# Judge's Commentary: The Outstanding Airport Screening Papers

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## Introduction

The final judging for the 2003 Interdisciplinary Contest in Modeling took place at the United States Military Academy on March 8, 2003. The judges spent a long, but enjoyable, day reading an excellent set of papers submitted by the student teams. Because of the complexity of the problem and the wide variety of available and reasonable solution approaches, the judges' evaluation process focused on the following general areas.

## Modeling

The judges evaluated the student teams' creative application of existing and novel mathematical modeling techniques to the defined problems. Particular attention was placed upon the identification and appropriateness of the underlying modeling assumptions and model validation efforts.

## Analysis

The judges evaluated the breadth and depth of the numerical analysis each team performed using their models. Particular attention was placed upon the reasonableness of conclusions and sensitivity analysis.

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# Communication

To convey the quality of their modeling and analysis activities, student teams had to communicate effectively in their report. Key factors in this communication included organization, clarity and brevity of information. Particular emphasis was placed upon each team's one-page summary.

The Outstanding papers were the ones that provided excellent communication of valid modeling activities, meaningful numerical analysis and thoughtful conclusions. Papers that fell short typically fell into one of two categories:

- well-written papers with questionable models or limited analysis, or
- papers that hid excellent modeling and analysis work with marginal communication.

# The Problem

This year's problem dealt with baggage screening and flight scheduling at a commercial airport. Clearly, these areas have received increased attention (especially baggage screening) since the tragic events of September 11, 2001. The student teams were required to analyze the required capacity for two types of baggage screening machines and to develop a recommended flight schedule for the airport's peak hour. Limited data was provided on the characteristics of peak hour flights and the passengers that utilize them. In addition to the modeling and analysis, the teams were asked to investigate emerging technologies in the area of baggage screening. In addition to the documentation of their modeling and analysis efforts, student teams drafted a position paper and two memos that communicated their findings, conclusions and recommendations.

This problem was an excellent choice for ICM. The multidisciplinary nature of airport security is clear, and the specific problems defined by the authors captured the essence of many fundamental areas of mathematical modeling. Most importantly, the problems included sufficient complexity to require the students to go beyond "textbook operations research" and utilize their creative problem-solving skills.

The problem was written by Dr. Sheldon Jacobson and Dr. John Kobza. Dr. Jacobson is Associate Professor of Mechanical and Industrial Engineering and Director of the Simulation and Optimization Laboratory at the University of Illinois Urbana-Champaign. Dr. Kobza is Associate Professor of Industrial Engineering at Texas Tech University. They have significant research experience in the area of transportation security, and they recently received the Aviation Security Research Award for their work in access control and checked baggage screening. In addition to authoring the problems, Drs. Jacobson and Kobza made valuable contributions as insightful members of the final judging panel.

# Modeling Approaches

The majority of the mathematical modeling and analysis utilized by the student teams was applied to Tasks 1, 3, and 6. The approaches to Tasks 1 and 6 were very similar. Many teams attempted to apply the results of queueing analysis for M/M/s systems. While the baggage screening system is a queueing system, there were several common shortcomings in analyses of this type. First, many teams failed to identify and discuss the underlying assumptions of an M/M/s queue. Certainly, the assumption of constant average arrival rate is questionable at best. Second, many teams applied the steady-state (long-run) results from queueing theory to a period of time ranging from one to three hours.

Other teams applied "back-of-the-envelope" or simulation-based capacity analysis. This approach avoided the restrictive assumptions of queueing theory but led to two other common shortfalls:

- Many teams assumed that the baggage screening system is "empty and idle" at the beginning of the peak hour. In reality, it is more likely that the hours preceding and following the peak hour are "near peak."
- Many teams identified the number of machines that could handle the required load without any required queueing. A more cost-effective approach would be to design a system that experiences some queueing during peak demand but has the ability to "recover" in time.

A common shortcoming in both the queueing analysis and capacity analysis approaches was that teams did not recognize that a large proportion of passengers would be connecting through the airport. The baggage for these passengers would not have to be screened.

The majority of student teams recognized Task 3 as a scheduling problem, but they also realized that this problem is much more complex than traditional scheduling problems found in the literature. As a result, most teams developed heuristic procedures that "smooth" the flow of passengers through the airport during and around the peak hour. Many of these procedures suffered from several of the assumptions mentioned above regarding Tasks 1 and 6. Some teams did manage to formulate reasonable mathematical optimization models of the scheduling problem. Solution approaches for these optimization models ranged from traditional discrete optimization algorithms (embedded in software) to search-based heuristics such as genetic algorithms.

It was somewhat surprising that few teams modeled the problem in such a way that captured the interactions between the baggage screening and fight scheduling sub-problems. A few of the teams did combine the two problems into a large-scale simulation effort with simulation-based optimization heuristics applied to derive the solution. However, these comprehensive approaches were the exception not the rule.

The papers that moved forward in the competition tended to have a foundation in well-known modeling approaches with problem-specific customization based on the creativity and skill of the team. Many of these papers included self-evaluation of the modeling assumptions and some degree of validation based on preliminary analysis. Some teams used data from real airports and airlines to contribute to or validate their results. As always, sensitivity analysis was appreciated and rewarded by the judges.

# Conclusions

My recommendations for future student teams are:

**Assumptions** Identify and critique (in writing) the assumptions of your models. Sometimes restrictive assumptions have to be made. Be sure that the judges realize you are aware of and concerned about these assumptions.

**Analysis** Spend as much time as you can on numerical analysis of the model. Use this analysis to perform "sanity checks" on the model. Do not just report the output. Comment on the reasonableness of the results. Perform extensive numerical experiments to eliminate bias resulting from assumptions, estimations or initial conditions. Summarize your analysis clearly in tabular or graphical form.

**Communication** Do not neglect the writing. Clear communication makes it easier to identify outstanding work. To be perfectly honest, good communication improves the judges' frame of mind.

**References** Clearly cite information that you utilize from published sources (books, papers, Websites, etc.). This will make it clear to the judges that you have properly and completely researched the problem. However, do not rely exclusively on existing work and do not copy text from existing sources without properly documenting the sources. Note that we did experience a few isolated instances of plagiarism and excessive copying in the competition.

# About the Author

Richard Cassady is an assistant professor in the Dept. of Industrial Engineering at the University of Arkansas. His primary research interests include application of operations research in the area of repairable systems modeling. He teaches undergraduate and graduate courses in the areas of probability and statistics, stochastic processes, and reliability.