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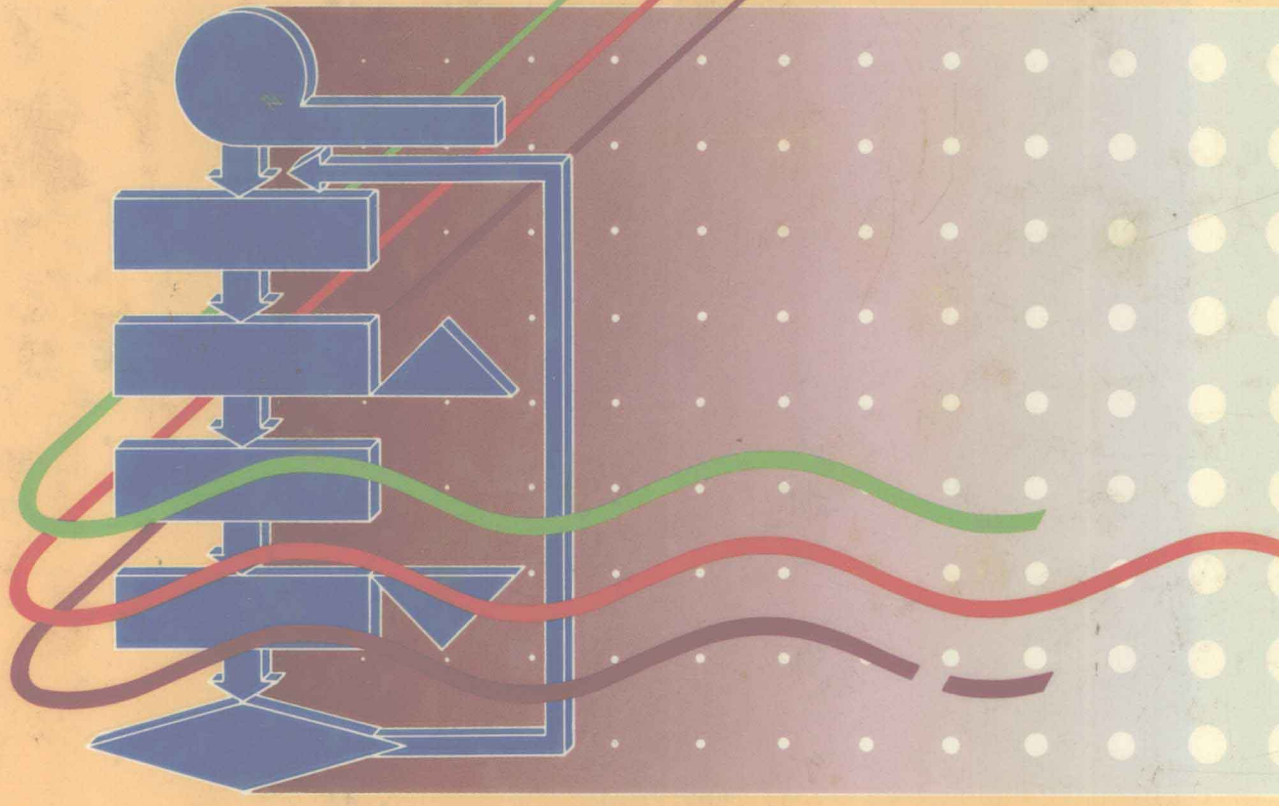
Thomas J. Schriber

An Introduction to Simulation



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An Introduction to Simulation Using GPSS/H

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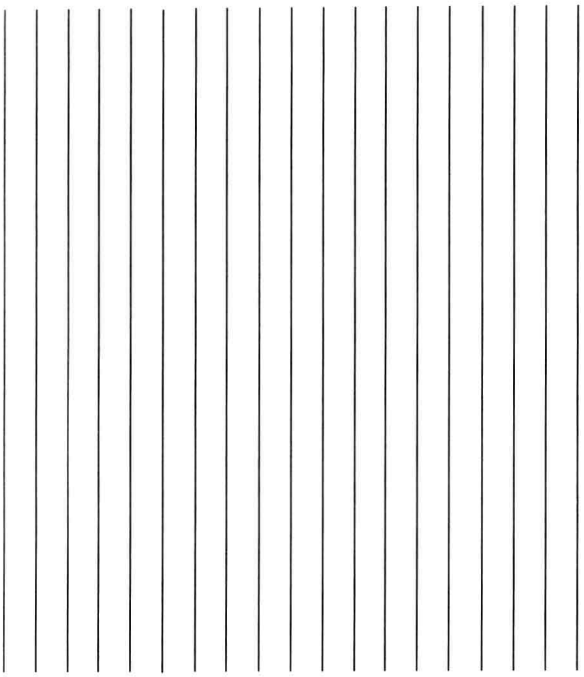

Preface

For the Student.

Computer-based simulation modeling is an exciting, satisfying, and practical technique that can be used to experiment with various designs for complex systems in such areas as manufacturing, health care, transportation, communications, and computing. This book introduces building and experimenting with simulation models using a powerful, flexible, fast, and well-established simulation modeling language, GPSS/H (General Purpose Simulation System/H). GPSS/H is frequently used in industry, so you might find that knowledge of GPSS/H will be of direct benefit to you in your career. Even if you work eventually with an alternative simulation language similar in type to GPSS/H, you will find that the priniciples learned in this book can be readily used to develop an operational capability with the alternative language. Student DOS-GPSS/H is contained on a disk supplied with this book, so GPSS/H-based simulation is only as far away as the nearest DOS-based microcomputer.

You can use this book in a relatively formal way in a course on simulation, or you can use the book outside of formal coursework as the basis for self-study of the foundations of simulation using GPSS/H. Every attempt has been made to write the book in such a way that the ideas it contains can be mastered successfully without the need to rely on lectures, although lectures can enrich, extend, and speed up the learning of the material presented here.

Numerous exercises are built into the book. Most of them involve hands-on use of GPSS/H. Some of the exercises call for use and/or modification of GPSS/H models that are discussed in the book and supplied on a disk that comes with the book. Solutions to many of the exercises are presented in an appendix, so you can immediately check your thinking and your work against these solutions.

The book has two prerequisites. First, some familiarity with computer use is assumed. This familiarity can involve such things as the use of a computer for word processing, or text editing, or spreadsheeting, or filing, or database applications, or electronic mail. It need not include experience in computer programming. The computer-familiarity prerequisite is indicated because this book contains no introductory material on computer use as such.

The other prerequisite is a first course in probability and statistics. How does this material come into play? The types of system for which simulation models are built using GPSS/H can include components that behave in random but statistically predictable fashion. Incorporation of "statistical predictability" (which is explained in the book) in a model involves working with random numbers, random variables, and probability distributions. Furthermore, if one or more of the components of a simulation model varies at random, then values characterizing a model's behavior vary at random. An objective of simulation is to observe such values

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and then use the observed values to make inferences about long-run model behavior. This explains why a first course in probability and statistics is a prerequisite for successful use of this book. (Many students have told me that the study of simulation brings probability and statistics to life for them for the first time.) Fingertip knowledge of such material is not assumed, however. Instead, all such needed material is commented on and summerized (but not developed) in the book, and its use is illustrated with examples.

Except for the indicated basic background in probability and statistics, there are no mathematical prerequisites for use of this book. Simulations of the type we will study do not involve formulating and then solving sets of equations, as you will see.

So now you should be able to get started with your introduction to simulation using GPSS/H. You can go immediately to Chapter 1 and proceed from there. Best wishes for successful use of the book, and for enjoying yourself in the process.

For the Instructor.

This book can be used in a simulation course in a number of different ways. The alternatives depend on the purpose of the course, the instructor's approach to dealing with the material in the book, the duration of the academic term, and whether the course is to be based on a modeling language, with general principles of simulation playing a secondary role, or is to emphasize general principles of simulation, with use of a modeling language playing a secondary role. Several broad possibilities are suggested later.

As for the purpose of a first course in simulation, a distinction can be made between a course whose objective is to build a base of understanding for students who have no intention of going on to become practitioners of simulation (their goal may be to become informed consumers of results produced by practitioners), and a course being taken by students who might eventually become simulation practitioners. Students in BBA or MBA programs (especially those specializing in operations management, statistics and management science, or computer and information systems), for example, might fall into the former category. Industrial engineering students at all degree levels, operations research majors, and Ph.D. students (who might intend to use simulation methodology in their dissertation work) in operations management, operations research, in a range of engineering specializations, or in health-care management or public administration, for example, might fall into the latter category. Although students in the former category can be well served by a single course in simulation, those in the latter category cannot learn enough about simulation in a single course (in my opinion) to satisfy their needs. (See Section 8 of Chapter 1 in this regard.) Whether both types of students can be served equally well in one and the same first course is debatable. In any event, this book is designed for use in a first course, not in a two-course sequence. (Not many of us have the privilege of offering a two-course sequence in simulation, despite the importance of simulation in the view of both operations-research practitioners and educators. See Section 4 of Chapter 1 for documented insights into the importance of simulation.)

In my experience, both types of students just mentioned are strongly motivated by a first course that emphasizes a modeling language, with general principles playing a secondary role. (Let's face it, it is fun, challenging, satisfying, and stimulating to build simulation models, get them running correctly, and then perform experiments with them.) Simulation is a topic that shouldn't simply be "talked about," but that should be "done." (As someone has said, simulation, like football, is a contact sport.) In this approach, practice both informs and motivates an interest in theory, with a focus on practical problems leading to an interest in the more abstract considerations that provide results useful in coping with practical problems. Under ideal circumstances, an instructor can move back and forth with considerable success between practice on the one hand, and theoretical considerations on the other.

An instructor's approach to dealing with material of the type in this book can also influence the number of simulation topics covered in a first course, and helps determine how much time students must invest in the course outside of class. At the one extreme, an instructor might give detailed lectures on the material in this book and perhaps challenge the students with quick exercises to be done in class and then to be immediately discussed in class. This approach saves student time outside of class but doesn't leave much class time for other things. At the other extreme, an instructor might give brief overview lectures (or no lectures at all) on the material in this book, expecting students to master the material on their own and demonstrate mastery by handing in various GPSS/H modeling assignments. The time students must spend on a course can increase dramatically if this approach is taken. (The number of office hours that must be held to clarify

issues that otherwise could have been methodically explained in lecture can also increase dramatically.) The class time freed up in this approach, however, can be used to extend the range of topics covered in the first course. In this approach, for example, an instructor might base the course on a general-purpose simulation textbook (see item 3 further on), and have the students use this GPSS/H book as an accompanying text whose contents are largely up to the student to master.

The rate at which material of the type in this book can be covered in lecture also depends on whether or not transparencies are used to support lectures. I can supply to adopters paper copies of transparencies that can be used in giving detailed lectures on the material in this book. (See below. For the most part, these transparencies are large-scale versions of figures and tables in the book.)

Keeping the preceding considerations in mind, here are some possible patterns for use of this book in a first course in simulation:

1. If an instructor gives detailed lectures on material in this book, and if these lectures *lead* the corresponding reading assignments, this book can be the basis for an entire course. The student time saved when lectures lead the reading can be spent doing more out-of-class hands-on exercises than might otherwise be reasonably required. In my experience using this approach, students can hand in about 12 modeling assignments during a 15-week term. (These assignments progress from simpler exercises up to the level of more demanding activities, the last of them, in my case, based on a current paper from the literature.) There is also time for students to extend their base of simulation literacy by reading and reporting on the simulation chapters in several operations research books and by studying and reporting on simulation applications they find by searching the literature. (See Exercises 1 and 4 in Section 11 of Chapter 1.) Time permitting, the instructor might also introduce students to detailed aspects of some GPSS/H capabilities that are beyond the scope of this book (see Chapter 17, and especially Section 28 of that chapter, in this regard), demonstrate Proof (the animation and presentation software produced by the vendor of GPSS/H), and perhaps teach some operational skills in the use of Proof to produce animations and presentations.

2. If an instructor limits himself or herself to giving overview lectures on the material in this book, then the book can also be the basis for an entire course. In this approach, students must spend more time outside of class studying the material in the book, but the book can be covered more quickly in lecture. This leaves more class time in the latter part of the term for additional activities of the type mentioned under item 1 and can also leave enough time for students to do a simulation project in the closing weeks of the term. (If a student project is assigned, then the instructor probably should introduce students to detailed aspects of some GPSS/H capabilities that are beyond the charter of this book. See Chapter 17, and especially Section 28 of that chapter, in this regard. Some instructors might choose to have their students pursue any needed additional details on their own, as a test of their ability to come to grips with new material in independent fashion.)

3. Another possibility is to base a simulation course on a general simulation text such as Banks and Carson (1984), Law and Kelton (1982, 2nd edition forthcoming in 1990), or Watson and Blackstone (1989) while using this book as an adjunct to introduce operational aspects of a modeling language. This book is written in such a style that it can be studied without being lectured on extensively (but with corresponding demands, of course, on the use of student time outside of class).

The three patterns just described are suggestive, not exhaustive. Various permutations of these patterns can be developed to suit the needs of instructors and their students.

For instructors who have learned or taught from *Simulation Using GPSS* (Schriber, 1974), it may be helpful to comment on the differences between that book and this one. Sometimes referred to as the Red Book or as Big Red, the 1974 book is extensive in covering the Blocks in IBM's GPSS/360 (a product of the late 1960s) and providing detailed examples of their use, but is not extensive otherwise. It contains no overview of simulation and no GPSS material relative to the statistical analysis of output, or variance reduction techniques, or selecting the probable best from two or more competing alternatives, for example. Furthermore, given the vintage of GPSS/360, the Red Book takes a batch-oriented approach in discussing the internal aspects of GPSS. In contrast, the present book is not as extensive with respect to the coverage of Blocks in the fast, extremely powerful implementation of GPSS known as GPSS/H. It provides an *introduction* to GPSS/H,

not a comprehensive treatment of the language. But this book *does* contain an overview of simulation and material on statistical analysis of output, variance reduction techniques, and selecting the probable best from two or more competing alternatives, and shows by discussion and example how GPSS/H can be brought to bear in these important areas. Furthermore, this book uses an interactive approach to teach GPSS/H, with batch use not operationalized until Chapter 6, and with additional aspects of interactive use extending even beyond that point. Like the Red Book, this book explains and illustrates the data structures (Chains) and processing algorithms (including GENERATE-Block initialization, the Scan Phase, and the Clock Update Phase) on which GPSS/H is based, so that the student has the priceless satisfaction of understanding *how* a GPSS/H simulation proceeds. Whereas that material was dealt with largely in desktop fashion in a single dose in the Red Book, a much more satisfying and gradual hands-on, interactive approach is taken in dealing with that material here.

If you teach from this book, you might send me a note on your school's letterhead to tell me that (University of Michigan, Ann Arbor, MI 48109-1234). You will then receive instructional-support material. You are also encouraged to send me exercises you might compose for use with the book. Some of these might then be included (conditioned on your approval, and with credit given to you) in later editions of the book. Your general comments and innovative ideas for successful use of the book are also welcome.

Acknowledgments

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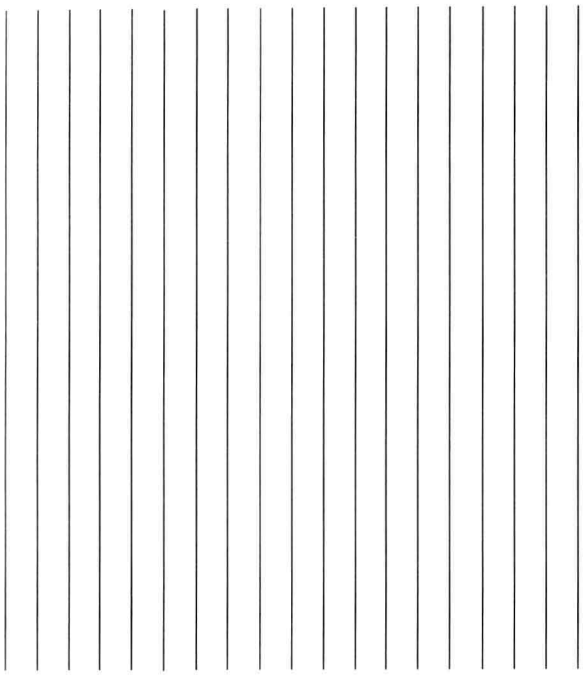
THOMAS J. SCHRIBER
Ann Arbor
January 1990



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