SUMA K5690 Environmental Infrastructure for Sustainable Cities: Moving from Concept to Reality
Fall 2016
Thursdays, 6:10-8:00 PM
3 Credits

Instructor: Carter Strickland, Carter.Strickland@hdrinc.com

Office Hours: Office hours will be held on Mondays from 4 to 6 PM in 2929 Broadway, 5th Floor or by appointment

Response Policy: My preferred means of communication is email to the address above. Students should expect a response from me within 24 hours.

Course Overview

Sustainability requires the efficient use of resources. In our modern, highly-developed society the least carbon- and energy-intensive pattern of settlement occurs in compact, walkable cities. The foundation for these cities is the integrated networks of infrastructure that allow us to move, eat, drink, play, and survive extreme weather. As our population shifts to urban and coastal areas, we will need to build more systems to maintain sustainability. Yet we are building too little, too slowly to maintain our existing infrastructure, let alone build next generation systems that will accelerate our society to a truly low-carbon future. Our existing transportation, water, parks, freight, solid waste, and energy infrastructure is crumbling, and new needs such as coastal flood mitigation and resiliency are not being met. With little political will for massive public works programs, and current practices that are slow and costly, cities are starting to use innovative ways to deliver these critical assets, including design-build procurement, long-term concessions, private operation, maintenance and financing, and other forms of public-private partnerships. Cities and states are pooling resources to solve problems through infrastructure exchanges and accelerators. And project developers are thinking of creative ways to create multiple function infrastructure that is also resilient and sustainable.

This course is designed to create the leaders of tomorrow who will overcome these challenges and build our sustainable cities. Using case studies of “environmental infrastructure” – public water, transportation, freight, parks, resiliency, solid waste, and energy infrastructure – this course covers the project life cycle from planning to asset management and provides the foundation needed for to design and deliver infrastructure services and build cities. Students will be introduced to creative planning and project conception, cost-benefit analysis, prioritization, alternative delivery and private-public partnerships, coalitions of interested stakeholders and partners, funding and financing, governance, and considerations about operations and maintenance. They will apply these lessons to present solutions of current infrastructure issues in both group and individual formats that mimic the professional settings they will face after graduation, and will learn to receive and provide constructive feedback from and to their peers.

This course is approved for the M.S. in Sustainability Management curriculum area requirements Area 3 Physical Dimensions and Area 5 General and Financial Management.

Learning Objectives

By the end of this course, students will be able to:

• Discuss the importance of infrastructure to creating sustainable cities;
• Discuss and analyze standard infrastructure development stages and requirements;
• Explain the characteristics and benefits of public private partnerships and alternative delivery mechanisms and analyze whether those mechanisms are appropriate for any or all stages of a particular project;
• Structure an infrastructure delivery plan;
• Present analysis and solutions in different formants (group oral presentation with slides/graphics, and a written memorandum and business case); and
• Develop expertise on the subject matters chosen for the group and individual project.

Readings

Individual readings are included in the course calendar below. The following book is useful for general reference:


Resources

Columbia University Library
Columbia’s extensive library system ranks in the top five academic libraries in the nation, with many of its services and resources available online: http://library.columbia.edu.

SPS Academic Resources
The Office of Student Life and Alumni Relations (SLAR) provides students with academic counseling and support services such as online tutoring and career coaching: http://sps.columbia.edu/student-life-and-alumni-relations/academic-resources.

Course Requirements (Assignments)

1. Group Presentation on an Infrastructure Problem and Potential Solutions

Students will form “consultancies” of up to 4 students, which have been hired by a public agency or authority to help solve a complex issue. Groups must finalize their case city/region and topic by the second week of the course. The output will be a Powerpoint to inform public officials whether to support an infrastructure project (but be prepared to answer how presentation would be adjusted for meetings with the public financial backers, and other stakeholders). Students will be challenged to explain the issue, to present analysis, and to propose solutions in 10 slides and 15 minutes.

The presentation should be developed using the following structure, and to answer the following questions:

1. Problem definition: What is the problem? Why is it a problem? For whom is it a problem?
2. Problem analysis: What are the causes of the problem? What role can infrastructure and supporting policy interventions play in solving it? What data exists or can be created to help inform the problem?
3. Solution generation: What is the solution? How does it solve the problem? What is required for its implementation? Who should do what when? What are threats along the way? How can these be dealt with?
4. Solution and alternatives analysis: In which measure does the solution solve the problem? How certain of its effectiveness are we? Do the benefits/advantages outweigh the benefits/disadvantages? How can the solution be improved following the assessment?

Progress Milestones:
• Groups formed (random team assignments given in Class 2);
• topics submitted (Class 3); consultation with professor (office hours before Class 4);
• team meetings (outside of class between Classes 4 and 7); and
• presentation and feedback (during Class 7).

2. Individual Memorandum and Business Case Evaluation on an Infrastructure Delivery Plan
Following the same structure and questions used to frame the group presentation, each student will prepare a memorandum and business case evaluation for a delivery plan to address a historic or current infrastructure problem. (If the topic is historical, the memorandum must describe what happened, why, and how, but must include critical analysis, such as whether there were better alternatives, why worse alternatives were rejected, how project or program procurement, governance, financing could have been improved, or any other topic. The length should be long enough to inform the audience but not too long to fit into a busy schedule – the target length should be between 10 and 20 pages (or about 2,500 to 5,000 words).

Here are just a few topical environmental infrastructure issues to consider for group and individual projects:

<table>
<thead>
<tr>
<th>Transportation</th>
<th>Energy</th>
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<tbody>
<tr>
<td>Gateway tunnels (and original tunnels built by Pennsylvania Railroad)</td>
<td>Transmission Lines (HydroQuebec, Hudson Valley)</td>
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<tr>
<td>Airport rail connections (LaGuardia, Denver)</td>
<td>Indian Point Nuclear Plan</td>
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<td>LaGuardia Airport renovation</td>
<td>Pipelines (Keystone, Spectra, Constitution, Northeast Energy Direct)</td>
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<tr>
<td>Stewart Airport renovation, business plan</td>
<td>Vehicle charging stations (Electric, CNG, hydrogen)</td>
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<td>California High Speed Rail</td>
<td>LNG Piers</td>
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<td>Amtrak NE Corridor (Stations, Penn/Moynihan Station, Acela)</td>
<td>Fracking</td>
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<td>Bike lanes</td>
<td>Off-shore/On-shore Wind Power farms</td>
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<td>Autonomous Vehicles</td>
<td>Solar installations (distributed and in solar farms)</td>
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<td>Electric Charging Station Networks</td>
<td>Microgrids / nanogrids</td>
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<td>Rapid Bus Transit</td>
<td>Anaerobic digester or landfill gas</td>
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<td>Multi-modal stations</td>
<td>Biomass-based liquid fuels</td>
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<td>Brooklyn-Queens light rail system</td>
<td>Distributed generation (microturbines, fuel cells, storage)</td>
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<td>Uber</td>
<td>Hydropower</td>
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<th>Water / Wastewater</th>
<th>Solid Waste</th>
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<tr>
<td>Rondout West Branch Tunnel Repair</td>
<td>Marine Transfer Stations / 91st Street MTS</td>
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<tr>
<td>Green Infrastructure</td>
<td>Transfer Stations</td>
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<td>Stormwater Utilities</td>
<td>Scrap Yards</td>
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<td>Lake Powell Pipeline</td>
<td>Landfills</td>
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<td>Carlsbad Desalination Plant</td>
<td>Incinerators / Waste to Energy Facilities</td>
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<td>Santa Clara Reuse Plant</td>
<td>Garbage disposals</td>
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<td>San Antonio Water Purchase Agreement</td>
<td>Parks, Open Space, Natural Infrastructure</td>
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<td>Bayonne, NJ O&amp;M Agreement</td>
<td>Orchard Beach/Pelham Parkway</td>
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<td>Rialto, CA O&amp;M Agreement</td>
<td>Plazas / sidewalks / green corridors</td>
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<tr>
<td>Three Gorges Dams</td>
<td>Parks</td>
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<td>Resource recovery from wastewater (phosphorus, Class A biosolids, energy, reusable water)</td>
<td>Marine Park</td>
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<td>Resiliency projects (Sandy coastal protection around Manhattan, Seaport City Multi-Purpose Barrier, NY Harbor Surge Barrier, Katrina, NOLA Levees)</td>
<td>Jamaica Bay Wetlands</td>
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<td>Colorado/Texas/California Water Plans</td>
<td>Protective Beach Dunes</td>
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<td>Oyster reefs</td>
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<td>Floyd Bennett Field</td>
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Progress Milestones:
- topics submitted (Class 8);
- consultation with professor (office hours between Classes 9 and 10); and
- presentation and feedback (during Classes 11 and 12).
Evaluation / Grading

Student work and progress towards course goals will be evaluated by professional standards, i.e., demonstrating a thorough understanding of applicable concepts, comprehensive research, rigorous analysis, and an unbiased, persuasive, and clear recommendation for action. In other words, a public official would find the presentation or document to be a sound basis to make a decision. Our emphasis is on depth of thought, clarity of expression, and brevity, not the number of words. Students are encouraged to spend at least twice as much time thinking and talking through the problem and solutions, as in writing. Once students have a clear, logical framing of the problem and solution, the writing will be better and easier.

Grades will be determined from the following allocation:

- 15% Participation
- 35% Group Presentation on an Infrastructure Problem and Potential Solutions
- 50% Individual Memorandum and Business Case Analysis on an Infrastructure Delivery Plan

All assignments are graded on a scale of 0-100. Points awarded to individual assignments translate into letter grades for the course in the following manner: an A+ is awarded for truly extraordinary work, above and beyond course requirements and even professional standards; an A is awarded for final scores in the 93 to 100 range; an A- for 90 to 92; B+ for 87 to 89; B for 84 to 86; B- for 80 to 83; C+ for 77 to 79; C for 74 to 76; C- for 70 to 73; D for 66 to 69; and an F for scores of 65 or less.

Course Policies

Participation and Attendance
Students are expected to be fully prepared for class by completing all reading and actively thinking about the issues to be discussed. Students are also expected to participate actively in class by enhancing our understanding, and not diverting or dominating the discussion but showing awareness of the flow of thought. Insightful questions count as least as much as insightful comments. Your participation will require that you answer questions, defend your point of view, and challenge the point of view of others. If you need to miss a class for any reason, please discuss the absence with me in advance.

Late work
There will be no credit granted to any written assignment that is not submitted on the due date noted in the course syllabus without advance notice and permission from the instructor.

Citation & Submission
All written assignments must cite sources and be submitted to the course website (not via email)
Course Schedule and Calendar

PART I: FOUNDATIONS FOR INFRASTRUCTURE DEVELOPMENT

Week 1:
1. The Role of Infrastructure in Economic Development and Environmental Protection

This class focuses on the relationship between infrastructure, the economy, public health, and the environment, and presents an overview of past and present infrastructure development in the U.S.

Discussion topics: Public “environmental infrastructure” and its relationship with social/civic, educational, housing, private facilities, and other infrastructure; patterns of development in an increasingly urban, coastal world; importance of managing infrastructure management to cities, economies, and the environment; public health and environmental metrics; development and the environment in historic context; preservation versus conservation; widespread changes in land use and climate change, how it informs our understanding of the “natural” world; historic role of the Jefferson Plan, Erie Canal, and Eisenhower Interstate Highway System to development in the use; Present state of U.S. infrastructure; ASCE scorecard; climate change and adaptation.

Case Studies and Readings:


The Fourth Regional Plan. Regional Plan Association, Forthcoming.


Week 2:
2. Making the Case for Infrastructure: Politics, Stakeholders, Planning, and Economics

This two-part class focuses on (1) key decision-makers, the political context of infrastructure, the role of strategic planning, and other methods for creating momentum for investment in infrastructure, and (2) the preliminary studies necessary for the development of infrastructure.

Discussion topics: (1) The role of politics, interest groups, elected leaders, public opinion, and governmental institutions in the formulation and management of public policy and programs; deciding what, when, and how to
build; relationship between strategic plans, master plans, facility plans; agenda setting; stakeholder and citizen participation; setting priorities; understanding and communicating risk; and (2) Planning, Pre-Design, Feasibility Studies, and Site Selection; assessment and management; condition assessment and asset management; benefit-cost analysis; life-cycle analysis; time value of money; business cases; alternatives analysis; environmental review; permitting; site assembly; eminent domain; stakeholder meetings and charrettes; siting and environmental justice.

Case studies and readings:


Week 3:
3. Financing, Funding and Procuring Infrastructure

This class presents options for funding and financing infrastructure, i.e., who should pay, how should funding be collecting and spent, and related topics, and the critical link between financing, feasibility, and actual design and construction.

Discussion topics: Which level of government sponsors which infrastructure sector projects (e.g., transportation is federal and state, water, wastewater and solid waste are local); taxes; tax increment financing; special improvement districts; user fees, enterprise funds, trust funds, and other income streams; municipal bonds (general obligation, revenue backed); tax exemption for municipal bonds; leveraging public assets; quantifying and monetizing benefits (e.g., naming rights); private financing (equity, debt); Federal Highway Trust Fund; Federal Land and Water Conservation fund; State Revolving Funds; TIFIA and WIFIA; Private Activity Bonds; earmarks. Project life-cycle (design, construction); variety of state and city procurement legislation; anti-corruption reforms; Wicks Law; role of labor unions; Project Labor Agreements; design-bid-build; design build and progressive design build; advanced procurement options; role of technical, procurement, legal, financial, design consultants; risk allocation and costing; guarantees and indemnities; project management; programs versus projects; on-call contracts.

Case studies:


**Week 4:**

4. *Taking the Long View Part I: Governance, Operations & Maintenance, and Asset Management*

This class discusses the problems around adequate running of infrastructure and problems of institutionalizing investments.

Discussion topics: Asset life cycle; asset performance; level of service; management metrics; adaptive management; funding streams; cross-agency issues; cross-boundary issues; cross-jurisdictional issues; flow control and legal issues.

Case studies and readings:


**Week 5:**

5. *Taking the Long View Part II: Sustainable Infrastructure and Resiliency*

This two-part class discusses “good” versus “bad” infrastructure, procedural and substantive protections, the tradeoff between the risks of non-action and the risks of bad decisions, and the including infrastructure to promote resiliency and adaptation to climate change, all through the lenses of (1) sustainability and (2) resiliency.

Discussion topics: Robert Moses versus Jane Jacobs; concepts of sustainability and resiliency; stakeholder involvement and environmental review revisited; centralized versus decentralized infrastructure; nature-based infrastructure; smart infrastructure; sustainable design and rating systems (LEED, Envision); the role of enduring and predictable subsidies for irrigation projects, solar farms, and wind farms; the ethanol problem; continuity of operations for communities and businesses.
Case studies and readings:


Week 6:


This class discusses creative solutions for financing, developing, and operating infrastructure that involve private or public partners.

Discussion topics: Revisiting stakeholders; advocacy groups; public-public partnerships and intergovernmental agreements; public-private partnerships (P3), public-public-private partnerships (P4); design build through design-build-finance-operate and maintain (DBFOM); international practices and norms where tax exempt financing doesn't exist; concession arrangements and contract oversight; conflict resolution; federal-state-local partnerships and federalism; infrastructure exchanges and accelerators, including the West Coast Exchange and the Intermountain Infrastructure Exchange.

Partnerships British Columbia

Case studies and readings:


Guest Lecturer: Eric Petersen, Hawkins Delafield & Wood

Week 7:
7. **Group Presentations and Discussions**

Student groups will make a presentation on an economic or environmental issue, present their analysis of alternatives, and to propose solutions. Groups are allotted 10 slides and 15 minutes, plus 5 minutes for additional discussion.

**PART II: APPLYING APPROACHES TO SOLVE INFRASTRUCTURE ISSUES**

Week 8:
8. **Transportation**

This class will be an advanced discussion of transportation infrastructure issues, including relationship to economic development, freight optimization in the urban context; emergency management provisions, tolling, and P3 arrangements.

Case studies and readings:


Guest Lecturer: Mike Schneider, HDR

Week 9:
9. **TBD: Infrastructure Field Trip and Discussion**

Week 10:
10. **Water and Solid Waste**

This two-part class will be (1) an advanced discussion of water infrastructure, including state plans recently completed by California, Texas, and Colorado, water trading for financing infrastructure, the role of technology, conservation, prioritization in the regulatory context, the phenomenon of bottled water and the Value of Water coalition, water rates, and privatization; and (2) an advanced discussion of solid waste infrastructure issues, including the economics of collection, recycling and sorting, closed loop theories and mechanisms, landfills, incinerators, waste to energy, organics and anaerobic digestion.

Case studies and readings:
Week 11:

11. Energy and Integrated City-Level Infrastructure

This two-part class will be (1) an advanced discussion of the infrastructure of energy generation and transmission, including utility scale installations, microturbines, transmission lines, microgrids, pipelines, the challenge of integrating renewables, storage, hydro-fracking, nuclear power, oil development and export, the role of innovation, carbon-taxes and trading, the problem of climate change, and (2) an advanced discussion of the complex interaction between infrastructure systems in an urban environment in an era of climate change.

Discussion topics: Urban land use forms and contexts; hierarchies of infrastructure; street work and conflicts; legal issues; aggregation versus dispersal; value creation and capture (enhance adjacent areas, intrinsic); parkland and recreational use; resiliency; stormwater management; transportation corridors and transit oriented development.

Case studies:


Week 12:

12. **Individual Presentations and Discussions**

Individuals will present their business case evaluations of an economic or environmental issue, present their analysis of alternatives, and to propose solutions. Individuals will be allotted time depending on enrollment.

Week 13:

13. **Individual Presentations and Discussion, Cont’d**

**School Policies**

*Copyright Policy*
Due to copyright restrictions, online access to this material is limited to instructors and students currently registered for this course. Please be advised that by clicking the link to the electronic materials in this course, you have read and accept the following:

The copyright law of the United States (Title 17, United States Code) governs the making of photocopies or other reproductions of copyrighted materials. Under certain conditions specified in the law, libraries and archives are authorized to furnish a photocopy or other reproduction. One of these specified conditions is that the photocopy or reproduction is not to be "used for any purpose other than private study, scholarship, or research." If a user makes a request for, or later uses, a photocopy or reproduction for purposes in excess of "fair use," that user may be liable for copyright infringement.

*Academic Integrity*
Columbia University expects its students to act with honesty and propriety at all times and to respect the rights of others. It is fundamental University policy that academic dishonesty in any guise or personal conduct of any sort that disrupts the life of the University or denigrates or endangers members of the University community is unacceptable and will be dealt with severely. It is essential to the academic integrity and vitality of this community that individuals do their own work and properly acknowledge the circumstances, ideas, sources, and assistance upon which that work is based. Academic honesty in class assignments and exams is expected of all students at all times.

SPS holds each member of its community responsible for understanding and abiding by the SPS Academic Integrity and Community Standards posted at [http://sps.columbia.edu/student-life-and-alumni-relations/academic-integrity-and-community-standards](http://sps.columbia.edu/student-life-and-alumni-relations/academic-integrity-and-community-standards). You are required to read these standards within the first few days of class. Ignorance of the School's policy concerning academic dishonesty shall not be a defense in any disciplinary proceedings.

*Accessibility*
Columbia is committed to providing equal access to qualified students with documented disabilities. A student’s disability status and reasonable accommodations are individually determined based upon disability documentation and related information gathered through the intake process. For more information regarding this service, please visit the University's Health Services website: [http://health.columbia.edu/services/ods/support](http://health.columbia.edu/services/ods/support).