MASTER OF SCIENCE
IN
OPERATIONS RESEARCH

AN EXPLORATORY ANALYSIS OF WATER FRONT FORCE PROTECTION MEASURES USING SIMULATION

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Since the *USS Cole* incident in October 2000, and particularly since the terrorist attacks of September 2001, Force Protection has become a fundamental issue. Of particular concern to the Navy is waterfront Force Protection: the protection of in-port High Value Units from attacks from the sea. The unpredictability of when or how a terrorist attack might be executed makes simulation an excellent tool for analyzing the waterfront force protection issue quantitatively. This thesis develops and implements a simulation model of Patrol Boats at the Naval Submarine Base in Bangor, Washington using Java and Simkit, both of which are platform independent, and therefore universally usable. The simulation is run pitting eight different notional Patrol Boat configurations (varying the number of patrol boats used, their intercepting and patrolling speeds, and their patrolling patterns) against eight notional terrorist attacks. The results of the simulation runs are analyzed, and general conclusions are drawn. The results indicate that the number of patrol boats used in an area and the speed they use to intercept threats are the most important factors of the four analyzed. Patrolling speed and patrolling patterns are found to be insignificant.

KEYWORDS: Force Protection, Simulation, Simkit, Modeling

AN EXPLORATORY ANALYSIS ON THE EFFECTS OF HUMAN FACTORS ON COMBAT OUTCOMES

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The purpose of this thesis is to investigate the effects of human factors on combat outcomes. An agent-based model called SOCRATES developed under the framework of Project Albert is used explore the emergent behaviors of the agents. Two experimental designs are used in this investigation: A Latin Hypercube and a Full-Factorial Design. Using the computing facilities at NPS, MITRE and MHPCC (Maui High Performance Computing Center), a total of 174,960 runs are made. The data suggest the existence of emergent patterns, and provide some insights into the question of how much more capable a smaller force must be in order to effectively battle a larger force. In addition, the analysis shows that the Latin Hypercube Design is able to identify the same significant factors in the scenario as are obtained by the Factorial Design, but with much fewer runs.

KEYWORDS: SOCRATES, Agent Based Simulation, Simulation, Human Dimension of Combat, Combat Models

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MH-60S HELICOPTER AND PILOTS TO COMBAT SUPPORT SQUADRONS

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The U.S. Navy is replacing the H-46 helicopter with the new MH-60S helicopter. The Fleet Introduction Team has developed a spreadsheet-based schedule that distributes new aircraft and MH-60S trained pilots to the active duty Helicopter Combat Support squadrons. This thesis develops an optimal distribution schedule for helicopters and pilots using an integer programming model called OTHCAM (Optimal Transition, HC Allocation Model) that minimizes lost flying days. OTHCAM takes into account variable training durations, travel times and tour lengths, as well as manpower and aircraft constraints. The output is a distribution schedule for new MH-60S helicopters and Fleet Replacement Squadron graduates that minimizes lost flying days while meeting manpower and operational requirements. The schedule developed by OTHCAM reduces lost flying days by 26% compared to the Fleet Introduction Team's existing spreadsheet schedule.

KEYWORDS: Aviation, Helicopter, Helicopter Master Plan, Schedule, Optimization, Modeling

THE MARINE THRITY-YEAR PLAN

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The U.S. Marine Corps is in need of a unified enlisted manpower model to guide the recruiting, training, promoting and discharging of an enlisted force of over 153,000 Marines. This thesis develops a set of linear programs (LPs) for this purpose. Each LP optimizes the estimated manpower structure within an occupational field by varying the number of recruits, promotions, and lateral moves over a 30-year time horizon, at a yearly level of detail. The goal is to meet annual force-level targets specified by Headquarters Marine Corps for cohorts defined by occupational specialty, and rank. Estimated attrition rates are key inputs; these are based on Kaplan-Meier estimators for "survival probabilities" computed from Marine Corps data covering 1990-2000. Current force strength data, also required by the LPs, is derived from the Marine Corps database. Average LP solving time is less than thirty minutes on a Pentium IV 2 Ghz personal computer, using the GAMS modeling system and the CPLEX LP solver.

KEYWORDS: Optimization Model, Manpower Model, Linear Program, Kaplan-Meier Estimator, Manpower Attrition, Force-Structure Planning, Data Analysis, Marine Enlisted Force Structure, Survival Probabilities, Enlisted Rank Structure

AGENT-BASED SIMULATION OF GERMAN PEACEKEEPING OPERATIONS FOR UNITS UP TO PLATOON LEVEL

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A significant challenge to the German Military Forces or "Bundeswehr" today is the development of tactics that will enable soldiers, airmen and sailors to be successful in small-scale peacekeeping operations.

This thesis develops an agent-based simulation for modeling peacekeeping operations at the platoon level. The simulation methodology combines agent-based modeling with discrete event simulation in two software packages called *Peacekeeping* and *TryShoot*. These software packages are used to model one part of a map exercise, the Kurzlage PRIZREN. The platoon of peacekeeping soldiers utilizes different kinds of tactics against different kinds of approaches by the civilians to reach their goal. This simulation yields insight into the modeled scenario and demonstrates the usefulness of agent-based simulation for the exploration of tactical concepts in a peacekeeping operation.

The analyzed results show that independent of the number of bystanders or the protester's behavior the peacekeepers always get better results in achieving their multiple objectives when they use a defensive tactical approach.

KEYWORDS: Peacekeeping, Agent-Based Modeling, Complex Adaptive Systems, Combat Model

COMMON RELEVANT OPERATIONAL PICTURE: AN ANALYSIS OF EFFECTS ON THE PROSECUTION OF TIME-CRITICAL TARGETS

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The conceptual template laid out in Joint Vision 2010 called for leveraging technological opportunities to achieve new and higher levels of effectiveness in a joint operating environment. Born out of this concept the U.S. Joint Forces Command developed a concept – the Common Relevant Operational Picture, or CROP. It is a presentation of timely, fused, accurate, assured and relevant information. The CROP concept addresses battlespace awareness, information transport and processing, combat identification and joint command and control – four of the six high priority challenges identified by the Joint Staff for the 21st century. This thesis investigates CROP, comparing and contrasting it to uncoordinated separate service systems in a time-critical targeting setting. The Measures of Effectiveness (MOEs) used are the time to kill a target and the number of weapons expended. Previous work on this problem used an analytical model with some simplifying assumptions concerning processing time latency following target detection. In this thesis, a simulation is used to investigate the validity of some of the analytical model assumptions. The simulation also extends the model for more general command and control time distributions and models Battle Damage Assessment. The results provide distributional information about the MOEs, showing how improvements in information sharing and optimal weapons assignment due to CROP can improve systems performance. However, this improvement is lost if processing time latency under CROP is too long.

KEYWORDS: Information Superiority, Combat Identification, Battlespace Environments, Battlespace Connectivity, Common/Consistent Tactical Picture, Integrated Fire Support, Knowledge Superiority and Assurance, Time Critical Strike

AN ANALYSIS OF ALTERNATIVES FOR RESUPPLYING THE SEA BASE

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In the concept papers, “Operational Maneuver From the Sea (OMFTS),” “Ship-to-Objective Maneuver (STOM),” “Sea-Based Logistics (SBL),” and “Maritime Prepositioning Force (MPF) 2010 and Beyond,” the Marine Corps laid out its vision of how it will conduct future amphibious warfare. Under OMFTS, combat forces will be deployed from the sea base directly to an objective ashore. This approach drastically

reduces or eliminates logistics infrastructure ashore and retains these capabilities at the sea base. Numerous studies have been conducted to date regarding future STOM requirements of moving forces, equipment, and supplies ashore; however, minimal effort has been exerted thus far in resolving the issue of sustaining the continuously-depleted resources of the sea base.

This thesis compares possible alternatives for resupplying the Expeditionary Maneuver Warfare (EMW) Sea Base (SB). Different scenarios are analyzed for how well each prospective resupply alternative is able to maintain required levels of food, fuel, and ordnance at the sea base with varying distances from the Forward Logistics Site (FLS). The scenarios differ by distances between the sea base and FLS, varying consumption rates at the sea base, and different shuttle ship alternatives. Sustainment requirements and sea base safety stock levels are determined and compared for twelve different scenarios. This analysis provides insight into the type, number, and capacity of resupply ships needed to maintain sustainment requirements at the sea base.

KEYWORDS: Operational Maneuver From The Sea (OMFTS), Sea-Based Logistics (SBL), Maritime Prepositioning Force Future (MPF(F)), Sustainment, Sea Base

INFORMATION SUPERIORITY AND GAME THEORY: THE VALUE OF VARYING LEVELS OF INFORMATION

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The ability to acquire and use information superiority to enhance combat power and contribute to the success of military operations is a primary factor in the fulfillment of the tenets of Joint Vision 2020. This thesis examines how various levels of information and information superiority affect strategy choices and decision-making in determining the payoff value for opposing forces in a classic zero-sum two-sided contest. The results show that if opposing forces possess options with equivalent strategic capabilities, the payoff advantage is determined by the quantity of choices from which to choose. The degree of advantage in payoff for the force with superior information is determined by the amount of choices and the quantity of bad information for the opponent. When a force possesses significantly fewer strategic options, more superior information is required to assume a payoff advantage, and for a force having more flexibility, significantly less information is required to affect an advantage in payoff. Additionally, we see that the effects of intelligence provides the greatest payoff advantage when a force possesses its maximum number of strategic options combined with the opposition also having its maximum number of choices.

KEYWORDS: Information, Simulation, Naval Combat

AN EXPLORATORY ANALYSIS ON THE EFFECTS OF INFORMATION SUPERIORITY ON BATTLE OUTCOMES

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Visions of future warfighting, such as Joint Vision 2020, emphasize using new technologies to obtain and exploit information advantages to achieve new levels of effectiveness in joint warfighting. Unfortunately, our warfighting models are notoriously poor at capturing the effects of information on battle outcomes. Moreover, traditional measures of effectiveness (MOEs) usually ignore the effects of information and decision making on battle outcomes. The Department of the Navy and other DoD organizations have tasked RAND to create a framework for developing measures and metrics to assess the impact of C4ISR

systems and procedures on battle outcomes. In order to quantify the effects of information and decision making on battle outcomes, RAND built a deterministic model and hypothesized a scenario involving the search for, and destruction of, a time-critical target (TCT). This thesis extends their work by making the simulation stochastic and exploring practical issues such as: (i) the effects of improved C4ISR systems and procedures on battle outcomes; (ii) which messaging and data processing delay reductions give the greatest improvements in kill probability; (iii) which command and control architecture provides the highest kill probability.

KEYWORDS: C4ISR, Exploratory Analysis, Stochastic Simulation, Information Superiority, Network-Centric Warfare, Combat Modeling