

## **1.201 Introduction to Transportation Systems**

### **Final Exam**

**Dec 20, 2006**

- This exam is graded out of 100 points, and is worth 30% of the final grade
- There are 4 questions worth 25 points each
- Each question should take approximately 45 minutes
- If you are stuck, please move ahead, and make sure that you get to every question
- Open book and open notes
- Computers are not allowed
- Best of luck!



## **Question 1 (25 points) composed of equally-weighted 1A and 1B**

### **1A - Congestion Pricing in New York City (12.5 points)**

Consider this recent article from the New York Times of November 24<sup>th</sup>, 2006 (edited by 1.201 teaching staff) headlined “Bigger Push for Charging Drivers Who Use the Busiest Streets.” This article described the use of *congestion pricing*, charging drivers for driving into parts of Manhattan as a way of reducing traffic congestion.

And then answer the following questions:

1. Identify three of the 30 key points you think are most important for this situation and justify your choices in a few sentences. (2.5)
2. List five groups of stakeholders and participants relating to this complex transportation situation and discuss their view—in a sentence or two-- of the congestion pricing plan advanced in this article. (3.0)
3. You are an aide to New York Mayor Michael R. Bloomberg. He has asked you to write a memo (one page in the blue book) suggesting a plan for how New York City might spend the monies collected through congestion charging in a way that makes transportation sense as well as political sense. Please write such a memo. (7.0)

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Abstracted from “Bigger Push for Charging Drivers Who Use the Busiest Streets,” *The New York Times*, November 24, 2006. by William Neuman

Congestion pricing, the idea of charging drivers for bringing vehicles into the busiest parts of Manhattan, has become a key strategy for transportation advocates and urban planners in New York.

A diverse array of civic and community groups – including such unlikely allies as conservative scholars and take-back-the-streets cycling advocates – are cautiously moving to raise the subject of congestion pricing in the hope of overcoming the resistance of New Yorkers and their political leaders. They are also hoping to influence a long-term strategic plan the city is preparing, which they expect will address traffic congestion.

“There are a number of groups, who come at this from very different perspectives, who don’t generally agree on a lot, who want to see this happen,” said Jeremy Soffin, vice president for public affairs of the Regional Plan Association, which studies transportation and development issues. “There’s been a concerted effort to work together.”

Now, an influential business group called the “Partnership for New York” expects to release a revamped study in early December that will analyze the cost of clogged streets, estimated at \$12 billion to \$15 billion a year. A related study done with Environmental Defense, a national environmental group, will look at the environmental costs of excess traffic and at the potential for congestion pricing to reduce traffic and thereby cut air pollution and, as a result, illnesses like asthma.

Ms. Wylde, president of the Partnership for New York, plans to discuss the economic study at a forum on Dec. 7 sponsored by the Manhattan Institute, a conservative research organization that is set to release a report of its own “on the feasibility of road pricing in New York.” The report is to include the results of focus groups meant to gauge the attitudes of New Yorkers toward such a program.

Some grass-roots groups have already begun to take up the issue.

On Nov. 14, about 50 people from a coalition of 125 civic and community groups gathered on the steps of City Hall to ask that New York Mayor Bloomberg consider a series of measures to reduce traffic.

The coalition is led by Transportation Alternatives, an organization that promotes mass transit and works to make streets more welcoming to pedestrians and cyclists. It includes neighborhood groups like Sustainable South Bronx and biking advocates like the FreeWheels Bicycle Defense Fund.

The coalition wants more speed bumps on neighborhood streets and a crackdown on illegal parking, but it also asks that the city study congestion pricing.

"Among all the measures we're discussing, it has the most potential for reducing traffic," said Paul Steely White, the director of Transportation Alternatives.

He acknowledged that it would be a big change for drivers to pay to use streets that they are accustomed to using free and that there was a lot of political ground to cover first.

Mr. White said any congestion pricing program would have to be combined with -- or preferably preceded by -- other measures like improving bus service and smoothing traffic flow. His group has asked the city to move beyond what has already been done to reduce the number of parking permits given to city employees, who drive to work in large numbers. Transportation Alternatives would also like to see more Midtown parking spaces converted to loading zones so that streets are not clogged with double-parked trucks unloading goods.

Advocates of congestion pricing are reluctant to make specific proposals on how it could be carried out in New York, but they often point to London as an example of a successful program.

Championed by an activist mayor, London's program began in early 2003 and has significantly reduced traffic and sped up bus lines. London drivers must pay as much as \$19 a day to enter the road pricing zone in the city center. They can pay in a variety of ways, including online, by phone, by mail or at designated shops or gas stations. Cameras around the congestion zone read vehicle license plates and feed the numbers to a computer that checks to see who paid their fees. Those who have not paid can be fined.

One of the most outspoken opponents of congestion pricing in New York has been David I. Weprin, a City Council member who represents some neighborhoods in eastern Queens that are far from subway lines and where residents with jobs in Manhattan are more likely to drive to work.

He said congestion pricing amounted to an unfair tax on residents in those areas, many of whom can ill afford it.

"The potential for causing hardship to people who rely on their cars in boroughs other than Manhattan is too great to try to implement congestion pricing at this point," Mr. Weprin said.

In response, advocates said revenue from a congestion pricing program should be reserved for public transportation improvements that would help the outer boroughs. For instance, if new or faster bus routes could bring residents into Manhattan or to subway stations more efficiently, they may be more willing to not drive. That would also help answer critics who have said congestion pricing is nothing more than a new tax that would go straight into the city's general budget.

Most of all, the advocates of congestion pricing have their eyes on the long-term strategic plan for the city being prepared by Deputy Mayor Daniel L. Doctoroff. The plan is a response to predictions that the city will add one million residents by 2025, and figuring out how to keep people and vehicles moving around an ever more crowded city will be an important part of it. The activists hope that it will include a recommendation for some form of congestion pricing.

Mr. Doctoroff refused to talk about what the plan would include, but he said he was aware that traffic is a concern.

"It's clear the level of congestion is an inhibitor to growth," Mr. Doctoroff said. "We believe that smart growth is good, and therefore we need to provide additional capacity on every mode of transportation." That, he said, includes city streets, and he added, "How we do that, that's what we're thinking through now."

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## **1B - Impact of Congestion on Urban Freight (12.5 points)**

Consider this article in a well-respected transportation newsletter called “Surface Transportation and Innovations” by Bob Poole. The article is headlined “Portland Confronts Good-Movement Congestion” and has been slightly edited by the 1.201 teaching staff. This article deals with the impact of congestion on freight transportation in Portland, Oregon

And then answer the following questions:

1. Identify three of the 30 key points you think are most important for this complex transportation situation, and justify your choices in a few sentences. (2.5)
2. List five groups of stakeholders and participants related to this complex transportation situation and indicate how they are affected, in one or two sentences each. (3.0)
3. As the article suggests, Portland has been a leader in transit, subsidized development around transit stations, and in introducing an urban growth boundary (which makes it difficult to build far from the urban core). In particular Portland advocates transit use, rather than automobile use, by travelers.

The question is what these policies have produced in the context of “sustainability” as we have discussed it in class. This is characterized by the 3 Es; Economic Development as enabled by mobility, Environmental Impact, and Social Equity. Identify three strategies for relieving congestion in Portland, including one NOT discussed in the article, and discuss how each of them performs on the three dimensions of sustainability in a few sentences each. (7.0)

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Abstracted from “Portland Confronts Freight-Movement Congestion” by Bob Poole

For much of the past two decades, Portland has been a leader in the transit and smart-growth approach to dealing with traffic congestion. The area has spent heavily on light-rail transit, subsidized development around transit stations, and imposed an urban growth boundary, among other things. Critics pointed out that its traffic congestion kept increasing, but some smart-growthers even viewed that positively, on the grounds that terrible congestion would push more people out of cars and onto transit.

But in trying to implement this vision, freight-movement was ignored. And eventually Portland’s business community started to notice that congestion was having serious impacts on them. Portland Gas & Electric finds that in just the last seven years, congestion has added 20 to 30 minutes to the travel times of its crews, which costs them \$30-50 per day for each of the 36 crews. Intel has had to shift the time for outgoing overnight shipments back two hours, to be

sure they get to the airport on time. SYSCO Food Services had to open a new distribution center in Spokane, WA because trips through Portland were taking so long. Even pizza operators have had to cut their radius of delivery.

The points come from a detailed study sponsored by the Portland business community, with the cooperation of Portland Metro and Oregon DOT. “The Cost of Congestion to the Economy of the Portland Region” is the first case study I’ve seen that focuses primarily on the costs of congestion to businesses and a metro area’s economy. It was carried out by Economic Development Research Group (EDRG), a Boston firm headed by economist Glen Weisbrod (*who studied transportation at MIT*), whose pioneering NCHRP study on the costs of congestion to regional economies I reported on in Issue No. 22.

Portland is particularly hard-hit by traffic congestion because “a significant part of [its] economy is based on the city’s location as a gateway port for marine and air movement, and intersection of major cross-continent highway and rail routes.” Because these functions all depend heavily on trucks, “they are particularly vulnerable to worsening highway congestion.” The study also notes that “The effects of congestion are eroding the significant progress that has been made in inventory management and control, by re-introducing uncertainty in shipping and receiving attributable to the over-the-road and ‘last mile’ portion of the supply chain system.”

The EDRG study used Portland’s transportation planning model to project congestion into the future, assuming the existing long-range transportation plan is implemented, as written. It predicts much worse congestion by 2025. Then it modeled Portland’s unfunded alternative plan, which increases both transit and highway capital spending by \$6.2 billion. The result is that congestion would still be worse than today, but that extra money would save 30 million vehicle-hours per year that would otherwise be wasted in congestion.

Had the modeling focused more on adding highway capacity, the savings might have been far greater. An earlier study by Hartgen & Fields estimated that spending \$2.7 billion more in Portland, solely to add highway capacity, would yield annual savings of 101 million hours per year by 2030, eliminating all Level of Service F conditions (the worst level of congestion). As the Portland business community ponders what to do next, they should take a closer look at which investments produce how much congestion reduction.

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## **Question 2 (25 points)**

This question deals with demand

**(Each question is worth 5 points)**

Consider a major metropolitan area which has extensive metro and bus networks, such as New York City, London, Tokyo or Mexico City. The focus of this question is the analysis of travel demand by transit in this city and specifically the choice of path (or route) to get from one point to another within the city. For the purposes of this question you may assume that there is a fixed demand matrix (i.e. that demand between origin-destination pairs is not a function of the level-of-service, and so can be assumed to be constant) representing travel by transit between all origin-destination pairs and that the only modes of interest are metro and bus.

- a) What data would you need to estimate a discrete choice binary logit model reflecting individual's choices between metro and bus in this city? You may assume that the attributes which affect choice are the in-vehicle time, walk access time, wait time and cost for the best paths between an origin-destination pair by bus and metro.

Up to the current time it has been assumed that the coefficients for in-vehicle time for metro and bus are the same – in other words passengers evaluate ten minutes of in-vehicle time on metro as being equivalent to ten minutes of in-vehicle time on bus. This assumption has been imbedded into the urban transport model system used in this area to plan and evaluate changes in the metro and bus system. However the result of the estimation of the utility function in the discrete choice model obtained from a study similar to that outlined in a) above, now show that passengers actually value in-vehicle time in bus as being 50% more frustrating than in-vehicle time in metro, i.e. the coefficient for in-vehicle time for bus is 1.5 times the coefficient for in-vehicle time for metro. Given this new information answer the following questions:

- b) List and explain the possible reasons why the model estimation results show that in-vehicle time for bus is less attractive than the in-vehicle time for metro.
- c) Discuss the implications of changing the coefficients of the in-vehicle time consistent with the newly estimated values on alternative investments on bus and metro improvements. You may assume that the urban transport model system had previously been fit to the available travel demand data but with the assumption, now proven wrong, that in-vehicle times were viewed as equivalent between metro and bus. Think through the implications of the model changes versus what would actually happen in the real world should proposed changes be implemented. Remember that the model system is fitted to actual data to describe current travel behavior and then applied with different attributes describing the proposed changes in the bus and/or metro systems.

Finally let us look at a more realistic scenario in which travelers are considering paths which combine metro and bus as well as several paths on both metro and bus.

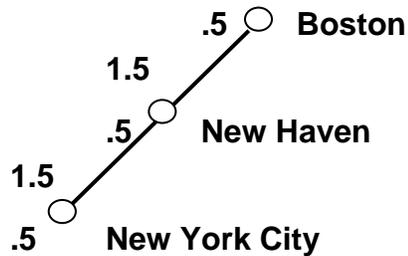
- d) What are the most important changes you would need to make in the structure of your model to deal with this more realistic but clearly more complex path choice problem?
- e) How could you deal with the issues of path overlap which will clearly arise in this version of the problem?

**Question 3 (25 points)**

This question deals with a simplified high-speed rail service in the Northeast Corridor.

In Option A, the service has three stops, in Boston, New Haven and New York City.

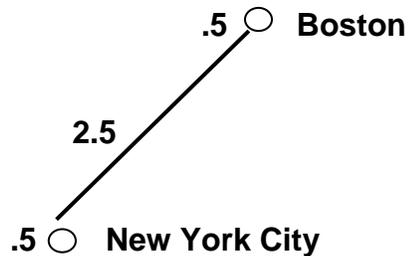
**OPTION A**



The link travel times are 1.5 hours between each pair of cities in both directions. The time it takes to service the train at each node is 0.5 hours.

People in Boston and New York City are interested in better service between these two major cities and suggest *not* stopping in New Haven. This is Option B.

**OPTION B**



The travel time between Boston and New York City in both directions is now 2.5 hours. The time it takes to service the train in Boston and New York City is still 0.5 hours.

1. (1 point)

Calculate the train-cycle for Option A and Option B.

2. (1 point)

How many trains do you need to operate 12 trains/day uniformly distributed throughout the day for Option B?

3. (1 point)

With that number of trains, what frequency can you provide for Option A, with the trains uniformly distributed through the day?

If the numbers come out non-integer, go back and check your work!

Here is some additional information.

The following is a matrix of K coefficients used for estimating demand between each pair of cities.

**K MATRIX**

	<b>Boston</b>	<b>New Haven</b>	<b>New York City</b>
<b>Boston</b>	X	50	200
<b>New Haven</b>	50	X	100
<b>New York City</b>	200	100	X

Here is the FARE Matrix -- FARES IN \$.

**FARE MATRIX**

	<b>Boston</b>	<b>New Haven</b>	<b>New York City</b>
<b>Boston</b>	X	100	200
<b>New Haven</b>	100	X	100
<b>New York City</b>	200	100	X

The demand between any pair of cities is

$$D = \frac{K \cdot \text{FREQ}}{T \cdot \text{FARE}} * 1000$$

**FREQ in trains/day**  
**T in hours**  
**FARE in \$**

Where

**T** is the travel time between those cities;

**K** is taken from the **K Matrix** for that city pair;

**FARE** is taken from the **FARE Matrix** for those two cities.

*To make the calculations simpler, the system is perfectly symmetrical with respect to direction of travel.*

4. (2 points)

Calculate the demand between all pairs of cities for both Options A and B.

NOW, you are ready to answer the real question!

5. (9 points)

**YOU ARE THE TRAIN COMPANY. SHOULD YOU STOP AT NEW HAVEN?**

Do whatever further calculations you need to and indicate whether or not you would stop at New Haven and explain why.

6. (7 points)

NOW, considering *only Option B*, and considering the travel time and train service times and the K matrix as *fixed*, explore some changes to this service and suggest which changes are a good idea.

7. (4 points)

Suggest some shortcomings in the model used in this analysis.

#### **Question 4 (25 points)**

This question deals with the Panama Canal

#### **Part 1 Background**

It is 1993. The Panama Canal handles about 165 million tons per year, tolls are \$3/ton, and annual revenues are nearly \$500 million. A demand study estimated that much more tonnage would flow through the Canal in the future, so long as sufficient capacity was available. This study ignored the effects of tolls and delays. It concluded that demand could increase to 363 million tons/year by 2020 and increase to nearly 500 million tons/year by 2060. The Panama Canal Authority has decided upon the following plan for expanding the capacity of the canal:

1. Acquire additional locomotives and install a navigation system by 1995 (at a total cost of \$140 million)
2. Start work on widening the cut so that it can allow bi-directional operation of Panamax ships by 2008 (at a cost of \$2 billion)
3. Double the tolls when Panama gains control of the canal in 2000 in order to:
  - a. Increase the funds available for investing in capacity improvements
  - b. Encourage the use of Panamax vessels
  - c. Provide a means of avoiding congestion at the canal
4. Complete the third set of locks by 2020 at a cost of \$4.3 billion
5. Widen the cut for bi-directional operation of Post-Panamax ships by 2025 at a cost of \$1 billion

The Panama Canal Authority anticipates that this plan will:

1. Provide sufficient capacity to meet demand through 2060.
2. Allow construction to be funded from toll revenues, without requiring the authority to borrow money or to sell bonds to finance the expansion.
3. Allow a fairly constant rate of investment in infrastructure from 1994 to 2025.

The plan immediately received widespread applause from most of the world's shipping community, because it would allow cheaper ocean transport and eliminate the possibility that the Panama Canal could become a bottleneck that restricts international trade. However, potential opposition to the proposal is expected from several sources:

1. Politicians in Panama
2. Bulk shippers
3. International construction companies that have the ability to finance and construct multi-billion-dollar infrastructure projects
4. Environmental groups in Panama

**Part 1 Questions (5 points each for a & b below):** For each of these groups:

- a. What complaints or objections do you anticipate?
- b. As the executive director of the Panama Canal Authority, how would you respond to this opposition? You may consider defending your plan, modifying your plan, or giving some sort of payment to those who would be hurt by the plan.

## **Part 2 Background**

It is now 2006. The Panama Canal Authority has followed the strategy outlined above for 13 years. The toll policy has led to the diversion of some freight, but annual tonnage has grown to 200 million tons per year. There has also been an increase in the average size of ships moving through the canal. As planned in 1993, tolls were sharply increased in 2000 and revenues are now about \$1.2 billion per year. The higher tolls have helped the canal avoid congestion.

However, Nicaragua has just announced plans to construct a sea-level canal through their country. This project is expected to cost \$20 billion, and it is expected to be completed by 2015. The project will provide a slightly shorter route between Asia and the Atlantic, and it will allow simultaneous bi-directional operation of Post-Panamax ships. The project will be financed by selling bonds and by loans from the Nicaraguan government; the average interest rate is expected to be about 6% per year.

## **Part 2 Questions (5 points each for c, d & e below)**

Your role is to identify and assess ways that the Panama Canal Authority might respond to this competitive threat (5 points each):

- c. How would a new Canal in nearby Nicaragua affect the Panama Canal?
- d. Identify three ways that the Panama Canal Authority could react to the proposal to build a new canal.
- e. Discuss the advantages and disadvantages of each alternative, and recommend and justify one of them as the best strategy for the Panama Canal Authority.