

**VIRGINIA TECH
NORTHERN VIRGINIA CENTER
GRADO DEPARTMENT OF INDUSTRIAL & SYSTEMS ENGINEERING**

ISE 5984: Advanced Dynamic Modeling

Spring 2007
Dr. Hazhir Rahmandad

I. GENERAL COURSE INFORMATION

Course Description and Objectives

Accelerating economic, technological, social, and environmental changes challenge engineers, managers, and policy makers to learn at increasing rates. We must increasingly learn how to design and manage complex systems with multiple feedback effects, long time delays, and nonlinear responses to our decisions. Hard modeling skills and soft stake-holder interaction skills are both required for successful design, implementation, and management of complex enterprises. In this course, we introduce several required skills for building robust models of dynamic socio-technical systems, and through real-world projects, students build their soft skills in client interaction, project management, and teamwork. The skills developed in this course build upon those introduced in ENGR 5104 and are essential for students who want to use their modeling skills on real world problems. Moreover, projects in this course provide opportunities for graduate students to find interesting research questions for their graduate research.

This course introduces modeling and client interaction skills required for building robust models of complex, dynamic enterprises, and for successful implementation of strategies designed through the modeling process. A structured approach to identification and modeling of dynamic problems is introduced and applied within projects in different companies. Tools and skills for sensitivity analysis and Monte-Carlo simulation, optimization, model calibration, and data manipulation in dynamic models are also discussed.

Student teams work with real world managers to tackle some of their most pressing problems. The task is to define the problem, understand its causes, and design solutions. To accomplish all of this, students follow the system dynamics “standard method”, a sequence of steps that leads from problem definition to policy design. Class participants are supported in their endeavor by class mates and by the instructors. Students deliver significant value to the participating organizations; taking away from the course enhanced skills in both consulting and system dynamics.

The grading of the course is largely based on personal projects. As part of the project, student teams will develop a short tutorial on one of the advanced topics discussed in the course. They will also evaluate the tutorials from other teams in the class.

Major Course Concepts and Techniques

1. Process consultation
2. Group model building
3. Standard method for modeling
4. Molecules for modeling
5. Model calibration
6. Optimization of non-linear models
7. Monte-Carlo simulation analysis
8. Advanced modeling tools (subscripts, loop knockout, data manipulation)

Educational Objectives

There are two broad educational objectives that are addressed in this course. First, the development of client interaction skills necessary for conducting consulting, as well as research projects intimately involved with human stake-holders. Second, the development and introduction of tools and skills used in advanced dynamic modeling projects.

Prerequisites

Graduate standing in the industrial and systems engineering degree programs.
ENGR 5104 or equivalent

Professor

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Class Meeting Time and Place

Thursday: 7:00 p.m. - 9:45 p.m.
Blacksburg: Room Torgersen Hall 1030
Falls Church: Room 206

Required Texts

1. Sterman, John D. (2000), *Business Dynamics: Systems Thinking and Modeling for a Complex World*, Irwin McGraw-Hill, ISBN: 0-07-231135-5. (Abbreviated as BD)
2. Schein, E. H. 1988. *Process consultation*. Reading, Mass., Addison-Wesley Pub. Co. (Abbreviated as PC)
3. Additional readings, including reference guide to molecules, will be posted on Blackboard.

Software

Vensim DSS (Decision Support System). Vensim DSS is Ventana's top-of-the-line version. Ventana generously allows VT students taking this course to use the software for academic purposes without charge, for the duration of the course. Instructions for obtaining Vensim DSS will be given in class.

II. OUTLINE OF TOPICS AND READINGS

Subject to change

Date	Class	Topic	Group Presentation	Reading
1/18	1	Introduction and overview, Choose Projects, Variables, Reference Modes, and Momentum policies		Forrester 85 Process overview
1/25	2	Group Model Building, Dynamic Hypothesis, Molecules Intro	H1: Variables, ref modes, mom. policies	PC pp. 1-29 Andersen et al 97
2/1	3	Layered Loops, Sources of Data, Molecules	H2: Rough dynamic hypotheses	PC pp.30-40 Forrester 92; MM: Producing (ProducingBacklogByDoing work, BuildingInventoryByDoing Work, Estimated RemainingDuration, ResourcesFromAction)
2/8	4	Modeling Process: Loops or Sectors, Molecules	H3: Dynamic Hypotheses	PC 42-83 smooth (and workforce, firstOrder Stock Adjustment, Trend)
2/15	5	Equilibrium, Molecules	H4: Mini Presentation	PC 84-122 Decay (materialDelay, ResidenceTime, PresentValue)
2/22	6	Analysis: Loop Knockout, Molecules	H5: First loop	PC 123-171 Ford 99 BrokenCascade (SplitFlow, WorkAccomplishmentStructure, Low-VisibilityPipelineCorrection),
3/1	7	Table Functions: Knowledge Elicitation, Molecules	H6: First Loop Analysis	PC 172-200 Ford and Sterman 98 UnivariateAnchoring andAdjustment (SeaAnchorandAdjustment , protectedSeaAnchorandAdjustment, SeaAnchorPricing, SmoothPricing)
3/8		Spring Break, No Class		

3/15	8	Subscripts, Molecules	H7: Second Loop Model	PC 201-248 Molecules to cover: TradCoflow (TradCoflowExperience, TraditionalCascadedCoflow, HinesCoflow)
3/22	9	Monte Carlo Simulation	H8: Second Loop Analysis	BD 21.4.11, Vensim Reference Manual, Ch10, From Sensitivity Simulations to Combinatorial Sensitivity
3/29	10	Data Connections	H9: Third Loop Model	Vensim Reference Manual, Ch9
4/5	11	Optimization, All parameter change sensitivity	H10: Third Loop Analysis	Oliva 2003, Vensim Reference Manual, Ch10, From Payoff Definition to Using Output Files
4/12	12	Calibration and Kalman Filtering	H11: Open Modeling/ Analysis	Vensim Reference Manual, Ch10, From Kalman Filtering On
4/19	13	Advanced Analysis techniques	H12: Open Modeling/ Analysis	Ford and Flynn 05 Mojtahedzadeh 04
4/26	14	Final Notes	Final Presentations	
5/3		Reading Day, No Class		

Reading Assignments

The reading assignments will be modest in this course. Readings from Schein's book will be assigned to help with the consulting process. We will not discuss these explicitly in the classroom but we will discuss any process issues you have in your interaction with your client. Additional papers may be assigned for specific technical topics. We assume a general familiarity with Sterman's text, which is a reference book for the course, but no required reading will be assigned from that.

Readings from Hine's introduction to molecules are short. For each molecule assigned, open it in Vensim (Windows>Molecules, after installing molecules) and guess what equations are used for each variable. Also try to come up with other examples for the specific molecules. Then go to Hines's reference and see the equations as well as additional application examples for the specific molecule. This process will build your intuition for application of molecules and robust formulations.

Weekly Presentations

Each team will be presenting their weekly progress in short presentations (10-15 min) and we will discuss these in the class and provide feedback. Teams should send their presentations to the instructor by one hour before the start of the class. Also upload your team's presentation on the digital dropbox on Blackboard. Name your files as: TeamName-WeekX.ppt, where TeamName

is the name of your team and X is the session of the class for which you have prepared this presentation. The instructor will upload all the files on his computer and will project them on the screen, while the team members discuss the content.

III. Projects and Tutorials

The course is organized around your team projects. You select your team and your project on the first session and will follow a structured process for interacting with clients during this project. Adherence to this process is critical to enable timely management of the project. You will have weekly presentations of your project progress and opportunity to receive feedback from the instructor and your class-mates.

There is no final project report to be submitted for this course. Projects are evaluated based on their progress throughout the semester, the openness to learning shown by the team, quality of modeling and analysis, and the insights the project has generated for all the parties involved.

For the final presentation you are encouraged to invite your client to join the session and view the final presentation of your work and the work of other students. The final presentations are all planned for the April 26th session of the class (same hours as the normal class hours).

In the development of your project you should select one of the advanced techniques discussed in the course and build a short tutorial about that technique. To reduce your workload, you are encouraged to select a technique that adds value to your project, or your team is more interested in it. We will discuss the selection of tutorial topics during the semester. The tutorials are team-based (one tutorial per team) and should be developed to enable somebody not familiar with specific functionality in Vensim to understand the basic logic of the method and to use the feature in a simple example.

The tutorial document is often accompanied with relevant models and additional vensim files that together create a complete, stand-alone, package that can be used by anybody who wants to learn the specific feature in Vensim. The tutorial report file has the size limit of **maximum 20 pages** (font size 12, times new roman, 1.5 line spacing, margins of 1” on all sides) including all the graphics and is due **April 28th**.

Each team will be randomly assigned to review three tutorials and their accompanying files. You will assess the usefulness of the tutorial for a novice user of the technique. Instructions for submission of tutorial reviews will be discussed during the semester. Reviews are due on **May 5th**.

IV. COURSE GRADING

<u>Grade Distribution</u>	<u>% of Final Grade</u>
Class Participation	15
Project	55
Tutorial	20

