

The Pox Problem

Introduction

The little community of Pox exists by the sea. Although a very stable community, a transportation study is felt desirable to ascertain the long range impact of some proposed changes in Pox's economy.

Figure 1 displays Pox's land use. Most areas of the community are in residential or vacant land use. The people of Pox are employed in 1) the CBD area which provides governmental, service-oriented, retail and cultural activities; 2) the hotel complex and beach areas cater to "northern" tourists and 3) an industrial section provides light manufacturing products and tourist trinkets. Trip making in Pox is directly related to land use functions with the following trip pattern.

Zone	Work Trips	Social-Rec. Trips	Shopping Trips
A CBD Area	X	X	X
B Hotel Complex – proposed	X	X	X
C Beach	X	X	-
D-H Residential	0	0	-
I Industrial	X	-	0
J Outlying Shopping Center	X	-	-
K Suburbia	0	0	-
X–indicates zone attracts trips			0
0–indicates zone produces trips			

It is anticipated that the existing land-use pattern and travel pattern will continue with one major exception. Recently, a large corporation has proposed construction of a huge luxury hotel complex in the next five years. Preliminary plans indicate that the hotel complex will be located in the vacant land between the CBD and the beach. Such a large complex would increase the flow of tourists to Pox, add new employment opportunities and substantially assist in the dynamic economic development of Pox. Naturally, the development will alter Pox's travel pattern and will also require that the suburban area of Pox be developed into residential use in order to accommodate the influx of new population.

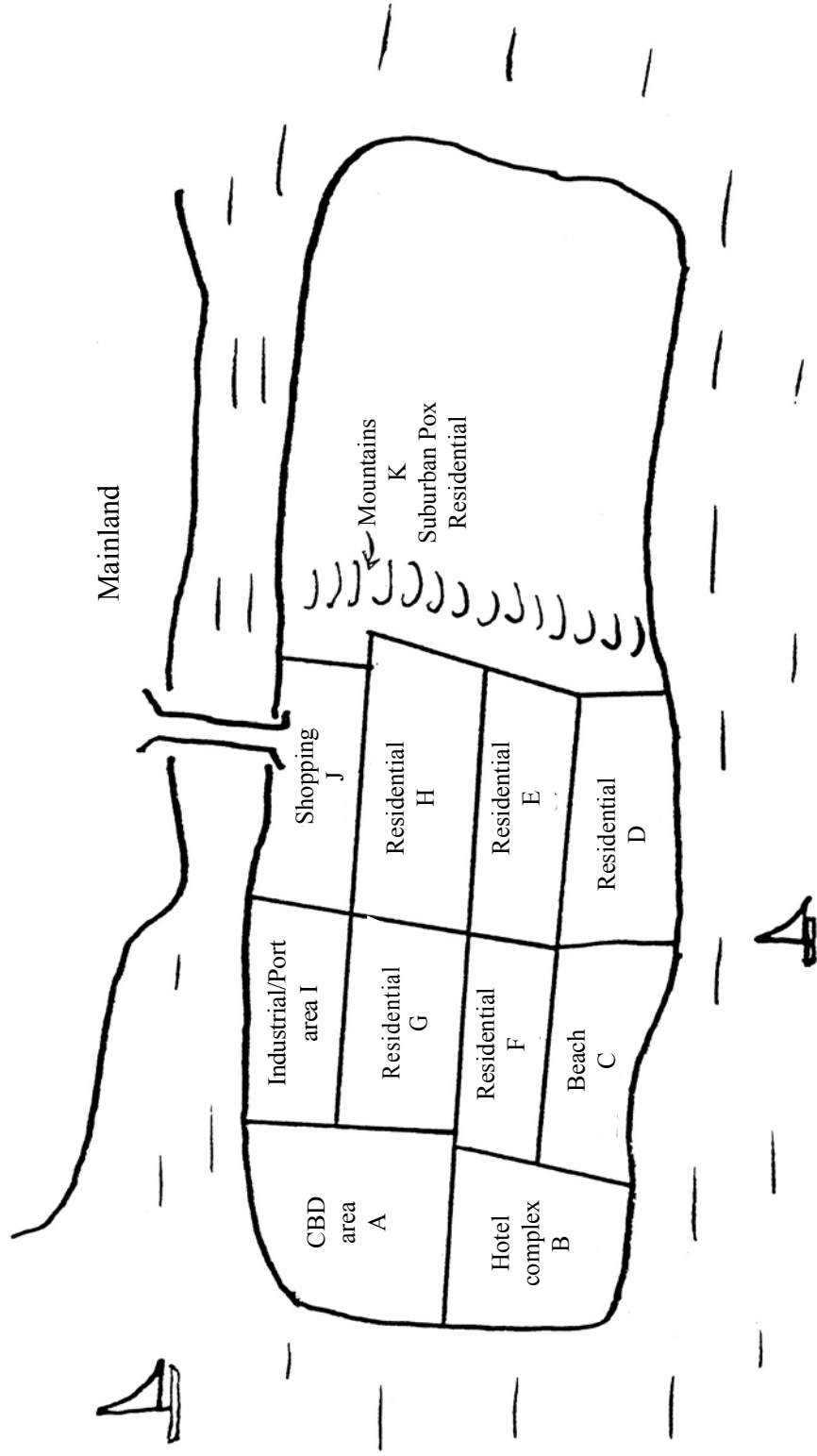
Likewise, the development of Pox's suburbia will require that a new transportation link be constructed through the mountains in order to make suburban Pox an integral part of Pox proper.

The location and nature of service provided (freeway or transit system) on this link will likewise have an impact upon Pox's travel patterns. Due to the unique topographical constraints and existing level of development within Pox it is assumed that the transportation investment will not alter the land-use patterns and a "one shot" plan is feasible. Use 2005 as the planning horizon period. Pox's traffic network is shown in Figure 2.

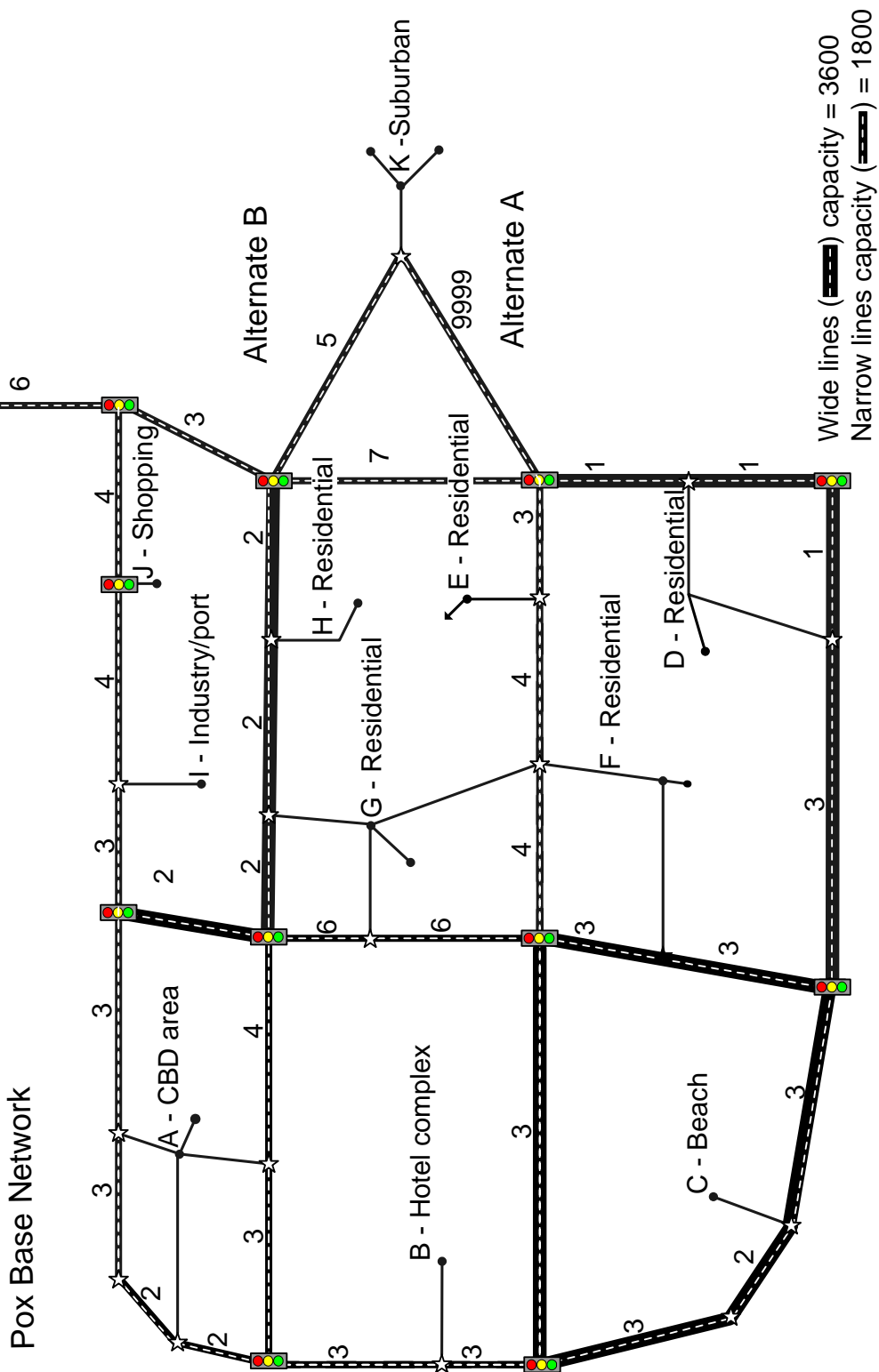
Note: Doing the Pox problem requires some time, especially parts III and IV. It is due in four parts; allow enough time to do it all.

See the class syllabus for due dates.

Figure 1 - Pox Land Use



13 - External Station



Part I:

In Part I you will make forecasts of future conditions in the city of Pox. This involves four steps: Population forecast, economic forecast, land use, and auto ownership.

1) Population Forecast

Given the following information predict the population for year 2010:

1940	3,400
1945	6,600
1950	10,200
1955	13,600
1960	15,700
1965	16,700
1970	18,700
1975	20,400
1980	21,100
1985	22,100
1990	22,500
1995	23,200

Show your prediction with a graphical presentation and justify your prognosis.

2) Economic Forecast

Pox had an estimated 4,400 persons employed in basic industries in 1995 and an historical total employment to basic employment ratio of 3.15 to 1. If jobs grow at the same rate as the population and the hotel provides an additional 1000 basic jobs by the year 2000, what is the total 2010 employment of Pox? Is this a reasonable employment level for the population forecast above? If not, what is a reasonable population for 2010? You should redo the population to allow for natural growth and the extra growth because of the new hotel. Hold the percent of the population employed as a constant.

3) Land-Use

Assume the capacity (ability of a residential zone to accommodate extra population) is noted on the table below along with each zone's relative growth index potential (summary of each zone's amenity rating—index of relative price, accessibility, family income and tax rate).

<u>Zone</u>	<u>Capacity left</u>	<u>1995 population</u>	<u>Growth Index</u>
A	500 pop.	500	0
D	400	2,100	276
E	1,000	3,300	218
F	0	3,000	30
G	500	5,000	6
H	0	4,300	400
K	15,000	5,000	1,000

Allocate a future population growth of 8,500 people to the residential zones – show calculations; note you will have to do this in several iterations; if a zone is full, it cannot receive more people.

4) Automobile Ownership

Although car ownership is not a land use category, it is nevertheless a measure of land use activity, and inasmuch is an important part of the analysis. For Pox, car ownership will increase because 1) population will increase and 2) the number of cars will increase due to a higher rate of car ownership.

The following model has been developed from previous studies elsewhere to determine auto ownership per household:

$$\text{Autos/HH} = .11 * \text{Pers/HH} + .41 \ln(\text{Ave. Income}) - .12 \ln(\text{HH}/10 \text{ Acres}) - 2.6$$

Using this equation, calculate auto ownership for the following zones:

<u>Zone</u>	<u>Persons/H H</u>	<u>Average Income</u>	<u>HH/10 acres</u>	<u>Autos/HH</u>
A	2.8	18,000	18	
D	2.8	18,000	18	
E	2.8	18,000	18	
F	2.8	18,000	18	
G	3.6	25,000	12	
H	2.8	18,000	18	
K	3.9	20,000	4	

Pox, Part II:

Assume that the following results were found from Part I. Using this information you will need to predict future trip making in Pox.

Socio-economic Characteristics -- Forecast Results -- 2010

<u>Zone</u>	<u>Pop. HH (DU)</u>		<u>Autos</u>	<u>Labor f</u>	<u>Retail</u>	<u>Recr.</u>	<u>Other</u>	<u>Total Empl.</u>
A	500	179	246	299	1938	500	2700	5138
B	0	0	0	0	1100	2000	900	4000
C	0	0	0	0	800	500	800	2100
D	2500	893	1231	1494	0	0	0	0
E	4300	1536	2117	2569	0	0	0	0
F	3000	1071	1477	1792	0	0	0	0
G	5042	1401	2311	3012	0	0	0	0
H	4300	1536	2117	2569	0	0	0	0
I	0	0	0	0	0	0	4700	4700
J	0	0	0	0	1800	0	1200	3000
K	12057	3092	5327	7203	0	0	0	0
Totals	31700	10322	10664	18938	5638	3000	10300	18938

Pop. = population in zone

HH = number of households (note this is the same as the number of Dwelling units)

Autos = automobile ownership in zone

Labor f = labor force in the zone

Retail = retail zonal employment

Recr. = recreational zonal employment

Other = other employment

Total empl = total zonal employment

5) Trip Generation

Based upon an O-D survey conducted in 1995 the following zonal trip rates and zonal socioeconomic characteristics were computed.

<u>Zone</u>	<u>1995 Work Trip Productions</u>	<u>1995 Households</u>	<u>Labor Force</u>	<u>Density/ sq. mile</u>
D	2500	900	1000	50
E	4290	1500	2000	10
F	2750	1000	1250	20
G	4000	1400	1750	60
H	4130	1500	500	10
K	8700	3100	200	45

<u>Zone</u>	<u>1995 Work Trip Attractions</u>	<u>Total Employment</u>	<u>Retail Employment</u>	<u>No. of Parking Meters</u>
A	7200	4900	400	1000
B	6000	4100	2000	50
C	2700	2000	450	1900
I	6100	4200	27	1500
J	3550	2500	50	1500

Using the O-D data, develop a simple linear trip generation equation for home to work trips (production) and home to work trips (attraction). Use the one variable that seems to most directly relate to trip making.

Assume that you also got the following regression equations for shopping and recreational travel. Determine the number of trips (stratified by work, socio-recreational, and shopping) produced and attracted in each traffic zone for 2010. Use the forecast socioeconomic characteristics on the first page of this section for your calculations. Note that the types of trips attracted and produced in each zone represent the land use functions existing in that zone to satisfy trip making. Thus, the port complex will not be involved with shopping or socio-recreational trips. It is assumed other trip purposes (residential, commercial, school, etc.) and linked trips are too insignificant to include.

The shopping and socio-recreational trip equations are as follows:

Trip Production in Residential Zone:

$$\text{Shopping trips} = .76 * \text{Autos} + .07 * \text{Population}$$

$$\text{Socio-recreational trips} = .79 * \text{Autos} + .20 * \text{Population}$$

Trip Attractions for non-work purposes:

$$\text{Shopping trips} = 2.5 (\text{Retail Employment})$$

$$\text{Socio-recreational trips} = 2.2 (\text{Retail Employment} + \text{Recreational employment})$$

Use a spreadsheet program (Excel, Quattro, etc.) or work by hand to complete the 2010 Trip Generation (Production and Attraction) Table as shown below. You will probably want to put the input data in one part of the spreadsheet, then the equation parameters and then the output table.

Zone	Work	Attracted trips		Produced		
		Shop	Soc.-Rec.	Work	Shop	Soc.-Rec.
A						
B						
C						
D						
E						
F						
G						
H						
I						
J						
K						
Totals						

Compare the Total Trip Productions and Attractions for all zones for each purpose. Adjust trip productions so that they have the same total as the trip attractions for each trip purpose. (Keep the proportion of trips produced in each zone constant.)

6) Computer Forecasts (Trip Generation):

Input the network and zonal data into GNE. First check the course web page for any current instructions. Start with the file GME under Engineering Apps/CivilEngineering/GNE and open the file QRSEasy.DTA from S:/QRSII. Plot links and be sure to label all nodes and links. Include both Alternatives A and B in your network with a capacity of 1800, but use a travel time of 9999 for Alternative B. The following data should be entered:

Systems Menu (under Schema menu):

Through penalty = 0
Left turn penalty = 0.25
Immediate right penalty = 0
Other movements penalty = 0
Scale = 48
Default speed = 20
Income or autos/HH = 1
Urban area population = 35
Starting hour = 0
Ending hour = 23

Centroids. Give each centroid a label and enter data for each centroid as given at the beginning of Part II or as calculated.

Average autos/HH (calculate from the data table)
Number of retail employees
Number of non-retail employees (recreational plus other employment)
Number of dwelling units (households)
Intrazonal time
(use work sheet to calculate this with 30 mph intrazonal speed, and a one square mile area, or enter 1.5)
Demographic 4 = Recreational employment
Demographic 5 = 0

Intersections with penalties:

Set cycle length at 60 seconds, leave all other attributes at zero (through, left, intermediate right and other movements adjustments, minimum unsignalized capacity).

Two Way Links:

Label the links.

Set approach codes as follows:

for north-south links 1 S 3 M

for east-west links 2 S 3 M

for diagonal links

SW to NE 3 S 3 M

SE to NW 4 S 3 M

(Note: Use a capital M for those links shown as double lines in the diagram and a small m for those shown as single lines.)

Travel time A to B and free travel time (use the same # for all three as given on the network drawing)

Capacity = 1800 – single line; 3600 – double line

Save your network on a floppy or your I drive with the name poxbase.dta or something like that

Go to QRS II and do the following

a) Modify trip attraction rates under the parameters/trip generation/attractions menu as follows:

Home based work

Make sure parameters = 1.45 for retail and non-retail employment. Set the other parameters to 0.

For the Home based non-work category, enter the coefficients from the equations used in trip generation for the shopping trips

For home based ? enter the socio-recreational coefficients. Make sure they correspond to where you put the data on the centroids

b) Modify trip production rates in QRS II as follows:

Under the Parameters/Trip Generation/Trip Productions menu, check Use Average Productions and set the total to 14.1. Make sure the NHB Productions Equal Attractions box is checked, leave the others blank. For balancing type use Hold Attract for all trip purposes.

c) Go to the Files menu and indicate the name and location of your highway network file (A:\poxbase.dta, for example). Under the Files/ Run Controls menu, click on the Reports button and designate the directory where you want the answer to be placed (probably on the I drive). Click off the Include Transit box.

Go to the Reports/Highway/Other menu and make sure that the PSANDAS.TXT file is checked.

d) Go ahead with the calculations. Hit the Run button. When done, leave QRS and look at a file called PSANDAS.TXT with the Windows Notepad. This file will be saved on the directory you designated in step c.

e) Compare the results of your hand calculations for work trips with those from QRS II.

Pox Part III

7) Trip Distribution

In order to distribute trips, it is first necessary to know the travel times between all pairs of zones. This information is then used along with trip productions and attractions to distribute trips using the gravity model.

a) Minimum Time Path: Determine the minimum time path between the designated zones that interchange work trips. For future reference also keep track of those links that appear on the minimum time path. Reference should be made to your GNE network for highway travel times. Consider only the north alternative (B) and ignore the south alternative (A) in these calculations. **Add 3 minutes intrazonal or initial travel time for each O-D pair.**

You will want to find the paths from the trip producing zones – A, D, E, F, G, H and K – to the trip attracting zones – A, B, C, I, and J. This is a total of 35 values. This can be done by inspection, by using the Moore algorithm, or with GNE.

To use GNE, go to the Tools→ mark shortest path to find the minimum paths. See the course web page for details of how to do this as well as how to view the travel times on the screen using View→toolbars and the Link Label buttons.

Complete the minimum travel time table as shown below.

Zones	Minimum Travel Time
K-A	
K-B	
K-C	
K-I	
K-J	
H-A	
H-B	
H-C	
H-I	
H-J	
G-A	
G-B	
G-C	
G-I	
G-J	
F-A	
F-B	
F-C	
F-I	
F-J	

Zones	Minimum Travel time
E-A	
E-B	
E-C	
E-I	
E-J	
D-A	
D-B	
D-C	
D-I	
D-J	
A-A	
A-B	
A-C	
A-I	
A-J	

b) Internal Trips: Using the competing gravity which has been identified as being accurate for forecasting travel in a community such as Pox, determine zone to zone trip interchanges for work trips (you may want to develop a spreadsheet template to help you do this. Do two iterations and show initial A_j , A_j after one iteration and A_j after two iterations. Note: Only do work trips.

$$T_{ij} = P_i * \left(\frac{\frac{A_j}{D_{ij}^b}}{\sum_{x=1}^n \left(\frac{A_x}{D_{ix}^n} \right)} \right)$$

where

T_{ij} = trips originating in zone i with destination in zone j for a given trip purpose

P_i = total trips produced in zone i for a given trip purpose

A_j = total trips destined to zone j for a given trip purpose

D_{ij} = travel time (from minimum time path) between zone i and j (prom prev page, including intrazonal time)

b = empirical constant taken to be **2.0 for work trips**, 3.0 for shopping and commercial travel and 2.35 for social-recreational travel.

Use the following data:

Zone	Productions	Attractions
A	505	7,450
B	0	5,800
C	0	3,045
D	2,526	0
E	4,345	0
F	3,030	0
G	3,962	0
H	4,345	0
I	0	6,815
J	0	4,350
K	8,747	0
Totals	27,460	27,460

c) Tourist Travel: With the use of a Fratar model expand the number of trips between the external zone, K, B and C (use two iterations). These are trips made by the tourists. The base year trip interchanges and growth factors are as follows:

Zone	Expansion Factor	Existing Number of Trips Between Zones				
		External	B	C	K	Total
External	2.0	---	200	600	1200	2,000
B	3.0	200	---	300	100	600
C	2.0	600	300	---	600	1,500
K	1.0	1,200	100	600	---	1,900

d) Convert Person Trips to Vehicle Trips: Develop a combined trip table for work and tourist person trips and for vehicle trips from Zone K to all other zones. Assume that you also found the following table of person trips for other trip purposes. The following auto occupancy rates should be assumed: shopping trips 1.5, social recreation 2.0, work trips 1.1, and tourist travel 2.0. Assume that there is no transit service.

Person Trip Table

	Shopping	Social-Recreation	Work	Tourist
K-A				
K-B	1,050	2,750		
K-C	785	1,200	Use results from part 6b	Use results from part 6c
K-I				
K-J				
K-External	2,120	1,700		

The Vehicle Trip table should look the same, but show numbers of vehicle trips.

Pox - Part IV:

In Part IV you will add a transit alternative and conduct trip assignment. Note step 11 which involves the use of QRS/GNE.

9) Mode Split

The mayor of Pox has expressed an interest in providing transit service in Pox. Two routes are planned. The first would run from the suburban area, Zone K, via Alternative B and Second Street (streets are numbered from the top of the city) to the street intersection of the CBD, and the second would run from a stop on the street at the beach area, then east, then north, then west on Second Street to the CBD. It is expected that the bus travel time would be 50% greater than the auto travel times on each link.

- 1) Design the routes so that they can use a pulse schedule system, i.e. so that the buses meet at the CBD every 30 minutes and that there is a reasonable layover for the drivers at the CBD end of the route (2-10 minutes). Buses should ideally have a round trip travel time of a little less than 30 minutes or some multiple.
- 2) How much equipment is required? This is the cycle time divided by the headway – 30 minutes
- 3) How could you extend the second route to make it more productive (less layover time) ?
- 4) Calculate the mode split for work trips only for the zone pairs listed below using the Logit model ($C_1 = 2$ mins./min., $C_2 = \$0.05/\text{min.}$, $C_3 = 30$ min. for buses and $C_3 = 0$ for autos, $\theta = -.030$). Assume 5 minute walk times at both ends of auto and transit trips and 1/2 hour bus headways. Wait times are half the headway with a maximum of 10 minutes. Assume a fare of \$1.00 will be charged and that auto travel costs \$0.09/mile (\$0.03/minute at 30 mph), occupancy = 1.0, parking in the CBD costs \$2.00/day. Parking cost elsewhere is zero. (Note: include only 1/2 of parking costs for the trip to the CBD.)

K-A

K-B

K-C

10) Traffic Assignment

Assume that the following vehicle trip totals are expected by the year 2010 from Zone K to other zones.

K-A	4157
K-B	3361
K-C	1771
K-I	2747
K-J	2576

- Find the minimum path tree from Zone K to all other zones. Do this separately with Highway Alternative B in the network and with Highway Alternative B in the network (but not both in at the same time). Use a travel time of 7 minutes for Alternative A.
- Alternative A: Assign these trips to the network using alternative A (and not B). Sum the total vehicle minutes of travel using alternative A. It could be done directly on your diagram. Just put the volumes for each D-D pair in the minimum path links and add them up, or you can use a table like that below. Then do the same thing for alternative B. Which has the lowest total vehicle hours of travel?
- Alternative B: Repeat step C to determine the effects if Alternative B (and not A) were to be implemented. What is the change in total vehicle minutes if Alternative B were to be implemented versus Alternative A?
- Determine the volume to capacity ratios for the links A and B in the each of the networks. Use the link volume shown above and the capacities on the links.

Link	Trip Interchanges					Total Link Volume	Travel Time	Vehicle Minutes
	K-A	K-B	K-C	K-I	K-J			
1-2								
1-7								
1-9								
2-1								
2-3								
2-6								
.								
.								
.								

11) Pox-QRS

Computer Forecasts (Trip Distribution and Assignment):

Using the Pox network you created earlier, set the starting hour to 14 and the ending hour to 16. Save the network and analyze it with QRS with the following changes under the Parameters menu:

- a) Modify the Vehicle Assignment Parameters as follows:

Change Number of Iterations to 10
Check Vine Building and Method of Successive Averages.

- b) Set Trip Distribution Type to Exponential and use 0.1 as the exponents. Check HBW, HBNW, and NHB trip purposes.

- c) Go ahead with calculations. This will produce a file of results called OUTPUT.DTA. Return to GNE; open the file OUTPUT.DTA and view your results. You should examine volume to capacity ratios on the links. This can be done several ways (method 3 is the easiest):

1) Open each link and look at data for traffic volumes and capacity and calculate V/C ratios by hand.

2) Extract the data to a spreadsheet and do calculations to determine V/C ratios.

3) Use GNE to calculate the V/C directly and display the results on the screen with GNE. Open the file NICEOUT.DTA and append your OUTPUT.DTA file. Then, under GNE/Tools/Calculate read the file **VCRATIO.PGM** from the R directory. Refresh the graphics (showerhead button). Display the V/C ratios on the two-way links. Show links that have V/C ratios greater than 0.9. Use View/Search/LinkSearch/Two-wayStreets/Attributes and set the V/C ratio range from 0.9 to 10.0.

- d) Go back to GNE and modify your base network to include Alternative A with a 7 minute travel time but not Alternative B (change the times to 9999). Do this again with Alternative A but not B (delete B and put A back in) and compare the results.

- e) Add capacity to one link or add a totally net link to the network to deal with the most congested part of the network (include just Alternative B, not A). How does this affect V/C ratios?

Show V/C ratios before and after the change.

12) Transit design and evaluation:

Following similar procedures such as you have done so far, two major transit alternatives have been developed and analyzed. These are described on the following page and should be compared using the following criteria:

Travel Demand

trips/day
passenger miles
passenger hours

Level of Service

Average headway
Transfers/trip
Hours of operation
Average fare
Average speed

Costs

Capital–total
Annual
Capital
Operating
Revenues
Net

Impacts

Population served
Jobs served
Congestion effect
Households displaced
Development effect
Energy saved
Jobs created

a) Determine vehicle fleet size for each alternative, daily cost and daily revenues and expand to yearly estimates. Using this information and other information given develop an evaluation matrix using the criteria listed above.

b) Compare these alternatives using **either**

1) a weighting scheme (weigh all criteria equally within each of the four categories above and weigh travel demand at 40%, level of service at 30%, costs at 15% and impacts at 15%). or

2) a multi-number approach such as trade-off analysis.

c) Discuss your selection.

Data for all transit alternatives

10% spares

10% layover

1.5 load factor

Peak services is provided 4 hours per day, base service uses 50% of the peak vehicles operate 300 days/year

Annualization factors = .03 for shops, LRT vehicle; .10 for buses, .02 for track (multiply the initial costs by these numbers to determine annual costs)

20% of ridership is in the peak hour

Alternative 1

Bus system

- two 10 mile lines, 15 mph avg. speed. Route 1 has a daily ridership of 2800 and route 2 has a daily ridership of 2000 people.
- 50 passenger buses
- operate for a total of 16 hrs./day
- fare = \$0.75
- bus cost = \$120,000
- shop cost = \$1,000,000
- average operating cost = \$25/bus hour (includes all costs)
- average total daily ridership = 7000 trips on route 1 and 5000 on route 2 with an average length of 8.0 miles
- 10% of the trips made are as transfers, therefore 90% of the total trips produce revenues
- no displacement, no significant development effect, energy savings of 0.5 gal./trip, serves 20,000 people, 9000 jobs

Alternative 2

Light rail system

- two 10 mile lines, average speed = 20 mph
- 150 passenger vehicles, 16 hours/day operation, 4 hours peak service
- fare = \$0.50
- vehicle cost = \$800,000 each
- shop cost = \$2,000,000
- construction costs \$4,000,000/mile
- average operating cost = \$30/vehicle hour
- average daily ridership = 14,000 trips/day on route 1 and 10,000 per day on route 2, with an average length of 8.0 miles, 10% transfers
- 10 households displaced, major CBD development expected (\$20 to \$40,000,000 investment), saves .8 gal. fuel/transit, serves 20,000 people, 9,000 jobs, reduced street congestion
- creates 10 jobs per \$1,000,000 of construction activity during construction