



## Course Description

### Orf 467

## Transportation Systems Analysis and Planning v1.0

Fall 2015/16

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| Professor Alain L Kornhauser  | <b>Class Hours:</b> Mon. & Wed. 1:30- 2:50 pm<br><b>Location:</b> 101 Sherrerd Hall (ORFE Building)           |
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| email: <a href="mailto:alaink@princeton.edu">alaink@princeton.edu</a> | <b>Precept:</b> Mondays 7:30-8:20pm & 8:30-9:20pm<br><b>Location:</b> 001 Sherrerd Hall (ORFE Building) (TBA) |
| Tel: 609-258-4657   |   |
| <b>Course Requirements:</b>   | <b>% of final grade</b>   |
| bi-weekly assignments   | 30%   |
| "tenth - week" exams  | 30%   |
| Term project due at end of Reading Period                             | 30%   |
| Class participation   | 10%   |

### Course Description

Studied is the transportation sector of the economy from a systems technology and planning perspective. The focus is on fundamental modeling and analytical methodologies that support

- regional, national and international; long and short-range; capital and operational Planning,
- real-time operational decision making by transportation companies, and
- the formulation and analysis of long-range automation investments focused on the transportation sector of the economy.

The transportation sector of the economy is one in which a continuing “tug-of-war” exists between the private sector and the public sector that seeks a balance between private sector market forces and broad oversight and infrastructure investments by the public sector. Shifting priorities focused on stimulating broad economic recovery and job creation provide an opportunity for enhancing mobility through synergistic investments in transportation by both the public and private sectors of the economy. The development of successful innovative investments requires a fundamental, thorough and deep understanding of the demand for mobility by both people and goods as well the physical and operational characteristics of the supply-side technologies.

In the recent past the major issues have been associated with

- energy: 1/3 of the energy consumed in the US is consumed by the transportation sector. Today, essentially all is carbon based. Concern about global warming, oil spills, \$147 a barrel oil, hybrids, Personal Electric Vehicles (PEVs),
- security: the heightened sensitivity following 9-11 and international terrorism
- funding: the construction and maintenance of road and public transportation infrastructure has been funded by taxes on gasoline which has plateaued with declining expectations. Can concepts

such as "value" (aka congestion) pricing, private toll roads, VMT (vehicle-mile-tax), and for-profit mass transportation pick up the slack?

- local issues of traffic congestion, road construction, transportation-related environmental issues and the stagnation of transportation funding sources are dominant themes of grass roots planning and policy analysis,
- Intelligent Transportation Technology (ITS): With roots in Personal Rapid Transit (PRT) beginning more than 40 years ago, computer and information technology has promised that it would revolutionize mass transit and provide unparalleled mobility for all. To date, success has been mixed. PRT never got off the ground, but is still trying. Automated Highway System (AHS) have suffered a similar fate. More modest efforts involving electronic tolling (EZPass, et al), turn-by turn navigation ([CoPilotLive](#) et al) have become mainstream and once promising "v2v" and "[connected vehicle](#)" initiatives seem to be running out of steam (*as they should be*) .
- New and exciting are systems look to deliver improved mobility through vehicle sharing that augments traditional vehicle ownership and conventional mass transit. This includes the recent surge of [bike sharing](#), [car sharing](#) (including [personal cars](#)) and [mobile app based](#) ride finding systems ([Uber](#), [Lyft](#), etc.).
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- What is **HOT** is what I have dubbed as "[SmartDrivingCars](#)". This term includes partially automated vehicles that simply have "automated collision avoidance and lane centering driver assistance systems", through "driverless cars" that can operate completely empty with no human onboard. The vehicles can be cars, buses or trucks; anything that operates on existing streets and highways. The simple collision-avoidance version holds the promise of substantially improving safety **and** saving money. The driverless version holds the promise of substantially reducing (>50%) energy consumption and pollution, eliminating congestion, providing high-quality demand-responsive mobility to essentially everyone at a very affordable cost without public subsidy. Seems like a winner!!

This automation technology is rapidly evolving in vehicles. Spurred by Google's efforts to deliver a driverless car to the marketplace, the traditional automobile industry has responded by beginning to roll out its own collision-avoidance technology that may well make driverless technology a reality in the near future. Since the evolution of this technology may well have a viable "business case" through fundamental safety improvements in its innovative stage, it may well have a feasible evolutionary path to attainment of full driverless. If so, such technology could dramatically change personal mobility and have a substantial impact on land-use and the future shape of our cities. A substantial portion of the course will be oriented to the study this technology and its implications on how we live.

The first part of the course, "policy, planning and decision making", surveys the transportation sector of the economy by studying and evaluating the current level of mobility involving people and goods and the balance between Federal, regional and local transportation agencies, private transportation providers, consumers of transportation and those impacted by transportation. Studied are the roles played by each of the participants in the transportation sector of the economy. The historical evolution of transportation policy will a basis for understanding the current relation between the supply and demand for transportation and provide a perspective for evaluating the change in that balance that driverless technology may impose.

The second part of the course, "analytical models of transportation demand and technology", focuses on the quantitative aspects of the demand for mobility / transportation and the design, planning and analysis of transportation systems. Studied are the methodologies used in the transportation planning process: its objectives, its models and its data requirements. Focus will be on methodologies for quantifying the demand for transportation and analytical processes for the planning and design of infrastructure, facilities and systems that are appropriate for addressing broad national policy issues as well as detailed and specific local circulation and traffic issues. In particular, the classical four-step travel analysis process will be studied involving: Trip Generation, Trip Distribution, Modal Split and Traffic Assignment with Trip Generation and Distribution first studied from a spatially and temporally aggregated perspective and then from an individual traveler perspective. The individual perspective will allow for the synthesis of precise temporal and spatial trip inventories that assemble to reflect the aggregate characteristics of the mobility

of the society. These methodologies will be used to synthesize each of the Billion individual trips that are made across the US of A (including the 30+ million made in New Jersey) on a typical day that are critically important for doing a credible assessment of the operational aspects of technologies such as autonomousTaxis (aTaxis)

The third part of the course, "technologies", focuses on emerging technologies that may improve mobility, the economy and address environmental concerns. Studied are the various elements of SmartDrivingCars (SDC) that apply advanced communications, computation, information and control systems to improve the financial viability and reduce the environmental impact of mobility systems as well as advanced traveler information systems and advanced transportation management systems. Of particular interest will be a new "mass" transit concept consisting of autonomous vehicles: autonomousTaxi or aTaxi operating on the existing roadway infrastructure. Armed with the synthesis of each trip made by each person on a typical day in the US of A generated in the 2<sup>nd</sup> part of the course, the class will design aTaxi systems throughout the country. This will involve the judicious location of aTaxi stands (stations) throughout the region of study and the operational simulation of the aTaxi system to best serve those trips as well as the retention and inclusion the existing Transit commuter rail and Express bus services. Each student will be responsible for the design and operational analysis of the aTaxi system for at least one region. Included will be the real-time vehicle dispatch and empty vehicle management. The class will work together to create a unified synergistic system for the entire state. Work on the system will evolve throughout the semester. Interim results and findings will be presented at two interim workshops. A Final workshop, presenting final recommendations, will take place at the end. A substantial Final Report documenting the design and analysis will be prepared by the class.

Course requirements include weekly readings, bi-weekly assignments, one "tenth week" exam, a term project and class participation. Two (2) 80 minute classes plus a 50 minute precept. We'll also visit some transportation facilities in the metropolitan area and have several distinguished practitioners come speak with us. The term project will consider an area-wide autonomousTaxi (aTaxi) system for various regions across the country. From a modeling point of view, this system is essentially a PRT system operating on the existing street and road system. The focus will be on the precise location of aTaxi stands (equivalent to PRT stations) and the operational analysis focused on optimizing the aTaxi dispatch and empty vehicle management so as to deliver the best service at each station. Central to this analysis will be the synthesis of the precise spatial and temporal demand for transportation by each individual living or working in New Jersey on a typical weekday. Investigated will be the arrival characteristics of these patrons at each aTaxi stand, their assignment to a waiting aTaxi and the occupancy and operational characteristics of the aTaxi vehicles. The synthesis of the travel demand was last year's class project. It developed the methodology for the [synthesis of individual travel demand in New Jersey](#). Hill Wyrrough extended the synthesis to the whole country in his [2014 Senior Thesis](#). The USA synthesis will be recreated. Based on that demand pattern, the aTaxi stations will be assigned precise locations. This will yield temporal demand patterns for each for which an "optimal" operational plan will be devised. This will culminate in a final report: The Design and Performance of an area-wide aTaxi System for New Jersey, that will be similar in structure to the one prepared by Orf467F12, [Uncongested Mobility for All in NJ](#), as well as previous years' reports that focused on PRT for New Jersey rather than aTaxis: [Orf467F10](#), [Orf467F09](#), [Orf467F08](#); [PRT for New Jersey, Orf 467F07](#); [PRT for Counties in NJ, OrfF05](#); [PRT for NJ, Orf467F04](#)

## [Syllabus](#)

## [Enrolled Students](#)

***Reference Textbooks (These are background text. Most readings are available on the web through links on the syllabus):***

Levinson,D., & Krizek, K. [The End of Traffic and the Future of Transport](#). Amazon eBook 2015  
Cascetta, Ennio *Transportation Systems Analysis, Models & Applications*, 2<sup>nd</sup> Ed. Springer, 2009, ISBN 978-0-387-75856-5  
TRB, [Revised Monograph on Traffic Flow Theory: A State-of-the-Art Report](#)  
Small, K. A. and E. T. Verhoef, *The Economics of Urban Transportation*, Routeledge, 2007, ISBN10: 0-415-28514-3

Ahuja, R. K, T. L. Magnanti & J. T. Orlin , (Magnanti) *Network Flows, Theory, Algorithms and Applications*, Prentice Hall 1992, ISBN 0-13-617549 (**excellent classic reference text on networks**)  
Meyer, M. D., & Miller, E. J. (M&M) *Urban Transportation Planning, A Decision-Oriented Approach*, 2<sup>nd</sup> ed. McGraw-Hill, 2001, ISBN 0-07-242332-3  
Ran, B., Boyce, D. *Dynamic Urban Transportation Network Models*, Lecture Notes in Economics & Mathematical Systems, #417, Springer-Verlag  
Oppenheim, N. *Urban Travel Demand Modeling*, Wiley, 1995, ISBN 0-471-55723-4  
<http://www.bts.gov/> US Transportation Statistics <http://www.fhwa.dot.gov/tea21/index.htm> Current  
Federal Transportation Legislation <http://www.fhwa.dot.gov/trafficinfo/index.htm#TRFF> National traffic  
& road closure