

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

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make better
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state-of-the-art
simulation
training!**

FALL 2011

SCHEDULE OF SIMULATION SHORT COURSES:

COURSE 1

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

(See below for Part II)

NOVEMBER 14-16, 2011 WASHINGTON, DC

COURSE 2

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

NOVEMBER 17-18, 2011 WASHINGTON, DC

COURSE 3

**How to Validate Your Models
and Simulations**

DECEMBER 15-16, 2011 PHOENIX, AZ

COURSE 4

**Design of Experiments for Simulation
Modeling: Factor Screening,
Prediction, and Optimization**

NOV. 29 - DEC. 1, 2011 WASHINGTON, DC

COURSE 5

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

DECEMBER 2, 2011 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 – **vendor training or university courses on how to use a simulation 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 self study 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, 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 Boeing, GM, Hewlett-Packard, IBM, Lockheed Martin, Los Alamos National Lab, NASA, NATO, NSA, U.S. Air Force, U.S. Army, and U.S. Navy.

Critical Questions That the Seminar Will Answer:

- 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 accurately model the randomness in your system?
- How can you determine the correct length of a simulation run?
- What are 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*

“**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*

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

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 135,000 copies in print
 - Referenced three times more than any other book in the *Proceedings of the 2004-2010 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
- Components and logic of a simulation model
- 10 crucial steps in a sound simulation study

2. Selecting Simulation Software

- Advantages of simulation software versus programming languages
- 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”
 - 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

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 a triangular distribution in the absence of data
- ExpertFit distribution-fitting software
- Computer implementation of input models
 - Random-number generators
 - Generating random values from a distribution

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*

“**The seminar provided me with all of the skills necessary to use simulation modeling. I was very impressed by your knowledge, dedication, and professionalism.**” *Industrial Engineer, Vancouver Port Authority*

“**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 comparisons 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. 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, Northrup Grumman, Sandia National Labs, U.S. Air Force, U.S. Army, U.S. Forces Korea, and U.S. Navy.

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:

- | | |
|---|---|
| <p>1. Advanced Techniques for Output-Data Analysis</p> <ul style="list-style-type: none"> ■ Analyzing steady-state simulations ■ Estimating probabilities and percentiles ■ Dealing with multiple measures of performance <p>2. Comparing Alternative System Designs</p> <ul style="list-style-type: none"> ■ Confidence intervals for comparing two or more systems ■ Using the variance-reduction technique common random numbers to obtain more precise comparisons ■ “Tricks” for synchronizing random numbers across different system designs <ul style="list-style-type: none"> • Multiple random-number streams • Generation of all entity attributes upon arrival • “Wasting” random numbers • “Feeding” the same entity arrivals to several simulation models | <p>3. Design of Experiments for Simulation Modeling</p> <ul style="list-style-type: none"> ■ How experimental design can identify important system factors ■ The danger of changing one factor at a time ■ Factorial and fractional factorial designs <p>4. Simulation-Based Optimization</p> <ul style="list-style-type: none"> ■ How the integration of optimization modules into simulation software has added a whole new dimension to simulation modeling ■ Live optimization of a model with 7 decision variables <p>5. Agent-Based Simulation</p> <ul style="list-style-type: none"> ■ 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, Boeing, Booz Allen & Hamilton, ConocoPhillips, Defense Modeling and Simulation Office, Hewlett-Packard, Kimberly-Clark, M&M/Mars, Monsanto, Oak Ridge National Lab, SAIC, 3M, Tropicana, U.S. Air Force, U.S. Army, U.S. Marines, and U.S. Navy.

Dr. Law has presented more than 500 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 has more than 135,000 copies in print 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 University of Wisconsin-Madison and the University of Arizona. He has a Ph.D. in industrial engineering and operations research from the University 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, ITT, Stanley Tools, U.S. Air Force, U.S. Army, U.S. Marines, 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, and International Council on Systems Engineering (INCOSE).

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
7. **Performing a Structured Walk-through of the Assumptions Document**
 - Format and important 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 fundamental principles
 - Common problems with data
12. **Additional Topics**
 - Model calibration and how it differs from validation
 - Independent model validation
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) ¹	Hewlett-Packard	Missile Defense	Nortel Networks (2)	UPS
AT&T (8)	IBM (6)	Agency	Northrop Grumman	U.S. Air Force (24)
Boeing (5)	Intel	MITRE (2)	NSA (5)	U.S. Army (37)
Caterpillar (2)	Lockheed Martin (10)	Motorola	Sandia National	U.S. Forces Korea
Coca-Cola	Los Alamos	Nabisco	Labs (2)	U.S. Navy (13)
General Electric	National Lab (2)	NASA (3)	3M (2)	Whirlpool (3)
General Motors (6)	M&M/Mars	NATO	Time Warner	Xerox (2)

¹ Indicates number of seminars

COURSE 4

■ Design of Experiments for Simulation Modeling: Factor Screening, Prediction, and Optimization

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 very often *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 due to time constraints 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. **Students will analyze experimental data in class using a leading DOE software package.** Versions of this seminar have been presented to Lockheed Martin, NSA, 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

- Minimum-run 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

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
 - Latest developments in public-domain toolkits for ABS, and their modeling flexibility, 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
 - Supply chains
 - Consumer behavior
 - Sociology
 - And many more...

“ This is the most comprehensive explanation of ABS that I have seen. I feel that I actually understand ABS now, which I did not as of 8:00 AM. ”

Operations Research Analyst, IRS

SIMULATION CONSULTING

We have been providing expert simulation-consulting services to clients since 1978 in such application areas as defense, manufacturing, communications networks, transportation, services, and healthcare.

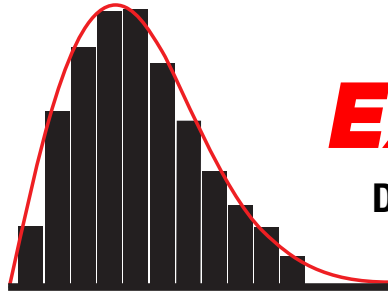
Consulting services provided:

- Complete simulation studies – ConocoPhillips, Hewlett-Packard, Kimberly-Clark, M&M/Mars, U.S. Army
- Validation/evaluation of existing models – Booz Allen & Hamilton, Defense Modeling and Simulation Office, ITT, U.S. Air Force, U.S. Army, U.S. Marines
- Statistical analyses – Accenture, NIST, Oak Ridge National Lab, Office of Naval Research, SAIC
- Evaluation/selection of simulation software – CACI, International Paper, PROMODEL Corp., 3M, U.S. Army
- Litigation support – Jones Day, MBHB

“ The simulation model showed that the capacity of our existing transportation system could handle the anticipated workload, which kept us from purchasing new equipment that cost more than \$52,000,000. The success of this project guaranteed that our company would use simulation in the future. ”

Rodger Thompson
Senior Consultant for Strategic Planning

ANNOUNCING VERSION 8



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- Local area network (LAN) versions
- Gives correct distribution format for direct input to 19 simulation products
- Comprehensive help for all menus and results tables/graphs, as well as tutorials and 8 complete examples
- Developed by Dr. Averill M. Law, who is widely recognized as one of the world’s foremost authorities on simulation and distribution fitting

“ I have purchased more than **35 copies of ExpertFit** over the years while working for several different employers. We have found that the software is not only reliable, but takes into account everything necessary to give our simulation models the right statistical ‘Fit’ to our data as if an ‘Expert’ statistician were doing the analysis. Moreover, it is easy to use and is updated regularly. ”

David Ferrin, CEO/President Northern Lights System Navigation, Inc.

“ **ExpertFit** has been used at Georgia Tech for almost 20 years. Thousands of undergraduate and graduate students have been able to experience the detailed steps involved in fitting statistical distributions to data sets. **ExpertFit** is an excellent software package that does what it promises to do very well, intuitively, and correctly! ”

Christos Alexopoulos & David Goldsman, Professors School of Industrial & Systems Engineering, Georgia Tech

“ 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



ExpertFit is bundled with the Flexsim simulation software
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Course Fees and General Information

COURSE FEES: ■ Course 1: \$2200 ■ Course 2: \$1800 (\$990 with Course 1) ■ Course 3: \$1500
■ Course 4: \$2200 ■ Course 5: \$990. 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, 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

Seminars are presented at conveniently located hotels. For hotel information, see our website www.averill-law.com or call us at 520-795-6265. This information will also be given in your confirmation letter. Hotels will block a group of rooms until approximately four weeks before the seminar. Mention Averill M. Law & Associates and the seminar when you contact the hotel.

CANCELLATIONS

Refunds, less a \$100 cancellation fee, will be given for cancellations made 14 or more calendar days before the first day of the seminar. After that only student substitutions or class transfers will be allowed. *Circumstances may make it necessary for Averill M. Law & Associates to cancel a seminar.*

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SIMULATION MODELING seminars

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