SYST 659 Introduction to Systems Engineering

Spring 2009

Thomas H. Speller
Associate Professor
Systems Engineering and Operations Research

This is an introductory course in systems engineering with a focus on information technology systems. Emphasis will be on the development of analytical, technical, management, and teamwork skills through exercises in planning, documentation, presentation, and the creative process of IT engineering design. 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 use SysML as the language for analyzing and describing case studies (providing system design information for stakeholders) in systems engineering.

Prerequisites: graduate student standing in the masters degree Applied IT program

Learning Objectives

SYST 659 should be considered as an introductory course where students will show their understanding of concepts and methods by applying the lessons learned from the lectures in report outs for team case studies. This course will give students opportunities to apply class lecture content in IT system scenarios, simulating real life situations. Students will demonstrate their assimilation of relevant information to the course professor, who will review by oral presentations and written reports in lieu of a final exam.

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. The student will be on the path toward becoming a systems engineer.

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

Course and Team Assignment Requirements

- 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 6-7 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. The modeling language chosen for this course is SysML using the Enterprise Architect tool.

Course Content

Introduction

- Systems engineering
- System architecture
- Product development
- Systems Engineering Life Cycle
- Glossary of terms used in the course

Stakeholders, The Problem Statement

- Needs, Wants analysis
- Identification of system stakeholders
- Defining the problem statement
- Use Cases and an early introduction to the SysML Methodology/Enterprise Architecture Tool

System Architecting Methodology, Creativity, Functional Decomposition, Families of Products, Market Introduction Strategy

- Ambiguity, Creativity, and Complexity
- Holistic view of system architecting
- Function
- Form
- Analysis of Alternatives (AoA)
- Intent specification
- Integrality and modularity
- What is creativity, How is creativity used in the system architecting and elsewhere in the system design development lifecycle?
- Creativity techniques

Human-System Integration, Technology Strategy, Control Theory

- Human factors
- Human-Machine activity delegation

- Comparative technology trajectory analysis for determining the best technology strategy
- Appropriability, intellectual property,
- p-Diagram
- Feedback systems
- Human and machine
- System dynamics
- Robust designs

System Engineering Representation Schema and Methodologies

- UML
- SysML, introduction to the language and Enterprise Architecture CASE tool
- IDEF0
- Brief exposure to DoDAF, MoDAF, ToGAF, NASA's SE frameworks
- Quality standards
- What, Why, When, How, Who, How much framework
- Overview of other system representation schema

Translating Wants/Problem Statement into Engineering Terms, Fault Tree Analysis

- Quality Function Deployment (House of Quality), Kano quality model
- Fault-tree analysis (FTA)
- Failure mode, effects, & criticality analysis (FMECA)
- Pareto diagrams for frequency of fault occurrence
- Introduce the Ishikawa cause-and-effect (fishbone) diagram
- The design checklist (work flow scheme)

Economics of System Engineering (Total Life Cost, Managerial Accounting)

- The Business Case
- Project management
- Scheduling techniques (PERT, Gantt)
- Costs (types)
- Product/project development
  - Cash flow analysis
- Explanation of how the business case can affect the technical case

System Cost Estimating, Decision Analysis

- Work breakout structure (WBS) (product tree approach), the time flow of costs during development and during phases of the total life cycle
- Expert, algorithmic, and hybrid estimating approaches
- Estimates to complete
- Influence diagrams
- Decision trees

Process Engineering, Supply Chains

- What is and Why have a process?
- Theory of Constraints (TOC)
- e-enterprise information systems
- e-commerce
- B2B
- System dynamics
    - Bullwhip effect
- Architecture and Make/Buy Decision-making
    - Core competency
    - Integrality vs. modularity

Organizational Processes, Organizational Architectures

- Political – Cultural – Strategic
- Leadership
- Organizational system (individual, team or other group, enterprise)
    - Alignment
- Fundamental organization architectures: hierarchical, layered, matrix, network
    - Design structure matrices (coupling and dependency of tasks)

System Integration and Testing, System Operation and Support

- The integration of engineering disciplines
- Management of the "ilities"; DFx or design for the "ilities"
    - Reliability
- Evaluation and Testing
    - Life cycle property activities
    - Reduction of risk most cost-effectively
- Testing of subsystems
- Prototyping
- System Integration
- Design for reliability
- Installation and test
- In-service support
- Upgrades
- Maintenance
- Configuration control (families of products, market introduction)
- Change control

Software Engineering, Net Centricity

- Abstraction
- Modularity
- Coupling/dependency strength
- Design for XX (DFx)

- Changeability, flexibility, extensibility
- Reuse
- Fundamental organization architectures: hierarchical, layered, matrix, network (revisited)
- Web services
- Service Object Architecture (SOA)
- Cloud computing

Extra class time is reserved at the end of the semester for continuing discussion of the above topics.

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:

Thomas Speller Lecturer/Coach ST2-437 703-993-1672 tspeller@gmu.edu

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

Course Texts and Readings:

Texts:

1. Sage, A.P. and J.E. Armstrong, *Introduction to systems engineering*. 2000: Wiley New York.
2. Friedenthal, S., R. Steiner, and A. Moore, *Practical Guide to SysML: The Systems Modeling Language*. 2008: Morgan Kaufmann; Elsevier Science.

Cases:

Case studies are contained in our course locker at the Harvard Business School with the URL http://harvardbusinessonline.hbsp.harvard.edu/relay.jhtml?name=cp&c=c25675 . 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.

Grading Policy:

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

A 1-5 grading scale will be used to reflect the degree of the above characteristics in your work **and** classroom performance. Note that a grade of 3 is the base level of expectation from students, whereas a 1 is unacceptable and a 2 falls short of expectations. The grades 4-5 are used for above average answers with a 5 representing work that goes well beyond expectations. There are 13 assignments over the course of the term. 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.

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.