Memorandum

To: The Faculty of the College of Engineering

From: The School of Aeronautics and Astronautics

Date: April 6, 2023

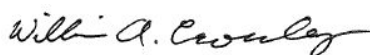Re: New Graduate Course, **AAE 57100 Complex System Safety**

The faculty of the School of Aeronautics and Astronautics have approved the following new course. This action is now submitted to the Engineering Faculty with a recommendation for approval.

Course no. **AAE 57100 Complex System Safety**
Fall, Lecture, Cr. 3

Description: The objective of this course is to provide students with the ability to assess the safety risk posed by engineering systems, taking into consideration hardware, software, human, and organizational factors, and using risk assessment tools that are used in practice in industry.

Reason: This course takes a system safety perspective to engineering system safety risk management. The focus is on system, or process, accidents, as opposed to occupational safety. The course provides theory and methods applicable to a wide range of complex engineering systems, with examples drawn from aerospace, transportation, and the chemical and nuclear industries. The course is complementary to other courses offered in the COE, such as IE558 Safety Engineering, and CHE 42000 Process Safety Management and Analysis, NUCL 55200 - Thermal-Hydraulics and Reactor Safety.

In addition to AAE graduate and undergraduate students, this course has been taken by students in the Interdisciplinary Online Masters, and from Engineering Management, Engineering Education, Mechanical Engineering, Industrial Engineering and Civil Engineering.

William A. Crossley
Uhrig & Vournas Head of Aeronautics and Astronautics,
and Professor of Aeronautics and Astronautics

SCHOOL OF AERONAUTICS AND ASTRONAUTICS
Neil Armstrong Hall of Engineering
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Office: 765-494-5117

Enrollment History – Previously taught as AAE 590 System Safety and/& Reliability

Enrollment		Fall 2009	Fall 2014	Fall 2018	Fall 2019	Fall 2020	Fall 2021	Fall 2022
GR - Graduate School PWL Enrollment	AAEN - Aeronautics & Astronautics	15	14	14	6	11	18	18
	ENMG - Engineering Management					1	2	2
	ENED - Engineering Education						1	
	IDE - Interdisciplinary Engineering		1	1		2		
	MECH - Mechanical Engineering					1	1	
	IE - Industrial Engineering			1	1			
	CIVL - Civil Engineering						1	1
AE - School of Aero and Astro Engr Undergraduates	AAE - Aero & Astro Engineering	13	24	5	10	11	7	21
LA - College of Liberal Arts Undergraduates	LAUD - General Undecided		1					
GR - Graduate School Pro Ed (CEC) Enrollment	IDE - Interdisciplinary Engineering			42	14	28	16	
	IE - Industrial Engineering			1		1	1	
	MECH - Mechanical Engineering			1	1	3	1	
	ECEN - Electrical & Computer Engr						1	
	AAEN - Aeronautics & Astronautics			8	5	14	8	
	ENMG - Engineering Management					1		
GR - Graduate School Pro Ed (CEC) Enrollment	IDE - Interdisciplinary Engineering							13
	AAEN - Aeronautics & Astronautics							13
Totals		28	40	73	37	73	57	68

AAE 590 Complex System Safety
Fall 20**

TR 10:30 to 11:45 am

WANG2555

Face-to-Face and Async-Online

Instructor: **Prof. Karen Marais,** kmarais@purdue.edu, ARMS 2041

Teaching Assistant: *****,** ***

CRNs: 28672, 24249, and 28610

1   Introduction

Have you ever wondered why it's often so hard to figure out what caused an accident? Have you wondered why we've never found flight MH370? Why accidents like Deepwater Horizon happen? Or how smart engineers could make basic unit conversion errors for weeks (Mars Climate Orbiter)?

This Fall in AAE590, Prof. Marais will be offering answers to these questions and many more. You will work in teams to investigate a particular high-profile accident in detail. We will learn about the latest theories in accident progression and risk assessment, and how we can use these theories to design and operate safer systems.

The course will be interactive and feature a combination of presentations, individual work, group work, and class discussions. Grades will be based on class participation, team projects and presentations, and individual assignments. No final exam.

The course can be taken as a design elective by AAE seniors.

Class times and assignment due dates are all in the Eastern Time Zone. Plan your work accordingly.

2   Course Objective and Learning Outcomes

The **objective** of this course is to provide students with the ability to assess the safety risk posed by engineering systems, taking into consideration hardware, software, human, and organizational factors, and using risk assessment tools that are used in practice in industry.

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

- Describe several frameworks and theories for assessing and improving system safety
- Describe key elements of published system safety and risk assessment studies
- Describe different models used to model accidents.

- Apply different models to model accidents.
- List the steps in developing a system safety plan
- Recognize the extent of problems in system safety and risk assessment
- Describe the role of various systems and factors in creating safety and in causing errors and adverse events
- Discuss problems and issues in measuring and reporting safety
- Demonstrate knowledge of the basics of conducting an incident or accident investigation
- Design solutions to improve safety
- Discuss the ethical, legal, and regulatory implications related to safety
- Compare the different types of instruments/methods available to assess system safety
- Critique the use of commonly used system safety and risk assessment techniques in specific applications

3   Contact

Please feel to email me with questions. Please put "590S&R" in the subject line of all your emails to me or the Teaching Assistant.

On-campus students: Please make use of our time in class to ask lots of questions. Remember, if you're wondering about something, chances are someone else is too!

4   Learning Resources and Reference Text

Brightspace Learning Management System:

Access the course videos, materials, and resources via Purdue's BS learning management system. Begin with the Start Here tab, which describes how the course Brightspace is organized. We strongly suggest that you explore and become familiar not only with the site navigation but with content and resources available for this course. See the Student Services widget on the campus homepage for resources such as Technology Help, Academic Help, Campus Resources, and Protect Purdue.

Textbook:
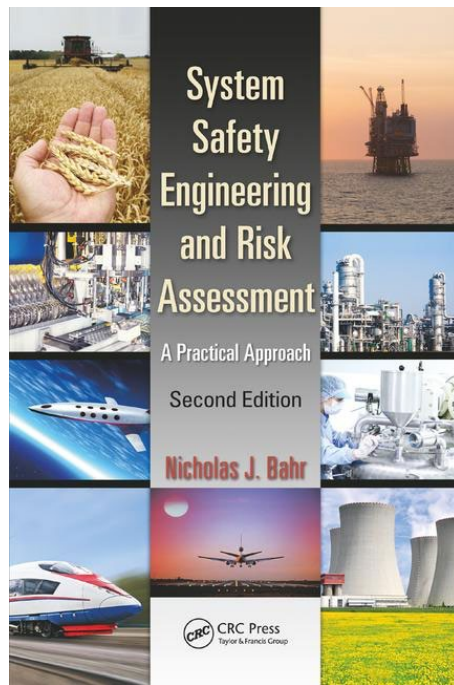
Available online at no cost through Purdue Libraries. Do not buy this book! (unless you really want your own hardcopy.)

5 Assignments

The course has team and individual assignments. You will have one team for all team assignments. We will have three main types of assignments:

5.1 Individual Weekly Reflections

Each week, we will have one or more readings, and ask you to prepare a response to the readings and class material. Readings will be academic papers and sometimes "popular science" articles or textbook extracts—see the Readings folder on Brightspace (BS). Where applicable, we will also point out relevant supporting chapters from Bahr, or from other selected texts (these supporting readings will be available online on BS). We will provide a prompt for your response on Brightspace. Reflections are due each Sunday by 11:59 pm.

You may skip a maximum of two reflections with no penalty.

5.2 Team Assignment 1: One Accident Case Study

- Accidents will be assigned in the first two weeks of class based on enrolment.
- Prepare a 15-minute video presentation on your accident, and a one-page summary. Your one-page summary should make appropriate use of text and graphics to convey efficiently the most important aspects of the accidents. See BS for examples.
- Your presentation should include
  - Story of the accident
  - Two different models of the accident (see lectures in week 2), along with critiques of the models' strengths and weaknesses

- o Why the accident happened, including proximate and root causes
- o Lessons learned
- o References page
- Making your video:
  - o Your presentation may be narrated by one speaker if you wish.
  - o See BS for more info on video making resources
- Uploading your final material:
  - o **Your video and summary are due on BS by 6 pm the day before your due date**. Also upload a pdf version of whatever visual aids you use in your video (e.g., PowerPoint, Prezi). Please use the following file name convention for your files:
    - ▪ Slides: AAE590_ACS_Slides_Team#.pdf
    - ▪ One-pager: AAE590_ACS_OnePager_Team#.pdf

5.3 Team Assignment 2: Team Term Project

- Investigate a safety related topic of your interest. I am open to a wide range of topics, please get in touch with me to discuss your ideas. **Project proposals are due by 11:59 pm on the 8th of September**.
- Prepare a conference style paper (~6,000 to 10,000 words)
  - o Your **paper is due by 11:59 pm on the Thursday of the Quiet Period**.
  - o Your paper should be a conference-style paper. Check the Graduate Student Formatting Checklist file on BS for more information.
  - o In particular, your paper must include an abstract. Consult the Purdue OWL for guidance on how to write an abstract.
    https://owl.purdue.edu/owl/purdue_owl.html
  - o ~6,000 words
  - o Single column, 12-point font, 1.5 spacing, full justification
  - o You may choose any reference format you like; keep it consistent. Consult the Purdue OWL for guidance on how to cite sources.
    https://owl.purdue.edu/owl/purdue_owl.html
  - o All figures and tables must be cited.
  - o Include page numbers.
- Prepare a final presentation video (15 to 20 minutes, no more than 20 minutes).
  - o Your **video and slides are due on BS by 6 pm the day before final presentations begin.** Please stay tuned for the exact date, which will depend on final course enrolment.
  - o Upload a pdf version of whatever visual aids you use in your video (e.g., PowerPoint, Prezi).
- Please use the following file name convention for your files:
    - ▪ Slides: AAE590_TTP_Slides_Team#.pdf
    - ▪ Report: AAE590_TTP_Report_Team#.pdf
- More details in class!

6 Evaluation

All assignments, presentations, etc., must be submitted on BS. No email submissions will be accepted. Late submissions will be accepted only in exceptional circumstances. Make sure to

communicate with me clearly and ASAP in case you anticipate a late submission, or have missed a submission.

Your grade will be calculated as follows:

- Accident Case Study: 25%
- Weekly Reflections: 20%
- Team Term Project: 50%
- Final Project Peer Review: 5%

The grade mapping is as follows:

A+   98.00 – 100.00%
A   94.00 – 97.99%
A-   90.00 – 93.99%
B+   87.00 – 89.99%
B   84.00 – 86.99%
B-   80.00 – 83.99%
C+   77.00 – 79.99%
C   74.00 – 76.99%
C-   70.00 – 73.99%
D+   67.00 – 69.99%
D   64.00 – 66.99%
D-   60.00 – 63.99%
F   <=60.00%

Outstanding, A. The student exhibits a high degree of critical analysis of the theoretical and practical dimensions of the topic through written and oral presentations. Mastery of complex material and ideas is immediately evident. Assignments are treated with sensitivity and subtlety of thought. The quality of the writing and background research is exemplary.

Good, B. The student shows above average analysis, critical thinking and independent thought. Written and oral assignments are addressed in reasonable depth and breadth. The student demonstrates an above average ability to present and write in an intelligible style and to condense material meaningfully and with a concern for priorities of that material.

Adequate, C. The student demonstrates adequate comprehension of the topic. Written and oral presentations are on topic and a reasonable response to material covered in the course, but go no further. Facts are stated accurately; the quality of writing is sufficiently intelligible with enough elaboration and enough connections made between ideas to permit a reader to understand the point of the assignment.

Marginal, D. The student shows less than adequate comprehension of the material covered by the course. Written and oral presentations are a less than adequate summary of sources or are considerably off-topic. Facts are stated inaccurately or ambiguously; the writing style is difficult to follow; there is insufficient elaboration to permit reader's comprehension of relations among ideas; little judgment is shown in selecting detail for inclusion in assignments.

Unacceptable, F. The student demonstrates a failure to comprehend the topic. Written and oral presentations are disorganized and unintelligible. The student clearly does not meet the minimal requirements of the course.

The final date to withdraw from a course with a W or WF for Fall 2022 is Tuesday, Oct. 25.

7 2022 Course Outline, subject to minor modifications

Lecture Date	Topic	ACS
1: 23 August	Introduction and logistics.	N/A
2: 25 August	Definitions and Concepts	N/A
3: 30 August	Accident Modelling 1	N/A
4: 01 September	Accident Modelling 2	N/A
5: 06 September	Safety Knowns and Unknowns	N/A
6: 08 September	Safety Culture 1	Piper Alpha, 1988
7: 13 September	Safety Culture 2	USAF Boeing C-17A Lot XII Globemaster III 28 July 2010
8: 15 September	Human Factors 1	737 MAX Accidents, 2018 and 2019
9: 20 September	Human Factors 2	2001 Japan Airlines mid-air incident
10: 22 September	Software Safety 1	AA965 Cali Accident 1995
11: 27 September	Software Safety 2	VSS Enterprise, 2014
12: 29 September	Probability Primer	"Demon Core" Accidents, 1945 and 1946
13: 04 October	Introduction to Safety Analysis	Three Mile Island, 1979
14: 06 October	System and System Safety Requirements	I-35W Mississippi River bridge, 2007
N/A: 11 October	OCTOBER BREAK NO CLASS	N/A
15: 13 October	General Hazard Analysis Introduction	Hyatt Regency Walkway Collapse, 1981
16: 18 October	FMEA and FMECA 1	Mont Blanc Tunnel Fire, 1999
17: 20 October	FMEA and FMECA 2	Kaprun Funicular Railway, 2000
18: 25 October	Fault Tree Analysis 1	MV Sewol, 2014
19: 27 October	Fault Tree Analysis 2	Soyuz MS-10, 2018
20: 01 November	Other Techniques	ISS Expedition 36 Water Leak
21: 03 November	Risk Mitigation Introduction	Black Hawk Friendly Fire, 1994
22: 08 November	Architectural Approaches to Safety	Valujet Flight 592 1996

Lecture Date	Topic	ACS
23: 10 November	Probabilistic Approaches to Safety	BP Texas City, 2005
24: 15 November	Process Rigor Approaches to Safety	Deepwater Horizon, 2010
25: 17 November	Risk Mitigation Conclusion	
26: 22 November	Safety Cases and Wrap-up	N/A
N/A: 24 November	THANKSGIVING NO CLASS	N/A
27: 29 November	Final Presentations	N/A
28: 01 December	Final Presentations	N/A
29: 06 December	Final Presentations	N/A
30: 08 December	Final Presentations	N/A

8   Policy Matters

8.1   Netiquette

We all want a safe online learning environment. All opinions and experiences, no matter how different or controversial they may be perceived, must be respected in the tolerant spirit of academic discourse. You are encouraged to comment, question, or critique an idea, but don't attack individual people. Our differences, some of which are outlined in the University's nondiscrimination statement below, add richness to this learning experience. Please consider that sarcasm and humor can be misconstrued in online interactions and generate unintended disruptions. Working as a community of learners, we can build a polite and respectful course ambience. Please read the Netiquette rules for this course:

- Do not dominate any discussion. Give other students the opportunity to join in the discussion.
- Do not use offensive language. Present ideas appropriately.
- Be cautious in using Internet language. For example, do not capitalize all letters since this suggests shouting.
- Avoid using vernacular and/or slang language. This could possibly lead to misinterpretation.
- Keep an "open-mind" and be willing to express even your minority opinion.
- Think and edit before you push the "Send" button.
- Do not hesitate to ask for feedback.

8.2 Academic Integrity

"As a boilermaker pursuing academic excellence, I pledge to be honest and true in all that I do. Accountable together - we are Purdue."

Do not cheat. In this class, cheating means passing off someone else's work as your own, whether it is a classmate, a friend, or an author from a paper or blog. Copying work directly from any source for your assignments will be considered cheating, and will be handled the same manner as cheating on examinations. Anything you submit should be at least 90% your own work. If you are confused at all about what is allowed and what is not, please ask the instructors.

For your team assignments, do not copy old presentations or designs. Be an active member of the team and pull your weight throughout the semester. If you face any discrimination in your team or are treated disrespectfully, please contact the instructors immediately.

Commercial Note Taking during lectures (University Senate Document 03-9, April 19, 2004.): As used in this paragraph, the term "instructor" is defined as the individual who authored the material being presented as part of the course.

Among the materials that may be protected by copyright law are the lectures, notes, and other material presented in class or as part of the course. Always assume the materials presented by an instructor are protected by copyright unless the instructor has stated otherwise. Students enrolled in, and authorized visitors to, Purdue University courses are permitted to take notes, which they may use for individual/group study or for other non-commercial purposes reasonably arising from enrollment in the course or the University generally.

Notes taken during lectures are, however, generally considered to be "derivative works" of the instructor's presentations and materials, and they are thus subject to the instructor's copyright in such presentations and materials. **No individual is permitted to sell or otherwise barter notes, either to other students or to any commercial concern, for a course without the express written permission of the course instructor.** To obtain permission to sell or barter notes, the individual wishing to sell or barter the notes must be registered in the course or must be an approved visitor to the class. Course instructors may choose to grant or not grant such permission at their own discretion, and may require a review of the notes prior to their being sold or bartered. If they do grant such permission, they may revoke it at any time, if they so choose.

Purdue's student guide for academic integrity also has some useful information.

8.3 Nondiscrimination Statement

Purdue University is committed to maintaining a community which recognizes and values the inherent worth and dignity of every person; fosters tolerance, sensitivity, understanding, and mutual respect among its members; and encourages each individual to strive to reach his or her own potential. In pursuit of its goal of academic excellence, the University seeks to develop and nurture diversity. The University believes that diversity among its many members strengthens the institution, stimulates creativity, promotes the exchange of ideas, and enriches campus life. More details are available on our course Brightspace table of contents, under University Policies.

The School of Aeronautics and Astronautics is also committed to a climate of inclusion; if you need to report an issue of hate or bias, you may use the link at the top right of our page here: https://engineering.purdue.edu/AAE/aboutus/Diversity/index_html.

8.4   Medically Excused Absence Policy for Students (MEAPS)

Students are eligible for **up to fifteen (15) days** for medically excused absences per academic year with **no more than ten (10) academic calendar** (during the fall and spring semester) **days taken consecutively**, for the Medical Excused Absence Policy. Total absences, including travel, may not exceed 1/3 of the course meetings for any course. A **student can contact the Office of the Dean of Students (ODOS)** to request that a notice of the leave be sent to instructors when a situation involving hospitalization, emergency department or urgent care visit emerges. The student can then provide documentation of hospitalization, emergency department or urgent care visit as proof of legitimate absence to the ODOS as soon as these documents are available.

When documentation is presented to the Office of the Dean of Students, **a verified absence notification will be sent to the student's instructors**. With a verified absence notification from the ODOS, no penalty will be applied to a student's absence for reasons of hospitalization, emergency department or urgent care visit and the student will be given the opportunity to make up course work as defined in the course syllabus. Unique or variant exceptions should be dealt with in a negotiated manner between the student and professor, which may include involving the Department Head, Dean of the school or college, or ODOS, to review and consult on his or her situation.

8.5   Accessibility and Accommodations

Purdue University strives to make learning experiences accessible to all participants. If you anticipate or experience physical or academic barriers based on disability, you are welcome to let us know so that we can discuss options. We also encourage you to contact the Disability Resource Center at: drc@purdue.edu or by phone: 765-494-1247. More details are available on our course Brightspace under Accessibility Information.

8.6   Mental Health

If you find yourself beginning to feel some stress, anxiety or feeling slightly overwhelmed, try WellTrack. Sign in and find information and tools at your fingertips, available to you at any time.

If you need support and information about options and resources, please contact or see the Office of the Dean of Students. Call 765-494-1747. Hours of operation are M-F, 8 am- 5 pm.

If you find yourself struggling to find a healthy balance between academics, social life, stress, etc., sign up for free one-on-one virtual or in-person sessions with a Purdue Wellness Coach at RecWell. Student coaches can help you navigate through barriers and challenges toward your goals throughout the semester. Sign up is completely free and can be done on BoilerConnect. If you have any questions, please contact Purdue Wellness at evans240@purdue.edu.

If you're struggling and need mental health services: Purdue University is committed to advancing the mental health and well-being of its students. If you or someone you know is feeling overwhelmed, depressed, and/or in need of mental health support, services are available. For help, such individuals should contact [Counseling and Psychological Services (CAPS)](#) at 765-494-6995 during and after hours, on weekends and holidays, or by going to the CAPS office of the second floor of the Purdue University Student Health Center (PUSH) during business hours.

8.7 Basic Needs Security

Any student who faces challenges securing their food or housing and believes this may affect their performance in the course is urged to contact the Dean of Students for support. There is no appointment needed and Student Support Services is available to serve students 8 a.m.-5 p.m. Monday through Friday. Considering the significant disruptions caused by the current global crisis as it related to COVID-19, students may submit requests for emergency assistance from the [Critical Needs Fund](#).

8.8 Emergency Preparation

The Campus Emergency Status webpage is your primary online resource for current and developing **PurdueALERT** information and changes to the operational status of campus.

In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances beyond the instructor's control. Relevant changes to this course will be posted onto the course website or can be obtained by contacting the instructors or TAs via email or phone. You are expected to read your @purdue.edu email on a frequent basis. You can find more information on Brightspace.