UNIVERSTY OF SOUTHERN CALIFORNIA
COURSE OBJECTIVES AND REQUIREMENTS
SYSTEMS ENGINEERING THEORY AND PRACTICE (SAE 541)

Instructor: Dr. Robert Minnichelli

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(urgent use only – use DEN Discussion Board for most questions, Email for more private discussions like grading, issues, etc.)

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Office Hours: Friday 3:00-4:00 PT via BlueJeans? (TBR – details to follow)

Teaching Assistant: TBD

Phone:

Office Hours:

Email:

Class:

References:

Required:

1. International Council of Systems Engineering, *Systems Engineering Handbook: A Guide for System Life Cycle Processes and Activities,* 4th Edition, 2015. Hardcopy from Wiley, or online from INCOSE.org (electronic version is free with student membership or for USC students; instructions for USC student download is provided in DEN SAE 541 course area)
2. Department of Defense Acquisition University, *Systems Engineering Fundamentals,* 2001. (http://spacese.spacegrant.org/SEModules/Reference%20Docs/DAU_SE_Fundamentals.pdf)
3. *NASA Systems Engineering Handbook,* NASA/SP-2007-6105 Rev1, December 2007 (http://www.acq.osd.mil/se/docs/NASA-SP-2007-6105-Rev-1-Final-31Dec2007.pdf)

Recommended:

4. *Systems Engineering and Analysis,* 5th Edition, Blanchard and Fabrycky, Prentice Hall, 2011.
5. *Defense Acquisition University Guidebook,* Chapter 4, "Systems Engineering", 2013. (free online: https://acc.dau.mil/docs/dag_pdf/dag_ch4.pdf)
6. Other references will be uploaded to DEN, a few to be assigned as required readings throughout the course.

Other Resources:

USC Distance Education Network (DEN): http://gapp.usc.edu/den

USC DEN Desire2Learn: https://www.uscden.net/

Administrative:

DEN Exams and Proctoring,	denexam@usc.edu, (213) 821-3136 Fax: (213) 821-0851
Instructional Support Center,	dennotes@usc.edu. (213) 740-9356
Technical Support, Online Services, Webcast Problems, Software Questions or General Technical Questions	webclass@usc.edu (213) 821-1321

Course Description:

Systems engineering is the engineering discipline dedicated to the integrated system design from a holistic perspective. It involves viewing the system problem space in its entirety from the initial concept throughout the lifecycle to retirement. As systems and system of systems grow in complexity, the importance of an interdisciplinary approach that takes in consideration stakeholder's needs, design, cost, production, safety, quality, test, implementation and the impact of the system's use in the environment, becomes increasingly important.

This course will acquaint the student with both the theory and practice of the discipline of systems engineering and the systems engineering design approach to devise a system solution, which meets customer/stakeholder objectives optimally within available resources. The course will discuss solving open-ended problems, employing creativity, formulating of problem and need statements and requirements, management of complex systems requirements, examining alternative solutions, utilizing concurrent engineering design, and considering a variety of realistic constraints, such as economic (business case) factors, safety, reliability, aesthetics, environmental, ethics, social impact, production, and operations.

Among the topics to be covered in the class are:

- Perspectives of Systems, System Types and the System Architecture
- The Value of Systems Engineering
- Systems Engineering Process, Acquisition, & Life Cycle Models
- Systems Engineering Standards
- The Systems Approach
- Requirements & Functional Analysis
- Synthesis & Architecting
- Systems Analysis and Control
- Model Based System Engineering
- Integration, Verification, Validation, and Test
- Real World Considerations & Advanced Topics

Course Objectives:

Scope

Systems engineering is a multi-disciplined approach to transform operational needs and requirements into an integrated system design solution through the concurrent considerations of the entire enterprise and life cycle of the system under consideration. This course will acquaint you with concept of systems and the role systems engineering plays in their development. It will also provide a basic framework for problem solving and integrated enterprise thinking within the systems engineering process.

It is the intent of this course to give the student a strong foundation in the fundamentals of system engineering, and at the same time, introduce the student to innovative systems approach to problem solving and team leadership.

Goals

1. Establish an understanding of basic system and systems engineering concepts and terms.
2. Introduce systems engineering as a problem solving process / approach and its relationship to program life cycle.
3. Instill in the minds of the students that systems engineering is holistic thinking.
4. Understand the systems engineering technical processes and their interactions.
5. Produce various systems engineering artifacts.
6. Reflect the systems engineering principles in the development of artifacts.
7. Understand useful theories, models, techniques and tools.
8. Address design for operational feasibility (specialty engineering) concepts.
9. Enable the students to develop their enterprise thinking and leadership skills by developing a class project at a level that could be presented to professional organizations or as an initial acquisition initiative.

Course Highlights:

1. Homework assignments
2. Midterm exam / Final exam
3. Group and individual projects

These activities are to provide a valuable learning experience by demonstrating your knowledge, comprehension, application, analysis, synthesis, and evaluation of the subject material. You will be expected to apply systems thinking and utilize the systems engineering process during the course.

Course Grading:

USC Grading Policies shall be followed. The course activity breakdown is as follows:

Homework Assignments	20%
Midterm/Final exam	40%

Group/Individual Project 40%

All assignments will be submitted through DEN Desire2Learn for this class, unless otherwise noted by the instructor or teaching assistant. Please use Microsoft Word or PowerPoint or PDF documents for your submitted assignments.

Unless otherwise noted by the instructor or teaching assistant, homework is due at 10:00 am PT on the day of the lecture (Tuesday) following the week that it is assigned. Please consult the teaching assistant or instructor before the day the homework is due if there are special circumstances that prevent you from submitting homework on time.

Academic Integrity Statement - The School of Engineering adheres to the University's policies and procedures governing academic integrity as described in USC Campus. Students are expected to be aware of and to observe the academic integrity standards described in USC Campus, and to expect those standards to be enforced in this course: scampus.usc.edu

Students with Disabilities:

Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to me (or to TA) as early in the semester as possible. DSP is located in STU 301 and is open 8:30 a.m. - 5:00 p.m., Monday through Friday. The phone number for DSP is (213)740-0776.

Classroom Courtesies:

Standard classroom courtesies are expected from students attending the lectures on campus. Cell phone use and conversations among students are not allowed. These practices are distracting to the on-going lecture. These courtesies also extend to DEN students who should mute their phones during lecture when not speaking to the class.

Plagiarism:

University policies on plagiarism are in effect. For the final project paper, material may not be directly extracted from web sites or other sources, including internal company documents unless properly cited. Quotations within quotation marks are expected and references cited. Papers will be submitted to turnitin.com.

Planned Course Schedule (subject to change):

Mtg #	Topic	Reading and Homework Assigned
1 Aug 25	Course Overview // Introduction to Systems Engineering Concepts	INCOSE SEH, Ch. 1&2 DoD SE Fundamentals, Ch. 1&2 NASA SEH, Ch. 1&2 HW #1 (incl. "book report" topic)
2 Sep 1	Systems Engineering Processes Overview & Life Cycles // Value of Systems Engineering // "Book Report" selection due	INCOSE SEH, Ch. 3 DoD SE Fundamentals, Ch. 3 NASA SEH, Ch. 3 HW #2 (incl. proposed team project topic)
3 Sep 8	Stakeholders, Needs, Scope, and CONOPS // Proposed project topic due	INCOSE SEH, Ch. 4.1-4.2 DoD SE Fundamentals, Ch. 4.1 NASA SEH, Ch. 4.1 HW #3 (incl. prioritized teaming topics)
4 Sep 15	Requirements Analysis and Development // Prioritized team topics due early	INCOSE SEH, Ch. 4.3 DoD SE Fundamentals, Ch. 4 NASA SEH, Ch. 4.2, 6.2, App. C HW #4 (incl. one artifact of team mtg)
5 Sep 22	Functional Analysis and Allocation	INCOSE SEH, Ch. 4.3 DoD SE Fundamentals, Ch. 5 NASA SEH, Ch. 4.3, App. F HW #5
6 Sep 29	Design Synthesis and System Architecting // "Book Report" due	INCOSE SEH, Ch. 4.4-4.5 DoD SE Fundamentals, Ch. 6 NASA SEH, Ch. 4.4, 7.2-7.3, App. O HW #6 (incl. "book report")
7 Oct 6	Systems Analysis and Control	INCOSE SEH, Ch. 4.6, Ch. 5 DoD SE Fundamentals, Ch. 9-12 NASA SEH, Ch. 6.4-6.7 HW #7
8 Oct 13	Team presentations / feedback / review	DoD SE Fundamentals, Ch. 13-15 HW #8 (incl. term paper topic selection)
9 Oct 20	Midterm Exam (Open Book, Proctored) // Term paper topic due	HW #9 (just term paper abstract/ref.)
10 Oct 27	Interface analysis // Implementation, Integration, & Transition // Term paper draft abstract and preliminary reference list due	INCOSE SEH, Ch. 4.7-4.14, 9.6-9.7 NASA SEH, Ch. 5.1-5.2, 5.5, 6.3, App H, L HW #10
11 Nov 3	Verification, Validation, & Test // Mission Assurance	INCOSE SEH, Ch. 4.9, 4.11 DoD SE Fundamentals, Ch. 7 NASA SEH, Ch. 5.3-5.4, App. D, E, I HW #11
12 Nov 10	Model-Based Systems Eng. Guest Lecturer: M. Sievers (SAE547)	INCOSE SEH, Ch. 9.1-9.5 HW #12

13 Nov 17	Decision Analysis and System Architecture Value Functions // Cost Analysis	INCOSE SEH, Ch. 5.3 NASA SEH, Ch. 4.3, 6.2, 6.8 HW #13 (incl. term paper)
14 Nov 24	Specialty Engineering, Security // Focused Final Exam Topic List // Term papers due	INCOSE SEH, Ch. 10 HW #14
15 Dec 1	SE Applications // Review / Final Exam focus areas	
No Class Dec 8	USC "Study Day"	
16 Dec 15	Final Exam (open book, proctored)	

Book Report: (Optional, Extra Credit)

Select one book from the list below that you haven't read before signing up for this class:

- Donella Meadows, "Thinking in Systems: A Primer", 2008. 240 pages.
- Hammond and Keeney, "Smart Choices: A Practical Guide to Making Better Decisions", 2002. 256 pages.
- Peter Bernstein, "Against the Gods: The Remarkable Story of Risk", 1998. 400 pages.
- Maier and Rechtin, "The Art of Systems Architecting", 3rd Edition, 2009. 472 pages.

None of these teach systems engineering processes the way we study them in this class. They are all somewhat peripheral, but definitely related, to the core topics in this class. And they are all relatively easy reading (although they all take work to put into practice).

Identify your selected book at Week 2 as part of homework #1. Submit your "book report" (2-3 pages) in Week 6 as part of homework #5. Your report should address the question: How do the concepts in this book relate to the system needs and requirements development process? It should also refer to and integrate into the theme at least 3 concepts or quotes from different parts of the book.

This should be a fun assignment that lets you explore a peripheral topic of interest while integrating it into your "systems thinking" approach.

Team Project (20% of course grade):

During weeks 3 – 8, we'll divide into 6-7 teams of 4-5 students (or "groups" in Desire2Learn) to conduct team projects. Each team will develop a specification for a new capability of some sort that goes beyond currently available capabilities and present that spec in a 12-minute presentation in the style of an abbreviated

requirements review. You can develop a whole new concept, or you can develop the "next generation" of an existing capability, with some clear advances not currently available. It's o.k. if the concept is one that others have considered, and even tried to develop, as long as it has not been successfully implemented yet.

Just to give you some starting ideas and the type of projects envisioned, here are a few potential topics. You definitely should not limit yourself to this list.

- A drought-sensitive urban water distribution system
- Formula race car with some innovative (could be fictional) new technology
- Next generation smart home system
- Next generation smart car system
- A commercially-oriented GPS-like or GPS-augmentation (space) system
- A UAV system to enhance large event security
- A single, innovative, high-tech ride at an amusement park
- An entire new theme park focused on wiz-bang technology
- A college campus secure transportation system
- Next generation DEN system for USC Viterbi

Please do not use projects from your work. You can use projects from other people's work if there is sufficient openly published information that you don't need to pursue proprietary information, and if the implementation is still undetermined.

Teaming approach: As part of HW#2 (due week 3), each student individually develops a proposed topic to the one-chart level that can be distributed to the class and includes:

- Title / Topic
- 3-5 bullet preliminary summary of needs (no implementation)
- 3 different potential approaches to implementation that could be studied (preliminary – these don't need to carry over to the group's approach to the overall project)
- Two specific potential one-hour weekly meeting times (PT) you would be willing to help organize (your group may use one or both of these, and that may vary week by week depending on the activity)
- Any other supporting background or information that will fit on the one chart that you wish to include….

I will quickly review and potentially combine any very similar proposals, then make them available to the class and distribute a prioritization form. (Note: your one-chart summary does demonstrate some system concept thinking and will be graded along with the rest of HW#2.)

As part of HW#3 (due week 4), each student fills out the prioritization form, identifying 1 through N preference of which topics they would like to team on – the top criteria should be to prioritize topics whose meeting times you can actually make if assigned to

that team. I will then group students into teams based on the highest-interest topics. The team should meet at least once as quickly as possible because…

As part of HW#4 (due week 5), each student includes one artifact that the group generated during its first meeting, preferably a preliminary project schedule with at least some individual assignments. While every student should try to make all the team meetings, if you really have to miss the first one, it doesn't mean you fail this exercise; it means you need to take the initiative to contact and discuss the meeting with a teammate after the fact (and then try harder to contribute the next week…). DEN resources will be available to support collaborative, distance meetings. In addition, some of the homework questions in HW#4-7 will have you apply the week's concepts to your project. These questions you should discuss and work on as a team, but still submit individually.

During week 8 class, the team makes a 12-minute presentation of their results to the class. Team submits one "specification" and one presentation the following day (any significant but simple feedback from the presentation can be incorporated in this next-day update). Format of submissions will be discussed in class in advance.

As part of HW#8 (due week 9), each student rates each teammate:

- Exceeded expectations and sort of "carried the team"
- "Pulled his or her weight"; contributed substantially and consistently to ideas and discussions – I expect most people to be in this category
- Participated somewhat, minor contributions, but not really significant; this is also how you should rate someone if you really don't know if they contributed or not
- Completely slacked off; just didn't contribute at all, maybe didn't even show up

Grading: The grade of everyone on the team will be dominated by the graded quality of the products and presentation. There may be small individual adjustments up and down due to teammate ratings. I will not indicate if any adjustments were made in the grade provided to the student. Please don't discuss with any teammate before the fact how you will rate another teammate. Please don't discuss your grade on your project with your teammates after the fact – their grade may be different.

Individual Term Paper (20% of course grade):

After the group projects have all been completed and turned in, you will select an individual term paper topic to work on during weeks 9-14. Potential topics include:

- Continuing your group project (but individually) through the design and verification planning phases, potentially refining the spec as well. If multiple people in the team do this, I expect them to explore somewhat different solution approaches.

- Continuing *someone else's* group project through the design and verification planning phases, potentially refining the spec as well.
- Critiquing your own group or another group's analysis approach, generating design review action items, and providing feedback (as though it's going to the team, but it won't) from a "consultant's perspective" on how to improve their SE processes going forward.
- Conducting a system engineering analysis on a system development currently in the news (but not one that you are working on at work…).
- Integrating a discussion or module on ethics applied throughout the SE Process as part of a SE curriculum (like SAE 541) – this could include a brief presentation during the final lecture in addition to the paper

This term paper should be 10-15 pages and be substantiated with references.