SAE 549: Systems Architecting

Class Session: Tuesdays, 3:30 pm – 6:40 pm, Online and Location RTH 109 On-Campus

Class Section: 32332D (DEN/Off-campus) and 32349D (On Campus)

Contact Information:

Instructor: Kenneth Cureton   Teaching Assistant: Shatad Purohit
Office hours: by appointment   Office hours: by appointment
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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 Texts: *Note: you can download these books via the DEN/D2L or USC Libraries for free. They are available in HARDCOPY format via the USC Bookstore, but you can use the PDF versions posted on the DEN site under "References & Readings" or from the USC Libraries*

➤   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. (2009). The Art of Systems Architecting, Third Edition. Boca Raton, FL: CRC Press ISBN 13: 978-1-4200-7913-5 (Hardcopy) or ISBN: 978-1-4200-7913-5 (paperback)

■ 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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<u>**Grade**</u>

Your grade will be based on:

> Homework assignments (total of 5 assignments) ungraded
> Midterm paper = 35%
> Final paper = 65%

<u>**Homework Assignments:**</u>
For five homework assignments, you'll analyze a hypothetical new system, described in the first lecture. You are to analyze that proposed new system using the tools, techniques and concepts presented in each lecture and the assigned readings for that lecture. The expected size of each homework assignment is about 1 page of text (additional artwork is optional and not required.)

The specific analyses are assigned at the end of the first five lectures, and homework will be due before class the following lecture. The homework assignments are required but not graded. They are reviewed, and you will receive comments regarding your answers.

Note that homework assignments are individual efforts. Collaboration on the homework assignments is forbidden.

<u>**Midterm Paper:**</u>
You will combine and integrate your five homework assignments to form a midterm paper in place of a Midterm Exam. More specific instructions regarding this paper will be given in the first class session.

<u>**LENGTH:**</u>   The midterm paper should be approximately 6 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 midterm paper must be submitted through the Desire to Learn (D2L) system. Links for submitting assignments is on D2L (http://courses.uscden.net).

<u>**DEADLINE:**</u>   Midterm papers are due on **July 11, 2023 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 midterm paper.*

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

Final Paper:
The final paper should address the following problem:
Describe and analyze the architecture of a selected system (see below). Your analysis must discuss how the architecting process led to the architecture. The architecting process must address the heuristics used, key tradeoffs, questions posed, people involved, options generated, and decisions made.
   Submit a maximum one page abstract for approval by June 20, 2023 3:30 PM Pacific Time.

You 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)

You 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.

LENGTH: The final 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 final paper must be submitted through the Desire to Learn (D2L) system. Links for submitting assignments is on D2L (http://courses.uscden.net).

DEADLINE: Final papers are due on **August 8, 2023 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 final paper is forbidden. Violators will receive an automatic F grade for the final paper.
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Class Grade

Your class grade is based on the midterm paper (35% of your total grade) and the final paper (65% of your total grade).

Your class grade is computed as follows:

The Midterm Paper score (a maximum of 35 points) is summed with the Final Paper score (a maximum of 65 points). The grand total of points is divided by 25 (to scale your total to a range of four-to-zero):

CLASS SCORE = (MIDTERM PAPER SCORE + FINAL PAPER SCORE) / 25

This class score is converted into a letter grade for the class:

A	4.0 to above 3.7
A-	3.7 to above 3.3
B+	3.3 to above 3.0
B	3.0 to above 2.7
B-	2.7 to above 2.3
C+	2.3 to above 2.0
C	2.0 to above 1.7
C-	1.7 to above 1.5
D+	1.5 to above 1.0
D	1.0 to above 0.7
D-	0.7 to above 0.5
F	0.5 or below.

This letter grade is reported to USC as your class grade.

Schedule of Class Sessions: Any changes will be announced.

2023	Lecture Topics	Readings
May 23	**1. Intro to SAE Program, the course, the instructor, and systems architecting**	1. Preface from Maier & Rechtin, 2009 2. Part I: Introduction from Maier & Rechtin, 2009 3. Chapter 1 from Madni 2018 *Homework #1 Assigned*
May 30	**2. System Architecture and Architectural Frameworks**	1. Chapter 6 from Madni 2018 2. Chapter 11 from Maier & Rechtin 2009 *Submit student bio by 3:30 PM Tuesday May 30, 2023 Pacific Time* *Homework #1 Due by 3:30 PM Tuesday May 30, 2023 Pacific Time* *Homework #2 Assigned*
Jun 6	**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 5.1 from Bahill & Madni 2017 5. Chapter 6 from Madni 2018 *Homework #2 Due by 3:30 PM Tuesday June 6, 2023 Pacific Time* *Homework #3 Assigned*
Jun 13	**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 #3 Due by 3:30 PM Tuesday June 13, 2023 Pacific Time* *Homework #4 Assigned*
Jun 20	**5. Heuristics**	1. Part I Chapter 2 and Appendix A from Maier & Rechtin 2009 2. Section 2.4 from Bahill & Madni 2017 *Submit final paper abstract by 3:30 PM Tuesday June 20, 2023 Pacific Time* *Homework #4 Due by 3:30 PM Tuesday June 20, 2023 Pacific Time* *Homework #5 Assigned*
Jun 27	**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 7, Human Performance Enhancement, from Madni 2018 *Homework #5 Due by 3:30 PM Tuesday June 27, 2023 Pacific Time*
Jul 4	**Independence Day Holiday (no class meeting)**	(none)
Jul 11	**7. Modeling, Simulation, and Prototyping**	1. Part III: Models and Modeling and Chapter 8 from Maier & Rechtin 2009 2. Chapter 5 from Madni 2018 *Midterm Paper Due by 11:59 PM July 11, 2023 Pacific Time*.
Jul 18	**8. 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

2023	Lecture Topics	Readings
Jul 25	**9. Systems Architecting of Complex Systems**	1. Section 2.2.7 from Madni 2018
Aug 1	**10. Systems Architecting of Fault-Tolerant and Trusted Systems**	(none)
Aug 8	**11. 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 3 from Maier & Rechtin 2009 4. Chapter 11 from Madni 2018 ***Final Paper Due by 11:59 PM August 8, 2023 Pacific Time***

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" 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, policy.usc.edu/scientific-misconduct.

Support Systems:

Counseling and Mental Health - (213) 740-9355 – 24/7 on call
studenthealth.usc.edu/counseling
Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.
National Suicide Prevention Lifeline - 1 (800) 273-8255 – 24/7 on call
suicidepreventionlifeline.org
Free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week.
Relationship and Sexual Violence Prevention Services (RSVP) - (213) 740-9355(WELL), press "0" after hours – 24/7 on call
studenthealth.usc.edu/sexual-assault
Free and confidential therapy services, workshops, and training for situations related to gender-based harm.

Office of Equity and Diversity (OED) - (213) 740-5086 | Title IX – (213) 821-8298
equity.usc.edu, titleix.usc.edu
Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants.

Reporting Incidents of Bias or Harassment - (213) 740-5086 or (213) 821-8298
usc-advocate.symplicity.com/care_report
Avenue to report incidents of bias, hate crimes, and microaggressions to the Office of Equity and Diversity |Title IX for appropriate investigation, supportive measures, and response.

The Office of Disability Services and Programs - (213) 740-0776
dsp.usc.edu
Support and accommodations for students with disabilities. Services include assistance in providing readers/notetakers/interpreters, special accommodations for test taking needs, assistance with architectural barriers, assistive technology, and support for individual needs.

USC Campus Support and Intervention - (213) 821-4710
campussupport.usc.edu
Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

Diversity at USC - (213) 740-2101
diversity.usc.edu
Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

USC Emergency - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call
dps.usc.edu, emergency.usc.edu
Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

USC Department of Public Safety - UPC: (213) 740-6000, HSC: (323) 442-120 – 24/7 on call
dps.usc.edu
Non-emergency assistance or information.