Preface

This fourth edition of *Simulation with Arena* has the same goal as the first three editions: to provide an introduction to simulation using Arena. It is intended to be used as an entry-level simulation text, most likely in a first course on simulation at the undergraduate or beginning graduate level. However, material from the later chapters could be incorporated into a second, graduate-level course. The book can also be used to learn simulation independent of a formal course (more specifically, by Arena users). The objective is to present the concepts and methods of simulation using Arena as a vehicle to help the reader reach the point of being able to carry out effective simulation modeling, analysis, and projects using the Arena simulation system. While we'll cover most of the capabilities of Arena, the book is not meant to be an exhaustive reference on the software, which is fully documented in its extensive online reference and help system.

Included is a CD with the Arena 10.0 academic software and all the examples in the text. A Web site for the book can be found at http://www.arenasimulation.com/programs/sim_w_Arena_4.asp. We encourage all readers to visit this site to learn of any updates or errata for the book or example files supplied, possible additional exercises, and other items of interest. The site also contains material to support instructors who have adopted the book for use in class, including downloadable lecture slides and solutions to exercises; university instructors who have adopted the book should contact the local McGraw-Hill representative for authorization (see http://www.mhhe.com/catalogs/sem/engineering to locate representatives in the U.S., or call 1-609-426-5793 to locate representatives outside the U.S.).

We've adopted an informal, tutorial writing style centered around carefully crafted examples to aid the beginner in understanding the ideas and topics presented. Ideally, readers would build simulation models as they read through the chapters. We start by having the reader develop simple, well-animated, high-level models, and then progress to advanced modeling and analysis. Statistical analysis is not treated as a separate topic, but is integrated into many of the modeling chapters, reflecting the joint nature of these activities in good simulation studies. We've also devoted more advanced chapters to statistical issues and project planning to cover more advanced issues not treated in our modeling chapters. We believe that this approach greatly enhances the learning process by placing it in a more realistic and (frankly) less boring setting.

We assume neither prior knowledge of simulation nor computer-programming experience. We do assume basic familiarity with computing in general (files, folders, basic editing operations, etc.), but nothing advanced. A fundamental understanding of probability and statistics is needed, though we provide a self-contained refresher of these subjects in Appendices C and D.

Here's a quick overview of the topics and organization. We start in Chapter 1 with a general introduction, a brief history of simulation, and modeling concepts.

Chapter 2 addresses the simulation process using a simple simulation executed by hand and briefly discusses using spreadsheets to simulate very simple models. In Chapter 3, we acquaint readers with Arena by examining a completed simulation model of the problem simulated by hand in Chapter 2, rebuilding it from scratch, going over the Arena user interface, and providing an overview of Arena's capabilities; we also provide a small case study illustrating how knowledge of just these basic building blocks of Arena allows one to address interesting and realistic issues.

Chapters 4 and 5 advance the reader's modeling skills by considering one "core" example per chapter, in increasingly complex versions to illustrate a variety of modeling and animation features; the statistical issue of selecting input probability distributions is also covered in Chapter 4 using the Arena Input Analyzer.

Chapter 6 uses the model in Chapter 5 to illustrate the basic Arena capabilities of statistical analysis of output, including single-system analysis, comparing multiple scenarios (configurations of a model), and searching for an optimal scenario; this material uses the Arena Output and Process Analyzers, as well as OptQuest for Arena.

In Chapter 7, we introduce another "core" model, again in increasingly complex versions, and then use it to illustrate statistical analysis of long-run (steady-state) simulations. Alternate ways in which simulated entities can move around is the subject of Chapter 8, including material-handling capabilities, building on the models in Chapter 7. Chapter 9 digs deeper into Arena's extensive modeling constructs, using a sequence of small, focused models to present a wide variety of special-purpose capabilities; this is for more advanced simulation users and would probably not be covered in a beginning course.

In Chapter 10, we describe a number of topics in the area of customizing Arena and integrating it with other applications like spreadsheets and databases; this includes using VBA (Visual Basic for Applications) with Arena. Chapter 11 shows how Arena can handle continuous and combined discrete/continuous models, such as fluid flow. Chapter 12 covers more advanced statistical concepts underlying and applied to simulation analysis, including random-number generators, variate and process generation, variance-reduction techniques, sequential sampling, and designing simulation experiments. Chapter 13 provides a broad overview of the simulation process and discusses more specifically the issues of managing and disseminating a simulation project.

Appendix A describes a complete modeling specification from a project for *The Washington Post* newspaper. In Appendix B, we give an overview and a link to problem statements for the Arena modeling contest held annually by the Institute of Industrial Engineers (IIE) and Rockwell Automation. Appendix C gives a complete but concise review of the basics of probability and statistics couched in the framework of their role in simulation modeling and analysis. The probability distributions supported by Arena are detailed in Appendix D. Installation instructions for the Arena academic software can be found in Appendix E. All references are collected in a single References section at the end of the book. The index is extensive, to aid readers in locating topics and seeing how they relate to each other; the index includes authors cited.

As mentioned above, the presentation is in "tutorial style," built around a sequence of carefully crafted examples illustrating concepts and applications, rather than in the conventional style of stating concepts first and then citing examples as an afterthought. So it probably makes sense to read (or teach) the material essentially in the order presented. A one-semester or one-quarter first course in simulation could cover all the material in Chapters 1–8, including the statistical material. Time permitting, selected modeling and computing topics from Chapters 9–11 could be included, or some of the more advanced statistical issues from Chapter 12, or the project-management material from Chapter 13, according to the instructor's tastes. A second course in simulation could assume most of the material in Chapters 1–8, then cover the more advanced modeling ideas in Chapters 9–11, followed by topics from Chapters 12 and 13. For self-study, we'd suggest going through Chapters 1–6 to understand the basics, getting at least familiar with Chapters 7 and 8, then regarding the rest of the book as a source for more advanced topics and reference. Regardless of what's covered, and whether the book is used in a course or independently, it will be helpful to follow along in Arena on a computer while reading this book.

The CD included contains the academic version of Arena (see Appendix E for installation instructions), which has all the modeling and analysis capabilities of the complete commercial version but limits model size. All the examples in the book, as well as all the exercises at the ends of the chapters, will run with this educational version of Arena. The CD also contains files for all the example models in the book, as well as other support materials. This software can be installed on any university computer as well as on students' computers. It is intended for use in conjunction with this book for the purpose of learning simulation and Arena. It is not authorized for use in commercial environments.

If you were familiar with the third edition, here are the main changes:

- All the examples have been updated to conform to the current Arena version (10.0). The software is largely consistent with what was discussed in the third edition, but there are several new features and capabilities that we illustrate, including model documentation, enhanced plots, file reading and writing, printing, and animation symbols.
- Section 2.7 in Chapter 2 is new and gives a brief introduction to using spreadsheets to simulate, with an examples of both a static and a dynamic model.
- Section 3.5 in Chapter 3 is new and gives a case study of parallel vs. serial processing, illustrating that just this basic set of Arena tools enables one to address interesting and practical issues.
- In Chapter 5, we have replaced the car-repair model in the third edition with an enhanced version of the call-center model similar to what was in the first two editions. However, we build it up in three stages to enable more manageable teaching chunks.

- Chapter 6 has the same mission as in the third edition (statistical analysis for terminating systems), but uses the enhanced call-center model from Chapter 5.
- The new Chapters 7, 8, 9, 12, and 13 cover the same material as in the third edition, except for updates.
- Chapter 10 has a new Section 10.6 on real-time integration, sharing simulation data with other devices during a run.
- Chapter 11 has a new Section 11.2.4 on the Flow Process panel for continuous-change modeling.
- Appendix B, on the contest problems, has been reduced to a single page, and the (growing) list of problem descriptions has been moved to the public Web site.
- The support materials on the Web site (slides and solutions) have all been updated.

As with any labor like this, there are a lot of people and institutions that supported us in a lot of different ways. First and foremost, Lynn Barrett at Rockwell Automation really made this all happen by reading (and re-reading and re-re-reading, and then fixing) our semi-literate drafts, orchestrating the composing and production, reminding us of what month (and year) it was, and tolerating our tardiness and fussiness and quirky personal-hyphenation habits; her husband Doug also deserves our thanks for putting up with her putting up with us. Rockwell Automation provided resources in the form of time, software, hardware, technical assistance, and moral encouragement; we'd particularly like to thank the Arena development team—Norene Collins, Cory Crooks, Glenn Drake, Tim Haston, Cynthia Kasales, Judy Kirby, Frank Palmieri, Dave Takus, Christine Watson, and Vytas Urbonavicius—as well as Steve Frank, Judy Jordan, Gavan Hood, Scott Miller, Dennis Pegden, Jon Phillips, Darryl Starks, and Nancy Swets. And a special note of thanks goes to Deb Sadowski for her writing and influence as a co-author of the first two editions. The Department of Quantitative Analysis and Operations Management at the University of Cincinnati was also quite supportive.

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W. David Kelton
University of Cincinnati
david.kelton@uc.edu

Randall P. Sadowski
Rockwell Automation
rpsadowski@ra.rockwell.com

David T. Sturrock
Rockwell Automation
dtsturrock@ra.rockwell.com