MASTER OF SCIENCE
IN
OPERATIONS RESEARCH

MODELING HUMAN ELEMENTS OF DECISION-MAKING

Amy L Barsnick-Lieutenant , United States Navy
B.A., University of Washington, 1991
Master of Science in Operations Research-June 2002
Advisors: Nita Lewis Miller, Department of Operations Research
LTC Saverio Manago, USA, Department of Operations Research
Second Reader: MAJ Matt Chesney, USA, Department of Operations Research

Combat models attempt to represent the various factors that can influence combat outcomes. The most difficult of these factors to define and represent are the purely human inputs into the combat equation. These include factors such as personality, emotion, and level of expertise, which vary from individual to individual. The process of decision-making during combat is one of the most problematic modeling challenges. Traditional models of human decision-making do not adequately address the factors listed above. This thesis addresses this issue by proposing an influence diagram, which builds on traditional utility theory to include the human element in combat decision-making. The model is examined by application to three historical case studies. The results show that the outputs of the model are consistent with the end-state of the three historical battles.

KEYWORDS: Combat Modeling, Decision-Making, Human Factors, Bayesian Network

OPTIMIZING THE CAPACITY AND OPERATION OF U.S. ARMY AMMUNITION PRODUCTION FACILITIES

Vedat Bayram-First Lieutenant, Turkish Army
B.S., Turkish Army Academy, 1997
Master of Science in Operations Research-June 2002
Advisor: Gerald G. Brown, Department of Operations Research
Second Reader: Robert F. Dell, Department of Operations Research

As the executive agent for ammunition, the Army manages the arsenals and plants that produce conventional ammunition for the Department of Defense. This industrial base must be able to manufacture a wide range of ammunition and ordnance items. In peacetime, the Army tests new rounds, makes training rounds, and manufactures rounds or components for war reserves, stockpile maintenance and upgrades. The Army must also manage and maintain capacity to replenish ammunition consumed by major theater wars without expanding the industrial base. The combined organic and inorganic industrial base can meet current requirements, but parts are becoming obsolete, and are expensive to operate. To improve efficiency and reduce per-unit costs while maintaining strategic control of this key defense capability, the Army is seeking to reconfigure facilities, and stabilize production rates. The Army realizes that the industrial base structure has to change. This thesis provides a prototypic decision support model that captures the essence of their problem by optimizing transition actions while satisfying complicated long-term constraints on resources, management, and capacity. The model suggests yearly decisions for a planning horizon of a decade or more, and is demonstrated with 16 organic installations, structures located therein, and process centers housed in those structures.

KEYWORDS: Optimization, Mixed Integer Program, Decision Support Tool, Industrial Base, Arsenal, Army Ammunition Plant, Reconfiguration, Consolidation, Privatization, Unutilized Capacity, Infrastructure Cost, Requirements, Peace Time, Replenishment, GOGO, GOCO

AN ANALYSIS OF LOGISTICS RESPONSE TIMES FOR REQUISITIONS OF NAVAL AVIATION REPAIRABLE ITEMS

Gregory L. Booth-Lieutenant Commander, United States Navy
BA., Virginia Military Institute, 1991
Master of Science in Operations Research-June 2002
Advisor: Robert A. Koyak, Department of Operations Research
Second Reader: CDR Kevin J. Maher, USN, Department of Operations Research

Minimized safety level investment, while achieving high service levels and low customer wait time, is critical to the performance of the United States Navy supply system. The Naval Inventory Control Point (NAVICP) uses the Uniform Inventory Control Program to compute safety levels for each of the stock items they maintain. To assist in computing these levels, NAVICP aggregates repairable items based on demand and cost. The performance metrics used to measure the effectiveness of the model, Supply Material Availability and Average Days Delay, are affected by this aggregation. The purpose of the thesis is to describe an alternative methodology of aggregation that will allow NAVICP to allocate its item management skills more efficiently.

The proposed methodology, based on item cost, demand, and Logistics Response Times for requisitions, can improve inventory performance without increasing the workload of item managers. Using analysis of variance, an analytical approach is adopted to ascertain whether an item has an average Logistics Response Time that exceeds the Navy's goal. It is shown that the proposed aggregation can improve Supply Material Availability and safety level investments while better managing items based on Logistics Response Time.

KEYWORDS: Logistics Response Time, Safety Levels, Shortage Costs, Levels Setting Segmentation Indicator, Operations Research, Analysis of Variance, Naval Aviation Repairables

ARMY RESERVE TRAINING SEAT ALLOCATION MODEL

Sylvester H. Brown-Major, United States Army Reserve
B.S., Georgia Southern College, 1985
M.A., Webster University, 1994
Master of Science in Operations Research-June 2002
Advisor: David Olwell, Department of Operations Research
Second Reader: Samuel E. Buttrey, Department of Operations Research

This thesis reduces wasted Reserve training seats by one-fourth, improving resource use and increasing readiness. The Army Reserve currently uses approximately 80% of its scheduled Initial Entry Training seats each year (wasting over 3000 seats for soldiers assigned to Troop Program Units). Reasons include misalignment of Basic Combat Training with follow-on Advanced Individual Training, scheduling too many seats during a period when targeted trainees are not available for training, and limited training capacity for specific specialties that units require for improved readiness. The Office of the Chief, Army Reserve Personnel Division negotiates with other Army components in the Training Resource Arbitration Panel to make adjustments to schedules of the Army Training Requirements and Resources System. Input from Recruiting Command and expert judgment is inadequate. This thesis allocates Army Reserve seats among competing needs of Army components and within available resources to increase seat utilization, thus increasing readiness. The model was validated by comparing historical training with model results and use these results to establish feasible training schedules to meet future goals and respond to readiness, recruiting and retention in the Army Reserve. This model provides a Reserve training schedule for FY 03 that optimally allocates funded training resources to improve unit readiness, achieves fiscal year goals established by the Structure Manning Decision Review, and eliminates mismatches between basic and advanced training that caused lost training resources in the past. The Army Reserve can set various goals and establish a schedule that remains responsive to historical starts. When specialty readiness prioritization occurs, users will simply establish weights for these priorities as part of the input data. This model requires data inputs from the Army Training Requirements and Resources System and the Total Army Personnel Database - Reserve. A reduction in training seat loss from 20% to approximately 15% is expected. This means that over 15,000 Reserve soldiers will become specialty qualified during FY03 versus 13,000,

improving readiness in Troop Program Units. The Personnel Division should implement this model to help in the Training Resource Arbitration Panel process.

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

REAL-TIME ENGAGEMENT AREA DEVELOPMENT PROGRAM

Joseph A. Burger-Captain, United States Army
B.S., Cornell University, 1992
Master of Science in Operations Research-June 2002
Advisor: Gordon Bradley, Department of Operations Research
Second Reader: LTC Saverio Manago, USA, Department of Operations Research

The Real-Time Engagement Area Development Program (READ-Pro) is a PC-based prototype system which provides company-level commanders with real-time operational analysis tools to develop engagement areas (EA) for direct fire (DF) systems. READ-Pro automates and streamlines the current manual system. READ-Pro significantly enhances the evaluation of a defense by presenting the commander with a visual display of the coverage and a quantitative measure of its fragility. READ-Pro also supports the rapid evolution to a better defense by providing visualization of the coverage and a quantitative evaluation at each step in the engagement area development process.

READ-Pro creates a layered environment consisting of digital terrain elevation data (DTED©), a standard military map, overlays, and imagery. A ModSAF line-of-sight (MLOS) algorithm, based on the ModSAF terrain model, calculates measures of effectiveness related to line-of-sight coverage. READ-Pro also includes a Monte-Carlo Simulation to quantify the fragility of a defense.

READ-Pro incorporates the tactics, techniques and procedures used in today's Army, namely the troop-leading procedures and seven steps of engagement area development. Thus, READ-Pro can also be used to train leaders on the fundamentals associated with engagement area development.

KEYWORDS: Engagement Area Development, Real-time Analysis, XML, Loosely Coupled Components, Company Level Analysis, Java, DTED

THE EFFECT OF SOUND SPATIALIZATION ON RESPONSES TO OVERLAPPING MESSAGES

James R. Campbell, III-Lieutenant, United States Navy
B.A., The Ohio State University, 1995
M.H.A., The Ohio State University, 1997
Master of Science in Operations Research-June 2002
Advisor: LCDR Russell D. Shilling, USN, Department of Operations Research
Second Reader: Robert R. Read, Department of Operations Research

The purpose of this research was to determine if a spatialized headphone display would improve users' recognition accuracy when listening to more than two overlapping messages. This type of task has numerous applications in a variety of different military settings, such as aviation communications and combat information centers.

Two experiments were conducted in the Advanced Auditory Displays Laboratory at the Naval Postgraduate School. The first experiment was a pilot study, which was designed to identify the factors that contributed to changes in response accuracy rates. The conclusion of this effort was a decision to use a chi-squared analysis and a multivariate logit regression, which could examine the influence of several factors in addition to spatialization.

Results indicated that participants accurately identified 43% of the messages in the spatialized condition, but only 17% of the messages in the non-spatialized condition. Chi-squared tests indicated a dependent relationship between accuracy and spatialization under a variety of conditions. The logit regression model confirmed these conclusions and indicated that the chance of a completely correct response was improved by approximately 30% with the use of spatialization.

KEYWORDS: Communications, Auditory Displays, Sound Localization, Spatialization, Overlapping Messages, Spatial Audio, Logit Regression, Cochran's Test

MULTIPLE SENSOR CREDIT APPORTIONMENT

Mason W. Crow-Captain, United States Army
B.S., United States Military Academy, 1993
Master of Science in Operations Research-June 2002
Advisor: LTC Eugene P. Paulo, USA, Department of Operations Research
Co-Advisor: Sergio Posadas, TRAC-WSMR
Second Reader: Susan M. Sanchez, Department of Operations Research

Methods to individually allocate credit to multiple sensors assist Army decision makers during Objective Force development and integration. Sensor credit apportionment supports a knowledge-based common operating picture by providing a means to assess and compare the variety of automated and human sources that contribute to the common operating picture (U.S. Army White Paper, 2001). This thesis develops and assesses such a method. The method determines the contribution of individual sensors (person or platform that provides specific target information) to successful commander decision making. The method utilizes data fusion, decision analysis, and information quality to credit each sensor according to the benefit they provide a commander. A stochastic simulation provides the means to generate an environment in which to test and compare sensor performance, and to assess the credit apportionment method.

KEYWORDS: Multiple Sensor Credit Apportionment, Data Fusion, Decision Analysis, Information Quality, Simulation

MODELING ROBOT SWARMS USING AGENT-BASED SIMULATION

Alistair Dickie-Captain, Australian Army
B.S.c., University College (University of New South Wales), 1995
Master of Science in Operations Research-June 2002
Thesis Advisor: Gordon Bradley, Department of Operations Research
Thesis Advisor: John Hiles, The Modeling, Virtual Environments, and Simulation (MOVES) Institute
Second Reader: Arnold Buss, Department of Operations Research

In the near future advances in mechanical and electrical engineering will enable the production of a wide variety of relatively low cost robotic vehicles. This thesis investigates the behavior of swarms of military robots acting autonomously. The Multi-Agent Robot Swarm Simulation (MARSS) was developed for modeling the behavior of swarms of military robots. MARSS contains state, sensing, and behavioral model building tools that allow a range of complex entities and interactions to be represented. It is a model-building tool that draws theory and ideas from agent-based simulation, discrete event simulation, traditional operations research, search theory, swarm theory, and experimental design. MARSS enables analysts to explore the effect of individual behavioral factors on swarm performance. The performance response surface can be explored using designed experiments. A model was developed in MARSS to investigate the effects of increasing behavioral complexity for a search scenario involving a swarm of Micro Air Vehicles (MAVs) searching for mobile tanks in a region. Agreement between theoretical and simulated search scenarios for simple searchers was found. The effect of increased MAV sensory and behavioral capability was demonstrated to be important. Little improvement was observed in swarm performance with these capabilities, however agent performance was adversely affected by reacting to increased knowledge in the wrong way. The utility of MARSS for conducting this type of analysis was demonstrated.

KEYWORDS: Robot, Swarming, Swarm, Multi-Agent, Agent-Based, Simulation

OPTIMAL SELECTION OF ARMY MILITARY CONSTRUCTION PROJECTS

James D. Dzwonchyk-Captain, United States Army
B.S., United States Military Academy, 1993
Master of Science in Operations Research-June 2002
Advisor: Robert F. Dell, Department of Operations Research
Co-Advisor: William J. Tarantino, Center for Army Analysis
Second Reader: Eva D. Regnier, Defense Resources Management Institute

The Assistant Chief of Staff for Installation Management (ACSIM) manages all Army military construction (MILCON) implementation and requests. Annually, the ACSIM submits a prioritized list of MILCON projects requiring Congressional approval. Typically, Congress does not approve all Army requests. This thesis develops an integer linear program, PESA (Project Evaluation and Selection Assistant), to assist the ACSIM evaluate and select the best set of MILCON projects under various policies and budgets; thus assisting ACSIM develop a defendable set of MILCON projects to submit to Congress. Using a budget of $600 million (funds allocated in fiscal year 2001) and data for 62 projects for fiscal year 2001, it was recommend funding a set of 50 projects that adhere to the following: fund each Major Army Command's projects in priority; limit each Major Army Command to less than 25% of the total budget; and use at least 80% of the total budget on the worst condition facilities. It was demonstrated how this set of 50 projects better adheres to Army policies than those that would be recommended by the current Army technique.

KEYWORDS: Military Construction, Project Selection, Integer Linear Programming, Optimization, Facilities, Optimal Funding

A MINEFIELD RECONNAISSANCE SIMULATOR

Mauricio Jose Machado Guede-Civilian, Brazilian Navy
B.S., Fluminense Federal University, 1984
Master of Science in Operations Research-June 2002
Advisor: Alan R. Washburn, Department of Operations Research
Second Reader: Samuel E. Buttrey, Department of Operations Research

The Navy plans to do covert reconnaissance of minefields with a remote underwater vehicle that includes two sensors, one long-range (LR) and one short-range (SR). LR can detect mines, but it cannot distinguish them from harmless mine-like objects. SR can tell the difference, but only by approaching to within short range. A program called MIRES (Minefield Reconnaissance Simulator) is implemented to answer the questions of how the vehicle should perform a search and to estimate the number of mines remaining in the area once the reconnaissance is over. MIRES investigates four modes of search; a planned search with departure to identify an object, a planned search with no departure, and two kinds of random search. It compares these types of search and identifies the best search mode for a given scenario.

KEYWORDS: Unmanned Undersea Vehicle, Long-Term Mine Reconnaissance System, Mine Detection, Minesweeping

STATISTICAL VALIDATION OF AIR SURVEILLANCE TRACK QUALITY NUMBERS FOR JOINT INTEROPERABILITY TESTING

Jeffrey S. Gulick-Major, U.S. Army
B.A., Ouachita Baptist University, 1989
Master of Science in Operations Research–June 2002
Advisor: Robert A. Koyak, Department of Operations Research
Second Reader: Patricia A. Jacobs, Department of Operations Research

Joint interoperability is fundamental to the effectiveness of a Theater Air and Missile Defense (TAMD) family of systems. A family of systems is a network of service platforms that track and report airborne objects with the objective of achieving a single integrated air picture. Responsibility for reporting a particular track is assigned to the system that claims to have the best positional accuracy. Systems report

"track quality" numbers over the network to communicate their accuracy assessments to other systems. A track quality number is based on the size of a calculated 95 percent region of uncertainty for the position of the object that is tracked. Verifying that reported track quality numbers are accurate is a critical part of an interoperability test and evaluation program for a TAMD family of systems.

In this thesis methodologies are developed for evaluating track quality numbers based on a comparison of each system's actual tracking errors to areas of the uncertainty regions implied by the track quality numbers that were reported in joint air surveillance exercises. These exercises may involve hundreds of "truth objects" that are simultaneously tracked. The manner in which these truth objects are associated with tracks is an important part of the test and evaluation process. Alternative methods for making these associations are discussed. Statistical hypothesis tests are developed to assess the validity of track quality numbers for each system in order to support joint interoperability certification decisions.

KEYWORDS: Tracking, Track Quality, Interoperability, Test and Evaluation, Theater Air and Missile Defense

A SIMULATION TO DETERMINE THE EFFECT THAT THE ARMY BASIC OFFICER LEADERSHIP COURSE WILL HAVE ON ACCESSION TRAINING

Erik K. Hovda-Captain, United States Army
B.S., United States Military Academy, 1991
Master of Science in Operations Research-June 2002
Advisor: Paul Sanchez, Department of Operations Research
Second Reader: David Olwell, Department of Operations Research

The United States Army is currently considering a significant change in the way they train newly commissioned officers. The Army's Training and Doctrine Command (TRADOC) plans to add a course to accession training called the Basic Officer Leadership Course (BOLC), which would teach officers of all Army Competitive Category (ACC) branches core leadership and common skills requirements at three Army installations in the United States. This thesis develops a simulation that explores the length of time newly commissioned officers spend training once TRADOC implements BOLC and establishes training policies for the new course. The model is implemented in the Java programming language, with Simkit as the simulation package. The simulation output is a list of 225,000 simulated officers with their training time recorded, which were aggregated into mean and variance measurements for each design point. Upon this aggregated data a regression analysis was executed, which feeds into a loss function that penalizes excess time spent in accession training. Minimizing the loss function returns optimal policy settings for BOLC's implementation. This analysis shows that the most significant policies in the accession training system are the maximum and minimum class size for a BOLC class and the ratio of ROTC officers who receive immediate active duty status upon commissioning. My analysis also shows that placing BOLC into the simulated accession training system caused an increase of approximately 23 days in training time.

KEYWORDS: Simulation, Manpower Modeling, Simkit, Scheduling, Basic Officer Leadership Course, Robust Experiment Design, Gridded Factorial Experiment Design, Regression

DISTRIBUTING INTRA-THEATER WARTIME FUEL REQUIREMENTS FOR OPERATION ENDURING FREEDOM

Aristides Iliakis-Lieutenant Commander, Supply Corps, United States Navy
B.S., University of Washington, 1989
Master of Science in Operations Research-June 2002
Advisor: Robert F. Dell, Department of Operations Research
Second Reader: David A. Schrady, Department of Operations Research

The Commander-in-Chief, United States Central Command (USCENTCOM) Joint Petroleum Office (JPO) works in close coordination with the Defense Energy Support Center (DESC) to provide contracts with worldwide refineries to produce required petroleum, oil and lubricants (POL), and oversee storage and distribution of these products throughout the Central Command. The JPO and DESC must ensure that fuel

inventories are sufficient to satisfy the theater's wartime fuel requirements. Prior to this thesis JPO and DESC used a system of spreadsheets and daily fuel usage information to determine sufficiency of POL wartime requirements. This thesis provides an integer linear program (ILP) to assist in the distribution of these wartime requirements. Using a wartime scenario based on notional data provided from Operation Enduring Freedom, this thesis models deliveries of three fuel types using three modes of delivery between six refineries, six Defense Fuel Support Points (DFSPs) and 13 end-use sites. Spanning a 120-day scenario, the ILP minimizes undelivered requirements using available in-theater fuel inventories and fuel contracts. Analyses using the ILP indicate the insufficiency in the existing truck delivery capabilities to support increased wartime demands and suggest how to overcome this insufficiency. Additionally, the model identifies the need for contract supplements when original fuel agreements become exhausted.

KEY WORDS: Fuel, Distribution, Petroleum Distribution Planning, Linear Programming, Integer Linear Programming, Optimization.

HOW AGENT BASED MODELS CAN BE UTILIZED TO EXPLORE AND EXPLOIT NON-LINEARITY AND INTANGIBLES INHERENT IN GUERRILLA WARFARE

Arif Ilker Ipekci-First Lieutenant, Turkish Army
B.S, Turkish Army Academy, 1996
Master of Science in Operations Research-June 2002
Advisor: Tom Lucas, Department of Operations Research
Second Reader: LTC Saverio Manago, USA, Department of Operations Research

Since the end of WWII, a host of groups and states have pursued their interests in the Low Intensity Conflict (LIC) environment. One of the characteristics of LIC is that it is executed mostly by the rules of asymmetric war or guerrilla warfare. This thesis utilizes the recently developed agent-based model Map Aware Non-Uniform Automata (MANA) to explore non-linearity and intangibles inherent in guerrilla warfare. An infiltration scenario is developed based on the author's experiences fighting guerrillas in the mountains of Southeast Turkey. To simultaneously investigate the effects of as many as 22 input variables, recently developed Near Orthogonal Latin Hypercube Designs and Fractional Factorial Designs are used. Utilizing a personal computer and the computational capabilities of supercomputers run by Mitre for the Marine Corps Combat Development Center (MCCDC), approximately 200,000 MANA runs were completed. Several statistical models are developed and compared using a variety of diverse statistical techniques, including Cluster Analysis, Neural Networks, Regression Trees, Linear Regression, and Bayesian Networks. The results of the analysis suggest that the outcome of an infiltration scenario is heavily dependent on the Red agent parameters. The analysis also reveals the Red Stealth parameter as the most important factor in predicting the MOEs.

KEYWORDS: Agent Based Models, Guerrilla Warfare, Exploring Non-linearity and Intangibles, Terrorism, Infiltration, Complex Adaptive Systems, Latin Hypercube Designs, Bayesian Networks, Regression Trees, Neural Networks, Cluster Analysis, Data Mining Applications, Low Intensity Conflict, MANA

EVALUATION OF FRAUD DETECTION DATA-MINING USED IN THE AUDITING PROCESS OF THE DEFENSE FINANCE AND ACCOUNTING SERVICE

Donald J. Jenkins-Lieutenant, United States Navy
B.A./B.S., University of San Diego, 1994
Master of Science in Operations Research-June 2002
Advisor: Samuel E. Buttrey, Department of Operations Research
Second Reader: Lyn R. Whitaker, Department of Operations Research

The Defense Finance and Accounting Service (DFAS) uses data mining to analyze millions of vendor transactions each year in an effort to combat fraud. The long timeline required to investigate potential fraud precludes DFAS from using fraud as a supervised modeling performance measure, so instead it uses the conditions needing improvement (CNI) found during site audits. To verify this method, a thorough

literature review is conducted which demonstrates a clear relationship between fraud and CNIs. Then recent site audits are analyzed to prove that supervised modeling is detecting CNIs at a higher rate than random record selection. The next phase of the research evaluates recent models to determine if models are improving with each new audit. Finally, to enhance the supervised modeling process, four initiatives are proposed: a revised model scoring implementation, a knowledge base of audit results, alternative model streams for record selection and a recommended modeling process for the CNI knowledge base. The goal of the proposed enhancements is to improve an already successful program so that the data-mining efforts will further reduce taxpayer losses through fraud, error or misappropriation of funds.

KEYWORDS: Fraud Detection, Data-mining, Auditing, Neural Networks, Classification

OPTIMIZING ACTIVE GUARD RESERVE ENLISTED MANPOWER

Alan K. Schrews-Captain, United States Army Reserve
B.B.A., West Georgia College, 1991
Master of Science in Operations Research-June 2002
Advisor: Richard E. Rosenthal, Department of Operations Research
Advisor: Laura M. Williams, Department of Operations Research
Second Reader: Thomas P. Moore, Naval War College

The principal mission of the United States Army Reserve (USAR) is to maintain properly trained and equipped units available to promptly mobilize for war, national emergency, or other contingency operations, and to assist the Army in projecting land combat power. The Active Guard Reserve (AGR) program provides active duty reserve soldiers (officer and enlisted) to Army Reserve units and Regular Army units to support reserve missions. The proper placement and manning of the AGR force is critical to the readiness of the Army Reserve and to the strength of the Total Army.

To assist the efforts of the Office of the Chief, Army Reserve, Program Analysis and Evaluation division (OCAR-PAE) to analyze the AGR enlisted force, this thesis develops an optimization model known as the AGR Enlisted Manpower Projection Model (AGR-EMPM). The primary purpose of the model is to serve as a manpower forecasting and decision analysis tool. The model aggregates at the career management field level by rank, active federal service, and time in grade. With a 7-year planning horizon, the model is ideally suited for near term policy analysis. To demonstrate the usefulness of the model, scenarios relating to stop loss and accessions are analyzed.

KEYWORDS: Optimization, AGR, Active Guard Reserve, USAR, Manpower Modeling, Enlisted Modeling, Army Reserve, AGR Program, Military Manpower Modeling

A METHODOLOGY FOR EVALUATING THE TRUTH SPACE IN TESTING FOR THE SINGLE INTEGRATED AIR PICTURE

Gregory K. Smith-Captain, United States Army
B.S., United States Military Academy, 1992
Master of Science in Operations Research-June 2002
Advisor: Robert A. Koyak, Department of Operations Research
Second Reader: Thomas W. Lucas, Department of Operations Research

In a changeable and complex military environment, a coherent picture of the air theater is a necessity. To achieve this Single Integrated Air Picture (SIAP) requires the sharing of information across air surveillance platforms. An accurate and timely SIAP will promote a cohesive and orchestrated air defense. Testing and evaluation of networked air surveillance systems is essential to promote the development of a SIAP in joint operations. Performance assessment can identify shortfalls within the systems or within the communication platforms. In this thesis, it is proposed that attributes of the "truth space" also be integrated into performance assessments. The methodology developed in this thesis provides a basis for evaluating how truth-space complexity affects joint engagement effectiveness. The metrics are suitable for the evaluation of air surveillance performance in relation to the maneuvering of aircraft, and to the proximity of aircraft to each other in the surveillance space.

KEYWORDS: Single Integrated Air Picture (SIAP), SIAP, Single Integrated Air Picture, SIAP Attributes, SIAP Metrics

OPTIMAL SCHEDULING OF BULK PETROLEUM TANKERS IN THE WESTERN PACIFIC

Scott C. Smith-Lieutenant Commander, United States Navy
B.S., The Pennsylvania State University, 1990
Master of Science in Operations Research-June 2002
Advisor: Robert F. Dell, Department of Operations Research
Second Reader: CAPT Jeffery E. Kline, USN, Department of Operations Research

The Commander-in-Chief, U.S. Pacific Command (USCINCPAC), oversees U.S. military operations in the Pacific and Indian Oceans, also known as Pacific Command (PACOM). The USCINCPAC Joint Petroleum Office and Defense Energy Support Center-Pacific oversee and manage the storage and distribution of all petroleum products in PACOM. Currently, tanker schedules are generated manually, in part, because existing models do not account for vital details such as contracting information. This thesis develops an integer linear program, the Western Pacific Tanker Scheduling Model (WPTSM), to prescribe a daily tanker schedule that satisfies petroleum requirements in the Western Pacific while accounting for all vital details. WPTSM is demonstrated using a wartime scenario over a 120-day planning horizon. With over 6,500 mike barrels (MBBLs) or thousands of barrels in daily requirements, WPTSM assigns 44 deliveries using a long-term chartered T5 tanker, long-term chartered T1 tanker and ten short-term spot charters. In addition to this deliver schedule, WPTSM recommends supplemental contracts for 235 MBBLs of F-76, 470 MBBLs of JP-5, and 1,283 MBBLs of JP-8 from five different refineries to satisfy daily requirements. Subsequent analyses with WPTSM show how use of war reserve fuel can lessen the need for these supplemental contracts.

KEYWORDS: Fuel, Petroleum, Distribution, Transportation, Logistics, Integer Linear Programming, Optimization, Scheduling, Tanker

A BAYESIAN MODEL TO INCORPORATE HUMAN FACTORS IN COMMANDER'S DECISION MAKING

Sakura S. Therrien-Captain, United States Army
B.S., University of Central Florida, 1994
Master of Science in Operations Research-June 2002
Advisors: Nita Lewis Miller, Department of Operations Research
LTC Saverio Manago, USA, Department of Operations Resarch
Second Reader: MAJ Matt Chesney, USA, Department of Operations Research

In the near future, commanders and their respective staffs will interact with subordinate and opposing forces whose physical and cognitive behaviors are represented in software and simulation. This paper presents a model of the human factors and environmental variables that influence stress and risk assessment. These variables contribute to situational awareness, which is a force protection issue.

Leaders integrate information from various sources. These sources range from observations, training, orders, and reports. The leaders use this knowledge with doctrine and tactics to develop an understanding of the situation. This paper describes a Bayesian network model of the variables associated with risk assessment and stress in combat scenarios. The level of situational awareness is determined by what the commander knows about the unit and the surrounding conditions. This model lends structure to the environment and enables a probabilistic interpretation of risk and stress levels. This model is applicable to various combat scenarios ranging from brief engagements to sustained operations.

KEYWORDS: Bayesian Network, Risk Assessment, Situational Awareness, Stress Performance, Task Force Smith, Battle of Midway, Battle of Kursk

NETWORK INTERDICTION
BY LAGRANGIAN RELAXATION AND BRANCH-AND-BOUND

Adnan Uygun-First Lieutenant, Turkish Army
B.S., Turkish Army Academy, 1997
Master of Science in Operations Research-June 2002
Advisor: R. Kevin Wood, Department of Operations Research
Second Reader: Kelly J. Cormican, Department of Operations Research

The maximum-flow network-interdiction problem (MXFI) arises when an interdictor, using limited interdiction resources, wishes to restrict an adversary's use of a capacitated network. MXFI is not easy to solve when converted to a binary integer program. Derbes (1997) uses Lagrangian relaxation to solve the problem, at least approximately, for a single value of available resource, *R*. Bingol (2001) extends this technique to solve MXFI approximately for all integer values of *R* in a specified range. But, "problematic *R*-values" with substantial optimality gaps do arise. Optimality gaps are reduced in two ways. First, the best Lagrangian multiplier for problematic *R*-values is found by following the slope of Lagrangian function. Secondly, a limited-enumeration branch-and-bound algorithm is applied. Our algorithms are tested on six different test networks with up to 402 nodes and 1826 arcs. The algorithms are coded in Java 1.3 and run on a 533 MHz Pentium III computer. The first technique takes at most 39.3 seconds for any problem, and for one typical problem it solves 8 of the problem's 15 problematic *R*-values. For that problem, the second technique solves four of the remaining problematic *R*-values, but run time increases by two orders of magnitude.

KEYWORDS: Network Interdiction, Mathematical Modeling, Lagrangian Relaxation, Branch-and-Bound