ME 516: MODELING AND ANALYSIS OF COMPLEX SYSTEMS
(COMPLEX SYSTEM DESIGN)
Fall 2011 Term: ROG 332 and CESD Lab BAT 349
Course Website: http://classes.engr.oregonstate.edu/mime/fall2011/me516/

Instructor:

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Course Description:

Introduction to challenges and considerations when designing complex systems. Fundamentals of systems engineering and system level modeling methods used in practice. Models and tools used to enable the use of models for trade studies during the design of complex systems. Model based design environments and methodologies.

Learning Outcomes:

By the completion of this course, students will be able to:

- Identify major challenges in complex system design
- Utilize models during complex system design
- Utilize system engineering tools in a complex system design environment
- Present findings in a professionally written report and an oral presentation

Textbook:

No textbook is assigned. Reading assignments will be handed out for selected topics either from published articles or books. Suggested books for reading include:

- The art of systems architecting. M.W. Maier and E. Rechtin
- Introduction to systems engineering. A.P. Sage and J. E. Armstrong
- Space mission analysis and design. J. R. Wertz and W. J. Larson

Grading:

Reading assignments & Individual assignments	40% Interim Team Assignments
Design Projects (team)	10% Team Grid Design Presentations
	10% Team-X/ModelCenter Integration Demo
	20% Final Team Proposal
	20% Paper Summaries/Discussion Forums

Lecture format:

Lectures will be 75 minutes long in general on Mondays and Wednesdays, 4:00-5:15pm. However, there will be exceptions during visitor lectures and software training sessions, which will require a longer (2-hr) period, as detailed below. ***Specifically, the following lectures will require additional time so will take the full 2-hr lecture time:***

Week 4: Monday's lecture by Steve Wall from NASA JPL (2 hours)
Week 5: Monday's lecture by Dr. Mike Yukish from Pennstate (2 hours)
Week 6: ModelCenter training session by Douglas VanBossuyt from Oregon State (2-2 hour sessions)
Week 8: Decision making in design by Dr. David Ullman from Robust Decisions, Inc. (2 hours)
Week 9: Industry practice: Andrew Christensen, BPA (may be during D/M area seminar)

Special Needs:

Students with documented disabilities who may need accommodations, who have any emergency medical information the instructor should know of, or who need special arrangements in the event of evacuation, should make an appointment with the instructor as early as possible, no later then the first week of the term. Accommodations are collaborative efforts between students, faculty and Disability Access Services (DAS). Students with accommodations approved through DAS are responsible for contacting the faculty member in charge of the course prior to or during the first week of the term to discuss accommodations. Students who believe they are eligible for accommodations but who have not yet obtained approval through DAS should contact DAS immediately at 737-4098.

Academic Integrity:

Academic dishonesty is prohibited and considered a violation of the OSU Student Conduct Regulations. It includes cheating, the intentional use of unauthorized materials, information, or study aids); fabrication, assisting in dishonesty or tampering (intentionally or knowingly helping or attempting to help another commit an act of dishonesty or tampering with evaluation instruments and documents); and plagiarism, intentionally or knowingly representing the words or ideas of another person's as ones' own. If you have a question regarding academic integrity, please talk to the instructor or refer to the OSU student conduct homepage at http://osu.orst.edu/admin/stucon/index.htm.

Assignments (see Course web site: http://classes.engr.oregonstate.edu/mime/fall2011/me516)

- Reading assignments (RA1, RA2, etc.)
- Design project assignments (DA1, DA2, etc.)

Design Project:

In this course, your teams will together generate a preliminary concept design for a future Smart Grid system. Smart grid represents the vision of the future power systems, which encourages integration of renewable energy sources, distributed generation, and plug-in hybrid and electric vehicles in distributed power systems. Smart grid adds complexity and challenges to various controllers at all levels of power grids. Therefore, new control and management paradigms, and advanced computational methodologies are required for planning, optimization, fast control of power system elements, processing of field data, and coordination across the grid. Your challenge is to develop a defendable proposal for such a system for consideration for funding from a board of university and government partners. **Your task is to demonstrate and write a proposal to a board of funders to convince them that you've designed the best smart grid system.** There will be two main parts to the design project:

1. Each team will select one electrical power grids in North America as part of a possible smart integrated grid system, develop the related system models, conduct a trade study, simulate models in Model Center, and demonstrate it to the board of funders. The major interconnections include the Western Interconnection and the Eastern Interconnection. The minor interconnections include the Texas interconnection and the Quebec interconnection. Your proposed smart grid will use one of these interconnections and enhance them by adding additional powers sources. The additional power sources can include wind, solar, wave, battery, thermal, nuclear, etc. **The end goal is to design a smart grid system that minimizes cost and power consumption, while maximizing the percentage of total power from renewables.**

2. The four teams will then integrate their individual enhanced smart grid systems, demonstrate a simulation of the integrated system, and conduct an integrated Team-X trade propose ways in which the integrated North American grid can be enhanced to minimize cost and power consumption while maximizing renewables. Various trades should be considered including increasing the number of grids, replacing old power sources with new power sources, funneling energy through the different grids depending on the strengths of each individual interconnection, and demonstrate, in ModelCenter in a Team-X setup, how the new and improved interconnections can be integrated for the next future North American smart power grid.

Requirements for Design Projects:

- Proposal: Description of the individual power grid for your team project and the additional power sources that will be explored
- Interim assignments: Use of methods presented in class, observations, insights
- Software training assignments: ATSV, ModelCenter
- Progress reports/presentations
- Team report of design project: implementation of method(s) for your selected smart grid design
- Integrated Team-X demo: each team will play the role of design study leads for ONE interconnection with the instructors as the customers and demonstrate how the future North American smart grid system will be designed and integrated using Model Center in a Team-X setup

<u>Reading Assignments and Paper Discussion Forums:</u>

In addition, each team will be responsible for conducting a round-table discussion of a seminal journal paper for their selected systems and/or a class reading assignment. This will require each team to reach a consensus on a paper to read and analyze thoroughly, distribute to the rest of the team, present findings, and prepare points of discussion during the round-table session. The reading assignments will include a summary by each team member (individual).

Requirements for Reading Assignments:

- Summary of assigned reading material, including a critical assessment of the contributions and quality of the paper (1-3 pages depending on length and number of papers/chapters)
- ModelCenter training summary

Requirements for Research Paper Discussion Forums:

One discussion forum prepared and conducted by each of the four teams to discuss specific topics in class

- ALL:
  - Conduct brief literature search and summarize findings
- LEAD TEAM:
  - Select 2 papers from list and distribute to all the other teams
  - Prepare and conduct a critical discussion of the papers
- ALL:
  - Summary synthesis of the two papers based on discussion
- LEAD TEAM:
  - Collect and grade summary synthesis writeups from class based on discussion

Topics and Approximate Schedule:

Wk 1: 9/26-9/28: Complex Engineered Systems

Course introduction & teaming

Complex Systems Design: Systems Engineering View

RA1: Summary: US-Canada Power System Outage Task Force/Case Study

DA1: Initial findings presentations of the four interconnections by teams (10 minutes each)

Wk 2: 10/3-5: Model Based Design

Introduction to Modeling and Model Based Design

RA2: Paper discussion forum 1: Smart grid system designs

DA2: Team assignment & presentation: Proposal & presentation for smart grid design

Wk 3: 10/10-12: Systems Engineering

Introduction to System Engineering

RA3: Paper discussion forum 2: Complex system failures due to systems engineering issues

DA3: Team assignment & presentation: Subsystem descriptions and functional decomposition, and block diagram for smart grid system design, description of different power sources and their characteristics

Wk 4: 10/17-19: Applications of Model Based Design

Design Trade Studies using low-fidelity models ***(Joint Lecture with Steve Wall/NASA JPL)***

RA4: Summary: Space mission design (SMAD chapters 11, 12, 20)

~~DA4: Team assignment & presentation: Space mission design using low fidelity models~~

Wk 5: 10/24-26: Design Trade Space Exploration &Visualization

Trade space analysis & sampling the trade space (ATSV) ***(Joint Lecture with Dr. Mike Yukish/Pennstate)***

RA5: Summary: ATSV and trade space exploration (due Mon 10/24)

DA5: Team assignment: ATSV exercise & report as assigned by Matt Frye (due Wed 11/1)

Wk 6: 10/31-11/2: Model Based Design Tools: Model Center

Model-based design: ModelCenter self training and analysis of simple problem: ***4-hour Training, Phoenix Integration, Inc. (led by Douglas VanBossuyt)***

RA6: Summary: ModelCenter training material screenshots and description (individual due Mon 11/7)

DA6: Team assignment: Discussion of ModelCenter brake example and discussion of how ModelCenter will be used for the design project (due Mon 11/7)

Wk 7: 11/7-11/9: Collaborative Design Environments: Team X

Integrated System Design in a Team-X environment

RA7: Paper discussion forum 3: Software for Collaborative Design Environments (due Mon 11/7)

DA7: Team assignment: Smart Grid System modeling and optimization progress report (due Mon 11/14)

—no lecture on Wednesday 11/9: Self-study: Finalizing project and demo

Wk 8: 11/14-16: Decision Support for Complex System Design

Decision support tools (Accord) ***(Joint lecture with Dr. David Ullman, Robust Decisions Inc.)***

ModelCenter power grid integration discussion ***(led by Douglas VanBossuyt)***

RA8: Paper discussion forum 4: Decision making in system design (due Wed 11/16)

DA8: Team assignment: North American System integration proposal (due Mon 11/21)

Wk 9: 11/21-23: Design Projects

Industry Practice: Modeling of power grids ***(Invited talk by Andrew Christensen, BPA)***

RA9: Summary of invited talk (due Wed 11/23)

—no lecture on Wednesday 11/23: Self-study: Finalizing project and demo

Wk 10: 11/28-11/30: Final Presentations & Demos

DA9: Individual grid design presentations on Monday 11/28

DA10: ModelCenter grid integration discussion and/or demo on Wednesday 11/30 ***(led by VanBossuyt)***

DA11: Final written team proposals due Friday 12/2, 5pm