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Workpackage Leader: I.N.L.G. van Schagen

A Database for a Pedestrian and Pedal Cyclist Traffic Model

I.N.L.G. van Schagen (ed.)

DRIVE Project V1031

An Intelligent Traffic System for Vulnerable Road Users

A DATABASE FOR A PEDESTRIAN AND PEDAL CYCLIST TRAFFIC MODEL THEORETICAL CONSIDERATIONS AND EMPIRICAL DATA

I.N.L.G. van Schagen

Deliverable No. 9
Workpackage 6: Database Construction
Workpackage Leader: I.N.L.G. van Schagen, TRC, University of Groningen

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PUBLIC REPORTS OF DRIVE PROJECT V1031

Workpackage 1

Ekman, L., Draskòczy, M. (1989) Problems for vulnerable road users in Sweden. Final report for workpackage 1 of DRIVE project V1031: An intelligent traffic system for vulnerable road users. WP 299, Institute for Transport Studies, University of Leeds.

Schagen, I.N.L.G. van, Rothengatter, J.A. (1989) Problems for vulnerable road users in the Netherlands. Final report for workpackage 1 of DRIVE project V1031: An intelligent traffic system for vulnerable road users. WP 300, Institute for Transport Studies, University of Leeds.

Tight, M.R., Carsten, O.M.J., Sherborne, D.J. (1989) Problems for vulnerable road users in Great Britain. Final report for workpackage 1 of DRIVE project V1031: An intelligent traffic system for vulnerable road users. WP 292, Institute for Transport Studies, University of Leeds.

Workpackage 2

Tight, M.R., Carsten, O.M.J. (1989) Problems for vulnerable road users in Great Britain, The Netherlands and Sweden. Final report for workpackage 2 of DRIVE project V1031: An intelligent traffic system for vulnerable road users. WP 291, Institute for Transport Studies, University of Leeds.

Workpackage 3

Hopkinson, P.G., Carsten, O.M.J., Tight, M.R. (1989) Review of literature on pedestrian and cyclist route choice criteria. Final report for workpackage 3 of DRIVE project V1031: An intelligent traffic system for vulnerable road users. WP 290, Institute for Transport Studies, University of Leeds.

SUMMARY

A traffic model in general and more specifically a traffic model on a meso and micro level that takes into account pedestrians and pedal cyclists requires a great deal of empirical data and this data must be stored in a database in such a format that the model can retrieve it. Three categories of empirical data and therefore three types of databases must be distinguished:

–location-specific database
–knowledge base
–safety base

In this report the theoretical considerations behind the three-part division are discussed and the location-specific data and the behavioural knowledge data are elaborated.

The required location-specific data are flow, origin-destination of pedestrian and pedal cyclist trips and the physical characteristics of the location to be modelled. A computer programme was developed to store these data in ASCII-format output files. This programme is described and the data collection procedures in each of the three experimental locations (Bradford (GB); Groningen (NL); and Växjö (S)) is specified. The data itself is available on floppy disc, but not discussed here.

To fill the behavioural knowledge base, literature reviews took place and a number of additional field studies were carried out. The studied topics were crossing strategies at pelican crossings (only in the Bradford situation), red light violation of pedestrians and pedal cyclists, gap acceptance of pedestrians and pedal cyclists and rule compliance of road traffic towards pedestrians and pedal cyclists. The applied data collection procedures and definitions are described and the results presented.

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1 INTRODUCTION

I.N.L.G. van Schagen

Walking and pedal cycling are environmental friendly and, within built-up areas, efficient transport modes. Accident involvement and accident risk, however, are important negative characteristics (see Tight and Carsten, 1989). It is not without reason that pedestrians and pedal cyclists are commonly referred to as unprotected or vulnerable road users. Another negative factor for pedestrian and pedal cyclist traffic is that the needs of these modes are often disregarded or placed second to the needs of motorized traffic, for example by planners and traffic engineers.

The project, of which this report is one of the outcomes, is developing a set of tools to improve the situation for the vulnerable road users, both in terms of safety and in terms of mobility. Two approaches are being followed. On the one hand, a pedestrian and a pedal cyclist traffic model is being developed, that will be able to predict the effects of infrastructural and technical measures on vulnerable road user traffic flows and safety. On the other hand, a number of infrastructural measures will be applied and evaluated, in particular microwave detection equipment that makes it possible to adapt a traffic light cycle to the actual presence of pedal cyclists or pedestrians. The results of these evaluation studies will be used as a validation of the model's predictive power.

This report is part of the modelling approach of the project. It presents a theoretical framework for the representation of empirical data that feeds the model (database construction) and the results of a number of small-scale observation studies that were carried out to fill the database.

Given the objectives of this project, the pedestrian and cyclist model will focus on a meso situation, so that the effects of infrastructural changes on traffic behaviour, route choice and safety can be predicted. In each of the three participating countries (Great Britain, the Netherlands and Sweden) a three-junction area with high pedestrian flows and, for the Netherlands and Sweden, with high pedal cyclist flows was selected as the modelling area. A detailed description of the chosen sites can be found in Van Schagen (1990).

In Britain the situation is located in Bradford on the outer ring road. Figure 1 is a schematic map of this situation. All of the three main junctions are traffic light controlled and there are no special pedestrian facilities at these junctions. The traffic lights are unconnected. At one of the midblocks there is a pelican crossing for pedestrians, that can be activated by a push button.

Figure 1:The Experimental Site in Bradford (GB)

In Groningen (in the northern part of the Netherlands) the situation is located near the city centre on one of the main entry/exit roads (Figure 2). Two of the junctions have traffic lights, which are interconnected. The crossroads are part of the inner ring road system and both have one-way traffic. The main road is one-way for motorized vehicles except for busses, taxis and pedal cyclists. All the junctions are equipped with pedestrian zebra crossings without pedestrian lights.

Figure 2:The Experimental Site in Groningen (NL)

The location in Sweden is to be found in Växjö, a town in the south of the country. The three junctions, in the middle of the town centre (see figure 3), all have traffic lights and pedestrian crossing lights, which have to be activated by a push button. The pedestrian crossings are not conflict free: pedestrians have green at the same time as parallel road traffic.

Figure 3:The Experimental Site in Växjö (S)

To let the pedestrian and cyclist model run, much data is required on both the traffic conditions in the experimental situations (e.g. flows, origin-destination matrices) and more general behavioural characteristics of the pedestrians and pedal cyclists. This data must be logically stored in a database and be easily retrievable to enable the model to produce valid descriptions and predictions of each of the situations. In Chapter 2 a conceptual framework for classifying different types of data is presented. A distinction is made between a location-specific database, a knowledge base and a safety base. Chapter 3 describes a computer programme that was developed to store flow and origin-destination data in the location specific database and the applied data collection method. Chapter 4 presents literature and observational data on pedestrian and pedal cyclist's behaviour, collected in each of the three countries, that will form the input of the knowledge base. Chapter 5 finishes the report with some overall conclusions.

3 CONCEPTUAL FRAMEWORK OF DATABASE CONSTRUCTION

J.A. Rothengatter

Basically, a meso model aims to predict a set of “performance” characteristics of a meso world consisting of several related junctions. Given the project's objectives, the output of the pedestrian model can be defined as follows:

a. Flow and junction capacity
Changes in signal set-up and cycle times will have major effects on flow and junction capacity. There are already models available that predict such effects for vehicular traffic (e.g. SATURN). Although capacity for pedestrian traffic will not be a factor of importance in most cases (as demand is unlikely to exceed supply), the main flow might be redirected because of changes in signal settings.

b. Delay times
Delay times are assumed to affect both red light violation and the attractiveness of routes for the different groups of road users. Red light violation is assumed to have a safety effect, but is in any case to be considered as a negative effect that should be minimized. The attractiveness factor is linked to pedestrian flow migration.

c. Safety effects
An objective measure should be found that predicts the effects of infrastructural changes upon safety for particular types of crossings. This is particularly important in relation with pedestrian flow migration.

The outcomes of the cyclist model are similar except for the flow prediction. The meso world that is modelled is too small to study flow migration of cyclists: the route choices within the area are limited. Junction capacity for cyclist traffic, on the other hand, is of concern, in particular, in the Netherlands.

In order to produce output the model needs to have information about the location whose performance it has to predict, and needs to have information about the behavioural and safety implications of the location's characteristics. This is the area of database construction.

The information about the location is, of course, location-specific. For example, every junction will have specific traffic intensity distributions, specific road width and specific cycle times. Hence, this set of information needs to be collected for every location whose performance the model wishes to predict. This information as such is not sufficient to run the model. For example, the database may inform the model that leg A carries 1000 cyclists and 500 cars an hour, but this means very little, if the model does not “know” how cars and cyclists generally behave and interact. This type of information should be considered separately from the location specific data because it is, or at least need not be, location-specific, and can be applied to all locations or specific sets of locations. The set of information which is not location-specific is contained in a knowledge base. The same considerations apply, mutatis mutandis, for the safety aspects: again general information is required to allow the model to produce predictions of safety effects. Hence a safety base is an additional requirement. These components — location-specific database, knowledge base, safety base — are further elaborated below.

4.1 LOCATION-SPECIFIC DATABASE

The location-specific database contains the information that needs to be collected for the junction(s) to which the model is applied. What information is essential to the functioning of the model needs to be established empirically. At present, this can only be logically inferred. Obviously, choosing a too limited set of variables will result in a model that has poor predictive validity, and choosing a too extended set of variables will result in a model that requires an unnecessary amount of data collection which will be prohibitive to the model application. At present, the following classes of variables are considered:

–Physical characteristics of the junction(s)
–Signal characteristics and cycle times
–Origin-destination matrix

4.3 KNOWLEDGE BASE

Much of the information relevant to the model's accuracy can be considered as general knowledge, contained in a separate knowledge base. Again, what information is relevant to the functioning of the model needs to be established empirically. However, in this case the trade-off is different. While a too limited set of information will, again, limit the model's power of prediction, a too extensive set may at most result in using unnecessary computing time. The main problem is that the information needs to be extracted from the available empirical studies, and, if not available, needs to be established by carrying out additional observation studies. If the latter are necessary, this does not need be carried out at the experimental locations. Indeed, it is advisable to obtain the information at other locations, since this would avoid possible overestimation of the model's predictive power.

The format of the information in the knowledge base can be twofold. For example, the likelihood of pedestrian red light violation can be presented in the form of a set of tables with percentages of different mean speeds for approaching traffic, different traffic intensities, different length of red phases, different road width and so on. However, it is also possible to present this information in the form of equations expressing the relationship between the above variables and red light violation. Though, in the end, the equation-like format is easier to apply, it requires so much detailed empirical data that it is not feasible within the scope of this project.

In principle, the architecture of the knowledge base should allow the possibility of adjusting or replacing the information if situation-specific information is available or if need for adjustment can be logically inferred. For example, if location-specific information about pedestrian red light violation is available, this information should replace the general information contained in the knowledge base. Alternatively, specific circumstances may require additional data collection or data adjustment. For example, if the situation that is modelled has a specific population as might be the case in the neighbourhood of homes for the elderly or schools, the general behavioural information about the “average” pedestrian no longer applies.

4.5 SAFETY BASE

For the construction of the safety base, two approaches could be followed. The first is to include empirical data concerning behaviour-safety relationships or the relationships between physical and/or signal characteristics and safety. If this approach is followed, the format and implementation would be the same as for the knowledge base. However, it should be anticipated that little empirical data about the above mentioned relationships is available, and that such data is not easily obtainable. It will therefore be necessary to include data which is not empirically-based and no more than educated guesses. The model's predictions will in that case be as good as the guesses. Establishing the validity of these guesses is likely to involve an extensive data collection effort.

The alternative approach is a mechanistic safety model. The model (to be distinguished from the movement model per se) would contain no more than a set of likelihood equations based on flow information. The simplest form of such equations would take into account the conflicting flows for each manoeuvre and the distribution of these flows. Further sophistication could be achieved by taking into account platooning and such like, while a third level of sophistication would take into account scenario-type information for each possible flow conflict. Of course, the more sophistication is built into this mechanistic approach, the more it starts resembling the empirical data approach. However, this approach has the advantage that it is far more systematic than the haphazard accumulation of empirical data.

4.7 CONCLUSIONS

Three separate databases were proposed: a location-specific database, a knowledge base and a safety base. Specific input for a location is required for the location-specific database only. The knowledge and safety bases contain general information, that is applicable to all or at least a specific set of locations. In this way the data collection effort for future use will be limited. If location-specific data on behaviour or safety is available, the model will have to be able to take into account the modifications of the general information. This will increase the predictive power of the model.

The characteristics and content of the location-specific database are elaborated in Chapter 3. The knowledge base is discussed in Chapter 4. At present, the behavioural data do not yet have the equation-like form. Observational data and, if available, literature data with respect to gap acceptance, red light violation and priority rule compliance, are reported as such. In the next stage of the project (Workpackage 8) the empirical behavioural data will be integrated with the model's lay out. Then it will be decided in what form the data will have to be represented to serve the needs of the model. The safety base is still empty and will remain empty if the mechanistic point of view is chosen. The location-specific data on flow and signal cycles and knowledge of some behavioural characteristics of pedestrians and cyclists will feed the safety submodel.

5 LOCATION SPECIFIC DATA

I.N.L.G. van Schagen and P.K. Westerdijk

6.1 THE DATABASE CONSTRUCTION PROGRAMME

As explained in the previous chapter, location-specific data must be collected for each location that is modelled. In order to make the data entering procedure in the model's application more user-friendly and to store the data in a format readable by the model, a computer programme was developed that asks for required flow and origin-destination information and stores this information in ASCII format data output files. The computer programme distinguishes between absolutely necessary information and additional information without which the model still runs though with decreased predictive power. The idea behind the distinction between necessary and additional information is that, in practice, specified data will often not be available and extensive data collection will be too demanding of effort. However, if it is available, the model must be able to deal with it, because it will probably improve the outcome of the model.

The programme can handle a location with maximally nine related junctions and an infinite number of exit and entry points between the junctions (e.g. side roads). A floppy disc containing the programme can be found at the back of the report. The programme is started by the command DB-VRU.

The first step in the programme is the description of the area that is to be modelled: the number and codes or names for the junctions, the extra exit and entry points between the junctions and the presence of pedestrian or traffic lights. These data are saved in a file called AREA.DAT and are referred to throughout the rest of the programme.

Then the flow data part of the programme can be started, beginning with motorized vehicles. The minimum requirement is the total car inflow by leg by junction for an hour period. The programme can handle a number of specifications in the motorized vehicle flow data:

- –flow by manoeuvre by leg by junction
- –flow in peak and off-peak hours
- –flow of different categories of motorized vehicles (buses, light good vehicles, heavy good vehicles, motor cycles, taxis, private cars)

and all combinations of these specifications.

Another requirement is the flow data (specified or not by manoeuvre) at the extra entry/exit points between the junction. All data on motorized vehicle flow is saved in file CARFLOW.DAT.

The next step is the flow data on pedal cyclists. This part of the programme only needs to be run, if the model is used to predict delay or safety for pedal cyclists. Again, the

minimum requirement is the total inflow by leg by junction for an hour period. Specifications can be entered about:
–flow by manoeuvre by leg by junction
–flow in peak and off-peak hours
–flow by gender and/or (six) age groups

and all combinations of these.

The same applies for the extra entry/exit points between the junctions: the minimum is the inflow per hour; specifications in terms of manoeuvre, peak/off-peak hours, age and gender are possible. Pedal cyclists may also enter or leave the area at places that are not directly accessible by pedal cyclists (e.g. blocks of shops, pedestrian zones), because they can easily mount or dismount their bicycle. The number of entry and exit points might therefore be larger than for motorized vehicles. The data on pedal cycle flow is saved in a file CYCFLOW.DAT.

The next two steps in the programme concern pedestrian flow at junctions and other entry/exit points and pedestrian flow at midblocks, respectively saved in the files PEDFLOW.DAT and MIDBLOCK.DAT. If pedestrian movement is one of the objectives of the model's application, the total pedestrian inflow at junctions and other entry/exit points is again the minimum requirement. Contrary to motorized traffic and pedal cyclists, pedestrians can enter a junction at both sides of the road, so that the total number of inflow possibilities at a normal four legged junction is eight instead of four. Specifications can be given on:

–direction (crossing diagonally is considered as a separate direction)
–peak/off-peak periods
–gender and (six) age categories

and on all combinations.

The inflow at entry/exit points other than junctions (side roads, blocks of shops, residential areas) is requested as well, if available, specified by direction, age and gender. A side road is considered as two entry/exit points to cover pedestrians at both sides of a road.

Midblock crossings are important movements of pedestrians that the model should take into account. The sections between junctions or side roads were divided into an arbitrary number of midblocks in the area description stage. A midblock can be a pelican crossing, a midblock non-signalised zebra crossing or a part of the road without pedestrian facilities. For all defined midblocks the number of crossing pedestrians must be entered. If available a distinction can be made between peak and off-peak hours and/or between different age and gender categories.

Apart from flow data, the model needs information on the place where a pedal cyclist or a pedestrian enters the model area (the origin) and the place where he/she leaves the model area again (the destination). For all possible origin-destination pairs the programme asks for the number of pedestrians or pedal cyclists who moved through the area in the defined way. These data will be saved in the file MATRIX.DAT.

The last step of the programme is the correction of the default data in the knowledge base, if location specific data are available. This part of the programme is not yet worked out, as it requires discussion on the format and level of detail of the behavioural data. As was indicated in Chapter 2, this will be part of the next workpackage in this project: integration of model and empirical data. To illustrate the working of the programme, the average speeds of cars, pedal cyclists and pedestrians are already entered in the programme. The programme shows the default value of each variables and asks whether this default value is (seemingly) correct or that it should be replaced by another value on the basis of location-specific empirical data. The default data are stored in the file KNOWBASE.DAT.

When the programme is finished, seven files are created: AREA.DAT, CARFLOW.DAT, CYCFLOW.DAT, PEDFLOW.DAT, MIDBLOCK.DAT, MATRIX.DAT and KNOWBASE.DAT. A codebook of these files is presented in Appendix 1.

6.3 FLOW DATA AND ORIGIN-DESTINATION DATA IN BRADFORD, GRONINGEN AND VÄXJÖ

Flow data was collected in each of the three experimental locations, that is for a three-junction area. Video observations of the junctions during a peak period and an off-peak period were analyzed in the laboratory. Counts were made of the number of motorized vehicles (in Bradford split up into five categories, in Groningen into two categories), the number of pedal cyclists and the number of pedestrians by manoeuvre. In Bradford the peak period observations took place between 07:30 and 09:00 and between 15:00 and 18:00, the off-peak between 09:30 and 11:00. In Groningen the peak period observations were carried out between 15:30 and 17:30 and the off-peak between 09:30 and 11:30. The observations in Växjö were between 12:00 and 13:00 for the peak period and between 09:00 and 10:00 for the off-peak period.

Apart from flows on junctions, a number of other flows in the area were recorded as well: pedestrian crossings at midblocks, pedestrians entering and leaving shops, pedestrians entering and leaving buses (only if there were bus stops in the modelling area, which was the case in Groningen). Observations were carried out manually in both a peak period and an off-peak period. The observation time was generally shorter than the observation time on the junctions (see Table 1).

Table 1:Observation time (in minutes) for pedestrian flows at midblock crossings, in and out of buses and in and out of shops

	Bradford		Groningen		Växjö	
	peak	off-peak	peak	off-peak	peak	off-peak
buses	–	–	120	120	–	–
midblock	40	40	60	60	60	60
shops	40	40	20	20	60	60

Information on origin and destination was collected with the aid of a questionnaire, which was presented to approximately 1000 pedestrians in Bradford, Groningen and Växjö and to approximately 1000 pedal cyclists in Groningen and Växjö. The question on origin and destination was only part of the purpose of the questionnaire study. The other aspects of the questionnaire study are described in Van Schagen (1990).

The data collected in the Bradford, Groningen and Växjö situation have been entered into files by using the programme described. The output files of each of the three locations can be found at the floppy disc at the back (Appendix 2). In order to avoid mixing up the data of different locations, the default extension .DAT is replaced by the extension .BRA for the Bradford data, .GRO for the Groningen data and .VAX for the Växjö data.

7 KNOWLEDGE BASE

8.1 DEFINITIONS AND DATA COLLECTION METHOD

J.M. Spikman and I.N.L.G. van Schagen

With regard to the development of a knowledge base, behavioural data has been collected on pedestrian and pedal cyclist red light violation, gap acceptance and rule compliance, to provide the model with data concerning vulnerable road users' behaviour in relation to other traffic and in relation to the use of cyclist/pedestrian facilities. As the ultimate purpose of this project is to increase safety and to decrease delay for vulnerable road users, information about behavioural aspects which can cause delay and/or unsafety for VRUs is necessary. Relevant factors are, for example, waiting for traffic lights, crossing a road and getting no priority when having right of way. Investigation of red light violation, gap acceptance and rule compliance could provide useful data about the type and duration of delays to vulnerable road users and the way they handle these situations. In part, these data has been collected by a review of the relevant literature in each of the three countries. In addition, small field studies have been carried out in each of the experimental areas.

In sections 4.2 through 4.4, the results of the literature review and the field studies in the experimental area are discussed for Great Britain, the Netherlands, and Sweden respectively. In the field studies carried out in each of the countries, as far as possible a similar methodology was applied and the same definitions were used. The definitions and methodology for data collection on red light violation, gap acceptance and rule compliance are discussed below.

For each factor, relevant sites within the experimental area were chosen and on every chosen location video recordings or manual counts took place during a peak and an off-peak period. These were all done on normal working days during hours that shops were open.

Red light violation

Both for pedestrians and cyclists four categories were distinguished, depending on the stage of the traffic light during arrival and departure:

	Traffic light	
	Stage arrival	Stage departure
a. Green cyclists/walkers	green	green
b. Green waiters	red	green
c. Red cyclist/walkers	red	red
d. Yellow cyclists/walkers	yellow/flashing	yellow/flashing

If possible, for each observed pedestrian or pedal cyclist, gender and age category (<12 yr, 12-60 yr and >60 yr) was determined. After having counted the numbers of pedestrians and/or cyclists in each of the four categories, the following had to be computed, for peak and off-peak periods:

–total number of people arriving (a+b+c+d)
–number of people arriving at green and yellow/flashing (a+d), as a percentage of the total number of people arriving (a+b+c+d)
–number of people arriving at red (b+c)
–number of people arriving at red who don't wait for green (c), as a percentage of the total number of people arriving at red (b+c).

These percentages had to be computed for the total group and for the gender and age categories distinguished, if these variables were recorded.

Gap acceptance

To get an indication about the gaps that pedestrians and cyclists accept when crossing a road, a small field study was carried out. To compute the accepted gaps, the following data of each observed crossing had to be collected:

Pedestrians

First lane crossing

T–1:the moment the pedestrian reaches the kerb
T0:the moment the pedestrian leaves the kerb
T1:the moment the pedestrian reaches the centre line of the road
T2:the moment the first car (or other road traffic) reaches the (imaginary) crossing line of the pedestrian

Second lane crossing

T3:the moment the pedestrian leaves the centre line
T4:the moment the pedestrian reaches the kerb at the other side
T5:the moment the first car (or other road traffic) reaches the (imaginary) crossing line of the pedestrian.

Cyclists, going straight on

First lane crossing

T–1:the moment the front wheel of the bicycle reaches the (imaginary) line between the kerbs of the side road
T0:the moment the front wheel of the bicycle crosses the (imaginary) line between the kerbs of the side road
T1:the moment that the cyclist (not the wheels) reaches the centre line of the road
T2:the moment the first car (or other road traffic) reaches the imaginary crossing line of the cyclist

Second lane crossing

T3:the moment the cyclist leaves the centre line
T4:the moment the cyclist rides parallel to the kerb of the chosen road
T5:the moment the first car (or other road traffic) reaches the (imaginary) crossing line of the cyclist.

For cyclists turning left, the points of time were the same, but with regard to T4, the chosen road was identical to the one which was crossed. For cyclists turning right, only four points of time could be determined, identical to going straight on, first lane crossing, with the exception of T1: the moment the cyclist rides parallel to the kerb of the chosen road.

Accepted gaps had to be computed by the formula T2–T1 (first lane) and the formula T5–T4 (second lane), only if the gap was smaller than 8 seconds. If there was no crossing traffic within 8 seconds, it was determined that there was no question of gap acceptance. Furthermore, approaching traffic had to go faster than 10 km/hr, otherwise there is also no question of gap acceptance, and the observation had to be made when traffic was effectively free-flowing, e.g. not approaching a red light.

This definition of gap, i.e. "the gap between the moment the pedestrian/cyclist reaches the centre line of the road or kerb and the moment the first vehicle reaches the imaginary crossing line of the pedestrian/cyclist" differs from the definition of gap generally used in gap acceptance studies. The definition used here was chosen for practical reasons, in that it is easier to observe the arrival at the centre line of a road than arrival at a not yet defined place somewhere in the middle of a lane, as is done in other gap acceptance studies. The consequence of this definition is that gaps can be negative (i.e. when a pedestrian/cyclist has not yet reached the centre line at the moment road traffic passes) and therefore that the gaps reported here are an underestimation of accepted gaps according to the "normal" definition.

On the basis of the recorded times per crossing, the delay times could be computed by the formula T0–(T–1) (first lane) and the formula T3–T1 (second lane). If a pedestrian/cyclist did not stop before crossing the road, T0–(T–1) will be zero.

If possible, pedestrians/cyclists were divided into gender and age (<12 yr, 12-60 yr and >60 yr) categories. For both groups, for every category and time period (peak and off-peak) of the computed gaps the medians had to be computed instead of the averages, to minimize the role of extreme values.

Rule compliance

Rule compliance, in particular vehicle compliance to priority rules, is a factor that influences the throughput of pedestrians and pedal cyclists. Again a small field study was carried out to obtain an indication about the effects of rule compliance of motorized road traffic towards pedestrians and cyclists.

Given the experimental situations in the three countries, six priority rules could be relevant. Not every rule was relevant in each country, because the situations in which a rule was relevant were not present everywhere.

For pedestrians there are four possible priority rules:

Rule 1: cars and other road traffic have to yield for pedestrians who cross during the green stage of the pedestrian light.

Rule 2: turning cars and other road traffic have to yield for pedestrians who are on the same road and want to cross.

Rule 3: turning cars and other turning road traffic, having green light, have to yield for pedestrians on the same road who are crossing during the green stage of the pedestrian light.

Rule 4:cars and other road traffic have to yield for pedestrians who are about to cross at a (non-signalized) zebra crossing.

For cyclists there were two possible priority rules:

Rule 1:turning cars and other turning road traffic have to yield for cyclists who go straight on at the same road, both when going in the same and in the opposite direction.

Rule 2:cars and other traffic approaching a major road have to yield for cyclists who are riding on the major road.

For both groups (pedestrians and cyclists) there had to be recorded the total number of relevant encounters (a relevant encounter is defined as an encounter between a pedestrian/cyclist (VRU) and other road traffic where at least one slows down in anticipation of yielding, or stops to avoid a conflict), divided into six categories:

A1:number of encounters between a VRU and a motorized vehicle, where the VRU slows down or stops and is forced to yield

B1:number of encounters between a VRU and a(-nother) cyclist, where the VRU slows down or stops and is forced to yield

A2:number of encounters between a VRU and a motorized vehicle, where the VRU slows down or stops, but is given priority

B2:number of encounters between a VRU and a (-nother) cyclist, where the VRU slows down or stops, but is given priority

A3:number of encounters between a VRU and a motorized vehicle, where the VRU does not need to slow down or stop (i.e. the vehicle slows down or stops to yield)

B3:number of encounters between a VRU and a (-nother) cyclist, where the VRU does not need to slow down or stop (i.e. the cyclist slows down or stops to yield).

For both groups, for every relevant rule and time period (peak and off-peak), percentages of A and B had to be computed, so the relative occurrence of VRUs being delayed because of getting no priority could be determined.

8.3 PEDESTRIAN BEHAVIOUR IN BRADFORD

O.M.J. Carsten, F.C. Hodgson and M.R. Tight

8.4.1 Crossing behaviour in pelican zones

No relevant literature on pedestrian crossing behaviour in pelican zones has been found. The observation data on pedestrian crossing behaviour was collected at the pelican crossing in the Bradford study area (see Figure 1), using video observation. A total of 199 crossings within the area of the pelican (i.e. within the area delineated by the zigzag lines) were recorded. Of these crossings, 124 took place during a peak period (08:00-09:00 and 15:00-15:40) while the rest were in an off-peak period (09:30-10:40).

By no mean all the pedestrian crossed on the pelican proper. Many crossed on either side of the crossing but within the area of the zigzags. Here there were some large differences by type of pedestrian and by time period (peak or off-peak). Overall 128 of 199 crossings were on the pelican proper, while 70 were outside the crossings and one was partially in the crossing. Table 1 shows how the use of the pelican was broken down by sex. In the case of males, slightly less than half crossed in the pelican proper, while the overwhelming majority of females (85%) crossed on the pelican rather than near it. Table 2 shows the same distinction by age group. Here a substantial difference can be observed between the under-13 age group, of whom 88 percent used the crossing proper, and all other ages, for whom there was a roughly equal split between crossing on the pelican and crossing near the pelican.

Table 1: Crossings in pelican zone by sex

	Males	Females
On pelican	46.8%	84.6%
Partly on pelican	0.9%	0.0%
Not on pelican	52.3%	15.4%
	100%	100%
	(n=109)	(n=78)

Table 2: Crossings in pelican zone by age

	0-12 yr	13-59 yr	60+ yr
On pelican	88.1%	52.6%	42.9%
Partly on pelican	0.0%	0.9%	0.0%
Not on pelican	11.9%	46.5%	57.1%
	100%	100%	100%
	(n=67)	(n=114)	(n=14)

Table 3 shows the use of the pelican by time period. During the off-peak period 81 percent of the crossings were on the pelican as compared to 54 percent during the peak period.

Tables 4 and 5 show that this difference between the peak and off-peak periods cannot be attributed entirely to the kinds of pedestrians crossing the road in the two time periods. Looking at the split by sex in Table 4, both males and females show a greater tendency to use the pelican in the off-peak period. Examining the split by age in Table 5, both the under-13 age group and older pedestrians were more likely to use the crossing proper during the off-peak periods. It should be noted that 100 percent of children used the crossing proper in the off-peak period.

Table 3: Crossings in pelican zone by peak/off-peak

	Peak	Off-Peak
On pelican	54.0%	81.3%
Partly on pelican	0.8%	0.0%
Not on pelican	45.2%	18.7%
	100%	100%
	(n=124)	(n=75)

Table 4: Crossings in pelican zone by peak/off-peak and sex

	Peak	Off-Peak
Males		
On pelican	35.1%	71.4%
Partly on pelican	1.4%	0.0%
Not on pelican	63.5%	28.6%
	100%	100%
	(n=74)	(n=35)
Females		
On pelican	78.9%	90.0%
Not on pelican	21.1%	10.0%
	100%	100%
	(n=38)	(n=40)

Table 5: Crossings in pelican zone by peak/off-peak and age

	Peak	Off-Peak
0-12 yr		
On pelican	73.3%	100.0%
Not on pelican	26.7%	0.0%
	100%	100%
	(n=30)	(n=37)
13+ yr		
On pelican	46.7%	63.2%
Partly on pelican	1.1%	0.0%

Not on pelican	52.2%	36.8%
	100%	100%
	(n=90)	(n=38)

8.4.3 Red light violation and delay times

No literature was found on pedestrian red light violation. There has been some previous research carried out looking at pedestrian delay times. Wilson and Grayson (1980) in a study of three roads in busy shopping areas, showed that the mean delay at the kerb was on average 2.4 seconds, and varied from 1.8 seconds for males to 2.7 seconds for females. Total road crossing delay, taking into account the delay experienced in the road as well as that at the kerb, was also calculated and shown to vary markedly with age, with an average of 4.8 seconds for 15-19 year olds to 8.4 seconds for pedestrians aged 70 or over.

Goldschmidt (1977) looked at pedestrian delay at a number of types of crossing location, including random crossing points, signalised junctions, pedestrian refuges, zebra crossings and pelican crossings. On the basis of empirical research he came up with a number of equations, using a multiple regression analysis, which described the mean pedestrian delay and the proportion of pedestrians delayed at each of the types of crossing location. These were as follows:

At random crossing points:
$d = 1.26 + 4.54x10^{-6}Q^2$
$p = 1.01 - e^{-1.03x10E-3Q}$

At signalised junctions:
$d = 0.68 + 5.84x10^{-5QE2}/W - 1.12x10^{-4}Q^{1.5} + 0.071G$
$p = -0.04 + 0.018\sqrt{Q}$

At refuges:
$d = 4.21 + 1.56x10^{-6}Q^2$
$p = 1.0 - e^{-1.06x10E-3Q}$

At zebra crossings:
$d = -0.95 + 0.38\sqrt{H}$
$p = 0.17 + 0.032\sqrt{H}$

At pelican crossings:
$d = 6.99 + 2.28x10^{-6}Q^2 - 0.51F$
$p = 0.44 + 0.092S + 0.0019M$

Where:
d =mean pedestrian delay
p =proportion of pedestrians delayed
Q =traffic flow (vehicles per hour)
H =medium and heavy goods vehicle flow (vehicles per hour)
W =road width (metres)
G =length of green phase (driver aspect of signals) in seconds
M =minimum length of red phase (pedestrian aspect of signals) in seconds

F =length of flashing green (pedestrian aspect of signals) in seconds
S =estimated vehicle speed (1 = congested stop/start driving, 2 = below 20mph, 3 = 20-30 mph, 4 = over 30 mph)

In summary the Goldschmidt study found that delays at zebras correlated better with flows of medium and heavy goods vehicles than with total traffic flows. The author theorizes: "This may reflect a reduced willingness on the part of large vehicles to stop, as well as a degree of intimidation of the pedestrian." Another finding was that, on average, the delay at pelican crossings was two or three times as great as the delay at zebras. Pelican crossings are often set to a delay of up to 45 seconds between pressing of the button by a pedestrian and activation of the signal. Many pedestrians, especially men, were observed to become impatient and to cross before the lights changed, while others, especially the elderly, were unable to react quickly enough to a change in the lights and so were left stranded for considerable periods. Some critics of pelican crossings have termed them pedestrian-delay devices.

Another study (JURUE, 1975) came up with the following best predictive equation for delay time:

$$d = 0.3 + 6.7\text{x}10^{-6} Q^2$$

Where:
d =mean delay in seconds
Q =traffic flow in vehicles per hour

This study was carried out only at random crossing points and found that delay could be predicted by traffic flow alone.

Work in Coventry (City of Coventry, 1973) modelled pedestrian crossing time by traffic flow and road width where there were no crossing facilities and by traffic flow alone where there were zebras or traffic signals. An increase in flow from 1000 to 2000 vehicles per hour raised crossing time where there were no facilities by about 60 percent.

Crompton (1978) took some of these ideas further in a study of pedestrian delays and their relationship with traffic, layout characteristics, and certain types of traffic management measures. By means of an interview survey he looked at the numbers of people who noticed delay, the numbers of people who were annoyed by delay, the numbers of people who have difficulty in crossing and the numbers of people who worry about the safety in crossing roads.

It was shown that noticeability increases logarithmically with increases in mean delay, largely irrespective of type of crossing. He found that the relationship between delay and those noticing delay could be expressed as follows:

$$\%\text{ noticing delay} = 23.7 + 38.8 \log(\text{delay in seconds})$$

It was also shown that for mean delays of up to about 10 seconds, a 2 second increase in mean delay will increase the proportion noticing delay to a significant degree; but for longer mean delays a larger increase in mean delay (5-6 seconds) is needed to make a significant change in the proportion noticing. In short, doubling the delay results in a 12 percent increase in the proportion noticing delay. The relationship differed somewhat with age, with older people in the survey noticing being delayed less then younger people.

Annoyance arising from delay was measured in terms of the numbers of people who commented adversely in terms of either impatience, difficulty in crossing or worry about the danger of crossing. Two equations were derived which identified the relationship between the percentages of people who were annoyed and delay at different types of location:

At random sites:

% annoyed = 45.7 + 1.89 mean delay (seconds)

At pelican crossings:

% annoyed = 11.8 + 1.9 mean delay (seconds)

Equations, based on the mean delays, were also derived to determine the proportions of pedestrians experiencing difficulties crossing roads at 3 different types of sites:

At random sites:

% experiencing difficulties = 26.1 + 2.1 mean delay (seconds)

At pelican crossings:

% experiencing difficulties = –13.3 + 2.0 mean delay (seconds)

At zebra crossings:

% experiencing difficulties = 10.4 + 2.6 mean delay (seconds)

Finally a series of equations were derived which showed the relationship between mean delay and the proportion of pedestrians who were worried about crossing:

At refuges:

% worried = 25.6 + 1.2 mean delay (seconds)

At pelicans:

% worried = 11.8 + 0.79 mean delay (seconds)

At zebras:

% worried = 20.4 + 3.1 mean delay (seconds)

It should be noted that all of these relationships are described as being provisional, and in some cases the correlation coefficients associated with the equations are not especially high. However, the equations do seem to be some of the best estimates of such relationships presently in existence.

A study by Grayson (1975) looked at the crossing behaviour of adults and children at a sample of four sites in England. This showed substantial differences in the crossing behaviour of children and adults. In terms of mean kerb delay, children generally were delayed for longer than adults. There was also a substantial difference in the delay at the kerb when there were no vehicles present between adults and children. In general children waited for longer periods than adults, even when no vehicle was present.

It is important to note one feature of the various delay studies. They cannot observe changes in pedestrian behaviour caused by the delay. This was noted by Goldschmidt:

> [Waiting] cannot be seen in isolation from the individuals affected, nor from the alternative actions available to the pedestrian. A pedestrian trying to cross the road, but unable to do so immediately, may either wait at the kerbside until the road is clear, or he may walk along the kerb, continuously looking for a gap in the traffic, and then cross without stopping. Alternatively, he may decide to walk to a pedestrian crossing before attempting to cross. In extreme cases, he may adjust his route to avoid crossing the road altogether.

Observations in the Bradford experimental situation were carried out to collect more information on red light violation and delay times. From the same set of video observations as used for the crossing behaviour in pelican zones, the light setting and delay time was recorded for those who crossed on the pelican. This information was obtained for 106 of the 128 individuals who used the crossing. The light setting was observed from down the road and thus it was the vehicle light setting that was observed; the pedestrian setting was deduced from the vehicle setting. The overall distribution of crossings by light setting is shown in Table 6. From the table it can be observed that, among those who crossed on the pelican, there was a very low rate of red-light violation (only 9.4 percent overall). Of the violators, three people crossed while the vehicle light was green, while 7 crossed when the vehicle light was amber, i.e. about to change to red. This latter group of red-light violators might be termed “early walkers” in that they cross when the pedestrian light is just at the point of turning green. It is interesting to note that the mean delay of 12.7 seconds experienced by this group is considerably longer than the 3.4 seconds experienced by those who crossed when the vehicle light was green, although given the small number of observations these results should be treated with caution. Another interesting result is the delay time for those who cross when the pedestrian signal flashing green. They seems to consist in the main of delayed crossers rather than late arrivals and have the highest mean delay time of any group.

Table 6: Crossings at the pelican by light setting

Light for Vehicle	Light for Pedestrian	N	Col%	Mean Delay (sec.)

Red	Green	76	71.7	11.4
Flash. amber	Flash. green	20	18.9	22.2
Green	Red	3	2.8	3.4
Amber	Red	7	6.6	12.7

Looking at the light setting by sex in Table 7, it can be seen that there is little difference in the rate of red-light violation by sex. There is a substantial difference, however, in the proportion of males and females who set out on flashing green: females are far more likely to do this than males.

Table 8, showing the light setting by age group, indicates that those who set out on flashing green are predominantly children. The delayed crossers are therefore mainly female and mainly children.

Table 9 indicates that a higher proportion of pedestrians cross with a green light during the peak period as compared to the off-peak period. The delayed crossing phenomenon occurs almost entirely during the off-peak period.

Table 7: Crossings at the pelican by light setting and sex

Light	Males		Females	
for pedestrians	N	Col%	N	Col%
Green	34	81.0	32	59.3
Flashing green	1	2.4	19	35.2
Red	7	16.7	3	5.6

Table 8: Crossings at the pelican by light setting and age

Light	0–12		13+	
for pedestrians	N	Col%	N	Col%
Green	39	73.6	34	68.0
Flashing green	14	26.4	6	12.0
Red	0	0.0	10	20.0

Table 9: Crossings at the pelican by light setting and peak/off-peak

Light for	peak off-peak			
pedestrians	N	Col%	N	Col%
Green	40	83.3	36	62.1
Flashing green	1	2.1	19	32.8
Red	7	14.6	3	5.2

8.4.5 Gap acceptance

Very little work exists on pedestrian gap acceptance. The only study of note is Wilson and Grayson (1980) who used as their measure of gap acceptance the amount of time each pedestrian had to spare over an approaching vehicle (a value they called the `safety gap'). They found that the range of safety gap values was considerable and hence only examined the incidence of small safety gaps of less than 2 seconds duration. Their results showed that male pedestrians had higher proportions of safety gaps under 2 seconds than female pedestrians. No significant trends in age were found. They conclude that small safety gaps may not be reliable indication of dangerous crossing manoeuvre, and may even be a reflection of skill in the crossing task. They also conclude that gap acceptance measures by themselves do not appear a particularly fruitful area for further research, and a more detailed analysis of pedestrian/vehicle interaction would seem preferable.

The gap acceptance observation study was carried out at one of the junctions in the Bradford experimental situation. The video tapes were analyzed for gaps following the standard project formula and using a stop watch to obtain the timings. The video information covered a period of 7 hours 50 minutes over a period of four days. The total number of crossings recorded was 236, of which 160 were at the light (i.e. in front of the stop line), 60 were not at the light (i.e. behind the stop line and within 20 metres of it) and 16 were partially at the light.

Gap acceptances were only analyzed when the traffic was not stopped by a red light. Thus of the 160 crossings at the light, only the 19 that took place when the light was not red on the road crossed were included. Of the 76 other crossings, 41 were from the west side to the east side of the junction, when the lights were red, i.e. the first half of the crossing was over a lane that was stopped for the red light. The crossing of the first lane by this group was not analyzed, since the traffic was theoretically held for the light. Finally all cases with no gap recorded or a gap of more than 8 seconds were deleted (it was assumed that, if a gap were greater than 8 seconds, there was no approaching traffic). This left a total of 13 gaps in the first half of the road and 33 gaps in the second half. The average gap in the first half of the road was 3.21 seconds with a minimum of 0.07, and the average gap in the second half was 2.90 seconds with a minimum of 0.12. The two very small gaps are from the same individual. The average gap by sex (all gaps) was as follows:

Males:	3.30 seconds (N=27)
Females:	2.54 seconds (N=19)

Thus women appear to have a slightly lower average gap. Looking at gap by age, the distribution of average gap was:

0-12:	2.30 seconds (N=4)
13-59:	3.02 seconds (N=36)
60+:	3.23 seconds (N=6)

Children seem to be accepting the smallest gaps, but the numbers are too small for the results to be very reliable and it should be noted that all the children were females.

The average gaps by peak/off-peak were as follows:

Peak:	3.50 seconds (N=37)
Off-peak:	2.86 seconds (N=9)

The peak period data collection took place between 15:00 and 17:05; the off-peak between 09:30 and 11:40. Given the small number of observations in the off-peak period, no firm conclusions should be drawn.

8.4.7 Rule compliance by vehicles

There is a substantial body of literature on the amount and type of violations by vehicles at traffic signals. However, no literature has been found which reports on the way in which pedestrians and road traffic interact in priority situations.

Vehicles are required by law to stop at a pelican crossing when the lights are red and to yield to pedestrians in the crossing when the lights are flashing amber (Rule 1, par. 4.1.). During the video observation period no vehicles were detected violating either of these rules. Vehicles are also required to stop at normal traffic lights (Rule 5). If they run the light, they may as a result force a pedestrian who is already crossing to yield by stopping abruptly or to take evasive action. Video observations were carried out on one of the light-controlled crossroads. The observations were carried out for a period of just over seven hours (covering both peak and off-peak times) over five days. During this time 68 vehicles were observed running the red light. Twenty-six of these vehicles interfered with a total of 39 pedestrians crossing the road, who were forced to slow down and yield. Thus while pedestrians crossing on the pelican seem to be relatively secure, those crossing at the light-controlled junction are at risk even from traffic approaching the junction when the light is red. Since turning vehicles are not required by British law to yield to pedestrians, the same pedestrians would be at risk from turning vehicles.

8.5 PEDESTRIAN AND PEDAL CYCLIST BEHAVIOUR IN GRONINGEN

J.M. Spikman and E.J. Westra

8.6.1 Red light violation

Pedestrians

Because there are no pedestrian lights in the Groningen experimental area, a field study concerning pedestrian red light violation could not be carried out. However, the literature provides some figures about the Dutch situation. An extensive study by Oude Egberink and Rothengatter (1984), carried out on 32 locations in eight Dutch cities, yielded a percentage “green walkers” of 71 percent and a percentage “red walkers” (related to the number of pedestrians arriving at red) of 45 percent, which means that averaged over all the observed locations almost half of the pedestrians arriving at red do not wait for green.

Pedal cyclists

An investigation which was carried out in seven Dutch cities on different kinds of intersections (BGC, 1988), revealed that red light violation is highest on crossings where cyclists ride parallel to the main traffic stream (22-35%), and considerably lower when cyclists have to cross the main traffic direction (3-7%). The average for all types of intersections was 15 percent. An earlier study (BGC, 1984) showed that red light violation varies in different Dutch cities, ranging from 5 percent (Enschede) to 31 percent (Amsterdam). Van Dooren found in his study (1985) an average percentage of 52 percent for Amsterdam. These figures show the importance of local characteristics and intersection design on red light violation.

In addition to the literature data, a small field study on red light violation of pedal cyclists was carried out. Video recordings were made on all six locations where there are traffic lights in the experimental area. At two locations a one-hour survey in a peak period and a one-hour survey in an off-peak period were carried out: a traffic light in the main road (see Figure 2) and the connected traffic light on the bridge. The recordings of these two locations were made with a time coder connected to the video equipment, with the purpose determining gaps accepted by people who violate the red lights in the main road. On each of the four other locations, registrations were made for a quarter of an hour, both in a peak and an off-peak period without a time coder.

The results show that red light violation percentages markedly differ for the six locations that were observed. A division between the two locations on the bridge and the remaining four is proposed. The traffic lights on the bridge are connected with the traffic lights in the main street, so that the number of cyclists arriving during red at the bridge is very small and predominantly consists of cyclists who violated the light in the main street. For both groups of locations the observations were added and average percentages were computed. Tables 9–13 show for both groups and both time periods (peak/off-peak) the number of people who arrive at green or yellow (and don't have to wait) as percentage of the total number of people passing and the number of people who arrive at red and don't wait for green as percentage of the total number of people who arrive at red.

Table 10: Pedal cyclists' red light violation at the bridge (2 traffic lights) in a peak period (total observation time: 75 min.)

		% arriving at green	% violating red
Sum total	n=1230	89.0%	51.5%
Males	n=633	88.0%	65.5%
Females	n=597	90.5%	35.5%
Age: < 12 yr	n=4	67.0%	0.0%
12–60 yr	n=1192	89.0%	52.5%
> 60 yr	n=34	98.0%	0.0%

Table 11: Pedal cyclists' red light violation at the bridge (2 traffic lights) in an off-peak period (total observation time: 75 min.)

		% arriving at green	% violating red
Sum total	n=644	89.0%	48.5%
Males	n=312	88.0%	48.5%
Females	n=332	89.5%	49.0%
Age: < 12 yr	n=5	80.0%	0.0%
12–60 yr	n=597	88.5%	48.5%
> 60 yr	n=42	95.5%	50.0%

Table 12: Pedal cyclists' red light violation in the "not bridge" situations (4 traffic lights) in a peak period (total observation time: 105 min.)

		% arriving at green	% violating red
Sum total	n=1418	31.5%	27.7%
Males	n=762	30.7%	34.2%
Females	n=656	31.0%	17.7%
Age: < 12 yr	n=7	0.0%	16.5%
12–60 yr	n=1371	32.7%	28.0%
> 60 yr	n=40	17.7%	25.7%

Table 13:Pedal cyclists' red light violation in the "not bridge" situations (4 traffic lights) in an off-peak period (total observation time: 105 min.)

		% arriving at green	% violating red
Sum total	n=570	30.7%	42.0%
Males	n=297	32.0%	45.2%
Females	n=273	28.7%	38.5%
Age: < 12 yr	n=0	–	–
12–60 yr	n=542	31.2%	41.7%
> 60 yr	n=28	21.0%	28.2%

Because the traffic lights on the bridge are connected to lights in the major road, the numbers of cyclists arriving in the green stage are very high both in peak and off-peak periods: almost 90 percent. About 50 percent of the cyclists arriving during the red stage violate the light. For the remaining four locations, the averaged percentage of cyclists arriving in the green stage is both in peak and in off-peak periods about 30 percent. During peak hours, red light violation is less (28%) than during off-peak hours (42%), when averaged over the four locations.

Because of the very small number of people in the age categories <12 yr and >60 yr, the conclusions about these age groups must be treated carefully. On the average older pedal cyclists seem to violate the light less often than 12 to 60 year old pedal cyclists. This finding is confirmed by the literature, which reports a higher safety-mindedness among the elderly (e.g. Brouwer, 1988). During off-peak hours, red light violation seems to be about the same for both genders, but during peak hours there are about twice as many men as women who violate the red light.

8.6.3 Gap acceptance

Pedestrians

No relevant literature was found. In a small field study pedestrians were observed at two types of locations in the experimental area: a midblock crossing and a zebra-crossing on a non-signalized junction. On both locations video recordings were made for one hour during a peak period and one hour during an off-peak period. All recordings were made with a time coder connected to the video equipment, so a time signal would be visible on the video screen.

The results are shown in Tables 14 and 15.

Table 14: Median gaps (sec.) of pedestrians at a non-signalized zebra crossing

	First lane		Second lane	
Sum total	3.14	(n=92)	1.56	(n=105)
Male total	3.72	(n=50)	2.02	(n=54)
Female total	2.96	(n=42)	1.52	(n=51)
Peak total	3.28	(n=49)	1.40	(n=56)
Males	4.12	(n=28	1.78	(n=30)
Females	2.92	(n=21)	1.20	(n=26)
Off-peak total	3.12	(n=43)	2.16	(n=49)
Males	2.84	(n=22)	2.40	(n=24)
Females	3.12	(n=21)	2.16	(n=25)

Table 15:Median gaps (sec.) of pedestrians at midblock crossing without pedestrian facilities

	First lane		Second lane	
Sum total	2.64	(n=72)	2.54	(n=76)
Male total	2.68	(n=41)	2.80	(n=49)
Female total	2.60	(n=31)	1.84	(n=27)
Peak total	3.36	(n=35)	3.10	(n=34)
Males	3.24	(n=16)	2.96	(n=27)
Females	3.88	(n=19)	3.24	(n=17)
Off-peak total	2.28	(n=37)	1.38	(n=32)
Males	2.24	(n=25)	1.66	(n=22)
Females	2.50	(n=12)	1.20	(n=10)

The median of the accepted gaps of pedestrians is slightly shorter than 3 seconds. In general pedestrians accept smaller gaps at the second lane crossing, compared to the first lane. However, the difference between first and second lane crossing can almost totally be explained by the zebra crossings: the difference between median gaps at the first and the second lane is relatively large, probably because the pedestrians expect road traffic to yield or slow down if they are already crossing at the zebra, which is in accordance with the Dutch traffic code. The median gap of the first lane is longer at zebra crossings as compared to midblock crossings. During peak hours, the median gaps are longer than during off-peak periods apart from the second lane crossing at the zebra. For both situations and both lanes, women tend to accept shorter gaps than men, although the differences are very small. The number of observed pedestrians in the youngest and oldest age category was too small to draw reliable conclusions.

Pedal cyclists

In a study by Top and Timmermans (1987), gap acceptance of cyclists was investigated. Their definition of accepted gap differed from the one used in this study, because they computed the time difference between the moment the cyclist passed the crossing line with the approaching vehicle and the moment the approaching vehicle passed this line. They also computed rejected gaps, when a cyclist decided not to cross the street when there was approaching traffic. To do this they computed the velocity with which the cyclist approached the street to cross, computed the moment that the cyclist would have reached the crossing line with that velocity and the moment that the approaching vehicle passed that line. The difference between these two moments was the rejected gap and could, contrary to the accepted gap, be a negative value. Table 16 shows percentages of cyclists who accept and reject a given gap for all gaps from 0 to 9 seconds, both for first and second lane crossing.

Table 16:Pedal cyclists' accepted and rejected gaps (from: Top and Timmermans, 1987)

	First lane			Second lane		
GAP (sec.)	ACC	REJ	N	ACC	REJ	N
0 to 1	39%	61%	28	22%	78%	9
1 to 2	29%	71%	14	75%	25%	20
2 to 3	70%	30%	23	85%	15%	13
3 to 4	86%	14%	21	78%	22%	18
4 to 5	100%	0%	12	77%	23%	13
5 to 6	95%	5%	21	71%	29%	7
6 to 7	100%	0%	10	92%	8%	13
7 to 8	100%	0%	13	100%	0%	5
8 to 9	100%	0%	6	100%	0%	3

The gap that is accepted by 50 percent of the cyclists is between 2 and 3 seconds for the first lane and for the second lane between 1 and 2 seconds. However, gaps longer than 3 seconds are relatively more often rejected when crossing the second lane than the first lane. One of the possible explanations is that cyclists apply a different criterion at the second lane, because only one more lane has to be crossed. Another possibility is that the gap of the second lane is estimated before crossing the first lane, so that the estimate is less accurate.

In the additional field study in the experimental area, cyclists were observed on two locations: a non-signalized junction and a signalized junction (in combination with red light violation observations). Video recordings were made of cyclists going straight on, turning left and turning right, for one hour during a peak period and one hour during an off-peak period. The results are shown in Tables 17 and 18.

Table 17: Median gaps (sec.) of pedal cyclists at a non signalized junction

	First lane		Second lane	
Sum total	2.70	(n=104)	2.02	(n=38)
Male total	2.76	(n=65)	1.76	(n=25)
Female total	2.52	(n=39)	2.24	(n=13)
Peak total	2.45	(n=64)	1.70	(n=28)
Males	2.62	(n=46)	1.70	(n=20)
Females	1.96	(n=18)	1.80	(n=8)
Off-peak total	3.54	(n=40)	5.76	(n=10)
Males	3.44	(n=19)	4.44	(n=5)
Females	3.64	(n=21)	5.84	(n=5)

Table 18: Median gaps (sec.) of red violating pedal cyclists

Peak total	2.52	(n=3)
Off-peak total	2.14	(n=10)
Male total	2.52	(n=7)
Female total	1.74	(n=6)

The results indicate that pedal cyclists accept smaller gaps during peak hours than during off-peak hours. The difference is most pronounced at the second lane crossing, though the small number of observations might have distorted the gap values. During peak hours, the median gap is longer for the first lane crossing, but the opposite is true during off-peak hours. With regard to the first lane, men and women have the same median gap value, but with regard to the second lane, women seem to accept longer gaps. The median gap, accepted by cyclists who violate the red light, is shorter during off-peak hours and shorter for women. However, the number of observations is too small to draw firm conclusions.

8.6.5 Rule compliance

Pedestrians
No relevant literature was found that reported the way road traffic and pedestrians interact in priority situations and whether this interaction caused unnecessary delay for the pedestrians. A small observation study was carried out to collect some data on this topic. In the Groningen situation, there are two relevant situations in which priority rules could be violated. These concerned the following rules:

Rule 2:Turning cars and other road traffic have to yield for pedestrians who are on the same road and want to cross.

Rule 4:Cars and other road traffic have to yield for pedestrians who are about to cross at a (non-signalized) zebra crossing.

For both situations a one hour survey during a peak period and a one hour survey during an off-peak period was carried out and the results are shown in Tables 19–22.

Table 19: Rule compliance of road traffic towards pedestrians (Rule 2) in a peak period

	The partner	
The pedestrian	car	pedal cycle
yielded	19%	43%
slowed down but got priority	19%	0%
got priority undisturbed	62%	57%
	100% (n=26)	100% (n=7)

Table 20: Rule compliance of road traffic towards pedestrians (Rule 2) in an off-peak period

	The partner	
The pedestrian	car	pedal cycle
yielded	28%	100%
slowed down but got priority	5%	0%
got priority undisturbed	67%	0%
	100% (n=18)	100% (n=1)

Table 21: Rule compliance of road traffic towards pedestrians (Rule 4) in a peak period

	The partner	
The pedestrian	car	pedal cycle
yielded	15%	43%
slowed down but got priority	8%	0%
got priority undisturbed	77%	57%
	100% (n=13)	100% (n=28)

Table 22: Rule compliance of road traffic towards pedestrians (Rule 4) in an off-peak period

	The partner	
The pedestrian	car	pedal cycle
yielded	40%	43%
slowed down but got priority	10%	14%
got priority undisturbed	50%	43%
	100% (n=10)	100% (n=21)

With regard to pedestrians, cyclists cause more often delay than motorized vehicles, when the pedestrian has right of way. When averaged over both situations and time periods, pedestrians are in about 40 percent of the relevant encounters delayed even though they have right of way. It should be noted however, that the number of observations is small.

Pedal cyclists
A study of priority behaviour of different types of traffic participants (Advisie, 1985) yielded Table 23, which concerns the situation in which the cyclist rides on a major road and other traffic approaches from a side road (i.e. the cyclist has priority):

Table 23:Percentage of correct and incorrect application of the priority rules of different types of road users towards a cyclist (from: Advisie, 1985)

	Cyclist with priority	
Vehicle without priority	Gets/takes priority (correct)	Gets/takes no priority (not correct)
Bus	88%	12%
Car	80%	20%
Moped	63%	37%
Bicycle	56%	44%
All	72%	28%

This table shows that in encounters with other cyclists, the target cyclist has to yield more often, while he has priority, than in encounters with motorized traffic.

In the Groningen situation, there were two relevant rules for pedal cyclists. These were:

Rule 1:Turning cars and other turning road traffic have to yield for cyclists who go straight on, both when going in the same and in opposite direction.
Rule 2:Cars and other traffic approaching a major road have to yield for cyclists who are riding on the major road.

The results of a small field study in these situations are shown in Tables 24–27.

Table 24:Rule compliance of road traffic towards pedal cyclists (Rule 1) in a peak period

	The partner	
The cyclist	car	pedal cycle
yielded	69%	20%
slowed down but got priority	12%	0%
got priority undisturbed	19%	80%
	100% (n=16)	100% (n=10)

Table 25:Rule compliance of road traffic towards pedal cyclists (Rule 1) in an off-peak period

The cyclist	The partner car	pedal cycle
yielded	25%	0%
slowed down but got priority	0%	0%
got priority undisturbed	75%	100%
	100% (n=4)	100% (n=7)

Table 26:Rule compliance of road traffic towards pedal cyclists (Rule 2) in a peak period

The cyclist	The partner car	pedal cycle
yielded	17%	10%
slowed down but got priority	25%	0%
got priority undisturbed	58%	90%
	100% (n=36)	100% (n=30)

Table 27:Rule compliance of road traffic towards pedal cyclists (Rule 2) in an off-peak period

The cyclist	The partner car	pedal cycle
yielded	18%	22%
slowed down but got priority	12%	11%
got priority undisturbed	70%	67%
	100% (n=17)	100% (n=9)

Contrary to the figures in the literature, in this study cyclists are more often delayed in relevant encounters with motorized vehicles than in encounters with other cyclists. Because of the relatively small number of encounters of the last type, no firm conclusions can be drawn. During peak hours, cyclists are more often delayed, because of priority failures of other road traffic than during off-peak hours. When averaged, cyclists are unnecessary delayed in about 30 percent of the relevant encounters with other traffic.

8.7 PEDESTRIAN AND PEDAL CYCLIST BEHAVIOUR IN VÄXJÖ

M. Draskòczy

8.8.1 Red light violation

Pedestrians

Garder (1982) made a study at 38 intersections in 15 different towns in Sweden and developed a model of the influence of different intersection-related factors on pedestrian red light violation. The model looks as follows:

$$R = 9.8\,T + 0.79\,B + 5.4\,O - 9.3\,G + 8.2\,FG - 4.8\,FR + 0.017\,V + 4.0\,S + 8.8\,A - 3.9$$

where

R =the percentage of red walkers among the pedestrians who arrive on red

T =town size, T=1 if population < 30,000
T=2 if 30,000 < population > 200,000
T=3 if Malmö (240,000 inhabitants)
T=4 if Gothenburg (440,000 inhabitants)
T=5 if Stockholm (660,000 inhabitants)

B =street width in meters

O =presence of refuge 0 if refuge is lacking
1 if refuge exists

G =number of pedestrians per hour on the zebra/1000

FG =number of cars per hour that pass the zebra during the green time of the pedestrian signal (mostly turning cars)/1000

FR =number of cars per hour that pass the zebra during the red time of the pedestrian signal/1000

V =red time in seconds at the pedestrian signal during a cycle

S =signal characteristic 1 if fixed-time signal
2 if vehicle actuated

A =push-button 1 if push-button use is needed for pedestrians to get green
0 else.

The following factors were also tested: weather, centrality of the intersection and if the intersection had scramble or not. None of these factors had any influence on the number of red walkers.

A short field study was made at one of the traffic light controlled junctions in the Växjö experimental location. Video registrations were made during one hour at a peak and one hour at an off-peak period. Peak period means lunch-time or late afternoon hours, off-peak period means early afternoon or late morning hours in the Växjö field studies. Tables 28 and 29 show the results.

In order to compare the influence of the period with the influence of the place on pedestrian behaviour, a peak-period on the spot observation was carried out at another intersection in the experimental area. These results are presented in Table 30.

Table 28:Percentage of pedestrians arriving at green and percentage of red light violators in a peak period

		% arriving at green	% violating red
Sum total	n=311	59.2%	40.9%
Male total	n=145	60.0%	53.5%
Female total	n=166	58.4%	30.5%
Male < 12 yr	n=3	100.0%	—
12–60 yr	n=139	59.0%	54.4%
> 60 yr	n=3	66.6%	0.0%
Fem. < 12 yr	n=1	100.0%	0.0%
12–60 yr	n=155	58.1%	32.2%
> 60 yr	n=10	60.0%	0.0%

Table 29:Percentage of pedestrians arriving at green and percentage of red light violators in an off-peak period

		% arriving at green	% violating red
Sum total	n=217	52.1%	44.2%
Male total	n=79	49.4%	45.1%
Female total	n=138	53.6%	43.7%
Male < 12 yr	n=2	100.0%	—
12–60 yr	n=67	50.7%	45.4%
> 60 yr	n=10	30.0%	42.9%
Fem. < 12 yr	n=1	0.0%	100.0%
12–60 yr	n=122	55.7%	46.3%
> 60 yr	n=15	40.0%	22.2%

Table 30:Percentage of pedestrians arriving at green and percentage of red light violators in a peak period

		% arriving at green	% violating red
Sum total	n=155	14.2%	66.9%
Male total	n=69	13.1%	68.3%
Female total	n=86	15.1%	65.7%
Male < 12 yr	n=6	33.3%	50.0%
12–60 yr	n=61	11.5%	70.4%
> 60 yr	n=2	0.0%	50.0%
Fem. < 12 yr	n=2	100.0%	—
12–60 yr	n=77	13.0%	71.6%

> 60 yr	n=7	14.3%	0.0%

The results of these observations stress the importance of the local characteristics on red walking. The comparison between the two peak period observations at two locations indicates, that the red light violation rate is higher in situations where the chance of arriving at the pedestrian green stage is lower. Comparing the peak and off-peak violation rates in the same situation, the results show a slight average increase in red light violation in peak periods. Men tend to cross more often through red in peak periods, while women tend to cross less often through red in peak periods. The number of observations in different age categories is too small to allow for conclusions.

Pedal cyclists

Video recordings were made to collect data on pedal cyclists' red light violation: one hour at a peak and one hour at an off-peak period. Tables 31 and 32 show cyclist red light violation by peak / off-peak.

Table 31:Percentage of pedal cyclists arriving at green and percentage of red light violators in a peak period

		% arriving at green	% violating red
Sum total	n=43	53.3%	15.0%
Male total	n=27	55.5%	25.0%
Female total	n=16	50.0%	0.0%
Male < 12 yr	n=0	—	—
12–60 yr	n=25	56.0%	27.0%
> 60 yr	n=2	50.0%	0.0%
Fem. < 12 yr	n=0	—	—
12–60 yr	n=16	50.0%	0.0%
> 60 yr	n=0	—	—

Table 32:Percentage of pedal cyclists arriving at green and percentage of red light violators in an off-peak period

		% arriving at green	% violating red
Sum total	n=30	43.3%	17.6%
Male total	n=18	44.5%	20.0%
Fem. total	n=12	41.7%	14.3%
Male < 12 yr	n=1	100.0%	—
12–60 yr	n=16	43.7%	22.2%
> 60 yr	n=1	0.0%	0.0%
Fem. < 12 yr	n=0	—	—
12–60 yr	n=12	41.7%	14.3%
> 60 yr	n=0	—	—

Even though the number of observations of pedal cyclists is markedly smaller than those of pedestrians, the same tendencies can be seen when comparing men and women in a peak and an off-peak period: red light violation increases in peak periods for men and in off-peak periods for women. The overall difference between peak and off-peak periods is negligible. Conclusions on age differences cannot be drawn on the basis of these results.

8.8.3 Gap acceptance

Pedestrians

A Swedish road capacity manual (Stätensverk, 1977) contains a table on the relationship between the width of the road at a non-signalized pedestrian crossing and the critical gap between the vehicles going along the road. Critical gap means a time gap between vehicles which is accepted or rejected by pedestrians who want to cross the road. This table is shown here as Table 33.

Table 33:Critical gaps for pedestrians for different road width (from: Stätensverk, 1977)

	Critical gap, accepted by			
Road width	85%	90%	95%	99% of the pedestrians
4 m	6.1 sec	6.7 sec	7.6 sec	9.3 sec
6 m	7.7 sec	8.4 sec	9.5 sec	11.7 sec
8 m	8.6 sec	9.4 sec	10.6 sec	13.0 sec
10 m	10.3 sec	11.3 sec	12.7 sec	15.6 sec

In addition, a small field study was carried out at the Växjö site during one peak and one off-peak hour. The definition of gap in this field study, i.e. "the gap between the moment the pedestrian reaches the centre line of the road or kerb and the moment the first vehicle reaches the imaginary crossing line of the pedestrian" differs from the definition usually used in gap acceptance studies and fits better the definition of PET (post encroachment time). Cooper (1984) defined PET as ". . . the time difference between the moment an 'offending' vehicle passes out of the area of potential collision and the moment of arrival at the potential collision point by the `conflicted' vehicle." We refer to our gap as PET in the next tables in order to distinguish the two terms. The results of the analyses of the video recordings are shown in Tables 34 and 35.

Table 34: Median PET values at pedestrian mid-block crossings

Sum total	(n=37) 3.5 sec	
male	(n=23) 3.4 sec	
female (n=14)	3.5 sec	
peak total	(n=21) 3.8 sec	
male	(n=13) 3.8 sec	shortest: 1.2 sec
female	(n=8) 4.3 sec	shortest: 2.2 sec

off-peak total	(n=16)	3.2 sec
male	(n=10)	3.4 sec shortest: 0.8 sec
female	(n=6)	2.9 sec shortest: 0.5 sec

Table 35: Median PET values of red walking pedestrians

Sum total	(n=38)	2.9 sec
male	(n=24)	2.6 sec
female	(n=14)	3.4 sec
peak total	(n=18)	3.1 sec
male	(n=11)	2.6 sec shortest: 0.6 sec
female	(n=7)	3.6 sec shortest: 1.0 sec
off-peak total	(n=20)	2.9 sec
male	(n=13)	2.6 sec shortest: 0.4 sec
female	(n=7)	2.9 sec shortest: 1.8 sec

The number of observed cases is very small because of the relatively low vehicle speeds, especially at the intersection, where the majority of the cars were turning (the speed was often less than 10 km/h). PET was quite often higher than 8 sec because of the relatively low traffic volume. The results indicate that pedestrians who violate the light accept smaller PETs than at midblock crossings. Peak and off-peak and gender differences are very small.

Pedal cyclists

A study made by Ekman (unpublished) in Malmö analyzed the time gaps between the vehicles driving on a main road and whether these gaps were accepted or rejected by pedal cyclists arriving on a crossing cycle path. The main road which had to be crossed by the pedal cyclists was 15 m wide with a refuge in the middle. The number of interactions observed was 425. In this study a gap was defined as the time between the pedal cyclist having left the collision course and the car having passed the path of the crossing cycle. The results are shown in Table 36.

Table 36:Percentage of gap acceptance of pedal cyclists (from: Ekman, unpublished)

Gap length	Acceptance by cyclists
< 3.0 sec	0.7%
3.0–3.5 sec	14.5%
3.6–4.0 sec	20.8%
4.1–4.5 sec	41.5%
4.6–5.0 sec	52.2%
5.1–5.5 sec	76.1%
5.6–6.0 sec	82.1%

> 6.0 sec	80.8%

The Växjö field study on pedal cyclists' gap acceptance was limited to cyclists who violated the traffic light at an intersection, because the study area only contained signalized intersections. Pedal cyclist red light violation was not frequent in the study area and even less frequent in the vicinity (less than 8 sec distance) of vehicles. Only three cases were observed, all of whom were men, whose accepted gaps (PET) were 2.0, 2.0 and 2.9 sec.

8.8.5 Rule compliance

Pedestrians
In the Växjö situation, rule 1 (see par. 4.1.) "Cars and other road traffic have to yield for pedestrians who cross during the green stage of the pedestrian light" occurs when cars or cyclists violate the red light. Such a situation together with the close presence of a pedestrian was practically non-existing or so rare that we could not observe it.

A short field study was made regarding rule 3 "Turning cars and other turning road traffic, having green light, have to yield for pedestrians on the same road who are crossing during the green stage of the pedestrian light". Observations were carried out in all three of the intersections during one peak and one off-peak hour. Tables 37 and 38 present the results of the three intersections together because of the low frequencies.

Table 37:Rule compliance of road traffic towards pedestrians (Rule 3) in a peak period

	The partner			
The pedestrian	car		pedal cycle	
yielded	7.3%		11.8%	
slowed down but got priority	1.4%		11.8%	
got priority undisturbed	91.3%		76.4%	
	100.0%	(n=218)	100.0%	(n=17)

Table 38:Rule compliance of road traffic towards (Rule 3) in an off-peak period

	The partner			
The pedestrian	car		pedal cycle	
yielded	14.0%		40.0%	
slowed down but got priority	—		—	
got priority undisturbed	86.0%		60.0%	
	100.0%	(n=57)	100.0%	(n=5)

It can be concluded that the majority of the pedestrians get priority if they have right of way. In encounters with cars only approximately 10 percent of the pedestrians experience unjustified delay. In encounters with pedal cyclists this percentage seems to be somewhat higher, though the number of observations is too small to draw reliable conclusions.

Pedal cyclists

A short field study was made regarding the following rule: "Turning cars and other turning road traffic have to yield for cyclists who go straight on, both when going in the same and in the opposite direction". Observations were carried out in all three of the intersections during one peak and one off-peak hour. The results of the three intersections are presented together because of the low frequencies.

Table 39:Rule compliance of road traffic towards pedal cyclists in a peak period

	The partner	
The pedal cyclist	car	pedal cycle
yielded	2.6%	—
slowed down but got priority	5.3%	—
got priority undisturbed	92.1%	100.0%
	100.0% (n=38)	100.0% (n=3)

Table 40:Rule compliance of road traffic towards pedal cyclists in an off-peak period

	The partner	
The pedal cyclist	car	pedal cycle
yielded	14.3%	—
slowed down but got priority	—	—
got priority undisturbed	85.7%	100.0%
	100.0% (n=21)	100.0% (n=2)

The results for the pedal cyclists shown in Tables 39 and 40 resemble those of the pedestrians. In approximately 10 percent of the encounters between a pedal cyclist and a car, where the pedal cyclist should have priority, the pedal cyclist was delayed. Cyclist/cyclist encounters were seldom observed.

8.9 LOCATIONAL SIMILARITIES AND DIFFERENCES

I.N.L.G. van Schagen

The observation studies at the three locations are suitable for some tentative conclusions about locational differences and similarities in pedestrian and pedal cyclist behaviour. The applied methodology was almost identical and the same definitions were used. There are, however, important differences between the type and function of locations where the data was collected (see also Van Schagen, 1990). At least part of the differences found must be attributed to these locational differences. Nevertheless, it seems useful to compare some of the major findings in each of the locations. The results should be treated with caution, not only because of the mentioned locational differences, but also because of the relatively small number of observations.

8.10.1 Red light violation

Pedestrians

A comparison between the British and Swedish situations (Bradford and Växjö) shows that red light violation of pedestrians is far less common in the British situation. In Växjö 40 to 60 percent of the pedestrians arriving at red did not wait for the light to turn green. In Bradford approximately 9 percent of the pedestrians crossed when the pedestrian light was red. Contrary to the Swedish percentages, the British percentage is related to the total number of arriving pedestrians and not only those arriving at red. Hence, the given 9 percent might be a slight underestimation. The difference between the two locations can at least be partly explained by the difference in road traffic flow, which is markedly higher in the British experimental area. As is shown in the formula of Garder (1982), flow is an important factor influencing pedestrian red light violation. In both countries there was a tendency for more men than women to violate the red light. The overall difference in red light violation between peak and off-peak periods is negligible in Växjö, while in Bradford red light violation is more common in off-peak periods, perhaps explained by heavy traffic in peak periods.

Pedal cyclists

Red light violation by pedal cyclists was observed in the Swedish and Dutch situation (Växjö and Groningen respectively). The number of people who violate the light is markedly higher in the Netherlands than in Sweden, even though car flow is higher in the Dutch situation. A highly tentative explanation might be that the Dutch cycle more frequently and cover more distance than the Swedes (Tight and Carsten, 1989) and that, therefore, the Dutch feel more self secure and rely more on their manoeuvrability. As in the case of pedestrians, in both countries women less often violate the red light than men. In Sweden the peak and off-peak results are comparable. In the Netherlands red light violation rates are lower in peak periods. Even though the number of observations is too small to draw firm conclusions, the results indicate without exception that young children (< 12 years) and the elderly (> 60 years) are more inclined to wait until the light turns green. This finding is confirmed by the literature: Maring and Van Schagen (1990) found that both children and the elderly have relatively positive attitudes towards traffic rules in general and are more inclined to comply with the rules in comparison to the young and middle aged adults.

8.10.3 Gap acceptance

Pedestrians

On the average, the gap or PET accepted by half of the pedestrians is approximately 3 seconds in the British and Dutch situation and 3.5 seconds in the Swedish situation. The results of Bradford and Groningen show that the accepted gaps on the second lane of the road are shorter than those on the first lane. Several reasons can be thought of. It is probably more difficult to estimate gaps in the second half while still standing at the kerb. Another possible explanation is that pedestrians who decide to cross in two steps have to choose between waiting relatively unprotected in the middle of the road or accepting a somewhat more critical gap. A last explanation might be that pedestrians expect road traffic to slow down to yield once they are already crossing. Women tend to accept smaller gaps then men, at least in Bradford and Groningen. In Växjö, the opposite was found. The overall differences are small, however. In general it was found that the accepted gaps are smaller in off-peak periods than in peak periods.

Pedal cyclists

The gap acceptance study on pedal cyclists in Växjö was too small to allow reliable locational comparisons. The gap acceptance tables found in the literature indicate that pedal cyclists in the Netherlands accept markedly smaller gaps than those in Sweden. The median gap for the first lane crossing in the Netherlands is between 2 and 3 seconds and for the second lane crossing between 1 and 2 seconds. In Sweden, the comparable gap is between 4.6 and 5 seconds. However, the locational characteristics, in particular road width, and the gap definition differ in both studies.

8.10.5 Rule compliance

The rules favouring pedestrians and pedal cyclists were different in each of the three experimental area. A direct comparison is therefore not possible. A global overview shows that both in Växjö and in Groningen pedestrians and pedal cyclists experience delays, because other road traffic does not always yield when they have to. Rule compliance to rules that favour non-motorized traffic seems to be worse in the Netherlands than in Sweden and, though the number of observations is small, pedal cyclists seem to be less inclined to follow the priority rules than car drivers in interaction with pedestrians and other pedal cyclists. This finding can be explained by something frequently mentioned in the literature, namely the role of economy principle in determining pedal cyclists' behaviour (see Tamsma, 1984). In Växjö and in the pelican crossing situation in Bradford no or almost no cases were observed where a car violated the light and then hindered a pedestrian.

9 CONCLUDING REMARKS

I.N.L.G. van Schagen

A traffic model in general and even more specifically a traffic model on a meso level, that takes into account pedestrians and pedal cyclists, requires much empirical data and this data must be stored in a database in such a format that the model can use it. In Chapter 3 a distinction was made between three categories of data and thus between three separate databases in order to provide the model with information to predict road capacity, delay times and safety for pedestrians and/or pedal cyclists. The three categories of empirical information are:

–location-specific data (e.g. flow, origin-destination, traffic signals etc.) that needs to be collected for each situation in which the model is applied, stored in the so called "location-specific database";

–knowledge of pedestrians' and pedal cyclists' behaviour (e.g. red light violation, gap acceptance, average speed), that in principle is generally applicable and thus needs not to be collected each time the model is applied in a new situation. If location-specific data are available, this will of course increase the predictive power of the model, which means that the model must be flexible enough to deal with different types of data. This data is stored in the "knowledge database";

–data that are needed to predict the safety effects of particular changes in the infrastructure or signal settings, stored in the "safety database". This can be based on either empirical data about the relationship between all types of physical characteristics and safety or on flow data to predict conflict/accident likelihoods.

The reader may have noticed that there are a number of differences between the theoretical considerations as presented in Chapter 2 and the practical elaborations as described in Chapter 3 and more specifically in Chapter 4. Two of these points are interrelated and should be mentioned in more detail: data collection outside (Chapter 2) or inside (Chapter 4) the experimental area and presentation of the knowledge data in equation-like format (Chapter 2) or as raw data (Chapter 4).

In Chapter 2 it was recommended, that the database be filled with data collected at other places than the situation to be modelled. The most important reason is that data collection within the model area easily leads to an overestimation of the predictive power of the model. This recommendation is linked to the idea that empirical information on pedestrian and pedal cyclist behaviour should ideally be presented in the form of equations in which all influencing external factors are weighted. A nice example of such a formula is given in the Swedish contribution (section 4.4.1) on red light violation. It can been seen in this example that traffic behaviour is influenced by many factors. It was, however, not feasible to carry out all the observation studies needed to compute reliable weighting factors within the framework of this project. Without detailed information on the exact influence of physical characteristics on behaviour, it does not make sense to collect data outside the experimental area.

A provisional solution has been chosen for the elaboration of the knowledge database as presented in Chapter 4: data collection in each of the model areas and storing the information as raw data. The data will be integrated with the model as the next activity of the project. The data collection effort must, however, be considered as the first step in providing to equation-like formulas. A number of possible influencing factors have been studied (e.g. flow dependency, age dependency and gender dependency of behaviour). In a later stage beyond the time borders of this project, if more concrete behavioural data become available through other studies, the knowledge database and the model can be restructured relatively easily to handle behavioural formula's.

The discussion in Chapter 2, however, made clear that the results of the forthcoming test runs of the pedestrian and pedal cyclist traffic model should be treated carefully in order to avoid overestimation of its robustness and power.

In general it can be concluded that the empirical data presented herein, together with the data presented by Van Schagen (1990) and Westerdijk (1990), form a solid basis for the test runs of the model, so that can be determined whether the behavioural information collected now is enough to predict flows, delay times and safety of pedestrians and pedal cyclists.

11 REFERENCES

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APPENDICES

APPENDIX 1
CODE BOOK FOR DB–VRU DATA FILES

0. General: the code book is given for an area in which the main road goes in a North-South direction. If the main road goes in a West-East direction the directions change as follows:

- north becomes west
- west becomes south
- south becomes east
- east becomes north

Inflow means the flow that enters the area or a junction within the area; outflow means the flow that leaves the area.

1. File AREA.DAT
line 1 (respectively):
–number of junctions in the area
–number of extra entry/exit points between junction 1 and 2 at the west side of the road
–1=most northern entry/exit point (entry/exit 1) not accessible for vehicles
2=most northern entry/exit point (entry/exit 1) accessible for vehicles
–1=next northern entry/exit point (entry/exit 2) not accessible for vehicles
2=next northern entry/exit point (exit/entry 2) accessible for vehicles etc.
–number of extra entry/exit points between junction 1 and 2 at the east side of the road
–1=most northern entry/exit point not accessible for vehicles
2=most northern entry/exit point accessible for vehicles
–1=next northern entry/exit point not accessible for vehicles
2=next northern entry/exit point accessible for vehicles etc.
–number of extra entry/exit points between junction 2 and 3 at the west side of the road etc.

line 2 (respectively):
–0=no traffic lights at junction 1
1=vehicle traffic lights at junction 1
2=vehicle traffic light + pedestrian lights at junction 1
–0=no traffic lights at junction 2
1=vehicle traffic lights at junction 2
2=vehicle traffic light + pedestrian lights at junction 2
–0=no traffic lights at junction 3
1=vehicle traffic lights at junction 3
2=vehicle traffic light + pedestrian lights at junction 3
–etc.
line 3 (respectively):
–total number of extra entry/exit points
–1=area direction mainly north-south
2=area direction mainly west-east

–FALSE=no extra entry/exit points accessible for vehicles
TRUE=one/more extra entry/exit points accessible for vehicles
line 4:
–(default) name of junction 1
line 5:
–(default) name of junction 2
line 6:
–(default) name of junction 3
etc.
line x:
–(default) name of 1st extra entry/exit point between junction 1 and 2
line x+1:
–(default) name of 2nd extra entry/exit point between junction 1 and 2
etc
line y:
–(default) name of 1st extra entry/exit point between junction 2 and 3
etc.

2. File CARFLOW.DAT
line 1 (respectively):
–1=vehicle flow data available
–1=average 1 hour vehicle flow data available
2=average 1 hour vehicle flow data for peak/off-peak periods
–1=vehicle inflow data for junction per leg available
[2=non–existent]
3=vehicle inflow data per leg and outflow direction available
–0=no extra entry/exit point accessible for vehicles
1=vehicle inflow/outflow at extra entry/exit points available
2=vehicle inflow/outflow specified for direction available
–0=flow data per vehicle type available
1=flow data per vehicle type not available
–0=flow data for buses not available
1=flow data for buses available
–0=flow data for light good vehicles not available
1=flow data for light good vehicles available
–0=flow data for heavy good vehicles not available
1=flow data for heavy good vehicles available
–0=flow data for taxis not available
1=flow data for taxis available
–0=flow data for private cars not available
1=flow data for private cars available
–0=flow data for motor cycles not available
1=flow data for motor cycles available
–0=no remaining groups
1=flow data for remaining groups put together

line 2 (respectively):
–vehicle inflow from the north of junction 1, off-peak
–bus inflow from the north of juncton 1, off-peak

–lgv inflow from the north of juncton 1, off-peak
–hgv inflow from the north of juncton 1, off-peak
–taxi inflow from the north of juncton 1, off-peak
–private car inflow from the north of juncton 1, off-peak
–motorcycle inflow from the north of junction 1, off-peak
–other vehicle inflow from the north of junction 1, off-peak
–vehicle inflow from the north of junction 1, peak
–bus inflow from the north of juncton 1, peak
–lgv inflow from the north of juncton 1, peak
–hgv inflow from the north of juncton 1, peak
–taxi inflow from the north of juncton 1, peak
–private car inflow from the north of juncton 1, peak
–motorcycle inflow from the north of junction 1, peak
–other vehicle inflow from the north of junction 1, peak

(if no peak/off peak data available, the off-peak lines contain the general averages and the peak lines contain zeros)
(0=either data not available or no vehicle inflow observed)

line 3 (respectively):

–vehicles from north to west at junction 1, off-peak
–buses from north to west at juncton 1, off-peak
–lgv's from north to west at juncton 1, off-peak
–hgv's from north to west at juncton 1, off-peak
–taxis from north to west at juncton 1, off-peak
–private cars from north to west at juncton 1, off-peak
–motorcycles from north to west at junction 1, off-peak
–other vehicles from north to west at junction 1, off-peak
–vehicles from north to west at junction 1, peak
–buses from north to west at juncton 1, peak
–lgv's from north to west at juncton 1, peak
–hgv's from north to west at juncton 1, peak
–taxis from north to west at juncton 1, peak
–private cars from north to west at juncton 1, peak
–motorcycles from north to west at junction 1, peak
–other vehicles from north to west at junction 1, peak

(0=either data not available or no vehicle inflow observed)

line 4 (respectively):

–vehicles from north to south at junction 1, off-peak
–buses from north to south at juncton 1, off-peak
–lgv's from north to south at juncton 1, off-peak
–hgv's from north to south at juncton 1, off-peak
–taxis from north to south at juncton 1, off-peak
–private cars from north to south at juncton 1, off-peak
–motorcycles from north to south at junction 1, off-peak
–other vehicles from north to soouth at junction 1, off-peak
–vehicles from north to south at junction 1, peak
–buses from north to south at juncton 1, peak
–lgv's from north to south at juncton 1, peak

–hgv's from north to south at juncton 1, peak
–taxis from north to south at juncton 1, peak
–private cars from north to south at juncton 1, peak
–motorcycles from north to south at junction 1, peak
–other vehicles from north to south at junction 1, peak
(0=either data not available or no vehicle inflow observed)

line 5 (respectively):
–vehicles from north to east at junction 1, off-peak
–buses from north to east at juncton 1, off-peak
–lgv's from north to east at juncton 1, off-peak
–hgv's from north to east at juncton 1, off-peak
–taxis from north to east at juncton 1, off-peak
–private cars from north to east at juncton 1, off-peak
–motorcycles from north to east at junction 1, off-peak
–other vehicles from north to east at junction 1, off-peak
–vehicles from north to east at junction 1, peak
–buses from north to east at juncton 1, peak
–lgv's from north to east at juncton 1, peak
–hgv's from north to east at juncton 1, peak
–taxis from north to east at juncton 1, peak
–private cars from north to east at juncton 1, peak
–motorcycles from north to east at junction 1, peak
–other vehicles from north to east at junction 1, peak
(0=either data not available or no vehicle inflow observed)

line 6 (respectively):
–vehicle inflow from the west of junction 1, off-peak
–bus inflow from the west of juncton 1, off-peak
–lgv inflow from the west of juncton 1, off-peak
–hgv inflow from the west of juncton 1, off-peak
–taxi inflow from the west of juncton 1, off-peak
–private car inflow from the west of juncton 1, off-peak
–motorcycle inflow from the west of junction 1, off-peak
–other vehicle inflow from the west of junction 1, off-peak
–vehicle inflow from the west of junction 1, peak
–bus inflow from the west of juncton 1, peak
–lgv inflow from the west of juncton 1, peak
–hgv inflow from the west of juncton 1, peak
–taxi inflow from the west of juncton 1, peak
–private car inflow from the west of juncton 1, peak
–motorcycle inflow from the west of junction 1, peak
–other vehicle inflow from the west of junction 1, peak
(0=either data not available or no vehicle inflow observed)

etc.
at line 7: from west to south
at line 8: from west to east
at line 9: from west to north

at line 10: inflow from the south
at line 11: from south to east
at line 12: from south to north
at line 13: from south to west
at line 14: inflow from east
at line 15: from east to north
at line 16: from east to west
at line 17: from east to south

at line 18 through 33: junction 2
at line 34 through 49: junction 3
etc.

After having described the junctions in the area, the carflow at extra exit/entry points, if present, is described.

line x:
– total outflow of vehicles (1–8 categories) at exit point 1, or (if available) outflow at exit point 1 coming from the north, off-peak
– total outflow of vehicles (1–8 categories) at exit point 1, or (if available) outflow at exit point 1 coming from the north, peak

line x+1:
– outflow of vehicles (1–8 categories) at exit point 1 coming from the south (if not available, a zero), off-peak
– outflow of vehicles (1–8 categories) at exit point 1 coming from the south (if not available, a zero), peak

line x+2:
– total inflow of vehicles (1–8 categories) at entry point 1, (or if available) inflow at entry point 1 going to the north, off-peak
– total inflow of vehicles (1–8 categories) at entry point 1, (or if available) inflow at entry point 1 going to the north, peak

line x+3:
– inflow of vehicles (1–8 categories) at entry point 1 going to the south (if not available, a zero), off-peak
– inflow of vehicles (1–8 categories) at entry point 1 going to the south (if not available, a zero), off-peak

etc. for all extra entry/exit points

3. File CYCFLOW.DAT
line 1 (respectively):
–0=no cyclist flow data available (rest of file is empty)
1=cyclist flow data available
–1=average 1 hour cyclist flow data available
2=average 1 hour cyclist flow data for peak/off-peak periods
–1=cyclist inflow data for total junction available

2= non–existent
3=cyclist inflow data per leg and outflow direction available
–1=cyclist inflow/outflow at extra entry/exit points available
2=cyclist inflow/outflow specified for direction available
–1=no specification of cyclist flow data by gender
2=specification of cyclist flow data by gender
–1=no specification of cyclist flow data in age groups
2=specification of cyclist flow data in two age groups
3=specification of cyclist flow data in three age groups
4=specification of cyclist flow data in four age groups
5=specification of cyclist flow data in five age groups
6=specification of cyclist flow data in six age groups
if age group specification:
–minimum and maximum age of first age group
–minimum and maximum age of second age group
–etc.

line 2 (respectively):
–cyclist inflow from north of junction 1, off-peak

[if available:
–cyclist inflow from north of junct. 1, male, age 1, off-peak
–cyclist inflow from north of junct. 1, male, age 2, off-peak
–cyclist inflow from north of junct. 1, male, age 3, off-peak
–cyclist inflow from north of junct. 1, male, age 4, off-peak
–cyclist inflow from north of junct. 1, male, age 5, off-peak
–cyclist inflow from north of junct. 1, male, age 6, off-peak
–cyclist inflow from north of junct. 1, fem., age 1, off-peak
–cyclist inflow from north of junct. 1, fem., age 2, off-peak
–cyclist inflow from north of junct. 1, fem., age 3, off-peak
–cyclist inflow from north of junct. 1, fem., age 4, off-peak
–cyclist inflow from north of junct. 1, fem., age 5, off-peak
–cyclist inflow from north of junct. 1, fem., age 6, off-peak]
–cyclist inflow from the north of junction 1, peak

[if available:
–cyclist inflow from north of junct. 1, male, age 1, peak
–cyclist inflow from north of junct. 1, male, age 2, peak
–cyclist inflow from north of junct. 1, male, age 3, peak
–cyclist inflow from north of junct. 1, male, age 4, peak
–cyclist inflow from north of junct. 1, male, age 5, peak
–cyclist inflow from north of junct. 1, male, age 6, peak
–cyclist inflow from north of junct. 1, fem., age 1, peak
–cyclist inflow from north of junct. 1, fem., age 2, peak
–cyclist inflow from north of junct. 1, fem., age 3, peak
–cyclist inflow from north of junct. 1, fem., age 4, peak
–cyclist inflow from north of junct. 1, fem., age 5, peak
–cyclist inflow from north of junct. 1, fem., age 6, peak]

(if no peak/off peak data available, the off-peak line contains the general averages and the peak line contains zeros)

line 3 (respectively):

–cyclists from north to west at junction 1, off-peak
[if available specified by gender and age: see line 2]
–cyclists from north to west at junction 1, peak
[if available specified by gender and age: see line 2]

line 4 (respectively):

–cyclists from north to south at junction 1, off-peak
[if available specified by gender and age: see line 2]
–cyclists from north to south at junction 1, peak
[if available specified by gender and age: see line 2]

line 5 (respectively):

–cyclists from north to east at junction 1, off-peak
[if available specified by gender and age: see line 2]
–cyclists from north to east at junction 1, peak
[if available specified by gender and age: see line 2]

line 6 (respectively):

–cyclist inflow from the west of junction 1, off-peak
[if available specified by gender and age: see line 2]
–cyclist inflow from the west of junction 1, peak
[if available specified by gender and age: see line 2]

line 7 (respectively):

–cyclists from west to south at junction 1, off-peak
[if available specified by gender and age: see line 2]
–cyclists from west to south at junction 1, peak
[if available specified by gender and age: see line 2]

line 8 (respectively):

–cyclists from west to east at junction 1, off-peak
[if available specified by gender and age: see line 2]
–cyclists from west to east at junction 1, peak
[if available specified by gender and age: see line 2]

line 9 (respectively):

–cyclists from west to north at junction 1, off-peak
[if available specified by gender and age: see line 2]
–cyclists from west to north at junction 1, peak
[if available specified by gender and age: see line 2]

line 10 (respectively):

–cyclist inflow from the south of junction 1, off-peak
[if available specified by gender and age: see line 2]
–cyclist inflow from the south of junction 1, peak

[if available specified by gender and age: see line 2]

line 11 (respectively):
–cyclists from south to east at junction 1, off-peak
[if available specified by gender and age: see line 2]
–cyclists from south to east at junction 1, peak
[if available specified by gender and age: see line 2]

line 12 (respectively):
–cyclists from south to north at junction 1, off-peak
[if available specified by gender and age: see line 2]
–cyclists from south to north at junction 1, peak
[if available specified by gender and age: see line 2]

line 13 (respectively):
–cyclists from south to west at junction 1, off-peak
[if available specified by gender and age: see line 2]
–cyclists from south to west at junction 1, peak
[if available specified by gender and age: see line 2]

line 14 (respectively):
–cyclist inflow from the east of junction 1, off-peak
[if available specified by gender and age: see line 2]
–cyclist inflow from the east of junction 1, peak
[if available specified by gender and age: see line 2]

line 15 (respectively):
–cyclists from east to north of junction 1, off-peak
[if available specified by gender and age: see line 2]
–cyclists from east to north of junction 1, peak
[if available specified by gender and age: see line 2]

line 16 (respectively):
–cyclists from east to west of junction 1, off-peak
[if available specified by gender and age: see line 2]
–cyclists from east to west of junction 1, peak
[if available specified by gender and age: see line 2]

line 17 (respectively):
–cyclists from east to south of junction 1, off-peak
[if available specified by gender and age: see line 2]
–cyclists from east to south of junction 1, peak
[if available specified by gender and age: see line 2]

line 18 (respectively):
–cyclist inflow from the north of junction 2, off-peak
[if available specified by gender and age: see line 2]
–cyclist inflow from the north of junction 2, peak
[if available specified by gender and age: see line 2]

etc. for all of the junctions in the area

After having described the junctions in the area, the cyclist flow at extra exit/entry points is described.

line x:
– total outflow of cyclists at exit point 1, or (if available) outflow at exit point 1 coming from the north, off-peak
[if available specified by gender and age]
– total outflow of cyclists at exit point 1, or (if available) outflow at exit point 1 coming from the north, peak
[if available specified by gender and age]

line x+1:
– outflow of cyclists at exit point 1 coming from the south (if not available, a zero), off-peak
[if available, specified by gender and age]
– outflow of cyclists at exit point 1 coming from the south (if not available, a zero), peak
[if available, specified by gender and age]

line x+2:
– total inflow of cyclists at entry point 1, (or if available) inflow at entry point 1 going to the north, off-peak
[if available, specified by gender and age]
– total inflow of cyclists at entry point 1, (or if available) inflow at entry point 1 going to the north, peak
[if available, specified by gender and age]

line x+3:
– inflow of cyclists at entry point 1 going to the south (if not available, a zero), off-peak
[if available, specified by gender and age]
– inflow of cyclists at entry point 1 going to the south (if not available, a zero), off-peak
[if available, specified by gender and age]

etc. for all extra entry/exit points

4. File PEDFLOW.DAT
line 1 (respectively):
–0=no pedestrian flow data available (rest of file is empty)
1=pedestrian flow data available
–1=average 1 hour ped. flow data available
2=average 1 hour ped. flow data for peak/off-peak periods
–1=ped. inflow data for total junction available
[2= non–existent]
3=ped. inflow data per leg and outflow direction available
–1=ped. inflow/outflow at extra entry/exit points available
2=ped. inflow/outflow specified for direction available
–1=no specification of ped. flow data by gender
2=specification of ped. flow data by gender
–1=no specification of ped. flow data in age groups
2=specification of ped. flow data in two age groups
3=specification of ped. flow data in three age groups
4=specification of ped. flow data in four age groups
5=specification of ped. flow data in five age groups
6=specification of ped. flow data in six age groups
if age group specification:
–minimum and maximum age of first age group
–minimum and maximum age of second age group
–etc.

line 2 (respectively):
–ped. inflow from the north of the north-west corner of junction 1, off-peak
[if available:

–ped. inflow at that place, male, age 1, off-peak
–ped. inflow at that place, male, age 2, off-peak
–ped. inflow at that place, male, age 3, off-peak
–ped. inflow at that place, male, age 4, off-peak
–ped. inflow at that place, male, age 5, off-peak
–ped. inflow at that place, male, age 6, off-peak
–ped. inflow at that place, female, age 1, off-peak
–ped. inflow at that place, female, age 2, off-peak
–ped. inflow at that place, female, age 3, off-peak
–ped. inflow at that place, female, age 4, off-peak
–ped. inflow at that place, female, age 5, off-peak
–ped. inflow at that place, female, age 6, off-peak

–ped. inflow from the north of the north-west corner of junction 1, peak

[if available:
–ped. inflow at that place, male, age 1, peak
–ped. inflow at that place, male, age 2, peak
–ped. inflow at that place, male, age 3, peak
–ped. inflow at that place, male, age 4, peak
–ped. inflow at that place, male, age 5, peak
–ped. inflow at that place, male, age 6, peak
–ped. inflow at that place, female, age 1, peak
–ped. inflow at that place, female, age 2, peak
–ped. inflow at that place, female, age 3, peak
–ped. inflow at that place, female, age 4, peak
–ped. inflow at that place, female, age 5, peak
–ped. inflow at that place, female, age 6, peak

(if no peak/off peak data available, the off-peak line contains the general averages and the peak line contains zeros)

line 3 (respectively):
–ped. from north of north-west corner of junction 1 to west, off-peak
[if available, specified by gender and age, see line 2]
–ped. from north of north-west corner of junction 1 to west, peak
[if available, specified by gender and age, see line 2]

line 4 (respectively):
–ped. from north of north-west corner of junction 1 to south, off-peak
[if available specified by gender and age: see line 2]
–ped. from north of north-west corner of junction 1 to south, peak
[if available specified by gender and age: see line 2]

line 5 (respectively):
–ped. from north of north-west corner of junction 1 to off-peak
[if available specified by gender and age: see line 2]
–ped. from north of north-west corner of junction 1 to east, peak
[if available specified by gender and age: see line 2]

line 6 (respectively):

–ped. from north of north-west corner of junction 1 crossing diagonally, off-peak

[if available specified by gender and age: see line 2]

–ped. from north of north-west corner of junction 1 crossing diagonally, off-peak

[if available specified by gender and age: see line 2]

etc. for all inflow/outflow direction combinations

line 7: ped. inflow from the west of north-west corner
line 8: ped. from west of north-west corner to south
line 9: ped. from west of north-west corner to east
line 10: ped. from west of north-west corner to north
line 11: ped. from west of north-west corner, crossing diagonally
line 12: ped. inflow from the south of north-west corner
line 13: ped. from south of north-west corner to east
line 14: ped. from south of north-west corner to north
line 15: ped. from south of north-west corner to west
line 16: ped. from south of north-west corner, crossing diagonally
line 17: ped. inflow from the east of north-west corner
line 18: ped. from east of north-west corner to north
line 19: ped. from east of north-west corner to west
line 20: ped. from east of north-west corner to south
line 21: ped. from east of north-west corner, crossing diagonally
line 22: ped. inflow at north-west corner from diagonal crossing, line 23: ped. from diagonal crossing to north
line 24: ped. from diagonal crossing to west
line 25: ped. from diagonal crossing to south
line 26: ped. from diagonal crossing to east

line 27 through 51 applies to the south-west corner of junction 1
line 52 through 76 applies to the south-east corner of junction 1
line 77 through 101 applies to the north-east corner of junction 1
line 102 through 126 applies to the north-west corner of junction 2
etc.

After having described the junctions in the area, the pedestrian flow at extra exit/entry points is described.

line x:

–total outflow of ped. at exit point 1, or (if available) outflow at exit point 1 coming from the north, off-peak (if no peak/off peak data available: general average)

[if available specified by gender and age]

–total outflow of ped. at exit point 1, or (if available) outflow at exit point 1 coming from the north, peak (if no peak/off-peak data available: zeros)

[if available specified by gender and age] line x+1:

–outflow of ped. at exit point 1 coming from the south (if not available, a zero), off-peak
[if available, specified by gender and age]
–outflow of ped. at exit point 1 coming from the south (if not available, a zero), peak
[if available, specified by gender and age]

line x+2:

–total inflow of ped. at entry point 1, (or if available) inflow at entry point 1 going to the north, off-peak
[if available, specified by gender and age]
–total inflow of ped. at entry point 1, (or if available) inflow at entry point 1 going to the north, peak
[if available, specified by gender and age]

line x+3:

–inflow of ped. at entry point 1 going to the south (if not available, a zero), off-peak
[if available, specified by gender and age]
–inflow of ped. at entry point 1 going to the south (if not available, a zero), peak
[if available, specified by gender and age]

etc. for all extra entry/exit points

N.B. An exit/entry point, that is also accessible for cars must be considered as two exit/entry points for pedestrians: first the northern pavement, then the southern pavement.

5. File MIDBLOCK.DAT
line 1 (respectively):

–total number of distinguished midblock crossing places (if no midblock data available: rest of file is empty)
–1=average 1 hour ped. flow data available
2=average 1 hour ped. flow data for peak/off-peak periods
–1=no specification of ped. flow data by gender
2=specification of ped. flow data by gender
–1=no specification of ped. flow data in age groups
2=specification of ped. flow data in two age groups
3=specification of ped. flow data in three age groups
4=specification of ped. flow data in four age groups
5=specification of ped. flow data in five age groups
6=specification of ped. flow data in six age groups
if age group specification:
–minimum and maximum age of first age group
–minimum and maximum age of second age group
–etc.

line 2 (respectively):

–number of midblocks between junction 1 and 2
–0=midblock 1 (most northern) has no facilities
1=midblock 1 is pelican crossing
–0=midblock 2 has no facilities
1=midblock 2 is pelican crossing
–etc.
–number of midblocks between junction 2 and 3
–0=midblock 1 has no facilities
1=midblock 2 is pelican crossing
–etc.
–number of midblocks between junction 3 and 4
–etc.

line 3 (respectively):

–ped. at midblock 1 between junction 1 and 2 from west to east, off-peak
[if available:
–ped. at midblock 1, west to east, male, age group 1, off-peak
–ped. at midblock 1, west to east, male, age group 2, off-peak
–ped. at midblock 1, west to east, male, age group 3, off-peak
–ped. at midblock 1, west to east, male, age group 4, off-peak
–ped. at midblock 1, west to east, male, age group 5, off-peak
–ped. at midblock 1, west to east, male, age group 6, off-peak
–ped. at midblock 1, west to east, fem., age group 1, off-peak
–ped. at midblock 1, west to east, fem., age group 2, off-peak
–ped. at midblock 1, west to east, fem., age group 3, off-peak
–ped. at midblock 1, west to east, fem., age group 4, off-peak
–ped. at midblock 1, west to east, fem., age group 5, off-peak
–ped. at midblock 1, west to east, fem., age group 6, off-peak
–ped. at midblock 1 between junction 1 and 2 from west to east, peak
[if available:
–ped. at midblock 1, west to east, male, age group 1, peak
–ped. at midblock 1, west to east, male, age group 2, peak
–ped. at midblock 1, west to east, male, age group 3, peak
–ped. at midblock 1, west to east, male, age group 4, peak
–ped. at midblock 1, west to east, male, age group 5, peak
–ped. at midblock 2, west to east, male, age group 6, peak
–ped. at midblock 1, west to east, fem., age group 1, peak
–ped. at midblock 1, west to east, fem., age group 2, peak
–ped. at midblock 1, west to east, fem., age group 3, peak
–ped. at midblock 1, west to east, fem., age group 4, peak
–ped. at midblock 1, west to east, fem., age group 5, peak
–ped. at midblock 1, west to east, fem., age group 6, peak

line 4 (respectively):

–ped. at midblock 1 between junction 1 and 2 from east to west, off-peak
[if available, specified by gender and age, see line 3]
–ped. at midblock 1 between junction 1 and 2 from east to west, peak
[if available, specified by gender and age, see line 3]

etc. for all midblock crossing places

(if no peak/off-peak data available, the off-peak lines contain the general average 1 hour flow data; the peak lines contain zeros)

6. File MATRIX.DAT
line 1 (respectively):
–0=no O-D data for vehicles available
1=O-D data for vehicles available
–number of entry/exit points for vehicles
–0=no O-D data for cyclists available
1=O-D data for cyclists available
–number of entry–exit points for cyclists
–0=no O-D data for pedestrians available
1=O-D data for pedestrians available
–number of exit/entry points for pedestrians
(each exit/entry point accessible for vehicles equals two exit/entry points for pedestrians (both sides of the road)

line 2
–name of first entry/exit point (O-1, D-1) for vehicles
line 3
–name of 2nd entry/exit point (O-2, D–2) for vehicles
etc.

line x
–number of vehicles with O-1 and D-1
–number of vehicles with O-1 and D–2
–number of vehicles with O-1 and D–3
–etc.

line x+1
–number of vehicles with O-2 and D-1
–number of vehicles with O-2 and D-2
–number of vehicles with O-2 and D-3
–etc.
etc.

(if more than 20 O-D points, O-1 and D-21, D-22 etc. is located at the second line; O-2 and D-21, D-22 etc. at the fourth line and so on.)

Exactly the same procedure is applied to the cyclists and the pedestrians:

line y:
–name of first entry/exit point (O-1, D-1) for cyclists

line y+1:
–name of 2nd entry/exit point (O-2, D-2) for cyclists

etc.

(If for one or more transport modes no O-D data are available, all lines for that/those mode(s) are left out.)

N.B. In the O-D matrix no distinction is made between vehicle categories, age and gender groups and peak/off-peak.

APPENDIX 2
DB-VRU PROGRAMME AND DATA FILES

This floppy disc contains the DB-VRU programme for entering and storing flow data and origin-destination matrices of the model area. The programme can be started by typing DB-VRU. This floppy disc also contains the data files (ASCII-format) of the Bradford situation (*.BRA), the Groningen situation (*.GRO) and the Växjö situation (*.VAX).