1. Report number
VK-2261-303

2. ISSN-number
LVV-Rapport
0920-0592

3. Title
Contributions to Workshop Eurobike in Helsinki

4. Theme
Traffic Engineering

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6. Project
Bicycle Traffic

7. Organisation
Delft University of Technology
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8. Type of report
Laboratory Report

9. Sponsor
-

10. Date
March 1994

11. Summary
In this report three subjects relevant for the study of bicycle traffic are presented, giving the state of the art in The Netherlands. They were presented at a workshop of Eurobike, a consortium preparing to carry out practically oriented research about bicycle traffic in European urban areas.

The general set-up of the National Travel Survey is described. This survey also includes trips made by bicycle. Some details are given about the size of the survey, the change in method to collect the data in 1985 and the response rate. The modal split as a function of trip distance and the distribution function for bicycle traffic are given as examples of results that can be derived from the survey.

In the safety part statistics are given about the general fatality rate of cyclists and other modes of traffic. Two studies to determine criteria for the need for separate cycle paths are described. A study proposal for analysing safety and behaviour in terms of risk for a mix of fast and slow traffic on an arterial is presented.

The third subject is the cycle planning model Quo-Vadis that can be used to determine the best possible cycling network and the best allocation of the budget for bicycle facilities. A short description of the model and its required input is presented. The traffic model part can determine cycle intensities over the period 7 AM to 7 PM on every link of the network and the origins and destinations of the flow. The evaluation part can be used to evaluate an existing network and to assess the effect of measures improving the network. The combination of the model with accident data and the determination of yard-sticks for safety can give indications of how to improve safety.

12. External contacts
-

13. Pages
20

14. Price
Dfl. 50,-
(included all charges)
Contributions to Workshop Eurobike

in Helsinki

Hein Botma

March 1994

Delft University of Technology
Faculty of Civil Engineering
Department Infrastructure
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Summary

National Travel Survey
In many countries mass motorization and the increase in mobility have been the incentives to collect data about the mobility of the total population on a continual basis. In the Netherlands the National Travel Survey (NTS) is carried out by the National Bureau of Statistics since 1978. To reduce costs the method of collecting the data was changed substantially in 1985. In the near future the survey will be extended.

The task of the NTS is described as follows: "To establish the mobility pattern of the Dutch population by point of departure (origin) and destination, period of mobility, mode of transport and purpose of the journey; in addition, ample attention must be paid to the factors explaining the various discernable patterns of mobility".

The sample unit is the household. Household data and data about every member of it are collected. Of all members over 11 years one day journey data is collected by means of a diary.

Every day a new sample of 60 households is drawn. From 1978 up to and including 1987 some 92,000 households have participated in the survey; corresponding to 261,000 persons and 1,148,000 trips.

Since 1985 data are collected using: 1) letter for introduction; 2) telephone interview (computer assisted) for household data; and 3) written diary questionnaire for individual data and journey characteristics. The change of data collection method in 1985 reduced the costs and made it possible to continue the NTS.

Several imperfections of the survey have been studied and where possible corrections have been derived. For example: Based on a study of the bias of people estimating trip distances, which depend upon mode and distance, correction factors have been derived.

Many travel characteristics, relations and trends can be derived from the NTS data. Some examples are: Combined with data about accidents the road death per 100 million km per age group and per mode; The average number of km per year on bicycle and its development in time; Differences in use of modes depending on city size, length and purpose of trip, etc.; Trip production rates depending on age, size of town, trip purpose, etc.

Road safety
Analysis of road safety can based on recorded accidents and on traffic behaviour in a broad sense. Recording of accidents is far from complete: for fatal accidents it is nearly 100%, for hospital-treated casualties it is 65% and for other casualties only 20%. There are indications that the under reporting is much higher for bicyclists than for car occupants.
Data from the National Travel Survey can be used to estimate distances covered and consequently all types of accidents rates can be determined, on national level, in a town, under special conditions such as darkness, etc. However, most of these analysis are not straightforward and rather expensive. The results can be used to determine the size of the safety problems and the priorities of measures and more detailed studies.

For rural roads criteria have been established about the requirement of separate facilities for bicycles as a function of intensities of vehicles and bicycles based on accidents.

In built-up areas the new Dutch Design Manual gives criteria based on the intensity of vehicles and their speed. A recent study to found those criteria quantitatively on accidents and distances covered of bicycles and vehicles was not successful.

For several reasons surrogate yard sticks for safety are required. They vary from intensities, number of meetings and overtakings to analysis of conflicts where time to collision and post encroachment time are used. Detailed registration and analysis of behaviour can reveal the functioning of new solutions but the validity of the yard sticks is sometimes debatable and in the end has to be established by using accident data.

A main problem is the effect of a cycle path that has a positive effect on safety at arterials and a negative effect at intersections. Three out of four accidents with injuries in urban areas are occurring at intersections. The safety effect of cycle lanes is still largely unknown.

Based on these facts a proposal is presented to investigate the behaviour of bicycle and fast traffic on arterials with respect to each other and interpret this behaviour in terms of risk.

**Cycling Planning Model**

This model was developed by the consultant DHV Environment and Infrastructure for the Dutch Ministry of Transport and Public works in the framework of the Masterplan Bicycle. The model is a tool that can be used to produce information useful in answering the following questions:

- what is the best possible cycling network;
- what is the best allocation of the budget.

The model has two main parts: a traffic model and an evaluation model. With the traffic model one can determine the intensity over the period 7 AM to 7 PM on every link and the origins and destinations of the flow. The following trip purposes are distinguished: work (=20% of all trips), education(13%), shopping (33%) and other(34%).

With the evaluation model one can show how far cyclists deviate from the straight-line compass route which is a yard stick for accessibility and where cycling facilities are needed or are most effective to improve safety.
The traffic model has the usual modules: trip production; trip distribution; (stochastic) assignment; calibration and forecasting.

Required social economic data per zone are: number of inhabitants; number of jobs in shops and other; location of schools and the number of pupils.

Trip production factors based on the National Travel Survey data have been determined and can be used unless more specific ones are available. The distribution function is also based on NTS data.

The network for bicycles needs more detail than a network for cars, because the distances of cycle trips are shorter and cyclists have a very flexible route choice. The type of cycle facility, cycle lane, cycle path or nothing, is also a required property of the links. Mean speed at links and delay at intersections determine the resistance of routes. The delay is dependant on the car intensity, hence these should be known or estimated.

The model can be used on a PC, it is flexible, easy to operate and has much graphical output. The most ideal situation is a combination with the Quo-Vadis car model but the program can also communicate with other models.
1. INTRODUCTION

Eurobike is the name of a network formed by partners in six different European countries. Its aim is to carry out practically oriented research about bicycle traffic.

The motivation is the following: In most large and middle sized cities in Europe the increasing car traffic is causing unacceptable levels of congestion, road accidents, fragmentation of areas, air and noise pollution. These problems have a negative effect on the quality of life of people living in these cities. Cycling is an important alternative mode to the car in that it is efficient in terms of space and (often) in terms of time and has a large potential contribution to the reduction of urban environmental and safety problems.

Unfortunately the knowledge about bicycle traffic in general is not sufficient to help the development of cyclist facilities. This has led to an implicit planning bias in favour of the car and public transport over the bicycle. This is also the case in European countries and regions where there is or has been a traditional high use of the bicycle. Even if there is a political will to reduce car traffic and favouring the bicycles, the tools for carrying out this policy are not available.

As a first step Eurobike has held a workshop in Helsinki in March of 1994. Short presentations about the state of the art in several countries were given and methodological aspects were discussed. Study proposals were drawn up in several working groups. In the end an integrated study proposal will be made and funding will be asked from the EC in the framework of the "Fourth framework programme for Community activities in the field of research, technological development and demonstration for the period 1994-98 specifying inter alia the activities to be carried out in the field of transport".

At this workshop three presentations about the state of the art in The Netherlands were given.

The first is about the National Travel Survey. This subject was chosen because it is a rather unique survey and it produces a lot of statistical information about bicycle traffic.

The second presentation is about the road safety of bicycle traffic in The Netherlands. It concentrates on studies carried out to determine requirements for separate cycle path or lanes for bicycle traffic. It ends with a proposal to study the safety of mixed traffic, that is a road used by a mixture of fast and slow traffic that are not physically separated.

The third presentation is a short description of a recently developed traffic planning model that focuses on bicycle traffic and is a tool for the planning of bicycle facilities.

The three subjects form the chapters 2, 3 and 4 of this report.
2. THE NATIONAL TRAVEL SURVEY OF THE NETHERLANDS

2.1. Introduction

In many countries mass motorization and the increase in mobility have been the incentives to collect data about the mobility of the total population on a continual basis. In the Netherlands the National Travel Survey (NTS) is carried out by the Netherlands Bureau of Statistics (CBS) since 1978. To reduce costs the method of collecting the data was changed substantially in 1985. In the near future the survey will be extended.

The goal of the NTS is described as follows: "To establish the mobility pattern of the Dutch population by point of departure (origin) and destination, period of mobility, mode of transport and purpose of the journey; in addition, ample attention must be paid to the factors explaining the various discernable patterns of mobility". The requirement to collect explanatory factors has lead to the scheme in Figure 2.1 with three levels of data: on households, individuals and journeys.

Fig 2.1 - Levels in data collected
The sample unit is the household. Every day a new sample of 60 households is drawn, stratified by province and degree of urbanization; every household has an even chance of being selected.

Household data and data about every member of it are collected. Of all members over 11 years **one day journey data** is collected by means of a diary. So in fact we have available data on an individual or disaggregated level.

From 1978 up to and including 1987 some 92,000 households have participated in the survey; corresponding to 261,000 persons and 1,148,000 trips.

2.2. Some details of the survey

Since 1985 data are collected using: 1) a letter for introduction; 2) a telephone interview (computer assisted) for household data; and 3) a written diary questionnaire for individual data and journey characteristics. The change of data collection method in 1985 reduced the costs and made it possible to continue the NTS.

Several imperfections of the survey have been studied and where possible corrections have been derived. For example: Based on a study of the bias of people estimating trip distances, which depend upon mode and distance, correction factors have been derived. It turned out that people underestimate distances lower than 1 km and overestimate longer distances.

Especially the distances covered by car from the NTS have been compared with the results from the continuous "Car Panel", also carried out by the CBS, and aiming at patterns in car ownership and distances driven.

The effect that people without a telephone or with an unlisted number cannot be in the sample were investigated and turned out to be negligible.

An optimal reweighing of the sample is done by using a) the day in the period and b) a combination of the three variables: 1) respondent’s age; 2) car ownership and age of car; and 3) degree of urbanization.

As usual with this type of survey the non-response is substantial but the response rate seems to stabilize as a function of time; see Table 2.1.

<table>
<thead>
<tr>
<th>Year</th>
<th>'85</th>
<th>'86</th>
<th>'87</th>
<th>'88</th>
<th>'89</th>
<th>'90</th>
<th>'91</th>
</tr>
</thead>
<tbody>
<tr>
<td>Household (1)</td>
<td>75</td>
<td>76</td>
<td>76</td>
<td>75</td>
<td>77</td>
<td>74</td>
<td>76</td>
</tr>
<tr>
<td>Diaries (2)</td>
<td>86</td>
<td>83</td>
<td>79</td>
<td>73</td>
<td>75</td>
<td>75</td>
<td>76</td>
</tr>
<tr>
<td>Product (1)*(2)</td>
<td>65</td>
<td>63</td>
<td>60</td>
<td>55</td>
<td>58</td>
<td>56</td>
<td>58</td>
</tr>
</tbody>
</table>

**Table 2.1**

Response rates 1985-1991 in percentages

Eurobike Helsinki 3
Table 2.2 gives an impression of the quality of the results as far as sampling errors are concerned.

**TABLE 2.2**

<table>
<thead>
<tr>
<th>Mode of Transport</th>
<th>Average distance (km)</th>
<th>95%-confidence interval (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car-driver</td>
<td>17.2</td>
<td>3.3</td>
</tr>
<tr>
<td>Car-passenger</td>
<td>8.7</td>
<td>5.6</td>
</tr>
<tr>
<td>Bus/tram/metro</td>
<td>1.8</td>
<td>8.2</td>
</tr>
<tr>
<td>Train</td>
<td>3.6</td>
<td>12.5</td>
</tr>
<tr>
<td>Moped</td>
<td>0.3</td>
<td>14.6</td>
</tr>
<tr>
<td>Bike</td>
<td>3.2</td>
<td>3.8</td>
</tr>
<tr>
<td>Walk</td>
<td>0.9</td>
<td>4.0</td>
</tr>
<tr>
<td>All modes</td>
<td>36.5</td>
<td>2.5</td>
</tr>
</tbody>
</table>

2.3. Some results regarding bicycle traffic

Many travel characteristics, relations and trends can be derived from the NTS data. Some examples are:
- Combined with data about accidents the traffic fatalities per 1000 million km per age group and per mode;
- The average number of km per year on bicycle and its development in time;
- Trip production rates depending on period of day and trip purpose;
- Model split as a function of distance; see Figure 2.2.
  The use of moped with a total share of 1.4% has been left out in this figure.
- Distribution functions for bicycles per trip purpose, see Figure 2.3.

![Share of mode (%)](image-url)

**Fig. 2.2 - Model split as a function of distance in 1990**
An example of a study carried out by Delft University of Technology about bicycle traffic using the data from the NTS is the following. Subject was the combined use of bicycle and public transport. The importance of this travel chain can be illustrated by the statistic that in 1988 45% of train passengers went to the station by bicycle or moped. The goal was to estimate the effect on modal choice when bicycle availability and parking facilities are optimal at origin and destination side of the public transport trip.

The main result of the study was that the measure will:
1. reduce the total distance covered by car with 1.2 %
2. increase the total distance covered with main line public transport with 14 %.

### 2.4 References

- Goeverden, C.D. van & Egeter, B.
- Hendrikkx, F.W.M.
  Measuring mobility. Netherlands Official Statistics; Quarterly Journal of CBS, 3(1988);3;3-23
- Moritz, G.
3. ROAD SAFETY OF BICYCLE TRAFFIC IN THE NETHERLANDS

3.1. Introduction

Analysis of road safety can be based on recorded accidents and on traffic behaviour in a broad sense.

Registration of accidents is far from complete: for fatal accidents it is nearly 100\%, for hospital-treated casualties it is 65\% and for other casualties only 20\%. There are indications that the under recording is much higher for bicyclists than for car occupants. A study of the British TRL confirms this tendency.

Data from the National Travel Survey can be used to estimate distances covered and consequently all types of accidents rates can be determined, on national level, in a town, under special conditions such as darkness, etc. However, most of these analysis are not straightforward and can be expensive. The results can be used to determine the size of the safety problems and the priorities of measures and more detailed studies. See Table 3.1 for an example.

**TABLE 3.1**

<table>
<thead>
<tr>
<th></th>
<th>Car-occupants</th>
<th>Cyclists</th>
<th>Moped</th>
<th>All modes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fatalities</strong></td>
<td>7.0</td>
<td>5.1</td>
<td>21.5</td>
<td>16.1</td>
</tr>
<tr>
<td><strong>Hospital-inj.</strong></td>
<td>52.4</td>
<td>36.2</td>
<td>221.7</td>
<td>167.7</td>
</tr>
<tr>
<td><strong>Other injured</strong></td>
<td>119</td>
<td>110</td>
<td>564</td>
<td>578</td>
</tr>
</tbody>
</table>

From the table can be seen the general improvement in safety from 1986 to 1992, only the mopeds are a large exception. For cyclists there is a small increase in the class "other injured". Another statistic about the role of mopeds in safety is that they contribute 105 (8.2\%) to the total number of people killed in traffic of 1285 in 1992.

In general the interpretation of such statistics must be done carefully. The fact that cyclists run a higher risk per distance covered than car occupants does not imply that a changeover from car use to bicycle use for short trips will lead to more victims.

To determine the required facilities for bicycles based on accident statistics in certain conditions is difficult because for such purposes the number of recorded accidents is often too low. Two examples of such studies will be presented; one for determining standards for rural roads and one in the framework of the Eurobike Helsinki.
new Dutch Design Manual.

A special Dutch problem is the presence of mopeds that mostly use the same facilities as bicycles, but have a much higher speed and a fatality rate of round 5 times that of cyclists.

3.2. Requirements of separate cycle paths for rural roads

For rural roads standards have been established about the requirement of separate paths for bicycles. The criterion chosen was the number of accidents with two-wheelers (bicycles and mopeds) per km road length and this was analysed as a function of the average annual daily intensities of motorized traffic and two-wheelers.

*Figure 3.1* is a presentation of the results. It can be seen that in a large number of cells the accidents were too few in number to come to a conclusion. This lack of recorded accidents is often a disadvantage to reach statistical reliable results.

<table>
<thead>
<tr>
<th>2-w/24 h</th>
<th>+</th>
<th>+</th>
<th>+</th>
<th>+</th>
</tr>
</thead>
<tbody>
<tr>
<td>500-600</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>400-500</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>300-400</td>
<td>-</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>200-300</td>
<td>-</td>
<td>0</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>100-200</td>
<td>-</td>
<td>+</td>
<td></td>
<td>0</td>
</tr>
<tr>
<td>0-100</td>
<td></td>
<td></td>
<td>+</td>
<td>0</td>
</tr>
</tbody>
</table>

Veh/24 h

<table>
<thead>
<tr>
<th>0-1000</th>
<th>1000-2000</th>
<th>3000-4000</th>
<th>4000-6000</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

+ with path is safer
- without path is safer
blank not enough data

*Fig. 3.1* - Results of comparison of roads with and without cycle paths

3.3. Requirements of separate cycle paths or cycle lanes in Design Manual

In built-up areas the new Dutch Design Manual gives recommendations based on the intensity of motorized vehicles and their 85 percentile speed driven; see *Figure 3.2*. The new point is that the recommendation is independent of the intensity of bicycles. The idea is that everywhere where bicycles are present, they deserve a safe ride. Of course the priorities of constructing cycle paths or cycle lanes can depend on the number of cyclists using the facility.
A recent study (Tromp 1993) to base those criteria quantitatively on accidents and distances covered of bicycles and motorized vehicles was not really successful. Accident rates of cyclists and mopeds on routes (consisting of arterials and intersections) with and without separate cycle path were compared. They turned out to be the same in both cases but on routes with cycle path cycle and car intensities and car speeds were higher than in the cases without cycle path. Due to this confounding of explanatory variables no firm conclusions could be drawn. On the other hand this has been one of the first studies in which accident rates of bicycles in a specific situation were determined and analysed.

![Intensity of motorvehicles (1000 pcu/24 hours)](image)

**Fig. 3.2 - Generally preferred facility for bicycles**

3.4. Alternative yardsticks for safety

For several reasons surrogate yard sticks for safety are required. They vary from intensities, number of meetings and overtakings to analysis of conflicts where time to collision (TTC) and post encroachment time (PET) are used. Detailed registration and analysis of behaviour can reveal the functioning of new solutions and lead to more understanding of the causes of accidents. The validity of the yard sticks is sometimes debatable and in the end has to be established by using accident data.

A main problem is the effect of a cycle path that has a positive effect on safety at arterials and a negative effect at intersections. Three out of four accidents with injuries in urban areas are occurring at intersections. The safety effect of cycle lanes is still largely unknown.
3.5. Study proposal

The Transportation Research Laboratory (TRL) of Delft Technical University has carried out studies about the behaviour of cyclists on separate cycle paths. Speed, lateral positions, frequency and dimensions of overtaking manoeuvres have been determined; see Botma&Papendrecht(1991). Based on these behaviour parameters a so-called hindrance model for traffic on separate cycle path has been developed. With this model the required width of a cycle path to guarantee a certain quality of flow can be determined. The results of this approach are included in the new Design Manual.

The general idea of the hindrance model, that is to calculate the frequency of manoeuvres and giving them a weight, has a wider field of application than for separate cycle paths only. It seems worthwhile to extend this approach to mixed traffic on arterials with and without cycle lanes. How often does a cyclist leave a cycle lane in order to carry out an overtaking and how often does this coincide with the presence of a car in the manoeuvre space. To answer those questions one first has to know more about longitudinal and lateral behaviour of several road users and their interactions.

In a first step speeds, lateral positions of two-wheelers and motorized vehicles will be measured and analysed at cross-sections in several conditions. The TRL has at its disposal a measuring device special developed for these type of measurements. With this mat, in which a large number of tape switches is mounted, lateral positions can be registered with a precision of 10 cm; see Figure 3.3. The speed can be derived from the instants the wheels pass the 50 cm long switches at a distance of 30 cm. Because instants are recorded with a precision of 1/10,000 s the distance of 30 cm is long enough to determine a reliable speed.

![Fig. 3.3 - Measuring mat with configuration of tape switches](image)
The ultimate goal of the study is to establish relations between:
- flow characteristics:
  a) intensity and composition of two-wheeler traffic;
  b) intensity, composition and speed of motorized traffic;
  c) observable characteristics of the manoeuvres;
  d) yardsticks derived from the characteristics of the former three points
- road characteristics;
- accident data.

The relations found can be used:
- to establish criteria for separation or fast and slow traffic in terms of
  intensities of both slow and fast traffic and of the speed of fast traffic in
  order to guarantee a certain safety level;
- to evaluate special situations or new solutions that pretend to be more safe.

3.6. References

- Botma, H & Papendrecht, J.H. 
- Botma, H & Papendrecht, J.H. 
  Operational quality of traffic on a bicycle path. Compendium 63th annual 
- C.R.O.W. 
  Sign up for the bike. Design manual for a cycle-friendly infrastructure. Ede, 
  The Netherlands, 1993.
- Committee RONA 
  Working Group Bicycle Traffic. Draft guide lines for the construction of 
  cycle paths along rural roads, 1984 (in Dutch).
- Ministry of Transport, Public Works and Water Management 
- Tromp, J.P.M. 
  Safety of bicycle routes. Presented at "Verkeerskundige Werkdagen", 
  CROW 1993 (in Dutch).
4. CYCLING PLANNING MODEL QUO-VADIS

4.1. Introduction

This traffic flow model has been developed by the consultant DHV Environment and Infrastructure for the Dutch Ministry of Transport and Public works in the framework of the Masterplan Bicycle. The city of Breda (123,00 inhabitants) was used as a pilot.
The model is a tool that can be used to produce information useful in answering the following questions:
- what is the best possible cycling network;
- what is the best allocation of the budget for bicycle facilities.

The model has two main parts: a traffic model and an evaluation model.

With the traffic model one can determine the intensity over the period 7 AM to 7 PM on every link and the origins and destinations of the flow. In contrast to most car models it is not only the peak hour that is of importance; usually there is no capacity problem for bicycle traffic. The goal is to describe the use of bicycles and their safety at all times. For practical reasons a limitation to the day period (7 till 7) has been made; in this period about 88% of the bicycle traffic takes place.

A split up between trip purposes can also be made. The following trip purposes are distinguished: work (=20% of all bicycle trips), education (13%), shopping (33%) and other (34%).

With the evaluation model one can show how far cyclists deviate from the straight-line compass route which is a yard stick for accessibility and where cycling facilities are needed or are most effective to improve safety.

4.2. Short description of the model

The traffic model has the usual modules: choosing zones; defining the network; trip production; trip distribution; (stochastic) assignment; calibration and forecasting.

Zones
When choosing zones one has to take into account the natural barriers for bicycles, such as railway lines, waterways, motorways, main arterials, etcetera. The required zone size depends on the size of the study area. For cycle traffic inside built-up areas a recommended size is 250 by 250 m or a number of inhabitants between 1000 and 1500. It is recommended to include important destinations for cyclists, such as schools, stations, shopping centres and work concentrations as a separate zone.
Required social economic data per zone are: number of inhabitants; number of jobs in shops and other jobs; location of schools and the number of pupils.
Network
The network for bicycles needs more detail than a network for cars, because the distances of cycle trips are shorter and cyclists have a very flexible route choice. The type of cycle facility, cycle lane, cycle path or nothing (that means mixed slow and fast traffic), is also a required property of the links. Mean speed at links and delay at intersections determine the impedance of the routes. The delay is dependant on the car intensity, hence these should be known or estimated.

Trip production
The ideal input for a cycling model can be obtained by a house-to-house survey, supplemented by information from road side interviews. However, this is often too expensive. An attractive alternative is to base the trip production on social economic data and special collected data about destinations such as schools, shopping centres and stations.

Trip production factors based on the National Travel Survey data have been determined and can be used unless more specific ones are available; see Table 4.1 for an example.

TABLE 4.1

<table>
<thead>
<tr>
<th>Period</th>
<th>Trip-purpose</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>7-9</td>
<td>House-Work</td>
<td>0.0608</td>
</tr>
<tr>
<td></td>
<td>House-Education</td>
<td>0.0433</td>
</tr>
<tr>
<td>9-16</td>
<td>House-Work</td>
<td>0.0293</td>
</tr>
<tr>
<td></td>
<td>House-Education</td>
<td>0.0078</td>
</tr>
<tr>
<td></td>
<td>House-Shop</td>
<td>0.1026</td>
</tr>
<tr>
<td></td>
<td>Work-House</td>
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</tr>
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</tr>
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<td>0.1792</td>
</tr>
<tr>
<td>16-19</td>
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<tr>
<td></td>
<td>Other Departures&amp;Arrivals</td>
<td>0.0795</td>
</tr>
</tbody>
</table>

The distribution function is also based on NTS data; see chapter 2.
The distribution itself is according to the much used model:

\[ P_{ij} = C \alpha_i \beta_j A_i B_j F(T_{ij}) \]

in which

- \( P_{ij} \) = number of trips from zone i to j
- \( C \) = constant term
- \( \alpha_i \) & \( \beta_j \) = polarities or balancing factors
- \( A_i \) = number of arrivals in zone i
- \( B_j \) = number of departures from zone j
- \( F(T_{ij}) \) = function of travel time \( T_{ij} \) between zone i and j

**Assignment**

Just like car drivers cyclists do not always choose the objectively shortest route. They do not all have the same knowledge of distances and travel times and differ with respect to appraisal of other characteristics of a route. However, in the large Delft cycling study (see Gommers & Bovy, 1987), it was found that 70% of the cyclists use a route that takes no more than 10% extra time compared to the fastest.

To take account of the variation in route choice a stochastic assignment technique is used. This means that the travel time on a route during the assignment calculations is varying by chance (Gaussian probability distribution). The crucial point is to estimate the parameters that govern the fluctuations.

**Calibration**

The so-called binary calibration is used, which is based on assuming that the counts are independent Poisson drawings and applies the maximum likelihood estimation method; see Hamerslag & Immers (1988). The parameters of the model are modified but not so far that the countings are reproduced perfectly. No absolute value can be attached to counts because they fluctuate from day to day.

### 4.3. Safety

Accident data including locations can be input in the model and shown on graphs of the network. These graphs are very useful for detecting accident concentrations and relate those in a qualitative way to other factors, say to the intensities of bicycles and cars, the type of facility, and, when close to or at intersections, to type of control, etcetera.

In the new Dutch Design Manual (CROW, 1993) the necessity of separation of bicycle and motorized traffic depends mainly on the intensity and 85 percentile speed of the cars. With Quo-Vadis these criteria can be applied to all links of the network (given the speed of cars or an estimate of it is available) and will show where the separation is not adequate. The urgency of the separation can be related to the intensity of bicycles and accident data.
For intersections there are not yet criteria that help to choose between solutions: no priority; priority with signs; traffic lights; roundabout. However, extensions of the model are under development to determine a conflict score for intersections. It is based on the product of the intensities of bicycles and cars but with a lot of detail. E.g. cycles turning to the right get a very low weight, crossing cycles a weight equal to 1 and cycles turning left a larger weight. The weights also depend on the type of control of the intersection.

4.4. Applications

With the model one can forecast the effect of changing social economic characteristics (say a new living quarter, school, brain park) and of a change of the bicycle and/or car facilities (say a new tunnel or bridge only for bicycles that drastically alters the ratio of travel time by car and bicycle).

The model is useful for:
- determination of the number of bicycles per trip purpose and period of the day on each link and intersection
- calculating how long the detour of cyclists is compared to a straight line; this is a good yardstick for accessibility by bicycle
- looking for missing links in the main network and determining their benefit when being added
- to determine where cycle paths are needed for safety reasons and set the priority
- presenting the occurrence of accidents on a network in a clear way; equally useful for traffic engineers and politicians
- finding potential unsafe intersections, characterised by long delay for cyclists
- looking for possibilities to give cyclists advantage over car drivers in terms of travel time
- communicating with lay-men such as municipal politicians, police officers etcetera because the graphical output of the model is easy to assess.

4.5. Practical points

The model can be used on a PC, it is flexible, easy to operate and has much graphical output. The most ideal situation is a combination with the Quo-Vadis car model that can also calculate traffic over a longer period than the peak period and can produce traffic environment maps (noise and air pollution). However, the software package QUO-VADIS-bicycle can also communicate with other models. It is at the disposal of most consultants and large local authorities in The Netherlands. Consequently it can be expected that the experience in using this program will increase rather fast.
4.6. Importance of this model for Eurobike

The strongest point of using a model such as Quo-Vadis are:
- possibilities to evaluate and compare measures without carrying them out yet;
- different types of information can be used to make the model better represent reality;
- after the model has been calibrated for a study area it can be used for several years
- it does give a good estimate of the amount of bicycle kilometres distributed over several conditions;
- even if only accident data on an aggregate basis are available, it is better to relate it to a weighted exposure than an overall one;
- when accident data are available with location their number can be related to the flows of bicycles (preferably added with the flows of cars) and the type of facility.

Conclusion

The model can be used as an integrator in which results of different parts of the studies, carried out in the framework of Eurobike, are united. The combination will be much more useful than the collection of the separate parts.

4.7. References

- C.R.O.W.
- DHV Environment and Infrastructure
- Gommers, M.J.P.F. & Bovy, P.H.L.
- Hamerslag, R. & Immers, L.H.
- Ministry of Transport and Public Works & DHV Environment and Infrastructure
  Brochure: More and safer cycling. The introduction of a cycling model.
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