APPLICATIONS OF SIMULATION
Spring Term, 2008

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Objectives
This course builds on the coverage of simulation in the core Decision Science course and
deepens the student’s knowledge and abilities in performing simulation studies in a variety of
application areas. It also introduces the student to discrete-event simulation for modeling
systems with queuing behavior, and dynamic system simulation for modeling systems with
feedback. The course will emphasize model building using Crystal Ball, a Monte Carlo
simulation add-in for Excel, Extend+, a visual-interactive programming tool for discrete-event
simulation, and IThink, a tool for dynamic system simulation.

The course begins with a review of the basics of Monte Carlo simulation modeling using
spreadsheets: deterministic modeling and sensitivity analysis, identifying random variables,
selecting probability distributions, structuring simulations, and analyzing outputs. We will
cover a range of applications from finance (e.g., valuation, cash management, real options),
marketing (e.g., market share with advertising and promotions), operations (e.g., capacity
planning, inventory management), and economics (e.g., competitive bidding). These
applications allow us to introduce advanced simulation topics such as optimization of
simulation models, as well as to provide the student with a broad range of simulation
modeling experience and skills.

The middle portion of the course focuses on discrete-event simulation, which is used to model
queuing behavior in systems such as manufacturing processes, service sector business
processes, call center operations, and hospital emergency rooms. While simple models of
these systems can be built in a spreadsheet, Extend+ provides a flexible and powerful
environment for modeling in this domain.

The final portion of the course is devoted to dynamic system simulation, which involves
modeling systems that evolve over time and are subject to feedback. This is a powerful
approach for modeling long-term, strategic business problems that are typically thought to be
too complex and too qualitative to benefit from modeling. IThink will be used to model these
systems.

Requirements

Homework
There will be homework for every class. A typical homework assignment will consist of one or
more business situations requiring simulation modeling and analysis. Students will be
expected to present their models and the conclusions they have drawn from those models in
class. Students are encouraged to work individually on all assignments, and are also
encouraged to discuss their results (models and conclusions) with each other. Solutions to
homework problems will be posted after class.
Optional Project
Students who wish to compete for an H grade will carry out a self-selected project related to simulation. (Students who choose not to carry out a project will receive a maximum grade of S+). Projects are normally done individually. However, project teams are possible with my permission, if justified by the scale and level of challenge of the project. The results of these projects will be presented during the exam week. More information on the projects will be provided separately.

Project Schedule
April 2: initial project proposal
May 8: interim report
May 22: draft final report
May: final project presentations

Office hours
During five weeks of the term the assignment will consist of a modeling project to be performed in teams of two. The Wednesday class will be cancelled during these weeks, and students will be required to use office hours on Monday or Tuesday in preparation for class on Thursday.

I will hold open office hours on Tuesdays from 2-4:00 in Tuck 210. I will be available at other times by appointment.

Attendance
All policies of the Tuck School apply. In addition, unexcused absences will lead to reduced grades as follows:
2 unexcused absences: LP
3 unexcused absences: F

Materials
Text
There is no text for this course. Several chapters from the second edition of The Art of Modeling with Spreadsheets will be used as readings. Readings from other texts will be supplied where necessary.

The following texts may be used for reference.

Introduction to Simulation and Risk Analysis, James Evans and David Olson, Prentice Hall, 2002.
This is an MBA-level text that covers Monte Carlo and discrete-event simulation. The software used for Monte Carlo simulation is Crystal Ball. For discrete-event simulation this text uses ProcessModel, which is similar to Extend+.

Another MBA-level text, but with an engineering flavor. It uses @Risk (instead of Crystal Ball) and Arena (instead of Extend).

Simulation Modeling and Analysis, Averill Law and David Kelton, McGraw-Hill, 1999. This is one of the standard graduate-level references on simulation methods. It emphasizes discrete-event simulation and provides more of the theory behind simulation than the other books listed here.

Business Dynamics, John Sterman, McGraw-Hill, 2000. The definitive text on dynamic system simulation. The software used is IThink, but equivalent models can be built in Extend+.

Simulation Modeling using @Risk, Wayne Winston, Duxbury, 2001. This book contains a number of interesting examples worked out in detail. @Risk is the major competing product to Crystal Ball. @Risk models can be converted to Crystal Ball fairly easily.

Would-be Worlds: How Simulation is Changing the Frontiers of Science, John Casti, Wiley, 1997. This is a fascinating and accessible book on the frontiers of computer modeling and simulation. The focus is primarily on science, but a number of applications in economics and business are included.


Decision Making under Uncertainty with RiskOptimizer, Wayne Winston, Palisade, 1999. RiskOptimizer does for @Risk what OptQuest does for Crystal Ball: optimize simulation models. This book contains many interesting examples, most of which can be solved using Crystal Ball and Optquest.

Software
The students will use Crystal Ball 2000 7.2, Extend+ V6, and IThink Version 9. The Sensitivity Toolkit, a publicly available add-in to Excel, will also be used. (The Toolkit can be downloaded from http://mba.tuck.dartmouth.edu/toolkit/.)

All students should check the version of Crystal Ball they have installed and upgrade to version 7.2 if necessary with the help of Tuck Computing. A disk for Extend+ will be included in the course packet. Ithink will be downloaded from the web (instructions will be

Grading
Grades will be based on homework assignments, class participation, three quizzes, and the optional project. (Students who choose not to carry out a project will receive a maximum grade of S+.) Extraordinary contributions to the intellectual process of the course will also be recognized in the final grade. The following weights will be used in grading:

Quiz on Monte Carlo Simulation 25%
Quiz on Discrete-Event Simulation 25%
Quiz on Dynamic System Simulation 25%
Class participation 25%
Optional project (only for students seeking an H)
Schedule

03/26/2008
Introduction to Simulation

Preparation: Review The Art of Modeling with Spreadsheets 2nd edition, Chapter 15. Check that Crystal Ball 7.2 is running on your computer, along with the Sensitivity Tookit. Install Extend+ from the CD supplied in your registration packet.

Topics:
- Course objectives
- Logistics
- Expectations
- Overview of simulation
- Monte Carlo
- Discrete-event
- Dynamic system
- Benefits and limitations of simulation
- Review of homework

Assignments
- Prepare the Office Building case, available in the course packet. Save your model in the course folder under Homework/March 28. Use the following naming convention: PowellS.Office.328.xls.

03/27/2008
Monte Carlo Simulation


Topics:
- Deterministic modeling
- Sensitivity analysis
- Simulation process
- Crystal Ball Sensitivity
- OptQuest mechanics
- OptQuest tips
- Review of homework

Assignments
- Prepare Equilibrium in Competitive Bidding, Exercise 16, Art of Modeling with Spreadsheets Chapter 15 pp. 421-422.

04/02/2008
Monte Carlo Simulation

No class this day. Office hours this week required.

Assignments
- Read The Art of Modeling with Spreadsheets, 2nd edition, Chapter 16, Section 3.
- Prepare: Call Center Staffing

04/03/2008
Optimization in Simulation

Preparation: Call Center Staffing
Assignments

**Initial Project Proposal**
Prepare a short summary of your proposed project. Describe the problem area and the sources of information you will use. Outline any specific problems you anticipate encountering.

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**04/09/2008**
Monte Carlo Simulation
No class this day. Office hours this week required.
Assignments
Prepare: *Capacity Planning*

**04/10/2008**
Solver and OptQuest
Preparation: *Capacity Planning*

**04/10/2008**
Take-home quiz on Monte Carlo simulation

**04/16/2008**
Introduction to Discrete-Event Simulation
Preparation: Read *Business Process Modeling, Simulation, and Design*, Chapter 7

Topics:

- Applications of discrete-event simulation
- Common features
- Little’s Law
- Cycle time and capacity
- Sources of queues
- Queuing models in Excel
- Extend+ versus Excel
- Lab: simple waiting line

**04/17/2008**
DES Modeling Skills Lab
Preparation: Car Wash case.

Topics:

- Extend concepts
- Discrete event library
- Modeling by Elaboration
- Lab: Car Wash model

**04/23/2008**
Discrete-event Simulation

No class this day. Office hours this week required.
Preparation: Adoption Process in a Humane Society

04/24/2008
Managing Customer Service

Preparation: Adoption Process in a Humane Society

04/30/2008
Discrete-event Simulation

No class this day. Office hours this week required.

Preparation: Valley of Hope Hospital

05/01/2008
Health Care Planning
Preparation: Valley of Hope Hospital

05/01/2008
Take-home quiz on discrete-event simulation

05/07/2008
Introduction to Dynamic System Simulation

Preparation:
Read Business Dynamics, Chapter 1, pp. 3-39.
Prepare: Consultants, Inc.
Topics:
What is DSS?
How does it differ from other simulation approaches?
Typical problems
Strengths and weaknesses
Barriers to learning
Examples: inventory; market share

05/08/2008
DSS Modeling Skills Lab

Preparation: Work through IThink tutorials MBS1-MBS5.

Interim Project Proposal
Prepare an interim report on your project. Describe the current problem statement. Outline any specific problems you anticipate encountering.

05/14/2008
Dynamic Systems Simulation

No class this day. Office hours this week required.

Assignments
Prepare: Stop-Smoking Campaign
05/15/2008
Policy Analysis with DSS

Preparation: Stop-Smoking Campaign

5/21/2008
Strategic Innovation and the Science of Learning I

Visitor: Chris Trimble

Preparation: Readings will be distributed May 17. Plan on spending two hours solo and another two hours in a group preparing for class.

05/22/2008
Strategic Innovation and the Science of Learning II

Visitor: Chris Trimble

Preparation: TBD.

Note: Class will begin at 12:30. Lunch will be available in the classroom at 12:15.

Final Project Report

Submit a draft of the final report on your project. This should include a description of the problem and the model(s) you have built, along with your final recommendations and conclusions.

05/22/2008
Take-home quiz on dynamic system simulation

Quiz
date?

Project Presentations