CE 599 Special Topics: Modeling Transportation Network Supply and Demand

Units: 4

Spring, 2019

Friday 9:00 AM – 12:20 PM, half if this time is spent in a computerized classroom, and half in a conventional classroom.

Location: TBD, 100 minute/Week of lecture in a standard classroom and 100 minute/Week in the SAL computerized classroom.

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CE 586 Catalogue Course Description Effective Fall, 2019
Theories and applications of transportation network demand and supply models and simulation techniques. Hands-on opportunities to work with simulation software to solve problems.

Detailed Course Description

Content: This course presents theories and applications of transportation network demand and supply models and simulation techniques. The course provides a firm grounding in modeling and optimization of transportation networks. A review of discrete optimization and static transportation network analysis will be provided in the first few lectures. The course covers representation, modeling and algorithms for solving different network problems. Both analytical and simulation-based network assignment models and vehicle routing problems are discussed. Strategic issues such as network design, congestion pricing and lane management models are discussed in the later sections of the course. The emphasis in this course is on practical applications, analysis of algorithms and the ability to solve such problems. Students learn the details of four-step travel demand model process through classroom exercises, and acquire hands-on experience with current software tools. They practice transportation network design and editing, implementing various network assignment algorithms, network optimization strategies, and reporting various network performance measures such as Vehicle Miles Travelled

(VMT), Level of Service (LOS) and turning movements. Basic undergraduate engineering knowledge of programming, operations research, and optimization models may be required for the Homework sets and the final Project.

Organization: Half of the weekly lecture period takes place in a conventional classroom to avoid the inevitable distraction presented by access to a computer and the internet. During this portion of the lecture, the instructor teaches various algorithms and methods to solve transportation network analysis and transportation demand modeling problems, with an emphasis on theory. The second half of each lecture period takes place in a Viterbi computerized classroom in Salvatori Computer Science Center, during which the instructor guides students in the implement of these algorithms to solve posted assignments using the state-of-the-art software functions and scripts.

Collectively, the learning objectives for the course ensure that students become proficient at transportation network modeling. The class project is fundamental to the course, and to achieving this proficiency. Each project must include specific, key model elements, and develop a representative transportation demand model. The instructor works directly with each project team in turn to implement these elements and ensure that they complete their model.

Students in this course learn many algorithms for network analysis. Homework assignments are theoretical, completed out of class, and are executed individually. Classroom exercises are more applied and computationally oriented, support skills needed for the class project, and require using programing or modeling software to implement algorithms to solve problems. Students work on aspects of their final class project and related assignments using travel demand modeling software or other programing software. The instructor guides students in their initiation of classroom exercises and answer questions in class, but exercises are generally completed on a take-home basis. Classroom exercises can be pursued collaboratively, including the take-home portions, but must be submitted individually.

Learning Objectives

Students will become proficient at transportation network modeling. By the end of this course, students will be able to:

1. relate the overall purpose of Transportation Network Analysis (TNA) to the transportation planning process;
2. identify different optimization techniques standard for modeling flows in transportation networks such as user equilibrium and stochastic optimization techniques, and apply them;
3. understand different transportation network management policies such congestion pricing and lane management, and apply them in a class project;
4. analyze and solve models used to make better network management decisions and to improve system performance;

5. understand the overall input and output data types and sources, procedures, and models for each stage of a four-step, large-scale travel demand model;
6. produce valid results and interpret these results with respect to each of the four components of a large-scale travel demand model;
7. apply the travel demand procedures to a sample transportation network using modeling software, with focus on network analysis; and
8. implement basic models and analysis in one of the transportation network modeling software packages.

Prerequisite(s): None
Co-Requisite(s): None
Concurrent Enrollment: None
Recommended Preparation: Students should have basic knowledge of one programing language such as Python, VBA, C, Java, or R; a prior introduction to transportation modeling at the level of CE 471 or PPD/CE 633; basic statistics at the level of ISE 225, CE 408, or EE 364; and linear programing and basic optimization concepts at the level of ISE 330. Students who are uncertain about their backgrounds should discuss the matter with the instructor in advance.

Technological Proficiency and Hardware/Software Required
The USC Viterbi School provides students with free access to one of the leading transportation demand modeling software packages available in the market. Students need not have prior experience with this software, but are expected to be familiar with using USC Viterbi virtual machines and basics of one programing language.

Course Notes
Selected course lectures and classroom exercises are posted on the class Blackboard website. Students are expected to routinely attend the class and take notes for study and review.

Required Readings
- Ahuja, R.K., Magnanti, T.L. and Orlin, J.B. Network Flows: Theory, Algorithms and Applications. Prentice-Hall Inc., 1993. Available at the USC Bookstore or online at http://dspace.mit.edu/bitstream/handle/1721.1/49424/networkflows00ahuj.pdf
- Sheffi, Y. Urban Transportation Networks: Equilibrium Analysis with Mathematical programming methods. Prentice-Hall Inc., Englewood Cliffs, NJ, 1985. Available online for free at http://web.mit.edu/sheffi/www/selectedMedia/sheffi_urban_trans_networks.pdf
- Selected Articles will be distributed during the class via Blackboard
- Transportation modeling Software tutorials

Supplementary Materials
- Ortuzar & Willumsen (2011). Modeling Transport (4th) Wiley. Available at the USCBookstore (optional)

- Bell, M.G.H., and Iida, Y. Transportation Network Analysis. John Wiley & Sons, 1997. ISBN 0471 96493 X. Available at the USC Bookstore.

Description of Assignments

- Midterm exams are written tests and will be graded out of 100 points for each exam.
- Classroom exercises and homework assignments require students to use a transportation modeling software package, Microsoft Excel, online search, or excute simple programing in any language.
- The final project consists of building a case study model in the identified transportation modeling software. Students will work on teams of two on the final project. The project is due the day the final examination would otherwise be scheduled.
- Students are expected to deliver two, 10-minute presentations during the course to show their progress, and a final written report of their case study model scenario analysis.
- Students may do field work in their study area to collect network operational and characteristic information such as number of lanes, speed, intersection geometry or signal timing. The field work is recommended but not required.

Assignment Rubrics

Each homework assignment and classroom exercise is posted on class blackboard page on as indicated in the Course Schedule. The instructions for classroom exercises also are posted prior to class, and students should familiarize themselves with the exercise before the class period. This maximizes the value of class time.

Assignment Submission Policy

- Each student is expected to submit his/her assignment via the class blackboard pages.
- Submissions should conform to the course schedule.
- Students can work together on classroom exercises, but they need to submit their work individually. Homework assignments should be executed and submitted individually.

Grading Timeline

- Grades will be posted on class web page within two weeks after each assignment submission.

Additional Policies

- Attendance is not graded, but routine attendance is highly recommended.

Grading Breakdown
The following weights apply.

Class Component	Points	% of Course Grade
Homeworks / Classroom exercises	4 Homework sets of 100 points each 8 Classroom execises with take-home elements of variable credit	20
Midterm Exam	100	40
Final Project & Presentation	100	40

Extra credit worth up to 10%: A research paper on a topic related to the course material. The subject of the paper must be submitted to the instructor for approval no later than week 4. The paper is a voluntary extra credit opportunity accounted for after draft letter grades are computed. Students are in no way disadvantaged if they do not elect to submit a paper. Submission can help their performance. Not submitting has no impact.

Grading Scale
Course final grades will be determined using the following scale:

A	A-	B+	B	B-	C+	C	C-	D+	D	D-	F
95-100	90-94	87-89	83-86	80-82	77-79	73-76	70-73	67-69	63-66	60-62	59 or below

This scale is presented for the sake of completeness. Courses in which students earn grades below a C cannot be presented for credit toward graduation in a USC graduate program, though the course grade remains part of the students graduate GPA.

Course Project Description
The class project is designed for students to learn how to use state-of-the-art transportation network analysis tools to develop real-world network improvement Strategies. Students form teams of two and pick one project. Most of the final project requires application of transportation modeling software and Microsoft Excel data analysis. There are two options for projects:

1) The instructor provides a general, semi-complete transportation model. Each team has to complete and validate their model. During the lectures we review various policies to improve transportation network performance metrics such as lane management policies, congestion pricing, signal improvements, and multi modal network assignment solutions. Students define and analyze three scenarios to improve their model transportation network's performance. An improvement scenario can be defined based on policies and solutions discussed in the class, or can be a creative new policy.

2) Students may propose their own transportation modeling project, but need to convince the instructor that their project is appropriate with respect to scope, that the workload is reasonable, and that they can follow all the required steps and exercises with their proposed model. The instructor may specify changes to ensure feasibility and relevance of the project.

Project Timeline:

- 3rd week: Instructor introduces projects.
- 4th week: Project proposal, students decide teams and projects
- 6th week: Prepare the project contract (1 page)
- 8th week: Midterm progress report (10 min presentation)
- 15th week: Project presentation
- Finals week: Final report submission on the day a final exam would otherwise be scheduled.

Grading breakdown for the course project:

- A base credit (50%) is given if basic features of the project are implemented in a timely way (model 30%, reports 10%, presentations 5%, schedule 5%)
- Credit for GUI/usability design: 15%
- Credit for creativity, new ideas, adding good features, problem solving: 20%
- Presentation to the class: 15%

Weekly Course Schedule

Week	Topics / Activities	Readings	Assignments/ Deliverables/ Due dates
Week 1	Overview • Transportation planning Process • Transportation system analysis o Introduction to concepts/ components /data require-ments in transportation modeling with focus on the network aspects	Read Ortuzar Ch 1 Skim Ortuzar 2-3	
Week 2	Fundamentals of Network Models • Structure • Graphical Representation • Network Characteristics o Link Flows o Link Costs o Link Bounds o External Flows • Conservation of Flow • Algebraic Structure o Primal/ Dual Formulation Classroom Exercise #1: Introduction to the modeling software	Skim Ahuja Ch 1 Read Ahuja Ch 2 Identify your team partner	Classroom Exercise #1 has no take-home portion
Week 3	Fundamentals of Network Models -Graph Theory • Connectivity, constraint, tree, path, tour, degree,… • Minimum Spanning Tree • Edge Covering: Chinese Postman Problem • Euler tours and paths • Node Covering: Travelling Salesman problem • Heuristics Multi-route Node Covering Problem Classroom Exercise #2: Introduction to 4-step demand model software terminologies , zoning, land use , trip generation	Read related sections from Ahuja Ch 3- 5. (the order of subjects in class may be different than the text book) Read Ortuzar Ch 1 Read Ortuzar Ch 4.1	Homework #1 will be posted and is due by week 5

Week 4	Transportation Network problems • The Hitchcock Problem, … • Transshipment Problems • General Network Optimization Algorithms Classroom Exercise #3: Continue on 4-step model discussion. • Step 1 Trip Generation • Step 2-Trips Distribution /Gravity Model • Review projects descriptions	Read related sections from Ahuja Ch 3-5 Read Ortuzar Ch 5.1, 5.2	Results from the take-home portion of Classroom Exercise # 2 are due
Week 5	Transportation Network problems- continue • Minimum Path Algorithms • Label Correcting and Label Setting Algorithms • All Nodes to All Nodes Algorithms • K-Shortest Path Algorithm Classroom Exercise #4: Network coding , setup geometry, attributes, direction, functional class, connectors, Network visualization, GIS application	Read related sections from Ahuja Ch 3-5	Homework #2 will be posted and is due by week 7 Results from the take-home portion of Classroom Exercise #3 are due Homework # 1 due
Week 6	Network Trip Assignment • Conceptual Formulations • Wardrop's Principle I - User Equilibrium • Wardrop's Principle II - System Optimal • Multipath Assignment (Dial's Algorithm) Network Trip Assignment – continue • Equivalency of Beckmann and Wardrop Formulations. Classroom Exercise #5: Continue on 4-step model discussion. • Step 3-Mode split • Step 4- Network assignment	Read Sheffi Ch 1-3 (skim 2)	Results from the take-home portion of Classroom Exercise #4 are due

Week 7	Non-Equilibrium (Heuristic) Methods • All-or-Nothing Loading • Capacity Restraint Assignment • Incremental Assignment • Iterative Assignment • Multipath / Probabilistic Assignment Classroom Exercise #6: Continue on Step 4- Trip Assignment • Multiclass assignment • Stochastic method • AON method	Read Sheffi Ch 4-5 (skim 4) Read Ortuzar Ch 10.1 - 10.5, 10.7	Homework #3 will be posted and is due by week 9 Results from the take-home portion of Classroom Exercise #5 are due Homework # 2 due
Week 8	Review Assignment 1 and 2 , Review Sample Problems for Midterm Classroom Exercise #7: Review progress with each group, resolve any issue.		Results from the take-home portion of Classroom Exercise #6 are due Classroom Exercise #7 has no take-home portion
Week 9	Other Transportation Networks • Supply chain Network • Transit Network • Ride sharing Network • Multi modal networks Special applications/ case studies/ research papers- presentation by students Classroom Exercise #8: Review interim project report	Slides/ articles will be provided Student presentations	Interim project report Homework # 3 due Classroom Exercise #8 has no take-home portion
Week 10	Mid term Project presentation	Student presentations	
Week 11	Network improvements • Resiliency • Bottlenecks • Performance measures o Average and marginal cost o VMT, VHT, V/C /LOS/ delay Classroom Exercise #9: Model Calibration and Validation	Slides will be provided in advance. Class notes.	

Week 12	Overview of Travel Forecasting • Alternative analysis • FHWA Guidelines Classroom Exercise #10: band width, select zone/link, Turning movement reports. Exporting performance measures	Slides will be provided in advance. Class notes.	Homework #4 will be posted and is due by week 14 Results from the take-home portion of Classroom Exercise #9 are due
Week 13	Advanced Network Topics: • Data structure, Representation and storage o Node-Link Incidence Matrix o Node-Node Adjacency Matrix o Ladder Representation o Forward Star Representation • Elastic Demand • Stochastic User Equilibrium • Dynamic Traffic Assignment • Equilibrium, Dynamic Equilibrium Classroom Exercise #11: Scenario analysis, forecasting future year , final project troubleshooting	Class notes, Research articles Read Sheffi Ch. 6, 11-12 (skim 10)	Results from the take-home portion of Classroom Exercise #10 are due
Week 14	Advanced Network Topics-continue • Origin-Destination Table Generation Methods – application of big data • Nonlinear optimization: Constraints, Gradients and Search • Variable Demand; Joint Travel Decisions; Link Interactions • Multi modal networks • Freight networks Optional student presentations Project presentations	Class notes, Research articles Project Report Due: last Friday	Homework # 4 due Results from the take-home portion of Classroom Exercise #11 are due
Week 15	Review – Sample Problem solving Project presentations		
Finals Week	Final project due.		Date: For the date and time of the final for this class, consult the USC *Schedule of Classes* at classes.usc.edu.

Statement on Academic Conduct and Support Systems

Academic Conduct:
Plagiarism – presenting someone else's ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in *SCampus* in Part B, Section 11, "Behavior Violating University Standards" policy.usc.edu/scampus-part-b. Other forms of academic dishonesty are equally unacceptable. See additional information in *SCampus* and university policies on scientific misconduct, http://policy.usc.edu/scientific-misconduct.

Support Systems:
Student Counseling Services (SCS) – (213) 740-7711 – 24/7 on call
Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention. engemannshc.usc.edu/counseling

National Suicide Prevention Lifeline – 1 (800) 273-8255
Provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week. www.suicidepreventionlifeline.org

Relationship and Sexual Violence Prevention Services (RSVP) – (213) 740-4900 – 24/7 on call
Free and confidential therapy services, workshops, and training for situations related to gender-based harm. engemannshc.usc.edu/rsvp

Sexual Assault Resource Center
For more information about how to get help or help a survivor, rights, reporting options, and additional resources, visit the website: sarc.usc.edu

Office of Equity and Diversity (OED)/Title IX Compliance – (213) 740-5086
Works with faculty, staff, visitors, applicants, and students around issues of protected class. equity.usc.edu

Bias Assessment Response and Support
Incidents of bias, hate crimes and microaggressions need to be reported allowing for appropriate investigation and response. studentaffairs.usc.edu/bias-assessment-response-support

The Office of Disability Services and Programs
Provides certification for students with disabilities and helps arrange relevant accommodations. dsp.usc.edu

Student Support and Advocacy – (213) 821-4710
Assists students and families in resolving complex issues adversely affecting their success as a student EX: personal, financial, and academic. studentaffairs.usc.edu/ssa

Diversity at USC
Information on events, programs and training, the Diversity Task Force (including representatives for each school), chronology, participation, and various resources for students. diversity.usc.edu

USC Emergency Information
Provides safety and other updates, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible. emergency.usc.edu

USC Department of Public Safety – UPC: (213) 740-4321 – HSC: (323) 442-1000 – 24-hour emergency or to report a crime.
Provides overall safety to USC community. dps.usc.edu