SAE 549: Systems Architecting   **Summer 2018**

Class Session: Tuesdays, 6:00 pm – 9:10 pm, OHE 136

Class Section: 32322D (DEN/Off-campus) and 32349R (On Campus)

Contact Information:

Instructor: Kenneth Cureton   Teaching Assistant: None
Office hours: Tuesdays, 4:00 – 5:30 PM
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Course Learning Objectives:

- To improve students' ability to think critically, ask the right questions, and apply the right methods when architecting various types of systems.
- To improve students' understanding of the role of system architects and their relationship to systems engineers and transdisciplinary systems engineering.
- To introduce the students to new, advanced multidisciplinary topics (e.g., systems thinking, systems modeling, psychological principles in systems architecting, biologically-inspired architectures, agent-based modeling, human capabilities and limitations) relevant to complex systems architecting.
- To introduce the students to key concepts in performing trade-off analysis which is important to both systems architecting and engineering.

Readings and Notes:

- Weekly lecture notes will be posted on the Desire to Learn (http://courses.uscden.net)
- Required Reader:
  ➤ Rechtin, E. (1991), Systems architecting: Creating and building complex systems. Englewood Cliffs, NJ: Prentice Hall. ISBN: 0-13-880345-5. *Note: This text is out of print, but is available in the USC Bookstore as the "Course Reader" for SAE 549.*
- Required Text:
  ➤ Madni, A.M., "Transdisciplinary Systems Engineering: Exploiting Convergence in a Hyper-Connected World," Springer 2018 *Note: you can download this book through USC Libraries for free.*
- Recommended Reading:
  ➤ Bahill, T. A., Madni, A.M., "Trade-off Decisions in Systems Design" Springer, 2017. *Note: you can download this book through USC Libraries for free.*
  ➤ Maier, M., & Rechtin, E. (2000). The Art of Systems Architecting, Second Edition. Boca Raton, FL: CRC Press e-book ISBN: 978-1-4200-5852-9
  ➤ Maier, M., & Rechtin, E. (2009). The Art of Systems Architecting (3rd ed.). Boca Raton, FL: CRC Press ISBN: 978-1-4200-7913-5
  ➤ Nadler, G., & Chandon, W. (2004). Smart questions: Learn to ask the right questions for powerful results (1st ed.). San Francisco, CA: Josey-Bass ISBN: 978-0787971373

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Grade

Your grade will be based on:

> Homework assignments (total of 4 assignments) = 20%
> Midterm exam = 30%
> Final term paper = 50%

Homework

- Each homework assignment will consist of a few questions that ask students to briefly apply that week's learning to analysis of a hypothetical new system. The homework will be assigned at the end of Lectures #2, #3, #5, and #6 and will be **due before start of class** the following week. Late submissions will receive a maximum of half-credit after the due date/time. Answers to all homework assignments will be reviewed in Lecture #11.

- **Collaboration on the homework assignments is forbidden**. Violators will receive an automatic score of zero for that assignment.

Exam

- The exam will consist of multiple questions that will test students' knowledge about the fundamentals of systems architecting, complex systems, and systems thinking. The exam will be on all the subjects covered in previous lectures and assigned readings. This will be timed exam (2 hours and 40 minutes). The exam will be available on D2L at any time between **Thursday July 5, 2018 at 6:00 AM Pacific Time** and **Sunday July 8, 2018 at 6:00 PM Pacific Time**. Answers to the exam will be reviewed in Lecture #11.

- **Collaboration on the exam is forbidden**. Violators will receive an automatic F for the course.

Term Paper:

The term paper should address the following problem:

Describe and analyze the architecture of a selected system (see below). Your analysis should discuss how the architecting process led to the architecture. The architecting process should address the heuristics used, key tradeoffs, questions posed, people involved, options generated, and decisions made.

> *Submit a maximum 1 page abstract for approval by*
> *June 19, 2018 6:00 PM Pacific Time on your chosen system.*

Student must write on a **specific** system from one of the following categories.

- Automated (Self-Driving) Cars
- Smart Phones or Smart Tablet Computers
- Space Telescopes
- Robotic Systems (including Unmanned Space Exploration)
- Manned Space Transport
- Passenger Aircraft
- Airborne Platforms (Fighter / Bomber Aircraft / Helicopter / Unmanned Aerial Vehicles)

SYLLABUS

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<u>**LENGTH:**</u>   The term paper should be approximately 8 pages (excluding references, appendices, and cover page), single-spaced, single column, standard (1" top and bottom, 1.25" left and right) margins, 12-point Times New Roman type.

<u>**DELIVERY:**</u>   The term paper must be submitted through the Desire to Learn (D2L) system. Links for submitting final paper will be available on D2L (http://courses.uscden.net).

<u>**DEADLINE:**</u> Term papers are due on **August 7, 2018 at 11:59 PM Pacific Time.** *No late papers will be accepted after the due date and time, and the student will receive an automatic F grade for the final paper.*

Collaboration or plagiarism in the term paper is forbidden. Violators will receive an automatic F grade for the final paper.

UNIVERSITY LEVEL ISSUES

- **Statement for 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 GFS 120 and is open 8:30 a.m.–5:00 p.m., Monday through Friday. The phone number for DSP is (213) 740-0776.

- **Statement on Academic Integrity**:
USC seeks to maintain an optimal learning environment. General principles of academic honesty include the concept of respect for the intellectual property of others, the expectation that individual work will be submitted unless otherwise allowed by an instructor, and the obligations both to protect one's own academic work from misuse by others as well as to avoid using another's work as one's own. All students are expected to understand and abide by these principles. *Scampus,* the Student Guidebook, contains the Student Conduct Code in Section 13.00, while the recommended sanctions are located in Appendix A: https://scampus.usc.edu/university-student-conduct-code/. Students will be referred to the Office of Student Judicial Affairs and Community Standards for further review, should there be any suspicion of academic dishonesty. The Review process can be found at: http://www.usc.edu/student-affairs/SJACS/.

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<u>**Schedule of Class Sessions:**</u> Any changes will be announced.

2018	Lecture Topics	Readings
May 22	1. Intro to SAE Program, the course, the instructor, and systems architecting	1. "Preface" from Rechtin, 1991 2. Chapter 1,2, and 3 from Rechtin, 1991 3. Chapter 1 from Madni 2018
May 29	2. System Architecture and Architectural Frameworks	1. Chapter 6 from Madni 2018 2. Chapter 15 from Rechtin 1991 *Submit student bio by 6:00 PM Tuesday May 19, 2018 Pacific Time* *Homework #1 Assigned*
Jun 5	3. Architecture Trade-off Analysis	1. Madni, A.M., Ross, A. "Exploring Concept Trade-offs," Chapter 10 in "Trade-off Analytics," Eds Parnell G., Wiley 2016 2. Ordoukhanian, E, Madni, A.M., "System Trade-offs in Multi-UAV Network", AIAA Space 2015, August 31-Sep 2, 2015, Pasadena, CA *(Google Scholar)* 3. Section 2.3 from Bahill & Madni 2017 4. Chapter 5 from Bahill & Madni 2017 5. Chapter 6 from Madni 2018 *Homework #1 Due by 6:00 PM Tuesday June 5, 2018 Pacific Time* *Homework #2 Assigned*
Jun 12	4. Systems Thinking	1. Madni, A.M. "Generating Novel Options During Systems Architecting: Psychological Principles, Systems Thinking, and Computer-Based Aiding," pages 1-9, *Systems Engineering*, Volume 16, Number 4 2013. *(Google Scholar)* 2. Chapter 2 from Madni 2018 *Homework #2 Due by 6:00 PM Tuesday June 12, 2018 Pacific Time*
Jun 19	5. Heuristics	1. Appendix A from Rechtin 1991 2. Section 2.4 from Bahill & Madni 2017 *Submit abstract by 6:00 PM Tuesday June 19, 2018 Pacific Time* *Homework #3 Assigned*
Jun 26	6. Human-System Integration: Implications for Systems Architecting	1. Madni, A.M. "Integrating Humans With and Within Complex Systems: Challenges and Opportunities," (Invited Paper) *CrossTalk, The Journal of Defense Software Engineering*, May/June 2011, "People Solutions." (Google Scholar) 2. Madni, A. M. 2010. Integrating Humans With Systems and Software: Technical Challenges and Research Agenda. *Systems Engineering*, 13(3): 21. 3. Chapter 11 from Rechtin 1991 4. Chapter 7, Human Performance Enhancement, from Madni 2018 *Homework #3 Due by 6:00 PM Tuesday June 26, 2018 Pacific Time* *Homework #4 Assigned*
Jul 3	7. Modeling, Simulation, and Prototyping	1. Chapter 3 from Rechtin 1991 2. Chapter 5 from Madni 2018 *Homework #4 Due by 6:00 PM Tuesday July 3, 2018 Pacific Time* *Note: Midterm Exam this weekend!*
Jul 10	8. Systems Architecting and Political Process	1. Chapter 12 from Art of Systems Architecting by Maier, M., & Rechtin, E, SECOND Edition. Available for free download through USC libraries.
Jul 17	9. Systems Architecting, Complexity and Complex Systems	1. Section 2.2.7 from Madni 2018

2018	Lecture Topics	Readings
Jul 24	10. Special Topics - Guest Lecture	(none)
Jul 31	11. Case Study and Homework Review	(none)
Aug 7	12. Course Review	1. Madni, A.M. and Sievers, M. Systems Integration: Key Perspectives, Experiences, and Challenges, 2013 2. Madni, A.M., and Sievers, M. "System of Systems Integration: Key Considerations and Challenges." *Systems Engineering* (2013). 3. Chapter 16 from Rechtin 1991 4. Chapter 11 from Madni 2018 ***Final Term Paper Due by 11:59 PM August 7, 2018 Pacific Time***

Assigned Readings List

You can download these papers from Google Scholar or USC Libraries for free.

- Madni, A.M. "Generating Novel Options During Systems Architecting: Psychological Principles, Systems Thinking, and Computer-Based Aiding," pages 1-9, *Systems Engineering*, Volume 16, Number 4 2013

- Ordoukhanian, E, Madni, A.M., "System Trade-offs in Multi-UAV Network", AIAA Space 2015, August 31-Sep 2, 2015, Pasadena, CA

- Simon, H. A. 1976. How Complex are Complex Systems? PSA: Proceedings of the Biennial Meeting of the Philosophy of Science Association, 1976: 507-522.

- Madni, A.M. "Integrating Humans With and Within Complex Systems: Challenges and Opportunities," (Invited Paper) CrossTalk, The Journal of Defense Software Engineering, May/June 2011, "People Solutions."

- Madni, A. M. 2010. Integrating Humans With Systems and Software: Technical Challenges and Research Agenda. Systems Engineering, 13(3): 21.

- Madni, Azad M. "Elegant systems design: Creative fusion of simplicity and power." Systems Engineering 15.3 (2012): 347-354.

- Madni, Azad M., et al. "Toward an Experiential Design Language: Augmenting Model-based Systems Engineering with Technical Storytelling in Virtual Worlds." Procedia Computer Science 28 (2014): 848-856.

- Madni, Azad M. "Expanding Stakeholder Participation in Up-front System Engineering through Storytelling in Virtual Worlds." Systems Engineering 18.1 (2015): 16-27.

- Madni, A.M. and Sievers, M. Systems Integration: Key Perspectives, Experiences, and Challenges, 2013

- Madni, A.M., and Sievers, M. "System of Systems Integration: Key Considerations and Challenges." Systems Engineering (2013).

- Simon, H. A. 1962. The Architecture of Complexity. Proceedings of the American Philosophical Society, 106(6): 467-482.

- Madni, A.M., Ross, A. "Exploring Concept Trade-offs," Chapter 10 in "Trade-off Analytics," Eds Parnell G., Wiley 2016