SIE 454A/554A: The Systems Engineering Process
Fall 2016
M&W 3-4:15
AME S212

Instructor: Ricardo Valerdi
Office: Old Engineering Building, room 225
Telephone: (520) 621-6561
E-mail: rvalerdi@arizona.edu
Office Hours: Mon and Wed, 2:00-2:45 PM and by appointment.

Teaching Assistants: Harish Krishnan
Office: Old Engineering Building, room TBD
E-mail: harishkrishnan@email.arizona.edu
Office hours: Tues & Thurs, 2-3 PM

Prerequisite: Advanced standing in the College of Engineering; or
SIE 250 Introduction to Systems and Industrial Engineering

Course Description
Processes and tools for engineering large-scale, complex systems: architecture, requirements, risk management, evaluation criteria, concept exploration, decision making, tradeoff studies, life-cycle models, decomposition, system coupling, test, verification, validation, system modeling, business process re-engineering, sensitivity analysis, teamwork, process maturity and documentation.

Course Objectives
This course is aimed at developing your capability of systems thinking by introducing classical and advanced systems engineering theory, methods, and tools. After taking this course, you should be able to:

- Apply systems engineering methodologies & tools to the design of large, complex systems from eliciting customer requirements through disposal
- Apply systems engineering methodologies & tools to a real project for a real customer
- Judge the applicability of any proposed process, strategy, or methodology for systems engineering using the fundamental concepts from disciplines such as probability, economics, and cognitive science
- Understand system engineers' role and responsibilities and their role within organizations
- Understand the dynamics of teams and their role in successful projects
- Recognize the value and limitations of modeling and simulation
- Apply problem solving skills to a variety of puzzles that are representative of real-world challenges
- Communicate effectively with team members and customers through both oral and written means

Required Course Texts

1. Readings based on "Blanchard, B. S. and Fabrycky, W. J., *Systems Engineering and Analysis* (5th Edition), Prentice Hall, 2010." Note: do not purchase the complete book, a custom course reader has been created with selected chapters from the book. It can be purchased at the UA Bookstore or via http://uabookstores.arizona.edu/. On a temporary basis, the book is available to view at: http://www.learningace.com/textbooks/34249-systems-engineering-and-analysis-fifth-edition
2. DeMarco, T. and Lister, T., *Peopleware: Productive Projects and Teams* (3rd Edition), Addison-Wesley Professional, 2013.

Supplemental Resources

Air Force Institute of Technology Systems Engineering Case Studies, http://www.afit.edu/cse/cases.cfm

INCOSE Systems Engineering Handbook

Course Schedule

Lecture	Homework due & Readings
Lecture 1 (Aug 22) – Intro and course overview ▪ Learning style assessment ▪ Course overview ▪ What is systems engineering? ▪ Technology readiness levels	Syllabus review Last year's midterm exam
Lecture 2 (Aug 24) – Systems Theories ▪ Systems thinking ▪ Wymorian theory of SE ▪ Wiener's cybernetic principles ▪ Bertalanffy's General System Theory ▪ Checkland's Soft Systems Methodology	Blanchard & Fabrycky, Ch. 1 Systems Science and Engineering
Lecture 3 (Aug 29) – Product Life Cycles Requirements Engineering Guest lecture: Prof. Joe Valacich Life cycles ▪ Waterfall/Vee/Spiral model ▪ Product development life cycles ▪ Systems engineering standards	Valacich, J. S., Parboteeah, D. V., Wells, J. D., The online consumer's hierarchy of needs, *Communications of the ACM*, 50(9), 2007. Valerdi, R. What is Systems Engineering? *Industrial Engineer*, 24(2), 2012. Braun, W., The System Archetypes, 2002. **HW #1:** Learning styles assessment survey (http://learning.maxmo.net/), 1-slide PowerPoint introduction, 1-page summary of one of the Systems Engineering Case Studies provided
Lecture 4 (Aug 31) – Requirements Engineering ▪ Stakeholder salience ▪ Characteristics of good requirements ▪ Requirements derivation and decomposition ▪ System specification ▪ Functional analysis	Maiden, N., Gizikis, A., Where do Requirements Come From?, *IEEE Software*, Sept/Oct 2001. Blanchard & Fabrycky, Ch. 2 Brining Systems Into Being **HW #2:** Ch.1 questions 1, 2, 5, 6, 7, 8, 9, 16, 18, 26, 30 Ch. 2 questions 7, 8, 13, 16, 18, 25* *You may choose from any of the following three journals: *Systems Engineering*, *IEEE Systems*, or *Information Knowledge & Systems Management*
Labor Day – No Class	

Lecture 5 (Sept 7) – Requirements Engineering ▪ Examples of good and bad requirements ▪ Requirements writing activity Guest lecture: Sophie DeBolt	Blanchard & Fabrycky, Ch. 3 Conceptual System Design **HW #3:** Ch. 3 questions 3, 5, 10, 18
Lecture 6 (Sept 12) – Unintended consequences Guest lecture: Prof. Terry Bahill	
Lecture 7 (Sept 14) Concept selection/trade space exploration ▪ Pugh method ▪ Tradespace exploration	Blanchard & Fabrycky, Ch. 4 Preliminary System Design **HW #4:** Ch. 4 questions 1, 13, 23
Lecture 8 (Sept 19) – Systems engineering case studies	**Deliverable #1:** Project proposals
Lecture 9 (Sept 21) – Detailed Design ▪ Systems engineering modeling ▪ Artifacts ▪ Design reviews	
Lecture 10 (Sept 26) – Verification & validation ▪ Use cases ▪ Test strategies ▪ Test planning & execution	Blanchard & Fabrycky, Ch. 5 Detail Design and Development **HW #5:** Ch. 5 Title questions 4, 13, 18, 21, 22
Lecture 11 (Sept 28) – Decision making ▪ Multi-attribute utility theory ▪ Risk and uncertainty	
Lecture 12 (Oct 3) – System attributes (ilities) and human factors ▪ Reliability & Maintainability ▪ Human systems integration	Blanchard & Fabrycky, Ch. 6 System Test, Evaluation, and Validation **HW #6:** Ch. 6 Title questions 5, 11, 13
Lecture 13 (Oct 5) – Life-Cycle Costing ▪ Design to cost ▪ Activity-based costing ▪ Parametric cost estimation	
Lecture 14 (Oct 10) – Reusability and COTS ▪ Reuse principles ▪ Reuse framework ▪ Commercial-off-the-shelf evaluation	Blanchard & Fabrycky, Ch. 7 Alternatives and Models in Decision Making **HW #7:** Ch. 7 Title questions 16, 17, 20, 35, 39 Wang, G., Valerdi, R. and Fortune, J., "Reuse in Systems Engineering," *IEEE Systems Journal, 4(3)*, 376-384, 2010.
Lecture 15 (Oct 12) – Systems Architecting heuristics ▪ The architecting paradigm ▪ Heuristics as tools ▪ Limitations of heuristics	Rechtin, E., *Systems Architecting: Creating & Building Complex Systems*, Prentice-Hall, 1991.
Lecture 16 (Oct 17) – Engineering Teams ▪ Productivity ▪ Parkinson's Law	Blanchard & Fabrycky, Ch. 8 Models for Economic Evaluation **HW #8:** Ch. 8 Title questions 1, 6, 15, 29 DeMarco & Lister, Ch. 1-9
Lecture 17 (Oct 19) – Engineering Teams ▪ E-factor ▪ Workspaces ▪ Turnover	**HW #9:** Midterm questions DeMarco & Lister, Ch. 10-17

Lecture 18 (Oct 24) – Engineering Teams ▪ High-performing teams ▪ Groupthink, madness of crowds **Midterm exam is distributed**	DeMarco & Lister, Ch. 18-26
Lecture 19 (Oct 26) – Engineering Teams ▪ (De)motivational posters ▪ Delays in process improvement	DeMarco & Lister, Ch. 27-34
Lecture 20 (Oct 31) – Economic Evaluation ▪ Value engineering ▪ Time value of money ▪ Make-buy decisions ▪ Profitability evaluation	
Lecture 21 (Nov 2) – Architectures and architecting ▪ Views ▪ Heuristics ▪ Methods	Blanchard & Fabrycky, Ch. 17 Design for Affordability **HW #10:** Ch. 17 Title questions 2, 9, 12, 13, 18
Lecture 22 (Nov 7) – Process Improvement ▪ Lean, six sigma, theory of constraints ▪ Capability maturity models ▪ Balancing agility and discipline	
Lecture 23 (Nov 9) – Systems Integration & Interfaces	**Deliverable #2:** To be defined based on negotiated scope of final project
Lecture 24 (Nov 14) – Planning & Organization ▪ Systems Engineering Management Plan ▪ Statement of Work	Blanchard & Fabrycky, Ch. 18 Systems Engineering Planning and Organization
Lecture 25 (Nov 16) – Program Management ▪ The iron triangle ▪ Earned Value ▪ PERT carts ▪ Leading indicators for systems engineering	Blanchard & Fabrycky, Ch. 19 Program Management, Control, and Evaluation
Lecture 26 (Nov 21) – Model-Based Systems Engineering, Risk analysis ▪ Object-oriented design ▪ DODAF ▪ Dependency Structure Matrix ▪ Risk assessment/quantification/mitigation	
Lecture 27 (Nov 23) – Soft skills for engineers ▪ Negotiation & interviewing ▪ Personality assessment ▪ Ethics	
Lecture 28 (Nov 28) – System dynamics ▪ Modeling dynamic processes ▪ Firefighting ▪ Management flight simulators	Sterman, J. D., *Business Dynamics: Systems Thinking and Modeling for a Complex World*, McGraw-Hill/Irwin, 2000. Repenning, N., P. Goncalves, and L. Black (2001). Past the Tipping Point: The Persistence of Fire Fighting in Product Development, *California Management Review*, 43, 4: 44-63.
Nov 30, Dec 5 and 7	
Final exam week	Final project report

Homework assignments
There are ten homework assignments, you are responsible for completing all of them. The ten homework assignments are worth 20% of your grade. Assignments must be 2-3 pages in length (single spaced) and must be submitted electronically via the D2L website before each class meeting. Penalties will be applied for late submissions.

Midterm Exam
An exam will be administered approximately two-thirds of the way through the semester to assess progress on learning objectives. Rather than testing memorization, the focus will be on the application of concepts from the first half of the class. Questions for the midterm will be a combination of multiple choice and essay questions generated from student inputs and instructor-generated questions.

Final Project
The best way to learn systems engineering is to apply it to a real situation. You will be expected to find an existing effort where you can apply one or more concepts learned in the class. Deliverables include a project proposal, status report, and final project report. Specific content will be negotiated on a case by case basis. Arrangements may be made for team projects but the content will be commensurate with expected person-effort.

Basis of grade

Component	Weight	Notes
Homework	20%	10 assignments @ 2% each
Midterm	40%	Around the end of October
Final project	40%*	Towards the end of the semester

*Final project grade is comprised of Deliverable #1 (2.5%) + Deliverable #2 (2.5%) + Final written report (35%).

Accessibility and Accommodations
Our goal in this classroom is that learning experiences be as accessible as possible. If you anticipate or experience physical or academic barriers based on disability, please let me know immediately so that we can discuss options. You are also welcome to contact Disability Resources (520-621-3268) to establish reasonable accommodations. For additional information on Disability Resources and reasonable accommodations, please visit http://drc.arizona.edu/.

If you have reasonable accommodations, please plan to meet with me by appointment or during office hours to discuss accommodations and how my course requirements and activities may impact your ability to fully participate.

Please be aware that the accessible table and chairs in this room should remain available for students who find that standard classroom seating is not usable.

Inclusive Excellence is a fundamental part of the University of Arizona's strategic plan and culture. As part of this initiative, the institution embraces and practices diversity and inclusiveness. These values are expected, respected and welcomed in this course.

Threatening Behavior Policy
The UA Threatening Behavior by Students Policy prohibits threats of physical harm to any member of the University community, including to one's self. See: http://policy.arizona.edu/education-and-student-affairs/threatening-behavior-students.

Code of Academic Integrity
Students are encouraged to share intellectual views and discuss freely the principles and applications of course materials. However, graded work/exercises must be the product of independent effort unless otherwise instructed. Students are expected to adhere to the UA Code of Academic Integrity as described in the UA General Catalog. See: http://deanofstudents.arizona.edu/academic-integrity/students/academic-integrity

The University Libraries have some excellent tips for avoiding plagiarism available at: http://www.library.arizona.edu/help/tutorials/plagiarism/index.html

Selling class notes and/or other course materials to other students or to a third party for resale is not permitted without the instructor's express written consent. Violations to this and other course rules are subject to the Code of Academic Integrity and may result in course sanctions. Additionally, students who use D2L or UA email to sell or buy these copyrighted materials are subject to Code of Conduct Violations for misuse of student email addresses. This conduct may also constitute copyright infringement.

UA Nondiscrimination and Anti-harassment Policy
The University is committed to creating and maintaining an environment free of discrimination, http://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy

Our classroom is a place where everyone is encouraged to express well-formed opinions and their reasons for those opinions. We also want to create a tolerant and open environment where such opinions can be expressed without resorting to bullying or discrimination of others.

Subject to Change Statement
Information contained in the course syllabus, other than the grade and absence policy, may be subject to change with advance notice, as deemed appropriate by the instructor.