ANALYSING LOOP DATA FOR QUICK EVALUATION OF TRAFFIC MANAGEMENT MEASURES

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1. INTRODUCTION

In The Netherlands transport and traffic policy heavily relies on traffic management. Building new roads is either too expensive or too difficult due to spatial and environmental conditions. Road pricing will not be feasible the coming years, so traffic management is the key direction in which solutions for the increasing congestion problems have to be found (Ministry of Transport and Water Management, 2005) and this is the case since the nineties from the previous century. From 1989 on, a lot of traffic management measures were implemented, varying from a motorway traffic management system to overtaking prohibitions for trucks and special rush hour teams of the traffic police (see figure 1).

Figure 1: Examples of traffic management measures

In The Netherlands traditional traffic management is in most cases used only on a local level. It lacks an integrated and network wide approach. The main reason for this is that different network types (e.g. motorways and urban roads) are operated and maintained by different road managers. In practise these road managers are only responsible for their own part of the network and normally they do not communicate or cooperate that much. To deal with this, The Netherlands have adopted a different approach, described in the Handbook Sustainable Traffic Management (STM) (Rijkswaterstaat, 2003). The handbook describes a step-by-step method that enables policy makers to translate policy objectives into concrete measures. The STM method consists of clearly defined steps that can be summarised as: defining policy objectives, assess current situation, determine bottlenecks and create solutions. The nine-step process helps to develop a network vision based on policy objectives, shared by all participating stakeholders. In addition, the STM method will provide the stakeholders with a first indication of the measures required to achieve effective traffic management in line with the shared vision. For this, the Regional Traffic Management Explorer (RTME) was developed. This sketch and calculation tool supports the steps needed for STM and makes it possible to determine the effects of proposed traffic management services and measures. These effects can then be compared to the formulated policy objectives or other sets of measures. For more information on the method, the RTME and its applications, the reader is referred to Taale *et al.* (2004) and Taale and Westerman (2005).

Evaluation has always been an important subject in The Netherlands. A lot of traffic management measures were evaluated, resulting in numerous evaluation reports, describing large measurement programs and thorough statistical analysis. Table 1 gives an overview of most of these evaluation studies, grouped by measure type. The table shows for every measure if measurements have been used, if the behaviour of drives has been studied and if the conclusions are based on real measurements or estimates (e.g. simulation studies). It also shows the number of studies done for that specific measure. Of course some studies are more profound than others. Table 2 gives the same list of measures, but now with a summary of the effects found.

Table 1: Evaluation of traffic management measures

Measure	Traffic Measurements	Behaviour	Estimate	Number of studies
Motorway Traffic Management System	√	√		8
Speed Measures (80 km/hr zones)	√			7
Ramp Metering	√			15
Overtaking prohibition trucks	√	√		8
Peak lanes (using hard shoulder)	√	√		6
Buslanes, trucklanes, tidal flow lanes	√	√		4
Measures for Road Works	√	√		3
Traffic Signal Control	√			9
Other measures	√	√		11
Incident Management (camera's)	√	√	√	6
Dynamic Route Information Panels (VMS)	√	√		15
Radio Traffic Information		√		9
Traffic Management Program	√		√	3
Total				**104**

Control measure — Incident management — Information measure

Table 2: Summary of important effects

Measure	Effect on traffic	Effect on capacity
Motorway Traffic Management System	Flow improvements 0%- 5%	0% to 5%
Speed Measures (80 km/hr zones)	Congestion varies from -40% to +50%	–9% to +4%
Ramp Metering		0% to +5%
Overtaking prohibition trucks	Different per location	–4% to +4%
Peak lanes (using hard shoulder)	Decrease travel times from 1 to 3 minutes Extra traffic from 0% to +7%	+7% to +22%
Buslanes, trucklanes, tidal flow lanes	Travel time busses/trucks –14 minutes Travel time other traffic from –5 to +2 minutes	
Measures for Road Works	Less demand, sometimes to –11% Less traffic sections with road works: to –38%	
Traffic Signal Control	Change in travel times from –33% to +10%	
Other measures	Congestion from –28% to +45%	
Incident Management (camera's)	Congestion –7% (Utrecht)	
Dynamic Route Information Panels (VMS)	Congestion from –7% to –30%	
Radio Traffic Information	Route changes, more change if travellers are informed individually	

Control measure Incident management Information measure

Gradually, the need arose to do a quick evaluation, instead of an extensive one; just to see if a traffic management measure was working in real life or not, without having the costs of a thorough evaluation. To support this need, the AVV Transport Research Centre developed a tool to process and analyse the data for a stretch of motorway available from the loop detectors. The tool takes the files with data (on a minute by minute base) and processes them. The data consists of speeds and flows per lane or carriageway. If data is missing, a procedure tries to fill the gaps. Of course, this can only be done if the gaps are not too large. After this a lot of indicators are calculated: flows and speeds on an aggregated level, travel time, vehicle kilometres, total delay, etc.
The tool was used to assess the effectiveness of some speed measures on three motorways. In remainder of the paper the tool and the applications will be described, together with the results of the quick assessments. But first something is said about the data used.

2. DATA

2.1 Collection

The basis for traffic management and for measurements forms a monitoring system, consisting of paired loop detectors on a large part of the motorway. This monitoring system stems from the motorway traffic management system, which is operational since the eighties and was mend for queue warning (automatic incident detection) and as a tool to support road works (closing lanes). The data, which was used for these functions, was also available for other purposes, such as research and that's how the monitoring system started.

The monitoring system covers about 1000 kilometres of the motorway network, which is about 2350 kilometres in length. More and more, data from this monitoring system is available for all kinds of research purposes. Monitoring starts with the loops in the road surface (see figure 2) about 500 metres apart on busy motorways and less dense on others. These loops detect the passages of vehicles and send this information to the detector stations, which calculate speeds, flows and vehicle classifications. Since 2005 this is done per lane. Before that, the data was always available per cross-section and sometimes per lane. The measurements are converted into data per minute and sent to the regional traffic control centres.

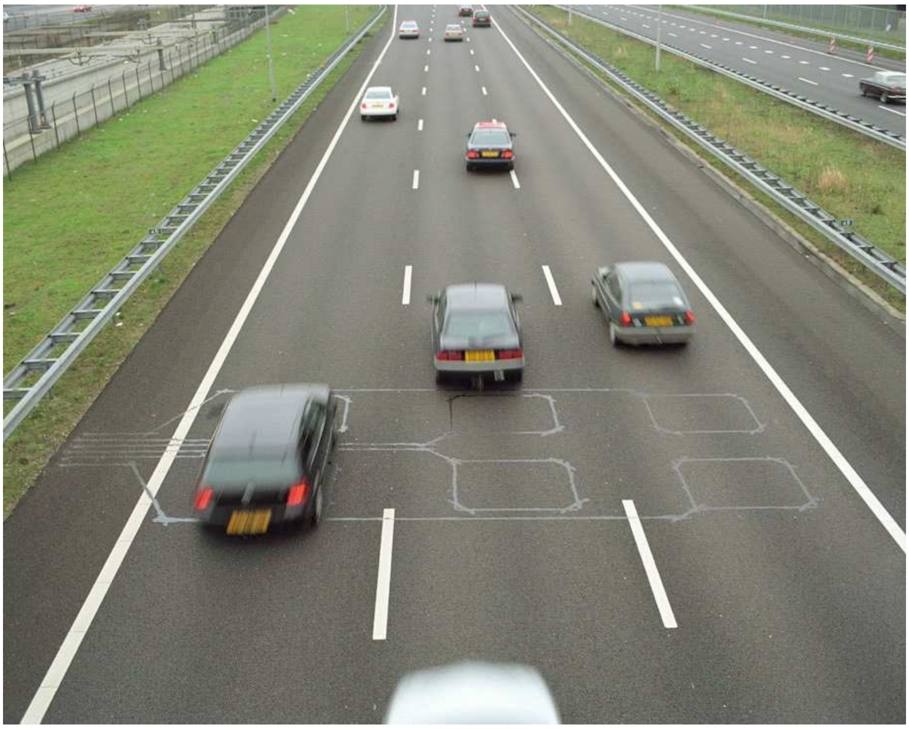

Figure 2: Paired loops

The monitoring system gives a continuous view on the actual conditions on the road network. Based on the information given by the system, measures can be taken, automatically, such as the queue warning system, or by hand by the traffic operators in the traffic centres.

2.2 Format

The regional traffic control centres collect the data from the detector stations in their region. The Netherlands is divided into 5 regions, each with its own control centre, shown as a black dot in figure 3. The colours on the map visualise the five regions.

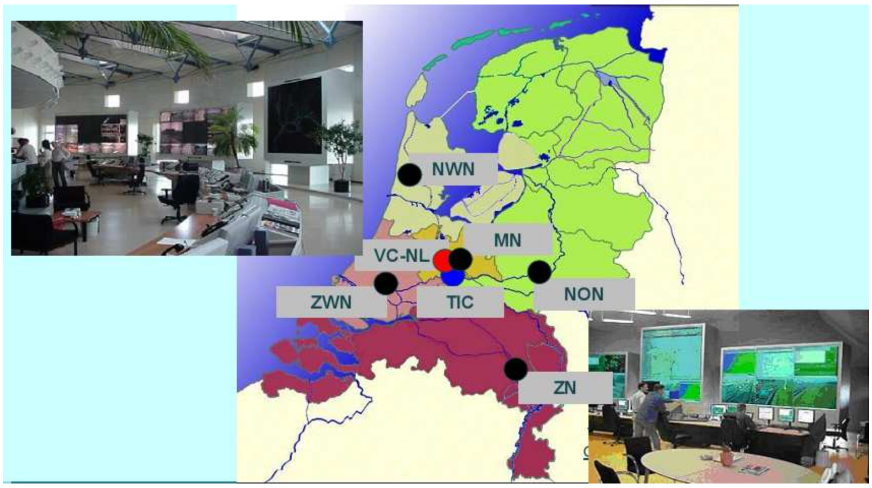

Figure 3: Traffic control centres in The Netherlands

In the control centres the data is organised in files and databases. Each file contains the data in ASCII format of every measurement location in the region for a certain minute. The name and extension of the file represents the date and time and the region. An example is “0505121526.01c”, which can be read as: ‘05’ = year 2005, ‘05’ = month May, ‘12’ = day in month, ‘15’ = hour, ‘26’ = minute, ‘01c’ = the code for the region (in this case Central Netherlands). To save storage space, each file is zipped into the GZ format.

The content of a file and the meaning is shown in figure 4. Each measurement location consists of two lines, one to identify the type [TSW] and location and one with the data [SIV].

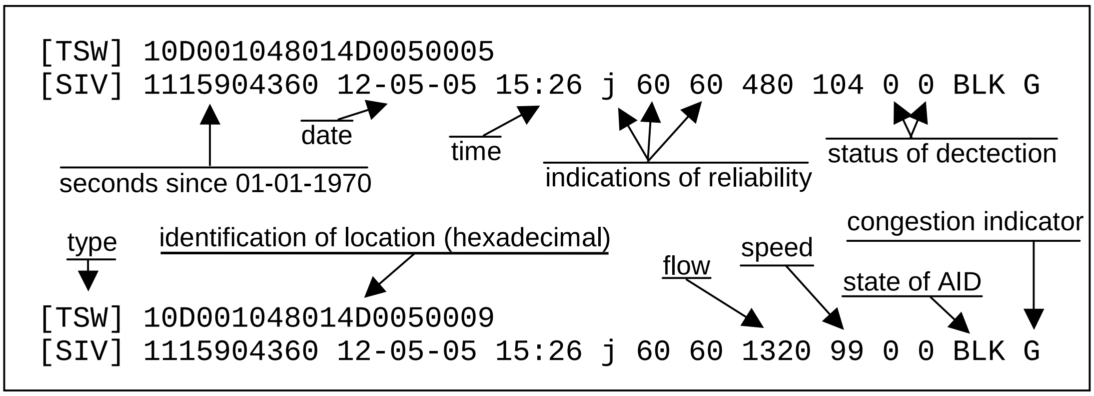

Figure 4: Example of data

These data files form the basis of the quick assessments. In the next chapter the tool is described with which these data files can be processed into traffic indicators.

3. MONIGRAPH

MoniGraph is a tool which processes, analyses and visualises monitoring data from motorway stretches. Input for the tool is information about the motorway stretch, the date and time period the user wants to analyse, the type and location of the data and some parameters for the analysis. This information can be specified via the user interface (figure 5) or a text input file (in ASCII format). The output consists of graphs on speeds, flows and travel times, a text file (also ASCII) with all the information shown in the graphs and some extra information on the quality of the data and some network indicators (total distance travelled, total delay, total congestion, etc.).

In the remainder of this chapter the three processes (process, analyse and visualise data) are described in detail.

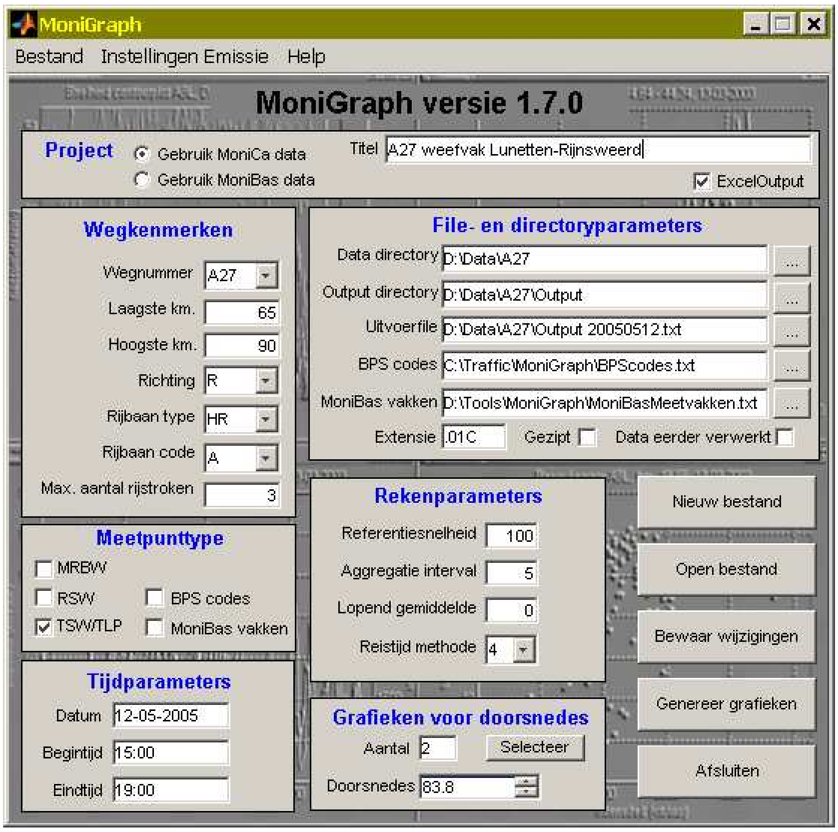

Figure 5: User interface of MoniGraph

3.1 Processing of data

The data files, belonging to the date and period specified by the user, are copied to a separate directory and, if necessary, they are unzipped. Then the first data file is read and the identification of the measurement locations is compared with the identifications belonging to the motorway stretch the user has specified. This has to be done, because the file contains the measurement locations of the whole region. The available measurement locations are stored and then for every minute in the time period the corresponding data file is opened and the flow, speed and congestion information for the measurement locations involved is searched and stored.

It is possible that one or more files are missing or that within a file the minute data for a measurement location is missing. If this is the case and if it's possible, the missing data is estimated from surrounding data. If files are missing, files from previous or later minutes are copied, but with a limit of 5 minutes. If data is missing for certain measurement locations, an attempt is made to estimate the data from surrounding locations and minutes. Figure 6 shows some examples. The white circles are missing points and the red lines give the relation with the data that is used to estimate the data for the white circles.

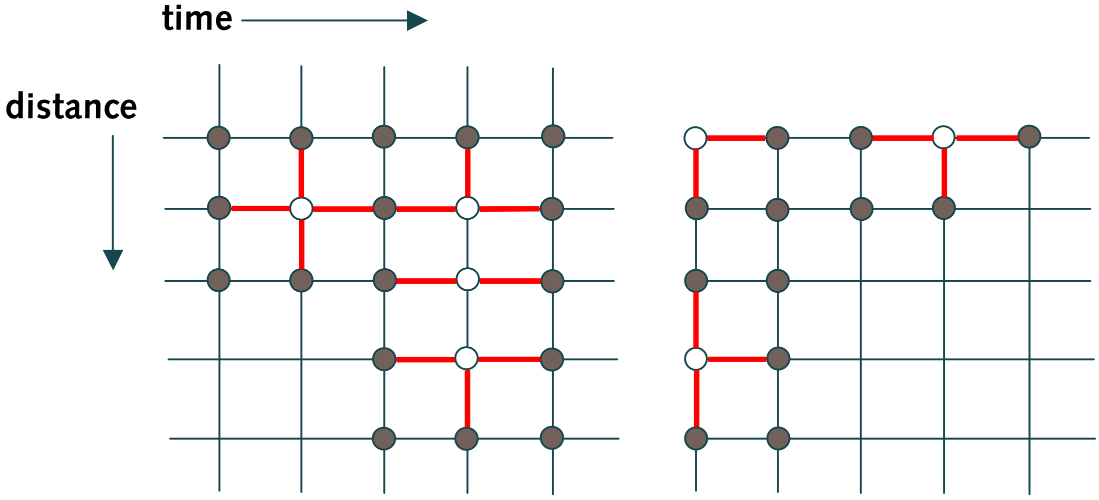

Figure 6: Dealing with missing data

The completed data is written to the output file and stored separately, so that the processing of data for that road, day and time period has to be done only once.

3.2 Analysis of data

Based on the flows and speeds the travel time for that motorway stretch can be calculated. This can be done using three different methods: a simple method using instantaneous speeds (based on the assumption that a vehicle covers the motorway stretch in one minute) and two trajectory methods, one based on piece-wise constant speeds and one based on piece-wise linear speeds (see figure 7, measurement locations are on 250, 750 ,1250 m., etc.).

For both trajectory methods it is assumed that a vehicle enters the motorway stretch and travels through time and space to the end. The difference is in the speeds used: constant for the section around the measurement location, or linear increasing and decreasing, dependent on the measured speeds on the neighbouring sections (see figure 7). For a detailed description the reader is referred to Van Lint and Van der Zijpp (2003).

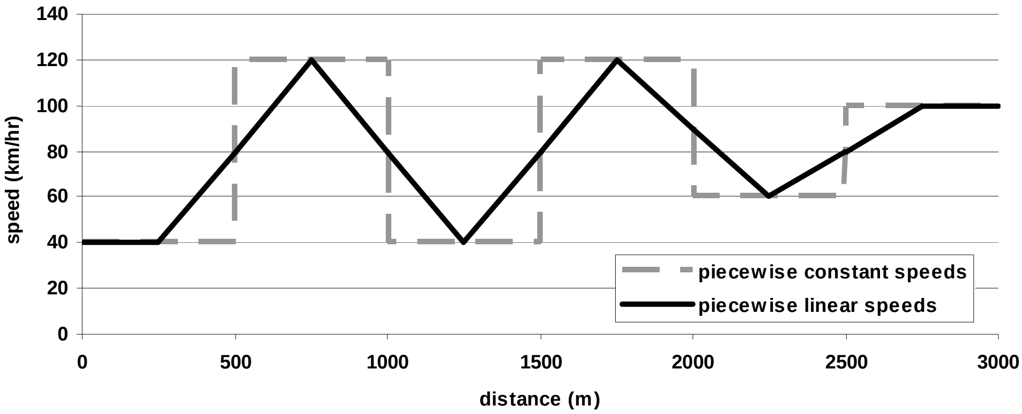

Figure 7: Trajectory methods for travel time

Next to the travel time network indicators are calculated. The network indicators are: total time spent, total delay, total distance travelled, total distance travelled in congestion, average network speed, sum of minutes and measurement locations with congestion and congestion weight (product of distance and time of road sections with speed lower than 50 km/hr).

3.3 Visualisation of data

All data used and indicators calculated are saved in a text file. The data is also visualised in a number of graphs: flow contour plot, speed contour plot, travel time plot, travel speed plot, a plot with flows and speeds for every measurement location and a fundamental diagram for every measurement location. Examples of a speed contour plot and a travel time plot are given in figure 8 and figure 9.

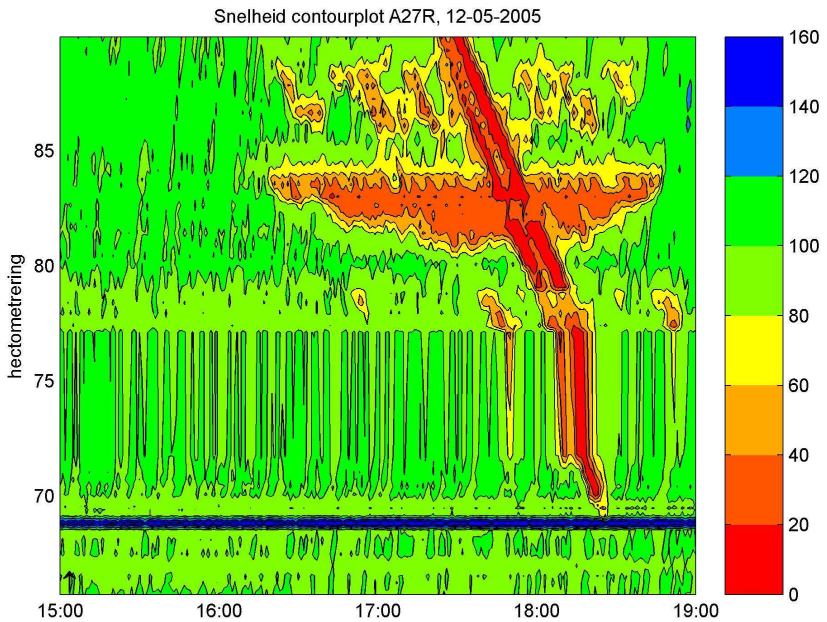

Figure 8: Speed contour plot

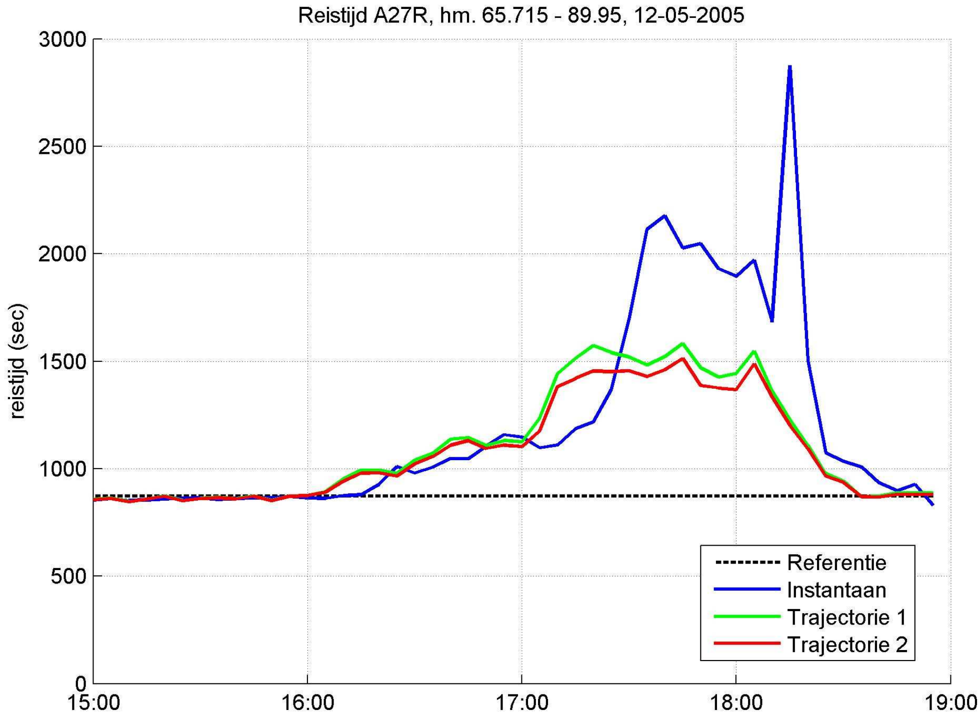

Figure 9: Travel times

From figure 8 it can be seen that the bottleneck is located around km. 84, although a shock wave is coming from a downstream section around 17:30 hrs. Between km. 71.8 and 77.1 there is no data available, so the interpolation is not so smooth. The measurement location on km. 68.8 gives erroneous data: the speeds are far too high.

The difference in the results of the three methods to estimate the travel time can be clearly seen in figure 9. The peaks in the instantaneous travel time (blue line) are due to the shock wave. The trajectory methods deal with the shock wave far more smoothly.

4. EXAMPLES OF QUICK ASSESSMENTS

4.1 Introduction

In this chapter some quick assessments done with the MoniGraph tool are discussed. The discussion focuses on the traffic management measure and the results with MoniGraph. In all cases MoniGraph was used to get a first impression of the effects of the measure. After that an extensive evaluation was held to be able to draw more definite conclusions about the effects. The map in figure 10 shows the locations of the traffic management measures discussed in the next paragraphs.

4.2 Dynamic speeds A1

From September 2002 to April 2003 a pilot with dynamic speed limits was done on the A1 motorway between Apeldoorn and Deventer (location 1 in figure 10). On this site a speed limit was shown during the onset of congestion, with the aim to prevent or delay the start of congestion. The normal speed limit on this stretch is 120 km/hr. During the pilot speeds of 100 km/hr and 80 km/hr were shown.

Figure 10: Location of measures

The evaluation reported by DHV (2003) produced some strange results. Therefore, MoniGraph was used to check these results and to see if a cause could be found. The data from the before and after measurements was collected. For 15 evening peaks (15:30 – 20:00 hrs) in the before period and 37 in the after period the data was processed with MoniGraph. The results are shown in table 1. Most important result is that the traffic demand in the after period was much less than in the before period. That put a different complexion on the matter. Noticeable is also the reduction in the standard deviation for congestion weight and total delay. The total delay increases because the reference speed was kept on 100 km/hr.

Table 1: Results for the A1 pilot

	Before	After	Change
Average congestion weight	323	230	-29%
Standard deviation congestion weight	300	154	-49%
Average total delay (veh.hr)	490	511	4%
Standard deviation total delay	321	160	-50%
Average travel time (sec.)	724	723	0%
Average number of vehicle kilometres	221	223	1%
Standard deviation veh.km.	11,1	10,6	-5%
Total demand (km. 88,745, 15:30-20:00)	52200	46591	-11%
Average demand (km. 88,745, veh/hr)	2900	2588	-11%

4.3 80 km/hr zone A12 The Hague

Due to problems with noise and pollution in the neighbouring residential area of The Hague, it was decided to limit the speed on a part of the motorway A12 from 100 to 80 km/hr in both directions (location 2 in figure 10). This reduction was implemented in November 2005 and was supported with a rigid form of speed control: measuring the average speed on the stretch and fining everybody driving faster than the allowed average speed 80 km/hr. The evaluation of this measure was planned for 2006 and the results should come available in May 2006.

In January 2006 a traffic information service company published the news that congestion was increased a lot on that stretch of motorway. Therefore, it was decided to do a quick evaluation to see if this was the case or not. Data for a number of days from October, November and December 2005 were used to get a quick look at the effects of the speed measure. The results are given in tables 2 and 3 for 2 stretches: A12 direction The Hague, morning peak (07:00 – 11:00 hrs.) and A12 direction Zoetermeer, evening peak 15:00 - 19:00 hrs.).

Table 2: Results for the A12 80 km/hr zone (towards The Hague)

	Before	After	Change
Average congestion weight	564	750	33%
Average total delay (veh.hr)	914	1302	42%
Average travel time (sec.)	710	785	11%
Average number of vehicle kilometres	187	184	-2%
Average demand	3147	3048	-3%

Table 3: Results for the A12 80 km/hr zone (towards Zoetermeer)

	Before	After	Change
Average congestion weight	465	518	12%
Average total delay (veh.hr)	901	1027	14%
Average travel time (sec.)	691	721	4%
Average number of vehicle kilometres	186	192	1%
Average demand	2798	2654	-5%

It is clear that for both stretches the situation did not improve with the measure, to say the least. Based on these results, some extra measures were taken to improve the situation. The final evaluation, including measurements of noise and pollution, should lead to more decisive conclusions.

4.4 Traffic signal control A58

The motorway junction A58-A27 called Hooipolder is partly signal controlled. A new type of control strategy (based on fuzzy logic) was tested for this junction. To see if this was an improvement, an evaluation was done. Part of the study consisted of analyse monitoring data with MoniGraph for one arm of the junction (location 3 in figure 10). For three periods of the day (morning peak, between peaks and evening peak) the data was processed. After the first assessment some changes in the control strategy were implemented and some extra days were analysed. In table 4 this is the After+ situation. The improvements appeared to be effective.

Table 4: Results for the signal controlled junction A58-A27

	Before	After	After+	Change
Morning peak				
Average total delay (veh.hr)	28,4	31,1	15,24	-46%
Average number of veh.km.	66,5	66,1	64,7	-3%
Average demand	1572	1568	1600	2%
Between peaks				
Average total delay (veh.hr)	2,7	2,7	2,6	-5%
Average number of veh.km.	25,2	25,2	23,4	-7%
Average demand	1226	1249	1225	0%
Evening peak				
Average total delay (veh.hr)	266,1	347,4	172,2	-35%
Average number of veh.km	82,9	82,8	77,4	-7%
Average demand	2261	2250	2224	-2%

5. CONCLUSIONS

Traffic management is an important part of the transport and traffic policy in The Netherlands. This is supported by a number of evaluation studies, both for single traffic management measures as for management programs.

There is a need to get a quick idea of the effects of traffic management measurements. The possibilities to do research are there, because of the availability of monitoring data (speed and flows per minute) for a large part of the motorway network.

MoniGraph is a tool to process, analyse and visualise monitoring data and to give insight in the traffic situation and the effects of traffic management measures, as shown by the examples described.

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