Architecting Resilient Systems

Syllabus

Instructor

Scott Jackson

SAE 599: 3 Units

Meeting

simultaneous webcast

University of Southern California

Spring 2010

Contents

Contact Information

Instructors

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I encourage you to contact me by e-mail, or to stop by in person for office hours: these interactions may make a more significant contribution to your overall learning than you initially suppose. Topics might include research problems, questions, ideas or interesting readings.

Course website: http://den.usc.edu

Purpose

This course is intended for students who have either taken both SAE, 541 Systems Engineering Theory and Practice, and SAE 549, Systems Architecting, or are familiar with the concepts in these courses through experience or personal learning. However, neither of these courses is a prerequisite for this course. This course should be especially helpful to doctoral students who wish to explore systems approaches beyond the conventional boundaries of these disciplines.

Course Description

This course will explore the multidisciplinary nature of system resilience and its contribution to the creation of systems that will anticipate and avoid catastrophic accidents and survive and recover from disruptions. Systems of interest may include civil infrastructures, enterprises, product-centered enterprises, or technological systems. Disruptions may either be internal or external and may be either historical disruptions or unpredicted disruptions. Internal disruptions include reliability failures and human error. External disruptions may include terrorist attacks, hurricanes, earthquakes, tsunamis, and tornadoes. Case histories will be examined from a resilience point of view to determine the degree of either resilience or brittleness of the systems involved. Typical cases will include Katrina, the Nagoya accident, the Comet aircraft, the Tacoma Narrows bridge disaster, Challenger, Columbia, the Metrolink 111 accident, and many others. Case studies demonstrating various degrees of resilience include Apollo 11 and 13, the New York Power Restoration after the twin towers attack, and the Sioux City aircraft accident, and the US Airways ditching in the Hudson River. Students should have a thorough understanding of the many facets that make a system brittle, that is, subject to catastrophic failure beyond the traditional technical aspects, of the holistic and analytical methodologies that are required to create resilient systems, and of the managerial aspects that are required to implement system resilience within an organization. Students will learn how resilience requires considerations beyond traditional safety, reliability, and reductionist systems engineering methods. Since the discipline is in a seminal stage, we will become a part of the on-going maturation in thinking on this subject. Sample past term papers covering a wide range of subjects can be found on http://www.usc.edu/dept/ise/assets/007/64702.pdf.

Objectives

At the conclusion of this course, it is expected that you will

- Have a thorough understanding of the many facets that make a system brittle, that is, subject to catastrophic failure beyond the traditional technical aspects
- Understand the multidisciplinary challenges that make a system resilient to these disruptions, that is, avoid, survive and recover from these disruptions
- Understand the holistic and analytical methodologies that are required to create resilient systems
- Understand the managerial aspects that are required to implement system resilience within an organization
- Be able to analyze historical disasters from a resilience point of view

At the conclusion of this course it the expectation that you will be capable of examining case histories and principles that will lead to design practices for creating system resilience.

Readings

Books	**Jackson, Scott, *Architecting Resilient Systems: Accident Avoidance and Survival and Recovery from Disrup*tions. John Wiley & Sons, Inc., 2000. This book also has questions at the end of each chapter to be used as assignments. This book also has a comprehensive list of references.**
Other sources	**Woods, David D. *et al*, *Resilience Engineering: Concepts and Precepts*, Ashgate Publishing Limited, UK, 2006** ***Proceedings of the Second Resilience Engineering Symposium*, Juan-les-Pins, France, 2006 (http://www.resilience-engineering.org/)** ***Proceedings of the Third Resilience Engineering Symposium*, Juan-les-Pins, France, 2008 (http://www.resilience-engineering.org/)** ***System Resilience Annotated Bibliography*, INCOSE Resilient Systems Working Group, 2007** **Jackson, Scott, "A Multidisciplinary Framework for Resilience to Disasters and Disruptions," Journal of Design and Process Science, June 2007 (to be provided to the students)** **Madni, Azad, and Jackson, Scott, "Towards a Conceptual Framework for Resilience Engineering." IEEE Systems Journal, June 2009.** **CIP [Critical Infrastructure Protection] Program Discussion Paper Series, *Critical Thinking: Moving From Infrastructure Protection to Infrastructure Resilience*, George Mason University, February 2007.**

Assignments, Grading, & Evaluation

Assignment, overall percent	When	Description	Off-nominal conditions
Class participation, 10%	Each session	Attendance at each class, participation and contribution in class. Discussions of course content with us, for example via e-mail, phone, or in office hours, also count for class participation.	Let us know beforehand, if you know you will not be able to be with us real-time.
Short assignments, 25%	Likely every week	2 or more pages depending on length needed to support the thesis (single spaced, Times New Roman, 12pt equivalent). Short assignments will be based on the topics marked Further Exploration at the end of each chapter. Students may also write on a subject of their own choosing providing it pertains to the topic being covered. It will be a good strategy for the student to make these weekly assignments part of and/or supporting of the term paper. The paper may also focus on a particular aspect of resilience, such as culture or risk. Assignments will be due on alternate weeks.	Late after the beginning of class on the due date. • If late, loses two grade levels (e.g. an A becomes a B) on the first week; not accepted after that without prior approval. • Contact the instructor before the due date if you have a contingency.
Term paper, first cut, 15%	Due mid-term	7 – 10 (max) research paper (single spaced, Times New Roman, 12pt equivalent). The objective of the term paper is to develop from a case history (to be chosen by the student) a resilience analysis of that case. The premise is that most resource material is not analyzed from this perspective. So the term paper is an extension of existing material. This paper will explain what attributes of a particular system had that made it resilient (if it was) and what attributes it could have to make it resilient (if it wasn't). Grading will depend, to a great extent, on the degree of insight demonstrated by the student.	Same as for short assignments
Term paper, final version, 30%	Due on last day	15 – 20 pages (max) research paper (single spaced, Times New Roman,	

Assignment, overall percent	When	Description	Off-nominal conditions
	of class	12 pt equivalent)	
Presentations, 20%	Last two days	Short, 15-20 minutes, presentations by students on their term papers	

Grading Philosophy

As a research course, the grades for this class are not based on the knowledge of a given body of material. The grades for both assignments and term papers are based on the ability of the student to understand and analyze systems and their resilience or brittleness. However, a top-level grade would result from a combination of factors, for example: Does the paper have a thesis, that is, a point that will be supported by additional evidence throughout the paper? Is the point original, that is, is it a conclusion that has not been extracted from the public literature? Does the paper cite specific resilience principles in the architecture of the system that either makes it resilient or brittle? Is the paper framed within a resilience context? Are the resilience principles properly interpreted? Are all necessary resilience principles cited to prove the point, that is, does the paper not omit obvious principles for the case studied? More detailed grading aspects will be provided at the beginning of the semester.

Other Considerations

Inquisitiveness Since the discipline of system resilience is young, many of the techniques and approaches are yet to be discovered. While students in this course are not expected to make break-through discoveries, it is expected that that they will delve into the principles and perhaps extract conclusions that might not be apparent to the first time investigator. They might, for example, be able to analyze case studies and determine how systems either failed due to brittleness or succeeded due to thoughtful planning by the designer or simply due to inherent resilience. If they can speculate on how a failed system might have been designed to be more resilient, then insight will have been achieved.

Other University Policies

Disability Policy Statement 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 the professor (or to TA) as early in the semester as possible. DSP is located in STU 301 and is open 8:30 a.m. - 5:00 p.m., Monday through Friday. The phone number for DSP is (213)740-0776.

Academic Integrity	While the USC policy on Academic Integrity applies to all courses, such as this one, it is further expected that since this is a research-oriented course, all conclusions and materials will be the original thoughts of the students. Copying from sources, such as books, the internet, reports and internal company documents is not appropriate. Brief quotations using quotation marks and proper attributions are appropriate. Wikipedia, in itself is not a legitimate source, although using it to find legitimate sources is permissible.

Class Schedule

The chapters and homework assignments are only approximate and subject to change, as necessary, due to availability of guest lecturers and the estimated length of time to discuss each topic.

SAE 599, Architecting Resilient Systems	**Mondays at 6:30 pm in RTH 115**

Wk	2010	Topic	Chapter in book	Assignments Due
1		Overview, system resilience and related concepts	1, 2	
2		Continuation of Chapter 2, Disruptions; case histories	2, 3, 4	
3		Case Histories	4	Topics at the end of Chapters 1 & 2*
4		Case Histories (cont'd); Capabilities	4, 6	
5		Architecting resilience; use of heuristics	8	Topics at the end of Chapter 3 & 4*
6		System resilience infrastructure; Architecting resilience (cont'd)	7, 8	
7		Cultural factors as they affect system resilience	5	Topics at the end of Chapter 6 & 8*
		Spring Break		
8		System resilience governance; Measuring system resilience;	9, 10	Term paper outline and draft
9		The cost of system resilience; Implementing system resilience	11. 12	
10		A summary of themes: a review; a final word	13, 14	Topics at the end of Chapters 7, 9, & 10*
11		**Guest lecture (Stu Hann):** advanced aspects of system safety	6	
12		**Guest lecture (Dr. McQuinn):** cognitive engineering;	8	Topics at the end of Chapters 11, 12, 13, & 14*
1\3		**Guest lecturer (Dr. Friedman):** management of resilience	6	
14		Presentations	10	
15		Presentations		Term paper, final draft

*Or a topic of the student's own choosing