Why did we write this book?

Simulation is an amazing tool. While it is not likely to provide a solution for world peace anytime soon, it can help solve a number of critical business and logistic problems faster and more accurately than any other method of analysis. What's more, simulation studies regularly identify cost savings and business insights that are many times the cost of the study. If you need to make a decision involving a complex or dynamic process, simulation is the tool for you.

We're guessing that you have this book in your hands at this very moment because you've already heard some of the good news about simulation and want to know more about it. In fact, we'll even go so far as to speculate that you aren't just looking to satisfy some intellectual curiosity, but are ready to dive right in and use simulation to solve a real problem. If that is the case, then you have the right book in your hands.

As you can tell from its title, the goal of this book is to help you learn to use SIMUL8, a tool for developing simulation models. While you will pick up quite a bit about general simulation modeling along the way, we do not intend it to be a basic textbook on the theory of simulation. There are already several fine books written on this subject and we did not seek to duplicate those efforts here.

We go much further than the manual that comes with the software package. We feel that there is a lot of information that just could not be covered in a basic help manual. We want you to know *how* and *when* to use the features in SIMUL8, not simply point out that they exist. We're also going to share a few secrets and tricks that we learned the hard way, so you won't have to. That way you can get the most out of SIMUL8, and simulation, that you possibly can.

We like to think of ourselves as professional problem solvers. For well over 10 years, we have been building complex simulation models and have chosen to use SIMUL8 as our simulation engine. That means that we have a lot of experience building simulation models of all shapes and sizes, and more importantly, we know how to twist and turn SIMUL8 to produce the desired effects. These insights are going to give you the leg-up you'll need to begin building models right away.

Who is this book for?

We have made every effort to write this book so that SIMUL8 users at *all* levels will find something helpful within its covers. At one end of the spectrum are those who have heard about simulation and are ready to start using it, but have never built a model. Users falling into this group are probably sitting down to learn SIMUL8 for the first time as they open this book. At the other end of the spectrum are users who have long simulation modeling careers already behind them, and who may already have extensive experience with SIMUL8. These users may be looking for detailed information about the latest

SIMUL8 features, or perhaps hoping to pick up additional SIMUL8 tricks to add to their modeling arsenal.

Instead of dividing this book into beginning vs. advanced topics, we have progressed on a topic-by-topic basis, sometimes mentioning advanced modeling tips along with basic instructions. This seems to be the most useful structure when presenting materials intended for a wide audience. Because of this type of construction, there is something useful for everyone in almost every chapter. The few exceptions would be the most basic introductory information. However, we would still like to encourage even experienced readers to skim the first few chapters.

Why SIMUL8?

Over the years, we have had many opportunities to use and evaluate many simulation languages, such as Arena (Rockwell Corporation), Witness (Lanner Group), and ProModel (ProModel Corporation). As principals in an independent consulting firm, we are free to use any simulation language that we choose and we choose to use SIMUL8 for one overriding reason – it is the one that meets our needs. Here are the main reasons why we choose SIMUL8 over the competition:

SIMUL8's user-interface is intuitive, well organized, and easy to work with.

SIMUL8 is virtually unlimited in the size and complexity of simulation models that are possible. We have developed models with over 800 work centers and 1.5 million individual work items. The limitation lies instead with the speed of your processor, and with the amount of RAM you have.

SIMUL8 Corporation is dedicated to continually developing and enhancing their product. The addition of database functions, a Visio interface, XML support, COM capability, and the ability to build models through code, are leading features in the simulation industry. These features allow for leading-edge Windows development capabilities.

SIMUL8 offers a rapid development environment. Based on a modern Windows architecture, many developers are finding that the development time on a consulting project can be accomplished in half of the time that is required in some other languages.

Good (though not amazing) animation is quick and easy to put together thereby reducing the development time. SIMUL8's graphical capabilities are arguably its weakest feature, although in many ways, we find the simplicity of SIMUL8's graphics to be one of its strengths. Unless you have the need for very specific high-end graphics, SIMUL8's capabilities are more than adequate.

SIMUL8 competes very well, feature for feature, with simulation tools costing 15 times as much or more. SIMUL8 is priced for widespread implementation in any organization on a large or small scale. The nice thing about SIMUL8 is that it has the powerful features needed for professional development without the price tag historically associated with high-end simulation tools. In the end, we focus on building serious, industrialstrength models, many of which are meant to solve multi-million dollar problems. We use SIMUL8 every day. We stretch it, pull it, and twist it, and so far have not broken it.

Our Relationship with SIMUL8 Corporation

We have a mutually beneficial relationship with SIMUL8 that dates back many years. We frequently team up with SIMUL8 Corporation in providing a testing ground for their latest upgrades, as well as providing professional consulting services to many of their clients. As you will see throughout this book, we have a great deal of respect for the founder Mark Elder, for the company, and for the product they have produced.

On the other hand, we are most definitely an independent organization with high standards and a reputation to uphold. We are under no obligation to use SIMUL8, or to keep quiet about aspects we don't like. Our mission is to produce the most useful and accurate reference we possibly can, and as such, we don't pull any punches. As much respect as we have for SIMUL8, wherever there's an area that can be improved, we'll say so. One of the more positive outcomes of being so outspoken is that many of SIMUL8's newer features are there because we asked for them.

Using the Guide

Learning SIMUL8 progresses from comprehensive coverage of the fundamentals to detailed discussions of more advanced features. It is intended to be a workbook that builds on your understanding of each of the concepts and features discussed in each of the chapters. We have found in our own studies that this is the most useful way to organize a manual to appeal to both beginners and advanced students. (It also happens to be the way we organize our training courses.)

Learning SIMUL8 will also serve you well as a reference guide, allowing you to quickly find information about Visual Logic commands, the DDE Library, COM objects, as well as solutions to all of the Test Your Understanding assignments and Challenges.

If you are a beginner, the way to get the most out of this manual is to treat it as a tutorial; read it from front to back, play with the sample models, and do each one of the assignments at the end of the chapters. Make sure you check your answers on the included CD and SIMUL8 References guide and that you understand why the sample model is the way it is. Advanced users looking to get more information about specific features will find that they can easily go to the topic in question and find what has been improved, see screenshots of the new dialog boxes, and learn not only if the new feature is useful, but how to use it and incorporate it into future models.

In **Part I: Getting Started**, we provide a high-level overview of SIMUL8's structure and most basic elements. Here, we provide an introduction to all of the primary simulation objects, teach you how to get around the SIMUL8 interface, and outline the many tools and options available to you in SIMUL8. This section will be very useful to new

SIMUL8 users, but should also be skimmed even by more experienced readers, as we cover all of the latest interface changes.

Part II: Creating the Model moves into detailed descriptions of the model-building elements introduced in Part I. This section contains the core material that any SIMUL8 user must become familiar with in order to create effective models. Because the in-depth coverage of each object naturally considers basic features as well as advanced, Part II will be of interest to all readers. Much of this information has never before been collected in a single place (or, in some cases, documented at all), so we have found that even experienced SIMUL8 users tend to discover SIMUL8 features they didn't know existed. There's a good chance that you will add something to your SIMUL8 arsenal after reading this section.

Part III: Driving the Model is intended to help you move forward with the model once you've created it. This section of the book will help you answer questions such as "How do I collect and interpret results from my model?" It also includes a comprehensive chapter on debugging your models. This often-overlooked area is one of the most important tasks you'll tackle in building a model. We'll describe the tools available to you in SIMUL8, along with some of the debugging tricks we've developed over the years. Once you've built your model, review this section to get it working correctly, and to get the most out of it.

Part IV: Putting It All Together is a bit of a catchall section that we've created to cover some of the more advanced skills required in building a model. This is the area where you'll find the largest repository of our experience. This section contains information that has not been comprehensively documented anywhere else.

Part V: References presents comprehensive information for each and every Visual Logic, DDE and COM command. To our knowledge, this is the only reference with such comprehensive coverage of all current commands. Since discussing this very advanced information at the same time the general concepts are taught would have been overwhelming for beginners, we decided to pull the command lists into a separate reference guide. We anticipate that you'll find yourself turning to this guide often as your experience with SIMUL8 increases.

This guide includes solutions to the over 25 assignments contained throughout the manual, an index, as well as a quick reference chart for SIMUL8's many shortcut keys.

Conventions

We have used certain conventions throughout the book to help you quickly identify key information.

TTTT TTTT	Warning	Unless you are careful here, you could do something potentially disastrous.
I	Note	Remember this. You may find it important in your everyday use of SIMUL8.
	Bugs	Look for these potential modeling problems to be pointed out to you in the Debugging chapter.
\odot	On the CD	Supplement your reading by experimenting with a related sample model.
SØ PRO	Professional Edition	This feature is found within SIMUL8's Professional Edition.

Using the CD

Installation

We regard the CD accompanying this book to be an integral part of the learning process. Our experience has taught us that users begin to appreciate and truly understand modeling concepts only after they've had a chance to create a few models of their own. We encourage you to explore the many models and demonstration programs referred to throughout your reading.

To install the CD, simply place the CD from the back of the book into your CD-ROM drive. An interface will appear on your screen that allows you to choose from several different options.



Sample Models

We understand that it is one thing to have a list of capabilities in your hands, but something else altogether to see a detailed illustration of the concept laid out in front of you. This is why our CD contains over 140 models that allow you to see the concepts in action. Each chapter contains related sample models for you to observe, analyze, and modify. These examples are intended to help you see how actual simulations operate, how they are put together, and how to put what you've learned to use in your own simulation model.

Solutions to Test Your Understanding

There is nothing quite as useless as a training manual that gives complicated problems, but no solutions. After all, how do you know if you're right? Even though there is usually more than one right way to put a model together in simulation, we've tried to give you one of the many possible correct ones in the solutions to the "Test Your Understanding" questions that are included at the end of each chapter. These are listed by chapter on the CD and are in the SIMUL8 References guide. These will be a great source of information for you as you look through the models and discover how they were built. What objects did we use? What properties do the objects have? How does it compare with your test model? In real world consulting projects, there isn't a solution handbook that you can check, but we still think it is useful to gain some confidence in the accuracy of your answers as you learn.

Formula One Help

SIMUL8 contains several third-party components. The most notable example is the Formula One Spreadsheet module. While we've tried to explain the most commonly used features of this third party product in great detail, there may still be users with a need for the extreme detail provided by the manuals from the original vendor. We've made these help files available for you on the CD. For more information, please see page 357 in the Information Store chapter.

Supporting Applications

In the course of completing our simulation consulting engagements, we've found a number of very useful accessory programs. We collected demonstration versions of them on the CD so that you can try them out for yourself.

Paint Shop Pro

We use this application when we are putting additional graphics into our simulation models. It is usually necessary to resize any image to the preferred 32×32 pixels before placing it into SIMUL8. You can use any graphics application to do this, but we have added this demo to the CD just so you can get an idea of what you will need to do.

Statistical Software Demos

BestFit

BestFit is a Windows program that finds the distribution that best fits your data. You simply import your data set into BestFit and click on the Run Fit button. BestFit tests up to 27 different distribution types to find the best fit for your data. You can display results as presentation-quality graphs, or generate a full statistical report.

ExpertFit

ExpertFit gives you access to 40 probability distributions where the chosen distribution can be put into the proper format for direct input to 26 simulation-software products. It contains the Chi-square, Kolmogorov-Smirnov, and Anderson-Darling goodness-of-fit tests as well as providing more than 30 high-quality plots of your data.

Stat::Fit

Stat::Fit was created to analyze the data for discrete event simulation or other event driven modeling then it statistically fits your data to the most useful analytical distribution. Some features include descriptive statistics, parameter estimates, goodness of fit tests, graphical analysis, random variate generation, and printed reports.

MINITAB

MINITAB software, created by Minitab Inc., is used interactively to provide data manipulation and statistical analysis for small to medium sized datasets where data are

held in a temporary worksheet of rows and columns. SIMUL8 and Minitab have worked together in the past to allow collected results to be easily downloaded to the MINITAB software. We thought it would be interesting for you to see the other side of the simulation world where the model you create and the results generated from it become the basis for a statistical analysis.

V.I.S.A. (Visual Interactive Sensitivity Analysis)

V.I.S.A. is a decision support tool that helps you compare alternative strategies or options against multiple criteria. Visual Thinking International, the parent company of SIMUL8 Corporation, develops and markets this software application.

Volo View Express

Volo View Express lets you view and print the basic design drawing file formats without requiring the full version of the AutoCAD® software. You don't need to install or know how to use AutoCAD in order to access, mark up, or accurately print computer-aided designs. It enables you to quickly open drawings then pan and zoom between different drawing layers. Volo View Express displays the basic design file formats of DWG, DXFTM, and DWF (ePlot and eView). Volo View Express runs inside Microsoft® Internet Explorer.

Work Study+TM

Work Study+, from Quetech Inc. (www.Quetech.com) is a Palm[™] application for performing time studies and data sampling. With it you can create custom element categories that can be organized hierarchically, perform continuous, snapback and sampling studies with real-time visual feedback of each element's properties (such as time, performance, level time, and cycle number), and view statistical information immediately upon study completion - all without the need to go to your PC.

Prerequisite Knowledge

We want this book to be useful for SIMUL8 users of all levels and backgrounds. To that end, we've tried to limit the number of prerequisites as much as possible. However, we do have a consulting practice that we very much enjoy and would like to get back to, so we weren't inclined to write the 3000 page tome that would be required to cover everything comprehensively. This means that we have had to assume a few things.

While we do review a few of the fundamental simulation concepts, we don't try to replace a full college-level course here. You will find that it is very easy to start putting simulation models together in SIMUL8, even if you know absolutely nothing about simulation. If you are looking for simulation to provide a general 'feel' for the way a process works, or to present the process to others in a graphically compelling way, you can probably get along without much core simulation knowledge for quite some time. However, because so much of simulation depends upon modeling randomness, we can't avoid using concepts such as 'probability distributions.' Even though we don't expect

you to recite exactly which distribution should be used under which conditions, you should at least know what we mean by a probability distribution. You should also know that computers deal with randomness by creating pseudo-random number streams, each of which is based on a random number seed.

While we presume that you are familiar with the concept of representing a process with a mathematical model, we do touch on this briefly, just as a refresher, but it is not in enough detail to serve as your only introduction. Fortunately, this idea is intuitive to most users, so it isn't typically a problem. If any one of these concepts are unfamiliar to you, it would be wise to consult a basic undergraduate text before you get too far along in your modeling career.

Basically, if you are relying on specific simulation output figures to make a decision, and you want to be able to trust the results of your study, then you will need a strong grounding in basic simulation skills, especially probability and statistics. If you are developing a model in support of a multi-million dollar decision, you can bet your boss will want reasonable assurance that Scenario B really is better than Scenario A. This means that you can prove that you've modeled the random dynamics and interactions accurately, and that this difference between scenario results really is statistically significant (e.g., the use of multiple streams of random numbers introduces statistical issues that you will need to be aware of).

Required skills for the truly proficient simulation analyst include programming and code writing skills, experience with developing effective data structures, a decent grounding in probability and statistics, and excellent communication skills. All of these skills are important, but we think the most significant skill is the ability to think logically. This concept is often referred to as 'mathematical maturity.' Any exposure to advanced mathematics, while not strictly required, will serve you well. "Required Skills of a Simulation Analyst" by Rohrer & Banks in the May 1998 issue of *IIE Solutions* is an article worth reading on the subject.

If you happen to be short on some of these skills, don't panic. Even though the more you know about general modeling skills, probability, and statistics, the easier it will be to learn SIMUL8, we invite you to try SIMUL8 anyway. There is no reason that you can't start learning SIMUL8 in parallel with brushing up on the other subjects. Besides, once you start using SIMUL8, we think you will find it so compelling that you will be motivated to go back and pick up some of those extra skills required for professional-level simulation studies.

For more details on where you can brush up on these concepts, please see one of the excellent books on basic simulation and other related disciplines in the chapter entitled A Modeler's Toolkit or see our website located at *www.NovaSim.com*.

Setting Expectations

Simulation can be conceptually challenging for many people. At its higher levels, successful simulation modeling requires an analytical mindset that does not come naturally to everyone. This is not to say that it can't be learned, but only that it may take a bit of effort. The background and diverse skill set required in undertaking large, complex simulation projects can also be a challenge.

The good news is that, by and large, if the idea of simulation has caught your fancy, you'll probably do well in learning it. That may sound like a big leap, but our reasoning is actually fairly simple. Simulation tends to appeal to people who already look at the world through an analytical mindset. In all likelihood, you were driven to learn simulation because you appreciate the need to break systems down into essential elements and to understand how these elements work together dynamically. If this is indeed how you are already accustomed to approaching problems, you'll do just fine.

Although the mechanism to build simulation models becomes easier with every new version of simulation software released, the fundamental ability to formulate problems does not get easier. We have taught many people, face to face, about how to build simulation models using SIMUL8 and can attest to the wide range of ability to grasp the concepts of simulation. It is certainly challenging to look at a real world problem with all its complexities, abnormalities, obscurities, and random events and convert it into a meaningful simulation model.

Don't be discouraged. In fact, we have included the following table to let you know that you are not alone in finding some of this difficult, and that perseverance will pay off. The table is intended to serve as a guide to the level of difficulty you face in trying to incorporate various concepts of real world systems and the SIMUL8 software into your model. The rows contain concepts that share approximately the same level of difficulty and are ranked on a scale of 1 through 10.

Difficulty Level	Simulation Concept or Application						
1	Basic Objects	Routing Arrows	Simple Process Times	Clock Properties			
2	Simple Routing	Automatic Results	Using Templates	Simple Graphics			
3	Simple Resources	Shift Patterns	Distributions	Importing Visio, SDX or AutoCAD			

Difficulty Level	Simulation Concept or Application						
4	Labels	Jobs Matrix	Cycle Matrix	Simple Batching	High Volume Processes		
5	Multiple Item Types (Products)	Item Dependent Process Times	Simple Visual Logic	Information Store	Process Objects		
6	Custom Results	Dynamic Routing	Dynamic Calculations	OptQuest for SIMUL8	Database Functions		
7	Complex Visual Logic	Transport Plug-In	3-D Graphics	Complex Batching			
8	Custom-User Interface Development	Complex Resource Management					
9	Generic/ Dynamic Models (Templates)						
10	Custom Optimization	Dynamic Scheduling Algorithms					

We have taught simulation to many people and will be using our experience to take you through the concepts in the table one by one (sometimes more than once!). Many people learn the basic concepts of arrivals, servers, and queues in a very short time-period, but when the lesson turns to the more advanced concept of labels (Difficulty Level 4), we find the learning time slows a bit. Considering that everything else in SIMUL8 builds upon your knowledge and use of labels, it is absolutely necessary that you take all the time you need to grasp the concept of distinguishing different characteristics of work items. Having said that, you will notice that this manual doesn't cover all of the concepts listed in the table. This is because each of the Level 10 concepts warrants a book all its own!

The following graph converts these levels into a learning curve with a time scale. It is by no means scientifically calculated and is only an observation. The curve defines the average number of weeks it takes to learn the various concepts. The line between the 7th and 8th difficulty level divides the curve into two categories: part-time and full-time. This line denotes where the advanced concepts become so intensive that you are probably looking at simulation as your full-time job. For example, the concept of complex routing and dynamic calculations (Difficulty Level 6) would take about 6 weeks of learning time.



Simulation Learning Curve

Sources for Help

NovaSim

NovaSim is a professional simulation services company specializing in using SIMUL8. We enjoy helping others to learn simulation. If you have questions, comments, or just wonder about how and when to use simulation, we would love to hear from you. We'd also love to have you join us for one of our intensive, informative and fun live seminars. Our website at *www.NovaSim.com* contains many hints, tips, simulation models, case studies, and words of encouragement regarding simulation. Please feel free to contact us at:

NovaSim, LLC

1000 Geneva Street Bellingham, WA 98229 (800) 538-6394 LearningS8@NovaSim.com

SIMUL8 Knowledge Base and Café

SIMUL8 Corporation maintains a both a searchable knowledge base and message board. The Knowledge Base is a searchable database of SIMUL8 concepts. The café provides a forum where the community of SIMUL8 users can post questions, observations, or comments regarding SIMUL8 and simulation. It is quite active and a good source for meeting other people who are facing similar modeling situations. The technical support team at SIMUL8 administers it, but the general user community answers many questions (we're on there quite a bit ourselves).

Find the SIMUL8 Knowledge Base at http://simul8.com/support/knowledge/.

Find the Café at www.SIMUL8.com/cafe.

Obtain general support for SIMUL8 at www.support.SIMUL8.com.

SIMUL8 Manual and On-Line Help

Although this book is very comprehensive, we are not going to repeat everything contained in the software manual provided by SIMUL8. You may not have received a hardcopy of the manual but you should have an electronic copy of the software as an Adobe PDF. You should find it in the SIMUL8 folder *c:\Program Files\SIMUL8*.

SIMUL8's on-line, context-sensitive help, and especially the 'bubble' help within the software are both valuable resources, and are often convenient reminders of the many properties of the object dialogs.

Reference Books

We have included a list of books that we have found valuable on simulation, statistics, programming, operations research, and project management on page 570. Also, our Simulationist's Bookshelf has an up-to-date list at *www.NovaSim.com/Bookstore.htm*.

We'd Love Your Feedback...

We plan to keep this guide up to date as SIMUL8 continues to grow and evolve. We'd love to hear what you have to say about this first edition. We've said that we don't pull any punches and we don't want you to either. If there is a topic that you don't understand, or that you wish we'd have covered, let us know. We will collect all suggestions and incorporate them in future editions.