CE 599: Special Topics in Civil Engineering
Modeling Transportation Network Supply and Demand
3 units
Spring, 2018
Friday 9:00AM - noon. The hour from 11:00 AM to noon involves hands on computational modeling exercises

Location: TBD, one hour in a computerized classroom

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(Draft) Catalogue Description
Theories and applications of transportation network demand and supply models and simulation techniques. Hands-on opportunities to work with simulation software.

Course Description
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 for the students to come up to speed. The course will discuss representation, modeling and algorithms for solving different problems. Both analytical and simulation-based network assignment models will be discussed. In addition, strategic issues such as network design and congestion pricing models will be 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. Some basic programming knowledge may be required for the problems sets, the final Project.

Learning Objectives
By the end of this course, students will be able to…

1. Understand the overall input and output data types and sources, procedures, models for each stage of the four step travel demand model.

2. Produce valid results and interpret those results for each of the four components of a travel demand model.

3. Apply the travel demand procedures to a sample transportation network using modeling software with focus on network Analysis (CUBE).
4. Relate the overall purpose of the Transportation network Analysis to transportation planning process

5. Identify different optimization techniques in transportation networks and apply them such as all-or-nothing assignment, user equilibrium, stochastic optimization techniques

6. Understand different transportation network management policies such congestion pricing and lane management and apply them in class project.

7. Ability to analyze and solve models to make better decision to improve system performance.

Prerequisite(s): None.
Recommended Preparation: Students should have basic knowledge of one programing language (such as Python, VBA, C, Java, R,...), and should have a prior introduction to transportation modeling at the level of CE 471 or PPD/CE 633.

Course Notes
Selected course lectures and lab exercises will be posted on the class Blackboard website. Students are expected to attend the class and take notes for majority of the course.

Required Readings and Supplementary Materials
Text books:

- 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
- Cube Tutorials

Supplementary Materials (Relevant but not required)

- Ortuzar & Willumsen (2011). Modeling Transport (4th) Wiley. Available at the USC Bookstore (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 and Assessment of Assignments

- Midterm and final exams are written closed book tests and will be graded out of 100 points for each exam.
- Lab and homework assignments require students to use CUBE and Microsoft Excel.
- The final project is a CUBE model and students will work on teams of two. Students are expected to have two 10-minute presentations during the course to show their progress and a final written report of their CUBE model result and scenario analysis.
- Students may do field work of their study area to collect network operational and characteristic information such as number of lanes, speed, intersecting geometry or signal timing. The field work is recommended but not required.

Grading Breakdown

The following weighting scheme will be applied:

Assignment	% of Grade
Homework/Lab exercises	20
Midterm Exam	40
Final Project and Presentation	40
Total	100

Extra credit worth up to 10%: A research paper on a topic related to course material. Subject of the paper must be submitted to the instructor for approval no later than week 3.

Assignment Submission Policy

- Assignments will be collected at the beginning of the class. Students are expected to submit their work in paper.
- Presentations and CUBE models will be submitted via course website.

Additional Policies

- Late assignments and deliverables are penalized by 50%.
- The lowest grade Homework/Lab will be dropped.
- Attendance is not graded but highly recommended.

Course Project

CE 599 Project Description

Class projects are designed for students to learn how to use the state-of-the-art transportation network analysis tools to develop real-world network improvement strategies. A group of two students should form a team and pick one project. Most of

the projects require CUBE software and Microsoft Excel data analysis. There will be two options for projects:

1) The instructor will provide a general, semi-complete CUBE model. Each team has to complete and validate their model. During the lectures we will 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 are expected to define and analyze 3 scenarios to improve their model's transportation network performance. An improvement scenario can be defined based on policies and solutions discussed in the class or can be a creative new policy.

2) The students may propose their own CUBE model project but they need to convince the professor that their project is appropriate and the workload is reasonable.

Project Timeline:

- 2nd week: Introduction to projects by instructor
- 3rd week: Project proposal, students decide team and project
- 4th week: Prepare the project contract (1 page)
- 8th week: Midterm progress report (10 min presentation)
- 15th week: Final report, Project presentation

Grading breakdown for the course project:

- A base credit (50%) will be given if basic features of the project is implemented timely (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%

Course Schedule: A Weekly Breakdown

Session	Lecture	Note
Week 1	**Overview** • **Transportation planning Process** • **Transportation system analysis** o **Introduction to concepts/ components /data requirements 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 Attributes** • **Conservation of Flow** • **Algebraic Structure** o **Primal / Dual Formulation** **Lab: Introduction to CUBE and team project**	Skim Ahuja Ch 1 Read Ahuja Ch 2
Week 3	**Fundamentals of Network Models -Graph Theory** • **Connectivity, constraint, tree, path, tour,..** • **Minimum Spanning Tree** • **Edge Covering: Chinese Postman Problem** • **Euler tours and paths** • **Node Covering: Travelling Salesman problem** • **Heuristics Multi-route Node Covering Problem** **Lab: Over view of 4-step demand model and simple implementation in CUBE** • **Zoning, Land Use** • **Step 1-Trip Generation**	Read only related sections from Ahuja Ch 3-5.(the order of subjects in class may slightly different than the text book) Read Ortuzar ch 1 Read Ortuzar ch 4.1
Week 4	**Transportation Network problems** • **The Hitchcock Problem, …** • **Transshipment Problems** • **General Network Optimization Algorithms** ***Assignment 1*** **Lab: Continue on 4-step model discussion.** • **Step 2-Trips Distribution** • **Gravity Model** • **PA to OD** • **Step 3-Mode split**	Read only related sections from Ahuja Ch 3-5.(the order of subjects in class may slightly different than the text book) Lab handout will be provided Read Ortuzar ch 5.1, 5.2
Week 5	**Transportation Network problems- continue** • **Minimum Path Algorithms** • **Label Correcting and Label Setting Algorithms** • **All Nodes to All Nodes Algorithms** • **Kth-Shortest Path Algorithm** **Lab: Continue on 4-step model discussion** • **Visualization, some GIS applications** • **Review projects descriptions**	Read only related sections from Ahuja Ch 3-5.(the order of subjects in class may slightly different than the text book) Lab handout will be provided

Week 6	**Network Trip Assignment** • **Conceptual Formulations** • **Wardrop's Principle I - User Equilibrium** • **Wardrop's Principle II - System Optimal** • **Multipath Assignment (Dial's Algorithm)** ***Assignment 2*** **Lab: Continue on 4-step model discussion** • **Network coding: setup geometry, attributes, direction, class, connectors, delays, …**	Read Sheffi Ch 1-3 (skim 2) Lab handout will be provided
Week 7	**Non-Equilibrium (Heuristic) Methods** • **All-or-Nothing Loading** • **Capacity Restraint Assignment** • **Incremental Assignment** • **Iterative Assignment** • **Multipath / Probabilistic Assignment** **Lab: 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
Week 8	**Review Assignment 1 and 2** **Review Sample Problems for Midterm** **Lab: Review progress with each group, resolve any issue.**	
Week 9	**Other Transportation Networks** • **Supply chain Network** • **Transit Network** • **Ride sharing Network** • **Multi modal networks** **Lab: Review progress with each group, resolve any issue.**	Slides/ articles will be provided
Week 10	**Mid term** **Project presentation**	Student presentations
Week 11	**Network improvements** • **Resiliency** • **Bottlenecks** • **Performance measures (PM) :** o **Average and marginal cost** o **VMT, VHT, V/C** **Lab: Model Calibration and Validation**	Slides will be provided in advance. Class notes.

Week 12	**Overview of Travel Forecasting** • **Alternative analysis** • **FHWA Guidelines** ***Assignment 3*** **Lab: Scenario analysis, band width, select zone/link, Turning movement forecast**	
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** • **Dynamic Traffic Assignment** • **Boundedly-rational User Equilibrium** **Lab: project troubleshooting**	Project Report Due: last Friday Read Sheffi Ch. 6, 11-12 (skim 10)
Week 14	**Advanced Network Topics-continue** • **Origin- Destination Matrix Estimation (ODME)– application of big data for network assignment** **Optional student presentations** **Lab: Project presentation**	Class notes, Research articles
Week 15	**Review assignment(s)– Sample problem solving** **Lab: Project presentation**	
Final	**Final Exam** **Project presentation**	

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 Section 11, *Behavior Violating University Standards* https://scampus.usc.edu/1100-behavior-violating-university-standards-and-appropriate-sanctions. 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.

Discrimination, sexual assault, and harassment are not tolerated by the university. You are encouraged to report any incidents to the *Office of Equity and Diversity* http://equity.usc.edu or to the *Department of Public Safety*

http://capsnet.usc.edu/department/department-public-safety/online-forms/contact-us. This is important for the safety of the whole USC community. Another member of the university community – such as a friend, classmate, advisor, or faculty member – can help initiate the report, or can initiate the report on behalf of another person. *The Center for Women and Men* http://www.usc.edu/student-affairs/cwm/ provides 24/7 confidential support, and the sexual assault resource center webpage http://sarc.usc.edu describes reporting options and other resources.

Support Systems

A number of USC's schools provide support for students who need help with scholarly writing. Check with your advisor or program staff to find out more. Students whose primary language is not English should check with the *American Language Institute* http://dornsife.usc.edu/ali, which sponsors courses and workshops specifically for international graduate students.

The Office of Disability Services and Programs provides certification for students http://sait.usc.edu/academicsupport/centerprograms/dsp/home_index.html with disabilities and helps arrange the relevant accommodations. If an officially declared emergency makes travel to campus infeasible, *USC Emergency Information http://emergency.usc.edu* will provide safety and other updates, including ways in which instruction will be continued by means of blackboard, teleconferencing, and other technology.