# Network Design in Transportation Systems Syllabus

**Fall 2015**

## Instructor Information


| Instructor | Email | Office Location |
|---|---|---|
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## General Information

### Description

Transportation sustains economic and social activity. Freight transportation, a vital component of the economy, supports a variety of activities by ensuring the efficient movement and timely availability of raw materials and finished goods.

This course will investigate the strategic, tactical and operational issues associated with designing freight transportation networks. To that end, the strategic timeframe would focus on in-depth discussion surrounding classical models in transportation network design. Most of the discussion surrounding the tactical and operational issues would be focused on road, railroad, and intermodal transportation of freight. Finally, some topics on collaborative logistics and network design would be presented. All the above topics will be covered using a selection of application and theoretical papers.

### Course Objectives

- Understand the different managerial issues involved in designing freight transportation networks.
- Discuss the classical discrete network design models –such as the service network design.
- Develop an understanding of the tactical and operational issues in road and railroad freight transportation.
- Comprehend the nuances of intermodal transportation, with a focus on rail-truck combination.
- Understanding of how different types of collaboration among freight carriers can lead to a more efficient transport and what synergies are hidden in inter-carrier/inter-modal collaboration.

## Course Materials

### Required Materials

This course will draw materials from a variety of sources including basic textbooks and peer-reviewed journal articles. The pertinent reading materials are indicated after each topic in the course schedule. The instructor will provide a copy of the materials. More details is provided in course outline.

## Course Main Topics:

| Topic | Reading |
|---|---|
| ***Introduction*** | • Supply Chain Management: Strategy, Planning, and Operation -5/E: by S. Chopra and P. Meindl:<br>  ○ Ch. 05: Network Design in the Supply Chain.<br>  ○ Ch.14: Transportation in a Supply Chain. |
| ***Basic Network Models*** | • Ahuja, Ravindra K., Thomas L. Magnanti, and James B. Orlin. "Network Flows: Theory, Algorithms, and Applications". Prentice Hall.<br>  ○ A short review of some chapters in my lecture slides!<br>• Traveling Salesman Problem & Vehicle Routing Problem and their applications<br>  ○ An Overview of TSP, a book chapter!<br>  ○ An Overview of Vehicle Routing Problems, a book chapter!<br>  ○ Laporte, Gilbert. "What you should know about the vehicle routing problem."*Naval Research Logistics* 54.8 (2007): 811-819. |
| ***A review on Facility Location Models*** | ***Set covering:***<br>• Church, R.L. and Meadows, M. (1979) "Location modeling utilizing maximum service distance criteria", Geographical Analysis, 11, 358-373.<br>• Toregas, C., Swain, R., ReVelle, C. and Bergman, L. (1971) "Optimal location under time or distance constraints", Operations Research, 19, 1363-1373.<br>***Maximal covering:***<br>• Church, R.L. and ReVelle, C. (1974) "The maximal covering location problems", Papers of the Regional Science Association, 32, 101-118.<br>• Daskin, M.S. and Owen, S.H. (1998) "Two new location covering problems: The partial covering p-center problem and the partial set covering problem", Geographical Analysis, 31, 217-235.<br>***p-Center***:<br>• Hakimi, S. (1964) "Optimum location of switching centers and the absolute centers and medians of a graph", Operations Research, 12, 450-459.<br>***p-Dispersion:***<br>• Kuby, M. (1987) "The p-dispersion and maximum dispersion problems", Geographical Analysis, 19, 315-329.<br>***p-Median:***<br>• Hakimi, S. (1964) "Optimum location of switching centers and the absolute centers and medians of a graph", Operations Research, 12, 450-459.<br>***Fixed charge:***<br>• Balinski, M.L. (1965) "Integer Programming: Methods, Uses, Computation", Management Science, 12, 253-313.<br>***Hub:***<br>• Campbell, J.F. (1994) "Integer programming formulation of discrete hub-location problem", European Journal of Operational Research, 72, 387-405.<br>• O'Kelly, M.E. (1986a) "Activity levels at hub facilities in interacting networks", Geographical Analysis, 18, 343-356.<br>• O'Kelly, M.E. (1986b) "The location of interacting hub facilities", Transportation Science, 20, 92-106.<br>***Maxisum:*** |

| Topic | Reading |
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| | • Erkut, E. and Neuman, S. (1989) “Analytical models for locating undesirable facilities”, Journal of Operational Research, 40, 275-291.<br>• Erkut, E. and Neuman, S. (1991) “A multiobjective model for locating undesirable facilities”, Annals of Operational Research, 40, 209-227. |
| ***Location-Routing*** | • Min, H., Jayaraman, V. and Srivastava, R. (1998) “Combined location-routing problems: A synthesis and future research directions”, European Journal of Operational Research, V. 108(1), 1-15.<br>• Gábor Nagy, Saïd Salhi, (2007), "Location-routing: Issues, models and methods", European Journal of Operational Research, V. 177(2), 649-672.<br>• Prodhon, Caroline, and Christian Prins. "A survey of recent research on location-routing problems." European Journal of Operational Research 238.1 (2014): 1-17. |
| ***Facility Location Network Design*** | • Current, J.R. (1988) “The design of a hierarchical transportation network with transhipment facilities”, Transportation Science, 22, 270-277.<br>• Current, J.R. and Pirkul, H. (1991) “The hierarchical network design problem with transhipment facilities”, European Journal of Operational Research, 73, 114-126. |
| ***Service Network Design*** | • Crainic, Teodor G., and Jean-Marc Rousseau. "Multicommodity, multimode freight transportation: A general modeling and algorithmic framework for the service network design problem." Transportation Research Part B: Methodological 20.3 (1986): 225-242.<br>• Crainic, Teodor Gabriel. "Service network design in freight transportation."European Journal of Operational Research 122.2 (2000): 272-288.<br>• Crainic, Teodor Gabriel. "Long-haul freight transportation." Handbook of transportation science. Springer US, 2003. 451-516.<br>• Wieberneit, Nicole. "Service network design for freight transportation: a review."OR spectrum 30.1 (2008): 77-112.<br>• Andersen, Jardar, Teodor Gabriel Crainic, and Marielle Christiansen. "Service network design with management and coordination of multiple fleets." European Journal of Operational Research 193.2 (2009): 377-389. |
| ***Railroad Transportation System*** | ***Yard operations:***<br>• Petersen, E.R. (1977a) “Railyard Modeling. Part I. Prediction of Put-Through Time”, Transportation Science, 11, 37-49.<br>• Petersen, E.R. (1977b) “Railyard Modeling. Part II. The Effect of Yard Facilities on Congestion”, Transportation Science, 11, 50-59.<br>***Railcar grouping (blocking):***<br>• Newton, H.N., Barnhart, C. and Vance, P.M. (1998) “Constructing railroad blocking plans to minimize handling costs”, Transportation Science, 32, 330-345.<br>• Ahuja, R.K., Jha, K.C. and Liu, J. (2007) “Solving real-life railroad blocking problems”, Interfaces, 37, 404-419.<br>***Routing:***<br>• Crainic, T.G., Ferland, J-A., and Rousseau, J.-M. (1984) “A tactical planning model for rail freight transportation”, Transportation Science, 18, 165-184.<br>• Crainic, T.G., Florian, M., and Leal, J.-E. (1990) “A model for the strategic planning of national freight transportation by rail”, Transportation Science, 24, 1-24.<br>***Routing & Scheduling:*** |

| Topic | Reading |
|---|---|
| | • Gorman, M.F. (1998) “An application of genetic and tabu searches to the freight railroad operating plan problem”, Annals of Operations Research, 78, 51-69. |
| ***Collaborative Logistics*** | • Ergun, Ozlem, Gultekin Kuyzu, and Martin Savelsbergh. "Reducing truckload transportation costs through collaboration." Transportation Science 41.2 (2007): 206-221.<br>• Agarwal, Richa, and ÖZlem Ergun. "Mechanism design for a multicommodity flow game in service network alliances." Operations Research Letters 36.5 (2008): 520-524.<br>• Houghtalen, Lori, Özlem Ergun, and Joel Sokol. "Designing mechanisms for the management of carrier alliances." Transportation Science 45.4 (2011): 465-482.<br>• To be updated soon! |
| ***Multi-Modal Transportation*** | • Crainic, T.G. and Kim, K.W. (2007) “Intermodal Transportation in Handbook in Operations Research & Management Science (eds) C. Barnhart and G. Laporte, pages 467-477.<br>• Macharis, C. and Bontekoning, Y.M. (2004) “Opportunities for OR in intermodal freight transport research: A review”, European Journal of Operational Research, 153, 400-416.<br>• SteadieSeifi, M., et al. "Multimodal freight transportation planning: A literature review." European journal of operational research 233.1 (2014): 1-15. |

## Evaluation

| Item | % Score |
|---|---|
| ***Final Exam*** | 20% |
| It will be a 2-hour closed book exam that will test you on the concepts introduced in the course. This will entail some basic formulation and analytical questions. | |
| ***Assignments*** | 40% |
| There will be five or six (or more!) assignments covering the foundations and mathematical formulation of the topics discussed in the course. The due dates will be set during semester. Although GAMS as modeling language and Cplex as solver is recommended, students are free to choose a modeling environment (GAMS, AMPL, …) and an MILP solver to solve assignments. | |
| ***Course Project*** | 40% |
| Students have two options to choose.<br>1- Choose a recently published journal paper and try to reproduce it.<br>2- Review a topic in freight transport, define a research problem, formulate the problem and solve it.<br>Students are encourage to choose option 2. Once you have an idea about the possible topic, it is in your interest to discuss it with the Instructor - for both feasibility and approval. Each student is expected to provide a 1-page summary of the proposed topic by the 6$^{th}$ week of the term. Instructor try to support students in coding and other steps of providing research report. | |