Spring 2013
Dr. M. Roper

Scope

The effective design of complex systems determines system performance, ensures the delivery of high quality products, provides for marketplace success, and ensures long-term enterprise survivability. The systems engineering process is one of the more accepted paradigms for ensuring robust system design. In addition, accelerating economic, technological, social, and environmental changes challenge engineers and managers to learn at increasing rates. They must effectively learn how to design and manage complex systems with multiple feedback effects (loops), long time delays, and nonlinear responses to their decisions. This requires the engineer to use systems thinking in conjunction with a number of different modeling approaches (e.g., system dynamics, agent based modeling) in support of the design proposed by the systems engineering process. Systems thinking is a school of thought that focuses on recognizing the interconnections among the parts of a whole entity (the system) and synthesizing the interconnections into a unified view of the whole entity (the system). System dynamics is a modeling approach that investigates the information feedback characteristics of complex dynamic systems to show how system structure, managerial policies and decisions, and system delays interact to influence future system growth and stability.

In this course, students will conduct a semester research project that brings together the principles of the systems engineering life-cycle process, systems thinking, and dynamic modeling. As part of their research project students will implement these principles in order to propose a new system design or improve an existing system design. The justification for this new design will be motivated by an observed existing performance problem. The linkage between the system engineering process and dynamic modeling will be researched in the literature, and a qualitative dynamic model will be formulated and executed in support of the system design.

This is the capstone course for the MS degree in Systems Engineering, and requires the knowledge of the two required graduate systems engineering courses ENGR 5004 and ENGR 5104. This course utilizes and integrates the concepts and approaches covered in these courses. The course requires that a design or redesign of a complex system be carried out, and fundamental issues in the systems engineering process, systems thinking, and dynamic modeling be addressed.

Graduate Honor System

The Virginia Tech Graduate Honor System is in effect for this course, and all assignments shall be subject to the stipulations of the Graduate Honor Code which is located online at http://ghs.grads.vt.edu/. Please take the time to read this document and make sure that you
understand your responsibilities as a student. Be informed of the potential violations of the Graduate Honor Code: Cheating, Plagiarism, Falsification, and Academic Sabotage. Plagiarism or other forms of violations of the Graduate Honor System will not be tolerated. Take time to read how to avoid plagiarism which is located online at [http://ghs.grads.vt.edu/student/avoiding.html](http://ghs.grads.vt.edu/student/avoiding.html). Please contact the instructor if you have questions about the Graduate Honor System at Virginia Tech.

**Prerequisites**

This course uses the systems engineering process, systems thinking, and modeling concepts and techniques covered in ENGR 5004 and ENGR 5104. Both courses are prerequisites for this course.

**Major, Measurable Learning Objectives**

Having successfully completed this course, the student will be able to:

- Prepare a scoping document (proposal) to define a project that addresses a specific performance problem that originates from an existing or new system under consideration;
- In the context of the project, complete the design steps that demonstrate knowledge of the systems engineering process;
- In the context of the project, demonstrate knowledge of systems’ thinking when executing the design process using the systems engineering process;
- Formulate and execute a qualitative dynamic model in support of the systems engineering process;
- Effectively communicate the design and modeling results in written and oral form;
- Demonstrate system integration principles when conducting the system design and modeling;
- Include and integrate different engineering disciplines when conducting a systems engineering design project;

**Course Grading**

Failure to complete the deliverables more than once during the semester will result in a failing grade. This will be strictly enforced. This course is designed to provide the student with a capstone design experience and success or failure in the course will be evaluated based on the progress during the semester and on the final project report and presentation. It should also be noted that the course is based on a P/F basis, not on an A/F basis as are the more formal Research and Thesis and Project and Report classes.

**Professor**

Dr. Martha A. (Marti) Roper  
Phone: 703-314-6130  
Office Hours: By appointment  
E-mail: roperm@vt.edu
Class Meeting Time

Tuesday: 7:00 PM - 9:45 PM (approximately every other Tuesday; see meeting times later in this syllabus)

Meeting Times and Course Deliverables

Each student will join a team (2-4 members) that will complete the project during the semester. Students that are alone at remote sites are required to join a team that already has two members at another site. One of the reasons for requesting that students work in teams is that the system design that is based on the system engineering process and the understanding and modeling of its dynamics is a team sport. The semester project requires that all students focus on the important key issues associated with all the phases of the systems engineering process and the important dynamics that are inherent part of this process. Each member of the team will assume an important role. For example, the four roles when you develop the qualitative system dynamics model may be the facilitator/interviewer, the modeler, recorder/interpreter and the modeling process monitor. Furthermore, each team member may assume the responsibility of the completion of a specific phase within the systems engineering management process. It is imperative that each team member denote in the final document the roles that they assumed during the execution of the project.

During the semester, each project development team is required to submit specific sections of the research project report (milestones) as well as power point presentations (ten slides maximum) that summarize progress to date. It is understood that these deliverables represent work in progress. However, as the semester progresses, the expectation is that these deliverables will include updates due to feedback at each milestone to the fullest extent feasible. These documents need to be submitted through e-mail to the members of their assigned project evaluation team and to the drop box in VT Scholar (scholar.vt.edu/portal) at least three days (this means by 12 midnight Saturday) prior to next class presentations. Each team submission has to use the following naming convention: Group Members' Names_Site_Milestone_#_Date (for example, Jones_Smith_Williams_Milestone_#1_2_13_12).

As part of executing the semester project, each project development team will also serve as a project evaluation team to another development team for each milestone deliverable. These assignments will be rotated in order to allow teams to receive broader and more comprehensive feedback. As a project evaluation team, the group will provide feedback to the development team in terms of its deliverables and overall progress. Each project evaluation team will be asked to provide a written (2 page minimum write-up or “track changes” feedback) and an in-class summary (6 slide maximum power point presentation) of their feedback to the project.
development team prior to the following class meeting for each milestone. Project evaluation teams must submit these two deliverables by 4:00pm on the day of the class meeting.

Each team submission should use the following naming convention for critique submissions: Group Members’ Names_ critiquing_GroupMembers’ Names_Site_Milestone_#_Date (for example, Jones_Smith_Williams_critiquing_Davis_Hill_Wood_Milestone_#1_2_13_12).

During each class meeting, project development teams will present their milestone, followed by the project evaluation team presentation. The instructor will then provide oral feedback on the milestone presentations. The instructor will also provide a written assessment of each milestone to each project development team.

For the final presentations, it may be necessary to schedule the presentations for more than one night, but we will attempt to fit all presentations during the first date. Each student is required to participate in their team’s presentation. At least two guest faculty members will also be evaluating the final presentations and reports.

Also, so that the faculty can determine the pass-fail grade for each student, make sure to include in your written final project report a brief description of the roles and responsibilities of each team member in the project. On the day of the final presentation, each team will be required to bring two hard copies of the final report. The evaluation forms that will be used to evaluate your projects will be made available on Scholar.

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<thead>
<tr>
<th>Day</th>
<th>Topic</th>
<th>Presentations and Project Sections Completed</th>
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<tbody>
<tr>
<td>1/22</td>
<td>Introduction and Overview; Systems Engineering and Analysis; The Dynamic Modeling Process; The Formation of the Project Teams and Evaluation</td>
<td>Powerpoint Unit Lectures (on Scholar)</td>
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<tr>
<td>2/5</td>
<td>Problem Definition; System Definition; Organizational Context</td>
<td>Milestone #1 Presentations (Scoping Document) Sections 2.1-2.5 Section 4</td>
</tr>
<tr>
<td>2/19</td>
<td>Overview of System/Subsystem Definition; Literature Review Dynamic Problem Articulation</td>
<td>Milestone #2 Presentations Section 3 Section 5 Section 8</td>
</tr>
<tr>
<td>3/5</td>
<td>System Design: Conceptual and Detailed Design; Qualitative Model Development</td>
<td>Milestone #3 and 4 Presentations Section 6 and 9</td>
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3/26 System Design: The Rest of the System Life-Cycle Milestone #5 Presentations Section 7

4/16 Results and Conclusions Milestone #6 Due Section 10 and 11

4/30 Final Projects Due (No Class Meeting and No Project Evaluation Team Deliverables)

5/7 Final Project Presentations

Texts, Case Studies and References


Example Project and Reports Prior to the Systems Engineering Project Course


