Monograph:
Tillis, T., Hodgson, F. and Sherborne, D.J. (1995) Assessment of the Effectiveness of the Greek Implementation. VRU-TOO Deliverable 14. Working Paper. Institute of Transport Studies, University of Leeds , Leeds, UK.

Working Paper 442

Published paper
T. Tillis, F. Hodgson, D.J. Sherborne (1995) *Assessment of the Effectiveness of the Greek Implementation. VRU-TOO Deliverable 14.* University of Leeds, Working Paper 442

VRU-TOO

Vulnerable Road User Traffic Observation and Optimization

DRIVE II Project V2005
Deliverable 14
Workpackage PP4

Assessment of the Effectiveness of the Greek Implementation

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Deliverable type:	P
Contract date:	December 1994
Submission date:	September 1995

Commission of the European Communities - R&D programme
Telematics Systems in the Area of Transport (DRIVE II)

The research reported herein was conducted under the European Community DRIVE II Programme. The project is being carried out by a consortium comprising: Institute for Transport Studies, University of Leeds; West Yorkshire Highways Engineering and Technical Services; Traffic Research Centre, University of Groningen; Department of Traffic Planning and Engineering, Lund Institute of Technology; FCTUC, University of Coimbra; FEUP-DEC, University of Porto and Transport Environment Development Systems, Athens;. The opinions, findings and conclusions expressed in this report are those of the author alone and do not necessarily reflect those of the EC or of any organization involved in the project.

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EXECUTIVE SUMMARY

The work of VRU-TOO is targeted specifically at the application of ATT for the reduction of risk and improvement of comfort for Vulnerable Road Users, namely pedestrians. To achieve this, the project combines pilot implementations in three countries (U.K., Portugal and Greece) with behavioural studies and the development of computer simulation techniques. At the same time the pilot implementations are fitted into specific Local and National policy contexts.

The present deliverable focuses on the pilot implementation in Elefsina, Greece. A key signalised intersection in the city centre has been equipped with microwave pedestrian detectors that:

Detect, in advance, pedestrians approaching the intersection and pass the information to the signal controller. The pedestrian green is activated without the pedestrians having to press the button.

Detect pedestrians using the crossing and pass the information to the signal controller. The pedestrian green is then extended, if necessary, for pedestrians who would otherwise have no time to clear the intersection before the signals changed.

In the future, the planned improvement of conditions for Vulnerable Road Users will also depend on the availability of pedestrian flow data, at a level comparable to that for vehicular traffic. A demonstration of the suitability of microwave detectors to collect such data on pedestrian flows has also been performed. Microwave detectors are suitable for obtaining pedestrian counts and can go a long way in closing the data 'quality gap' between vehicular and pedestrian traffic, at least in low to medium pedestrian flow conditions.

An evaluation of the effects of pedestrian detectors on the safety of the intersection and on the behaviour of pedestrians is presented, as are details of the experiments in Elefsina, and an assessment of 'before' and 'after' conditions. No negative effects on vehicular traffic have been registered while the effects on pedestrian delay and safety have been positive. The effects, however, are small in magnitude which may be due to the constraints which have been placed upon the extent to which the pedestrian green time can be increased within this experiment.

Potential adoption of the pedestrian detection techniques, as investigated, may improve the performance of signalised intersections and crossings from the point of view of pedestrian without causing undue disadvantages for vehicles. It also provides the traffic engineer with the information and flexibility to make alterations in a logical manner to the priorities given to different classes of road user. In addition, microwave detectors can provide the necessary quantity and quality of data for the design and evaluation of comprehensive traffic management schemes.

The diffusion of the techniques and their use will be based, to a large extent, on the standards setting functions of National Authorities. An additional aim of the Elefsina pilot has been to provide to the Ministry of Environment and Public Works information on the effectiveness of techniques developed, in order to proceed with possible modifications in standards and recommended practices for signal installations, to include pedestrian detectors.

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1 INTRODUCTION

1.1 GENERAL BACKGROUND

The work of VRU-TOO is targeted specifically at the application of ATT for reducing risk and improving comfort (e.g. minimisation of delay) for Vulnerable Road Users, namely pedestrians. To achieve this, the project operates at three levels. At the European level practical pilot implementations in three countries (U.K., Portugal and Greece) are linked with behavioural studies of the micro-level interaction of pedestrians and vehicles and the development of computer simulation models. At the National level, the appropriate Highway Authorities are consulted, according to their functions, for the pilot implementations and informed of the results. Finally, at the local level, the pilot project work is fitted into specific local (municipality) policy contexts in all three pilot project sites. The present report focuses on the Elefsina pilot application in Greece and the relevant National and Local policy contexts are the following:

At the National level, the ultimate responsibility for road safety and signal installations rests with the Ministry of Environment and Public Works. The Ministry is responsible for the adoption of standards and solutions for problems and also for a large number of actual installations, since local authorities lack the size and expertise to undertake such work on their own. One of the project's aims is to provide information to the Ministry as to the suitability of the methods developed for aiding pedestrian movement, ultimately leading to a specification for its wider use. The Ministry is expecting to use the final results of the present study for possible modifications of its present standards for pedestrian controlled traffic signals.

At the local level (Elefsina) the municipality has, in the past, pursued environmental improvements through pedestrianisation schemes in the city centre. At the same time it has developed a special traffic management policy, to solve a particularly serious problem of through traffic. A summary of the policy is contained in Appendix A and more details in a previous deliverable (Tillis, 1992). In the particular case of Elefsina pedestrian induced delay to through vehicular traffic, may form a key element in this policy ensuring at the same time, an incentive to divert to the existing bypass and enhancing pedestrian movement. The effectiveness of pedestrian detection techniques tested in the pilot, will provide valuable information on the future implementation of the policy.

Thus, the Elefsina Pilot Project operates at the same time on three levels:

It provides a basis, in combination with the other two pilot project sites, for comparing the effects of pedestrian detection on pedestrian safety and comfort at a European level.

It provides information to the National authorities (Ministry of Environment and Public Works) for their standards setting, scheme design and implementation tasks.

It fits into a comprehensive plan at the local level for effecting environmental improvements and enhancing pedestrian amenity and comfort at the same time.

In addition, an investigation into the capabilities of pedestrian detectors to function as data collection devices, was performed. The data 'quality gap' between vehicular and pedestrian traffic may be closed with the utilisation of microwave pedestrian detectors, providing a more solid foundation for the planning for total person movement through networks (vehicle occupants, public transport passengers, pedestrians).

This the second deliverable issued for Elefsina and comprises of the main section which contains a description of the work undertaken, the results and a number of appendices serving as background material in support of the statements in the main text.

1.2 OVERVIEWOF TRIAL

1.2.1 Problem Statement

The safety and comfort of pedestrians using signalised intersections or pelican-type crossings, poses difficult problems in scheme design. From the point of view of pedestrians, they would like to have immediate priority over vehicular traffic, when reaching the crossing and, particularly those walking at lower speed such as the elderly and handicapped, ample time to cross in safety. However considerations of street capacity utilisation for vehicular movement (minimise stops, delays), are potentially in conflict with pedestrian safety and comfort. If we consider the situation of a pedestrian crossing facility at a minor crossroads, then if the minor side street gains priority whenever a pedestrian reaches the crossing or is given enough green time for the slowest pedestrian to cross the road completley, a serious conflict emerges between pedestrian safety/comfort and traffic efficiency. This conflict is resolved usually at the expense of pedestrians even where pedestrian detection (in the form of push buttons) is used. This means that the signals will only change after a pedestrian reaches the crossing point and presses the button and even then the length of the green time will be a pre-set average value.

Accurate detection of pedestrians has been, in the past, very difficult to accomplish. Pedestrians, unlike vehicles, do not change magnetic fields or cause inductive variations. They cannot be dependent upon to follow a specific path, based on their observed direction of travel. Furthermore they cannot be relied upon to take a specific action to make their presence known to a signal controller. The most common device for detecting pedestrians has been the pedestrian push button - a simple heavy duty, momentary contact switch, located as conveniently as possible, in the path of the pedestrian. Pressing the button closes a circuit, which places a call on the appropriate controller detector input.

The weakest link in the chain, is the specific action required by pedestrians to perform, most do not make the effort and cross the intersection unsafely. The reasons for this are mainly inconvenient placing of buttons, long waiting times and, primarily, lack of awareness on the part of pedestrians of the advantages they gain by pressing the button. At intersections some think that it is acceptable to cross on the vehicular green, along with moving side road traffic or that pressing the button is not necessary, if waiting vehicles will bring the green. At some crossings long waiting times and perceived gaps in traffic may induce pedestrians to violate the red and cross unsafely. Finally vehicular traffic efficiency considerations usually dictate short pedestrian green times, i.e. for reasonably fast pedestrians - this results in slower pedestrians still being on the crossing while vehicles start moving. The above problems occur within Greece, but are common in all countries.

The use of microwave technology to detect pedestrians as employed in the present project, has the potential to remove the weak link in the chain (action by the pedestrian) and thus provide safer and more comfortable conditions for crossing. The expectancies of all road users should provide the basis of scheme design and, following discussion with Ministry officials, it was decided to include in the Elefsina pilot two applications for pedestrians:

Advanced detection of pedestrians as they approach the intersection (in conformity with the other two pilot trials) and

Incremental extension of pedestrian green for those pedestrians that do not have time to clear the junction before the red man comes on. (this part of the trial was not strictly speaking part of the project, but was carried out at the specific request of the Greek Ministry)

The first application aids pedestrian movement by eliminating the need to push the button, while pedestrian delays are reduced since the controller knows a pedestrian is approaching well before he reaches the crossing point. The second application allows the traffic engineer to use a lower "average" green time for pedestrians as standard in the knowledge that an extension period (in increments) can be used to account for the occasional slower pedestrian. In this way it is expected that delays to traffic over long periods of the day are minimised whilst ensuring that all pedestrians can cross safely. Thus, at the project level in VRU-TOO, all possible applications of pedestrian detectors are included, i.e. advanced detection, extension of green for approaching pedestrians and extension of green for crossing pedestrians.

The past difficulties in accurately detecting pedestrians have also had a negative impact in the quantity and quality of data available for pedestrian demand (expensive human observer methods were the only alternative). The ease with which data on vehicles can be collected may have been an important contributing factor in the preoccupation with vehicular traffic and disregard for pedestrians in most current traffic management schemes where, as a rule, minimising of vehicular delay is the target, rather than person delay. The microwave technology utilised in the present project may also contribute in closing this 'information gap'. In order to check whether this approach was possible, an additional experiment was also conducted in Elefsina to verify the potential of microwave detectors to provide data on pedestrian traffic demand. In this work a long term pedestrian flow profile was produced from a data logger attached to a pedestrian detector which was sited on a well-used pedestrian route.

1.2.2 Systems Overview

The characteristics of the systems installed are summarised in Table 1.1. It should be noted that in terms of functionality, as proposed in Project V 2056 (CORD Consortium, 1993), the intersection application would come under F 3.2 (SF 3.2.1 & SF 3.2.3). The pedestrian counting capability may also be classified under some functions or sub-functions (e.g. Network State Surveillance SF 3.1.1 or SF 3.3.3), although clearly the functional classification of V 2056 refers to vehicles rather than persons. In terms of potential, the pedestrian detection techniques may be also be used in traffic demand management schemes, predictions of pedestrian volumes etc.

TABLE 1.1: SYSTEMS OVERVIEW

TEST SITE	SYSTEM	SYSTEM OBJECTIVES	FUNCTIONALITY	MAJOR TECHNOLOGY	COMMENTS
Pedestrian crossing at railway line in Elefsina, Greece	Microwave Detectors and Data Logger	Establish the potential of Microwave Detectors to provide data on pedestrian flows	Monitoring of pedestrian demand (directionally)	Microwave Technology for Vehicle detection modified for use in Pedestrian detection	Pedestrian counts summed at 5 min intervals for long periods
Signalised Urban Crossroads in Elefsina, Greece	Microwave Detectors and Signal Controller	Reduced pedestrian delay Increased pedestrian safety Increased pedestrian comfort while crossing No increase in queue lengths No negative effect on intersection capacity	Intersection Control Monitoring and Actuating by two methods : 1. Pre-arrival pedestrian detection 2. Extension of pedestrian green time at junction	Microwave Technology for Vehicle detection modified for use in Pedestrian detection	Real Time response to pedestrian demand as they approach the junction or while crossing

2 EVALUATION AND OBJECTIVES

2.1 THE DECISION CONTEXT

The Decision-Makers : As mentioned previously, the Ministry of Environment and Public Works has the responsibility for most signal installations including pelican-type pedestrian crossings. They are charged with both road safety and vehicular traffic efficiency. Requests for installations come from municipalities or from the Ministry's own departments. The effect of pedestrian detector controlled signals on major road flows, on accidents and the effectiveness of such detection for pedestrians are key concerns. Municipalities can, in principle, proceed with their own installations, but subject to approval (and supervision) by the Ministry.

As far as the local level of decision making is concerned in Elefsina, any negative effects on major road flows (more delays), would be regarded as a positive attribute of the application, given the municipality's traffic policy. So, apart from the safety of pedestrians, the Municipality is most concerned with improving conditions for pedestrian trips (reduction of delay and increase in reliability and comfort).

The Geographical Area of Influence: The area of influence of the application, apart from the immediate local around the intersection may extend a few blocks, if the benefits of pedestrian detection over a conventional installation, result in route shifts for pedestrians (more pedestrians using the facility). The issue of route shifts is, however, difficult to assess since it is the perceived time (gains) that would have an influence on behaviour and not the actual (e.g. see Bovy & Stern, 1989). Route shifts of motorised traffic now going through the city (main road flow) are unlikely to occur since any additional delays caused by the trial would be small and variable, and thus unlikely to result in diversion. Therefore the assessment is confined to the immediate area of the intersection.

User Groups Affected: Pedestrians and vehicle occupants are the two general groups potentially affected by the application. It is necessary to distinguish between small vehicles (mainly private cars) and large vehicles (buses, trucks), i.e. between commercially used vehicles and those that are not. Different subgroups of pedestrians may be affected in different degrees. For example, elderly pedestrians or in general pedestrians walking at lower than normal pace, may find the green extension application advantageous. In order to assess this, it is necessary to inform users on the way the intersection functions..

In summary the assessment of the Elefsina pilot, based primarily on the requirements of the Ministry as the key decision maker, is confined to the area immediately surrounding the intersection and crossings, distinguishes the traffic effects between those on private cars and large vehicles and examines the response of pedestrians to the different operational aspects of the installation (when those are known to users).

2.2 SPECIFIED OBJECTIVES

The assessment objectives for intersection control are summarised in Table 2.1. Whilst the emphasis on pedestrian safety holds at both levels of decision making, the Ministry is expected to give greater weight on possible negative effects on traffic flow and the Municipality on reducing travel time for pedestrians. Since the full implementation of the Municipality's traffic policy is not forthcoming, the Ministry's requirements predominate. In addition the Ministry is concerned with the cost of installations and possible compatibility problems between pedestrian detectors and current types of installations.

TABLE 2.1: ASSESSMENT OBJECTIVES

DECISION MAKER	OBJECTIVE CATEGORY	OBJECTIVE	EVALUATION CATEGORY
CITY MUNICIPALITY	Pedestrian Travel Efficiency	Reduce waiting time for pedestrians	Technical Assessment
	Pedestrian Safety and Comfort	Increased safety and comfort for pedestrians	Technical Assessment
MINISTRY OF ENVIRONMENT AND PUBLIC WORKS	Vehicle Movement Efficiency	No increase in vehicle queues No negative effect on intersection capacity	Technical Assessment
	Pedestrian Safety and comfort	Increased Safety and comfort for Pedestrians	Technical Assessment
	Standards Setting-Adoption	Cost - Compatibility with existing installations	Technical Assessment

2.3 POTENTIAL IMPACTS AND IMPACTS ASSESSED

The potential impacts of deploying pedestrian detectors at signalised intersections are:

Cost and Compatibility: Of interest to the Ministry of Environment and Public Works in the case of Greece, since they have to bear the cost of most installations. The extra cost involved in including pedestrian detectors at a typical signal installation, the compatibility of pedestrian detectors with controllers and the installation practices followed in Greece, are key concerns.

Travel Time: The benefits or disbenefits to users, regarding travel time of vehicle occupants and pedestrians depends upon the total trip time **as perceived** by them. Strictly speaking travel time should refer separately to persons (pedestrians, car occupants, bus passengers) and vehicles (mainly commercial). The existence of thresholds is a further complicating factor. Keeping in mind the subjectivity of the index, the assessment concentrates on absolute (objective) changes in travel times for pedestrians in the immediate area around the intersection.

Operating costs: They refer to vehicles and vehicle operators. The major determinant of most operating cost components, is kms driven, with the exception of fuel consumption which is affected by traffic conditions. The average (composite) passenger car when idling has a fuel consumption rate of 0.58 gal/h or 2.3 litres/h. Thus the pilot has a potential effect only in the idling fuel consumption component of operating costs. In any case private cars are examined separately from large vehicles (trucks, buses).

Comfort: One of the major aims of the project is to improve comfort for Vulnerable Road Users. Comfort may be defined as a state of subjective well being. Subjective well being is much influenced by personal expectations on the situation - although there are no generally accepted definitions of comfort. It may be easier to define discomfort or stress aspects which depend on the reliability and convenience of a transport system. Within the transport sector, comfort is influenced by traffic, road, vehicle and traffic control systems. When considering comfort in ATT three aspects are important:

Improvement in information
Increase in information flow
Changes in performance tasks (e.g. driving task)

In addition the comfort for pedestrians can also be related to the conditions the pedestrians encounter when they reach the kerb edge. This can be described in terms of the signal settings when they reach the kerb, and/or the length of the time they have to wait before the "green man" is shown.

Safety: One of the major aims of the project is to establish the safety potential of using microwave detection for pedestrians in crossings. The evaluation criteria should, in theory, refer to damages to persons or material (e.g. fatalities, serious or slight injuries, material damage). In view of the short timescale the project considered that the use of trained personnel using the Swedish traffic conflict technique(Hydén 1987) to observe the junction was one of the best ways to assess the effects of the pilot project implementations as it was not possible to use accident data. It is one of the main principles of the project that accidents and conflicts are part of a continuum of events and that the safety of a new implementation can be assessed using the traffic conflict technique. The project, following the Swedish traffic conflicts technique, adopted the following definition of a conflict, "a traffic conflict is an observable situation in which two or more road users approach each other in space and time to such an extent that a collision is imminent if their movements remain unchanged". The technique relies on judgements of speed and the distances between two road users. In addition information relating to the number of vehicle red light violations has been used.

Air pollution and Noise: The potential negative impacts of additional exhaust fumes are not considered explicitly in the present project, although the potential does arise for benefits to accrue from vehicle re-routing. The same holds for noise pollution.
The potential impact of pedestrian detection techniques are summarised in Table 2.2.

TABLE 2.2: POTENTIAL IMPACTS ON USERS

IMPACT GROUP	PEDESTRIANS		VEHICLES	
IMPACT SYSTEM	WEST CROSSING	EAST CROSSING	WEST CROSSING	EAST CROSSING
Travel Time	++		+/-	+/-
Operating Costs			+/-	+/-
Comfort	+	++		
Accidents	++	++		

(Key: ++ very positive + positive
- negative +/- uncertain)

2.4 INDICATORS SELECTED

The present report is, in essence, concerned with the technical performance of the system. The behavioural results of the system's performance for all three pilot applications will be presented in a later deliverable. In addition, the effect of informing users on the intersection operation is assessed. The following indicators have been chosen:

A : Traffic Movement Efficiency

Queue Lengths : Separately for private cars and 'large' (i.e. trucks, buses) vehicles. Also separately for each crossing (main road) to take account of directional imbalance in volumes. A requirement of the application would be that no detectable increase in queue lengths be observed. Queue length, for the scale of the pilot, is not a measure of travel time benefits (or disbenefits) to users, for the reasons mentioned previously. Instead, from a systems point of view, queue length is taken to be a proxy for the fuel component of vehicle operating costs and, indirectly, of air pollution.

Pedestrian induced extensions of the side road green may have an impact on the signal junction capacity and level of service, by changing the signalisation conditions input module. Side road traffic demand may also be affected. The change in signalisation conditions and the impact on side road traffic was registered with the following indicators.

Number of Extensions : The extensions to the side road vehicle green are determined, in the after situation, by pedestrian demand and not by vehicles (before traffic condition). Any changes will affect the signalisation conditions.

Length of Extensions : Similarly the length of extensions is also determined by pedestrians, in the after situation. Any changes will also affect the signalisation conditions.

Distribution of Extensions Throughout the Day : Finally the distribution of extensions throughout the day are also pedestrian determined in the after situation. This may affect main road traffic but also side road traffic if the demand patterns of pedestrians and traffic (local) are different.

B. Pedestrian Comfort

Use of Crossings : In order to measure the effects of information provision on the relative use of the two crossings (comfort measure), the number of pedestrians using each (before and after the information campaign) and their situational characteristics was recorded.

TABLE 2.3: INDICATORS SELECTED

OBJECTIVE AREA	OBJECTIVE	INDICATOR
Traffic Movement Efficiency	No negative impacts on main road vehicular traffic movement	Vehicular queue lengths per vehicle category and crossings.
	No negative impacts on Signalised intersection capacity	Number of Pedestrian green Extensions Length of Extensions
	No negative impacts on side road traffic movement	Distribution of Extensions throughout the day
Pedestrian Movement Efficiency	Increased pedestrian comfort while crossing the road	Use of crossings Number of pedestrians arriving on green signal

3 DESCRIPTION OF TRIAL

3.1 SITES CHOSEN

In contrast with the other two pilot project sites (Leeds and Porto), the Elefsina pilot was not based on an existing signalised intersection. In line with the municipality's (through) traffic restraint policy and as a building block towards its full implementation, it was decided to request the Ministry of Environment and Public Works for a completely new signal installation at a previously unsignalised junction. The Municipality undertook the infrastructure works and the Ministry the provision of equipment. In the event four possible sites were considered for the VRU-TOO pilot, two already signalised intersections and two unsignalised. The sites are shown in Fig. 1. The unsignalised intersection at Iroon Polytehneiou and Dimitros Street was finally chosen. The installation will remain in place after the completion of the project as a permanent demonstrator. Site details are shown in Fig. 2.

For investigating the potential of microwave detectors to count pedestrians, one detector was installed at one of the two main level crossings of the Railway line going through Elefsina (upstream of Dimitros Street). The advantages offered at this site are that it is one of the two most important points where all pedestrians moving North-South have to pass - thus providing a good approximation of cross-city pedestrian traffic demand for N-S movements. The detector was connected to a conventional traffic data logger. Details of the experiment are contained in Appendix B. The counting configuration was dismantled in late 1993 and the microwave detector was later used for the main pilot application at Dimitros - Iroon Polytechneiou intersection.

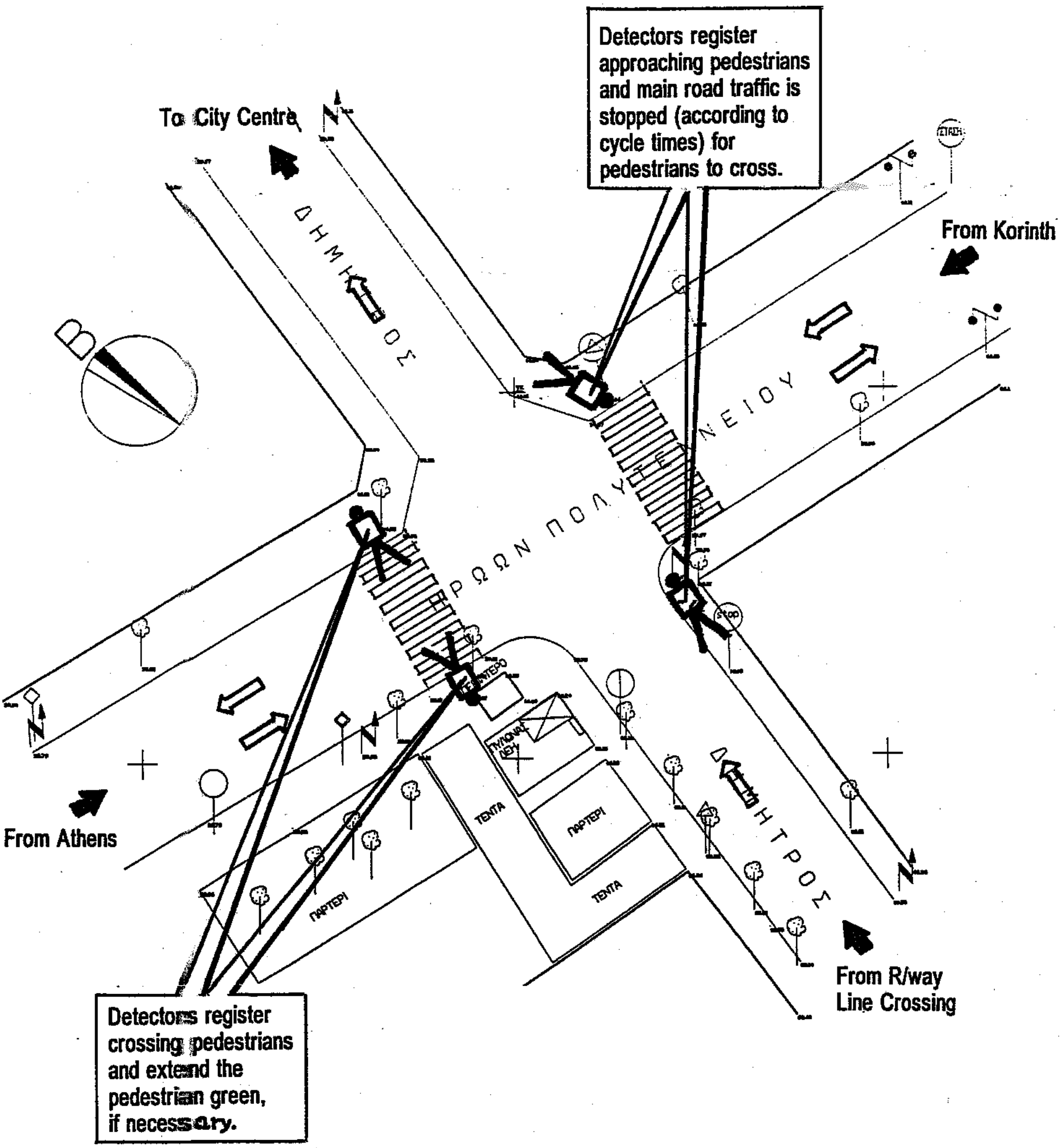
3.2 HARDWARE

The system consists of the following hardware:

A signal controller SIEMENS type MQ. The infrastructure works were carried out by the Municipality of Elefsina and the equipment was supplied by the Ministry of Environment Planning and Public Works. Some basic characteristics of the controller are contained in Appendix C.

Microwave technology was used for pedestrian detection. The detectors operate on the Doppler effect - a microwave signal is emitted by the detector which is reflected back at the detector by the moving object, in our case a pedestrian. The shift in frequency caused by the movement of the pedestrian is sensed by the detector electronics which cause a pedestrian-actuation output. More details on pedestrian detection techniques are contained in a previous deliverable (Sherborne, 1992). Four microwave detectors were supplied by Microsense (UK) and suitably installed and connected to the controller. The detectors are vehicle detectors modified by the

Fig. 2 LAYOUT OF EXPERIMENTAL SITE



manufacturer to account for the lower speed of pedestrians. Basic characteristics of the specific detectors used, are given in Appendix C.

3.3 INTEGRATION OF SYSTEMS

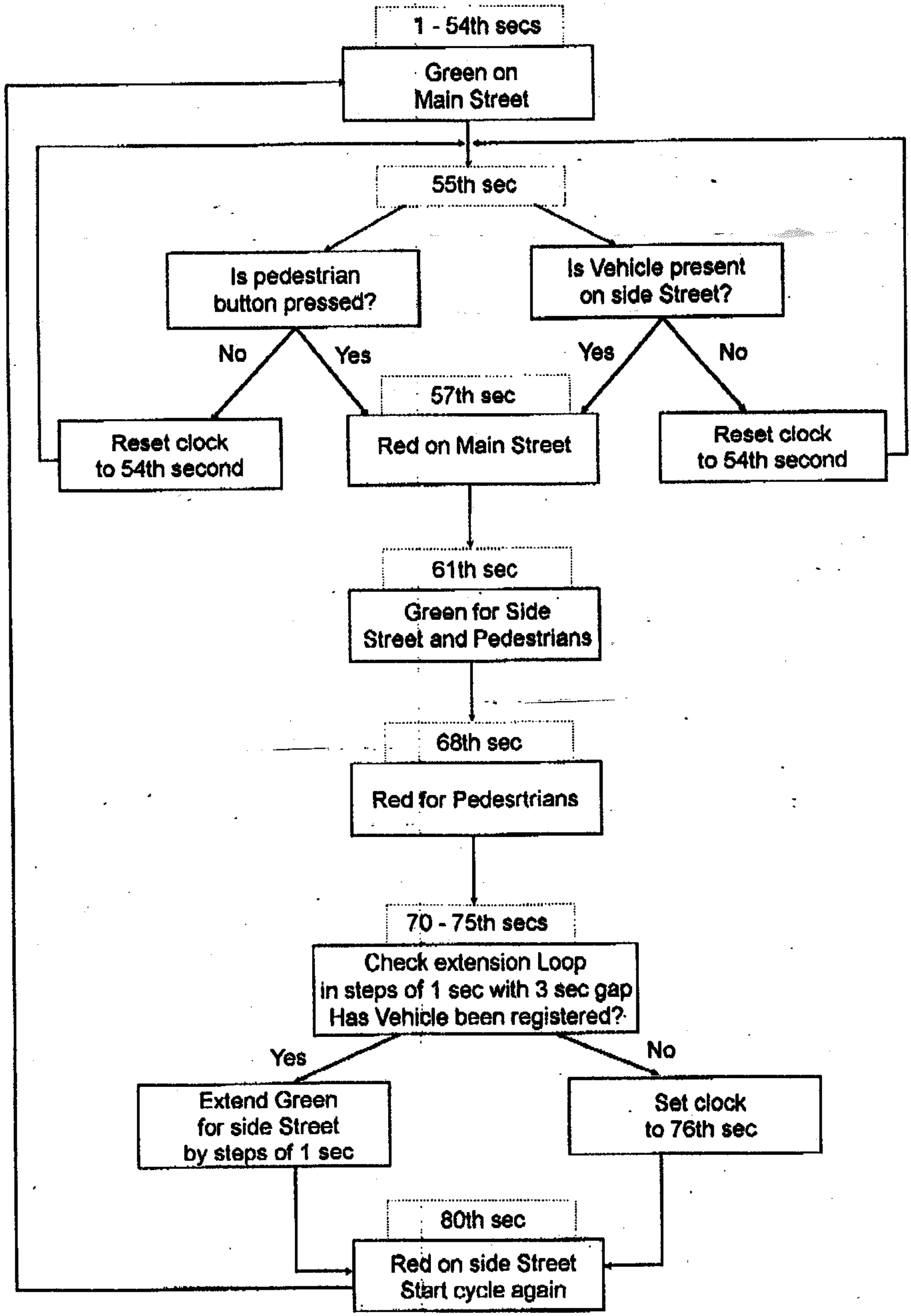
The operation of signals is performed by two programmes written in SIEMENS's MASMO language by the Ministry of Environment and Public Works - one for operation without and one for operation with the pedestrian detectors.

Signal Operation Without Pedestrian Detectors : The installation is a typical one for Greek conditions. It involves two phase control and semiactuated operation, where the main street has a 'green' indication at all times until the presence detector on the side street determine a vehicle present or any of the pedestrian push buttons are pressed. The signal then provides a 'green' phase for the side street and a pedestrian green, if a button has been pressed. Vehicle turning movements are permitted at the same time as pedestrians are crossing. The duration of the side street green may be extended as determined by an extension loop located some 15 m. from the junction, up to a preset maximum. The operation is described in Fig 3. Thus the cycle length and green times vary in response to side road traffic demand and the pedestrian "green-man" is activated by pressing the pedestrian push-buttons.

Signal Operation with the Pedestrian Detectors : The pedestrian detectors have been placed in the junction as shown in Fig. 2. In case of no car traffic demand from the side road, the detectors register the presence of pedestrians as they approach and trigger the controller for cutting off the green for the main road (only for the western crossing). In addition once the detectors register continuous presence of pedestrians crossing the road they trigger the controller to extend the green time available for them, to cross (only for the eastern crossing). The vehicle extension loop is deactivated and service of side road traffic relies only on the presence loop. Thus the demand responsive character of the intersection is now based on two aspects of pedestrian demand: presence (western crossing) and speed while crossing (Eastern crossing). The operation with pedestrian detectors is shown in Fig 4.

Timing programmes and general layout details are given in Appendix D.

Fig.3 ELEFSINA SIGNAL CONTROL (BEFORE)



3.4 FIELD TRIAL AND PLAN

The realisation of the Elefsina scheme involved planning of a number of activities. A key issue was the actual signal installation which was completed in the period November - December 1993 (infrastructure works + placement of equipment). The pedestrian data collection configuration was set up in August 1993 and measurements lasted from late September to early December 1993.

Following the signal installation, the before and after studies were carried out in the period January - May 1994. This involved the co-operation and assistance of outside bodies not directly involved with the DRIVE programme. The survey of users response to information was carried out during October 1994.

4 RESULTS

4.1 ESTIMATES OF IMPACTS

4.1.1. Cost and Compatibility

A limited application involving 2 crossings at one junction where green extension is given to pedestrians while crossing, would raise the cost of a new signal installation by 10 %. The cost of advance detection of pedestrians will vary according to prevailing circumstances in each site. If we assume 2 directions on each intersection corner the cost may rise to 20%. of a new intersection. (Prices in Greece: a typical intersection such as the one installed in Elefsina costs 5 million drs. (17,000 ECU s) including infrastructure works).

Ministry personnel were consulted and supervised the installation. No problems were found in terms of compatibility between microwave detectors and signal controllers. In addition, the work required to position and connect the detectors was simple.

4.1.2. Impacts on Pedestrian Safety, Movement and Delay

Safety: Due to the fact that the time period available for evaluation of the implementation was too short to record accident information; proxies for safety were used as described in 2.3.

Conflicts: The overall hypothesis was that the number of serious conflicts would reduce between the before and after situations as a direct effect of the pilot project implementations. In addition a number of other hypotheses (specified below), were developed because they were more able to test fully any effects of the pilot project implementations.

H_1 The number of pedestrian-car conflicts will decrease.
H_2 The number of pedestrian-car conflicts per lane will decrease.
H_3 The number of conflicts for each pedestrian direction will decrease.
H_4 The number of pedestrian-car conflicts according to whether the pedestrian is in their first, second or last lane of crossing will decrease.
H_5 The ratio of pedestrians crossing to conflict will reduce.

It is generally recognised that conflicts have a Poisson distribution. It was decided that the hypotheses would be tested by calculating the probabilities of the frequency of occurrence of events comparing the before and after studies using Poisson probabilities. Where appropriate, i.e. both observations being compared are greater than 10, then approximation to the normal distribution was made assuming that the mean and the variance are the same and using a continuity correction factor of .5. The period of observation in both the before and after studies was considered to be 1, regardless of the number of days or hours over which the observation actually took place. The accepted level of significance was .05.

Conflict studies were done for 9 days in both the before and after studies. Only serious pedestrian and car conflicts were recorded. Conflicts were only recorded during times when it was not raining.

The conflict studies were conducted at two zebra crossings situated on the two main arms of the site. This analysis has divided the site into four lanes as shown in Figure 5. Statistical analysis was done to answer hypotheses 1, 2 and 4. It was inappropriate because of the implementation design to test hypotheses relating to the pedestrian direction and there was not the relevant data to be able to check the pedestrian and vehicle volume to conflict ratios.

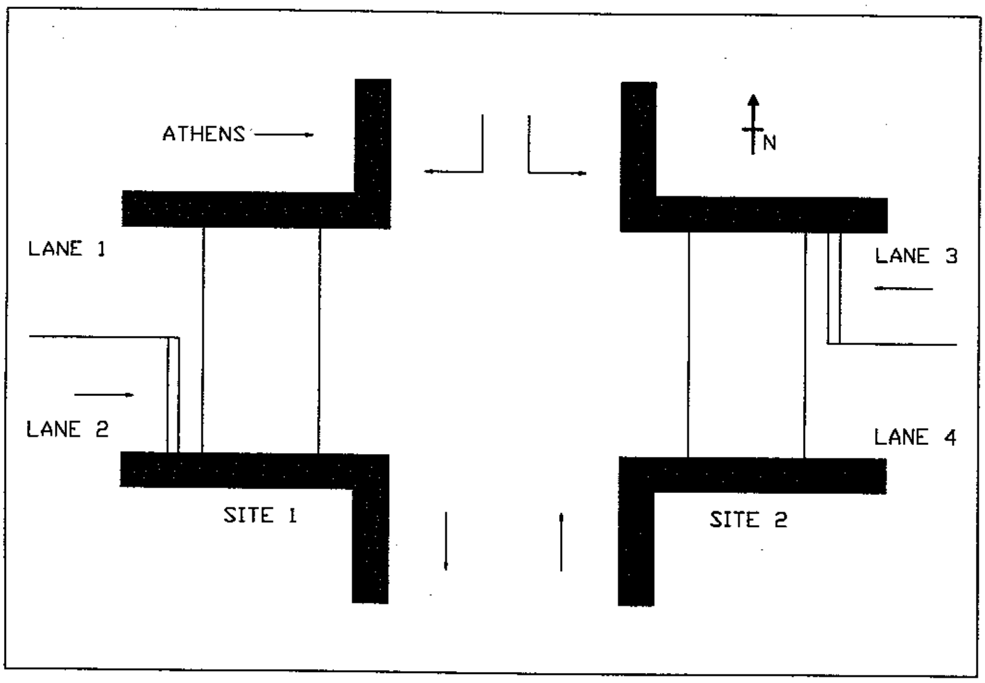


Fig. 5 The Elefsina Junction

Hypothesis 1: The number of pedestrian-car conflicts will decrease.

The first test was to ascertain whether the overall observed number of conflicts had significantly changed between the before and after studies. 82 conflicts were collected in the before study and 64 in the after study. (z= 2.04, critical value 1.960, p=.025 using a one-tailed test.) This was a significant reduction in the number of conflicts between the before and the after studies.

Hypothesis 2: The number of pedestrian-car conflicts per lane will decrease.

At lane 1 there were 25 conflicts in the before study and 17 in the after study. This reduction was significant using a one-tailed test at the p=.05 level, (z score 1.7 and critical value 1.645.) There was no change in the number of conflicts observed at lane 2. 15 conflicts were observed in both the before and after studies. At lane 3 a non-significant increase in conflicts occurred between the before and after studies from 24 to 28. (z score 0.71.) Finally at lane 4 there was a decrease in the number of conflicts from 18 to 4. Using a one-tailed test this was significant at the p=.0005 level. (z score 3.42 and critical value 3.291.)

Hypothesis 4: The number of pedestrian-car conflicts according to whether the pedestrian is in their first, second or last lane of crossing will decrease.

It was not considered appropriate to test hypotheses concerning the approach direction of the pedestrian as the implementations did not operate differently depending on the direction in which the pedestrian approached. The fourth hypothesis is concerned with where the conflict occurred in relation to the duration of time which the pedestrian spends on the crossing. That is, the test is whether the conflict takes place in the pedestrians first lane of crossing or the last lane they cross. This is particularly relevant to those pilot project implementations which extended the length of the pedestrian green man light.

At lane 1 the number of conflicts occurring when the pedestrian was in their first lane of crossing was 4 in the before study and 6 in the after study. Tests showed that this was not a significant increase. At the same lane 21 conflicts were observed in the before study where pedestrians were in their second lane of crossing and in the after study the observed number of conflicts had reduced to 11. This reduction was found, using a one-tailed test, to be significant at a level of probability of .025. (Critical value was 1.960 and the z score was 2.29.) In summary the findings are that at lane 1 there was a significant reduction in the number of conflicts where the pedestrian was in their second lane of crossing.

At lane 4 there was a reduction between the before and after studies in the observed conflicts when the pedestrian was in the first lane of crossing from 6 to 3. The probability of this occurring was .09. The number of conflicts observed in the before study when the pedestrian was in the second lane of crossing in site 4 was 12 and in the after study 1. This was a significant reduction in observed events. (p=.0004.)

5 conflicts were recorded at lane 2 in the before study and 5 conflicts in the after study when the pedestrian was in their first lane of crossing. There was also no change in the number of conflicts involving pedestrians in their second lane of crossing; 10 conflicts were observed in both the before and after studies.

During the before study at lane 3, 11 conflicts were observed involving pedestrians in their first lane of crossing and 12 conflicts were observed in the after study. This was not a significant increase. There were 13 conflicts involving pedestrians in their second lane of crossing in the before study at site 3 and 16 in the after study. Once again this was not a significant increase.

In addition data was collected on the light phase at the time of the conflict. In the before study 9.8% of conflicts were recorded without the light phase being known and in the after study this figure was 18.8%. The total number of conflicts in the before study which occurred whilst the pedestrian light did not show a green man was 41 (50%) and in the after study this was 29 (45%).

Summary

The tests have shown that there was a significant reduction ($p=.025$) in the number of conflicts at the junction in Elefsina between the before and after studies. The reduction occurred on lane 1 ($p=.05$) and lane 4 ($p=.0005$). The reduction has in particular been for those conflicts involving pedestrians who are in their second lane of crossing at lane 1 ($p=.025$) and lane 4 ($p=.0004$).

Red Light Violations

Throughout the trial the number of vehicles on the main road which violated the red traffic signals was recorded. Comparing the totals on a "before" and "after basis showed there was no significant change.

In addition the number of pedestrians who also violated the red pedestrian light remained unchanged.

Pedestrian Movement and Delay

The mean pedestrian flow in the Western crossing (from Korinth) was 2.17 and 1.97 pedestrians/minute for the before and after situation respectively.

The waiting times for pedestrians arriving on red were:

Before : Mean 18.44 secs (s.d. 19.78)
After : Mean 17.02 secs (s.d. 13.09)

Pedestrians waiting longer than 10 secs : Before 52.3 %, After 63.1 %
Pedestrians waiting longer than 20 secs : Before 37.5 %, After 41.7 %
Pedestrians waiting longer than 30 secs : Before 28.4 %, After 17.9 %

Thus the only measurable improvement in waiting times for pedestrians was in the number that had to wait for a long time (more than 30 seconds)

4.1.3. Impacts on Traffic Efficiency

See Appendices F and G for more details

The mean queue length of private cars on the main road has been reduced from 6.7 to 5.9 and 3.7 to 3.3 between the before and after situations for the directions from Athens and Korinth respectively. The frequency of no private cars queuing has increased from 23 to 40 and from 25 to 65 for the two directions respectively.

The relative changes, before-after, for large vehicles are much less pronounced. However, the number of vehicles queuing may not be a good indicator due to the variation in flow levels. A second level of comparisons was made using the index: Vehicles Queuing / Total Vehicles passing, per cycle, vehicle category and direction.

As far as heavy vehicles are concerned (i.e. those commercially used) the before and after situations are the same (at the 0.05 conf. level). For private cars, from the direction of Korinth, again there is no difference observed. However, some difference has been detected for the direction from Athens.

There is a significant drop in the number of extensions to the side road green (-36.5%) between the before and after situations (over a 10 hr period). The drop in the total seconds of extension is much less pronounced (-13.6%) and the average length of extension has increased by 40% in the after condition. Aggregating the data for every 6 cycles shows no difference in the distribution of extensions throughout the day. However, the distribution of times of extensions throughout the 10 hr period is significantly different.

4.1.4 The role of user experience

The VRU-TOO pilot applications in Elefsina and also in Porto and Leeds, have shown that the deployment of pedestrian detectors have the potential to reduce pedestrian delay (along the routes served). Furthermore safety is improved as well as the reliability and comfort of pedestrian trips. Familiarity with, and experiencing of those changes may become important in pedestrian travel behaviour, since it may lead to learning. Familiarity with such changes, introduced into the traffic environment, may lead pedestrians to arrive at decisions on route choice which carry a higher utility than others (i.e. along 'safer', 'quicker' or more 'comfortable' routes). Such decisions are, however, unlikely to be made, if the factors, that the experiments influence (delay, safety, comfort), are irrelevant in the decision making process (route choice) of individuals or their magnitude is too small; resulting in the individual being unable or unwilling to learn from the changes introduced, and evaluate his/her decisions accordingly.

The scale of the VRU-TOO applications, as mentioned previously, is local thus resulting in a scale of benefits which is regarded as low in producing the necessary stimulus for learning. Thus directly questioning users on their actual behavioural changes was considered inadequate to produce any useful insights. In order to gauge possible effects it was regarded as more appropriate to trace individual attitudes at a preliminary level. The issue is to what extent are users prepared to change their current behaviour (route choice) in order to obtain safer and more comfortable crossing conditions. A survey was carried out in Elefsina where users were asked if they were prepared to walk longer in order to obtain safety and comfort benefits. The concept of safety was related to the existence of the signalised intersection and the 'comfort' variable was referred to walking conditions found in pedestrian precincts. More details are found in Appendix J. The broad conclusions of the analysis are presented here.
The route choice factors that are most important appear to be safety and comfort. Distance and Time are not so critical in this particular case probably due to the grid type structure of the road network. Accordingly people are prepared to walk some distance away from their chosen route in order to benefit from better safety and comfort conditions. As the distance increases fewer people are prepared to make the tradeoff. The provision of improved safety produces, comparatively, larger shift than comfort. The provision of both improvements together produces, predictably, larger comparative shifts. It should be noted that the scale of benefits indicated to the responders was significant (e.g. cross at the signal or have a good wide surface to walk). Such improvements are of a magnitude that can lead to learning and modification in route choice decisions. Consequently, if spot improvements are considered, they have to be of a significant scale (e.g. a new signal crossing). If only small improvements are considered, they have to be applied over a large network, so that their additive effects can lead to learning and adaptation of route choice behaviour.

4.2 PROBLEMS

The problems may be distinguished into 2 categories: practical problems in installation operation and problems inherent in the methods used.

Practical Problems

As far as practical problems are concerned they have been minimal. As mentioned previously there have been no problems in the actual installation in terms of compatibility of equipment. The procedure for pointing the detectors at the required area and removing all unwanted registrations was more difficult. Situational characteristics and conditions require some care when pointing the detectors. In the case of the Elefsina installation some problems were found with the leftmost detector position on the Western crossing. A large glazed surface opposite the detector was flexing when large vehicles passed and the 'movement' was picked by the detector. The detector was tilted towards the pavement and the unwanted signals disappeared. Also in the pedestrian profile work the detector had to be 'masked' by placing a piece of cardboard on its right side in order to eliminate vehicles from entering into the detection zone. (This was mainly due to the presence of a junction and hence turning traffic in the vicinity of the detector)

Problems of Methods Used

The main problem in the signal application concerns advanced detection of pedestrians. In the western crossing approaching pedestrians are registered but it is not known (it cannot be) if they intend to cross or will turn and continue along the main street sidewalk. From the point of view of an individual detector this may be a serious problem but not at the level of the whole intersection. For example such a 'false' reading from the Northern detector would have an impact on the intersection:

IF there is no vehicle demand from the side road AND
IF none of the two buttons has been pressed at the Eastern crossing AND
IF no pedestrian has been detected from the Southern detector AND
IF no pedestrians moving parallel at Iroon Polytehneiou Str. have pressed any of the two buttons at the Western crossing

ONLY then cars moving on the main street will be stopped for no reason.

The above conditions that correspond to very low levels of activity in the area (pedestrian and vehicle traffic), are regarded as unlikely to happen very often, at least not within the period of the signal operation (06.00 - 24.00). Therefore, at least in Elefsina, the problem is not considered important. Nevertheless the problem of detecting people who do not intend to cross may be important in other sites. It is for this reason that pre-installation feasibility trials are important to confirm that the site is suitable.

The Eastern crossing has no such problems with false detection. The detectors start to operate only when the main street traffic has been stopped and pedestrians start crossing. In addition, left turning vehicles pass parallel to the detector face and are not registered, as verified by field observations during installation.

It should be stressed at this point that the results of the pilot in terms of traffic impact, although encouraging, are not conclusive. The number and length of extensions, for example, was determined only from the Eastern crossing pedestrian demand. In widespread implementations both crossings would be controlled in the same manner. However, resource limitations did not permit fuller investigation by, for example, having both crossing points operate with extension of green while crossing (and doing before-after work) and then converting the intersection to advanced detection (and repeating the before-after measurements). Nevertheless the results provide a solid foundation for taking other steps for widespread diffusion of the techniques.

In the set up for counting pedestrians, there were also some 'false detection' They concern cyclists that were riding close to the carriageway edge and in some cases using the crossing due to the presence of automobiles etc. Difficult site conditions and the requirement to be fairly close to a power source made the choice of the point almost inevitable despite the 'false' readings.

4.3 DISCUSSION OF RESULTS

4.3.1. Pedestrian Profiles at Railway Crossing

The movement of pedestrians in Elefsina, as in most other urban areas, is characterised by the specific land use structure, the route limitations (crossings of railway line) and the times that the various activities operate. The level of traffic through the junction taken over all days can be considered light to medium. Pedestrian flow data covering many days (46 in our case) can be reduced to a few representative profiles for distinct periods within a day, as shown analytically in Appendix I. From these representative patterns it is possible to build typical daily profiles such as the one shown in Fig. 4. Prediction of pedestrian volumes in cases of special days or periods (e.g. Christmas, Summer holidays) would also be possible by picking the corresponding special block from a (computer) library and synthesising the daily pattern.

The method of data collection is simple and inexpensive. The data collected can provide valuable input in planning studies and signal control applications.

4.3.2. Signalised Intersection

The impacts measured and presented previously seem small. This is not unexpected due to the size of the pilot. The impacts are in general positive. There is a drop in conflicts, average waiting time for pedestrian and standard deviation of waiting times.

Queue lengths do not seem to be affected, with the probable exception of cars coming from the direction of Athens. However main street car traffic has benefited in terms of green time available. In particular commercially used vehicles have not been affected, in terms of queue lengths. For private cars, there is a significant drop in the frequency of zero queue lengths observed. There is however an increase in the length of the (fewer) extensions which affects the length of queues, particularly in the direction from Athens.

In general, over long periods in a day, main road traffic has benefited this, however does not hold for side road traffic (local traffic). The demand pattern in the before situation (in terms of length of extension demanded throughout the day) is entirely different from the after situation (where the length of extension is determined by the pedestrian demand). In terms of size, the impact is small due to the low traffic volume in the side road.

5 DISCUSSION OF IMPLICATIONS

5.1 IMPLICATIONS FOR PEDESTRIAN DETECTION EQUIPMENT

The detectors used are microwave vehicle detectors that have been modified, in terms of speed threshold, to account for the low speed of pedestrians. Their angle of view is limited to 30 degrees and this is typical for most manufacturers. However, if it is required to detect pedestrians approaching from all sides in a pelican-type crossing the cost of installation may rise substantially. This holds also in the case of a signalised intersection. The 30 degrees detection angle is sufficient for 'extension of green while crossing' applications. If the advanced detection for pedestrians ideas developed in this project gain wider adoption, it will be necessary for manufacturers to develop detectors with various angles of detection and range in order to reduce the total costs for installations. There is already evidence that manufacturers are taking the results of this trial on board in the development of the next generation of detectors.

Pedestrian detectors can also be used to count pedestrians for any period of time. Counting cannot be 100% accurate but, if sited carefully, the counts provide a major step forward in determining pedestrian movement profiles over extended periods of time. Thus the quality of data available for pedestrian movement may start to approximate that for vehicular traffic. However, some more development effort may be necessary if present day detectors are to be used for counting. Since, with present designs, detectors are always combined with signals there are no problems of power supply. However, for purposes of counting, the detectors must gain a measure of autonomy by being powered by batteries. It is also possible to combine the two uses by using the counting of pedestrians to affect the green time given to pedestrians.

5.2 IMPLICATIONS FOR SIGNALISED TRAFFIC CONTROL AT ISOLATED SITES

The combination of advanced detection with green extension would provide a major improvement for pedestrians, at isolated signal controlled sites. The effects on vehicular traffic are expected to vary, in general. As demonstrated in the pilot application it is possible to apply the pedestrian detection techniques with no measurable negative impact on vehicular traffic. Under certain circumstances the effects on vehicular traffic may be positive if, for example, a conventional installation provides for pedestrian green time based on the slowest possible pedestrian speed, the upgrading of the installation with detectors for green extension while crossing, will ensure that the amount of green given to pedestrians will match their various speeds. So when and only when needed will the longer green periods be used, ensuring over extended periods of time, a more efficient traffic stream.

5.3 IMPLICATIONS FOR SIGNAL TIMING SCHEMES

Signal timings at road junctions are generally optimised with respect to minimising vehicular delay. This outcome will reduce costs both to drivers in terms of reduced delay and lower fuel consumption and to the environment in terms of reduced congestion and less pollution. Pedestrian crossings on the other hand may increase vehicular delay and may therefore be seen to be in direct conflict with one of the major aims of most current traffic management schemes. The deployment of pedestrian detectors for advanced detection or green extension may also be seen to reinforce this conflict, particularly in cases of area traffic control systems. When, however, the optimisation is referred to persons instead of cars (private car occupants, bus passengers, pedestrians) a different situation emerges. There is still need to minimise the negative environmental consequences of car use (pollution, energy use) but, in terms of delay, car occupants, bus passengers and pedestrians should be treated alike. The increasing popularity of bus priority schemes reflects such considerations. Pedestrian priority at signals, as investigated in this project, and bus (or high occupancy vehicles) priority measures are akin in terms of philosophy and differ from measures that take as a reference point the vehicle. Comprehensive schemes aiming at person rather than vehicle, movement efficiency, can now include pedestrians directly. This may have an important impact on the form of such schemes and their effects.

5.4 IMPLICATIONS FOR THE DIFFUSION OF TECHNIQUES (MARKET POTENTIAL)

The procurement and installation of signals in Greece is currently done by the Ministry of Environment and Public Works. In identifying the market potential for intersection control that takes into account pedestrian demand it is necessary to identify cases of situations where this type of control is most appropriate. For example pelican-type crossings outside schools may benefit from the application both in terms of the advanced detection and in terms of green extension. More specifically the potential for green extension is seen as being more immediate, since it is implementable with the currently available detectors, either at pelican type crossings or at isolated signalised intersections. Under certain site specific conditions the advanced detection could also be deployed.

Taking into account the already expressed interest of the Ministry for green extension applications a copy of the projects final report will be supplied to the Ministry the aim being to include pedestrian detection capability in the specifications for all new pelican type crossings as a first step. The upgrading of already existing installations would be the second step and extension of the application to isolated signalised intersections the third. A carefully selected extended application covering a number of different situations is thought essential in order to fully realise the potential of the application in Greece.

In conclusion the market potential for pedestrian detection at isolated intersections will be a function of:

The launching of state administered pilot applications in particular classes of situations (schools, rail station crossings, crossings to/from major bus terminals or stops etc.).

The production of National standards for such crossings.

The results from other pedestrian detection trials

5.5 PLANNING IMPLICATIONS

As can be seen from the results of the present pilot, the maximum achievable improvement in an isolated spot may not be great. The results should also be viewed with the possible existence of thresholds in mind. In general it should be expected that the effectiveness of measures aimed at individual crossings are, inevitably, difficult to demonstrate statistically. Without doubt the wider the area of action the stronger the effects become.

The reasons for the above are not just statistical. Area-wide schemes are more likely to arise from an awareness of area rather than spot problems and are more likely to be based on comprehensive planning with area effects in mind. The deployment of the techniques investigated in the present project in area wide schemes, may provide an important aid to planning for environmental improvements for pedestrians. Both the monitoring and control capabilities would be useful. For example the concepts for pedestrian dedicated networks in cities (Ramsay, 1990) can usefully deploy the techniques in the present project rather than provide for under or over passes which, in many central areas, are difficult to construct. The techniques can also be used to tackle the centre-arterial interface problem which has been identified as the most serious safety problem (not only for pedestrians) in centre planning (Brindle, 1984).

6 CONCLUSIONS

The work undertaken in the pilot project in Elefsina has demonstrated:

The usefulness of microwave detection technology for collecting data on pedestrian flows. Furthermore it has demonstrated that such data are amenable to similar analysis as vehicle traffic data and it is possible to arrive at typical profiles of pedestrian movement for long periods of time. There is thus the potential for future traffic schemes to be based on pedestrian flow data of acceptable quality and close the quality gap that exists between vehicle traffic data and pedestrian traffic. Monitoring of pedestrian demand is also possible.

The deployment of microwave detectors in Greece has been straightforward with no problems in terms of the particular installation practices followed. The detectors have proved to be durable and reliable in terms of detecting pedestrians.

Microwave detectors can be deployed in such a way as to have minimal adverse effects on vehicular movement.

There appears to be significant safety benefits in the deployment of pedestrian microwave detectors at intersections.

There appears to be benefits in terms of reducing pedestrian delay. Those results are relatively small in magnitude for an isolated junction.

In situations of light to medium pedestrian flows extension of green time for pedestrians may bring overall traffic benefits, by more productive use of the time-space available at a crossing or intersection.

The capabilities of detectors to count pedestrians and the possible ways to control signalised intersections that are opened up, may have an important part to play in modifying current practice in signalisation improvement schemes. Some more development work is required by manufactures to fully realize the potential.

7 REFERENCES

Bovy, P.H.L., Stern, E. (1989). Route Choice : Wayfinding in Transport Networks. Kluwer Academic Publishers.

Brindle R.E. (1984). Town Planning and Road Safety. ARRB, Special Report CR 33, Victoria

CORD Consortium (1993). Recommended Definitions of ATT Subfunctions, Functions and Areas. Deliverable D003 - Part 6. CEC DRIVE II Programme. Brussels.

Ramsay A. (1990). A Systematic Approach to the Planning of Urban Networks. In Tolley R. (Ed.) 'The Greening of Urban Transport'. Belhaven Press, London.

Sherborne D. (1992). Existing Techniques for Detecting Vulnerable Road Users. V2005 Deliverable 4. West Yorkshire Highways, Engineering and Technical Services.

Tillis A. (1992). Details of Existing Site in Greece. V2005 Deliverable 2, TRENDS

APPENDIX A

The Traffic Policy of the Municipality of Elefsina

APPENDIX A: THE TRAFFIC POLICY OF THE MUNICIPALITY OF ELEFSINA

The municipality has a long standing commitment to improve conditions for vulnerable road users - cyclists and pedestrians in particular. In addition a major environmental objective is to shift through traffic from using the old intercity route running through the city to the existing bypass (which implies longer routes for vehicles). The traffic policies of the Municipality have been explained in a previous deliverable (Tillis, 1992). [1]

Given that the city possesses pedestrian accessibility, due to its size and the concentration of land uses, the city authorities have pursued the issue of enhancing pedestrian amenities through the provision of pedestrian facilities particularly the pedestrianisation of streets. Pedestrianized streets increase the comfort of walking but, in Elefsina at least, the reliability and safety of a pedestrian trip will still be hampered by the need to cross the old intercity arterial which still has high traffic volumes. At the same time traditional static traffic calming solutions could not be applied to the street for a variety of institutional and practical reasons. The municipality has been considering the issue of putting signals along the street that would serve the twin aims of increasing the safety and reliability of pedestrian trips and introducing a disincentive (delays) for through traffic. The capabilities of pedestrian detector equipped junctions to aid in its policies and the importance attached to such facilities by the public, as compared with fully pedestrianized streets would be a major determinant of the future allocation of funds for the implementation of the policy. In addition, the overall scheme includes the placement of two "Variable Message" Signs at the city entrances to inform approaching drivers of the delays to be expected, if they decide to travel through the city instead of using the bypass.

The amount of delay imposed to through traffic may vary throughout the day, depending on the general pedestrian activity (as established, for example, from the pedestrian profiles, see Appendix I). Thus, for periods of the day when pedestrian demand is low, no penalty will be imposed on through traffic.

The full implementation of this policy will, however, not be forthcoming in the foreseeable future due to the lack of funds.

APPENDIX B

Collection of Pedestrian Flow Data

B.1. Location and Method

B.2. Results

APPENDIX B: COLLECTION OF PEDESTRIAN FLOW DATA

B.1. LOCATION AND METHOD

The data were collected using a MICROSENSE microwave detector, adjusted in terms of speed threshold for pedestrians, connected to a GK 4000 traffic counter. The traffic counter was supplied by HETS suitably modified to receive input from the microwave detector. The detectors and counter were installed at the railway junction upstream of the experimental site. See Fig 1. The installation at the Railway crossing is shown in the Fig B.1 that follows.

The location chosen, is one of the two major Railway crossings in the city and the data collected can provide a very good first approximation on the general level of pedestrian activity for the whole city. Due to the limited resources available for this experiment it was not possible to count both directions.

One detector was installed in order to count the pedestrians walking towards the city centre. The geometrics of the situation were such that cars, cyclists etc. could also be counted and so it was decided to 'mask' the detector by placing a hard board on its right side. The memory of the counter did not seem to be sufficient for this type of application requiring frequent visits to download data and in future trials other types of counters may be more appropriate.

The data set has covered the period October - November 1993. Measurements were also continued in December but some unexpected results were obtained (no pedestrian traffic for 3-4 hrs at midday for a few days). Therefore those measurements were totally discarded. Unfortunately during the months October-December 93 there were severe regional power supply problems resulting in voltage drops during certain periods of the day. Thus many days had to be discarded since there were complete blocks of hours missing. The final data set consists of the days shown in Table B.1.

In order to investigate the accuracy of the readings, manual counts were performed. A total of 60, 5min periods were covered by the manual counts - 10 correspond to an evening count (17.45 - 18.30) and the remaining are morning period counts (8.50 - 9.45, 9.40 - 10.35, 10.40 - 11.30, 10.25 - 11.00, 8.50 - 9.45). The comparison between observed and detected numbers of pedestrians is analysed below. It should be noted that the detector counts a group of people walking together as one reading and the observer on site has attempted to follow this logic as well. This means that actual number of pedestrians may be higher than represented by the detector readings or the manual observations. In addition, it was observed that cyclists may frequently verge into the detection zone.

Fig. B.1.

POSITION OF DETECTOR AND COUNTER

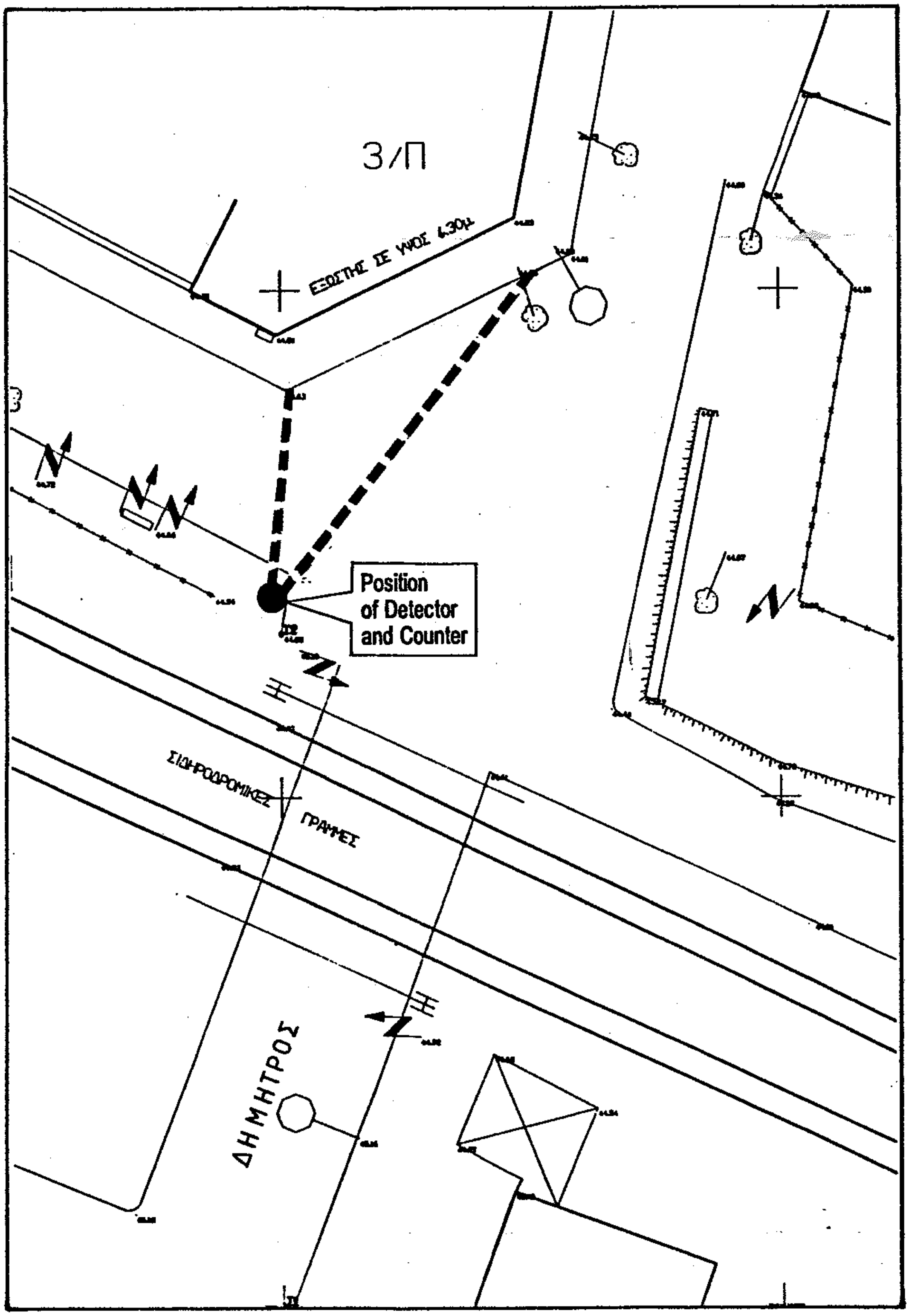


Table B.1: Calendar of measurements

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
			OCTOBER 93			
			6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31			**NOVEMBER 93**			
					5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	

Numbers in **bold** represent dates on which measurements were taken.

B.2. RESULTS

The results of the comparison are presented in the following pages. There is about 20% difference between observer and detector readings. The addition of cycles seems to improve the match slightly. Given that the observer had to "guess" the detector readings in cases of people walking in groups and/or cycles verging in the detector field, the results seem adequate.

Microwave detectors for pedestrians, when properly installed and in situations where the influence of other traffic and factors is minimised (e.g. an underpass or overpass), would provide a very good approximation of the actual number of pedestrians. With such data in hand, long term pedestrian profiles can be built and used for predictions as shown in Appendix I.

The data thus collected may be used to built long term pedestrian profiles that can, it turn, serve as an important input to planning and traffic signalization schemes. The analytical procedures used to develop one directional profile in the case of Elefsina are contained in Appendix I.

Table B.2: Paired Comparisons between observer and machine counts

A. Descriptive Statistics

Variable	N	Mean	Std Dev.	Avg Devn
MM	60	9.116	4.088	3.273
MO	60	6.633	3.262	2.730
MC	60	7.916	3.688	3.042
MM-MO	60	2.483	1.808	1.515
MM-MC	60	1.200	1.665	1.300

B. Test Statistics

Null hypothesis: mean difference = 0.00

Spearman Rank Correlation

	R	P
MM-MO	0.8846	0.000
MM-MC	0.8963	0.000

Null hypothesis: median of pop differences = 0.00

Wilcoxon Matched Pairs Test

	Test Value	P-Value
MM-MO	1.500	0.000
MM-MC	117.000	0.000

MM = Pedestrians Recorded by detector
MO = Pedestrians Recorded by observer
MC = Pedestrians and Cyclists recorded by observer

Regression
MO = 0.065 + 0.721 * MM
r = 0.9029
(see Fig. B.2)

CLE = 0.405 + 0.824 * MM
r = 0.913
(see Fig. B.3)

Fig.B.2: No of Pedestrians Recorded
Detector vs Observer

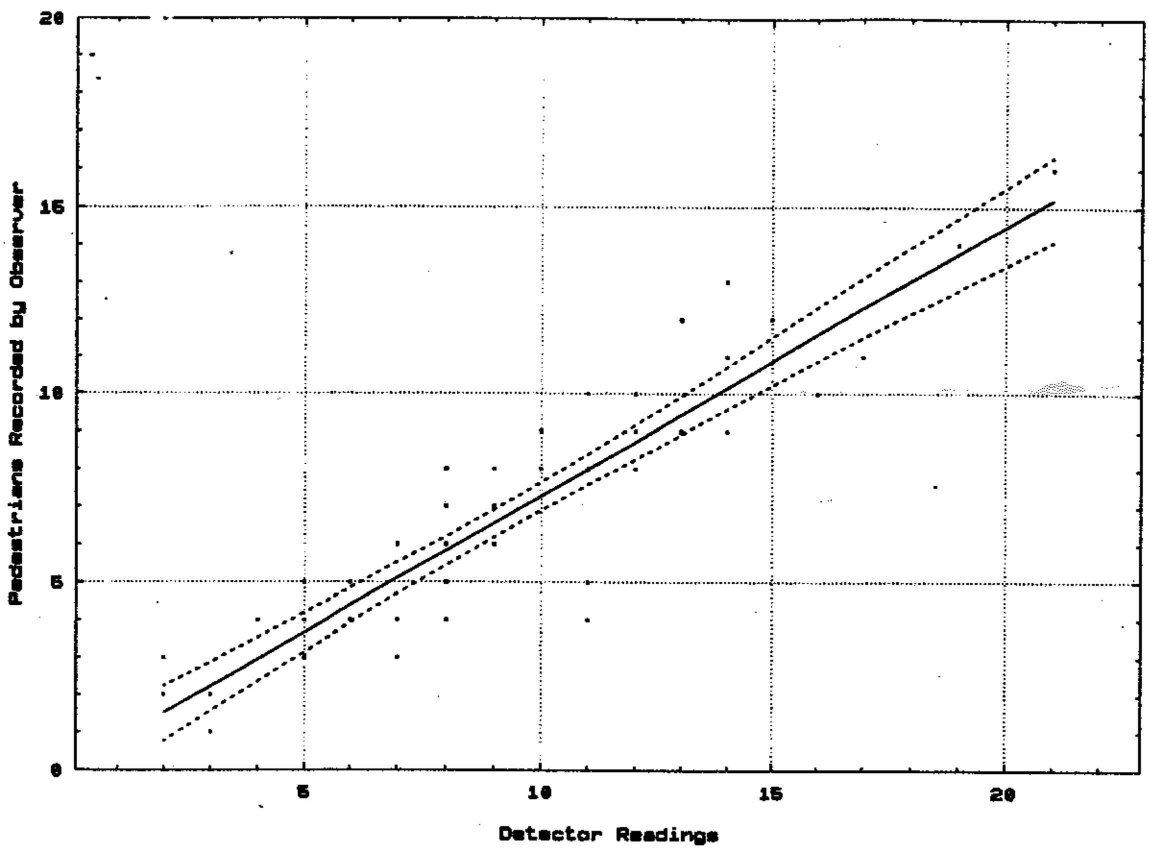
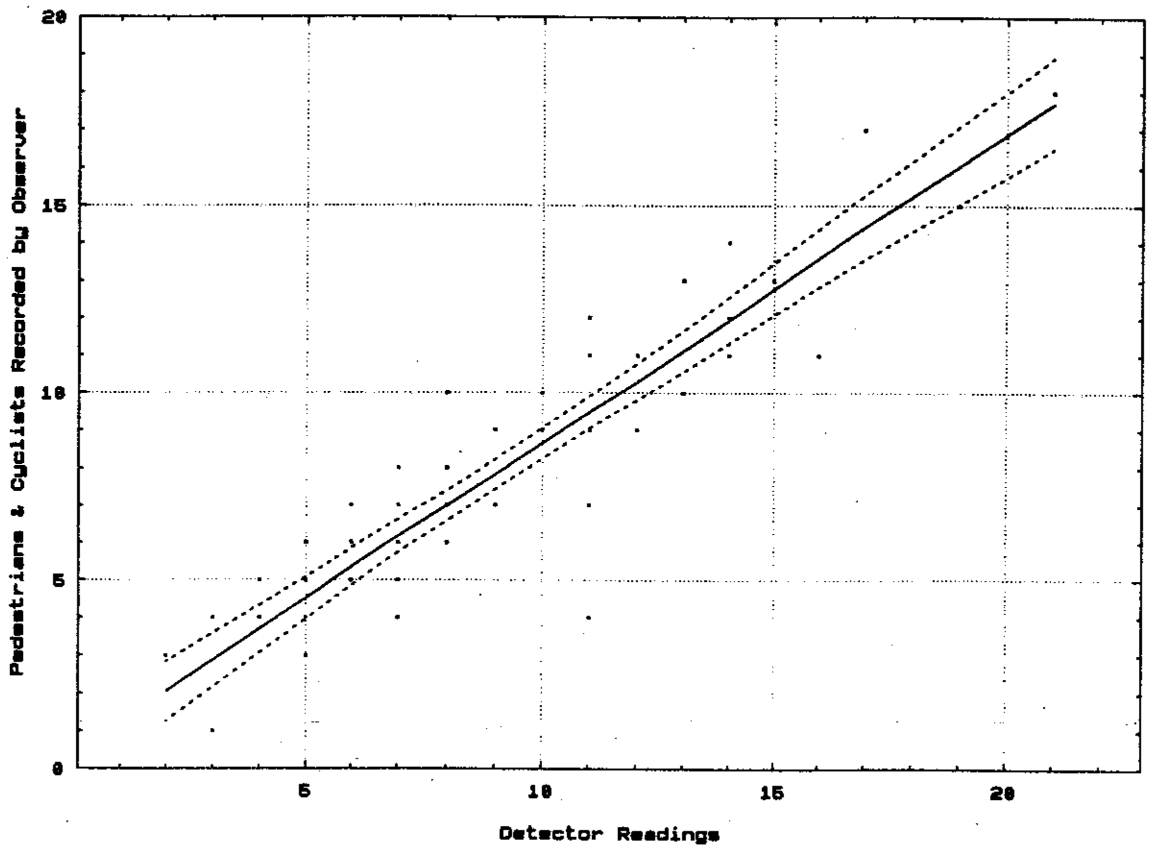


Fig.B.3: No of Pedestrians & Cyclists Recorded
Detector vs Observer



APPENDIX C

Equipment Details

C.1. Signal Controller

C.2. Microwave Detector

C.1. SIGNAL CONTROLLER

1. TRAFFIC-ACTUATED FUNCTIONS

1.1. Foreword

The complete description of the controllers M32 and MQ Version A70 consist of three parts, which are obtainable separately

- Part 1: Introduction, scope of application, operation, technical concept, installation and maintainance (Order No. A24705-A586-*-7604 for M32, A24705-X-A516-*-7604 for MQ)
- Part 2: Instructions for input of traffic engineering data (Order No. A24705-X-A585-*-7604 for M32 and MQ)
- Part 3: Data input language MASMO for traffic-actuated control (Order No. A24705-X-A563-*-04 for M32 and MQ).

For reasons of clarity and on account of the large volume of material, the complete subject of data input is divided into two parts (Part 2 and Part 3). Part 2 contains, amongst other things, the following data input information:

- Basic data input
- Signal plans for local mode
- Coordinated control
- Centralized control

Operating instructions for loading the data memory and general information on data input are also contained in Part 2 and are therefore not repeated in the present volume, Part 3. The input of data for traffic-actuated control is explained specifically in this document.

1.2. General

The M32/MQ controller contains a microcomputer which permits the traffic-acutated mode of operation of the controller to be preset and implemented in the form of a process-oriented program (data input). This program for traffic-actuated operation is written in a relatively simple, easily readable and easy-to-learn data input language, the MASMO*) language, and links the messages and traffic data from the contacts and detectors to the appropriate commands for the relevant signal groups on the basis of the decision for optimization logic formulated in the program. Traffic data collection and editing, execution of the decision logic and setting the signal group statuses are performed in real-time mode, i.e. decisions on the basis of the preset traffic-actuated operations and their technical effects upon signals are always made at the correct time (second), regardless of the internal, temporal nesting of the program sections of the operating system in the processor. The minimum signalling reaction time to an incoming message is less than one second.

Timing of the program run of the operating system in the processor is controlled by means of external clock pulse generators (ZEISIG transmission system from the control room, radio clock, mains frequency or similar). Program loops which are run following a 20 ms cycle and 100 ms cycle are provided for traffic data collection and editing. The traffic-actuated decisions and settings of the corresponding signal group statuses are carried out following a second rhythm. Longer timing cycles (e.g. 60 second clock for signal plan selection) must be generated by means of appropriately small MASMO program sections on the basis of this second clock cycle.

*) MASMO = M32 controller adaptive signal plan modification

From the point of view of control, anything which can be formulated in the MASMO language can be implemented with the M32/MQ controller, i.e. all conventional, previously known control methods. However, over and above this, the M32/MQ controller can also be used to implement completely new methods, optimization methods with complex traffic data editing etc. The small, incomplete selection of possible control modes is listed below:

- Demands with various priorities and any combinations of these demands with or without cancellations (priority to public transport, fire department, emergency service vehicles, trams and trains etc.).
- Traffic-actuated apportionment of green times for signal groups and stages on the basis of various methods (gaps, detector occupancy, waiting times etc).
- Centralized and local stage control (stage selection), fully traffic-actuated, semi-traffic-actuated, fixed-time control, with any number of stages and any number of stage sequences and combinations (sometimes also termed signal plan generation).
- Local signal group control, fully traffic-actuated (stage generation), semi-traffic-actuated.
- Centralized signal group control with local traffic-actuated operations of an extremely varied type.
- Centralized synchronization with call of the signal plan and local traffic-actuated operations of an extremely varied type.
- Local optimization of signal control on the basis of waiting time, traffic density, etc.
- Green time apportionment on the basis of the number of vehicles which have arrived during red.
- All-red systems or immediate-green systems.
- Signal group control with decentralized modification (SDM), for further details, refer to Appendix.
- Speed acquisition on motorways and control of entrances (queue warning systems, alternating traffic signs).

There are substantial differences between the possible methods as regards the work involved and thus, the costs of implementing a control method. Within certain limits, standardized MASMO input programs are available for methods which are used and required relatively frequently. These programs need to be compiled (relatively simply) from ready modules and the parameters entered (refer to Enclosure 12).

Naturally, the time and effort required for compiling an input program of this type is substantially less than that for implementing a completely new control method which must be written specifically in MASMO language instruction by instruction, and which must then, finally, be carefully tested. The cost of a "one-off" or initial input of this type may be quite considerable and must be added to the basic price of a controller

1.3. Interrelationship of the MASMO functions and the other functions in the M32/MQ controller

Embedding of the MASMO section in the remaining functional structure of the M32 controller is illustrated in Enclosure 10. It provides an overview of how statuses and values can be tested and interrogated or changed and influenced in specific areas (lists) of the data memory (RAM). The contents of the data memory are represented either as wavy or rectangular bit-structured boxes. The actual basic operating system of the controller is contained in the so-called program memory (ROM), the contents of which cannot be changed during the program run. Functions contained in the program memory are represented by means of rectangular boxes which specify the relevant program name or the functions.

C.2. MICROWAVE DETECTOR

2. *SPECIFICATIONS*

Detection Zone

When correctly installed, the initial detection point for normally encountered motor powered road vehicles will usually be in the range of 40 to 60 metres from the stopline. The width of the beam is such that detection is possible across two normal lanes of traffic.

Supply

Three versions are available:

1. 192 - 276 Volts AC @ less than 25W
2. 88 - 127 Volts AC @ less than 25W
3. 24 ± 20% Volts AC/DC @ less than 300mA

Note - AMD-T versions are only available in 110V AC and 24V AC/DC.

ADD versions are only available in 24V AC/DC.

Output

Failsafe relay, contacts 250V

A daylight visible LED is illuminated while a detect signal is present.

Mechanical

Case material	-	Stainless steel, plastic powder coated
Window	-	Ultra violet stabilized, rigid PVC
Dimensions	-	232mm x 108mm x 154mm (excluding glands, cable and mounting bracket)
Weight	-	3.4kg including Microsense stainless steel mounting bracket

General

Transmitter Frequency	-	10587 ± 10 MHz
Output Power	-	Less than 15dBm
Speed Threshold	-	AMD-T = 2.5 mph AMD/ADD = 5.0 mph

Operating temperature range: -30°C to +70°C

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3. *OPTIONS*

Apart from the three standard power supply variations there are also three options available. (See section 4 for details of order codes).

Option "P" is an RF output power monitor. This is designed to give the customer confidence that their microwave detector unit is continuing to perform to specification over a period of time. In the event of a gradual decay in transmitter output to a level where performance may start to be affected, or on complete failure of the transmitter apparatus, a permanent output will be generated. This can then be sensed in the traffic controller by the detector fault monitor in the usual way. This feature is fitted as standard to the ADD, but is an optional extra on other versions.

Option "N" is a circuit that will cause the detector unit to generate a 0.5 second output pulse every 2.5 minutes in the absence of vehicle generated detections.

The AMD-T contains modified circuitry that automatically includes the option "N" (nudge circuit) and also incorporates a reduced speed detection threshold of 2.5 mph. In addition, all AMD-T detectors have a single cable and no connector.

4. *EQUIPMENT DESCRIPTION*

The equipment label can be found on the rear of the detector case. The unit type information given is as detailed below:-

e.g. AMD-R-24-PN

AMD: Equipment

R: Output

24: Supply Voltage

PN: Options

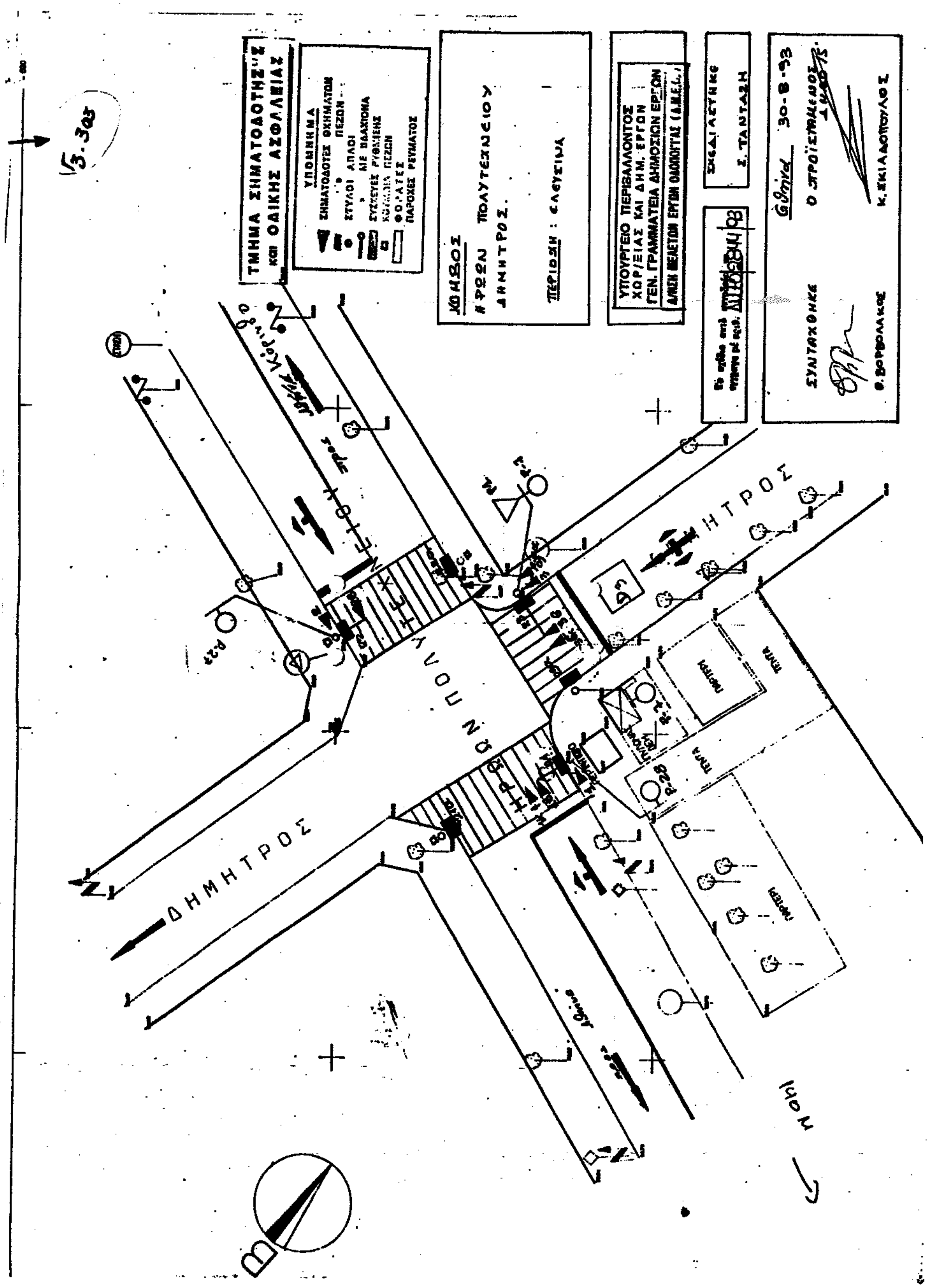
APPENDIX D

Signalisation Plans

Fig. D.1. General Layout Plan

Table D.1. Programme 1 (Before)

Table D.2. Programme 2 (After)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ΥΠΟΜΝΗΜΑ
ΚΟΜΒΟΣ
ΠΟΛΥΤΕΧΝΕΙΟΥ
ΔΗΜΗΤΡΟΣ
ΠΕΡΙΟΧΗ : ΕΛΕΥΣΙΝΑ
ΥΠΟΥΡΓΕΙΟ ΠΕΡΙΒΑΛΛΟΝΤΟΣ
ΧΩΡ/ΞΙΑΣ ΚΑΙ ΔΗΜ. ΕΡΓΩΝ
ΓΕΝ. ΓΡΑΜΜΑΤΕΙΑ ΔΗΜΟΣΙΩΝ ΕΡΓΩΝ
ΣΧΕΔΙΑΣΤΗΚΕ
Σ. ΤΑΝΤΑΣΗ
30-8-93
ΣΥΝΤΑΧΘΗΚΕ
Θ. ΒΟΡΒΟΛΑΚΟΣ
Ο ΠΡΟΪΣΤΑΜΕΝΟΣ
Κ. ΣΚΙΑΔΟΠΟΥΛΟΣ
ΠΟΛΥΤΕΧΝΕΙΟΥ
ΔΗΜΗΤΡΟΣ
ΔΗΜΗΤΡΟΣ

ΠΡΟΓΡΑΜΜΑ ΛΕΙΤΟΥΡΓΙΑΣ ΦΩΤΕΙΝΗΣ ΣΗΜΑΤΟΔΟΤΗΣΗΣ

(Με επενέργεια από την κυκλοφορία)

α/α	Νο Σηματοδότη	Μέγιστο πράσινο αρχή-τέλος	Ελάχιστο πράσινο αρχή-τέλος	Μέγιστη διάρκεια	Ελάχιστη διάρκεια	χρονικό διάκενο (gap)
1	1-16	Θ.Α	0-57	Θ.Α	57	
2	2-28	Θ.Α	0-57	Θ.Α	57	
3	3-36	61-76	61-71	15	10	3sec
4	21-210	–	61-68	–	7	
5	22-220	–	61-68	–	7	
6	23-230	–	79-56	–	57	
7	1k	0-57	0-57	59	57	
8	3k-36k	61-76	61-71	15	10	
9						
10	3-36	3k,36k				
11						
12						
13						
14						
15						
16						
17						
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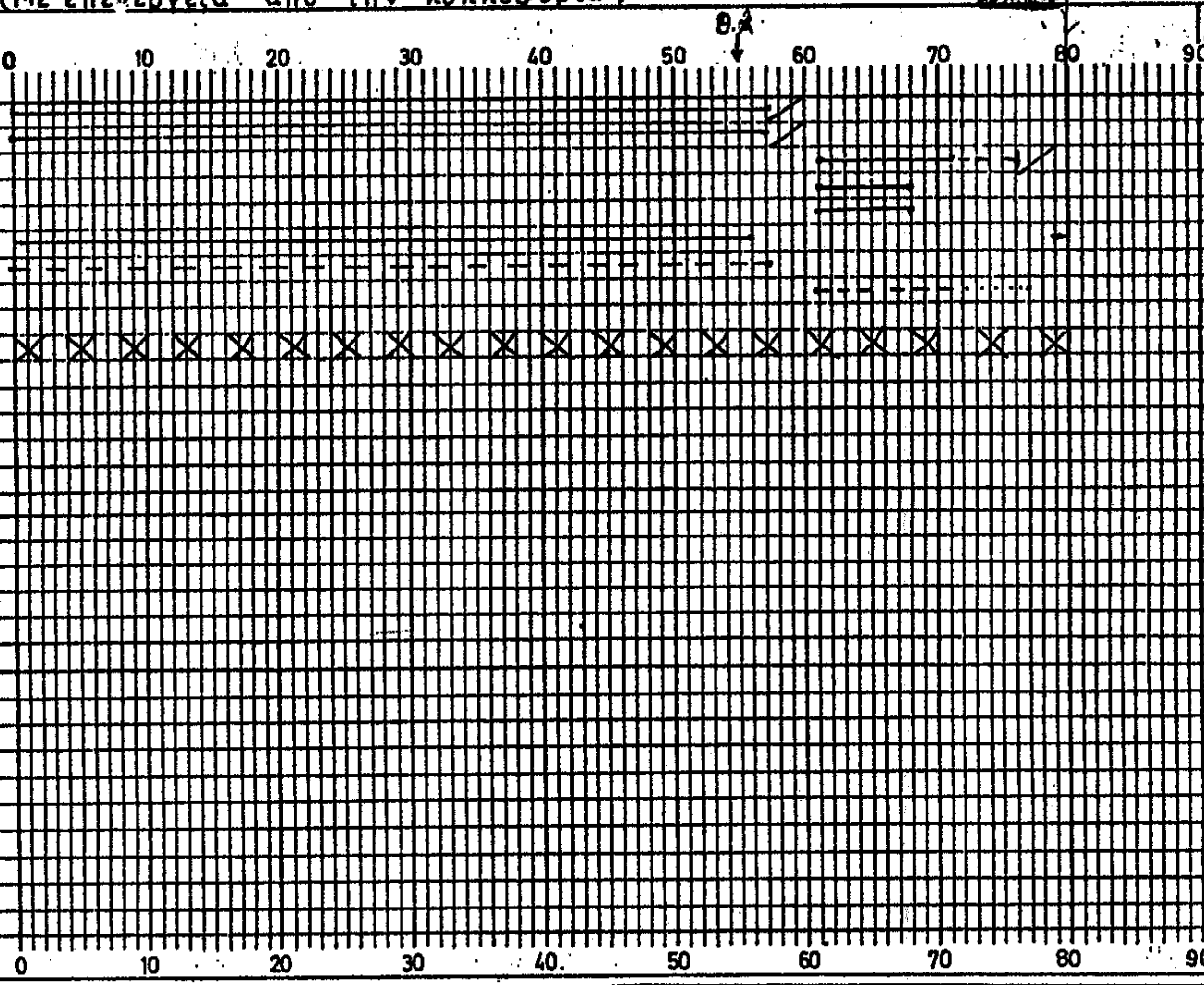


ΥΠΟΥΡΓΕΙΟ ΠΕΡΙΒΑΛΛΟΝΤΟΣ
ΧΩΡ/ΞΙΑΣ ΚΑΙ ΔΗΜ. ΕΡΓΩΝ
ΓΕΝ. ΓΡΑΜΜΑΤΕΙΑ ΔΗΜ. ΕΡΓΩΝ
Δ/ΝΣΗ ΜΕΛΕΤΩΝ ΕΡΓΩΝ ΟΔΟΠΟΙΙΑΣ (Δ.Μ.Ε.Ο)
ΤΜΗΜΑ ΣΗΜΑΤΟΔΟΤΗΣΗΣ ΟΔΙΚΗΣ ΑΣΦΑΛΕΙΑΣ

ΚΟΜΒΟΣ
ΗΡ. ΠΟΛΥΤΕΧΝΕΙΟΥ – ΔΗΜΗΤΡΟΣ
ΠΕΡΙΟΧΗ: ΕΛΕΥΣΙΝΑ
ΠΡΟΓΡΑΜΜΑ
ΩΡΕΣ ΛΕΙΤΟΥΡΓΙΑΣ: Από 6:00 το πρωί μέχρι 24.00

ΣΥΝΤΑΧΘΗΚΕ
Θ. ΒΟΖΒΟΛΑΚΟΣ

Αθήνα 31-8-93
Ο ΠΡΟΪΣΤΑΜΕΝΟΣ Δ.Μ.Ε.Ο/Σ
Κ. Σ. ΚΙΑΔΟΠΟΥΛΟΣ

ΔΜΕΟ/2844/93/Γ3.303

ΠΙΝΑΚΑΣ ΕΝΔΙΑΜΕΣΩΝ ΧΡΟΝΩΝ

ΕΚΚΙΝΗΣΗ

ΕΚΚΕΝΩΣΗ	1-1β	2-2β	3-3β	21-21a	22-22a	23-23a											
1-1β		–	4	3	4	–											
2-2β	–		3	4	3	–											
3-3β	3	4		–	–	3											
21-21a	7	6	–		–	–											
22-22a	6	7	–	–		–											
23-23a	–	–	5	–	–												

ΥΠΟΥΡΓΕΙΟ ΠΕΡΙΒΑΛΛΟΝΤΟΣ
ΧΩΡ/ΞΙΑΣ ΚΑΙ ΔΗΜ ΕΡΓΩΝ
ΓΕΝ. ΓΡΑΜΜΑΤΕΙΑ ΔΗΜ. ΕΡΓΩΝ

Δ/ΝΣΗ ΜΕΛΕΤΩΝ ΕΡΓΩΝ
ΟΔΟΠΟΙΪΑΣ (Δ.Μ.Ε.Ο)

ΤΜΗΜΑ ΣΗΜΑΤΟΔΟΤΗΣΗΣ
Κ' ΟΔΙΚΗΣ ΑΣΦΑΛΕΙΑΣ

ΚΟΜΒΟΣ

ΗΡ. ΠΟΛΥΤΕΧΝΕΙΟΥ - ΔΗΜΗΤΡΟΣ

ΠΕΡΙΟΧΗ: ΕΛΕΥΣΙΝΑ

ΔΜΕΟ/2844/93/Γ3.303

Αθήνα 31-8-93

ΣΥΝΤΑΧΘΗΚΕ

Θ. ΒΟΡΒΟΛΑΚΟΣ

Ο ΠΡΟΪΣΤΑΜΕΝΟΣ ΔΜΕΟ/5

Κ. ΣΚΙΑΔΟΠΟΥΛΟΣ

APPENDIX E

Workplan for the Elefsina Pilot,

Data Collection and Analysis

APPENDIX E: WORKPLAN FOR THE ELEFSINA PILOT, DATA COLLECTION AND ANALYSIS

WORK ORDER	TASK DESCRIPTION	PARTNER
1	Install Detector and Counter for Pedestrian Profiles	TRENDS/HETS
2	Data Collection on Pedestrian Flows	TRENDS
3	Install Signals	TRENDS/MUNICIPALITY/MINISTRY
4	Analyse pedestrian Profiles	TRENDS
5	Ship & Install Video in Elefsina	TRC
6	Elefsina before Video Data	TRC/ITS
7	Elefsina before Queue Lengths Data	TRENDS
8	Elefsina before Conflict data	ITS
9	Ship Video: Elefsina to TRC(NL)	TRENDS/TRC
10	Analyse Elefsina before Data	ITS
11	Install detectors in Elefsina	TRENDS
12	Enter Elefsina before Video Data	TRC
13	Ship & Install Video in Elefsina	TRC
14	Elefsina after Video Data	TRC/ITS
15	Elefsina after Queue Length Data	TRENDS
16	Elefsina after Conflict data	ITS
17	Ship Video: Elefsina to TRC(NL)	TRENDS/TRC
18	Entry of Elefsina after Video Data	TRC
19	Analyse Elefsina after Video Data	TRC
20	Analyse Elefsina after Conflict Data	ITS
21	Collection of Data on Green Extensions	TRENDS
22	Draft Elefsina Pilot Project Report	TRENDS
23	Survey of Users response to Information Supplied	TRENDS
24	Final Submission of Report	HETS

APPENDIX F

Effects of Pedestrian Detector Operation on Main Road Queue Lengths

F.1. Introduction

F.2. Effects on Queue Lengths

APPENDIX F: EFFECTS OF PEDESTRIAN DETECTOR OPERATION ON MAIN ROAD QUEUE LENGTHS

F.1. INTRODUCTION

In order to investigate possible negative consequences of pedestrian detector controlled intersection, on the efficiency of traffic flow, queue length measurements were conducted both for the before and after situations.

The data were collected simultaneously with the video recordings for the Behavioural Studies 4 work package, and for 1 hour each day (9-10, 10-11, 11-12, 12-13, 13-14) separately for each direction and for two vehicle categories: small (mainly private cars) and large (trucks and buses) both for the before and after situations.

F.2. EFFECTS ON QUEUE LENGTHS

Examining firstly the number of vehicles in the queues before and after, the results are inconclusive.

In Table F.1 some basic statistics are presented. The frequencies of observing a given length of queue (in number of vehicles) are shown in the Figures that follow.

As far as the direction from Athens (Fig. F.1) for private cars there appears to be a significant difference in the before-after situation particularly evident in the zero queue value. Zero queues are also more frequently observed for vehicles travelling in the direction of Korinth. (Fig. F.2).

In contrast for heavy vehicles for both directions the before (after queue lengths follow the same pattern (Figs F.3 and F.4).

Fig.F1: Private Cars from Athens
Frequencies of Queue Lengths before and after

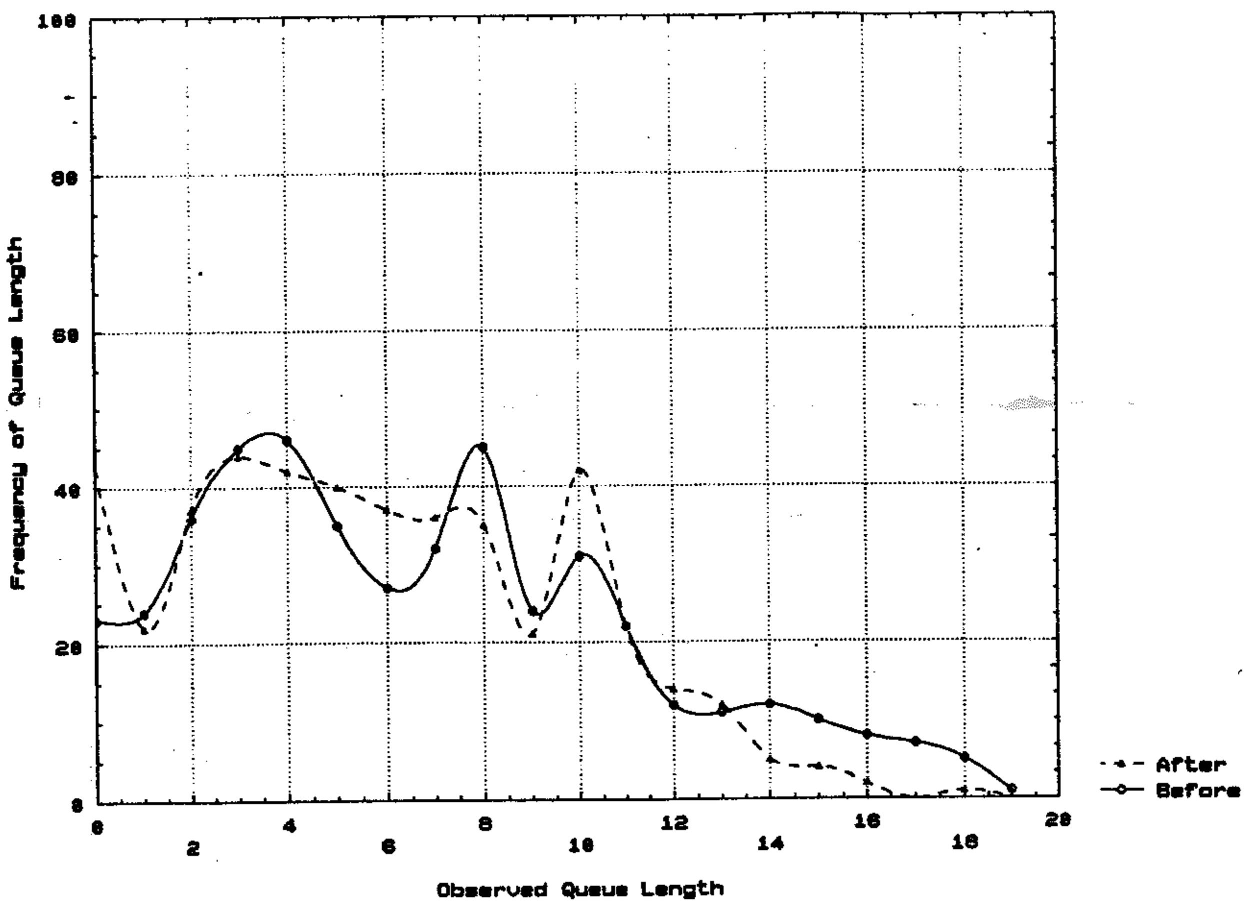


Fig.F2: Private Cars from Korinth
Frequencies of Queue Lengths before and after

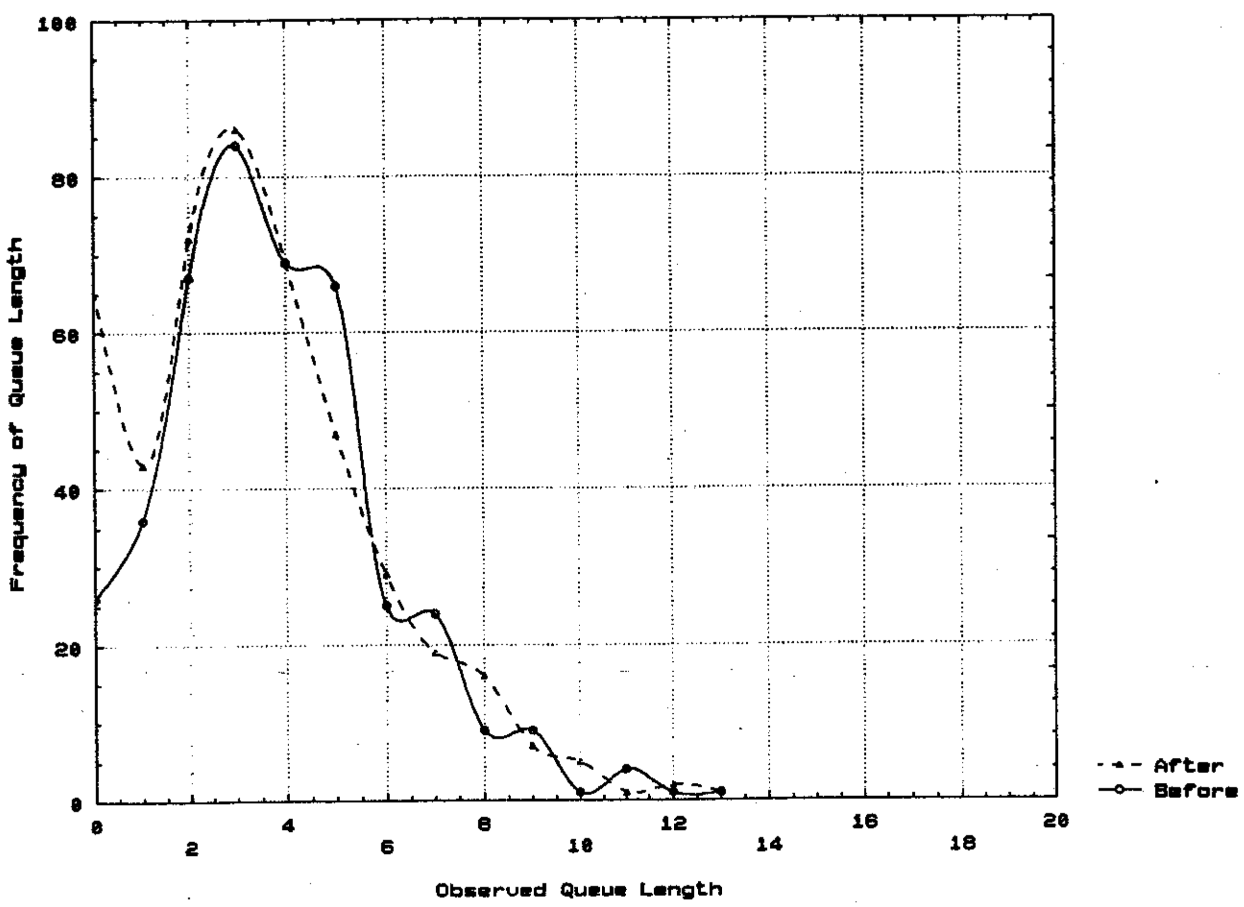


Fig.F3: Large Vehicles from Athens
Frequencies of Queue Lengths before and after

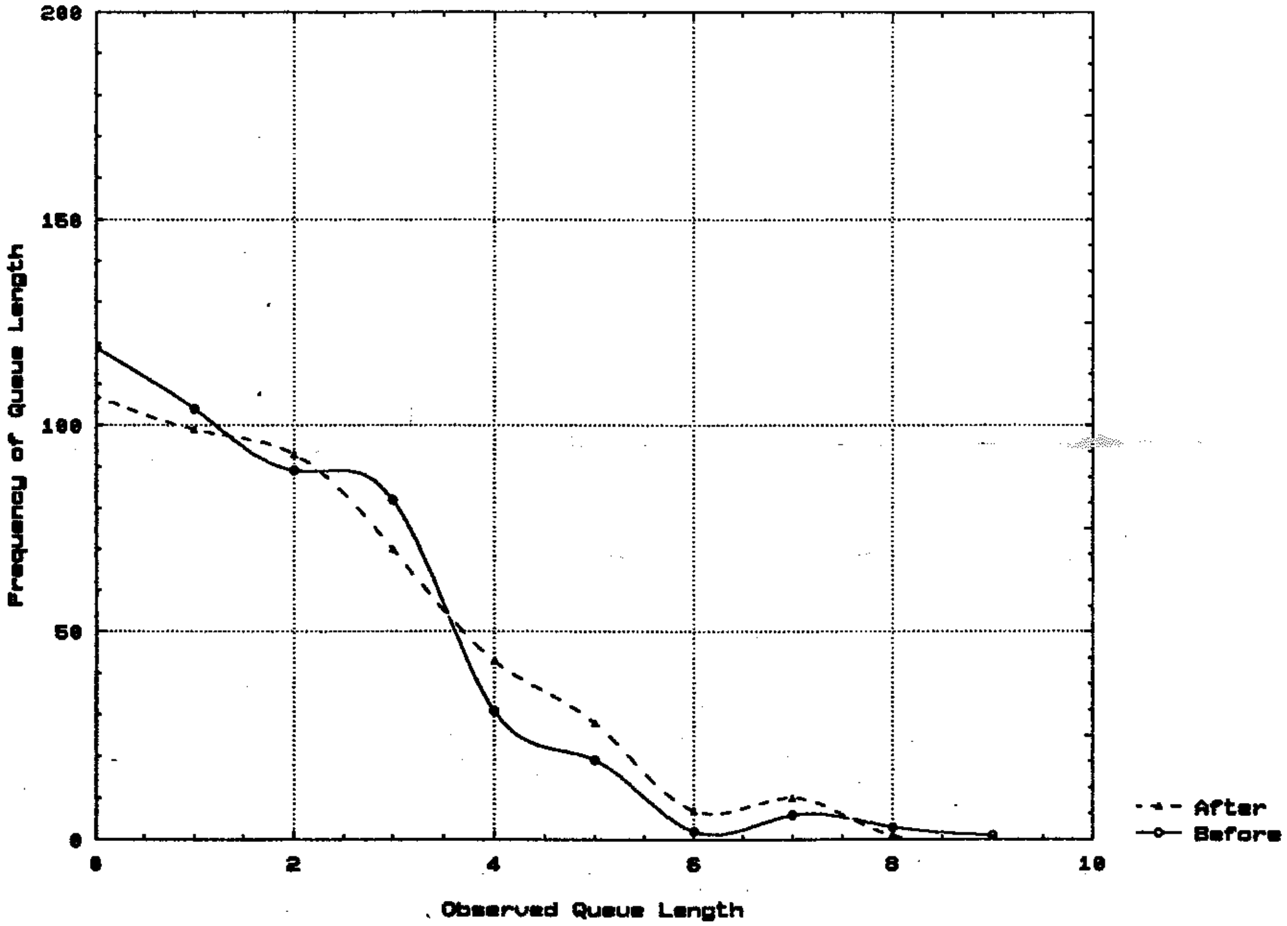
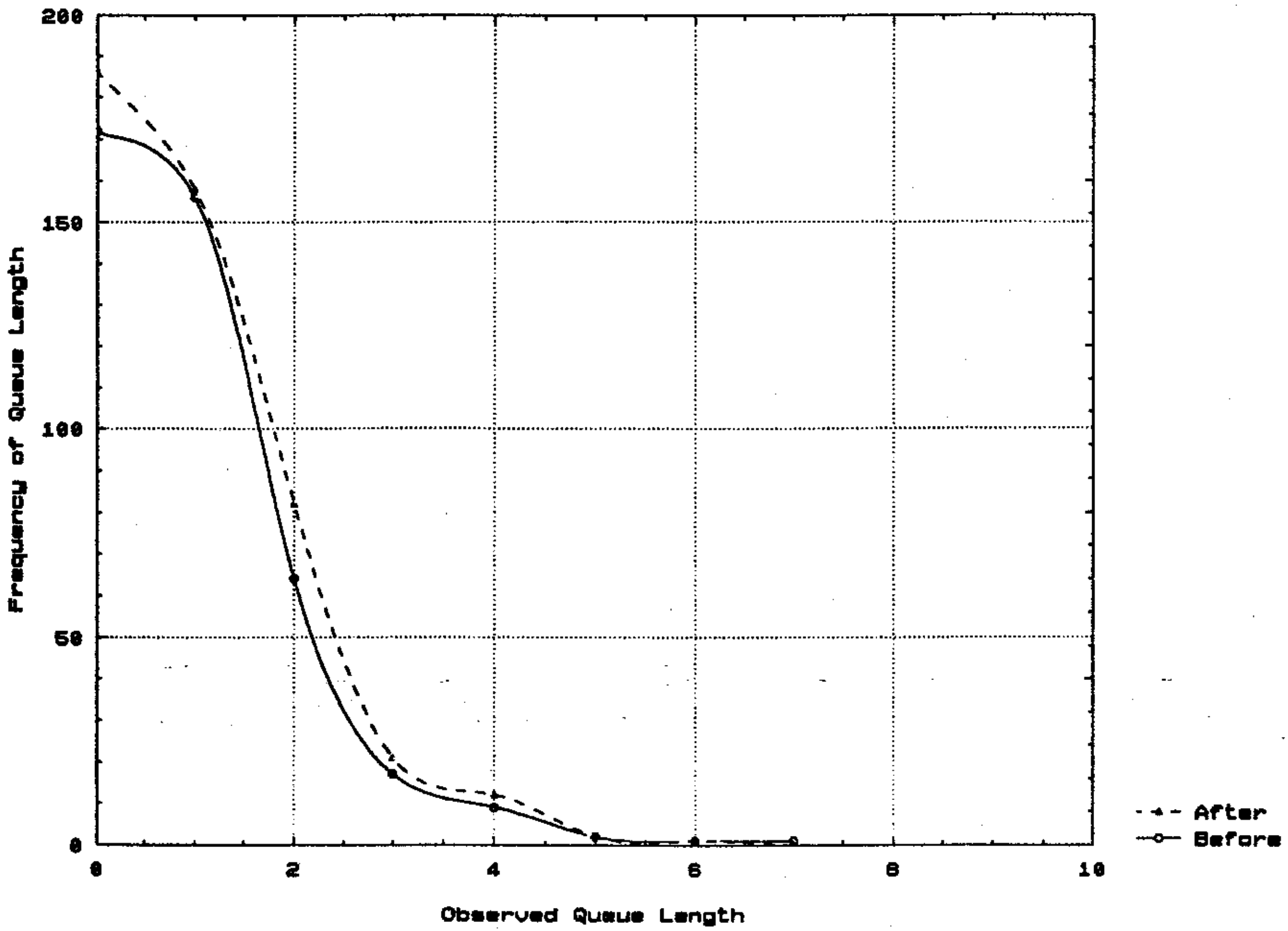


Fig.F4: Large Vehicles from Korinth
Frequencies of Queue Lengths before and after



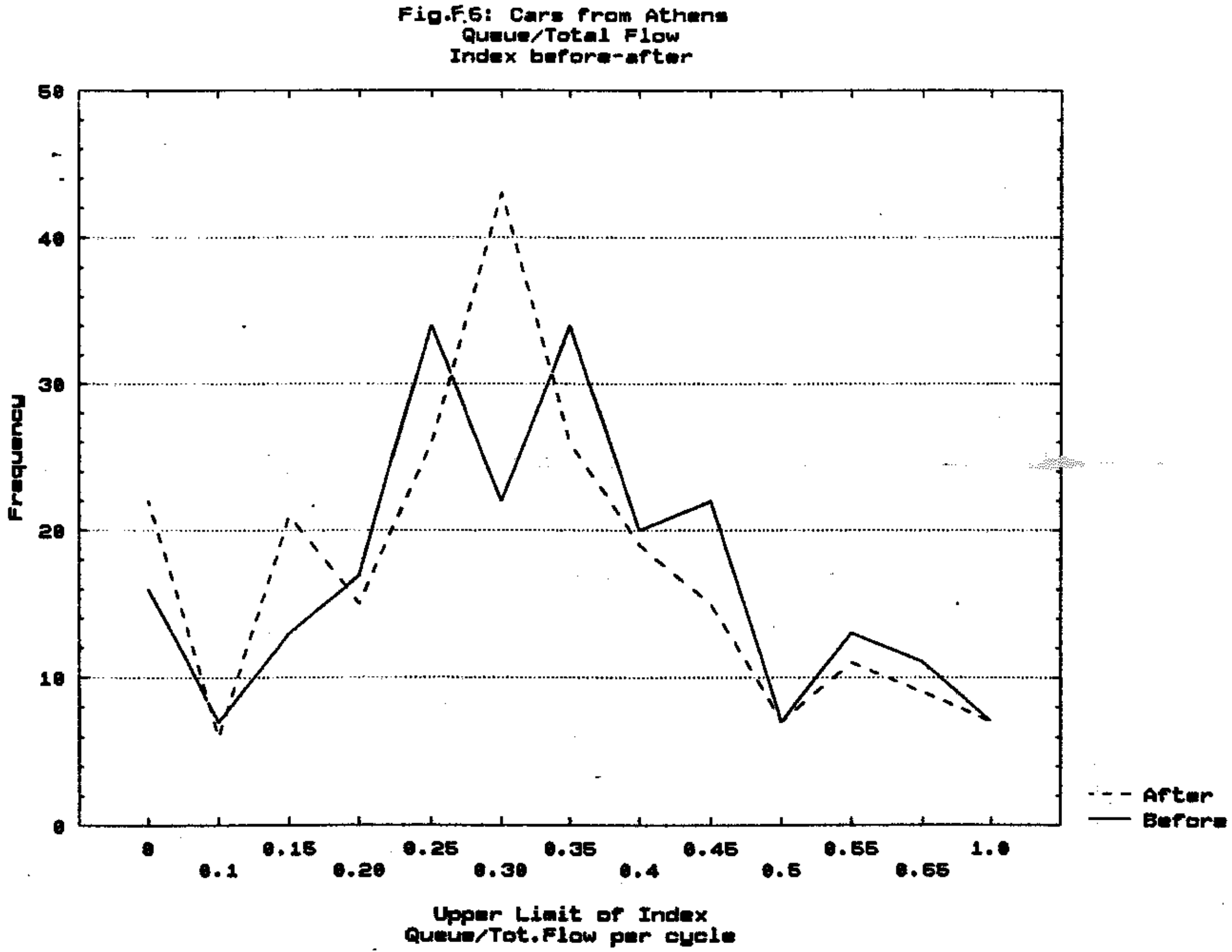


Fig.F.6: Cars from Athens
Queue/Total Flow
Index before-after
Frequency
0
10
20
30
40
50
0
0.1
0.15
0.20
0.25
0.30
0.35
0.4
0.45
0.5
0.55
0.65
1.0
Upper Limit of Index
Queue/Tot.Flow per cycle
After
Before

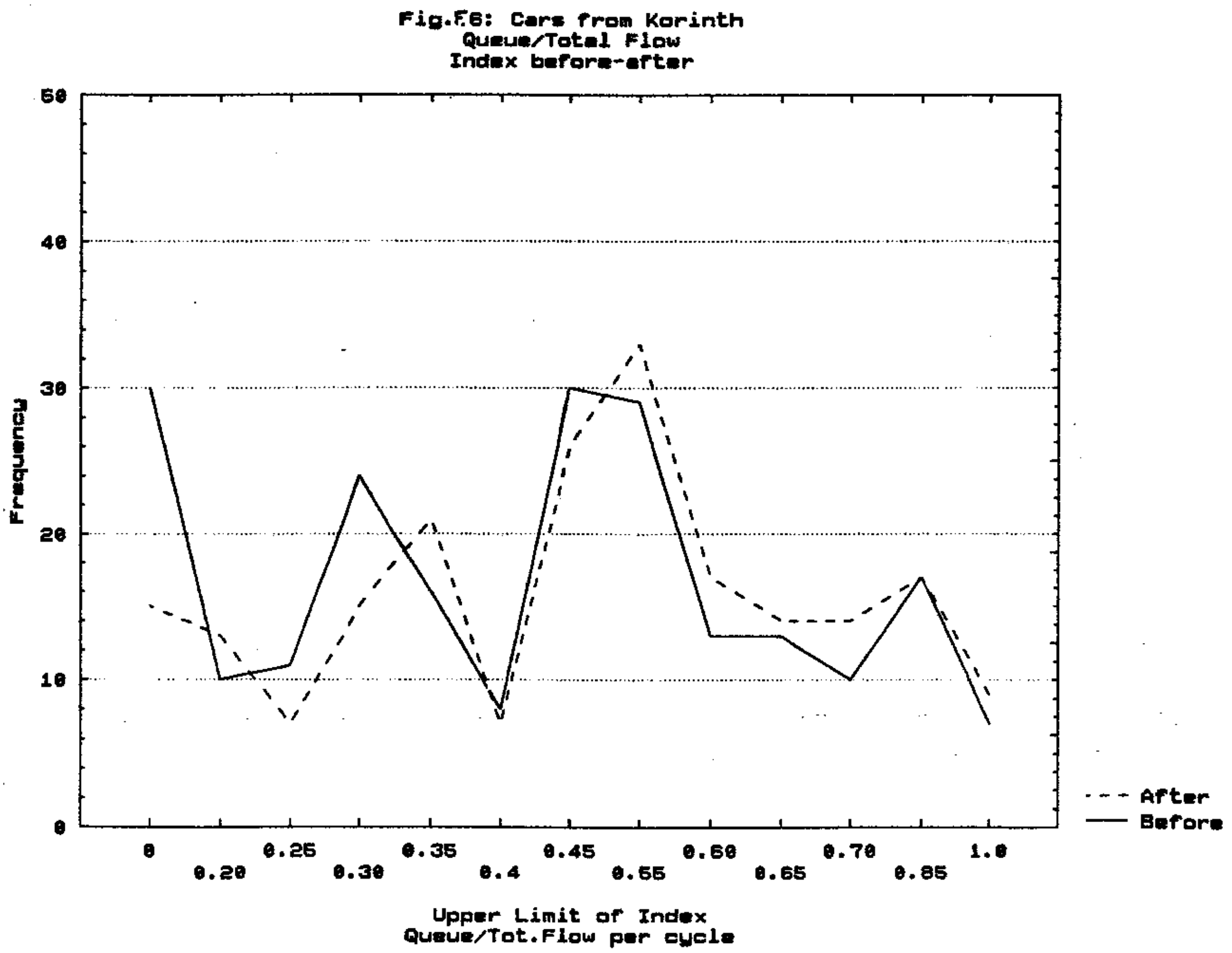


Fig.F.8: Cars from Korinth
Queue/Total Flow
Index before-after
Frequency
0
10
20
30
40
50
0
0.20
0.25
0.30
0.35
0.4
0.45
0.55
0.60
0.65
0.70
0.85
1.0
Upper Limit of Index
Queue/Tot.Flow per cycle
After
Before

Fig.F7: Large Vehicles from Athens
Queue/Total Flow
Index before/after

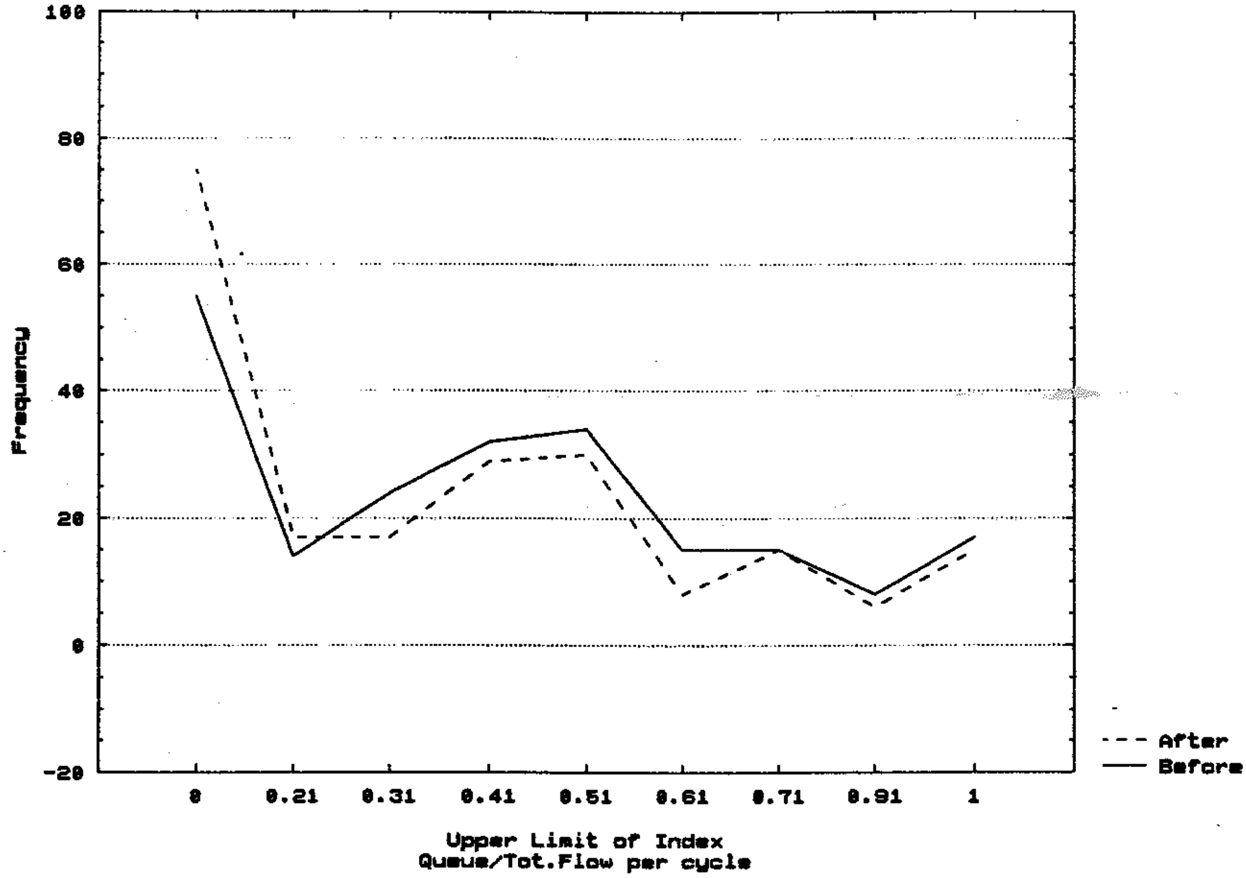


Fig.F8: Large Vehicles from Korinth
Queue/Total Flow
Index before/after

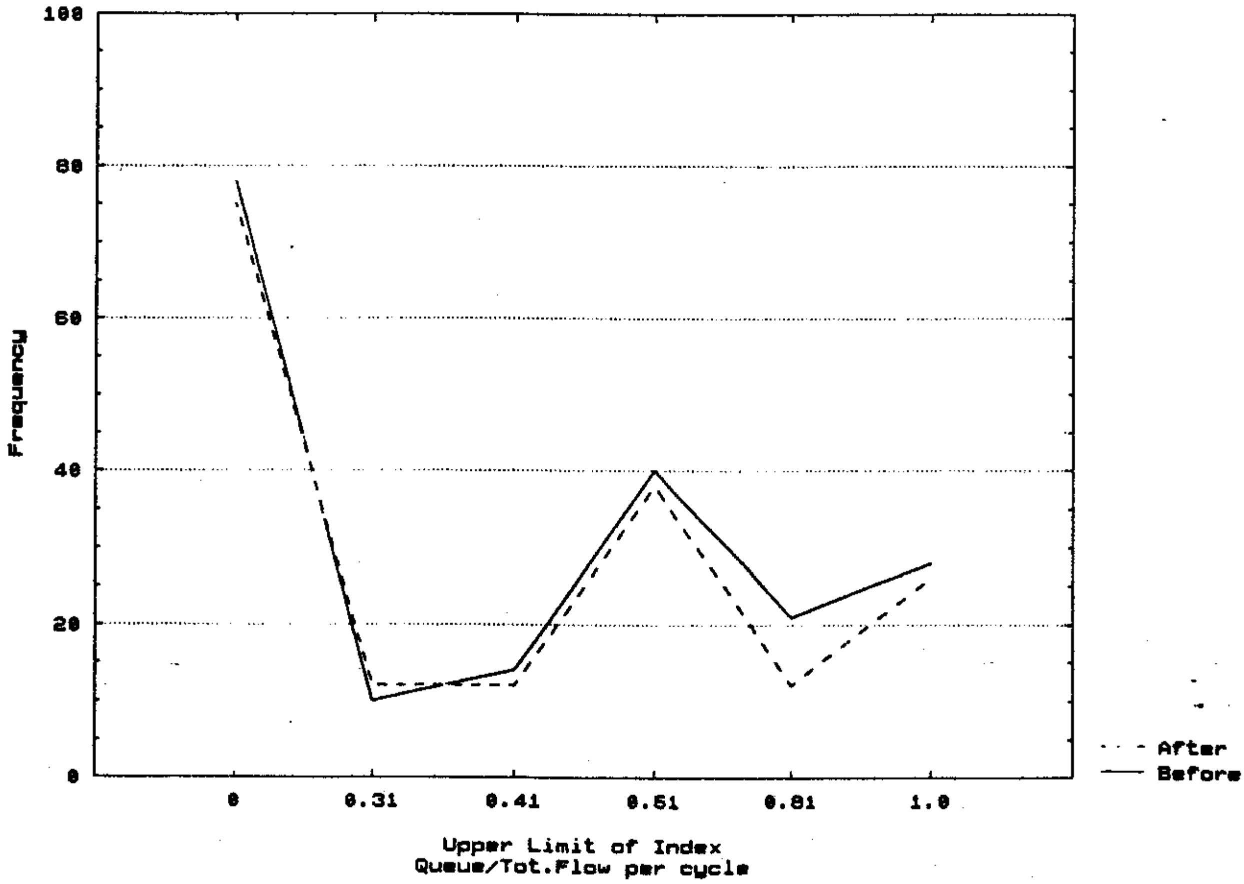


Table F.1: No of Vehicles Queuing, Descriptive Statistics

			Mean	Std Dev.	Avg Dev.
FROM ATHENS	Private Cars	Before	6.721	4.435	3.659
		After	5.906	3.891	3.252
	Large Vehicles	Before	1.828	1.679	1.332
		After	2.024	1.762	1.398
FROM KORINTH	Private Cars	Before	3.739	2.281	1.775
		After	3.359	2.471	1.942
	Large Vehicles	Before	0.933	1.063	0.761
		After	0.971	1.058	0.782

However, the number of cars in the queue per se is not a very good indicator for comparison since traffic flow levels may have been different between the two measurement periods (e.g. seasonal variation). The before/after data were compared on the basis of the index: (No of vehicles in queue)/(Total vehicles passing in the cycle) The corresponding graphs are presented in the following figures (5, 6, 7, 8) in the same sequence as before. As can also be seen from Table F.2 in terms of heavy vehicles and private cars from Korinth the before and after situations compare well at the 0.05% level (no difference). However the direction from Athens shows a difference.
It is difficult to ascribe this difference to the operation of detectors, since the some effect would have been apparent for the other direction.

Table F.2: Observed vs. Expected frequencies x^2 test

	difference	x^2
From Athens (pr. cars)	12	24.42
From Korinth (pr. cars)	12	19.48
From Athens (heavy)	8	14.71
From Korinth (heavy)	5	4.9

It may however be possible that more pedestrian-determined extensions to the main street red are having an effect on the platoons arriving from the previous signals, while arrivals at the other direction are random.
A comparison of pedestrian and vehicle determined extensions to the red phase for main traffic is contained in Appendix G.

APPENDIX G

Comparison between Vehicle and Pedestrian induced extension to the side road Green Time

G.1. Introduction

G.2. Number of Extensions and Length

G.3. Distribution of Extensions throughout the Day

APPENDIX G: COMPARISON BETWEEN VEHICLE AND PEDESTRIAN INDUCED EXTENSION TO THE SIDE ROAD GREEN

G.1. INTRODUCTION

As mentioned previously in Appendix F, there appears to be a problem in identifying the traffic effects of the installation in the direction from Athens. In essence the difference between the situation before-after lies in the number of extensions (now determined at least in part by pedestrian demand), their distribution throughout the day (again a function of pedestrian demand) and the length of the extension. In order to measure the difference between the before and after statistics, the green times of the side street were recorded in a before-after environment for a period of 10 hours/day (1 day before-1 day after). The results of the comparison are presented below, in Table G.1.

G.2. NUMBER OF EXTENSIONS AND LENGTH

The frequency distribution of green times for the side street are shown in the table below:

Table G.1: Frequency distribution of green times for the side street

Length of Green time	Before	After	% Difference
10	111	245	+121
11	189	77	-59
12	81	46	-43
13	41	43	+5
14	31	24	-23
15	11	34	+209
Total	464	469	+1
Total Extensions	353	224	-36.5
Total seconds of ext.	653	564	-13.6
Avg length of ext.	1.8	2.52	+40

The frequency distributions are shown in the Figure G.1. There are significant differences. In the after situation the number of extensions is much reduced, although the longer possible extensions (>3 secs) remain approximately the same.
The average length of extension in the after situation is 40% higher.

G.3. DISTRIBUTIONS OF EXTENSIONS THROUGHOUT THE DAY

The number of extensions and extension times were summed for every 6 cycles. The distribution of extensions and extension times throughout the day are shown in figures G.2, G.3.

The number of extensions throughout the day (per 6 cycles) does not seem to be affected (x^2 test, see Fig. G.4).

However the times of extensions vary significantly in the before and after situation (x^2 test, see Fig. G.5).

G.4. DISCUSSION OF RESULTS

Over a long period of the day the pedestrian induced extension results in more green time allocated to the main road flow (less number of extensions). This is at the expense of side road traffic.

Pedestrian induced extension, are however longer than vehicle-induced.

In general the demand pattern for side road vehicle extension is different from the pedestrian demand. Thus there has been an effect on local vehicular traffic. Local vehicular traffic levels are however, small (see Appendix H) and, in terms of magnitude, the impact it is regarded negligible.

Fig.G.1: Seconds of Green Time for Side Road Traffic
Frequency of Occurence

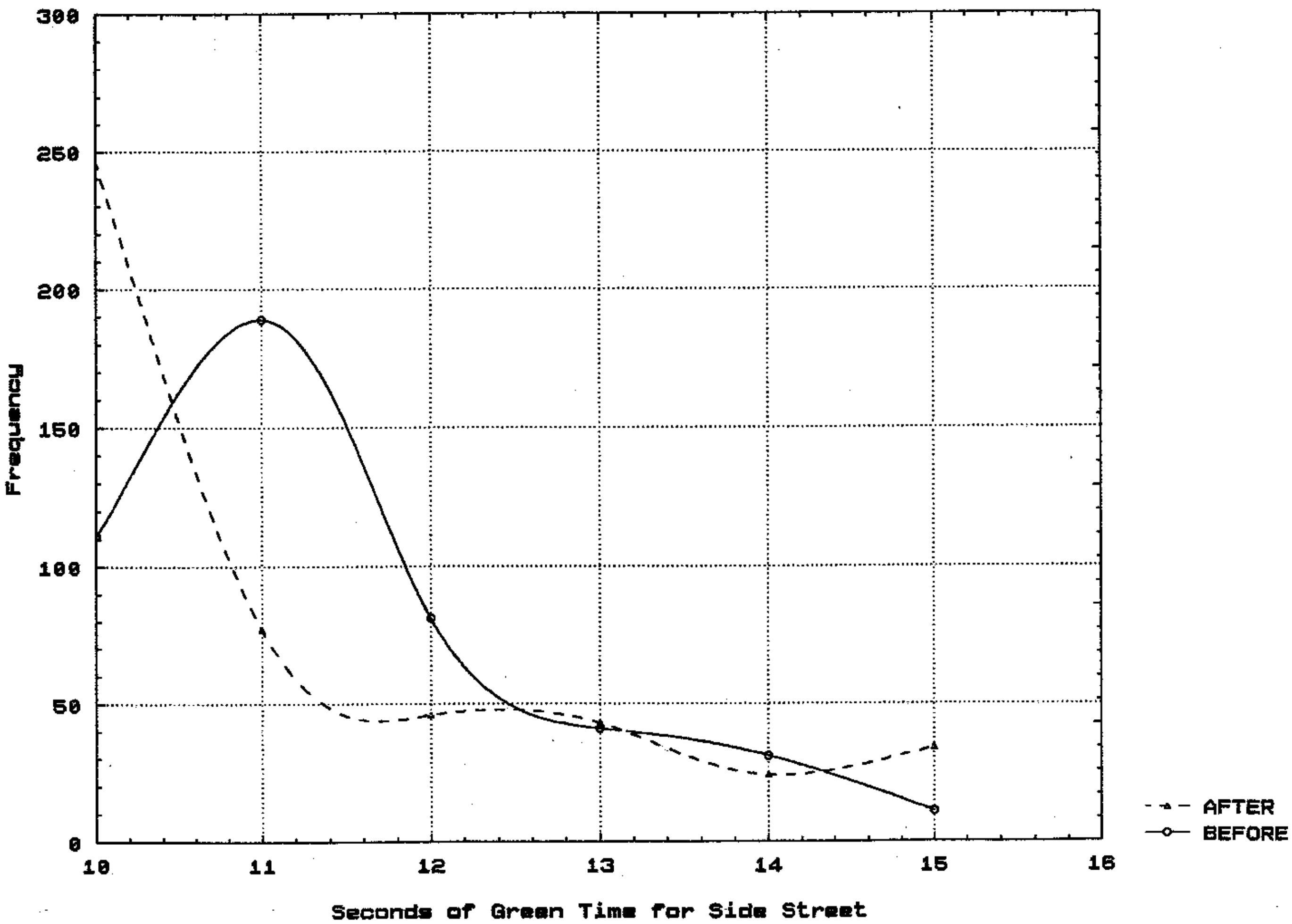


Fig.G.2: Before Situation
Number of extensions and seconds

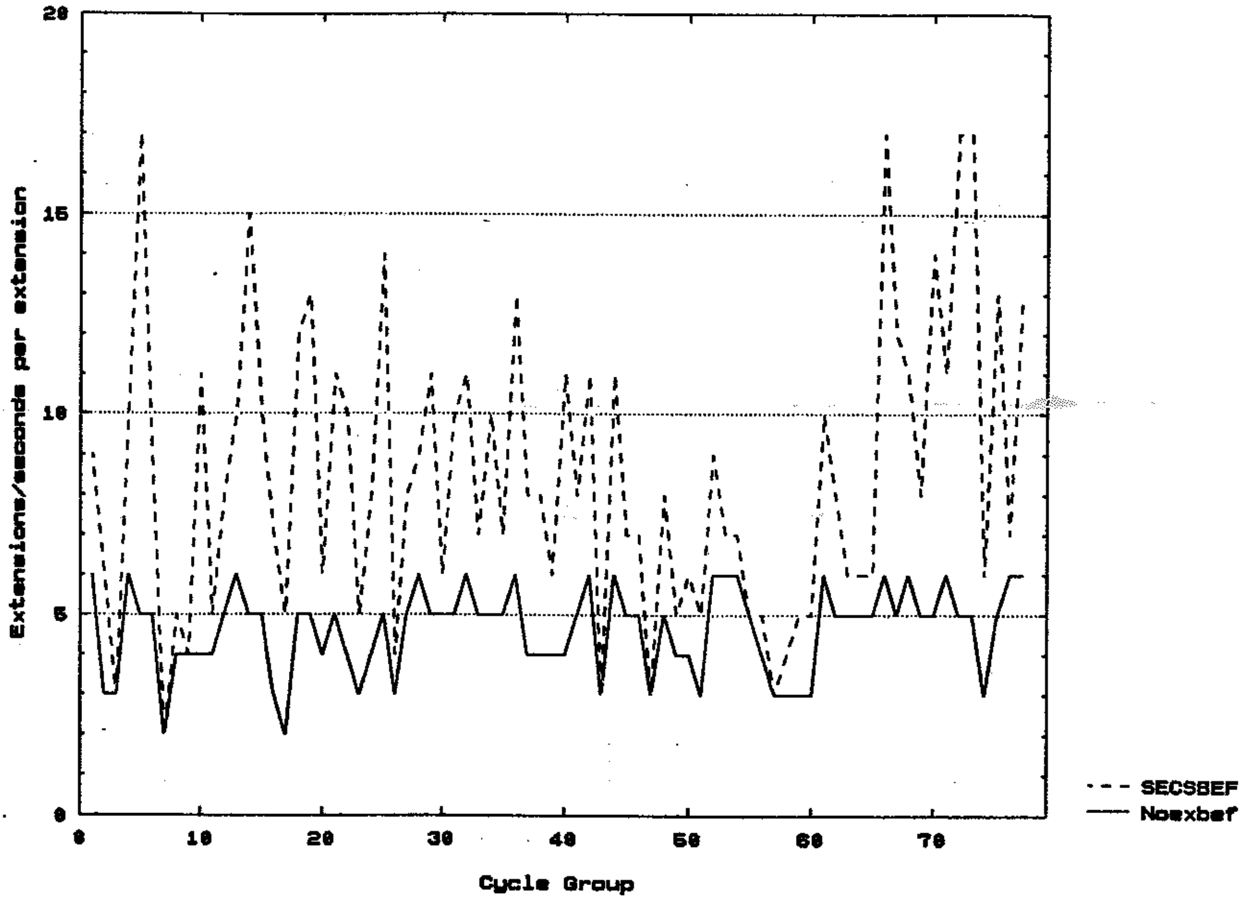


Fig.G.3: After Situation
Number of extensions and seconds

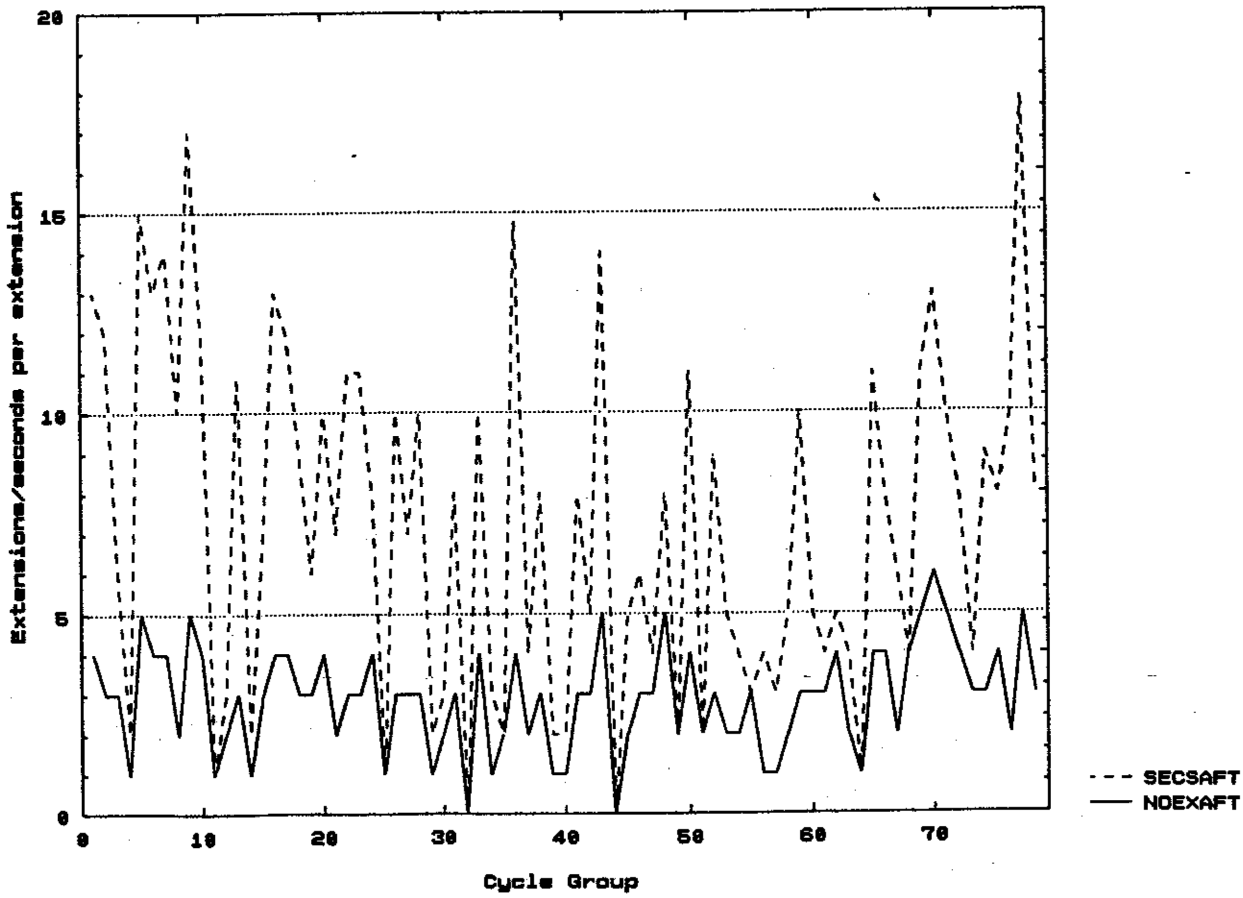


Fig.G.4: Observed vs. Expected Extensions (in secs)
Chi-Square = 92.28333 df = 76

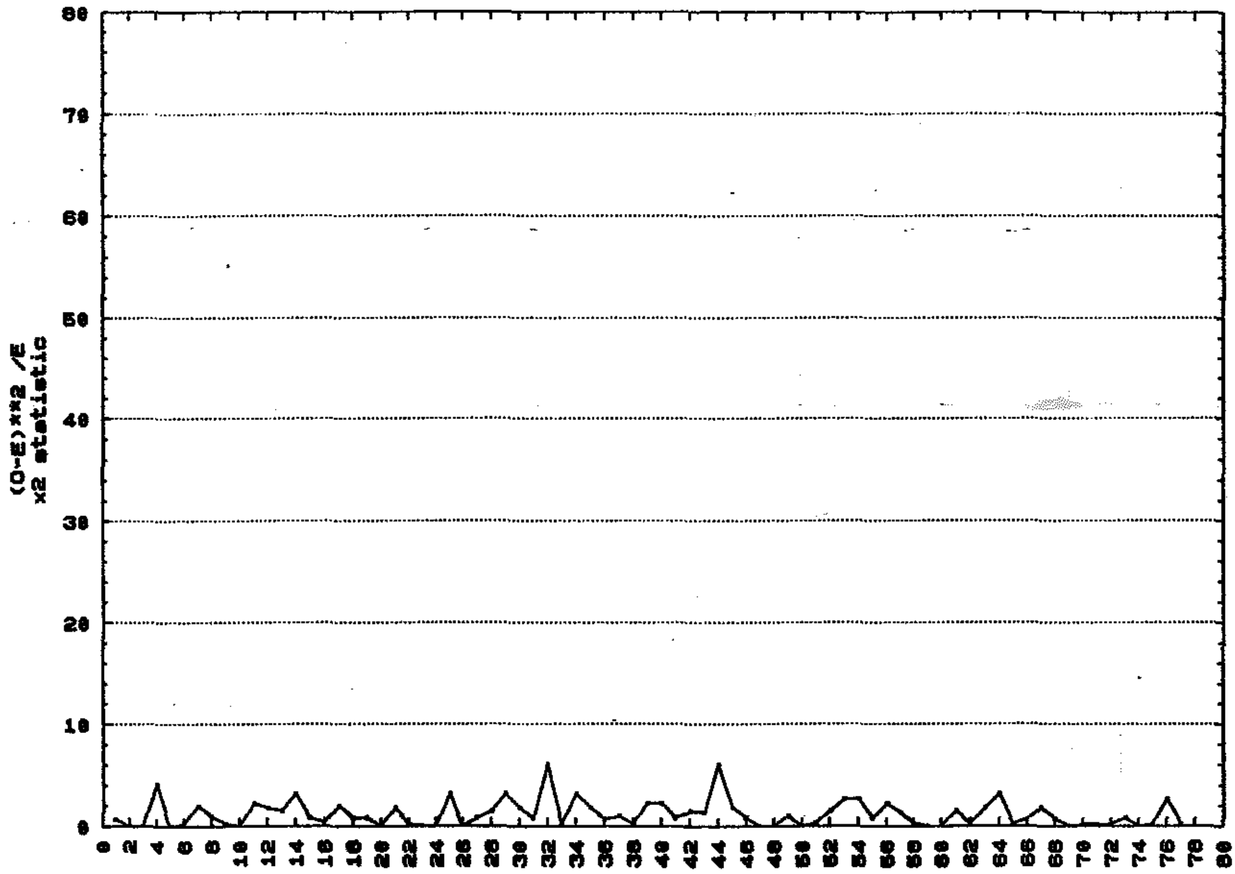
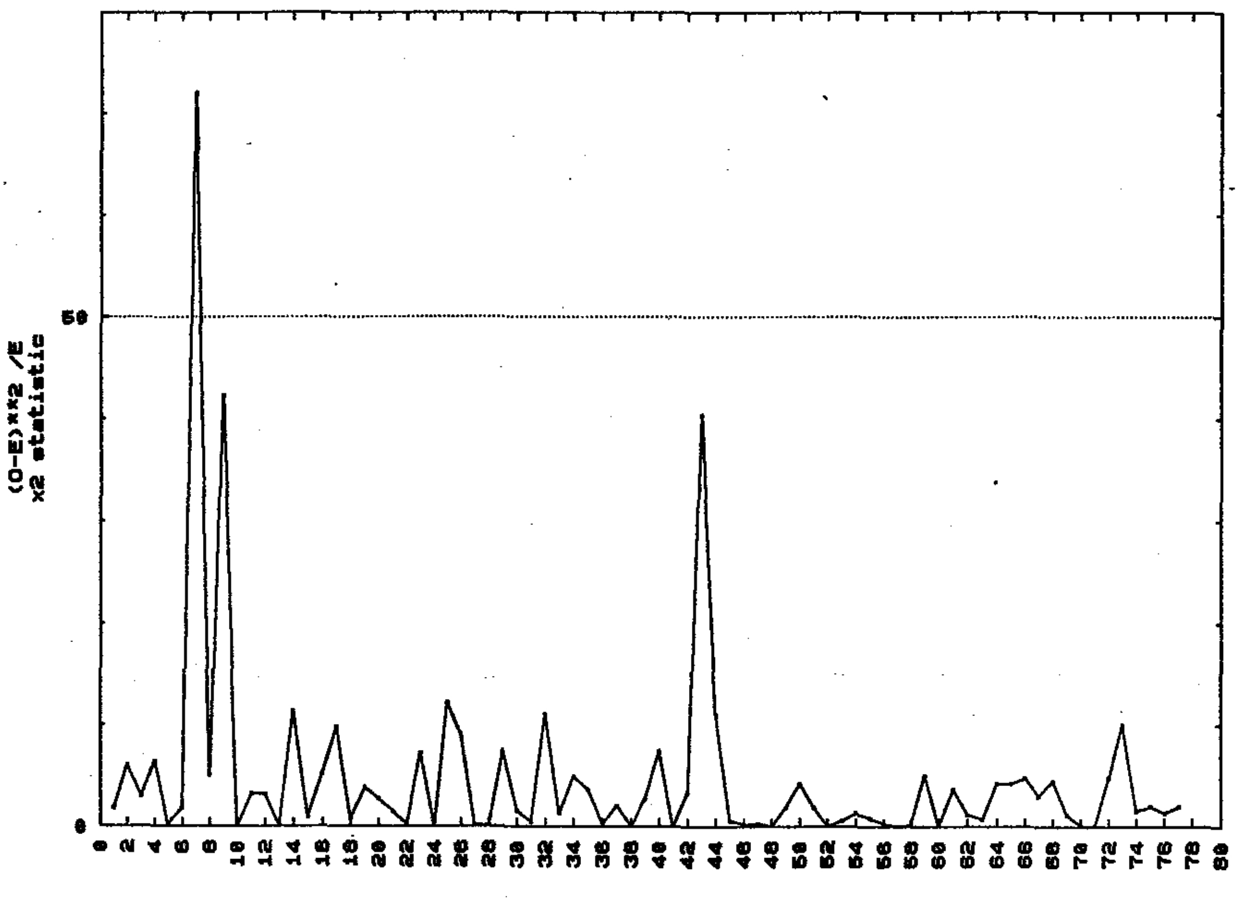


Fig.G.5: Observed vs. Expected Extensions (in secs)
Chi-Square = 371.7699 df = 76



APPENDIX H

Traffic Flows

APPENDIX H: TRAFFIC FLOWS

Traffic flows at the chosen intersection have been measured before the actual signal installation for all veh categories (cars, buses, trucks, cyclists).

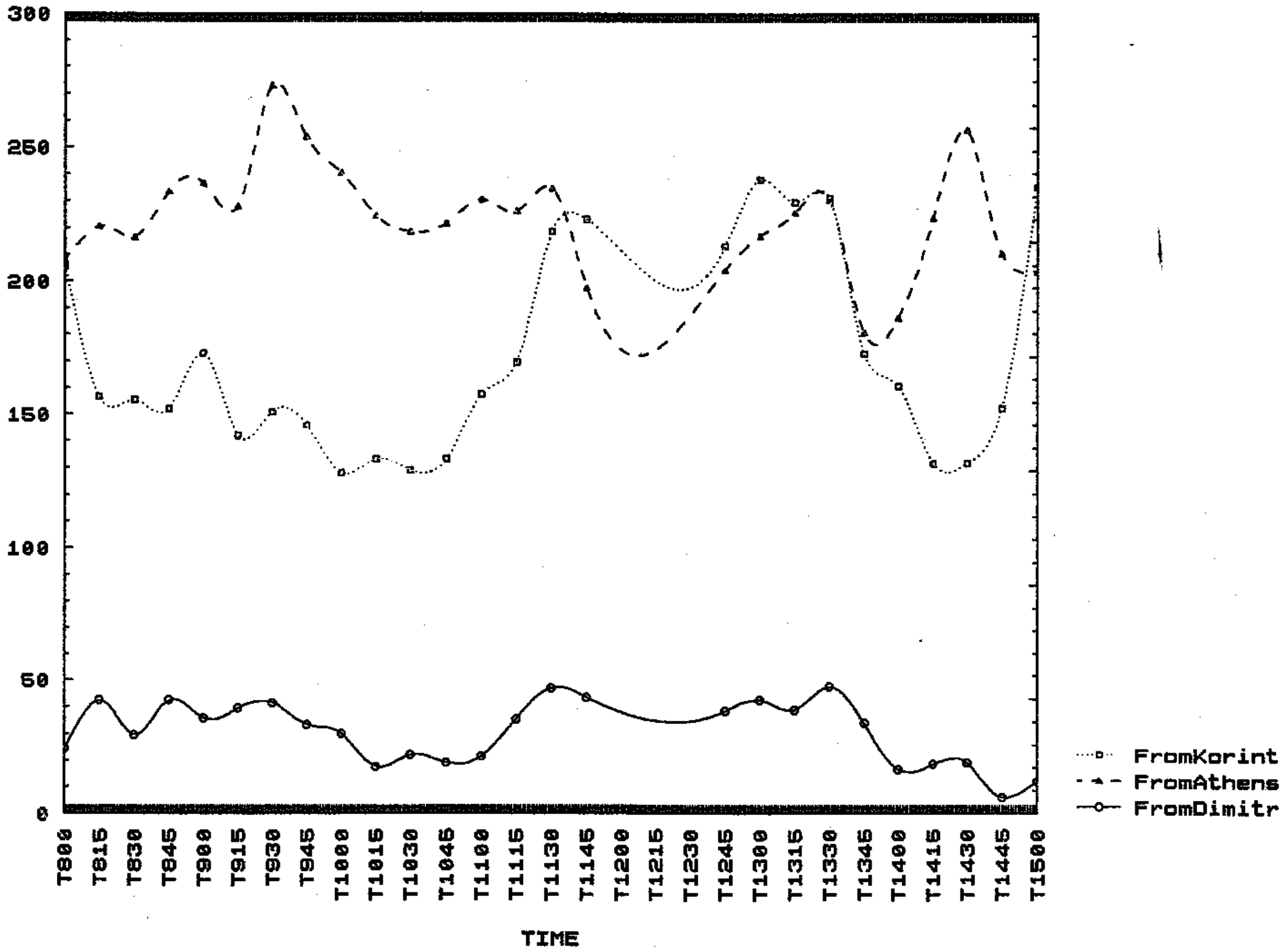
The data are summarised below in pcu's/15 min intervals.

Table H.1: PCU's junction. Basic Statistics

	Min	Max	Mean	Std Dev.
From Dimitros	6.0	47.5	27.2	13.0
From Athens	180.5	273.0	221.2	21.9
From Korinth	112.0	238.0	166.0	37.9

The variation throughout the measurement period is depicted in the fig. that follows.

Fig. H.1: Traffic Flow Level Variation (PCU's)



APPENDIX I

Development of Pedestrian Profiles

I.1. Introduction

I.2. Data Analysis

I.3. Development of Profile

I.4. Comments on Results

APPENDIX I: DEVELOPMENT OF PEDESTRIAN PROFILES

I.1. INTRODUCTION

Microwave detectors for pedestrians can be used as data collection devices (see appendix B) to establish the time varying level of pedestrian traffic over an entire area, by placing them at key locations where pedestrians pass (e.g. an underpass.)

Such an experiment was conducted in Elefsina, as described in Appendix B. The data set obtained contains 46 days of measurements of long term pedestrian profiles that have been developed from pedestrians making the N-S movement.

I.2. DATA ANALYSIS

The purpose of data analysis is to investigate the possibilities of representing pedestrian demand over a long period, by a limited number of patterns. By combining patterns all possible profiles may be synthesised. The patterns may be useful in a number of applications.

They may be used to aid in planning studies and facility design and also in signalisation schemes. Eventually, real time monitoring of flows may be used in arriving at predictions of the evolution of pedestrian demand throughout the day, by selecting the appropriate pattern(s) from the library. This would mean that pedestrians could then be treated in a similar manner to that for vehicles in a traffic management scheme.

In order to record levels of pedestrian activity over a large area it is necessary to site the detectors at key points in the network (e.g. under or over passes). In cases of special generators such as train stations separate measurements should be performed for local intersection control. However there are likely to be particular problems in using this technique in congested areas.

The results of the analysis presented in the following chapters is valid only for Elefsina. Pedestrian demand is a function of the hours of operation and the intensity of land uses and separate measurements should be conducted in each city/area where data of this type are required.

However, the method of analysis is general and can be applied to any area. The method and results for Elefsina area presented below.

I.2.1. Introduction

In this section data analysis is performed. For this purpose MATLAB has been used. Several of the algorithms used for the segmentation and clustering and classification are developed (e.g. [1], [2], [3]).

The data includes the number of pedestrians counted in 5 minute periods over 46 days. A few days have been excluded from the data set due to missing data (see also Appendix B). The data set is viewed as a 46x288 matrix M. Each row corresponds to one of the 46 days and each column to a 5 minute period (see also Fig. I.1). The analysis of the matrix M involves three main tasks: preliminary statistical analysis, segmentation and clustering and classification.

The first task includes some basic statistical procedures that enhance the structural information of the data set matrix. Segmentation is an operation on the rows (days) of the matrix, it aims to divide each day into consecutive homogeneous blocks. The division of segments should reflect the variability of the signal at the block boundaries.

The final phase utilises the information obtained by the segmentation process to create smaller categories than the number of rows. It operates on block columns of M and makes no assumptions about the number of groups. The clustering algorithms employed are variants of the k nearest neighbour technique and are implemented by the Hamming neural network architecture. They also feature an iterative optimization procedure for the shaping of the categories.

I.2.2. Basic Statistical Analysis

In this phase some basic statistical processing is conducted in order to gain an insight into the structure of the data matrix M and in order to prepare the ground for the subsequent phases. Fig. I.2 shows some first order statistics information. Four curves are plotted. Curve 1 shows the daily mean evolution of pedestrians crossing the junction. Curve 2 shows the daily minimum while curve 3 shows the daily maximum. Finally, curve 4 illustrates the daily standard deviation (variance).

The correlation matrix of the data set, that was constructed does not provide a clear and indicative information of the structural relationships of the pedestrian daily counts.

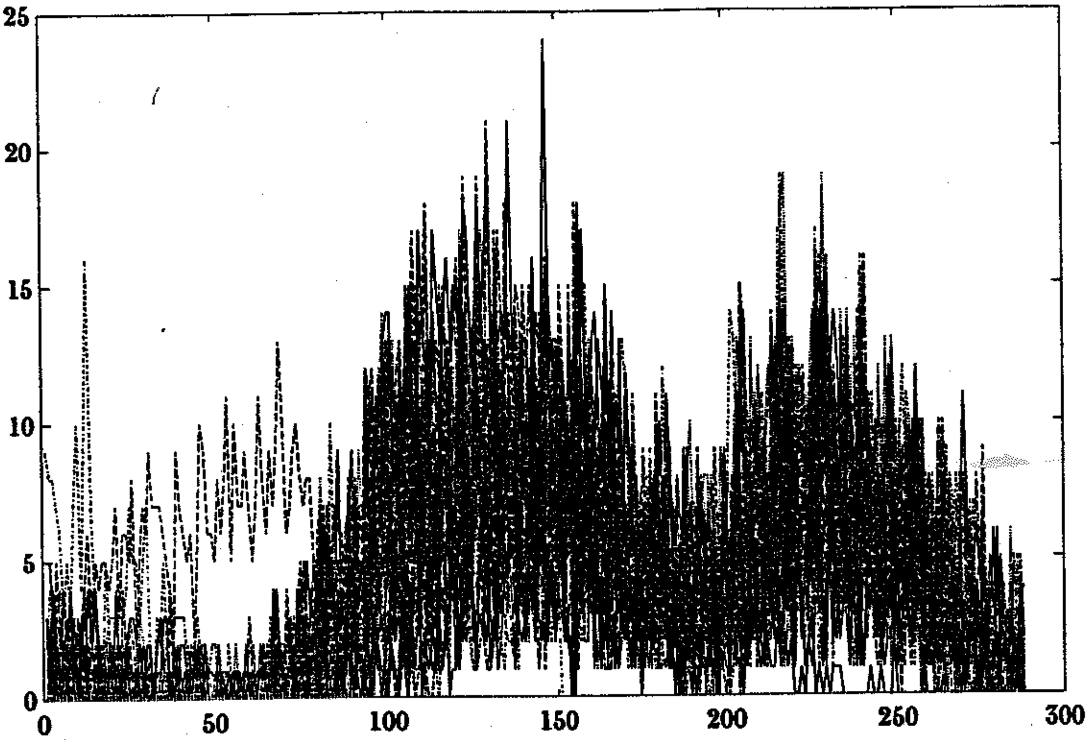


Fig. 1: Plots of the 46 days curves.

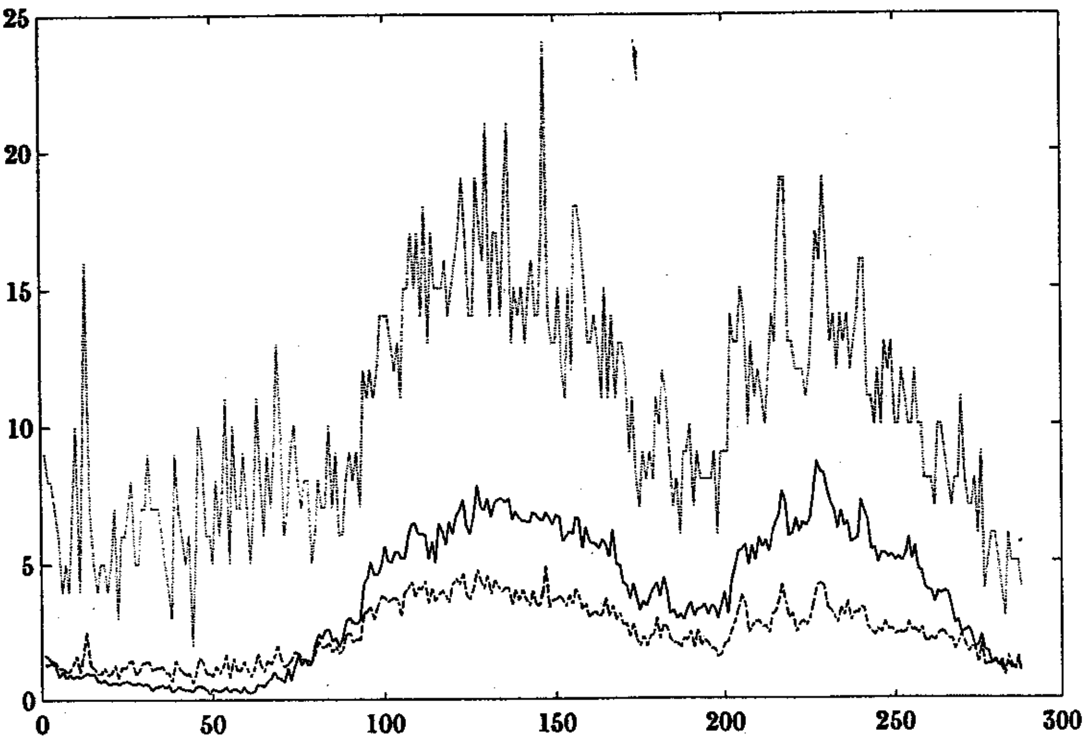


Fig. 2: Curve 1 (solid line) shows the daily mean evolution of pedestrians crossing the junction. Curve 2 (which coinsides with the x axis) shows the daily minimum. Curve 3 (dotted line) shows the daily maximum. Finally, curve 4 (dashed line) illustrates the daily standard deviation

I.2.3. Segmentation

Segmentation aims at splitting each row (day) in successive blocks. It is not regarded appropriate to employ an averaging blocking scheme, namely partition, which relies on the average daily pedestrian evolution. Instead a segmentation procedure for each day will be applied. The results will be used to come up with common daily blocks on the basis of a common intersection principle.

A detailed description of the segmentation method is given next. It involves the following steps.

Step 1: Smoothing
Each row (day) is smoothed to remove outliers and noisy effects. Smoothing is done as follows. Each value (pedestrian counts per period of five minutes) is estimated by a linear combination of a fixed number of past and future values. The smoother is determined by averaging over a window of 11 lags. Plot of the original data and their smoothed counterparts are illustrated in Fig. I.3.

Step 2: Row segmentation
Segmentation of each row is performed as follows. Each smoothed day is partitioned into half hour blocks. The mean values of each block j of day i $ì_i(j)$ is determined. Two consecutive blocks j, j+1 are merged into a single block if the difference $|ì_i(j)-ì_i(j+1)|$ does not exceed a threshold value è (è, common to all days). Otherwise, if

$$|ì_i(j)-ì_i(j+1)| > è,$$

the two blocks are separated into distinct patterns.

Application of the above procedure gives rise to a partition of each day into segments (unions of consecutive half hour intervals). It is conceivable that the segmentation of two days generally differ. For subsequent clustering analysis all days must have the same segmentation. To achieve such a common partitioning the following approach was applied (see also Fig. I.4). The length s(1) of the first segment is determined by the smallest first segment length among all days. Let s(2) denote the smallest distance between the beginning of each (row) day and the end of the second segment among all days. Then s(2)-s(1) is the length of the second block of the data. This block begins from the right frontier of the first block. In general, the length of the k-th block of the data is s(k)-s(k-1), while its starting point is the end of the k-1 block.

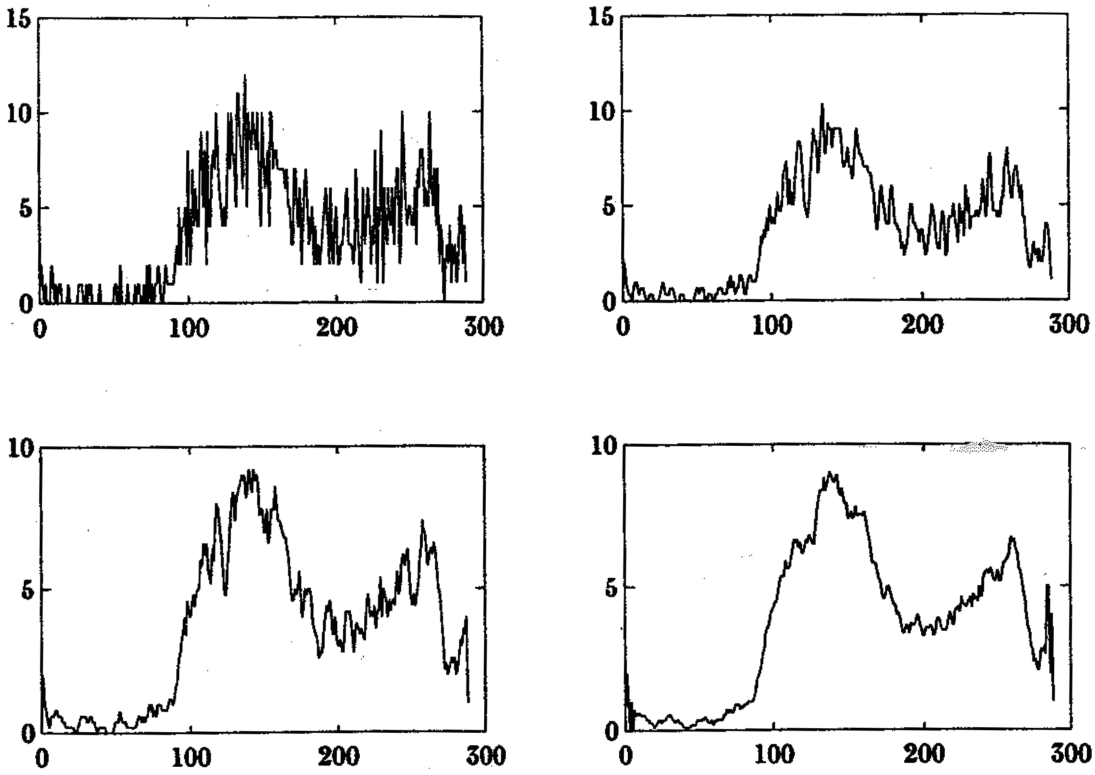


Fig. 3: The first plot shows the evolution of the 23rd day, while the second, the third and the fourth plot show the smoothed versions of the first plot using a moving average method, with size of window 3, 5, 11 respectively.

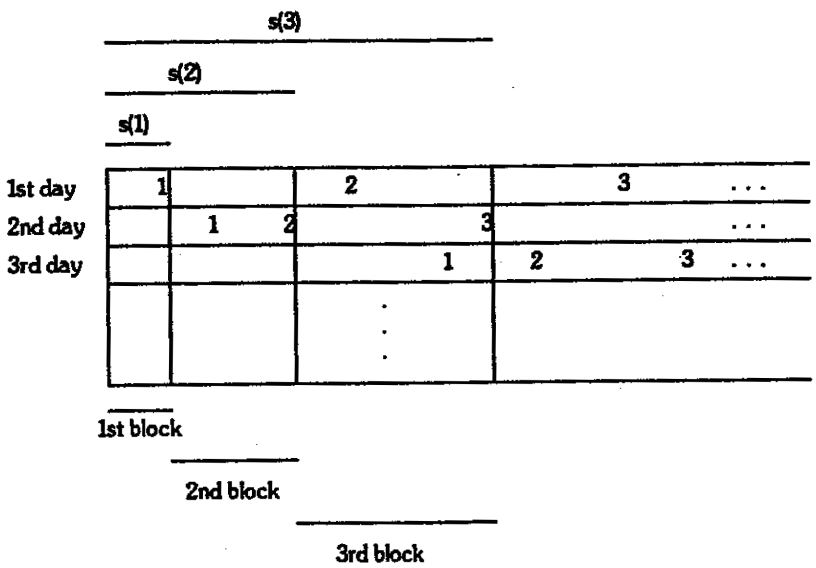


Fig. 4: The common partitioning procedure. In this figure the numbers denote the end of the corresponding blocks. Thus for the third day, the number 1 denotes the end of the first block of that day. The vertical lines define the blocks into which the the above matrix is seperated.

The above procedure is repeated until all segments have been formed. Tables I.1, I.2 and I.3 show various segmentations for different values of the threshold è (è) and for different basic intervals.

The segmentation used in the next phase is the one where the basic time interval is half an hour and the threshold 1.1. Note that the choice of the basic time interval to be half an hour reduces the probability of having high variation in the same time interval.

Table I.1

1.1	1.5	1.8
6	18	18
18	84	84
78	96	96
96	108	120
102	114	150
108	162	234
132	168	264
138	222	288
162	228	
168	234	
174	240	
222	288	
228		
234		
240		
246		
264		
288		

The above table shows the segmentations provided when the basic time interval is half an hour and the thresholds are 1.1, 1.5 and 1.8 respectively. Thus, for è=1.1, the first block contains the first half hour (i.e. the first 6 five minutes intervals or from 00.00 to 00.25) while the second contains the next one hour (i.e. the next 12 five minutes intervals or from 00.30 to 01.25). The last item of each column corresponds to the end of the last block.

The Table I.2 shows the segmentations provided when the basic time interval is one hour and the thresholds are 1.7, 1.9 and 2.2 respectively. Thus, for è=1.9, the first block contains the first hour (i.e. the first 12 five minutes intervals or from 00.00 to 00.55) while the second contains the next six hours (i.e. the next 72 five minutes intervals or from 01.00 to 06.55). The last item of each column corresponds to the end of the last block.

Table I.2

1.7	1.9	2.2
12	12	12
84	84	84
96	96	96
108	120	120
132	156	168
156	168	264
168	216	276
216	264	288
240	288	
264		
288		

The Table I.3 shows the segmentations provided when the basic time interval is two hours and the thresholds are 2.5, 3 and 3.5 respectively. Thus, for è=2.5,the first block contains the first two hours (i.e. the first 24 five minutes intervals or from 00.00 to 01.55) while the second contains the next six hours (i.e. the next 72 five minutes intervals or from 02.00 to 07.55). The last item of each column corresponds to the end of the last block.

Table I.3

2.5	3.0	3.5
24	72	72
96	96	96
120	144	168
144	168	240

168	240	288
240	288	
264		
288		

I.2.4. Clustering

In this section the two unsupervised learning algorithms that have been used for the clustering of the 18 groups of 46 vectors resulted by the segmentation phase are presented. The first of these, which subsequently will be called UCA (from Unsupervised Clustering Algorithm), aims at the determination of number of clusters and the preliminary assignment of the training vectors to each one of these, while the second, which is also known as the Lloyd's algorithm, aims at the refinement of the clustering results of the first algorithm. Note that for the second algorithm the number of clusters is determined from the first one.

In the sequel a brief description of the above algorithms takes place.

Let G be of the form:

$G = \{x_i: x_i \, E \, S, \; i=1,\ldots,p\}$,

where, S is a closed subset of R^d and p is the number of the training patterns.

UCA algorithm requires that all inputs of the data set are presented to the network three times. Also, a threshold of dissimilarity è is required. The first run aims at the determination of the clusters. More specifically, we assume that the first training vector x_1 is the representative of the first cluster. Every other training vector x whose distance from any other cluster representative formed up to the time x is presented, is greater than è, defines a new cluster. During the second run, assignment of the remaining training vectors (i.e. those that were not used as cluster representatives at the previous case) to the above defined clusters is carried out. Finally, at the third run the update of the cluster representatives takes place. The final values of the cluster representatives are simply the means of the training vectors that belong to the respective cluster.

The Lloyd's algorithm is an iterative scheme. In our case, this algorithm is initialized by the output of UCA. At each iteration, two main steps are carried out. During the first, the computation of the distances d(x,w) between each training vector x and each cluster representative w takes place. Then, assignment of each pattern x to the class whose representative is closer to x is carried out*. During the second phase, the evaluation of the new centroids takes place, as well as the average distortion, which is defined as:

$$D = \frac{1}{p} \sum_{i=1}^{p} d(x_i, w_{xi}),$$

where w_{xi} is the cluster representative to which the vector x_i belongs and d(x,y) denotes the distance between vectors x and y (here we used as d() the squared Euclidean distance).

As a stopping criterion of the above iterative scheme, the value of the ratio $(D_m - D_{m+1})/D_m$ is used. More specifically, if this value is smaller than a suitably chosen threshold t, then the

* If $d(x,w_i)=d(x,w_j)=\min_k d(x,w_k)$, with i j, then assign x to cluster C_i cluster, for which j is smallest. This is one tie-breaking rule, used to resolve the above situation, the occurrence of which has probability zero when real valued vectors are considered.

algorithm stops. In practice, the Lloyd's algorithm stops after a relatively few number of iterations.

I.2.5. Results

From the segmentation phase, the data matrix was divided into 18 blocks, each one containing 46 training vectors. During the clustering phase the UCA and the Lloyd's algorithm have been used in that order for each one of the 18 data blocks. In the sequel a detailed description of the results obtained from the above algorithms for each data block is given. The numbering of days (patterns) is presented in diary form below:

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
			OCTOBER 93			
			6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30
31						
			NOVEMBER 93			
					5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	

Numbers in **bold** indicate dates on which measurements were taken.

- *1st block:* This block corresponds to the period 00.00-00.25.

For è=50 we have the following results:

Cluster 1 contains the patterns 1, 2, 4, 6, 7, 9, 10, 11, 12, 13, 14, 15, 16, 18, 19, 20, 21, 22, 23, 24, 25, 26, 28, 29, 30, 31, 32, 35, 36, 37, 38, 39, 43, 44, 45, 46.

Cluster 2 contains the patterns 3, 5, 17, 27, 33, 34, 40, 41, 42.

Cluster 3 contains the pattern 8.

The cluster representatives are (The last representative is an outlier, i.e. a special day):

C_1	C_2	C_3
0.7222	2.7778	9.0000
0.9167	2.1111	8.0000
0.9722	2.2222	8.0000
0.7500	2.6667	7.0000
0.5556	1.4444	6.0000
0.7500	2.0000	3.0000

2nd block: This block corresponds to the period 00:30-01:25.
For è=50 we have the following results:

Cluster 1 contains the patterns 1, 2, 6, 7, 9, 11, 12, 13, 14, 15, 16, 18, 19, 20, 21, 22, 23, 25, 26, 28, 29, 30, 31, 32, 33, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46.
Cluster 2 contains the pattern 3.
Cluster 3 contains the patterns 8.
Cluster 4 contains the patterns 4, 5, 10, 17, 24, 27, 34.

The cluster representatives are:

C_1	C_2	C_3	C_4
0.7027	4.0000	3.0000	2.1429
0.4865	1.0000	5.0000	1.8571
0.7568	3.0000	3.0000	1.4286
0.4865	1.0000	7.0000	1.5714
0.5135	1.0000	10.0000	1.5714
0.5405	3.0000	4.0000	1.5714
0.4054	4.0000	9.0000	1.8571
0.3784	6.0000	16.0000	1.4286
0.5946	2.0000	7.0000	1.7143
0.5946	5.0000	3.0000	2.0000
0.4324	4.0000	2.0000	1.2857
0.3784	5.0000	2.0000	1.2857
0.4054	5.0000	2.0000	1.5714

(Note that the second and the third cluster correspond to outlier patterns)

- *3rd block:* This block corresponds to the period 01:30-06:25.

For è=80 we have the following results:

Cluster 1 contains the patterns 1, 2, 4, 5, 6, 7, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46.

Cluster 2 contains the pattern 3.

Cluster 3 contains the pattern 8.

The cluster representatives are :

C_1	C_2	C_3
0.5909	5.0000	2.0000
0.4318	4.0000	3.0000
0.4318	5.0000	3.0000
0.4318	7.0000	3.0000
0.4545	3.0000	3.0000
0.4545	6.0000	3.0000
0.4773	6.0000	4.0000
0.4091	5.0000	7.0000
0.2955	8.0000	5.0000
0.4318	2.0000	5.0000
0.4773	5.0000	3.0000
0.2727	7.0000	5.0000
0.3182	6.0000	7.0000
0.2955	9.0000	2.0000
0.2045	7.0000	0
0.2727	7.0000	3.0000
0.2955	7.0000	2.0000
0.3182	6.0000	5.0000
0.2955	5.0000	2.0000
0.4545	4.0000	2.0000
0.2045	2.0000	3.0000
0.1364	9.0000	3.0000
0.2955	7.0000	3.0000
0.2045	6.0000	3.0000
0.2500	5.0000	1.0000
0.2273	6.0000	1.0000
0.2273	2.0000	2.0000
0.2955	5.0000	3.0000
0.2727	10.0000	1.0000
0.2500	9.0000	1.0000
0.2273	6.0000	1.0000
0.0455	6.0000	2.0000
0.2500	5.0000	2.0000
0.1818	8.0000	0
0.1591	6.0000	1.0000
0.2045	8.0000	1.0000

0.2273	11.0000	0
0.1591	5.0000	1.0000
0.1818	10.0000	1.0000
0.2273	7.0000	0
0.0909	7.0000	1.0000
0.2500	9.0000	1.0000
0.1364	7.0000	0
0.1364	5.0000	1.0000
0.1591	7.0000	0
0.3182	11.0000	0
0.3864	8.0000	0
0.2955	6.0000	2.0000
0.4773	9.0000	0
0.6364	7.0000	1.0000
0.8636	9.0000	0
0.5227	13.0000	1.0000
0.5682	10.0000	0
0.5227	6.0000	0
1.0682	7.0000	0
0.5000	9.0000	1.0000
1.0000	10.0000	2.0000
1.4545	8.0000	2.0000
1.1364	7.0000	1.0000
1.3182	8.0000	2.0000
1.0682	8.0000	2.0000

(Note that the second and the third cluster correspond to outlier patterns)

- *4th block:* This block corresponds to the period 06:30-07:55.
  For è=180 we have the following results:

  Cluster 1 contains the patterns 1, 3, 6, 7, 8, 12, 13, 15, 19, 20, 28, 29, 30, 32, 37, 38, 39, 42, 43, 44, 46.

  Cluster 2 contains the patterns 4, 5, 9, 10, 16, 17, 21, 22, 23, 24, 25, 26, 27, 31, 33, 34, 40, 41, 45.

  Cluster 3 contains the patterns 11, 18.

  Cluster 4 contains the patterns 2, 14, 35, 36.

The cluster representatives are:

C_1	C_2	C_3	C_4
2.0000	0.6842	1.5000	1.0000
2.8095	0.8947	5.0000	1.7500
3.6667	0.6842	5.0000	2.5000
2.7143	0.9474	6.0000	3.7500
3.8095	0.8947	5.5000	2.2500
3.7619	0.8421	4.0000	3.7500
2.6667	1.0000	4.0000	4.0000
2.8095	1.0000	7.0000	2.7500
3.0952	0.4211	3.0000	2.7500
2.6667	1.0000	5.5000	4.2500
3.8095	0.9474	7.0000	5.0000
3.8571	0.9474	6.5000	6.5000
4.4762	0.8947	4.0000	2.7500
3.5714	0.9474	5.0000	6.0000
3.8571	1.1053	5.0000	5.5000
5.6667	1.6842	12.0000	5.2500
6.0000	1.3684	7.5000	9.5000
6.7619	2.2632	10.0000	6.5000

- *5th block:* This block corresponds to the period 08:00-08:25.

For è=150 we have the following results:

Cluster 1 contains the patterns 1, 6, 7, 8, 9, 13, 14, 15, 19, 29, 32, 35, 36, 38, 39, 40, 43, 44, 46.

Cluster 2 contains the patterns 3, 4, 5, 10, 16, 17, 21, 22, 23, 24, 25, 26, 27, 31, 33, 34, 41, 45.

Cluster 3 contains the patterns 2, 11, 12, 18, 20, 28, 30, 37, 42.

The cluster representatives are:

C_1	C_2	C_3
6.2105	1.9444	6.3333
6.6316	1.2778	6.7778
6.5263	1.1667	8.8889
7.2105	2.1667	9.0000
6.2632	1.9444	8.8889
5.5789	1.7222	10.3333

I.4. COMMENTS ON RESULTS

The ability of identifying different blocks of levels of pedestrian demand throughout the day, opens up the possibility of including pedestrians explicitly in overall network control strategies (through traffic signals).

Traffic management schemes have started moving away from exclusive preoccupation with vehicular movement towards the consideration of person movement. This is evident by the increased popularity of bus priority schemes.

Traffic control systems may evolve to explicitly consider pedestrians - by detecting broad levels of demand at key sections in the network to decide on strategic control and then using detectors at local controllers to effect control at a local level, as presented in the following figure.

The development of priority networks for pedestrian travel to/from major activity centres will benefit from such applications.

APPENDIX J. RESULTS OF ATTITUDES SURVEY

The survey was conducted in Elefsina in December 1994 and involved interviewing 232 persons. The questionnaire is not presented as such, but explained together with the analysis of results.

J.1 REFERENCE VARIABLES PROFILES

Personal Variables

The information on personal variables is depicted in figure J.1 that follows. There is a very high proportion of responders that walk and cross I. Polytehneioy Str. every day (54%). Most responders fall into the 20-39 age group (48%) with relatively few elderly persons (10%). Females are 70% of the total sample. Most people follow the same route in order to cross I. Polytehneiou although they are aware of other alternatives.

Situation Variables

The information on situation variables is depicted in the figure J.2 that follows. Most responders were walking alone, not carrying things or accompanying children. The main trip purpose was Shopping/Bank (43%).

Route Attributes Rating

Responders were asked to list the route attributes they take into account when choosing a route and to rate the attributes of the route they follow on a six point scale. The results are shown in figure J.3 that follows. Time and distance were not considered as important attributes by a significant proportion of responders (35% and 48% respectively). This is probably due to the grid type network structure where time or distance gain opportunities are limited. In contrast safety was not considered as a route choice factor by only 5% percent of the responders. This is probably due to the generally low level of safety in crossing I. Polytehneiou Str., as evident in the poor ratings safety and traffic conditions, get. The comfort variable 'walk surface' comes next in getting poor ratings. Finally, overall, Safety and Comfort variables (Walk Surface, traffic conditions, pleasantness) seem to be the most important factors taken into account in the route choice decisions of pedestrians in Elefsina.

Responses to Scenarios

Responders were asked if they were prepared to walk 200 or 400 m. more in order to get better 'comfort' conditions (SWALK i.e. a very wide sidewalk) or better 'safety' conditions (SIGNAL i.e. cross at the signal) or both. Their responses were registered in a six point scale. The results are shown in figures J.4 and J.5 that follow where scenario I refers to the 200 m. alternative and scenario II to the 400 m. alternative.

Predictably, less people are prepared to change in the case of the 400 extra m. alternative and more people are prepared to change if both increased comfort and safety are provided. The results are further depicted in fig. J.6 that follows.

Finally, the potential of persons to trade off walking distance for safety and comfort may be influenced by whether or not they take into account certain factors when selecting routes. In figures J.7 and J.8, the potential response to the two scenarios is classified according to each factor taken or not taken into account in the route selection process. The results are summarised in tables J.1 and J.2 for responses 4 and 5 added together i.e. those that are likely to change and those that definitely will change (the 'positives').

TABLE J.1 Responses of 'positives' by whether or not they have taken into account each route factor compared to the average response. Scenario I. Walk 200 more metres.

		SWALK + 200 M. (%)	SIGNAL + 200 M. (%)	SWALK + SIGNAL + 200 M. (%)
FACTOR TAKEN OR NOT INTO ACCOUNT	AVERAGE RESPONSES FOR SAMPLE	70.3	71.1	82.3
TIME	NO	77.1	71.7	85.1
	YES	68.9	72.6	83.0
DISTANCE	NO	80.2	81.4	91.9
	YES	68.8	65.6	80.6
SAFETY	NO	80.0	80.0	80.0
	YES	74.1	73.0	86.2
PLEASANTNESS	NO	61.5	65.3	76.9
	YES	77.5	78.1	88.7
ACTIVITIES	NO	82.2	80	91.1
	YES	71.2	68.9	82.5
TRAFFIC CONDITIONS	NO	68.7	68.8	81.3
	YES	74.4	74.4	86.6
SHADE	NO	73.4	71.1	84.5
	YES	77.1	75.5	86.5
SURFACE	NO	57.1	78.5	78.6
	YES	77.7	74.6	88.8

From the above table it is seen that those that do not take into account distance are more positively inclined, compared to the average, to change route. The same holds for those that do not take into account time and those that take into account safety (but with smaller difference from the average).

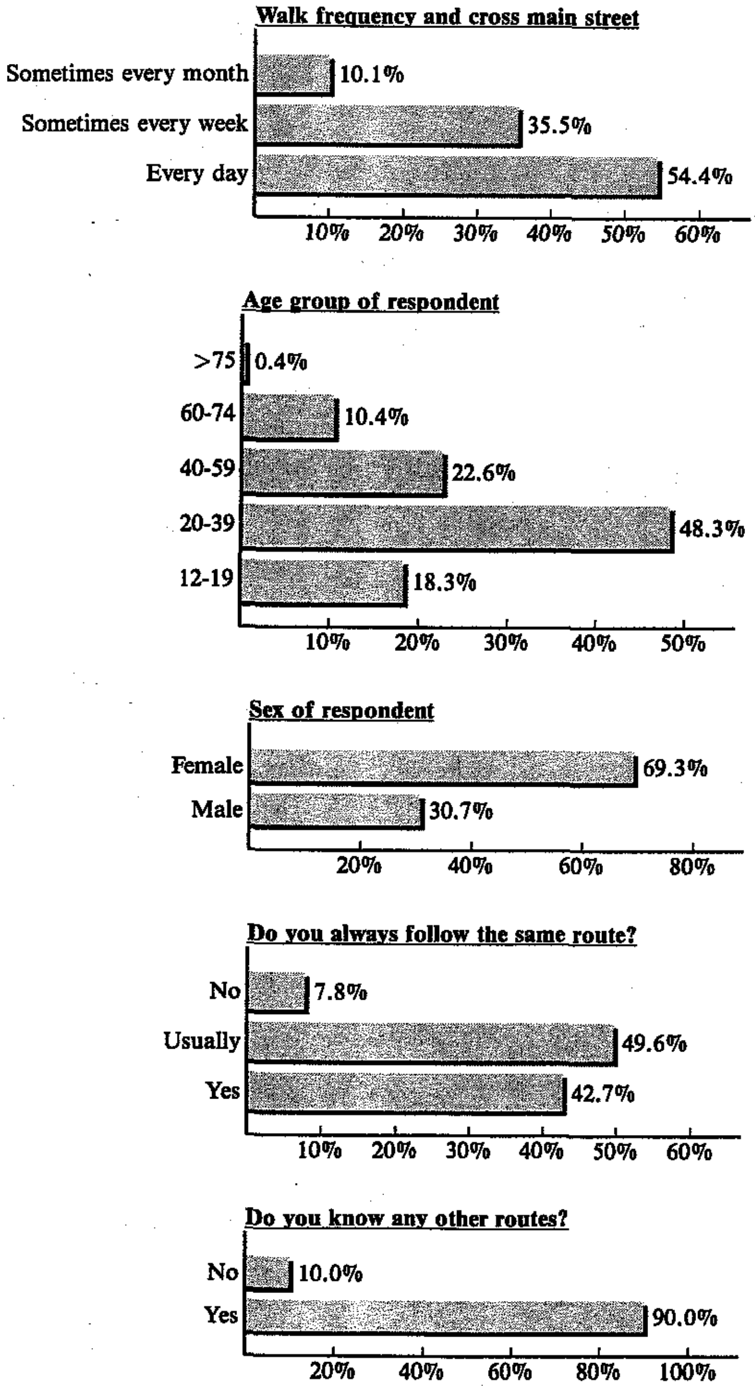
TABLE J.2 Responses of 'positives' by whether or not they have taken into account each route factor compared to the average response. Scenario II. Walk 400 more metres.

		SWALK + 400 M. (%)	SIGNAL + 400 M. (%)	SWALK + SIGNAL + 400 M.
FACTOR TAKEN OR NOT INTO ACCOUNT	AVERAGE RESPONSES FOR SAMPLE	32.8	37.6	48.2
TIME	NO	46.5	46.5	59.1
	YES	27.3	35.6	43.9
DISTANCE	NO	44.0	47.6	58.3
	YES	29.2	37.1	47.2
SAFETY	NO	44.4	55.5	66.6
	YES	36.1	40.8	52.7
PLEASANTNESS	NO	37.5	41.7	54.1
	YES	36.7	44.3	55.1
ACTIVITIES	NO	48.9	51.1	58.2
	YES	32.8	40.6	53.9
TRAFFIC CONDITIONS	NO	53.3	53.3	60.0
	YES	34.8	41.4	52.7
SHADE	NO	41.5	39.0	56.1
	YES	36.2	45.7	54.3
SURFACE	NO	41.7	50.0	50.0
	YES	36.8	41.8	55.1

For the second scenario the comments that were made above for scenario I also hold.

FIGURE J.1

PERSONAL VARIABLES



- *6th block:* This block corresponds to the period 08:30-08:55.
  For è=250 we have the following results:

  Cluster 1 contains the patterns 4, 7, 8, 9, 12, 13, 14, 15, 16, 19, 23, 26, 30, 32, 33, 38, 40, 43, 46.

  Cluster 2 contains the patterns 3, 5, 10, 17, 21, 22, 24, 25, 27, 31, 34, 41, 45.

  Cluster 3 contains the patterns 1, 2, 6, 11, 18, 20, 28, 29, 35, 36, 37, 39, 42, 44.

  The cluster representatives are:

C_1	C_2	C_3
5.8947	0.7692	8.9286
5.5789	1.8462	8.3571
5.6842	1.5385	7.7857
4.8947	1.0769	9.2143
5.7368	1.3846	10.4286
7.2632	1.1538	10.0000

- *7th block:* This block corresponds to the period 09:00-10:55.
  For è=600 we have the following results:

  Cluster 1 contains the patterns 1, 2, 3, 4, 7, 8, 9, 12, 13, 14, 15, 16, 19, 23, 26, 29, 30, 32, 33, 38, 39, 40, 43, 44, 46.

  Cluster 2 contains the patterns 6, 11, 18, 20, 35, 36, 37.

  Cluster 3 contains the patterns 5, 10, 17, 21, 22, 24, 25, 27, 31, 34, 41, 45.

  Cluster 4 contains the patterns 28, 42.

  The cluster representatives are:

C_1	C_2	C_3	C_4
7.6800	9.0000	1.7500	9.0000
7.1600	6.7143	1.6667	15.5000
6.6800	9.7143	1.2500	13.5000
6.4000	11.0000	1.3333	11.0000
5.8000	8.2857	1.0000	0.0000
6.5200	8.7143	1.0000	14.0000
5.0400	8.1429	1.5000	14.0000
7.1200	9.8571	1.9167	12.0000

6.6800	9.0000	1.8333	14.5000
6.6400	8.0000	1.0000	12.5000
6.9200	9.7143	2.6667	12.0000
6.2400	11.2857	1.5000	12.5000
7.6800	11.2857	1.1667	11.0000
7.2800	11.2857	2.4167	13.0000
7.4000	12.4286	2.4167	16.0000
6.5200	10.0000	2.4167	14.5000
6.8800	9.1429	1.5000	11.5000
7.6000	11.1429	1.2500	11.5000
8.0400	13.1429	2.3333	18.5000
7.2800	12.5714	2.0833	13.5000
7.4800	10.8571	2.1667	13.5000
7.6000	12.7143	2.2500	15.0000
7.3200	10.2857	2.2500	12.0000
8.6400	9.4286	1.8333	13.0000

- *8th block:* This block corresponds to the period 11:00-11:25.
For è=200 we have the following results:

Cluster 1 contains the patterns 1, 2, 3, 4, 6, 7, 8, 9, 11, 12, 13, 14, 15, 16, 18, 19, 23, 26, 29, 30, 32, 33, 36, 37, 38, 39, 40, 41, 43, 44, 46.

Cluster 2 contains the patterns 5, 10, 17, 21, 22, 24, 25, 27, 31, 34, 45.

Cluster 3 contains the patterns 20, 28, 35, 42.

The cluster representatives are:

C_1	C_2	C_3
8.7419	1.5455	11.5000
8.5161	2.1818	12.2500
8.4516	2.1818	11.0000
8.0323	2.5455	15.0000
7.5161	1.9091	11.7500
7.5161	2.4545	13.5000

- *9th block:* This block corresponds to the period 11:30-13:25.
  For è=600 we have the following results:

  Cluster 1 contains the patterns 1, 2, 3, 4, 7, 8, 9, 11, 12, 13, 14, 16, 19, 23, 26, 29, 30, 32, 33, 38, 39, 43, 44, 46.

  Cluster 2 contains the patterns 5, 10, 15, 17, 24, 27, 34, 41.

  Cluster 3 contains the patterns 21, 22, 25, 31, 45.

  Cluster 4 contains the patterns 6, 18, 20, 28, 35, 36, 37, 40, 42.

  The cluster representatives are:

C_1	C_2	C_3	C_4
7.1667	5.5000	0	9.7778
7.0833	4.3750	0	10.3333
7.2917	4.6250	0	9.5556
7.2500	5.0000	0	9.2222
7.2500	5.0000	0	11.1111
8.2500	5.1250	0	7.7778
7.3333	4.7500	0	9.8889
7.0833	3.6250	0	11.1111
6.5833	4.0000	0	13.6667
6.7083	5.7500	0	10.7778
7.2917	4.1250	0	9.3333
7.7083	4.5000	0	9.7778
7.8750	3.8750	0	9.3333
6.5417	3.1250	0	9.2222
7.3750	3.3750	0	7.5556
6.9167	3.1250	0	10.0000
7.3333	3.1250	0	8.3333
7.4583	4.1250	0.8000	9.7778
7.9167	3.5000	2.0000	8.2222
6.4167	4.0000	1.2000	6.7778
7.2500	4.0000	2.2000	7.8889
6.9167	3.7500	1.2000	7.3333
6.7083	3.0000	1.4000	7.7778
6.4167	3.5000	1.6000	7.8889

- *10th block:* This block corresponds to the period 13:30-13:55.
  For è=150 we have the following results:

  Cluster 1 contains the patterns 1, 2, 11, 18, 25, 28, 32, 33, 35, 36, 39, 40, 42, 44, 46.

  Cluster 2 contains the patterns 3, 4, 5, 6, 7, 8, 9, 12, 13, 14, 16, 19, 20, 23, 24, 26, 29, 30, 34, 37, 38, 41, 43.

  Cluster 3 contains the patterns 10, 15, 17, 21, 22, 27, 31, 45.

  The cluster representatives are:

C_1	C_2	C_3
7.6000	5.6957	1.0000
7.7333	6.1304	1.3750
9.0000	5.0870	1.0000
7.8000	5.1304	0.6250
8.4667	6.4348	1.0000
7.1333	5.0000	0.6250

- *11th block:* This block corresponds to the period 14:00-14:25.
  For è=70 we have the following results:

  Cluster 1 contains the patterns 1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 14, 16, 17, 18, 19, 20, 23, 24, 25, 27, 28, 29, 34, 35, 36, 38, 39, 41, 44.

  Cluster 2 contains the patterns 2, 40.

  Cluster 3 contains the patterns 15, 21, 22, 31, 45.

  Cluster 4 contains the patterns 13, 26, 30, 32, 33, 42, 43, 46.

  Cluster 5 contains the pattern 37.

  The cluster representatives are:

C_1	C_2	C_3	C_4	C_5
4.2667	12.0000	0	8.5000	5.0000
4.0333	10.0000	0	6.3750	3.0000
3.9000	11.5000	0	4.8750	12.0000
3.8000	5.5000	0	4.6250	6.0000
4.3667	10.0000	0	4.0000	11.0000
3.9667	6.0000	0	4.5000	2.0000

- *12th block:* This block corresponds to the period 14:30-18:25.
For è=700 we have the following results:

Cluster 1 contains the patterns 1, 2, 4, 5, 6, 9, 10, 11, 13, 16, 17, 18, 20, 23, 24, 26, 27, 30, 33, 34, 37, 40, 41.

Cluster 2 contains the pattern 21.

Cluster 3 contains the patterns 15, 22, 31, 45.

Cluster 4 contains the patterns 3, 7, 8, 12, 14, 19, 25, 28, 29, 32, 35, 36, 38, 39, 42, 43, 44, 46.

The cluster representatives are:

C_1	C_2	C_3	C_4
3.5652	0	0	3.7222
4.0000	0	0	4.0000
3.9130	0	0	3.6667
3.9565	0	0	4.7222
4.6087	0	0	4.5000
4.2174	0	0	5.4444
3.9565	0	0	4.4444
4.5652	0	0	5.5556
3.8261	0	0	5.1667
3.3478	0	0	3.6667
3.5652	0	0	3.7222
3.3913	0	0	3.1667
3.0000	0	1.5000	3.7222
3.3478	0	0.7500	2.9444
2.8261	0	1.2500	4.4444
3.9130	0	0	3.9444
3.0435	0	0.7500	3.6667
3.1739	0	1.2500	4.0000
3.0870	0	1.7500	4.1111
3.4783	0	2.5000	3.8333
2.3043	0	3.0000	4.2222
3.3913	0	4.7500	3.2778
3.0435	0	3.2500	3.8889
2.5652	0	4.7500	3.1667
3.0000	0	3.7500	4.0556

3.4783	0	3.0000	4.7778
2.0435	0	6.0000	3.9444
3.3913	0	8.2500	4.8333
3.5217	0	7.2500	6.0556
3.1739	0	8.5000	7.7222
3.0000	0	9.5000	7.9444
3.8696	0	9.2500	7.3333
3.9130	0	6.7500	5.9444
4.2609	0	8.0000	7.0000
3.3043	0	8.0000	6.8889
4.0870	0	9.7500	7.5556
4.5217	0	9.2500	6.2778
4.3478	0	6.7500	7.6667
4.3478	0	6.0000	6.7778
4.7391	0	7.0000	7.7778
4.5652	0	10.2500	8.1667
4.9130	0	7.7500	9.0000
5.3913	0	14.2500	9.2222
5.8261	0	11.5000	8.2778
4.4348	0	8.0000	7.6667
4.6957	0	6.5000	7.8889
5.9565	0	8.5000	7.2222
5.1304	0	8.2500	7.1111

- *13th block:* This block corresponds to the period 18:30-18:55.
  For è=110 we have the following results:

  Cluster 1 contains the patterns 1, 3, 10, 11, 13, 14, 17, 20, 29, 32, 36, 37, 42, 46.

  Cluster 2 contains the patterns 2, 5, 21, 23, 24, 27, 34.

  Cluster 3 contains the patterns 6, 12, 19, 30, 45.

  Cluster 4 contains the patterns 4, 9, 16, 26, 31, 33, 40, 41.

  Cluster 5 contains the patterns 7, 8, 15, 18, 22, 25, 28, 35, 38, 39, 43, 44.

The cluster representatives are:

C_1	C_2	C_3	C_4	C_5
6.1429	3.0000	10.0000	5.8750	7.5833
6.7143	2.7143	7.4000	5.3750	8.0000
6.5714	2.2857	5.6000	8.3750	8.0833
6.2143	3.0000	9.6000	7.0000	10.8333
9.4286	2.8571	8.0000	5.5000	13.4167
10.3571	3.2857	12.8000	4.0000	9.6667

- *14th block:* This block corresponds to the period 19:00-19:25.
For è=100 we have the following results:

Cluster 1 contains the patterns 1, 3, 6, 7, 8, 12, 13, 14, 15, 18, 19, 22, 25, 28, 29, 30, 31, 32, 36, 38, 39, 43, 45, 46.

Cluster 2 contains the patterns 2, 21.

Cluster 3 contains the patterns 4, 5, 9, 10, 16, 17, 23, 24, 26, 27, 33, 34, 37, 40, 41, 44.

Cluster 4 contains the patterns 11, 20, 35, 42.

The cluster representatives are:

C_1	C_2	C_3	C_4
10.7500	0.5000	4.9375	9.7500
9.5000	0	5.9375	5.7500
8.7500	0.5000	5.0625	8.7500
7.4167	0.5000	5.6875	11.2500
7.3750	0.5000	4.3125	9.2500
9.1250	0	4.8125	4.5000

- *15th block:* This block corresponds to the period 19:30-19:55.
For è=140 we have the following results:

Cluster 1 contains the patterns 1, 3, 6, 8, 12, 14, 19, 22, 28, 29, 31, 32, 45, 46.

Cluster 2 contains the patterns 2, 4, 5, 9, 10, 13, 16, 17, 21, 23, 24, 26, 27, 33, 34.

Cluster 3 contains the patterns 7, 11, 15, 18, 20, 25, 30, 35, 36, 37, 38, 40, 41, 42, 43, 44.

Cluster 4 contains the pattern 39.

The pattern representatives are:

C_1	C_2	C_3	C_4
8.8571	3.9333	6.2500	6.0000
9.8571	3.8000	5.6875	10.0000
6.5000	3.2667	7.0625	9.0000
9.2857	3.6000	4.9375	2.0000
5.3571	3.7333	8.0625	9.0000
8.3571	4.2667	8.4375	16.0000

- *16th block:* This block corresponds to the period 20:00-20:25.

For è=70 we have the following results:

Cluster 1 contains the patterns 1, 6, 8, 30, 36, 44, 46.

Cluster 2 contains the patterns 2, 21.

Cluster 3 contains the patterns 3, 7, 23, 24, 26, 28, 33, 35, 38, 41, 45.

Cluster 4 contains the patterns 4, 5, 9, 10, 13, 16, 18, 27, 29, 34, 37.

Cluster 5 contains the patterns 11, 12, 17, 19, 20, 25, 39, 40, 42, 43.

Cluster 6 contains the patterns 14, 15, 22, 31, 32.

The cluster representatives are:

C_1	C_2	C_3	C_4	C_5	C_6
11.7143	0	6.7273	4.9091	5.6000	9.4000
6.1429	0.5000	5.8182	4.7273	9.6000	8.6000
4.4286	0	5.4545	4.9091	6.2000	8.4000
6.5714	0	4.5455	5.9091	5.7000	6.8000
4.0000	0.5000	7.7273	3.1818	4.5000	6.8000
5.2857	0	5.1818	5.4545	4.9000	8.0000

- *17th block:* This block corresponds to the period 20:30-21:55.

For è=200 we have the following results:

Cluster 1 contains the patterns 1, 4, 5, 6, 7, 10, 11, 13, 14, 16, 17, 20, 27, 30, 34, 35, 40, 41, 42, 43, 44.

Cluster 2 contains the patterns 2, 21, 24, 37.

Cluster 3 contains the patterns 3, 8, 9, 23, 25, 26, 29, 32, 33, 46.

Cluster 4 contains the patterns 12, 18, 22, 36, 38.

Cluster 5 contains the patterns 15, 19, 28, 31, 39, 45.

The cluster representatives are:

C_1	C_2	C_3	C_4	C_5
4.3810	2.0000	5.9000	7.2000	8.1667
4.5714	1.0000	6.9000	6.0000	6.0000
5.7619	1.7500	4.5000	7.8000	4.8333
4.7143	1.0000	6.0000	5.6000	6.6667
5.0476	1.2500	5.6000	6.0000	6.6667
4.5238	2.0000	4.4000	6.0000	8.8333
5.0000	1.5000	6.9000	6.4000	4.8333
5.4762	2.2500	7.0000	5.8000	7.6667
5.2857	0.7500	6.7000	3.6000	5.6667
5.6667	1.7500	6.1000	4.4000	7.6667
4.6190	0.7500	6.5000	4.4000	4.8333
4.6667	1.2500	7.2000	1.8000	4.8333
3.3810	1.2500	6.1000	4.4000	4.8333
3.3810	0.5000	5.1000	5.8000	4.8333
3.6667	1.0000	4.2000	5.6000	4.8333
2.9524	0.5000	5.0000	4.0000	4.5000
3.1429	1.0000	5.3000	5.0000	5.1667
2.9048	2.0000	6.5000	3.2000	4.1667

18th block: This block corresponds to the period 22:00-23:55.
For è=200 we have the following results:
Cluster 1 contains the patterns 1, 2, 4, 5, 6, 7, 10, 11, 12, 13, 14, 17, 18, 19, 20, 21, 24, 27, 28, 29, 30, 31, 34, 35, 36, 37, 38, 41, 42, 43, 44, 45.

Cluster 2 contains the patterns 3, 8, 9, 15, 16, 22, 23, 25, 26, 32, 33, 39, 40, 46.

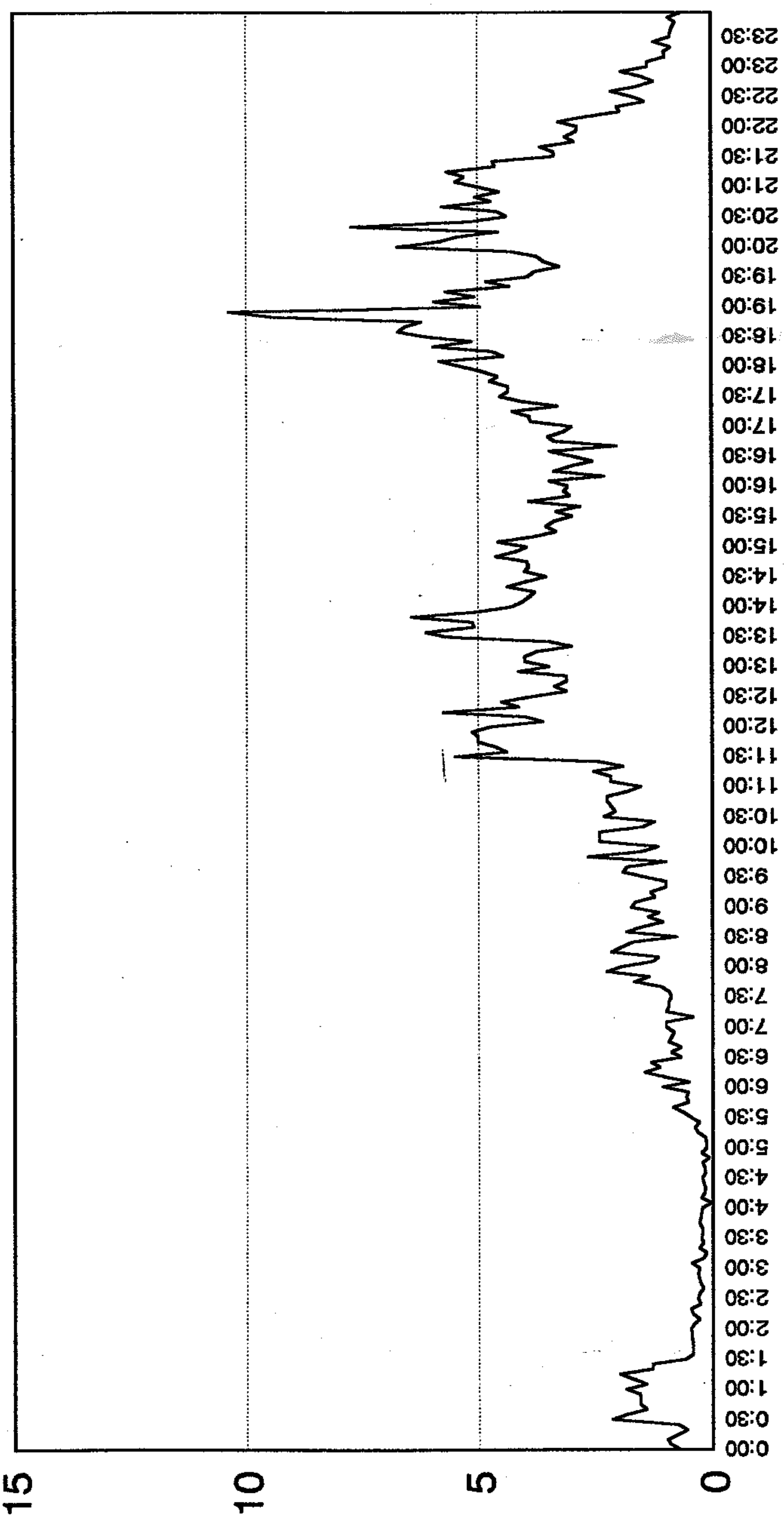
C_1	C_2
2.8750	6.2857
3.2813	5.0714
2.6563	4.7143
1.9688	4.4286
2.0313	4.7143
1.4375	4.5000
1.7188	4.1429
2.1563	3.4286
1.5938	3.9286
1.2500	3.2857
1.5313	2.7143
1.9375	3.1429
1.3750	2.5714
1.3750	2.4286
1.0000	1.8571
1.0313	2.2857
0.8750	1.8571
1.2500	1.6429
0.9063	1.0714
0.8750	2.2143
0.8438	1.5714
0.7813	1.9286
0.9375	2.2857
0.6563	1.3571

I.3. DEVELOPMENT OF PROFILES

The clusters developed in the previous section may be used to arrive at profiles of pedestrian demand throughout the day. Typical profiles for a whole week containing only the most common blocks are presented in the figures that follow. In future applications it may be possible to determine the choice of the next block through real-time monitoring of the flow.

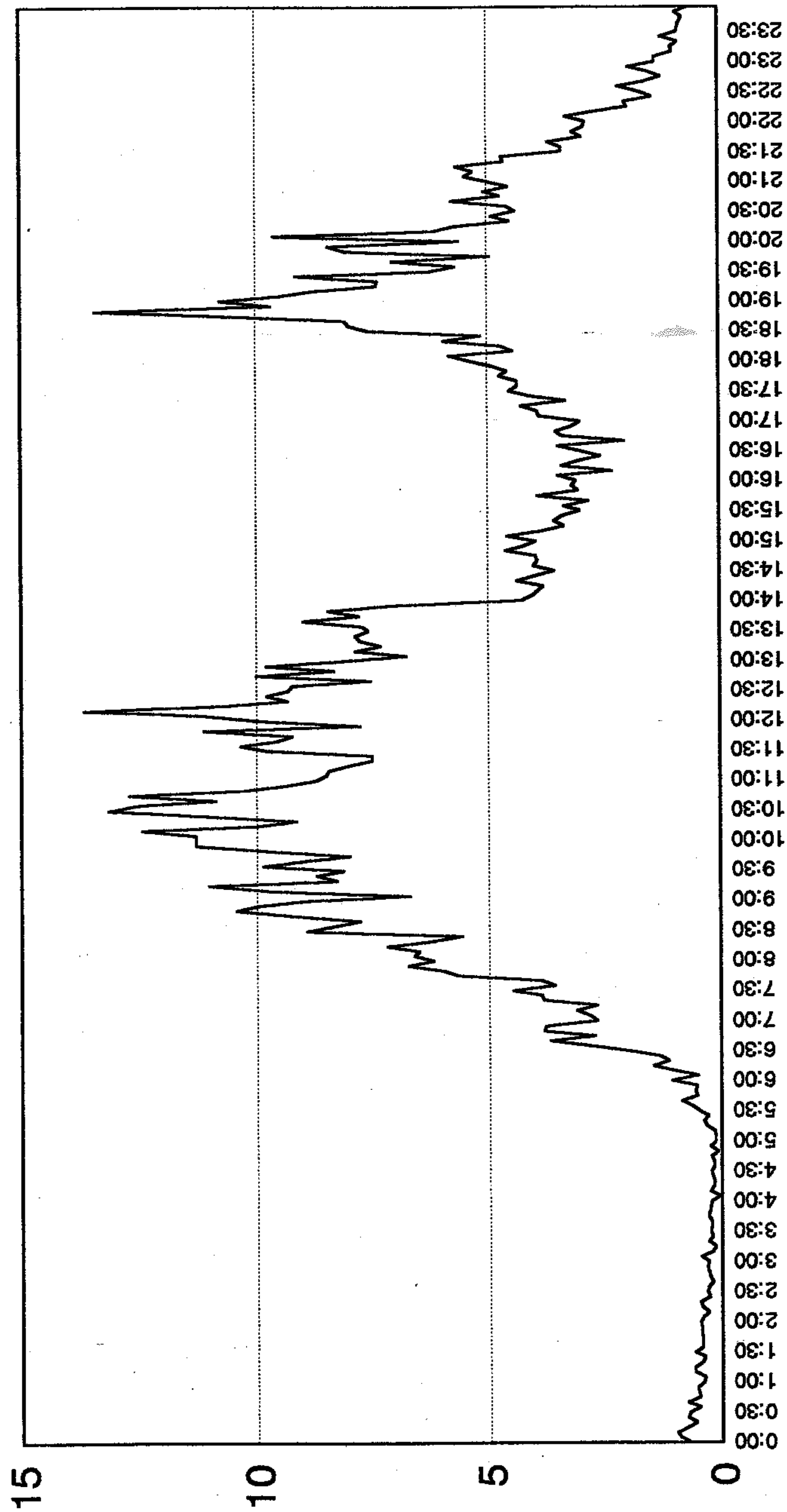
Sunday

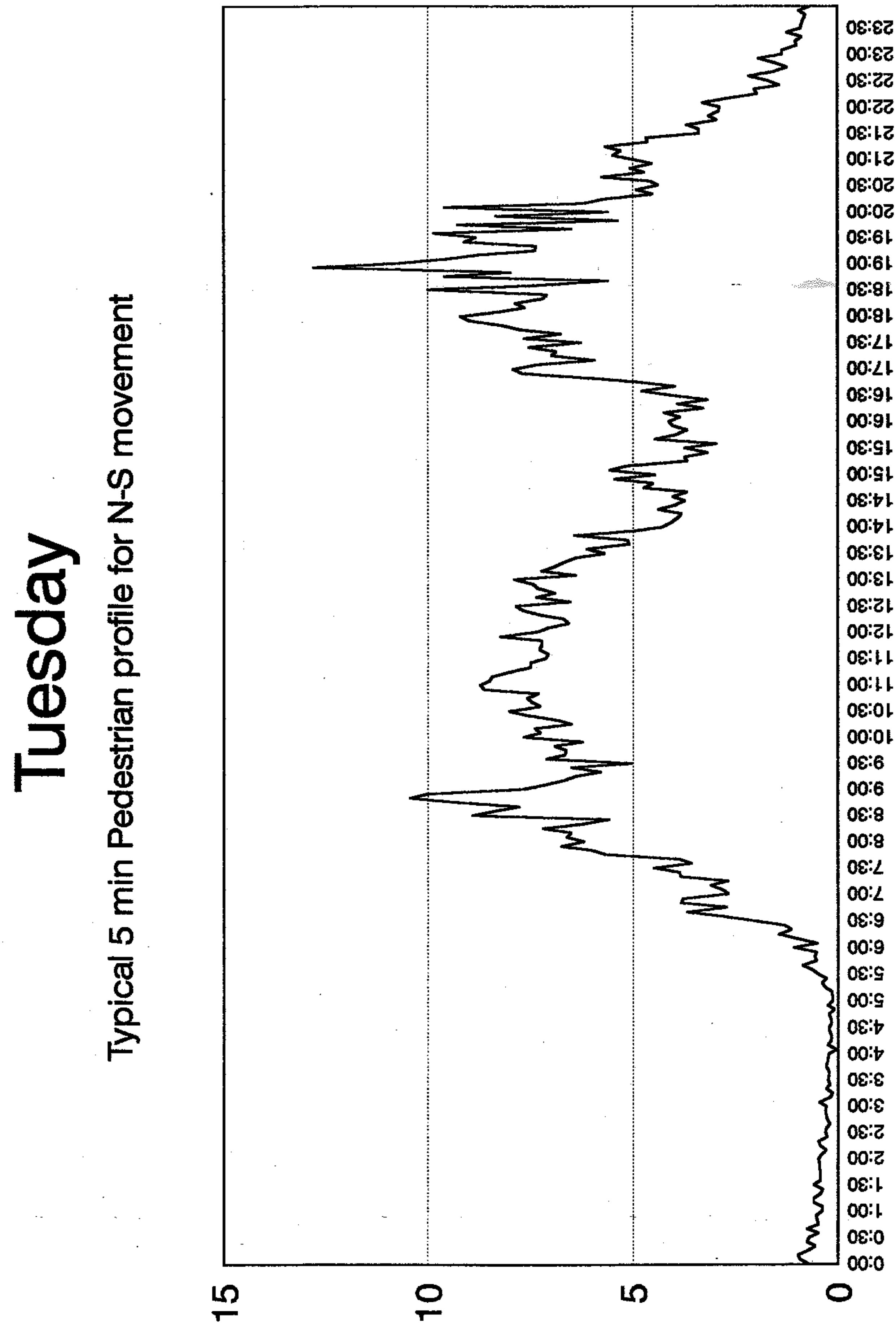
Typical 5 min Pedestrian profile for N-S movement



Monday

Typical 5 min Pedestrian profile for N-S movement




Tuesday
Typical 5 min Pedestrian profile for N-S movement
15
10
5
0
0:00
0:30
1:00
1:30
2:00
2:30
3:00
3:30
4:00
4:30
5:00
5:30
6:00
6:30
7:00
7:30
8:00
8:30
9:00
9:30
10:00
10:30
11:00
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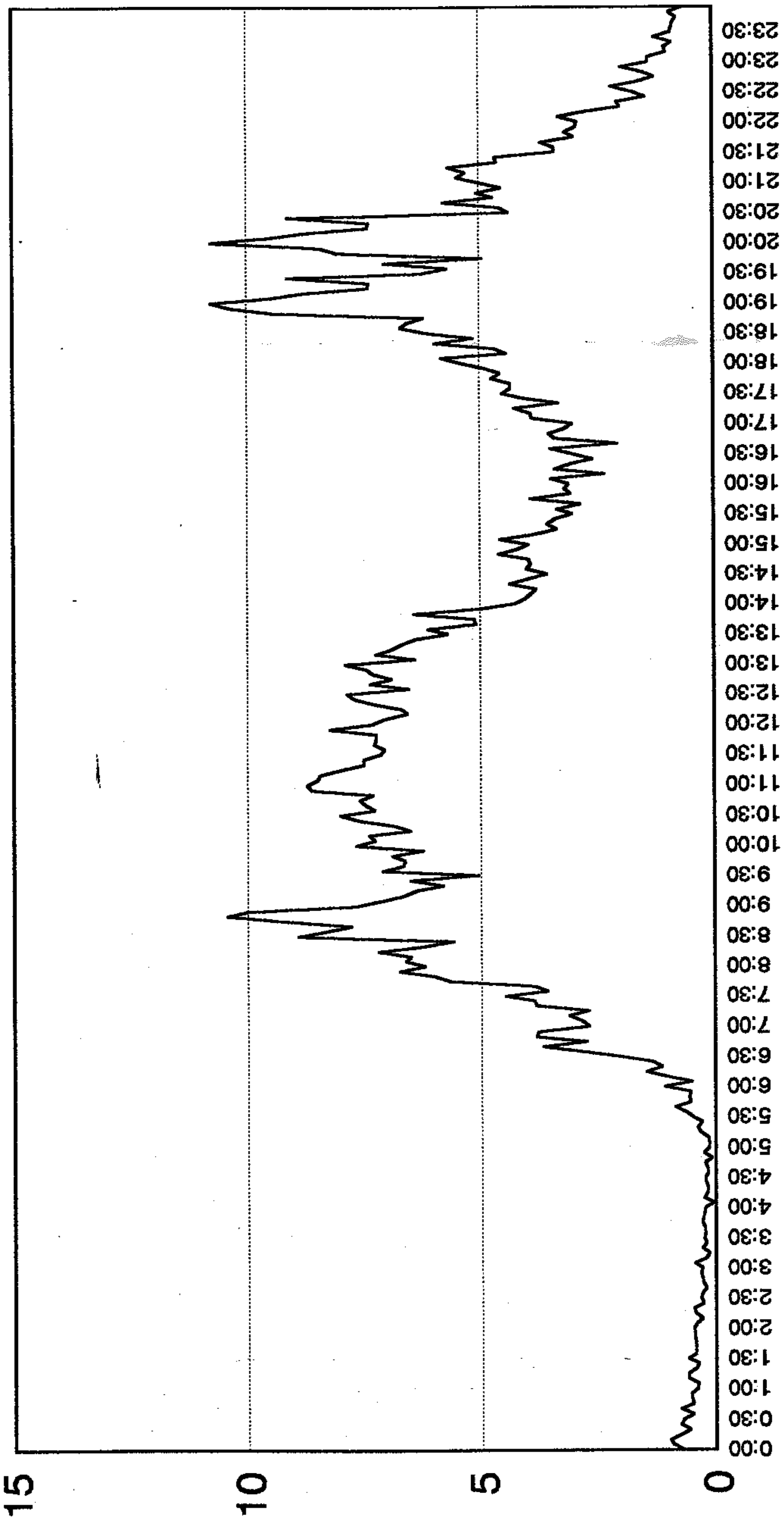
18:30
19:00
19:30
20:00
20:30
21:00
21:30
22:00
22:30
23:00
23:30

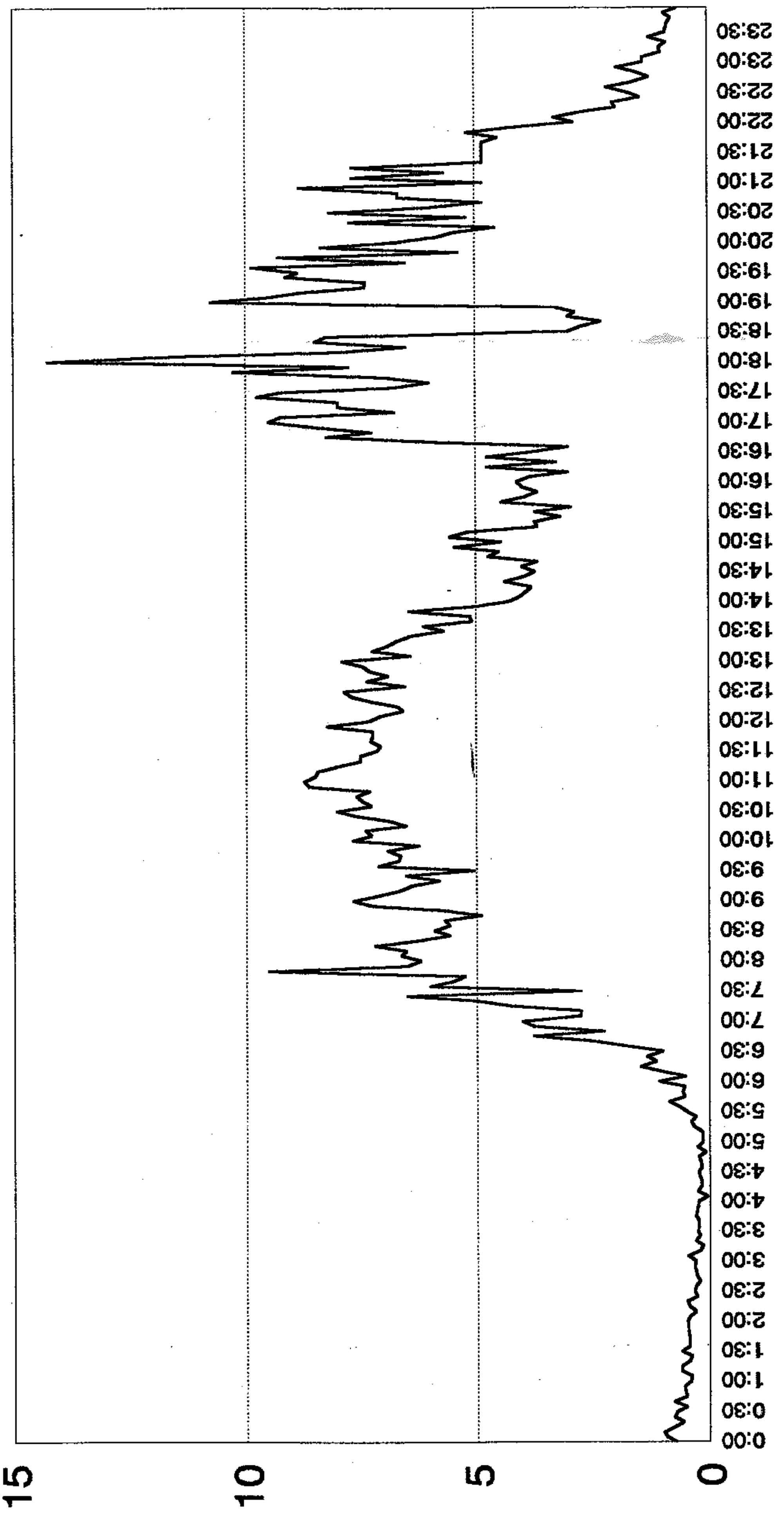
Wednesday

Typical 5 min Pedestrian profile for N-S movement



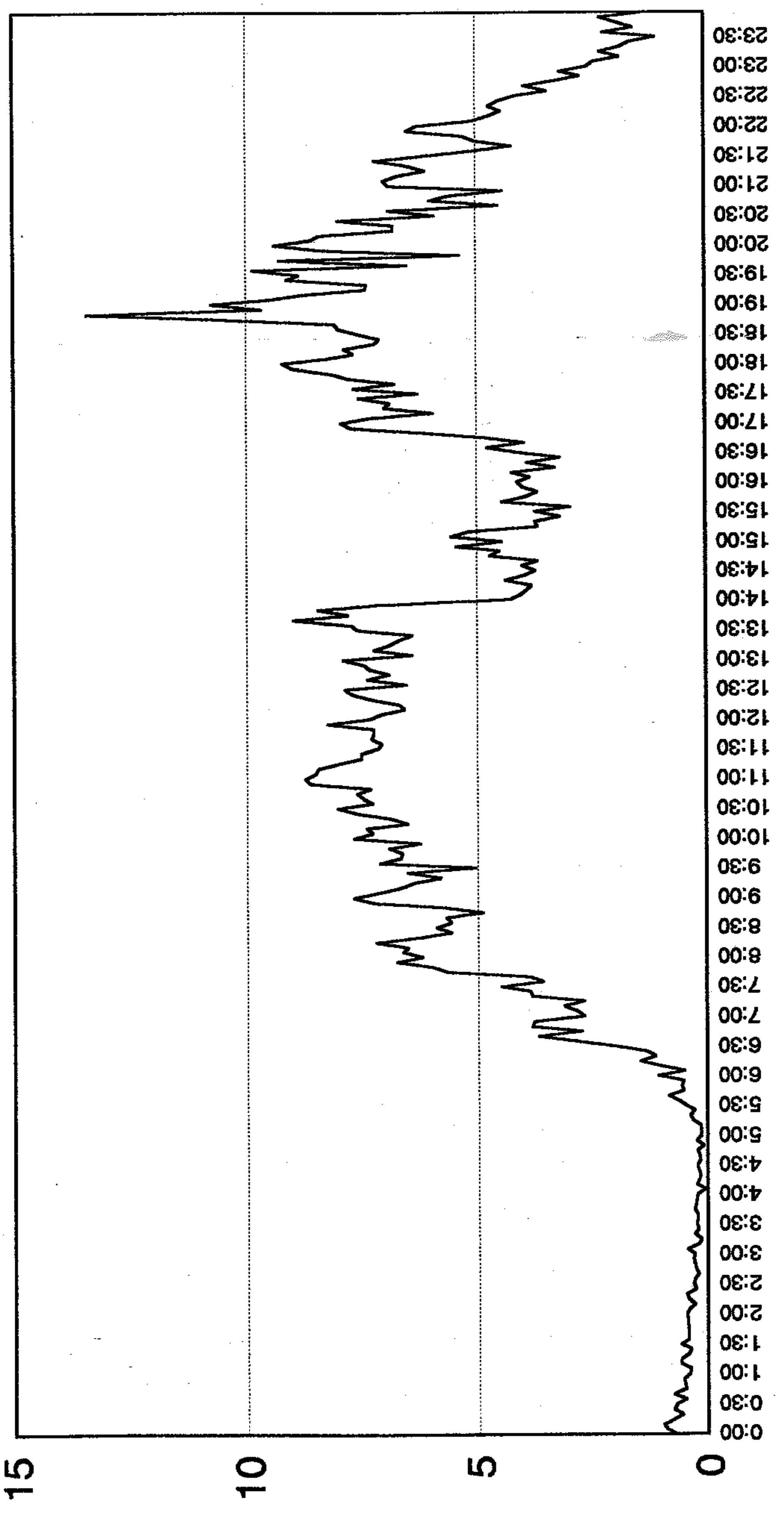
Thursday

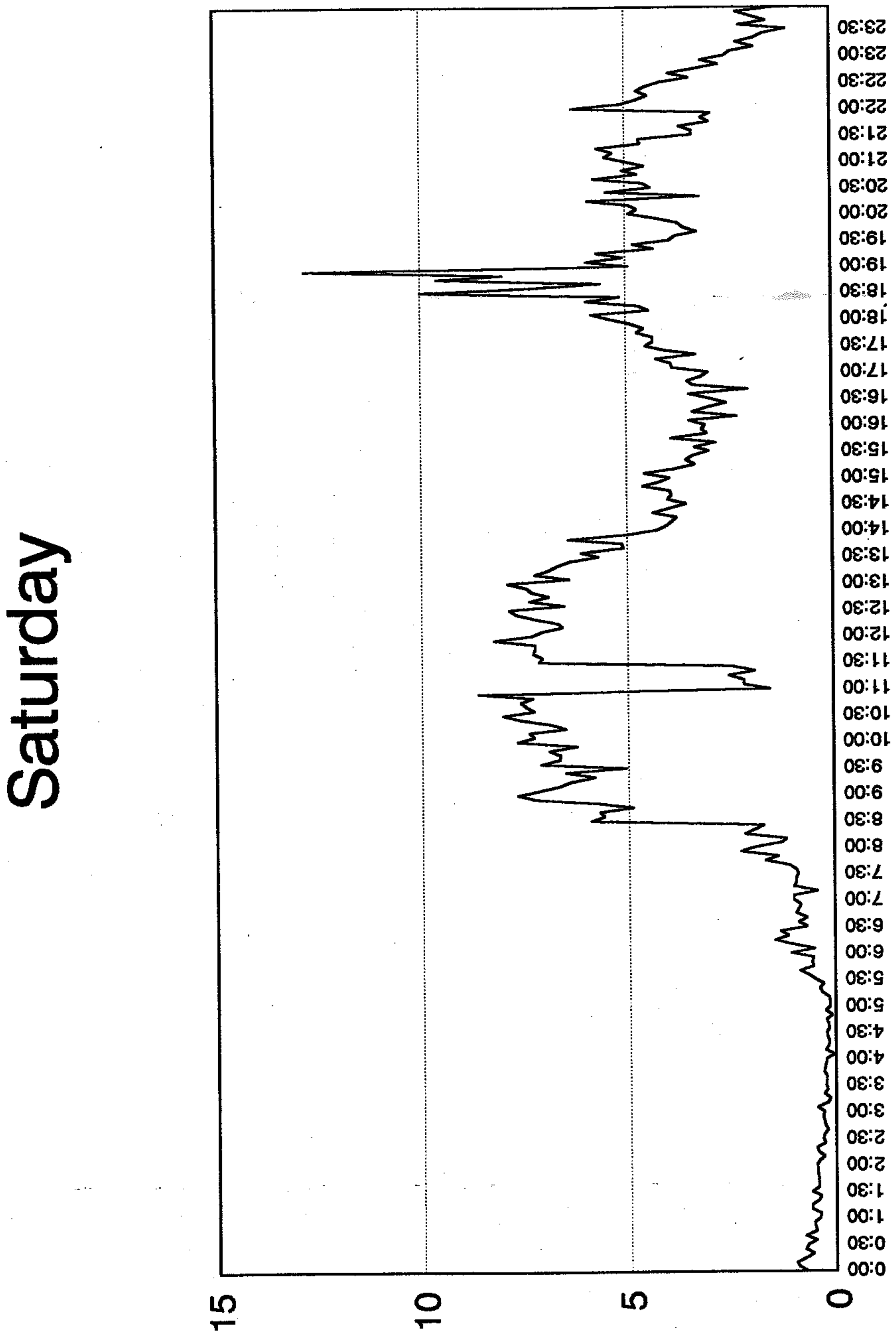
Typical 5 min Pedestrian profile for N-S movement



Friday

Typical 5 min Pedestrian profile for N-S movement




Saturday
15
10
5
0
0:00
0:30
1:00
1:30
2:00
2:30
3:00
3:30
4:00
4:30
5:00
5:30
6:00
6:30
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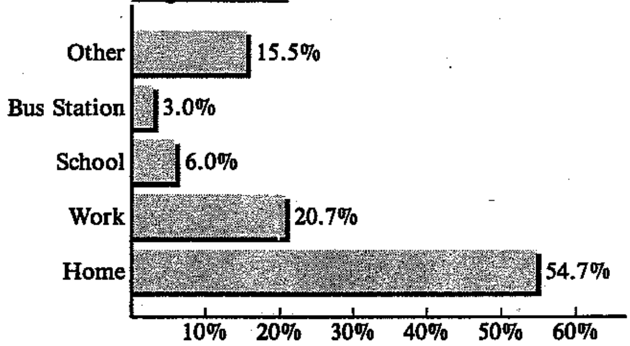
23:00
23:30

Origin land use



Destination land use

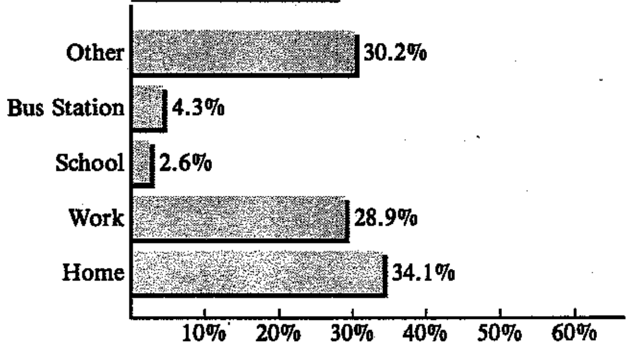
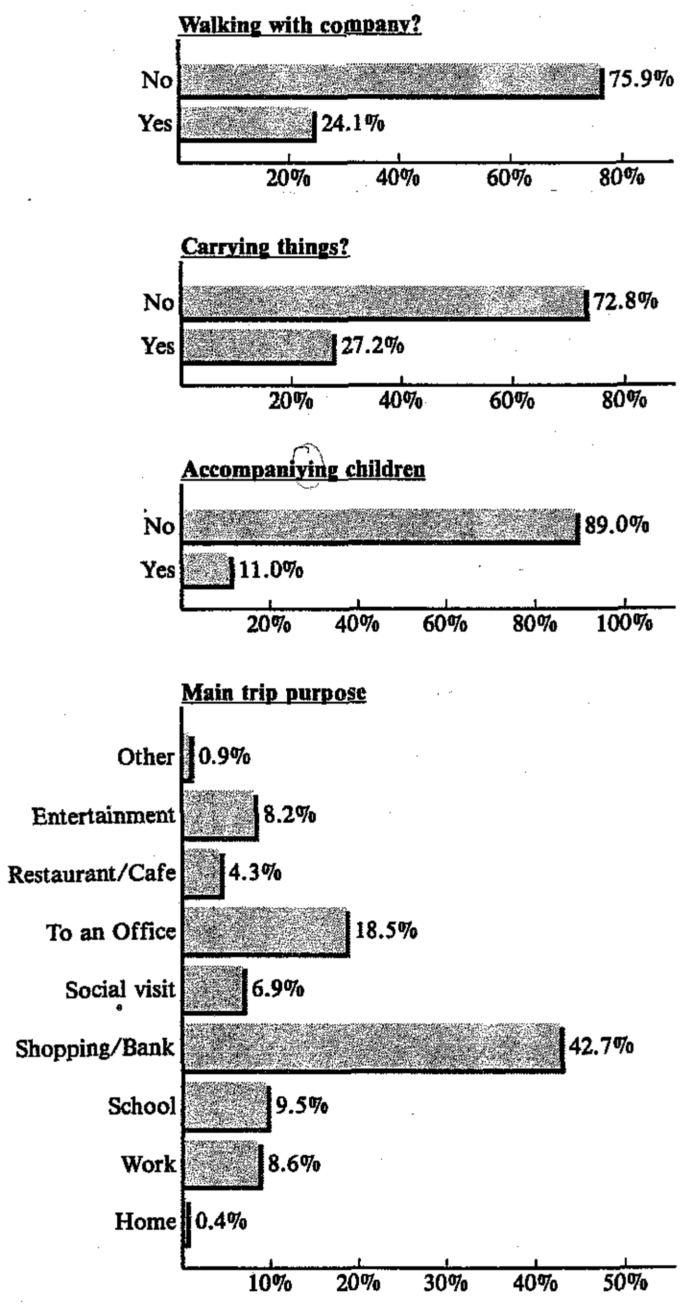
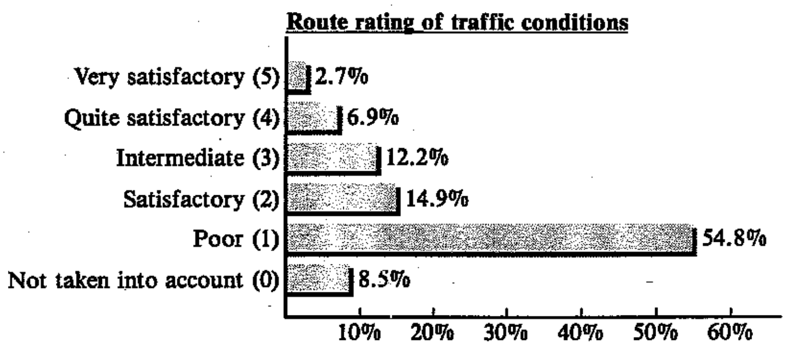
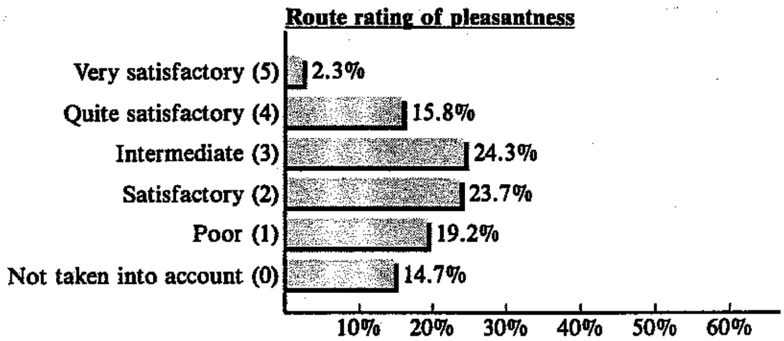


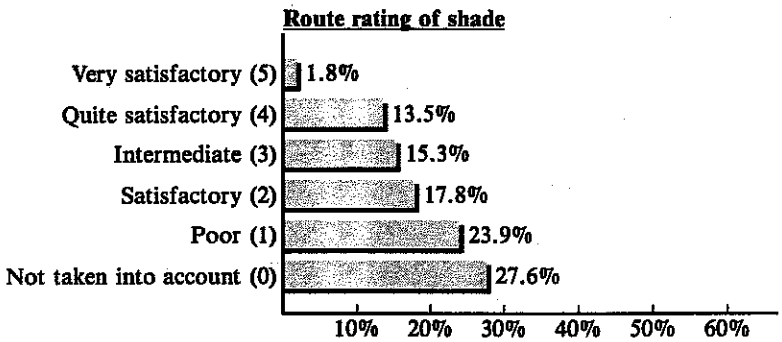
FIGURE J.2

SITUATION VARIABLES




Route rating of traffic conditions
Very satisfactory (5)
2.7%
Quite satisfactory (4)
6.9%
Intermediate (3)
12.2%
Satisfactory (2)
14.9%
Poor (1)
54.8%
Not taken into account (0)
8.5%
10%
20%
30%
40%
50%
60%


Route rating of pleasantness
Very satisfactory (5)
2.3%
Quite satisfactory (4)
15.8%
Intermediate (3)
24.3%
Satisfactory (2)
23.7%
Poor (1)
19.2%
Not taken into account (0)
14.7%
10%
20%
30%
40%
50%
60%


Route rating of shade
Very satisfactory (5)
1.8%
Quite satisfactory (4)
13.5%
Intermediate (3)
15.3%
Satisfactory (2)
17.8%
Poor (1)
23.9%
Not taken into account (0)
27.6%
10%
20%
30%
40%
50%
60%

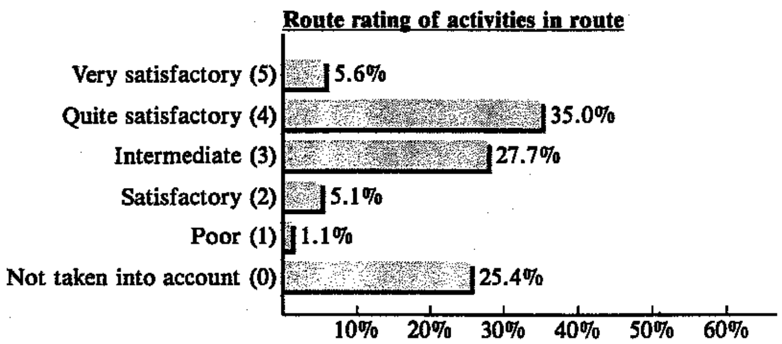
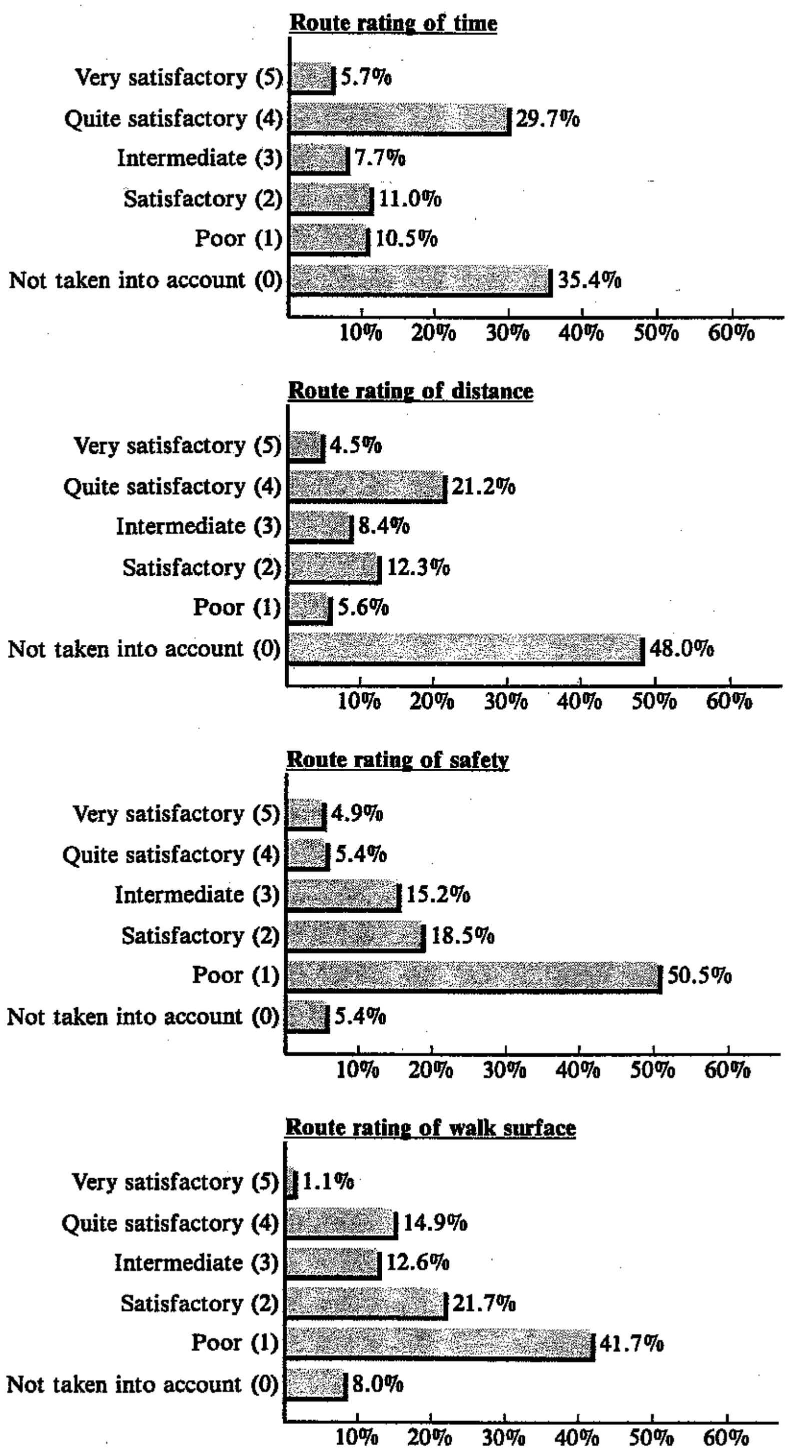
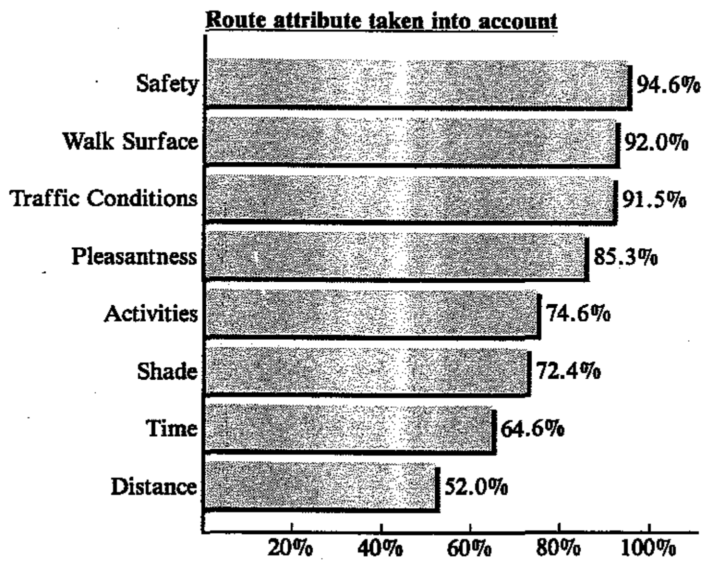

Route rating of activities in route
Very satisfactory (5)
5.6%
Quite satisfactory (4)
35.0%
Intermediate (3)
27.7%
Satisfactory (2)
5.1%
Poor (1)
1.1%
Not taken into account (0)
25.4%
10%
20%
30%
40%
50%
60%

FIGURE J.3

ROUTE ATTRIBUTES RATING





Route attribute taken into account
Safety
Walk Surface
Traffic Conditions
Pleasantness
Activities
Shade
Time
Distance
94.6%
92.0%
91.5%
85.3%
74.6%
72.4%
64.6%
52.0%
20%
40%
60%
80%
100%

FIGURE J.4

POTENTIAL RESPONSE TO SCENARIOS (I)

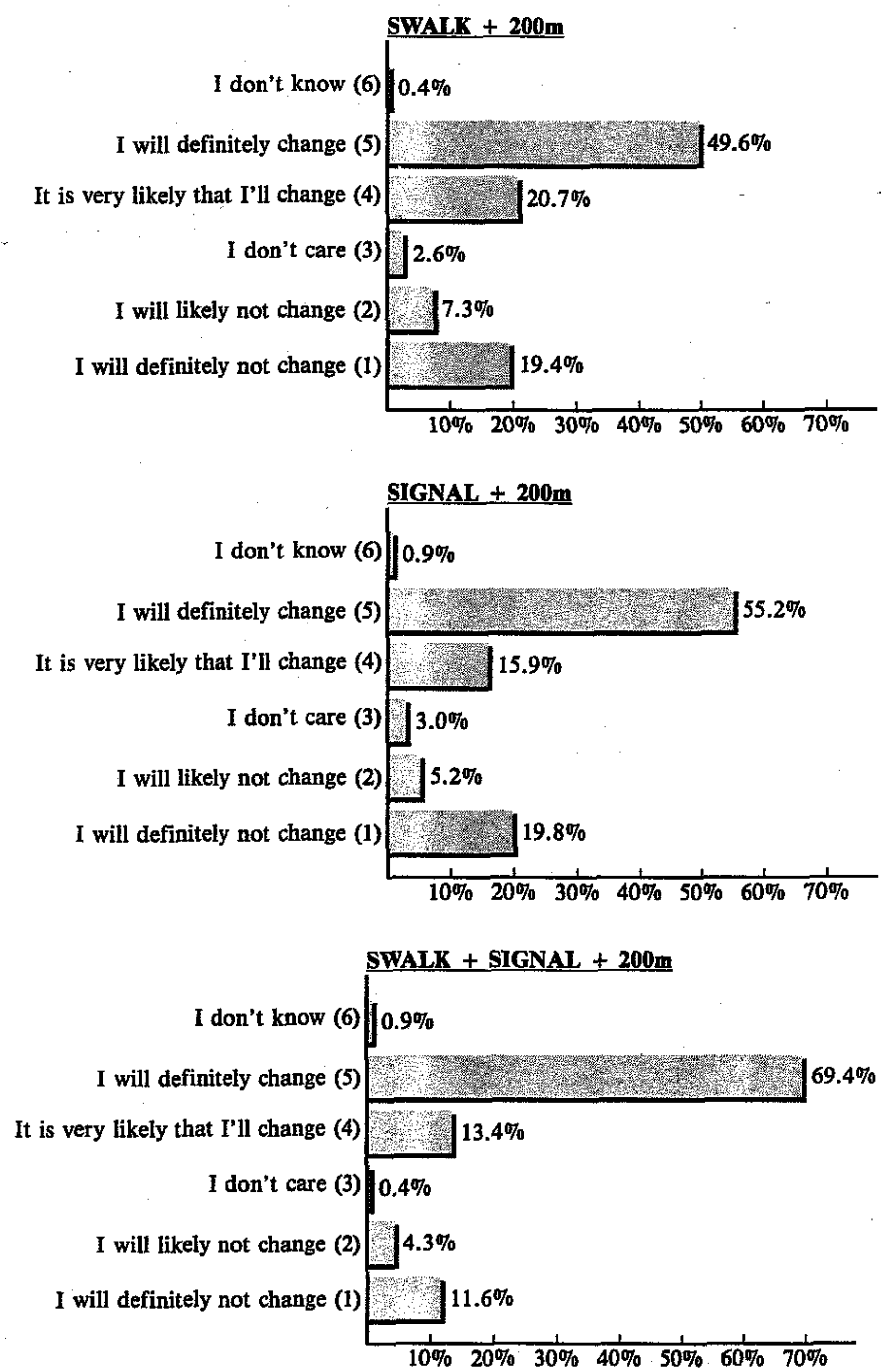


FIGURE J.5

POTENTIAL RESPONSE TO SCENARIOS (II)

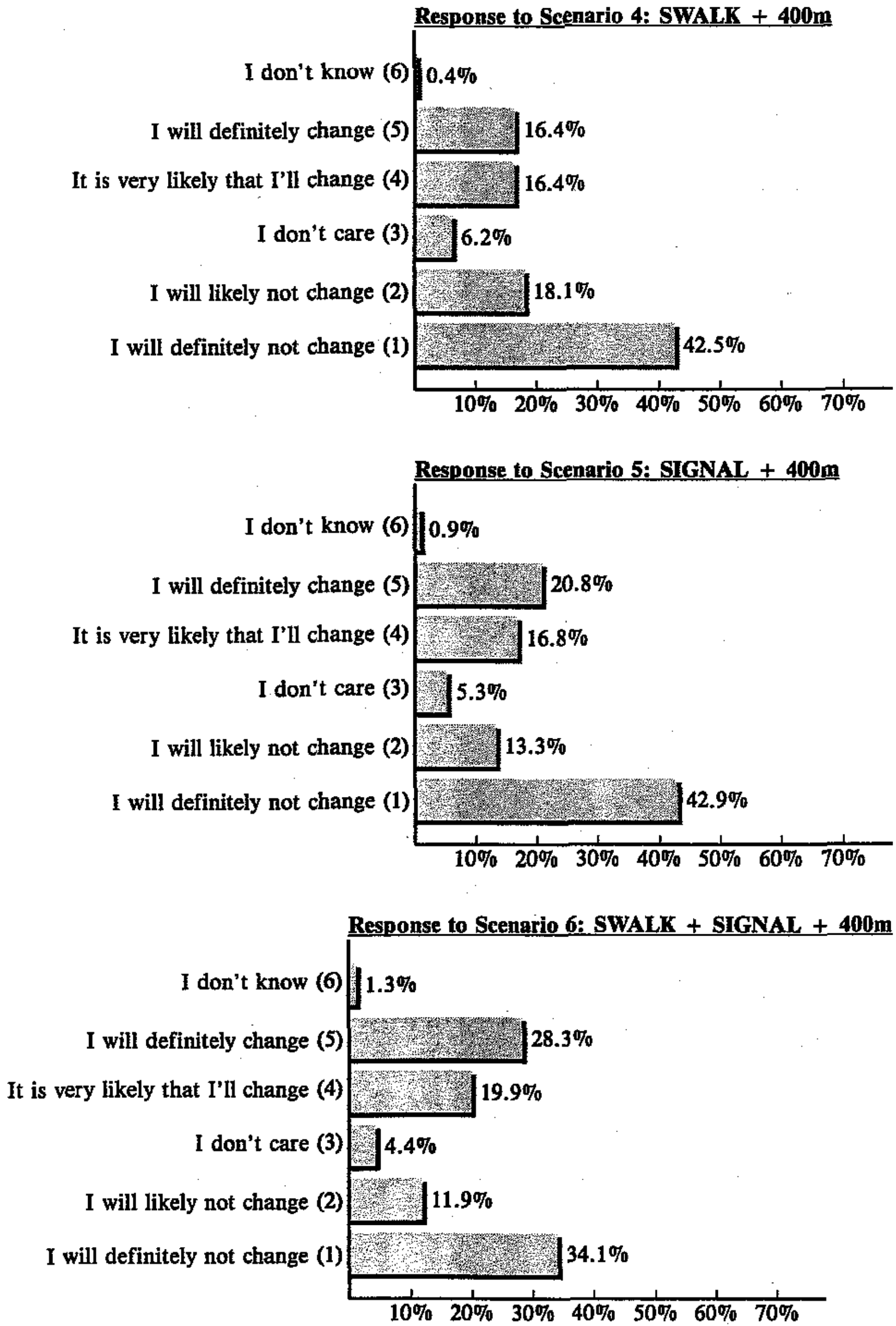


FIGURE J.6

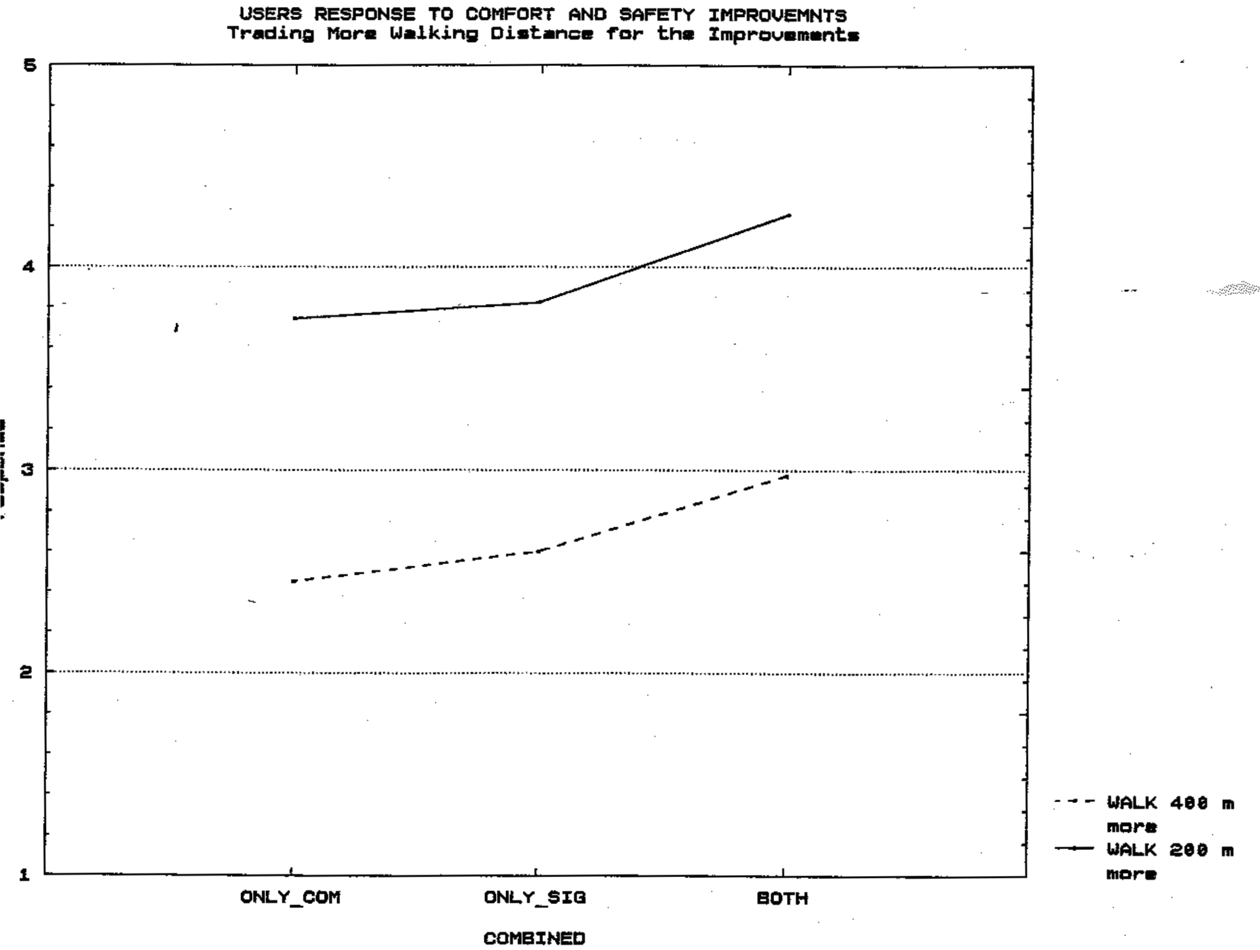
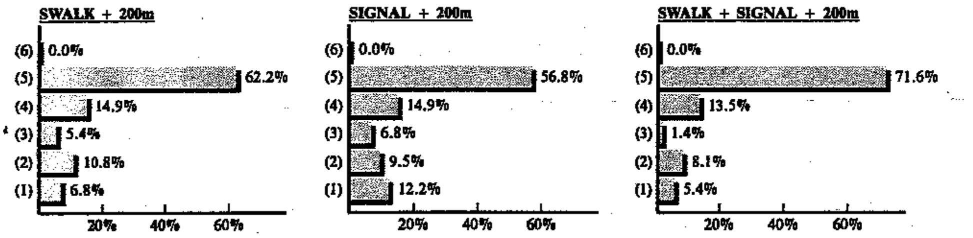

USERS RESPONSE TO COMFORT AND SAFETY IMPROVEMNTS
Trading More Walking Distance for the Improvements
5
4
3
2
1
ONLY_COM
ONLY_SIG
BOTH
COMBINED
WALK 400 m more
WALK 200 m more

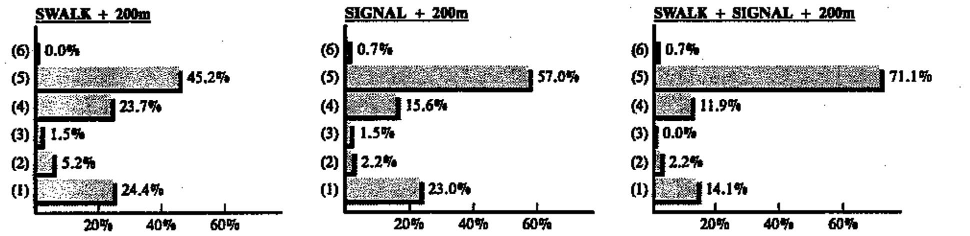
FIGURE J.7

POTENTIAL RESPONSE TO SCENARIOS (I) BY WHETHER OR NOT TIME WAS TAKEN INTO ACCOUNT

Time was not taken into account :

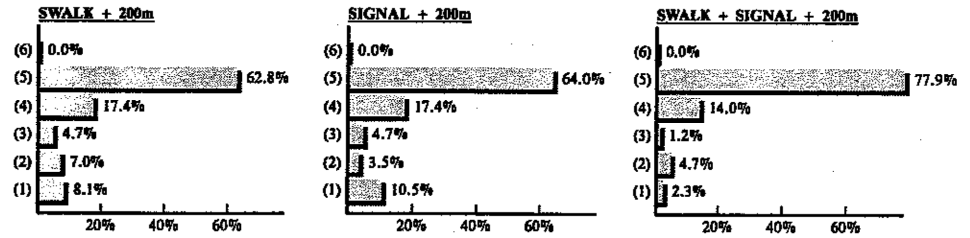


Time was taken into account :

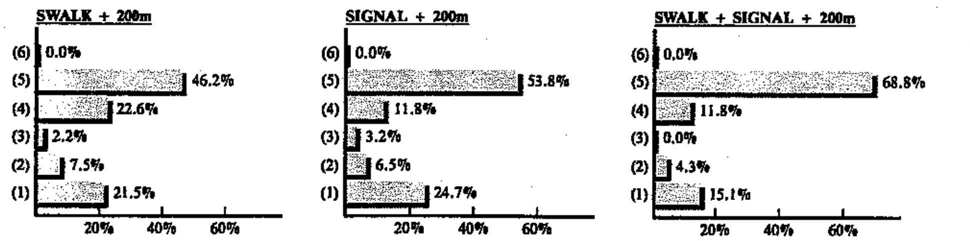


POTENTIAL RESPONSE TO SCENARIOS (I) BY WHETHER OR NOT DISTANCE WAS TAKEN INTO ACCOUNT

Distance was not taken into account :

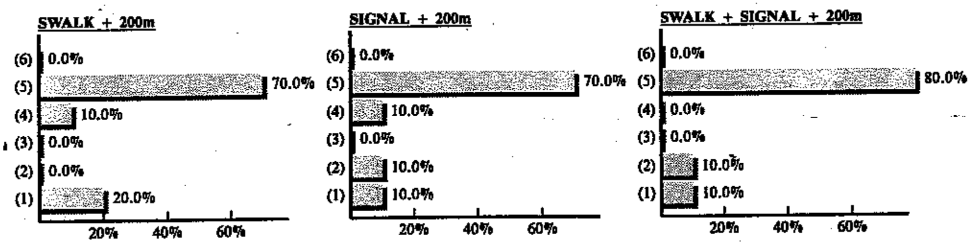


Distance was taken into account :

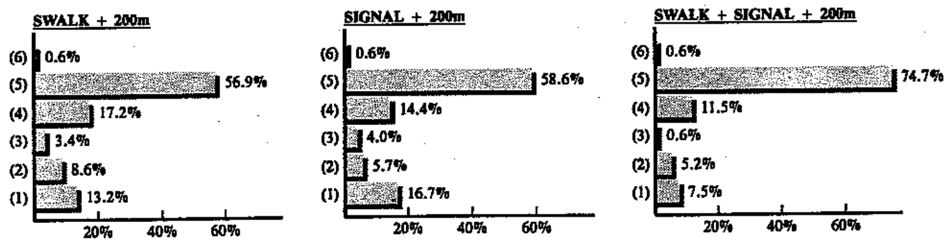


POTENTIAL RESPONSE TO SCENARIOS (I)
BY WHETHER OR NOT SAFETY WAS TAKEN INTO ACCOUNT

Safety was not taken into account :

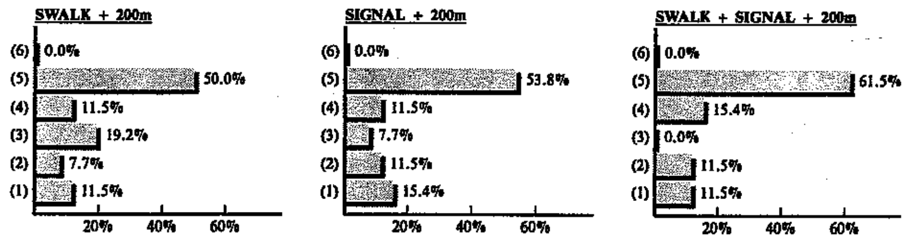


Safety was taken into account :

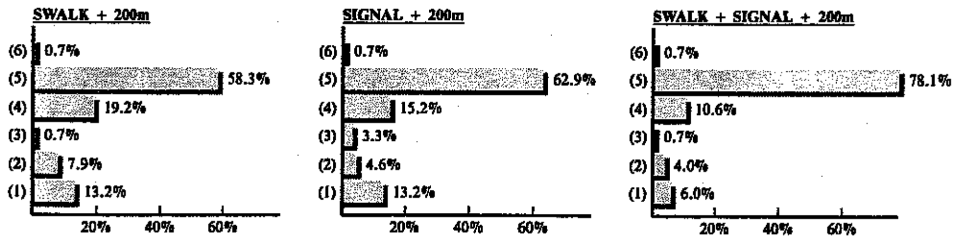


POTENTIAL RESPONSE TO SCENARIOS (I)
BY WHETHER OR NOT PLEASANTNESS WAS TAKEN INTO ACCOUNT

Pleasantness was not taken into account :



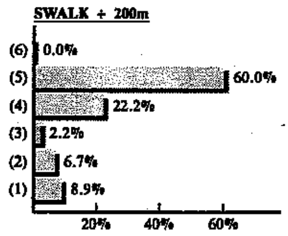
Pleasantness was taken into account :

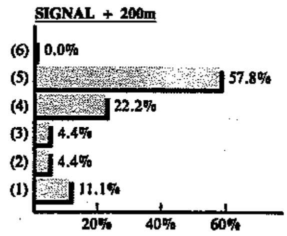


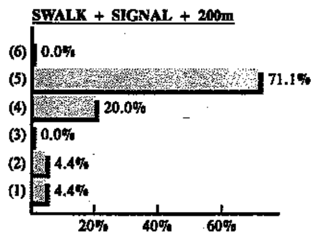
POTENTIAL RESPONSE TO SCENARIOS (I)

BY WHETHER OR NOT ACTIVITIES WERE TAKEN INTO ACCOUNT

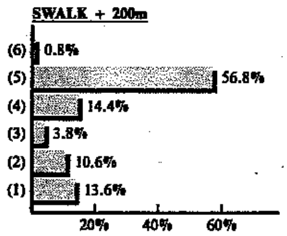
Activities were not taken into account :

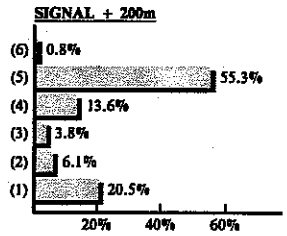


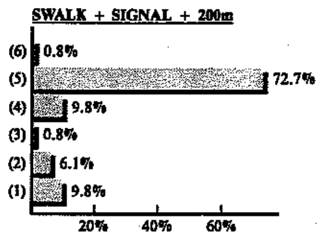




Activities were taken into account :



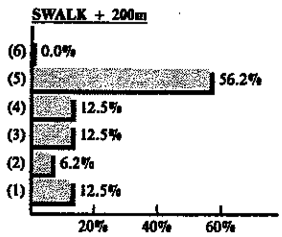


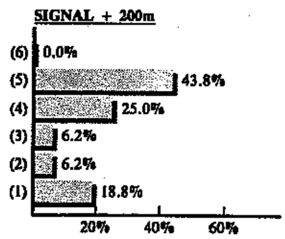


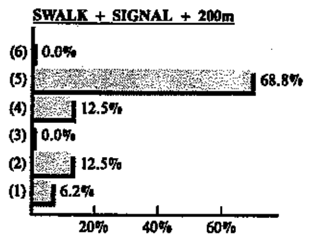
POTENTIAL RESPONSE TO SCENARIOS (I)

BY WHETHER OR NOT TRAFFIC CON/S WERE TAKEN INTO ACCOUNT

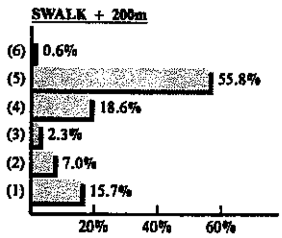
Traffic conditions were not taken into account :

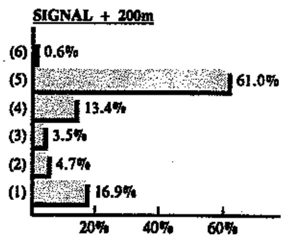


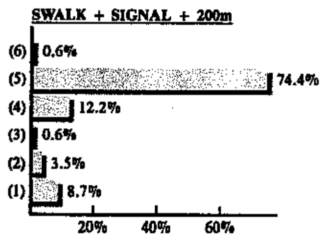




Traffic conditions were taken into account :

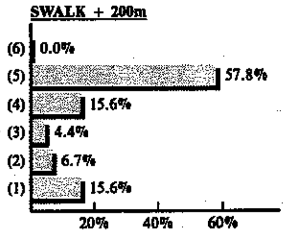


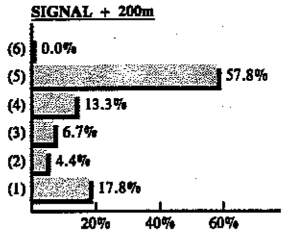


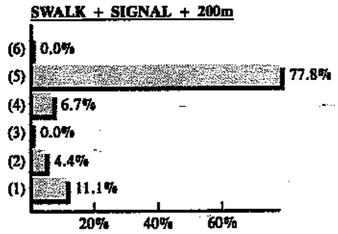


POTENTIAL RESPONSE TO SCENARIOS (I)
BY WHETHER OR NOT SHADE WAS TAKEN INTO ACCOUNT

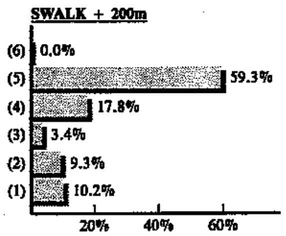
Shade was not taken into account :

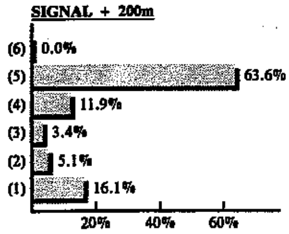


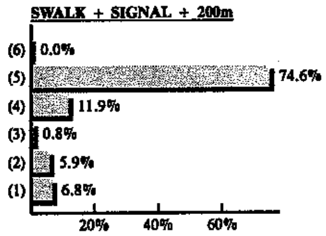




Shade was taken into account :

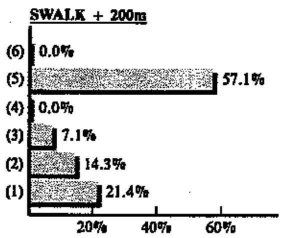


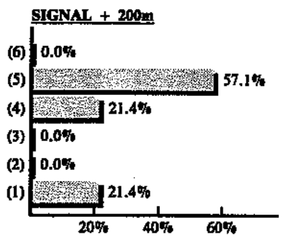


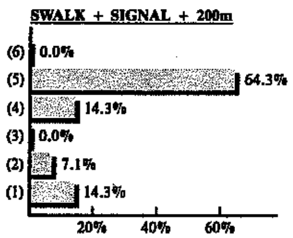


POTENTIAL RESPONSE TO SCENARIOS (I)
BY WHETHER OR NOT SURFACE WAS TAKEN INTO ACCOUNT

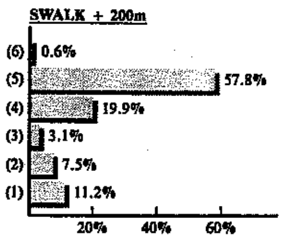
Walk surface was not taken into account :

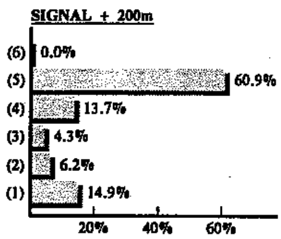






Walk surface was taken into account :





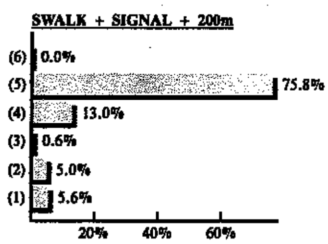
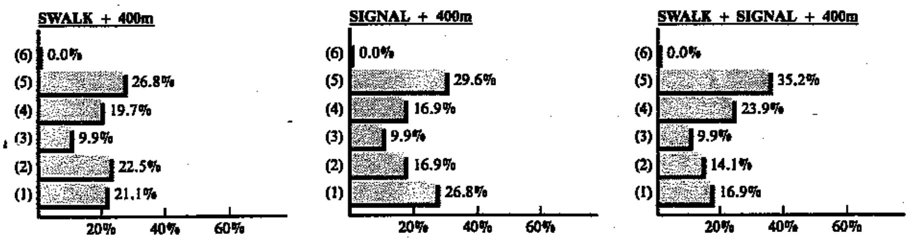


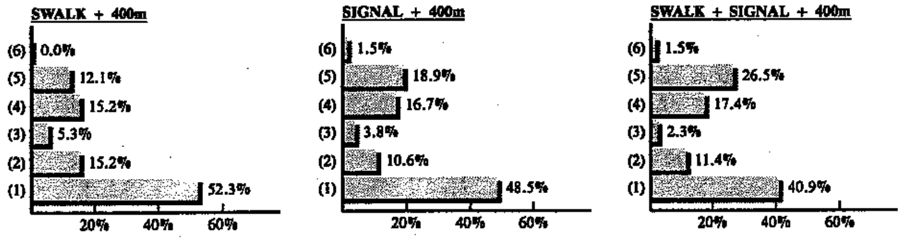
FIGURE J.8

POTENTIAL RESPONSE TO SCENARIOS (II)
BY WHETHER OR NOT TIME WAS TAKEN INTO ACCOUNT

Time was not taken into account :

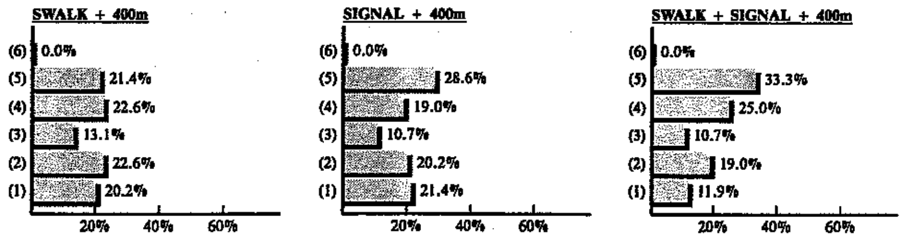


Time was taken into account :

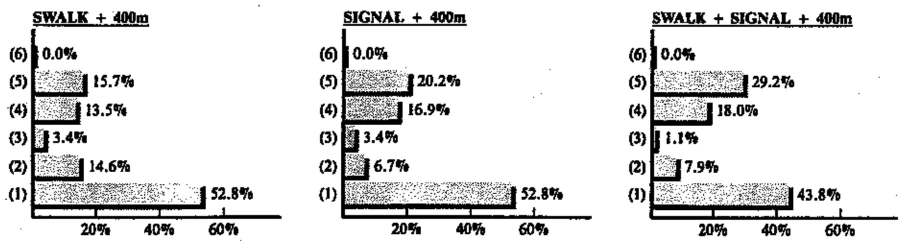


POTENTIAL RESPONSE TO SCENARIOS (II)
BY WHETHER OR NOT DISTANCE WAS TAKEN INTO ACCOUNT

Distance was not taken into account :

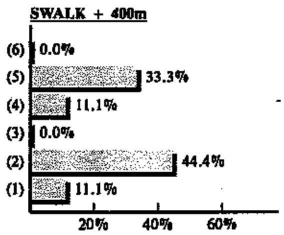


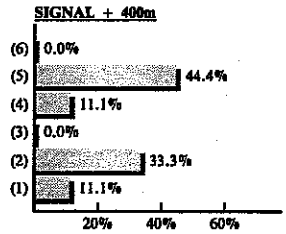
Distance was taken into account :

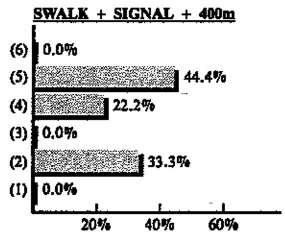


POTENTIAL RESPONSE TO SCENARIOS (II)
BY WHETHER OR NOT SAFETY WAS TAKEN INTO ACCOUNT

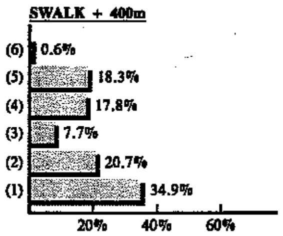
Safety was not taken into account :

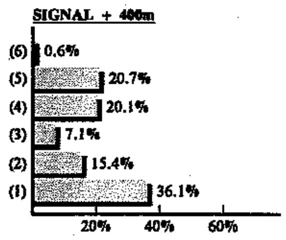


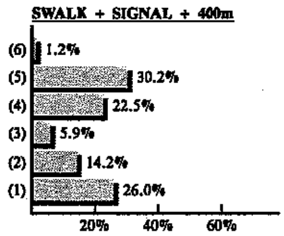




Safety was taken into account :

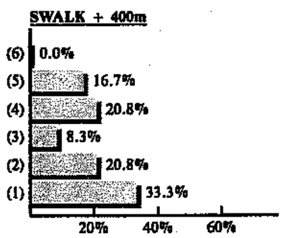


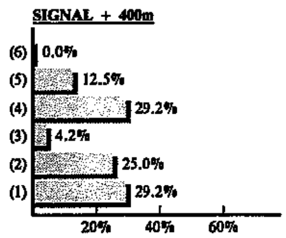


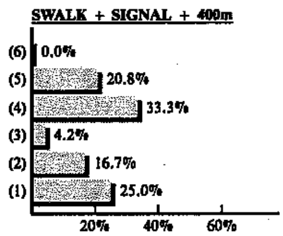


POTENTIAL RESPONSE TO SCENARIOS (II)
BY WHETHER OR NOT PLEASANTNESS WAS TAKEN INTO ACCOUNT

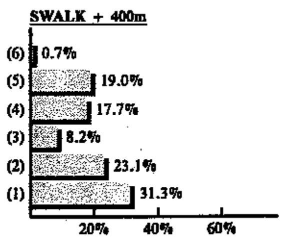
Pleasantness was not taken into account :

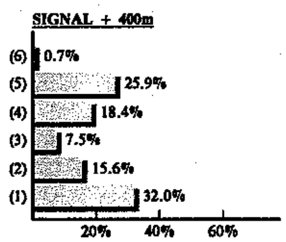


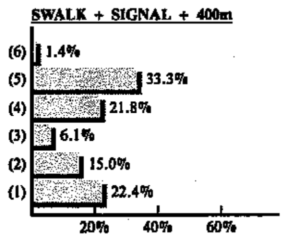




Pleasantness was taken into account :



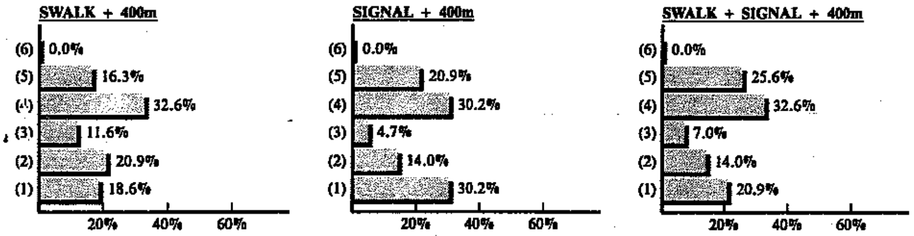




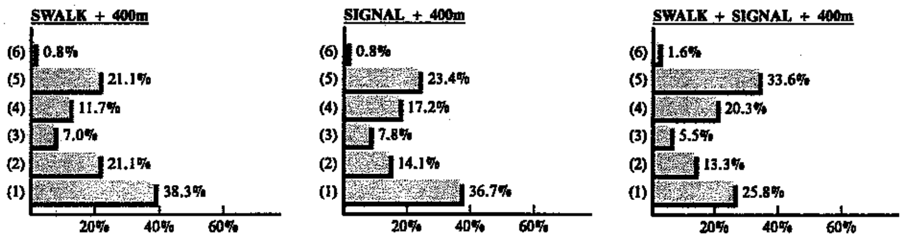
POTENTIAL RESPONSE TO SCENARIOS (II)

BY WHETHER OR NOT ACTIVITIES WERE TAKEN INTO ACCOUNT

Activities were not taken into account :



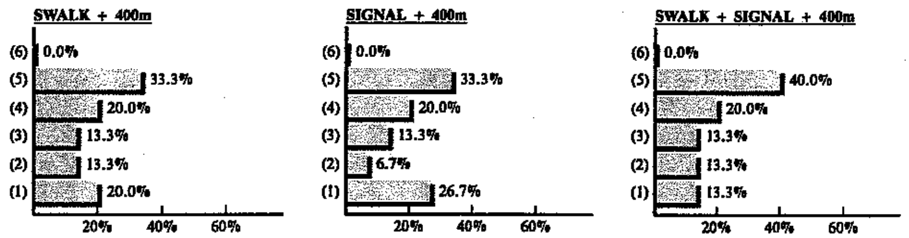
Activities were taken into account :



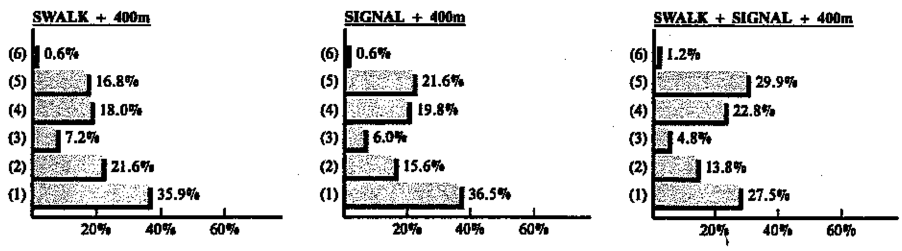
POTENTIAL RESPONSE TO SCENARIOS (II)

BY WHETHER OR NOT TRAFFIC CON/S WERE TAKEN INTO ACCOUNT

Traffic conditions were not taken into account :



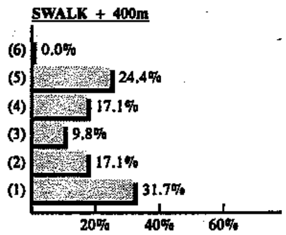
Traffic conditions were taken into account :

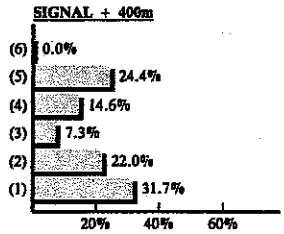


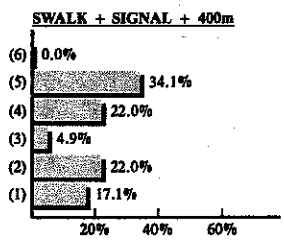
POTENTIAL RESPONSE TO SCENARIOS (II)

BY WHETHER OR NOT SHADE WAS TAKEN INTO ACCOUNT

Shade was not taken into account :







Shade was taken into account :