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SIMULATION TEXT BOOKS – OLD AND NEW (PANEL)

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ABSTRACT

In order to get more people to use simulation, improved teaching of simulation is important. In this context, textbooks and, more generally, teachware play a critical role. The panel looks at some of the older and successful textbooks as well as textbooks and teachware that are quite new and in some cases are still under development.

1 INTRODUCTION

Each of the six members on this panel is an author or co-author of one or more simulation textbooks and/or of other forms of simulation "teachware" that span a time interval of nearly thirty years, ranging in copyright dates from 1974 to 2003. The panelists have been assembled based on the variety of contexts which caused them to go through the process of becoming simulation textbook and teachware authors in the first place (and, in one case, the designer and implementer of new versions of a classic simulation language). The particular panelists are only representative, having been drawn from a larger pool of persons who could serve admirably on such a panel, bringing their experiences and observations to bear on the discussion.

In order of appearance, Ingolf Ståhl points out the critical role played by textbooks and other teachware in the dissemination and practical use of simulation. He surveys the pre-1980 simulation textbook scene and discusses his motivations for designing and implementing a continuing series of his own versions of GPSS and writing the corresponding instructional material supporting those creations.

Tom Schriber then reviews the circumstances that brought him to the point of studying GPSS, introducing it into the University of Michigan's MBA program, and designing teaching notes evolving into a textbook that saw wide use over a period of many years.

The next panelist, Jerry Banks, tells how he was drawn into the simulation area and describes a shortfall in the simulation textbook literature that drove him and his co-author, John Carson, to convert their teaching notes into a textbook. Jerry describes how that book evolved over time into second and third editions, and took on new co-authors, with a fourth edition now in progress.

Averill Law follows with a discussion of another highly successful simulation textbook, co-authored with his one-time Ph.D. student, David Kelton, published in three editions, and with a fourth edition now planned. The Law and Kelton book appeals to a broad market and reflects both the expertise of its two co-authors, and their substantial body of experience in teaching simulation to numerous students of diverse background over the years.

Next in line is Andy Seila. His recently published textbook (with Pandu Tadikimalla and Vlatko Ceric) reflects experiences in teaching simulation in schools of business, where the application areas include finance, marketing, real estate, and accounting, in addition to the more traditional application area of operations management. Seila's discussion includes putting the simulation student market into categories that span several types of students,

ranging from those with strong quantitative and theoretical skills to those having a focus that tends to be more on the applied side of simulation studies.

The sixth and last panelist, Rich Born, homes in on the adaptation and exploitation of technology to improve current forms of simulation teachware. Born and Ingolf Ståhl have developed an evolving set of more than 400 PowerPoint slides that they have used over time to drive in-class presentation and discussion of simulation concepts based on Ståhl's WebGPSS. This material, which takes advantage of the technology by including dynamic presentation of concepts where appropriate, points out the direction in which future simulation teachware might well be headed.

The panelists provide a rich body of knowledge and experience in the delivery of simulation know-how, both to beginners and to those who have some seasoning in the area. But session attendees will also have insights and experiences to reflect in this regard. After the panelists have made their comments, the floor will be open to members of the audience, who are invited to ask questions about what the panelists have said, and to enhance the panelists' comments with observations of their own. In the final analysis, the purpose of the panel is to set thoughts into motion regarding the role that simulation textbooks and, more generally, simulation teachware, can and should play in the education of simulation practitioners and consumers.

2 INGOLF STÅHL: "SIMULATION MADE SIMPLE WITH WEBGPSS"

The panel deals with simulation textbooks, old and new. This is in my view a crucial part of simulation education. When getting the privilege of being coordinator for the track on education, my starting point was the following question: Knowing that simulation is such a powerful and useful tool, why is it not used more in society? My main idea of an answer is that education plays a critical role and by improvement in education we can get simulation spread. In this effort of better education, I believe that textbooks play a key-role. No simulation system is really better than its "teachware". In order to get teachers to give good courses, they must have access to good textbooks. Textbooks also play a key-role in self-study. Finally, textbooks sometimes also influence the development of new software, a topic to which I will return.

When calling for a panel on textbooks, old and new, there were several reasons for including the old textbooks. Only by knowing where we come from, can we know where we are going. I believe a lot can be learned from studying the history of simulation textbooks when developing new teachware. We can learn what textbooks met with especially strong student acceptance. To understand why they did so, we must study not only the textbooks themselves, but also look at what competition was available at the time of releasing the textbooks.

Since we have the good fortune of having on our panel the author of the Red Book, which was the textbook which really brought simulation into mainstream teaching at both engineering and business schools, I had thought it would be a good starting point for a discussion of the Red Book to see what other textbooks were around at that time. I have hence compiled a set of references on pre-1980 textbooks. The reason for going up to 1979, is that it was in the late 70s that the Red Book had its main growth.

For my compilation of this list, I have depended greatly on a list compiled by Schriber (1992), but also on some 30 odd simulation books that I own and the list of references in these books, in particular that of Kreutzer (1986). I have excluded manuals, books with editors, very technical books and textbooks in which simulation is only a small part. Since other members of the panel also refer to some books in this listing, I have put this list of pre-1980 textbooks ahead of the general references in this paper.

It appears that the majority of books are in some way oriented towards teaching some kind of programming to implement simulation models, although many books also contain general theory. As concerns these language oriented books, the group of textbooks which use **FORTRAN** as the main language seems to be the largest group with Naylor *et al.* (1966), Martin (1968), Meier *et al.* (1969), Emshoff and Sisson (1970), Schmidt and Taylor (1970), Maisel and Gnugoli (1972), McMillan and Gonzales (1973), Shannon (1975), Fishman (1978) and Deo (1979). The second largest group is focused on **GPSS** with Gordon (1969), Reitman (1971), Greenberg (1972), Schriber (1974), Gordon, G. (1975), O'Donovan (1976) and Bobillier, et al. (1976)

There are also several textbooks based on what one can call the **GASP-SLAM-family** with Pritsker and Kiviat (1969), Pritsker (1974), Pritsker and Young (1975), Pritsker (1977) and Pritsker and Pegden (1979). There are also several textbooks based on **SIMSCRIPT:** Markowitz et al. (1963), Wyman 1970, Kiviat et al. (1973) and on **Simula**: Birtwistle et al. (1973), Franta, (1977) and Birtwistle (1979). Finally, there is one book on **Hokus**: Poole & Szymankewicz (1977) and one using **pseudo-code:** Lewis & Smith (1979).

Other books give more of a broad general **overview** without language focus. Examples of such books are Chorafas (1965), Mize and Cox (1968) and Fishman (1973). Others are mainly known for a focus on **modeling theory.** Here we find Tocher (1962), containing the three-phase approach, but also some information on GSP, the General Simulation Program, the oldest simulation language, and the well-known book by Zeigler (1976). Other books are more focused on statistics and experimentation, like Naylor (1969) and Kleinen (1974; 1975).

Among other types of simulation textbooks we have some on **continuous simulation,** like Forrester (1961) and Korn and Wait (1978). We also have textbooks on simulation of **human behavior in the firm or society,** like Bonini

(1963), Dutton and Starbuck (1971), Guetzkow et al. (1972) and Frazer (1975).

Having thus overviewed the pre-1980 literature, it is time for me to note that in this panel we can celebrate the 30 years of the Red book. Even if it has 1974 as the printing year, all the work on it was ready already in 1973. Furthermore, a substantial introductory part of the Red Book can be found as a 77-page chapter by Schriber in McMillan and Gonzales (1973). I am not the only one who immediately ordered the Red Book after reading this chapter. This book has been a constant great source of inspiration for my own development of a series of textbooks on GPSS, indeed much smaller in size than the original Red Book, but at least during the last few years having the same color.

Before I give the word back to Tom Schriber, I should like to return to my earlier statement that textbooks sometimes also influence the development of new software. This is certainly true as regards the Red Book. The development of micro-GPSS (Ståhl 1990), and consequently of WebGPSS (Ståhl 2002) and WinGPSS (Herper and Ståhl 1999), are heavily dependent on the choices Tom made in the Red Book for what GPSS block types to use in the 27 case studies in this book. Here 28 of the 44 block types of GPSS/360 were selected. As I show in a recent paper (Ståhl, 2003), these choices were very wisely made. The aim of our streamlined micro-GPSS was then that we with even fewer block types should be able to rewrite all the Red Book case studies with the same amount of code, which we have managed to do.

3 THOMAS J. SCHRIBER: "THE RED BOOK"

The following remarks repeat and extend similar remarks made earlier (Schriber 1991).

Half way through my first year (1966-67) on the faculty at the University of Michigan's School of Business Administration, my department chair asked me to develop a course on discrete-event simulation for the MBA curriculum. I had never studied discrete-event simulation and so, as a dutiful Assistant Professor, I rolled up my sleeves and dug in. After getting a feeling for the topic and then surveying the language scene, I concluded that GPSS might be the best choice of language for such a course. Why? Because it had the merits of being sparse in its syntax, and of letting the model builder think quite directly in terms of the elements of the system for which a model was being built. (It would not be necessary for the students to learn the syntax and semantics of a programming language and deal with the coding of event routines and the like, which would almost be guaranteed to lead to low enrollments in the MBA environment, and perhaps now in many other environments, too, in the point-and-click world of today.)

Attracted to GPSS as I was, I did not yet fully appreciate the merits of its process-interaction approach. These merits have been well described by Henriksen (Schriber et al. 1991), and are repeated here verbatim:

"… consider how simulation was done before the release of Geoffrey Gordon's General Purpose System Simulator in October, 1961. Prior to that time, virtually all discrete event simulation was done using an event-based paradigm. … One described a system as a collection of events, and one wrote a "chunk" of code for each event...

"The event-based approach had one big advantage and one big disadvantage. The advantage was that it required no specialized language or operating system support. Event-based simulations could be implemented in procedural languages of even modest capability. … The disadvantage of the event-based approach was that describing a system as a collection of events obscured any sense of process flow. … In complex systems, the number of events grew to a point that following the behavior of an element flowing through the system became very difficult.

"In the early 1960s, alternative approaches were available. The most obvious choice was some form of process interaction. Unfortunately, process interaction was understood only by an elite group of individuals and was beyond the reach of ordinary programmers. 'Multithreaded applications' were talked about in computer science classes, but rarely used in the broader community.

"This was the primordial soup out of which the Gordon Simulator arose. Gordon's transaction flow world-view was a cleverly disguised form of process interaction that put the process interaction approach within the grasp of ordinary users. … Gordon did one of the great packaging jobs of all time. He devised a set of building blocks that could be put together to build a flowchart that graphically depicted the operation of a system. Under this modeling paradigm, the flow of elements through a system was readily visible, because that was the focus of the whole approach."

Little realizing back then what a treasure was at hand, in the summer of 1967 I scrambled to study GPSS and fashion a syllabus for the first offering of the requested simulation course in the fall of 1967.

The available GPSS literature was quite thin, so I began developing my own notes and examples, often only a skip and a jump ahead of the students. That was in the days when it was typical to lecture at a blackboard. But that meant you couldn't cover much material in class. (It took too long to draw block diagrams on the blackboard.) So I began to summarize lectures on transparencies and used a projector to cover the material faster. The students couldn't write quickly enough to keep up, so after each class copies were made of the transparencies to give out at the next class. This was inefficient, but it worked as a stopgap measure for the first two course offerings.

Jim Henriksen (James O. Henriksen) was a student in Michigan's MBA program at the time, and took the second (winter 1968) offering of the simulation course. Jim sat quietly in the back row and said nothing for the first sev-

eral weeks of the course. However, he projected an undeniable presence, even in a class of forty nine students (seven rows, seven seats per row, all filled). I thought, "Who is that guy back there anyway?" One day Jim then asked the first in a series of penetrating questions that gave me a lot of insight into "that guy." (As it turned out, Jim had a part time job in those days, too, maintaining simulation software in the University of Michigan's academic computing system. So in our relationship, Jim came to me as a student, and I went to him as a software specialist when bugs surfaced in GPSS/360. When we ran into bugs, Jim was the guy who jumped into the GPSS/360 assembly language code to find and fix the bugs. About 30 bugs were found and fixed at Michigan in 1968-69!)

In the summer of 1968, just after Jim took the course, I cleaned up my lecture materials and contracted with a local printer to have them printed in softbound form. The resulting "book" was put on consignment at a local bookstore for use in the 1968-69 academic-year offerings of the course. Representatives from several publishers saw the "book" and offered to publish it in a formalized version. After several preliminary printings were tested at Michigan, the "Red Book" hit the streets in 1974 (Schriber 1974).

One characteristic of the "Red Book" was that it explained not only "what GPSS does" but also "how it does it." In other words, a purely "black box" approach was eschewed by explaining the internal logic of GPSS. The need for this approach was driven by my Michigan students, who continually asked me, "tell me how this works; tell me how that works." The discussion of internal algorithms was not relegated to an appendix, where many might overlook it, but was built into the book mainline, starting as early as possible (starting on page 59 in a 530 page book). The objective was to educate modelers who *understand* the effects and interactions that result when they arrange the GPSS blocks in certain ways, rather than simply laying out the blocks mechanically and hoping that the desired effect would result. My strong belief in giving emphasis to such understanding continues to be reflected today in a series of tutorials given at each Winter Simulation Conference from 1995 forward (Schriber and Brunner 2003).

The "Red Book" seemed to fill a gap in the simulation textbook literature in the 1970s and on into the 1980s, both nationally and internationally. (The book was translated into Russian in 1980 (Schriber 1980) and, with its red cover retained, became known in that version as the "Red Red Book.") Later, when people asked why there wasn't yet a second edition of the "Red Book," the answer was something like "Why produce a second edition now? The first edition is still doing just fine." The book went through about 40 printings, producing over 50,000 copies, a record in its time.

Eventually that 1968 student, Jim Henriksen, came out with his own mainframe GPSS/H (Henriksen and Crain 1977), and in due course it migrated to the desktop. Here was a compelling reason to write another GPSS book, this one on GPSS/H (Schriber 1991). To keep the price down, the publisher set a page limit of 400 pages. GPSS/H is far too rich to be fully covered in detail in 400 pages, so the 1991 book turned out to be only introductory in nature (although, like its predecessor, it includes a discussion of internal logic). It was unfortunate not to be able to include the full treatment that GPSS/H was being given in courses at Michigan. Even today, when a copy of the "Red Book" comes into view, I sometimes find my thoughts moving in the direction of a comprehensive "Son of Red Book"…

4 JERRY BANKS: "DISCRETE-EVENT SYSTEMS SIMULATION"

4.1 Background

My first brush with simulation was in the preparation of my dissertation on the subject of inventory system analysis. It was limited to Monte Carlo generation of lead-time demand from distributions of lead-time and demand. In 1965, I came to Georgia Tech as an assistant professor where I taught an introductory survey course in operations research, electronic data processing, and inventory modeling. Then, I went to the U.S. Army for two years to serve a commission.

Upon returning to Georgia Tech, I was told that I would be teaching production control. It included a laboratory on simulation. I was told that the lab consisted of teaching GPSS and that I could learn about it in a short course for faculty taught by an interested party associated with Georgia Tech's internal information services department. When the instructor began his explanation, a light went on and my affair with simulation began.

About six years later it was decided that a discrete-event simulation course should be taught. I was asked to design it. But, I wasn't the first person to teach it. In 1979, a real simulation person joined the faculty, John Carson, who had been a student of Averill Law at the University of Wisconsin. Both of us were teaching the undergraduate simulation course, but we were complaining that the textbooks didn't please us. We were trying a different text each year.

In a moment of weakness, we said that we should just write a textbook as we both had made piles of notes. We contacted some publishers, one of which was Prentice-Hall. After an afternoon of protracted discussion in 1981, we signed a publication contract promising a manuscript one year from that date. Two years later, we presented the manuscript for *Discrete-Event Systems Simulation*. The text came out in September of 1983 with a 1984 copyright date (Banks and Carson 1984).

We are in the throes of preparing the fourth edition of this text. In the 20+ years that we have been working on the four editions of the text, we have added and deleted materials. We try to keep the number of pages to a reasonable size, but the text is growing. In this portion of the *Proceedings* entry, I will explain some of the rationale that went into the various editions.

4.2 First Edition (1984)

Some of the facts are as follows:

Co-authors: Jerry Banks and John S. Carson, II
Chapters: 12
Pages: 514
Cover: White, Prentice-Hall International Series in Industrial and Systems Engineering

Our philosophy was to teach by example. Hence, we had many small examples that could be 'grasped' by the student. Thus, when talking about the Kolmogorov-Smirnov test for randomness, our example had but five numbers. We used a table and a figure to depict the method for performing the test. No real world application is going to test five numbers for randomness; maybe they would test 50,000 numbers. We also had a lot of exercises for the students. Many of them were exam questions that we had used over the years. A Solutions Manual was available from the publisher.

The text was divided into four parts with chapters as follows:

Part One: Introduction to Discrete-Event Simulation
Introduction to Simulation
Simulation Examples
General Principles and Computer Simulation Languages
Part Two: Mathematical and Statistical Models
Statistical Models in Simulation
Queueing Models
Inventory Systems
Part Three: Random Numbers
Random Number Generation
Random Variate Generation
Part Four: Analysis of Simulation Data
Input Data Analysis
Verification and Validation
Output Analysis for a Single Model
Comparison and Evaluation of Alternative System Designs

4.3 Second Edition (1996)

Quite a few years lapsed between the first and second editions. Some of the related facts are as follows:

Co-authors: Jerry Banks, John S. Carson, II, and Barry L. Nelson
Chapters: 13
Pages: 548
Cover: Blue, Prentice-Hall International Series in Industrial and Systems Engineering (not mentioned on the cover)

John Carson left Georgia Tech for a full time consulting practice in 1986 and I had been on the faculty for quite a few years. We needed new blood. We got it by adding Barry Nelson, Northwestern University, as a co-author. I would estimate that 30% of the content was changed.

A chapter on Simulation of Manufacturing and Material Handling Systems was added. The chapter on Inventory Systems was deleted. The chapter on General Principles and Computer Simulation Languages was split into two chapters.

Getting modern, we asked users to contribute errata through a link on Barry Nelson's website. Eventually, we decided to manage the Solutions Manual distribution to maintain more control of the situation. Interestingly, we learned that about half the adopters of the first edition taught in computer science related programs. So, even though the text was in the same series as the first edition, that wasn't mentioned on the cover. We had our own cover design, different from the cover design of the series.

4.4 Third Edition (2000)

The time between the second and third editions was just four years. Some of the related facts are as follows:

Co-authors: Jerry Banks, John S. Carson, II, Barry L. Nelson, and David M. Nicol
Chapters: 14
Pages: 594
Cover: Red, Prentice-Hall International Series in Industrial and Systems Engineering (mentioned on the cover)

Note that a fourth author was added. David Nicol, Dartmouth College, joined us. His expertise is in the simulation of computer and communications systems. A chapter on the Simulation of Computer Systems was added by David Nicol. Note the color of the text. When asked by Prentice-Hall what color the cover should be, Barry Nelson's son, Kyle, said "Red", a very patriotic decision (red, white, and blue). Now, really getting with the program, David Nicol created a website for the text. Its URL is www.bcnn.net

4.5 Fourth Edition (in Preparation)

Some of the related facts are as follows:

Co-authors: Jerry Banks, John S. Carson, II, Barry L. Nelson, and David M. Nicol
Chapters: 15
Pages: Approximately 634
Cover: to be determined

The fourth edition will have an additional chapter on the simulation of communication systems. The verification and validation chapter, not touched since the first edition, will be revised completely. The Simulation of Manufacturing and Material Handling Systems chapter will be extended to about twice it current size. To make some room, the chapter on Simulation Software will be shortened. In the first edition of the text, it made sense to discuss differ-

ent simulation languages. But simulation software products are now distinguished by their interfaces as much as their internals (although, I disagree with that method of distinction) making comparison less meaningful.

4.6 Summary

Time passes, things change. The fourth edition will probably be 50% different from the first edition. Yes, there has been a lot of new material. But, also, there are better ways to say the same thing. And, the applications of simulation continue to expand. Yes, the software has changed a lot. But, it has gotten to the point where it doesn't mean much to discuss software. We'll tell our readers to look at the corresponding websites!

5 AVERILL M. LAW: "SIMULATION MODELING AND ANALYSIS"

When I first conceived of a "Simulation Modeling and Analysis" book in 1979, there was not an acceptable vehicle for teaching a Master's Degree industrial engineering course that focused on the methodology of simulation modeling. The books that were available at that time were of three types. First, there were a few books on the use of a particular simulation language [e.g., Schriber's excellent book on GPSS (1974)]. There was also the sophomore-level book by Shannon (1975), which was somewhat qualitative in nature but had excellent discussions of topics such as model validation. Finally, there was the classic book on simulation methodology by Fishman (1973). However, this book was, in my opinion, primarily oriented toward a Ph.D.-level course in simulation and did not cover a number of topics that a simulation practitioner needed to know, such as model validation and the overall conduct of a simulation study. Thus, there was a large chasm in the spectrum of simulation books that were available at that time. This served as the motivation for co-authoring *Simulation Modeling and Analysis* with David Kelton (Law and Kelton 1982). The outline for the book was generated from teaching approximately 30 public and onsite simulation short courses from 1977 to 1979. These courses were primarily attended by people who worked in industry or in the military, and who had degrees in engineering or mathematics.

The first edition of the book (copyright 1982) was only 400 pages in length and had a largely academic flavor. The second edition (copyright 1991) grew to 759 pages and added a chapter on manufacturing applications. It also included more extensive discussions of simulation software, model validation, and how to conduct a successful simulation study. The third edition (copyright 2000) grew by a more moderate amount (only 760 pages, but set in a smaller type font) and has enhanced discussions of topics such as model validation, simulation input modeling, random-number generation, experimental design, and optimization. It has more than 195 examples, 325 figures, and 245 homework problems. The goal of all three editions has been to provide a comprehensive and technically correct treatment of simulation modeling, but to make the material more understandable by using intuition and numerous figures.

Simulation Modeling and Analysis has sold more than 80,000 copies and a fourth edition is planned for the near future. The primary academic market for the book is sophomore to Ph.D. level courses in industrial engineering and operations research. However, it is also used in management science/quantitative methods departments in business schools, as well as in computer science departments. Finally, it is extensively used as a reference book by simulation practitioners in industry.

6 ANDREW F. SEILA: "APPLIED SIMULATION MODELING"

Let me start by observing that with regard to simulation textbooks, one size doesn't fit all. It is not possible to write a simulation textbook that will satisfy all potential readers.

We can identify four distinct markets for simulation textbooks:

1. Undergraduate business and IE students and MBA students
2. IE/OR graduate students
3. Ph.D. students and researchers
4. Engineers and managers in the workforce

Students in the first category cannot be assumed to have an extensive background in mathematics, statistics or computer science, which are the basic building blocks of simulation methodology. They plan to use simulation to analyze problems in risk management, finance, operations and other areas of system management. They are focused on problem solving and see simulation as a tool to find better solutions or decisions. This group needs a text that concentrates primarily on concepts, applications, model construction and interpretation of results.

The second category consists of master's level students with engineering, mathematics, statistics or computer science backgrounds. They are comfortable solving mathematical problems and are skilled in statistics and computer programming. They are still applications-oriented, however, and plan to use simulation to analyze complex problems in manufacturing or service operations. They also could plan to become simulation software developers. They need a textbook that carefully explains the modeling and statistical methodology behind simulation at a level that allows them to develop applications using basic software tools such as C/C++.

The third group includes Ph.D. level researchers who either use simulation in their research or are doing research in some area of simulation methodology. They need a text with extensive mathematical content and proofs of results.

The fourth group consists of people in the workforce who need to learn simulation and plan to do so by reading a book. They might have a background in business, engineering, public health, etc. and need to use simulation to model a problem at work. In many respects, this market is much like the first market. The people cannot be assumed to have extensive mathematical, statistical or programming skills, and their objective is to use simulation to enhance decision making. They differ from the first group, however, in the fact that they do not have an instructor to clarify and explain the material in the textbook. They need a book that, like the first group, deals mainly with concepts and applications, but the book should be carefully written so the material can be understood without additional supporting materials. This book should be more tutorial in nature than the book for the first group.

Let me now turn to my co-authored textbook. The idea to write a simulation textbook, which ultimately resulted in *Applied Simulation Modeling* (Seila, Tadikamall and Ceric, 2003), originated in 1989 at the Winter Simulation Conference in Atlanta. At the time, Pandu Tadikamalla (University of Pittsburg) and I (University of Georgia) were both teaching simulation to graduate students (and also to undergrads, in my case) in business schools. We were both dissatisfied with the current selection of textbooks, which were excellent for students in IE/OR, computer science and other areas where a strong background in mathematics and statistics is required and expected. We did not intend to write a book to compete with the excellent simulation books by Law and Kelton (2000), Fishman (1978) and Schriber (1974). Naively, we thought that we could just take our class notes and organize them into a textbook! Over the next 14 years, we went through many revisions. In 1995, we added Vlatko Ceric (University of Zagreb) as a co-author. Finally, in 2003, the first edition appeared.

As described above, we believe that business students are fundamentally different from students in IE/OR and computer science in their quantitative backgrounds, their motivations, and the application areas of interest to them. It was our objective to write a textbook that would recognize and address these issues.

While we were writing *Applied Simulation Modeling*, both the field of simulation and the target audience evolved, so we felt like we were shooting at a moving target. In the early 1990's, our simulation classes were filled with students studying management science, many of whom had undergraduate degrees in science or engineering. Management science was a required course in many MBA programs then, and simulation was a component of such a course. Interest was high in simulation and management science. In 1996, management science was removed from many MBA programs as a required course, and interest in all management science methodology, including simulation, decreased. (This trend seems to be reversing now.) Our textbook had to be revised, even before it was published, to address these changes.

The final product hopefully addresses the needs of business students, mainly MBAs, and will be attractive to some undergraduate programs in industrial engineering. Some characteristics that we tried to incorporate into the book are:

1. Concepts are explained at a level that assumes little background on the part of the reader.
2. Examples motivate and drive the flow of the book.
3. Statistical methodology is presented from the perspective of the user.
4. A spreadsheet is used as a simulation platform for models that can be represented in a spreadsheet, especially financial and risk analysis models.
5. A GUI software package, Arena, is used to teach modeling techniques for discrete event simulation.
6. A wide variety of models and modeling scenarios is included to motivate the reader and stimulate his or her imagination.
7. All steps in the systems analysis process are covered, from problem identification through using the simulation results for improved decision making.
8. Modeling and data analysis concepts are explained carefully so the user will be able to apply them in a correct way.
9. Simulation project management is discussed.
10. A discussion of the use of simulation results for improved decision making is provided, and it includes such topics as sampling error and modeling error considerations.

There is a certain tension between the desire to explain concepts carefully and the desire to get the reader's hands on a model quickly. We wanted to reduce the distance between the introduction of an idea and creation of a model that uses that idea. Our audience is often impatient with explanations until they have been shown that the methodology is useful to them. Thus, hands-on examples are frequently used to introduce and motivate new topics, with details coming later.

Many authors use the spreadsheet as a simulation platform because spreadsheets are widely available and most business students learn to use them in other parts of their curriculum. This trend will continue for the foreseeable future because spreadsheets are excellent tools to model and simulate a wide variety of problems, computing power is continuing to grow exponentially, and no competing platforms have been introduced recently.

While it is clear that computer technology is pushing textbooks toward different formats such as interactive websites and CD-ROM, it is also clear to me that at present there is no adequate substitute for the traditional paper textbook. Multimedia should be incorporated in the form of supplements for the textbook, especially in the case of business students. Interactive demonstrations of model

building, sampling and output analysis can greatly enhance the textbook's discussion of these concepts and show the student the pitfalls of using poor methodology. I am hard at work right now creating a user's manual and website for *Applied Simulation Modeling*.

Finally, since *Applied Simulation Modeling* is new, it is a work in progress. My co-authors and I will not know how well we guessed the market until we get feedback from the publisher and our colleagues. We welcome all comments, including criticisms, so we can make the second edition better.

7 RICHARD G. BORN: "WEBGPSS SLIDE PRESENTATION"

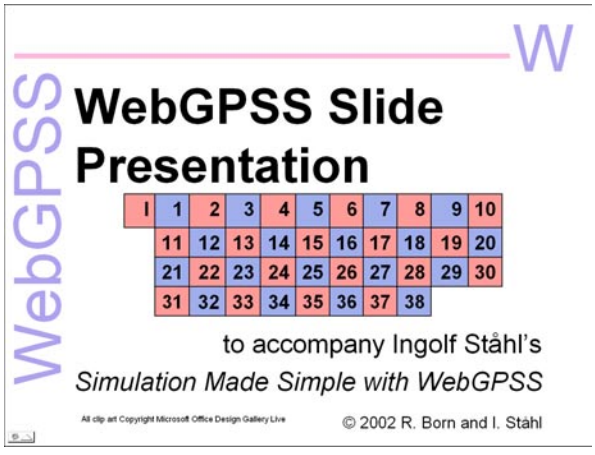
If the traditional simulation textbook, printed on paper, is the old, then what is the new textbook? Certainly, a key word that describes the new simulation textbook is *electronic*. Such a textbook may reside somewhere on a Web server and be accessed by students as they work their simulation models, or it may reside on a CD-ROM with access not requiring any connection to the Internet.

There is, indeed, a plethora of questions that can be addressed regarding this new breed of simulation textbook. What would be the characteristics of such an electronic simulation textbook? Would it simply be a combination of text and figures much like the traditional simulation textbook, or would it contain interactive exercises to help reinforce simulation concepts and terminology? Would the electronic textbook be *adaptable* as teachware in the classroom or could it be designed *from the start* as a combination textbook and classroom teachware? Would the electronic textbook only be a *complement* to the printed one, or is it possible that it could in the future *replace* the printed version altogether? What are the advantages and disadvantages of the electronic textbook? Can a well-designed simulation textbook/teachware package be helpful in the spread and usage of a specific vendor's software? In designing a simulation textbook/teachware package, should the developer stick with software that has stood the test of time and is widely available (e.g. Microsoft PowerPoint), or should the developer take on greater risks associated with the alternatives?

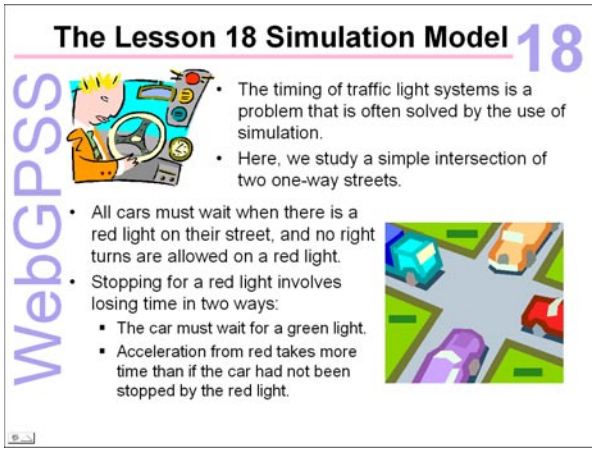
Let us now consider an example of a significant effort taken to develop teachware for a modern version of one of the classics of simulation, namely GPSS. When Ingolf Ståhl's micro-GPSS (Ståhl 1990) evolved into WebGPSS late in 2001 (Ståhl 2002), there was no question in my mind after reviewing the capabilities of WebGPSS and its direction for the future, that I would continue to teach simulation to our business students using WebGPSS. It was also clear to me that I wanted to take a more active part in the development process. I then proposed a plan to Ståhl to prepare a complete set of PowerPoint slides (more than 430 slides) for teaching the 38 lessons in his tutorial booklet entitled *Simulation Made Simple with WebGPSS* (Ståhl 2002). I have now used this evolving collection of slides, *WebGPSS Slide Presentation* (Born and Ståhl 2003), for three semesters to drive class discussions of simulation with WebGPSS, and Ståhl has used them in teaching WebGPSS to English-speaking students throughout Europe.

In my remaining space in these proceedings, I shall attempt to summarize the characteristics of this slide presentation that make it such a useful tool for classroom teaching. It is my belief that the real success of any simulation package is strongly dependent on the existence of suitable teachware. Most of us who teach simulation modeling, particularly at the university level, have very limited time to prepare this teachware, due to other responsibilities associated with professional activities, research, and service to the university and community at large. Yet good teachware, in conjunction with an enthusiastic teacher, can play a critical role in the student's understanding of simulation and should not, therefore, be neglected by vendors.

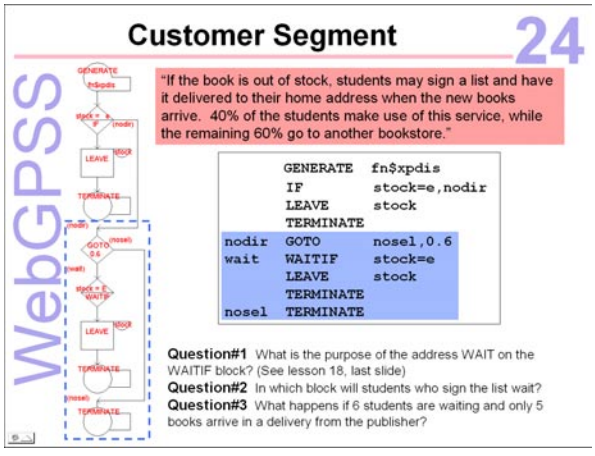
Characteristic 1 – Use a pleasing design with uniformity throughout, and quick access to individual lessons.



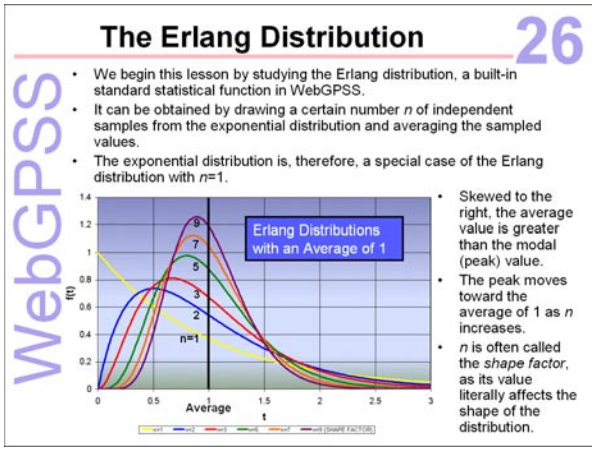
Characteristic 2 – Use bullets to introduce the simulation models for each lesson or chapter, with colorful clip art to help captivate student interest.



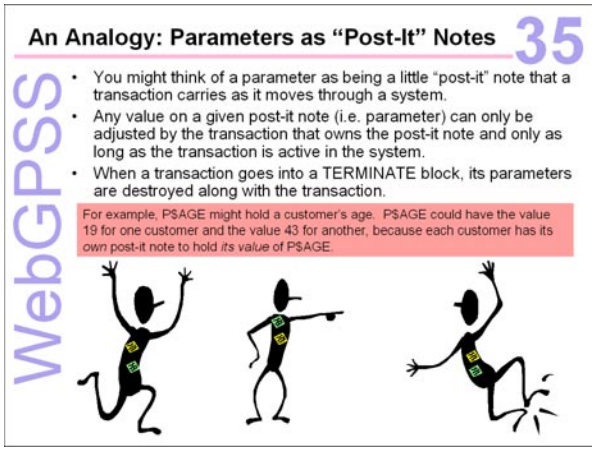
Characteristic 3 – Provide slides that allow discussion of code and block diagram views of a model, with each slide emphasizing just a portion of the model. Include questions that can be used to draw the students into active participation in model development. My students particularly like incentives such as "An A for the day" for correctly answering the more difficult questions. Students can jot down the answers to these questions in their printed copies of the slides during the discussion, and review them later as needed. Alternatively, some students open up the PowerPoint presentation on their laptop computers during class discussions and take notes with PowerPoint's built-in note-taking capability for individual slides.



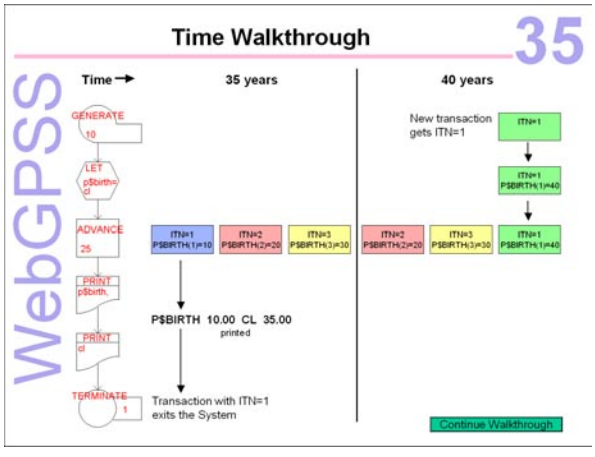
Characteristic 4 – Introduce new concepts with carefully and accurately designed diagrams and bullets that point out the main ideas concerning the new concept. A good way to get accurate and colorful diagrams is to construct them in Excel, save as a GIF file, and then import them into your PowerPoint slide.



Characteristic 5 – Whenever an analogy would help understanding of a simulation concept, don't hesitate to make use of it in the slide presentation. In the slide that follows, WebGPSS parameters are compared to "post-it" notes that a transaction can carry along with itself as it moves through a model.



Characteristic 6 – When it would help to prepare a dynamic slide, where each mouse click shows conditions changing in a simulation model over time, the extra investment in time required to prepare that slide can provide limitless insight to the student. The following slide, developed gradually through a series of mouse clicks, helps students understand the movement of transactions through a lock diagram as well as reuse of internal transaction numbers in conjunction with parameters.



Other characteristics also contribute to making PowerPoint teachware a valuable commodity in simulation education, but space is running out here to show example slides. Slides are needed that explain how to fill out dialog boxes for operands, functions, and experiments. Slides that explain the *business logic* behind each block in a GPSS model's block diagram can be of tremendous value to both business and engineering students. Indeed, as vendors begin to realize the value of PowerPoint teachware, additional characteristics of good presentation of simulation modeling concepts will emerge, with the student being the ultimate benefactor of the efforts of such vendors.

8 EPILOGUE

As stated in the introduction, "In the final analysis, the purpose of the panel is to set thoughts into motion regarding the role that simulation textbooks and, more generally, simulation teachware, can and should play in the education of simulation practitioners and consumers." Many of the considerations and challenges in this regard have been surfaced by the panelists, based on their own substantial and ongoing experiences in developing and maintaining simulation textbooks and teachware. What concluding observations can we make? Observations might include these:

- The perfect textbook is only a dream.
- With regard to simulation textbooks, one size doesn't fit all. ("Different strokes for different folks…")
- There are at least four distinct markets for simulation education: undergraduate business and industrial engineering students and MBA students; IE/OR graduate students; Ph.D. students and researchers; and engineers and managers in the workforce.
- Students entering the "simulation market" in any of its various segments are moving targets.
- Simulation software, methodology, and applications are also moving targets.
- A balance must be struck between methodology and applications.
- Spreadsheet-based simulation is gaining in popularity and importance and addresses applications outside the normal application areas of discrete-event simulation.
- The World Wide Web provides opportunities and challenges in the area of teachware.
- Interactive demonstrations of model building, sampling and output analysis can greatly enhance a textbook's discussion of these concepts and demonstrate the pitfalls of using poor methodology.
- "Tell me what it does; don't tell me how it does it" attitudes are prevalent and need to be addressed.
- Teaching philosophies can range from "spoon feeding" to "dig it out on your own," with everything in between.
- It can be as important to educate future simulation consumers, as it is to educate future simulation practitioners.

We fully expect that the panelists and members of the audience will make additional observations that will add to this list.

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