PTRC

Organised on behalf of the European Transport Forum by PTRC Education and Research Services

EUROPEAN TRANSPORT FORUM Annual Meeting

Proceedings of Seminar C

Policy, Planning and Sustainability

Volume P413

ISBN 0-86050-303-8
ISSN 0267-9718

25th European Transport Forum Annual Meeting

1 – 5 September 1997

POLICY, PLANNING AND SUSTAINABILITY

Proceedings of Seminars C and D
held at the
European Transport Forum Annual Meeting
Brunel University, England
1 - 5 September 1997

VOLUME P 413

Price for Delegates:	**£36.00**
Price for Non-Delegates	**£48.00**

Published by

PTRC EDUCATION AND RESEARCH SERVICES LTD

on behalf of

THE EUROPEAN TRANSPORT FORUM

1997

ACKNOWLEDGEMENT

PTRC would like to thank members of the Policy, Planning and Sustainablity Programme Committee who have so willingly given their time in helping to organise the programme for this Seminar:

George Hazel, City of Edinburgh Council, UK
Michael Bach, Department of the Environment, Transport and the Regions, UK
Neil Chadwick, Steer Davies Gleave, UK
Ian Chatfield, Nottinghamshire County Council, UK
Enzo Coccia, Regione dell Umbria, Italy
Arie Dekker, Provincie Overijssel, The Netherlands
Raimund Herz, Technische Universität Dresden, Germany
Bill Kennedy, European Bank for Reconstruction and Development, UK
Peter Lindner, HESS, Germany
Alan Lovell, West Sussex County Council, UK
Jörg Schönharting, Universität Gesamthochschule Essen, Germany
Rob Sheldon, Accent Marketing and Research, UK
Geoff Smith, Centro, UK
Gordon Stokes, Transport and Travel Research, UK
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Available from:
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Glenthorne House, Hammersmith Grove, London W6 0LG, UK

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A TRIO MANAGEMENT PACKAGE FOR RELIEVING TRAFFIC CONGESTION IN CAIRO: TRAFFIC, TRAVEL DEMAND AND LAND-USE MANAGEMENT

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1. INTRODUCTION

Transport mobility in urban areas is a necessity for promoting sustainable economic growth and development. Cairo, the capital of Egypt, is suffering from an acute traffic congestion problem causing delays, a reduction of safety records, substantial environmental losses in terms of pollution and energy consumption, see Khisty, 1993 for a general review of urban transport problems in developing countries and see Mitric, 1994 for a detailed review of urban transport problems in Cairo.

The traditional strategy for tackling the traffic congestion problem has been, for years, to add more capacity to the transport supply system through expansion of road network infrastructure by widening existing roads and constructing new ones, thus allowing for better traffic conditions. However, this approach has its limitations, in terms of absorbing an enormous amount of scarce financial and land resources, causing environmental intrusion, and generally increasing the environmental and safety hazards. Above all, this approach has frequently been reported to ultimately cause the generation of new and suppressed traffic. In many countries, where resources are becoming limited, the tendency has been to adopt policies and measures that enable the utilization of road space in the most efficient manner. Such strategy is known as Traffic Management and Control (TM&C). Both strategies can be grouped under the heading supply-based strategies.

In recent years, a significant change in thinking had emerged. This advocates demand-based strategies whereby policies and measures that affect the pattern of the demand for people to travel are selected and implemented. Such measures can be grouped under Travel (Traffic) Demand Management (TDM) and Land Use Management (LUM) strategies. The overall aim of this research is to provide a means of understanding TDM in a comprehensive manner and assist in decisions on whether to use and implement (i.e. assess potentiality of) TDM in relieving traffic congestion in Cairo.

2. OBJECTIVES

The main objectives of this research can be stated as follows:

1. To review and compare the main strategies adopted for relieving traffic congestion and in particular to review and categorise the various TDM policies and measures.
2. To recognize the work trip characteristics, patterns of parking of car users in Cairo and determinants affecting their mode choice to use the private car.
3. To expose car users to three main potential TDM alternatives namely, the introduction of: a new premium bus transit service, an organised carpooling service, and the possibility of teleworking, with the intention of identifying car users' acceptability of these measures and their perception towards possible modal shift and use of these services.

4. To assess the potentiality, in terms of acceptability, applicability and effectiveness, of a set of TDM, LUM and TM&C related measures that are meant to relieve the traffic congestion problem in Cairo.
5. To identify whether differences in socio-economic and work trip characteristics of car users would have a significant effect on their perceptual judgment towards the potentiality of TDM, LUM and TM&C related measures in relieving the traffic congestion problem in Cairo.
6. To suggest an integrated package of supply and demand based strategies, policies and measures that are meant to relieve traffic congestion in Cairo.

While, the first objective is discussed in the following section, the second to the fifth objective were mainly achieved through the statistical analyses of responses to a questionnaire survey conducted with a sample of car users in Cairo. The last objective was mainly based on the literature review, the results of the analysis of the questionnaire and the experiences of the authors.

3. STRATEGIES FOR RELIEVING TRAFFIC CONGESTION

Countries all over the world have been, for years, aspiring for economic growth. Recently, the term sustainability has been added to this goal to become sustainable economic growth. Sustainability reflects a concern for reducing resource and material consumption to ensure the ability of future generations to sustain themselves. As shown in Figure 1, the demand for travel is a derived demand resulting from societies' pursue towards sustainable economic growth as well as from the patterns of land use and urban development. In order to meet the demand for travel, transport infrastructure is constructed and transport facilities are provided. However, it is always the case in most urban areas and specially in developing countries that the transport supply system (mainly the road network) becomes inadequate in meeting current demands for travel. When this supply/demand imbalance occurs, the problem of traffic congestion arises. This problem is accompanied by other inter-related negative impacts, namely delays causing an increase in travel costs, traffic accidents, environmental pollution and energy consumption. All of these would have their negative feedback effects on the pursue for sustainable economic growth, see Figure 1.

The traditional strategy for tackling the traffic congestion problem has been, for years, to add more capacity to the transport supply system through expansion of road network infrastructure by widening existing roads and constructing new ones, thus allowing for better traffic conditions. This is known as Transportation System Management (TSM). However, this approach has its limitations, in terms of absorbing an enormous amount of scarce financial and land resources, causing environmental intrusion, and generally increasing the environmental and safety hazards. Above all, this approach has frequently been reported to ultimately cause the generation of new and suppressed traffic. In many countries, where resources are becoming limited, the tendency has been to adopt policies and measures that enable the utilization of road space in the most efficient manner. Such strategy is known as TM&C. Both strategies can be grouped under the heading supply-based strategies, see Figure 1. In recent years, a significant change in thinking had emerged. This advocates demand-based strategies whereby policies and measures that affect the pattern of the demand for people to travel are selected and implemented. Such measures can be grouped under TDM and LUM strategies, see Figure 1.

The primary purpose of TDM is to reduce the impact of travel on the road and transport system by improving the efficiency of demand for travel. This can be done by applying measures that are meant to modify car users' behaviour towards reducing the amount and need for car travel, increasing car usage efficiency and reducing the number of cars using the road system at any given point in time. These are accompanied by other measures that are meant to maximise travellers' moving capability of using the transportation system by providing a wide variety of mobility options. Indeed, it has been stated in one of the relatively recent World Bank reports, see Urban Transport in Asia 1991, that one of the World Bank advocated strategies is to lend on the basis of both TDM and environmental

management. For comprehensive guidelines and reference manuals on TDM, see Comsis and ITE, 1993, OECD, 1994 and AUSTROADS, 1995.

As regards LUM, its primary purpose is to control the trip generating characteristics of land use and to promote land use patterns that support TDM. A detailed study that looked at activities designed so that the most interesting land use and urban design variables could be tested to determine their influence on travel behavior was reported in Cambridge Systematics, 1994 .

The literature includes several classifications of congestion management strategies, policies and measures, see OECD, 1994 for a representation of the European classification, see AUSTROADS, 1991 for a representation of the Australian classification and see Comsis and ITE, 1994 as a representation of the American classification. Based on these and other sources, this research presents in Figure 2 a comprehensive hybrid categorisation of congestion management strategies, policies and measures.

The next sections present the details of an analysis of a questionnaire survey conducted with a sample of car users in Cairo with the intention of assessing the potentiality of TDM and other related measures in relieving traffic congestion in Cairo.

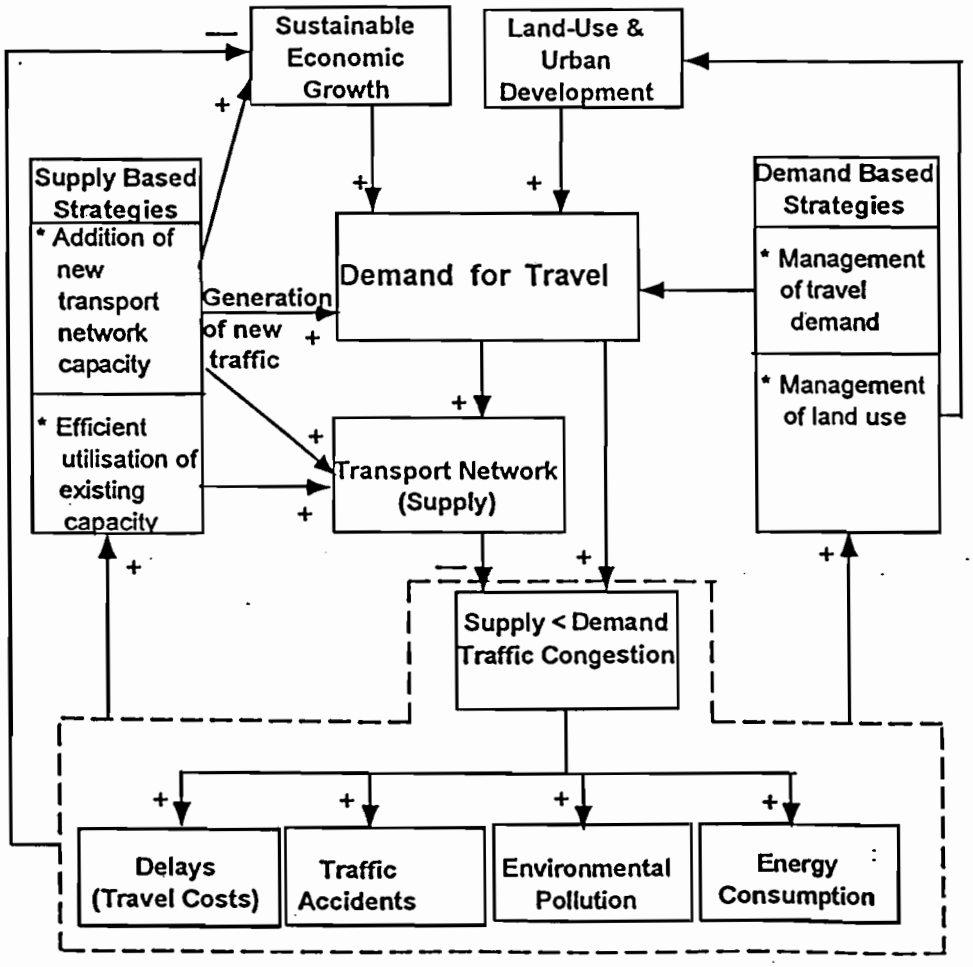


Figure 1: Main approaches for relieving traffic congestion

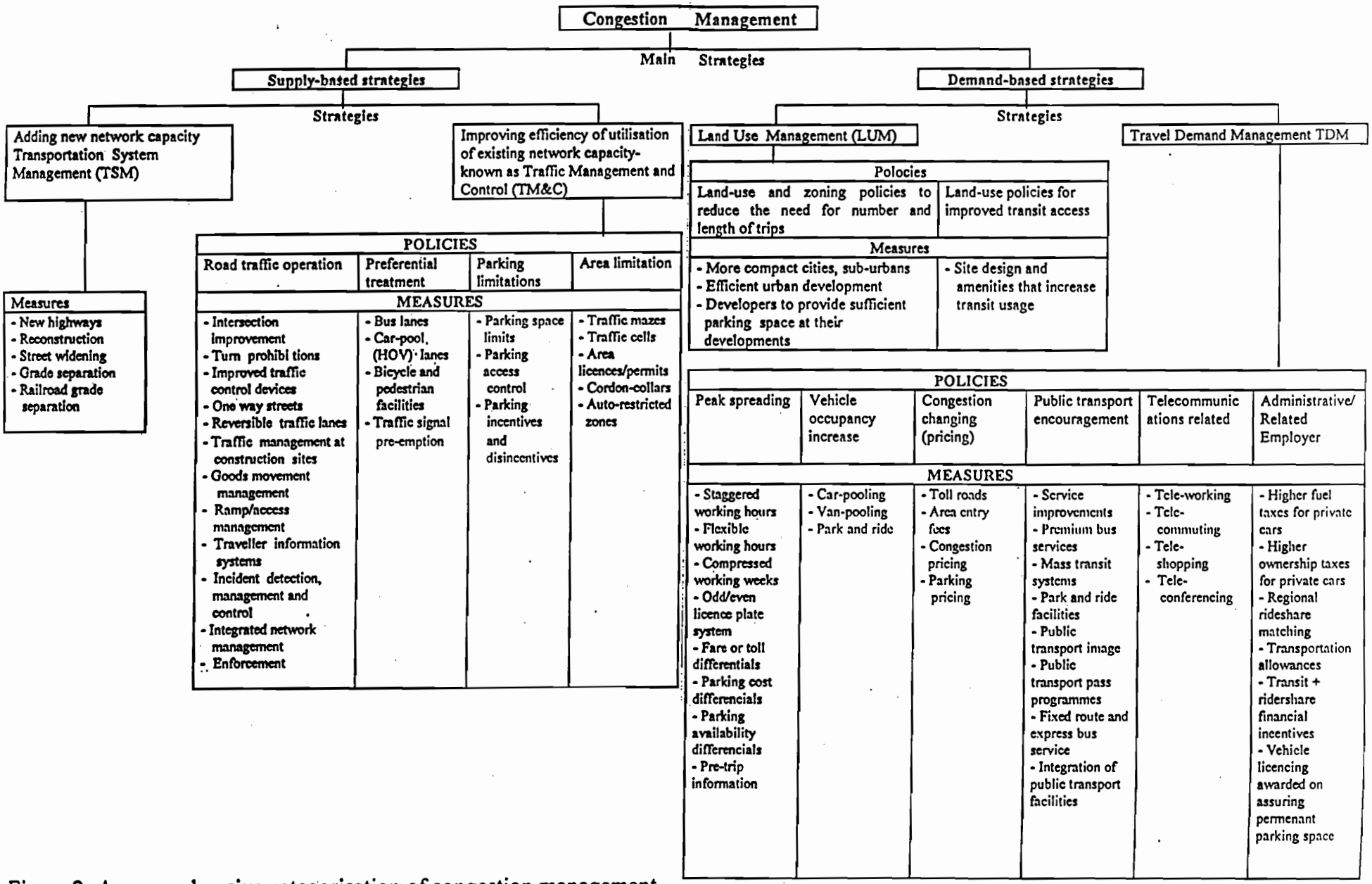


Figure 2: A comprehensive categorisation of congestion management strategies, policies and measures

4. SURVEY DETAILS AND SAMPLE REPRESENTATION

A questionnaire survey was conducted with a sample of car users in Cairo. The questionnaire comprises attitudinal ranking and choice type questions. Before designing the questionnaire, thorough discussions, and examination of relevant literature were carried out. These helped in identifying the different factors related to the potentiality of TDM measures in relieving traffic congestion that ought to be investigated and hence included in the questionnaire form. The questionnaire was piloted several times and the insight gained from meetings with car users, and interviews with transport experts helped in refining the questionnaire to its present form.

To capture a random sample of car users, the researchers were first oriented towards conducting household surveys (trip origin based surveys) as well as parking surveys (destination based). These two types of surveys are commonly used in TDM studies conducted elsewhere. However, logistical, resources and permission difficulties were envisaged in conducting household surveys.

Car owners are considered to be affluent groups of the society. Most car users are members in social-sporting clubs located in different affluent districts in Cairo. A common activity for car users is to visit these clubs specially at weekends. Therefore, it was decided to conduct most of the surveys with randomly selected members of clubs at the weekends. Three clubs were selected, namely Heliopolis and El-Shams clubs in Heliopolis, a district in the east of Cairo and El-Maadi club at El-Maadi, a district in the west of Cairo. The surveyors were instructed to ensure that at least two conditions are satisfied in respondents, namely a working adult having access to a private car and driving to work at least once a week. If several members of a family were present, the questionnaire was handed to only one member. In addition some questionnaires were distributed to car users at their work destination. Table 1 shows that a total of 731 valid questionnaire forms were obtained (i.e. a response rate of 70%). The response rate to the questionnaire survey was considered acceptable.

Table 1: Details of survey response rate

Number of questionnaire forms distributed	Number of questionnaires collected / returned	Number of valid responses	Response rate = No. of valid responses / No. of questionnaires distributed
1050	793	731	70 %

5. SOCIO-ECONOMIC CHARACTERISTICS

Socio-economic statistics of the sample of respondents is displayed in Table 2. The table shows that the respondents live mainly in Heliopolis, which is considered to be the most affluent district in Cairo with the highest car ownership. As shown, a typical family size of an affluent family in Egypt is 4 with an average monthly income of over 2000 Egyptian pounds (L.E.) ($ 1 = 3.4 L.E.). A typical rate of car ownership is 1 car per family with 2 members of the family having access to the car. The table shows the dominance of male respondents (91%) which can be taken to reflect that the majority of private car users in Cairo are males. Respondents represent several professions with the engineering profession being dominant. A typical work type is companies. Most of the work trip destinations are located in the districts of Giza (i.e. Mohendseen, Dokki, ..etc). The average age of the respondents was 45 years.

The questionnaire responses were analyzed to investigate, understand and statistically infer the work trip characteristics, patterns of parking, determinants affecting mode choice of private car, perception of car users towards potentiality, in terms of acceptability, applicability and effectiveness, of the main TDM, LUM and TM&C related measures in relieving traffic congestion in Cairo.

Table 2 Socio-demographic characteristics of questionnaire respondents

									Missing	Mode
House hold origin		Heliopolis	Maaady	Nasr City	Helwan	Others				Heliopolis
	%	45	28	15	4	8				45
Family size		1	2	3	4	5	6	> 6		4
(No. of family members)	%	2.5	10.5	19	43	16	7	2		43
Car ownership		1	2	3	>= 4					1
(No. of cars /family)	%	46	44	8	2					46
No. of car users / family		1	2	3	4	> 4				2
	%	24	50	12	6	1			7	50
Family income category		< 500	500-1000	1000-1500	1500-2000	> 2000				> 2000
	%	3	15	20	18	33			11	33
Gender		Males	Females							Males
	%	91	9							91
Profession		Engineers	Accountants	General managers	Teachers	Medical doctors	Business men	Others		Engineers
	%	19	15	12	10	7	6	11	20	19
Type of work		Companies	Universities	Hospitals	Ministries	Clubs	Schools	Others		Companies
	%	6	6	5	3	1	1	3	75	6
Work trip destination		Giza	Heliopolis	CBD	Nasr City	Maaady	Helwan	Others		Giza
	%	17	14	12	11	6	6	13	21	17

Valid responses = 731

6. WORK TRIP CHARACTERISTICS

In most urban areas, work trips constitute almost 50% or more of total trips. The questionnaire was only concerned with investigating the potentiality of introducing TDM, LUM and TM&C measures to relieve traffic congestion through the efficient management of the demand for making work trips by private cars. Work trip characteristics of respondents are displayed in Table 3. The table shows that the average time for a work trip in Cairo using a private car is 32 minutes. Almost 43% of the respondents work 6 days/week. However, a significant number of respondents (35%) work 5 days/week which is typical of private sector and banking. Most of respondents' weekly commuting to work is undertaken by private cars, where 35% have stated that they use their cars 6 times/week and 31% have stated that they use their cars 5 days/week. This demonstrates that almost 12% [(43+35)-(35+31)] of respondents have a tendency to leave their private cars and use another mode of transport, including car sharing, for at least one working day/week. This conclusion can be verified by looking at stated car occupancies which despite dominated by single occupancy vehicles (21%), yet 16.3% stated that their average car occupancy is 2 passengers, and 16% stated that their average car occupancy is 3 passengers. The majority of respondents (70%) stated that using a car is not essential for performing their work.

Table 3 Work trip characteristics of questionnaire respondents

Average work trip time (min.)	Working days / week Days (%)	Mode	Work trips by car /week Days (%)	Mode	Car occupancy (including driver) Passengers(%)	Mode	Car essential for work (%)	Mode
	1 (0.1)		1 (2.7)		1 (21.0)	1	Yes (15.1)	
	2 (1.1)		2 (4.4)		2 (16.3)		No (69.6)	No
	3 (3.1)		3 (6.0)		3 (16.0)			
32	4 (4.0)		4 (5.3)		4 (6.8)			
	5 (35.0)		5 (30.9)		5 (2.3)			
	6 (43.4)	6	6 (34.7)	6	> 5 (1.1)			
Missing	(9.2)		(12.9)		(36.5)		(15.3)	

7. PATTERNS OF PARKING

In an attempt to show the effect of parking patterns on road space utilization, Figures 3 and 4 display the percentage distribution of types of parking used by car owners at residential areas and work destinations. The figures demonstrate that 65% and 52% of respondents use on-street parking respectively at residential locations and work destinations. On-street parking usually takes place on both sides of the road. This leads to a reduction of the number of lanes for moving vehicles. This might be relatively acceptable in residential areas where traffic intensity and speeds are low, and parking is a necessity. However, most of the work sites are located on district or primary distributors meant to allow the through traffic movement and where on street parking should be banned or severely limited. Garage and off-street parking ought to be the option for work site parking. As shown from Figure 4, 45% of respondents use garage parking for their work trips. This should be further encouraged.

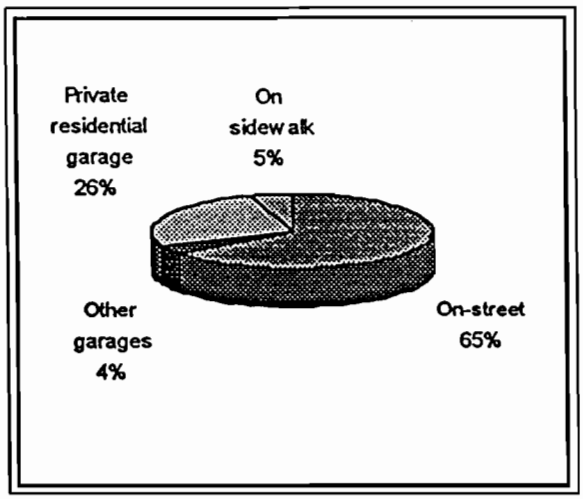


Figure 3: Parking patterns at residential areas in Cairo

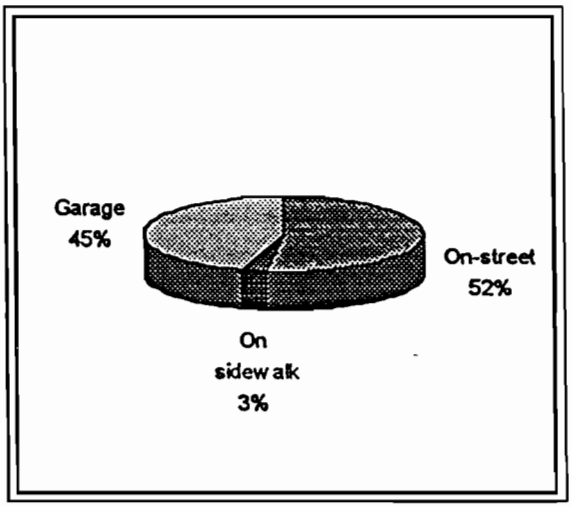


Figure 4: Parking patterns at work destinations in Cairo

8. DETERMINANTS AFFECTING CHOICE OF PRIVATE CAR FOR WORK TRIPS

The average weighted ranking of determinants thought to influence the choice of private car as an attractive mode for work trips is displayed in Figure 5. The figure shows that **"saving of time"** is considered by most respondents as the most important factor affecting their preference to use a private car as the mode for commuting to work. This is followed, in order, by:

- Comfort
- Door to door (home to work) mode of transport
- Feeling of privacy
- Security
- Social status
- Safety

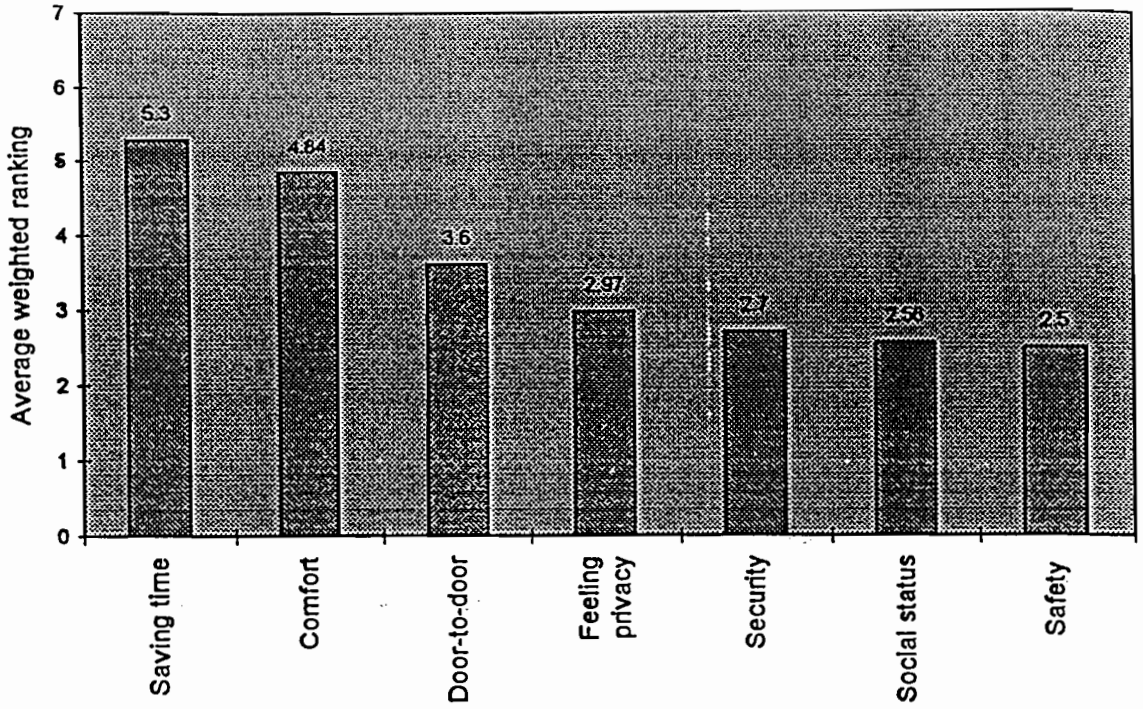


Figure 5: Average weighted ranking of determinants affecting choice of private car for work trips

9. PREMIUM BUS TRANSIT SERVICE: A PROPOSED TDM MEASURE

One of the well known TDM alternatives is to improve the level of service of public transit so as to attract car users to leave their cars and use these premium services. In an attempt to explore the perception of car users towards the importance of characteristics that might be present in a proposed premium bus transit service, Figure 6 shows the average weighted ranking of these characteristics. **"Buses guaranteed to arrive at scheduled and advertised times" is perceived as the most important** characteristic to be provided in the newly proposed service. This is followed, in order, by:

- Buses offering direct services with no need for transfers
- A convenient seat is guaranteed
- Bus stops near home/work
- Frequent service
- Fast service
- Air conditioned buses

By comparing the determinants affecting the preference of using private cars with the proposed premium bus service characteristics, one can notice the high importance placed on reliability and time saving factors. Respondents were also asked to state their attitude as to whether the provision of such a service would encourage them to leave their cars and use these premium buses, Figure 7 shows that 65% of the respondents stated their willingness to undertake such a modal shift.

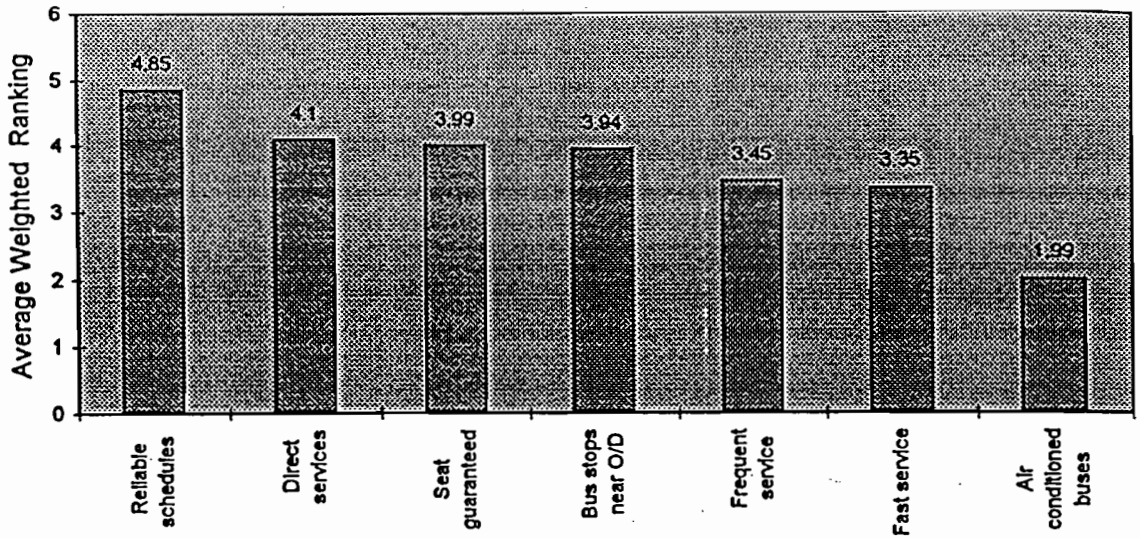


Figure 6: Average weighted ranking of characteristics of a proposed premium bus transit service

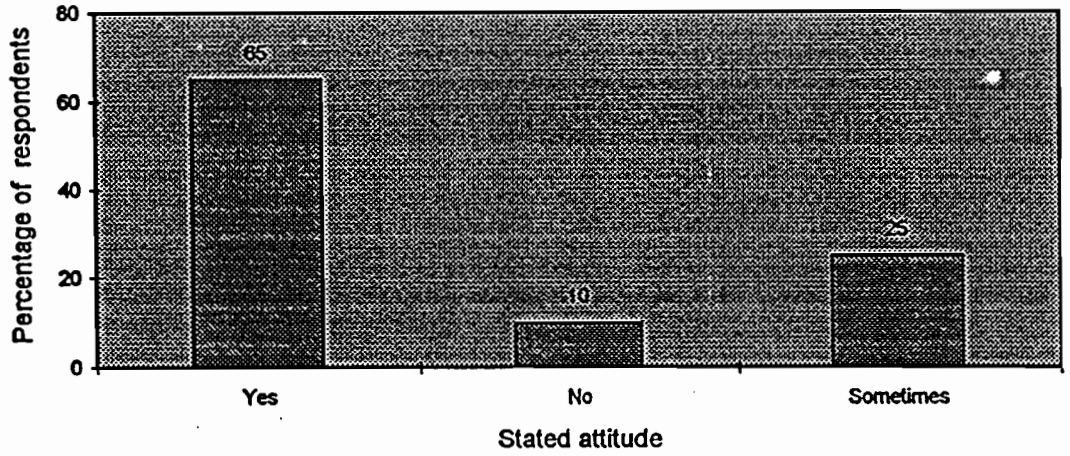


Figure 7: Attitude towards potential future usage of premium bus transit service

10. ORGANISED CARPOOLING: ANOTHER PROPOSED TDM MEASURE

Another well known TDM alternative is to increase the average occupancy of private cars through ride sharing (referred to as carpooling). Carpooling relies heavily on the desirability of private car owners to participate in such a system. It should be well organised to attract car owners into participation. In an attempt to explore the perception of car users towards the importance of factors that might discourage them from using a carpooling system, Figure 8 displays in order of magnitude, the average weighted ranking of these factors where **"fear of sometimes being delayed"** is perceived as the main possible disadvantage in such a system. This is followed, in order, by:

- Feeling that some privacy is lost
- Fear of sharing with unsafe drivers
- Feeling insecure of riding with people you do not know
- Do not like to share with smokers
- Do not like to share with talkative people
- Do not like to share with opposite gender

By comparing the determinants affecting the preference of using private cars with the factors that might discourage car owners to participate in a carpooling system, one can again notice the high importance placed on the time factor.

Respondents were asked to state their attitude as to whether the organization of such a ride share system, in a manner that avoids all the previously stated discouragement factors, would inevitably encourage them to leave their cars and carpool, Figure 9 shows that 49% of the respondents stated their willingness to use such a service. However, as shown in Figure 10, 52% of the respondents stated their unwillingness to participate with their own cars in such a system. The majority of the respondents (41%) thought that a private agency would be the best form for organising such service, see Figure 11.

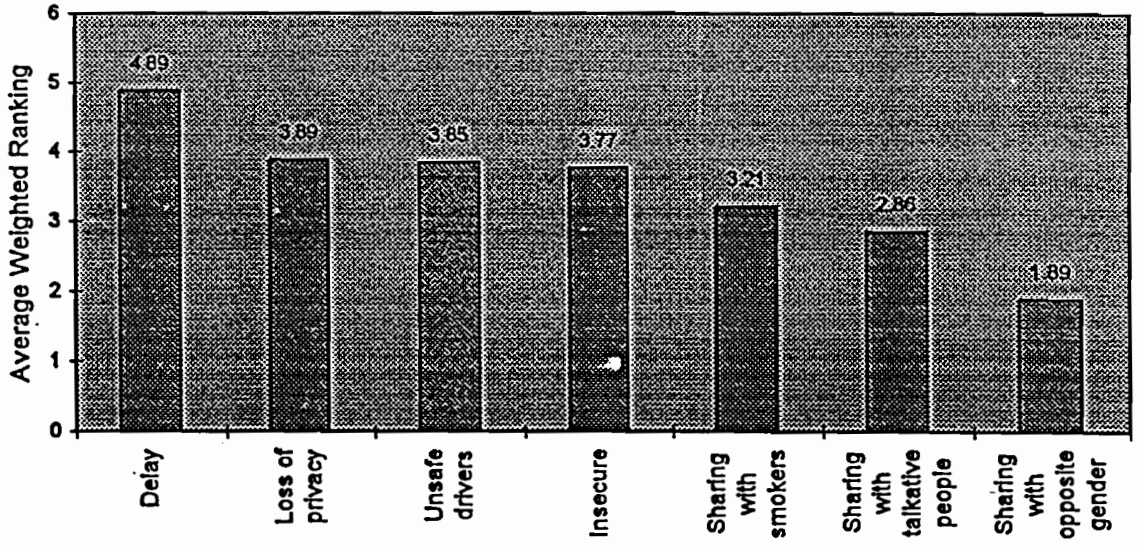


Figure 8: Average weighted ranking of factors discouraging participation in carpooling

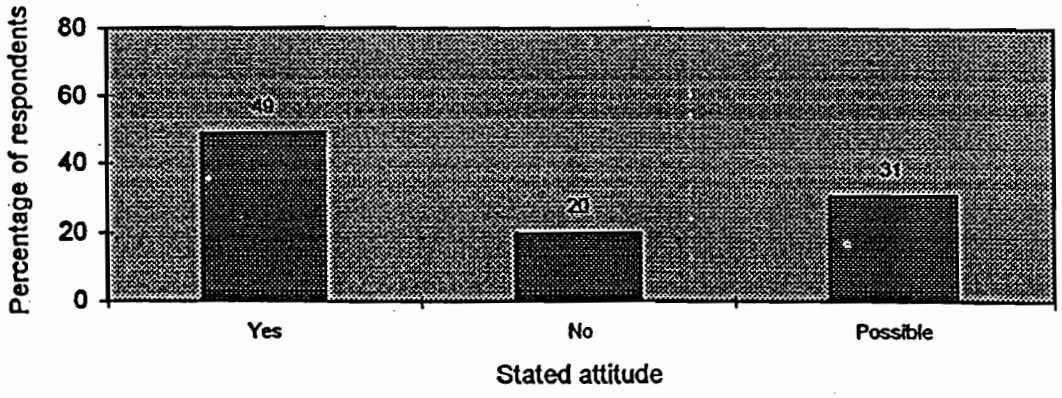


Figure 9: Attitude towards potential future usage of a well organised carpooling system

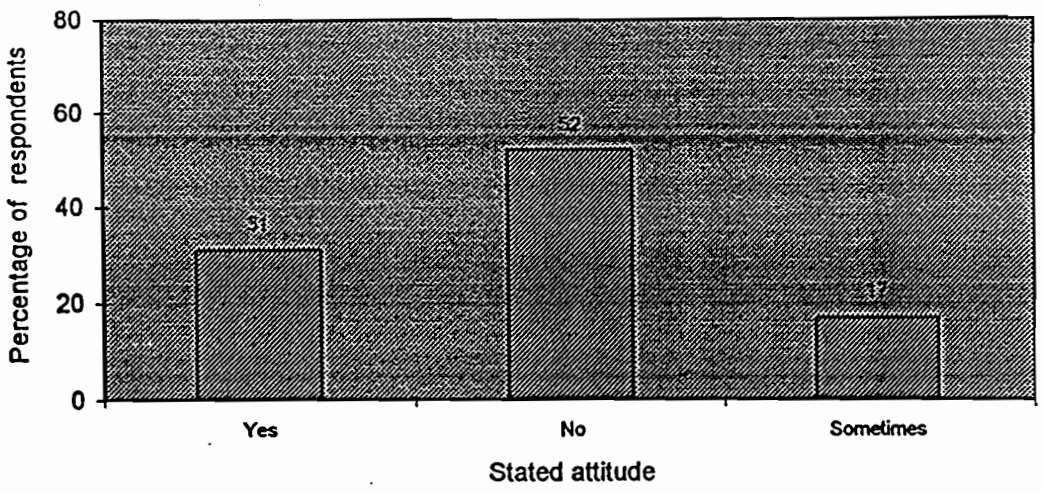


Figure 10: Attitude towards potential future participation (using own car) in a well organised carpooling

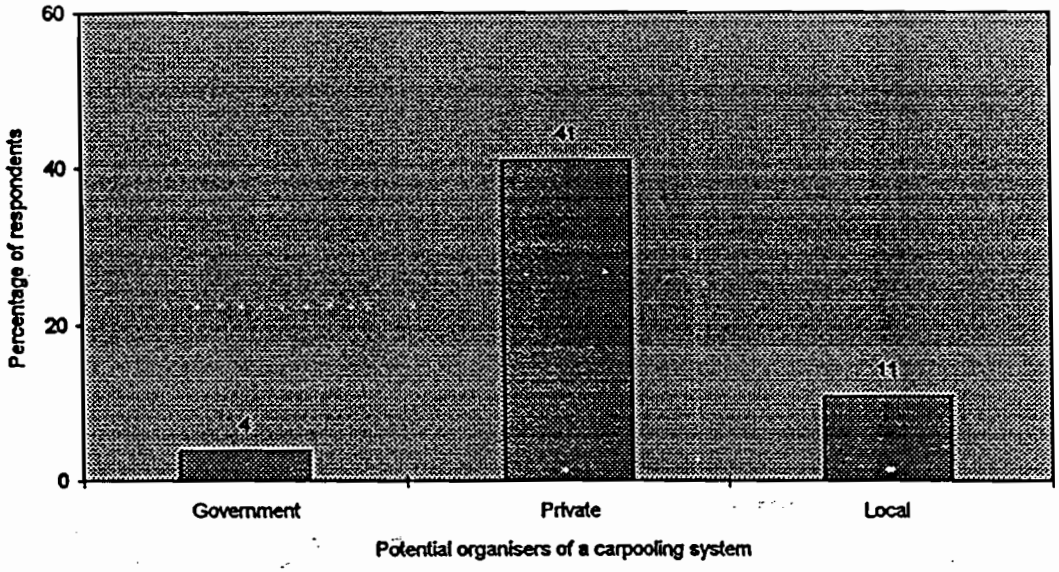


Figure 11: Potential organisers of a carpooling system (* Note : 44% are missing cases)

11. WORK AT HOME ALTERNATIVE (TELEWORKING)

In order to reduce the number of work trips, it could be proposed to carry out some of the work duties at home for a few days or more per week instead of doing all job tasks at the work place. This is one of the promising forms of TDM, known as 'teleworking'. Teleworking involves working for part of the time away from the usual work base. Teleworking could have a significant effect on travel behaviour not only for individuals involved in teleworking but also for their families. The effect on travel behaviour could include variations in the amount of travel, the modes used and the time of travel. Teleworking reduces the amount of car travel related to work trips, especially during congested periods. A recent

study that looked at the impact of telecommunications (including teleworking and telecommuting) on travel demand towards the next decade was reported in Risse et al., 1994.

Respondents were asked as to whether the nature of their jobs can allow them to carry out some of the work duties at home, Figure 12 shows that only 38% of respondents have indicated that some of their work duties can be performed at home. Of these respondents, 74% have indicated their willingness to be allowed to stay at home for some days during the week to perform such duties, see Figure 13.

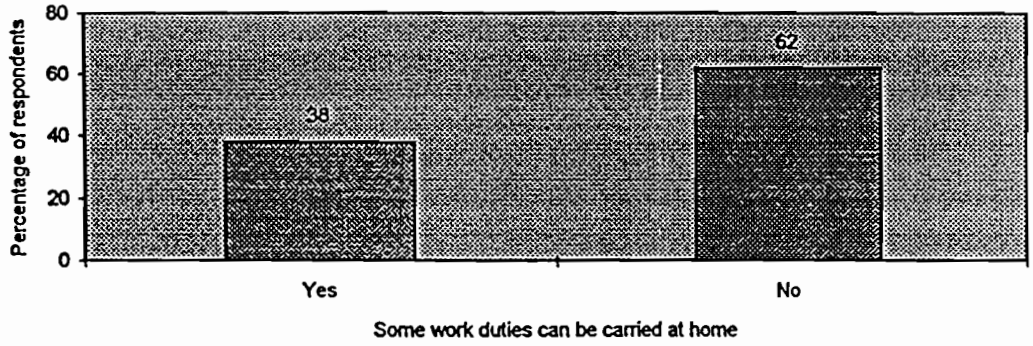
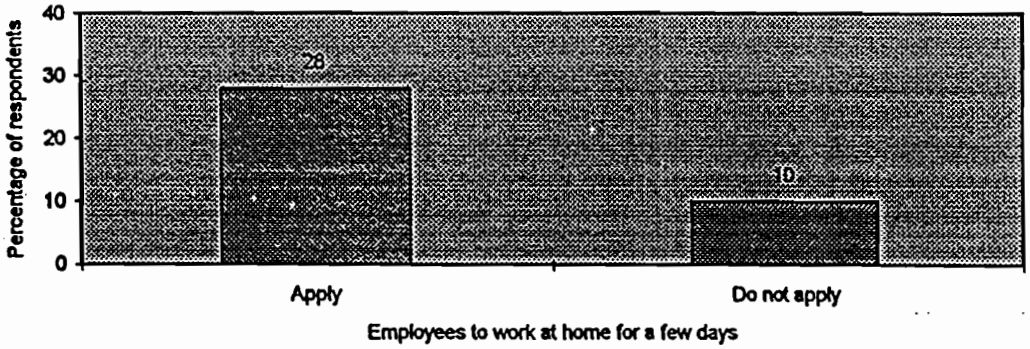


Figure 12: Potentiality of some work duties to be carried at home



* Note : Percentages are a split of respondents answering " yes " in previous figure

Figure 13: Acceptability of teleworking

12. APPLICABILITY AND EFFECTIVENESS OF SOME TDM, LUM & TM&C RELATED MEASURES IN RELIEVING TRAFFIC CONGESTION

Based on literature survey and authors' experience, a group of 6 TDM measures, 1 LUM measure and 2 TM&C related measures were selected as potentials for relieving traffic congestion in Cairo. These were listed in the questionnaire form and respondents were asked to indicate the applicability and extent of effectiveness of each of these measures in terms of relieving traffic congestion in Cairo. Table 4 shows the percentage of respondents indicating the applicability of the various measures. It is assumed that a respondent indicating the applicability of a measure, is in fact implicitly indicating his/her acceptability for the implementation of such a measure. As can be shown from the table, that staggered working hours is considered by most respondents (66%) to be highly applicable and by (26%) of these respondents to be fully effective. On the other hand, vehicle licensing to be granted on assuring permanent parking space was considered by most respondents (57%) to be inapplicable.

As for the proposed LUM related measure, the table demonstrates that the majority of respondents (68%) have indicated the applicability of developers having to provide parking space in their developments and 40% of these respondents indicated that such a measure could be fully effective in relieving traffic congestion.

As for the two TM&C measures, most respondents (60%) have also indicated that strict enforcement of illegal parking as well as the provision of parking incentives for High Occupancy Vehicles (HOV) and disincentives for Single Occupancy Vehicles (SOV) are highly applicable measures and (25%) of these respondents have pinpointed to the full effectiveness of such measures. This emphasises the results obtained regarding the potential congestion problems arising from on-street parking and hence the absorption of road space, causing a reduction in through traffic flow and leading to traffic congestion. On the other hand, the designation of exclusive separate lanes for HOV was perceived by 47% of respondents to be inapplicable.

Table 4: Applicability and effectiveness of Travel Demand Management, Land Use Management and Traffic Management & Control measures to relieve traffic congestion in Cairo

Type of suggested measures	Suggested measure	Applicability		Effectiveness		
		Not applicable (%)	Applicable (%)	Limited	Medium	Fully effective
TDM measures	Staggered working hours	19	66	18	22	26
	Odd-Even licence plate number system	51	34	11	11	12
	Vehicle licencing granted on assuring permenant parking space	57	28	12	8	8
	Enterance to CBD tolled	42	43	17	15	11
	Restriction on importing private cars	40	45	25	12	8
	No petrol subsidy for private cars	45	40	27	7	6
LUM measure	Developer to ensure provision of parking space in their developments	17	68	12	16	40
TM & C measures	Strict enforcement of illegal parking , parking incentives for HOV and disincentives for SOV	25	60	19	16	25
	Separate lanes execlusively for HOV	47	38	16	12	10

* Note : 15 % of respondents are inissing cases

13. CAR USERS PERCEPTUAL JUDGMENT ON TDM MEASURES AND ATTRIBUTES: IS THERE A DIFFERENCE

The questionnaire used in this research was designed to obtain the responses mainly in a categorical and ordinal form. According to Siegel and Castellan, 1988 'sample values almost invariably differ somewhat, and the question is, whether the differences among the samples signify genuine population differences, or whether they represent merely chance variations such as are expected among several random samples drawn from the same population. Nonparametric statistical tests can indicate whether differences in group samples are evident enough to lead to the conclusion that the circumstantial conditions of, or that the processes applied to, each of these groups are different. These tests are also well suited for analysing nominal and ordinal data.

13.1 Testing Hypothesis of No Difference in Responses Among Groups of Socio-Economic and Trip Making Characteristics

The aim of the analysis, presented in this sub-section, is to attempt to infer, statistically, whether there is any significant difference in the patterns of car users perceptual judgment regarding TDM measures and attributes as a result of variation in five socio-economic and three work trip characteristics.

The five selected socio-economic characteristics and their group divisions are as follows:

- Gender (male versus female)
- Family size (a family of 1 member versus 2 versus 3 versus 4 versus 5 versus 6 members)
- Family income category (<500 L.E., 500-1000, 1000-1500, 1500-2000, >2000 L.E.)
- Car ownership (1 car versus 2 versus 3 versus 4 cars)
- Car users per family (1 user versus 2 versus 3 versus 4 users)

On the other hand, the three selected work trip related characteristics and their group divisions are as follows:

- Car occupancy for work trips including driver (1 passenger versus 2 versus 3 versus 4 versus 5 passengers)
- Working days per week (1 day versus 2 versus 3 versus 4 versus 5 versus 6 days)
- Work days per week when car is used (1 day versus 2 versus 3 versus 4 versus 5 versus 6 days)

This comparison is meant to test whether, as a result of variability in these five socio-economic and three work trip related characteristics, there will be a difference in the way car users perceive determinants affecting their choice of private cars for commuting to work and the applicability and effectiveness of the different TDM measures.

Where the variability in a sampling parameter is only limited to two independent Groups (i.e. G = 2) as in gender (male versus female) the Wilcoxon-Mann-Whitney (M-W) test is appropriate. On the other hand, the Kruskal-Wallis one-way analysis of variance (K-W test) is considered to be the most appropriate test to establish whether there is a significant difference among G independent sample groups, (i.e. where G > 2), or whether they have been drawn from the same population. These tests allow the flexibility of the various samples to be random samples obtained from different populations, and where it is also acceptable to have these samples of different sizes.

The rejection/confidence level, i.e., the level of significance for each of these tests, is set at $\alpha = 0.05$, where the null hypothesis (H_0) suggests that there is no significant difference in the responses among the control groups (G) and that the samples are drawn from populations having the same distribution. On the other hand, the alternative hypothesis (H_1) assumes the converse; there is a significant difference in the responses among the control groups (G) and that the samples are drawn from populations stochastically different, i.e., having different statistical distributions explaining them. The null hypothesis is rejected if the M-W or the K-W tests produce values with a probability of occurrence, under the null hypothesis, equal to or less than α (the probability of rejection).

Results of applying these tests to some of the questionnaire parameters are displayed in Table 5. The table shows for each of the parameters tested using the M-W or the K-W test, the probability of occurrence, and whether the null hypothesis is rejected or not rejected and consequently whether there is a significant or non-significant difference.

13.2 Testing Hypothesis of No Agreement Among Respondents

A statistical measure of agreement and its significance were computed to test the judgmental consensus among all respondents to the questionnaire ranking questions.. Measures of agreement are, specifically, useful in obtaining an understanding and appreciation of inter-judgment reliability.

When the responses are at least of the ordinal level of information, the Kendall coefficient of concordance W test is useful in determining the agreement among several respondents. The W coefficient is a measure of the relation among several rankings given by the respondents. The W coefficient represents an index of the degree of difference between the actual agreement shown in the data, and the total perfect agreement. Values of the W coefficient range between zero and one.

The null hypothesis (H_0) suggests that the N sets of responses are independent, i.e., the respondents' rankings are unrelated to each other. N here is equal to the total number of valid responses. On the other hand, the alternative hypothesis (H_1) assumes the converse; that the N sets of responses are dependent, i.e., the respondents' rankings are related to each other. The rejection/confidence level, i.e. the level of significance for this measure of agreement test, is set at $\alpha = 0.05$.

If the null hypothesis is rejected, it is statistically inferred that the agreement among the N rankers is higher than it would be due to mere random chance. A high or a significant value of W could be understood as meaning that the respondents are applying the same criteria in ranking the questionnaire parameters. However, it should be clearly stated that a high or a significant value of W does not essentially mean that the observed rankings are the correct, impartial ones. Table 6 shows the value of W for each of the questions that were tested by the Kendall coefficient of concordance test, as well as whether the null hypothesis is rejected or not rejected.

13.3 Main Results of the Non Parametric Statistical Analysis of Questionnaire Responses

The main conclusions that can be inferred from the non parametric statistical analysis of the questionnaire responses can be summarised as follows:

1. The results of significance testing of the hypothesis of no difference in responses among the sample groups of respondents, displayed in Table 5, indicate that for most of the tested questionnaire components there is no significant, statistical difference in the responses among the various independent sample groups branching from the five selected socio-economic characteristics, namely gender, family size, family income category, car ownership, and car users per family.

2. The results of significance testing of the hypothesis of no difference in responses among the sample groups of respondents, displayed in Table 5, indicate that for most of the tested questionnaire components there is no significant, statistical difference in the responses among the various independent sample groups branching from the three selected work trip related characteristics, namely car occupancy for work trips, working days per week, and work days per week when car is used.

3. As a consequence of 1 and 2, it might be valid to draw conclusions pertaining to the potentiality (acceptability, applicability and effectiveness) of TDM measures in relieving traffic congestion in Cairo from the combined responses of these groups.

4. However, it is fair to state that some questionnaire components when tested showed that there exists a statistical difference in the way these were perceived by respondents belonging to the various independent sample groups. These are mainly displayed in Table 5.

5. The results of significance testing of the hypothesis of no agreement among car users in their ranking of: determinants affecting their choice of private car for work trips; characteristics of a proposed premium bus transit service; and factors discouraging participation in a carpooling system and displayed in Table 6, show that it is statistically plausible to reject the hypothesis of no consensus, regarding the rankings and that the respondents' ranking could be in agreement and hence could be related.

Table 5: Mann-Whitney and Kruskal-Wallis statistics to test differences in perceptual judgement of car users resulting from variability in socio-economic and work trip characteristics

Comparison parameters Question' components	Gender Male/female	Family size 1 to 6	Family income category 5 categories	Car ownership 1 to 4	Car users / family 1 to 4	Car occupancy 1 to 5	Working days / week 1 to 6	Work trip by car / week 1 to 6
Determinants affecting choice of private car for work trips Safety	0.103 (NR, NS)	0.2 (NR, NS)	0.868 (NR, NS)	0.895 (NR, NS)	0.007 (R, S)	0.664 (NR, NS)	0.072 (NR, NS)	0.121 (NR, NS)
Social status	0.014 (R, S)	0.007 (R, S)	0.216 (NR, NS)	0.258 (NR, NS)	0.369 (NR, NS)	0.534 (NR, NS)	0.026 (R, S)	0.155 (NR, NS)
Comfort	0.916 (NR, NS)	0.818 (NR, NS)	0.552 (NR, NS)	0.056 (NR, NS)	0.206 (NR, NS)	0.527 (NR, NS)	0.056 (NR, NS)	0.409 (NR, NS)
Saving of time	0.132 (NR, NS)	0.064 (NR, NS)	0.072 (NR, NS)	0.265 (NR, NS)	0.041 (R, S)	0.586 (NR, NS)	0.250 (NR, NS)	0.339 (NR, NS)
Feeling of privacy	0.901 (NR, NS)	0.156 (NR, NS)	0.749 (NR, NS)	0.741 (NR, NS)	0.112 (NR, NS)	0.002 (R, S)	0.003 (R, S)	0.000 (R, S)
Security	0.745 (NR, NS)	0.459 (NR, NS)	0.122 (NR, NS)	0.475 (NR, NS)	0.556 (NR, NS)	0.168 (NR, NS)	0.033 (R, S)	0.120 (NR, NS)
Door-to-door	0.435 (NR, NS)	0.021 (R, S)	0.226 (NR, NS)	0.563 (NR, NS)	0.227 (NR, NS)	0.267 (NR, NS)	0.085 (NR, NS)	0.36 (NR, NS)
Characteristics of a proposed premium bus service Bus stops near O/D	0.041 (R, S)	0.11 (NR, NS)	0.743 (NR, NS)	0.021 (R, S)	0.068 (NR, NS)	0.987 (NR, NS)	0.0502 (NR, NS)	0.045 (R, S)
Frequent service	0.663 (NR, NS)	0.917 (NR, NS)	0.123 (NR, NS)	0.232 (NR, NS)	0.943 (NR, NS)	0.902 (NR, NS)	0.304 (NR, NS)	0.468 (NR, NS)
Reliable schedules	0.194 (NR, NS)	0.838 (NR, NS)	0.539 (NR, NS)	0.698 (NR, NS)	0.415 (NR, NS)	0.610 (NR, NS)	0.282 (NR, NS)	0.821 (NR, NS)
Seat guaranteed	0.017 (R, S)	0.421 (NR, NS)	0.812 (NR, NS)	0.032 (R, S)	0.01 (R, S)	0.646 (NR, NS)	0.010 (R, S)	0.013 (R, S)
Air conditioned bus	0.003 (R, S)	0.005 (R, S)	0.362 (NR, NS)	0.046 (R, S)	0.002 (R, S)	0.720 (NR, NS)	0.535 (NR, NS)	0.370 (NR, NS)
Fast service	0.253 (NR, NS)	0.007 (R, S)	0.138 (NR, NS)	0.579 (NR, NS)	0.060 (NR, NS)	0.456 (NR, NS)	0.078 (NR, NS)	0.185 (NR, NS)
Direct service	0.851 (NR, NS)	0.762 (NR, NS)	0.489 (NR, NS)	0.861 (NR, NS)	0.385 (NR, NS)	0.663 (NR, NS)	0.644 (NR, NS)	0.856 (NR, NS)
Potential future usage of proposed premium bus service	0.959 (NR, NS)	0.268 (NR, NS)	0.001 (R, S)	0.119 (NR, NS)	0.235 (NR, NS)	0.660 (NR, NS)	0.180 (NR, NS)	0.104 (NR, NS)
Factors discouraging participation in car-pooling Loss of privacy	0.139 (NR, NS)	0.899 (NR, NS)	0.064 (NR, NS)	0.281 (NR, NS)	0.112 (NR, NS)	0.606 (NR, NS)	0.119 (NR, NS)	0.473 (NR, NS)
Insecure	0.621 (NR, NS)	0.074 (NR, NS)	0.000 (R, S)	0.000 (R, S)	0.011 (R, S)	0.701 (NR, NS)	0.411 (NR, NS)	0.118 (NR, NS)
Sharing with smokers	0.498 (NR, NS)	0.023 (R, S)	0.956 (NR, NS)	0.670 (NR, NS)	0.002 (R, S)	0.412 (NR, NS)	0.024 (R, S)	0.025 (R, S)
Sharing with opposite gender	0.001 (R, S)	0.047 (R, S)	0.236 (NR, NS)	0.635 (NR, NS)	0.645 (NR, NS)	0.694 (NR, NS)	0.025 (R, S)	0.135 (NR, NS)
Sharing with talkative people	0.204 (NR, NS)	0.151 (NR, NS)	0.003 (R, S)	0.451 (NR, NS)	0.453 (NR, NS)	0.627 (NR, NS)	0.026 (R, S)	0.052 (R, S)
Delay	0.102 (NR, NS)	0.015 (R, S)	0.768 (NR, NS)	0.393 (NR, NS)	0.054 (NR, NS)	0.521 (NR, NS)	0.180 (NR, NS)	0.048 (R, S)
Unsafe drivers	0.364 (NR, NS)	0.095 (NR, NS)	0.013 (R, S)	0.011 (R, S)	0.000 (R, S)	0.727 (NR, NS)	0.990 (NR, NS)	0.063 (NR, NS)
Potential future usage of an organised car -pooling system	0.573 (NR, NS)	0.597 (NR, NS)	0.000 (R, S)	0.065 (NR, NS)	0.005 (R, S)	0.092 (NR, NS)	0.543 (NR, NS)	0.066 (NR, NS)
Potential future participation (using own car) in an organised car - pooling system	0.404 (NR, NS)	0.459 (NR, NS)	0.221 (NR, NS)	0.959 (NR, NS)	0.579 (NR, NS)	0.332 (NR, NS)	0.477 (NR, NS)	0.146 (NR, NS)
Applicability/ effectiveness of TDM and TM & C measures - TDM measures ..... Staggered working hours	0.957 (NR, NS)	0.637 (NR, NS)	0.762 (NR, NS)	0.116 (NR, NS)	0.284 (NR, NS)	0.355 (NR, NS)	0.739 (NR, NS)	0.040 (R, S)
Odd/even licence plate no. system	0.143 (NR, NS)	0.256 (NR, NS)	0.508 (NR, NS)	0.482 (NR, NS)	0.405 (NR, NS)	0.898 (NR, NS)	0.834 (NR, NS)	0.529 (NR, NS)
Vehicle licencing dependent on availability of parking space	0.454 (NR, NS)	0.388 (NR, NS)	0.986 (NR, NS)	0.765 (NR, NS)	0.221 (NR, NS)	0.596 (NR, NS)	0.376 (NR, NS)	0.345 (NR, NS)

R : Null hypothesis is rejected
NR : Null hypothesis is not rejected
S : Significant difference
NS : Non significant difference

Table 5: Continued

Entrance to CBD tolled	0.084 (NR, NS)	0.041 (R, S)	0.630 (NR, NS)	0.561 (NR, NS)	0.039 (R, S)	0.616 (NR, NS)	0.314 (NR, NS)	0.663 (NR, NS)
Restriction on importing private cars	0.117 (NR, NS)	0.981 (NR, NS)	0.525 (NR, NS)	0.188 (NR, NS)	0.650 (NR, NS)	0.795 (NR, NS)	0.403 (NR, NS)	0.197 (NR, NS)
No petrol subsidy for private cars	0.988 (NR, NS)	0.298 (NR, NS)	0.009 (R, S)	0.182 (NR, NS)	0.145 (NR, NS)	0.587 (NR, NS)	0.109 (NR, NS)	0.251 (NR, NS)
---- TM & C measures ------- Developers to ensure provision of enough parking space	0.307 (NR, NS)	0.964 (NR, NS)	0.004 (R, S)	0.194 (NR, NS)	0.431 (NR, NS)	0.414 (NR, NS)	0.194 (NR, NS)	0.922 (NR, NS)
Parking incentives / disincentives	0.945 (NR, NS)	0.532 (NR, NS)	0.399 (NR, NS)	0.870 (NR, NS)	0.282 (NR, NS)	0.704 (NR, NS)	0.102 (NR, NS)	0.138 (NR, NS)
Parking lanes exclusive for HOV	0.042 (R, S)	0.329 (NR, NS)	0.357 (NR, NS)	0.794 (NR, NS)	0.551 (NR, NS)	0.619 (NR, NS)	0.201 (NR, NS)	0.353 (NR, NS)

R : Null hypothesis is rejected
NR : Null hypothesis is not rejected
S : Significant difference
NS : Non significant difference

Table 6: Kendall Concordance statistics to examine consensus among respondents' ranking of ordinal questionnaire components

Agreement statistics	Kendall Concordance Test		
Ranking of	N	W	Null hypothesis
Determinants affecting choice of private car for work trip	640	0.217	Rejected
Characteristics of a proposed premium bus transit service	595	0.148	Rejected
Factors discouraging participation in carpooling system	571	0.145	Rejected

14. A PROPOSED INTEGRATED PACKAGE TO RELIEVE TRAFFIC CONGESTION IN CAIRO

Transportation systems are multi-dimensional in that they are multi-modal, multi-sectoral, multi-faceted, multi-problematic, multi-purpose, multi-operational, multi-organisational, multi-effect, multi-ownership, multi-network, multi-technological, and multi-disciplinary. In complex, large scale systems, like transport, problems are rooted in the basic structure of the system. Actions taken to deal with one problem may create difficulties else where.

In addition to the desirable outcomes of the transport system in terms of mobility and accessibility, traffic congestion and other negative outcomes also result of this complex system. Traffic congestion possesses a lot of the above stated multi-dimensionality. Most traffic congestion relieve programmes can be described as piecemeal approaches, i.e. looking at separate solutions for single problems at single sites. However, this research as others, see May, 1991a & b, advocates the development of integrated packages to relieve the traffic congestion problem in Cairo. It has been also recently reported in Replogle and Dittmar, 1994, that all metropolitan areas in the USA over 200,000 should develop effective congestion management systems which integrate TDM into transportation planning, programming and operations and include LUM and pricing elements. This requires TDM to be integrated into all aspects of transportation and community planning and development, rather than being treated as an add-on to the current process.

This research develops an integrated congestion relief package for the city of Cairo. The package would encompass different:

- strategies,
- policies; and
- measures

that are known to play a role in relieving traffic congestion and associated problems. Several studies were undertaken to asses the effectiveness of congestion relief packages in different parts of the world, see Ingham, 1992 for a study that used SATURN to quantify the effect of congestion relief measures in the Johannesburg CBD, see Jraiw, 1992 for a quantification of the cost effectiveness of TDM in Melbourne, see Mierzejewski, 1991 for a cost effectiveness study on TDM in Florida. The most comprehensive of these studies was undertaken by Coleman et al., 1990 which looked at the effectiveness of TDM throughout the USA.

Prioritisation and choice of congestion relief packages can be based on criteria such as:

- public acceptability
- applicability and effectiveness
- potentiality of package ingredients to work together towards achieving favorable traffic conditions within available resources.
- ease of implementation and maintenance;
- level of support and political acceptance.
- economic appraisal;

The integrated package of strategies, policies, and measures meant to relieve traffic congestion in Cairo is displayed in Figure 14. The formation of this integrated package was partly guided by the above stated prioritisation criteria and partly dependent on the literature examination, the results and conclusions of this research and the experiences of the authors. As shown in the Figure, the package integrates supply and demand based strategies including TSM, TM&C, LUM and TDM strategies. Within each of these strategies, a number of policies are selected, which is then more detailed into a set of related specific measures.

An action program for the implementation of this integrated traffic congestion relief package ought to be developed. This entails splitting the implementation of the package into parallel and sequential stages and time framing these stages. It also requires establishing the necessary contacts and preparations with the various agents and organizations at the different levels through which the integrated package would be implemented. All in all, this is meant to coordinate, harmonise and guarantee the smooth implementation of these stages of the developed integrated traffic congestion relieve package through the various organisations.

15. CONCLUSION

The overall aim of this paper was to provide a means of understanding TDM in a comprehensive manner and assist in decisions on whether to use and implement (assess potentiality of) TDM in relieving traffic congestion in Cairo. The paper discussed why the need for TDM has arisen, the objectives of TDM, and presented an overview of TDM. The paper reviewed and compared the main strategies adopted for relieving traffic congestion and in particular the various TDM policies and measures.

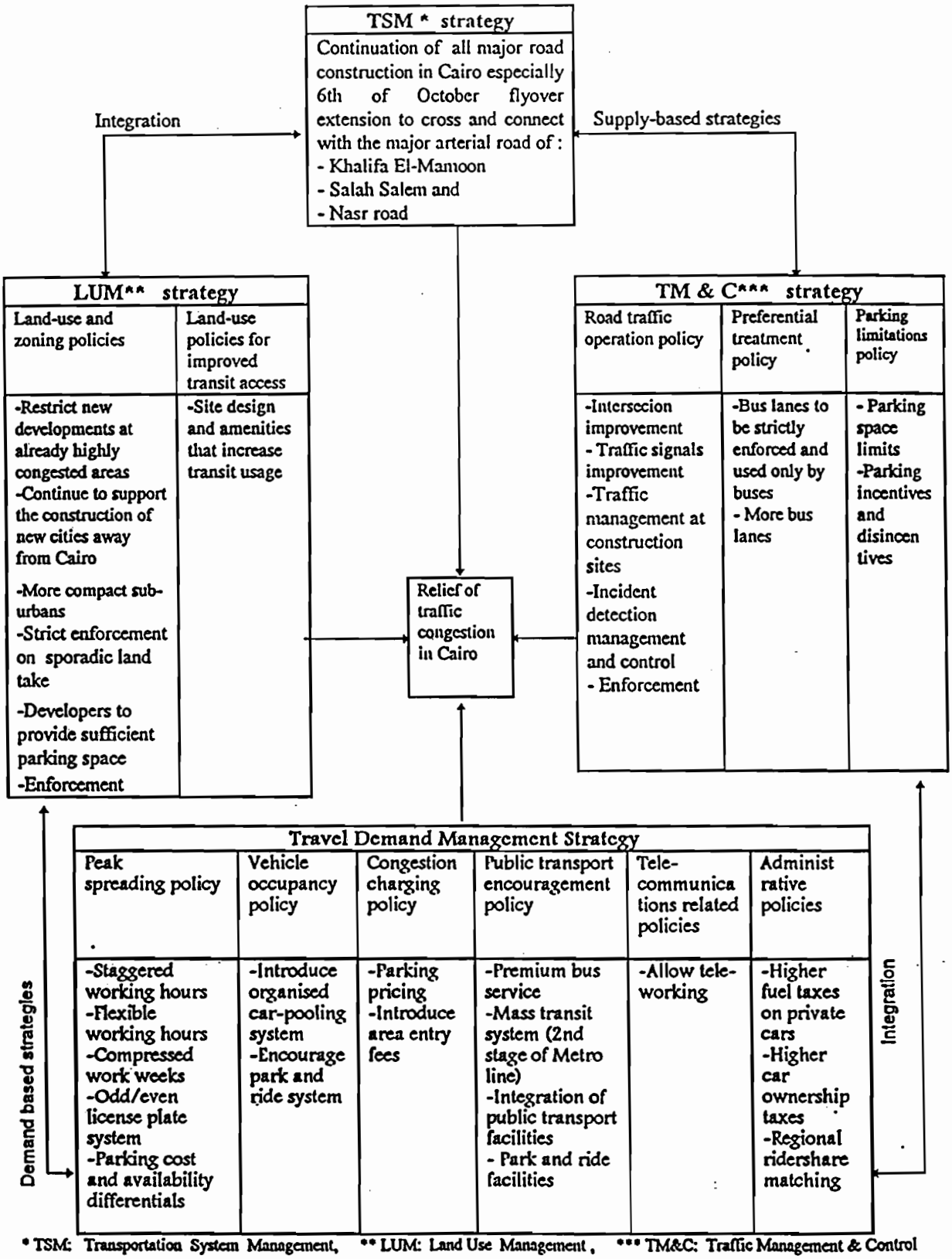


Figure 14: A proposed integrated package to relieve traffic congestion in Cairo

The paper went on to present the results of an attitudinal questionnaire survey conducted with a sample of car-users in Cairo. The questionnaire was meant to recognize the work trip characteristics, patterns of parking of car users in Cairo and determinants affecting their mode choice to use the private car. The first main objective of the questionnaire was to expose car users to three main potential TDM alternatives namely, the introduction of: a new premium bus transit service, an organised carpooling service, and the possibility for teleworking with the intention of identifying car users' acceptability of these measures and their perception towards possible modal shift and use of these services.

The second main objective of the questionnaire was to assess the potentiality, in terms of acceptability, applicability and effectiveness, of a set of TDM, LUM and TM&C related measures that are proposed to relieve the traffic congestion problem in Cairo.

The paper presented the results of a nonparametric statistical analysis that is meant to identify whether differences in socio-economic and work trip characteristics of car users would have a significant effect on their perceptual judgment towards the attributes and potentiality (acceptability, applicability, effectiveness) of TDM, LUM and TM&C related measures in relieving the traffic congestion problem in Cairo. Finally, the paper concluded with developing an integrated package of supply and demand based strategies, policies and measures that is meant to relieve traffic congestion in Cairo.

The main conclusions of this research can be summarised in the following points:

- A typical family size of an affluent family in Egypt is 4 with an average monthly income of over 2000 Egyptian pounds.
- A typical rate of car ownership is 1 car per family with 2 members of the family having access to the car.
- The majority of private car users in Cairo are males.
- The average time for a work trip in Cairo using a private car is 32 minutes.
- The majority of car users in Cairo work 6 or 5 days per week.
- The majority of car users in Cairo commute to work using their private cars.
- Almost 12% of car users in Cairo might have a tendency to leave their private cars and use another mode of transport, including car sharing, for at least one working day per week.
- The majority of car users perceive that using a car is not essential for performing their work.
- The majority of car users in Cairo use on street parking respectively at residential locations and work destinations.
- "Saving of time" is considered by most car users as the most important factor affecting their preference to use a private car as the mode for commuting to work. This is followed, in order, by: comfort, door to door (home to work) mode of transport, feeling of privacy, security, social status, and safety.
- "Buses guaranteed to arrive at scheduled and advertised times" is perceived by car users as the most important characteristic to be provided in a newly proposed premium bus transit service. This is followed, in order, by: buses offering direct services with no need for transfers, a convenient seat is guaranteed, bus stops near home/work, frequent service, fast service, and air conditioned buses.
- By comparing the determinants affecting the preference of using private cars with the proposed premium bus service characteristics, one can notice the high importance placed on reliability and time saving factors.
- The majority of car users stated that they would be encouraged to leave their cars and use a premium bus transit service.

- "Fear of sometimes being delayed" is perceived by car users as the main possible discouraging factor for using a carpooling system. This is followed, in order, by: feeling that some privacy is lost, fear of sharing with unsafe drivers, feeling insecure of riding with people you do not know, do not like to share with smokers, do not like to share with talkative people, do not like to share with opposite gender.
- By comparing the determinants affecting the preference of using private cars with the factors that might discourage car owners to participate in a carpooling system, one can again notice the high importance placed on the time factor.
- Respondents were asked to state their attitude as to whether the organization of such a ride share system, in a manner that avoids all the previously stated discouragement factors, would inevitably encourage them to leave their cars and carpool, 49% stated their willingness to use such a service. However, 52% of the respondents stated their unwillingness to participate with their own cars in such a system. The majority of the respondents (41%) thought that a private agency would be the best form for organising such service.
- 38% of respondents have indicated that some of their work duties can be performed at home. Of these respondents, 74% have indicated their willingness to be allowed to stay at home for some days during the week to perform such duties.
- "Staggered working hours" is considered by most car users to be a highly applicable TDM measure and 26% of these respondents indicated that such measure could be fully effective in relieving traffic congestion. On the other hand, the vehicle licensing to be granted on assuring permanent parking space was considered by most car users to be inapplicable.
- As for the proposed LUM related measure, the majority of car users have indicated the applicability of developers having to provide parking space in their developments and 40% of these respondents indicated that such measure could be fully effective in relieving traffic congestion.
- As for the two TM & C measures, most car users have also indicated that strict enforcement of illegal parking as well as the provision of parking incentives for HOV and disincentives for SOV are highly applicable measures and 25% of these respondents have pinpointed to the full effectiveness of such measures in relieving traffic congestion. This emphasises the results obtained regarding the potential congestion problems arising from on-street parking, causing a reduction in through traffic flow and leading to traffic congestion. On the other hand, the designation of exclusive separate lanes for HOV was perceived by 47% respondents to be inapplicable.
- For most of the tested questionnaire components there is no significant, statistical difference in the responses among the various independent sample groups branching from the five selected socio-economic characteristics, namely gender, family size, family income category, car ownership, and car users per family.
- For most of the tested questionnaire components there is no significant, statistical difference in the responses among the various independent sample groups branching from the three selected work trip related characteristics, namely car occupancy for work trips, working days per week, and work days per week when car is used.
- As a consequence of the above stated two conclusions, it was valid to draw conclusions pertaining to the potentiality (acceptability, applicability and effectiveness) of TDM measures in relieving traffic congestion in Cairo from the combined responses of these groups.
- However, it is fair to state that some questionnaire components when tested showed that there exists a statistical difference in the way these were perceived by respondents belonging to the various independent sample groups.
- The results of significance testing of the hypothesis of no agreement among car users in their ranking of: determinants affecting their choice of private car for work trips; characteristics of a proposed premium bus transit service; and factors discouraging participation in a carpooling system, show that it is statistically plausible to reject the hypothesis of no consensus, regarding the rankings and that the respondents' ranking could be in agreement and hence could be related.

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