# CE 156
# INFRASTRUCTURE PLANNING AND MANAGEMENT

INSTRUCTOR
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This course focuses on the physical infrastructure systems that support society, including transportation, communications, power, water, and waste. These are complex, large-scale, expensive systems that must be planned for and managed over a long-term horizon. We will emphasize economics-based, analytical tools, including topics of supply, demand, and evaluation. Problem sets, case studies, and a class project provide for hands-on experience with a range of infrastructure systems, issues, and methods of analysis. By the end of the course, you will have an understanding of the role and workings of infrastructure as well as of the analytical tools required to plan and manage these systems.

This is a 3 unit undergraduate course. Prerequisites are a basic knowledge of calculus and probability.

# SCHEDULE

## Topic 1: Basics of infrastructure and of this course (3 weeks)

We'll start by providing an overview of the course and describing the major infrastructure systems: what they are, their components and technologies, and why they are critical.

*Readings*

- Ascher (2005) *The Works: Anatomy of a City*. The Penguin Press, New York. Purchase from UC Bookstore, Amazon, etc.
- ULI and Ernst & Young (2013) *Infrastructure 2013: Global Priorities, Global Insights,* The Urban Land Institute, Washington DC. Available free: http://www.uli.org/infrastructure-initiative/infrastructure-2013-explores-global-infrastructure-priorities/
- Goodman and Hastak (2006) Infrastructure Planning Handbook: Planning, Engineering, and Economics. McGraw Hill / ASCE Press. Chapter 1. Available on bSpace.
- American Public Works Association (2013) APWA 2013 Public Works Projects of the Year. Available free: http://www.apwa.net/Media/2013/7/17/2013-Public-Works-Projects-of-the-Year
- World Bank (2012) *Transformation Through Infrastructure*. Selected pages handed out in class.
- Gomez-Ibanez (2010) *California High-Speed Rail*. Harvard Kennedy School of Government Case Program #1935. This and all Harvard Kennedy School Cases are available for purchase from *http://www.ksgcase.harvard.edu/content/how_to_order.html* .
- Harvard Kennedy School (1986) Learning by the case method. Free resource available at *http://www.ksgcase.harvard.edu/* .

*Assignments*

- Problem sets #1 and #2.
- Read Gomez-Ibanez (2010) and Harvard Kennedy School (1986) before the designated lecture and be prepared to discuss the case in class. Also answer the short questionnaire on bSpace before the designated lecture (the questionnaire is to inspire you to do the reading in advance).

## Topic 2: Demand for Infrastructure (3 weeks)

Critical inputs to infrastructure planning are understanding user demand and user benefits. This is also the analytical piece that typically has the largest margins of error due to the uncertainty of human response. In this module we will cover the basic principles from microeconomics used to study demand, namely utility theory and concepts of price elasticity and consumer surplus. We'll also discuss the use of surveys to gather information on demand, and the development of demand models to estimate consumption levels. Issues of demand management (e.g., for transport, water, and power) will also be addressed.

*Readings*

- Beimborn and Kennedy (2005) *Inside the Blackbox: Making Transportation Models Work for Livable Communities*. Available on bSpace.
- Pindyck and Rubinfeld (1989) *Microeconomics*, Chapter 3: Consumer Behavior. Available on bSpace.
- Train (2009) *Discrete Choice Analysis*, Chapters 2 and 3. This covers discrete choice theory (logit, etc.). Available for free at *http://elsa.berkeley.edu/books/choice2.html*. Read pages 11-22, 29-32, 34-40, 42-48, 60-61, 71-74 (BART case study), starting and stopping at logical places on the page (e.g., section headings).

- Gomez-Ibanez and Khuong (2010) *Electric Vehicles in Cities*. Harvard Kennedy School of Government Case Program #1932.

*Assignments*
- Problem sets #3 and #4 (part).
- Read Gomez-Ibanez and Khuong (2010) case before the designated lectures and be prepared to discuss the cases in class. Also answer the short questionnaire on bSpace before the designated lecture.

## Topic 3: Supply of Infrastructure (3 weeks)

In this module, we'll cover issues regarding the provision of infrastructure systems, including design issues of what technology, how much, where, at what price, and at what level of risk. Methods from economics are emphasized including the use of production functions (the basic model of how resources are transformed to achieve objectives), cost functions of construction and maintenance, and marginal analysis (methods for optimizing resource allocation). We'll also go over methods necessary to perform the analysis, namely mathematical optimization.

*Readings*
- de Neufville (1990) *Applied Systems Analysis: Engineering Planning and Technology Management*. McGraw-Hill Publishing Company. Chapters 1-6. Available for free at *http://ardent.mit.edu/real_options/ASA_Text/asa_Text_index.html*
- Lee (2009) *New Delhi Water and Power*. Harvard Kennedy School of Government Case Program #1891.

*Assignments*
- Problem sets #4 (part) and #5.
- Read Lee (2009) before the designated lecture and be prepared to discuss the cases in class. Also answer the short questionnaire on bSpace before the designated lecture.

## Topic 4: Evaluation of Infrastructure Investments (2 weeks)

After having learned about supply and costing issues and demand issues, it's time to put them together in evaluating infrastructure investments. Society needs to invest strategically, so how can it compare various projects and choose where to invest? Here we'll discuss cost-benefit analysis, including issues of project life cycle and discount rates, prioritization, pricing difficult to price items (for example, a life), dealing with uncertainty and risk, and environmental and social sustainability.

*Readings*
- de Neufville (1990) *Applied Systems Analysis: Engineering Planning and Technology Management*. McGraw-Hill Publishing Company. Chapters 10-13. Available at *http://ardent.mit.edu/real_options/ASA_Text/asa_Text_index.html*
- Gomez-Ibanez (1996) *Santiago's Sewage.* Harvard Kennedy School of Government Case Program #1362.

*Assignments*
- Problem set #6.
- Read Gomez-Ibanez (1996) before the designated lectures and be prepared to discuss the cases in class. Also answer the short questionnaire on bSpace before the lecture.

### Topic 5: Term Project (2 weeks)

It's time to put your knowledge to work and explore an area of infrastructure analysis that is of interest to you… and teach it to your fellow students. Your task is to research a particular infrastructure project and, within that project, a particular decision made. The goal is to better understand the **analytical processes** by which real infrastructure decisions are made. Therefore, you need to not only describe the big picture of the project, but also delve deep into a particular decision within the project and the technical analysis behind that decision. For example, **what** was decided (e.g., to extend a runway at LAX in a particular manner) but **how** this decision was made (e.g., What were the alternatives? How did they evaluate the alternatives? What analytical tools did they use?). You also want to be critical (e.g., Did they miss something in their analysis? Are there assumptions they've made that are questionable?).

*Assignment*

- Deliverables are a class presentation (25 minutes, including Q&A) and the PowerPoint file. Groups must be 4-6 people and students are responsible for finding a group and defining a topic. The project will be introduced in Topic 1, initial project ideas (and group members) are due during Topic 2 and by the end of Topic 3 you need to have spoken with the Prof and/or GSI about your project. The presentations will be scheduled the last two weeks of class.

*Readings as listed above may be adjusted as necessary.*

## COURSE REQUIREMENTS AND GRADING

- Participation (5%) – Includes Harvard Kennedy School case studies.
- Problem sets (25%) – 6 total, approximately 1 every two weeks.
- Group project (20%) – Deliverable is an in-class presentation near the end of the term.
- Midterm exam (20%) – Tuesday March 18 in class.
- Comprehensive final exam (30%) –Friday May 16, 7-10 PM.

# CLASS SCHEDULE

*May be adjusted as necessary.*

| Week | Day | Month | Date | Lecture Topic | Problem Sets OUT | Problem Sets IN | "Special" events |
|---|---|---|---|---|---|---|---|
| 1 | Tue | Jan | 21 | Topic 1: Basics of Infrastructure | 1 | | |
| 1 | Thur | Jan | 23 | | | | |
| 2 | Tue | Jan | 28 | | | | |
| 2 | Thur | Jan | 30 | | | 1 | HKS Case Study: High Speed Rail |
| 3 | Tue | Feb | 4 | | 2 | | The Works in-class presentations |
| 3 | Thur | Feb | 6 | | | | The Works in-class presentations |
| 4 | Tue | Feb | 11 | Topic 2: Demand for Infrastructure | | | |
| 4 | Thur | Feb | 13 | | | | |
| 5 | Tue | Feb | 18 | | 3 | 2 | |
| 5 | Thur | Feb | 20 | | | | |
| 6 | Tue | Feb | 25 | | | | Initial project proposals |
| 6 | Thur | Feb | 27 | | | | HKS Case Study: Electric Vehicles in Cities (SF) |
| 7 | Tue | Mar | 4 | Topic 3: Supply of Infrastructure | 4 | 3 | |
| 7 | Thur | Mar | 6 | | | | |
| 8 | Tue | Mar | 11 | | | | |
| 8 | Thur | Mar | 13 | | | 4 | |
| 9 | Tue | Mar | 18 | | | | **MIDTERM EXAM** |
| 9 | Thur | Mar | 20 | | 5 | | By end of this week, talk with Prof/GSI about project |
| ~~10~~ | ~~Tue~~ | ~~Mar~~ | ~~25~~ | | | | SPRING BREAK |
| ~~10~~ | ~~Thur~~ | ~~Mar~~ | ~~27~~ | | | | SPRING BREAK |
| 11 | Tue | Apr | 1 | | | | HKS Case Study: New Delhi Water and Power |
| 11 | Thur | Apr | 3 | Topic 4: Evaluation of Infrastructure Investments | | | |
| 12 | Tue | Apr | 8 | | 6 | 5 | |
| 12 | Thur | Apr | 10 | | | | |
| 13 | Tue | Apr | 15 | | | | HKS Case Study: Santiago's Sewage |
| 13 | Thur | Apr | 17 | | | 6 | Buffer Day |
| 14 | Tue | Apr | 22 | Topic 5: Term Project Presentations | | | In-class project presentations |
| 14 | Thur | Apr | 24 | | | | In-class project presentations |
| 15 | Tue | Apr | 29 | | | | In-class project presentations |
| 15 | Thur | May | 1 | | | | Course wrap-up |
| 16 | Tue | May | 6 | | | | RRR - no class |
| 16 | Thur | May | 8 | | | | RRR - review session |
| F | Fri | May | 16 | | | | **FINAL EXAM 7:00-10:00 PM** |