SYLLABUS

SAE 549: Systems Architecting **Fall 2024**

Class Session: Monday, 12:00 pm – 2:40 pm

Class Section: 32319D (DEN/Off-campus)

Contact Information:

Instructor: Prof. Azad M. Madni
Office hours: By Appointment Only
Office location: OHE 500T
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Kindly use online discussion boards (available on Brightspace) if you have any questions on course materials, mid-terms, or final exam. The turnaround time to answer questions is 24 hours. The use of email should be limited to emergency situations.

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, human behavior modeling) relevant to complex systems architecting.
- To introduce the students to key concepts associated with trade-off analysis which are important to both systems architecting and engineering.

Readings and Notes:

- Weekly lecture notes will be posted on the Brightspace, the online platform
- Required Texts:
  - Bahill, T. A., Madni, A.M., *"Trade-off Decisions in Systems Design*" Springer, 2016
  - Madni, A.M. *Transdisciplinary Systems Engineering: Exploiting Convergence in a Hyper-connected World*, Springer, 2018
  - Maier, M., & Rechtin, E. (2009). The art of systems architecting (3rd ed.). Boca Raton, FL: CRC Press ISBN: 978-1-4200-7913-5
- Recommended Reading:
  - Madni, A.M. and Augustine, N. (Eds.) Handbook of Model Based Systems Engineering, Springer, 2023

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

Grade

Your grade will be based on two mid-terms (50% of your final grade) *and* a final exam *(50% of your final grade).* The exams will be administered online through Brightspace.

Mid-Term Exams

- Each mid-term 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. Each exam is a timed exam (2 hours and 40 minutes).

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

Final Exam:
The final exam will cover 70% of the material after the second mid-term and 30% of the material from the first 2 mid-terms

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/.

Schedule of Class Sessions: The exact schedule is likely to change, based on availability of guest lecturers. Dates of readings may change to align with other schedule adjustments. Changes will be announced.

2024	Lecture Topics	Readings
Aug 24	SAE Program, Course Overview, Systems Architecting Part 1	-First 4 chapters of Maier and Rechtin, 2009 *Submit student bio by 11:30 AM on Aug 30*
2-Sep	University Holiday – No Class	
9-Sep	Systems Architecting Part 2	-Madni, A.M. Generating Novel Options During Systems Architecting: Psychological Principles, Systems Thinking, and Computer-Based Aiding," Systems Engineering, Volume 17, Number 1, pp. 1-9, 2014.
16-Sep	Transdisciplinary Engineering	-Madni, A.M. Transdisciplinary Systems Engineering: Exploiting Convergence in a Hyperconnected World, Springer 2018
23-Sep	**Mid Term (25%)**	
30-Sep	Guest Lecture – Model-Based Systems Architecting using Dependency Structure Matrix	-Purohit, S. and Madni, A.M. A Model-Based Systems Architecting and Integration Approach Using Interlevel and Intralevel Dependency Matrix, in *IEEE Systems Journal*, 2021, doi: 10.1109/JSYST.2021.3077351. -Madni, A.M. and Sievers, M. Model-Based Systems Engineering: Motivation, Current Status, and Research Opportunities, *Systems Engineering*, Vol. 21, Issue 3, p. 172-190, 2018.
7-Oct	Role of Heuristics in Systems Architecting and Ontology-Enabled Systems Architecting	-Appendix A of Rechtin 1991 -Section 2.4 of Bahill & Madni 2017 -Madni, A.M. Minimum Viable Model to Demonstrate the Value Proposition of Ontologies for Model Based Systems Engineering, 2020 Conference on Systems Engineering Research, Redondo Beach, CA, Oct 8-10, 2020.
14-Oct	Guest Lecture – Ontology-Enabled Hardware-Software Testbed for Engineering Adaptive Systems	Ordoukhanian, E. and Madni, A.M. Ontology-Enabled Hardware-Software Testbed for Engineering Adaptive Systems, In Madni, A.M. er al., (Eds.) Recent Trends and Advances in Model Based Systems Engineering, Springer, 2022
21-Oct	**Mid Term (25%)**	
28-Oct	Role of Digital Twin Technology in SA/SE	Madni, A.M., Madni, C.C., and Lucero, D.S. Leveraging Digital Twin Technology in Model-Based Systems Engineering, MDPI Systems, special issue on "Model-Based Systems Engineering," 7(1), 7, 2019.
4-Nov	Human-System Integration: Implications for Systems Architecting	Madni, A.M. "Integrating Humans with and Within Software and Systems: Challenges and Opportunities," (Invited Paper) *CrossTalk, Journal of Defense Software Engineering*, May/June 2011, "People Solutions." Madni, A.M. "Integrating Humans with Software and Systems: Technical Challenges and a Research Agenda," *Systems Engineering*, Vol. 13, No. 3, pp. 232-245, Autumn (Fall) 2010.

11-Nov	University Holiday – No Class	
18-Nov	Guest Lecture – Software Defined Vehicles	S. Purohit, A. Madni, A. Adiththan and A. M. Madni, "Digital Twin Integration for Software Defined Vehicles: Decoupling Hardware and Software in Automotive System Development," 2023 IEEE International Conference on Systems, Man, and Cybernetics (SMC), Honolulu, Oahu, HI, USA, 2023, pp. 1259-1264, doi: 10.1109/SMC53992.2023.10394507.
25-Nov	Augmented Intelligence and Human-Machine Teaming Architectural Framework	Madni, A.M. Exploiting Augmented Intelligence in Systems Engineering and Engineered Systems, *INSIGHT Special Issue*, Systems Engineering and AI, April 2020, https://doi.org/10.1002/inst. 12282.
2-Dec	**Final Exam (50%)**	

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," *Systems Engineering*, Volume 17, Number 1, pp. 1-9, 2014.
- Madni, A.M., Madni, C.C. and Sievers, M. "Adaptive Cyber-Physical-Human Systems," 2018 INCOSE International Symposium, July 7-12, 2018.
- Madni, Azad M., and Michael Sievers. "Chapter 1 System of Systems Integration: Fundamental Concepts, Challenges and Opportunities." 1-34.
- Madni, A.M., Sievers, M. "Model-based systems engineering: Motivation, current status, and research opportunities", INCOSE 20th Anniversary Special Issue, 2018
- Madni, A.M., Erwin, D., and Sievers, M. Constructing Models for Systems Resilience: Challenges, Concepts, Formal Methods, and Illustrative Examples, *Systems*, 2020, *8*,3; doi:10.3390/systems8010003
- Trujillo, A. and Madni, A.M. MBSE Methods for Inheritance and Design Reuse, in *Handbook of Model Based Systems Engineering* Madni, A.M. and Augustine, N. (Eds.), Springer 2023
- Wheaton, M. and Madni, A.M. Modeling of Case Studies for Dynamic Exploration of Alternate Outcomes, 2021 AIAA SciTech, Nashville, Tennessee, Jan 11-15, 2021.
- Madni, A.M. Exploiting Augmented Intelligence in Systems Engineering and Engineered Systems, *INSIGHT Special Issue*, Systems Engineering and AI, April 2020, https://doi.org/10.1002/inst. 12282.
- Madni, A.M., Madni, C.C., and Lucero, D.S. Leveraging Digital Twin Technology in Model-Based Systems Engineering, MDPI *Systems*, special issue on *"Model-Based Systems Engineering,"* 7(1), 7, 2019.
- Madni, A.M. "Integrating Humans with and Within Software and Systems: Challenges and Opportunities," (Invited Paper) *CrossTalk, Journal of Defense Software Engineering*, May/June 2011, "People Solutions."
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- Ordoukhanian, E. and Madni, A.M. Ontology-Enabled Hardware-Software Testbed for Engineering Adaptive Systems, In Madni, A.M. er al., (Eds.) Recent Trends and Advances in Model Based Systems Engineering, Springer, 2022
- Madni, A.M. Minimum Viable Model to Demonstrate the Value Proposition of Ontologies for Model Based Systems Engineering, 2020 Conference on Systems Engineering Research, Redondo Beach, CA, Oct 8-10, 2020.
- Purohit, S. and Madni, A.M. A Model-Based Systems Architecting and Integration Approach Using Interlevel and Intralevel Dependency Matrix, in *IEEE Systems Journal*, 2021, doi: 10.1109/JSYST.2021.3077351.
- Madni, A.M. and Sievers, M. Model-Based Systems Engineering: Motivation, Current Status, and Research Opportunities, *Systems Engineering*, Vol. 21, Issue 3, p. 172-190, 2018.
- Madni, A.M. Generating Novel Options During Systems Architecting: Psychological Principles, Systems Thinking, and Computer-Based Aiding," *Systems Engineering*, Volume 17, Number 1, pp. 1-9, 2014.
- Madni, A.M., Sievers, M. and Madni, C.C. Adaptive Cyber-Physical-Human Systems: Exploiting Cognitive Modeling and Machine Learning in the Control Loop, *INSIGHT*, Vol. 21, Issue 3, pp. 87-93, 2018.