TRASEE™: Educational Paradigm of the SAE Program

Transdisciplinary Systems Engineering Education (TRASEE) paradigm is the educational paradigm underlying USC’s Systems Architecting and Engineering (SAE) Program. This paradigm is based on *Transdisciplinary Systems Engineering: Exploiting Convergence in a Hyperconnected World*, written by Professor Azad Madni, University Professor and Executive Director of the SAE Program, University of Southern California. It addresses the needs of 21st century systems engineering workforce and the proclivities of 21st century learners. Its three transdisciplinary pillars are:

- 21st Century Mindset
- Storytelling as a Pedagogical Strategy
- Hands-On Learning with Digital Twins

**21st Century Mindset:** TRASEE exploits concepts from cognitive psychology, biology, social sciences, and economics to expand the frontiers of systems engineering thinking. It is based on developing an innovation-oriented mindset for the 21st century workforce. It emphasizes the development of interdisciplinary skills and leadership qualities that balance *opportunism* and *pragmatism* when making decisions especially in the face of uncertainty and ambiguity. It fosters the development of specific leadership qualities during systems engineering including the ability to envision and evaluate alternate futures before making decisions in the present, engaging in and learning from self-reflection, and resisting the tendency to become enamored with one’s own ideas. It offers strategies to counter such cognitive biases (e.g., explicitly address worst case scenarios).

**Storytelling-Enabled Teaching Approach:** TRASEE exploits storytelling concepts from the entertainment and cinematic arts in its teaching approach. Through this approach, it transforms relatively passive instructor-led lectures into interactive storytelling and role-playing exercises that foster learner engagement, and material retention and recall. Students are encouraged to envision and evaluate alternate futures as a means to inform and guide decision-making and action-taking in the present. It views stories as a means not just to educate, but to inspire and motivate learners. Stories in the form of vignettes (i.e., mini-scenarios) presented in the classroom provide context for question-answering while making the class interactive and the learning experience enjoyable. By wrapping stories around systems engineering, engineering concepts are remembered in context, making them easier to recall and apply at some later point in time. TRASEE combines storytelling with *principles from the learning sciences*: learning should be learner-centric; learning should build on prior knowledge; and learning should allow the learner to extrapolate the material learned to new problem situations. Students quickly learn that stories are an effective means for eliciting and sharing tacit knowledge and building and engaging communities of learners in shared practices, while exploring new practices through changes in what-if assumptions and conditions. Stories are an effective enabler of
interdisciplinary skills acquisition. They also provide ample opportunities (e.g., decision-making with partial information) for practicing engineering leadership. TRASEE emphasizes that stories are an effective means for capturing historical lessons and lessons learned, and are an effective vehicle for continuous improvement in engineering decision making. When executed in simulation, stories enable discovery of new knowledge as alternate futures are explored with what-if conditions. In this sense, stories become effective “experience accelerators.” TRASEE also employs stories to convey abstract concepts such as “ethics,” and “societal norms” and “culture.” Ultimately, storytelling is an effective pedagogical strategy with self-reflective properties that encourages and enhances critical thinking and systems thinking.

**Hands-on Learning with Digital Twins:** TRASEE exploits key concepts such as digital twins from digital engineering (DE) to afford rich hands-on learning opportunities to students in SAE’s Distributed Autonomy and Intelligent Systems Laboratory (DAIS). The creation and application of digital twins within a Model Based Systems Engineering (MBSE) rubric allows students to increase their knowledge of system verification and validation testing while exploiting the growing convergence of MBSE and DE.

SAE courses, built on this foundational paradigm, have been disseminated within the program and the systems engineering communities at large through various means including INCOSE and IIESE webinars, keynotes and invited presentations, international conferences, aerospace companies, and IEEE SMC Technical Committee on MBSE.