

ASTE 599

Safety of Space Operations

Units: 3

Term—Day—Time:

Spring Semester

Day – TBD;

6:40-9:20 pm

Location: DEN only

Instructors:

Prof. Michael Kezirian, USC

Contact: kezirian@usc.edu

Jerry Haber, Acta, LLC

Contact: haber@actainc.com

Catalog Description

Safety of Space Operations presents the engineering methods used for compliance and risk management of launch and reentry, space environment and space traffic management.

Course Description

The astronautical engineering course focuses the risks of orbital and suborbital operations, the regulatory requirements for managing these risks, and the technology to implement the risk management regime.

The first part of the course explores on-orbit risk management. The course will consider environmental hazards, specifically the threats posed by micrometeoroid and orbital debris and inherent radiation. It will also explore key issues of space traffic management and space situational awareness, critical to the operation of spacecraft and constellations of spacecraft working collectively. In addition, the course will cover the operational issues association with extravehicular activity.

The second part of the course addresses launch and reentry risks. It begins with introducing the engineering basics associated with understanding, analyzing, and managing these risks. Important elements of this include understanding risk measures, risk drivers and the levels of fidelity of data development and analysis that may be required in order to ensure operations are “safe-enough”. The course considers characterizing sources of risks (normal vehicle operations, vehicle malfunctions), resulting hazards (debris – inert and explosive), populations and assets at risk, propagation of hazards to populations at risk, quantifying risk and designing risk mitigation strategies, as needed.

Learning Objectives

Upon completion of this course, students acquire understanding of the following:

- Planning practices to manage risks to life and property from space operations.
- Advanced analysis methods, such as those used to calculate launch and re-entry debris impact risk.
- Safety considerations relating to the general public and the environment in addition to personnel and asset protection
- Implementation of safe operation procedures, such as on-orbit space traffic management

Instructor – Prof. Michael Kezirian

Dr. Kezirian is a specialist in space safety. A former Associate Technical Fellow for the Boeing Company, he most recently supporting the Commercial Crew Program (Boeing CST-100 Starliner). He led the COPV Analysis Team for the Orbiter Project (Space Shuttle) and was a key COPV design engineer for the Nitrogen Oxygen Recharge System for the International Space Station and the COPV Composite Stress Rupture for the Orbiter (Space Shuttle). Previously, Dr. Kezirian was a spacecraft autonomy engineer for government communication and commercial satellite programs at Boeing and a propulsion engineer at TRW Space and Technology (now Northrop Grumman) in Southern California. He is the editor-in-chief of the *Journal of Space Safety Engineering* and President of the International Space Safety Foundation.

Instructor – Jerry Haber

Jerry Haber is Vice President of ACTA LLC, international leaders in managing launch and reentry safety. He was recently awarded the Jerome Lederer Space Safety Pioneer award by the International Association for the Advancement of Space Safety (IAASS) for his leadership in launch and reentry safety modeling, safety criteria development and analyses since 1968. He was the technical lead on modeling and policy formulation for the guidelines employed by the US National Ranges (RCC 321). He has supported space-lift programs ranging from the early Scout launchers thru the Space Shuttle to modern launchers. He has taught courses in launch and reentry safety to the staffs of the major national ranges, international space agencies and launch operators for more than a decade.

Prerequisite(s): None

Co-Requisite(s): None

Concurrent Enrollment: None

Recommended: ASTE 535 Space Environments and Spacecraft Interactions, or experience in space industry

Course Notes

Course notes are mandatory for the class and will be available for download in PDF format from the VSoE D2L site.

Technological Proficiency and Hardware/Software Required

Internet access is required for viewing course notes, lectures, and other materials on D2L. Students must be able to view and print PDF documents. No specialized computational tools are required.

Required & Supplementary Reading Material

Firooz A. Allahdadi, Isabelle Rongier and Paul D. Wilde, Safety Design for Space Operations, 2013, Butterworth-Heinemann, ISBN 978-0-08-096921-3

FAA Draft Advisory Circular AC 450.115-1 High Fidelity Flight Safety Analysis

Homework

Homework assignments will be problems designed for students to demonstrate understanding of scientific fundamentals and engineering principles of course concepts. Homework is assigned on a weekly basis. All homework is individual effort.

Homework assignments are designed for students to follow the processes that space mission operators perform to obtain launch licenses. Through these assignments, the students demonstrate their understanding of methods for quantifying and managing risk. For environmental hazards associated with micrometeoroid and orbital debris, students will utilize the engineering simulation tools developed by NASA to assess risk accounting for spacecraft size, orbit parameters and duration of mission.

Grading

Homework	30%
Midterm exam	35%
Final exam	35%

Assignment Submission Policy

Homework assignments are due at the beginning of each lecture, through D2L. Graded assignments will be returned in a timely manner, ideally the following week. Solutions will be posted to D2L.

ASTE 599: Safety of Space Operations

Course Schedule

Week	Date	Topic	notes	HW Assignment Due
Week 1	Jan 14	Orbital Environment Space Surveillance	1	
Week 2	Jan 21	Government and Industry Tools for Mission Planning	2	1
Week 3	Jan 28	Collision Risk (on Orbit)	3	2
Week 4	Feb 4	Risk Reduction Methods Inspection Capabilities and Criteria	4	3
Week 5	Feb 11	Collision Avoidance Maneuvers	5	4
Week 6	Feb 18	Space Traffic Management / Space Situational Awareness	6	5
Week 7	Feb 25	Radiation Environment and Operations	7	6
Week 8	Mar 3	Mid-Term Exam		7
Week 9	Mar 10	Launch and Reentry Objectives of Flight Safety Analysis Stakeholders Measures Processes Analysis Levels of Fidelity	8	
	Spring Recess, March 15-22			
Week 10	Mar 24	Risk Acceptability What is the Problem to be Solved? General Risk Analysis Procedures	9	8
Week11	Mar 31	Supporting Data Requirements Impact Prediction and Debris Footprint Impact probabilities of Scheduled Debris	10	9
Week 12	Apr 7	Impact Dispersions of Normal and Malfunctioning Vehicles	11	10
Week 13	Apr 14	Corridor Approach to Risk Analysis	12	11
Week 14	Apr 21	Planned and Random Reentry Risk	13	12
Week 15	Apr 28	Range Safety Risk Management and Risk Mitigations (Note: HW14 due May 1)	14	13
		Final Exam	Date and time as schedule by USC Schedule of Classes	

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 and 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. The university prohibits discrimination or harassment based on the following *protected characteristics*: race, color, national origin, ancestry, religion, sex, gender, gender identity, gender expression, sexual orientation, age, physical disability, medical condition, mental disability, marital status, pregnancy, veteran status, genetic information, and any other characteristic which may be specified in applicable laws and governmental regulations. The university also prohibits sexual assault, non-consensual sexual contact, sexual misconduct, intimate partner violence, stalking, malicious dissuasion, retaliation, and violation of interim measures.

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 Support and Advocacy - (213) 821-4710

uscса.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.