SYST 520 –Systems Engineering:

Design, Development and Integration

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This is a course in the design, development and integration of systems from individual systems to system-of-systems. Lessons are reinforced by case studies and assignments, taking a holistic systems view and integrating aspects of product development and system architecture within systems engineering. This course will teach UML and SysML as model based system engineering languages for systems design, analysis and documentation in a concurrent engineering team oriented design setting. The system language IDEFx will be covered to the degree that students can read and interpret legacy systems documented using IDEFx.

In addition to lectures a case study approach will employed to develop analytical, technical, management, and teamwork skills through exercises in planning, documentation, presentation, and the creative process of systems engineering design.

Prerequisites: graduate student standing

Learning Objectives

This course will give students opportunities to apply class lecture content to system design and integration scenarios, simulating real life situations. Students will demonstrate their assimilation of relevant information to the course professor, who will review by oral presentations, written reports, and a final examination.

It is the objective that the students will come out of the course with a fundamental understanding of systems engineering (understand the document deliverables of a systems engineer), system architecture, and product development, as well as their application to various contexts. In part this is a preparatory course in the fundamentals of system architecture from a design viewpoint, to be expanded upon in later advanced courses, e.g. SYST 620, 621, 622.

Creative / Critical Process Thinking

Given a specific systems engineering problem to address, students should be able to

- Select relevant applications from their knowledge base of systems engineering methods and analytical approaches

- Generate, as a team, synthesized approaches suitable for a successful resolution of the problems presented in case studies

Case study assignments will be conducted by student teams

The essence of my approach to this course entails the presentation of descriptive, prescriptive, and normative principles (with best practices) followed by a case study. The cases serve as scenarios, mini-projects in applied "real life" experiences built upon the class topic. Cases are carefully selected from various sources for techno-socio and economic complex system development, and questions or tasks requiring a response are tailored to the lessons learned for the week. Teams of three members carry out the assignments that call for applying class knowledge, skills, and tools to the case problem.

- The class will be divided into diverse interdisciplinary teams.
- Each team will tackle cases and other assignments on a weekly basis.
- The course will require on average 10 hours per person per week.
- Each team will be composed of 3 students who will be responsible for:
    - developing a case or other assignment analysis and solution
    - producing written and/or oral deliverables
- The deliverables must incorporate a system representation methodology/modeling language for communication among stakeholders.

Assigned Readings other than the course textbook (not the cases which are copyright restricted) will be posted to Blackboard.

The assigned readings for the next week will be listed at the end of each lecture and in the course schedule.

Team Preparation

Group (team) work is encouraged for purposes of general class preparation and for written assignments. We have found that groups generally develop better solutions and that students learn from one another in such group interactions. Your team size should be three students (alternatively two, but not one) and discussion of the assignment should be limited to members of your team (not other class member or students who have studied the case previously).

Most managers spend little time reading and less time writing reports (other than for schedules, graphs and spreadsheets). Most of their interactions are oral (or email). This is especially true for managers in operations-intensive settings. For this reason, the development of oral and written skills is given a high priority in this course. The classroom should be considered a training ground in which you can develop your ability to present your analyses and recommendations clearly, to convince your peers of the correctness of your approach to complex problems, and to illustrate your ability to achieve the desired results through the implementation of that approach.

Some criteria for a constructive case discussion:

1. Is the participant a good listener?
2. Are the points made relevant to the current discussion? Are they linked to the comments of others?
3. Do the comments show clear evidence of appropriate and insightful analysis of the case data?
4. Is there willingness to participate?
5. Is their willingness to test new ideas or are all comments "safe"?
6. Do comments clarify and highlight the important aspects of earlier ideas and lead to a clearer statement of the relevant concepts and issues (i.e., move the discussion along)?
7. Is there a comfortable balance of listen and talk, give and take of ideas?

Grading Policy:

You will be evaluated based on your depth and breadth of thinking, comparable to assessing quality and productivity in an enterprise.

Possible solutions will be discussed in class to bring out the most important issues but will not be distributed in writing. The case write-up will be graded with consideration of the following points:

Analysis

1. Does the analysis address the major issues in the case?
2. Does the analysis incorporate the relevant tools?
3. Are assumptions made in the analysis stated explicitly?
4. Does the analysis isolate the fundamental causes of problems in the case?

Recommended Actions

1. Are the criteria for choosing among alternative recommendations stated?
2. Are the criteria appropriate?
3. Is the plan of action integrated in a logical way and linked to the analysis?
4. Is the action plan specific, complete, and practical?
5. Is it likely that the recommendations will achieve their intended results?

Exhibits

1. Are the analyses illustrated by the exhibits done correctly?
2. Do the exhibits support and add to the written response on key points?

(Exhibits should contain specific types of analyses, such as financial analysis, breakeven charts, cost analysis, process-flow analysis, etc. They should contain any relevant supporting information that is too detailed for the body of the paper. Exhibits must not be simply an extension of the text.)

Presentation

1. Is the paper “right-sized” (e.g., not too long)?
2. Is the presentation of professional quality?
3. Is the paper logically consistent and effectively structured to sell its recommendations?

Assignments are indicated in the course schedule. All are equal weight and are due on Mondays.

Each team will appoint a project manager for that week who will be responsible for assembling the report and submitting it to the Assignments folder on Blackboard. E-mail should be used as the backup. The report cover page must name the manager and provide students’ names and e-mail contact information for the entire team. The project manager will normally get double the project grade that week. I will e-mail responses to that week's project manager for distribution to the rest of the team. Cases will be discussed normally at the start of each class followed by a lecture format.

The grading will be weighted as follows:

15% on class participation, based on the criteria above

70% on group case write-ups and/or other assignments, based on the criteria above

15% final exam on model based system design proficiency

Weekly Deliverables for the Systems Engineering Course

1. Team submissions will be digital in MSWord 2007 or MSPowerPoint 2007 to the Blackboard course website https://gmu.blackboard.com/

Instructor:

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Engineering 2238 703-993-1672 tspeller@gmu.edu

Office hours: Fri. 14:30-16:30 ET or by appointment

Course Texts and Readings:

Texts (required):

1. Buede, D., *The Engineering Design of Systems: Models and Methods.* Second ed. 2009, New York, NY, USA: John Wiley & Sons, Inc.
2. Friedenthal, S., R. Steiner, and A. Moore, *Practical Guide to SysML: The Systems Modeling Language*. 2008: Morgan Kaufmann; Elsevier Science. (updated as of the August 28, 2009 reprinting)

Texts (not required but suggested):

- C. H. Fine, *Clockspeed: Winning Industry Control in the Age of Temporary Advantage.* (Perseus Books, New York, 1998).
- E. Goldratt, E. Schragenheim and C. Ptak, *Necessary But Not Sufficient*. (North River Press Great Barrington, MA, 2000).

Cases:

Case studies are contained in our course locker at the Harvard Business School with the URL http://cb.hbsp.harvard.edu/cb/access/4489164 . Click on this link to select, pay for, and download cases used in this course. You must register the first time you visit this site.

Other course readings will be provided on the course website, Blackboard https://gmu.blackboard.com/

Collaboration tool:

This course will provide a URL for the tool Elluminate that will be unique to each team for synchronous team collaboration (by sharing applications, models, VoIP, video, and audio) in conducting their case and other assignments.

Dissemination Policy:

The information provided by the students should not be proprietary but instead openly shareable with others for research and educational purposes.

Systems engineering is an evolving field, and good and creative new thoughts and ideas developed by members of the class may be folded into the next iteration of teaching and research. This is how scholarship develops. Any future reuse will be credited to former students in a general way. Should you publish a work, then the citation will be given in the future.

Policy on Academic Integrity:

In the corporate environment and in various cultures it may be important to obtain a good answer to the question at hand while it may not be as important to be original or cite sources of ideas used. This is not the case at George Mason University, where it is important to create original work **and** to cite the source of ideas very carefully and completely. The George Mason University Honor Code can be found at: http://www.gmu.edu/catalog/apolicies/#faculty_responsibilities. These policies underscore the importance in academia of creativity and proper acknowledgment of sources. In order to achieve the objectives of this course, the work of individuals and teams must be original or where appropriate must cite the contribution of others and relevant sources.

Class Outline

Class 1: Course Syllabus, Course Topics, History, System Architecture, Case Study

Topics:

- Course Syllabus
- Course Topics
- Assignment 1
- Start of a Glossary
- Brief History of Systems Engineering
- Introducing the Importance of System Architecture

Class 2: SysML and Example Cases

Topics:

- Technology Convergence Case Study Review
- Model Based Systems Engineering: System Modeling Language (SysML)
    - MBSE Motivation and Scope
    - System Modeling Using SysML
    - System Model as an Integration Framework
    - Dishwasher Example
    - Reference to OOSEM Example (Chapter 16)
    - Summary

Class 3: Stakeholders and Problem Statement

Topics:

- Case Study, "Turning Around Runaway Information Technology Projects" and "Why Projects/Products Fail"
- System Architecture
    - Function
- Product Design and Development Process (PDDP)
- Stakeholders Identification and Analysis of their:
    - Needs
    - Wants
- The Problem Statement
- System Use Cases (UML, SysML) and Requirements

Class 4: Creativity in Systems Engineering/System Architecting

Topics:

- Case Study, SysML Use Case
    - Stakeholders and Requirements
- System Architecture
    - Form

  - Form-Function
- PDDP ↔ System Architecture ↔ Systems Engineering
- Creativity in the Systems Engineering/System Architecting
  - Nature (as a guide to creativity), Evolutionary Computation, Design Rules, and Combinatorics
  - Work of Vance and de Bono
  - TRIZ Theory
  - Radiant Thinking, Mind Mapping tool

Class 5: Technology Strategy and Human-System Integration in the System Development Process

Topics:

- Case Study: Creativity, Function → Form
- Technology Strategy
  - Economic Cycles
  - Technological Evolution of Systems
  - Strategy Development
- Human-System Integration (HSI) in the System Development Process
  - Human Factors

Class 6: Systems Engineering, Representation Schema, and Architectures

Topics:

- Managing the Enterprise by Means of Systems Engineering
- Systems Engineering Representation Schema
  - System Architecture Representation Schema
  - Process Models in Systems Engineering:
    Conceive, Design, Implement, & Operate (CDIO)
  - Examples of How Systems Engineering is Currently Implemented
  - Full Integration of Human Systems and System Engineering
  - Systems Engineering based on Quality Standards

Class 7: Translating Needs/Wants, Problem Statement, Requirements into Engineering Terms; Dependable and Safe Systems

Topics:

- GE Case Study Analysis
- Translating Wants, Problem Statement into Engineering Terms
- Dependability of Systems (Trustworthy Systems)

Class 8: Economics of Systems Engineering (Total Life Cycle Cost, Managerial Accounting for Decision-making)

Topics:

- Review of Submitted HoQ Matrices (Multiple Level Flow Down)
- Economics of Systems Engineering (Total Life Cycle Cost, Managerial Accounting)
- Managerial Accounting (Cost Accounting)
- Cash Flow Analysis for Project and System Design Decision-making

Class 9: System Cost Estimating and Scheduling; Decision Analysis under Uncertainty

Topics:

- System Cost Estimating and Scheduling
- Decision Analysis under Uncertainty

Class 10: Theory of Constraints, Process Engineering (reengineering), Supply Chains and Value Chains (2 parts extending into lecture 11)

Topics:

- Process Engineering
  - Theory of Constraints
  - Process Reengineering
- Life Cycles and Strategic Value Chain Design
  - Core Competence
  - The Physics of Flow
  - Lifecycles and Evolution
  - Supply Chain Design
    - Architecting
  - System Architecture Implications for the Value Chain

Class 11: Organizational Processes, Organizational Architectures

Topics:

- Organizational Processes
  - Strategy
  - Politics
  - Culture
  - Leadership
    - Negotiation
    - Alignment
  - Initiatives
- Organizational Architectures
- Initiative Example: Strategically Aligned Incentive Systems
- Technology Strategy, Innovation, and Organization Processes

Class 12: System Integration, Evaluation and Testing, System Operation and Support

Topics:

- Systems Integration
- Evaluation and Testing
- Introduction to Service-Oriented Architectures
    - Web-Services

Class 13: IDEFx

Class 14: Software Engineering, Net Centricity, Search and Retrieval Systems; Course Summary

Topics:

- Software Engineering
- Net Centricity
- Search and Retrieval Systems
- Course Summary

Class 15: Final Exam