SAE 549: Systems Architecting   **Spring 2019**

Class Session: Mondays, 3:30 pm – 6:10 pm, OHE 100B

Class Section: 32319D (DEN/Off-campus) and 32349D (On Campus)

Contact Information:

Instructor: Mr. Kenneth Cureton   Grader: Mr. Shatad Purohit
Office hours: Mondays, 1:30 – 3:00 PM   Office hours: Mondays, 1:30 – 3:00 PM
Office location: RAN 215 & Virtual   Office location: RAN 215 & Virtual
Office phone: 213-740-1713   Office phone: 213-740-1713
E-mail: cureton@usc.edu   E-mail: shatadkp@usc.edu

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 Texts: *Note: you can download these books through USC Libraries for free.*

➢ Madni, A.M., "Transdisciplinary Systems Engineering: Exploiting Convergence in a Hyper-Connected World," Springer 2018 *(also available for purchase in the USC Bookstore)*

➢ Bahill, T. A., Madni, A.M., "Trade-off Decisions in Systems Design" Springer, 2017.

➢ 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

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- ■ Required Readings: *Note: you can download these papers via the DEN/D2L or 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

  ➢ Madni, A.M., Madni, C.C. and Sievers, M. "Adaptive Cyber-Physical-Human Systems," 2018 INCOSE International Symposium, July 7-12, 2018.

  ➢ 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, 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).

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

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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 #13.

■ **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 Lectures #1 through #6 and related assigned readings. This will be timed exam (2 hours and 40 minutes). The exam will be available on D2L at any time between **Thursday March 7, 2019 at 6:00 AM Pacific Time** and **Sunday March 10, 2019 at Midnight Pacific Time**. Answers to the exam will be reviewed in Lecture #13.

■ **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 vehicle or phone/tablet (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*
> *February 11, 2019 3:30 PM Pacific Time on your chosen vehicle or phone/tablet.*

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)

Students should **not** propose an individual component or subsystem or process, but an entire vehicle (or phone/tablet) from one of the above categories in the above list.

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LENGTH: 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.

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

DEADLINE: Term papers are due on **May 6, 2019 at Midnight 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.

2019	Lecture Topics	Readings
Jan 7	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
Jan 14	2. **System Architecture and Architectural Frameworks**	1. Chapter 6 from Madni 2018 2. Chapter 15 from Rechtin 1991 *Submit student bio by 3:30 PM Monday Jan 14, 2019 Pacific Time* *Homework #1 Assigned*
Jan 21	**Martin Luther King's Birthday (holiday)**	(no lecture this day)
Jan 28	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 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 3:30 PM Monday Jan 28, 2019 Pacific Time* *Homework #2 Assigned*
Feb 4	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. 2. Chapter 2 from Madni 2018 *Homework #2 Due by 3:30 PM Monday Feb 4, 2019 Pacific Time*
Feb 11	5. **Heuristics**	1. Appendix A from Rechtin 1991 2. Section 2.4 from Bahill & Madni 2017 *Submit abstract by 3:30 PM Monday Feb 11, 2019 Pacific Time* *Homework #3 Assigned*
Feb 18	**President's Day (holiday)**	(no lecture this day)
Feb 25	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." 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 3:30 PM Monday Feb 25, 2019 Pacific Time* *Homework #4 Assigned*
Mar 4	7. **Guest Lecture: Mr. Edwin Ordoukhanian: System Architecting Leadership**	(no readings required) *Homework #4 Due by 3:30 PM Monday Mar 4, 2019 Pacific Time*
Mar 7-10	**Midterm Exam**	*2 hour 40 minute timed exam at any time of your choice between March 7 at 6 AM and March 10 Midnight (Pacific Times)*
Mar 11	Spring Break	(no lecture this day)

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2019	Lecture Topics	Readings
Mar 18	**8. Modeling, Simulation, and Prototyping**	1. Chapter 3 from Rechtin 1991 2. Chapter 5 from Madni 2018
Mar 25	**9. Cyber-Physical Systems**	1. Madni, A.M., Madni, C.C. and Sievers, M. "Adaptive Cyber-Physical-Human Systems," 2018 INCOSE International Symposium, July 7-12, 2018.
Apr 1	**10. Systems Architecting of Complex Systems**	1. Section 2.2.7 from Madni 2018
Apr 8	**11. Guest Lecture: Ms. Marilee Wheaton: Model Based Tradeoffs for Affordable Resilient Systems**	(none)
Apr 15	**12. Case Study and Homework Review**	(none)
Apr 22	**13. 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
Apr 29	**Study Days**	(no lecture this day)
May 6	**Final Exam Week (no exam)**	(no lecture this day) ***Final Term Paper Due by Midnight May 6, 2019 Pacific Time***