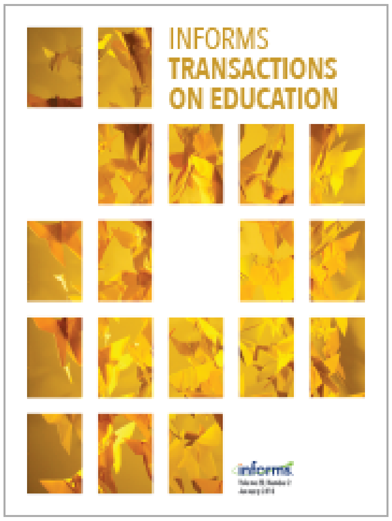

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Case Article

U.S. Army Deployment to the Middle East

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This paper describes a modeling and simulation case study relating to Army platoons deploying to the Middle East. The study tasks students with analyzing routes for deploying troops travel through in an effort to decrease the average time a soldier spends in transit. Students with little simulation experience are able to become familiar with modeling software. Student groups are instructed to identify where bottlenecks occur in the queuing system and to find creative solutions to alleviate those bottlenecks. Additionally, the case study illustrates the concepts of input and output analysis, random numbers, random variate generation, and probability distributions.

Keywords: modeling; simulation; ARENA; queuing; probability distributions; random variate generation
History: Received: December 2014; accepted: April 2016.

1. Introduction

In an effort to stress the importance of simulation and familiarize our students with modeling software our instructors developed a case study analyzing the deployment process for U.S. soldiers, which is a realistic problem facing the Air Mobility Command. The typical student we teach has a limited operations research (OR) background (particularly in modeling and simulation) and has little experience with commercial simulation software such as Rockwell Software's ARENA.

Many of our students have deployed multiple times over the last decade and understand the frustration of being stranded at military airports for long periods of time while deploying. Here we task the students to minimize the average time a platoon spends in transit to a deployment location. When first describing the problem to the class, many students shared their personal experiences from this process. An objective of this assignment is connecting a novel operations research topic to a practical process many of the students have experienced. As one student put it, "I hate flying and being in airports—I put myself in this mindset and the rest followed."

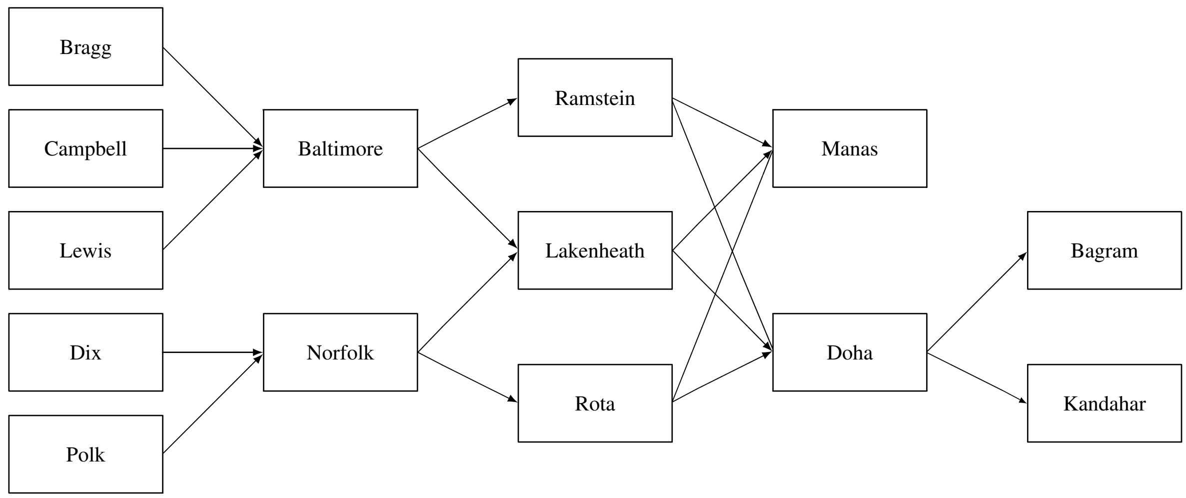
The baseline model is shown in Figure 1, with the arrows indicating the routes currently flown to get platoons from their home stations to their deployed locations. Students construct this model in discrete-event simulation software and then make alterations to the model to decrease the average time a platoon takes to deploy.

2. Pedagogical Goals

The Army Deployment case study builds on the students' understanding of key principles relating to modeling and simulation and focuses on the following learning goals:

- Building familiarity with simulation software for use in future projects.
- Analyzing statistical output from simulation software for the purposes of finding inefficiencies in routing networks.
- Modifying system inputs to understand corresponding changes in system outputs.
- Constructing confidence intervals based on multiple trials of the same model, underscoring the importance of replications in simulation.
- Discovering the benefits (insight on possible improvements) and limitations (difficulty of formulation) of math programming in stochastic scenarios.
- Learning techniques to communicate with non-technical stakeholders by constructing and briefing a presentation to a non-OR decision-maker.

Figure 1 **Flight Routes**



This case study complements instruction relating to spreadsheet modeling, basic modeling terminology, random variate generation, input and output analysis, probability distributions, bottleneck analysis, and queueing. Additionally, students are shown an example where formulating a math program in a stochastic environment may be difficult and where an approximate solution via simulation is preferred.

3. Classroom Experience

We distribute the case study to students after ten hours of instruction on simulation fundamentals. This study gives the students their first hands-on experience with simulation software. The students work on an assignment based on the case study in small groups (3–4 students) which the instructor creates to ensure diversity of skill. The instructor provides the baseline model (available as supplemental material at http://dx.doi.org/10.1287/ited.2016.0162ca) to the students; however, if this case study was given to a more advanced group then it would be reasonable to have them construct the baseline model. (Later in the course, our students have a follow-on study where they must build a model from scratch on a real-world queuing system.)

The instructor begins by outlining the situation described in the case study and the multiple deliverables of the assignment. The baseline model is displayed and run for the students, allowing them to see how the entities (platoons) flow through the system, how bottlenecks appear at both batching and process blocks, how statistics can be recorded, how to change replication parameters, and how to interpret the model outputs (time in system, works-in-progress, resource utilization). Once briefed on the basics, groups are encouraged to spend thirty minutes familiarizing themselves with the model in their groups during class time with the instructor available to answer questions.

The deliverables are the groups' improved models in addition to a fifteen-minute presentation on their methodology, results, and analysis. Typically, the groups have two weeks to complete the assignment. Student feedback indicates that most groups spend between eight and fifteen hours on the assignment with a few individuals spending over twenty-four hours.

The assignment has four sections (described in the "Case: U.S. Army Deployment to the Middle East" article) and the groups brief the results for each section to a notional decision-making panel. The Air Mobility Command commander who chairs the notional panel has a limited OR background (as would be typical for a general in that position) forcing the students to build graphs and illustrations which can be easily understood by a non-technical decision-maker.

Each group managing to lower the average deployment time by 25% on the fourth part of the assignment receives additional points, and the students are made aware of the 76.2 hour record for the fourth part. Afterwards, students commented that these goals gave them the motivation to continue to refine their models and think of creative solutions.

4. Conclusion

The primary benefits of the case study are threefold: learning to work with discrete-event simulation software, learning to optimize simulation models, and learning to effectively communicate technical information.

Further, students who have taken a typical introductory math programming course will find a major take-away from this study relates to how math programming and simulation differ, and, importantly, how system optimization can be difficult using simulation (versus math programming where solvers are readily available). However, simulation often provides benefits from its ability to handle complex stochastic problems. Through this study, students realize how simulation can be another valuable tool in their OR toolbox.

Against a background of a real-world problem that some military OR analysts could face, the Army Deployment case study gave the students experience with simulation and ARENA to apply to OR projects in their assigned organizations. A student commented that he intends to download ARENA for analytical use upon returning to his unit. Another remarked, "I can now see the benefit of modeling systems in many OR settings." While the project has a military function, students of any background who are learning simulation software for the first time will find it both instructive and enjoyable.

5. Additional Resources

The following case studies have a similar pedagogical goal of introducing students to discrete-event simulation software:

- Pich MT, Chick SE (2006) *Process Control at Compaq Computer Corp.: Computer Simulations—Promodel*. INSEAD, January 2006.
- Shapiro RD, Gray AE (2011) *ExtendSim Simulation Exercises in Process Analysis, User's Guide*. Harvard Business School Supplement 694-043, August 2011.
- Huckman RS, Shapiro RD (2015) Harvard Business School Exercise 614-029, September 2015.

Supplemental Material

Supplemental material to this paper is available at http://dx.doi.org/10.1287/ited.2016.0162ca.

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Banks J, Carson II JS, Nelson BL, Nicol DM (2010) *Discrete-Event System Simulation* (Prentice Hall, Upper Saddle River, NJ).

Kelton WD, Sadowski RP (2002) *Simulation with ARENA* (McGraw-Hill, New York).