OBJECTIVE: To determine a cost/effective management plan for the Marine’s fleet of aging KC130 tanker aircraft, and to determine the number of such aircraft required.

SUMMARY: The Marines’ current KC130F/R aircraft must eventually be replaced with new KC130J aircraft. Considering the effects of fatigue, corrosion, and obsolescence on the current fleet, the plan that minimizes the present value of all costs is to immediately retire the F/R-series aircraft and replace them with new aircraft. However, the cost of a plan where current aircraft are upgraded, maintained, and operated for an additional 10 years is not substantially greater. Approximately 100 KC130J aircraft would be needed to meet the stated needs of the Marines. Besides aerial refueling, the Marines use KC130s for ground refueling, cargo delivery, and airborne command and control.

PUBLICATION:

THESIS DIRECTED:

DoD KEY TECHNOLOGY AREA: Air Vehicles

KEYWORDS: Cost/effective, Refueling

OBJECTIVE: Use large-scale mathematical programming techniques to solve deterministic and stochastic extensions of important combinatorial optimization models and develop graph and network algorithms for dynamic map-based military planning applications. This is a continuing research project.

SUMMARY: One part of this research designed and developed a toolkit of methods to quickly construct graph and network algorithms. The algorithms were integrated into a dynamic map-based military planning system that operates over heterogeneous computer networks. The system can download algorithms over a computer network and execute them to analyze operations. The design allows algorithms to be easily added to the planning system. Another part of this research developed new Monte Carlo methods for evaluating the accuracy of solutions to stochastic programming models. A new class of simplicial penalties applicable in lieu of polyhedral cuts to encourage admissible integer polyhedral solutions was also developed.
PUBLICATIONS:


CONFERENCE PRESENTATIONS:


THESES DIRECTED:


DoD KEY TECHNOLOGY AREAS: Computing and Software, Modeling and Simulation, Other (Decision Support Systems)

KEYWORDS: Integer Programming, Stochastic Programming, Dynamic Planning

AN ARCHITECTURE FOR DYNAMIC PLANNING SYSTEMS USING LOOSELY COUPLED COMPONENTS

Gordon H. Bradley, Professor
Arnold H. Buss, Assistant Professor
Department of Operations Research
Sponsors: Air Force Office of Scientific Research and Naval Postgraduate School

OBJECTIVE: The research is designing and developing an architecture for dynamic map-based military planning applications using new platform independent software technology. The new architecture, called "loosely coupled components," is based on collections of components that operate on a computer network and access data, algorithms and other information over the network. The components perform basic tasks: accessing and displaying maps, displaying node-arc representations of applications over the maps, allowing user access to node and arc properties by accessing the visual representations, executing algorithms for planning, performing Monte Carlo simulations, and visually presenting the solution. The set of components supports the quick and inexpensive construction of a wide variety of map-based planning systems. The architecture allows the components to be designed and constructed independent of each other and to be easily added to the system. This is a continuing research project.

SUMMARY: The research results have been used to build three prototype advanced planning systems: (1) interdiction and restoration of supply lines, (2) planning Special Forces operations, and (3) map-based simulation of military convoys. Each prototype demonstrates the application of the architecture to a specific planning system. Under development are systems for: (1) after action review of live fire tactical exercises using GPS devices, and (2) wireless networks for planning and operations.

CONFERENCE PRESENTATIONS:


THESES DIRECTED:


DoD KEY TECHNOLOGY AREAS: Computing and Software, Modeling and Simulation, Other (Decision Support Systems)

KEYWORDS: Map-Based Military Planning, Component-Based Design, Network Optimization

IMPROVEMENT IN THE JOINT STAFF PHASED THREAT DISTRIBUTION (JSPTD) MODEL

Gerald Brown, Professor
Rob Dell, Associate Professor
Alexandra Newman, Research Assistant Professor
Alan Washburn, Professor

Department of Operations Research
Sponsor: Joint Staff (J8)

OBJECTIVE: J8 currently has the responsibility to determine each service’s share of the targets that will need to be dealt with in a large war; that is, to distribute the targets over the services. J8 has proposed using a large linear program to help automate this process, the JSPTD model. The objective is to make the model more efficient, reduce the need for hard-to-determine data, and incorporate a realistic ground war.

SUMMARY: A revised model called JCCM (Joint Combat Capability Model) has been developed. JCCM incorporates multiple phases of the war, terminating each at a time dependent on the state of the battle. The war is fought in 3-day periods, in each of which is fought an optimized air-to-ground battle and a non-optimized ground-to-ground battle. The two parts communicate through surviving numbers of platforms, munitions, and targets. The structure of JCCM is a
master FORTRAN program that calls a ground-to-ground subroutine and makes calls via GAMS to an air-to-ground optimizer. A four-phase war takes about 10 minutes to fight on a modern PC. Software has been delivered to J8, along with an unpublished report.

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

**KEYWORDS:** Optimization, Weapon Allocation

**FUTURE TECHNOLOGIES FOR SPECIAL OPERATIONS MISSION PLANNING, ANALYSIS, REHEARSAL, AND EXECUTION (MPARE)**

Gordon H. Bradley, Professor  
Arnold H. Buss, Assistant Professor  
LTC Joel Parker, USA  
Department of Operations Research  
Sponsor: U.S. Special Operations Command

**OBJECTIVE:** Research and analyze emerging and leap-ahead technologies in support of USSOCOM in the system requirement stage for its Mission Planning, Analysis, Rehearsal, and Execution (MPARE) initiative. Advise and support Modeling and Simulation group on technology trends and future technology capabilities in C4I. This is a continuing research project.

**SUMMARY:** Participated as part of the Requirements Integration Program Team (RIPT) with responsibilities to contribute to the development of the Concept of Operations (CONOP) and Operational Requirements Documents (ORD). Information was also provided on technological trends in C4I and possible "leap ahead" technologies.

**CONFERENCE PRESENTATIONS:**


**THESES DIRECTED:**


**DoD KEY TECHNOLOGY AREAS:** Computing and Software, Modeling and Simulation, Other (Decision Support Systems)

**KEYWORDS:** Map-based Military Planning, Component-Based Design, Network Optimization

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**OPTIMIZING NAVY PROGRAM PLANNING**

**Gerald G. Brown, Professor**

**Robert F. Dell, Associate Professor**

**Department of Operations Research**

**Sponsor: Chief of Naval Operations (N81)**

**OBJECTIVE:** The goal is to equip N-81 by the end of this fiscal year with a desktop, optimization-based decision support tool to integrate, rationalize, and schedule the way in which and the rate at which Navy capital spending programs should be conducted over the next 25 years.

**SUMMARY:** We have formulated an optimization model of the Navy’s spending plans for major weapons systems (e.g., ships and aircraft) and demonstrated it with current planning data. Our goal is to prescribe complete scenarios that follow all Navy guidelines, including details such as keeping shipyards efficiently employed, synchronizing submarine production across yards, and meeting IWAR (Integrated Warfare Architecture) requirements. Program costs are nonlinear functions of volume, expressing the effects of learning and efficiencies of scale. The intent is to provide complete scenarios that can be used by the existing N81 scenario analysis tool EPA-TOA. Currently, complete scenarios must be manually assembled --- a slow, laborious task that frequently results in undetected errors. Results have been briefed, and further direction from N81 is forthcoming.

**THESES DIRECTED:**


**DoD KEY TECHNOLOGY AREAS:** Computing and Software, Modeling and Simulation, Other (Optimization and Decision Support)

**KEYWORDS:** Optimization, Large-Scale Optimization, Program Planning
OPERATIONS RESEARCH

SUPPORT FOR THE CENTER FOR OPERATIONS RESEARCH,
NATIONAL SECURITY AGENCY (U)
Gerald G. Brown, Professor
Department of Operations Research
Sponsor: National Security Agency

OBJECTIVE: Provide on-call analytical support to the National Security Agency.

SUMMARY: Available from sponsor.

PUBLICATION:

THESES DIRECTED:


DoD KEY TECHNOLOGY AREAS: Computing and Software, Modeling and Simulation, Other (Optimization and Decision Support)

KEYWORDS: Optimization

MARITIME OPERATIONS SIMULATION VALIDATION AND APPLICABILITY ASSESSMENT FOR DEEPWATER ACQUISITION
Arnold H. Buss, Assistant Professor
Thomas Halwachs, Senior Lecturer and Associate Provost
Department of Operations Research
Sponsor: United States Coast Guard Research and Development Center

OBJECTIVE: Conduct a verification, validation, and applicability assessment for MarOpsSim, a simulation model under development for the United States Coast Guard to support the new Deepwater Acquisition process.

SUMMARY: MarOpsSim is a multi-mission discrete event simulation model currently being developed for the United States Coast Guard to support performance assessment and analysis alternatives. In accordance with sound principles of modeling and simulation (M&S) development, verification and validation (V&V) of MarOpsSim was performed, and a review of its domain of applicability needs conducted, prior to its acceptance for use in the Deepwater Acquisition process. The V&V effort included: validation of basic simulation mechanisms, including event management, random variate generation, and scripting; validation of basic platform modeling, including movement and sensing; validation of environmental modeling; validation of database and input models; verification of scripts and input configurations; and provide recommendations for possible model improvements. This constituted Phase I of the V&V effort for MarOpsSim. Phase II is to be completed in FY 00.

PUBLICATION:

DoD KEY TECHNOLOGY AREA: Modeling and Simulation
OPTIMIZATION MODELS FOR INSTALLATION MANAGEMENT
Robert F. Dell, Associate Professor
Department of Operations Research
Sponsors: United States Army Base Realignment and Closure Office and Naval Postgraduate School

OBJECTIVE: Develop optimization models to assist with installation management.

SUMMARY: The investigator is providing research, support, and development of optimization models to assist the Army’s Base Realignment and Closure Office (BRACO). The integer-linear program, BAEC (Budget Allocation for Environmental Cleanup), was one of the primary 1999 development efforts. BAEC schedules environmental cleanup of sites at military installations that are closing or being realigned. BAEC input for each site specifies a funding timetable for each cleanup phase, as well as several other site characteristics (for example, reuse, legal agreements, risk, presence of unexploded ordinance) that help gauge the relative benefit of timeline adherence. Using each site’s relative benefit, BAEC provides a yearly budget allocation to sites that adheres to budget limitations and provides the greatest overall benefit.

CONFERENCE PRESENTATION:

THESES DIRECTED:

DoD KEY TECHNOLOGY AREA: Other (Optimization)

KEYWORDS: BRAC, Capital Budgeting, Optimization, Mixed Linear Integer Programming Application
MODELING THE IMPACT OF INFORMATION OBTAINED FROM REALISTICALLY IMPERFECT SENSOR SYSTEMS ON INTERACTIVE AND JOINT CONFLICTS.

SUMMARY: Models for the effect of Battle Damage Assessment on Targeting have been formulated and studied. The effect of various levels of sensor effort on combat has been and is being modeled in various scenarios. Models to assess the suitability of UAVs have been formulated and studied. Models for suppression of enemy air defense have been formulated and studied. A discrete time combat model using killer/victim scoreboards from a high resolution combat simulation has been formulated and studied.

PUBLICATIONS:


CONFERENCE PRESENTATIONS:


THESES DIRECTED:


OTHER:


DoD KEY TECHNOLOGY AREAS: Human Systems Interface, Modeling and Simulation

KEYWORDS: Combat Models, Bayesian Perception Updating, Decision Analysis

TRAINING AND RESEARCH SUPPORT FOR DIRECTOR, OPERATIONAL TEST AND EVALUATION
Donald P. Gaver, Distinguished Professor
Patricia A. Jacobs, Professor
Department of Operations Research
Sponsor: Director, Operational Test and Evaluation

OBJECTIVE: Purpose of the research is to develop training and reference material on a web site and new methodology for operational testing use emphasizing modeling and simulation.

SUMMARY: Models to assess the operational suitability of sensor platforms have been formulated and studied. Materials for an operational test and evaluation web site have been developed.

CONFERENCE PRESENTATION:


THESIS DIRECTED:


DoD KEY TECHNOLOGY AREAS: Human Systems Interface, Modeling and Simulation

KEYWORDS: Military Test and Evaluation, Statistical Data Analysis, Decision Analysis, Modeling and Simulation

DEVELOPMENT OF EA-6B ANALYSIS OF ALTERNATIVE (AOA) METHODOLOGY AND TEMPLATE
Thomas H. Hoivik, Senior Lecturer
Department of Operations Research
Sponsor: Chief of Naval Operations

OBJECTIVE: To develop a step-by-step analytical methodology and template for N88 (Aircraft Requirements) to use when writing and conducting an Analysis of Alternatives for future weapon systems.

SUMMARY: N88 requested detailed guidance on how to conduct an Analysis of Alternatives (AoA) for electronic combat systems and platforms to meet near and far term (to year 2020) critical requirements. This research investigated
and developed a detailed Analysis of Alternatives methodology for both short term and long term Electronic Combat systems mission requirements. The analysis methodology included step by step development procedures, roles of quantitative models and simulation, suggested methodology structures, appropriate player roles for assistance, and a tailored template for the EA-6B immediate follow-on requirements. The AoA methodology was structured to be in conformance with DoD directives and will be used as a base reference and guide for all N88 platform requirement analysis.

DoD KEY TECHNOLOGY AREA: Electronic Warfare

KEYWORDS: Analysis of Alternatives, Electronic Combat, Electronic Warfare

ANALYSIS OF THE ARMY WARFARE EXPERIMENT (AWE) RESULTS ON ACQUISITION DECISION MAKING

Thomas H. Hoivik, Senior Lecturer
Department Operations Research
Sponsor: United States Army Training and Doctrine Command (TRADOC)

OBJECTIVE: To evaluate the validity of the Army Task Force XXI Advanced Warfighting Experiment (TF XXI AWE) objective of providing information to support investment decision and refinement of requirements for information age technologies.

SUMMARY: This research was conducted to determine the use of Advanced Warfighting Experiments to support material acquisition decisions. Specifically, the research evaluated the effectiveness of the Army Task Force XXI Advanced Warfighting Experiment (TF XXI AWE) objective of providing information to support investment decisions and refinement of requirements for information age technologies. A formative evaluation process methodology was used. Data were collected from appropriate program offices and user representatives to determine the perceived utility of the recommendations and level of implementation. Subjective data detailing why specific recommendations were or were not implemented were used to determine the contributing factors to a program’s ability to benefit from participation in the experiment.

PUBLICATION:


THESIS DIRECTED:


DoD KEY TECHNOLOGY AREA: Battlespace Environments

KEYWORDS: Test and Evaluation, Army Warfighting Experiments, Acquisition, Formative Evaluation Process

RESEARCH IN APPLIED STATISTICS: CAPTURE-RECAPTURE METHODS AND MEASUREMENT ERROR MODELS

Robert A. Koyak, Assistant Professor
Department of Operations Research
Sponsor: Naval Postgraduate School

OBJECTIVE: Initiate research into applied statistical problems related to two areas of methodology: (1) estimation of the size of a population, using capture-recapture methods, and (2) model fitting and estimation when predictor variables are measured with error.
SUMMARY: Research in CY 1999 emphasized two themes. One theme concerned the development and estimation of nonlinear measurement error models. This work resulted in the revision of a paper on this subject that is scheduled for publication in 2000. The other theme concerned the use of capture-recapture methods to improve estimation of the size of a population. Research focused on a method known as raking, which is used for smoothing capture-recapture estimates. The statistical foundation of raking methodology was explored, and an efficient computational algorithm for computing raking estimates was developed.

PUBLICATION:


CONFERENCE PRESENTATIONS:


DoD KEY TECHNOLOGY AREA: Other (Probability and Statistics)

KEYWORDS: Capture-Recapture, Population, Measurement

INTEROPERABILITY TESTING
Robert A. Koyak, Assistant Professor
Department of Operations Research
Sponsor: Defense Information Systems Agency

OBJECTIVE: Investigate areas of possible collaboration between NPS and the Joint Interoperability Test Command (JITC) in a range of areas related to interoperability testing, leading to research projects for NPS faculty and thesis topics for NPS students.

SUMMARY: The Department of Defense requires that all command, control, communications and computer intelligence (C4I) systems and automated information systems (AIS) be certified as interoperable between the services. JITC is responsible for the testing and certification of these systems. Research in CY 1999 on this brief project was limited to exploring opportunities for NPS to collaborate with JITC, leading to improvement in the fulfillment of JITC’s interoperability testing mission. This work has continued into CY 2000 notably in the identification of statistical problems related to the interoperability testing of theater missile defense systems.

PUBLICATION:


DoD KEY TECHNOLOGY AREAS: Command, Control and Communications, Computing and Software, Modeling and Simulation, Other (Testing and Evaluation)

KEYWORDS: Interoperability, Testing
FORECASTING THE RETENTION OF NAVAL AVIATORS
William K. Krebs, Assistant Professor
Samuel E. Buttrey, Assistant Professor
Department of Operations Research
Sponsor: Naval Air Systems Command

OBJECTIVE: Navy, Marine, and Air Force senior leadership has stated that at the current rate of pilot resignation and that given the paucity of aviators accepting the bonus, operational readiness can be expected to decrease.

SUMMARY: In the past couple of years, the Armed Forces have had to cope with an increasing number of pilots opting for civilian employment rather than making a career in military aviation. Representative Spence, Chairman of the House Armed Services Committee, attributes the exodus of military personnel leaving active duty service to the decline in the quality of military life (National Defense Authorization Act for Fiscal Year 2000 (S. 1059)). Our 1998 Navy and Marine Corps aviation survey results found that aviators cited “time away from home,” “pay satisfaction,” and “work hours,” as the primary reasons for leaving the military (Buttrey and Krebs, 1998). In support of these survey findings, the Cumulative Continuation Rate (CCR), an instrument used to measure military retention, has shown a general increase in aviator losses these past three years. During this same period, even though there has been an increase in the size of the Aviation Continuation Pay bonus, the number of aviator resignations has continued to increase. A decision tree model was developed comprised of attributes from the Officer Master File to predict classes of aviators who were more likely to leave military service. Our model, capable of measuring retention behavior at any point in an aviator’s career, outperformed the CCR and brought favorable responses from our sponsors.

THESES DIRECTED:


DoD KEY TECHNOLOGY AREA: Manpower, Personnel and Training

KEYWORDS: Aviators, Retention, Force Forecasting

PERCEPTUAL PLASTICITY IN A VIRTUAL ENVIRONMENT
William K. Krebs, Assistant Professor
Department of Operations Research
Sponsor: Naval Postgraduate School

OBJECTIVE: To investigate low-level perceptual-adaptation effects caused by long-term exposure to a virtual environment (VE).

SUMMARY: This research investigated low-level perceptual-adaptation effects caused by long-term exposure to a virtual environment (VE). Subjects in a VE experience various levels of “simulator sickness” of unknown origin. Researchers suspect the sickness is due to a sensory perceptual mismatch between vestibular-ocular and somatosensory inputs. Previous studies used questionnaires to measure subject discomfort, but this does not isolate the relationship between VE exposure and simulator sickness. This study used several visual psychophysical tests (e.g., eye movements) to measure the amount of plasticity that may occur with immersion in a VE. The results failed to find any statistically significant changes in low-level vision functions. However, as with virtually every other study done on simulator sickness, this study did find statistically significant differences in comfort level (as measured with the Simulator Sickness Questionnaire) when using a head-mounted display and a 3-panel display, as compared to a control condition. Although the VE simulator sickness study produced mixed results, the hardware system capabilities led to other research ideas that enabled students to pursue topics pertaining to training, shipboard display design, and assessing basic visual performance in a virtual environment. Specifically, a visual navigation display to assist shipboard conning
OPERATIONS RESEARCH

officers when maneuvering in a battle group formation was developed and tested, investigations also focused on whether surface warfare officers’ ship handling skills deteriorate after a two-year shore tour.

PUBLICATIONS:


CONFERENCE PRESENTATION:


THESES DIRECTED:


DoD KEY TECHNOLOGY AREAS: Human Systems Interface, Biomedical, Modeling and Simulation

KEYWORDS: Virtual Environment, Simulator Sickness, Adaptation, Depth Perception, Displays, Training

BEYOND THIRD GENERATION: ASSESSMENT OF SENSOR FUSION FOR N88’S F/A-18 TARGETING REQUIREMENTS

William K. Krebs, Assistant Professor
Department of Operations Research
Sponsors: National Research Laboratory, Defense Advanced Research Project Agency (DARPA), and Lockheed Martin

OBJECTIVE: To demonstrate the improvement of dual-band color fusion imagery over single-band imagery with low-light level or short wavelength infrared and long-wave infrared uncooled sensors.

SUMMARY: Images were collected with low-light level or short wavelength infrared and long-wave infrared uncooled sensors, and were combined by an image fusion algorithm derived from a computational model of human retinal processing (Scribner, Satyshur, and Kruer, 1993; Werblin et al., 1997). Test stimuli were collected with sensors mounted atop a vehicle, helicopter, or an F/A-18. The data collection equipment consisted of multiple CPUs with internal hard drives to record real-time digital data at 30 frames/second. Targets (military vehicles, man-made structures, and automobiles) were randomly positioned against various types of natural backgrounds (grass, mountains, sand, and trees) under different nighttime illumination conditions. Multiple behavioral experiments were conducted to measure subjects’ ability to detect the presence of a target within each scene. Results: Overall, sensor-fused imagery produced performance better than or equivalent to that produced by either format of single-band imagery. Conclusions: Sensor fusion may provide an effective method of facilitating the detection of hazards under low visibility conditions.
OPERATIONS RESEARCH

PUBLICATIONS:


CONFERENCE PRESENTATION:


THESES DIRECTED:


DoD KEY TECHNOLOGY AREAS: Human Systems Interface, Modeling and Simulation, Air Vehicles, Sensors, Ground Vehicles

KEYWORDS: Sensor Fusion, Multi-Spectral, Human Performance, Target Recognition, Driving Aids, Enhanced Vision

A HUMAN FACTORS CRITIQUE OF MULTI-SPECTRAL IMAGERY

William K. Krebs, Assistant Professor
Department of Operations Research
Sponsor: Naval Engineering Logistics Office

OBJECTIVE: To assess whether multi-spectral imagery may improve mission planning.

SUMMARY: Image analysts located at the Joint Intelligence Centers assist military operators in developing mission plans by providing intelligence resources pertaining to friendly capabilities, battlefield characteristics, enemy responses,
and weather. In some situations—an amphibious landing, for example—existing intelligence resources are not adequate to provide the operator a comprehensive assessment of the coastal landing zone. The Navy’s Tactical Exploitation of National Capabilities (TENCAP) Office proposed that hyperspectral imagery may increase mission planners’ confidence in assessing unidentified threats, thereby increasing the operator’s situational awareness. This study was divided into two phases: The task analysis was performed on an amphibious landing operation to identify what resources an image analyst uses to develop a mission plan; and the human performance assessment quantified the extent to which the addition of hyperspectral imagery to standard information sources enhances object recognition and situation awareness. The qualitative and quantitative results showed that multi-spectral imagery increases observers’ ability to recognize targets, thereby increasing mission planning effectiveness. Although the multi-spectral imagery reduced image analysts’ uncertainty in formulating a mission plan, a significant number of observers preferred panchromatic imagery and criticized the inconsistent color schemes between images in multi-spectral imagery. To integrate multi-spectral imagery into mission planning, image analysts must be specially trained to interpret a multi-spectral scene and understand how to exploit its spectral characteristics.

THESES DIRECTED:


DoD KEY TECHNOLOGY AREAS: Human Systems Interface, Command, Control, and Communications, Sensors

KEYWORDS: Hyperspectral Imagery, Multispectral Imagery, Image Interpretation, Amphibious Planning

MODELING ATTRITION OF FIRST-TERM ARMY ENLISTED PERSONNEL

Harold J. Larson, Professor
Samuel E. Buttrey, Assistant Professor
Department of Operations Research
Sponsor: Office of the Deputy Chief of Staff, Personnel (ODCSPER)

OBJECTIVE: The Army is updating its military strength management system. That system is used for modeling near-term needs for, and adjustments to, manpower levels, as well as for longer term projections. One portion, the Enlisted Loss Inventory Model (ELIM), projects losses of first-term enlisted personnel. The model bases its projections on characteristic groups (c-groups), whose structure has remained unchanged since the strength management system was initially implemented. These c-groups partition first-term enlisted personnel according to sex, education level, mental category (AFQT group) and term of service in a specific way. It is presumed that members of different c-groups will have different propensities toward attrition. In recent years, however, forecasts made by the ELIM model have not been satisfactory.

This study used Classification and Regression Tree methodology (CART) to generate c-groups for use with ODCSPER’s new Military Strength Management System; these new c-groups are designed to differ in first-term retention rates, to the maximum extent possible. As this project continued, interest was also expressed in categorizing differences in retention in the early months of a recruit’s first term. In addition, interest arose in groupings which distinguished three groups: those who did not complete the first term, those who did complete the first term but did not re-enlist, and those who did choose to re-enlist at the completion of the first term. CART has also been used for these efforts.

SUMMARY: This project was completed at the end of calendar year 1998, and the final report has been delivered to the sponsor. The CART methodology has been useful in defining new c-groups in which attrition rates varied somewhat more that the old. Misclassification rates are also reduced; the improvement is small in percentage terms but reasonably large in terms of the increased number of correct predictions. The technique also demonstrated that attrition rates peak in the early months and reach a steady-state by about month nine; that race and sex are important factors in producing groups with different attrition rates, and that both the peak and steady-state rates are highest for white females and
lowest for non-white males. This is partly, but not entirely, because females, especially white females, tend to sign up for the longest terms. The best groups for predicting re-enlistment differ somewhat from those that are best for predicting completion. Finally, the college bonus programs do play a role in re-enlistment, as suspected, but not in term completion.

DoD KEY TECHNOLOGY AREA: Manpower, Personnel, and Training

KEYWORDS: CART, Retention, Force Forecasting

DECOMPOSITION TECHNIQUES WITH TRUNCATED SUBPROBLEMS
Siriphong Lawphongpanich, Associate Professor
Department of Operations Research
Sponsor: Naval Postgraduate School

OBJECTIVE: To investigate theoretical and empirical convergence of decomposition techniques in which the subproblem is solved crudely.

SUMMARY: The investigation focused on decomposition techniques for large-scale optimization problems. These techniques typically decompose a large problem into two smaller ones. One is called a ‘master problem’ and the other, a ‘subproblem’. These two problems are solved sequentially many times until a solution to the original (large-scale) problem is found. In practice, these techniques are quite successful when the subproblem has a special structure, for which an efficient algorithm exists. When the subproblem is complicated, these techniques are typically abandoned.

To make these decomposition techniques applicable to more problems, the investigation emphasized on making the techniques more amenable to the latter case, i.e., when the subproblem is difficult to solve. The basic idea is to not solve the subproblem optimally when it is difficult to do so. Instead, the algorithm for the subproblem should be terminated after a few iterations.

During 1999, the convergence of the standard simplicial decomposition in which the algorithm for the subproblem is truncated after one iteration is established. To demonstrate its merit, preliminary numerical experiments for the cutting plane algorithms with truncated subproblems were also completed.

PUBLICATION:

DoD KEY TECHNOLOGY AREA: Other (Optimization)

KEYWORDS: Decomposition Techniques, Nonlinear Programming, Multicommodity Flows

OPTIMAL RECRUIT TRAINING CENTER AND FOLLOW-ON SCHOOL CAPACITIES
Siriphong Lawphongpanich, Associate Professor
CDR Ronald Brown, USN
Department of Operations Research
Sponsor: Chief of Naval Operations

OBJECTIVE: To develop an optimization model that is useful for determining the training capacities for the U.S. Navy’s Recruit Training Center and the follow-on schools.

SUMMARY: Prior to joining the fleet, all new recruits must undergo initial training which typically consists of two parts. One is basic training or boot camp and the other is A-School. At A-School, recruits must take one or more courses as required by their designated ratings. Unlike typical academic institutions, recruits at A-School take one course at a time. When several courses are required, they are taken one at a time in a sequence called a pipeline.
To determine whether there is sufficient A-School capacity, this investigation approached the problem in an indirect manner. For a given A-School capacity, this investigation developed an optimization model for evaluating the efficiency of A-School training. The model has an underlying network structure and minimizes the amount of time the recruits have to wait for A-School instruction. By varying A-School capacity, the trade-off between capacity and waiting time for instruction can be quantified.

**PUBLICATION:**


**DoD KEY TECHNOLOGY AREA:** Other (Optimization)

**KEYWORDS:** Training Capacities, Recruit Training Center

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**PLANNING PROCUREMENT AND DEPLOYMENT OF SPACE AND MISSILE ASSETS**

Alexandra M. Newman, Research Assistant Professor

Gerald Brown, Professor

Robert F. Dell, Associate Professor

Richard E. Rosenthal, Professor

Department of Operations Research

Captain Angela Giddings, USAF

United States Air Force Material Command

Sponsor: United States Air Force Space Command

**OBJECTIVE:** To improve modeling efforts to aid in the procurement of space-based systems over a 25-year time horizon (ongoing).

**SUMMARY:** The Space Command Optimizer of Utility Toolkit (SCOUT) is a linear integer program used by the Air Force Office of Aerospace Studies to help plan the research and development of space-based systems over a 25-year horizon. SCOUT recommends a mix of concepts, current systems, and launches, that minimizes shortfalls in task performance, while adhering to constraints on budget, launcher demand, launcher availability, and logical constraints governing the precedence and interdependence of systems. The current research goal is to improve SCOUT’s performance by ensuring validity of the model, and decreasing the CPU time necessary to complete a model run.

**PUBLICATION:**


**OTHER:**


**DoD KEY TECHNOLOGY AREAS:** Modeling and Simulation, Space Vehicles

**KEYWORDS:** Budgeting, Capital Budgeting, Space Systems
OBJECTIVE: To improve modeling efforts to aid in the selection and firing of Tomahawk missiles from surface ships and submarines (ongoing).

SUMMARY: Tomahawk missile allocation for tasking requirements has traditionally been done manually. Automatic selection of these missiles improves accuracy and consistency in selection, residual firing capabilities, and decreases unnecessary missile expenditure. They are currently extending existing work by developing a model to aid in the automatic selection of Tomahawk missiles in a multi-time period, multi-surface ship environment, taking into consideration initial geographic location of ships, preferences as to how missile firings are allocated to ships, and the relative importance of various taskings. They are also developing a separate, but related, model for submarine missile allocation.

THESES DIRECTED:


DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Surface/Under Surface Vehicles – Ships and Watercraft

KEYWORDS: Missiles, Missile Selection, Naval Operations

OBJECTIVE: To study the holding time distribution of lost training time for the various categories of enlisted training dead time. To seek identifying factors that can separate efficient and inefficient enlisted training pipeline course sequences. This project continues into 2000.

SUMMARY: The major Navy enlisted training dead time categories are AI for awaiting instruction; II for interrupted instruction; and AT for awaiting transfer. The man-days lost in these categories (and broken out by subcategories) are compiled quarterly for the many training courses sponsored by the various Navy commands. Such data are approximate snapshots, and can be used to identify those courses, and those seasons that have low and high rates for lost time. The twenty-five courses that are the worst offenders in 1998 have been selected for deeper study. Monthly snapshot data have been acquired for these courses and for the four years 1996 through, 1999. They are under study for temporal shifts in the rates by course, by season and by year. Categorical Data models are being fitted.

But certain types of information cannot be extracted from snapshot data. Causes of attrition and setbacks may be related to the content, time scheduling and other organizational aspects of the individual course segments and their relationships to their pipes. Also the interrupted instruction (II) may be affected by this distinction. Some pure longitudinal data for the courses, segments and the pipelines have been acquired. That is, data collected at times
measured from the time of convening the course rather than from some fixed date on the calendar. Problems of the type mentioned can be studied using longitudinal data. Models for describing them are under development. Suitability of Data Mining techniques for the discovery of structure in the data is being explored.

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

**KEYWORDS:** Dead Time, Training, Attrition

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**OPTIMIZATION MODELING FOR AIRLIFT MOBILITY**

Richard E. Rosenthal, Professor  
Laura M. Williams, Research Assistant Professor  
Department of Operations Research  
Sponsor: United States Air Force Studies and Analysis Agency

**OBJECTIVE:** To provide research and support for the Air Force air mobility modeling effort by enhancing the Naval Postgraduate School/RAND Mobility Optimizer (NRMO) model and supporting studies performed with the model. This is a continuing project that has been funded since FY95.

**SUMMARY:** A new model interface using a standard software package was designed, and its implementation and testing is in progress. The graphical user interface will make the use of the NRMO model much easier to learn and use. Support for the OSD(PA&E) Optimization Modeling in support of Tanker Requirement Study 05 was given. This support included setting up a secure NRMO environment, and creating and running a baseline scenario.

**PUBLICATION:**


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

**KEYWORDS:** Mobility, Air Mobility, Optimization

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**GENERALIZED NETWORK ENLISTED COMPONENT OF THE ACTIVE ARMY STRENGTH FORECASTER (A2SF)**

Richard E. Rosenthal, Professor  
Laura M. Williams, Research Assistant Professor  
Department of Operations Research  
Sponsor: Army Office of the Deputy Chief of Staff, Personnel (ODCSPER)

**OBJECTIVE:** (1) To research, design and implement a prototype generalized network model for the enlisted component of the Active Army Strength Forecaster (A2SF). The purpose of the model is to maintain the Army’s enlisted force as closely as possible to prescribed levels. (2) To research and design a prototype model to post-process the results of the generalized network enlisted with grade model (EG) of the Active Army Strength Forecaster (A2SF). The purpose of the model is to distribute the losses and promotions forecasted by the EG model into the Military Occupational Specialty (MOS) dimension.

**SUMMARY:** (1) A prototype generalized network model with grade detail, but aggregated with respect to specialty, called the Enlisted-Grade (EG) model has been designed, implemented, verified and delivered. The findings resulting from the research and development of the prototype model will serve as a guide to the contractor in its development of the production system. (2) A prototype model which will optimally distribute the resulting losses and promotions forecasted by the EG model over the MOS dimension has been designed. The design has been delivered, and implementation of a prototype is in progress.
TACTICAL LOGISTICS SUPPORT SYSTEM AND SEA-BASED LOGISTICS
David A. Schrady, Professor
Department of Operations Research
Sponsor: Deputy Chief of Naval Operations (Logistics)

OBJECTIVE: The first objective was to transform the Tactical Logistics Support System (TACLOGS) software so that it complies with DII COE 3.1 standards. The second objective was to begin modeling sea-based logistics.

SUMMARY: The task has been to rewrite the software in JAVA, to create the HCIs with Visual Café, to incorporate compliance with DII COE 3.1, and have the new version run on a PC under the NT operating system vice the UNIX platform of the JMCIS version of TACLOGS. Five releases of the new TACLOGS software were received from the contractor between March and December. All were tested and extensive testing notes written. Each version has been an improvement, but the latest still does not have all the functionality required. Having the 3.1 version of TACLOGS ready for inclusion in the SQT-2 test of the Global Command and Control System-Maritime 3.1 was an objective that was not realized. There has been substantial work on sea based logistics modeling accomplished and a technical report is in preparation. Analysis has focused on the operational aspects of sea-based logistics (SBL) including characterization of the range of types and sizes of forces to be supported by SBL, estimation of the sustainment requirements of such forces, and determination of the feasibility of SBL sustainment for the forces postulated.

THESIS DIRECTED:

AGGREGATED COMBAT MODELS II
James G. Taylor, Professor
Department of Operations Research and Modeling, Virtual Environments and Simulation Academic Group
Sponsor: United States Army Center for Army Analyses

OBJECTIVE: To improve quantitative methodology for assisting in the selection of aggregated-force combat models and submodels, particularly for the attrition process. Also, to improve attrition methodologies for such models.

SUMMARY: This work was limited to the reporting of last year’s research. Past research had focused on determining the theoretical basis of ATCAL (i.e. underlying conceptual and mathematical models and solution methodology for the mathematical equations) and identifying how to improve it. Based on development of general hierarchy-of-models methodology, the ATCAL algorithms (both replay model and estimation of parameter values from high-resolution-combat-simulation output) were completely re-engineered and suggestions for short-term improvement (of the existing algorithms) developed. The director of CAA was briefed on these results. Also, new results for single-weapon-system-type kill rates in Lanchester-type combat models were developed, as an extension of last year’s critique of the proposed JWARS ground-combat attrition methodology. OSD PA&E will consider these results for the direct-fire ground-combat attrition algorithm in JWARS.
OPERATIONS RESEARCH

CONFERENCE PRESENTATIONS:


THESIS DIRECTED:


DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Ground-Force-on-Force Attrition, Attrition-Calibration (ATCAL) Method, Joint Warfare System (JWARS)

SUPPORT AND REVIEW OF THE MODELING OF GROUND COMBAT IN ITEM

James G. Taylor, Professor
Department of Operations Research and Modeling, Virtual Environments and Simulation Academic Group
Sponsor: Joint Training, Analysis, and Simulation Center

OBJECTIVE: To provide necessary background and inputs for specific topics/methodologies (concerning the representation of ground combat) of interest to the Joint Training, Simulation and Analysis Center (JTASC) to support its use/development of the Integrated Theater Engagement Model (ITEM)

SUMMARY: This work was originally funded to investigate the theoretical basis of the attrition-calibration (ATCAL) approach, with an eye on improving how ground-combat attrition and opposed-force movement are played in the Integrated Theater Engagement Model (ITEM). With the advent of JWARS, however, the sponsor directed that efforts be redirected towards helping improve ground-combat attrition in JWARS. Consequently, research was focused on the development of new results for single-weapon-system-type kill rates in Lanchester-type combat models, which OSD PA&E will consider for the direct-fire ground-combat attrition algorithm in JWARS.

CONFERENCE PRESENTATION:


OTHER:


DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Ground-Force-on-Force Attrition, Attrition-Calibration (ATCAL) Method, Joint-Warfare Campaign Models
NEW METHODOLOGY FOR AGGREGATED COMBAT MODELS
James G. Taylor, Professor
Department of Operations Research and Modeling, Virtual Environments and Simulation Academic Group
Sponsor: United States Marine Corps Combat Development Command

OBJECTIVE: To evaluate the adequacy of existing combat-modeling methodologies (especially for attrition) and models (especially JWARS) for current and future USMC Combat Development Command analysis needs.

SUMMARY: Efforts focused on development of new results for single-weapon-system-type kill rates in Lanchester-type combat models, an extension of last year’s critique of the proposed JWARS ground-combat attrition methodology. OSD PA&E will consider these results for the direct-fire ground-combat attrition algorithm in JWARS.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: Ground-Force-on-Force Attrition, Attrition-Calibration (ATCAL) Method, Joint Warfare System (JWARS)

LARGE-SCALE MIXED INTEGER PROGRAMMING
R. Kevin Wood, Professor
Department of Operations Research
Sponsor: Joint Warfare Analysis Center

OBJECTIVE: This continuing research program seeks to develop theory and algorithms for solving analytical models related to civilian and military infrastructure.

SUMMARY: Available from sponsor.

DoD KEY TECHNOLOGY AREAS: Computing and Software, Modeling and Simulation, Other (Optimization and Decision Support)

KEYWORDS: Optimization
**JOURNAL PAPERS**


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OPERATIONS RESEARCH


TECHNICAL REPORTS


CONTRIBUTIONS TO BOOKS
