Strategies for the Alleviation of Traffic Congestion in the Central City of Athens

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(ABSTRACT)

An impressive population growth and a rapidly expanding motor vehicle fleet have resulted in the "strangulation" of the city of Athens. Smog, traffic congestion, parking shortages, noise and excessive delays are everyday problems for the Athenians. The street network and the public transportation systems are not able to accommodate the existing traffic demands.

An effort was made to address the transportation needs, that require an immediate solution, in the central Athens area. Traffic counts and physical characteristics were obtained for the street network of the central city. A traffic simulation model, MASSVAC2, was employed for simulating existing traffic conditions during the noon peak period, assessing the quality of operations, identifying street deficiencies and testing and evaluating different traffic management strategies for the central city of Athens.

The need for the establishment of a comprehensive transportation plan, which consists of traffic management policies, traffic restraints, public transport improvements, and construction of a rail rapid transit system and a freeway-expressway system, was particularly stressed. The essential for effective coordination between agencies related to transportation management was also emphasized, for the alleviation of traffic congestion

in the central area and the increase in the overall transport efficiency in the city of Athens.

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Table of Contents

List of Figures

List of Tables

Chapter 1

Introduction

1.1 Background of the Problem

Athens is somewhat unique in that now nearly four million people residing within its environment represent nearly one third of the total population of the nation of which it is the capital. This concentration of people has created many problems in the capital's ability to provide economic opportunities, housing, and transportation. The transportation problems are tremendous by all standards and with the passage of each day the situation becomes more critical, because of a rapidly expanding motor vehicle fleet.

The conditions of street traffic in Athens today are not unlike those which are being experienced in most large cities of Europe and North America. Extreme congestion, loss of time, high levels of pollution, and high accident incidence are natural resultants of a motor vehicle fleet which has outgrown the capacity of city plans conditioned by the circulation needs of a previous era. The city of Athens also suffers from parking deficiencies, ailing public transport system that is overcrowded during the rush hours, unsatisfactory conditions for pedestrians, and degradation of the urban environment through noise, pollution, danger and ugliness.

Underlying the severity of the urban transport problems in Athens is the acute shortage of resources. Provision of expensive long-life urban transport infrastructure sufficient to match the large additions to population has proven impossible.

The transport problem in Athens is not a simple one, because of the complex nature of the interrelationships between the major systems that comprise the urban environment.

1.2 Research Objectives

The main objectives of this thesis are:

1. To present the overall picture of the transportation system in the city of Athens, and address the present transport problems and needs.
2. To accomplish the following, through the use of a dynamic simulation model:
   - Simulate traffic behavior during the noon peak period throughout the central area.
   - Analyze and assess the quality of traffic operations within the whole network.
   - Identify problematic areas and deficiencies in the street system.
   - Develop, test and evaluate different traffic management strategies.
3. Recommend specific strategies that will improve the existing traffic conditions in the center of Athens.
4. Describe the main policies that could form part of an overall transportation plan, which in turn will increase the efficiency of the transportation system in Athens.

1.3 Outline of the Remaining Chapters

A brief introduction to the problem and the main objectives of this study were discussed in this chapter.

Chapter 2 describes briefly the existing transportation situation in the city of Athens. The physical characteristics of the transportation system, along with street capacities, variations in traffic volumes, travel speeds and a brief summary of previous transportation studies conducted for the Athens area, are presented in this chapter.

Chapter 3 is devoted to a review of literature relevant to existing network traffic operation simulation models. In the review, the advantages and drawbacks of the models in dealing with the analysis of complex networks are discussed.

In Chapter 4, a brief overview of the theoretical aspects of MASSVAC2, the simulation model used for the study of the central Athens network, is presented.

Chapter 5 presents the application of MASSVAC2 in simulating traffic management strategies for the central city of Athens, and the results obtained from the simulation runs.

In Chapter 6, an overall transportation plan to solve the existing transport problems in Athens is presented. The plan consists of traffic management policies and restraints, improvements in public transportation systems and construction of a Metro system and new road infrastructure.

Finally in Chapter 7, conclusions of this study plus recommendations for further research are discussed.

Chapter 2

Transportation Situation in Athens

2.1 Historical Background

The developed nations of the West and the developing countries of the East meet at Athens. In many ways a western city, Athens has also some characteristics of cities of the Middle East or South America. Noisy or shabby, with much lower levels of income than in Western Europe, Athens has experienced an enormous population growth due largely to the influx of people from central Greece and the Greek islands. While these areas declined in population, Athens has struggled to provide housing for the immigrants.

Despite its historical image, Athens is a rather modern city. At the beginning of the nineteenth century it was little more than a village, nestling around the Acropolis. In 1833 it was made the capital of the newly formed state of Greece, but in 1853 it still contained no more than 36,000 people. Then the big growth began. Reaching 300,000 in 1900, a million before the Second World War, two millions in the 1960s, its population is expected to surpass four millions by the end of the century (Thomson, 1977). Although many plans have been produced for the city center, the rest of the city, i.e. 98

percent of the area, has developed without any planning. The Athens area has joined up with the port of Piraeus and little open space has been left within the built-up area.

Table 2.1 shows the dramatic increase of the population and that of the vehicle fleet in the Athens region over the past 25 years. To make matters worse, the existing road and street system has been unable to expand and accomodate the increasing traffic demands.

The loss of wealth and of amenity that Athens is inflicting on itself through traffic congestion is already very large. There is an enormous waste of manpower, because life can no longer be divided between work, sleep and leisure; there is a fourth division of time spent sitting in vehicles, which are moving far too slowly, if moving at all. There is also waste of capital, since too many vehicles have to be provided to do the necessary work of transport. Finally there is a waste of fuel -- all of it imported.

All these economic wastes add up to hundreds of thousands of drachmas per year. Nevertheless, the worst waste of all is the life loss in accidents which is expected to rise with traffic unless effective measures are taken.

2.2 Air Pollution

Traffic congestion has reached intolerable levels in Athens, resulting in a severe air pollution problem among other negative impacts. The Greek household word "nefos" is used to describe the yellowish-brown cloud of smog, a cocktail of pollutants, that lies over the city in windless weather and makes breathing a health hazard.

It has been estimated that transportation accounts for 60 percent by weight of all pollution in the city of Athens (Kousios *et al.*, 1987). The bulk of this comes from the

Table 2.1 Growth in Athens between 1960 and 1985

YEAR	POPULATION		PRIVATE VEHICLES		OWNERSHIP INDEX	
	No. of people (million)	Average annual rate of increase	No. of cars (thousand)	Average annual rate of increase	Inhabitants per vehicle	Average annual rate of increase
1960	1.80		28.0		64.3	
		3.6%		19.4%		15.3%
1965	2.15		68.0		31.6	
		2.8%		15.5%		12.3%
1970	2.47		139.8		17.7	
		2.1%		13.2%		10.8%
1975	2.75		260.3		10.6	
		1.5%		12.7%		11.0%
1980	2.97		473.4		6.3	
		1.0%		6.7%		5.6%
1985	3.12		656.5		4.8	

gasoline used in automobiles. Most of this pollution is thus emitted at ground level in close proximity to population centers. It is on this basis that the automobile is referred to as the most important pollution source.

The level of pollution generated by vehicle traffic in the city of Athens is influenced by a number of factors. The most important factors include:

- **Transportation mode:** Passenger traffic is carried primarily by automobiles and buses. Automobiles generate much higher pollutant emissions per passenger mile than buses do. With respect to fuel economy buses are more than four times as efficient as automobiles.
- **Traffic flow conditions:** Traffic flow conditions influencing vehicle air pollutant emissions and fuel consumption include driving modes (idle, cruise, acceleration and deceleration), number and duration of stops, speed changes, operating speed, length of vehicle trips, etc.
- **Roadway design:** This includes influencing factors such as roadway grade, curvature, intersection design, surface conditions, etc.

A recent study was carried out to estimate the amount of the major air pollutants (particulates, HC, NO_x, CO, SO_x) emitted by vehicle traffic in the city of Athens. The results of this study (Kousios *et al.*, 1987) are presented in Table 2.2.

2.3 Road Network System

In 1971, there were about 530 kilometers of main roads in Athens, i.e. 1.3 kilometers per square kilometer, which is close to the American norm of 1.4 kilometers per square kilometer. But because of the higher living densities in Athens, the ratio of main road

Table 2.2 Emissions of Major Air Pollutants in Athens (1987)

Source (vehicles)	Particulates (tons/day)	HC (tons/day)	NO_x (tons/day)	CO (tons/day)	SO_x (tons/day)
Gasoline	0.8	6.6	12.0	94.0	1.6
Diesel	2.8	4.2	6.9	1.9	3.6

to population is only 1.8 kilometers per 10,000 inhabitants as compared with 9.2 kilometers per 10,000 inhabitants in the United States (Frantzeskakis, 1971). Moreover, the so-called main roads are mostly only two-lane arterials; there are no expressways (apart from the ones close to the airport).

Hence the traffic capacity of the system per capita is vastly smaller than that of a large American-type city. On the other hand, the car ownership level is lower when compared with American levels and the traveled distance is much shorter in a high-density city like Athens, where the average work trip is only ten minutes long (compared with an American equivalent of sixteen minutes). Additionally, most personal journeys are short enough to be made on foot or by using a bus, thus reducing the traffic demand on the street network.

Nevertheless, the attachment of the Greek to his car seems particularly strong. Greeks, it is said, are not like Londoners: to them it is important that they should use their cars.

The traffic situation is worsened in the city center because of the topographical and historical features. The presence of high, steep hills within the city -- notably the Acropolis Hill, the Lykavitos Hill and the Hill of Nymphs -- causes the traffic to converge on one corridor only, through Amalias Avenue and Syntagma Square.

The radial arterials converge upon two principal hubs in the Core Area: Omonoia Square and Syntagma Square. These two public squares are the focal points of central city commercial activity. Connecting these two nuclei are the principal commercial streets of Athens: Panepistimiou, Stadiou and Akadimias.

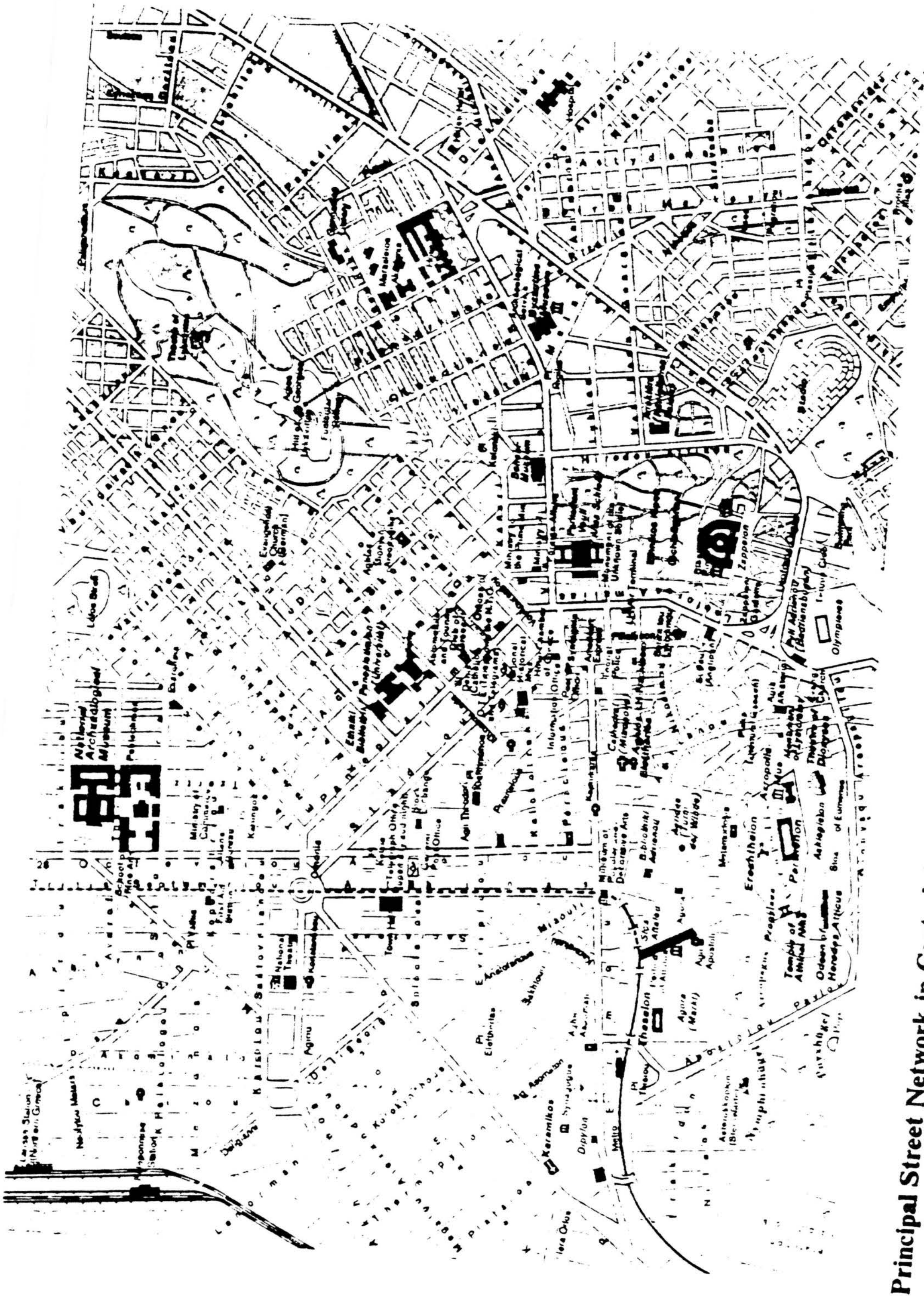
The road system, shown in Figure 2.1, is one of mainly arterial and collector streets and has significant deficiencies. The most obvious system deficiencies are the lack of adequate lateral and circumferential connections between development corridors served by the radial system. An analysis of the existing patterns of travel in Athens would not be entirely indicative of the influence of the inadequate lateral connections. Normal movements between adjacent urban masses may simply have been diverted to other areas, or have been entirely inhibited due to the lack of connecting facilities. These conditions are imposing unnecessary burdens on the radial streets, particularly within the central city area, and extra burdens of time and expense on the traveling public.

2.4 Public Transit System

A single-line underground railway, dating back to the 1890s, runs from Piraeus through the center of Athens to Kifissia in the north, a distance of 26 kilometers. Apart from this line, which carries 9 percent of public transport passengers, all transport is by road.

Three nationalized organizations provide public transport services: Hellenic Electric Railways, Ltd. (EHS) runs buses, and the underground railway. The Electric Transport Co. (HEM) operates trolley buses. A group of agencies, known as Urban Motor Bus Common Revenue Agencies (KTEL), is the largest public transport company of the city (67% of bus fleet, 66% of vehicle-kilometers, 60% of passengers). Six such agencies operate in different parts of the metropolis.

The 1976 statistics for the bus, trolley bus and underground systems show that the public transport ridership has decreased since 1972 (SOFRETU *et al.*, 1977):



2.1 Principal Street Network in Central Athens.

- the vehicle-kilometers per year for the total number of vehicles of the operating companies have decreased by 13% (159,088,000 vehicle-kilometers in 1972, and 137,795,000 vehicle-kilometers in 1976), and
- the annual mean number of paid public transport trips per inhabitant in the Athens region has decreased by 30% (325 trips per inhabitant per year in 1972, and 227 trips in 1976).

The role played by public transport is, however, still preponderant in the Athens area. In 1972, 68 percent of motorized trips were made using public transport decreasing to 60 percent for 1976.

While the underground railway covers the densest corridor, the buses cover about fifteen other routes, serving the ribbon development along every main road out of the city. The principal routes extend about 20 kilometers from the city center along the coast in each direction and inland. Coverage of the city is good, with some 200 lines serving 2,200 kilometers, and almost all points in the built-up area are within 300 meters of a bus stop (Thomson, 1977).

2.5 Major Traffic Barriers

Some of the existing deficiencies in the Athens street system are aggravated by a number of major traffic barriers. The most obvious barriers are the mountains which surround and define the Athens Basin. Within the Athens area there are other topographic barriers which have inhibited unrestricted development of the street system. These topographic features are the Tourkovounia Hills, the Lykavitos Hill and, to a lesser degree, the Philopappou Hill, the Acropolis Hill, the Ardittos Hill, and the Strefi Hill. Other traffic barriers are the railroads and large areas of land devoted to uses which should not be traversed by surface roadways. Examples of these areas are the airports, cemeteries, and major parks. As a result of these and other traffic barriers, the provision of some new and critical links in the street system has been difficult.

There are also many monuments and archaeological sites in Athens which must be considered when planning new transportation facilities. However, they should be viewed as points of control, rather than traffic barriers, when new routes or widenings of existing streets are planned. Meanwhile every effort should be made to respect these sites.

While there are important sites and buildings at various locations throughout the Athens area, most of them are concentrated in the Athens central city area. The most important sites and buildings within the central city area are shown in Figure 2.2. Included are the important sites of ancient and Roman times, the sites of Byzantine Churches (many of which are actually located within existing street rights-of-way), and major public buildings which have been erected since 1832. The archaeological zone which has been cleared and excavated is also shown. All of these buildings and sites have been considered as inviolate in the investigations of transportation needs in Athens. Any subsequent recommendations which are in apparent conflict with this principle should be modified to imply that revisions of alignment are intended at those points of conflict rather than encroachments upon these important sites.

2.6 Street Capacity

An examination of street volumes alone will not give an indication of the sufficiency of the street system. While volumes are reliable indicators of corridor quantity demands, they do not provide a measure of the volume-system relationship. In order to assess the factor of quality in the traffic services provided by the system, it is necessary to evaluate

2.2 Important Sites and Monuments in the Central City of Athens.

the capacity of the system and relate these findings to the existing traffic flow. This comparison will expose the deficient elements and provide a basis for estimating present and future system needs, as well as establishing these needs in order of priority.

When reference used to be made to the capacity of an urban street, the subject was normally *practical capacity*, which may be defined as the maximum number of vehicles that can pass through a given point on a roadway during a given period of time, without the traffic density being so great as to cause unreasonable delay, hazard, or restriction to the drivers' freedom to maneuver under the prevailing roadway and traffic conditions (Smith, 1963). In urban conditions, the need for a higher quality of service has brought about a change in the application of "capacity" in the design and operations of streets and highways, in favour of the concept of levels of service (Drew, 1968). This concept is defined as a qualitative measure describing operational conditions within a traffic stream, and their perception by motorists and/or passengers (Transportation Research Board, 1985). Factors which are involved in the level of service are speed and travel time, freedom to maneuver, traffic interruptions, comfort and convenience, safety, and operating costs.

The operation of vehicles on urban arterial streets is influenced by the following three main factors:

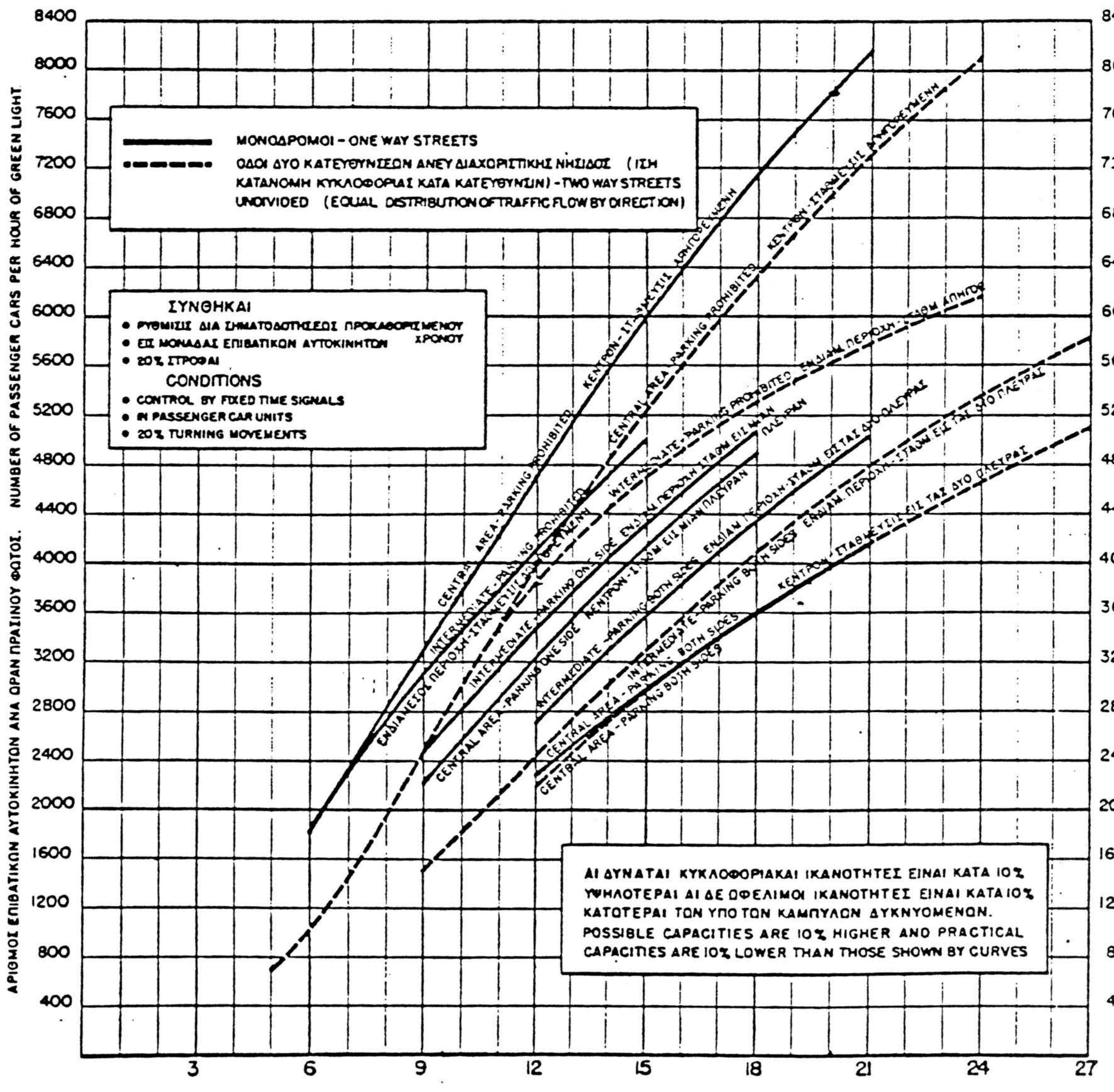
1. **The arterial environment**, which includes the geometric characteristics of the facility and adjacent land uses.
2. **The interaction between vehicles**, which is determined by traffic density, the composition of the traffic stream, and turning movements.
3. **Traffic signals**, which force vehicles to stop and to remain stopped for a certain time, and then release vehicles in platoons.

To determine street capacities within the Athens area, basic capacity curves, supported by years of research and much empirical data, were adapted to prevailing street, traffic and control conditions and converted to metric values. Adjustments to the basic curves were made after a series of field observations during peak hours on streets operating at obvious levels of peak capacity. The adjusted capacity curves derived from these studies are illustrated in Figure 2.3 (Smith, 1963). Ten curves are shown reflecting the capacity variations on central city streets, streets in the intermediate areas, one-way and two-way streets, and finally, streets with parking either permitted or prohibited. The capacity values are based on a constant assumption of 100 percent "green" time, 20 percent turning movements at intersections, and a 50-50 split in directional flow. Capacity ratings for each link in the system are factored values which reflect the actual conditions of "green" time and directional split existing on each link. These capacity ratings were used as input data for the Athens central city street network which is described and detailed in Chapter 5.

2.7 Travel Speeds and Travel Times

In 1973, driving-speed studies were carried out by Traffic Division personnel (Ministry of Public Works) on the entire Athens area arterial system. Four driving runs, two in each direction, were made on each link of the system with elapsed times between systems intersections recorded. One round trip was made during a peak hour and another during an off-peak hour. These driving runs were carried out utilizing the standard "floating car" technique.

The purpose of the speed and time studies was twofold. Firstly, an analysis of comparative speeds throughout the network has aided in determination of system deficiencies.



2.3 Street Capacity Curves for the City of Athens.

Secondly, and more importantly, the driving-time data were needed to establish the minimum travel paths from all sections of the city to all other sections.

Although, according to this study, the average speeds in the Athens central city ranged from 15 to 25 kilometers per hour (Smith, 1973), recent estimations show that the average speeds range from 8 to 20 kilometers per hour. Extremely low speeds are noted on all streets adjacent to Constitution and Omonoia squares. Delay time in the Athens central city averages 100 percent of total travel time caused primarily by congestion and normal signal delays. During peak hours, traffic is almost stagnant resulting in an extension of peaking characteristics in both location and time.

2.8 Traffic Variations.

Traffic volumes fluctuate constantly on different segments of the roadway network. These fluctuations are obvious during the course of a day, and perceptible during the course of a week or a year. While average daily traffic is a useful index of the relative importance of each segment within the system, the characteristics of traffic variation must be known in order to assess the sufficiency of the segments and to determine the design features necessary to accommodate future traffic loads.

2.8.1 Hourly Traffic Variations.

The most important variation characteristic in determining the capacity of a street is the hourly variation. If traffic demands were uniformly spread throughout the day, a much greater volume could be served than under conditions where heavy traffic loads are imposed at only two or three peak periods.

There are three well-defined peak periods of traffic. In one of these the traffic is predominantly inbound, and in the other two it is predominantly outbound. The morning inbound peak occurs between 7:00 and 9:00 a.m., with other inbound peaks occurring during the hours beginning at 1:00 p.m. and 5:00 p.m. The evening outbound peak occurs between 8:00 and 10:00 p.m., with a second outbound peak of near equal magnitude occurring between 1:00 and 3:00 p.m. Lowest values during the daylight hours occur between 3:00 p.m. and 5:00 p.m. These fluctuations are, of course, an accurate reflection of normal business hours throughout the Athens Central Business District (CBD). Shops and offices close around 2:00 p.m., and there is a general exodus then from the central city. The tempo of street traffic during this commercial lull is substantially slackened until about 5:00 p.m., when the central city re-opens for business.

The percentage values shown in Table 2.3 indicate the percentage of total daily traffic which occurs during each hour of the day. Values are given for "home" origins, "home" destinations, and "non-home based" trips. Absolutely uniform volumes throughout the day would produce an hourly value of 4.2 percent, which is the theoretical lower limit for a peak-hour value (Smith, 1963). The habit of taking an afternoon "siesta" was revealed by the very small number of trips observed between 3:00 and 5:00 p.m., i.e. less than seven percent of the total daily traffic. The nocturnal orientation of the Athenian social life is reflected by the fact that over 12 percent of all "home" destined trips occurred between 10:00 p.m. and midnight.

The hourly directional variation pattern is considerably more marked on radial arterials than on Core Area streets or circumferential arterials. Syngrou Avenue and Kifissias Avenue, both radial arterials, exhibit wide variations in directional volumes, whereas Alexandras Avenue has a relatively even split throughout the day. The latter, due to its

Table 2.3 Hourly Traffic Variations

Origin hour	Home origins (percent)	Home destinations (percent)	Non-home based (percent)	Total trips (percent)
0:00- 0:59(a.m.)	0.4	1.3	1.9	1.0
1:00- 1:59	0.1	0.6	0.1	0.3
2:00- 2:59	0.0	0.2	0.0	0.1
3:00- 3:59	0.0	0.2	0.0	0.1
4:00- 4:59	0.9	0.1	0.1	0.5
5:00- 5:59	2.8	0.1	0.6	1.4
6:00- 6:59	7.9	0.4	1.8	4.1
7:00- 7:59	13.2	0.3	4.0	6.9
8:00- 8:59	6.6	0.8	6.1	4.4
9:00- 9:59	7.5	2.9	8.7	6.1
10:00-10:59	5.6	4.8	13.5	6.0
11:00-11:59(a.m.)	2.9	6.2	14.3	5.8
12:00-12:59(p.m.)	2.2	6.7	10.2	5.3
1:00- 1:59	2.3	11.6	5.7	6.3
2:00- 2:59	1.1	10.2	3.3	5.4
3:00- 3:59	2.0	4.0	1.4	3.0
4:00- 4:59	4.9	2.2	1.7	3.3
5:00- 5:59	8.2	4.0	3.5	5.8
6:00- 6:59	8.0	5.8	4.3	6.5
7:00- 7:59	8.7	6.1	7.7	7.6
8:00- 8:59	6.5	11.2	5.4	8.0
9:00- 9:59	4.2	7.9	3.1	5.3
10:00-10:59	2.8	7.7	1.3	4.3
11:00-11:59(p.m.)	1.2	4.7	1.3	2.5
Total	100.0	100.0	100.0	100.0

circumferential nature, does not exhibit the effects of traffic "polarization" which is exerted by the central city on radial arterials.

2.9 Previous Transportation Studies

In 1957, a Traffic Division for Athens was set up in the Ministry of Public Works which has since introduced a lot of traffic management. In 1962, the Ministry engaged the American Consultants, Wilbur Smith and Associates, to carry out a transportation study for the whole Athens Basin; and the following year the same firm was asked to carry out a parallel study of public transport. Both studies were completed in 1965.

The Wilbur Smith recommendations were approved by the government. Regarding the highway network, the consultants predicted a five-fold increase in traffic volumes by 1980, if cars continued to be used in the same way as in 1965. To accomodate the increase in traffic demand, they proposed 96 kilometers of expressways and 190 kilometers of new and improved arterial roads, costing about 60 million pounds at 1965 prices. The expressways would encircle the city center. In particular, it was recommended that the main railway line be converted into a freeway - the rail traffic being relocated elsewhere:

> *A compelling reason for the relocation of the railroad and the terminal facilities is the fact that the removal of the railroads would leave a right-of-way sufficient for the construction of a major freeway...Passing as near to the central business district as it does, the advantages of utilizing this right-of-way for a freeway route cannot be overemphasized. The advisability of constructing two parallel freeways as close together as the Kifissos freeway and the Parnis freeway will be questioned, but the assignments of 1980*

traffic to the proposed facilities definitely demonstrate the need for both (Smith, 1963).

This passage indicates the typical approach to urban transport planning as recently as 1965. It was recognized that the city center presented a special problem in the sense that a freeway solution was patently impossible and a good public transport solution was imperative. The percentage of cars commuting to the center was proposed to be reduced --by means of parking controls and better public transport-- to 5 percent, an exceptionally low figure.

For public transport, Wilbur Smith proposed a 21-kilometer extension to the existing electric railway, serving four new routes and giving better distribution in the city center. The basic idea was to create a triangular "loop" in the center with six radial lines feeding into it. For eleven other corridors not served by the railway, express bus services were proposed.

Although approved by the departments concerned, these plans were never implemented. Many of the rights-of-way have now been occupied by new blocks of flats. One reason is economic; the rapid spread of the city makes it difficult enough to finance essential new infrastructure in the new suburbs without, at the same time, trying to drive costly new roads and railways through the older built-up area.

Another reason for inaction has been a lack of conviction that the right solution has been found. Wilbur Smith was obliged to plan the transport system without the benefit of a strategic land-use plan. They assumed that the mononuclear form of the city would be retained. By 1971 the dominant planning philosophy was, however, in favor of decentralization. The government could not accept the idea that only 5 percent of city-center workers should commute by car. They looked for a level of about 20 percent. They saw the problem of Athens as simply one of traffic congestion, and the need was to enable more people to use cars more easily. Since they could not afford the costly freeway facilities, together with the even more expensive railway facilities, designed to serve the requirements of the monocentric city, they saw the answer in a polycentric city.

Athens has undoubtedly reached a size where sub-centers are justified. The problem is to determine what kind of activities should go into the sub-centers and how to attract them there.

The preoccupation with decentralization in Athens probably arises from the failure of the city to decentralize naturally. In most cities, the process occurs automatically after a certain size has been reached, because it becomes progressively more difficult to provide certain services from the center, as the distance to the "market" increases, and it becomes progressively easier to provide the services locally as the local market increases. Thus, certain types of services tend increasingly to be supplied in a sub-center for a sector of the city. In Athens, this process does not seem to have occurred very successfully, possibly because of the highly fragmented state of local government. It is also the fragmented state of local government that is likely to obstruct the implementation of any master plan.

Chapter 3

Overview of Traffic Simulation Models

3.1 Traffic Simulation Models in General

The importance of characterizing traffic in a city network stems from the need to evaluate and compare transportation management strategies in terms of their overall network impact, to assess the quality of operations and identify deficiencies in a given network, and to monitor the level of traffic service over time in a designated area.

One tool that is particularly effective for evaluating transportation management strategies applied to a dynamic environment is traffic simulation. Simulation models provide the means for evaluating a wide spectrum of traffic management schemes within the framework of a controlled experiment. This simulation approach is far more appealing and practical than a strictly empirical approach, for the following reasons:

1. It is much less costly.
2. Results are obtained in a fraction of the time required for field experimentation.
3. The data generated by simulation include measures of effectiveness that cannot, in a practical sense, be obtained empirically.

4. Disruption of traffic operations, which often accompanies field experimentation, is completely avoided.
5. Many transportation management strategies involve significant physical changes that are not acceptable for experimental purposes.
6. Testing and evaluating various alternatives under the same conditions is feasible.

Simulation models are specifically designed to describe the dynamic effects of traffic flow. Factors that impede traffic can be explicitly represented in great detail. Consequently, simulation tools can provide a detailed description of the dynamic performance of traffic over a network.

Traffic simulation models can be macroscopic or microscopic depending on the approach used in observing the traffic. Macroscopic models consider the traffic stream as composed of platoons of vehicles and concentrate on the relationship between speed, flow, and density. On the other hand, microscopic models are based on factors that govern the movement of a single vehicle as a separate and identifiable entity in the traffic stream with respect to other vehicles in that stream.

There are three classes of traffic simulation models: single road, single intersection, and network models. Network models are the most complex ones. Some represent surface streets only, while others can include freeway networks. These models are very useful in testing signal control strategies, traffic diversion strategies, attempts to add or delete streets from the network, and similar tactics. A survey of traffic simulation models revealed that there are as many as 104 models, but only a few models are considered useful and operational in dealing with current traffic problems (Gibson and Ross, 1977).

In the following sections, a review and a brief description of some of the most important network traffic operation simulation models are presented.

3.2 TRAFLO - TRAffic FLOw simulation model

The TRAFLO model developed for the Federal Highway Administration (FHWA) is actually a software system that consists of five functionally independent models (Lieberman and Andrews, 1980). The logical structure of TRAFLO is designed to permit these independent models to interface with one another so as to form a coherent, integrated system. Four of the models simulate traffic operations over a specified network of roadways; the fifth model is an equilibrium traffic assignment model.

The analyst can select those component models that are most responsive to his needs. There are three components available for simulating arterial roadways, ranging from a microscopic, event-based model (Level I) to a macroscopic model (Level III) in which intersections are treated as impedance points along a route (Eiger *et al.*, 1980).

The TRAFLO model requires considerable data input depending on the chosen simulation level(s). For each network link several input parameters are required including speed, number of lanes, channelization, grade of downstream links, along with various signal inputs at each intersection. In using the traffic assignment model, the user must also specify the trip table that defines the volume of traffic traveling from each origin to each associated destination.

The TRAFLO model provides various output parameters for four different categories: freeway operations, arterial operations, arterial environment and measures of effectiveness.

Some advantages of the model are:

1. Input data are printed out in an easy-to-use format and can be checked prior to execution.
2. New alternatives and variations of earlier options require only minor data input modification.
3. Traffic assignment and simulation are accomplished in a single computer run.
4. Useful statistics are produced for analysis and evaluation of the whole network and individual links.
5. A good overall level of traffic assignment calibration is achieved with a reasonable number of computer runs.
6. Standard output includes a comprehensive set of measures of effectiveness (MOEs) than can be very useful in evaluating different alternatives.

Negative aspects of the model include the following:

1. The required input data is comprehensive and extremely detailed.
2. The computer costs of the assignment-simulation run are high.
3. The model is still in the "debugging" stage.
4. The environmental MOEs do not represent the actual conditions existing in a congested network.
5. The traffic assignment model used does not take into consideration the effect of traffic signals on link capacities.

3.3 NETSIM - NETwork SIMulation model.

The NETSIM simulation model is based on a microscopic simulation of individual vehicles which are moved through the system along the links, according to specified controls at nodes, stochastically determined turning movements and deterministic car following (KLD and Associates, 1977). NETSIM can be used for simulating traffic performance under a wide mix of traffic control and traffic management strategies and under heavy traffic demand.

The basic input requirements of the model are the network geometry, signalization information, speeds, headways, types of traffic control, and traffic counts which consist of both input flow rates and turning movements. The standard output of the NETSIM model includes estimates of important traffic parameters such as:

- total vehicle minutes of travel time,
- number of vehicles discharged,
- total vehicle miles of travel distance,
- average travel time per vehicle,
- average travel time per vehicle mile,
- average speed, and
- average delay time per vehicle.

The estimates of the traffic parameters are provided both on a link-by-link basis and on a network basis.

NETSIM is a widely validated procedure and it provides the user the opportunity to test and evaluate different strategies just by changing the underlying assumptions that are built into the model.

Despite the popularity of the program, NETSIM presents some serious drawbacks:

1. Input preparation is difficult and time consuming because of the detailed data required.
2. The model capabilities are too limited in terms of the size of the network it can handle and the number of vehicles it can process.
3. The computer costs associated with each simulation run are extremely high.
4. The simulated movements of queueing vehicles have little to do with the discharge times generated separately from a probability distribution. Consequently, the simulated speed profiles may not be compatible with the discharge times. This in turn, leads to systematic biases in the simulated dwell characteristics.
5. The model is not able to handle scenarios that require route diversion by drivers, because of its inability to include a dynamic route selection.

3.4 TRANSYT-7F: TRAffic Network StudY Tool

TRANSYT-7F was developed by the University of Florida Transportation Research Center (TRC) for the FHWA and is an "americanized" version of the British TRANSYT-7 traffic signal timing optimization program (Wallace *et al.*, 1981). It contains, as an integral element, a simulation program that can be used without the optimization feature if desired.

The program is totally macroscopic and completely deterministic. It provides optimal signal timing plans which minimize stops, delay, and fuel consumption, and can be used to time isolated intersections or coordinated arterial or network systems. It could also produce a full set of link and network measures of effectiveness.

The model has a limit of up to 50 intersections (nodes) with up to 250 directional links. One of the most interesting output features of the model is a series of plots of the density of traffic as it moves in time and distance.

3.5 SIGOP-III

SIGOP III, developed for FHWA, is a macroscopic signal timing design and analysis model (Lieberman and Woo, 1982). It is very similar and has the same principles of the TRANSYT model. Like TRANSYT, it contains a macroscopic model of traffic flow which can be used to evaluate the stops and delays of an existing signal system.

The logic of SIGOP III uses dynamic programming techniques to represent traffic streams as being states with specific properties, which pass through stages (the intersections), where they are transformed by the decision variables (traffic control) into departing streams which exhibit different state properties.

Input preparation is fairly straight forward. Output includes time space plots of signal control along specified arterials as well as link statistics. SIGOP III computer speed varies linearly with the size of the network so that it is slower than TRANSYT for small networks and is somewhat faster for large networks.

3.6 EMME/2

EMME/2, developed by the University of Montreal Transportation Research Center and INRO Consultants Inc., is a multi-modal urban and regional transportation planning system designed for interactive-graphics use (Florian and Nguyen, 1985). It contains about 50 modules which are subdivided into the following groups: 1) utilities, 2) network editor, 3) matrix editor, 4) function editor, 5) assignment procedures, 6) results.

Demand modeling, including trip generation, trip distribution, and mode choice, is carried out within the matrix editor. The assignment procedures include the following features: 1) equilibrium road assignment, 2) multipath transit assignment, 3) multimodel equilibrium assignment. The network editor contains a network calculator which provides the capability of performing calculations with the network data and the results of assignments.

The microcomputer version handles problems of up to 800 zones, 10,000 nodes, 32,000 links, and 600 transit lines.

3.7 MASSVAC2

MASSVAC2 is a mass evacuation computer model developed at the Civil Engineering Department of the Virginia Polytechnic Institute and State University. The model has two levels of analysis: a macroscopic and a microscopic level. The macroscopic level simulates the evacuation process on a highway network by looking at the major network arteries as a complete and integrated system. It provides an estimation of maximum network evacuation time and total vehicle travel time along with other output according to specified options. The microscopic level deals with a selected subnetwork of the whole network, where congestion is taking place, and provides solution through transportation management strategies (Hobeika *et al.*, 1985).

For the purpose of this thesis, MASSVAC2 was employed for simulating traffic performance under various traffic management strategies for the central city of Athens. Even though, in the case of Athens, MASSVAC2 is not utilized for evacuation purposes, it is believed that the model can yield reasonable and useful results for the scenarios under study.

Chapter 4

MASSVAC2 - Theoretical Aspects of the Model

4.1 Model Criteria

When developing MASSVAC2, the following criteria were utilized (Radwan et al., 1985):

1. The simplicity of the model should not be achieved at the expense of good and reasonable results.
2. The model should be dynamic in updating the status of traffic speeds, volumes, travel times, and queue build-ups on highways as frequently as possible.
3. The model should be equipped with the capacity-restraint concept.
4. The model should have the capability of evaluating the impact of future land use plans, and traffic operation and management strategies, on evacuation times and rates.
5. Preparation of the model input data should be simple.
6. The model output should be easily analyzed and interpreted.

4.2 Model Module

4.2.1 Trip Distribution

The shortest-path algorithm is a necessary algorithm in almost all assignment methods. This algorithm helps determine the shortest path for each origin-destination (O-D) pair, as well as build the shortest impedance tree from any origin to all the nodes in a network.

MASSVAC2 uses the shortest-path algorithm in Dial's traffic assignment technique, and the distribution of trips is based on the shortest path from origin to destination. In this case, the shortest path is based upon travel time rather than distance. The travel time is calculated using the Bureau of Public Roads (BPR) equation, which assumes that there is a relationship between travel time and the volume assigned to each link in a highway network (BPR, 1964). This standard equation is in the following form:

$$T = T_0\left[1 + 0.15\left(\frac{V}{C}\right)^4\right]$$

where,

T = link travel time;

T_o = unimpeded link travel time;

V = volume assigned to the link;

C = practical capacity of the link.

Using this formula, the shortest paths are found from each origin to all destinations. Vehicular trips are distributed to the paths proportionally to the weighted inverse of travel time on them. An O-D table is thus formed, which is used as part of the input in

Dial's traffic assignment model. MASSVAC2 is flexible enough to offer the user the option to bypass the trip distribution model and provide an O-D table of his own as input to the traffic assignment model.

4.2.2 Traffic Assignment

Traffic assignment is defined as the process of determining a route or routes of travel and allocating the centroid-to-centroid trips to these routes (FHWA, 1972). In most widely used traffic assignment models, all trips between a fixed origin and destination are assigned to the links constituting a single shortest connecting path. This technique is known as "all-or-nothing" assignment. The benefit of this method is that it is easy to understand and apply, but it possesses the following serious shortcomings:

- It lacks stability. A trivial change in a network's link times can cause gross changes in the forecasted link volumes.
- It fails in at least two instances to reflect the actual behavior of trips over a network. Firstly, it cannot consider the effect of capacity restraint and, secondly, it is unable to allow for realistic random variation of route selection among individual tripmakers.
- It is inaccurate when it comes to the estimation of the system's travel time and the link volumes.

A street-network system, particularly when operating or at near-capacity volumes (the case of the central city of Athens), provides many alternate paths between the same origin and destination which vary slightly with respect to length. A realistic model would be a "multipath" assignment model, which would apportion trips to all of these paths in a probabilistic manner reflecting their relative likelihood of use (Dial, 1970). The best-known and most often cited model for probabilistic traffic assignment is Dial's multipath traffic assignment model, and this is what MASSVAC2 uses as a traffic assignment technique.

Dial's model allocates trips to alternative "efficient" paths through a two-pass Markov approach. The efficient paths are defined as the paths which comprise links with positive assignment-likelihood. A link has a positive assignment-likelihood only when its initial node is closer to the origin node than its final node. The model possesses the following features (Dial, 1970):

1. It gives all reasonable paths between a given origin and destination a non-zero probability of use, while all unreasonable paths are given a probability of zero.
2. All reasonable paths of equal length have an equal probability of use.
3. Among two or more reasonable paths of unequal length, the shortest one has the highest probability of use.
4. The user has some control over the path diversion probabilities.
5. The assignment algorithm does not explicitly enumerate the paths it loads; all efficient paths between a given origin and destination are loaded simultaneously.

As mentioned earlier, the probabilistic multipath assignment model is a two-pass Markov model. In the first pass, the probability of using each reasonable path is calculated based on a comparison between the travel time on the reasonable path and the travel time on the shortest path. The following formula is used in calculating the probabilities:

$$a(m) = e^{\theta \Delta t}$$

where,

a(m) = probability (likelihood) of choosing path m;

θ = factor for diversion probability;

Δt = the time difference between minimum time path and time via another reasonable path.

The parameter θ allows the user to affect diversion probabilities. When θ increases, the probability that a trip will use a shortest path also increases. When θ is zero, all efficient paths have equal likelihoods of being selected. When θ is large, i.e., 10 or larger, the effect is a multiple shortest-path assignment, which assigns trips to all and only the shortest paths. This allows the user to perform the equivalent of an all-or-nothing assignment that appropriately considers parallel routes.

In the second pass of the model, trips are assigned based on the previously calculated probabilities. The model stochastically diverts trips to alternate paths, but trips are not explicitly assigned to routes. Instead, they are probabilistically diverted at each node encountered to the competing links entering the node. The fraction of trips assigned to each alternate link is a diversion probability based on the comparative length and number of efficient paths through the link. The results are link volumes and an expected volume of trips through each converging link's initial node. The process is then reapplied to these nodes, etc., until the origin node is reached.

The primary advantage of Dial's algorithm is that it represents well the actual behavior of trip makers in choosing a travel route by allowing many alternative routes to be considered without having to enumerate and describe them explicitly.

Although the parameter θ gives the user the ability to control the diversion between paths, it also provides an additional variable which must be adjusted and refined in the model calibration process. For each individual case there is a value for θ, which does the best job in duplicating the results of human behavior, although there are very few guidelines currently available for the selection of proper values for this diversion parameter (Morris, 1973).

4.2.3 Capacity-Restraint Approach in Traffic Assignment

The capacity-restraint approach in traffic assignment considers that the impedance to flow on a link will increase as the number of vehicles utilizing the link per unit of time increases. The two following assumptions are taken into account:

- link volume/time relationships are significant, and
- tripmakers interact optimally in such a way that minimizes average trip length (i.e. total travel time).

The capacity-restraint assignments are most useful in allocating trips in urban transportation networks (i.e. central Athens), where oversaturated links are present.

Dial's probabilistic assignment model can cope with the capacity-restraint problem. The addition of capacity-restraint modification to Dial's model increases the accuracy and validity of route selection and network loading. MASSVAC2 utilizes the above feature in treating transportation networks macroscopically. In this way, the model effectively accounts for dynamically changing network characteristics in a rational, well-behaved manner. As the "efficient" paths become heavily loaded, the secondary paths become relatively more attractive, and their share of trips increase. As these secondary paths get filled up, the tertiary, and possibly the primary paths, increase their relative attractiveness. The diversion probabilities between competing paths gradually oscillate around a trend towards equal likelihood of use. Upon completion, the model sums the incremental loadings for an estimate of the link volumes over the entire assignment period.

4.2.4 Vehicle-Loading Pattern

Studies in the social-science field related to evacuation proved that highway network loading starts at a low rate at the beginning and as time progresses the rate increases, until it reaches its maximum threshold, which is approximately at the midpoint of the total loading period. Then, the rate decreases until it reaches the end of the loading period. The cumulative volume plotted over time follows an S-shaped curve (Radwan et al., 1985). MASSVAC2 shares the assumption that the cumulative evacuation vehicle-loading pattern follows a logit curve. The following formula is used:

$$CL = \frac{1}{1 + e^{[-LP \times (DT - HLT)]}}$$

where,

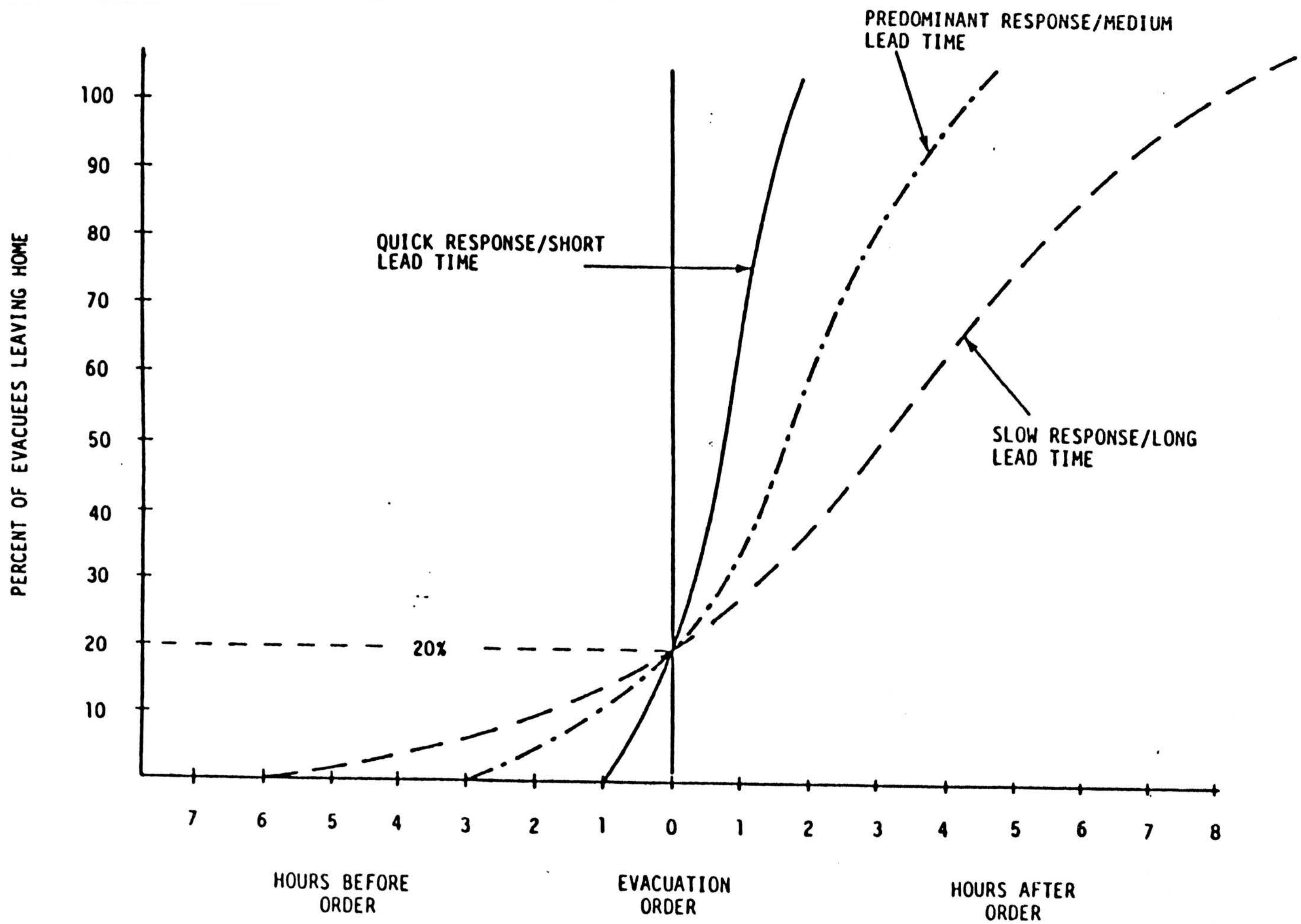
CL = cumulative loading;

LP = loading parameter (1/minutes);

DT = time (minutes);

HLT = half-loading time (minutes).

In Figure 4.1 there are three S-shaped curves (steep, flat and lazy). The steep curve represents the quick response of the public to the evacuation order. The flat curve represents the predominant response that was obtained from the stated responses by individuals involved in actual evacuation. Finally, the lazy curve represents the slow response of the public to the evacuation order due to the long lead time available before the occurrance of the disaster. The loading parameter, LP, controls the steepness of the



4.1 Evacuation Response Curves.

S-shaped curve, and previous studies have shown that values of 0.04, 0.022, and 0.01 should be used for steep, flat and lazy curves respectively (Jamei, 1984).

The half-loading time, HLT, is a parameter which is specified by the user and represents the time at which half of the total volume must be loaded on the network. The current clock time, DT, is incrementally increased at each time period of the simulation, and ranges from 15 to 60 minutes depending on the total volume to be loaded on the network. For each time interval, the model moves all the vehicles to their destination and all MOEs statistics are updated. The incremental analysis is continued until all the volume is loaded, then the model proceeds with clearing the network over time until all vehicles have been cleared and the final evacuation time is obtained.

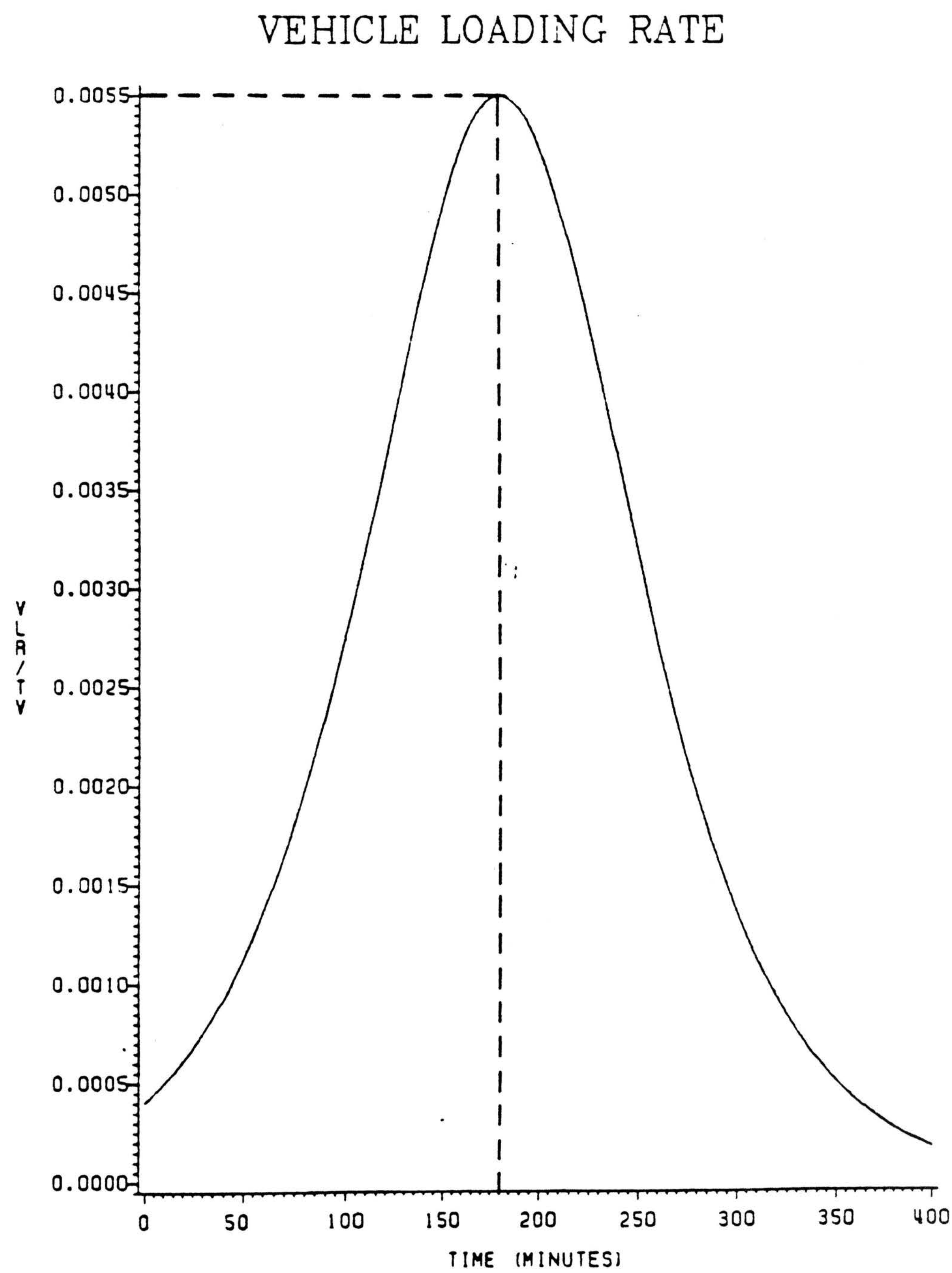
Since the cumulative evacuation vehicle-loading pattern is assumed to follow a logit curve, the vehicle-loading rate is assumed to follow a normal curve, which is the derivation of a logit curve. This can be seen in Figure 4.2, and the formula for the vehicle-loading rate can be derived by taking the partial derivative of equation (1) with respect to time DT and multiplying it with the total evacuation demand (Hwang, 1986):

$$VLR = \frac{TV \times \left[LP \times e^{[-LP \times (DT-HLT)]}\right]}{\left[1 + e^{[-LP \times (DT-HLT)]}\right]^2}$$

where,

VLR = vehicle-loading demand rate (vehicles/unit time);

TV = total evacuation demand (vehicles).



4.2 Vehicle-Loading Rate vs. Time Relationship.

4.3 Evacuation Time

Evacuation time or clearance time of the network is defined as the time required to clear all evacuating vehicles from the roadway (Jamei, 1984). Although the loading period, which can be specified by the user, is for most cases 4, 8 or 16 hours, the clearance time would not necessarily be close to these values. The presence of congested links in a road network causes the overall clearance time to be prolonged, since the capacity-restraint feature of the model does not allow overloading on congested links.

The clearance time is affected by the following factors:

- the size of the network,
- total vehicular trips to be evacuated from the network,
- loading period, and
- capacity of the streets in the network.

4.4 Traffic Operation and Management Strategies

MASSVAC2 is equipped with a series of traffic operation and management strategies that can increase the transport efficiency in an urban transportation network. These strategies are classified into the three following categories (Jamei, 1984):

1. **Traffic Control Strategies:** they involve switching of the signals to flashing operation at street intersections with low traffic volumes on the side streets.
2. **Facility Physical Strategies:** they involve use of the shoulders on freeways and expressways, and as a result an increase in capacity of certain links is achieved.

3. **Traffic Flow Directional Strategies:** they involve converting two-way streets into one-way streets or prohibiting entries at certain locations in a road network.

4.5 Operational Methodology

It is appropriate and helpful in understanding the model, to review the different stages that MASSVAC2 goes through before yielding the final simulation results:

1. A shortest path algorithm is used and the shortest paths are found from each origin to all destinations.
2. The "efficient" paths of the network are determined using Dial's traffic assignment technique.
3. The vehicle-loading volume is calculated for each simulation interval.
4. Volume is assigned to the "efficient" paths proportionally to the weighted inverse of travel time on them.
5. Traffic flow is capacity-constrained.
6. If the volume to capacity ratio is less than one, the overall volume is discharged. If the volume to capacity ratio is greater than one, some portion of the volume is being discharged, depending on the link type, and the remaining volume is queued on the link and added to the volume of the next simulation interval.
7. When all volume to be evacuated has been loaded on the network, the loading process stops and the model proceeds with clearing the network.
8. The network clearance time is obtained when all evacuating vehicles have been cleared from the network and have reached their destinations.

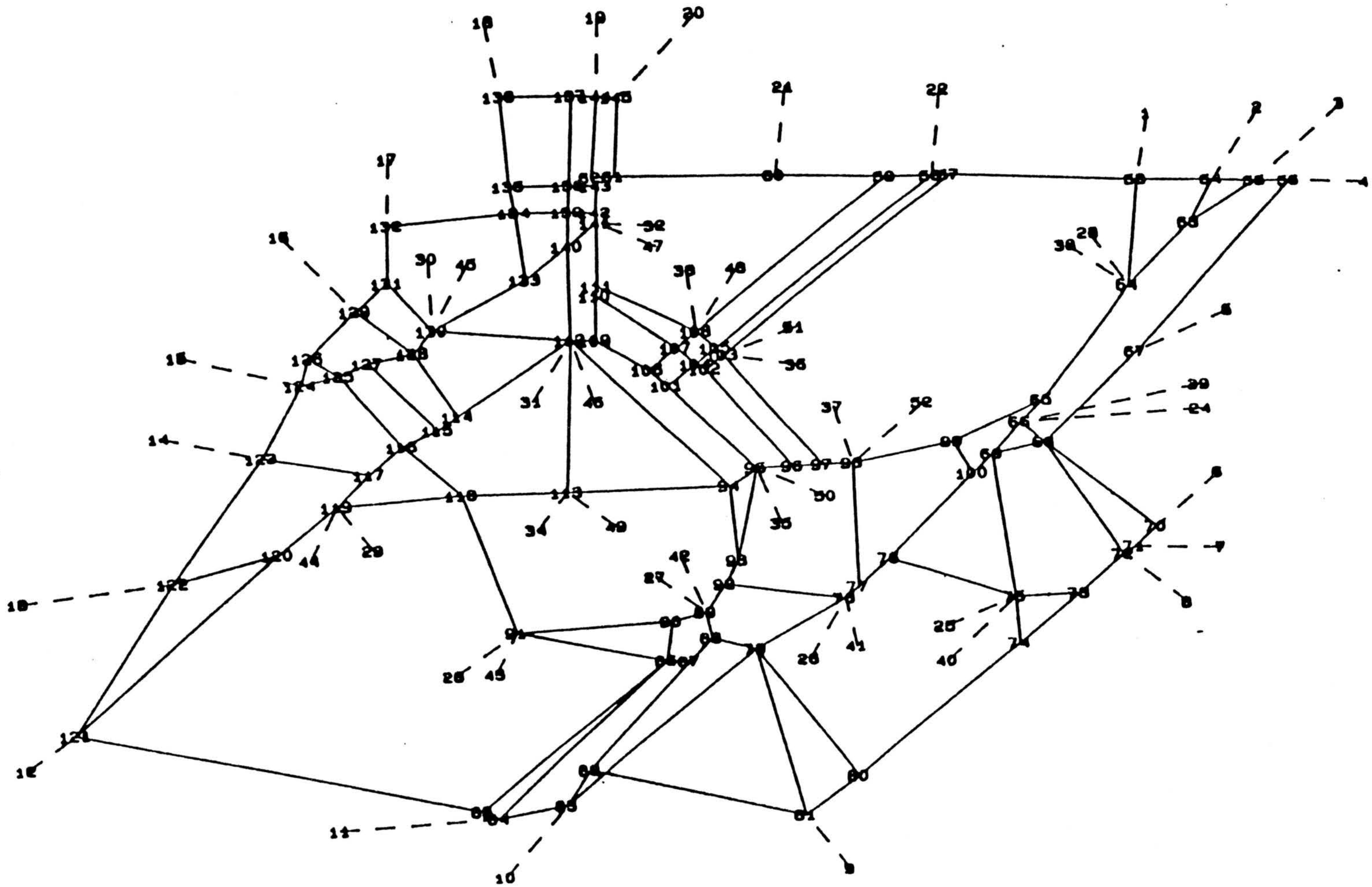
Chapter 5

Traffic Management Strategies for the Central City of Athens.

5.1 Network Coding

The network used for representing the central city of Athens is shown in Figure 5.1. The coding of the network was based on the following considerations:

1. The network included the central area of Athens for which an auto-restriction program has been instituted (section 6.2 provides more details on the auto-restriction program). Some extensions to the restricted area were also included in the network, since they are part of the overall central area transportation problems of the city.
2. Because of the size of the area under consideration, the links coded in the network were mainly major arterials and collector streets.
3. Fifteen origin and twenty-two destination nodes were coded in the network. The fifteen origin nodes were also considered as possible destination nodes, which brought the total number of destination nodes to thirty-seven.



5.1 MASSVAC2 Network Coding for the Central City of Athens.

The input data for the central Athens network for MASSVAC2 is presented in Appendix B. Input data include the following:

1. Operational Strategy (loading period, macroscopic or microscopic level runs, various output options).
2. Link information (capacity, number of lanes, link length, free flow speed, existing volume, etc.)
3. Origin to destination trip table.

More information about the MASSVAC2 input methodology and requirements is included in Appendix A.

5.2 Traffic Volumes

The central city network consists mainly of major arterials and collectors. Major arterial streets are the primary traffic carriers and accommodate heavy movements through principal areas and neighborhoods of the city. Collector streets are local facilities, which serve residential areas as feeders to and from major arterials, and as collectors of traffic moving between neighborhood streets. Numerous intersections and other traffic impedances on these facilities reduce driving speeds and traffic capacities.

Street capacities in the Athens central area are particularly stressed, and most of the main thoroughfares of the area are at present operating over capacity. In the past 25 years the very rapid evolution of household motorization has resulted in an impressive increase of traffic volumes throughout the study area. Table 5.1 presents the increase of vehicle flow rates on the main thoroughfares of Athens between the years 1976 and 1987.

Table 5.1 Mean Daily Vehicle Flow Rates on Main Thoroughfares of Athens in 1976 and 1987

Name of thoroughfare	Daily flow rate	Daily flow rate	Percentage increase
	1976	1987	
Kifissias Ave.	72,648	106,024	45.9
Messogion Str.	44,854	89,776	100.2
Vas. Sofias Ave.	72,840	105,954	45.5
Alexandras Ave.	65,382	91,068	39.3
Ippokratous Str.	20,678	24,458	18.3
Stadiou Str.	33,610	50,758	51.0
Panepistimiou Str.	59,149	62,386	5.5
Akadimias Str.	30,418	36,062	18.6
Patission Str.	34,642	43,752	26.3
Acharnon Str.	38,057	49,744	30.7
Lenorman Str.	31,118	50,202	61.3
Iera Odos Str.	25,785	34,813	35.0
Petrou Ralli Str.	30,083	57,888	92.4
Sygrou Ave.	50,086	70,079	39.9
Frantzi Str.	30,515	33,164	8.7
Ilioupoleos Ave.	31,695	39,387	24.3

The traffic volumes used in this study (as input data for the "seed" volumes of the coded network) were available from the files of the Traffic Division of the Ministry of Public Works. In 1987, a traffic counting program was undertaken at 444 selected points throughout the Athens area (YPEHODE, 1987). The voluminous data collected in the counting program was adjusted to the same base by factoring the actual volumes to account for monthly and daily variations. This adjusted value is the annual average daily traffic (ADT). This figure was further adjusted to convert the value into equivalent average daily passenger-car units (ADPU).

5.3 Travel Data

The most recent and detailed data on travel of persons and vehicles in the Athens region was compiled in 1972, in a report entitled "Athens-Attica Region-Traffic and Transportation Study-Final Report," established by the American consulting firm Wilbur Smith and Associates. Based on this study, traffic within the urban area is distributed over three categories (Smith, 1973):

- trips within the center;
- trips between the center and other sectors, and trips between peripheral sectors, crossing the center;
- trips between peripheral sectors, not crossing the center.

Table 5.2 represents the results of the above study for the Athens region. It has been estimated that the average annual increase of traffic in the Athens region, over the last 15 years, is equal to 2.625 percent (YPEHODE, 1987). The total number of daily vehicular trips for the Athens area, for 1987, can be found using the following trip compounding formula:

Table 5.2 Daily Travel Data for the Athens Area (1972)

	Trips within the center	Other trips involving the center	Sub-total	Trips not involving the center	Total
Vehicle-trips	173,448	453,026	626,474	784,728	1,411,202
Percent	12.29	32.10	44.39	55.61	100.00

$$A = B \times (1 + \alpha)^n$$

where,

A = number of total daily vehicular trips in 1987;

B = number of total daily vehicular trips in 1972;

α = average annual increase of traffic;

n = number of years between 1972 and 1987.

hence,

$$A = 1{,}411{,}202 \times (1 + 0.02625)^{15} = 2{,}081{,}550 \text{ daily vehicle trips}$$

Assuming that the distribution of trips within the Athens area, which is shown in Table 5.2, has not changed in the 15 year period between 1972 and 1987, the overall picture of daily travel within the Athens region for 1987, is presented in Table 5.3. The above assumption was based on the following:

- the central area has retained its importance as the focal point of the commercial activity in the city, and
- the land-use characteristics of the area have not changed significantly, and thus, new traffic corridors have not been developed and the trip distribution has not been altered.

5.4 Study Period

Traffic in the central Athens network was studied for the time between 12 p.m. and 4 p.m. The selection of this period was based on the following considerations:

Table 5.3 Daily Travel Data for the Athens Area (1987)

	Trips within the center	Other trips involving the center	Sub-total	Trips not involving the center	Total
Vehicle-trips	255,822	668,178	924,000	1,157,550	2,081,550
Percent	12.29	32.10	44.39	55.61	100.00

- During this time the most intense outbound peak occurs in the study area, and
- MASSVAC2, being primarily an evacuation program, is able to simulate traffic in a more realistic manner during an outbound peak, which resembles an evacuation from the center of the city.

As mentioned earlier, MASSVAC2 can employ for the study of a network three different loading periods: 4, 8, and 16 hours. There are also three different S-curves that could be used for loading a network. For the purpose of this study, the quick response S-curve (short lead time) was used, which loads the trips over a period of 4 hours. This curve represents the actual situation in central Athens accurately, since the network loading starts at a low rate at the beginning (12 p.m.) and, as time progresses, the rate increases until it reaches its maximum threshold around halfway from the total loading period (2 p.m.).

It can be seen (Table 2.2) that the number of total trips made in the four-hour period of interest, is equal to 20 percent of the total trips made daily in the Athens area. Based on the above criterion, and the 1987 daily travel data for the Athens region, the travel data for the four-hour study period was calculated, and is shown in Table 5.4.

5.5 Origin-Destination Table

Origin and destination surveys are designed to provide sample information on movements of persons, vehicles, and goods in urbanized areas. In 1972, the consulting firm of Wilbur Smith and Associates, carried out a comprehensive origin and destination survey in the city of Athens. The following five separate surveys were conducted to gather the sample data necessary to measure existing travel habits:

Table 5.4 Travel Data in Athens for the Period between 12:00pm and 4:00pm

	Trips within the center	Other trips involving the center	Sub-total	Trips not involving the center	Total
Vehicle-trips	51,150	133,650	184,800	231,510	416,310
Percent	12.29	32.10	44.39	55.61	100.00

- home interview survey,
- roadside survey,
- commercial vehicle survey,
- employment survey, and
- transit survey.

Detailed trip information was obtained relating to the origin, destination, purpose, mode of travel and other pertinent factors. Based upon these surveys, Wilbur Smith and Associates developed a technique of "synthesizing" travel demands for any given set of land-use characteristics and population spatial distribution.

The Wilbur Smith study was used to generate an O-D table for the central city of Athens, which was subsequently used as input to the traffic assignment model of MASSVAC2 and is shown in Table 5.5. The generation of the O-D table was based on the following considerations:

- The travel patterns existing in 1972 were assumed to be identical to the ones present in 1987.
- The central city of Athens was divided into fifteen zones, which encompass, as far as possible, homogeneous population groups.
- The area surrounding central Athens was divided into 22 zones to permit an analysis of the trip generating influence of the central area on municipalities in the peripheral area.
- The increase in traffic, in the period between 1972 and 1987, was assumed to be homogeneous throughout the central area.

Table 5.5 Origin-Destination Table (vehicle-trips) for Central Athens Network

	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	D14	D15	D16	D17	D18	D19	D20	D21	D22	total
O1	509	1375	703	392	307	300	363	193	503	435	209	95	102	109	111	132	259	192	352	362	219	211	7433
O2	487	1339	677	307	392	402	399	280	909	1013	235	202	165	151	229	189	350	201	201	182	101	83	8494
O3	392	702	603	185	285	405	452	372	1023	632	290	101	93	99	232	132	300	101	211	198	102	91	7001
O4	403	895	529	203	203	220	332	281	1400	1327	382	332	192	162	330	232	299	153	300	280	132	130	8717
O5	207	789	423	80	180	80	307	153	1235	1334	423	400	311	280	402	253	321	201	192	180	101	92	7944
O6	283	403	272	97	97	50	189	103	532	882	307	529	400	411	402	302	322	185	201	190	92	90	6339
O7	203	392	302	118	118	107	101	92	395	623	332	730	695	660	832	457	502	202	209	180	88	80	7418
O8	323	683	400	230	130	89	135	53	302	472	222	622	709	701	1432	1009	1345	832	702	690	222	245	11548
O9	489	893	603	300	200	200	309	192	992	1139	209	932	895	882	1387	847	1320	825	823	850	401	415	15103
O10	332	890	575	180	180	115	135	103	301	459	192	403	302	259	650	409	803	529	703	790	332	340	8982
O11	399	831	585	290	200	100	150	95	298	523	211	412	240	232	623	411	590	323	692	720	432	411	8768
O12	225	400	285	60	150	80	212	101	471	621	360	402	199	200	280	221	238	172	202	110	132	112	5233
O13	501	1503	805	302	352	220	311	218	1435	1342	473	711	592	601	892	749	702	630	821	760	289	321	14530
O14	380	1057	687	272	222	125	139	95	384	401	252	209	182	179	280	201	432	103	432	413	473	460	7378
O15	400	1400	730	325	325	180	382	155	1073	892	327	202	109	99	124	109	236	190	521	498	225	260	8762
total	5533	13552	8179	3341	3341	2673	3916	2486	11253	12095	4424	6282	5186	5025	8206	5653	8019	4839	6562	6403	3341	3341	133,650

Table 5.5 Origin-Destination Table (vehicle-trips) for Central Athens Network (continued)

	D23	D24	D25	D26	D27	D28	D29	D30	D31	D32	D33	D34	D35	D36	D37	total
O1	0	0	423	382	301	102	203	309	403	422	430	132	135	320	487	4049
O2	0	0	400	301	232	123	232	404	379	403	350	109	201	409	603	4146
O3	303	452	0	0	201	78	199	202	322	380	203	93	119	372	432	3356
O4	364	370	0	0	0	92	182	219	268	203	192	88	73	201	392	2644
O5	203	201	302	0	0	0	130	132	232	139	262	0	0	203	238	2042
O6	187	253	203	252	0	0	123	387	402	392	209	72	72	182	392	3126
O7	152	156	192	195	183	102	0	232	372	209	242	102	80	109	388	2714
O8	201	109	150	165	107	40	232	0	0	192	202	109	109	132	253	2001
O9	432	401	332	423	327	140	293	0	0	302	209	233	191	472	675	4430
O10	329	252	238	101	139	37	153	201	100	0	0	152	142	309	452	2605
O11	332	301	252	101	153	52	108	192	92	0	0	139	167	0	439	2328
O12	325	301	203	182	0	62	259	185	203	179	192	0	0	302	392	2785
O13	722	709	603	549	0	122	377	523	739	927	632	0	0	543	0	6446
O14	422	409	292	198	232	83	172	203	436	230	0	130	92	0	382	3281
O15	632	689	502	373	273	92	201	392	349	472	457	227	0	538	0	5197
total	4604	4603	4092	3222	2148	1125	2864	3581	4297	4450	3580	1586	1381	4092	5525	51,150

5.6 Summary of Model Input

The coded network, which represents the central city of Athens, displayed the following characteristics:

• Number of origins:	15
• Number of destinations:	37
• Number of nodes:	145
• Number of links:	294
• Vehicular trips generated by the origin zones:	184,800
• Vehicular trips attracted by the central area:	51,150
• Vehicular trips attracted by the peripheral area:	133,650

MASSVAC2 was used to test the Athens network under different transportation management strategies (scenarios). The model was run under the following combination of options:

- Macroscopic simulation level.
- Various time intervals: 15, 30 and 60 minutes.
- Various values for the diversion probability factor (θ).
- Fixed trip table.
- Fixed loading period: 4 hours.
- Simulation under existing volume (daytime loading).

5.7 Model Output

The output of the MASSVAC2 computer model varies depending on the options specified in the input file. The output of interest for the central Athens network includes:

1. Trip table from any origin to the assigned destinations at each loading period and also the overall O-D table at the end of the simulation.
2. Tracing of the selected paths from any origin to the assigned destinations.
3. Statistics concerning the link characteristics at each loading interval: volume/capacity ratios, link density, link travel time, and travel speeds. These statistics represent the measures of performance for the overall network.
4. Listing of congested links and their corresponding volumes and capacities at each loading interval.
5. Overall volumes assigned to each link in the network at the end of the simulation run.
6. Evacuation times of the network at each time interval, the overall network clearance time and the total vehicle-travel time at the end of the simulation.

A sample of the model output for the central Athens network is presented in Appendix C.

5.8 Sensitivity Analysis

The model was run under the combination of options which yielded the minimum network clearance time and minimum total vehicle-travel time. A sensitivity analysis was thus necessary, so that the values chosen for certain input variables would yield the "best" results for the central Athens network. The variables studied in the sensitivity analysis were:

- the time intervals for loading vehicular trips, and
- the diversion probability factor.

5.8.1 Time Intervals

The model was simulated under the following time intervals: 15, 30 and 60 minutes and the results of the simulation runs are shown in Table 5.6.

It is obvious that the network clearance time and the total vehicle-travel time were reduced with decreasing time intervals. This was expected, since at smaller time increments lower vehicular volumes are being loaded on the network, thus reducing the number of congested links, and this in turn results in smoother traffic flow, with lower total vehicle-travel time and lower network evacuation time.

The simulation for the central Athens network was performed under 15-minute time intervals. This value also simulates actual traffic conditions in a more realistic manner, because in urban networks trips are being loaded at small time intervals.

5.8.2 Diversion Probability Factor

The model was simulated under the following values for the diversion probability factor: 1.5, 6, and 10, and the results of the simulation runs are shown in Table 5.7.

Table 5.7 shows that the network clearance time and the total vehicle-travel time were lower for lower values of the parameter θ . This can be attributed to the fact that when

Table 5.6 Sensitivity Analysis for Loading Intervals

	15 minutes	30 minutes	60 minutes
Max. network clearance time (minutes)	1,210.084	1,503.325	1,886.166
Total vehicle travel time (veh-min)	26,466,512	32,729,332	43,980,480

Table 5.7 Sensitivity Analysis for Diversion Parameter

	$\theta=1.5$	$\theta=6.0$	$\theta=10.0$
Max. network clearance time (minutes)	1,210.084	1,441.957	1,832.502
Total vehicle travel time (veh-min)	26,466,512	28,618,416	41,930,201

the value of θ decreases, the number of efficient paths selected for the traffic assignment between any origin and the assigned destinations, increases. This results in a more accessible network, with less congestion and delays on the links, and reduced total vehicle-travel time and network evacuation time.

The value of 1.5 was used for the diversion probability parameter, when simulating the model for the case under study.

5.9 Validation of the Model

MASSVAC2 can be used for testing and evaluating different traffic management scenarios for the central Athens network, only if it produces credible results that are consistent with available field data. The validation of the model was accomplished by comparing the overall volumes assigned to the major links in the network, at the end of a simulation run, (using the O-D table shown in Table 5.5), with the actual traffic volumes that were collected for the main streets in the network in 1987. A 20 percent fraction of the actual daily volumes was used, so as to compare the simulated and the actual data for the same period between 12 p.m. and 4 p.m. The results of the comparison are shown in Table 5.8.

Due to the closeness of the compared traffic volumes, it was decided to use the MASSVAC2 model for the analysis of the network.

Table 5.8 Validation of MASSVAC2 for the Central Athens Network

Name of street	Simulation volumes (vehicles)	Actual volumes (vehicles)	Discrepancy (percent)
Ymittou Str.	3,896	4,449	-12.4
Amalias Ave.	19,917	22,779	-12.6
Sungrou Ave.	11,393	12,323	-7.5
Vas.Sofias Ave.	22,292	21,191	8.5
Vas.Konstantinou Ave.	20,100	18,119	10.9
Alexandras Ave.	16,482	18,014	-8.5
Panepistimiou Str.	11,698	10,796	8.4
Akadimias Str.	6,139	7,212	-14.9
Patission Str.	15,288	13,858	10.3
Lenorman Str.	6,539	6,519	0.0
Filellinon Str.	7,958	8,184	-2.8
Tritis Septemvriou Str.	9,714	8,734	11.2
Arditou Ave.	14,601	17,843	-18.2
Vas.Alexandrou Ave.	6,444	5,519	16.8
Fidippidou Str.	3,479	3,468	0.0
Kallirois Str.	9,103	8,670	5.0
Pireos Str.	9,043	7,802	15.9
Konstantinoupoleos Ave.	5,892	5,661	4.1
Achilleos Str.	10,098	9,455	6.8

5.10 Traffic Management Scenarios

5.10.1 Scenario #1

The central Athens network was simulated using different percentages of the original O-D table. Six simulation runs were performed according to the following corresponding percentages of the O-D table:

- 100 percent,
- 75 percent,
- 60 percent,
- 50 percent,
- 40 percent, and
- 25 percent.

A summary of the results for scenario #1 is shown in Table 5.9. A listing of the most frequently encountered congested streets in the network, during scenario #1, is presented in Table 5.10, and their location in the network is shown in Figure 5.2.

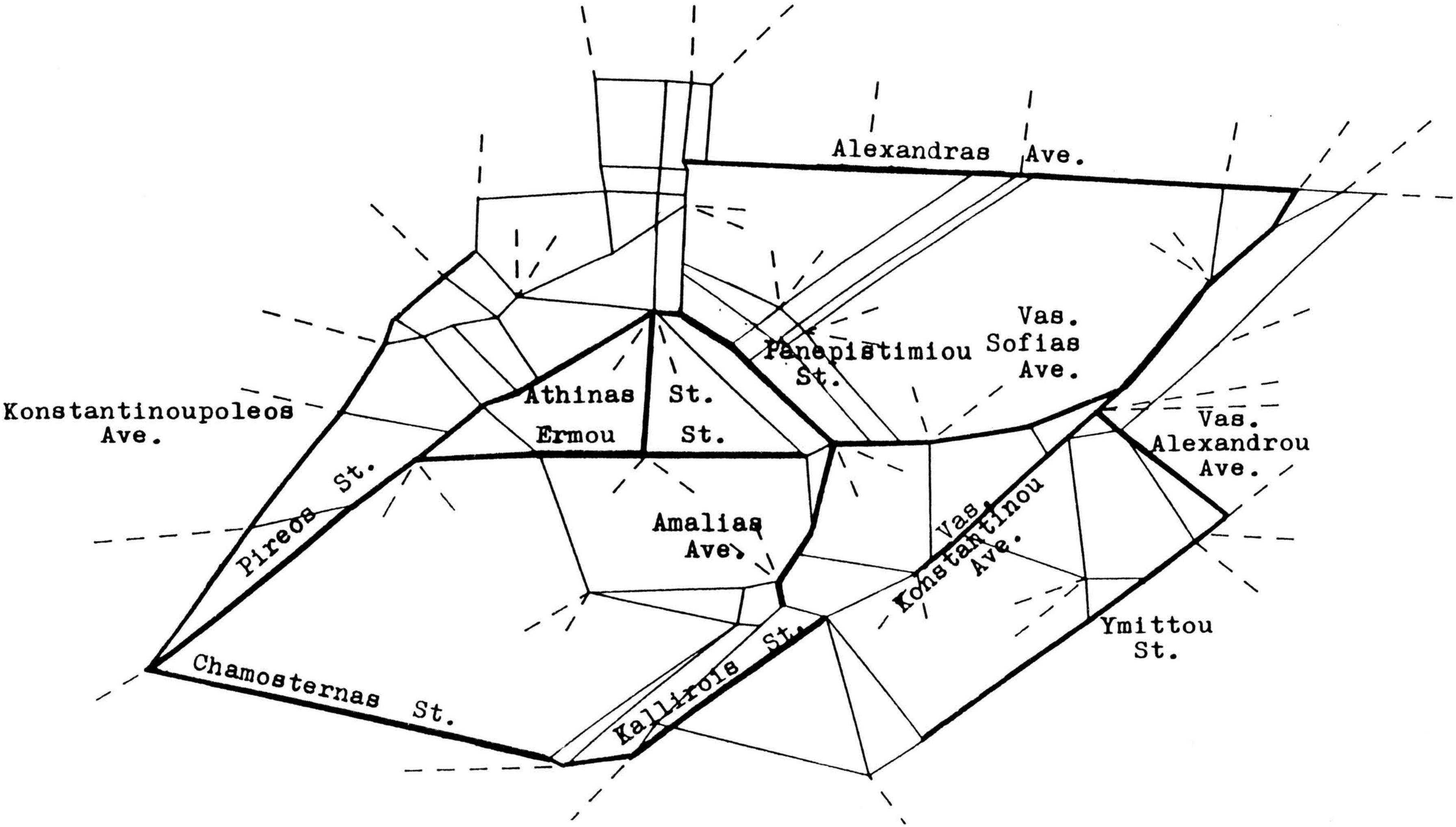
According to certain estimates, recent measures taken by public officials (such as restriction of taxi circulation in the central area, and staggering of working hours), have reduced the amount of vehicle traffic in the central city by 40 percent. For this reason, the simulation run performed using 60 percent of the original O-D table is of particular interest, since it represents the actual existing conditions in the central city of Athens. The following scenarios that were studied, involve the evaluation of traffic operation and management strategies in the Athens network, using an O-D table which was 60 percent of the one shown in Table 5.5.

Table 5.9 Summary of Results for Scenario #1

Percentage of O-D table	100%	75%	60%	50%	40%	25%
Max. network clearance time (minutes)	1,210.084	847.956	626.755	551.069	412.608	411.484
Total vehicle travel time (veh-min)	26,466,512	11,671,655	6,866,335	5,277,829	3,469,138	1,810,708
Average vehicle travel time (minutes)	143.2	84.2	61.9	57.1	46.9	39.2

Table 5.10 Congested Streets in the Central Athens Network

Alexandras Avenue
Kallirois Street
Chamosternas Street
Vas. Sofias Avenue
Ymittou Street
Vas. Alexandrou Avenue
Vas. Konstantinou Avenue
Konstantinoupoleos Avenue
Pireos Street
Amalias Avenue
Panepistimiou Street
Ermou Street
Athinas Street



5.2 Congested Streets in Central Athens.

5.10.2 *Scenario #2*

Hypothesis:

- Addition of one lane per direction in Alexandras Avenue.
- Increase in capacity of Alexandras Avenue (from 1,033 veh/hour per lane to 1,500 veh/hour per lane).

A summary of the results for scenario #2, is presented in Table 5.11.

5.10.3 *Scenario #3*

Hypothesis:

- Increase in capacity of Kallirois Street (from 950 veh/hour per lane to 1,300 veh/hour per lane).
- Increase in capacity of Chamosternas Street (from 950 veh/hour per lane to 1,300 veh/hour per lane).

A summary of the results for scenario #3, is presented in Table 5.12.

5.10.4 *Scenario #4*

Hypothesis:

- Increase in capacity of Vas. Sofias Avenue (from 950 veh/hour per lane to 1,500 veh/hour per lane).
- Increase in capacity of Chersifronos Street (from 650 veh/hour per lane to 1,000 veh/hour per lane).

Table 5.11 Summary of Results for Scenario #2

Maximum network clearance time	568.583 minutes
Total vehicle travel time	7,851,983 vehicle-minutes
Average vehicle travel time	70.8 minutes
Time savings (network)	-985,648 vehicle-minutes
Time savings (per vehicle)	-8.9 minutes
Time savings (percent)	-14.3%

Table 5.12 Summary of Results for Scenario #3

Maximum network clearance time	524.025 minutes
Total vehicle travel time	5,785,818 vehicle-minutes
Average vehicle travel time	52.2 minutes
Time savings (network)	1,080,517 vehicle-minutes
Time savings (per vehicle)	9.7 minutes
Time savings (percent)	15.7%

- Increase in capacity of Ymittou Street (from 933 veh/hour per lane to 1,300 veh/hour per lane).
- Increase in capacity of Vas. Alexandrou Avenue (from 750 veh/hour per lane to 1,200 veh/hour per lane).
- Increase in capacity of Vas. Konstantinou Avenue (from 833 veh/hour per lane to 1,500 veh/hour per lane).

A summary of the results for scenario #4, is presented in Table 5.13.

5.10.5 Scenario #5

Hypothesis:

- Increase in capacity of Konstantinoupoleos Avenue (from 925 veh/hour per lane to 1,300 veh/hour per lane).
- Increase in capacity of Pireos Street (from 1,075 veh/hour per lane to 1,500 veh/hour per lane).

A summary of the results for scenario #5, is presented in Table 5.14.

5.10.6 Scenario #6

Hypothesis:

- Reversal in direction for Akadimias Street (instead of traffic moving from Kaningos Square to Vas. Sofias Avenue, traffic will be moving from Vas. Sofias Avenue to Kaningos Square).

A summary of the results for scenario #6, is shown in Table 5.15.

Table 5.13 Summary of Results for Scenario #4

Maximum network clearance time	496.175 minutes
Total vehicle travel time	6,040,930 vehicle-minutes
Average vehicle travel time	54.5 minutes
Time savings (network)	825,405 vehicle-minutes
Time savings (per vehicle)	7.4 minutes
Time savings (percent)	12.0%

Table 5.14 Summary of Results for Scenario #5

Maximum network clearance time	532.345 minutes
Total vehicle travel time	5,754,914 vehicle-minutes
Average vehicle travel time	51.9 minutes
Time savings (network)	1,111,421 vehicle-minutes
Time savings (per vehicle)	10.0 minutes
Time savings (percent)	16.2%

Table 5.15 Summary of Results for Scenario #6

Maximum network clearance time	556.848 minutes
Total vehicle travel time	6,523,790 vehicle-minutes
Average vehicle travel time	58.8 minutes
Time savings (network)	342,545 vehicle-minutes
Time savings (per vehicle)	3.1 minutes
Time savings (percent)	5.0 %

5.10.7 Discussion of Results

A summary of the results obtained for the six scenarios under study, is presented in Table 5.16.

For scenario #1, the improvements realized in the network in terms of travel time are great, when assuming reductions in the number of vehicle trips in the study area. These reductions can be accomplished by the following measures: traffic management policies, traffic restraints, public transport improvement, development of rapid transit, and new road construction. These measures are discussed in greater extent in chapter 6.

For scenario #2, the increase in capacity and the addition of one lane per direction for Alexandras Avenue, resulted in travel time losses when compared to the existing network. This is due to the fact that Alexandras Avenue is probably the most heavily traveled link in the Athens area. It is the only lateral east-west connection between the Kifissias-Messogion development corridors and the Patission corridor. Increase in capacity and road space, attracted more traffic, resulting in more congestion and greater delays for the link itself and, for the network as a whole.

For scenario #3, scenario #4, and scenario #5, the capacity improvements to the existing infrastructure, resulted in significant travel time savings for the overall network.

For scenario #6, the reversal of Akadimias Street, resulted in a slight improvement of the network, in terms of travel time, but before coming to a final conclusion more detailed study needs to be done.

The proposed increase in capacity of the most heavily congested arterials in the network, can be accomplished by enforcing the following measures:

Table 5.16 Summary of Results for Scenario #1 - Scenario #6 (for 60% of original O-D table)

	Scenario#1	Scenario#2	Scenario#3	Scenario#4	Scenario#5	Scenario#6
Maximum network clearance time (minutes)	626.755	568.583	524.025	496.175	532.345	556.848
Total vehicle travel time	6,866,335 (veh-min)	7,851,983	5,785,818	6,040,930	5,754,914	6,523,790
Average vehicle travel time (minutes)	61.9	70.8	52.2	54.5	51.9	58.8
Network time savings (veh-min)	-	-985,648	1,080,517	825,405	1,111,421	342,545
Time savings per vehicle (minutes)	-	-8.9	9.7	7.4	10.0	3.1
Time savings (percent)	-	-14.3	15.7	12.0	16.2	5.0

- Closure of all median breaks except at signal controlled intersections.
- Installation of interconnected signals at arterial and secondary intersections.
- Complete prohibition of parking.
- Complete prohibition of standing vehicles, passenger loading and unloading, and goods loading and unloading.
- Prohibition of pedestrian crossings, except at signal controlled intersections and pedestrian under-crossings.
- Provision of special lanes at bus stops outside the moving traffic.
- Permitting right turns only at selected minor street intersections.

Among the other benefits which the improvements recommended in major arterials will produce are the following:

- Removal of arterial (through) traffic from local and collector streets in residential neighborhoods.
- Improvement of service between various sections of the central area.
- Improvement of access to the downtown core.

These will result in:

- A reduction in traffic delays and congestion.
- A reduction in the incidence of traffic accidents.

Chapter 6

Coherent Strategies for the Future

6.1 Increasing Transport Efficiency.

There is no formal accepted methodology available for deriving an overall urban transportation strategy. The Athens transportation situation has to be considered on its merits taking into account, as much as possible, the particular characteristics of this unique city. The main travel-related policies, which could form part of an overall strategy, include public transport improvement, new road and rail construction and improvements to existing infrastructure, planning regulations, traffic engineering measures, bus priority systems, traffic restraint, pedestrianisation, goods vehicle prohibitions and parking, loading and unloading restrictions. These can be used in various combinations to fulfill the strategy, within the constraints imposed by the finance available. The following sections describe briefly a number of those issues, though the guidance which can be given is necessarily limited by the lack of knowledge of the longer-term impacts and possible feedbacks.

6.2 Traffic Management-Restraints

The common objective of traffic management policies is to make the best use of available resources, and the act of "restraint" enters as a result of current situations wherein traffic takes up too many of the constrained resources of environment and space. Restraint policies work by changing the observed behavior of travelers in making modal choice, routing, and other travel decisions, including the decision to make the trip at all. Physical restraint schemes operate by prohibition or restriction of some or all classes of traffic in a given area, where fiscal schemes operate by imposing extra monetary payment on traffic using road or parking space in this area. Either type of policy will alter the balance between modes of travel, and may also affect the number of trips made.

Over the past few years various measures have been taken by the public officials in order to improve the transportation situation in the city of Athens:

- Installation of one-way streets and new traffic lights.
- Erection of roadway infrastructures, with the short-term projects of Pireos Street, Iera Odos Street, and the creation of parking lots near Akadimias Street and in the heart of the Athens city center.
- Strict parking prohibitions in some areas of the city center.
- Institution of an auto-restriction program for the central area of Athens (since September 1982). A program of "alternate day" car use has been established for a defined central area of the city. Restrictions apply to Monday through Friday, between the hours of 6:30 a.m. and 4:00 p.m. The last digit of vehicle license numbers determines what vehicles are allowed to drive in the restricted area. Vehicles having license plate numbers ending in digits of one to five and those whose plates end in digits six to zero are allowed to use the restricted area on alternate week days. Buses,

taxis and motorcycles are exempt from the restriction measures, and the vehicle restriction is lifted on major holidays and during the summer. [1]

Although the above measures have slightly improved the traffic conditions in central Athens, a series of more drastic measures must be taken to realize significant improvements. The traffic restraint measures that need to be taken should rationally reduce automobile usage without massive failure of the street system. This calls for a careful balance between road capacity and demand. Some of the measures that can be introduced are:

1. Changes to the street network, with exceptions for public transport, can be used to make vehicular journeys in the central city inconvenient, and so to encourage journeys to be made by public transport or on foot. Such schemes are often associated with the creation of pedestrian malls, which have attractions in themselves. The separation of vehicular and pedestrian traffic also results in improvement of pedestrian safety. The creation of auto-free zones and pedestrian malls will preserve and revitalize the city center and improve the environmental quality. Public transport (trolley buses and buses) should be allowed to cross the auto-free zones until the completion of the construction of the new underground metro facilities.
2. Present efforts to persuade drivers of private cars to voluntarily use public transport means for home to work trips, should be intensified. It is essential to improve public transport and make it more attractive by means that are discussed in a later section.

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[1] Due to a recent deteriotation in environmental conditions and traffic congestion, the restrictions were extended up to 8 p.m. and, also, taxis were included in the traffic ban.

3. Control of parking in the center of the city should be intensified. This is desirable in order to enhance the commercial life of the downtown area and to make best use of the space available for moving traffic.
4. A well coordinated signal control system should be installed at the main thoroughfares of the central city.
5. A joint project should be developed between the city's transportation department and large employers in order to encourage commuting employees to ride in company provided vans or buses.
6. In the future, road pricing, which can be achieved by electronic or other means, may provide an ideal technique for influencing choice of mode and route.
7. Regulations limiting hours of deliveries of goods in congested areas is justified, particularly as parking charges have much less effect on commercial than on private automobile traffic.
8. Staggering of working hours can also be a very effective solution in alleviating traffic. It gives less freedom of choice of working hours, or none at all, and its aim is to spread traffic peaks over a longer time by staggering the beginning and end of working hours. This arrangement is also applicable over weekly timespans (i.e. staggering of weekends) and yearly timespans (staggering of annual holidays).[2] If staggered hours are well coordinated with measures concerning the timing of journeys, their implementation could help reduce road congestion, revigorate the city center and reduce public transport costs by raising the speeds of public transport vehicles and spreading their occupancy more evenly.

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[2] Beginning February 1, 1988, the Greek Government has implemented continuous working hours for all the employee force.

9. Public officials should stop treating land-use and transport policies in isolation. Transport policies should be considered in relation to the planning and business elements, taking account of their longer-term impacts and possible feedback.

With the identification of the above measures deemed appropriate, evaluation criteria should be established to analyze the degree of effectiveness of the individual techniques. The criteria established are:

- effectiveness in reducing peak period congestion,
- cost of implementation,
- indirect consequences,
- time lag considerations between adoption and implementation of each measure,
- institutional support,
- public acceptance,
- private organizational acceptance,
- compatibility with laws and regulations, and
- readiness of implementation.

6.3 Public Transport

Although almost any point of the developed city is less than 300m from a bus stop, the consistent decrease of the annual transit rides per capita observed since 1965 indicates that Athens has entered the vicious circle which causes the continuous decline of public transport. The increase in road traffic has led to serious problems of congestion arising from limitations in the capacity of roads and from the effects of street parking on the movement of vehicles. The increasing volume of traffic and the congestion, thus created, have had a direct impact on public transportation giving rise to increased costs of operation and delay. This has resulted in an increasing number of passengers abandoning public transportation in favor of their own cars which in turn has increased the congestion.

In order to reduce the present levels of traffic congestion in Athens, the existing trend of continuous decline of public transport has to be reversed. To achieve this aim the public transport alternative presented must be attractive and offer a high level of service.

Buses provide an important early-action approach to achieving better use of existing streets. They are six times as efficient in the number of peak-hour passengers carried per arterial street lane; and they are twice as efficient as cars in per capita energy consumption based on prevailing car occupancy rates. These reasons underlie the establishment of bus priorities and the implementation of related measures in order to improve service and increase ridership.

The objectives are to apply measures which:

- alleviate existing bus service deficiencies,
- achieve attractive and reliable bus service,
- serve demonstrated existing demands,
- provide reserve capacity for future growth in bus trips, and
- are consistent with long-range transit improvement and downtown development programs.

Bus priorities should be developed as an integrated system of treatments which improve bus speeds and schedule dependability. Parts of the system may involve special bus rights-of-way while other parts may provide preferential use of city streets or operation in mixed traffic. Bus routes should be restructured; peak bus flows (one-way) of 60 to 90 buses per hour represent a desired flow density. In Athens, frequencies of more than 200 buses per hour per direction are encountered at Vasilissis Sofias Avenue, Panepistimiou Street and Amalias Avenue. At Amalias Avenue, the number per direction even exceeds 300 buses per hour at morning peaks.

Some special bus facilities, that have been used successfully to a great extent in many European cities can also be applied to central Athens. These facilities include:

1. **Normal flow curb bus lanes** are the most common bus priority treatment, are the easiest to implement, have the lowest installation costs, and have least impact on intersecting driveways and street routings. However, experience shows they are the least effective in terms of travel times saved.
2. **Contra-flow curb bus lanes** enable buses to operate opposite to the normal traffic flow on one-way streets. They utilize available street capacity in the off-peak direction of flow and permit curb space on both sides of one-way streets to be used for passenger loading, thereby increasing bus loading capacity. Contra-flow lanes normally require one-way street systems with reasonable spacing between signalized intersections (generally 500 feet or more). Provision for, or prohibition of, left turns if often necessary. Their unusual nature of operation, however, suggests possible discontinuance if a major accident arises.
3. **Median bus lanes** eliminate the passenger loading curb access, and service problems associated with curb lanes. Median lanes require prohibiting left turns on two-way streets and rerouting these movements. Bus stops located on islands must have reasonable passenger protection, and special fencing may be required to assure pedestrian entry and exit at designated intersections or crosswalks.

4. **Bus-only streets** in the city center are the most effective surface bus distribution option. They separate bus and car traffic, clearly identify bus routes, and can be readily enforced. They can be designed as part of an overall downtown environment, including widening of sidewalks and provision of pedestrian amenities.

The above mentioned priority measures should expedite bus service without adversely impacting general traffic flow. Planning, design and operation should be based on accepted traffic and transit engineering principles. Conflicts should be minimized, clearly defined, and carefully controlled. Buses must be able to enter and leave priority lanes easily, and alternative routings must be available for potentially displaced car traffic. New problems should not be created, nor should existing problems merely be transferred from one location to another.

6.4 Rapid Transit

Building a subway in Athens has always been a lively topic of debate since the beginning of the century. The first line opened in 1904 and was gradually extended until it linked the port of Piraeus with Kifissia, once a pine-forested summer resort, but now an Athens suburb north of the city. As the Greek capital expanded over the last 30 years to include most of the Attica plains, mass-transit experts have been examining the problem of Athens' antiquated subway system. There have been several preliminary studies undertaken exploring the possibilities of expanding the rail-transit system. Under the present plan, the existing 26-kilometer line will be joined by two new routes criss-crossing the city center. The implementation of the new rapid rail transport system in the central zone of Athens has been approved by the Ministry of Transport and Communications.

The recommendations of the consultant engineers assigned to the metro project should enable Athens to be equipped with a modern metropolitan network, based on the most recent technical and scientific principles adapted to the specific conditions of the Athenian metro, and meeting three requirements (SOFRETU *et al.*, 1977):

- answer the immediate need to service the central zone of Athens,
- compatibility with future expansions capable of meeting long term transport requirements in the Greater Athens region,
- authorize the possible incorporation of the existing metro in the network.

6.4.1 Selection of the Metro Network

Multiple considerations interact in the selection of a network on a short term basis. This choice must be the synthesis of the objectives aimed for and the constraints they impose. The objectives should be as follows:

- foresee the long term network by connecting the corridors in the most heavily developed urban areas which have been observed or desired,
- service the central area and the sectors in this area with the highest population and employment density,
- in connection with the preceding objective, improve the surface traffic conditions in the center and obtain maximum profitability from the short term project for the public, by drawing traffic within the center towards the metro and by intercepting as much private car and bus peripheral-center traffic as possible,
- service the socially underprivileged zones with a low motorization rate,
- incorporate the existing metro line in the overall network.

Constraints involve implementation of the project which should:

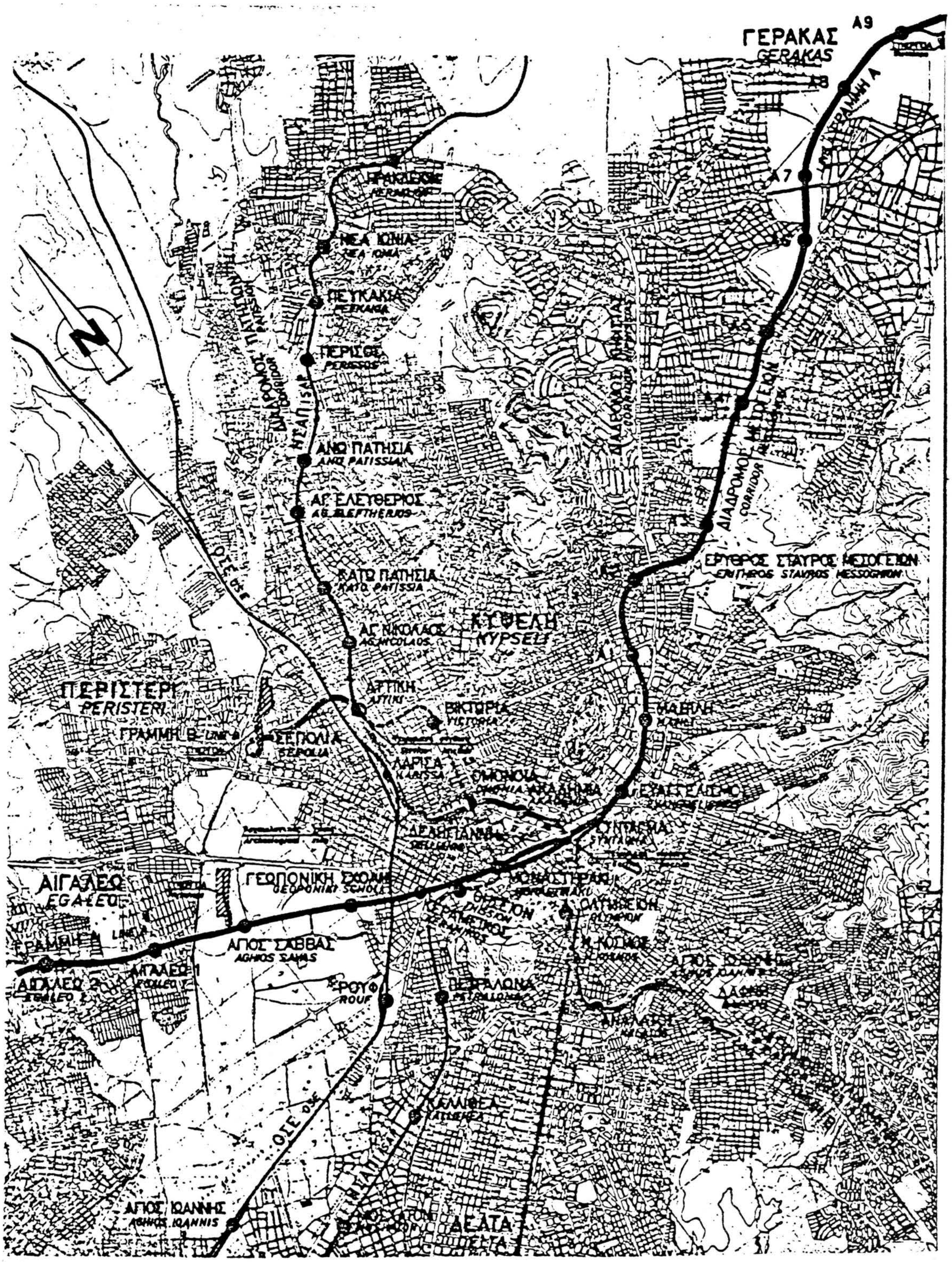
- minimize the costs of project implementation,
- respect archeological sites,
- enable the installation of appropriate parking facilities, and contact between bus terminals and metro lines and the major channels of access to the center,
- protect future developments and therefore be able to adopt to future network extensions without major transformation of basic structures, facilities and operational methods proposed.

Under the present plan the network recommended portrayed in Figure 6.1, consists of two new lines (SOFRETU *et al.*, 1977):

Line A: Aghia Paraskevi district - Egaleo district - city of Piraeus through Vasilissis Sofias Avenue to the center, Messogion Avenue to the east, Iera Odos Street to the west up to Egaleo, then to the south up to Piraeus. In the initial stage, this line is limited to the Ambelokipi-Monastiraki sector, but the line extension to the west up to Egaleo and the north-east up to Sotiria district has been recommended.

Line B: Peristeri district - Ellinikon district through Panepistimiou Street and Vouliagmenis Avenue. In the initial network, this line stops at the Daphni district in the Vouliagmenis corridor, but the recommendation is to have the initial network include the extension of this line up to the Kifissos river to the north of Larissa station.

The metro system was designed for the horizon year 2000 for a passenger flow on the section with the heaviest traffic, in the direction with the heaviest traffic, at peak hour:



6.1 Layout of the Proposed Metro System for the City of Athens.

- approximately 25,000 passengers on line A (Monastiraki-Syntagma interstation)
- approximately 34,000 passengers on line B (Olympion-Syntagma interstation).

6.4.2 The Need for Reconsideration of Metro.

People in the Athens area are beginning to wonder whether the current plan for building the new metro system can be carried to completion. An escalation in the cost of construction and problems associated with the ruins of ancient Athens that must lie beneath the proposed subway stations have undermined the original financial agreement and raised doubts that the rail system can be built as planned.

Decision makers will face some difficult choices as they finalize the financial agreement and the metro plan. To prepare for those decisions, public officials should be able to answer some key questions: Is rail rapid transit worth the cost? If so, where? And what else must be done at the same time to ensure that the potential benefits of rapid transit are realized? It is one of the hardest tasks to try to assess the impacts of rail investment, both directly, in terms of passenger levels and the financial performance of urban passenger transport undertakings, and indirectly, in terms of the effects of urban activity patterns.

The basic difficulties with the metro solution are two. First, there is the huge capital cost of the project. One billion dollars is too much money to spend on anything unless it will do some very wonderful things for people. The citizens of Athens should look at each one of those still-unspent dollars as critically as if someone were proposing that they be spend on higher welfare payments or on buying land for parks.

The second difficulty is that separated rights-of-way are constrained in the sense that once a route has been developed, it is fixed in location and limited as to type of traffic. This is why the metro project should be drawn up in coordination with a complete reconstruction of the surface network (buses and trolley buses) in order to adopt the future underground system and the whole future mass transit system (buses, trolley buses, metro) to the Athens population requirements. If this is not achieved and because of the space specifity of the metro there is a serious danger of accentuating the traffic problems that the metro is designed to reduce. Road congestion and air pollution may eventually increase rather than decrease.

6.5 Road Construction

In 1965, Wilbur Smith and Associates proposed that a system of freeways and expressways would have to be developed for the city of Athens. The recommended system was largely determined by the then existing patterns of urbanization and the topographic barriers in the Athens area. Essentially, the recommended plan consisted of four district functional elements. The first element in the plan was a freeway-expressway loop circumscribing the central city area. The second feature of the plan was the system of six radial freeways and expressways which followed the principal development corridors. The third feature of the plan was the lateral connectors: one east-west route, and one north-south route. Finally, there was a penetration expressway route designed to serve as a collector and distributor of central city traffic. The freeway-expressway system was recommended because of the many benefits which this system would provide to road users, property owners, and all residents of the Athens area. These benefits would be realized mainly because of the following advantages of urban freeways:

- Freeways provide greater traffic capacity. Urban freeways can serve as much as three times the traffic which comparable arterials can.
- Freeways reduce travel time. This speed advantage of freeways is largely due to the elimination of intersecting traffic flows.
- Freeways are safer. The present high incidence of motor-vehicle accidents at many intersections on the existing arterial system is an indication of the need for safer primary routes.
- Freeways are convenient. Most trips are free-flow or continuous, without the inconvenience and delay of stop-and-go driving.
- Freeways improve access to the central district. The downtown area benefits from a well-designed freeway system by the elimination of non-productive through traffic from local central city streets, so that these streets become reserved for shopper access, other local business traffic, and tourists.
- Freeways serve heavy traffic.
- Freeways provide economic benefits to users. Direct economic benefits to potential freeway users can be estimated, based on empirical studies of freeway operations elsewhere. Tangible economic savings stem from reductions in accident costs, lower motor-vehicle operating costs, and time savings.

For reasons discussed in an earlier chapter (section 2.9), these plans were never implemented (except for the construction of the Vouliagmenis Avenue freeway-expressway, and the Syngrou Avenue expressway).

The cost of an extensive freeway-expressway system will appear to be tremendous by all standards when compared to the current rate of public works expenditures for roadway improvements in the Athens area. It is very difficult to know whether new road construction in the congested city of Athens really justifies its cost, because present methods of analysis are incapable of taking into account all the many repercussions of such construction. This is because the new roads will form part of a complex interconnected network and will consequently affect the distribution of traffic, the urban environment and public transport use over a wide area, and will have different impacts on different social groups. Even estimating what the final door-to-door speeds will be after construction of the new road is difficult. It seems likely that, in the absence of road improvements, the network speed would fall because growth in car ownership increases the number of potential travelers on the network, and that proportion who will tolerate a lower travel speed becomes greater. It is against this background that the benefits of new urban road construction should be judged.

6.6 Coordinated Transportation

If urban transport in Athens is to be satisfactory both operationally and financially, it is necessary for the appropriate urban transport policies to be determined and carried out within the framework of a coherent strategy, so that they do not annul each other. Powerful economic and social forces are continually at work producing changes in the capital city of Greece, and it is essential that the policies adopted are capable of fulfilling their objectives within this context. Thus transport policies should not be considered in isolation from the planning and business elements; a coherent overall strategy for transport should consider all the interactions between planning, transport and the economy which have a direct effect on travel, particularly those which have feedback effects.

Large metropolitan areas, like the Athens area, are just one geographic, social and economic unit. They must be treated as such, for one jurisdictional area generates traffic problems for another. The lack of effective administrative coordination has contributed to the continuous worsening of the transportation situation in Athens. Work between those responsible for overall planning, those responsible for designing and constructing roadways, and those financing, operating and managing the transit services has always been problematic.

Solutions to problems of coordination, which avoids the dangers of overcentralization and overregulation, will often be found to include the establishment of a small analytical and policy unit close to the center of municipal decision making. The major issues are not merely technical; they generally involve evaluation of gains and losses to different groups of citizens and the performance of managements of the different agencies. Such a unit should ensure adequate contacts between the agencies and also provide a link with the wider aspects of urban planning. The inevitable limitations of such a unit need, however, to be borne in mind in allocating responsibilities, if it is not itself to become a bottleneck. Clearly, there is no short or simple answer since political conditions and personalities must in practice also be taken into account.

Chapter 7

Conclusions and Recommendations

7.1 Conclusions

Several traffic management scenarios for the central Athens network, were tested and evaluated using the MASSVAC2 simulation model, and the following conclusions were drawn:

1. During peak periods, and when traffic restrictions do not apply for the central network, most of the streets in the area operate over capacity, traffic is almost stagnant, and excessive delays are observed throughout the whole area.
2. The decrease in traffic demands, by means of traffic restraint and other control policies, results in significant improvement realized in terms of travel times, driving speeds and, in general, overall quality of traffic operations. Although the estimated 40 percent decrease in traffic demands, achieved through the inclusion of taxis in the auto-restriction program and the staggering of working hours, results in smoother traffic flows throughout the central area, the deficiencies of the street network are still apparent.

3. The most important deficiencies identified in central Athens, are associated with streets which form the boundaries of the auto-restricted area (Alexandras Avenue, Ymittou Street, Kallirois Street, Chamosternas Street, Pireos Street, Konstantinoupoleos Avenue and Vas. Alexandrou Avenue), and with main arteries in the area (Vas. Sofias Avenue, Amalias Avenue, Vas. Konstantinou Avenue, Panepistimiou Street, Ermou Street, and Athinas Street).
4. Every reasonable effort should be made to approach the standards of the *deficient* streets in the network to expressway standards and increase their capacities.
5. MASSVAC2 is primarily an evacuation program, and when used for simulating traffic, it clears every vehicle out of the network, which, of course, is not the exact case for the outbound noon peak period for the central Athens network. Thus, the results obtained are exaggerated in terms of total vehicle-travel times and total network clearance times, but they are still very useful when comparing the different traffic management scenarios.

In addressing the overall transport problems in the city of Athens, this study reached the following conclusions:

1. It should be recognized that it is impossible and undesirable for financial and environmental reasons, to meet the full demand for individual car traffic. It is necessary to consider measures, which prevent the generation of new individual traffic from and to the city center, and reduce the demand for vehicular traffic while maintaining full accessibility.
2. The transportation system in the Athens area must be viewed as an integrated system planned and designed to move passengers and goods and consisting of all the available transportation modes. Efficiency in such a total system can only be

achieved by coordinating the individual elements through operating, regulating and control policies.

3. The specific measures may involve better traffic control and management, improved transit service and operations, provision of rail rapid transit system, construction of new road infrastructure and improvement of the existing one, and concerted efforts to modify travel patterns through such measures as parking management, changes in work schedules and restraint of automobile use in the central Athens area.

7.2 Recommendations

The MASSVAC2 simulation model can be used to evaluate and compare, in terms of their overall network impact, additional transportation management strategies, which involve the following physical changes of the street network:

1. The development of an arterial route parallel to Alexandras Avenue and to its north, which will be an additional lateral connection, much needed in the central Athens network.
2. The construction of grade-separated interchanges at Amalias Avenue, Ermou Street, Pireos Street and Achilleos Street.
3. The development of a ring road, surrounding the central area of the city, by extending Ymittou Street up to Alexandras Avenue, and by improving the connection between Alexandras Avenue and Konstantinoupoleos Avenue.

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Appendix A

MASSVAC2 - Data Input Methodology

Network Coding

A network consists of nodes and arcs. This presentation is useful for modeling a wide range of physical and conceptual situations. Network modeling has been used to represent the road system in a city.

A node is the point where two or more links intersect. There are three different types of nodes: origin, destination and regular. Origin and destination nodes are connected to the network by a single dummy arc (link with infinite capacity). An arc (link) is the line which connects two nodes. A node might have more than one link connected to it (i.e., an intersection). Assigning numbers to nodes and links is known as network coding. It is recommended to follow the rules explained below for coding the network. Any other method would increase the memory requirements of the program and would not guarantee accurate results.

Nodes ought to be numbered in the following way:

1. The destination nodes should be numbered first. The numbering should start from number one and continue until all the destination nodes are assigned a number. Numbers should not be skipped at any point during the coding of the nodes.
2. Next, numbers should be assigned to origin nodes in the same way as in destinations nodes. The numbering should restart with the number following the last destination number. If some origins are to be used as destinations also, additional nodes should be created and numbers should be assigned to them as for any additional destination nodes.

3. Last, numbers should be assigned to all the intermediate nodes. The numbering should restart with the number following the last number assigned to the last origin node. A clockwise or counterclockwise direction should be followed, in which the adjacent nodes are numbered sequentially. Using the above approach, the identification of a node and the region in which it is located would be easier.

An example of coding a simple network is shown in Figure A.1.

Links do not need to be numbered because they are assigned numbers internally by the model based on node numbers. The following approach is used in numbering the links:

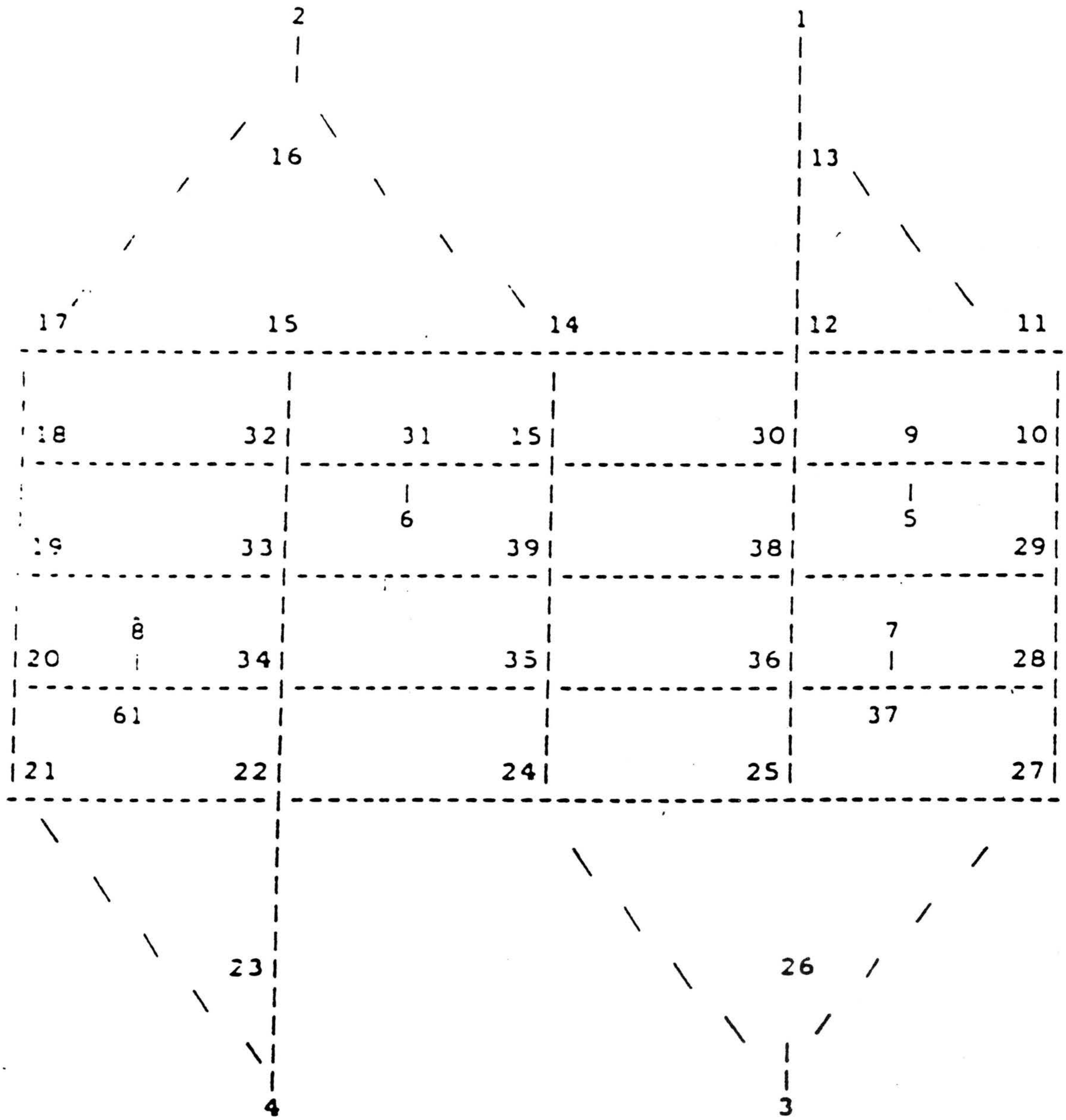
1. The links are entered in the model by their origin node (A-node) and their destination node (B-node).

2. The model internally sorts the links. Links with the smallest origin node and the smallest destination node at the same time will be located at the top of the link deck. The sequence of links in the input deck is arbitrary, but the the A-nodes of the links should be in a consecutive increasing order.

3. Using the above approach, two directional flow could exist between any two nodes and the links connecting those nodes will have completely different numbers.

4. If two links have the same origin node but different destination nodes, the link with lower destination node will be located on top and will be given a lower link number than the other one.

Coding the network is the major task of input data preparation. Other required input data serves the following purposes:



A.1 Network Coding Example.

- Control the type of operational strategy (i.e., loading period, microscopic level runs).
- Specify information about the links in the network (i.e., capacity, number of lanes, link length).
- Describe the origin to destination trip table or generate trip table knowing the origins and the destinations capacities.

Next, it is necessary to go over the specific input cards and explain the required variables in each of them. There are seven different categories of input cards. Each category may consist of one or more cards depending on the network size in terms of numbers of origins, destinations, and links. However, five out of seven card categories need only one input card.

Card Type 1.

Format: 3I5

Three variables are found in this card type:

IGN IDS NLINK

where:

IGN = Maximum number of destinations.

IDS = Cumulative number of destinations plus origins.

NLINK = Maximum number of links.

It is important to input these data accurately, because the execution time of the computer program is directly influenced by the magnitude of the above variables.

Card Type 2.

Format: I5, 2F5.0, 6I5.

Nine variables are required for this card type:

MACRO TS THL ISCEN1 ISCEN2 ISCEN3 ISCEN4 IPR1 IPR2

where:

MACRO = Option to run the program either under macroscopic simulation level (MACRO = 1) or under microscopic level (MACRO = 0).

TS = Time interval for scanning the program and loading some portion of the vehicular trips. A value in the range of 15 to 60 minutes is recommended.

THL = Time at which half of the total trips need to be loaded on the network. Suggested values are: 120, 240 or 360 minutes.

A value of one should be input in order to activate the remaining options on card type 2, otherwise zero should be entered.

ISCEN1 = Option for using the shoulders on freeways or expressways.

ISCEN2 = Option for simulating the network either with already existing volumes (the case in daytime) or with an empty network (the case during nights).

ISCEN3 = Option for changing the signal to flashing operation at intersections with low volume on the side streets.

ISCEN4 = Option for using one-way flow operation.

IPR1 = Option to print the paths from any origin to any destination.

IPR2 = Option to print statistics for links with positive volume.

Card Type 3.

Format 40I2.

Only one variable is found in this card type: JFAC.

JFAC for a specific destination could be set to one, if it is needed to generate more paths toward that specific destination. For each destination a value of one or zero is needed.

Card Type 4.

Format: F5.0

Only one variable is found in this card type: CHOICE.

The value of CHOICE could be 2, 1 or 0. As will be seen later, the value of CHOICE influences the required input data on card type 7.

Card Type 5.

Format: I5, F5.0

Two variables are found in this card type:

OPT PARM1

where:

OPT = Option for printing the statistics of the links after each iteration (OPT = 1), or at the end of the final iteration (OPT = 0).

PARM1 = The value used in assignment technique and it ranges from 1 to 10. Smaller values create more paths from an origin to a destination.

Card Type 6.

Format: I3, 3I4, F4.2, I3, F6.0, I2, F4.0, 3F5.0, I2, F6.0, 1X,A12.

The variables describing each link's characteristics are found in this card type. One card with the following variables is needed for every single link in the network:

ZO A B ZZ D ELEV C NLANES SO FL EL EZ NTYPE VSEED STR

where:

ZO = Identifies the zone where a specific link is located.

A = Origin or starting node of a link.

B = Destination or end node of a link.

ZZ = Downstream node of a link.

D = Link's distance (in miles).

ELEV = Elevation of area in which a link is located (in feet).

C = Capacity of a link (veh/hour per lane).

NLANES = Number of lanes on a link.

SO = Free flow speed on a link (mph).

FL = This value is set to one for those links which their capacities need to be doubled, otherwise it is zero.

EL = The travel time of links with EL equal to one is set to infinity after 75% of the trips are loaded.

EZ = The travel time of links with EZ equal to one is set to infinity at the start of the simulation.

NTYPE = Specifies the type of a link.

VSEED = Existing volume on a link during daytime.

STR = Identifies the name of a link.

Card Type 7.

Format: 13F5.0

The input variables on this card are influenced by the value of CHOICE on card type 4. If CHOICE is equal to zero, number of trips from any origin zones should be typed in card type 7. If the number of origins exceeds 13, another card should be used with the same format.

If CHOICE is equal to 1, number of trips from any origin and then capacities of each destination should be input in the same format mentioned above.

Finally, if CHOICE is equal to 2, the trip table which is the number of vehicular trips from any origin to all the destinations should be input in card type 7. For any origin the number of trips going to all the destinations, even if it is zero, should be input first and then the next origin should be considered.

Thus, the number of cards required for card type 7 may vary and is influenced by number of origins, destinations and CHOICE type.

Appendix B

Input file for the Central Athens Network

```
  37   52  294
   1  15. 120.     0    1    0     0    0    0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
  2.
   0  1.5
 1  38  64   0 1.0  5 9999. 1 50.   0.    0.    0. 5     0. DUMMY
 2  39  66   0 1.0  5 9999. 1 50.   0.    0.    0. 5     0. DUMMY
 3  40  74   0 1.0  5 9999. 1 50.   0.    0.    0. 5     0. DUMMY
 4  41  78   0 1.0  5 9999. 1 50.   0.    0.    0. 5     0. DUMMY
 5  42  89   0 1.0  5 9999. 1 50.   0.    0.    0. 5     0. DUMMY
 6  43  91   0 1.0  5 9999. 1 50.   0.    0.    0. 5     0. DUMMY
 7  44 119   0 1.0  5 9999. 1 50.   0.    0.    0. 5     0. DUMMY
 8  45 128   0 1.0  5 9999. 1 50.   0.    0.    0. 5     0. DUMMY
 9  46 109   0 1.0  5 9999. 1 50.   0.    0.    0. 5     0. DUMMY
10  47 141   0 1.0  5 9999. 1 50.   0.    0.    0. 5     0. DUMMY
11  48 108   0 1.0  5 9999. 1 50.   0.    0.    0. 5     0. DUMMY
12  49 113   0 1.0  5 9999. 1 50.   0.    0.    0. 5     0. DUMMY
13  50  95   0 1.0  5 9999. 1 50.   0.    0.    0. 5     0. DUMMY
14  51 103   0 1.0  5 9999. 1 50.   0.    0.    0. 5     0. DUMMY
15  52  98   0 1.0  5 9999. 1 50.   0.    0.    0. 5     0. DUMMY
 1  53   1   0 1.0  5 9999. 1 50.   0.    0.    0. 5     0. DUMMY
 1  53  54   00.19  5 1033. 3 50.   0.    0.    0. 1   478. ALEXANDRAS1
 1  53  57  580.49  5 1033. 3 50.   0.    0.    0. 1   442. ALEXANDRAS2
 1  54   2   0 1.0  5 9999. 1 50.   0.    0.    0. 5     0. DUMMY
 1  54  53   00.19  5 1033. 3 50.   0.    0.    0. 1   493. ALEXANDRAS1
 1  54  55   00.12  5  800. 3 50.   0.    0.    0. 1   309. FIDIPPIDOU1
 1  54  63  640.12  5  950. 3 50.   0.    0.    0. 1   365. VAS.SOFIAS1
 1  55   3   0 1.0  5 9999. 1 50.   0.    0.    0. 5     0. DUMMY
 1  55  54   00.12  5  800. 3 50.   0.    0.    0. 1   184. FIDIPPIDOU1
 1  55  56   00.09  5 1000. 3 50.   0.    0.    0. 1   173. FIDIPPIDOU2
 1  55  63   00.19  5  800. 3 50.   0.    0.    0. 1   208. MESSOGION
 1  56   4   0 1.0  5 9999. 1 50.   0.    0.    0. 5     0. DUMMY
 2  56  67   00.75  5  900. 2 50.   0.    0.    0. 1   248. MICHALAKOP.1
14  57  58   00.05  5 1033. 3 50.   0.    0.    0. 1   442. ALEXANDRAS3
 1  57  53   00.49  5 1033. 3 50.   0.    0.    0. 1   459. ALEXANDRAS2
14  58  22   0 1.0  5 9999. 1 50.   0.    0.    0. 5     0. DUMMY
11  58  59  600.12  5 1033. 3 50.   0.    0.    0. 1   362. ALEXANDRAS4
14  58  57  530.05  5 1033. 3 50.   0.    0.    0. 1   433. ALEXANDRAS3
14  58 105   00.83  5  900. 3 45.   0.    0.    0. 1   245. IPPOKRATOUS1
11  59  58   00.12  5 1033. 3 50.   0.    0.    0. 1   402. ALEXANDRAS4
11  59  60   00.30  5 1033. 3 50.   0.    0.    0. 1   389. ALEXANDRAS5
11  60  21   0 1.0  5 9999. 1 50.   0.    0.    0. 5     0. DUMMY
11  60  59  58 0.3  5 1033. 3 50.   0.    0.    0. 1   350. ALEXANDRAS5
10  60  61   00.43  5 1033. 3 50.   0.    0.    0. 1   322. ALEXANDRAS6
10  61  60   00.43  5 1033. 3 50.   0.    0.    0. 1   371. ALEXANDRAS6
10  61  62   00.06  5 1033. 3 50.   0.    0.    0. 1   273. ALEXANDRAS7
10  61 145   00.27  5  800. 3 45.   0.    0.    0. 1   175. MAVROMATEON
10  62  61   00.06  5 1033. 3 50.   0.    0.    0. 1   368. ALEXANDRAS7
10  62 143   00.03  5  867. 3 50.   0.    0.    0. 1   393. PATISSION 2
10  62 144   0 0.2  5  867. 3 50.   0.    0.    0. 1   208. PATISSION 1
```

1	63	54	00.12	5	950.	3	50.	0.	0.	0.	1	325.	VAS.SOFIAS1
1	63	55	00.19	5	800.	3	50.	0.	0.	0.	1	197.	MESSOGION
1	63	64	00.25	5	950.	3	50.	0.	0.	0.	1	531.	VAS.SOFIAS2
1	64	23	0 1.0	5	9999.	1	50.	0.	0.	0.	5	0.	DUMMY
1	64	53	00.35	5	1000.	2	40.	0.	0.	0.	2	220.	SOUTSOU
1	64	63	00.25	5	950.	3	50.	0.	0.	0.	1	490.	VAS.SOFIAS2
2	64	65	00.46	5	950.	3	50.	0.	0.	0.	1	502.	VAS.SOFIAS3
2	65	64	00.46	5	950.	3	50.	0.	0.	0.	1	581.	VAS.SOFIAS3
2	65	66	00.09	5	833.	3	50.	0.	0.	0.	1	383.	VAS.KONST. 1
2	65	99	00.29	5	950.	3	50.	0.	0.	0.	1	348.	VAS.SOFIAS4
2	66	24	0 1.0	5	9999.	1	50.	0.	0.	0.	5	0.	DUMMY
2	66	65	00.09	5	833.	3	50.	0.	0.	0.	1	465.	VAS.KONST. 1
2	66	68	00.09	5	750.	4	50.	0.	0.	0.	1	288.	VAS.ALEX. 1
2	66	69	00.12	5	833.	3	50.	0.	0.	0.	1	409.	VAS.KONST. 2
2	67	5	0 1.0	5	9999.	1	50.	0.	0.	0.	5	0.	DUMMY
2	67	56	00.75	5	900.	2	50.	0.	0.	0.	1	290.	MICHALAKOP.1
2	67	68	00.49	5	900.	2	50.	0.	0.	0.	1	312.	MICHALAKOP.2
2	68	67	00.49	5	900.	2	50.	0.	0.	0.	1	282.	MICHALAKOP.2
2	68	66	00.09	5	750.	2	50.	0.	0.	0.	1	138.	VAS.ALEX. 1
2	68	69	00.12	5	900.	2	50.	0.	0.	0.	1	267.	MICHALAKOP.3
3	68	70	00.43	5	750.	2	50.	0.	0.	0.	1	172.	VAS.ALEX. 2
3	68	72	00.43	5	950.	1	40.	0.	0.	0.	2	80.	FORMIONOS
2	69	66	00.12	5	833.	3	50.	0.	0.	0.	1	423.	VAS.KONST. 2
3	69	75	0 0.5	5	900.	2	50.	0.	0.	0.	1	203.	SP.MERKOURI
2	69	100	00.09	5	833.	3	50.	0.	0.	0.	1	407.	VAS.KONST. 3
3	70	6	0 1.0	5	9999.	1	50.	0.	0.	0.	5	0.	DUMMY
3	70	68	00.43	5	750.	2	50.	0.	0.	0.	1	104.	VAS.ALEX. 2
3	70	71	00.08	5	933.	3	45.	0.	0.	0.	1	132.	YMITTOU 1
3	71	7	0 1.0	5	9999.	1	50.	0.	0.	0.	5	0.	DUMMY
3	71	72	00.06	5	933.	3	45.	0.	0.	0.	1	222.	YMITTOU 2
3	72	8	0 1.0	5	9999.	1	50.	0.	0.	0.	5	0.	DUMMY
3	72	68	00.43	5	950.	1	40.	0.	0.	0.	2	101.	FORMIONOS
3	72	73	00.19	5	933.	3	45.	0.	0.	0.	1	220.	YMITTOU3
3	73	74	00.22	5	933.	3	45.	0.	0.	0.	1	209.	YMITTOU4
3	73	75	00.17	5	850.	2	50.	0.	0.	0.	1	139.	EFTIHIDOU
3	74	25	0 1.0	5	9999.	1	50.	0.	0.	0.	5	0.	DUMMY
3	74	75	00.16	5	850.	2	50.	0.	0.	0.	1	153.	VRIAXIDOS
3	74	80	0 0.6	5	933.	3	45.	0.	0.	0.	1	233.	YMITTOU5
3	75	69	0 0.5	5	900.	2	50.	0.	0.	0.	1	198.	SP.MERKOURI
3	75	73	740.17	5	850.	2	50.	0.	0.	0.	1	162.	EFTIHIDOU
3	75	74	800.16	5	850.	2	50.	0.	0.	0.	1	135.	VRIAXIDOS
3	75	76	00.39	5	900.	2	50.	0.	0.	0.	1	173.	ERATOSTHENOU
3	76	75	00.39	5	900.	2	50.	0.	0.	0.	1	180.	ERATOSTHENOU
4	76	77	780.11	5	833.	3	50.	0.	0.	0.	1	392.	VAS.KONST.5
4	76	100	00.35	5	833.	3	50.	0.	0.	0.	1	401.	VAS.KONST.4
4	77	76	00.11	5	833.	3	50.	0.	0.	0.	1	379.	VAS.KONST.5
4	77	78	00.08	5	833.	3	50.	0.	0.	0.	1	363.	VAS.KONST.6
4	78	77	760.08	5	833.	3	50.	0.	0.	0.	1	499.	VAS.KONST. 6
4	78	26	0 1.0	5	9999.	1	50.	0.	0.	0.	5	0.	DUMMY
4	78	79	00.28	5	800.	3	50.	0.	0.	0.	1	449.	ARDITOU

4	78	92	00.34	5	883.	3	50.	0.	0.	0.	1	244.	VAS.OLGAS
4	79	78	00.28	5	800.	3	50.	0.	0.	0.	1	433.	ARDITOU
4	79	81	00.59	5	900.	3	45.	0.	0.	0.	1	357.	VOULIAGMENIS
4	79	83	00.76	5	950.	3	50.	0.	0.	0.	1	343.	KALLIROIS 1
5	79	88	00.14	5	1050.	2	50.	0.	0.	0.	1	204.	ATH.DIAKOU
3	80	81	00.19	5	650.	2	40.	0.	0.	0.	2	89.	CHERSIFRONOS
4	80	79	00.56	5	750.	3	45.	0.	0.	0.	1	394.	ILIOUPOLEOS
4	81	9	0 1.0	5	9999.	1	50.	0.	0.	0.	5	0.	DUMMY
4	81	82	0 0.7	5	750.	2	50.	0.	0.	0.	1	173.	FRANTZI
4	82	81	0 0.7	5	750.	2	50.	0.	0.	0.	1	180.	FRANTZI
5	82	83	00.15	5	867.	3	50.	0.	0.	0.	1	309.	SYGROU 1
5	82	87	00.43	5	867.	3	50.	0.	0.	0.	1	368.	SYGROU 2
5	83	10	0 1.0	5	9999.	1	50.	0.	0.	0.	5	0.	DUMMY
4	83	79	00.76	5	950.	3	50.	0.	0.	0.	1	313.	KALLIROIS 1
5	83	84	00.19	5	950.	3	50.	0.	0.	0.	1	345.	KALLIROIS 2
5	83	82	00.15	5	867.	3	50.	0.	0.	0.	1	319.	SYGROU 1
5	84	11	0 1.0	5	9999.	1	50.	0.	0.	0.	5	0.	DUMMY
5	84	83	00.19	5	950.	3	50.	0.	0.	0.	1	325.	KALLIROIS 2
6	84	85	1210.06	5	950.	3	50.	0.	0.	0.	1	218.	KALLIROIS 3
6	84	86	00.68	5	1400.	2	40.	0.	0.	0.	2	164.	DIMITRAKOP.
6	85	84	00.06	5	950.	3	50.	0.	0.	0.	1	287.	KALLIROIS 3
6	85	121	01.24	5	950.	3	50.	0.	0.	0.	1	248.	CHAMOSTERNAS
6	86	85	0 0.7	5	1250.	2	40.	0.	0.	0.	2	147.	VEIKOU
6	86	90	00.13	5	1500.	1	40.	0.	0.	0.	2	129.	MAKRIGIANNI
6	86	91	00.43	5	850.	1	40.	0.	0.	0.	2	143.	ROV.GALLI
5	87	82	00.43	5	867.	3	50.	0.	0.	0.	1	382.	SYGROU 2
6	87	86	00.06	5	850.	2	40.	0.	0.	0.	2	112.	CHATZICHRIS.
5	87	88	00.09	5	867.	3	50.	0.	0.	0.	1	305.	SYGROU 3
5	88	79	00.14	5	1050.	2	50.	0.	0.	0.	1	220.	ATH.DIAKOU
5	88	87	00.09	5	867.	3	50.	0.	0.	0.	1	311.	SYGROU 3
5	88	89	00.11	5	1000.	4	50.	0.	0.	0.	1	452.	SYGROU 4
5	89	27	0 1.0	5	9999.	1	50.	0.	0.	0.	5	0.	DUMMY
5	89	88	00.11	5	1000.	4	50.	0.	0.	0.	1	515.	SYGROY 4
5	89	90	00.12	5	825.	2	50.	0.	0.	0.	1	120.	DION.AREOP.1
5	89	92	00.11	5	1000.	4	50.	0.	0.	0.	1	473.	VAS.AMALIAS1
6	90	86	00.13	5	1500.	1	40.	0.	0.	0.	2	129.	MAKRIGIANNI
5	90	89	00.12	5	825.	2	50.	0.	0.	0.	1	132.	DION.AREOP.1
6	90	91	00.43	5	975.	2	50.	0.	0.	0.	1	88.	DION.AREOP.2
6	91	28	0 1.0	5	9999.	1	50.	0.	0.	0.	5	0.	DUMMY
6	91	86	00.43	5	850.	1	40.	0.	0.	0.	2	143.	ROV.GALLI
6	91	90	00.43	5	975.	2	50.	0.	0.	0.	1	88.	DION.AREOP.2
6	91	118	00.53	5	1225.	1	40.	0.	0.	0.	2	217.	APOST.PAVLOU
4	92	78	00.34	5	883.	3	50.	0.	0.	0.	1	163.	VAS.OLGAS
5	92	89	00.11	5	1000.	4	50.	0.	0.	0.	1	502.	VAS.AMALIAS1
5	92	93	95 0.1	5	1000.	4	50.	0.	0.	0.	1	560.	VAS.AMALIAS2
5	93	92	0 0.1	5	1000.	4	50.	0.	0.	0.	1	570.	VAS.AMALIAS2
13	93	95	00.32	5	1000.	4	50.	0.	0.	0.	1	560.	VAS.AMALIAS3
13	94	93	920.27	5	963.	4	50.	0.	0.	0.	1	409.	FILELLINON
13	94	95	00.09	5	750.	4	50.	0.	0.	0.	1	261.	GEORGIOU A
13	95	35	0 1.0	5	9999.	1	50.	0.	0.	0.	5	0.	DUMMY

13	95	93	920.32	5	1000.	4	50.	0.	0.	0.	1	167.	VAS.AMALIAS3
13	95	96	970.09	5	950.	3	50.	0.	0.	0.	1	279.	VAS.SOFIAS 8
13	95	101	1060.39	5	1133.	6	50.	0.	0.	0.	1	624.	PANEPISTIM.1
13	96	95	00.09	5	950.	3	50.	0.	0.	0.	1	398.	VAS.SOFIAS 8
13	96	97	980.09	5	950.	3	50.	0.	0.	0.	1	360.	VAS.SOFIAS 7
13	97	96	950.09	5	950.	3	50.	0.	0.	0.	1	299.	VAS.SOFIAS 7
15	97	98	00.08	5	950.	3	50.	0.	0.	0.	1	360.	VAS.SOFIAS 6
14	97	103	00.41	5	1000.	2	40.	0.	0.	0.	2	238.	SOLONOS 1
15	98	37	0 1.0	5	9999.	1	50.	0.	0.	0.	5	0.	DUMMY
4	98	77	780.42	5	1250.	2	50.	0.	0.	0.	1	168.	IR.ATTIKOU
15	98	97	00.08	5	950.	3	50.	0.	0.	0.	1	329.	VAS.SOFIAS 6
15	98	99	00.29	5	950.	3	50.	0.	0.	0.	1	392.	VAS.SOFIAS 5
2	99	65	00.29	5	950.	3	50.	0.	0.	0.	1	403.	VAS.SOFIAS 4
15	99	98	00.29	5	950.	3	50.	0.	0.	0.	1	388.	VAS.SOFIAS 5
15	99	100	00.12	5	900.	2	50.	0.	0.	0.	1	201.	RIZARI
2	100	69	00.09	5	833.	3	50.	0.	0.	0.	1	386.	VAS.KONST. 3
4	100	76	00.35	5	833.	3	50.	0.	0.	0.	1	400.	VAS.KONST. 4
15	100	99	00.12	5	900.	2	50.	0.	0.	0.	1	189.	RIZARI
9	101	106	00.08	5	1160.	5	50.	0.	0.	0.	1	587.	PANEPISTIM.2
14	102	103	00.08	5	750.	2	40.	0.	0.	0.	2	125.	ASKLIPIOU 2
13	102	96	00.44	5	1225.	4	50.	0.	0.	0.	1	382.	AKADIMIAS 1
14	103	36	0 1.0	5	9999.	1	50.	0.	0.	0.	5	0.	DUMMY
14	103	57	00.86	5	750.	2	40.	0.	0.	0.	2	110.	ASKLIPIOU 1
14	103	105	00.03	5	1000.	2	40.	0.	0.	0.	2	187.	SOLONOS 2
14	104	101	1060.11	5	1100.	3	45.	0.	0.	0.	1	198.	IPPOKRATOUS3
14	104	102	00.03	5	1225.	4	50.	0.	0.	0.	1	347.	AKADIMIAS 2
14	105	104	00.08	5	900.	3	45.	0.	0.	0.	1	232.	IPPOKRATOUS2
11	105	108	00.08	5	1000.	2	40.	0.	0.	0.	2	247.	SOLONOS 3
11	106	107	00.11	5	800.	2	40.	0.	0.	0.	2	128.	CH.TRIKOUPI3
9	106	109	00.19	5	1160.	5	50.	0.	0.	0.	1	540.	PANEPISTIM.3
11	107	104	00.08	5	1133.	3	50.	0.	0.	0.	1	238.	AKADIMIAS 3
11	107	108	00.08	5	1050.	2	40.	0.	0.	0.	2	152.	CH.TRIKOUPI2
11	108	33	0 1.0	5	9999.	1	50.	0.	0.	0.	1	0.	DUMMY
11	108	111	00.34	5	1000.	2	40.	0.	0.	0.	2	203.	SOLONOS 4
11	108	59	00.73	5	1050.	2	40.	0.	0.	0.	2	196.	CH.TRIKOUPI1
9	109	110	00.14	5	825.	2	50.	0.	0.	0.	1	153.	PATISSION 7
9	109	112	00.04	5	1160.	5	50.	0.	0.	0.	1	383.	PANEPISTIM.4
11	110	107	00.29	5	1067.	3	50.	0.	0.	0.	1	251.	AKADIMIAS 4
9	110	109	1120.14	5	825.	2	50.	0.	0.	0.	1	263.	PATISSION 7
10	110	111	1410.03	5	825.	2	50.	0.	0.	0.	1	140.	PATISSION 6
10	111	110	00.03	5	825.	2	50.	0.	0.	0.	1	245.	PATISSION 6
10	111	141	0 0.2	5	825.	2	50.	0.	0.	0.	1	203.	PATISSION 5
9	112	31	0 1.0	5	9999.	1	50.	0.	0.	0.	5	0.	DUMMY
9	112	94	00.68	5	1300.	3	50.	0.	0.	0.	1	484.	STADIOU
12	112	113	0 0.5	5	750.	2	50.	0.	0.	0.	1	111.	ATHINAS
9	112	114	1150.36	5	1075.	2	50.	0.	0.	0.	1	195.	PIREOS 1
8	112	130	00.32	5	825.	2	50.	0.	0.	0.	1	176.	AG.KONSTANT.
9	112	140	00.31	5	825.	4	50.	0.	0.	0.	1	437.	TRITIS SEP.1
12	113	34	0 1.0	5	9999.	1	50.	0.	0.	0.	5	0.	DUMMY
12	113	94	0 0.4	5	1050.	2	40.	0.	0.	0.	2	151.	ERMOU 1

9	113	112	0 0.5	5	750.	2	50.	0.	0.	0.	1	111.	ATHINAS
12	113	118	00.28	5	750.	2	50.	0.	0.	0.	1	153.	ERMOU 2
9	114	115	00.07	5	1075.	2	50.	0.	0.	0.	1	195.	PIREOS 2
9	114	112	00.36	5	1075.	2	50.	0.	0.	0.	1	203.	PIREOS 1
8	115	127	0 0.3	5	850.	2	40.	0.	0.	0.	2	143.	MYLLEROU
9	115	116	00.09	5	1075.	2	50.	0.	0.	0.	1	182.	PIREOS 3
9	115	114	1120.07	5	1075.	2	50.	0.	0.	0.	1	195.	PIREOS 2
12	116	118	00.22	5	950.	2	50.	0.	0.	0.	1	232.	ASOMATON
7	116	117	00.16	5	1075.	2	50.	0.	0.	0.	1	182.	PIREOS 4
9	116	115	00.09	5	1075.	2	50.	0.	0.	0.	1	180.	PIREOS 3
7	117	119	00.16	5	1075.	2	50.	0.	0.	0.	1	168.	PIREOS 5
7	117	123	0 0.3	5	800.	2	50.	0.	0.	0.	1	130.	IERA ODOS
7	117	116	00.16	5	1075.	2	50.	0.	0.	0.	1	169.	PIREOS 4
6	118	91	00.53	5	1225.	1	40.	0.	0.	0.	2	217.	APOST.PAVLOU
12	118	113	00.28	5	750.	2	50.	0.	0.	0.	1	153.	ERMOU 2
7	118	119	00.35	5	825.	2	50.	0.	0.	0.	1	113.	ERMOU 3
7	119	29	0 1.0	5	9999.	1	50.	0.	0.	0.	5	0.	DUMMY
7	119	118	00.35	5	825.	2	50.	0.	0.	0.	1	100.	ERMOU 3
7	119	117	00.16	5	1075.	2	50.	0.	0.	0.	1	138.	PIREOS 5
7	119	120	00.25	5	1075.	2	50.	0.	0.	0.	1	187.	PIREOS 6
7	120	119	00.25	5	1075.	2	50.	0.	0.	0.	1	232.	PIREOS 6
7	120	121	00.81	5	1000.	2	50.	0.	0.	0.	1	208.	PIREOS 7
7	120	122	00.31	5	750.	2	50.	0.	0.	0.	1	108.	MEG.VASILIOU
7	121	12	0 1.0	5	9999.	1	50.	0.	0.	0.	5	0.	DUMMY
6	121	85	841.24	5	950.	3	50.	0.	0.	0.	1	196.	CHAMOSTERNAS
7	121	122	00.62	5	925.	2	50.	0.	0.	0.	1	219.	LEOF.KONST.1
7	121	120	00.81	5	1000.	2	50.	0.	0.	0.	1	208.	PIREOS 7
7	122	13	0 1.0	5	9999.	1	50.	0.	0.	0.	5	0.	DUMMY
7	122	121	00.62	5	925.	2	50.	0.	0.	0.	1	219.	LEOF.KONST.1
7	122	123	0 0.5	5	925.	2	50.	0.	0.	0.	1	178.	LEOF.KONST.2
7	122	120	00.31	5	750.	2	50.	0.	0.	0.	1	122.	MEG.VASILIOU
7	123	14	0 1.0	5	9999.	1	50.	0.	0.	0.	5	0.	DUMMY
7	123	122	0 0.5	5	925.	2	50.	0.	0.	0.	1	132.	LEOF.KONST.2
7	123	117	0 0.3	5	800.	2	50.	0.	0.	0.	1	128.	IERA ODOS
7	123	124	00.27	5	925.	2	50.	0.	0.	0.	1	136.	LEOF.KONST.3
8	124	15	0 1.0	5	9999.	1	50.	0.	0.	0.	5	0.	DUMMY
7	124	123	00.27	5	925.	2	50.	0.	0.	0.	1	146.	LEOF.KONST.3
8	124	125	00.12	5	1100.	2	50.	0.	0.	0.	1	193.	ACHILLEOS 1
8	124	126	0 0.1	5	925.	2	50.	0.	0.	0.	1	121.	LEOF.KONST.4
7	125	116	00.32	5	900.	2	40.	0.	0.	0.	2	146.	THERMOPYLON1
8	125	124	00.12	5	1100.	2	50.	0.	0.	0.	1	278.	ACHILLEOS 1
8	125	127	1280.09	5	1100.	2	50.	0.	0.	0.	1	164.	ACHILLEOS 2
8	126	124	0 0.1	5	925.	2	50.	0.	0.	0.	1	161.	LEOF.KONST.4
8	126	125	00.07	5	900.	2	40.	0.	0.	0.	2	117.	THERMOPYLON2
8	126	129	00.18	5	925.	2	50.	0.	0.	0.	1	102.	LEOF.KONST.5
8	127	125	00.09	5	1100.	2	50.	0.	0.	0.	1	309.	ACHILLEOS 2
8	127	128	00.08	5	1100.	2	50.	0.	0.	0.	1	182.	ACHILLEOS 3
9	128	114	00.27	5	900.	2	40.	0.	0.	0.	2	135.	KOLOKYNTHOUS
8	128	127	1250.08	5	1100.	2	50.	0.	0.	0.	1	270.	ACHILLEOS 3
8	128	129	00.17	5	800.	2	50.	0.	0.	0.	1	103.	LENORMAN

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 8 128 130    00.09  5 1100. 2 50.   0.   0.   0. 1  190. ACHILLEOS 4
 8 129  16   0 1.0   5 9999. 1 50.   0.   0.   0. 5    0. DUMMY
 8 129 128    00.17  5  800. 2 50.   0.   0.   0. 1  223. LENORMAN
 8 129 126    00.18  5  925. 2 50.   0.   0.   0. 1  181. LEOF.KONST.5
 8 129 131    00.14  5  925. 2 50.   0.   0.   0. 1  172. LEOF.KONST.6
 8 130  30   0 1.0   5 9999. 1 50.   0.   0.   0. 5    0. DUMMY
 8 130 128    00.09  5 1100. 2 50.   0.   0.   0. 1  252. ACHILLEOS 4
 9 130 112    00.32  5  825. 2 50.   0.   0.   0. 1  176. AG.KONSTANT.
 8 130 131   0 0.2   5 1067. 3 50.   0.   0.   0. 1  224. DELIGIANNI 1
 8 130 133    00.31  5  825. 2 50.   0.   0.   0. 1  179. MARNI 1
 8 131 129    00.14  5  925. 2 50.   0.   0.   0. 1  170. LEOF.KONST.6
 8 131 130   0 0.2   5 1067. 3 50.   0.   0.   0. 1  147. DELIGIANNI 1
 8 131 132    00.19  5 1067. 3 50.   0.   0.   0. 1  235. DELIGIANNI 2
 8 132  17   0 1.0   5 9999. 1 50.   0.   0.   0. 5    0. DUMMY
 8 132 131    00.19  5 1067. 3 50.   0.   0.   0. 1  263. DELIGIANNI 2
 8 132 134    00.34  5  800. 2 40.   0.   0.   0. 2   89. IPIROU 1
 8 133 130    00.31  5  825. 2 50.   0.   0.   0. 1  179. MARNI 1
 8 133 134    00.22  5  900. 2 50.   0.   0.   0. 1  140. ACHARNON 1
10 133 140    00.17  5  825. 2 50.   0.   0.   0. 1  180. MARNI 2
 8 134 132    00.34  5  800. 1 40.   0.   0.   0. 2   93. IPIROU 1
 8 134 133    00.22  5  900. 2 50.   0.   0.   0. 1  149. ACHARNON 1
 8 134 135 1360.09   5  900. 2 50.   0.   0.   0. 1  161. ACHARNON 2
10 134 139    00.15  5  800. 3 45.   0.   0.   0. 1  110. IPIROU 2
 8 135 134    00.09  5  900. 2 50.   0.   0.   0. 1  150. ACHARNON 2
 8 135 136    00.24  5  900. 2 50.   0.   0.   0. 1  174. ACHARNON 3
 8 136  18   0 1.0   5 9999. 1 50.   0.   0.   0. 5    0. DUMMY
 8 136 135 1340.24   5  900. 2 50.   0.   0.   0. 1  174. ACHARNON 3
10 137 136    00.19  5  800. 3 45.   0.   0.   0. 1  140. KODRICTONOS3
10 138 135    00.16  5  800. 3 45.   0.   0.   0. 1  187. IOULIANOU 2
10 138 137 1360.23   5  825. 4 50.   0.   0.   0. 1  289. TRITIS SEP.4
10 139 138    00.09  5  825. 4 50.   0.   0.   0. 1  312. TRITIS SEP.3
10 139 142    00.08  5  800. 3 45.   0.   0.   0. 1  139. IPIROU 3
10 140 133    00.17  5  825. 2 50.   0.   0.   0. 1  157. MARNI 2
10 140 139    00.12  5  825. 4 50.   0.   0.   0. 1  350. TRITIS SEP.2
10 140 141    00.12  5  825. 2 50.   0.   0.   0. 1  185. MARNI 3
10 141  32   0 1.0   5 9999. 1 50.   0.   0.   0. 5    0. DUMMY
10 141 111 110 0.2   5  825. 2 50.   0.   0.   0. 1  287. PATISSION 5
10 141 140    00.12  5  825. 2 50.   0.   0.   0. 1  199. MARNI 3
10 141 142 1430.04   5  867. 3 50.   0.   0.   0. 1  205. PATISSION 4
10 142 141    00.04  5  867. 3 50.   0.   0.   0. 1  309. PATISSION 4
10 142 143    00.14  5  867. 3 50.   0.   0.   0. 1  211. PATISSION 3
10 143 142 1410.14   5  867. 3 50.   0.   0.   0. 1  321. PATISSION 3
10 143 138    00.08  5  800. 3 45.   0.   0.   0. 1  218. IOULIANOU 1
10 143  62    00.03  5  867. 3 50.   0.   0.   0. 1  183. PATISSION 2
10 144  19   0 1.0   5 9999. 1 50.   0.   0.   0. 5    0. DUMMY
10 144  62   0 0.2   5  867. 3 50.   0.   0.   0. 1  485. PATISSION 1
10 144 137 1360.08   5  800. 3 45.   0.   0.   0. 1  156. KODRICTONOS2
10 145 144    00.06  5  933. 3 45.   0.   0.   0. 1  183. KODRICTONOS1
10 145  20   0 1.0   5 9999. 1 50.   0.   0.   0. 1    0. DUMMY
509.1375. 703. 392. 307. 300. 363. 193. 503. 435. 209.  95. 102.
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109.	111.	132.	259.	192.	352.	362.	219.	211.	0.	0.	423.	382.
301.	102.	203.	309.	403.	422.	430.	132.	135.	320.	487.		
487.	1339.	677.	307.	392.	402.	399.	280.	909.	1013.	235.	202.	165.
151.	229.	189.	350.	201.	201.	182.	101.	83.	0.	0.	400.	301.
232.	123.	232.	404.	379.	403.	350.	109.	201.	409.	603.		
392.	702.	603.	185.	285.	405.	452.	372.	1023.	632.	290.	101.	93.
99.	232.	132.	300.	101.	211.	198.	102.	91.	303.	452.	0.	0.
201.	78.	199.	202.	322.	380.	203.	93.	119.	372.	432.		
403.	895.	529.	203.	203.	220.	332.	281.	1400.	1327.	382.	332.	192.
162.	330.	232.	299.	153.	300.	280.	132.	130.	364.	370.	0.	0.
0.	92.	182.	219.	268.	203.	192.	88.	73.	201.	392.		
207.	789.	423.	80.	180.	80.	307.	153.	1235.	1334.	423.	400.	311.
280.	402.	253.	321.	201.	192.	180.	101.	92.	203.	201.	302.	0.
0.	0.	130.	132.	232.	139.	262.	0.	0.	203.	238.		
283.	403.	272.	97.	97.	50.	189.	103.	532.	882.	307.	529.	400.
411.	402.	302.	322.	185.	201.	190.	92.	90.	187.	253.	203.	252.
0.	0.	123.	387.	402.	392.	209.	72.	72.	182.	392.		
203.	392.	302.	118.	118.	107.	101.	92.	395.	623.	332.	730.	695.
660.	832.	457.	502.	202.	209.	180.	88.	80.	152.	156.	192.	195.
183.	102.	0.	232.	372.	209.	242.	102.	80.	109.	388.		
323.	683.	400.	230.	130.	89.	135.	53.	302.	472.	222.	622.	709.
701.	1432.	1009.	1345.	832.	702.	690.	222.	245.	201.	109.	150.	165.
107.	40.	232.	0.	0.	192.	202.	109.	109.	132.	253.		
489.	893.	603.	300.	200.	200.	309.	192.	992.	1139.	209.	932.	895.
882.	1387.	847.	1320.	825.	823.	850.	401.	415.	432.	401.	332.	423.
327.	140.	293.	0.	0.	302.	209.	233.	191.	472.	675.		
332.	890.	575.	180.	180.	115.	135.	103.	301.	459.	192.	403.	302.
259.	650.	409.	803.	529.	703.	790.	332.	340.	329.	252.	238.	101.
139.	37.	153.	201.	100.	0.	0.	152.	142.	309.	452.		
399.	831.	585.	290.	200.	100.	150.	95.	298.	523.	211.	412.	240.
232.	623.	411.	590.	323.	692.	720.	432.	411.	332.	301.	252.	101.
153.	52.	108.	192.	92.	0.	0.	139.	167.	0.	439.		
225.	400.	285.	60.	150.	80.	212.	101.	471.	621.	360.	402.	199.
200.	280.	221.	238.	172.	202.	110.	132.	112.	325.	301.	203.	182.
0.	62.	259.	185.	203.	179.	192.	0.	0.	302.	392.		
501.	1503.	805.	302.	352.	220.	311.	218.	1435.	1342.	473.	711.	592.
601.	892.	749.	702.	630.	821.	760.	289.	321.	722.	709.	603.	549.
0.	122.	377.	523.	739.	927.	632.	0.	0.	543.	0.		
380.	1057.	687.	272.	222.	125.	139.	95.	384.	401.	252.	209.	182.
179.	280.	201.	432.	103.	432.	413.	473.	460.	422.	409.	292.	198.
232.	83.	172.	203.	436.	230.	0.	130.	92.	0.	382.		
400.	1400.	730.	325.	325.	180.	382.	155.	1073.	892.	327.	202.	109.
99.	124.	109.	236.	190.	521.	498.	225.	260.	632.	689.	502.	373.
273.	92.	201.	392.	349.	472.	457.	227.	0.	538.	0.		

Appendix C

Sample of the Model Output for the Central Athens Network

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PRINT OPTION =  1 ASSIGNMENT PARM =     1.50000
THE O-D TRIP TABLE IS GIVEN, TOTAL PROD IS   110856.0
PROD FROM ORIGIN  38 GOES TO  35 DIFFERENT DEST
PROD FROM ORIGIN  39 GOES TO  35 DIFFERENT DEST
PROD FROM ORIGIN  40 GOES TO  35 DIFFERENT DEST
PROD FROM ORIGIN  41 GOES TO  34 DIFFERENT DEST
PROD FROM ORIGIN  42 GOES TO  32 DIFFERENT DEST
PROD FROM ORIGIN  43 GOES TO  35 DIFFERENT DEST
PROD FROM ORIGIN  44 GOES TO  36 DIFFERENT DEST
PROD FROM ORIGIN  45 GOES TO  35 DIFFERENT DEST
PROD FROM ORIGIN  46 GOES TO  35 DIFFERENT DEST
PROD FROM ORIGIN  47 GOES TO  35 DIFFERENT DEST
PROD FROM ORIGIN  48 GOES TO  34 DIFFERENT DEST
PROD FROM ORIGIN  49 GOES TO  34 DIFFERENT DEST
PROD FROM ORIGIN  50 GOES TO  33 DIFFERENT DEST
PROD FROM ORIGIN  51 GOES TO  35 DIFFERENT DEST
PROD FROM ORIGIN  52 GOES TO  35 DIFFERENT DEST


PROBABILISTIC  TRAFFIC ASSIGNMENT
TOTAL VEH TRAVEL TIME AT THIS INTERVAL =  189728.1 VEH-MIN
EVACUATION TIME3     37.438 INTERVAL=  15
EVACUATION TIME3     37.951 INTERVAL=  15
EVACUATION TIME3     38.267 INTERVAL=  15
EVACUATION TIME3     40.818 INTERVAL=  15
EVACUATION TIME3     48.421 INTERVAL=  15
EVACUATION TIME3     52.029 INTERVAL=  15
EVACUATION TIME3     54.641 INTERVAL=  15
EVACUATION TIME3     55.916 INTERVAL=  15
EVACUATION TIME3     56.699 INTERVAL=  15
EVACUATION TIME3     59.311 INTERVAL=  15
EVACUATION TIME3     60.959 INTERVAL=  15
EVACUATION TIME3     61.668 INTERVAL=  15
EVACUATION TIME3     64.502 INTERVAL=  15
EVACUATION TIME3     66.150 INTERVAL=  15
EVACUATION TIME3    108.608 INTERVAL=  15
EVACUATION TIME3    109.393 INTERVAL=  15
EVACUATION TIME3    109.593 INTERVAL=  15
EVACUATION TIME3    109.835 INTERVAL=  15
EVACUATION TIME3    110.036 INTERVAL=  15
EVACUATION TIME3    114.219 INTERVAL=  15
EVACUATION TIME3    124.042 INTERVAL=  15
EVACUATION TIME3    125.104 INTERVAL=  15
EVACUATION TIME3    125.517 INTERVAL=  15
EVACUATION TIME3    128.483 INTERVAL=  15
EVACUATION TIME3    130.265 INTERVAL=  15
EVACUATION TIME3    131.611 INTERVAL=  15
EVACUATION TIME3    131.849 INTERVAL=  15
EVACUATION TIME3    132.165 INTERVAL=  15
EVACUATION TIME3    133.309 INTERVAL=  15
EVACUATION TIME3    133.822 INTERVAL=  15
EVACUATION TIME3    134.138 INTERVAL=  15
EVACUATION TIME3    138.529 INTERVAL=  15
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EVACUATION TIME3 139.042 INTERVAL= 15
EVACUATION TIME3 139.358 INTERVAL= 15

CURRENT CLOCK TIME = 15 INTERVAL = 15.
TOTAL TRIP ASSIGNED AT THIS TS = 3561.7 IS 3.21%
CUMULATIVE TRIP ASSIGNED UP TO THIS TS = 3561.7 IS 3.21%

LINK	ANODE	BNODE	DIST	SPEED0	SPEED	TIME0	TIME	STR	VOLUME	CAPACITY	V/C RATIO	RVOL	FL	EL	EZ
1	38	64	1.00	50.00	50.00	1.20	1.20	DUMMY	221.27	9999.	0.09	0.00	0.00	0.00	0.00
2	39	66	1.00	50.00	50.00	1.20	1.20	DUMMY	243.60	9999.	0.10	0.00	0.00	0.00	0.00
3	40	74	1.00	50.00	50.00	1.20	1.20	DUMMY	199.65	9999.	0.08	0.00	0.00	0.00	0.00
4	41	78	1.00	50.00	50.00	1.20	1.20	DUMMY	218.96	9999.	0.09	0.00	0.00	0.00	0.00
5	42	89	1.00	50.00	50.00	1.20	1.20	DUMMY	192.52	9999.	0.08	0.00	0.00	0.00	0.00
6	43	91	1.00	50.00	50.00	1.20	1.20	DUMMY	182.36	9999.	0.07	0.00	0.00	0.00	0.00
7	44	119	1.00	50.00	50.00	1.20	1.20	DUMMY	195.25	9999.	0.08	0.00	0.00	0.00	0.00
8	45	128	1.00	50.00	50.00	1.20	1.20	DUMMY	261.08	9999.	0.10	0.00	0.00	0.00	0.00
9	46	109	1.00	50.00	50.00	1.20	1.20	DUMMY	376.48	9999.	0.15	0.00	0.00	0.00	0.00
10	47	141	1.00	50.00	50.00	1.20	1.20	DUMMY	223.30	9999.	0.09	0.00	0.00	0.00	0.00
11	48	108	1.00	50.00	50.00	1.20	1.20	DUMMY	213.91	9999.	0.09	0.00	0.00	0.00	0.00
12	49	113	1.00	50.00	50.00	1.20	1.20	DUMMY	154.54	9999.	0.06	0.00	0.00	0.00	0.00
13	50	95	1.00	50.00	50.00	1.20	1.20	DUMMY	404.34	9999.	0.16	0.00	0.00	0.00	0.00
14	51	103	1.00	50.00	50.00	1.20	1.20	DUMMY	205.40	9999.	0.08	0.00	0.00	0.00	0.00
15	52	98	1.00	50.00	50.00	1.20	1.20	DUMMY	269.01	9999.	0.11	0.00	0.00	0.00	0.00
16	53	1	1.00	50.00	50.00	1.20	1.20	DUMMY	106.64	9999.	0.04	0.00	0.00	0.00	0.00
17	53	54	0.19	50.00	2.62	0.23	4.34	ALEXANDRAS1	291.74	3099.	0.38	0.00	0.00	0.00	0.00
18	53	57	0.49	50.00	16.26	0.59	1.81	ALEXANDRAS2	161.73	3099.	0.21	0.00	0.00	0.00	0.00
19	54	2	1.00	50.00	50.00	1.20	1.20	DUMMY	261.24	9999.	0.10	0.00	0.00	0.00	0.00
20	54	53	0.19	50.00	16.08	0.23	0.71	ALEXANDRAS1	174.86	3099.	0.23	0.00	0.00	0.00	0.00
21	54	55	0.12	50.00	5.89	0.14	1.22	FIDIPPIDOU1	222.51	2400.	0.37	0.00	0.00	0.00	0.00
22	54	63	0.12	50.00	17.15	0.14	0.42	VAS.SOFIAS1	99.86	2850.	0.14	0.00	0.00	0.00	0.00
23	55	3	1.00	50.00	50.00	1.20	1.20	DUMMY	157.66	9999.	0.06	0.00	0.00	0.00	0.00
24	55	54	0.12	50.00	18.00	0.14	0.40	FIDIPPIDOU1	46.00	2400.	0.08	0.00	0.00	0.00	0.00
25	55	56	0.09	50.00	17.10	0.11	0.32	FIDIPPIDOU2	102.60	3000.	0.14	0.00	0.00	0.00	0.00
26	55	63	0.19	50.00	17.90	0.23	0.64	MESSOGION	52.00	2400.	0.09	0.00	0.00	0.00	0.00

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CONGESTED LINK: 17	VOL=	889.	CAP=	775.	ALEXANDRAS1	A= 53	B= 54
CONGESTED LINK: 30	VOL=	933.	CAP=	775.	ALEXANDRAS2	A= 57	B= 53
CONGESTED LINK: 36	VOL=	981.	CAP=	775.	ALEXANDRAS5	A= 59	B= 60
CONGESTED LINK: 39	VOL=	885.	CAP=	775.	ALEXANDRAS6	A= 60	B= 61
CONGESTED LINK:129	VOL=	614.	CAP=	413.	DION.AREOP.1	A= 89	B= 90
CONGESTED LINK:131	VOL=	506.	CAP=	375.	MAKRIGIANNI	A= 90	B= 86
CONGESTED LINK:135	VOL=	305.	CAP=	212.	ROV.GALLI	A= 91	B= 86
CONGESTED LINK:137	VOL=	388.	CAP=	306.	APOST.PAVLOU	A= 91	B=118
CONGESTED LINK:150	VOL=	795.	CAP=	713.	VAS.SOFIAS 7	A= 96	B= 97
CONGESTED LINK:153	VOL=	1049.	CAP=	500.	SOLONOS 1	A= 97	B=103
CONGESTED LINK:156	VOL=	829.	CAP=	713.	VAS.SOFIAS 6	A= 98	B= 97
CONGESTED LINK:163	VOL=	492.	CAP=	450.	RIZARI	A=100	B= 99
CONGESTED LINK:168	VOL=	670.	CAP=	375.	ASKLIPIOU 1	A=103	B= 57
CONGESTED LINK:169	VOL=	698.	CAP=	500.	SOLONOS 2	A=103	B=105
CONGESTED LINK:173	VOL=	624.	CAP=	500.	SOLONOS 3	A=105	B=108

CONGESTED LINK:180	VOL=	1214.	CAP=	525.	CH.TRIKOUPI1	A=108	B= 59
CONGESTED LINK:186	VOL=	459.	CAP=	413.	PATISSION 6	A=111	B=110
CONGESTED LINK:211	VOL=	453.	CAP=	413.	ERMOU 3	A=118	B=119
CONGESTED LINK:265	VOL=	407.	CAP=	200.	IPIROU 1	A=134	B=132
CONGESTED LINK:269	VOL=	483.	CAP=	450.	ACHARNON 2	A=135	B=134
CONGESTED LINK:282	VOL=	463.	CAP=	413.	PATISSION 5	A=141	B=111

CURRENT CLOCK TIME = 60 INTERVAL = 15.
TOTAL TRIP ASSIGNED AT THIS TS = 4906.9 IS 4.43%
CUMULATIVE TRIP ASSIGNED UP TO THIS TS = 13856.9 IS 12.50%

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LINK:225	OVERALL VOLUME	641.	LEOF.KONST.2	A=122	B=123
LINK:226	OVERALL VOLUME	132.	MEG.VASILIOU	A=122	B=120
LINK:227	OVERALL VOLUME	3014.	DUMMY	A=123	B= 14
LINK:228	OVERALL VOLUME	3751.	LEOF.KONST.2	A=123	B=122
LINK:229	OVERALL VOLUME	307.	IERA ODOS	A=123	B=117
LINK:230	OVERALL VOLUME	1398.	LEOF.KONST.3	A=123	B=124
LINK:231	OVERALL VOLUME	4922.	DUMMY	A=124	B= 15
LINK:232	OVERALL VOLUME	4451.	LEOF.KONST.3	A=124	B=123
LINK:233	OVERALL VOLUME	214.	ACHILLEOS 1	A=124	B=125
LINK:234	OVERALL VOLUME	971.	LEOF.KONST.4	A=124	B=126
LINK:235	OVERALL VOLUME	1799.	THERMOPYLON1	A=125	B=116
LINK:236	OVERALL VOLUME	5906.	ACHILLEOS 1	A=125	B=124
LINK:237	OVERALL VOLUME	202.	ACHILLEOS 2	A=125	B=127
LINK:238	OVERALL VOLUME	3369.	LEOF.KONST.4	A=126	B=124
LINK:239	OVERALL VOLUME	1016.	THERMOPYLON2	A=126	B=125
LINK:240	OVERALL VOLUME	934.	LEOF.KONST.5	A=126	B=129
LINK:241	OVERALL VOLUME	6708.	ACHILLEOS 2	A=127	B=125
LINK:242	OVERALL VOLUME	2531.	ACHILLEOS 3	A=127	B=128
LINK:243	OVERALL VOLUME	2761.	KOLOKYNTHOUS	A=128	B=114
LINK:244	OVERALL VOLUME	5056.	ACHILLEOS 3	A=128	B=127
LINK:245	OVERALL VOLUME	3807.	LENORMAN	A=128	B=129
LINK:246	OVERALL VOLUME	4020.	ACHILLEOS 4	A=128	B=130
LINK:247	OVERALL VOLUME	3390.	DUMMY	A=129	B= 16
LINK:248	OVERALL VOLUME	260.	LENORMAN	A=129	B=128
LINK:249	OVERALL VOLUME	4269.	LEOF.KONST.5	A=129	B=126
LINK:250	OVERALL VOLUME	1741.	LEOF.KONST.6	A=129	B=131
LINK:251	OVERALL VOLUME	2147.	DUMMY	A=130	B= 30
LINK:252	OVERALL VOLUME	4686.	ACHILLEOS 4	A=130	B=128
LINK:253	OVERALL VOLUME	1576.	AG.KONSTANT.	A=130	B=112
LINK:254	OVERALL VOLUME	4330.	DELIGIANNI 1	A=130	B=131
LINK:255	OVERALL VOLUME	3483.	MARNI 1	A=130	B=133
LINK:256	OVERALL VOLUME	4718.	LEOF.KONST.6	A=131	B=129
LINK:257	OVERALL VOLUME	480.	DELIGIANNI 1	A=131	B=130
LINK:258	OVERALL VOLUME	3772.	DELIGIANNI 2	A=131	B=132
LINK:259	OVERALL VOLUME	4811.	DUMMY	A=132	B= 17
LINK:260	OVERALL VOLUME	3006.	DELIGIANNI 2	A=132	B=131
LINK:261	OVERALL VOLUME	711.	IPIROU 1	A=132	B=134
LINK:262	OVERALL VOLUME	4201.	MARNI 1	A=133	B=130
LINK:263	OVERALL VOLUME	5085.	ACHARNON 1	A=133	B=134
LINK:264	OVERALL VOLUME	1666.	MARNI 2	A=133	B=140
LINK:265	OVERALL VOLUME	4732.	IPIROU 1	A=134	B=132
LINK:266	OVERALL VOLUME	587.	ACHARNON 1	A=134	B=133

LINK:267	OVERALL VOLUME	1244.	ACHARNON 2	A=134	B=135
LINK:268	OVERALL VOLUME	1098.	IPIROU 2	A=134	B=139
LINK:269	OVERALL VOLUME	1731.	ACHARNON 2	A=135	B=134
LINK:270	OVERALL VOLUME	1942.	ACHARNON 3	A=135	B=136
LINK:271	OVERALL VOLUME	2904.	DUMMY	A=136	B= 18
LINK:272	OVERALL VOLUME	174.	ACHARNON 3	A=136	B=135
LINK:273	OVERALL VOLUME	1276.	KODRICTONOS3	A=137	B=136
LINK:274	OVERALL VOLUME	2454.	IOULIANOU 2	A=138	B=135
LINK:275	OVERALL VOLUME	1145.	TRITIS SEP.4	A=138	B=137
LINK:276	OVERALL VOLUME	1472.	TRITIS SEP.3	A=139	B=138
LINK:277	OVERALL VOLUME	3596.	IPIROU 3	A=139	B=142
LINK:278	OVERALL VOLUME	6868.	MARNI 2	A=140	B=133
LINK:279	OVERALL VOLUME	3978.	TRITIS SEP.2	A=140	B=139
LINK:280	OVERALL VOLUME	3874.	MARNI 3	A=140	B=141
LINK:281	OVERALL VOLUME	2668.	DUMMY	A=141	B= 32
LINK:282	OVERALL VOLUME	4158.	PATISSION 5	A=141	B=111
LINK:283	OVERALL VOLUME	7321.	MARNI 3	A=141	B=140
LINK:284	OVERALL VOLUME	7391.	PATISSION 4	A=141	B=142
LINK:285	OVERALL VOLUME	1215.	PATISSION 4	A=142	B=141
LINK:286	OVERALL VOLUME	10539.	PATISSION 3	A=142	B=143
LINK:287	OVERALL VOLUME	913.	PATISSION 3	A=143	B=142
LINK:288	OVERALL VOLUME	2181.	IOULIANOU 1	A=143	B=138
LINK:289	OVERALL VOLUME	9827.	PATISSION 2	A=143	B= 62
LINK:290	OVERALL VOLUME	3938.	DUMMY	A=144	B= 19
LINK:291	OVERALL VOLUME	485.	PATISSION 1	A=144	B= 62
LINK:292	OVERALL VOLUME	436.	KODRICTONOS2	A=144	B=137
LINK:293	OVERALL VOLUME	339.	KODRICTONOS1	A=145	B=144
LINK:294	OVERALL VOLUME	3842.	DUMMY	A=145	B= 20

TOTAL VEH TRAVEL TIME = 6866335.0 VEH-MIN
MAXIMUM NETWORK CLEARANCE TIME EQUALS TO: 626.755
THE EVACUATION TIME NEEDED IF 20% OF THE TRIP HAS
BEEN LOADED BEFORE ISSUING THE EVACUATION ORDER IS 549.500
THE LOADING PERIOD IS NOT APPROPRIATE: EVACUATION TIME IS TOO LARGE

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