Beyond Lean:
Simulation in Practice
Second Edition

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Preface

Perspective

Lean thinking, as well as associated processes and tools, have involved into a ubiquitous perspective for improving systems particularly in the manufacturing arena. With application experience has come an understanding of the boundaries of lean capabilities and the benefits of getting beyond these boundaries to further improve performance. Discrete event simulation is recognized as one beyond-the-boundaries of lean technique. Thus, the fundamental goal of this text is to show how discrete event simulation can be used in addition to lean thinking to achieve greater benefits in system improvement than with lean alone.

Realizing this goal requires learning the problems that simulation solves as well as the methods required to solve them. The problems that simulation solves are captured in a collection of case studies. These studies serve as metaphors for industrial problems that are commonly addressed using lean and simulation.

Learning simulation requires doing simulation. Thus, a case problem is associated with each case study. Each case problem is designed to be a challenging and less than straightforward extension of the case study. Thus, solving the case problem using simulation requires building on and extending the information and knowledge gleaned from the case study. In addition, questions are provided with each case problem so that it may be discussed in a way similar to the traditional discussion of case problems used in business schools, for example.

An understanding of simulation methods is prerequisite to the case studies. A simulation project process, basic simulation modeling methods, and basic simulation experimental methods are presented in the first part of the text. An overview of how a simulation model is executed on a computer is provided. A discussion of how to select a probability distribution function to model a random quantity is included. Exercises are included to provide practice in using the methods.

In addition to simulation methods, simple (algebra-level) analytic models are presented. These models are used in partnership with simulation models to better understand system behavior and help set the bounds on parameter values in simulation experiments.

The second part of the text presents application studies concerning prototypical systems: a single workstation, serial lines, and job shops. The goal of these studies is to illustrate and reinforce the use of the simulation project process as well as the basic modeling and experimental methods. The case problems in this part of the text are directly based on the case study and can be solved in a straightforward manor. This provides students the opportunity to practice the basic methods of simulation before attempting more challenging problems.

The remaining parts of the text present case studies in the areas of system organization for production, supply chain management, and material handling. Thus, students are exposed to typical simulation applications and are challenged to perform case problems on their own.

A typical simulation course will make use of one simulation environment and perhaps probability distribution function fitting software. Thus, software tutorials are provided to assist students in learning to use the AutoMod simulation environment and probability distribution function fitting in JMP.

The text attempts to make simulation accessible to as many students and other professionals as possible. Experience seems to indicate that students learn new methods best when they are presented in the context of realistic applications that motivate interest and retention. Only the most fundamental simulation statistical methods, as defined in Law (2007) are presented. For example, the t-confidence interval is the primary technique employed for the statistical analysis of simulation results. References to more advanced simulation statistical analysis techniques are given as appropriate. Only the most basic simulation modeling methods are presented, plus extensions as needed for each particular application study.

The text is intended to help prepare those who read it to effectively perform simulation applications.

Using the Text

The text is designed to adapt to the needs of a wide range of introductory classes in simulation and production operations. Chapters 1 - 5 provide the foundation in simulation methods that every student needs and that is pre-requisite for studying the remaining chapters. Chapters 6, 7, and 8 cover basic ideas concerning how the simulation methods are used to analysis systems as well as how systems work. I would suggest that these 8 chapters be a part of every class.

A survey of simulation application areas can be accomplished by selecting chapters from parts III, IV, and V. A focus on manufacturing systems is achieved by covering chapters 9, 10, 11, and 12. A course on material handling and logistics could include chapters 13 through 18.

Compute-based activities that are a part of the problem sets can be used to help students better understand how systems operate and how simulation methods work. The case problems can be discussed in class only or a student can perform a complete analysis of the problem using simulation.

Acknowledgements

The greatest joy I have had in developing this text is to recall all of the colleagues and students with whom I have worked on simulation projects and other simulation related activities since A. Alan B. Pritsker introduced me to simulation in January 1975.

One genesis for this text came from Professor Ronald Askin. As we completed work on the text: *Modeling and Analysis of Manufacturing Systems*, we surmised that an entire text on the applications of simulation was needed to fully discuss the material that had been condensed into a single chapter.

Professor Jon Marvel provided invaluable advice and direction on the development of the chapter on cellular manufacturing systems.

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The specific contribution of each individual has been noted at the appropriate place in the text as well.