

**AVERILL M. LAW & ASSOCIATES ■**

# **SIMULATION MODELING S E M I N A R S**



**DR. AVERILL M. LAW**

*Internationally recognized simulation expert, consultant, author, and lecturer*

**GENERAL  
STATISTICS  
SEMINAR**

**NEW**

**COURSE 6**

**Applied Statistics for  
Engineers and Scientists**

**MAY 3-6, 2010  
WASHINGTON, DC**

*“This is one of the best classes I have had in nine years. I learned a lot and much more than I thought. I give this seminar a 10 overall.”*

*Electrical Engineer, U.S. Navy*

## **SPRING 2010**

**SCHEDULE OF SIMULATION SHORT COURSES:**

**COURSE 1**

**Simulation Modeling for  
System Design and Analysis, I:  
Fundamental Principles**

*(See below for Part II)*

**APRIL 12-14, 2010 WASHINGTON, DC**

**COURSE 2**

**Simulation Modeling for  
System Design and Analysis, II:  
Advanced Concepts**

**APRIL 15-16, 2010 WASHINGTON, DC**

**COURSE 3**

**How to Validate Your Models  
and Simulations**

**MAY 17-18, 2010 WASHINGTON, DC**

**COURSE 4**

**Design of Experiments for  
Simulation Modeling: Identifying  
Key System Factors**

**MAY 19-20, 2010 WASHINGTON, DC**

**COURSE 5**

**Agent-Based Simulation for  
Modeling Complex System  
Behaviors**

**MAY 21, 2010 WASHINGTON, DC**

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## OVERVIEW OF SIMULATION MODELING

Simulation modeling allows system developers and analysts to predict the performance of existing or proposed systems under different configurations or operating policies. This process, carried out before the existing system is actually changed or the new system is built, eliminates the risk of unforeseen bottlenecks, underutilization or overutilization of resources, and failure to meet specified system requirements.

Unfortunately, many people still believe that simulation is largely an exercise in computer “programming” when, in fact, programming represents only 25 to 50 percent of a sound simulation study. Our courses on simulation modeling and analysis are designed to provide you with the **complete set of skills** actually needed for simulation project success – training on how to use a simulation-software product is clearly **not** sufficient. You will learn the latest and most-important simulation techniques in a **small fraction** of the time that you could by reading on your own or by attending simulation conferences. Each topic builds on previous ones and is presented in an intuitive and understandable manner.

### COURSE 1

## ■ Simulation Modeling for System Design and Analysis, I: Fundamental Principles

This course is designed for operations research analysts, management scientists, systems analysts, military planners, engineers, computer scientists, and technical managers who would like to use simulation to design and optimize real-world systems. It encompasses a full spectrum of applications, including defense, manufacturing, transportation, process reengineering, contact centers, supply chains, communications networks, healthcare, and services. The course presents definitive methods for developing a simulation model, ensuring its validity, choosing simulation software, selecting input probability distributions, analyzing simulation runs, and project management. A case study illustrates the step-by-step application of simulation modeling techniques. The prerequisite for this seminar is a basic course in statistics, or the equivalent.

Versions of this seminar have been given for organizations such as AT&T, Boeing, Coca-Cola, GM, IBM, Intel, Lockheed Martin, Los Alamos National Lab, MITRE, NASA, National Security Agency, NATO, Northrop Grumman, U.S. Air Force, U.S. Army, and U.S. Navy.

### ***Critical Questions That the Seminar Will Answer:***

- What types of problems are ideally suited for simulation?
- What is a definitive overall approach for conducting a simulation study?
- How do you determine the best simulation software for your application?
- How do you decide on an appropriate level of model detail?
- What are the proven techniques for ensuring model validity and credibility?
- How can you correctly model the randomness in your system?
- How do you choose input probability distributions when no system data exist?
- How can you determine the correct length of a simulation run?
- How do you definitively choose a simulation warmup period?
- What are the 22 critical pitfalls in simulation modeling and how can they be avoided?

“**Best course that I have taken in at least 16 years. Instructor’s responsiveness and teaching methods/examples were excellent.**” *Operations Research Analyst, U.S. Army, Ft. Leavenworth, KS*

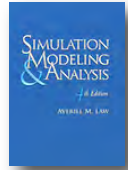
“**Outstanding! Dr. Law is truly the expert in his field.**” *Defense Analyst, Boeing*

“**I thoroughly enjoyed the course. My only regret is that I was not able to take the course 6 months ago - I could have avoided many mistakes.**” *Industrial Engineer, Ingersoll-Rand*

**See [www.averill-law.com](http://www.averill-law.com) for information on the ExpertFit distribution-fitting software.**

## EACH ATTENDEE WILL RECEIVE THE FOLLOWING:

- The book **Simulation Modeling & Analysis** (4th Edition) by Averill M. Law
  - Widely considered to be the “bible” of simulation
  - More than 125,000 copies in print
  - Referenced three times more than any other book in the *Proceedings of the 2004-2009 Winter Simulation Conferences*
- An opportunity to talk to Dr. Law on a one-to-one basis about your particular applications



### What You Will Learn:

#### 1. Designing and Optimizing Systems Via Simulation Modeling

- New system design: ensuring that system requirements are met
- Existing system modification: analyzing alternative configurations
- Advantages of simulation modeling over analytic solutions
- Components and logic of a simulation model
- Financial benefits of simulation illustrated by examples
- 10 crucial steps in a sound simulation study

#### 2. Selecting Simulation Software

- Advantages of simulation software versus programming languages
- General-purpose simulation packages versus application-oriented packages
- Important software features
  - Modeling flexibility
  - Ease of use
  - Hierarchy
  - Interoperability with other applications
  - Animation
  - Statistical capabilities
  - Quality documentation
- Live demonstrations of software

#### 3. Building Valid, Credible, and Appropriately Detailed Simulation Models

- Determining the level of model detail
  - Importance of a precise problem formulation
  - Involving subject-matter experts in model development
  - Sensitivity analyses
  - Iteratively increasing model complexity
- Techniques for increasing model validity and credibility
  - Regular interaction with management
  - Use of a written “assumptions document” (conceptual model)
  - Structured walk-through of assumptions document before programming

- Comparison of model and system outputs for an existing system

- Animation

- Statistical techniques for model validation
- Management’s role in the modeling process
  - Problem formulation
  - Approval of important model assumptions
  - Methods for enhancing management confidence in the model
- Verification, Validation, and Accreditation of Department of Defense models
- Numerous real-world examples

#### 4. Modeling Randomness in Real-World Systems

- Deciding between fitted theoretical distributions (e.g., exponential or normal) or empirical distributions when system data exist
- Using triangular, Weibull, or lognormal distributions in the absence of data
- ExpertFit distribution-fitting software
- Computer implementation of input models
  - Random-number generators
  - Generating random values from a distribution
- Modeling random equipment breakdowns
- Modeling arrivals to a system

#### 5. Reaching Correct Decisions from Simulation Output Data

- Critical importance of statistics for output-data analysis
- Defining experimental parameters
  - Determining the required number of simulation runs and their length
  - Specifying warmup-period duration
- Estimating desired measures of performance

#### 6. Case Study

- A detailed application of simulation techniques

#### 7. 22 Critical Pitfalls in Simulation Modeling and How to Avoid Them

- Modeling and validation
- Simulation software
- Modeling the randomness in a system
- Design and analysis of simulation experiments

“**Very informative and useful. You are very good at simplifying a complex concept so that it is understood by the student.**” *Analyst, Defense Intelligence Agency*

“**Your course is absolutely outstanding. Well worth the expense. I will recommend it to my associates.**” *Senior Consultant, Booz Allen & Hamilton*

## ■ Simulation Modeling for System Design and Analysis, II: Advanced Concepts

This course will discuss practical and easy-to-understand statistical techniques for comparing alternative system designs, variance-reduction techniques for obtaining more precise simulation results for the same amount of computing, the use of experimental design techniques to determine important system factors, and simulation-based optimization. The course will also present an introduction to **agent-based simulation**, which is arguably the "hottest" topic in simulation modeling today. All topics will be illustrated by one or more examples or case studies. The prerequisite for this seminar is the "Fundamental Principles" course, or the equivalent knowledge. Versions of this seminar have been given for organizations such as AT&T, Boeing, Joint Warfare Analysis Center, Nortel Networks, Sandia National Labs, U.S. Air Force, U.S. Army, U.S. Forces Korea, U.S. Navy, and Xerox.

**Each attendee who is taking this seminar as a stand-alone course will receive a copy of the book *Simulation Modeling and Analysis* (4th Edition) by Averill M. Law as part of their registration fee— this book is widely considered to be the "bible" of simulation.**

**What You Will Learn:**

### 1. Advanced Techniques for Output-Data Analysis

- Determining the number of simulation runs (replications) required to estimate a mean with a specified precision (e.g., with no more than 5 percent error)
- Estimating probabilities and percentiles
- Dealing with multiple measures of performance

### 2. Comparing Alternative System Designs

- Confidence intervals for comparing two or more systems
- Procedures to select the best system with a specified probability

### 3. Variance-Reduction Techniques

- Using the method of common random numbers to obtain more precise comparisons of alternative system designs
- "Tricks" for synchronizing random numbers across different system designs
  - Multiple random-number streams
  - Generation of all entity attributes upon arrival
  - "Wasting" random numbers
  - "Feeding" the same entity arrivals to several

simulation models

### 4. Design of Experiments for Simulation Modeling

- How experimental design can identify key system factors
- Factorial and fractional factorial designs for factor screening
- Response-surface designs for prediction and optimization
- Failure of classical statistical assumptions and how to address this in simulation modeling

### 5. Simulation-Based Optimization

- How the integration of optimization modules into simulation software has added a whole new dimension to simulation modeling
- Available optimization modules and what features to look for
- Live optimization of a model with 7 decision variables

### 6. Agent-Based Simulation

- What is agent-based simulation and how can it benefit your organization
- Available simulation software and toolkits
- Demonstration and analysis of an agent-based simulation

## ABOUT THE INSTRUCTOR

**DR. AVERILL M. LAW**, the President of Averill M. Law & Associates, is one of the world's foremost experts on simulation modeling. He has been a simulation consultant to numerous organizations including Accenture, ARCO, Boeing, Booz Allen & Hamilton, Defense Modeling and Simulation Office, Hewlett-Packard, Kimberly-Clark, M&M/Mars, Monsanto, SAIC, Sandia National Labs, 3M, Tropicana, Xerox, U.S. Air Force, U.S. Army, U.S. Navy, and U.S. Post Office.

Dr. Law has presented more than 480 simulation short courses in 18 countries. He has written or coauthored numerous papers and books on simulation, operations research, statistics, manufacturing, and communications, including the definitive book *Simulation Modeling and Analysis* that is used by more than 125,000 people and considered the "bible" of simulation. He developed ExpertFit, which has been the leading distribution-fitting software since 1983. He also produced several videotapes on simulation modeling. Dr. Law has been the keynote speaker at simulation conferences worldwide. **He won the 2009 INFORMS Simulation Society Lifetime Professional Achievement Award.**

Dr. Law has been a tenured faculty member at the Univ. of Wisconsin-Madison and the Univ. of Arizona. He has a Ph.D. in industrial engineering and operations research from the Univ. of California at Berkeley.

**How to Validate Your Models and Simulations** (1½ days)

The purpose of this one and a half day seminar is to present a comprehensive discussion of *practical techniques* for validating your models and simulations. All techniques will be illustrated by one or more examples based on actual simulation projects. **At the end of the seminar, each attendee will be familiar with “the” twelve fundamental validation techniques and know how to apply them to their models and simulations.** The development of this seminar has benefited from contracts with the Defense Modeling and Simulation Office (now the Modeling and Simulation Coordination Office) and the Office of Naval Research.

A particular highlight of this seminar is the discussion and illustration of an *assumptions document*, which is a detailed report delineating all model concepts, assumptions, algorithms, and data summaries. It serves as the main vehicle for communications among the project team, and it is a “blueprint” for creating the simulation computer program. It should not be confused with a conceptual model, which can be thought of as initial ideas on what a model will look like.

Dr. Averill M. Law, the course instructor, has been intimately involved in the problem formulation, validation, and analysis of approximately 40 simulation models. He has been a validation consultant to organizations such as Booz Allen and Hamilton, Federal Highway Administration, Stanley Tools, U.S. Air Force, U.S. Army, and U.S. Navy.

Versions of this seminar have been presented to Boeing, Lockheed Martin, NSA, Raytheon, Sasol Technology (South Africa), U.S. Army, U.S. Navy, International Council on Systems Engineering (INCOSE), International Society for Optical Engineering (SPIE), and International Test and Evaluation Association (ITEA).

**What You Will Learn:**

1. **Seven Important Steps in a Sound Study**
2. **Formulating the Problem Precisely**
3. **Talking to Appropriate Subject-Matter Experts (SMEs)**
4. **Interacting with the Decision-Maker on a Regular Basis**
  - Helps ensure that the correct problem is being addressed
  - Enhances the credibility of the simulation model
5. **Using Quantitative Techniques to Validate Components of the Model**
6. **Developing a Written Assumptions Document**
  - Purpose, components, and format
  - Detailed example
  - Construction for a legacy simulation model that has limited documentation
7. **Performing a Structured Walk-through of the Assumptions Document**
  - Format and benefits
  - Required attendees
8. **Using Sensitivity Analysis to Determine Important Model Factors**

- The critical danger of varying one factor at a time
  - Introduction to the proper design of experiments
9. **Results Validation**
    - Comparison of model output data with the comparable output data from a similar *existing system* using numerical statistics and graphical plots
    - Use of a Turing test
    - Evaluation of model output data by SMEs
    - Comparison of model output data with the comparable output data from *another model* that is thought to be “valid”
    - Use of confidence intervals and hypothesis tests to make comparisons
  10. **Using Animation to Show that a Model is not Valid and to Enhance Credibility**
  11. **Guidelines for Obtaining Good Model Data**
    - Two basic principles
    - Common difficulties
  12. **Additional Topics**
    - Model calibration and how it differs from validation
    - Independent model validation
    - Validation for agent-based simulation
  13. **6 Critical Pitfalls and How to Avoid Them**

**ONSITE TRAINING**

We can present a seminar on virtually any aspect of simulation at your facility. Topics include system design and analysis, model validation, agent-based simulation, design of experiments, and management overview. Previous clients include:

|                        |                     |                        |                              |                     |
|------------------------|---------------------|------------------------|------------------------------|---------------------|
| ALCOA (2) <sup>1</sup> | Hewlett-Packard     | Missile Defense Agency | National Security Agency (3) | UPS                 |
| AT&T (8)               | IBM (6)             | MITRE (2)              | Nortel Networks (2)          | U.S. Air Force (24) |
| Boeing (5)             | Intel               | Motorola               | Northrop Grumman             | U.S. Army (37)      |
| Caterpillar (2)        | Lockheed Martin (9) | Nabisco                | SEMATECH (6)                 | U.S. Forces Korea   |
| Coca-Cola              | Los Alamos          | NASA (3)               | 3M (2)                       | U.S. Navy (12)      |
| General Electric       | National Lab (2)    | NATO                   | Time Warner                  | Whirlpool (3)       |
| General Motors (6)     | M&M/Mars            |                        |                              | Xerox (2)           |

<sup>1</sup> Indicates number of seminars

## COURSE 4

### ■ Design of Experiments for Simulation Modeling: Identifying Key System Factors

Simulation models often have many input factors and determining which ones have a significant impact on performance measures (responses) of interest can be a truly daunting task. The common approach of changing one factor at a time is statistically inefficient and, more importantly, is very often just **incorrect**, because for many models factors **interact** to impact on the responses. In this seminar, we give a comprehensive presentation of design of experiments (DOE) **specifically for simulation modeling**, whose major goal is to determine which factors have the greatest effect on the responses, and to do so with the least amount of simulating. Other important uses of DOE are to develop a response surface (metamodel) based on the **important factors** to predict the model response for factor combinations that were not actually simulated or to find the factor-level combination that optimizes the simulation response.

We discuss a simple and widely applicable approach to performing DOE in the context of simulation modeling, whereas commonly used methods based on classical statistics (i.e., ANOVA) make **unrealistic assumptions** such as constant variances and normally distributed residuals. Important DOE techniques will be demonstrated using several leading DOE statistical packages. Versions of this seminar have been (or will be) presented to Lockheed Martin and Sasol Technology (South Africa).

#### What You Will Learn:

#### 1. Factorial Designs

- Determining which factors have the largest impact on the simulation responses (*factor screening or sensitivity analysis*)
- Main effects and interaction effects and their correct interpretation
- Why the ubiquitous one-factor-at-a-time approach is generally not recommended
- Failure of classical statistical assumptions (constant variances and normally distributed residuals) and how to circumvent this in simulation modeling

#### 2. Fractional Factorial Designs

- Finding the important factors with less computational effort
- Confounding of effects
- Resolution III, IV, V, and higher-level designs
- Fold-over designs

#### 3. Metamodels and Response Surfaces

- Central composite designs for fitting second-order metamodels
- Predicting model responses for factor combinations that were not simulated
- Finding the factor-level combination that optimizes a simulation response

#### 4. Space-Filling Designs for Simulation Metamodels

- Dealing with complex, nonlinear model responses
- Latin hypercube designs
- Kriging (Gaussian process modeling) for global metamodeling

#### 5. Commercial Software for DOE

- General-purpose statistical packages
- DOE-specific software packages

#### 6. Numerous Examples to Illustrate the Mechanics and Applications of DOE

## COURSE 5

### ■ Agent-Based Simulation for Modeling Complex System Behaviors

This one-day seminar provides a comprehensive introduction to agent-based simulation (ABS), which is currently the "hottest" topic in simulation modeling. In an ABS autonomous agents (people, vehicles, organizations, etc.), which have attributes and potentially complex behaviors, interact with each other and their environment over time toward the accomplishment of their goals. This allows an agent's behavior to depend on the current and past states of its environment, rather than being "scripted," which permits much more complex behaviors to be represented as compared to traditional models.

ABS has been successfully applied to a diverse set of problems, and improved software packages have facilitated the model-development process. However, learning ABS on one's own is **difficult**, at best, because of the genuine lack of specificity in the literature. Much of the confusion is due to the "smoke-screen" of attributes that are often associated with ABS, including autonomy, sensing and interacting with the environment (including other agents), learning, adaptation, behavior based only on "local" information, emergence, and complex adaptive systems. We address this conundrum by discussing what is believed to be the **real** essence of ABS. Several prominent ABS will be demonstrated. The development of this seminar has benefited from funding by the U.S. Army.

#### What You Will Learn:

#### 1. Agents and Agent-Based Simulation

- Agents as autonomous entities with attributes and complex behaviors

- Reactive versus adaptive (learn from previous experiences and change behavior rules) agents
- Bottom-up modeling and possible emergent system-level behavior
- When to use ABS

- Relationship of ABS to discrete-event simulation (DES)
2. **The Structure of an Agent and Time-Advance Mechanisms**
    - Agents with memory, rules, and a behavior engine
    - Time stepping versus next-event time advance and advantages/disadvantages of each
  3. **Historical Perspective**
    - Cellular automata
    - Growing artificial societies
    - Complex adaptive systems
  4. **Software for Agent-Based Simulation**
    - Commercial DES software with capabilities for ABS
    - Public-domain toolkits for ABS and their modeling flexibility, required programming, ease of use, and quality of documentation
    - Important defense-related ABS
  5. **Development of Several Agent-Based Simulation Models**
    - Example to illustrate how to implement basic reactive rules for agents
    - Example to illustrate learning and adaptation for agents
  6. **Successful Applications of Agent-Based Simulation**
    - Defense (e.g., irregular warfare)
    - Homeland security (evacuation of crowds, border control, etc.)
    - Traffic modeling
    - Epidemiology and bio-warfare
    - Supply chains
    - Consumer behavior
    - Sociology
    - Anthropology
    - And many more ...

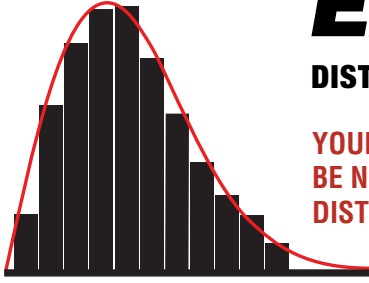
## COURSE 6

### Applied Statistics for Engineers and Scientists

Statistics is undoubtedly one of the most valuable of all disciplines, since virtually all organizations have data from which inferences must be drawn. In this course on statistics, you will learn the fundamental concepts (descriptive statistics, confidence intervals, hypothesis tests, regression, etc.) and be able to apply them immediately to the problems that you encounter on the job. This will be accomplished by the use of intuition, graphical plots, real-world examples, and numerous in-class student exercises using paper/pencil and a calculator. ***Whether you are new to statistics or are looking for a refresher course, you will find this seminar a great way to get up to speed quickly in a cost-effective manner. In fact, you will learn most of the important topics covered in a semester-long university course in just four days.*** This seminar has been presented to the U.S. Navy several times.

#### What You Will Learn:

1. **Overview**
  - Populations and samples
  - Descriptive statistics
  - Inferential statistics (confidence intervals and hypothesis tests)
  - Determining the relationship between two or more variables (regression analysis)
2. **Random Variables**
  - Definition and distribution function
  - Discrete random variables
    - Probability mass function
    - Bernoulli, binomial, geometric, and Poisson distributions and their applications
  - Continuous random variables
    - Probability density function
    - Normal, exponential, gamma, Weibull, and lognormal distributions and their applications
  - Characteristics of a random variable (mean, median, variance, standard deviation)
3. **Joint Probability Distributions**
  - Jointly distributed random variables
  - Marginal distributions
  - Independent random variables
  - Covariance and correlation
  - Statistics and their distributions
  - Distribution of the sample mean and the central limit theorem
4. **Point Estimation**
  - Unbiased estimator
  - Variance of a point estimator
5. **Estimators for the mean and variance**
5. **Descriptive Statistics**
  - Graphical plots (histogram, box plot, scatter plot)
  - Numerical summaries (sample mean, sample variance, skewness)
6. **Confidence Intervals Based on a Single Sample**
  - Correct interpretation
  - For large sample sizes
  - For normally distributed data
  - Intervals for means and proportions
7. **Hypothesis Tests Based on a Single Sample**
  - Hypotheses and test procedures
  - Type I error, type II error, and power
  - $P$ -values
  - Tests for means and proportions
8. **Inferences Based on Two Samples**
  - Hypothesis tests and confidence intervals
  - Comparing two means
  - Comparing two proportions
9. **Regression Analysis**
  - Linear regression models with one or more independent variables
  - Estimating model parameters
  - Determining the adequacy of the model
10. **Fitting Distributions to Data**
  - Estimating a distribution's parameters
  - Determining the quality of fit
    - Graphical comparisons
    - Goodness-of-fit tests
11. **Statistical Packages and Their Benefits**



# ExpertFit®

## DISTRIBUTION-FITTING SOFTWARE

**YOUR SIMULATION RESULTS CAN BE NO BETTER THAN THE PROBABILITY DISTRIBUTIONS THAT DRIVE YOUR MODEL!**

- **Automatic and accurate selection of the best probability distribution**
  - Determines the best-fitting probability distribution for your data set in just seconds
  - Decides whether the selected distribution is actually good enough to use in a simulation model, or whether an empirical distribution should be used instead
- **ExpertFit has the most comprehensive set of features**
  - Allows you to use 40 different distributions even if they are not in your simulation software
  - Provides more than 30 high-quality graphs and four *technically correct* goodness-of-fit tests
  - Allows multiple distributions on a plot
  - Sample sizes of 100,000
  - Batch-mode capability for analyzing a large number of data sets
- **ExpertFit can be configured to fit your particular needs**
  - There are two modes of operation that allow you to configure ExpertFit to your background and to your application.
  - *Standard Mode* contains features sufficient for 95 percent of all analyses and focuses the user on those features that are really important.
  - *Advanced Mode* contains numerous additional features for the sophisticated user.
- **ExpertFit is the most technically correct software**
  - Distribution-fitting methodology is based on 30 years of research and on experimentation with 35,000 data sets.
  - ExpertFit was developed by Dr. Averill M. Law, who is widely recognized as one of the world's foremost authorities on simulation and distribution fitting.
- **ExpertFit has the best documentation and technical support**
  - Provides 450 pages of context-sensitive help for all menus and all results tables/graphs
  - Online feature index and tutorials on goodness-of-fit tests, available distributions, etc.
  - User's Guide includes 8 complete examples.
  - Technical support by recognized experts on distribution fitting

**DON'T BE MISLEAD** by other distribution-fitting packages that have a small fraction of Expert's features, statistically invalid goodness-of-fit tests, inferior distribution-selection algorithms, and limited documentation. The old adage, "You get what you pay for" has never been truer!



ExpertFit is bundled with the Flexsim simulation software

[www.flexsim.com](http://www.flexsim.com)

“ I originally purchased a different distribution-fitting package, but I encountered many problems – it often said that no distribution fit or all distributions fit equally well. I also found, simply by “eye-balling” the graphs, that the suggested distributions were obviously selected incorrectly. I think that something was wrong with the ranking algorithm or goodness-of-fit tests.

As a result, I purchased **ExpertFit**. I've been very satisfied with it and never found any problems. (I'm an anal scientist who triple-checks everything.) It does the same as other analysis tools, but has more capabilities and always provides accurate results. ”

Raymond Ward

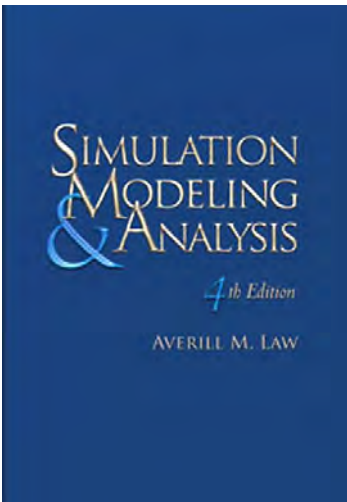
Operations Research Analyst

See [www.averill-law.com](http://www.averill-law.com) for more information on ExpertFit.

We offer a comprehensive set of simulation consulting services including complete simulation studies, technical guidance for an existing project (e.g., statistical analyses), validation of simulation models, evaluation and selection of simulation software, and litigation support.

Previous clients include Accenture, ARCO, Boeing, Booz Allen & Hamilton, Brooks Automation, CACI, Celera Genomics, Defense Modeling and Simulation Office, Federal Highway Administration, Hewlett-Packard, Jones Day (law firm), Kaiser Aluminum, Kal Kan, Kimberly-Clark, M&M/Mars, Monsanto, Oak Ridge National Lab, PROMODEL Corporation, SAIC, Sandia National Labs, Stanley Tools, Swedish Defence Materiel Administration, 3M, Tropicana, U.S. Air Force, U.S. Army, U.S. Navy, U.S. Post Office, Verizon, Veteran's Administration, and Xerox.

## SIMULATION BOOK



### ***Simulation Modeling and Analysis***

(Fourth Edition, McGraw-Hill, 2007) by Dr. Averill M. Law has been the leading simulation book since 1982. It is widely considered the “bible” of simulation with more than 125,000 copies in print. Additionally, it was referenced three times more than any other book in the *Proceedings of the 2004-2009 Winter Simulation Conferences*.

The book includes detailed discussions of all major topics in discrete-event simulation, including fundamentals of simulation, simulation software, model validation, selecting input probability distributions, random-number generators, generating random samples from a distribution, design and analysis of simulation experiments, variance-reduction techniques, and optimization. There are more than 205 examples, 320 figures, and 275 homework problems, as well as a comprehensive website. The book is equally well suited for use in university courses, simulation practice, and self study.

***See [www.averill-law.com](http://www.averill-law.com) for more information and to order at the lowest price available!***

***“ The best book around. It covers the most fundamental simulation materials with a reasonable level of theoretical and practical emphasis. ”***

*Ihsan Sabuncuoglu, Bilkent University*

***“ Compared to the old edition, this new edition contains up-to-date materials and provides more interesting examples and more figures to help readers understand materials better. ”***

*Seong-Hee Kim, Georgia Institute of Technology*

***“ The most comprehensive simulation textbook in the market. ”***

*Francisco Ramis, Universidad del Bio-Bio*

## Course Fees and General Information

**COURSE FEES:** ■ Course 1: \$2100 ■ Course 2: \$1800 (\$950 with Course 1) ■ Course 3: \$1500  
■ Course 4: \$1800 ■ Course 5: \$1050 ■ Course 6: \$2500. There is a 10% discount for registrations received and payments made one month or more before the first day of the seminar. There is a group discount when three or more people from your organization register for the same course. There is also a discount for full-time faculty members and graduate students. Contact us for details about discounts.

### PAYMENT

Payment can be made online by using our website [www.averill-law.com](http://www.averill-law.com), by check, by credit card (VISA, MasterCard, or American Express), or by purchase order. Payment must be received prior to the first day of class.

### SCHEDULE

Class runs from 8:30 A.M. to 4:30 P.M. Registration is at 8:00 A.M. on the first day of class.

### LOCATIONS AND HOTEL ACCOMMODATIONS

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