MASTER OF SCIENCE
IN
OPERATIONS RESEARCH

ANALYZING SOLDIER IN-PROCESSING AT THE UNITED STATES ARMY FIELD ARTILLERY TRAINING CENTER THROUGH SIMULATION

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Each year the United States Army in-processes thousands of new recruits at training centers. Variations in the number of recruits who arrive for in-processing, particularly surges during summer time, cause problems that ripple throughout the entire Army training base. This thesis gathers and analyzes historical recruit and in-processing data for one Army training base: Fort Sill, Oklahoma. The recruit reception process is modeled as a network flow problem and analyzed through the use of computer simulation. Analysis of the problem using the model compares the status quo to various options for improving recruit "throughput." Policy options are explored on a cost and benefit basis. Recommendations improve reception battalion "throughput" by making better use of existing resources, and establish guidelines for allocating additional resources, thus contributing to solving a significant scheduling problem for the Army Training Centers.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Simulation, In-processing, Basic Combat Training, One-Station-Unit-Training

A PARAMETRIC COST MODEL FOR ESTIMATING OPERATING AND SUPPORT COSTS OF U.S. NAVY (NON-NUCLEAR) SURFACE SHIPS

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With few effective decision-making tools to assess the affordability of major weapon systems, management of total ownership costs is continually misunderstood. Cost analysis provides a quick and reliable assessment of affordability. Because there is no standardized method for calculating reliable estimates of operating and support (O&S) costs (the principal component of total ownership cost), this thesis formulates a parametric cost model which can be used to determine the annual O&S costs of U.S. Navy (non-nuclear) surface ships based on known (or assumed) physical characteristics and manpower expectations. Source data for the cost model is obtained from the Navy Visibility and Management of O&S Costs (VAMOSC) database, a historical cost database maintained by the Naval Center for Cost Analysis (NCCA). Through standard regression and data analysis techniques, cost estimating relationships are developed for three major cost drivers: ship light displacement, ship overall length, and ship manpower. The formulated parametric cost model is a top-level and fairly reliable representation of average annual O&S cost, and it

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can be used by the DoD cost community to perform component cost analyses or independent cost estimates.

DoD KEY TECHNOLOGY AREAS: Surface/Under Surface Vehicles-Ships and Watercraft, Other (Cost Analysis)

KEYWORDS: Government, Cost Estimating, Ships, Operating and Support, Statistics/Regression

ASSESSING THE EFFECTIVENESS OF THE BATTLEFIELD COMBAT IDENTIFICATION SYSTEM
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The Battlefield Combat Identification System (BCIS) was developed at the direction of the Joint Chiefs of Staff following the Gulf War to address the problem of direct fire fratricide. The system is designed to improve target identification and increase situational awareness for ground combat forces. The purpose of this thesis is to determine whether BCIS improves combat effectiveness. Additionally, this thesis provides a simulation tool that is utilized to assess the effectiveness of BCIS variants. The experiment involves a simulation executed in Simkit simulating an M1A1 tank company performing two doctrinal missions (defense and movement to contact) under three different cases: without BCIS, with BCIS equipped for target identification only, and with BCIS equipped with a digital data link. The research assesses measures of performance to determine whether BCIS increases combat effectiveness. The measures of performance are the loss exchange ratio as a measure of lethality and the fratricide ratio as a measure of fratricide incidents. Results of the analysis indicate that BCIS does increase the combat effectiveness. Specifically, BCIS increase lethality and reduces fratricide over non BCIS equipped units. BCIS equipped with a digital data link did not provide an increase over the baseline BCIS.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Sensors

KEYWORDS: Fratricide, Combat Identification, Battlefield Combat Identification System

OPTIMAL SCHEDULING OF ARMY INITIAL ENTRY TRAINING COURSES
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Scheduling Army enlisted initial entry training is a complicated task currently done manually at the U.S. Army Training and Doctrine Command Headquarters, Fort Monroe, Virginia. Scheduling results are entered into the Army's automated training system used by both training centers and recruiters to assign enlistees to training spaces at training centers. This thesis develops a mixed integer program to plan monthly Basic Combat Training, One Station Unit Training, and Advanced Individual Training training schedules. The goals are to maximize the efficiency of the training schedule (by minimizing the number of recruits held over), to minimize the annual soldier training requirements not met, and to aspire to optimally fill courses. The model is implemented in the GAMS modeling language. The output is a matrix of 230 courses to 50 assigned start weeks. This approach accomplishes 94 percent of the annual Army requirements for fiscal year 2000 (FY00). Soldier holdover time is decreased to 90,360 weeks using the

optimal scheduling method compared with 180,000 weeks projected for FY00 using alternative methods. This improvement saves 1800 soldier years, or a brigade's worth of manpower for the Army at no additional cost. This approach effectively creates over 5500 additional training seats. This model should be implemented as a methodology for scheduling Initial Entry Training courses.

DoD KEY TECHNOLOGY AREA: Manpower, Personnel, and Training

KEYWORDS: Optimization, Linear Programming, GAMS, Integer Programming, Operations Research, Military Training, Scheduling

SPECIAL OPERATIONS MISSION PLANNING AND ANALYSIS SUPPORT SYSTEM
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Current mission preparation and analysis methods place an undue burden of effort on conventional and special operations forces to effectively synchronize and execute their increasingly complex operational responsibilities in a rapidly changing global environment. This thesis developed a tool for the United States Special Operations Command (USSOCOM) in support of their Mission Planning, Analysis, Rehearsal, and Execution (MPARE) initiative to allow special operations forces commanders and staffs to conduct mission planning and analysis in a distributed environment, and rapidly produce dynamic synchronization matrices and scheduling products. Operations research methods provide the foundation for the analysis. The system developed in this thesis is called the Special Operations Mission Planning and Analysis Support System (SOMPASS). SOMPASS is simple to learn and operate, provides dynamic changes with little effort, and is universal in application. This system has the capability to execute on any hardware platform, operate across any network connection, and expand easily to support additional users and requirements. This thesis provides not only a demonstration of capabilities through a special operations oriented illustrative scenario, but also a working product that can be adapted for use in mission planning and analysis by all units under USSOCOM.

DoD KEY TECHNOLOGY AREAS: Command, Control, and Communications, Computing and Software

KEYWORDS: Mission Planning, Analysis, Synchronization, Critical Path Method, CPM, Special Operations, MPARE, Java, Loosely Coupled Components

SIMULATION ANALYSIS OF UNMANNED AERIAL VEHICLES (UAV)
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Warfighting Commanders in Chief (CINCs) have identified a need to provide lower-level tactical units (especially brigades) with real-time responsive Reconnaissance, Surveillance, and Target Acquisition (RSTA). There are many unanswered questions, some of which are: “Which UAV system best suits the needs of the brigade commander?”, “How many UAVs does a brigade need?”, and “What are the Tactics, Techniques, and Procedures (TTP) for the use of this new system?” This thesis demonstrates the ability to design a small high resolution simulation which can be used to answer these questions. The simulation can be used throughout the acquisition process, and potentially beyond.

DoD KEY TECHNOLOGY AREAS: Air Vehicles, Computing and Software, Modeling and Simulation

KEYWORDS: Java, Modeling and Simulation, Simkit, Unmanned Aerial Vehicles

MODTERRAIN: A PROPOSED STANDARD FOR TERRAIN REPRESENTATION IN ENTITY LEVEL SIMULATION

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This thesis develops a standard Application Programmer's Interface (API) for modular terrain representation. The API hides the details of a terrain representation from an entity level simulation, thereby enhancing interoperability and flexibility. Additional contributions include reduced development costs, enhanced flexibility for developers, and the use of a component approach applicable to future simulations. Three reference implementations are developed in the thesis representing widely used terrain representations. These prototypes consist of a standard set of terrain services that can be used by a simulation developer without any knowledge of the underlying implementation. The prototypes serve as references, proof of the concept, and as tools for comparison and analysis of existing terrain algorithms. We demonstrate this comparison with the JANUS and Modular Semi-Automated Forces (MODSAF) line of sight algorithms. This set of API implementations also allows emerging simulations to use different terrain formats at run-time without source code changes. The API developed in this thesis is the basis for a United States Army Modeling and Simulation standard nomination.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Modeling and Simulation

KEYWORDS: Simulation, Standards, Terrain, Entity, Computer Generated Forces, Java, Loosely Coupled Components

AN EFFICIENCY ANALYSIS OF DEFENSE LOGISTICS AGENCY CONTRACT ADMINISTRATION OFFICES

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Restructuring within the Department of Defense since 1990 has forced the Defense Contract Management Command (DCMC) to reduce its staffing level from 24,000 to 14,000 employees. The Contract Administration Offices that make up DCMC have reduced from over 100 offices to only 65 offices. This study evaluates the efficiency of these Contract Administration Offices in the wake of this massive reorganization. Statistical analysis determined the most crucial inputs and outputs for use in an efficiency model. Data Envelopment Analysis (DEA) methodology identified efficient and inefficient Contract Administration Offices. Further analysis of the DEA models revealed potential improvement strategies for inefficient offices and suggests uses of the models for future personnel resource forecasting.

DoD KEY TECHNOLOGY AREA: Other (Contract Management)

KEYWORDS: Military Contract Administration, Data Envelopment Analysis, Military Acquisition

AUTOMATING A STUDY QUESTION METHODOLOGY TO ENHANCE ANALYSIS IN HIGH LEVEL ARCHITECTURE

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The Department of Defense (DoD) uses simulation for many purposes. Early computer based distributed simulation support environments allowed individual models to communicate with each other but fell short of providing a general distributed simulation solution until the advent of High Level Architecture (HLA). HLA allows users to combine sub-models into one simulation, but it employs a subscription based communications scheme that did not exist in previous support environments.

Analysts often use a decompositional approach to identify measures of effectiveness (MOE), measures of performance (MOP), and data requirements for studies and tests. Fundamental study questions or operational requirements are decomposed until supporting data from tests and simulations are identified. This thesis formalizes this decompositional process, calling it the Study Question Methodology (SQM) and procedurally describes the steps all analysts should use to establish a clear audit trail from question to data inputs. It applies the SQM process to a study question relating to attack helicopters to demonstrate the dendritic (tree-like decomposition) approach. This thesis also provides a general solution for automating the SQM (ASQM) for use in distributed simulations that use the HLA. The ASQM enhances the analyst's pre-, during-, and post-exercise analysis. It provides the ability to answer study questions, establishes a clear audit trail, and helps fill an analysis tool void that presently exists in HLA.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Other (High Level Architecture)

KEYWORDS: Distributed Simulation, Study Questions, EEA, MOE, MOP, Modeling and Simulation, High Level Architecture

AN OPTIMIZATION MODEL FOR SEA-BASED SUPPLY OF BULK FUEL FOR A DEPLOYED MARINE EXPEDITIONARY UNIT

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Operational Maneuver From the Sea (OMFTS) is a Marine Corps concept that shifts the emphasis from blue-water superiority to power projection in the littorals. OMFTS treats the sea as maneuver space, and moves forces directly from ship to objectives ashore with little or no prior build-up of supplies ashore. This thesis develops the Sea-Based Logistic Optimization Model (SBLOM), an integer programming model that assesses the feasibility of conducting sea-based logistics in an OMFTS scenario based on capabilities of current and future assets, e.g., the Landing Craft Air Cushion and the MV-22 Osprey aircraft. SBLOM minimizes (when feasible) the initial fuel requirement of the Marine Expeditionary Unit (Special Operations Capable) (MEU(SOC)) ashore, and develops a fuel-delivery schedule from the sea using the lift assets available on a group of three or four ships known as an Amphibious Readiness Group (ARG). Using two OMFTS scenarios, SBLOM is run with the ARG at stand-off distances of 50, 70, and 100 nautical miles. The scenarios involve a humanitarian mission and an amphibious raid. In all cases, the use of sea-based logistics is feasible: an optimal delivery schedule is developed that meets the daily fuel requirements of the MEU(SOC) and maintains sufficient fuel levels throughout the mission 5 duration.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Optimization, Linear Programming, Logistics