Course Number XXXX

Course Name: Designing Resilient Infrastructures

School Name:

Term:

Instructions and notes for the instructor for using this course outline.

Introduction:

This course arose from a request for a course in critical thinking about critical infrastructure. The author and program managers agreed that the best way to do that was a project based course where students took a specific infrastructure and developed a plan to make it more resilient. Critical thinking requires a cognitive framework and the one used in this course is that of *design* or *design thinking*. *Design* in this context is not engineering design with large numbers of calculations and drawings, but rather is a cognitive architecture explained in lesson one. When *design* is understood, the structure of the course makes more sense.

The course lessons focus on five areas that shape critical infrastructure design: policy, networks/system behavior, all hazards environment, risk management, technical design, and social implications, topics familiar to instructors and students with a Critical Infrastructure Security and Resilience (CISR) background. CISR students may have had course in each of these subjects already. The difference with this course is in how the subjects are approached. The policy section is not a deep dive into what our national or state CISR policies are, but rather is a discussion about how policy shapes the CISR environment. For example, the evolution and organization of the CISR sectors is an expression of what we feel, at the national level, are the most important infrastructure sectors. Policies shape what we must do, what we cannot do, what we would like to do, and what we will not do—this is the focus of the policy lesson. The same perspective applies to the other topics; the focus is on how and why these topics shape our critical infrastructure decisions and designs.

The course has four main components that guide students through the process of Designing Resilient Infrastructures. First, the lessons, as described above, help students understand how the topic areas shape the critical infrastructure environment. Second, the case studies and student presentations, allow the students to practice some of the skills learned in the lessons. Third, using the skills from the lessons and case studies, the homework focuses on an infrastructure of the student’s choosing and guides students in describing the current state of that infrastructure (in *design* terms, creating the environmental frame). Finally, the course project asks the student to develop a design concept to make the infrastructure more resilient (in *design* terms, creating the problem and solution frames). When the course is complete, the student should have a functional understanding of an infrastructure and a resilience strategy suitable for presentation to a CEO, Public Service Commission, community meeting, or board of directors.

Contents:

This outline contains four sections. The Course Syllabus provides the administrative instructions and general description of the course. The Homework and Course Project section provides all homework assignments and the concept and requirements for the course project. The Course Schedule gives the topics and assignments due for a 15 lesson + final exam version of this course along with suggestions for adapting the course to different lesson formats. Finally lesson sheets are provided for each of the 15 lessons along with suggestions for the final exam.

Organization of lesson sheets.

Each lesson sheet is generally organized as follows. First, if multiple topics are set up for the lesson, the lesson is broken down into two or three sections noted at the top of the page. Each topic is then organized with lesson objectives and references for the lesson. Next there is a “-----------------tear line----------“ which separates the student information from the instructor information. The sections below the tear line are suggestions for the instructor on discussion topics and questions, additional resources, and general notes. It is recommended that the items below the tear line not be shared with the students. Since the questions aid in the discovery learning process in class, too much foreknowledge inhibits the process.

Relation to other courses/stand alone

This course can work as a stand-alone course at the graduate or undergraduate level or as a course which follows and complements the other course outlines offered by the Center for Infrastructure Protection and Homeland Security. If offered with other courses, it is better placed later in the program as an integrating experience where students can bring their acquired knowledge to bear of the course topics, homework, and project.

Course History

This course is the result of five years of course development and has been taught, in this form, for three semesters as the undergraduate level and one at the graduate level through distance education. Many of the discussion points and questions have been raised by past students or have been found to be effective in promoting discussion which leads to achieving the learning objectives. The author is happy to discuss the course with potential instructors and may be contacted through GMU’s Center for Infrastructure Protection and Homeland Security.

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**Course Number XXXX**

**Course Name: Designing Resilient Infrastructures**

**School Name:**

**Course Syllabus**

**Term:**

Department:

Program:

Professor:

Telephone Number:

Office Location:

Office Hours:

Email:

Website:

**Course Description/Overview:**

This course requires students to apply the theory of critical infrastructure resilience to a real world infrastructure and design a plan addressing the relevant social, political, financial, technical, and other dimensions to make that infrastructure more resilient.

Critical Infrastructure Security and Resilience problems are social problems with a significant technical dimension which may be classified as complex-adaptive, social-technical, or wicked problems, depending on the details. As such, a purely technical problem solving approach is unlikely to result in a feasible, suitable, and acceptable solution. This course uses the concept of ‘design’ as a cognitive framework for ‘designing resilient infrastructures.’ Accomplishing this requires an understanding of national, regional, and local infrastructure policies, the ability to analyze networks and the All-Hazards Environment in the context of the infrastructure, and the application of risk management principles. Security and resilience strategies and design approaches are explored, evaluated, and applied to specific circumstances. This course does not address these dimensions generically, but rather as they apply specifically to an infrastructure of the student’s choosing.

Students participate in teaching the course through presentations on a variety of topics given throughout the term. Students additionally focus their own learning by selecting an infrastructure of choice for the integrated homework—course project package. The homework focuses on developing an understanding of the current state of an infrastructure while the project then uses this understanding to propose a plan to increase the resilience of the infrastructure in question. At the completion of the course project, students have a design for a resilient infrastructure suitable for presentation to a city council, chief executive officer, or public service commission.

This course is a graduate level course, currently structured for fifteen three hour attendances. However, each lesson could be split into thirds and the course easily converted to a 40 lesson format. Additionally, with small modifications to account for student experience, the course could be offered as an undergraduate elective for seniors.

**Credits Conferred: 3**

**Prerequisite:** Prerequisites depend on the place of the course in a program. If offered as a stand-alone course, it may be taught without prerequisites. In this case the lesson topics labeled ‘fundamentals’ are introductions to the given topics and the project expectations adjusted accordingly. If offered as part of a certificate or program, courses in introductory CIP/R, risk management, network analysis and CIP/R policy may be required as prerequisites. In this case lesson topics labeled ‘fundamentals’ should be adapted to be reviews.

**Course Objectives:**

a. Explain the impact of policies and regulations on critical infrastructure resilience.

b. Assess the All-Hazards Environment for a specific critical infrastructure element.

c. Analyze an infrastructure network to find the hubs and critical points of failure.

d. Apply Risk Management to critical infrastructure.

e. Evaluate proposed protective and resilience strategies, policies, and design approaches.

f. Design resilient infrastructures.

**Delivery Method:**

This course is a collaborative learning environment that relies on the expertise and experiences of the instructor and students. The course structure includes instructor facilitated discussions, student presentations on specific topic areas, and an integrated homework-course project package. Each lesson is set for 3 hours with breaks on the hour. The course structure is suitable for in person, synchronous distance education, or blended formats. Delivery by asynchronous distance education is possible but will requires some modifications on the part of the instructor to enable the necessary discussion.

**General Course Requirements:**

**1.** Class attendance is both important and required. If, due to an emergency, you will not be in class, you must contact your instructor via phone or email. Learners with more than two absences may drop a letter grade or lose course credit.

**2.** It is expected that assignments will be turned in on time (the beginning of the class in which they are due). However, it is recognized that learners occasionally have serious problems that prevent work completion. If such a dilemma arises, please speak to the instructor in a timely fashion.

**3.** The completion of all readings assigned for the course is assumed. Since class will be structured around discussion and small group activities, it is critical for you to keep up with the readings and to participate in class.

**4.** Turn off all beepers, pagers, and cell phones off before class begins.

**GRADING:**

Homework assignments: 5@100 points

HW 0: Infrastructure Selection

HW1: Infrastructure Description

HW2: Policy Analysis

HW3: Network Analysis

HW4: All Hazards Profile

HW5: Book Analysis

Case Study Exercises: 2@ 200 points

Course Project Report: 500 points

Course Project Presentation: 300 points

Final Exam: 300 points

Total: 2000 points

**Course Number XXXX**

**Course Name: Designing Resilient Infrastructures**

**Homework and Course Project**

HW 1-4 are all built around a particular infrastructure you choose to investigate. You need to pick something large, but not too large. It needs to be a manageable size and something you are familiar with or can get familiar with. For example, you could pick your home town’s water/wastewater infrastructure. Then, each of your homeworks will be done in the context of this infrastructure. Read through all the homework requirements and this will make sense. The homework assignments then become the background for your course project. A poor infrastructure selection will make the homework and project more difficult.

**HW 0 Infrastructure Identification**

0 Points

What infrastructure you will use as the basis for your homework problems? Make sure it is an infrastructure (i.e. a networked system. One lone item somewhere does not work). Read through all the homework requirements and the project requirements to make sure you can gather the needed information for a successful submission for the home works and the report.

**HW 1 Infrastructure Description**

100 Points

Using the Component Model (Generation, Bulk Transmission, Distribution, Use, Waste Management, Coordination) to describe your infrastructure. You will use these details for the rest of the term so get specific. Find out as much information as you can as you will use this for the remainder of the term.

**HW 2 Policy Analysis**

100 Points

All infrastructure activities take place in an environment of policy. To design a resilient infrastructure, you must first understand the policies that shape that infrastructure. Analyze and report on the policies, codes, standards, opinions, taxes, fees, regulations and anything along these lines that shapes your selected infrastructure. Convince me you understand your infrastructure.

**HW 3 Network Analysis**

100 Points

Conduct a network analysis of your infrastructure. Classify the network by type and topology. Determine the hubs. Analyze and assess the network nature of the infrastructure.

**HW 4 Hazard Analysis**

100 Points

Using FEMA 386-2, *Understanding your Risks: Identifying Hazards and Estimating Losses*, conduct a hazard analysis for a significant node or hub in your infrastructure. You will use Worksheet 1 and Worksheet 2 from this manual, the applicable USGS and FEMA websites, and your information from HW1 and HW2 to establish a hazard profile for the hub/node in question.

**HW 5 Infrastructure Related Book Analysis**

100 Points

Read a book related to infrastructure and write an analysis in terms of everything we have discussed in class. About 5 pages, double spaces, 1” margins, 12 font. Some suggested books:

* *Trainman* by P.T. Deutermann (A novel that raises all sorts of interesting issues from an infrastructure perspective)(disclaimer, the novel has the two obligatory sex scenes necessary to make it a potential movie script)
* *Against the Gods, The Remarkable Story of Risk*, by Peter L. Bernstein
* *Pillars of the Earth* by Ken Follet (a novel. Disclaimer: this book can be downright vulgar in places).
* *Roads to Power: Britain Invents the Infrastructure State.* Jo Guldi, Cambridge, Hass, Harvard University Press. 2012.
* *Pompeii*, Robert Harris, Nov 8, 2005
* *Sustainable Energy—without the hot air*, David JC MacKay, available at <http://www.withouthotair.com/>
* *Re Thinking a Lot: The design and culture of parking*, Eran Ben-Joseph, Feb 17, 2012
* *Next Generation Infrastructure: Principles for Post-Industrial Public Works,* Hillary Brown, Washington D.C., Island Press, 2014
* *The Knowledge: How to Rebuild Our World from Scratch,* Lewis Dartnell, New York City, Penguin Press, 2014

I’m not looking for a summary of the book. I’m looking for what is important in or about the book. What principles can we learn that can then be applied to other situations? You may select another book if you wish. If you do, the quality of the book chosen will influence your grade. (A really good analysis of *One Fish, Two Fish, Red Fish, Blue Fish* by Dr. Seuss won’t earn you a good grade)

**Course Project**

The course lessons introduce the concept of design and applies it to critical infrastructure. The homework problems enable students to understand, visualize, and describe the ‘current state’ of the infrastructure. The course project then challenges students to understand, visualize, and describe a future more resilient state of that infrastructure. Students then identify the ‘problem set’ which consists of the barriers that prevent or impede the transformation from the current to future state and develop a design strategy to overcome these problems, including addressing the social, political, financial, and technical dimensions.

**Course References:** The course is specifically designed to use publically available references (including many FEMA publications), the USGS websites, the Whole Building Design Guide ([www.wbdg.org](http://www.wbdg.org)) journal articles, and current events. Many of these are the actual references used by professionals in their practice. Specific references are noted for each lesson. One cautionary note, many of the website references are subject to change. If a particular link is no longer active, then an internet search of the topic should reveal the current link.

**Course Number XXXX**

**Course Name: Designing Resilient Infrastructures**

**Course Schedule**

|  |  |  |
| --- | --- | --- |
| Lsn # | Topic | Assignment Due |
| 1 | Course and Student Introduction  Problems and Problem Solving Techniques  Introduction to Design |  |
| 2 | The Role of Policy in Critical Infrastructure Security/Resilience  Fundamentals of Network Analysis  Fundamentals of Risk Management |  |
| 3 | Using Conceptual Models to Understand Infrastructure Systems  Introduction to the All Hazards Environment |  |
| 4 | Case Study 1: Understanding, Visualizing, and Describing an Infrastructure System | HW 0 |
| 5 | Student Presentations on elements of the All Hazards Environment | HW 1 |
| 6 | Fundamentals of Blast Effects | HW2 |
| 7 | Case Study 2: Creating an All Hazards Profile | HW3 |
| 8 | Student Presentations on Risk Management Approaches |  |
| 9 | Student Presentations on Design Strategies | HW4 |
| 10 | Book Analysis discussion  The Impact of the Social and Political Dimensions on Infrastructure | HW5 |
| 11 | Case Study 3: Public Perceptions of Infrastructure | Project: Desired future state |
| 12 | Using Design to shape Response and Recovery Plans | Project: Problem set |
| 13 | Course Project In-progress Review Session | Project: Logic of transformation |
| 14 | Project Presentations |  |
| 15 | Project Presentations and Course Review | Project Report |
| Final | Final Exam |  |

Instructor Notes: Preliminary project submissions are shown. Instructor may collect submissions or may use these as a guide for student to ensure they are progressing. A final exam period is shown. As school schedules vary, if lesson 15 is the final exam period, recommend deleting lesson 13. At the instructor’s discretion, the final report could stand in as the final exam. Additionally, the course could be delivered in a semester long format of 40-42 lessons by dividing each lesson into three parts. The lesson sheets are structured to support this division.

Lesson 1

Part 1-1: Course and Student Introduction

Part 1-2: Problems and Problem Solving Techniques

Part 1-3: Introduction to Design

1. **Course and Student Introductions**
   1. Lesson Objectives
      1. Explain the course structure, administrative policies, homework assignments, and course project.
      2. Explain something interesting or unique about each classmate.
      3. Describe the historical development of protective structures.
   2. References
      1. Assante, Michael J., *Infrastructure Protection in the Ancient World*. Proceedings of the 42nd Hawaii International Conference on System Sciences. 2009
      2. *Shifting Security Paradigms: Toward Resilience* by Lewis J. Perelman in Critical Thinking: Moving from Infrastructure Protection to Infrastructure Resilience, February 2007, Critical Infrastructure Protection Program, George Mason University School of Law. Available at [www.cip.gmu.edu/archive/archive/CIPPResilienceSeriesMonograph.pdf](http://www.cip.gmu.edu/archive/archive/CIPPResilienceSeriesMonograph.pdf)
   3. Student preparation
      1. Read *Infrastructure Protection in the Ancient World* and review *Shifting Security Paradigms: Toward Resilience.*

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* 1. Discussion Topics
     1. Introduce course and administrative materials
     2. Introduce instructor and classmates as both will be essential to learning
     3. Present a brief history of infrastructure security
     4. Discuss how infrastructure security has changed and remained constant over 2000 years
     5. Discuss enduring principles from the reading assignment.
  2. Instructor Note: The lexicon changed from Critical Infrastructure Protection/Resilience (CIP/R) to Critical Infrastructure Security and Resilience (CISR) in 2014.

1. **Problem and Problem Solving Techniques**
   1. Lesson Objectives
      1. Explain and characterize different kinds of problems.
      2. Associate an appropriate problem solving technique with a problem type.
   2. References
      1. Rittel, Horst W., Webber, Melvin M., *Dilemmas in a General Theory of Planning.* Policy Sciences 4, 1973, pages 155-169. Published by Elsevier Scientific Publishing Company, Amsterdam.
      2. Hodges, N.D.C. *The Method of Multiple Working Hypotheses*. Science, Vol 15. No. 366 (Feb. 7, 1890) pp 92-96.
      3. Dodder, Rebecca, S., Sussman, Joseph M., McConnell, Joshua B. *The Concept of the CLIOS Process: Integrating the Study of Physical and Policy Systems Using Mexico City as and Example.* March 5, 2004. Available at <http://esd.mit.edu/symposium/pdfs/papers/dodder.pdf>
   3. Student Preparation. Read *Dilemmas in a General Theory of Planning* and review *Dilemmas in a General Theory of Planning* and *The Concept of the CLIOS Process*

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* 1. Discussion Topics
     1. What is the easiest problem you have had to solve?
     2. What is the most difficult problem you have had to solve?
     3. What is the strangest problem you have had to solve?
     4. What is the difference between complicated and complex?
     5. List different problem types and their characteristics.
     6. Explain the statement, “The first step in the problem solving process is to determine the nature of the problem.” Do you agree or disagree?

1. **Introduction to Design**
   1. Lesson Objectives
      1. Explain ‘design’.
      2. Apply the concept of ‘design’ to Design Resilient Infrastructure
   2. References
      1. Buchanan, Richard. *Wicked Problems in Design Thinking.* Design Issues, Vol. 8, No. 2 (Spring, 1992), pp. 5-21. Published by The MIT Press.
      2. Wikepedia article on *design thinking* found at <http://en.wikipedia.org/wiki/Design_thinking>
      3. Banach, Stefan, J., Ryan, Alex. *The Art of Design: A Design Methodology.* Military Review, March-April, 2009. pp. 105-115.
      4. Eikmeier, Dale, C. *Design for Napoleon’s Corporal.* Small Wars Journal, September 27, 2010. Published by the Small Wars Foundation.
   3. Extended readings for a more in-depth look at ‘design’, if interested.
      1. Simon, Herbert A., *The Science of the Artificial, 3rd Edition.* Massachusetts Institute of Technology. 1999.
      2. Martin, Roger L., *The Design of Business.* Harvard Business School Publishing. 2009.
   4. Student Preparation: Read all articles listed in 3.2, References.

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* 1. Discussion Questions
     1. What, exactly, is this thing called design?
     2. What is it good for?
     3. What are its advantages and disadvantages?
     4. Can we add enough structure to the readings to give us a useful methodology without compromising the nature of the thing called ‘design’?
     5. How can we use ‘design’ to design resilient infrastructure?
  2. Instructor Note: The use of Army related references is not an attempt to make this an ‘Army’ course, but rather to leverage the Army’s experience in bringing design into an organization unfamiliar with it. Beginning in the early 2000s, the Army began to incorporate design into its planning process and as a result had to develop articles to explain it to a wide audience and teaching materials applicable to a wide range of students. As a result, Army literature contains a large number of concise articles, manuals, and teaching materials focused on the basic concepts of design.

Lesson 2

Part 2-1: The Role of Policy in Critical Infrastructure Security/Resilience

Part 2-2: Fundamentals of Network Analysis

Part 2-3: Fundamentals of Risk Management

1. **The Role of Policy in Critical Infrastructure Security/Resilience**
   1. Lesson Objectives
      1. Explain the difference between law, policy, strategy, and plans.
      2. Explain the relationship between law, policy, strategy, and plans.
      3. Summarize the Homeland Security elements of the United States’ National Security Strategy.
      4. Explain the place of Critical Infrastructure Security to the National Security Strategy.
      5. Explain how law, policy, strategy, and plans shape the environmental space and frame in a resilient infrastructure design.
   2. References
      1. Note: Current versions of appropriate references are constantly evolving so any specific reference listing, and often web locations, will quickly go out of date. Instead, conduct an internet search to find the most recent materials. The Center for Infrastructure Protection and Homeland Security at George Mason University maintains a listing of current document versions at <http://cip.gmu.edu/courses/reading-list/>. Refer to this list for the most current applicable documents
      2. Law: Homeland Security Act of 2002, Public Law107-296, November, 25, 2002
      3. Policy: Under President Bush, infrastructure protection policies were listed as Homeland Security Presidential Directives (HSPD). Under President Obama, they are listed as Presidential Policy Directives (PPD). Directives from prior administrations often remain in force as policy until superseded. Current presidential policy statements are maintained on the White House and the Department of Homeland Security Websites.
      4. Strategy: President Bush published both a Homeland Security Strategy and a National Security Strategy. President Obama integrated both as the National Security Strategy. Presidents are required to submit annual reports based on the strategy. Reports and strategies are available at the National Security Strategy Archive, <http://nssarchive.us/> .
      5. Plan: National Infrastructure Protection Plan. Conduct an internet search for past and present versions. Additional sector specific plans are also available on the DHS website.
   3. Student Preparation: Review the documents listed in sections 1.2.2 to 1.2.5.

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* 1. Discussion Topics
     1. How have events of the 21st century shaped the national security environment, policy, and strategy of the United States?
     2. How have events of the 21st century (think broadly, there are many) shaped the infrastructure security/resilience environment, policy, and strategy of the United States?
     3. How have the actions of the federal government shaped the infrastructure security/resilience perspectives and actions of state, local, and tribal governments, not-for-profits, for-profits, and public-private partnerships?
     4. How have the legal, policy, and strategy decisions of the federal government contributed to infrastructure protection/resilience and how have they hindered it.
     5. How do we write law, policy, strategy, and plans that actually work?
  2. Instructor Note: This section is not intended as an in depth look at law, strategy, policy, and plans, but rather to discuss the purpose of each of these types of documents, how they relate to each other, and, most importantly, how they would impact a resilient design. A perfect example is the issue with the Jones Act in moving road salt from Maine to New Jersey in 2014. Another example is the evolution of the terms and concepts from Critical Infrastructure Protection (CIP) to Critical Infrastructure Protection and Resilience (CIP/R) to Critical Infrastructure Security and Resilience (CISR).
  3. Instructor Note: The explanation of the terms in section 1.2, References, is provided as these have evolved over time and an instructor or students new to the topics might not realize that HSPDs have evolved to PPDs (and may evolve further in the next administration) and might take them as separate, unrelated items.

1. **Fundamentals of Network Analysis**
   1. Lesson Objectives
      1. Define the following network terms:

Network

Node

Hub

Link

Degree of node

Shortest path

Network Diameter

* + 1. Differentiate between random, scale-free, and small world networks based on the frequency distribution of node degree.
    2. Identify the hubs in a network
  1. References
     1. Barabasi, Albert-Laszlo, and Bonabeau, Eric. *Scale Free Networks.* Scientific American, May, 2003.
  2. Student Preparation: Read *Scale Free Networks* and come to class with the terms of section 2.1.1 defined.

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* 1. Discussion Topics
     1. Define and apply the key network terms above
     2. Why is network analysis an essential element of critical infrastructure protection/resilience?
     3. Is it possible for a network not to have a hub?
     4. According to the reference article, hubs are defined as nodes with a high degree of connectivity? Are there characteristics which could cause a node to be designated a hub? Can you offer a more comprehensive definition of a hub?
     5. For scale free and small world networks, a network analysis will tend to focus our resources on a small number of nodes (the hubs) in a network. What other factors will argue against focusing the majority of resources on a small number of nodes?
  2. Instructor Note: This section is not intended to be a mathematically rigorous treatment of network analysis. Rather it introduces basic concepts in network behavior, most importantly how different kinds of networks behave under duress. This understanding is essential in designing resilient infrastructure because it helps us determine which of the many nodes to focus our limited resources on.
  3. Instructor Note: Barabasi defines a hub as a node with a large number of links or connections. Through these connections, if the hub is removed, then the entire network is impacted. A better definition of hub looks at both connections and function. Some nodes have only a few connections but provide a unique function in the network. For example, in a water treatment network, the water source may only have one connection to the water treatment plant, but it is none the less essential to the system. A better definition of a hub is ‘a node whose loss has system wide impacts.’

1. **Fundamentals of Risk Management**
   1. Lesson Objectives
      1. Differentiate between risk assessment and risk management.
      2. Explain the basic elements of a risk management process.
      3. Apply the procedures of FEMA 426 to risk management for buildings.
      4. Name the three things that can be done with risk and explain their integration in risk management
   2. References
      1. BIPS 06/FEMA 426: Reference Manual to Mitigate Potential Terrorist Attacks against Buildings, 2nd Edition available at <http://www.dhs.gov/bips-06fema-426-reference-manual-mitigate-potential-terrorist-attacks-against-buildings-2nd-edition> . If the link no longer functions, a web search on FEMA 426 generally returns the current document in PDF form.
      2. Wikipedia page on risk management available at <http://en.wikipedia.org/wiki/Risk_management>
   3. Student Assignment: Review BIPS 06/FEMA 426 and the suggested Wikipedia page.

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* 1. Discussion topics
     1. What is the difference between risk assessment and risk management?
     2. What are the basic steps common to all risk management approaches?
     3. Once we identify risks, what are the three things we can do with the risk? (There are actually five but *#4--ignore the risk* is generally not a good idea and *#5--eliminate the risk by eliminating the process* doesn’t work for infrastructure since folks do want their electricity, gas, and water.)
     4. Does a generalized theory of risk management exist? If so, what does it look like?
     5. Can a risk management approach developed for one location, business, or condition be used in a different location, business, or condition?
     6. How can one scale a particular risk management approach from a large location to a small one? What would it take to use a risk management process developed for New York City in Salina, Kansas?
     7. Based on the answers to 3.2.5, is it possible to compare risks in New York City to risks in Salina, Kansas?
     8. When you ask a group of people to describe risk management, what are the following people likely to say:

--Engineer/building contractor

--College fraternity

--Critical Infrastructure Security/Resilience official

--CEO of an investment bank

--Auto insurance company

--Chief Security Officer of a petro-chemical plant

Do this different perspectives make it harder or easier to reach consensus on risk management for infrastructure?

* 1. Instructor Note: In a design approach we apply risk management to help formulate the problems set leads to an articulation of what we will do with the risk. For example, what level of hazard will we design to (reduce risk), what level of hazard will we have to recover from, what level of hazard are we going to accept, and how much insurance are we going to buy? All these things are necessary for a comprehensive resilient design and they begin with understanding risk management. The purpose of this section is not to make experts on BIPS06/FEMA 426, but rather to introduce this as an example of risk management. In later lessons, students will explore different risk management approaches, compare and contrast them, and discuss the difficulties in comparing the outputs (e.g. risk ratings) for different risk management approaches.

Lesson 3

Part 3-1: Using Conceptual Models to Understand Infrastructure Systems

Part 3-2: Introduction to the All Hazards Environment

1. **Using Conceptual Models to Understand Infrastructure Systems** 
   1. Lesson Objectives
      1. State the elements and their definitions of the five West Point Infrastructure Models[[1]](#footnote-1).
      2. Apply the West Point Infrastructure Models to identify, describe, assess, and improve infrastructures.
   2. References
      1. Hart, Steven D., J. Ledlie Klosky, and Scott Katalenich. "Conceptual Models for Infrastructure Leadership." Journal of Management in Engineering, 2013.
      2. Hart, Steven D, and J. Ledlie Klosky. *ASCE eLearning.* November 21, 2013. <http://www.asce.org/Member-Benefits/ASCE-eLearning-Webinars/#Past>

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* 1. Discussion Topics
     1. Before you read the references for this lesson, how would you have described an infrastructure?
     2. Who is involved in infrastructure discussions and decisions? How do they communicate with each other? How do they reach consensus? How does their education and experiences prepare them to engage in quality discussions and reach good decisions?
     3. Could you use the Component Model to describe an infrastructure you know nothing about? How about the natural gas infrastructure? I’m going to give you 15 minutes for research then ask you to describe it for us. (This is an excellent in class exercise).
     4. What is missing from the models?
     5. What other models are available to us to help us understand, visualize, and describe infrastructure?
  2. Instructor Note: The authors of the West Point Infrastructure Models are always interested in feedback on the use and application of the models. Please send any feedback to Dr. Steven D. Hart, P.E. at [hart.engineering@yahoo.com](mailto:hart.engineering@yahoo.com) .
  3. Instructor Note: Additional video presentations are currently being on these models and may be found by searching “West Point Infrastructure Models” or Center for Infrastructure Transformation and Education. It is anticipated that these will be available sometine in 2015. If more information is desired, please contact Dr. Steven D. Hart, P.E. at [hart.engineering@yahoo.com](mailto:hart.engineering@yahoo.com)

1. **Introduction to the All Hazards Environment**
   1. Lesson Objectives (these extend through all All Hazards Environment lessons).
      1. Explain and describe the concept of All Hazards Environment.
      2. List and describe each element of the All Hazards Environment
      3. Differentiate between probabilistic and random hazard events
      4. Compare and contrast the results of terrorist attacks and natural disasters present in terms of human life and damage.
      5. Develop a hazard-performance frontier for an infrastructure.
   2. References
      1. Understanding your Risk: Identifying Hazards and Estimating Losses (FEMA 386-2), Federal Emergency Management Agency, August 2001, available at <http://www.fema.gov/media-library/assets/documents/4241?id=1880> . Though somewhat dated (many of the listed web link no longer function, but a web search on the topic will reveal the current one) the concept remains valid and the approach is useful.
      2. In the 2013 National Infrastructure Protection Plan, *“The term “all hazards” means a threat or an incident, natural or manmade, that warrants action to protect life, property, the environment, and public health or safety, and to minimize disruptions of government, social, or economic activities. It includes natural disasters, cyber incidents, industrial accidents, pandemics, acts of terrorism, sabotage, and destructive criminal activity targeting critical infrastructure. (Source: PPD-21, 2013)”*
   3. Student Preparation: Familiarize yourself with FEMA 362-6, in particular, worksheets 1 and 2 at the back of the manual.

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* 1. Discussion topics
     1. What’s the difference between probabilistic and random hazard events?
     2. How does one assign a probability of occurrence to a future event when one has never happened in the past?
     3. Is there a difference in All-Hazard and Multi-Hazard?
     4. If an infrastructure professional considers a hazard, decides that it is extreme unlikely, does nothing about it, and then the hazard actually occurs, is the infrastructure professional legally, ethically, or morally responsible for the consequences?
     5. Does the level of damage you are willing to accept for an infrastructure change with the severity of the hazard? In other words, are you willing to accept more damage in the 500 year flood than you are in the 100 year flood? If you are, how can we use this to influence designs? How does it impact response and recovery plans?
     6. Is there an official definition for ‘all-hazards’? If so, can it be made relevant and useful to a very large group of stakeholders with diverse needs, conditions, and capabilities?
  2. Instructor Note: The purpose of this lesson is to introduce and frame the All Hazards Environment. The students will then present on different elements of the environment to gain a better understanding.
  3. Instructor Note: During the development of the course outline, the DHS project manager asked this question about section 2.4.5 above: “Acceptance of level of damage seems to include Resilience? Is that accurate? Does the design conversation include considerations for speed of recovery?” The course author’s response is: “Design planning absolutely does include speed of recovery. A facility owner must state, “I want to be back in operation 7 days after a Level 2 event (whatever you want level 2 to be)” which will drive the engineer to design a facility that can be fixed in 7 days (this is not part of the typical engineering design process), the operations manager to develop a plan for a 7 day repair, the supply manager to stockpile all the supplies necessary, the CFO to manage insurance and cash reserves to pay for all that, and the HR department to figure out how we are going to get the workers here to do the work, and the CEO to explain all this to the shareholders. This is what it means to ‘design’ a resilient infrastructure. And once we do that, we get to do it for a Level 3 (bigger) event where we need a 21 day recover because we are going to accept more damage in this larger, but more unlikely event. As will be seen in the All Hazards Environment Case Study, it is not sufficient to say we face flood and earthquake hazards; we must articulate the varying levels of those hazards and what we will do under each of the conditions.

Lesson 4: Case Study 1: Understanding, Visualizing, and Describing an Infrastructure System

In this lesson, students will execute Case Study 1: Expansion of Lifeline Services in Colorado Springs Colorado. Lesson objectives and references are contained in the case study. The case study ends with a student team presentation that visualizes and describes the water, wastewater, and electrical infrastructures of Colorado Springs, Colorado.

Lesson 5: Student Presentations on elements of the All Hazards Environment

1. Class Concept and instructor notes
   1. Students prepare and give presentations on different elements of the All Hazards Environment. Students should cover general information on the particular hazard as well as specific information on a hazard event (i.e. general flood concepts and the Mississippi River Flood of 1927).
   2. Suggested topics from the four areas are
      1. Earth Effects and Natural Disasters
         1. Earthquakes
         2. Floods
         3. High Wind Events
      2. Deliberate Malicious Acts
         1. Post September 11th terrorist event
         2. Pre September 11th terrorist event
         3. Work place violence (active shooter, disgruntled employee)
         4. Protests, destructive activism, and similar activities aimed against company functions
      3. Accidents
         1. Train derailment
         2. Ship striking a bridge pier
         3. I 35 bridge collapse (The bridge failed due to an undetected design error which may be considered an accident)
      4. Deterioration
         1. Mianus River Bridge Collapse
         2. Silver Bridge Collapse
         3. Pipeline explosion caused by aging pipes
   3. Presentation length is driven by number of students. Most topics can be covered in reasonable depth for the course in 20 minutes which gives room for up to 9 presentations in a 3 hour lesson block. Aim for at least one presentation in each area and diversity in topics (i.e. avoid three presentation on terrorist events focusing on car bombs).
2. **Student Presentations**
   1. Lesson Objectives
      1. Describe elements of the All Hazards Environment as probabilistic or non-probabilistic. For probabilistic events, give the design return interval or annual probability of occurrence.
      2. Explain hazard damage mechanisms and qualitatively describe damage from design events.
      3. Describe the purpose and function of hazard design standards
      4. Explain the hazard to infrastructure caused by accidents and deterioration
   2. References
      1. For deliberate malicious acts, accidents, and deterioration, an internet search of the suggested topics generally reveals relevant information. The topics listed are provided to prompt thought rather than as a ‘to do’ list. These presentations work best when students select information relevant to them and their personal experience or local events.
      2. For earth effects and natural disasters, both the US Geologic Survey and FEMA have a variety of useful references, both print and web-based, selections of which are listed below. Many other relevant and useful resources can be found on line.
      3. US Geologic Survey (USGS) Natural Hazards Web Page at <http://www.usgs.gov/natural_hazards/> . Contains information on all forms of earth based hazards including fact sheet aimed at the general user.
      4. Earthquakes
         1. USGS earthquake page: <http://earthquake.usgs.gov/>
         2. FEMA earthquake page: <http://www.fema.gov/earthquake>
         3. FEMA Publication 454, *Designing for Earthquakes: A Manual for Architects* available at <http://www.fema.gov/media-library/assets/documents/8669?id=2418> . This is a non-technical document that is understandable by most audiences.
         4. FEMA Publication 232 Homebuilders' Guide to Earthquake-Resistant Design and Construction available at <http://www.fema.gov/media-library/assets/documents/6015?id=2103> . This document is also generally understandable by most audiences.
      5. Floods
         1. USGS flood page: <http://water.usgs.gov/floods/>
         2. FEMA Publication 543, Design Guide for Improving Critical Facility Safety from Flooding and High Winds, January 2007, available at <http://www.fema.gov/media-library/assets/documents/8811>
         3. National Flood Insurance Program: <http://www.fema.gov/national-flood-insurance-program>
         4. FEMA Map Service Center for finding Flood Insurance Rate Maps (FIRM): <https://msc.fema.gov/webapp/wcs/stores/servlet/CategoryDisplay?catalogId=10001&storeId=10001&categoryId=12001&langId=-1&userType=G&type=1>
         5. In depth additonal resource: 10 hour on line course through the Emergency Management Institute, *IS-279: Engineering Principles and Practices for Retrofitting Flood-Prone Residential Structures* available at <http://training.fema.gov/EMIWeb/IS/courseOverview.aspx?code=IS-279>
      6. Wind Events
         1. FEMA Publication 543, Design Guide for Improving Critical Facility Safety from Flooding and High Winds, January 2007, available at <http://www.fema.gov/media-library/assets/documents/8811>
         2. FEMA Publication 320, Taking Shelter From the Storm: Building a Safe Room For Your Home or Small Business available at <http://www.fema.gov/safe-room-resources/fema-p-320-taking-shelter-storm-building-safe-room-your-home-or-small-business>
         3. FEMA Publication 361 Design and Construction Guidance for Community Safe Rooms available at <http://www.fema.gov/safe-room-resources/fema-p-361-design-and-construction-guidance-community-safe-rooms>
         4. Smith, Thomas L, Perotin, Manuel, and Walsh Erin. *Protecting Critical Facilities*, Civil Engineering, May 2012.
         5. *About Derechos* on the National Oceanic and Atmospheric Administration (NOAA—trivia: This is the seventh uniformed service of the United States. Can you name the other six?) available at <http://www.spc.noaa.gov/misc/AbtDerechos/derechofacts.htm>
         6. *State of the Art Protection Against Severe Storms* by H. Estrada and E. Kiesling available at <http://ascelibrary.org/doi/abs/10.1061/40798(190)34>

Lesson 6: Fundamentals of Blast Effects

1. Lesson Objectives.
   1. Explain the difference between incident pressure and reflected pressure in a blast event
   2. Explain the effect of blast to target range, orientation, and building shape on reflected pressure.
   3. Explain strategies for achieving standoff in building site layout.
   4. Explain strategies for retrofitting existing buildings to resist blast events.
   5. Explain the hazards posed by building glazing during a blast event and mitigation strategies for the same.
2. References
   1. Building response to blast loading is an extremely complex problem that requires an understanding of vibrations, structural dynamics, non-linear material response, and (everyone’s favorite) differential equations. It is graduate level engineering. However, a fundamental understanding can be gained by using these references found won the Whole Building Design Guide website ([www.wbdg.org](http://www.wbdg.org)). The WBDG is program of the National Institute of Building Sciences, and according to its website is the “only web-based portal providing government and industry practitioners with one-stop access to up-to-date information on a wide range of building-related guidance, criteria and technology from a 'whole buildings' perspective. Currently organized into three major categories—Design Guidance, Project Management and Operations & Maintenance—at the heart of the WBDG are Resource Pages, reductive summaries on particular topics.” The references below are from the WBDG Resource Pages
   2. Threat/Vulnerability Assessments and Risk Analysis by Nancy A. Renfroe, PSP and Joseph L. Smith, PSP, Applied Research Associates, Inc. available at: <http://www.wbdg.org/resources/riskanalysis.php>
   3. Design of Buildings to Resist Explosive Threats By Robert Smilowitz of Weidlinger Associates available at:

<http://www.wbdg.org/resources/resistexplosivethreat.php>

* 1. Blast Safety of the Building Envelope by Eve Hinman, PE ofHinman Consulting Engineers, Inc. available at:

<http://www.wbdg.org/resources/env_blast.php>

* 1. Effective Site Security Design from the GSA Site Security Design Guide available at:

<http://www.wbdg.org/resources/effective_sitesecurity.php>

* 1. The Site Security Design Process from the GSA Security Design Guide available at:

<http://www.wbdg.org/resources/sitesecurity_design.php>

* 1. Balancing Security/Safety and Sustainability Objectives by Richard Paradis and Bambi Tran available at: <http://www.wbdg.org/resources/balancing_objectives.php>
  2. Glazing Hazard Mitigation by Joseph L. Smith, PSP and Nancy A. Renfroe, PSP Applied Research Associates, Inc. available at: <http://www.wbdg.org/resources/glazingmitigation.php>
  3. Retrofitting Existing Buildings to Resist Explosive Threats by Daniel Watch and Deepa Tolat, Perkins + Will available at: <http://www.wbdg.org/resources/retro_rstexplo.php>

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1. Discussion Topics
   1. Discussion of past blast events, possibly including Oklahoma City, Baltic Exchange Bombing at 30 St Mary Axe, Bali night club, and Khobar Towers.
   2. What is the most effective strategy for reducing damage, injury, and death in a blast event?
   3. What is the most difficulty strategy for reducing damage, injury, and death in a blast event to implement?
   4. How much knowledge about blast loadings should a non-engineer infrastructure professional have? How difficult is it to attain this level of knowledge.
   5. How does one determine which buildings should be designed to resist blast effects and how large should the design basis threat be?
   6. What facilities other than buildings are vulnerable to blast events? What should be done about this?
   7. Why did Khobar Towers not experience a progressive collapse failure?
   8. Blast mitigation can be very expensive and the number of actual blast events is very, very low (at least in the United States). How does one justify blast mitigation measures with a cost/benefit analysis?
   9. When a structure’s blast performance is improved, what other features or performance measures suffer?
2. Instructor note: A full lesson on blast effects is included in the course outline for the following reasons: 1) students like it. 2) students always ask about bombs 3) it’s relevant to the to topic, 4) it is where we started recently. 5)as long as there are terrorists, it will be relevant because things blowing up cause terror 6) it is an immediate mass casualty event like none of the other threats. The topic is technical but can be taught using the provided references without math since the references used on the WBDG are written for general audiences. This module is also a good example of how a ‘non-expert’ can learn something about a topic and thereby better engage and converse with ‘experts’. It is also a good example of how decisions made early in the design process (like the architect wanting an overhanging plaza and huge windows) can cause headaches later on for the security design professionals. Thus is provides a good basis for discussion about integrated project teams and building in security and resilience from project inception.
3. Instructor Note: This lesson could easily be replaced with one on cyber security, climate change adaptation, system or network behavior, or the current hot-topic of the day. The most important learning points are that all of us can master enough basic information about a complex topic to engage with the experts in meaningful discussions and that the best plans result from involving the right people early in the design process.

Lesson 7: Case Study 2: Developing Infrastructure All Hazards Profiles

In this lesson, students will execute Case Study 2: *ACME Amazium Refinery: All Hazards Profile*. Lesson objectives and references are contained in the case study. To complete the case study in a 3 hour period, the class will have to divide up into teams of one or two with each team addressing a particular hazard. The case study ends with a combined presentation on the all hazards profile for the ACME Enterprises AMAZIUM Refinery.

Lesson 8 Student Presentations on Risk Management Approaches

1. Lesson Objectives
   1. Compare and contrast different approaches to risk management, paying particular attention to scale (i.e. number of people affected)
   2. Evaluate the transferability of a particular risk management approach from one location to another (i.e. will a New York City based approach work in Salina, Kansas?)
   3. Compare and contrast the risk ratings of different approaches
   4. Select, modify, or design a risk management approach appropriate for a specific circumstance.
2. Discussion Topics
   1. Students will conduct research and give presentations on different risk management approaches. Suggested approaches include:
      1. Engineering Security: Protective Design for High Risk Buildings available at <http://www.nyc.gov/html/nypd/downloads/pdf/counterterrorism/nypd_engineeringsecurity_full_res.pdf>
      2. UFC 4-020-01 DoD Security Engineering Facilities Planning Manual available at <http://www.wbdg.org/ccb/DOD/UFC/ufc_4_020_01.pdf>
      3. A Guide to Highway Vulnerability Assessment for Critical Asset Identification and Protection available at <http://highwaytransport.transportation.org/Documents/NCHRP_B.pdf>
      4. Maritime Security Risk Analysis Model of the US Coast Guard. Multiple on line presentations exist, but the actual model is not generally available.
      5. Dam Sector Consequence-Based Top Screen process. DHS information available at <http://www.dhs.gov/dams-sector-consequence-based-top-screen>

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* 1. Discussion notes
     1. Students can generally present well on these topics. Based on the experiences of the students, select other approaches to include in the discussion.
     2. The end goal is to compare and contrast the approached to see that while everyone may be doing risk management, everyone is doing it differently. For example, in the New York City manual, buildings with a population under 5,000 are low risk. In UFC 4-020, building with a population above 1000 are high risk.
     3. A major discussion point is how to compare ‘high’ risk assets across sectors. Based on the management approached provided, how does one compare a high risk dam, to a high risk bridge, to a high risk building? Does ‘high risk’ mean the same in each of these approaches?
     4. A good way to end the discussion is to ask the students to develop a risk management approach suitable for the infrastructure in a moderately sized metropolitan area with high-probability, high-consequence events. For example, Mobile, Alabama.
     5. During the writing of this course outline, the Ebola outbreak in Africa figured prominently in the news. An interesting thought experiment for students would be “With the goal of selecting the best location and operating procedures, how would you conduct risk assessment and management for a United States military field hospital deployed to a semi-failed state in a semi-permissive environment to deal with the outbreak of a highly infectious disease? Don’t forget about the Boko Haram terrorist two countries away.” Not of our risk management approach deal directly with this type of situation. One would have to fall back on first principles, which are not well articulated for risk management, and adapt and merge existing techniques. Questions like this also make outstanding final exams.

Lesson 9 Student Presentations on Design Strategies

1. Lesson Objectives
   1. Explain design strategies available to provide appropriate levels of performance and protection under different levels of hazards.
   2. Select appropriate protection strategies based on organizational needs, mission, and funding.
   3. Write an organizational performance statement which articulates how the organization’s facilities are expected to perform across the All-Hazards Profile.
2. Discussion Topics: Students will conduct research and give presentations on different strategies to provide the necessary performance and resilience in various elements of the All Hazards Environment. Suggested topics with references follow. Note that many of the references are the same as listed above because documents often both describe the hazard and the remedy. Suggested references are only starting points and many more are available as the state of the art is constantly updating.
   1. Earth Effects and Natural Disasters
      1. Earthquakes
         1. FEMA Publication 454, *Designing for Earthquakes: A Manual for Architects* available at <http://www.fema.gov/media-library/assets/documents/8669?id=2418> . This is a non-technical document that is understandable by most audiences.
         2. FEMA Publication 232 Homebuilders' Guide to Earthquake-Resistant Design and Construction available at <http://www.fema.gov/media-library/assets/documents/6015?id=2103> . This document is also generally understandable by most audiences.
      2. Floods
         1. FEMA Publication 543, Design Guide for Improving Critical Facility Safety from Flooding and High Winds, January 2007, available at <http://www.fema.gov/media-library/assets/documents/8811>
      3. High Winds
         1. FEMA Publication 543, Design Guide for Improving Critical Facility Safety from Flooding and High Winds, January 2007, available at <http://www.fema.gov/media-library/assets/documents/8811>
         2. FEMA Publication 320, Taking Shelter From the Storm: Building a Safe Room For Your Home or Small Business available at <http://www.fema.gov/safe-room-resources/fema-p-320-taking-shelter-storm-building-safe-room-your-home-or-small-business>
         3. FEMA Publication 361 Design and Construction Guidance for Community Safe Rooms available at <http://www.fema.gov/safe-room-resources/fema-p-361-design-and-construction-guidance-community-safe-rooms>
         4. Smith, Thomas L, Perotin, Manuel, and Walsh Erin. *Protecting Critical Facilities*, Civil Engineering, May 2012.
         5. Fortified Home program with information available at <https://www.disastersafety.org/fortified-main/fortified-home/>
         6. Insurance Institute for Business and Home Safety Research Center with information available at <https://www.disastersafety.org/research-center/> .This site has interesting videos of the high winds test facility with experiments on now buildings perform under high winds.
   2. Deliberate Malicious Acts
      1. Explosive Attacks
         1. All references listed above for lesson 6
         2. Chapter 3 of BIPS 06/FEMA 426: Reference Manual to Mitigate Potential Terrorist Attacks against Buildings, 2nd Edition available at <http://www.dhs.gov/bips-06fema-426-reference-manual-mitigate-potential-terrorist-attacks-against-buildings-2nd-edition> .
      2. Other Terrorist Attacks
         1. Chapter 4 of UFC 4-020-01 DoD Security Engineering Facilities Planning Manual available at <http://www.wbdg.org/ccb/browse_cat.php?c=4> along with other supporting UFC 4-series manuals available at the same site if more detail is required.
      3. Workplace violence/disgruntled employee
         1. Guidelines for Preventing Workplace Violence for Health Care & Social Service Workers by the Occupational Safety and Health Administration (OSHA) available at <https://www.osha.gov/Publications/OSHA3148/osha3148.html>
         2. Workplace Violence Prevention Readiness and Response By Stephen J. Romano, M.A., Micòl E. Levi-Minzi, M.A., M.S., Eugene A. Rugala, and Vincent B. Van Hasselt, Ph.D. on the FBI website at <http://www.fbi.gov/stats-services/publications/law-enforcement-bulletin/january2011/workplace_violence_prevention>
         3. Workplace Violence Prevention Strategies and Research Needs by the Centers for Disease Control and Prevention available at <http://www.cdc.gov/niosh/docs/2006-144/pdfs/2006-144.pdf>
      4. Destructive protests/destructive activism
         1. No suggestions available.
   3. Accidents
      1. Design of Blast-Resistant Buildings in Petrochemical Facilities, editied by William L. Bounds, P.E. Published by and available from the American Society of Civil Engineers at <http://www.asce.org/Product.aspx?id=2147487569&productid=175828556>
      2. UFC 3-340-02 Structures To Resist The Effects Of Accidental Explosions available at <http://www.wbdg.org/ccb/DOD/UFC/ufc_3_340_02.pdf>
   4. Deterioration
      1. Concrete deterioration <http://www.structuremag.org/article.aspx?articleID=590>

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1. Instructor Notes: Clearly this could fill the three hour lesson and then some. Time limits will be essential for limiting the amount of student work required and covering a variety of topics. Class schedule should leave time for discussion of strategies and how decisions are made to pursue or not pursue particular ones. Design strategies that work across multiple threats and hazards are essential to making the financial case for designing resilient infrastructure. Ask students to look for these multi-dimensional strategies across the presentations.

Lesson 10

Part 10-1: Book Analysis discussion

Part 10-2: The Impact of the Social and Political Dimensions on Infrastructure

**Part 10-1: Book Analysis discussion**

1. Lesson Objectives
   1. Analyze an infrastructure based book the infrastructure themes in any book using the tools and techniques provided by the course.
2. References.
   1. Books assigned in HW5

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1. Discussion Topics (not all questions apply to all books)
   1. What role does infrastructure play in the book?
   2. What about the infrastructure does the author get right?
   3. What about the infrastructure does the author miss?
   4. What are the strengths and weaknesses of the author’s arguments?
   5. How can the tools of this course (infrastructure models, design) be used to better understand the book?
   6. How can what we learn from the book shape our understanding and framing of real world problems and solutions?
   7. Consider how you might have read this book before this course and how you read in with this course. How has this course changed how you read and understood this book?
   8. How can we use what you learned in the book to improve the course?
   9. How can we use what you learned in the book to improve our ability to design resilient infrastructure?
2. Notes to instructor:
   1. A short list of suggested readings is included in the Homework 5 assignment. Any book with infrastructure works and it is often to the students’ and instructor’s advantage to allow the students to read a wide variety of books, including ones that might not really seem like they are infrastructure books. For example, from reading *World War Z: An Oral History of the Zombie War*, students have observed that after the zombie apocalypse there is no root beer because it takes ingredients from 7 countries to make root beer! Additionally the spread of the zombie contagion uses transportation infrastructure and mimics actual pandemics. Furthermore, the level of technology of different societies impacted how they were affected by the breakdown of international structures. At the writing of this course, the Ebola outbreak in Africa is figuring prominently in the news. Students could easily compare and contrast Ebola to the zombie contagion.
   2. For effective discussion, it is important to convey to the students that they are to analyze the book, not summarize it.
   3. The major point of the exercise it to enable the students to see the world in a way they would not have seen before. Once they realize they can do it in a book, encourage them to do it for real. Tell them to walk out of class and observe all the things that they merely passed by before.

**Part 10-2: The Impact of the Social and Political Dimensions on Infrastructure**

1. Lesson Objectives
   1. Explain the statement “All infrastructure problems are social problems” and the impact this fact has on infrastructure decision making.
   2. Identify contentious infrastructure decisions with significant social and political dimensions.
   3. Identify stakeholders in infrastructure decisions and assess their perspectives and positions.
   4. Present a complete and compelling 500 word newspaper style opinion piece advocating for or against an infrastructure issue or decision.
2. References
   1. These reference provide a sample of way organizations have sought to influence infrastructure decisions and issues that are currently being discussed.
   2. The Hudson River Sloop Clearwater: <http://www.clearwater.org/the-sloop/>
   3. The “Crying Indian” ad campaign of the 1970s: <http://www.adcouncil.org/Our-Work/The-Classics/Pollution-Keep-America-Beautiful-Iron-Eyes-Cody>
   4. Dominion Power’s Southeast Reliability Project
      1. Local newspaper article: <http://www.roanoke.com/news/natural-gas-pipeline-through-virginia-counties-is-considered/article_8b814f3c-e614-11e3-a267-001a4bcf6878.html>
      2. Community meeting to oppose: <http://transitionstaunton.org/2014/06/augusta-county-meeting-on-dominion-pipeline/>
      3. Newspaper from state capitol: <http://www.timesdispatch.com/business/economy/dominion-considers-new-w-va--va--n-c/article_6942227f-14ce-5057-a9f8-db729972e080.html>

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1. Discussion Notes
   1. This lesson sets up the case study for Lesson 11.
   2. Infrastructure problems are social problems because infrastructure provides a service that society requires to function, society pays for that function, society implicitly or explicitly approves how that function is provided, and society regulates that function through elected and appointed officials. In short, society gets a vote.
   3. The purpose of this discussion is to understand and experience the fact that the most logical infrastructure proposal will fail without the support of the public, regulatory bodies, and government legislatures/executives.
   4. Discuss how various stakeholders have used public discourse (articles, editorials, advertisements, and public relations campaigns) to sway public opinion on an infrastructure issue.
   5. Discuss ways in which one side has countered the arguments of another in public discourse on infrastructure issues.
   6. Other topics for discussion could include
      1. Keystone Pipeline
      2. Vermont Yankee Nuclear Power Plant
      3. The Northern Pass Power Line in New Hampshire.

Lesson 11: Case Study 3: Public Perceptions of Infrastructure

1. Lesson Objectives
   1. Explain the statement “All infrastructure problems are social problems” and the impact this fact has on infrastructure decision making.
   2. Identify contentious infrastructure decisions with significant social and political dimensions.
   3. Identify stakeholders in infrastructure decisions and assess their perspectives and positions.
   4. Present a complete and compelling 500 word newspaper style opinion piece advocating for or against an infrastructure issue or decision (or present the argument in another appropriate fashion—5 minute presentation, commercial, public service announcement).
2. Conduct of Class
   1. Select an infrastructure issue of importance to the class.
   2. Identify the major and minor stakeholders in the issue and have student groups assume the role of the most significant stakeholders.
   3. Articulate the positions, reasoning, and arguments of each stakeholder.
   4. Analyze the strengths and weaknesses of the stakeholder arguments.
   5. Explain the techniques each stakeholder is using to influence public opinion.
   6. Assess the impact of each stakeholder’s campaign.
   7. Present an argument supporting the stakeholder’s position to achieve lesson objective 2.4
   8. Conclude the class with considering that “all infrastructure problems are social problem” and how this fact impacts designing resilient infrastructures.
3. Lesson Note: This lesson is the practical exercise that goes with the discussion of Lesson 10-2. It is intended to be a student led lesson.

Lesson 12: Using Design to shape Response and Recovery Plans

1. Lesson Objectives
   1. Differentiate between Response and Recovery
   2. Explain the fundamental concepts of the National Response Framework and the National Disaster Recovery Framework
   3. Using an all-hazards profile and selected design strategies, articulate the post-event damage condition which is the start point for response and recovery.
   4. Explain how a resilient design concept integrates an all-hazards profile with appropriate design strategies supported by response and recovery plans to meet the objective of ‘designed to the 100 year event, resilient in the 500 year event.’
2. References
   1. Nation Response Framework available at: <http://www.fema.gov/media-library/assets/documents/32230>
   2. National Disaster Recovery Framework available at <http://www.fema.gov/national-disaster-recovery-framework>
   3. Yield Link System by Simpson Strong Tie available at [http://www.strongtie.com/products/strongframe/special\_mf/intro.asp#](http://www.strongtie.com/products/strongframe/special_mf/intro.asp)
   4. Instructor should insert state, local, or business plans appropriate to the course.

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1. Instructor Notes
   1. One purpose of developing an all hazards profile is to articulate the start point for disaster response and recovery[[2]](#footnote-2)--i.e. after the disaster, how broken is the infrastructure? This is done by articulating infrastructure performance across the full range of events in the all-hazards profile. The term ‘performance’ might be a sticking point for some because what is articulated in some cases is actually ‘failure’. The goal is to have this ‘failure’ happen in such a way that it is easily recoverable. In other words, we want the structure to ‘fail nicely.’ More importantly, when our infrastructure has ‘failed nicely’, we know what the failed condition looks like. This condition becomes the start point for response and recovery plans.
   2. An example of this concept is the Yield Link System by Simpson Strong Tie. The system concentrates the stress from an earthquake into the specific points on the frame which are designed to yield and dissipate the earthquake energy. Then after the earthquake, the links can be un-bolted and a new link bolted into place without removing the frame or other elements of the building.
   3. Another example considers level of flooding in a given event. In a smaller, less frequent event, a facility might expect one foot of water in the parking garage which would call for one level of response/recovery and in a more significant flood, the facility might expect six feet of water in the main floor which would clearly require a more significant response and recovery plan. The more significant plan could be facilitated by strategies specifically intended to make response and recovery easy and fast.

Lesson 13: Course Project In-progress Review Session

This lesson is provided for in-progress reviews on each student’s project. At this point, students should be able to present the environmental frame, current infrastructure state, desired future state, and a problem frame. The instructor should provide feedback on the projects strengths and weaknesses as well as guidance for project completion.

Instructors should consider having one or two students participate in the in-progress reviews as peer reviewers. Student peer reviewers gain experience by reviewing another student’s work and, given their backgrounds, may have specific knowledge or experience to contribute to the project. This additionally fosters a more collaborative study environment.

This review benefits students because they have an opportunity for corrections before the graded submission. As a result, their final product is better and they learn more. The review also benefits instructors because the final product is better and thus easier to grade.

Lesson 14: Project Presentations

1. Lesson Objectives-through their projects, students should demonstrate mastery of all the course objectives.
   1. Explain the impact of policies and regulations on critical infrastructure resilience.
   2. Assess the All-Hazards Environment for a specific critical infrastructure element.
   3. Analyze an infrastructure network to find the hubs and critical points of failure.
   4. Apply Risk Management to critical infrastructure.
   5. Evaluate proposed protective and resilience strategies, policies, and design approaches.
   6. Design resilient infrastructures.

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1. Instructor Notes
   1. Course objectives are tied to the homeworks and project steps. As a result a student’s level of achievement in each should be apparent in the project presentation.
   2. Aim for 15 to 20 minutes for the presentations. Any shorter and the student has probably not gained sufficient understanding of the problem and solution spaces. Any longer and the student does not understand the imperative to get to the point and convince the audience. If an audience is not convinced in 15-20 minutes (and that time is generous) it is unlikely that they will be convinced at all.
   3. Depending on the number of students in the class, the presentation may continue into lesson 15.

Lesson 15: Project Presentations and Course Review

This lesson completes project presentations as required with the remaining time for course review and summation.

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For the course review, on technique is to cause the students to reflect on what they have learned over the term. Useful questions for this reflection include

* What is the relationship to infrastructure and society?
* Why do we need infrastructure to be resilient? How many different reasons and perspectives can you come up with?
* Is there really a problem with ‘aging infrastructure’? If so, why have we not solved the problem already? What can these observations tell us about how best to achieve a resilient infrastructure?
* What is the biggest infrastructure challenge we face in the United States? Is it possible that our biggest infrastructure challenge as nothing to do with the infrastructure? To put another way, are our infrastructure challenges a second or third order effect of another problem?
* If given the task of improving the resilience of the XYZ Infrastructure, how do you feel about your ability to accomplish the task?
* If given the task of improving the resilience of the XYZ Infrastructure, what would the project team you assemble look like?
* What is the most significant thing you have learned this term?

Final Exam

Insert final exam instructions here.

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Some instructors may give a final exam while others may let the project presentation and report stand for the final grade. If a final exam is given, one option is to provide students with three to five readings on an infrastructure issue, ask the students to analyze the readings and then write a 500 word newspaper opinion piece related to the issue. A second option is to state, “Consider the course objectives and convince me of the degree to which you have mastered those objectives. Take no more than five pages. You will not convince me by simply coping your notes onto the pages. I want to see you think.” Both options have been tried and found to produce good results and to differentiate easily A, B, and C students.

If final exam is required and is to be given in lesson 15, then recommend moving the course project in-progress reviews to an out of class time.

1. These models are so named because they were developed by a faculty group in the Department of Civil and Mechanical Engineering at West Point. They have been published in a peer reviewed scholarly journal and a US Army Engineer Research and Development Center (ERDC) technical report as well as presented at ASEE and ASCE conferences and in an ASCE Webinar. [↑](#footnote-ref-1)
2. Though the purposes of the response and recovery phases are different, they begin and occur simultaneously as FEMA and many other organizations deploy response and recovery personnel and offices at the same time. [↑](#footnote-ref-2)