysis (CNA) have periodically modeled both DEP and Bootcamp attrition with logistic regression. This thesis analyzes current data provided by CNRC and CNA. Both DEP and Bootcamp attrition are modeled using logistic regression and tree-structured classification. For DEP, the logistic model indicates that individuals who accept incentives prior to enlistment (i.e., Navy College Fund or Enlisted Bonus Program)

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and individuals who change enlistment programs (while in DEP) have a significantly lower propensity to attrite from DEP than others. The DEP tree model indicates that an individual with a low Armed Forces Qualification Test (AEQT) score, no high school diploma and a long scheduled DEP duration has a 97% probability of attriting. For Bootcamp, the logistic model indicates that individuals who use tobacco products, individuals who do not exercise, and individuals that have criminal waivers have a significantly higher propensity to attrite than others. The Bootcamp tree model shows that smokers and individuals with low AFQT scores have higher propensities to attrite than others. The models are tested using random partitions and this analysis shows that all of the models predict poorly at the individual level, despite strong statistical significance.

**DoD KEY TECHNOLOGY AREA:** Manpower, Personnel, and Training

**KEYWORDS:** Attrition, DEP, Bootcamp, Logistic Regression, Tree-structured Classification, AFQT

### ANALYZING SENSOR-SHOOTER LINKS THROUGH SIMULATION

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Today's military is changing. We are changing the size and structure of our forces, reevaluating our missions, and looking at military applications of new and emerging technologies. Simulation will play a key role in aiding decision-makers during these changes. This thesis demonstrates the development and use of simple, single-purpose simulation models. These models answer specific questions and can be created quickly with readily available tools. The simulation developed in this thesis is designed to serve as a basis for further studies involving the Longbow Apache. This simulation is a stochastic, process-oriented, event-step model.

To demonstrate the use of this model, a comparative analysis was performed to evaluate two field artillery "call-for-fire" procedures. Is a proposed call-for-fire procedure based on new digital technologies superior to the current process? The experiment incorporated a pre/post-process design resulting in paired observations of the artillery's effectiveness before and after incorporation of the new technology.

Results indicate the proposed procedure is superior to the current procedure. Sensitivity analysis was also performed on two input parameters as a three-by-three factorial experiment. This analysis concluded the previous results were sensitive to the specific parameter values chosen. Recommendations are made for model improvement and topics for future study.

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

**KEYWORDS:** Digitization, Information Superiority, Dominant Battlespace Awareness

### ALLOCATING FLIGHT HOURS TO ARMY HELICOPTERS

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Army helicopter battalions, consisting of 24 helicopters valued from \$206.4 million (1311-60 Blackhawk battalion) to \$432 million (ALH-64 Apache battalion), allocate flight hours to helicopters using manual techniques that have caused an unnecessary decrease in battalion deployability. This thesis models the battalion's flight hour allocation problem using optimiza-

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tion; it develops both a mixed integer linear program and a quadratic program. The 2nd Battalion, 4th Aviation Regiment of 4th Mechanized Division, currently uses a spreadsheet implementation of the quadratic program developed by the author called QFHAM (Quadratic Flight Hour Allocation Model), that is available to other battalions for use with existing software and computer resources. The mixed integer linear program, called FHAM (Flight Hour Allocation Model) more appropriately models the problem, but requires additional software. This thesis validates the two models using actual flight hour data from a UH-60 battalion under both typical training and contingency scenarios. The models provide a monthly flight hour allocation for the battalion's aircraft that results in a steady-state sequencing of aircraft into phase maintenance, thus eliminating phase maintenance backlog and providing a fixed number of aircraft available for deployment. This thesis also addresses the negative impact of current helicopter battalion readiness measures on deployment and offers alternatives.

**DoD KEY TECHNOLOGY AREA:** Air Vehicles

**KEYWORDS:** Helicopter, Flight Hour Allocation, Phase Maintenance

### COMPANY TEAM SURVIVABILITY AT THE U.S. ARMY NATIONAL TRAINING CENTER

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This research answers the following questions about training exercises at the Army's National Training Center (NTC) at Fort Irwin, California: "Which company team was the most survivable in the task force?" and "What did that company team do differently to become the most survivable?" The research examines data collected over four month-long brigade training exercises at the NTC, including analysis of 88 company team battles. The measure of effectiveness (MOE) is the average system survival time for each company team for each battle. The company team that achieves the highest MOE score for a battle is considered the most survivable company team. The MOE is scaled for comparisons over the course of many battles. The MOE is then used as the dependent variable for a series of separate analyses of the data, which answer the second question. These analyses use a collection of 20 independent variables and six research questions to differentiate between more and less survivable company teams. The conclusions are that company teams whose leadership survives longer, who have a higher proportion of tanks, and who perform security operations better are more survivable. The research further recommends that the NTC's data collection efforts be automated and standardized among the collection teams.

**DoD KEY TECHNOLOGY AREAS:** Ground Vehicles, Manpower, Personnel, and Training

**KEYWORDS:** National Training Center (NTC), Company Team, Survivability