ABSTRACT

Evaluation of Truck Restrictions Using Simulation

by
Shaikh Mohamed Arif

Traffic congestion is a major problem in many central business districts. Many strategies have been proposed and implemented to solve or alleviate this problem. One of the most common strategies is to impose travel restrictions on the movement of trucks, without reviewing the economic consequences of goods movement restrictions on shippers, customers and on the overall business activity of the area.

This research examines the effect of various truck restrictive policies on the cost of urban goods movement, using the central business district of Manhattan as a case study. Computer simulation techniques are used to evaluate several scenarios under different regulations and obtain the travel time and speed of vehicles through the network. The cost incurred by the vehicles is computed and the economic impact and feasibility of the regulations are analyzed.

EVALUATION OF TRUCK RESTRICTIONS USING SIMULATION

by
Shaikh Mohamed Arif

A Thesis
Submitted to the Faculty of
New Jersey Institute of Technology
in Partial Fulfillment of the Requirements for the Degree of
Master of Science in Transportation
January, 1993

APPROVAL PAGE

Evaluation of Truck Restrictions
Using Simulation

by
Shaikh Mohamed Arif

Dr. Lazar N. Spasovic, Thesis Adviser
Assistant Professor of Management,
School of Industrial Management, NJIT

Dr. Louis J. Pignataro, Committee Member
Distinguished Professor of Civil and Environmental Engineering, and
Director of Center for Transportation Studies and Research, NJIT

Dr. Athanassios K. Bladikas, Committee Member
Associate Professor of Industrial and Management Engineering, and
Associate Director of Center for Transportation Studies and Research, NJIT

BIOGRAPHICAL SKETCH

Author: Shaikh Mohamed Arif

Degree: Master of Science in Transportation

Date: January, 1993

Undergraduate and Graduate Education:

- Masters of Science in Transportation
  New Jersey Institute of Technology, Newark, NJ, 1992

- Bachelor in Civil Engineering
  University of Poona, India, 1989

Major: Transportation Engineering

Dedicated to my family
everyone unique in their sacrifice
Ammi, Abba, Mommy, Pappa, Bade Abba, Bade Ammi,
Bhabi, Aslam bhai, Rukhsana, Yasmin, Ashfaque,
Afraz, Afaque, Sana, Saba, Azhan.

ACKNOWLEDGMENTS

The author would like to express his sincere gratitude and appreciation to all who provided valuable assistance and advice throughout the course of this research. Special thanks are due to Professor Lazar N. Spasovic, my thesis advisor, for his generous advice and guidance, to Dr. Louis J. Pignataro, Director of the Center for Transportation Research and Studies at New Jersey Institute of Technology, for his generous efforts in providing funding for the support of this research, to Professor Athanassios K. Bladikas for his advice and suggestions during the course of this thesis. Appreciation is also expressed to NYCDOT, and Urbitran, Garmen and Volmer Associates for providing the necessary data. Finally, special thanks to my friends, Nadeem, Ranga, Meher, Masood, Pat, Shahid and Naresh for their constant support throughout the research.

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

Figure Page

CHAPTER 1

INTRODUCTION

1.1 Overview

In March 1986 the New York City Department of Transportation imposed various traffic regulations along 49th and 50th Streets in midtown Manhattan. The regulations were restrictive and include the following:

- A curb side priority lane for buses and occupied taxis.
- A ban on curb side pick up and delivery during selected midday hours.
- A mandatory turn for all non - priority vehicles at the end of each block.

The effect of these restrictive policies on the cost of urban goods movement will be analyzed in this research using simulation techniques. The research will first present a methodological framework that is used to simulate various traffic scenarios under specific restrictive measures. Cost and time estimates will be made for each scenario. The methodological study developed in this thesis will be applied to a case study consisting of the Manhattan central business district in New York City. The study represents the network from 8th Avenue to Madison Avenue (in the East to West direction) and 42nd Street to 52nd Street (in the North to South direction).

TRAF-NETSIM, a simulation model developed for the Federal Highway Administration is used as an analytical tool to evaluate various restrictive regulatory strategies. In particular, the model will evaluate the impact of strategies on the system's operational performance. The impact will be determined in terms of travel time in the form of seconds per vehicle, vehicle-minute, speed and person-minutes. In addition the model will enable the researcher to visualize the impact of strategies on the flow of vehicles by using NETSIM's animation capabilities. Finally, the costs and the measure of effectiveness of the scenarios are compared and evaluated. This kind of analytical approach towards restrictive policies will achieve the following objectives:

- Enable the city authorities to evaluate the impact of various regulations on traffic flow before they implement them.
- Enable trucking companies to route their vehicles more efficiently.
- Forecast traffic conditions in planning new business districts or modifying present streets and traffic control policies in anticipation of future developments.

1.2 Background

Economic progress is inevitably tied to transportation. Trade or commerce cannot flourish without an adequate transportation system that provides service at reasonable cost, and without trade there can be little industrial activity and the associated employment, income, taxes and other economic benefits. Every business firm, regardless of what it produces or distributes, is in some way involved in transportation. The purpose or function of transportation is to provide a link between suppliers of goods or services and consumers. Good transportation is characterized with high quality of service (e.g., short travel time and high reliability) and low price (cost) to the user (shipper). The movement of goods to, from and within urban areas in particular have a tremendous impact on economic welfare and the development of those areas. Various studies have shown that the movement of urban goods is a very significant component of a national economy. A 1976 study by Kearny estimated using 1972 data, that the costs of moving goods within urban areas was equal to nearly 5% of gross domestic product. Therefore it is critical for an urban area to reduce the cost and improve the efficiency and service quality of goods movements.

1.3 Problem

The urban freight distribution is enormously complex. The complexity is in part caused by different and often conflicting objectives of parties involved in goods movement. Motor car drivers see delivery trucks as a nuisance on the roadway. The driver looking for a downtown parking spot resents that a large portion of curb space is devoted to loading zones. The retailer appreciates that truck brings the goods but regrets the fact that the loading zone takes away space that could be allocated to customer parking. The office building owner sees the provision of loading docks as unutilized (or dead) space and would rather receive the deliveries from the trucks parked at the curb space. On the other hand, the truck driver views private motorists as menaces as they create too much congestion and thus increase his operating costs. Furthermore, because of congestion the truck driver cannot make as many runs and thus his revenue will decrease. Pedestrians see large trucks as a threat and a main producer of air and noise pollution. Shops and industries seek to have a regular supply of finished and semi-finished products and components, and see the urban freight problem in terms of lost productivity. This is especially critical for retailers and manufacturers just-in-time concept wherein inventory costs are reduced by relying heavily on reliable transport links. Pavement engineers see trucks as breaking up the roads. Urban planners worry about the consequences of freight transport on the fabric of urban areas, while economists are concerned with the impact of urban goods costs on the economic viability of industries in the area.

The economic growth and rapid development of urban areas have dramatically increased the volume of goods movement. Urban goods are primarily moved by trucks. This increase of truck traffic in the central business district has led to various restrictive measures imposed by city and regional authorities. The general view is that the movement of trucks is the prime cause of adverse impacts such as congestion and delay on the movement of other vehicles. Public agencies in their attempt to minimize such adverse impacts, impose restrictions on the movement of trucks. In their opinion minimization of adverse impacts is achieved by introducing one or more of the following restrictions:

- Limiting the hours trucks are allowed to operate.
- Limiting truck access to residential areas.
- Limiting the movement of trucks on certain streets and avenues

- Banning the stopping and standing of trucks along certain streets.
- Limiting the parking of trucks for certain hours of the day.

The above policies are implemented without the complete analysis of consequences in terms of costs to the industry and the community. Because of the above regulations the truck pick-up and delivery operation is facing several problems such as:

- Just-in-time deliveries are becoming difficult to maintain, which results in increased cost of production and in turn costs the trucker loss of contracts.
- Increase in travel time due to increase in congestion and travel distance because of the regulatory measure caused detours.
- Increase in travel time due to unavailability of parking space.

1.4 Previous Study

Jovanis, Bashar and Haghani (1986) conducted a study to determine the effects of restrictive traffic regulations imposed on 49th and 50th Streets in the mid-town Manhattan area in New York City. The objective of the study was to measure the effect of the 49th and 50th Street regulations on travel time in the corridor around 49th and 50th Streets, and to separately estimate the impact of restrictions on loading and unloading of pickup and delivery vehicles along these streets. The restrictive regulations included a curbside priority lane for buses and occupied taxis (i.e., bus and taxi way), a ban on curbside pickup and delivery during selected mid-day hours, and a required turn for all non-priority vehicles (i.e., private cars, unoccupied taxis, trucks) at the end of each block. These restrictions were imposed simultaneously. The research team used data provided by the New York City Department of Transportation (NYCDOT) describing conditions prevailing before the implementation of the regulation. Because limited flow data were available for that time period, travel time was chosen as the primary measure of effectiveness. Travel times after implementation of the bus and taxiway were collected by the research team. A subsequent report by NYCDOT indicated that the total volume on

49th and 50th Streets had remained nearly the same, although the mix of vehicles had changed dramatically. There were many more taxis and fewer trucks and private automobiles. A before and after design analysis was thus undertaken using travel time as the primary measure of effectiveness.

After the bus and taxi way was implemented, goods vehicles were restricted to drive along 49th and 50th Streets and had to approach their targeted destination (i.e., shipper or receiver location) along the nearest Avenue and then, after turning, drive along 49th or 50th Street for less than a block. After serving a customer on one block of 49th or 50th Street the vehicle that needed to serve another customer on the next block of 49th and 50th Street had to make an eight block detour because of the mandatory turns and the network of one-way streets flowing in opposite directions.

After studying the before and after effects of the regulations, the team concluded that the priority lanes and mandatory turns had the greatest effect on travel time, and that the loading and unloading regulations make little sense and should be eliminated. Therefore, they recommended that to allow easy access for turns, curb use prohibitions should remain for the first third of each block. They also concluded that the cross town travel times did not change significantly for the entire day or for specific time periods during the day including the time when the curb use restrictions were in effect.

CHAPTER 2

METHODOLOGY

2.1 Introduction

This section develops a methodological framework for analyzing the cost of urban goods movement. Within this methodology several scenarios representing various restrictive policies for urban goods movements are developed, and the effect of restrictive regulatory policies on the travel time and cost of urban goods movements and on other vehicles such as cars and buses are obtained and evaluated. The methodological framework is first presented and then each scenario with specific restrictive policies is simulated using the network simulation software NETSIM. The simulation produced various measures of effectiveness for each scenario. The measures of effectiveness are travel time, speed, person travel time, etc. Costs are assigned to the measures of effectiveness. Finally the scenarios are compared with the cost of a baseline scenario in which no regulatory measures existed and the effects of the policies are analyzed.

2.2 Methodological Framework

A flowchart depicting the general methodological framework used to study the problem is presented in Figure 1. The flowchart shows three categories of data input.

- General data
- Freight data
- Restrictive regulations

These input data that are explained in detail below are simulated by NETSIM. The output obtained from the simulation is in the form of various measures of effectiveness. These measures, together with their unit costs, are evaluated and their economic effects are analyzed.

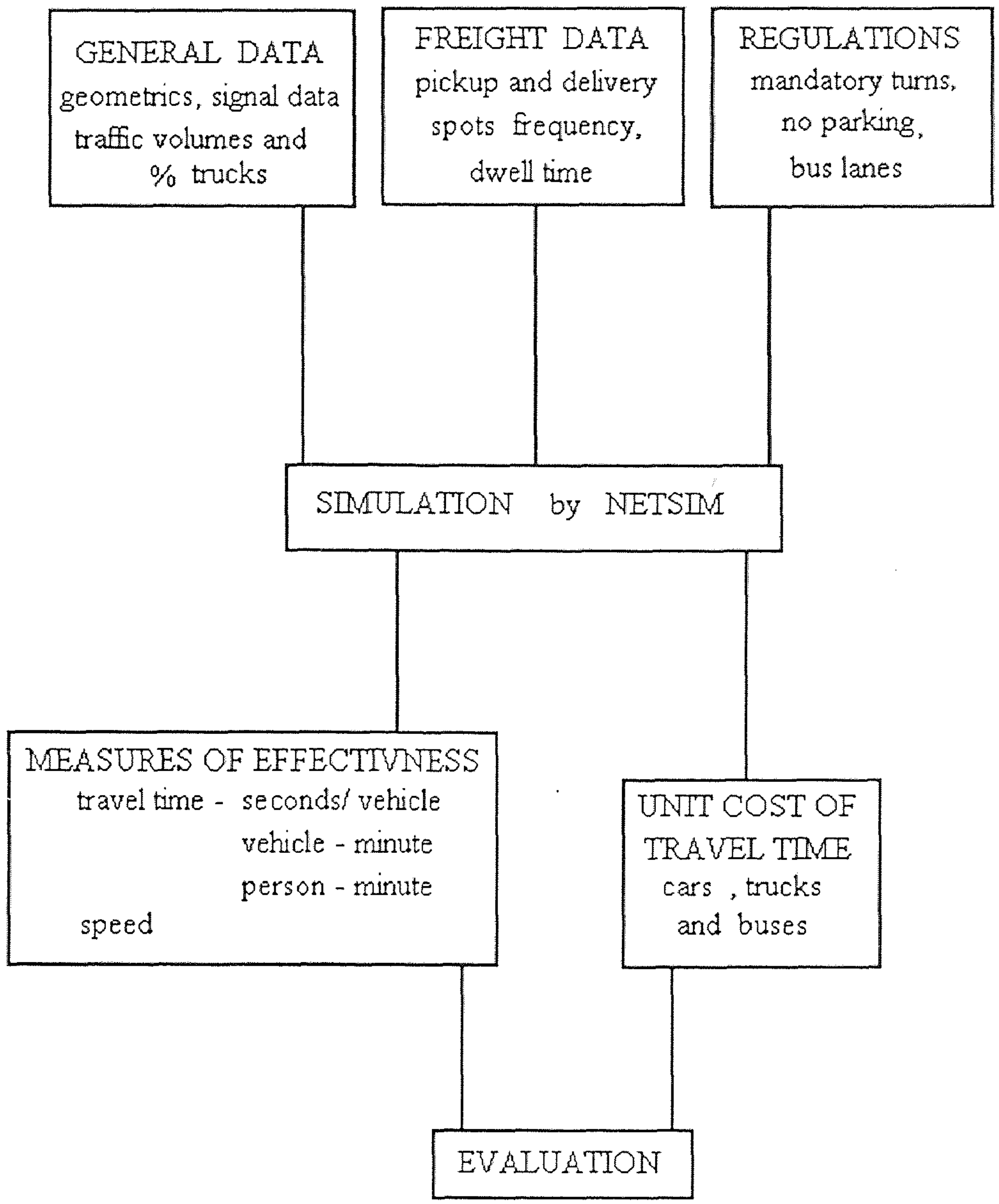


Figure 1. Methodological Framework

2.3 Data

The input data in the form of geometric parameters such as length of links, number of lanes, width of lanes, length and location of parking zones, traffic signal data, turning volumes, etc. were obtained from the Route 9A Study conducted in 1991 by Urbitran, Garmen and Volmer Associates. Route 9A is located in the west side of Manhattan and is scheduled for reconstruction in the near future.

The freight operation data such as locations of pick up and delivery stops, frequency of pick up and delivery, and average dwell time were collected during a comprehensive field study, undertaken by students of NJIT's Interdisciplinary Program in Transportation. The regulatory policies such as parking zones and their time limits, no standing zones, loading and unloading zones, mandatory turns, exclusive bus lanes, etc., were obtained from the Bureau of Traffic, for the Borough of Manhattan. An additional field study was conducted to carefully verify the signs posted on the streets. The regulations put into force are presented in Table 1.

With this data the network flows and operations were simulated using NETSIM. Certain changes were made in the input format to accommodate and emphasize pickup and delivery operations. The traffic simulation software is not designed to track the movement of individual freight vehicles through the network. It does have though the capability to track the movement of transit buses. The user can select the operating and physical characteristics of buses to mimic the characteristics of freight vehicles. Thus the operational characteristics and parameters for bus operations were replaced by those of pickup and delivery trucks. Bus routes are used to represent truck pickup and delivery routes. Similarly, bus stops, bus dwell times, and bus frequency are replaced by pickup and delivery spots, truck dwell time and truck frequency. The output of the simulation is in the form of measure of effectiveness (MOEs) that are listed in Table 2. In this research the primary concentration will be on MOEs such as travel time for trucks, buses and autos that are given in units of seconds per vehicle, vehicle-minutes and person-minutes. Unit

Table 1. Restrictive Policies in the Study Area

#	RESTRICTIVE POLICIES
1	NOPARKING 7am -7pm Except Sunday
2	NO STANDING Except Sunday 7am -7pm
3	NO STANDING Hotel Loading and Unloading
4	RED ZONE Tow and Fine $185
5	BUS LANE Buses and right turning only 4pm - 7pm Except Sunday
6	1 HOUR PARKING 10am - 10pm including Sunday
7	6 HOUR PARKING 8am - 7pm
8	NO STANDING Except NYP plate 3hr Parking
9	NO PARKING ANY TIME Taxi Stand
10	NO STANDING Except Trucks Loading and Unloading
11	TURN ALL TRAFFIC 8am - 6pm Except Buses and Medallion Taxis With Passengers
12	RESERVED For US Govt

Table 2. Measures of Effectiveness from TRAF-NETSIM cumulative out put : Link Specific Measures.

Measures	Units
Vehicle Stops	Percent
Mean Content	Vehicles
Mean Link Storage Area Consumed	Percent
Cycle Failure	Number of phase failures
Bus Travel	Bus Trips
Bus Passenger Travel	Person Trips
Bus Travel Time	Minutes
Bus Moving Time	Minutes
Bus Delay	Minutes
Bus Efficiency : Moving Time/ Total Travel time	Ratio
Bus Speed	Miles/ Hr [Kms/ Hr]
Bus Stops	Number of Stops
Fuel Economy	Vehicles-Miles/ Gallon [Vehicle-Kms/ Liter]

Table2 (cont'd): Measures of Effectiveness from TRAF-NETSIM cumulative output : Link Specific Measures.

Measure	Units
Travel	Vehicle Miles [Vehicle Kms] Person Miles [Person Kms] Vehicle Trips Person Trips
Total Travel Time	Vehicle Minutes Person Minutes
Moving Time	Vehicle Minute
Delay Time	Vehicle Minutes Person Minutes
Efficiency : Moving Time per Travel Time	Ratio
Mean Travel Time per Vehicle Mile	Minutes/ Vehicle-Mile [Minutes/Vehicle-Km]
Mean Delay per Vehicle-Mile	Minutes/Vehicle-Mile [Minutes/Vehicle-Km]
Mean Travel Time per Vehicle	Seconds/ Vehicle
Mean Delay per Vehicle	Seconds/ Vehicle
Mean Time in Queue	Seconds/ Vehicle
Mean Stopped Time	Seconds/ Vehicle
Mean Speed	Miles/ Hour [Km/ Hour]

Table2 (cont'd): Measures of Effectiveness from TRAF-NETSIM cumulative output : Turn Movement Specific Measures by Link.

Measure	Units
Travel	Vehicle Miles [Vehicle Kms] and Vehicle Trips
Total Travel Time	Vehicle Minutes
Moving time	Vehicle Minutes
Delay time	Vehicle Minutes
Effeciency : Moving Time/ Total Travel Time	Ratio
Mean Travel Time per Vehicle	Seconds/ Vehicle
Mean Delay per Vehicle	Seconds/ Vehicle
Mean Time in Queue	Seconds/ Vehicle
Mean Stopped Time	Seconds/ Vehicle
Mean Speed	Miles/ Hour [Kms/Hour]
Vehicle Stops	Percent

Table2 (cont'd): Measures of Effectiveness from TRAF-NETSIM cumulative output : Link Aggergations (Section-Specifc) Output.

Measure	Units
Travel	Vehicle-Miles [Vehicle- Kms] and Vehicle Trips
Total Travel Time	Vehicle Minutes
Delay Time	Vehicle Minutes
Mean Travel Time	Seconds/ Vehicle-Trip
Mean Speed	Miles/ Hour [Kms/ Hour]
Vehicle Speed	Percent
Mean Content	Vehicles

Table 2 (cont'd). Measures of Effectiveness from TRAF-NETSIM cumulative output : Bus - Station Specific Measures.

Measure	Units
Time bus station capacity exceeded	Seconds
Time bus station is empty	Minutes
Total bus dwell time	Minutes
Buses serviced	Number

Bus - Route Specific Measures

Measure	Units
Bus Travel on Route	Bus Trips and Person Trips
Total Bus Travel Time on Route	Bus-Minutes and Person-Minutes
Mean Travel Time on Route	Seconds/ Bus

costs for each of these MOEs is determined and costs to pickup and delivery vehicles, buses and autos affected by the restrictive policies are calculated.

2.4 Scenarios

Several scenarios each representing a regulatory measure were developed and the simulation of traffic flows under each scenario was performed using NETSIM. The following three policies, each incorporated within a scenario, were evaluated

- Mandatory turns
- No parking
- Exclusive bus lanes.

Each scenario has two cases. Case A represents the baseline case with no regulatory measure, and Case B represents the regulatory measures under study. These two cases were compared with each other in terms of MOEs and cost. In the input data, parameters such as geometric characteristics of the street network (e.g., lane width, length of links, signal timings, offsets, etc.) and the freight operations data (e.g., truck dwell time, truck frequency, etc.) are kept constant for all scenarios.

In the first scenario, shown in Figure 2, the regulatory effect of mandatory turns on pickup and delivery operations and on other non-priority vehicles such as cars and unoccupied taxis is examined. Two cases are considered in this scenario. In Case A there are no parking and no standing restrictions ineffect but there are no mandatory turn restrictions. In Case B mandatory left turns for non-priority vehicles are introduced.

In the second scenario, shown in Figure 3, the effect of parking zones on the travel time of pickup and other vehicles is analyzed. Two cases are also considered in this scenario. Case A has the same conditions as Case A of Scenario 1. In Case B additional parking zones are incorporated on certain Avenues.

In the third scenario, shown in Figure 4, the effect of exclusive bus lanes on the travel time of bus and other vehicles such as cars and pickup trucks is analyzed. Two

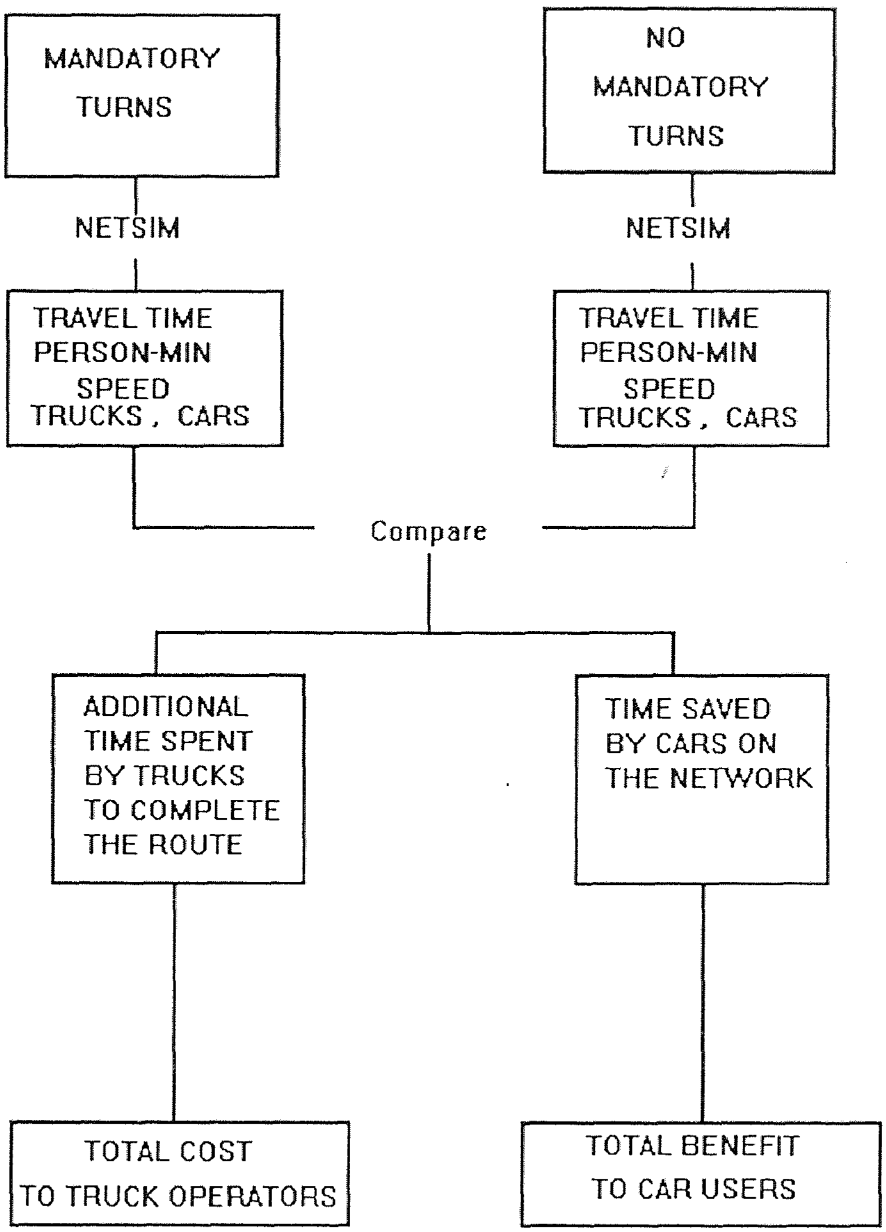


Figure 2. Flowchart for Scenario 1

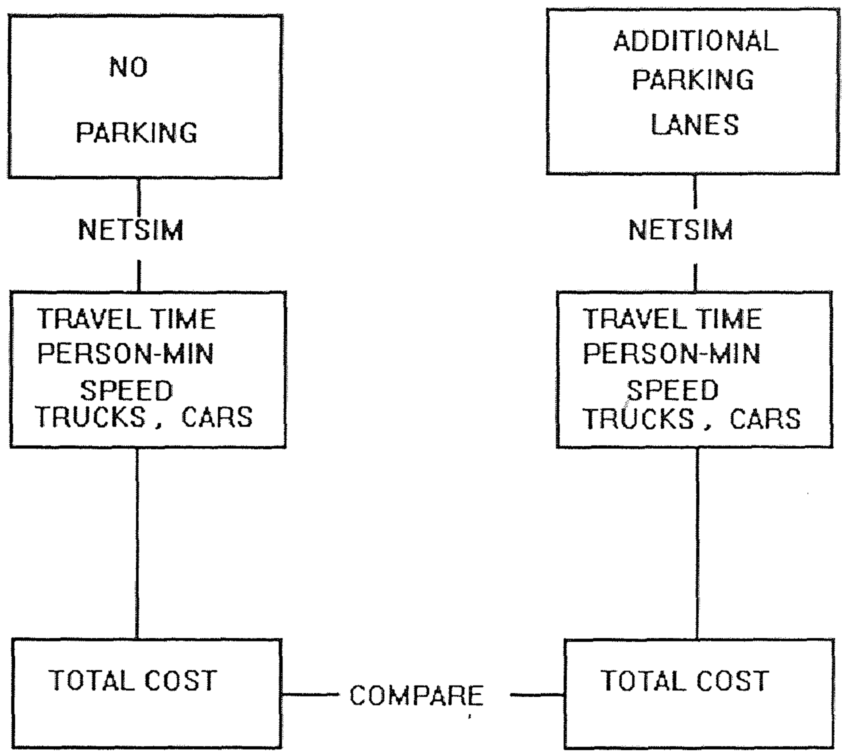


Figure 3. Flowchart for Scenario 2

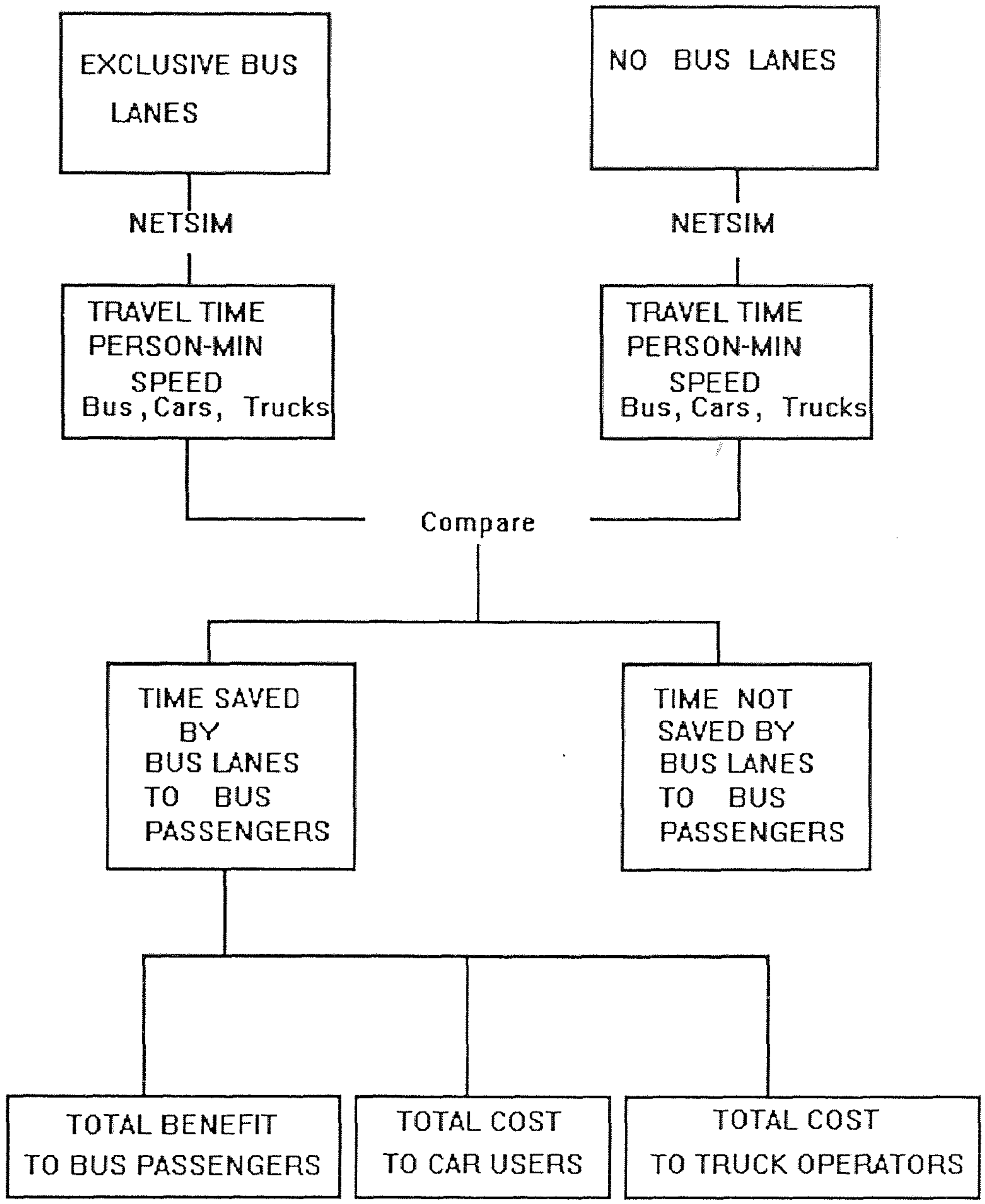


Figure 4 Flowchart for Scenario 3

cases are considered. In Case A all major restrictive policies are removed. There are no restrictions on parking for pickups at any time of day, but the length and locations of the zones remain unchanged as observed in the field study. There are no exclusive bus lanes. All lanes are utilized by all types of vehicles. The existing regulation of mandatory left turns for non priority vehicles is not implemented. In Case B the network is simulated with the same conditions as in Case A, but including exclusive bus lanes. Measure of effectiveness such as travel time, person travel minutes and speed are obtained from the output and compared. In this scenario the travel time for pickups is assumed to be the same as for other vehicles.

Using the unit costs for travel time as per American Association of State Highway Officials (AASHTO) standards, the monetary impacts on both pickup and delivery operators as well as on car passengers are analyzed for each scenario. The costs obtained for the two cases of each of these three scenarios are compared, and the effect of the policies is analyzed.

CHAPTER 3

CASE STUDY

3.1 Background

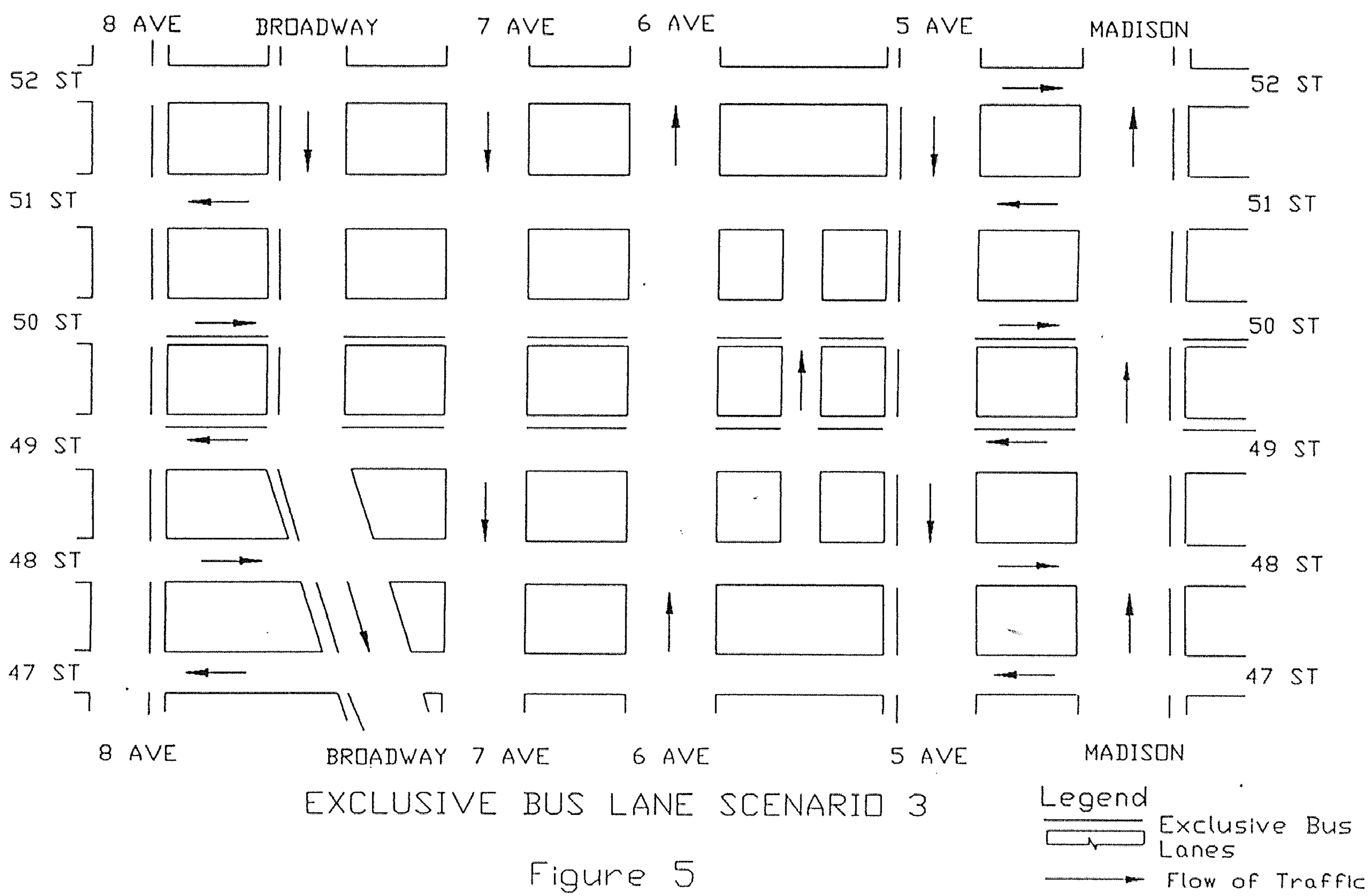
The case study used to apply the methodological framework presented in the previous chapter consists of a network of one way streets in downtown Manhattan between Eighth Avenue and Madison Avenue (in west to east direction) and 52nd to 47th Streets (in north to south direction). This is the central business district, with businesses ranging from small department stores to big hotels and shops. There is a heavy flow of pickup and delivery vans catering to these business. The very survival of these businesses depends upon the efficient operation of the pickup and delivery vans.

This network was specifically chosen since it has all the restrictive policies under consideration such as mandatory turns, no parking, and exclusive bus lanes. The Avenues have mainly six lanes with no parking or no standing along the curb side except on Broadway and Seventh Avenue (although for a limited time during the day) and for some small areas occupied by police and diplomatic vehicles. The streets have three lanes. Some streets have parking on one side for a limited number of hours. Most of the Avenues and Streets have one lane dedicated to the exclusive use of buses. The existing exclusive bus lanes are shown in Figure 5. For a certain period of the day 49th and 50th Streets have mandatory left turns for all vehicles except for buses and occupied taxies.

3.2 Data

The following data were collected for a Route 9A project by Urbitran, Garmen and Volmer Associates :

- Peak hour volumes
- Length of links
- Turning volumes
- Number of lanes



EXCLUSIVE BUS LANE SCENARIO 3

Figure 5

Since the actual signal coordination plans were unavailable, the signal optimization software TRANSYT 7F was used to optimize the network for peak hour volumes. The following parameters were calculated:

- Signal timings
- Offsets.

A brief review of TRANSYT 7F and the optimized offsets obtained are presented in Appendix A.

The following data were collected by a comprehensive field study undertaken by students of NJIT :

- Location of pickup and delivery
- Frequency of pickup and delivery (trucks per hour parking at the curb).
- Average dwell time of parked trucks.
- Bus routes, Bus stops, Bus dwell times, Bus frequency.

On site data were collected during the morning and evening peak hours and it was observed that pickup and delivery vans were almost 20% of the total traffic. It was also observed that on some streets the vans were double parked for loading and unloading causing obstruction and inconvenience to the traffic flow.

3.3 Scenarios

Several scenarios were developed, each scenario representing a particular regulatory measure relating to the urban goods movement.

3.3.1 Scenario 1

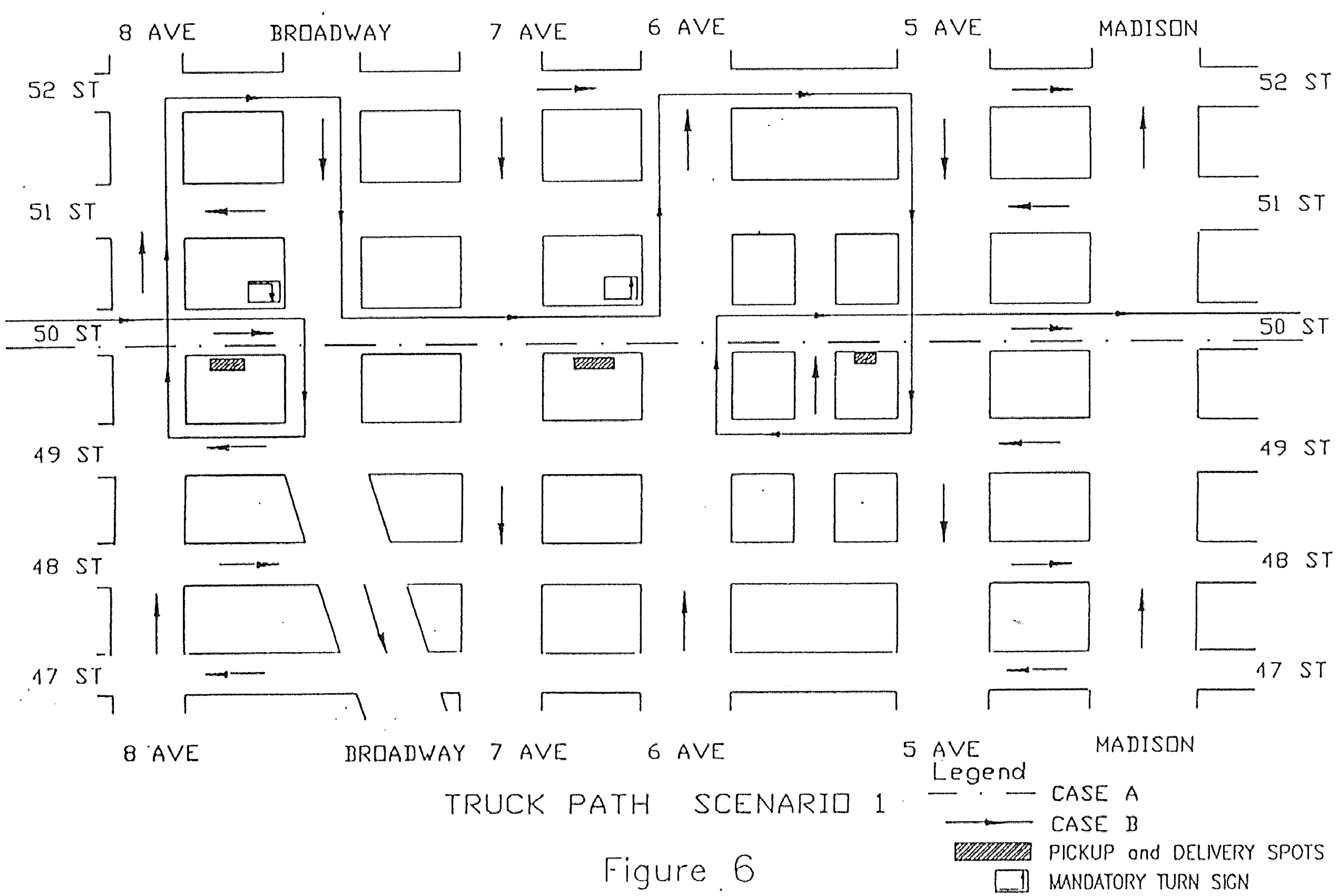
In this scenario the effect of 'mandatory turns' is analyzed. Mandatory turns imply that all vehicles other than buses and occupied taxis must make obligatory turns at the particular intersections. This regulatory measure is enforced on the intersections of 50th Street with Broadway (westbound traffic), and with 6th Avenue (westbound traffic).

Similarly, this regulatory measure is enforced on the intersections of 49th Street with Fifth Avenue (eastbound traffic), and with Sixth Avenue (eastbound traffic).

The mandatory turns cause all unoccupied taxis and trucks (i.e., all non-priority vehicles as they are called) that are required to make a stop at various locations along 50th or 49th Streets to travel around another eight blocks to complete the pickup or delivery operation. This extra distance of travel consumes a substantial amount of time, thus increasing the cost of operation. In this particular scenario the restrictions are simulated only on 50th Street. The following cases are considered and compared in this scenario.

- Case A : There are no restrictions on vehicle movements.
- Case B : The mandatory turn regulation is enforced.

As noted earlier, buses and bus routes are used to simulate trucks and their movement along the truck route. This is accomplished in the following manner: The dwell time of trucks is entered in the input card for the dwell time for buses. The observed average dwell time of trucks is about 12 minutes. Since there is a maximum bus dwell time restriction inherent to the software of 500 seconds, the dwell time for trucks is constrained to 500 seconds (8.5 min). Pickup and delivery spots are assumed to be along 50th Street and are represented on the input card for bus stations in the NETSIM software. They are also numbered as if they are bus stops. Since the software allows the bus stops to be only on the right side curb, the pickup and delivery spots are also restricted to the right curb only. The mean headway between trucks is assumed to be 550 seconds. This represents the observed time between the successive arrivals of delivery vehicles at the stops. The difference between cases A and B is only in the shortest path taken to complete the pickup or delivery operations. The paths taken in each case are shown in Figure 6. The regulations of mandatory turns are enforced on the intersections of 50th Street with Broadway and 50th Street with 6th Avenue. The pickup and delivery spots are assumed to be on the blocks between 8th Avenue and Broadway, 7th Avenue and 6th Avenue, and 6th Avenue and 5th Avenue. To complete the pickup and delivery



TRUCK PATH SCENARIO 1

Figure 6

operations on these three spots when mandatory turn regulation is in effect, trucks traveling along 50th street will have to follow the path described below:

After serving customers on the block between 8th Avenue and Broadway the trucks will have to turn right on Broadway and turn around the block to cut across 50th Street. They will travel for two blocks along 8th Avenue, turn on 52nd Street, again make a turn on Broadway and travel for two blocks to get back on 50th Street. After the customer on the block between 7th and 6th Avenues is served, the truck has to turn on 6th Avenue, travel for two blocks and again turn on 52nd Street. Then the truck will have to travel four blocks to serve a customer on the block between 6th and 5th Avenue. Thus in case B instead of traveling straight as in case A, the trucks have to travel an additional eight blocks to complete the pickup and delivery operation.

3.3.2 Scenario 2

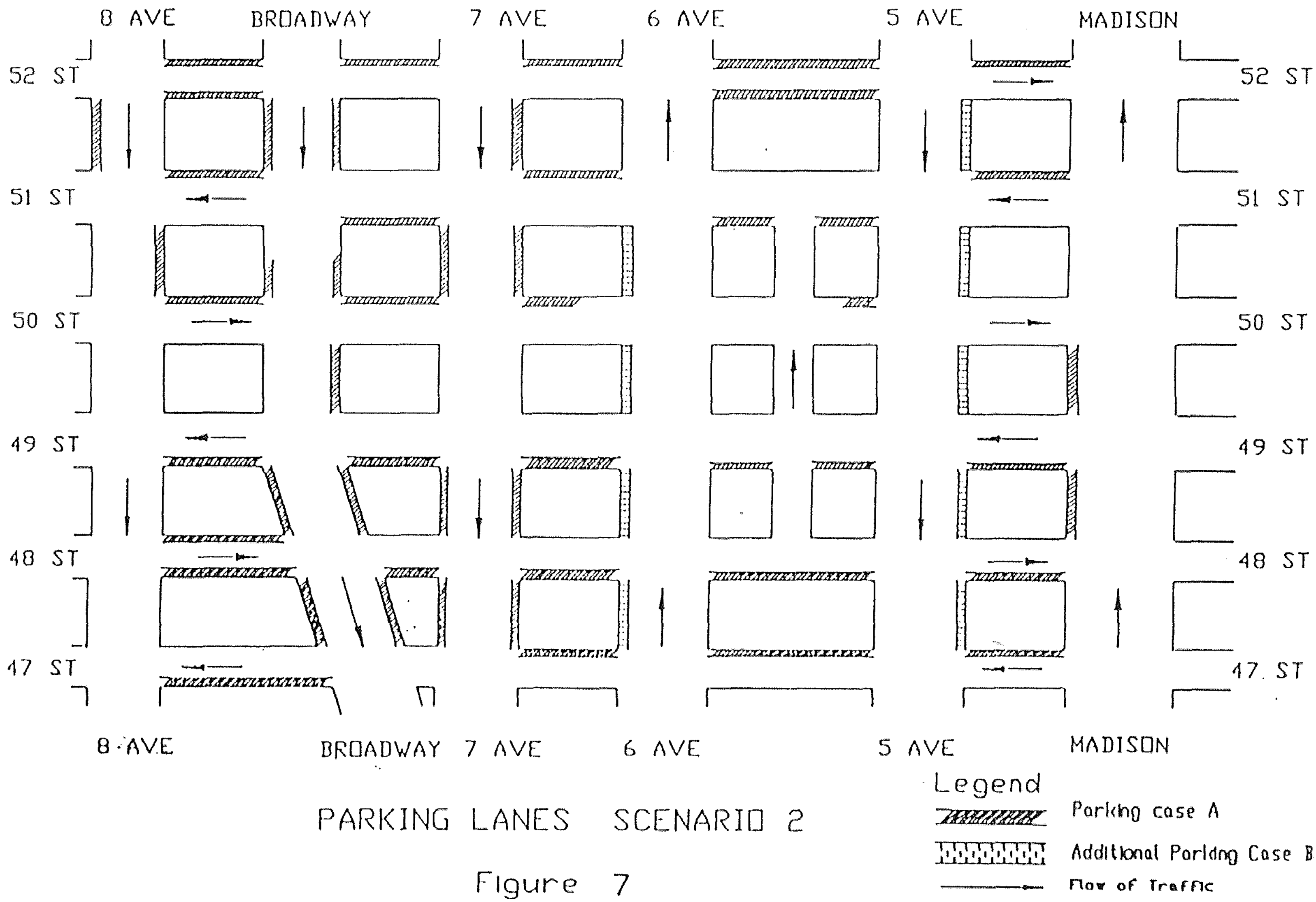
In this scenario the effect of parking zones is analyzed. Two cases are considered.

Case A : This case represents the base line case (i.e., no regulatory measures). The same conditions are considered as in Case A of Scenario 1.

Case B : Additional general parking is provided above what is currently available and contained in Case A. These parking lanes replace one full flowing lane, thus reducing the number of full lanes on 6th and 5th Avenues. The links and parking zones for each case are shown in Figure 7

3.3.3 Scenario 3

In this scenario the effect of exclusive lanes on the travel time of buses and vehicles such as cars and trucks is analyzed. The travel times for cars and trucks are assumed to be the same. The right most lane is dedicated to exclusive bus use. Two different cases of Scenario 3 are simulated.



PARKING LANES SCENARIO 2

Figure 7

Case A : This case presents the base line case with no exclusive bus lanes. All the lanes are utilized by all types of vehicles operating in mixed traffic.

Case B : In this case, the right most lane is dedicated to exclusive bus use. The locations of the exclusive bus lanes were shown in Figure 5.

All three scenarios are simulated by the simulation software NETSIM explained in the next chapter.

CHAPTER 4

NETWORK SIMULATION - NETSIM

4.1 Background

From available statistics we know that 40% of urban trips are undertaken under congested conditions at an annual cost of 37 billion hours of lost time. Hence, it is imperative that new and more productive tools be aggressively utilized to assist the engineer to improve traffic flow. In this environment, the engineer must achieve superior results in less time, with greater accuracy and reliability and at a lower cost than ever before. Techniques and procedures which were used in the past and which were based largely on empirically derived procedures documented in handbook formats are often no longer acceptable. Problems today often take the form of inter-related systems which must be treated as such and not partitioned into smaller, unrelated elements. The first step in the strategy to tackle these problems is to optimize the use of urban resources.

The concept of traffic control is to improve the movement of people and goods without impairing community values. Computer simulation is used as an analytical tool to achieve this objective. When a traffic system is represented by a computer simulation model, the effects of traffic management strategies and the system's operational performance can be determined in terms of measures of effectiveness such as average vehicle speed, vehicle stops, vehicle-miles of travel, fuel consumption etc. The simulation approach is appealing and practical since:

- It is less costly,
- Results are obtained fast,
- Data generated include many MOEs that cannot be obtained empirically,
- Disruption of traffic operations is avoided,
- Does not require physical changes to existing facilities,
- Provides highest level of detail and accuracy,
- Allows the designer to focus more on thinking, and

- Identifies weaknesses in concept and design.

The results generated by the model can form the basis of selecting the best candidate among competed concepts and designs so that the eventual field demonstration will have a high probability of success. An experiment that is unproductive, or worse counter productive, weakens the credibility of the responsible agency and acts as a deterrent to the implementation of other changes in the future.

4.2 Introduction

NETSIM is a Fortran-based software program developed by the Transportation Research Center of the University of Florida, for the Federal Highway Administration. It describes the operational performance of vehicles traveling over a network of non-access controlled streets. The internal logic of this microscopic model describes the movements of individual vehicles that are responding to external stimuli including traffic control devices, the performance of other vehicles, pedestrian activity, transit operations, and driver behavioral characteristics. Statistics that are gathered provide detailed traffic performance measures (e.g., speed, volume, density, delay, stops, intersection spill backs, queuing, turning movements, fuel consumption, emission pollutants) on each network link over a specified time interval. NETSIM provides an engineer with a detailed, realistic and dynamic history of traffic operations, which is generally superior to other tools.

4.3 Description

The traffic environment representation of NETSIM is as follows:

- Topology and geometry of roadways.
- Channelization of traffic.
- Movement of traffic
- Specification of the traffic control devices and their operational characteristics
- Traffic volumes

- Traffic composition
- Optionally, specification of bus transit system: routes, stations and frequency.

The physical environment is represented on a network comprised of directional links and nodes. Links represent streets, and nodes represent intersections or points where the geometric properties change. In NETSIM there are two program components; input processing, and microscopic urban simulation.

4.3.1 Input processing

NETSIM describes the changing conditions that prevail over a system of roadways, which not only differs from point to point but may also change in time. A maximum of 19 time periods can be specified. For each time period, input in the form of a sequence of cards depicting the network-wide conditions is specified. Each card type contains a specific set of data items. Before the final processing of the data NETSIM runs a diagnostic test which confirms the proper sequence of cards, verifies and that no required cards have been omitted, checks whether quantitative values are within a "reasonable" range, and that the set is complete. The NETSIM internal logic will never allow simulation to commence when any fatal errors are detected in the input stream.

The maximum size of the network that may be simulated by NETSIM is as follows:

- Number of links -- 150
- Number of Nodes (intersections or change of geometry) -- 75
- Number of actuated controllers -- 18
- Number of vehicles -- 1500
- Number of buses -- 256
- Number of bus routes -- 25
- Number of bus station --99

4.3.2 Simulation Model

Each vehicle on the network is treated as an identifiable entity. Each vehicle is identified by category (auto, car pool, truck, bus) and by type (each category can be sub divided into several types, e.g., a truck fleet may include several different types of trucks with different performance characteristics). Driver behavioral characteristics (passive, aggressive) are also assigned to each vehicle. Turning movements are assigned on the basis of of a distribution whose mean is provided as input and so are the free-flow speed, queue discharge headways and other behavioral attributes. Consequently, each vehicle's behavior may be simulated in a stochastic manner, reflecting real world processes. A detailed vehicle-specific traffic process is simulated so that bus-auto interaction may be explicitly modeled. In general, most conditions experienced in an urban traffic environment can be realistically described.

4.3.3 NETSIM Output

The TRAF-NETSIM program provides a wide range of measures of effectiveness (MOE) on a link specific basis and aggregated over the entire network. Table 2 (in chapter 2) lists the link-specific MOEs provided by the output.

There are two categories of output, the cumulative output or data accumulated since the beginning of the simulation, and the intermediate output or data describing current status.

Graphics

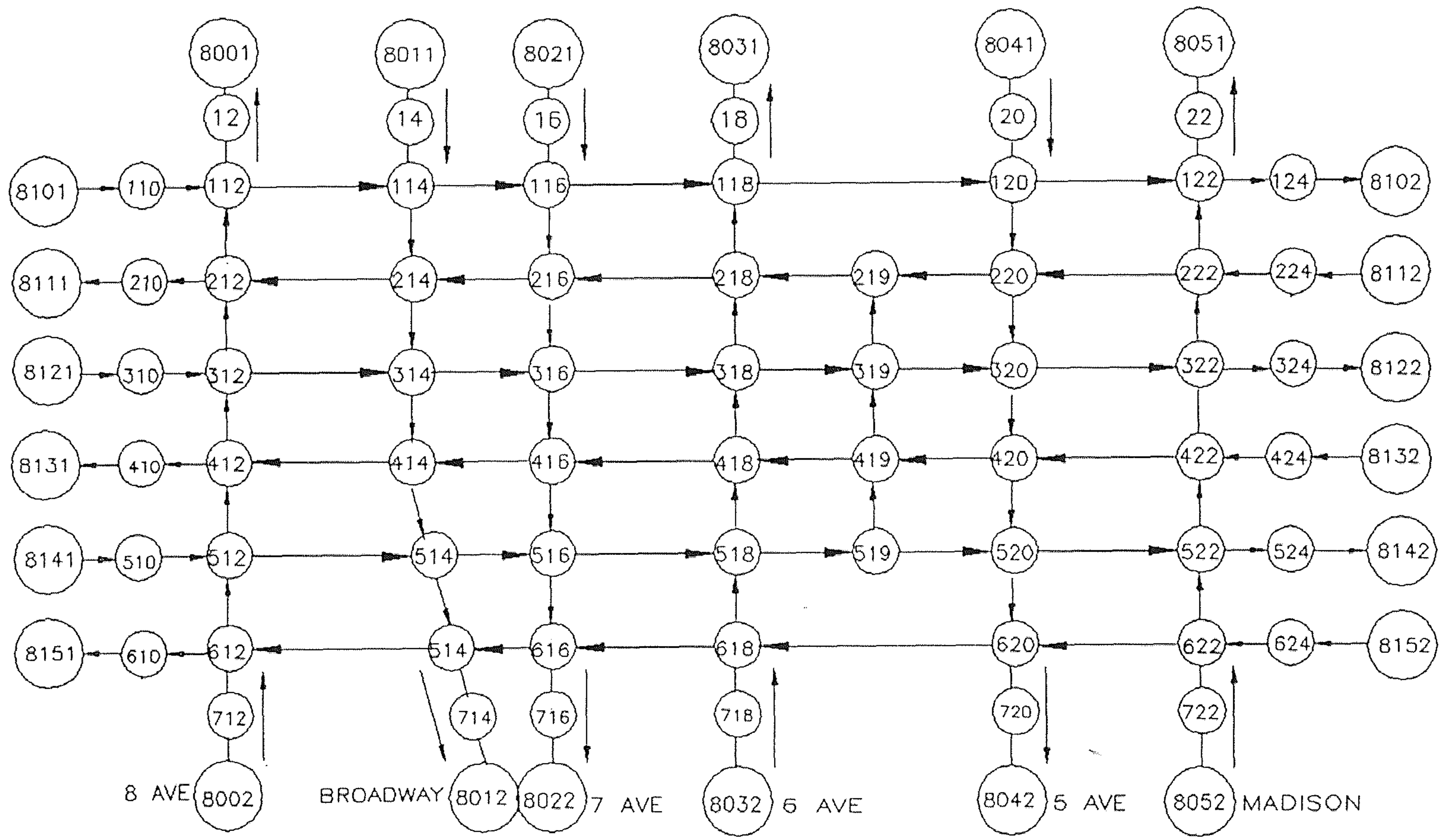
The graphics option allows the user to analyze the output of NETSIM through color displays which provide details of intersection geometrics or highlighting of potential 'hot spots' or problem areas in the network. An analytical display of the simulated traffic flow can also be requested.

4.4 Simulation of scenarios using NETSIM

The three scenarios described in Chapter 3 were simulated by NETSIM. The network is represented by nodes and links, where nodes are intersections and links are streets. The node-link representation of the network is shown in Figure 8. Data input is in the form of a sequence of input data cards. Since Cases A of Scenarios 1 and 2 are the same, they are called the base line case. The table for the input data for the base line case is presented in Appendix B.

The description of the input data is as follows:

- Link - Represents street or road denoted by a pair of node numbers.
- Length - It is the length of the link measured from stop line to stop line at each end of the link.
- Lane-full--Is the number of full flowing lanes, excluding parking lanes.
- PKT-- Pockets (short lengths of lanes or bays used by turning vehicles) of lanes if any. In this case study network there are no pockets .
- GRDPCT -- Percent of gradient of roads. Since the network is at ground level 0 % gradient is assumed.
- Link Type -- It gives the queue discharge characteristics. It is a statistical distribution based on driver characteristics.
- Channel -- Lane channelization codes are described at the end of the data input table Appendix B.
- Destination node -- These are the nodes towards which the traffic is moving.
- Lost time -- It gives the startup lost time experienced by traffic at each signalized intersection. In view of the traffic conditions in the sample network the value used is 0.5 seconds (minimum time accepted by the software)
- Q DIS Headway -- It is the queue discharge headway in seconds, 1.4 seconds is assumed throughout the network (minimum time accepted by the software) to reflect the congested conditions of the network.
- Free speed -- Desirable speed of the network. Average speed of 30 mph is assumed.



NETSIM NODES AND ENTRY NODES

Figure 8

- RTOR Code -- Right turn on red code.(1 represents there is no turn on red)
- PED Code -- It is the pedestrian code describing the intensity of pedestrian traffic. Heavy pedestrian crossing is considered in this study.
- Lane alignment -- Describes how the lanes on consecutive links are aligned.

The volume of traffic for the network is given for the entry node only. These volumes are tabulated in Appendix B and are common for all three scenarios. Volumes are given in number of vehicles per hour entering the network at the entry nodes, shown in Figure 9. The percentage of trucks within the network, observed during the field survey, is 20% on average.

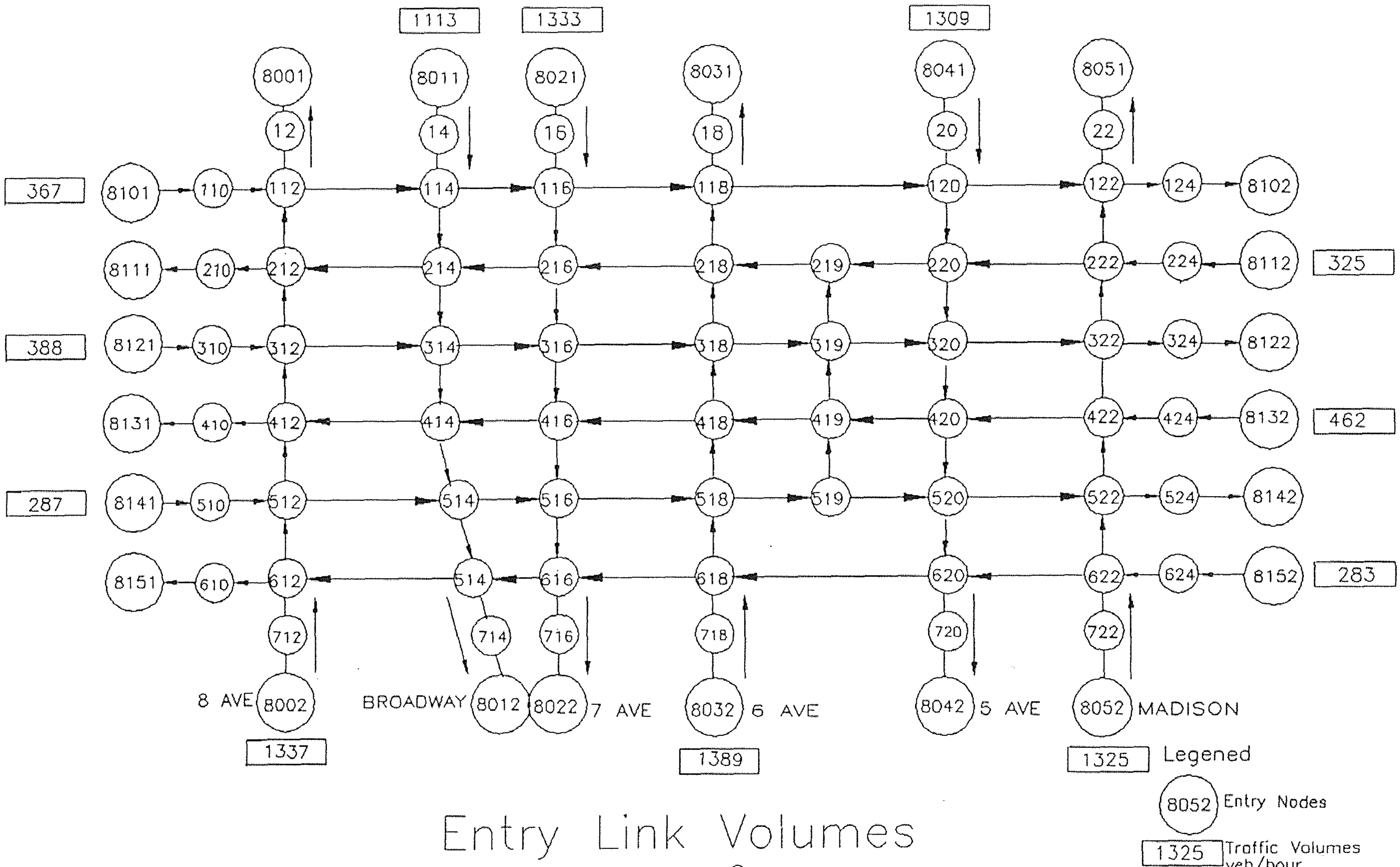
The parking activity details are contained in Appendix B and the meaning of the terms is as follows:

- Duration of Park -- Is the average time in seconds required to complete the parking maneuver.
- Parking frequency -- Is the number of vehicles being parked per hour per link. An average of 15 vehicles per hour is used on the basis on field observations.

The length of the parking lanes and their distance from the stop line are presented in Appendix B.

Data on the characteristics of the pickup and delivery stations are tabulated in Appendix B. Pickup stations are numbered serially. Their distance from the upstream node and the number of trucks it can accommodate is also given. Mean Dwell measure is the dwell time (the period of time the truck is parked for pickup or delivery operation). The observed value is an average of 12 minutes, but since the maximum time inherent to the software is 500 seconds this value is assumed through the network.

A Truck Route Path is the sequence of nodes defining the path. Only one truck pickup and delivery route is assumed in this study. The stations at which the truck stops on its route are tabulated in Appendix B. The mean headway between trucks is assumed to be 500 seconds. The network is split in several sections. Each section representing a



Entry Link Volumes
Figure 9

street, avenue or the path of the truck route. The description of the sections is tabulated in Table 3.

The complete network is simulated for a period of 2700 seconds for all scenarios. This time period of 2700 seconds is sufficient for at least one truck to complete its route in the network. The output in the form of section specific statistics in tabulated in Appendix B. The measure of effectiveness considered in this study are as described in Table 2. Similarly truck statistics are given for each link of the route and for each station.

In Scenario 2, an additional number of parking lanes are considered. The parking activity scheduled, and the section specific output are shown in Appendix C.

Case A of Scenario 3, the base line case, is different from Cases A of Scenarios 1 and 2 because it considers buses that operate in mixed traffic. In Case B exclusive bus lanes are introduced. The input and output tables are shown in Appendix D.

The definitions of all MOEs provided by the output are listed in Appendix E.

Table 3. SECTION DATA TABLE

SECTION NUMBER	SEQUENCE OF NODES DEFINING
1	312 314 414 412 312 212 112
2	112 114 214 314 316 318 218 118
3	118 120 220 320 420 419 418 318
4	318 319 320 322
5	312 314 316 318 319 320 322
6	422 420 419 418 416 414 412
7	222 220 219 218 216 214 212
8	112 114 116 118 120 122
9	612 512 412 312 212 112
10	114 214 314 414 514 614
11	116 216 316 416 516 616
12	618 518 418 318 218 118
13	120 220 320 420 520 620
14	622 522 422 322 222 122
15	512 514 516 518 519 520 522
16	622 620 618 616 614 612

CHAPTER 5

COST FACTORS

5.1 Introduction

The decision to implement or not implement a particular proposed transportation improvement is made in the context of local, state and federal political-governmental structures. For any given perceived need for a transportation improvement, there may be numerous ways of implementing the improvement. The alternatives may include the use of different modes, or consist of changes in physical or operating characteristics for a given mode. In each case, the alternatives for providing the improvement must be compared to each other and to the base case of doing nothing, to determine the most economic solution.

Perhaps the most critical element in any analysis is the estimation of those costs which are borne directly by the user of the transportation system that is considered for improvement. For highway systems, the total costs involved in the ownership and the use of the private vehicle fall into this category. What should be included also is direct user costs which are not directly measured in monetary units, and most importantly, travel time costs.

Direct benefits of transportation improvements are virtually always measured in terms of reduced costs. In most cases transportation improvements will result in reduced user costs, and particularly travel time.

After estimating the costs and benefits of any given transportation improvement, a comparison between them has to be made. Comparisons however require that all elements of costs and benefits be on a common basis. This requires that all monetary units be referenced to the same year.

5.2 Congestion costs

In most urban areas, the principal underlying cause of congestion is the car. The external congestion costs of urban goods movement arise, in the main, through the interference which the presence of trucks causes to the smooth flow of car traffic. Truck presence increases the degree of congestion, which would in any case be present as a result of the large number of cars seeking simultaneously to use limited roadway space.

Goods vehicles exacerbate congestion in three main ways:

(a) While in a stream of traffic, they can cause delays as a result of the difficulty which overtaking them can sometimes present. The extent of this problem in any one case will clearly depend on the volume and characteristics of the traffic, and dimension of the road concerned.

(b) While moving into, or out of, a traffic stream. A common problem results from old or poorly designed off-street delivery facilities with poor access, where turning vehicles awaiting entry, may cause major delays.

(c) While parked, and while loading or unloading. Car parking spaces may be taken up, or the smooth flow of traffic interrupted as a result of reduced road space.

The term "costs" is used to denote all of the economic, social, environmental and energy considerations. There are many costs of urban freight, some internal to the transportation system and reflected in freight rates and charges, while others are imposed on a wider system in terms of social or environmental costs. Hicks (1975) has suggested that the cost of urban freight can be split into four elements :

- Transport operation costs, which are essentially the direct costs of providing service.
- External costs, which include environmental impacts such as air and noise pollution, and the delay costs to other vehicles and pedestrians.
- Community costs, which are costs incurred by governments in planning, regulating and policing freight transport activities.

- Urban structure costs, which are a special subset of the external costs and relate to the interaction between freight facilities and the urban structure and land use planning.

Externalities in transport systems can be defined as "costs which are imposed on others as a result of the transport facility or of transport movement to which they are not a party" (Wohl and Martin, 1967). Some of these externalities include the cost of interaction between freight vehicles and other passengers and vehicles using the road system, and environmental effects, particularly noise and air pollution.

The urban structure cost element relates to the interaction between freight facilities and urban structure. These costs are very difficult to estimate and allocate, but clearly, goods transport does have an effect upon the fabric of urban structure. A city could not exist that did not allow for the inflow of food, energy and raw materials, the outflow of industrial products and waste, and the movement of commodities within the urban area. In short, goods movement is an essential component of the urban development process. Furthermore, the retail and industrial activity that depend on the flow of urban goods and services impact the land use pattern within an urban area

Freight may affect the urban economy in a direct way through its contribution to the viability (or lack of viability) of marginal industries, particularly in the city center. It may be that, by reducing freight costs, marginal industries can remain viable and, if the preservation of these industries is desirable on employment or other social grounds, the transport system can play a positive role in the development of urban areas.

5.3 Travel Time

In transportation systems, the main effect of improvements consists of user benefits in which travel time savings assume an important role. For time savings benefits to be included in cost-benefit analysis they must be expressed in monetary terms. Time savings should be considered as an opportunity for using the time allocated to a specific activity for another activity. In this sense, the value of travel time savings is equal to the opportunity cost of time. Thus, it is not meaningful to speak in terms of a single value of time because individuals derive different degrees of utility from different activities. The value that individuals attribute to time will vary depending on their satisfaction with the activity that is taking place in that time period. This implies that in the case of travel time savings, there will be more than a single value of time, the value being determined by the income level of the traveler, trip purpose, mode of travel used, the time of trips, the duration of travel and many other such factors.

5.4 Travel Time Savings and their Economic Value

There is no general agreement that all travel time savings have a value and that this value should be included in an economic appraisal of transport projects. For one category of travel time savings (e.g., working travel time savings) there is little conceptual difficulty involved in assigning a value, because this time is paid for by the employers and constitutes an element of the cost of production. A reduction in travel time during working hours would potentially enable employers to divert the manpower and equipment saved to additional productive purposes. In this sense, the work-related travel time savings results in increasing productivity and thus increasing gross national product. This increase would ultimately be reflected in the national income accounts.

In the case of working travel time savings the currently accepted procedure is to establish a value on the basis of information obtained from the market mechanism. There is a market for labor so that values of travel time savings during working hours can be related to wage rates or earning power. The conclusions of a study by Quarmby (1971) reflected that :

- The values of time are very nearly a constant proportion of wage rates (between 21% and 25% of the wage rates).

- There is insufficient evidence to conclude that bus time and car time have significantly different values.

In the work of Lisco (1967) the values of time obtained were about 40% - 50% of the average hourly earnings of the trip maker. The value of travel time was also researched by Chui and McFarland (1986) using a speed-choice model. They recommend a value of time for passenger vehicles of $10.40 (in 1985 dollars) per vehicle-hour (using an occupancy rate of 1.3 persons per car), and a value of $19.00 (in 1985 dollars) per vehicle-hour for trucks. These values of travel time will be used for the purpose of making comparisons in this research work. Since these values are in 1985 dollars, they are adjusted for 1992 dollars assuming an average of 4% annual rate of inflation. Hence the value of travel time for 1992 will be considered as follows:

Passenger vehicles - cars	-------	$ 13.68	per vehicle - hour	($ 0.23 / veh- minute)
Trucks	-------	$ 25.00	per vehicle - hour	($ 0.42 / veh- minute)
Passengers	-------	$ 10.52	per passenger - hour	($ 0.17 / pass- minute)

CHAPTER 6

ANALYSIS OF SIMULATION RESULTS

6.1 Scenario 1

6.1.1 Effect on travel time of vehicles other than trucks.

Table 4 gives the comparison of vehicle trips completed during the period of simulation and travel time (in vehicle-minutes) for Cases A and B. There is a minor decrease in the number of vehicle trips on the street on which the regulation is imposed (i.e., 50th Street). In the rest of the network there is a small increase in the number of vehicle trips. Travel time in vehicle-minutes decreases on 50th Street whereas there is an appreciable increase on 52nd Street and 8th Avenue. Table 5 contains the comparison of travel time (i.e., seconds required by each vehicle to complete the trip) and the average speed in miles per hour. There is a minor decrease in travel time (seconds/vehicle) on 50th Street, but there is an appreciable decrease in travel time on 51st Street. Also there is no appreciable change in average speed in the network.

Table 6 gives the comparison of travel time and speed, when the vehicle trips completed on each section is the same in both cases (unlike Table 4 where the travel time in vehicle-minutes is calculated on the basis of the vehicle-trips completed in the stipulated simulation period). This adjustment is made so that the time required for equal number of vehicles to complete the trip in either case can be compared. The decrease in travel time (vehicle-minutes) on 50th Street is just 11%, with an appreciable decrease in travel time of 33% generated on 51st Street.

6.1.2 Effect on travel time of trucks.

In the 2700 second simulation time period, three trucks are able to complete the route in Case A. The mean travel time for each truck is 2399.3 sec /truck (or 40 min). In Case B and for the same simulation time only one truck was able to complete the route with a mean travel time for each truck of 8841.0 sec per truck (147.35 min). The travel time for

Table 4. Scenario 1:

Comparison of vehicle trips completed and the travel time in veh-mins between the base line and the mandatory turns regulation cases.

(+) sign indicates increase in travel time over the base line.

Sect ion	Street or Avenue	VEHICLE TRIPS veh Base Line Case A	With Turns Case B	Diff	TRAVEL TIME veh-min Base Line Case A	With Turns Case B	Diff
1	Manda-	534	538	+4	1904	2039	+135
2	tory	558	569	+11	1983	1940	-43
3	Turn	551	552	+1	2375	2291	-84
4	Sections	364	357	-7	859	795	-64
5	50th ST	390	383	-7	1887	1698	-189
6	49th ST	235	240	+5	1746	1912	+166
7	51st ST	226	236	+10	2612	1827	-785
8	52nd ST	347	352	+5	1869	2194	+325
9	8th AV	924	928	+4	1690	1962	+272
10	Broadway	786	779	-7	1020	1090	+70
11	7th AV	998	1005	+7	1251	1304	+53
12	6th AV	1052	1093	+41	1647	1444	-203
13	5th AV	963	953	-10	1517	1489	-28
14	Madison	955	958	+3	1358	1329	-29
15	48th ST	279	277	-2	1319	1227	-92
16	47th ST	201	206	-5	1210	1054	-156

Table 5. Scenario 1.

Comparison of vehicle trips completed and the travel time

between the base line and the mandatory turns regulation cases.

(+)sign indicates increase in travel time and speed over the base line.

Sections	Street or Avenues	Travel Time sec/veh			Average speed mph		
		Base Line	With Turns	Diff	Base Line	With Turns	Diff
1	Manda-	214	227.3	13.3	8.2	7.7	0.5
2	tory	213.3	204.6	-8.7	9.6	10	-0.4
0	Turn	258.5	248.9	-9.6	8.5	8.9	-0.4
4	Sections	141.6	133.4	-8.2	7.6	8.1	-0.5
5	50th ST	290	265.9	-24.1	8.2	9	-0.8
6	49th ST	445.1	478.6	33.5	5.4	5	-0.4
7	51st ST	694.6	464	-230.6	3.4	5.1	-1.7
8	52nd ST	323.4	373.9	50.5	7.4	6.4	1
9	8th AV	109.7	126.9	17.2	8.7	7.5	1.2
10	Broadway	77.9	83.9	6	12.3	11.4	0.9
11	7th AV	75.3	77.9	2.6	12.7	12.3	0.4
12	6th AV	93.9	79.3	-14.6	10.2	12	-1.8
13	5th AV	94.5	93.8	-0.07	10.1	10.2	-0.1
14	Madison	85.3	83.2	-2.1	11.2	11.5	-0.3
15	48th ST	283.3	266	-17.3	8.4	9	-0.06
16	47th ST	362	307	-55	6.6	7.8	-1.2

Table 6. Scenario 1.

Comparison of travel time of vehicles in veh-mins between the base line

and mandatory turns regulation cases.

(+) sign indicates increase in travel time over the base line.

Sect ion	TRAVEL TIME Sec/ Veh - Trip		VEH TRIPS Veh	TRAVEL TIME Vehicle - minute		Difference	Change [%]
	Base Line	With Turns		Base Line	With Turns		
1	214	227.3	534	1904	2023	-119	6
2	213.3	204.6	558	1983	1903	-80	-4
3	258.5	248.9	551	2375	2286	-89	-4
4	241.6	133.4	364	859	809	-50	-6
5	290	256.9	390	1886	1670	-216	-11
6	445.1	478.6	235	1746	1874	128	7
7	644.6	464	226	2612	1748	-864	-33
8	323.4	373.9	347	1869	2162	293	16
9	109.7	126.9	924	1690	1954	264	16
10	77.9	83.9	786	1020	1095	75	7
11	75.3	77.9	998	1251	1296	45	4
12	93.9	79.3	1052	1647	1390	-257	-6
13	94.5	93.8	963	1517	1505	-12	-1
14	85.3	83.2	955	1358	1324	-34	-2
15	283.3	266	279	1319	1237	-82	-6
16	362	307	201	1210	1028	-182	-15

each truck to complete the route is more than the simulation period because initially the network is devoid of any vehicles. The software loads the network with vehicles till the network reaches equilibrium (i.e., the inflow and outflow of vehicles through the network are equal), this is known as the initialization period. At the beginning of this period since there is no impedance traffic flows at the desirable speed (30 mph). After the network reaches equilibrium, the software starts simulating vehicles and accumulating the MOE statistics. At the end of the simulation period, it estimates the mean travel time for each vehicle to traverse the route by adding the travel time on each link of the route although the times involved are not associated with the same vehicle.

The extra time required by each truck to complete the route when mandatory turns are imposed is 6441.7 sec (107 min per truck). The extra cost incurred by each truck will be 107 * $ 0.42 = $45. Hence for three trips the total cost incurred will be $ 135.00.

The time saved by cars traveling on 50th Street is 24.1 seconds/vehicle. During the simulation period of 2700 seconds on 50th Street under the case of mandatory turns, 383 vehicle trips are completed. Hence the travel time saved by vehicles on 50th Street is 9230.3 vehicle-seconds (i.e., 383 * 24.1) or 153.84 vehicle-minutes. The total benefit to the car owners is $ 35.38 (i.e., 153.84 * $ 0.23)

6.2 Scenario 2

In this scenario, the results for Case A are the same as those of the base line case (Case A) of Scenario 1. In Case B, a full lane is replaced by a parking lane along 5th and 6th Avenues. The introduction of this parking lane had a significant impact on all the Streets and Avenues in the network in terms of increased travel time and a reduction in vehicle trips.

Table 7 contains the comparison of vehicle trips for Cases A (base line) and B (additional parking), and the comparison of travel times (in vehicle-minutes). There is a

Table 7. Scenario 2

Comparision of vehicle trips and travel time between the base line and the additional parking cases.

(+) sign indicates increase in time over the base line.

Section	Street or Avenue	VEHICLE TRIPS Vehicles			TRAVEL TIME veh-min		
		Base Line Case A	Park Case B	Diff	Base Line Case A	Park Case B	Diff
5	50th ST	383	270	-113	1698	286	-1412
6	49th ST	240	164	-76	1912	2389	477
7	51st ST	236	163	-73	1827	3874	2047
8	52nd ST	352	290	-62	2194	1917	-277
9	8th AV	928	887	-41	1962	1646	-316
10	Broadway	779	639	-140	1090	1215	125
11	7th AV	1005	717	-288	1304	1925	621
12	6th AV	1093	674	-419	1444	3961	2516
13	5th AV	953	802	-151	1489	2043	554
14	Madison	958	891	-67	1329	1365	36
15	48th ST	277	207	-70	1227	1749	522
16	47th ST	206	156	-50	1054	1438	384

significant decrease in vehicle trips and thus travel time throughout the network. The maximum impact is experienced on 7th and 6th Avenues.

Table 8 shows the comparison of travel time (seconds/vehicle) and speed for both cases. Travel time increases throughout the network. The most significant impacts are experienced on:

- 6th avenue : 276% increase
- 48th street : 223.4% increase
- 50th street : 119% increase
- 7th avenue : 114% increase

Similarly there is a decrease in the average speed of vehicles on all links.

Table 9 shows the comparison of travel times (in seconds per vehicle) for both cases. The number of vehicle trips for Cases A and B are equalized for the purpose of on easy comparison. All the Streets and Avenues are affected by the addition of parking lanes, except for 8th Avenue and Madison Avenue where the increase in travel time is minor.

The introduction of additional parking had an impact on all the Streets and Avenues of the network in terms of increased travel time and reduction in volume. This dramatic increase in travel time is caused by the chain of spill-backs on most of the links resulting from the spill- backs on 5th and 6th Avenues.

The costs incurred by cars and trucks on the network for the stipulated simulation period are calculated by using \$ 0.23 per vehicle-minute as the value of time for cars and \$0.42 per vehicle-minute for trucks. The total additional cost incurred by cars and trucks due to the inclusion of additional parking is \$ 6101.20. Of this, \$4225.56 is contributed by cars and the remaining \$ 1875.64 by trucks. The benefit of replacing full lanes by parking lanes will depend on the requirement and necessity of loading and unloading spots along the streets and their financial returns.

Table 8. Scenario 2

Comparison of travel time and speed between the base line and additional parking cases.

(+) sign indicates increase in time over the base case

Section	Stre or Avenues	Travel Time sec/veh-trip Case A	Case B	Diff	%	Speed Case A	Case B	Diff
5	50th St	290	635.5	345.5	119	8.2	3.8	-4.4
6	49th St	445.1	875.1	430	97	5.4	2.7	-2.7
7	51st St	649.6	1276.9	632.3	84	3.4	1.9	-1.5
8	52nd St	323.4	396.5	46.1	22	7.4	6	-1.4
9	8th Ave	109.7	111.3	1.6	1.5	8.7	8.6	-0.1
10	Broadway	77.9	114.1	36.2	46	12.3	8.4	-3.9
11	7th Ave	75.3	161.1	85.8	114	12.7	5.9	-6.8
12	6th Ave	93.9	352.8	258.9	276	10.2	2.7	-7.5
13	5th Ave	94.5	153	58.5	62	10.1	6.2	-3.9
14	Madison	85.3	91.9	6.6	8	11.2	10.4	-0.8
15	48th St	283.3	506.7	223.4	79	8.4	4.7	-3.7
16	47th St	362	553.5	191.5	53	6.6	4.3	-2.3

Table 9. Scenario 2

Comparison of travel time between the base line and the additional parking cases.

(+) sign indicates increase in travel time over the base line case..

Section	Travel Time Sec/ Veh - Trip Base Line	Park	Vehicle Trips veh	Travel Time Vehicle - minute Base Line	Park	Diff	Change %
1	214	256.8	534	1904	2285	381	20
2	213.3	603.5	558	1983	5612	3629	183
3	258.5	619.6	551	2375	5690	3315	140
4	241.6	140.7	364	859	853	-6	-
5	290	635.5	390	1886	4131	2245	119
6	445.1	875.1	235	1746	3427	1681	96
7	644.6	1276.9	226	2612	4810	2198	84
8	323.4	396.5	347	1869	2293	424	23
9	109.7	111.3	924	1690	1714	24	1.5
10	77.9	114.1	786	1020	1495	475	47
11	75.3	161.1	998	1251	2680	1429	114
12	93.9	352.8	1052	1647	6186	4539	275
13	94.5	153	963	1517	2456	939	62
14	85.3	91.9	955	1358	1463	105	8
15	283.3	506.7	279	1319	2354	1035	78
16	362	553.5	201	1210	1854	644	53

6.3 Scenario 3

In this scenario there are nine bus routes along the Streets and Avenues of the network. In case B an exclusive bus lane is provided for the buses. In case A their are no exclusive bus lanes.

6.3.1 Effect of exclusive bus lanes on cars and trucks

Table 10 shows the change in travel time (veh-min) and vehicle trips caused by the introduction of exclusive bus lanes. The most significant change occurred on 49th Street and 8th Avenue. Table 11 shows that except for 6th Avenue, 48th Street and 47th Street (because there are no bus routes along them) there is an increase in travel time experienced by cars and trucks, throughout the network. The most significant impact is on 49th and 51st Streets. Average speed is also reduced on most of the sections except on 51st Street as it can be seen from the figures in Table 11.

Travel time for cars and trucks increases on all links, ranging from 4 sec/veh on 5th Avenue to 430.8 sec/veh on 49th Street. There is an appreciable decrease in travel time on 51st Street.

6.3.2 Effect on buses

Table 12 gives the difference in bus trips, bus travel time (bus-minutes), mean travel time (seconds/bus) and person travel time (minutes). It can be seen that the mean travel time for buses increases on Broadway when an exclusive bus lane is introduced. The most significant decrease in travel time for buses occurs on 49th Street. There is an appreciable increase in travel time on 50th Street and 5th Avenue. There is a substantial decrease in bus trips on Broadway on one of the routes. Except for Broadway there is a general decrease in travel time for buses using exclusive bus lanes on the avenues, but the decrease is nominal.

Table 10. Scenario 3

Comparison on the basis of travel time and vehicle trips for all types of vehicles between a case with exclusive bus lanes and a case without exclusive bus lanes.

(+) sign indicates increase in travel time and trips over the base line case.

Section	Route	Street or Avenue	TRAVEL TIME (Veh-min)			VEHICLE TRIPS		
			Base Line	With Lanes	Diff	Base Line	With Lanes	Diff
5	1	50th ST	1940.25	2929.37	+989.12	372	343	-29
6	8 , 9	49th ST	1870.48	3343.47	+1472.9	247	227	-20
7	6	51st ST	3252.52	2260.32	-992.2	219	227	+8
8		52nd ST	2074.98	2077.17	+2.19	351	334	-17
9	2	8th AV	1992.00	3773.52	+1781.5	933	732	-201
10	3 , 4	B'way	1028.53	1800.12	+771.59	785	670	-115
11	5	7th AV	1259.00	1430.37	+171.37	983	968	-15
12		6th AV	1697.97	1474.00	-223.97	1021	1079	+58
13	6	5th AV	1636.27	1685.98	+49.68	963	955	-8
14	7	Madison	1358.53	1517.67	+159.14	967	949	-18
15		48th ST	1318.55	1002.85	-315.7	276	227	-49
16		47th ST	1286.22	1350.43	+64.21	198	211	+13

Table 11. Scenario 3

Comparison of travel time and speed for all types of vehicles between the base line and exclusive bus lane cases.

(+) sign indicates increase in travel time over the base line case.

Sect	Route	Street or Avenue	TRAVEL TIME sec/veh			AVERAGE SPEED mph		
			Base Line	With Lanes	Diff	Base Line	With Lanes	Diff
5	1	50th ST	313.4	512.3	+198.9	7.6	4.7	-2.9
6	8 , 9	49th ST	454.8	885.6	+430.8	5.2	2.7	-2.5
7	6	51st ST	891.4	597.8	-293.6	2.7	4.0	+2.3
8		52nd ST	354.8	373.1	+18.3	6.7	6.4	-0.3
9	2	8th AV	128.1	309.4	+181.3	7.5	3.1	-4.4
10	3 , 4	Broadway	78.6	161.3	+82.7	12.1	5.9	-6.2
11	5	7th AV	76.9	88.7	+11.8	12.4	10.8	-1.6
12		6th AV	99.8	82.0	-17.7	9.6	11.6	+2.0
13	6	5th AV	101.9	105.9	+4	9.4	9.0	-0.4
14	7	Madison	84.3	96.0	+11.7	11.3	9.9	-1.4
15		48th ST	286.6	264.8	-21.8	8.3	9.0	+0.7
16		47th ST	389.1	384.4	-4.7	6.1	6.2	+0.1

Table 12. Scenario 3

Comparison of bus trips, travel time, mean travel time and person travel time for base line and exclusive bus lane cases.

(+) Sign indicates increase in travel time for buses over the base line.

Route	Street or Avenue	BUS TRIPS Base Line	With Lanes	Diff	TOTAL TRAVEL TIME BUS - MIN Base Line	With Lanes	Diff
1	50th ST	7	7	0	43.3	31.8	-11.5
2	8th AV	5	4	-1	19.9	14.8	-5.1
3	Broadway	7	5	-2	14.0	10.3	-3.7
4	Broadway	3	3	0	5.3	5.9	+0.6
5	7th AV	3	3	0	4.8	4.4	-0.4
6	5th AV	6	6	0	18.0	10.9	-7.1
7	Madison	8	7	-1	34.1	29.3	-4.8
8	49th ST	6	7	+1	62.8	41.9	-20.9
9	49th ST	6	7	+1	64.9	52.1	-12.8

Route	Street or Avenue	MEAN TRAVEL TIME SEC/BUS Base Line	With Lanes	Diff	PERSON TRAVEL TIME (min) Base Line	With Lanes	Diff
1	50th ST	370.7	272.4	-98.3	1081.3	749.6	-331.7
2	8th AV	239.2	221.8	-17.4	498.3	369.6	-128.7
3	Broadway	119.9	123.4	+3.5	349.6	257.1	-92.5
4	Broadway	105.7	117.3	+11.6	132.1	146.7	+14.6
5	7th AV	96.7	88.0	-8.7	120.8	110.0	-10.8
6	5th AV	180.3	109.2	-71.1	450.8	272.9	-177.9
7	Madison	255.8	250.9	-4.9	852.5	731.7	-120.8
8	49th ST	628.2	358.9	-269.3	1570.4	1046.7	-523.7
9	49th ST	648.7	446.9	-201.8	1621.7	1303.3	-318.4

Table 13. Scenario 3

Costs incurred by cars and trucks due to excess travel time in the case of exclusive bus lanes.

(-) sign indicates time saved and benefits.

SECT	VEHICLE TRIPS Veh		EXTRA TRAVEL TIME sec	EXCESS TRAVEL TIME min		COSTS $	
	CARS	TRUCKS		CARS	TRUCKS	CARS	TRUCKS
5	298	74	198.9	988	245	227	103
6	198	49	430.8	1422	352	327	148
7	175	44	293.6	856	215	197	90
8	281	70	18.3	86	21	20	9
9	746	187	181.3	2254	565	518	237
10	628	157	82.7	866	216	199	91
11	786	197	11.8	155	39	36	16
12	817	203	-17.7	-241	-60	-55	-25
13	770	192	4	51	13	12	5
14	774	193	11.7	151	38	35	16
15	221	55	-21.8	-80	-20	-18	-8
16	158	40	-4.7	-12	-3	-3	-1
				TOTAL COST $		1495	681

As shown in Table 13, the excess cost incurred by cars and trucks when there are exclusive bus lanes is $ 2176. Of this, $ 681 is incurred by trucks and $ 1495 by cars. The total benefit to bus passengers is computed in Table 14 and amounts to $ 318. Hence the cost to vehicles such as cars and trucks is considerably more than the benefits of bus passengers.

Graphical comparision of MOEs for each scenario is presented in Appendix F.

Table 14. Scenario 3.

Benefits to bus passengers in the case of exclusive bus lanes.

Route	Section	Saved Travel Time Sec/bus	Bus Trips	Saved Travel Time Bus - min	Saved Time Passenger minute	Benefits $
1	5	98.3	7	11.47	286.75	49
2	9	17.4	4	1.16	29	5
3	10	-3.5	5	-0.29	-7.29	-1.24
4	10	-11.6	3	-0.58	-14.5	-2.46
5	11	8.7	3	0.44	11	2
6	13	71.7	6	7.17	179.25	30
7	14	4.9	7	0.57	14.25	2
8	6	269.3	7	31.42	785.5	134
9	6	201.8	7	23.54	588.5	100
				Total Benefits $		318

Assumptions: 25 passengers/bus
Value of time = $ 0.17/passenger-minute

CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

It can be concluded from the analysis of Scenario 1 that the benefit to passenger cars and occupied taxis is significant compared to the costs incurred by trucks due to extra travel time. A marginal saving of $ 35.38 came at the expense of $ 135 increase in the truck operating cost. Assuming that trucks will transfer their costs to consumers via higher prices of goods or services, the public at large is the ultimate loser. Since only one truck route was simulated, it is recommended that more truck routes reflecting the real world situation be incorporated in the simulation and their impact evaluated.

It is observed from the analysis of Scenario 2 that, by replacing full flowing lanes by parking lanes, a heavy cost burden is placed on cars and trucks. Hence, this should be avoided if possible. But under exceptional cases where the concerned street has business whose very survival depends upon the pickup and delivery of goods, then the costs to cars and trucks should be weighted against the economic set back caused to the businesses of the area. The decision to replace the lane should depend upon this comparison.

The analysis of Scenario 3 shows that the benefit of introducing an exclusive bus lane is minor to bus passengers compared with the additional costs to cars and trucks. Hence the regulation of exclusive bus lanes should not be imposed on areas of heavy pickup and delivery operations.

Finally, NETSIM is not designed to simulate truck movements. It is recommended that the program and the inherent parameters of the software be modified to accommodate and simulate the movement of trucks. The simulation program should be validated by surveying the before and after effects of imposed regulations and comparing them to the simulation output of NETSIM.

APPENDIX A
TRANSYT 7F

TRANSYT 7F

The proper design of traffic signal timing can significantly affect traffic flow, fuel consumption, vehicle emissions and user and vehicle operating costs. Transyt 7F is an acronym for Traffic Network Study Tool version 7F. It is used to optimize coordinated traffic signal systems to reduce delay, stops and most significantly fuel consumption.

The Transyt model was developed by Dennis I. Robertson of the United Kingdom in 1967. The American version Transyt 7F which is based on Transyt-7 was developed for FHWA by the University of Florida Transportation Research Center.

One of the two major functions of Transyt-7F is to simulate the flow of traffic in a signalized network. Simulation is an analytical process that attempts to represent real world events. In this case traffic flowing through the network. Transyt-7F is a macroscopic computerized traffic simulation model. A macroscopic model is one that considers platoons of vehicles rather than individual vehicles which is the simulation philosophy of NETSIM. Transyt-7F's second function utilizes a platoon dispersion algorithm that simulates the normal dispersion (i.e., "the spreading out") of platoons as they travel downstream. It also considers traffic delay, stops, fuel consumption, travel time and other system resources.

Offsets

Offsets are explicitly optimized by Transyt-7F. The offset is the time period between cycle initialization at two successive signal controllers. Offsets are generally determined so that to the extent possible, traffic can flow through a number of signals without stopping. When optimizing, Transyt-7F minimizes an objective function called the performance index (PI). The PI is either a linear combination of delays, stops, and (optionally) excessive maximum backup of queues or excess operating costs.

Transyt-7F can explicitly optimize offsets and phase lengths for a given cycle length. The user can indicate whether offsets or phase lengths, or both, are to be optimized in a particular run. The methodology used for optimization is a gradient search technique referred to as iterative gradient.

Offset optimization

The offsets are optimized in a stepwise method by Transyt-7F. The steps are as follows:

(1) Initial signal plan simulated and initial PI is calculated.

(2) At the first signal, the offset is increased by an amount specified on the optimization step size list. The resulting traffic flows are resimulated on downstream links and a new PI is calculated.

(3) The new PI is compared with the previous value as follows:

(a) If the new PI is less than the previous value, the program continues to increase the offset by the same amount as long as the PI continues to decrease.

(b) If the new PI is greater than the previous value, the program will decrease the offset by the same amount and continue to decrease the offset by this amount as long as the PI continues to decrease.

(4) When no further improvements can be made by varying the offset at this signal the model goes to the next signal.

Phase Length Optimization

The Phase length optimization process is similar to the offset optimization process except that the changes in the phase lengths at each signal are examined

Interpretation of MOEs

Degree of saturation

Degree of saturation is the percent saturation of each link. It is an indicator of the degree of congestion that can be expected at a link. If the degree of saturation is less than 95% the traffic performance at a link will probably be acceptable and the other MOE values will be accurate. If it is above 95%, the link may be congested and cycle failures (failing to clear the queue on a link during the green period) are probable. In such cases, the MOE values may not actually represent actual conditions, (MOEs such as total travel time and fuel consumption). This is particularly true if the degree of saturation is greater than 110%.

Total Travel

Total travel, the total vehicle-miles per hour of travel and total travel time is the product of link traffic volume and link length. It includes both the time spent moving and the time in delay for vehicles on the link. It is used to evaluate improvements which lead to cruise speed increases.

Delay

The average delay per vehicle is the total delay on the link divided by the total flow on the link. The delay MOE value is the delay due to signal timing only. If the degree of saturation is greater than 100 %, the estimation of delay should not be taken as an absolutely reliable estimate. The amount of delay affects fuel consumption (i.e., idling consumes fuel non productively) so the fuel estimate as well as the total operating cost are likewise questionable under such conditions. Delay represents indirect costs to the motorists in terms of fuel consumption during idling.

Maximum Backup of Queue

The maximum backup of queue value is the maximum extension of the queue upstream of the link during the cycle. It includes vehicles which arrive during the green and join the back of the queue, while the front of the queue is discharging during the initial seconds of the effective green.

Fuel Consumption

Fuel consumption is based on the linear combination of total travel, delay and stops. It includes fuel consumed at cruise, idle, and acceleration and deceleration in units of gallons per hour.

Operating Costs

Operating costs include all costs associated with vehicle operations in the system. It is an estimate of the road user costs, including vehicle operation, fuel consumption, and passenger's time.

As of release 6 Transyt-7f considers the maximum backup of queue in the optimization process but the simulation still does not explicitly deal with spillovers. It is important to note that if a spillover actually does occur the traffic flow model does not give realistic results. The results of the simulation will not be reliable as long as a spillover is a distinct possibility.

Signal offsets at intersections obtained from optomization of signals by TRANSYT 7F

NETSIM Node #	T7F Node #	OFFSET
112	1	0
114	2	43
116	3	66
118	4	27
120	5	10
122	6	4
212	7	89
214	8	54
216	9	82
218	10	25
220	11	21
222	12	88
312	13	67
314	14	61
316	15	67
318	16	10
319	17	76
320	18	6
322	19	4
412	20	68
414	21	76
416	22	75
418	23	17
419	24	32
420	25	12
422	26	81
512	27	89
514	28	87
516	29	83
518	30	15
520	31	6
522	32	12
612	33	81
614	34	6
616	35	6
618	36	6
620	37	30
622	38	6

APPENDIX B
INPUT AND OUTPUT DATA OF SCENARIO 1

INPUT DATA DESCRIPTION FOR BASE LINE CASE (CASE A OF SCENARIO 1 AND SCENARIO 2)

NETSIM LINKS

LINK	LENGTH FT / M	-LANES- FUL L	PKT L	R	GRD PCT	LINK TYPE	-CHANNEL- CUR B234567	DESTINATION NODE LEFT	THRU	RGHT	DIAG	OPP. NODE	LOST TIME SEC	Q DIS HDWY. SEC	FREE SPEED MPH/KMPH	RTOR CODE	PED CODE	LANE ALIGN -MENT	STREET NAME
(8101, 110)	0/ 0	2	0	0	0	1*	0000000	0	112	0	0	0	.5	1.4	0/ 0	1	3	1-1	52 St
(110, 112)	100/ 30	2	0	0	0	1*	0000000	12	114	0	0	0	.5	1.4	30/ 48	1	3	1-1	52 St
(112, 114)	680/ 207	2	0	0	0	1*	0000000	0	116	214	0	0	.5	1.4	30/ 48	1	3	1-1	52 St
(114, 116)	300/ 91	2	0	0	0	1*	0000000	0	118	216	0	0	.5	1.4	30/ 48	1	3	1-1	52 St
(116, 118)	940/ 287	2	0	0	0	1*	0000000	18	120	0	0	0	.5	1.4	30/ 48	1	3	1-1	52 St
(118, 120)	1060/ 323	2	0	0	0	1*	0000000	0	122	220	0	0	.5	1.4	30/ 48	1	3	1-1	52 St
(120, 122)	520/ 158	2	0	0	0	1*	0000000	22	124	0	0	0	.5	1.4	30/ 48	1	3	1-1	52 St
(122, 124)	100/ 30	2	0	0	0	1*	0000000	0	8102	0	0	0	.5	1.4	30/ 48	1	3	1-1	52 St
(8112, 224)	0/ 0	2	0	0	0	1*	0000000	0	222	0	0	0	.5	1.4	0/ 0	1	3	1-1	51 St
(224, 222)	100/ 30	2	0	0	0	1*	0000000	0	220	122	0	0	.5	1.4	30/ 48	1	3	1-1	51 St
(222, 220)	520/ 158	2	0	0	0	1*	0000000	320	219	0	0	0	.5	1.4	30/ 48	1	3	1-1	51 St
(220, 219)	430/ 131	2	0	0	0	1*	0000000	0	218	0	0	0	.5	1.4	30/ 48	1	3	1-1	51 St
(219, 218)	630/ 192	2	0	0	0	1*	0000000	0	216	118	0	0	.5	1.4	30/ 48	1	3	1-1	51 St
(218, 216)	940/ 287	2	0	0	0	1*	0000000	316	214	0	0	0	.5	1.4	30/ 48	1	3	1-1	51 St
(216, 214)	280/ 85	2	0	0	0	1*	0000000	314	212	0	0	0	.5	1.4	30/ 48	1	3	1-1	51 St
(214, 212)	700/ 213	2	0	0	0	1*	0000000	0	210	112	0	0	.5	1.4	30/ 48	1	3	1-1	51 St
(212, 210)	100/ 30	2	0	0	0	1*	0000000	0	8111	0	0	0	.5	1.4	30/ 48	1	3	1-1	51 St
(8121, 310)	0/ 0	2	0	0	0	1*	0000000	0	312	0	0	0	.5	1.4	0/ 0	1	3	1-1	50 St
(310, 312)	100/ 30	2	0	0	0	1*	0000000	212	314	0	0	0	.5	1.4	30/ 48	1	3	1-1	50 St
(312, 314)	720/ 219	2	0	0	0	1*	0000000	0	316	414	0	0	.5	1.4	30/ 48	1	3	1-1	50 St
(314, 316)	260/ 79	2	0	0	0	1*	0000000	0	318	416	0	0	.5	1.4	30/ 48	1	3	1-1	50 St
(316, 318)	940/ 287	2	0	0	0	1*	0000000	218	319	0	0	0	.5	1.4	30/ 48	1	3	1-1	50 St
(318, 319)	630/ 192	2	0	0	0	1*	0000000	219	320	0	0	0	.5	1.4	30/ 48	1	3	1-1	50 St
(319, 320)	430/ 131	2	0	0	0	1*	0000000	0	322	420	0	0	.5	1.4	30/ 48	1	3	1-1	50 St
(320, 322)	520/ 158	2	0	0	0	1*	0000000	222	324	0	0	0	.5	1.4	30/ 48	1	3	1-1	50 St
(322, 324)	100/ 30	2	0	0	0	1*	0000000	0	8122	0	0	0	.5	1.4	30/ 48	1	3	1-1	50 St
(8132, 424)	0/ 0	2	0	0	0	1*	0000000	0	422	0	0	0	.5	1.4	0/ 0	1	3	1-1	49 St
(424, 422)	100/ 30	2	0	0	0	1*	0000000	0	420	322	0	0	.5	1.4	30/ 48	1	3	1-1	49 St
(422, 420)	520/ 158	2	0	0	0	1*	0000000	520	419	0	0	0	.5	1.4	30/ 48	1	3	1-1	49 St
(420, 419)	430/ 131	2	0	0	0	1*	0000000	0	418	319	0	0	.5	1.4	30/ 48	1	3	1-1	49 St
(419, 418)	630/ 192	2	0	0	0	1*	0000000	0	416	318	0	0	.5	1.4	30/ 48	1	3	1-1	49 St
(418, 416)	940/ 287	2	0	0	0	1*	0000000	516	414	0	0	0	.5	1.4	30/ 48	1	3	1-1	49 St
(416, 414)	260/ 79	2	0	0	0	1*	0000000	514	412	0	0	0	.5	1.4	30/ 48	1	3	1-1	49 St
(414, 412)	720/ 219	2	0	0	0	1*	0000000	0	410	312	0	0	.5	1.4	30/ 48	1	3	1-1	49 St
(412, 410)	100/ 30	2	0	0	0	1*	0000000	0	8131	0	0	0	.5	1.4	30/ 48	1	3	1-1	49 St
(8141, 510)	0/ 0	2	0	0	0	1*	0000000	0	512	0	0	0	.5	1.4	0/ 0	1	3	1-1	48 St

-LANES- -CHANNEL-

LINK	LENGTH FT / M	FUL L	PKT L	PKT R	GRD PCT	LINK TYPE	CUR B234567	DESTINATION NODE LEFT	THRU	RGHT	DIAG	OPP. NODE	LOST TIME SEC	Q DIS HDWY. SEC	FREE SPEED MPH/KMPH	RTOR CODE	PED CODE	LANE ALIGN -MENT	STREET NAME
(510, 512)	100/ 30	2	0	0	0	1*	0000000	412	514	0	0	0	.5	1.4	30/ 48	1	3	1-1	48 St
(512, 514)	760/ 232	2	0	0	0	1*	0000000	0	516	614	0	0	.5	1.4	30/ 48	1	3	1-1	48 St
(514, 516)	220/ 67	2	0	0	0	1*	0000000	0	518	616	0	0	.5	1.4	30/ 48	1	3	1-1	48 St
(516, 518)	940/ 287	2	0	0	0	1*	0000000	418	519	0	0	0	.5	1.4	30/ 48	1	3	1-1	48 St
(518, 519)	630/ 192	2	0	0	0	1*	0000000	419	520	0	0	0	.5	1.4	30/ 48	1	3	1-1	48 St
(519, 520)	430/ 131	2	0	0	0	1*	0000000	0	522	620	0	0	.5	1.4	30/ 48	1	3	1-1	48 St
(520, 522)	520/ 158	2	0	0	0	1*	0000000	422	524	0	0	0	.5	1.4	30/ 48	1	3	1-1	48 St
(522, 524)	100/ 30	2	0	0	0	1*	0000000	0	8142	0	0	0	.5	1.4	30/ 48	1	3	1-1	48 St
(8152, 624)	0/ 0	2	0	0	0	1*	0000000	0	622	0	0	0	.5	1.4	0/ 0	1	3	1-1	47 St
(624, 622)	100/ 30	2	0	0	0	1*	0000000	0	620	522	0	0	.5	1.4	30/ 48	1	3	1-1	47 St
(622, 620)	520/ 158	2	0	0	0	1*	0000000	720	618	0	0	0	.5	1.4	30/ 48	1	3	1-1	47 St
(620, 618)	1060/ 323	2	0	0	0	1*	0000000	0	616	518	0	0	.5	1.4	30/ 48	1	3	1-1	47 St
(618, 616)	940/ 287	2	0	0	0	1*	0000000	716	614	0	0	0	.5	1.4	30/ 48	1	3	1-1	47 St
(616, 614)	180/ 55	3	0	0	0	1*	0000000	714	612	0	0	0	.5	1.4	30/ 48	1	3	1-1	47 St
(614, 612)	800/ 244	2	0	0	0	1*	0000000	0	610	512	0	0	.5	1.4	30/ 48	1	3	1-1	47 St
(612, 610)	100/ 30	2	0	0	0	1*	0000000	0	8151	0	0	0	.5	1.4	30/ 48	1	3	1-1	47 St
(8002, 712)	0/ 0	6	0	0	0	1*	0000000	0	612	0	0	0	.5	1.4	0/ 0	1	3	1-1	Eighth Ave
(712, 612)	100/ 30	6	0	0	0	1*	0000000	610	512	0	0	0	.5	1.4	30/ 48	1	3	1-1	Eighth Ave
(612, 512)	280/ 85	6	0	0	0	1*	0000000	0	412	514	0	0	.5	1.4	30/ 48	1	3	1-1	Eighth Ave
(512, 412)	280/ 85	6	0	0	0	1*	0000000	410	312	0	0	0	.5	1.4	30/ 48	1	3	1-1	Eighth Ave
(412, 312)	280/ 85	6	0	0	0	1*	0000000	0	212	314	0	0	.5	1.4	30/ 48	1	3	1-1	Eighth Ave
(312, 212)	280/ 85	5	0	0	0	1*	0000000	210	112	0	0	0	.5	1.4	30/ 48	1	3	1-1	Eighth Ave
(212, 112)	280/ 85	5	0	0	0	1*	0000000	0	12	114	0	0	.5	1.4	30/ 48	1	3	1-1	Eighth Ave
(112, 12)	100/ 30	5	0	0	0	1*	0000000	0	8001	0	0	0	.5	1.4	30/ 48	1	3	1-1	Eighth Ave
(8011, 14)	0/ 0	4	0	0	0	1*	0000000	0	114	0	0	0	.5	1.4	0/ 0	1	3	1-1	Broadway
(14, 114)	100/ 30	4	0	0	0	1*	0000000	116	214	0	0	0	.5	1.4	30/ 48	1	3	1-1	Broadway
(114, 214)	280/ 85	4	0	0	0	1*	0000000	0	314	212	0	0	.5	1.4	30/ 48	1	3	1-1	Broadway
(214, 314)	280/ 85	4	0	0	0	1*	0000000	316	414	0	0	0	.5	1.4	30/ 48	1	3	1-1	Broadway
(314, 414)	280/ 85	4	0	0	0	1*	0000000	0	514	412	0	0	.5	1.4	30/ 48	1	3	1-1	Broadway
(414, 514)	280/ 85	4	0	0	0	1*	0000000	516	614	0	0	0	.5	1.4	30/ 48	1	3	1-1	Broadway
(514, 614)	280/ 85	4	0	0	0	1*	0000000	0	714	612	0	0	.5	1.4	30/ 48	1	3	1-1	Broadway
(614, 714)	100/ 30	4	0	0	0	1*	0000000	0	8012	0	0	0	.5	1.4	30/ 48	1	3	1-1	Broadway
(8021, 16)	0/ 0	5	0	0	0	1*	0000000	0	116	0	0	0	.5	1.4	0/ 0	1	3	1-1	Seventh Ave
(16, 116)	100/ 30	5	0	0	0	1*	0000000	118	216	0	0	0	.5	1.4	30/ 48	1	3	1-1	Seventh Ave
(116, 216)	280/ 85	5	0	0	0	1*	0000000	0	316	214	0	0	.5	1.4	30/ 48	1	3	1-1	Seventh Ave
(216, 316)	280/ 85	4	0	0	0	1*	0000000	318	416	0	0	0	.5	1.4	30/ 48	1	3	1-1	Seventh Ave
(316, 416)	280/ 85	4	0	0	0	1*	0000000	0	516	414	0	0	.5	1.4	30/ 48	1	3	1-1	Seventh Ave
(416, 516)	280/ 85	4	0	0	0	1*	0000000	518	616	0	0	0	.5	1.4	30/ 48	1	3	1-1	Seventh Ave
(516, 616)	280/ 85	4	0	0	0	1*	0000000	0	716	614	0	0	.5	1.4	30/ 48	1	3	1-1	Seventh Ave
(616, 716)	100/ 30	4	0	0	0	1*	0000000	0	8022	0	0	0	.5	1.4	30/ 48	1	3	1-1	Seventh Ave

-LANES- -CHANNEL-

LINK	LENGTH FT / M	FUL L	PKT L	PKT R	GRD PCT	LINK TYPE	CUR B234567	DESTINATION NODE LEFT	THRU	RGHT	DIAG	OPP. NODE	LOST TIME SEC	Q DIS HDWY. SEC	FREE SPEED MPH/KMPH	RTOR CODE	PED CODE	LANE ALIGN -MENT	STREET NAME
(8032, 718)	0/ 0	6	0	0	0	1*	0000000	0	618	0	0	0	.5	1.4	0/ 0	1	3	1-1	Sixth Ave
(718, 618)	100/ 30	6	0	0	0	1*	0000000	616	518	0	0	0	.5	1.4	30/ 48	1	3	1-1	Sixth Ave
(618, 518)	280/ 85	6	0	0	0	1*	0000000	0	418	519	0	0	.5	1.4	30/ 48	1	3	1-1	Sixth Ave
(518, 418)	280/ 85	5	0	0	0	1*	0000000	416	318	0	0	0	.5	1.4	30/ 48	1	3	1-1	Sixth Ave
(418, 318)	280/ 85	5	0	0	0	1*	0000000	0	218	319	0	0	.5	1.4	30/ 48	1	3	1-1	Sixth Ave
(318, 218)	280/ 85	5	0	0	0	1*	0000000	216	118	0	0	0	.5	1.4	30/ 48	1	3	1-1	Sixth Ave
(218, 118)	280/ 85	5	0	0	0	1*	0000000	0	18	120	0	0	.5	1.4	30/ 48	1	3	1-1	Sixth Ave
(118, 18)	100/ 30	5	0	0	0	1*	0000000	0	8031	0	0	0	.5	1.4	30/ 48	1	3	1-1	Sixth Ave
(519, 419)	280/ 85	1	0	0	0	1*	0000000	418	319	0	0	0	.5	1.4	30/ 48	1	3	1-1	Rocky Plaza
(419, 319)	280/ 85	1	0	0	0	1*	0000000	0	219	320	0	0	.5	1.4	30/ 48	1	3	1-1	Rocky Plaza
(319, 219)	280/ 85	1	0	0	0	1*	0000000	218	0	0	0	0	.5	1.4	30/ 48	1	3	1-1	Rocky Plaza
(8041, 20)	0/ 0	5	0	0	0	1*	0000000	0	120	0	0	0	.5	1.4	0/ 0	1	3	1-1	Fifth Ave
(20, 120)	100/ 30	5	0	0	0	1*	0000000	122	220	0	0	0	.5	1.4	30/ 48	1	3	1-1	Fifth Ave
(120, 220)	280/ 85	5	0	0	0	1*	0000000	0	320	219	0	0	.5	1.4	30/ 48	1	3	1-1	Fifth Ave
(220, 320)	280/ 85	5	0	0	0	1*	0000000	322	420	0	0	0	.5	1.4	30/ 48	1	3	1-1	Fifth Ave
(320, 420)	280/ 85	5	0	0	0	1*	0000000	0	520	419	0	0	.5	1.4	30/ 48	1	3	1-1	Fifth Ave
(420, 520)	280/ 85	5	0	0	0	1*	0000000	522	620	0	0	0	.5	1.4	30/ 48	1	3	1-1	Fifth Ave
(520, 620)	280/ 85	5	0	0	0	1*	0000000	0	720	618	0	0	.5	1.4	30/ 48	1	3	1-1	Fifth Ave
(620, 720)	100/ 30	5	0	0	0	1*	0000000	0	8042	0	0	0	.5	1.4	30/ 48	1	3	1-1	Fifth Ave
(8052, 722)	0/ 0	5	0	0	0	1*	0000000	0	622	0	0	0	.5	1.4	0/ 0	1	3	1-1	Madison Ave
(722, 622)	100/ 30	5	0	0	0	1*	0000000	620	522	0	0	0	.5	1.4	30/ 48	1	3	1-1	Madison Ave
(622, 522)	280/ 85	5	0	0	0	1*	0000000	0	422	524	0	0	.5	1.4	30/ 48	1	3	1-1	madison Ave
(522, 422)	280/ 85	4	0	0	0	1*	0000000	420	322	0	0	0	.5	1.4	30/ 48	1	3	1-1	Madison Ave
(422, 322)	280/ 85	4	0	0	0	1*	0000000	0	222	324	0	0	.5	1.4	30/ 48	1	3	1-1	Madison Ave
(322, 222)	280/ 85	5	0	0	0	1*	0000000	220	122	0	0	0	.5	1.4	30/ 48	1	3	1-1	Madison Ave
(222, 122)	280/ 85	5	0	0	0	1*	0000000	0	22	124	0	0	.5	1.4	30/ 48	1	3	1-1	Madison Ave
(122, 22)	100/ 30	5	0	0	0	1*	0000000	0	8051	0	0	0	.5	1.4	30/ 48	1	3	1-1	Madison Ave

* INDICATES DEFAULT VALUES WERE SPECIFIED

LINK TYPE

IDENTIFIES THE DISTRIBUTION USED FOR QUEUE DISCHARGE AND START-UP LOST TIME CHARACTERISTICS.

LANE CHANNELIZATION CODES

0 UNRESTRICTED
1 LEFT TURNS ONLY
2 BUSES ONLY
3 CLOSED
4 RIGHT TURNS ONLY
5 CAR - POOLS
6 CAR - POOLS + BUSES

RTOR CODES

0 RTOR PERMITTED
1 RTOR PROHIBITED

PEDESTRIAN CODES

0 NO PEDESTRIANS
1 LIGHT
2 MODERATE
3 HEAVY

BASE LINE CASE

ENTRY LINK VOLUMES

LINK	FLOW RATE (VEH/HOUR)	TRUCKS (PERCENT)	CAR POOLS (PERCENT)
(8101, 110)	367	20	0
(8112, 224)	325	20	0
(8121, 310)	388	20	0
(8132, 424)	462	20	0
(8141, 510)	287	20	0
(8152, 624)	283	20	0
(8002, 712)	1337	20	0
(8011, 14)	1113	20	0
(8021, 16)	1333	20	0
(8032, 718)	1389	20	0
(8041, 20)	1309	20	0
(8052, 722)	1325	20	0

PARKING ACTIVITY SPECIFICATIONS

LINK	DUR. OF PARK. MANEUVERS (SECONDS)	PARKING FREQUENCY (PER HOUR)	RIGHT CURB PARKING ZONE LENGTH FEET / METERS	RIGHT CURB PARKING ZONE DISTANCE TO STOPLINE FEET / METERS	LEFT CURB PARKING ZONE LENGTH FEET / METERS	LEFT CURB PARKING ZONE DISTANCE TO STOPLINE FEET / METERS
(520, 522)	20	15	392 / 119	40 / 12	0 / 0	0 / 0
(120, 122)	20	15	0 / 0	0 / 0	304 / 93	40 / 12
(622, 620)	20	15	392 / 119	40 / 12	0 / 0	0 / 0
(618, 616)	20	15	720 / 219	40 / 12	0 / 0	0 / 0
(614, 612)	20	15	0 / 0	0 / 0	680 / 207	40 / 12
(212, 112)	20	15	0 / 0	0 / 0	184 / 56	40 / 12
(312, 212)	20	15	104 / 32	40 / 12	0 / 0	0 / 0
(214, 212)	20	15	544 / 166	40 / 12	0 / 0	0 / 0
(514, 614)	20	15	184 / 56	40 / 12	184 / 56	40 / 12
(422, 322)	20	15	0 / 0	0 / 0	184 / 56	40 / 12
(516, 616)	20	15	184 / 56	40 / 12	184 / 56	40 / 12
(216, 214)	20	15	0 / 0	0 / 0	144 / 44	40 / 12
(118, 120)	20	15	904 / 276	40 / 12	904 / 276	40 / 12
(116, 118)	20	15	0 / 0	0 / 0	800 / 244	40 / 12
(512, 514)	20	15	520 / 158	40 / 12	400 / 122	40 / 12
(514, 516)	20	15	80 / 24	40 / 12	0 / 0	0 / 0
(519, 520)	20	15	320 / 98	40 / 12	0 / 0	0 / 0
(319, 320)	20	15	0 / 0	0 / 0	152 / 46	40 / 12
(219, 218)	20	15	0 / 0	0 / 0	440 / 134	40 / 12
(114, 116)	20	15	0 / 0	0 / 0	184 / 56	40 / 12
(414, 412)	20	15	0 / 0	0 / 0	600 / 183	40 / 12
(114, 214)	10	15	184 / 56	40 / 12	184 / 56	40 / 12
(414, 514)	20	15	184 / 56	40 / 12	184 / 56	40 / 12
(314, 414)	20	15	120 / 37	40 / 12	120 / 37	40 / 12
(416, 516)	20	15	184 / 56	40 / 12	184 / 56	40 / 12
(416, 414)	20	15	0 / 0	0 / 0	144 / 44	40 / 12
(112, 114)	20	15	504 / 154	40 / 12	0 / 0	0 / 0
(312, 314)	20	15	0 / 0	0 / 0	504 / 154	40 / 12
(116, 216)	20	15	0 / 0	0 / 0	184 / 56	40 / 12
(316, 318)	20	15	0 / 0	0 / 0	352 / 107	352 / 107
(418, 416)	20	15	0 / 0	0 / 0	800 / 244	40 / 12
(222, 220)	20	15	240 / 73	40 / 12	0 / 0	0 / 0
(422, 420)	20	15	0 / 0	0 / 0	400 / 122	40 / 12
(522, 422)	20	15	0 / 0	0 / 0	184 / 56	40 / 12
(220, 219)	20	15	0 / 0	0 / 0	304 / 93	40 / 12
(419, 418)	20	15	0 / 0	0 / 0	352 / 107	40 / 12
(518, 519)	20	15	488 / 149	40 / 12	0 / 0	0 / 0
(620, 618)	20	15	824 / 251	40 / 12	0 / 0	0 / 0
(516, 518)	20	15	824 / 251	40 / 12	0 / 0	0 / 0

(420, 419)	20	15	0 / 0	0 / 0	304 / 93	40 / 12
(314, 316)	20	15	0 / 0	0 / 0	144 / 44	40 / 12
(214, 314)	20	15	120 / 37	40 / 12	120 / 37	40 / 12
(216, 316)	20	15	184 / 56	40 / 12	120 / 37	40 / 12
(218, 216)	20	15	424 / 129	40 / 12	0 / 0	0 / 0

BASE LINE CASE (CASE A SCENARIO 1 AND 2)

PROPERTIES OF PICKUP AND DELIVERY STATIONS

PICKUP STATION NO.	LANE SERVICED	LINK	DISTANCE FROM UPSTREAM NODE FEET	/ METERS	CAPACITY (TRUCKS)	MEAN DWELL (SEC)	TYPE	PERCENT OF TRUCKS STOPPING
1	0	(312, 314)	270	82	3	500	1	100
2	0	(312, 314)	500	152	6	500	1	100
3	0	(312, 314)	710	216	6	500	1	100
4	0	(314, 316)	250	76	3	500	1	100
5	0	(316, 318)	240	73	3	500	1	100
6	0	(316, 318)	460	140	6	500	1	100
7	0	(316, 318)	930	283	6	500	1	100
8	0	(318, 319)	330	101	6	500	1	100
9	0	(318, 319)	610	186	6	500	1	100
10	0	(319, 320)	210	64	3	500	1	100
11	0	(319, 320)	420	128	6	500	1	100

THE TYPE CODE IDENTIFIES THE APPLICABLE STATISTICAL DISTRIBUTION OF DWELL TIME

TRUCK ROUTE PATH

ROUTE	SEQUENCE OF NODES DEFINING PATH
1	8121 310 312 314 316 318 319 320 322 324 8122

TRUCK STATIONS BY ROUTE

ROUTE	SEQUENCE OF STATIONS SERVICED BY ROUTE
1	1 2 7 10

BUS VOLUMES

ROUTE	VOLUME (VEH/HR)	MEAN HEADWAY (SEC)
1	7	550

SIMULATION OUTPUT BASE LINE CASE (CASE A SCENARIO 1 AND 2)

NETSIM SECTION SPECIFIC STATISTICS

	SECTION	VEHICLE MILES	VEHICLE TRIPS	VEHICLE-MINUTES DELAY TIME	VEHICLE-MINUTES TOTAL TIME	AVERAGE VALUES TRAVEL TIME (SEC/VEH-TRIP)	AVERAGE VALUES SPEED (MPH)	AVERAGE VALUES STOPS (PER TRIP)	AVERAGE VALUES CONTENT (VEH)
0	1	258.80	534	1386.12	1903.72	214.0	8.2	3.0	41
0	2	316.97	558	1349.51	1983.45	213.3	9.6	3.2	44
0	3	338.23	551	1698.41	2374.87	258.5	8.5	3.7	53
0	4	108.86	364	640.93	858.65	141.6	7.6	2.0	19
0	5	258.72	390	1369.10	1886.55	290.0	8.2	3.7	41
0	6	156.07	235	1434.38	1746.52	445.1	5.4	4.7	37
0	7	149.59	226	2313.21	2612.40	694.6	3.4	4.6	57
0	8	229.80	347	1409.19	1868.80	323.4	7.4	4.4	41
0	9	245.05	924	1200.14	1690.23	109.7	8.7	1.9	36
0	10	208.38	786	603.33	1020.10	77.9	12.3	1.5	23
0	11	264.52	998	722.23	1251.27	75.3	12.7	1.3	27
0	12	278.97	1052	1088.80	1646.75	93.9	10.2	1.5	36
0	13	255.38	963	1006.19	1516.95	94.5	10.1	1.9	34
0	14	253.22	955	851.62	1358.07	85.3	11.2	1.5	30
0	15	185.18	279	948.43	1318.78	283.3	8.4	3.6	28
0	16	132.92	201	944.08	1209.92	362.0	6.6	3.9	26
1									

NETSIM TRUCK STATISTICS

LINK	TRUCK TRIPS	TRAVEL TIME (MINUTES)	MOVING TIME (MINUTES)	DELAY TIME (MINUTES)	M/T	SPEED (MPH)	NUMBER OF STOPS
(8121, 310)	5						
(310, 312)	5	3.2	.2	3.0	.06	1.8	0
(312, 314)	5	44.7	1.4	43.4	.03	.9	5
(314, 316)	5	.9	.5	.5	.52	15.6	0
(316, 318)	4	37.2	1.4	35.8	.04	1.1	5
(318, 319)	4	4.3	1.0	3.4	.22	6.6	0
(319, 320)	3	27.9	.5	27.4	.02	.5	4
(320, 322)	3	1.3	.6	.7	.47	14.0	0
(322, 324)	3	.3	.1	.2	.36	10.8	0

NETSIM TRUCK-STATION STATISTICS

STATION NUMBER	TIME CAPACITY EXCEEDED (MINUTES)	TIME EMPTY (MINUTES)	TOTAL DWELL TIME (TRUCK-MIN.)	TRUCKS SERVICED
2	.0	4.6	40.5	5
7	.0	4.1	39.0	4
10	.0	15.8	29.5	3

1

CUMULATIVE NETWORK-WIDE TRUCK STATISTICS AT TIME 8:45: 0

ELAPSED TIME IS 0:45: 0 (2700 SECONDS), TIME PERIOD 1 ELAPSED TIME IS 2700 SECONDS

ROUTE STATISTICS

ROUTE	TRUCK TRIPS	TOTAL TRAVEL TIME (TRUCK-MIN.)	MEAN TRAVEL TIME (SEC/TRUCK)	TRAVEL TIME (MINUTES)
1	3	120.0	2399.3	2999.2

INPUT DATA SCENARIO 1 CASE B

TRUCK ROUTE PATHS

ROUTE	SEQUENCE OF NODES DEFINING PATH
1	8121 310 312 314 414 412 312 212 112 114 214 314 316 318 218 118 120 220 320 420 419 418 318 319 320 322 324 8122

TRUCK STATIONS BY ROUTE

ROUTE	SEQUENCE OF STATIONS SERVICED BY ROUTE
1	2 7 10

TRUCK VOLUMES

ROUTE	VOLUME (VEH/HR)	MEAN HEADWAY (SEC)
1	7	550

SIMULATION OUTPUT SCENARIO 1 CASE B

NETSIM SECTION SPECIFIC STATISTICS

				VEHICLE-MINUTES		--------------	AVERAGE VALUES		--------------
		VEHICLE	VEHICLE	DELAY	TOTAL	TRAVEL TIME	SPEED	STOPS	CONTENT
	SECTION	MILES	TRIPS	TIME	TIME	(SEC/VEH-TRIP)	(MPH)	(PER TRIP)	(VEH)
0	1	261.01	538	1517.40	2039.42	227.3	7.7	3.2	45
0	2	323.22	569	1293.81	1940.25	204.6	10.0	3.1	42
0	3	338.81	552	1613.09	2290.72	248.9	8.9	3.7	50
0	4	106.96	357	580.85	794.77	133.4	8.1	2.0	17
0	5	254.06	383	1190.37	1698.48	265.9	9.0	3.6	36
0	6	158.86	240	1593.82	1911.53	478.6	5.0	4.5	42
0	7	156.56	236	1513.49	1826.62	464.0	5.1	4.7	39
0	8	233.43	352	1727.57	2194.43	373.9	6.4	4.4	49
0	9	246.06	928	1470.22	1962.33	126.9	7.5	2.0	43
0	10	206.57	779	676.81	1089.95	83.9	11.4	1.5	23
0	11	266.40	1005	770.92	1303.72	77.9	12.3	1.3	29
0	12	289.83	1093	864.20	1443.85	79.3	12.0	1.4	32
0	13	252.70	953	983.90	1489.30	93.8	10.2	1.9	32
0	14	254.01	958	821.12	1329.15	83.2	11.5	1.4	29
0	15	183.47	277	860.16	1227.10	266.0	9.0	3.6	26
0	16	136.54	206	780.89	1053.97	307.0	7.8	4.0	23
1									

NETSIM TRUCK STATISTICS

LINK	BUS TRIPS	PERSON TRIPS	TRAVEL TIME (MINUTES)	MOVING TIME (MINUTES)	DELAY TIME (MINUTES)	M/T	SPEED (MPH)	NUMBER OF STOPS
(112, 114)	3	75	7.3	.8	6.5	.11	3.2	0
(118, 120)	3	75	2.5	1.2	1.3	.48	14.5	0
(8121, 310)	5	125						
(310, 312)	5	125	3.3	.2	3.1	.06	1.7	0
(312, 314)	5	125	47.3	1.4	46.0	.03	.9	5
(314, 316)	3	75	2.2	.3	1.9	.13	4.0	0
(316, 318)	3	75	28.6	1.1	27.5	.04	1.1	3
(318, 319)	2	50	.9	.5	.4	.53	15.9	0
(319, 320)	1	25	9.1	.2	9.0	.02	.5	2
(320, 322)	1	25	.3	.2	.1	.66	19.7	0
(322, 324)	1	25	.1	.0	.0	.73	22.7	0
(420, 419)	2	50	.9	.3	.6	.37	11.1	0
(419, 418)	2	50	5.0	.5	4.6	.09	2.8	0
(414, 412)	4	100	17.8	1.1	16.7	.06	1.8	0
(412, 312)	4	100	4.7	.4	4.3	.09	2.7	0
(312, 212)	4	100	.8	.4	.4	.54	16.2	0
(212, 112)	4	100	1.3	.4	.9	.33	9.9	0
(114, 214)	3	75	1.5	.3	1.2	.21	6.3	0
(214, 314)	3	75	1.2	.3	.8	.27	8.2	0
(314, 414)	5	125	3.3	.5	2.8	.16	4.8	0
(418, 318)	2	50	2.6	.2	2.4	.08	2.4	0
(318, 218)	3	75	2.3	.3	2.0	.13	4.1	0
(218, 118)	3	75	1.2	.3	.8	.27	8.2	0
(120, 220)	3	75	1.3	.3	.9	.25	7.6	0
(220, 320)	3	75	.5	.3	.2	.61	18.5	0
(320, 420)	2	50	1.4	.2	1.2	.15	4.5	0

NETSIM TRUCK-STATION STATISTICS

PICKUP STATION NUMBER	TIME CAPACITY EXCEEDED (MINUTES)	TIME EMPTY (MINUTES)	TOTAL DWELL TIME (TRUCK-MIN.)	TRUCKS SERVICED
2	.0	4.6	40.5	5
7	.0	17.9	25.0	3
10	.0	30.8	14.2	1

1 1

ROUTE STATISTICS

ROUTE	TRUCK TRIPS	TOTAL TRAVEL TIME (TRUCK-MIN.)	MEAN TRAVEL TIME (SEC/TRUCK)
1	1	147.4	8841.0

APPENDIX C
INPUT AND OUTPUT DATA OF SCENARIO 2

INPUT DATA SCENARIO 2 CASE B

PARKING ACTIVITY SPECIFICATIONS

LINK	DUR. OF PARK. MANEUVERS (SECONDS)	PARKING FREQUENCY (PER HOUR)	RIGHT CURB PARKING ZONE LENGTH FEET / METERS	RIGHT CURB PARKING ZONE DISTANCE TO STOPLINE FEET / METERS	LEFT CURB PARKING ZONE LENGTH FEET / METERS	LEFT CURB PARKING ZONE DISTANCE TO STOPLINE FEET / METERS
(520, 620)	20	15	0 / 0	0 / 0	184 / 56	40 / 12
(520, 522)	20	15	400 / 122	40 / 12	0 / 0	0 / 0
(120, 122)	20	15	0 / 0	0 / 0	304 / 93	40 / 12
(622, 620)	20	15	392 / 119	40 / 12	0 / 0	0 / 0
(618, 616)	20	15	720 / 219	40 / 12	0 / 0	0 / 0
(614, 612)	20	15	0 / 0	0 / 0	680 / 207	40 / 12
(212, 112)	20	15	0 / 0	0 / 0	184 / 56	40 / 12
(312, 212)	20	15	104 / 32	40 / 12	0 / 0	0 / 0
(214, 212)	20	15	544 / 166	40 / 12	0 / 0	0 / 0
(514, 614)	20	15	184 / 56	40 / 12	184 / 56	40 / 12
(422, 322)	20	15	0 / 0	0 / 0	184 / 56	40 / 12
(516, 616)	20	15	184 / 56	40 / 12	184 / 56	40 / 12
(216, 214)	20	15	0 / 0	0 / 0	144 / 44	40 / 12
(118, 120)	20	15	904 / 276	40 / 12	904 / 276	40 / 12
(116, 118)	20	15	0 / 0	0 / 0	800 / 244	40 / 12
(512, 514)	20	15	520 / 158	40 / 12	400 / 122	40 / 12
(514, 516)	20	15	80 / 24	40 / 12	0 / 0	0 / 0
(519, 520)	20	15	320 / 98	40 / 12	0 / 0	0 / 0
(319, 320)	20	15	0 / 0	0 / 0	152 / 46	40 / 12
(219, 218)	20	15	0 / 0	0 / 0	440 / 134	40 / 12
(114, 116)	20	15	0 / 0	0 / 0	184 / 56	40 / 12
(414, 412)	20	15	0 / 0	0 / 0	600 / 183	40 / 12
(420, 520)	20	15	0 / 0	0 / 0	184 / 56	40 / 12
(114, 214)	10	15	184 / 56	40 / 12	184 / 56	40 / 12
(414, 514)	20	15	184 / 56	40 / 12	184 / 56	40 / 12
(314, 414)	20	15	120 / 37	40 / 12	120 / 37	40 / 12
(416, 516)	20	15	184 / 56	40 / 12	184 / 56	40 / 12
(318, 218)	20	15	0 / 0	0 / 0	184 / 56	40 / 12
(416, 414)	20	15	0 / 0	0 / 0	144 / 44	40 / 12
(220, 320)	20	15	0 / 0	0 / 0	184 / 56	40 / 12
(112, 114)	20	15	504 / 154	40 / 12	0 / 0	0 / 0
(312, 314)	20	15	0 / 0	0 / 0	504 / 154	40 / 12
(116, 216)	20	15	0 / 0	0 / 0	184 / 56	40 / 12
(316, 318)	20	15	0 / 0	0 / 0	352 / 107	352 / 107
(418, 416)	20	15	0 / 0	0 / 0	800 / 244	40 / 12
(222, 220)	20	15	240 / 73	40 / 12	0 / 0	0 / 0
(422, 420)	20	15	0 / 0	0 / 0	400 / 122	40 / 12

DUR. OF PARK. LINK	PARKING MANEUVERS (SECONDS)	FREQUENCY (PER HOUR)	RIGHT CURB PARKING ZONE LENGTH FEET / METERS	RIGHT CURB PARKING ZONE DISTANCE TO STOPLINE FEET / METERS	LEFT CURB PARKING ZONE LENGTH FEET / METERS	LEFT CURB PARKING ZONE DISTANCE TO STOPLINE FEET / METERS
(522, 422)	20	15	0 / 0	0 / 0	184 / 56	40 / 12
(418, 318)	20	15	0 / 0	0 / 0	184 / 56	40 / 12
(220, 219)	20	15	0 / 0	0 / 0	312 / 95	40 / 12
(120, 220)	20	15	0 / 0	0 / 0	184 / 56	40 / 12
(419, 418)	20	15	0 / 0	0 / 0	352 / 107	40 / 12
(518, 519)	20	15	504 / 154	40 / 12	0 / 0	0 / 0
(618, 518)	20	15	0 / 0	0 / 0	184 / 56	40 / 12
(620, 618)	20	15	824 / 251	40 / 12	0 / 0	0 / 0
(518, 418)	20	15	0 / 0	0 / 0	184 / 56	40 / 12
(516, 518)	20	15	824 / 251	40 / 12	0 / 0	0 / 0
(420, 419)	20	15	0 / 0	0 / 0	312 / 95	40 / 12
(320, 420)	20	15	0 / 0	0 / 0	184 / 56	40 / 12
(314, 316)	20	15	0 / 0	0 / 0	144 / 44	40 / 12
(214, 314)	20	15	120 / 37	40 / 12	120 / 37	40 / 12
(216, 316)	20	15	184 / 56	40 / 12	120 / 37	40 / 12
(218, 216)	20	15	424 / 129	40 / 12	0 / 0	0 / 0

SIMULATION OUTPUT SCENARIO 2 CASE B

NETSIM SECTION SPECIFIC STATISTICS

				VEHICLE-MINUTES		-------------- AVERAGE VALUES --------------			
		VEHICLE	VEHICLE	DELAY	TOTAL	TRAVEL TIME	SPEED	STOPS	CONTENT
	SECTION	MILES	TRIPS	TIME	TIME	(SEC/VEH-TRIP)	(MPH)	(PER TRIP)	(VEH)
0	1	228.97	472	1563.12	2021.05	256.8	6.8	3.2	44
0	2	225.18	396	3536.19	3986.55	603.5	3.4	3.3	89
0	3	261.83	427	3882.57	4406.23	619.6	3.6	3.9	96
0	4	69.87	233	407.83	547.57	140.7	7.7	2.1	11
0	5	179.01	270	2502.13	2860.15	635.5	3.8	3.6	62
0	6	108.59	164	2172.17	2389.35	875.1	2.7	4.6	53
0	7	108.20	163	3257.25	3473.65	1276.9	1.9	4.4	76
0	8	192.32	290	1532.40	1917.03	396.5	6.0	4.4	41
0	9	235.20	887	1175.70	1646.10	111.3	8.6	1.8	35
0	10	169.39	639	875.92	1214.70	114.1	8.4	1.5	27
0	11	190.16	717	1544.82	1925.13	161.1	5.9	1.3	42
0	12	178.59	674	3603.48	3960.67	352.8	2.7	1.7	87
0	13	212.53	802	1618.27	2043.33	153.0	6.2	2.0	44
0	14	236.21	891	892.49	1364.92	91.9	10.4	1.4	31
0	15	137.31	207	1474.77	1749.40	506.7	4.7	3.8	39
0	16	103.36	156	1231.70	1438.43	553.5	4.3	3.9	31
1									

NETSIM BUS STATISTICS

LINK	BUS TRIPS	PERSON TRIPS	TRAVEL TIME (MINUTES)	MOVING TIME (MINUTES)	DELAY TIME (MINUTES)	M/T	SPEED (MPH)	NUMBER OF STOPS
(8121, 310)	5	125						
(310, 312)	5	125	3.2	.2	3.0	.06	1.8	0
(312, 314)	4	100	36.0	1.1	34.9	.03	.9	5
(314, 316)	4	100	.8	.4	.4	.48	14.5	0
(316, 318)	2	50	18.4	.7	17.7	.04	1.2	3
(318, 319)	2	50	2.2	.5	1.8	.21	6.4	0
(319, 320)	2	50	18.7	.3	18.4	.02	.5	2
(320, 322)	2	50	.6	.4	.2	.62	18.7	0
(322, 324)	2	50	.1	.1	.0	.90	27.3	0

NETSIM BUS-STATION STATISTICS

STATION NUMBER	TIME CAPACITY EXCEEDED (MINUTES)	TIME EMPTY (MINUTES)	TOTAL DWELL TIME (BUS-MIN.)	BUSES SERVICED
2	.0	4.4	40.6	5
7	.0	15.3	25.0	3
10	.0	28.4	16.7	2

1 1 CUMULATIVE NETWORK-WIDE BUS STATISTICS AT TIME 8:45: 0

ELAPSED TIME IS 0:45: 0 (2700 SECONDS), TIME PERIOD 1 ELAPSED TIME IS 2700 SECONDS

ROUTE STATISTICS

ROUTE	BUS TRIPS	TOTAL TRAVEL TIME (BUS-MIN.)	MEAN TRAVEL TIME (SEC/BUS)	PERSON TRIPS	PERSON TRAVEL TIME (MINUTES)
1	2	80.0	2401.0	50	2000.8

THESE ESTIMATES ASSUME AN AVERAGE BUS OCCUPANCY OF 25 PASSENGERS PER BUS THROUGHOUT THE NETWORK

OLAST CASE PROCESSED

APPENDIX D
INPUT AND OUTPUT DATA OF SCENARIO 3

INPUT DATA SCENARIO 3 CASE A

NETSIM LINKS

0

LINK	LENGTH FT / M	LANES: FUL L	LANES: PKT L	LANES: PKT R	GRD PCT	LINK TYPE	CHANNEL: CUR B234567	DESTINATION NODE LEFT	DESTINATION NODE THRU	DESTINATION NODE RGHT	DESTINATION NODE DIAG	OPP. NODE	LOST TIME SEC	Q DIS HDWY. SEC	FREE SPEED MPH/KMPH	RTOR CODE	PED CODE	LANE ALIGN -MENT	STREET NAME
(8101, 110)	0/ 0	2	0	0	0	1*	0000000	0	112	0	0	0	.5	1.4	0/ 0	1	3	1-1	52 St
(110, 112)	100/ 30	2	0	0	0	1*	0000000	12	114	0	0	0	.5	1.4	30/ 48	1	3	1-1	52 St
(112, 114)	680/ 207	2	0	0	0	1*	0000000	0	116	214	0	0	.5	1.4	30/ 48	1	3	1-1	52 St
(114, 116)	300/ 91	2	0	0	0	1*	0000000	0	118	216	0	0	.5	1.4	30/ 48	1	3	1-1	52 St
(116, 118)	940/ 287	2	0	0	0	1*	0000000	18	120	0	0	0	.5	1.4	30/ 48	1	3	1-1	52 St
(118, 120)	1060/ 323	2	0	0	0	1*	0000000	0	122	220	0	0	.5	1.4	30/ 48	1	3	1-1	52 St
(120, 122)	520/ 158	2	0	0	0	1*	0000000	22	124	0	0	0	.5	1.4	30/ 48	1	3	1-1	52 St
(122, 124)	100/ 30	2	0	0	0	1*	0000000	0	8102	0	0	0	.5	1.4	30/ 48	1	3	1-1	52 St
(8112, 224)	0/ 0	2	0	0	0	1*	0000000	0	222	0	0	0	.5	1.4	0/ 0	1	3	1-1	51 St
(224, 222)	100/ 30	2	0	0	0	1*	0000000	0	220	122	0	0	.5	1.4	30/ 48	1	3	1-1	51 St
(222, 220)	520/ 158	2	0	0	0	1*	0000000	320	219	0	0	0	.5	1.4	30/ 48	1	3	1-1	51 St
(220, 219)	430/ 131	2	0	0	0	1*	0000000	0	218	0	0	0	.5	1.4	30/ 48	1	3	1-1	51 St
(219, 218)	630/ 192	2	0	0	0	1*	0000000	0	216	118	0	0	.5	1.4	30/ 48	1	3	1-1	51 St
(218, 216)	940/ 287	2	0	0	0	1*	0000000	316	214	0	0	0	.5	1.4	30/ 48	1	3	1-1	51 St
(216, 214)	280/ 85	2	0	0	0	1*	0000000	314	212	0	0	0	.5	1.4	30/ 48	1	3	1-1	51 St
(214, 212)	700/ 213	2	0	0	0	1*	0000000	0	210	112	0	0	.5	1.4	30/ 48	1	3	1-1	51 St
(212, 210)	100/ 30	2	0	0	0	1*	0000000	0	8111	0	0	0	.5	1.4	30/ 48	1	3	1-1	51 St
(8121, 310)	0/ 0	2	0	0	0	1*	0000000	0	312	0	0	0	.5	1.4	0/ 0	1	3	1-1	50 St
(310, 312)	100/ 30	2	0	0	0	1*	0000000	212	314	0	0	0	.5	1.4	30/ 48	1	3	1-1	50 St
(312, 314)	720/ 219	2	0	0	0	1*	0000000	0	316	414	0	0	.5	1.4	30/ 48	1	3	1-1	50 St
(314, 316)	260/ 79	2	0	0	0	1*	0000000	0	318	416	0	0	.5	1.4	30/ 48	1	3	1-1	50 St
(316, 318)	940/ 287	2	0	0	0	1*	0000000	218	319	0	0	0	.5	1.4	30/ 48	1	3	1-1	50 St
(318, 319)	630/ 192	2	0	0	0	1*	0000000	219	320	0	0	0	.5	1.4	30/ 48	1	3	1-1	50 St
(319, 320)	430/ 131	2	0	0	0	1*	0000000	0	322	420	0	0	.5	1.4	30/ 48	1	3	1-1	50 St
(320, 322)	520/ 158	2	0	0	0	1*	0000000	222	324	0	0	0	.5	1.4	30/ 48	1	3	1-1	50 St
(322, 324)	100/ 30	2	0	0	0	1*	0000000	0	8122	0	0	0	.5	1.4	30/ 48	1	3	1-1	50 St
(8132, 424)	0/ 0	2	0	0	0	1*	0000000	0	422	0	0	0	.5	1.4	0/ 0	1	3	1-1	49 St
(424, 422)	100/ 30	2	0	0	0	1*	0000000	0	420	322	0	0	.5	1.4	30/ 48	1	3	1-1	49 St
(422, 420)	520/ 158	2	0	0	0	1*	0000000	520	419	0	0	0	.5	1.4	30/ 48	1	3	1-1	49 St
(420, 419)	430/ 131	2	0	0	0	1*	0000000	0	418	319	0	0	.5	1.4	30/ 48	1	3	1-1	49 St
(419, 418)	630/ 192	2	0	0	0	1*	0000000	0	416	318	0	0	.5	1.4	30/ 48	1	3	1-1	49 St
(418, 416)	940/ 287	2	0	0	0	1*	0000000	516	414	0	0	0	.5	1.4	30/ 48	1	3	1-1	49 St
(416, 414)	260/ 79	2	0	0	0	1*	0000000	514	412	0	0	0	.5	1.4	30/ 48	1	3	1-1	49 St
(414, 412)	720/ 219	2	0	0	0	1*	0000000	0	410	312	0	0	.5	1.4	30/ 48	1	3	1-1	49 St
(412, 410)	100/ 30	2	0	0	0	1*	0000000	0	8131	0	0	0	.5	1.4	30/ 48	1	3	1-1	49 St

-LANES- -CHANNEL-

LINK	LENGTH FT / M	FUL L	PKT L	PKT R	GRD PCT	LINK TYPE	CUR B234567	DESTINATION NODE LEFT	THRU	RGHT	DIAG	OPP. NODE	LOST TIME SEC	Q DIS HDWY. SEC	FREE SPEED MPH/KMPH	RTOR CODE	PED CODE	LANE ALIGN -MENT	STREET NAME
(8141, 510)	0/ 0	2	0	0	0	1*	0000000	0	512	0	0	0	.5	1.4	0/ 0	1	3	1-1	48 St
(510, 512)	100/ 30	2	0	0	0	1*	0000000	412	514	0	0	0	.5	1.4	30/ 48	1	3	1-1	48 St
(512, 514)	760/ 232	2	0	0	0	1*	0000000	0	516	614	0	0	.5	1.4	30/ 48	1	3	1-1	48 St
(514, 516)	220/ 67	2	0	0	0	1*	0000000	0	518	616	0	0	.5	1.4	30/ 48	1	3	1-1	48 St
(516, 518)	940/ 287	2	0	0	0	1*	0000000	418	519	0	0	0	.5	1.4	30/ 48	1	3	1-1	48 St
(518, 519)	630/ 192	2	0	0	0	1*	0000000	419	520	0	0	0	.5	1.4	30/ 48	1	3	1-1	48 St
(519, 520)	430/ 131	2	0	0	0	1*	0000000	0	522	620	0	0	.5	1.4	30/ 48	1	3	1-1	48 St
(520, 522)	520/ 158	2	0	0	0	1*	0000000	422	524	0	0	0	.5	1.4	30/ 48	1	3	1-1	48 St
(522, 524)	100/ 30	2	0	0	0	1*	0000000	0	8142	0	0	0	.5	1.4	30/ 48	1	3	1-1	48 St
(8152, 624)	0/ 0	2	0	0	0	1*	0000000	0	622	0	0	0	.5	1.4	0/ 0	1	3	1-1	47 St
(624, 622)	100/ 30	2	0	0	0	1*	0000000	0	620	522	0	0	.5	1.4	30/ 48	1	3	1-1	47 St
(622, 620)	520/ 158	2	0	0	0	1*	0000000	720	618	0	0	0	.5	1.4	30/ 48	1	3	1-1	47 St
(620, 618)	1060/ 323	2	0	0	0	1*	0000000	0	616	518	0	0	.5	1.4	30/ 48	1	3	1-1	47 St
(618, 616)	940/ 287	2	0	0	0	1*	0000000	716	614	0	0	0	.5	1.4	30/ 48	1	3	1-1	47 St
(616, 614)	180/ 55	3	0	0	0	1*	0000000	714	612	0	0	0	.5	1.4	30/ 48	1	3	1-1	47 St
(614, 612)	800/ 244	2	0	0	0	1*	0000000	0	610	512	0	0	.5	1.4	30/ 48	1	3	1-1	47 St
(612, 610)	100/ 30	2	0	0	0	1*	0000000	0	8151	0	0	0	.5	1.4	30/ 48	1	3	1-1	47 St
(8002, 712)	0/ 0	6	0	0	0	1*	0000000	0	612	0	0	0	.5	1.4	0/ 0	1	3	1-1	Eighth Ave
(712, 612)	100/ 30	6	0	0	0	1*	0000000	610	512	0	0	0	.5	1.4	30/ 48	1	3	1-1	Eighth Ave
(612, 512)	280/ 85	6	0	0	0	1*	0000000	0	412	514	0	0	.5	1.4	30/ 48	1	3	1-1	Eighth Ave
(512, 412)	280/ 85	6	0	0	0	1*	0000000	410	312	0	0	0	.5	1.4	30/ 48	1	3	1-1	Eighth Ave
(412, 312)	280/ 85	6	0	0	0	1*	0000000	0	212	314	0	0	.5	1.4	30/ 48	1	3	1-1	Eighth Ave
(312, 212)	280/ 85	5	0	0	0	1*	0000000	210	112	0	0	0	.5	1.4	30/ 48	1	3	1-1	Eighth Ave
(212, 112)	280/ 85	5	0	0	0	1*	0000000	0	12	114	0	0	.5	1.4	30/ 48	1	3	1-1	Eighth Ave
(112, 12)	100/ 30	5	0	0	0	1*	0000000	0	8001	0	0	0	.5	1.4	30/ 48	1	3	1-1	Eighth Ave
(8011, 14)	0/ 0	4	0	0	0	1*	0000000	0	114	0	0	0	.5	1.4	0/ 0	1	3	1-1	Broadway
(14, 114)	100/ 30	4	0	0	0	1*	0000000	116	214	0	0	0	.5	1.4	30/ 48	1	3	1-1	Broadway
(114, 214)	280/ 85	4	0	0	0	1*	0000000	0	314	212	0	0	.5	1.4	30/ 48	1	3	1-1	Broadway
(214, 314)	280/ 85	4	0	0	0	1*	0000000	316	414	0	0	0	.5	1.4	30/ 48	1	3	1-1	Broadway
(314, 414)	280/ 85	4	0	0	0	1*	0000000	0	514	412	0	0	.5	1.4	30/ 48	1	3	1-1	Broadway
(414, 514)	280/ 85	4	0	0	0	1*	0000000	516	614	0	0	0	.5	1.4	30/ 48	1	3	1-1	Broadway
(514, 614)	280/ 85	4	0	0	0	1*	0000000	0	714	612	0	0	.5	1.4	30/ 48	1	3	1-1	Broadway
(614, 714)	100/ 30	4	0	0	0	1*	0000000	0	8012	0	0	0	.5	1.4	30/ 48	1	3	1-1	Broadway
(8021, 16)	0/ 0	5	0	0	0	1*	0000000	0	116	0	0	0	.5	1.4	0/ 0	1	3	1-1	Seventh Ave
(16, 116)	100/ 30	5	0	0	0	1*	0000000	118	216	0	0	0	.5	1.4	30/ 48	1	3	1-1	Seventh Ave
(116, 216)	280/ 85	5	0	0	0	1*	0000000	0	316	214	0	0	.5	1.4	30/ 48	1	3	1-1	Seventh Ave
(216, 316)	280/ 85	4	0	0	0	1*	0000000	318	416	0	0	0	.5	1.4	30/ 48	1	3	1-1	Seventh Ave
(316, 416)	280/ 85	4	0	0	0	1*	0000000	0	516	414	0	0	.5	1.4	30/ 48	1	3	1-1	Seventh Ave
(416, 516)	280/ 85	4	0	0	0	1*	0000000	518	616	0	0	0	.5	1.4	30/ 48	1	3	1-1	Seventh Ave
(516, 616)	280/ 85	4	0	0	0	1*	0000000	0	716	614	0	0	.5	1.4	30/ 48	1	3	1-1	Seventh Ave

-LANES- -CHANNEL-

LINK	LENGTH FT / M	FUL L	PKT L	PKT R	GRD PCT	LINK TYPE	CUR B234567	DESTINATION NODE LEFT	THRU	RGHT	DIAG	OPP. NODE	LOST TIME SEC	Q DIS HDWY. SEC	FREE SPEED MPH/KMPH	RTOR CODE	PED CODE	LANE ALIGN -MENT	STREET NAME
(616, 716)	100/ 30	4	0	0	0	1*	0000000	0	8022	0	0	0	.5	1.4	30/ 48	1	3	1-1	Seventh Ave
(8032, 718)	0/ 0	6	0	0	0	1*	0000000	0	618	0	0	0	.5	1.4	0/ 0	1	3	1-1	Sixth Ave
(718, 618)	100/ 30	6	0	0	0	1*	0000000	616	518	0	0	0	.5	1.4	30/ 48	1	3	1-1	Sixth Ave
(618, 518)	280/ 85	6	0	0	0	1*	0000000	0	418	519	0	0	.5	1.4	30/ 48	1	3	1-1	Sixth Ave
(518, 418)	280/ 85	5	0	0	0	1*	0000000	416	318	0	0	0	.5	1.4	30/ 48	1	3	1-1	Sixth Ave
(418, 318)	280/ 85	5	0	0	0	1*	0000000	0	218	319	0	0	.5	1.4	30/ 48	1	3	1-1	Sixth Ave
(318, 218)	280/ 85	5	0	0	0	1*	0000000	216	118	0	0	0	.5	1.4	30/ 48	1	3	1-1	Sixth Ave
(218, 118)	280/ 85	5	0	0	0	1*	0000000	0	18	120	0	0	.5	1.4	30/ 48	1	3	1-1	Sixth Ave
(118, 18)	100/ 30	5	0	0	0	1*	0000000	0	8031	0	0	0	.5	1.4	30/ 48	1	3	1-1	Sixth Ave
(519, 419)	280/ 85	1	0	0	0	1*	0000000	418	319	0	0	0	.5	1.4	30/ 48	1	3	1-1	Rocky Plaza
(419, 319)	280/ 85	1	0	0	0	1*	0000000	0	219	320	0	0	.5	1.4	30/ 48	1	3	1-1	Rocky Plaza
(319, 219)	280/ 85	1	0	0	0	1*	0000000	218	0	0	0	0	.5	1.4	30/ 48	1	3	1-1	Rocky Plaza
(8041, 20)	0/ 0	5	0	0	0	1*	0000000	0	120	0	0	0	.5	1.4	0/ 0	1	3	1-1	Fifth Ave
(20, 120)	100/ 30	5	0	0	0	1*	0000000	122	220	0	0	0	.5	1.4	30/ 48	1	3	1-1	Fifth Ave
(120, 220)	280/ 85	5	0	0	0	1*	0000000	0	320	219	0	0	.5	1.4	30/ 48	1	3	1-1	Fifth Ave
(220, 320)	280/ 85	5	0	0	0	1*	0000000	322	420	0	0	0	.5	1.4	30/ 48	1	3	1-1	Fifth Ave
(320, 420)	280/ 85	5	0	0	0	1*	0000000	0	520	419	0	0	.5	1.4	30/ 48	1	3	1-1	Fifth Ave
(420, 520)	280/ 85	5	0	0	0	1*	0000000	522	620	0	0	0	.5	1.4	30/ 48	1	3	1-1	Fifth Ave
(520, 620)	280/ 85	5	0	0	0	1*	0000000	0	720	618	0	0	.5	1.4	30/ 48	1	3	1-1	Fifth Ave
(620, 720)	100/ 30	5	0	0	0	1*	0000000	0	8042	0	0	0	.5	1.4	30/ 48	1	3	1-1	Fifth Ave
(8052, 722)	0/ 0	5	0	0	0	1*	0000000	0	622	0	0	0	.5	1.4	0/ 0	1	3	1-1	Madison Ave
(722, 622)	100/ 30	5	0	0	0	1*	0000000	620	522	0	0	0	.5	1.4	30/ 48	1	3	1-1	Madison Ave
(622, 522)	280/ 85	5	0	0	0	1*	0000000	0	422	524	0	0	.5	1.4	30/ 48	1	3	1-1	madison Ave
(522, 422)	280/ 85	4	0	0	0	1*	0000000	420	322	0	0	0	.5	1.4	30/ 48	1	3	1-1	Madison Ave
(422, 322)	280/ 85	4	0	0	0	1*	0000000	0	222	324	0	0	.5	1.4	30/ 48	1	3	1-1	Madison Ave
(322, 222)	280/ 85	5	0	0	0	1*	0000000	220	122	0	0	0	.5	1.4	30/ 48	1	3	1-1	Madison Ave
(222, 122)	280/ 85	5	0	0	0	1*	0000000	0	22	124	0	0	.5	1.4	30/ 48	1	3	1-1	Madison Ave
(122, 22)	100/ 30	5	0	0	0	1*	0000000	0	8051	0	0	0	.5	1.4	30/ 48	1	3	1-1	Madison Ave

* INDICATES DEFAULT VALUES WERE SPECIFIED

LINK TYPE

IDENTIFIES THE DISTRIBUTION USED FOR QUEUE DISCHARGE AND START-UP LOST TIME CHARACTERISTICS.

LANE CHANNELIZATION CODES

0 UNRESTRICTED
1 LEFT TURNS ONLY
2 BUSES ONLY
3 CLOSED
4 RIGHT TURNS ONLY
5 CAR - POOLS
6 CAR - POOLS + BUSES

RTOR CODES

0 RTOR PERMITTED
1 RTOR PROHIBITED

PEDESTRIAN CODES

0 NO PEDESTRIANS
1 LIGHT
2 MODERATE
3 HEAVY

SIMULATION OUTPUT SCENARIO 3 CASE A

NETSIM SECTION SPECIFIC STATISTICS

				VEHICLE-MINUTES		AVERAGE VALUES			
	SECTION	VEHICLE MILES	VEHICLE TRIPS	DELAY TIME	TOTAL TIME	TRAVEL TIME (SEC/VEH-TRIP)	SPEED (MPH)	STOPS (PER TRIP)	CONTENT (VEH)
0	1	264.01	545	1145.31	1673.33	184.4	9.5	3.1	36
0	2	304.69	536	1574.48	2183.87	244.3	8.4	3.2	48
0	3	338.00	551	2017.81	2693.80	293.4	7.5	3.8	60
0	4	103.75	347	763.07	970.57	168.0	6.4	2.2	21
0	5	246.26	372	1447.72	1940.25	313.4	7.6	4.1	42
0	6	163.58	247	1543.33	1870.48	454.8	5.2	4.7	40
0	7	145.13	219	2962.26	3252.52	891.4	2.7	4.7	70
0	8	232.63	351	1609.72	2074.98	354.8	6.7	4.4	45
0	9	247.49	933	1497.02	1992.00	128.1	7.5	2.0	42
0	10	208.19	785	612.15	1028.53	78.6	12.1	1.5	23
0	11	260.58	983	737.84	1259.00	76.9	12.4	1.3	27
0	12	270.61	1021	1156.74	1697.97	99.8	9.6	1.4	38
0	13	255.35	963	1125.58	1636.27	101.9	9.4	2.0	36
0	14	256.37	967	845.80	1358.53	84.3	11.3	1.4	30
0	15	183.00	276	952.56	1318.55	286.6	8.3	3.6	28
0	16	131.48	198	1023.27	1286.22	389.1	6.1	4.0	28
1									

NETSIM BUS STATISTICS

LINK	BUS TRIPS	PERSON TRIPS	TRAVEL TIME (MINUTES)	MOVING TIME (MINUTES)	DELAY TIME (MINUTES)	M/T	SPEED (MPH)	NUMBER OF STOPS
(8121, 310)	7	175						
(310, 312)	7	175	.7	.3	.5	.37	11.1	0
(312, 314)	7	175	7.7	1.9	5.8	.25	7.4	0
(314, 316)	8	200	8.4	.8	7.6	.09	2.8	7
(316, 318)	7	175	3.5	2.5	1.0	.71	21.4	0
(318, 319)	7	175	7.1	1.7	5.4	.24	7.1	7
(319, 320)	7	175	3.0	1.1	1.9	.38	11.4	0
(320, 322)	7	175	12.2	1.4	10.8	.11	3.4	0
(322, 324)	7	175	.7	.3	.4	.39	11.6	0
(8132, 424)	14	350						
(424, 422)	14	350	1.6	.5	1.1	.33	9.9	0
(422, 420)	16	400	18.8	3.2	15.6	.17	5.0	0
(420, 419)	15	375	5.5	2.4	3.0	.45	13.4	0
(419, 418)	12	300	47.5	2.9	44.7	.06	1.8	14
(418, 416)	12	300	10.5	4.3	6.2	.41	12.2	0
(416, 414)	12	300	17.4	1.2	16.3	.07	2.0	12
(414, 412)	12	300	25.0	3.3	21.7	.13	3.9	0
(412, 410)	12	300	1.3	.5	.8	.36	10.8	0
(8002, 712)	5	125						
(712, 612)	5	125	1.0	.2	.8	.19	5.7	0
(612, 512)	5	125	8.8	.5	8.3	.06	1.8	5
(512, 412)	5	125	2.1	.5	1.6	.25	7.6	0
(412, 312)	5	125	5.9	.5	5.4	.09	2.7	5
(312, 212)	5	125	.9	.5	.4	.56	16.7	0
(212, 112)	5	125	.8	.5	.3	.64	19.1	0
(112, 12)	5	125	.3	.2	.1	.71	21.3	0
(8011, 14)	9	225						
(14, 114)	10	250	1.9	.4	1.5	.20	6.1	0
(114, 214)	10	250	2.8	1.1	1.8	.37	11.2	0
(214, 314)	10	250	2.0	1.1	.9	.53	15.9	0
(314, 414)	10	250	7.7	1.1	6.7	.14	4.1	10
(414, 514)	10	250	1.9	1.1	.8	.56	16.7	0
(514, 614)	10	250	2.3	1.1	1.3	.45	13.5	0
(614, 714)	10	250	.6	.4	.3	.58	17.5	0
(8021, 16)	3	75						
(16, 116)	3	75	.9	.1	.8	.13	3.9	0
(116, 216)	3	75	.8	.3	.4	.41	12.5	0
(216, 316)	3	75	.6	.3	.3	.50	15.1	0
(316, 416)	3	75	1.1	.3	.8	.28	8.5	0
(416, 516)	3	75	.8	.3	.5	.38	11.5	0
(516, 616)	3	75	.4	.3	.1	.73	22.0	0
(616, 716)	3	75	.2	.1	.0	.76	22.7	0
(8041, 20)	6	150						
(20, 120)	6	150	1.7	.2	1.5	.13	3.9	0

NETSIM BUS STATISTICS

LINK	BUS TRIPS	PERSON TRIPS	TRAVEL TIME (MINUTES)	MOVING TIME (MINUTES)	DELAY TIME (MINUTES)	M/T	SPEED (MPH)	NUMBER OF STOPS
(220, 320)	6	150	5.5	.6	4.9	.12	3.5	6
(320, 420)	6	150	4.2	.6	3.5	.15	4.6	6
(420, 520)	6	150	2.4	.6	1.7	.27	8.0	0
(520, 620)	6	150	1.8	.6	1.1	.36	10.9	0
(620, 720)	6	150	.5	.2	.3	.45	13.6	0
(8052, 722)	7	175						
(722, 622)	7	175	5.1	.3	4.9	.05	1.6	0
(622, 522)	7	175	4.7	.7	3.9	.16	4.8	7
(522, 422)	8	200	5.8	.8	4.9	.15	4.4	0
(422, 322)	8	200	5.7	.8	4.9	.15	4.4	8
(322, 222)	8	200	4.4	.8	3.5	.19	5.8	0
(222, 122)	8	200	7.6	.8	6.8	.11	3.3	8
(122, 22)	8	200	.8	.3	.5	.38	11.4	0

NETSIM BUS-STATION STATISTICS

STATION NUMBER	TIME CAPACITY EXCEEDED (MINUTES)	TIME EMPTY (MINUTES)	TOTAL DWELL TIME (BUS-MIN.)	BUSES SERVICED
1	.0	43.6	1.7	5
2	.0	43.8	1.3	5
3	.0	42.7	2.5	10
5	.0	43.8	1.5	6
6	.0	43.5	1.5	6
7	.0	43.5	1.8	7
9	.0	42.7	2.7	8
10	.0	42.3	2.7	8
11	.0	42.8	2.5	8
12	.0	42.7	2.3	7
13	.8	40.6	4.7	14
14	1.0	41.4	4.0	12

1

ROUTE STATISTICS

ROUTE	BUS TRIPS	TOTAL TRAVEL TIME (BUS-MIN.)	MEAN TRAVEL TIME (SEC/BUS)	PERSON TRIPS	PERSON TRAVEL TIME (MINUTES)
1	7	43.3	370.7	175	1081.3
2	5	19.9	239.2	125	498.3
3	7	14.0	119.9	175	349.6
4	3	5.3	105.7	75	132.1
5	3	4.8	96.7	75	120.8
6	6	18.0	180.3	150	450.8
7	8	34.1	255.8	200	852.5
8	6	62.8	628.2	150	1570.4
9	6	64.9	648.7	150	1621.7

THESE ESTIMATES ASSUME AN AVERAGE BUS OCCUPANCY OF 25 PASSENGERS PER BUS THROUGHOUT THE NETWORK
0LAST CASE PROCESSED

INPUT DATA SCENARIO 3 CASE B

NETSIM LINKS

0

LINK	LENGTH FT / M	-LANES- FUL L	PKT L	PKT R	GRD PCT	LINK TYPE	-CHANNEL- CUR B234567	DESTINATION NODE LEFT	THRU	RGHT	DIAG	OPP. NODE	LOST TIME SEC	Q DIS HDWY. SEC	FREE SPEED MPH/KMPH	RTOR CODE	PED CODE	LANE ALIGN -MENT	STREET NAME
(8101, 110)	0/ 0	2	0	0	0	1*	0000000	0	112	0	0	0	.5	1.4	0/ 0	1	3	1-1	52 St
(110, 112)	100/ 30	2	0	0	0	1*	0000000	12	114	0	0	0	.5	1.4	30/ 48	1	3	1-1	52 St
(112, 114)	680/ 207	2	0	0	0	1*	0000000	0	116	214	0	0	.5	1.4	30/ 48	1	3	1-1	52 St
(114, 116)	300/ 91	2	0	0	0	1*	0000000	0	118	216	0	0	.5	1.4	30/ 48	1	3	1-1	52 St
(116, 118)	940/ 287	2	0	0	0	1*	0000000	18	120	0	0	0	.5	1.4	30/ 48	1	3	1-1	52 St
(118, 120)	1060/ 323	2	0	0	0	1*	0000000	0	122	220	0	0	.5	1.4	30/ 48	1	3	1-1	52 St
(120, 122)	520/ 158	2	0	0	0	1*	0000000	22	124	0	0	0	.5	1.4	30/ 48	1	3	1-1	52 St
(122, 124)	100/ 30	2	0	0	0	1*	0000000	0	8102	0	0	0	.5	1.4	30/ 48	1	3	1-1	52 St
(8112, 224)	0/ 0	2	0	0	0	1*	0000000	0	222	0	0	0	.5	1.4	0/ 0	1	3	1-1	51 St
(224, 222)	100/ 30	2	0	0	0	1*	0000000	0	220	122	0	0	.5	1.4	30/ 48	1	3	1-1	51 St
(222, 220)	520/ 158	2	0	0	0	1*	0000000	320	219	0	0	0	.5	1.4	30/ 48	1	3	1-1	51 St
(220, 219)	430/ 131	2	0	0	0	1*	0000000	0	218	0	0	0	.5	1.4	30/ 48	1	3	1-1	51 St
(219, 218)	630/ 192	2	0	0	0	1*	0000000	0	216	118	0	0	.5	1.4	30/ 48	1	3	1-1	51 St
(218, 216)	940/ 287	2	0	0	0	1*	0000000	316	214	0	0	0	.5	1.4	30/ 48	1	3	1-1	51 St
(216, 214)	280/ 85	2	0	0	0	1*	0000000	314	212	0	0	0	.5	1.4	30/ 48	1	3	1-1	51 St
(214, 212)	700/ 213	2	0	0	0	1*	0000000	0	210	112	0	0	.5	1.4	30/ 48	1	3	1-1	51 St
(212, 210)	100/ 30	2	0	0	0	1*	0000000	0	8111	0	0	0	.5	1.4	30/ 48	1	3	1-1	51 St
(8121, 310)	0/ 0	2	0	0	0	1*	0000000	0	312	0	0	0	.5	1.4	0/ 0	1	3	1-1	50 St
(310, 312)	100/ 30	2	0	0	0	1*	2000000	212	314	0	0	0	.5	1.4	30/ 48	1	3	1-1	50 St
(312, 314)	720/ 219	2	0	0	0	1*	2000000	0	316	414	0	0	.5	1.4	30/ 48	1	3	1-1	50 St
(314, 316)	260/ 79	2	0	0	0	1*	2000000	0	318	416	0	0	.5	1.4	30/ 48	1	3	1-1	50 St
(316, 318)	940/ 287	2	0	0	0	1*	2000000	218	319	0	0	0	.5	1.4	30/ 48	1	3	1-1	50 St
(318, 319)	630/ 192	2	0	0	0	1*	2000000	219	320	0	0	0	.5	1.4	30/ 48	1	3	1-1	50 St
(319, 320)	430/ 131	2	0	0	0	1*	2000000	0	322	420	0	0	.5	1.4	30/ 48	1	3	1-1	50 St
(320, 322)	520/ 158	2	0	0	0	1*	2000000	222	324	0	0	0	.5	1.4	30/ 48	1	3	1-1	50 St
(322, 324)	100/ 30	2	0	0	0	1*	2000000	0	8122	0	0	0	.5	1.4	30/ 48	1	3	1-1	50 St
(8132, 424)	0/ 0	2	0	0	0	1*	0000000	0	422	0	0	0	.5	1.4	0/ 0	1	3	1-1	49 St
(424, 422)	100/ 30	2	0	0	0	1*	2000000	0	420	322	0	0	.5	1.4	30/ 48	1	3	1-1	49 St
(422, 420)	520/ 158	2	0	0	0	1*	2000000	520	419	0	0	0	.5	1.4	30/ 48	1	3	1-1	49 St
(420, 419)	430/ 131	2	0	0	0	1*	2000000	0	418	319	0	0	.5	1.4	30/ 48	1	3	1-1	49 St
(419, 418)	630/ 192	2	0	0	0	1*	2000000	0	416	318	0	0	.5	1.4	30/ 48	1	3	1-1	49 St
(418, 416)	940/ 287	2	0	0	0	1*	2000000	516	414	0	0	0	.5	1.4	30/ 48	1	3	1-1	49 St
(416, 414)	260/ 79	2	0	0	0	1*	2000000	514	412	0	0	0	.5	1.4	30/ 48	1	3	1-1	49 St
(414, 412)	720/ 219	2	0	0	0	1*	2000000	0	410	312	0	0	.5	1.4	30/ 48	1	3	1-1	49 St
(412, 410)	100/ 30	2	0	0	0	1*	2000000	0	8131	0	0	0	.5	1.4	30/ 48	1	3	1-1	49 St
(8141, 510)	0/ 0	2	0	0	0	1*	0000000	0	512	0	0	0	.5	1.4	0/ 0	1	3	1-1	48 St

-LANES- -CHANNEL-

LINK	LENGTH FT / M	FU L L	PKT L	PKT R	GRD PCT	LINK TYPE	CUR B234567	DESTINATION NODE LEFT	THRU	RGHT	DIAG	OPP. NODE	LOST TIME SEC	Q DIS HDWY. SEC	FREE SPEED MPH/KMPH	RTOR CODE	PED CODE	LANE ALIGN -MENT	STREET NAME
(510, 512)	100/ 30	2	0	0	0	1*	0000000	412	514	0	0	0	.5	1.4	30/ 48	1	3	1-1	48 St
(512, 514)	760/ 232	2	0	0	0	1*	0000000	0	516	614	0	0	.5	1.4	30/ 48	1	3	1-1	48 St
(514, 516)	220/ 67	2	0	0	0	1*	0000000	0	518	616	0	0	.5	1.4	30/ 48	1	3	1-1	48 St
(516, 518)	940/ 287	2	0	0	0	1*	0000000	418	519	0	0	0	.5	1.4	30/ 48	1	3	1-1	48 St
(518, 519)	630/ 192	2	0	0	0	1*	0000000	419	520	0	0	0	.5	1.4	30/ 48	1	3	1-1	48 St
(519, 520)	430/ 131	2	0	0	0	1*	0000000	0	522	620	0	0	.5	1.4	30/ 48	1	3	1-1	48 St
(520, 522)	520/ 158	2	0	0	0	1*	0000000	422	524	0	0	0	.5	1.4	30/ 48	1	3	1-1	48 St
(522, 524)	100/ 30	2	0	0	0	1*	0000000	0	8142	0	0	0	.5	1.4	30/ 48	1	3	1-1	48 St
(8152, 624)	0/ 0	2	0	0	0	1*	0000000	0	622	0	0	0	.5	1.4	0/ 0	1	3	1-1	47 St
(624, 622)	100/ 30	2	0	0	0	1*	0000000	0	620	522	0	0	.5	1.4	30/ 48	1	3	1-1	47 St
(622, 620)	520/ 158	2	0	0	0	1*	0000000	720	618	0	0	0	.5	1.4	30/ 48	1	3	1-1	47 St
(620, 618)	1060/ 323	2	0	0	0	1*	0000000	0	616	518	0	0	.5	1.4	30/ 48	1	3	1-1	47 St
(618, 616)	940/ 287	2	0	0	0	1*	0000000	716	614	0	0	0	.5	1.4	30/ 48	1	3	1-1	47 St
(616, 614)	180/ 55	3	0	0	0	1*	0000000	714	612	0	0	0	.5	1.4	30/ 48	1	3	1-1	47 St
(614, 612)	800/ 244	2	0	0	0	1*	0000000	0	610	512	0	0	.5	1.4	30/ 48	1	3	1-1	47 St
(612, 610)	100/ 30	2	0	0	0	1*	0000000	0	8151	0	0	0	.5	1.4	30/ 48	1	3	1-1	47 St
(8002, 712)	0/ 0	6	0	0	0	1*	0000000	0	612	0	0	0	.5	1.4	0/ 0	1	3	1-1	Eighth Ave
(712, 612)	100/ 30	6	0	0	0	1*	2000000	610	512	0	0	0	.5	1.4	30/ 48	1	3	1-1	Eighth Ave
(612, 512)	280/ 85	6	0	0	0	1*	2000000	0	412	514	0	0	.5	1.4	30/ 48	1	3	1-1	Eighth Ave
(512, 412)	280/ 85	6	0	0	0	1*	2000000	410	312	0	0	0	.5	1.4	30/ 48	1	3	1-1	Eighth Ave
(412, 312)	280/ 85	6	0	0	0	1*	2000000	0	212	314	0	0	.5	1.4	30/ 48	1	3	1-1	Eighth Ave
(312, 212)	280/ 85	5	0	0	0	1*	2000000	210	112	0	0	0	.5	1.4	30/ 48	1	3	1-1	Eighth Ave
(212, 112)	280/ 85	5	0	0	0	1*	2000000	0	12	114	0	0	.5	1.4	30/ 48	1	3	1-1	Eighth Ave
(112, 12)	100/ 30	5	0	0	0	1*	2000000	0	8001	0	0	0	.5	1.4	30/ 48	1	3	1-1	Eighth Ave
(8011, 14)	0/ 0	4	0	0	0	1*	0000000	0	114	0	0	0	.5	1.4	0/ 0	1	3	1-1	Broadway
(14, 114)	100/ 30	4	0	0	0	1*	2000000	116	214	0	0	0	.5	1.4	30/ 48	1	3	1-1	Broadway
(114, 214)	280/ 85	4	0	0	0	1*	2000000	0	314	212	0	0	.5	1.4	30/ 48	1	3	1-1	Broadway
(214, 314)	280/ 85	4	0	0	0	1*	2000000	316	414	0	0	0	.5	1.4	30/ 48	1	3	1-1	Broadway
(314, 414)	280/ 85	4	0	0	0	1*	2000000	0	514	412	0	0	.5	1.4	30/ 48	1	3	1-1	Broadway
(414, 514)	280/ 85	4	0	0	0	1*	2000000	516	614	0	0	0	.5	1.4	30/ 48	1	3	1-1	Broadway
(514, 614)	280/ 85	4	0	0	0	1*	2000000	0	714	612	0	0	.5	1.4	30/ 48	1	3	1-1	Broadway
(614, 714)	100/ 30	4	0	0	0	1*	2000000	0	8012	0	0	0	.5	1.4	30/ 48	1	3	1-1	Broadway
(8021, 16)	0/ 0	5	0	0	0	1*	0000000	0	116	0	0	0	.5	1.4	0/ 0	1	3	1-1	Seventh Ave
(16, 116)	100/ 30	5	0	0	0	1*	0000000	118	216	0	0	0	.5	1.4	30/ 48	1	3	1-1	Seventh Ave
(116, 216)	280/ 85	5	0	0	0	1*	0000000	0	316	214	0	0	.5	1.4	30/ 48	1	3	1-1	Seventh Ave
(216, 316)	280/ 85	4	0	0	0	1*	0000000	318	416	0	0	0	.5	1.4	30/ 48	1	3	1-1	Seventh Ave
(316, 416)	280/ 85	4	0	0	0	1*	0000000	0	516	414	0	0	.5	1.4	30/ 48	1	3	1-1	Seventh Ave
(416, 516)	280/ 85	4	0	0	0	1*	0000000	518	616	0	0	0	.5	1.4	30/ 48	1	3	1-1	Seventh Ave
(516, 616)	280/ 85	4	0	0	0	1*	0000000	0	716	614	0	0	.5	1.4	30/ 48	1	3	1-1	Seventh Ave
(616, 716)	100/ 30	4	0	0	0	1*	0000000	0	8022	0	0	0	.5	1.4	30/ 48	1	3	1-1	Seventh Ave

-LANES- -CHANNEL-

LINK	LENGTH FT / M	FULL L	PKT L	PKT R	GRD PCT	LINK TYPE	CUR B234567	DESTINATION NODE LEFT	THRU	RGHT	DIAG	OPP. NODE	LOST TIME SEC	Q DIS HDWY. SEC	FREE SPEED MPH/KMPH	RTOR CODE	PED CODE	LANE ALIGN -MENT	STREET NAME
(8032, 718)	0/ 0	6	0	0	0	1*	0000000	0	618	0	0	0	.5	1.4	0/ 0	1	3	1-1	Sixth Ave
(718, 618)	100/ 30	6	0	0	0	1*	0000000	616	518	0	0	0	.5	1.4	30/ 48	1	3	1-1	Sixth Ave
(618, 518)	280/ 85	6	0	0	0	1*	0000000	0	418	519	0	0	.5	1.4	30/ 48	1	3	1-1	Sixth Ave
(518, 418)	280/ 85	5	0	0	0	1*	0000000	416	318	0	0	0	.5	1.4	30/ 48	1	3	1-1	Sixth Ave
(418, 318)	280/ 85	5	0	0	0	1*	0000000	0	218	319	0	0	.5	1.4	30/ 48	1	3	1-1	Sixth Ave
(318, 218)	280/ 85	5	0	0	0	1*	0000000	216	118	0	0	0	.5	1.4	30/ 48	1	3	1-1	Sixth Ave
(218, 118)	280/ 85	5	0	0	0	1*	0000000	0	18	120	0	0	.5	1.4	30/ 48	1	3	1-1	Sixth Ave
(118, 18)	100/ 30	5	0	0	0	1*	0000000	0	8031	0	0	0	.5	1.4	30/ 48	1	3	1-1	Sixth Ave
(519, 419)	280/ 85	1	0	0	0	1*	0000000	418	319	0	0	0	.5	1.4	30/ 48	1	3	1-1	Rocky Plaza
(419, 319)	280/ 85	1	0	0	0	1*	0000000	0	219	320	0	0	.5	1.4	30/ 48	1	3	1-1	Rocky Plaza
(319, 219)	280/ 85	1	0	0	0	1*	0000000	218	0	0	0	0	.5	1.4	30/ 48	1	3	1-1	Rocky Plaza
(8041, 20)	0/ 0	5	0	0	0	1*	0000000	0	120	0	0	0	.5	1.4	0/ 0	1	3	1-1	Fifth Ave
(20, 120)	100/ 30	5	0	0	0	1*	2000000	122	220	0	0	0	.5	1.4	30/ 48	1	3	1-1	Fifth Ave
(120, 220)	280/ 85	5	0	0	0	1*	2000000	0	320	219	0	0	.5	1.4	30/ 48	1	3	1-1	Fifth Ave
(220, 320)	280/ 85	5	0	0	0	1*	2000000	322	420	0	0	0	.5	1.4	30/ 48	1	3	1-1	Fifth Ave
(320, 420)	280/ 85	5	0	0	0	1*	2000000	0	520	419	0	0	.5	1.4	30/ 48	1	3	1-1	Fifth Ave
(420, 520)	280/ 85	5	0	0	0	1*	2000000	522	620	0	0	0	.5	1.4	30/ 48	1	3	1-1	Fifth Ave
(520, 620)	280/ 85	5	0	0	0	1*	2000000	0	720	618	0	0	.5	1.4	30/ 48	1	3	1-1	Fifth Ave
(620, 720)	100/ 30	5	0	0	0	1*	2000000	0	8042	0	0	0	.5	1.4	30/ 48	1	3	1-1	Fifth Ave
(8052, 722)	0/ 0	5	0	0	0	1*	0000000	0	622	0	0	0	.5	1.4	0/ 0	1	3	1-1	Madison Ave
(722, 622)	100/ 30	5	0	0	0	1*	2000000	620	522	0	0	0	.5	1.4	30/ 48	1	3	1-1	Madison Ave
(622, 522)	280/ 85	5	0	0	0	1*	2000000	0	422	524	0	0	.5	1.4	30/ 48	1	3	1-1	madison Ave
(522, 422)	280/ 85	4	0	0	0	1*	2000000	420	322	0	0	0	.5	1.4	30/ 48	1	3	1-1	Madison Ave
(422, 322)	280/ 85	4	0	0	0	1*	2000000	0	222	324	0	0	.5	1.4	30/ 48	1	3	1-1	Madison Ave
(322, 222)	280/ 85	5	0	0	0	1*	2000000	220	122	0	0	0	.5	1.4	30/ 48	1	3	1-1	Madison Ave
(222, 122)	280/ 85	5	0	0	0	1*	2000000	0	22	124	0	0	.5	1.4	30/ 48	1	3	1-1	Madison Ave
(122, 22)	100/ 30	5	0	0	0	1*	2000000	0	8051	0	0	0	.5	1.4	30/ 48	1	3	1-1	Madison Ave

* INDICATES DEFAULT VALUES WERE SPECIFIED

LINK TYPE

IDENTIFIES THE DISTRIBUTION USED FOR QUEUE DISCHARGE AND START-UP LOST TIME CHARACTERISTICS.

LANE CHANNELIZATION CODES

0 UNRESTRICTED
1 LEFT TURNS ONLY
2 BUSES ONLY
3 CLOSED
4 RIGHT TURNS ONLY
5 CAR - POOLS
6 CAR - POOLS + BUSES

RTOR CODES

0 RTOR PERMITTED
1 RTOR PROHIBITED

PEDESTRIAN CODES

0 NO PEDESTRIANS
1 LIGHT
2 MODERATE
3 HEAVY

PROPERTIES OF BUS STATIONS

STATION NO.	LANE SERVICED	LINK	DISTANCE FROM UPSTREAM NODE FEET	DISTANCE FROM UPSTREAM NODE METERS	CAPACITY (BUSES)	MEAN DWELL (SEC)	TYPE	PERCENT OF BUSES STOPPING
1	0	(612, 512)	130	40	1	20	1	100
2	0	(412, 312)	130	40	1	15	1	100
3	0	(314, 414)	180	55	2	15	1	100
4	0	(218, 118)	130	40	1	15	1	100
5	0	(220, 320)	230	70	1	15	1	100
6	0	(320, 420)	230	70	1	15	1	100
7	0	(622, 522)	180	55	1	15	1	100
8	0	(422, 322)	130	40	1	20	1	100
9	0	(422, 322)	230	70	1	20	1	100
10	0	(222, 122)	180	55	2	20	1	100
11	0	(314, 316)	210	64	1	20	1	100
12	0	(318, 319)	530	162	1	20	1	100
13	0	(419, 418)	430	131	1	20	1	100
14	0	(416, 414)	160	49	1	20	1	100

0 THE TYPE CODE IDENTIFIES THE APPLICABLE STATISTICAL DISTRIBUTION OF DWELL TIME

1

BUS ROUTE PATHS

	ROUTE	SEQUENCE OF NODES DEFINING PATH										
0	1	8121	310	312	314	316	318	319	320	322	324	8122
0	2	8002	712	612	512	412	312	212	112	12	8001	
0	3	8011	14	114	214	314	414	514	614	714	8012	
0	4	8011	14	114	214	314	414	514	614	714	8012	
0	5	8021	16	116	216	316	416	516	616	716	8022	
0	6	8041	20	120	220	320	420	520	620	720	8042	
0	7	8052	722	622	522	422	322	222	122	22	8051	
0	8	8132	424	422	420	419	418	416	414	412	410	8131
0	9	8132	424	422	420	419	418	416	414	412	410	8131

1

BUS STATIONS BY ROUTE

SEQUENCE OF STATIONS SERVICED BY ROUTE

	ROUTE			
0	1	11	12	
0	2	1	2	
0	3	3		
0	4	3		
0	6	5	6	
0	7	7	9	10
0	8	13	14	
0	9	13	14	
1				

BUS VOLUMES

	ROUTE	VOLUME (VEH/HR)	MEAN HEADWAY (SEC)
0			
0	1	10	360
0	2	6	600
0	3	9	420
0	4	4	900
0	5	4	990
0	6	8	480
0	7	10	360
0	8	10	360
0	9	10	360
1			

SIMULATION OUTPUT SCENARIO 3 CASE B

NETSIM SECTION SPECIFIC STATISTICS

				VEHICLE-MINUTES		AVERAGE VALUES			
		VEHICLE	VEHICLE	DELAY	TOTAL	TRAVEL TIME	SPEED	STOPS	CONTENT
	SECTION	MILES	TRIPS	TIME	TIME	(SEC/VEH-TRIP)	(MPH)	(PER TRIP)	(VEH)
0	1	207.85	429	2807.65	3223.35	451.1	3.9	3.5	71
0	2	298.16	525	1992.10	2588.42	296.0	6.9	3.6	55
0	3	334.48	545	1943.61	2612.57	287.6	7.7	3.9	58
0	4	100.32	335	1246.29	1446.93	259.0	4.2	2.7	32
0	5	227.40	343	2474.56	2929.37	512.3	4.7	5.1	64
0	6	150.15	227	3043.16	3343.47	885.6	2.7	4.9	74
0	7	150.37	227	1959.58	2260.32	597.8	4.0	4.4	49
0	8	221.43	334	1634.30	2077.17	373.1	6.4	4.3	45
0	9	194.05	732	3385.41	3773.52	309.4	3.1	2.5	83
0	10	177.53	670	1445.06	1800.12	161.3	5.9	1.8	38
0	11	256.68	968	917.01	1430.37	88.7	10.8	1.4	32
0	12	286.02	1079	901.97	1474.00	82.0	11.6	1.4	32
0	13	253.27	955	1179.44	1685.98	105.9	9.0	2.1	36
0	14	251.57	949	1014.53	1517.67	96.0	9.9	1.7	33
0	15	150.60	227	701.64	1002.85	264.8	9.0	3.7	21
0	16	139.72	211	1070.99	1350.43	384.4	6.2	3.9	30

1

NETSIM BUS STATISTICS

LINK	BUS TRIPS	PERSON TRIPS	TRAVEL TIME (MINUTES)	MOVING TIME (MINUTES)	DELAY TIME (MINUTES)	M/T	SPEED (MPH)	NUMBER OF STOPS
(8121, 310)	8	200						
(310, 312)	8	200	.8	.3	.5	.37	11.1	0
(312, 314)	7	175	8.9	1.9	7.0	.21	6.4	0
(314, 316)	7	175	6.5	.7	5.8	.11	3.2	7
(316, 318)	7	175	3.7	2.5	1.2	.68	20.4	0
(318, 319)	7	175	6.3	1.7	4.6	.27	8.0	7
(319, 320)	7	175	2.0	1.1	.9	.57	17.1	0
(320, 322)	7	175	3.2	1.4	1.9	.43	12.8	0
(322, 324)	7	175	.3	.3	.1	.84	25.1	0
(8132, 424)	14	350						
(424, 422)	14	350	1.6	.5	1.1	.33	9.9	0
(422, 420)	14	350	3.9	2.8	1.1	.71	21.4	0
(420, 419)	14	350	3.0	2.3	.7	.76	22.9	0
(419, 418)	14	350	16.6	3.3	13.3	.20	6.0	14
(418, 416)	14	350	13.4	5.0	8.4	.37	11.2	0
(416, 414)	14	350	21.6	1.4	20.2	.06	1.9	14
(414, 412)	14	350	32.3	3.8	28.4	.12	3.6	0
(412, 410)	14	350	1.6	.5	1.1	.32	9.6	0
(8002, 712)	4	100						
(712, 612)	4	100	1.0	.2	.9	.15	4.4	0
(612, 512)	5	125	7.6	.5	7.1	.07	2.1	4
(512, 412)	5	125	2.0	.5	1.5	.27	8.0	0
(412, 312)	4	100	2.8	.4	2.3	.15	4.6	5
(312, 212)	4	100	.7	.4	.3	.60	18.2	0
(212, 112)	4	100	.5	.4	.1	.85	25.5	0
(112, 12)	4	100	.2	.2	.0	.90	27.3	0
(8011, 14)	9	225						
(14, 114)	9	225	2.3	.3	1.9	.15	4.5	0
(114, 214)	9	225	1.8	1.0	.8	.54	16.2	0
(214, 314)	9	225	2.3	1.0	1.3	.42	12.5	0
(314, 414)	8	200	6.8	.8	5.9	.13	3.8	9
(414, 514)	8	200	1.7	.8	.8	.50	15.1	0
(514, 614)	8	200	1.1	.8	.3	.76	22.8	0
(614, 714)	8	200	.3	.3	.0	.91	27.3	0
(8021, 16)	3	75						
(16, 116)	3	75	.9	.1	.7	.13	4.0	0
(116, 216)	3	75	.9	.3	.6	.33	10.0	0
(216, 316)	3	75	1.1	.3	.8	.28	8.3	0
(316, 416)	3	75	.5	.3	.2	.63	19.1	0
(416, 516)	3	75	.4	.3	.1	.83	24.9	0
(516, 616)	3	75	.4	.3	.1	.83	24.9	0
(616, 716)	3	75	.2	.1	.0	.76	22.7	0
(8041, 20)	5	125						
(20, 120)	5	125	.8	.2	.6	.23	7.0	0

NETSIM BUS STATISTICS

LINK	BUS TRIPS	PERSON TRIPS	TRAVEL TIME (MINUTES)	MOVING TIME (MINUTES)	DELAY TIME (MINUTES)	M/T	SPEED (MPH)	NUMBER OF STOPS
(220, 320)	5	125	4.3	.5	3.7	.12	3.7	5
(320, 420)	5	125	2.8	.5	2.3	.19	5.6	5
(420, 520)	6	150	1.1	.6	.5	.56	16.8	0
(520, 620)	6	150	.7	.6	.1	.87	26.0	0
(620, 720)	6	150	.3	.2	.0	.91	27.3	0
(8052, 722)	8	200						
(722, 622)	8	200	5.4	.3	5.1	.06	1.7	0
(622, 522)	8	200	4.8	.8	4.0	.18	5.3	8
(522, 422)	7	175	5.5	.7	4.7	.14	4.1	0
(422, 322)	7	175	4.7	.7	3.9	.16	4.8	7
(322, 222)	7	175	2.1	.7	1.3	.36	10.8	0
(222, 122)	7	175	5.8	.7	5.1	.13	3.8	7
(122, 22)	7	175	1.0	.3	.8	.26	7.8	0

NETSIM BUS-STATION STATISTICS

STATION NUMBER	TIME CAPACITY EXCEEDED (MINUTES)	TIME EMPTY (MINUTES)	TOTAL DWELL TIME (BUS-MIN.)	BUSES SERVICED
1	.0	43.7	1.3	4
2	.0	43.9	1.3	5
3	.0	42.8	2.3	9
5	.0	43.9	1.3	5
6	.0	43.8	1.3	5
7	.0	43.3	2.0	8
9	.0	43.2	2.3	7
10	.0	42.7	2.3	7
11	.0	42.7	2.3	7
12	.0	42.8	2.3	7
13	2.0	40.5	4.7	14
14	2.0	41.2	4.7	14

1 1

ROUTE STATISTICS

ROUTE	BUS TRIPS	TOTAL TRAVEL TIME (BUS-MIN.)	MEAN TRAVEL TIME (SEC/BUS)	PERSON TRIPS	PERSON TRAVEL TIME (MINUTES)
1	7	31.8	272.4	175	794.6
2	4	14.8	221.8	100	369.6
3	5	10.3	123.4	125	257.1
4	3	5.9	117.3	75	146.7
5	3	4.4	88.0	75	110.0
6	6	10.9	109.2	150	272.9
7	7	29.3	250.9	175	731.7
8	7	41.9	358.9	175	1046.7
9	7	52.1	446.9	175	1303.3

THESE ESTIMATES ASSUME AN AVERAGE BUS OCCUPANCY OF 25 PASSENGERS PER BUS THROUGHOUT THE NETWORK
OLAST CASE PROCESSED

APPENDIX E
DEFINITIONS OF MOEs

DEFINITIONS OF OUTPUT MOEs

Several MOEs that are used in this thesis are defined below.

Link Specific MOE

Move Time (Veh-Min)

The ideal travel time that would exist if all vehicle trips were performed at the mean free-flow speed of the link without any signal or other delay. It is computed as:

$$\frac{\text{Vehicle Trips * Link Length (ft)}}{\text{Mean Free-Flow Speed (ft/sec)}} \; / \; 60 \text{ (sec/min)}$$

Delay Time (Veh-Min)

The difference between the actual total travel time accumulated on the link and the idealized moving time that would exist if vehicles always moved at the mean free-flow speed without slowing for other vehicles or stopping in response to intersection control. This is computed as :

Total Travel Time (Veh-Min) - Moving Time (Veh-Min)

Total Time (Veh-Min)

Cumulative travel time of all vehicles which have traversed the link plus the travel time of all vehicles present on the link when the statistic is computed.

Vehicle Miles

This is equivalent to :

$$\frac{\text{Vehicle Trips * Link Length (ft)}}{\text{5280 (ft/ mile)}} - V$$

where V= adjustment for vehicles which entered the link via a right turn movement and therefore did not traverse the length of the upstream intersection.

Vehicle Trips

A full vehicle trip is recorded when a vehicle travels the full length of a link and discharges after system initialization (" fill " time) is completed.

One - half vehicle trip is recorded when :

- A vehicle that is on the link at the end of fill time, discharges from the link.
- A vehicle is on a link when statistics are gathered for output purposes.
- A vehicle exits the link into a sink node.
- A vehicle that enters the link from a source node, discharges from the link.

Vehicle Mins

Total time spent by all vehicles in traversing a link.

Mean Speed (mph)

$$\frac{\text{Total Vehicle Miles of Travel}}{\text{Total Vehicle Hours of Travel}}$$

Cum Veh Discharged

Total number of vehicles whose front end crossed the stopline of the link since system initialization completed.

Cum Stops

Total number of vehicles which came to a full stop at least once in trversing a link since system initialiation completed.

Tot Travel (Sec/Veh)

Average travel time required for a vehicle to complete one vehicle trip on a link. This is computed as

$$\frac{\text{Total Travel Time (Sec)}}{\text{Vehicle Trips}}$$

Delay Time (Sec/Veh)

Delay experienced by the average vehicle in completing one vehicle trip on a link.

Queue Time (Sec/Veh)

Average time spent by avehicle (in queue) waiting to discharge the link caused by :

- Traffic control
- Intersection capacity constraints
- Inadequate capacity of turn pockets
- Buses awaiting entry to a station
- Parkers, short or long term events

Stop Time (Sec/Veh)

The amount of time that the average vehicle is forced to travel at speeds of 3 fps or less due to traffic conditions on a given line (includes time spent by buses in dwell).

M/T

$$\text{Ratio of : } \frac{\text{Total Moving Time (Veh-Min)}}{\text{Total Travel Time (Veh-Min)}}$$

expressed as a percent. A low percentage value for this statistic implies that a large propotion of the travel time is spent under delayed conditions.

Percent of Vehicles stopped

The percentage of all vehicle trips in which a vehicle is forced to come to a complete stop at least once.

Mean Content (veh)

Average number of vehicles present on the link at any one moment during the course of the simulation.

Storage (%)

Propotion of the available lane-feet of a link which is occupied by vehicles on average during the course of the simulation.

Phase Failures

A phase failure occurs when a vehicle in queue at the start of its service green is unable to discharge before its next red.

Bus Transit MOE Definitions

Bus Minutes

The total travel time accumulated by all buses traversing the route since initialization completed.

Bus Trips

The num ber of buses which have completed the route after system initialization concluded.

Person Minutes

The amount of time spent by all individuals on buses traversing the route since system initialization completed. This estimate assumes an occupancy rate of 25 persons per bus throughout the route.

Person Trips

The number of persons on buses which have completed the route after system initialization concluded.

Seconds/Bus

The time it takes the average bus to traverse the entire route.

Station MOE Glossary

Bus Mins in Dwell

Total number of minutes (since the end of system initialization) accumulated by all buses that have stopped at the station to allow passengers to embarmk/disembark.

Buses Serviced

Total number of buses (since the end of system initialization) that have stopped at the stationto allow passengers to embark/disembark.

Secs Cap Exceeded

Total number of seconds (since the end of system initialization) that buses were forced to wait to enter the station because the station was already full.

Time Empty (Mins)

Total number of minutes (since the end of system initialization) that there were no buses present in the station.

Link Specific Bus MOE Glossary

Bus Trips

Total number of buses discharging the link since system initialization was completed.

Delay (Bus-Mins)

This is computed as the difference between the actual travel time required by all buses that travel the link and the time required if all buses travelled at free-flow speed throughout the link.

M/T (%)

The ratio of idealized moving time (at free speed) and actual total travel time experienced by buses on the link.

Number of Stops

Total number of stops made by buses on the link.

Person Trips

The number of persons travelling on buses which have completed their travel on the link.

Speed (mph)

Ratio of total bus miles and total bus hours of travel on the link.

Travel (Bus-Min)

Travel time spent by buses in traversing the link.

APPENDIX F
Graphs: Comparision of MOEs

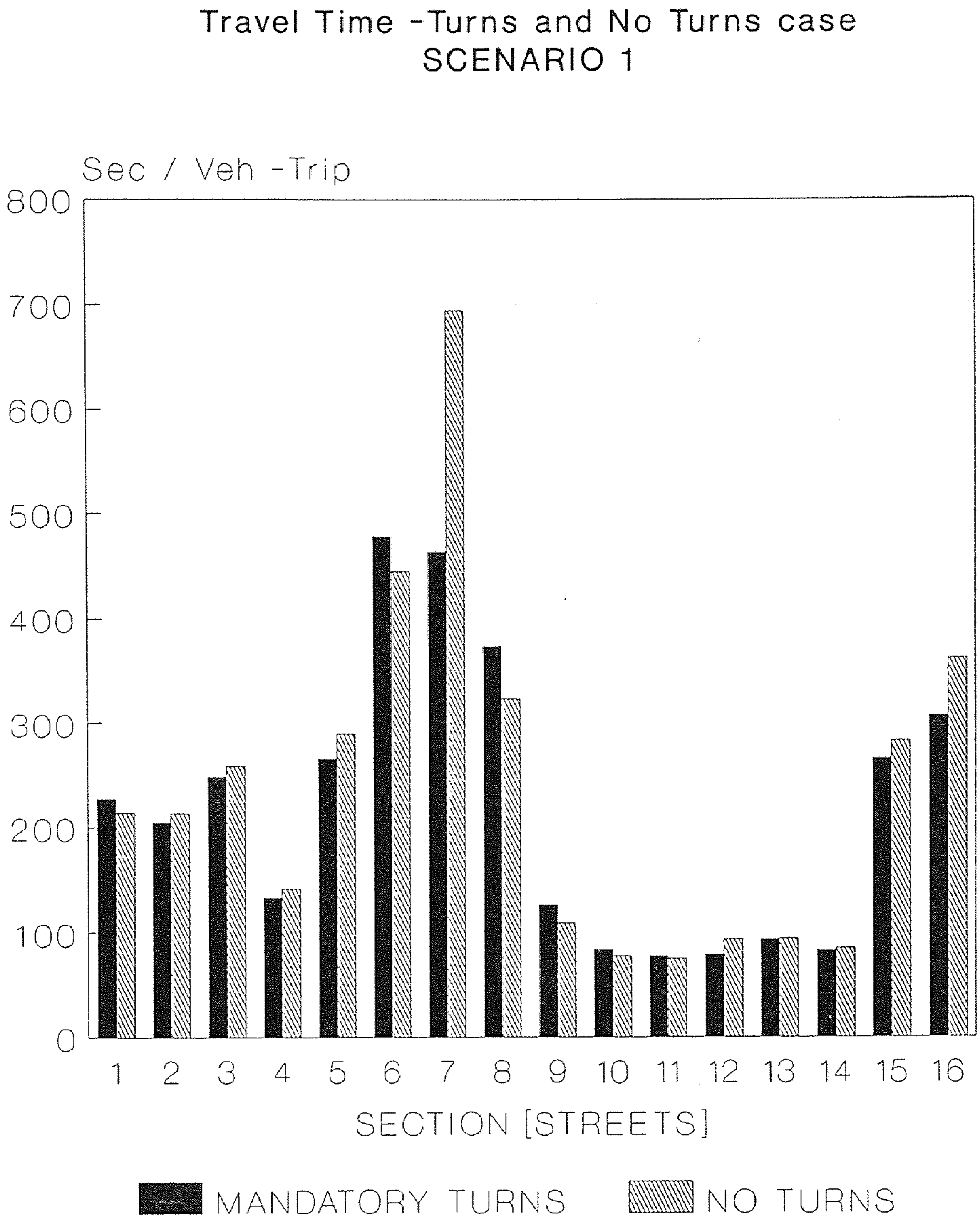


Figure F-1: Comparision of case(A) and case (B).Mandatory turns on section 5 (50th Street)

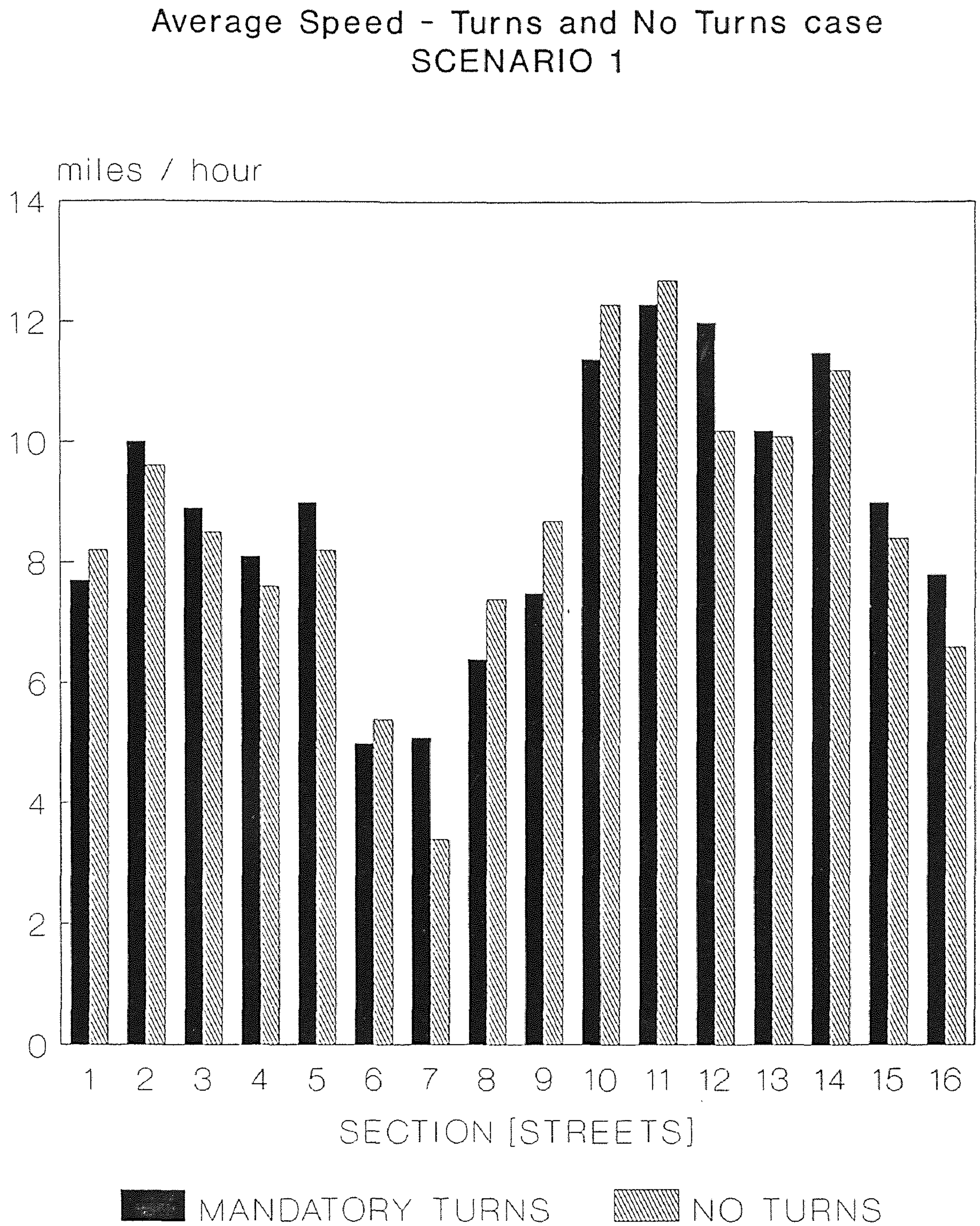


Figure F-2: Comparision of case (A) and case (B). Mandatory turns on section 5 (50th Street)

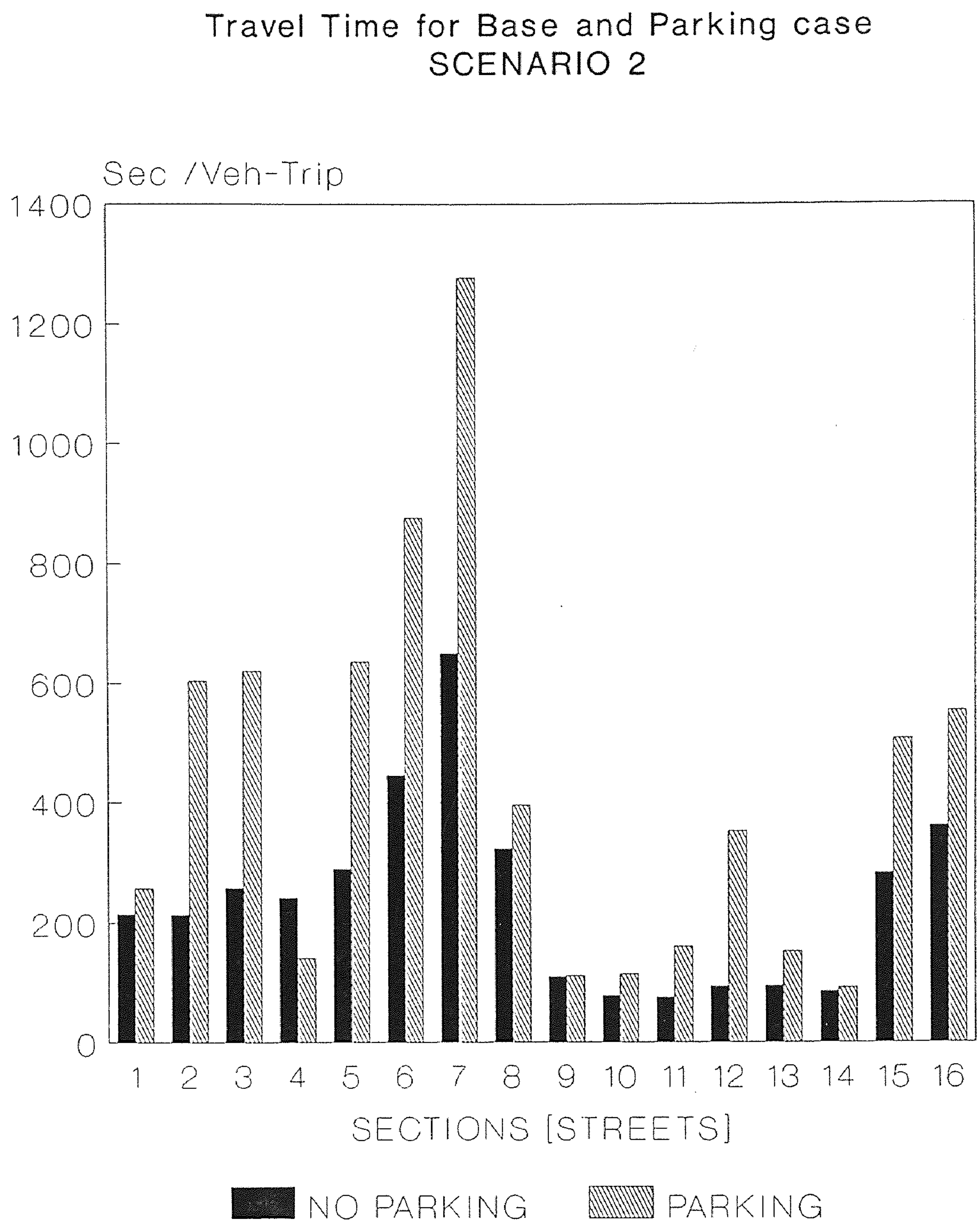


Figure F-3: Comparision of case (A) and case (B).Full lanes replaced by parkings on sections 12 and 13 (6th & 5th Avenue)

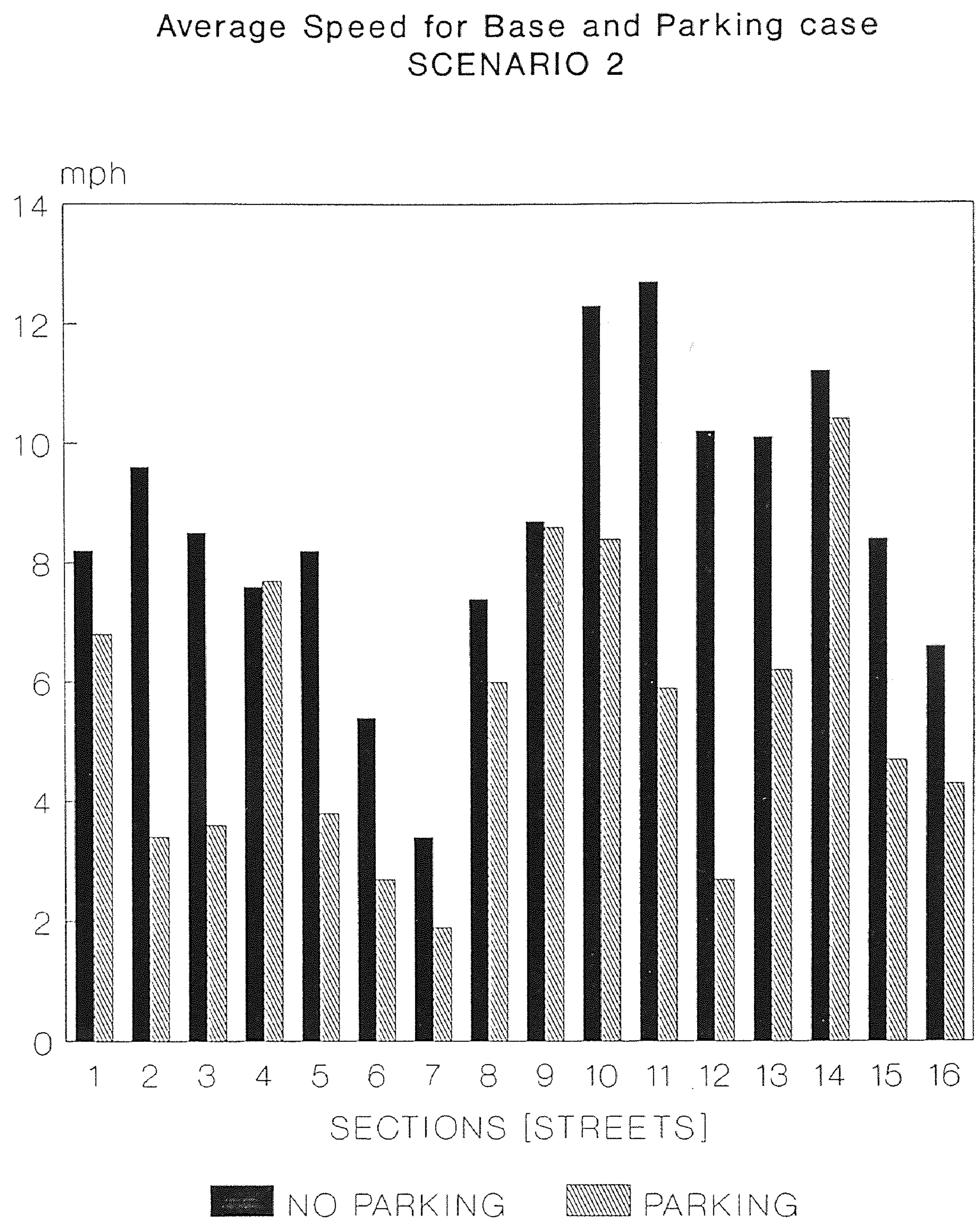


Figure F-4: Comparision of case (A) and case (B). Full lanes replaced by parking lanes on sect. 12 & 13 (6th & 5th Ave)

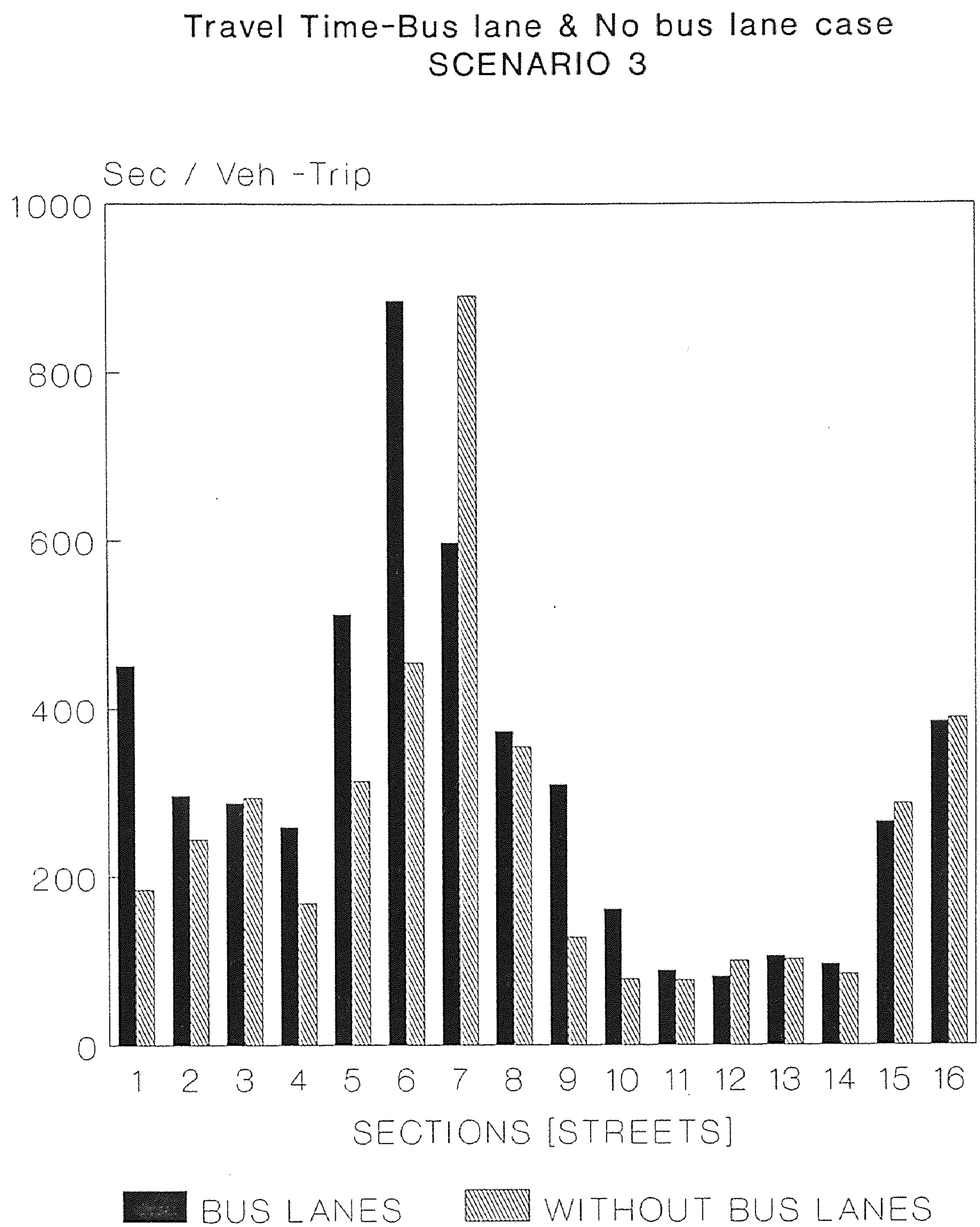


Figure F-5: Comparision of case (A) and case (B). Exclusive bus lanes on Sections 5, 6, 10, 11, 13 & 14

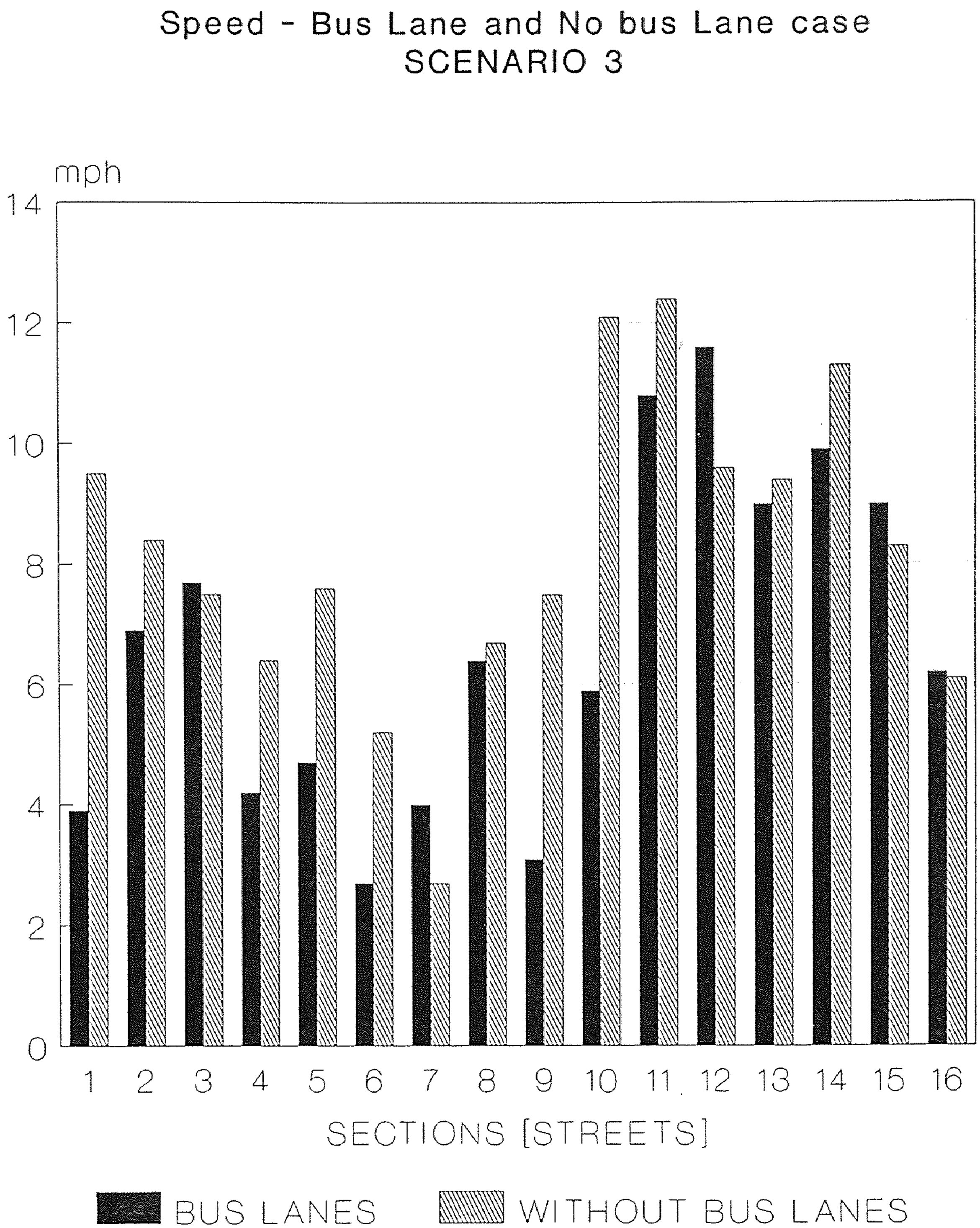


figure F-6: Comparision of case (A) and case (B). Exclusive bus lanes on Sections 5, 6, 9, 10, 13 & 14.

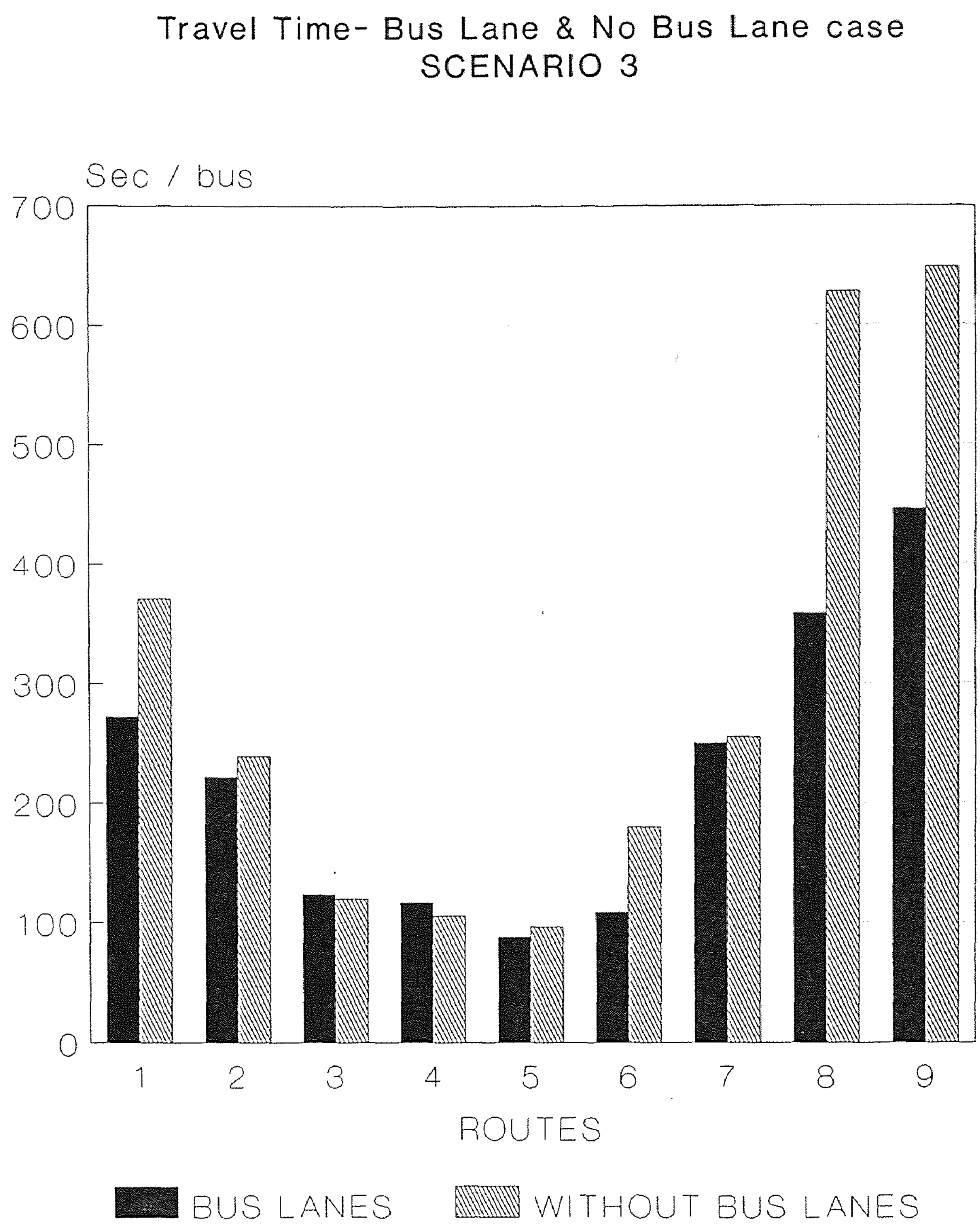


Figure F-7: Comparision ofcase (A) and case (B). Exclusive bus lanes on Sections 5, 6, 9, 10, 13 & 14.

BIBLIOGRAPHY

Button, K. J. and A. D. Pearman. " The Economics of Urban Freight Transportation." Macmillan (1981)

Chui, M. K. and W. F. McFarland. "The Value of Travel Time: New Estimates Developed Using A Speed-Choice Model." Research Report no.396-2F Texas Tran. Inst. (1986)

Harper, D.V. "Transportation in America. Users, Carriers, Government." Prentice-Hall (1982)

Jovanis, Paul P., Kambiz Bashar, and Ali Haghani. "Effect of 49th-50th Street Bus and Taxiway on Traffic Congestion in Manhattan." Transportation Research Record 1256 (1986)

Lisco, T. E. "The Value of Commuter's Travel Time: A Study in Urban Transportation" Ph.D. Dessertation, Department of Economics, University of Chicago, Illinois, (1967).

Ogden, K. W. "Urban Goods Movement : A Guide to Policy and Planning." Ashgate (1992)

Pignataro, Louis. J., "Transportation Economics." Course Notes for TRAN 610 taught at New Jersey Institute Technology in 1991.

Stammer, Robert. J. Jr., " Microcomputer Applications in Transportation II " American Society of Civil Engineers (1987)

____." TRAF-NETSIM, User's Manual." Federal Highway Adminstration. U.S. Departmant of Transportation.

Quarmby, D. A., "Choice of Travel Mode for the Journey to Work: Some Findings." Journal of Economics and Policy, Vol.1 No.3, (1967).