SYS 660: Decision and Risk Analysis

School of Systems and Enterprises
Fall 2023

Instructor:	Ting Liao, Assistant Professor
Course Website:	Canvas course webpage
Meeting Times:	Thursdays 3:30-6:00 pm
Classroom Location:	Gateway North 213
Contact Info:	tliao@stevens.edu
Office Hours:	1:00 – 2:30 PM Tuesday, North Building 220 or virtual RSVP via https://calendly.com/tliao-01/15min
TA:	Hossein Taramsari
TA Contact Info:	hbasereh@stevens.edu
TA Office Hours:	2:00 – 3:30 PM Monday in Babbio 503 or https://stevens.zoom.us/j/4538849267online

COURSE DESCRIPTION

The systems engineering process is not just a logical approach to designing and developing a system. It is also a phased approach to risk reduction. Each phase provides an opportunity to identify and manage technical and programmatic risks to the successful realization of the system. This necessarily means making tradeoffs between alternative approaches under uncertainty, both technical and programmatic. Generally, the greater the impact of the decision, the more effort it is worth expending to make the decision. This course will address techniques for making such high-impact decisions under uncertainty.

STUDENT LEARNING OUTCOMES

After successful completion of this course, students will be able to:

- Model a decision
- Make a value-based decision
- Model uncertainty
- Make a decision under uncertainty
- Identify, prioritize, and manage risks

COURSE FORMAT AND STRUCTURE

- The course will meet weekly for a 2.5-hour lecture/discussion session.

- Live attendance and participation are required (see Participation section on page 3).
- Most sessions involve in-class group discussions and activities.
- Slides will be posted on Canvas after class.
- The topics covered deal with unstructured problems and subjective assessments. In many cases, there are no strictly right or wrong answers. Consequently, the mid-term and final project will be open-ended, and you will be evaluated on how you approach the problems, not necessarily your answer.

TENTATIVE COURSE SCHEDULE

Week	Date	Topic(s)	Readings	Assigned	Due
1	9/7	Introduction: Decision and Risk Analysis in Systems Engineering	Clemen: Ch 1-2		
2	9/14	Structuring a Decision	Clemen: Ch 3	HW 1	
3	9/21	Tradeoffs under Certainty	Clemen: Ch 4-5	HW 2	HW 1
4	9/28	Probability Refresher	Clemen: Ch 7,11	HW 3	HW 2
5	10/5	Subjective Probability and the Value of Information	Clemen: Ch 8,12	HW 4	HW 3
6	10/12	Multi-Attribute Utility Theory	Clemen: Ch 14-17	HW 5	HW 4
7	10/19	Alternatives to MAUT	Kahneman	Take-home midterm	HW 5
8	10/26	Q&A Session			
9	11/2	Introduction to Risk Management			Take-home midterm
10	11/9	Cognitive Bias and Perceptions of Risk	Kahneman	HW 6	
11	11/16	Project Risk Management	http://bbp.dau.mil/docs/RIO-Guide-Jun2015.pdf	Project proposal	HW 6
12	11/23	No class (Thanksgiving)			Project proposal
13	11/30	Incorporating Financial Risk into Project Decisions	Clemen: Ch 13		
14	12/7	Risk of Extreme Events & Model Risk			
15	12/14	Project Presentations			Final project files & presentation

COURSE MATERIALS

Textbook(s): *Making Hard Decisions* (2nd or 3rd edition) – Robert T. Clemen and Terence Reilly (3rd ed. ISBN: 9780538797573; 2nd ed. ISBN: 9780534260347)

Other Readings: *Thinking Fast and Slow* – Daniel Kahneman (ISBN-10: 0374533555 or ISBN-10: 0374275637)

COURSE REQUIREMENTS

Participation Students are expected to show up on time to class sessions and participate in all class discussions and polls. Group discussions and team project work will take place during class, so missing class will be detrimental to your learning and your team's progress. Therefore, attendance will be taken and monitored, and it will count toward 10% of the course grade. Students who are clearly not actively present during class (nonresponsive to questions and/or not participating during group discussions) will be counted as absent.

Each class session will be worth 3 points. Full attendance and participation will earn 3/3. Showing up a little bit late (1-15 minutes) will earn a 2/3. Showing up very late (15-60 minutes) will earn 1/3. Showing up more than 60 minutes late will result in 0/3. Other partial attendance points (e.g., leaving early or during the middle) will be assigned at the instructor's discretion.

Students with legitimate reasons (e.g., sickness with written notice, job interview, athletic activities, etc.) can make up for the absence by reviewing the slides and writing a written response to the prompts posted to the "Assignments" page of Canvas.

Homework Graded homework assignments are individual and are due by the beginning of the next class after they are assigned. They are to be submitted electronically as coherent, standalone PDF files (problems should be clearly labeled and in the correct order, and any reference to code/Excel should include a full explanation of the solution). You may submit code or Excel files as supplements to your assignments, but you should not expect the grader to look at those to assess whether your response is correct/complete; to reiterate, the pdf should include complete responses to the homework problems. If it is clear that a graded assignment was not done individually, all students involved will receive a zero on the assignment.

Project The class project will be done in teams of 2-4. The objective is to develop a decision support system with instructor approval for a realistic decision problem of the group's choosing. Peer evaluations and instructor observations will be used to adjust grades based on individual contributions.

Exam The mid-term exam will be a take-home, open-ended exam. You will have 2 weeks to complete it.

GRADING PROCEDURES

Grading breakdown:

Class Participation	10%
Homework	30%
Midterm Exam	30%
Team Project	30%

Late policy: Late assignments will lose 10% per 24-hour period that they are late, up to 5 days. I.e., if an assignment is turned in after the deadline between 0-24 hours late, the maximum possible grade is 90%; the maximum grade for 24-48 hours late is 80%; etc.; assignments are not accepted 5 days or more after the deadline.

Grading questions: Once an assignment grade is posted, you will have one week to question your grade. After that, the grade will not be re-visited.

Citations: Any material (content or phrases) taken from outside sources and submitted as a supplement to your assignment should be clearly referenced. Any material taken word-for-word must be in quotations and cited properly. Written work is subject to screening. Plagiarism will result in a zero grade.

Canvas: The class Canvas site contains information on assignments and due dates, as well as course information. You are responsible for checking the site regularly for announcements, instructions, and course material.

Expected conduct: Instructors and students are expected to treat one another with respect at all times and abide by the Stevens Honor System.

ACADEMIC INTEGRITY

Graduate Student Code of Academic Integrity

All Stevens graduate students promise to be fully truthful and avoid dishonesty, fraud, misrepresentation, and deceit of any type in relation to their academic work. A student's submission of work for academic credit indicates that the work is the student's own. All outside assistance must be acknowledged. Any student who violates this code or who knowingly assists another student in violating this code shall be subject to discipline.

All graduate students are bound to the Graduate Student Code of Academic Integrity by enrollment in graduate coursework at Stevens. It is the responsibility of each graduate student to understand and adhere to the Graduate Student Code of Academic Integrity. More information including types of violations, the process for handling perceived violations, and types of sanctions can be found at www.stevens.edu/provost/graduate-academics.

LEARNING ACCOMMODATIONS

Stevens Institute of Technology is dedicated to providing appropriate accommodations to students with documented disabilities. The Office of Disability Services (ODS) works with undergraduate and graduate students with learning disabilities, attention deficit-hyperactivity disorders, physical disabilities, sensory impairments, psychiatric disorders, and other such disabilities in order to help students achieve their academic and personal potential. They facilitate equal access to the educational programs and opportunities offered at Stevens and coordinate reasonable accommodations for eligible students. These services are designed to encourage independence and self-advocacy with support from the ODS staff. The ODS staff will facilitate the provision of accommodations on a case-by-case basis.

Disability Services Confidentiality Policy

Student Disability Files are kept separate from academic files and are stored in a secure location within the Office of Disability Services. The Family Educational Rights Privacy Act (FERPA, 20 U.S.C. 1232g; 34CFR, Part 99) regulates disclosure of disability documentation and records maintained by Stevens Disability Services. According to this act, prior written consent by the student is required before our Disability Services office may release disability documentation or records to anyone. An exception is made in unusual circumstances, such as the case of health and safety emergencies.

For more information about Disability Services and the process to receive accommodations, visit https://www.stevens.edu/office-disability-services. If you have any questions please contact: Phillip Gehman, the Director of Disability Services Coordinator at Stevens Institute of Technology at pgehman@stevens.edu or by phone (201) 216-3748.

INCLUSIVITY

Name and Pronoun Usage

As this course includes group work and in-class discussion, it is vitally important for us to create an educational environment of inclusion and mutual respect. This includes the ability for all students to have their chosen gender pronoun(s) and chosen name affirmed. If the class roster does not align with your name and/or pronouns, please inform the instructor of the necessary changes.

Inclusion Statement

Stevens Institute of Technology believes that diversity and inclusiveness are essential to excellence in academic discourse and innovation. In this class, the perspective of people of all races, ethnicities, gender expressions and gender identities, religions, sexual orientations, disabilities, socioeconomic backgrounds, and nationalities will be respected and viewed as a resource and benefit throughout the semester. Suggestions to further diversify class materials and assignments are encouraged. If any course meetings conflict with your religious events, please do not hesitate to reach out to your instructor to make alternative arrangements.

You are expected to treat your instructor and all other participants in the course with courtesy and respect. Disrespectful conduct and harassing statements will not be tolerated and may result in disciplinary actions.

MENTAL HEALTH RESOURCES

Part of being successful in the classroom involves a focus on your whole self, including your mental health. While you are at Stevens, there are many resources to promote and support mental health. The Office of Counseling and Psychological Services (CAPS) offers free and confidential services to all enrolled students who are struggling to cope with personal issues (e.g., difficulty adjusting to college or trouble managing stress) or psychological difficulties (e.g., anxiety and depression). Appointments are strongly encouraged and can be made by phone (201-216-5177) or in-person (on the 7th floor of the Howe Center). CAPS is open from 9:00 am – 5:00 pm Mondays, Wednesdays, Thursdays and Fridays and from 9:00 am – 7:00 pm on Tuesdays during the Fall and Spring semesters.

EMERGENCY INFORMATION

In the event of an urgent or emergent concern about the safety of yourself or someone else in the Stevens community, please immediately call the Stevens Campus Police at 201-216-5105 or on their emergency line at 201-216-3911. These phone lines are staffed 24/7, year-round. Other 24/7 resources for students dealing with mental health crises include the National Suicide Prevention Lifeline (1-800-273-8255) and the Crisis Text Line (text “Home” to 741-741). If you are concerned about the well-being of another Stevens student, and the matter is *not* urgent or time-sensitive, please email the CARE Team at care@stevens.edu. A member of the CARE Team will respond to your concern as soon as possible.

COURSE REFERENCES

Decision Analysis

Clemen, R. T. and T. Reilly, (2014) Making Hard Decisions, 3rd ed, Mason, OH: South-Western.

Edwards, W., & Tversky, A. (1967). Decision Making. Middlesex, England: Penguin Books

Georgiadis, D.R., T.A. Mazzuchi, and S. Sarkani, (2013), Using Multi-Criteria Decision Making in Analysis of Alternatives for Selection of Enabling Technology, Systems Engineering, 16(3), 287-303.

Hammond, J. S., R. L. Keeney, and H. Raiffa, (1998), Even Swaps: A Rational Method for Making Trade-offs, Harvard Business Review, March-April 1998, pp. 137-149

Hammond, J. S., R. L. Keeney, and H. Raiffa, (1999) Smart Choices: A Practical Guide to Making Better Decisions, Boston, MA: Harvard Business School Press.

Howard, R.A., & Matheson, J.E. (2005). Influence diagrams. Decision Analysis, 2 (3), 127-143.

Keeney, R. L., and H. Raiffa, (1993) Decisions with Multiple Objectives: Preferences and Value Tradeoffs, Cambridge, UK: Cambridge University Press.

von Neumann, J., & O. Morgenstern, (1947). Theory of Games and Economic Behavior. Princeton, NJ: Princeton University Press.

Heuristics and Biases

Kahneman, D., (2011) Thinking Fast and Slow, New York, NY: Farrar, Straus, and Giroux.

Kahneman, D. and A. Tversky, (1973) On the psychology of prediction, Psychological Review, Vol 80, pp. 237-251.

Lowrance, W.W., (1974) Of Acceptable Risk: Science and the Determination of Safety, Los Altos, CA: William Kaufmann, Inc.

Morall, J.F., III, (1987) Chemical and Engineering News, September 14, 1987.

Tversky and Kahneman, (1974), Judgment Under Uncertainty: Heuristics and Biases, Science, Vol 185, 1974.

Risk Management

Kaplan, S., & Garrick, B. J. (1981). On the quantitative definition of risk. Risk Analysis, 1, 11–27.

Kaplan, S., Y.Y. Haimes, and B. J. Garrick, (2001), Fitting Hierarchical Holographic Modeling into the Theory of Scenario Structuring and a Resulting Refinement to the Quantitative Definition of Risk, Risk Analysis, 21(5), 807-819.

Haimes, Y. Y., (1991) ‘‘Total risk management.’’ Risk Analysis, 11(2), 169–171.

Haimes, Y. Y., (1998) Risk Modeling, Assessment, and Management, New York, NY: John Wiley & Sons, Inc.

Haimes, Y.Y., S. Kaplan and J. H Lambert, (2002), Risk Filtering, Ranking, and Management Framework Using Hierarchical Holographic Modeling, Risk Analysis, 22(2), 383-397.

US Department of Defense, (2006), Risk Management Guide for DoD Acquisition, 6th ed., Version 1.0, August 2006.

Extreme Events

Casti, J. (2012) X-Events: The Collapse of Everything, Harper-Collins: New York.

Gumbel, E.J., (2004) Statistics of Extremes, Mineola, NY: Dover Publications, Inc.

Sole, R. V. (2011). Phase Transitions. Princeton University Press

Taleb, N. N. (2010), The Black Swan, 2nd edition, Random House: New York, NY.

Financial Decisions

Luenberger, D. G., (1998) Investment Science, New York: Oxford University Press.

Pennock, M. J. (2010) Multi-Stage Real Options, In Rouse, W.B. (Ed), The Economics of Human Systems Integration, New York, NY: John Wiley & Sons, Inc.

Rouse, W.B., Howard, C.W., Carns, W.E., & Prendergast, E.J. (2000). Technology investment advisor: An options-based approach to technology strategy. Information • Knowledge • Systems Management, 2 (1), 63-81.

Systems Modeling

Haimes, Y.Y., (1981), Hierarchical holographic modeling, IEEE Transactions on Systems, Man, and Cybernetics, Vol. 11, no. 9, pp. 606-616.

Roy, C. J., & Oberkampf, W. L. (2011). A comprehensive framework for verification, validation, and uncertainty quantification in scientific computing. Computer Methods in Applied Mechanics and Engineering, 200(25), 2131-2144.

Runyon, R. P., (1977), Winning with Statistics, Addison-Wesley: Reading, MA.

Zeigler, B.P., H. Praehofer, and T.G. Kim, (2000), Theory of Modeling and Simulation, 2nd ed, Academic Press.