ISE-350: Principles of Systems Engineering

Units: 3

Term—Day—Time: Spring semester 2019, Mondays and Wednesdays, 2:00 pm to 3:20 pm

Location: KAP-148

Instructor: Neil Siegel, Ph.D.
The IBM Professor of Engineering Management,
Daniel Epstein Department of Industrial and Systems Engineering,
Viterbi School of Engineering

Office: OHE 310D

Office Hours: every Wednesday, 12:30 pm to 1:30 pm (additional office hours are available by appointment)

Contact Info: nsiegel@usc.edu, 424-373-0729
I usually respond the same day.

Teaching Assistant: Jacob Beaudin

Office: GER 242C

Office Hours: every Thursday, 11:20 am - 12:20 pm

Contact Info: jbeaudin@usc.edu, 815-263-9485

IT Help (for the Rhapsody laboratory)**:** John Ng

Hours of Service: Monday-Friday, 9:00 am to 4:00 pm

Contact Info: johnng@usc.edu

Course Description

Systems as complex collaborative ensembles of interconnected components. Theory and practice of requirements, design, implementation, testing, deployment, operation, and disposal. Case studies from real projects.

This course is designed for engineering undergraduate students interested in learning about the field of systems engineering.

Society today depends on many large systems – complex ensembles of capability, interconnected so as to provide some benefit not achievable by the individual components. Examples include air traffic control and scheduling, medical systems that optimize care and cost, the power grid that integrates many sources of energy to provide continuous electric service (even in the presence of disruptions and failures of components), systems that coordinate the supply chain of businesses so as to ensure continuous availability of desired products while also reducing waste, and so forth. It is not an exaggeration to say that society as we know and expect it could not exist without such systems, which provide safety, reliability, and affordability for many critical products and services.

Such systems are among the most complex artifacts ever created by humans. How does one learn to design and build such systems? This is the role of the field of ***systems engineering***. This course provides an introduction for aspiring practitioners and other interested persons into the art of creating such complex systems for our society.

Learning Objectives

By the end of the course, students will:

- Understand the motivation for systems thinking, and for the use of systems engineering
- Understand the systems engineering value-proposition, be familiar with examples of systems that are in use today, and understand the contribution of systems engineering to society
- Have been through an introduction and analysis of the major elements of the *system engineering process*, interspersed with examples (case-studies) drawn from real projects
- Have learned the complete *system life-cycle* (requirements, design, implementation, test, deployment, operations and maintenance, disposal), and also learned about key leverage points, and key lessons-learned from actual large projects
- Have learned about the methodologies, tools, representations, and analysis methods used in systems engineering, and (through the case studies from actual projects that are presented in the class) how systems engineers tackle and solve problems in roles ranging from an entry-level position on a large project, to chief systems engineer on a large project. These case studies cover both the technical and social aspects of being an effective systems engineer, including dealing with our non-technical stake-holders (which might include those who make procurement decisions, those who make funding decisions, those who make applicable laws and regulations, our customers and users, and

(increasingly) the general public and the media), as well as our fellow engineers and scientists.
- Acquired familiarization with the basic diagrammatic representations used in systems engineering
- Created some of those diagrams, against use-cases (sample problems) provided by the professor
- Learned and used a computer-based systems engineering tool (IBM Rational Rhapsody) to create automated representations of a use-case provided by the professor
- Have used the systems engineering analysis techniques taught in the lectures to solve example problems provided by the professor

Prerequisite(s): ISE 225, Engineering Statistics I
Co-Requisite(s): None
Concurrent Enrollment: None
Recommended Preparation: None

Course Notes
The course may be taken only for a conventional letter grade.

Lecture, 80 minutes, once per week.

Facilitated lab session, 80 minutes, once per week.

Outside study and homework includes reading assignments, short written summaries of those readings, individual study to master the lecture materials, and completion of projects started during the weekly facilitated lab sessions.

The professor will hold a minimum of 2 hours of office hours per week for students of this class, and will also be available for consultation via email.

Lecture slides will be posted on Blackboard.

Technological Proficiency and Hardware/Software Required
The IBM Rhapsody software will be used for a 4-week section of the course. That portion of the course will require ***that the students each load the Rhapsody software onto their own laptop computer*** (via the USC Viterbi "MyDesktop", which is available for both Windows and Macintosh computers). Normally, a USC computer laboratory that has that software already installed would be available to students, but due to construction, such a lab may not be available during the spring 2019 semester. Hence the need for the Rhapsody software to be installed onto the student's own computers.

Required Readings and Supplementary Materials
There will be one textbook to be purchased ("Managing Complex Technical Projects", Faulconbridge and Ryan, Artech House, ISBN 1-58053-378-7; available via the USC bookstore, and also conventional on-line sources, such as Amazon); additional reference materials will be provided via Blackboard by the professor.

Description and Assessment of Assignments

Homework will be assigned during the course, and will figure as a part of your grade (see the section below, "Grading Breakdown").

Most of the homework assignments consist of written summaries of your readings from the textbook. Instructions regarding this portion of the homework will be contained in the weekly lectures.

During the facilitated lab work, there will be work assigned to you, some of which will be accomplished during the lab sessions themselves. Your products from these sessions will also constitute homework, and will be counted towards your grade.

The specific homework assignments, their due-dates, and their point-value towards your grade for this course are summarized in the matrix below:

Assignments		
Due-Date	Faulconbridge chapter #	other
1/14/2019	1 (HW #1)	& a short bio of yourself
1/21/2019	2 (HW #2)	
1/28/2019	7 (HW #3)	
2/4/2019	3 (HW #4a)	
2/11/2019	4 (HW #5)	& the DoDAF drawings (HW #4b)
2/18/2019	5 (HW #6a)	
3/25/2019	6 (HW #7)	
4/1/2019	8 (HW #8)	& the SysML drawings (via Rhapsody) (HW #6b)
4/8/2019		
4/22/2019		Decision-tree (HW #9)

The eight Faulconbridge assignments are worth 15 points each
The DoDAF drawing assignment is worth 100 points
The SysML drawing assignment is worth 100 points
The decision-tree assignment is worth 80 points

All assignments should be turned in through Blackboard, except for the DoDAF drawings, which can be turned in via either Blackboard or via paper copy.

All homework and examinations will be graded by the professor.

Grading Breakdown

- Homework assignments – 40%
- Mid-term examination – 30%
- Final examination – 30%

The grading scale for the course is as follows:

A 941-1,000	A- 900-940	B+ 880-899	B 841-879	B- 800-840	C+ 766-799
C 733-765	C- 700-732	D+ 666-699	D 633-665	D- 600-632	F Below 600

The total for all point-scoring opportunities is 1,000; the mid-term examination is 300 points (e.g., 30% of your grade); final examination is 300 points (e.g., 30% of your grade); and the homework assignments are 400 points (e.g., 40% of your grade). Your grade will be based on your total point score, using the table above. During the conduct of the course, all of your examination and homework scores will be posted on Blackboard (usually within a couple of days), to which you can gain access anytime by logging in with your USC login information.

Note that this course can be taken ***only*** for a letter grade; taking the course on a pass/fail basis is not allowed.

Course Schedule: A Weekly Breakdown

Date	Lecture	Facilitated lab work
Week 1 (1-7-2019)	• Motivation • Course overview, expectations, texts	• Introduction to the assigned use-case (sample problem) • Introduction to the concept of systems diagrams, and in particular, to the *context diagram* • Build a context diagram for the assigned use-case, and turn it in as homework
Week 2 (1-14-2019)	• Overview of the method	• Case studies • Systems engineering "views" (graphical representations): DoDAF and SysML Introduction to another system diagram: the N2 chart
Week 3 (1-21-2019)	• Monday 21 January is a Federal holiday • We will have the lecture on Wednesday this week	• (used for a lecture, because of the holiday on Monday) • Requirements definition (part I) • Case studies
Week 4 (1-28-2019)	• Requirements definition (part II)	• Review the context diagrams • Build an N2 chart for the assigned use-case, and turn it in as homework • Introduction to a few more system diagrams, including the basic SYSML diagrams
Week 5 (2-4-2019)	• Design (part I): methodology • Case studies	• Review the N2 charts, etc. • Finish the DoDAF drawing package
Week 6 (2-11-2019)	• Design (part II): analysis methods	• Rhapsody session 1: Creating SysML diagrams using Rhapsody
Week 7 (2-18-2019)	• (Federal holiday)	• (used for a lecture, because of the holiday on Monday) • Design (part III): analysis methods
Week 8 (2-25-2019)	• Implementation and integration; use and disposal	• Review of the course so far
Week 9 (3-4-2019)	• **Mid-term examination**	• (No lab this week)
Week of 3-11-2019	• SPRING BREAK – no classes all this week	• (No lab this week)
Week 10 (3-18-2019)	• Designing the user experience • Testing *redux* • Case studies	• Rhapsody session 2: Creating SysML diagrams using Rhapsody
Week 11 (3-25-2019)	• Lessons-learned: twelve important concepts in systems engineering • Case studies	• Rhapsody session 3: Creating SysML diagrams using Rhapsody
Week 12 (4-1-2019)	• An engineering career: what do we actually do? • Mid-career change / getting ahead	• Rhapsody session 4: Creating SysML diagrams using Rhapsody
Week 13 (4-8-2019)	• Case study: Health-care as a systems-engineering opportunity • Discussion and analysis of the assigned use-case	• Work on the decision-tree example problem

Week 14 (4-15-2019)	• Risk management	• Work on the decision-tree example problem
Week 15 (4-22-2019)	• Summary of the course	• Q&A, in preparation for the final examination
Finals week (probably 5-6-2019)	• **Final examination**	• (no lab this week)

Additional Policies

Late homework assignments will usually be marked down for every day late; in general, ***no*** homework assignments will be accepted more than ***3 days after the due date***. The professor will try to make accommodation for legitimate personal crises. The professor, however, has no obligation to do so; such accommodation is at his discretion.

The professor will always endeavor to treat his students with respect and dignity; he expects that you will do the same, both to him, and to the other students in the class. He invites questions and discussion, but reserves the right to structure the course and the class time as he sees fit, including the right to request that a student take a line of discussion "off-line" to office hours if the professor believes that this line of discussion is not of general interest to the class, or not contributing to the established teaching objectives for this course.

To quote from a USC guidebook: "Behavior that persistently or grossly interferes with classroom activities is considered disruptive behavior, and may be subject to disciplinary action. Such behavior inhibits other students' ability to learn and an instructor's ability to teach. A student responsible for disruptive behavior may be required to leave class pending discussion and resolution of the problem, and may be reported to the Office of Student Judicial Affairs for disciplinary action."

USC Viterbi School Honor Code

The following is the USC Viterbi School honor code:

Engineering enables and empowers our ambitions and is integral to our identities. In the Viterbi community, accountability is reflected in all our endeavors.

Engineering+ Integrity.
Engineering+ Responsibility.
Engineering+ Community.
Think good. Do better. Be great.

These are the pillars we stand upon as we address the challenges of society and enrich lives.

This honor code was developed by Viterbi students.

In your written homework, please be sure to cite any referenced sources appropriately. We will not look kindly on plagiarism or cheating; we will hold you to the highest standards in this regard, and you will receive a grade of zero for the assignment if you are caught cheating or plagiarizing, which will result in a lowered or failing grade for the class. You will also be reported to the appropriate University office for plagiarizing, which could result in further sanctions, including suspension or expulsion from school. Don't do it.

The same, of course, applies to the examinations; you are expected to do your own work during the examination. The only legitimate sources of information about what to expect on the examinations are the professor and the TA currently assigned to the course.

Statement on Academic Conduct and Support Systems

Academic Conduct:
Plagiarism – presenting someone else's ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in *SCampus* in Part B, Section 11, "Behavior Violating University Standards" https://policy.usc.edu/scampus-part-b/. Other forms of academic dishonesty are equally unacceptable. See additional information in *SCampus* and university policies on scientific misconduct, http://policy.usc.edu/scientific-misconduct.

Support Systems:
Student Counseling Services (SCS) - (213) 740-7711 – 24/7 on call
Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention. https://engemannshc.usc.edu/counseling/

National Suicide Prevention Lifeline - 1-800-273-8255
Provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week. http://www.suicidepreventionlifeline.org

Relationship & Sexual Violence Prevention Services (RSVP) - (213) 740-4900 - 24/7 on call
Free and confidential therapy services, workshops, and training for situations related to gender-based harm. https://engemannshc.usc.edu/rsvp/

Sexual Assault Resource Center
For more information about how to get help or help a survivor, rights, reporting options, and additional resources, visit the website: http://sarc.usc.edu/

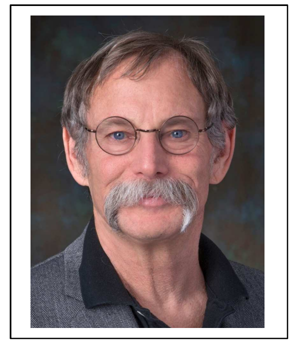
Office of Equity and Diversity (OED)/Title IX compliance – (213) 740-5086
Works with faculty, staff, visitors, applicants, and students around issues of protected class. https://equity.usc.edu/

Bias Assessment Response and Support
Incidents of bias, hate crimes and microaggressions need to be reported allowing for appropriate investigation and response. https://studentaffairs.usc.edu/bias-assessment-response-support/

Student Support & Advocacy – (213) 821-4710
Assists students and families in resolving complex issues adversely affecting their success as a student EX: personal, financial, and academic. https://studentaffairs.usc.edu/ssa/

Diversity at USC – https://diversity.usc.edu/
Tabs for Events, Programs and Training, Task Force (including representatives for each school), Chronology, Participate, Resources for Students

About the professor



Neil Siegel, Ph.D. is the IBM Professor of Engineering Management, in the Daniel Epstein Department of Industrial and Systems Engineering, at the Viterbi School of Engineering at USC. He was for many years the sector vice-president & chief technology officer at Northrop Grumman, at times responsible for as many as 12,000 engineers and scientists. Dr. Siegel has been responsible for a large number of successful military, Government, and commercial systems, including the Army's Blue-Force Tracking system, the Army's first unmanned aerial vehicle, the Counter-Rocket-Artillery-and-Mortar system, and many others.

These systems have repeatedly been cited as model programs and important National capabilities. He also led work for the steel industry, the movie industry, and other commercial enterprises. He has a large number of inventions that have been implemented into fielded U.S. Government products and systems (and also in commercial products by companies like Garman and Apple), and holds more than 20 issued patents. Several elements of these patents have been widely adopted, and are used in a billion devices around the world, such as smart-phones, GPS receivers, tablet computers, and so forth.

His expertise is recognized by the U.S. Government, as indicated by past membership on the Defense Science Board, the Army Science Board, and other senior government advisory panels.

His many honors include:

- Election to the U.S. National Academy of Engineering
- Member of the U.S. National Academy of Inventors
- Election as a Fellow of the IEEE
- Selection as a member of the National Academy of Inventors
- The IEEE Simon Ramo Medal for systems engineering and systems science
- The Army's Order of Saint Barbara
- The iCMG award for system architecture
- The Northern Virginia Technology Council CTO-of-the-year award
- His (former) company's Chairman's Award for Innovation (three times)

Programs that he has led have also won many honors, including the inaugural Crosstalk award as the best-ran software program in the entire U.S. government, the IDGA award as the "Most Innovative U.S. Government Program", and the Federal 100 Monticello Award.

His personal research contributions have centered around how to implement large, mobile, ad-hoc radio networks over relatively low data-rate carriers, focusing on what he calls "infrastructureless" networks (e.g., wireless radio-frequency networks that have no fixed infrastructure, such as cell-phone towers, repeaters, etc.) and techniques for achieving acceptable dynamics through what he calls "force-structure-aware" networks. He has been a pioneer in large-scale deployments of GPS-enabled applications (like the Blue-Force Tracking system). Much of his recent research has made contributions in the field of improving development methodology for large-scale systems, through the identification of novel root-causes of system-development failures, new methods to correct those root-causes, and application of those new techniques to problem domains such as health, energy, and Government information systems.