LARGE-SCALE OPTIMIZATION

Gordon H. Bradley, Professor
Gerald G. Brown, Professor
R. Kevin Wood, Professor
Department of Operations Research
Sponsor: Office of Naval Research and Naval Postgraduate School

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. We have also developed a new class of simplicial penalties applicable in lieu of polyhedral cuts to encourage admissible integer polyhedral solutions.

PUBLICATIONS:

Appleget, J. and Wood, K., 2000, "Explicit-Constraint Branching for Solving Mixed-Integer Programs," *Computing Tools for Modeling, Optimization and Simulation*, M. Laguna and J.L. González-Velarde, editors, Kluwer Academic Publishers, Boston, pp. 243-261.

Brown, G., Dell, R., and Olson, M., 2000, "Valid Integer Polytope (VIP) Penalties for Branch-and-Bound Enumeration," *Operations Research Letters*, 26, 117-126.

Israeli, E., and Wood, K., "Shortest-Path Network Interdiction," in review.

PRESENTATIONS:

Appleget, J. and Wood, R.K., "Explicit-Constraint Branching for Solving Mixed-Integer Programs," 7th INFORMS Computing Society Conference, Cancun, Mexico, 5-7 January 2000.

Bradley, G., Buss, A., Parker, J., and Sanchez, P., "Loosely Coupled Components Laboratory - Overview and Open House," Department of Operations Research Seminar, Monterey, CA, 27 January 2000.

Bradley, G. and Parker, J., "Loosely Coupled Components Working Group," OASD SO/LIC Special Operations C4I R&D Workshop, McLean, VA, 19-21 July 2000.

Bradley, G. and Buss, A., "Architecture for Dynamic Planning Systems Using Loosely Coupled Components," IFIP WORKING GROUP 7.6 Workshop on Virtual Environments for Advanced Modeling, Monterey, CA, 2-4 August 2000.

Bradley, G. and Parker, J., "Loosely Coupled Components Working Group," Inter-service Mission Planning Working Group Meeting (IMPWG), Huntsville, AL, 24-25 October 2000.

Morton, D., Salmeron, J., and Wood, R.K., "New Decomposition-Based Techniques for Solving Two-Stage Stochastic Programs," International Symposium on Mathematical Programming, Atlanta, GA, 7-11 August 2000.

Salmeron, J. and Wood, K., "Solving Stochastic Network Interdiction Problems," INFORMS National Meeting, San Antonio, TX, 5-8 November 2000.

Salmeron, J. and Wood, R.K., "A Sampling-Based Cutting Plane Method for Stochastic Programs," INFORMS National Meeting, Salt Lake City, UT, 7-10 May 2000.

Akgun, I. and Wood, R.K., "Multi-Unit Network Interdiction," INFORMS National Meeting, Salt Lake City, UT, 7-10 May 2000.

Wood, R.K. "Network Interdiction and Eavesdropping," Colloquium in Engineering Economic Systems and Operations Research, Stanford University, Palo Alto, CA, 9 May 2000.

Wood, R.K., "Network Interdiction and Eavesdropping," National Security Agency, Operations Research and Management Science Symposium, 11 April 2000.

THESES DIRECTED:

Balcioglu, A., "An Algorithm for Enumerating The Near-Minimum Weight s-t Cuts of a Graph," Masters Thesis, Naval Postgraduate School, March 2000.

Loh, Long Piao, "Deterministic and Stochastic Models of Biological Attacks on Seaports of Debarkation During a Major Theater War," Masters Thesis, Naval Postgraduate School, September 2000.

Akgun, I., "The K-Group Maximum-Flow Network-Interdiction Problem," Masters Thesis, Naval Postgraduate School, June 2000.

Bradford, R.D., III, "Solving Dynamic Battlespace Movement Problems Using Dynamic Distributed Computer Networks," Masters Thesis, Naval Postgraduate School, June 2000.

Lowell, J.P., "Graphic User Interface Design for Mapping, Information, Display, and Analysis Systems," Masters Thesis, Naval Postgraduate School, June 2000.

Moore M.A., III, "Ranger Air Load Planner," Masters Thesis, Naval Postgraduate School, June 2000.

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
Sponsor: Air Force Office of Scientific Research

OBJECTIVE: Design and develop architecture for dynamic map-based military planning applications using new platform-independent software technology. This is a continuing research project.

SUMMARY: The research has designed and developed a "loosely coupled components" architecture that has been demonstrated by constructing a map-based planning system for dynamic military planning. The architecture coordinates a collection of components that operate over heterogeneous computer networks. The system accesses and displays data, maps, overlays, algorithms, and other information. The components perform tasks such as: displaying maps, satellite images, and overlays; accessing, entering, and modifying data; constructing and displaying models of military operations; and accessing and executing algorithms to analyze operations. The design allows systems to be easily extended by adding addition components.

PRESENTATIONS:

Bradley, G., Buss, A., Parker, J., and Sanchez, P., "Loosely Coupled Components Laboratory - Overview and Open House," Department of Operations Research Seminar, Monterey, CA, 27 January 2000.

Bradley, G. and Parker, J., "Loosely Coupled Components Working Group," OASD SO/LIC Special Operations C4I R&D Workshop, McLean, VA, 19-21 July 2000.

Bradley, G. and Buss, A., "Architecture for Dynamic Planning Systems Using Loosely Coupled Components," IFIP WORKING GROUP 7.6 Workshop on Virtual Environments for Advanced Modeling, Monterey, CA, August 2000.

Bradley, G. and Parker, J., "Loosely Coupled Components Working Group," Inter-service Mission Planning Working Group Meeting (IMPWG), Huntsville, AL, 24-25 October 2000.

Bradley, G. and Buss, A., "Loosely Coupled Components Project: Map-Based Military Planning," The Third International Meeting of the INFORMS Military Application Society, San Antonio, TX, 5-8 November 2000.

THESES DIRECTED:

Armo, K.R., "The Relationship Between a Submarine's Maximum Speed and Its Evasive Capability," Masters Thesis, Naval Postgraduate School, June 2000.

Aydin, E., "Screen Dispositions of Naval Task Forces Against Anti-ship Missiles," Masters Thesis, Naval Postgraduate School, March 2000.

Bradford, R.D., III, "Solving Dynamic Battlespace Movement Problems Using Dynamic Distributed Computer Networks," Masters Thesis, Naval Postgraduate School, June 2000.

Lowell, J.P., "Graphic User Interface Design for Mapping, Information, Display, and Analysis Systems," Masters Thesis, Naval Postgraduate School, June 2000.

Mack, P.V., "THORN: A Study in Designing a Usable Interface for a Geo-Referenced Discrete Event Simulation," Masters Thesis, Naval Postgraduate School, September 2000.

Moore M.A., III, "Ranger Air Load Planner," Masters Thesis, Naval Postgraduate School, June 2000.

Turner, T.E., "A Simulation of the Joint Tactical Radio System Bandwidth Requirements to Support Marine Corps Ship to Objective Maneuver in 2015," Masters Thesis, Naval Postgraduate School, September 2000.

Woodaman, R.F.A., "Agent-Based Simulation of Military Operations Other Than War Small Unit Combat," Masters Thesis, Naval Postgraduate School, September 2000.

OTHER:

Bradley, G.H. and Buss, A., SOFLCC: A system to support real-time and near real-time decision-making for Special Operations Forces using network models based on the Loosely Coupled Components Architecture (LCCA).

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

KEYWORDS: Dynamic Planning, Loosely Coupled Components, Platform Independent Software, Java

LARGE-SCALE OPTIMIZATION

Gerald G. Brown, Professor
R. Kevin Wood, Professor
Department of Operations Research
Sponsor: Air Force Office of Scientific Research

OBJECTIVE: Use large-scale mathematical programming techniques to solve deterministic and stochastic extensions of important combinatorial optimization models and mathematical programs. Develop extensions of network-interdiction techniques to solve more general system interdiction models.

SUMMARY: We have devised and implemented a joint theater combat model to address a long-standing problem faced by the Joint Staff (J8): "How do you integrate the Air Force optimization view of air-to-ground combat with the Army simulation view of ground battle?" Our proof prototype, called the Fast Theater Model (FATHM), fights a full theater war with alternating air optimizations and Lanchester ground combat simulations. Full-scale war plans are optimized in about twenty minutes. Network interdiction models and solution techniques have been extended to solve system interdiction and defense models where a system is modeled as a linear or integer program, or as another interdiction model. The last generalization allows us to solve a tri-level system defense model where a network or other system is optimally hardened against attack. Extensions to stochastic interdiction models have been developed.

PUBLICATIONS:

Appleget, J. and Wood, K., 2000, "Explicit-Constraint Branching for Solving Mixed-Integer Programs," in *Computing Tools for Modeling, Optimization and Simulation*, M. Laguna and J.L. González-Velarde, eds., Kluwer Academic Publishers, Boston, pp. 243-261.

Brown, G., Dell, R., and Olson, M., 2000, "Valid Integer Polytope (VIP) Penalties for Branch-and-Bound Enumeration," *Operations Research Letters*, 26, pp. 117-126.

Israeli, E., and Wood, K., "Shortest-Path Network Interdiction," in review.

Brown, G.G. and Washburn, A, Dell, R.F., Giddings, A., and Rosenthal, R., "An Integer-Linear Program to Plan Procurement" and "The Fast Theater Model (FATHM)," Naval Postgraduate School Project Report, NPS-OR-01-002-PR, October 2000.

Newman, A.M. and Brown, G.G., "Deployment of Space and Missile Assets," Naval Postgraduate School Technical Report, NPS-OR-00-005, April 2000.

PRESENTATIONS:

Akgun, I. and Wood, R.K., "Multi-Unit Network Interdiction," INFORMS National Meeting, Salt Lake City, UT, 7-10 May 2000.

Appleget, J. and Wood, R.K., "Explicit-Constraint Branching for Solving Mixed-Integer Programs," 7th INFORMS Computing Society Conference, Cancun, Mexico, 5-7 January 2000.

Morton, D., Salmeron, J., and Wood, R.K., "New Decomposition-Based Techniques for Solving Two-Stage Stochastic Programs," International Symposium on Mathematical Programming, Atlanta, GA, 7-11 August 2000.

Salmeron, J. and Wood, R.K., "A Sampling-Based Cutting Plane Method for Stochastic Programs," INFORMS National Meeting, Salt Lake City, UT, 7-10 May 2000.

Salmeron, J. and Wood, R.K., "Solving Stochastic Network Interdiction Problems," INFORMS National Meeting, San Antonio, TX, 5-8 November 2000.

Wood, R.K., "Network Interdiction and Eavesdropping," Colloquium in Engineering Economic Systems and Operations Research, Stanford University, Palo Alto, CA, 9 May 2000.

Wood, R.K., "Network Interdiction and Eavesdropping," National Security Agency, Operations Research and Management Science Symposium, 11 April 2000.

THESES DIRECTED:

Akgun, I., "The K-Group Maximum-Flow Network-Interdiction Problem," Masters Thesis, Naval Postgraduate School, March 2000.

Arnold, A., "A Fast Heuristic for Tomahawk Land-Attack Predesignation," Masters Thesis, Naval Postgraduate School, June 2000.

Balcioglu, Ahmet, "An Algorithm for Enumerating the Near-Minimum Weight s-t Cuts of a Graph," Masters Thesis, Naval Postgraduate School, December 2000.

Baran, N., "Optimizing Procurement Planning of Navy Ships and Aircraft," Masters Thesis, Naval Postgraduate School, December 2000.

Gibbons, M., "Enumerating Near-Minimum Cuts in a Network," Masters Thesis, Naval Postgraduate School, June 2000.

Liebe, R.M., "Planning Flight Training for the Transition to the V-22 Osprey," Masters Thesis, Naval Postgraduate School, September 2000.

Loh, Long Piao, "Deterministic and Stochastic Models of Biological Attacks on Seaports of Debarkation During a Major Theater War," Masters Thesis, Naval Postgraduate School, September 2000.

Moore, M.A., "Ranger Air Load Planner," Masters Thesis, Naval Postgraduate School, June 2000.

Pfarrer, M., "Optimizing Procurement of Special Operations Weapons and Equipment," Masters Thesis, Naval Postgraduate School, June 2000.

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

KEYWORDS: Integer Programming, Stochastic Programming, Network Interdiction

LOGISTICS MODELING AND SIMULATION

Arnold H. Buss, Assistant Professor
Department of Operations Research
Sponsor: Lockheed Martin – DD21 Blue Team

OBJECTIVE: Support and theoretical development for DD21 Readiness (Ao and Ai) Modeling and Analysis This is a detailed Logistics Reliability, Availability and Maintainability (RAM) Analysis based on Baselines 4 and 5 with known parameters to the sub-system and possibly segment level (not to LRU which will not be available until Baseline 6).

SUMMARY: The object-oriented, discrete-event simulation developed in this study evaluates the rate at which DD21's weapon systems can complete arriving land attack tasks with its Advanced Gun and Vertical Launch Systems. The DD21 simulation measures how sensitive this completion rate is to discovery/localization of individual component failures. The DD21 simulation also provides for two distinct methods of scoring task completion: no scoring for a task completed after its intended time, and

partial scoring for such a task. The primary output from the simulation is the system effectiveness of DD21 over the course of its mission. Another output is the mean number of tasks lost due to failure for each weapon system.

THESIS DIRECTED:

Snyder, W.H., III, "An Event-Step Simulation for Evaluating DD21 System Effectiveness," Masters Thesis, Naval Postgraduate School, September 2000.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation

KEYWORDS: Logistics Modeling, Discrete Event Simulation, Sensitivity Analysis, Reliability, Availability, Maintainability, Readiness

MARITIME OPERATIONS SIMULATION VALIDATION FOR DEEPWATER ACQUISITION

Arnold H. Buss, Assistant Professor
Thomas Halwachs, Senior Lecturer
Department of Operations Research
Sponsor: U. S. 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 development, Verification and Validation (V&V) of MarOpsSim was perfomed, 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 recommendations for possible model improvements. This constituted Phase I of the V&V effort for MarOpsSim. Phase II is to be completed in FY 01.

PUBLICATION:

Buss, A.H. and Halwachs, T., "Core Validation for Maritime Operations Simulation (MarOpsSim)," Naval Postgraduate School Technical Report, NPS-OR-00-003, 2000.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation

KEYWORDS: Discrete Event Simulation, Coast Guard, Deepwater Acquisition, Movement and Sensing Algorithms, Environmental Modeling, Verification and Validation

CHAIR OF MANPOWER MODELING

Samuel Buttrey, Assistant Professor
Department of Operations Research
Sponsor: Office of Army Deputy Chief of Staff, Personnel

OBJECTIVE: Support ODCSPER in its redesign of manpower models; provide short- and long-term statistical consulting to ODCSPER and contractors on manpower issues; support Army thesis student research and advise theses as appropriate; act as liaison between ODCSPER and NPS faculty undertaking reimbursable research for ODCSPER.

SUMMARY: ODCSPER continues to upgrade its manpower planning and analysis systems. I have acted as a statistical consultant on design issues, like the division of first-term soldiers into characteristic groups that tend to be homogeneous with respect to attrition. The determination of the number and type of these groups has a large effect on the performance of network flow models proposed and implemented by the contractor. Other consulting issues have been handled as necessary. I advised the thesis of Captain Burger and supported that of Major Yamada.

THESES DIRECTED:

Burger, E.C., "A Multivariate Time Series Analysis of U.S. Army Recruiting," Masters Thesis, Naval Postgraduate School, June 2000.

Yamada, W.S., "An Infinite Horizon Army Manpower Planning Model," Masters Thesis, Naval Postgraduate School, June 2000.

DoD KEY TECHNOLOGY AREAS: Manpower, Personnel and Training

KEYWORDS: Retention, Force Forecasting

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 the primary 2000 development effort. BRACO used BAEC to help plan $620 million in environmental cleanup at 649 sites on 39 current and former Army installations. The integer-linear program OSAF (Optimal Stationing of Army Forces) was also started with the Center for Army Analysis to help answer a QDR (Quadrennial Defense Review) issue, "What are the infrastructure requirements to support the Army of the future?"

PUBLICATION:

Brown, G.G., Dell, R.F., and Olson, M.P., "Valid Integer Polytope (VIP) Penalties for Branch-and-Bound Enumeration," *Operations Research Letters*, 26, pp. 117-126.

THESES DIRECTED:

Oremis, S., "Funding Site Cleanup at Closing Army Installations: An Integer Linear Programming Approach," Masters Thesis, Naval Postgraduate School, December 2000.

Evans, J.A., "Who Responds and How Long Does it Take: Assigning Fire Station Areas of Responsibility," Masters Thesis, Naval Postgraduate School, June 2000.

DoD KEY TECHNOLOGY AREAS: Other (Optimization)

KEYWORDS: BRAC, Capital Budgeting, Optimization, Mixed Linear Integer Programming Application

OPTIMALLY SCHEDULING EA-6B DEPOT MAINTENANCE

Robert F. Dell, Associate Professor
Department of Operations Research
Sponsor: Naval Air Systems Command

OBJECTIVE: The goal is to equip the EA-6B Program Office with a desktop, optimization-based decision-support tool to schedule all depot maintenance (standard depot-level maintenance, wing center-section replacements, and major aircraft modifications) for the EA-6B prowler fleet through 2015.

SUMMARY: We have formulated an optimization model to assist in scheduling EA-6B depot maintenance (standard depot-level maintenance, wing center-section replacements, and major aircraft modifications) and major aircraft modification-kit acquisition. The model produces an induction schedule providing monthly recommendations for the first six years, a yearly schedule out to 2013, and yearly major aircraft modification-kit acquisition levels out to 2010. We have performed extensive testing of alternate depot induction policies using the model to show their impact on yearly depot workloads and yearly operational aircraft.

PRESENTATION:

Baker, R.O., Dell, R.F., and Meeks, B.P., "Optimally Scheduling EA-6B Depot Maintenance," National Meeting of the Institute for Operations Research and the Management Sciences, Salt Lake City, UT, 7-10 May 2000.

THESIS DIRECTED:

Baker, R.O., "Optimally Scheduling EA-6B Depot Maintenance and Aircraft Modification Kit Procurement," Masters Thesis, Naval Postgraduate School, September 2000.

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

KEYWORDS: Optimization, Large-Scale Optimization, Scheduling

PLANNING CAPITAL INVESTMENTS USING OPTIMIZATION

Robert F. Dell, Associate Professor
Department of Operations Research
Sponsor: Office of Naval Research

OBJECTIVE: Conduct basic research in optimal planning of capital investments with two short-term subjects, (a) the Capital Investment Planning Aide (CIPA) for U. S. Navy Force Structure planning and (b) the Japan Petroleum Distribution model (JPDM) for US Navy infrastructure planning.

SUMMARY: This was the first year of a multi-year effort to conduct research on theory and algorithms for solving real-world capital-budgeting problems with prescriptive optimization. The first year had two short-term goals. The first was to enhance the Capital Investment Planning Aide (CIPA) for U. S. Navy Force Structure planning. 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. The second short-term goal was to enhance the Japan Petroleum Distribution model (JPDM) for U. S. Navy infrastructure planning. The Commander-in-Chief, United States Pacific Command (USCINCPAC) Joint Petroleum Office used JPDM in April 2000 during Exercise Joint Reception, Staging, Onward Movement and Integration (JRSOI 2000) and again in August 2000 for Exercise Ulchi Focus Lens.

PUBLICATIONS:

Brown, G.G., Dell, R.F., and Olson, M.P., 2000, "Valid Integer Polytope (VIP) Penalties for Branch-and-Bound Enumeration," *Operations Research Letters*, 26, pp. 117-126.

Newman, A.M., Brown, G.G., Dell, R.F., Giddings, A., and Rosenthal, R.E., 2000, "An Integer-Linear Program to Plan Procurement and Deployment of Space and Missile Assets," Naval Postgraduate School Technical Report, NPS-OR-00-005, April 2000.

PRESENTATIONS:

Brown, G.G., Dell, R.F., and Halwachs, T.E., "Implementing Optimization Based Models for Acquisition," SMART (Simulation & Modeling Acquisition Requirements Training) Conference 2000 sponsored by the Assistant Secretary of the Army for Acquisition, Logistics, and Technology, Los Angeles, CA, 26-28 January 2000.

Dell, R.F., Brown, G.G., Field, R.J., and Newman, A.M., "Optimization Models for Military Capital Budgeting," 68th Military Operations Research Society Symposium, Colorado Springs, CO, 20-22 June 2000.

THESES DIRECTED:

Baran, N., "Optimizing Procurement Planning of Navy Ships and Aircraft," Masters Thesis, Naval Postgraduate School, December 2000.

Noble, J.D., "Scheduling and Distributing Intra-Theatre Wartime POL Requirements," Masters Thesis, Naval Postgraduate School, December 2000.

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

KEYWORDS: Optimization, Large-Scale Optimization, Program Planning, Budgeting, Capital Budgeting

OPTIMIZING NAVY PROGRAM PLANNING

Robert F. Dell, Associate Professor
Gerald G. Brown, Professor
Department of Operations Research
Sponsor: Chief of Naval Operations (N81)

OBJECTIVE: To provide N81 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. Our design has been briefed and approved, and we have started work on a graphical user interface.

PRESENTATIONS:

Brown, G.G., Dell, R.F., and Halwachs, T.E., "Implementing Optimization Based Models for Acquisition," SMART (Simulation & Modeling Acquisition Requirements Training) Conference 2000 sponsored by the Assistant Secretary of the Army for Acquisition, Logistics, and Technology, Los Angeles, CA, 26-28 January 2000.

Dell, R.F., Brown, G.G., Field, R.J., and Newman, A.M., 2000, "Optimization Models for Military Capital Budgeting," 68th Military Operations Research Society Symposium, Colorado Springs, CO, 20-22 June 2000.

THESES DIRECTED:

Baran, N., "Optimizing Procurement Planning of Navy Ships and Aircraft," Masters Thesis, Naval Postgraduate School, December 2000.

Field, R.J., "Planning Capital Investments in Navy Forces," Masters Thesis, Naval Postgraduate School, December 1999.

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

KEYWORDS: Optimization, Large-Scale Optimization, Program Planning, Budgeting, Capital Budgeting, Decision Support

PLANNING PROCUREMENT AND DEPLOYMENT
OF SPACE AND MISSILE ASSETS

Robert F. Dell, Associate Professor
Gerald G. Brown, Professor
Richard E. Rosenthal, Professor
Department of Operations Research
Thomas E. Halwachs, Senior Lecturer
Sponsor: United States Air Force Space Command

OBJECTIVE: To model how the Air Force Space Command should procure space-based systems over a 25-year time horizon.

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. We have documented how SCOUT is used and analyzed alternate models to improve SCOUT's fidelity and performance.

PUBLICATIONS:

Newman, A.M., Brown, G.G., Dell, R.F., Giddings, A., and Rosenthal, R.E., "An Integer-Linear Program to Plan Procurement and Deployment of Space and Missile Assets," Naval Postgraduate School Technical Report, NPS-OR-00-005, April 2000.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Space Vehicles

KEYWORDS: Optimization, Large-Scale Optimization, Program Planning, Budgeting, Capital Budgeting, Space Systems

RESEARCH IN JOINT WARFARE MODELING AND SIMULATION, EMPHASIZING INFORMATION WARFARE ISSUES

D. P. Gaver, Distinguished Professor
P. A. Jacobs, Professor
Department of Operations Research
Sponsors: Director, Operational Test and Evaluation,
Institute for Joint Warfare Analysis of the Naval Postgraduate School,
DSO National Laboratories, Singapore,
Naval Air Systems Command and the Joint Staff (J8)

OBJECTIVE: Purpose of the research is to formulate and study state space models for information operations in joint warfare with a view towards guiding allocation of acquisition and eventually operational resources. The emphasis is on modeling the impact of information obtained from realistically imperfect sensor systems on interactive and joint conflicts

SUMMARY: State space models for time critical targeting represented in Fleet Battle Experiment Foxtrot have been developed, populated with data from that experiment and studied. Meta-models for ground combat that are populated with estimates obtained from a high-resolution combat model have been developed and studied.

PUBLICATIONS:

Becker, K.D., Gaver, D.P., Glazebrook, K.D., Jacobs, P.A., Lawphonpanich, S., "Allocation of Tasks to Specialized Processors: A Planning Approach," *European Journal of Operational Research*, Vol. 126, (2000) pp. 80-88.

Gaver, D.P., Jacobs, P.A., Youngren, M.A., and Parry, S.H., "JSTOCHWARS and Beyond: Models for Force Motion and Interaction that Represent Uncertain Perception," Naval Postgraduate Technical Report, NPS-OR-00-007, September 2000.

Gaver, D.P., Jacobs, P.A., and Pilnick, S.E., "Operations Analysis of Fleet Battle Experiments Using the Battlespace Information War Methodology," Naval Postgraduate School Technical Report, NPS-IJWA-01-008, October 2000.

Gaver, D.P. and Jacobs, P.A., "DISC-O-TIC: A Discrete-Time Analytical Meta-Model for Use in Combat Systems Studies that Utilize High-Resolution Simulation Models," Naval Postgraduate School Technical Report NPS-OR-01-005 and NPS-IJWA-01-009, December 2000.

THESIS DIRECTED:

Andrade, S., "An Intelligent Agent Simulation of Shipboard Damage Control," Master's Thesis, Naval Postgraduate School, June 2000.

OTHER:

Bullock, G., "Delphi Software Implementation of Models for Blue Force Response to Region Invasion by Multi-Type Red Forces," September 2000.

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

D. P. Gaver, Distinguished Professor
P. A. Jacobs, Professor
Department of Operations Research

Sponsors: Director, Operational Test and Evaluation and U. S. Army TRADOC Analysis Command

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 for sequential stage system reliability growth via failure model removal have been formulated and studied. 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.

PUBLICATIONS:

Gaver, D.P., Jacobs, P.A., and Seglie, E.A., "System Reliability Growth via Failure Mode Removal," *Livre des Actes*, Vol. 1, MMR 2000, Methodology, Practice and Inference, 2nd International Conference on Mathematical Methods in Reliability. Laboratoire Statistique Mathématique et ses Applications, Université Victor Ségalen, Bordeaux, France, pp. 439-442.

Gaver, D.P., Jacobs, P.A., and Seglie, E.A.,"Reliability Growth in Stage-Wise-Functioning Systems by Failure Mode Removal," *Agenda Book for Workshop on Reliability Issues for DoD Systems*, 9-10 June 2000.

Gaver, D.P., Glazebrook, K.D., Jacobs, P.A., and Seglie, E.A., "Probability Models for Sequential-Stage System Reliability Growth Via Failure Mode Removal," Naval Postgraduate School Technical Report, NPS-OR-00-006, September 2000.

.

PRESENTATIONS:

Gaver, D.P., Jacobs, P.A., Olwell, D., and E. Seglie, E.A., "Probability Models for Sequential Stage System Reliability Growth Via Failure Mode Removal," Workshop on Reliability Issue for DoD Systems, Washington D.C., 9-10 June 2000.

Gaver, D.P., Jacobs, P.A., and Seglie, E.A., "Decision Criteria that Support Learning from Operational Testing," Joint Research Conference on Statistics in Quality, Industry and Technology, Seattle, WA, 26-28 June 2000.

Gaver, D.P., Jacobs, P.A., and Seglie, E.A., "System Reliability Growth Via Failure Mode Removal," Second International Conference on Mathematical Methods in Reliability, Bordeaux, France, 47 July 2000.

THESIS DIRECTED:

Unrath, C. "Dynamic Exploration of Helicopter Reconnaissance Through Agent-Based Modeling," Masters Thesis, Naval Postgraduate School, September 2000.

OTHER: Spreadsheet implementation of simulation of reliability tests

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

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

EXPLORATORY AEA MODELING AND ANALYSIS, USING BAT/IW

D. P. Gaver, Distinguished Professor
P. A. Jacobs, Professor
Department of Operations Research
Sponsor: Naval Air Systems Command

OBJECTIVE: Conduct exploratory scooping and analysis of options for follow-on to the EA6B AEA/SEAD Aircraft using modified BAT/IW. Consult on later phases of the AOA.

DoD KEY TECHNOLOGY AREA: Air Vehicles

KEYWORDS: Modeling, Simulation, Operations Analysis, Electronic Warfare

TOXICITY OF INHALED JET FUELS: RATIONAL ORGAN AND NEUROBEHAVIORAL TOXICITY ASSESSMENT OF A COMPLEX MIXTURE

D. P. Gaver, Distinguished Professor
P. A. Jacobs, Professor
Department of Operations Research
Sponsor: Naval Health Research Center Detachment – Toxicology

OBJECTIVE: Use mathematical computer-based modeling and statistical methods to quantify the neuropsychological effects of complex jet fuel multi-component vapors on operating personnel.

SUMMARY: Mechanistic models for the effect of a toxic substance on the liver have been developed.

DoD KEY TECHNOLOGY AREAS: Biomedical, Human Systems Interface, Environmental Quality

KEYWORDS: PBPK/PD Compartment Modeling, Predictive Toxicology, Mixture Toxicology

DEVELOPMENT OF A RESEARCH AND DEVELOPMENT PROGRAM AND METHODOLOGY FOR THE GOVERNMENT OF POLAND

Thomas H. Hoivik, Senior Lecturer
Department of Operations Research
Sponsor: Poland Extended International Military Education and Training (EIMET)

OBJECTIVE: To develop and establish a new military research, development and testing capability within the Polish government and industry that would allow Poland to significantly contribute to the NATO warfighting capability.

SUMMARY: This research project was in response to the Polish Ministry of Defense's request to DOD for help in establishing a new military research and development capability compatible with NATO nation models and organization structures. It entailed development of an initial long-range plan for establishing an effective RDT&E organization with a Life-Cycle Management Capability tailored to meet Polish Ministry of Defense (MOD) requirements and constraints. The focus of this research was to integrate the basic principles of systems engineering, decision analysis, and acquisition methodology into the Ministry of Defense's organization without threatening individual job security and power positions. It involved converting Polish MOD scientific and engineering personnel from the old Communist way of thinking into a systems engineering and analysis philosophy that included as a minimum, initial mission need and requirement analysis, tradeoff methodologies, the developmental process, cost-performance analysis, technical performance measurement, testing, production alternatives, and life-cycle logistics support.

A five-day RDT&E course was developed and presented to senior MOD executives and officials in Warsaw. The course included principles of systems engineering for high-technology programs, requirements analysis, system cost estimation, decision analysis, and acquisition process methodologies. It was well received by all attendees including Dr. Santorof, the head of the Polish Research and

Development Organization. As a result, Poland has requested continuing assistance from NPS in restructuring their MOD RDT&E process.

PUBLICATIONS:

Hoivik, T.H., "System Engineering for Polish High Technology Research and Development Programs," Poland MOD Distribution, December 1999.

DoD KEY TECHNOLOGY AREAS: Other (Systems Engineering)

KEYWORDS: Research and Development, Test and Evaluation, Systems Engineering

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

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

OBJECTIVE: Initiate research into applied statistical problems related to two areas of methodology: (i) estimation of the size of a population using capture-recapture methods, and (ii) model fitting and estimation when predictor variables are measured with error.

SUMMARY: Research in CY 2000 was funded for one quarter. During that time I continued to work on problems related to raking, a technique which is used to smooth capture-recapture estimates of population size. Funding from the William F. Donner Foundation was received in FY 2000 for research that was done in FY 1999 on capture-recapture models in the U.S. decennial census. This research was described in a paper that was published in conference proceedings in CY 1999. A paper that extends this work is in progress and will be submitted to an academic journal in CY 2001.

PUBLICATIONS:

Koyak, R.A., Schmehl, R.L., Cox, D.C., Dewalt, F.G., Haugen, M.M., Schwemberger, John G. Jr., and Scalera, John V., 2000, "Statistical Models for the Evaluation of Portable Lead Measurement Technologies--Part II: X-Ray Fluorescence Instruments," *Journal of Agricultural, Biological, and Environmental Statistics*, 5, pp. 37-57.

DoD KEY TECHNOLOGY AREAS: Other (Probability and Statistics)

KEYWORDS: Statistics, Capture-Recapture

DUAL SYSTEM ESTIMATION IN CENSUS 2000: HOW DOES RAKING DIFFER FROM SMOOTHING?

Robert A. Koyak, Assistant Professor
Department of Operations Research
Sponsor: William F. Donner Foundation

OBJECTIVE: Investigate the characteristics of "raking" in contrast to traditional smoothing techniques in connection with statistical adjustment of the U.S. decennial census.

SUMMARY: Funding from the William F. Donner Foundation was received in FY 2000 for research that was done in FY 1999 on capture-recapture models in the U.S. decennial census. This research was described in a paper that was published in conference proceedings in CY 1999. A paper that extends this work is in progress and will be submitted to an academic journal in CY 2001.

DoD KEY TECHNOLOGY AREAS: Other (Probability and Statistics)

KEYWORDS: Statistics, Raking, Census

STATISTICAL RESEARCH IN JOINT INTEROPERABILITY TESTING OF THEATER MISSILE DEFENSE SYSTEMS

Robert A. Koyak, Assistant Professor
Department of Operations Research
Sponsors: Defense Information Systems Agency, Joint Interoperability Test Command

OBJECTIVE: The focus of this research was to explore means by which the Joint Interoperability Test Command (JITC) could extend its interoperability-testing program for Theater Missile Defense families of systems to emphasize performance, in contrast to standards compliance.

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. Its testing mission encompasses Theater Missile Defense families of systems, in which assets across services are used to jointly track and engage ballistic missile threats. The development of performance-based metrics for assessing interoperability requires a detailed understanding not only of interoperability concepts, but also of the physics of ballistic missile trajectories, and of uncertainties inherent in multi-sensor, multi-target data fusion.

PUBLICATION:

Koyak, R.A., "Joint Interoperability of Theater Missile Defense Systems: Extending the Scope of Testing," Naval Postgraduate School Technical Report, NPS-OR-01-001, October 2000.

DoD KEY TECHNOLOGY AREAS: Command, Control and Communications, Sensors, Other (Theater Air and Missile Defense, Interoperability, Test and Evaluation)

KEYWORDS: C4I, Automated Information Systems, Ballistic Missile Threats

DECOMPOSITION WITH TRUNCATED SUBPROBLEMS

Siriphong Lawphongpanich, Associate Professor
Department of Operations Research
Sponsor: Unfunded

OBJECTIVE: To investigate properties and efficiency of decomposition techniques for mathematical programs in which the sub problems are solved crudely.

SUMMARY: In 2000, the investigation focused on decomposition strategies that result in nonlinear optimization sub problems. In practice, such strategies are typically ignored because the sub problems are computationally expensive to solve. However, this investigation was able to show that, instead of solving the nonlinear sub problems to optimality or nearly so, it is possible to truncate their solution algorithms after completing only one or two iterations and still guarantee theoretical convergence under some non-restrictive assumptions. An experiment with small nonlinear multicommodity network flow problems indicates that the technique is efficient and merits further investigation.

PUBLICATIONS:

Lawphongpanich, S., 2000, "Simplicial with Truncated Dantzig-Wolfe Decomposition for Nonlinear Multicommodity Network Flow Problems with Side Constraints," *Operations Research Letters*, 26, pp. 33-41.

DoD KEY TECHNOLOGY AREAS: Other (Optimization Techniques)

KEYWORDS: Decomposition, Optimization, Network Flows

ECONOMETRIC PROJECTION OF ARMY PERSONNEL STRENGTH
Siriphong Lawphongpanich, Associate Professor
Department of Operations Research
Sponsor: U. S. Army Office of Deputy Chief of Staff (Personnel)

OBJECTIVE: This study will develop an econometric model for forecasting retention rates of Army officers and enlisted personnel. The model will include economic, demographic, and service-specific factors relevant to the decision to remain in the Army. The main goal of this study is to replace the exponential technique used in the current Army's strength management system with the econometric model.

DoD KEY TECHNOLOGY AREAS: Manpower, Personnel and Training

KEYWORDS: Army's Strength Management System, Econometric Forecasting Model, Retention Rate

TREE-BASED METHODS FOR FORECASTING RETENTION RATES
Siriphong Lawphongpanich, Associate Professor
Department of Operations Research
Sponsor: U. S. Army Office of Deputy Chief of Staff (Personnel)

OBJECTIVE: One-third of the Army's budget is allocated to the Military Personnel Account (MPS); the key element of the MPA budget is determined by required strength projections for future forces. Forecasts of military strength are heavily dependent on prediction of retention rated for current personnel. This research will investigate the use of tree-based clustering methods and alternative forecasting procedures in improving the forecasts of retention rates for current personnel.

DoD KEY TECHNOLOGY AREAS: Manpower, Personnel and Training

KEYWORDS: Clustering, Tree-Based Methods, Retention Forecasts

LONGITUDINAL STUDY OF TRAINING DEADTIME
R. R. Read, Professor
Department of Operations Research
Sponsor: Chief of Naval Operations (N813)

OBJECTIVE: Recent studies have provided quantitative information relating to the very high cost of dead time (time that sailors are not undergoing training although assigned for training) in the Navy training system. These studies are based upon quarterly and monthly average on board (AOB) data, which provided the period, averages for numerous categories of dead time and non-dead time. Data of this type are readily accessible. It has been suggested that a different data structure, i.e., longitudinal data which records the time spent by sailors in the various categories measured from the beginning of the courses, may provide sharper information about what is happening in some instances and help to better understand the nature of the problems, their relative importance, and suggest types of remedial action.

SUMMARY: The present report presents some models of the longitudinal type and fits them to data. Specifically it treats the holding-time distributions measured from the beginning of a course until the entrance into a non-training state for academic attritions, academic setbacks, and interrupted instruction of the non-legal-holiday type. Analysis shows that there is considerable variability of these distributions from course to course and year to year. Also, the within-course variability is substantial. The process is

modeled as a non-homogeneous Poisson process. But there appears to be no stock models for the mean value function that are of general use. So these functions are modeled as step functions and the break points are estimated by maximum likelihood. It appears that at least five break points are needed for the courses studied. Also considered are the data needs for the longitudinal study of the downtimes between courses in a pipeline of courses.

PUBLICATIONS:

Read, R., Washburn A., and Thomas, L., 2000, "Estimating Means When Sampling Gives Probabilities as Well as Values or 'Looking a Gift Horse in the Mouth'," *Statistics and Computing* 10, pp. 245-252.

Read, R. R. "Longitudinal Studies Relating to Training Dead Time," to appear as an Naval Postgraduate School Technical Report in 2001.

PRESENTATION:

Read, R., 2000, "Rating and Prediction Using an Enhanced Bradley - Terry Model," Joint National Meetings of ASA, IMS, IBS, August, IN.

THESIS DIRECTED:

Li, Joseph, "A Poisson Regression Analysis of the Academic Setback in Naval Training Dead Time," Masters Thesis, Naval Postgraduate School, December 2000.

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

KEYWORDS: Statistics, Military Training

METHODOLOGY RESEARCH IN WARGAMING AND ANALYSIS

Richard E. Rosenthal, Professor
Donald Gaver, Distinguished Professor
Patricia Jacobs, Professor
Department of Operations Research
Sponsor: Joint Staff (J8)

OBJECTIVE: This is a continuation of research in Operations Methodology to support Joint Combat Analysis in the Force Structure, Resources and Assessment Directorate, Warfighting Analysis Division.

DoD KEY TECHNOLOGY AREAS: Computing and Software

KEYWORDS: Military Operations Research and Analysis

LAND ATTACK PREDESIGNATION (LAP)

Richard E. Rosenthal, Professor
Alexandra M. Newman, Research Assistant Professor
Department of Operations Research
Sponsor: Naval Surface Warfare Center-Dahlgren Division

OBJECTIVE: To optimally predesignate Tomahawk land attack missile strikes among units of a battle group.

SUMMARY: The Tomahawk land attack missile (TLAM) is the Navy's weapon of choice for striking shore targets from the sea. A TLAM launched from a surface combatant or a submarine is a reliable,

unmanned, long-range, accurate weapon with sufficient payload to threaten almost any shore target. We have developed optimization-based decision support tools to optimize TLAM strikes from single firing units or entire battle groups. The idea is to execute each strike efficiently while retaining residual firepower, and while considering a number of other essential details. By applying mathematical modeling, the result is the ability to plan fleet and theater-wide strikes in seconds.

PUBLICATION:

Brown, G.G., Newman, A.M., Rosenthal, R.E., and Rowe, A, "Optimizing Tomahawk Strikes," Naval Postgraduate School Project Report, NPS-OR-01-001-PR, April 2000.

THESES DIRECTED:

Arnold, A., "A Fast Heuristic for Land Attack Predestination," Masters Thesis, Naval Postgraduate School, June 2000.

Hodge, B.C., "A Heuristic for Land Attack Predestination," Masters Thesis, Naval Postgraduate School, December 1999.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation

KEYWORDS: Optimization, Weapon Allocation

GENERALIZED NETWORK ENLISTED COMPONENT OF THE ACTIVE ARMY STRENGTH FORECASTER

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

OBJECTIVE: 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: A prototypic Enlisted Specialty (ES) model formulation has been developed and delivered to the sponsor. The proposed ES model will optimally distribute the accessions, losses, promotions and Program Managed Losses (PMLs) forecasted by the EG model over the MOS dimension, as well as track the training and operating strength inventories by gender, grade and specialty. Additional features of the model include the handling of reclassifications between specialties, promotion zones and quality issues particular to each specialty.

PRESENTATIONS:

Williams, L.M. and Galing, S.E., "Redesigning the U.S. Army's Enlisted Manpower Forecasting Models," MORS Symosium, Air Force Academy, June 2000.

Williams, L.M. and Sweetser, W.A., "Redesigning the U.S. Army's Enlisted Manpower Forecasting Models," Navy Manpower Research and Analysis Conference, Center for Naval Analysis, October 2000.

DoD KEY TECHNOLOGY AREAS: Manpower, Personnel and Training

KEYWORDS: Manpower, Optimization

OPTIMIZATION MODELING IN SUPPORT OF TANKER REQUIREMENTS STUDY FOR 2005

Richard E. Rosenthal, Professor
Laura M. Williams, Research Assistant Professor
Anton Rowe, Research Assistant
Department of Operations Research
Lt Col Steven F. Baker, USAF
Naval War College
Sponsor: Office of the Secretary of Defense (PA&E)

OBJECTIVE: Air Mobility Command, Studies and Analysis Flight, is currently conducting a tanker requirements study (TRS-05). This new study is driven by the upcoming need to replace the KC-135 aircraft. An analysis of the tanker requirement will be an important input to the Analysis of Alternatives (AoA).

This study, the Optimization Modeling in Support of the TRS-05, supplements and enhances the TRS-05. The Naval Postgraduate School/Rand Mobility Optimizer (NRMO) was used to provide analysis of the tanker requirement in support of air mobility operations. The use of an optimization model offers unique insights that could guide investment decisions and allow more accurate judgment of tradeoffs between infrastructure investments and aircraft procurement investments. The primary objective was to determine the number of tanker airframes and aircrews needed to support the air mobility functions in the years 2005 and beyond.

SUMMARY: OSD and the Joint Staff have developed a series of all-services halt-phase Time-Phased Force Deployment Documents (TPFDDs) for use in the current Mobility Requirements Study (MRS-05), which are also the basis for the TRS-05 study. In this, the first year of the TRS-05, the non-WMD West-East MTW scenario has been converted for use by the NRMO model and validated against the results obtained by AMC/XPY using their legacy simulation model. A thorough analysis of tanker usage was performed using this scenario as well as excursions which parametrically alter the tanker force, airlift force, wind velocity, resource usage assumptions and base closures and limitations. Results of the analysis were briefed both at a MORS conference and to the sponsor, OSD (PA&E).

PUBLICATIONS:

Baker, S.F., Morton, D., Rosenthal, R.E., and Williams, L.M., "Optimizing Military Airlift," in review.

PRESENTATION:

Williams, L.M., Baker, S.F., and Rosenthal, R.E., "NRMO Enhancements and Modifications for TRS-05," MORS Symposium, Air Force Academy, June 2000.

DoD KEY TECHNOLOGY AREAS: Other (Optimization, Airlift, Mobility, Military Logistics)

KEYWORDS: Mobility, Air Mobility, Optimization, Tankers

SEA BASED LOGISTICS

D.A. Schrady, Distinguished Professor
Department of Operations Research
Sponsor: Naval Postgraduate School Institute for Joint Warfare Analysis

OBJECTIVES: To identify the operational factors that are critical to the viability of sea-basing the logistical support of forces operating ashore.

SUMMARY: Substantial work on sea based logistics modeling was accomplished and a technical report was completed. Analysis focused on the operational aspects of the concept 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. Having identified the critical factors affecting the feasibility of sea-based logistics, the 1982 Falklands War was examined in detail as the modern example of a plan to sea-based logistics.

PUBLICATION:

Schrady, D.A., "Sea-Based Logistics and Lessons from the Falklands," Naval Postgraduate School Technical Report, NPS-IJWA-00-002, May 2000.

PRESENTATION:

Schrady, D.A., "Sea-Based Logistics and Lessons from the Falklands," International Symposium on Military Operational Research, Shrivenham, United Kingdom, 31 August 2000.

THESIS DIRECTED:

Frey, Christopher M., "An Evaluation of Sea-Based Sustainment of Forces," Masters Thesis, Naval Postgraduate School, September 2000.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation

KEYWORDS: Naval Logistics, Sustainability, Sea-Based Logistics, OMFTS

ECONOMIC BENEFIT OF NAVAL FORWARD PRESENCE

D.A. Schrady, Professor
Department of Operations Research
R.L. Looney, Professor
Department of National Security Affairs
Sponsor: Chief of Naval Operations (N81)

OBJECTIVE: To evaluate the linkage between naval forward presence and economic security, peacetime interests, and globalization.

SUMMARY: In anticipation of the congressionally mandated 2001 Quadrennial Defense Review, our earlier research (1997) on the economic benefits of naval forward presence and crisis response was expanded in several significant ways. Four new crises, beyond the three used in the earlier research, were examined. Not only were these cases different, but they also differed in respect to the direct threat to world oil availability. Thus benefits were evaluated not just in terms of oil futures prices but also in terms of currency exchange ratios and U. S. and international equity markets. Finally, the question of causality between naval crisis response and improvement in energy prices, exchange ratios and equity market indices was examined using an adaptation of regression techniques called Event Analysis. The findings of the first study are confirmed with naval forward presence/crisis response shown to produce extensive economic benefits for the U. S. economy in each of the cases examined.

PUBLICATION:

Looney, R. and Schrady, D., "Estimating Economic Benefits of Naval Forward Presence," Naval Postgraduate School Technical Report, NPS-OR-01-004, October 2000.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation

KEYWORDS: Naval Forward Presence, Economic Benefits, Econometrics

SUPPORT AND REVIEW OF THE MODELING OF GROUND COMBAT IN INTEGRATED THEATER ENGAGEMENT MODEL

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 and 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 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. Only a small amount of time remained for this project during the reporting period.

PUBLICATION:

Taylor, J. G., Yildirim, U. Z., and Murphy, W. S., "Hierarchy-of-Models Approach for Aggregated-Force Attrition," *Proceedings of the 2000 Winter Simulation Conference*, J.A. Joines, R.R. Barton, K. Kang, and P.A. Fishwick (eds.), Winter Simulation Conference, Orlando, FL, December 2000, pp. 925-932.

PRESENTATION:

Taylor, J. G., Yildirim, U. Z., and Murphy, W. S., "Hierarchy-of-Models Approach for Aggregated-Force Attrition," 2000 Winter Simulation Conference, Orlando, FL, 11 December 2000.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation

KEYWORDS: Ground-Force-on-Force Attrition, Attrition-Calibration (ATCAL) Method, Joint-Warfare Campaign Models

JOINT COMBAT CAPABILITY

Alan Washburn, Professor
Gerald Brown, Professor
Department of Operations Research
Sponsor: Joint Staff (J8) and Naval Postgraduate School

OBJECTIVE: A prototypic combat model called JCCM (Joint Combat Capability Model) was developed and delivered to J8 in 1999. JCCM incorporates multiple phases of a war, terminating each at a time dependent on the state of the battle. The modeled war consists of 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 JCCM air-to-ground model is realistic, but the ground-to-ground model is not. The objective in FY2000 is to incorporate a realistic ground-to-ground model.

SUMMARY: The Army's COSAGE model of ground combat identifies both direct and indirect fire in its killer-victim scoreboards. A Lanchester equivalent, complete with a mechanism for reprogramming direct fire, has been built into JCCM. A master FORTRAN program reads the COSAGE scoreboards, calculates the Lanchester coefficients, and then alternately runs the ground-to-ground model or calls a linear program solver for the air-to-ground part. Some targets are vulnerable to ground platforms, some to air platforms,

and some to both. The model has been renamed Fast Theater Model (FATHM). FATHM requires about 20 minutes to fight a five-phase war to completion. Software has been delivered to J8.

PUBLICATION:

Washburn, A. and Brown, G., "The Fast Theater Model (FATHM)," Naval Postgraduate School Technical Report, NPS-OR-01-002-PR, 2000.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation

KEYWORDS: Optimization, Weapon Allocation

NAVY AIRLIFT
Alan Washburn, Professor
Department of Operations Research
William Gates, Associate Professor
Department of Systems Management
Sponsor: Chief of Naval Operations (N87)

OBJECTIVE: The Navy operates a fleet of operational support aircraft (OSA) that have the function of moving high priority passengers and cargo in wartime. The fleet is aging, and must gradually be replaced with more modern aircraft. The objective is first to measure the wartime demand for OSA transport in the event of a major war, and then to design a fleet that satisfies that demand at minimal cost.

SUMMARY: This study will be completed in FY2001**.**

THESIS DIRECTED:

Law, J., "Assessing the Performance and Cost of Logistics Airfleet Options," Masters Thesis, Naval Postgraduate School, December 2000.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation

KEYWORDS: OSA, Aircraft Scheduling

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, Infrastructure

SUMMER PROGRAM IN OPERATIONS RESEARCH TECHNOLOGY

R. Kevin Wood, Professor
Department of Operations Research
Sponsor: National Security Agency

OBJECTIVE: Provide leadership and technical guidance to graduate students in NSA's Summer Program for Operations Research Technology

SUMMARY: Professor Wood spent three months with NSA's Operations Research Group in Columbia, Maryland guiding graduate students in their analysis of some emergent OR problems at NSA. These problems included a simulation model of part of NSA's semiconductor production facility, some manpower issues, network interdiction and a number of classified topics. Classified project summaries were provided to NSA management upon completion of all projects.

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

KEYWORDS: Optimization

SUPPORT FOR THE CENTER FOR OPERATIONS RESEARCH, NATIONAL SECURITY AGENCY

R. Kevin Wood, Professor
Department of Operations Research
Sponsor: National Security Agency

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

THESIS DIRECTED:

Gibbons, M. J., "Enumerating Near-Minimum Cuts in a Network," Masters Thesis, Naval Postgraduate School, June 2000.

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

KEYWORDS: Optimization