The Assessment of Multiple Ramp-Metering on the Ringroad of Amsterdam

Taale, Henk; van Velzen, Bert

DOI
10.1049/cp:19960311

Publication date
1996

Document Version
Accepted author manuscript

Published in
Proceedings of the 8th International Conference on Road Traffic Monitoring and Control

Citation (APA)
Taale, H., & van Velzen, B. (1996). The Assessment of Multiple Ramp-Metering on the Ringroad of Amsterdam. In *Proceedings of the 8th International Conference on Road Traffic Monitoring and Control* (pp. 164-168). (Conference Publication; No. 422). Institution of Electrical Engineers (IEE). https://doi.org/10.1049/cp:19960311

THE ASSESSMENT OF MULTIPLE RAMP-METERING ON THE RINGROAD OF AMSTERDAM

H. Taale

Ministry of Transport, Public Works and Water Management

G.A. van Velzen

Grontmij Consulting Engineers, The Netherlands

INTRODUCTION

In a paper for the seventh international conference on Road Traffic Monitoring and Control the design of a coordinated ramp-metering system near Amsterdam was described by Taale et al (1). That paper only dealt with the implementation aspects of the system, such as the feasibility studies and the communication network. At the end also some remarks were made about the ramp-metering strategies, the assessment study and the planning. For the ramp-metering strategies a distinction was made between local strategies and coordinated strategies and these strategies were described briefly. For the assessment study the aspects to be considered were listed and something was said about the data collection. In the planning it was stated that the system would be operational in April 1994. But reality is more unruly than a planning. The local systems were installed and operating in June 1994, but due to technical and organizational problems the central system for the coordination will not be ready until March 1996. In the meantime the four local systems were assessed and this paper describes that assessment, which was carried out in the context of the DRIVE-II- EUROCOR project.

First a sketch of the situation is given, followed by some general remarks about the data collection. A description of the aspects that were assessed is given. Finally, results are given and some conclusions are drawn.

SITUATION

The A10 motorway is the ringroad around Amsterdam. It has connections with important motorways to other parts of The Netherlands, such as the A1 to the eastern parts, the A2 to Utrecht and the south and the A4 to The Hague and Rotterdam (see figure 1). The ring was closed in 1990 with the opening of the Zeeburgertunnel, the third crossing of the river IJ, apart from the Coentunnel and the IJtunnel. The A10 is a busy motorway with up to 93.000 vehicles per twenty-four hours in 1994 near the Coentunnel and 85.000 vehicles per twenty-four hours near the Zeeburgertunnel. On the ringroad congestion occurs very frequently, especially near the Coentunnel which is a major bottleneck. In 1989 the first ramp-metering system in the Netherlands was installed on the last on-ramp to the Coentunnel in the northern direction: the S101 (Hemhavens) on-ramp. As described by Middelham (2) the effects were positive. The number of 'rat runners' via the local network of Amsterdam to the Coentunnel decreased dramatically. As a result, more kilometres are travelled on the motorway. The speed in front of the tunnel increased substantially and the merging process improved. The maximum number of cars travelling through the Coentunnel did not change significantly. The travel time from the S101 on-ramp has increased (as expected), from the S102 and S104 it has decreased (as expected also). The road users were positive and the number of violations of the signal is low.

In Taale et al (1) is described that, in order to improve these positive effects, also the three on-ramps upstream should be metered. In June 1994 three new local systems have become operational on the on-ramps S102 (Nieuwe Havens), S104 (Bos en Lommer) and S105 (Geuzenveld). A sketch of the situation is given in figure 1.

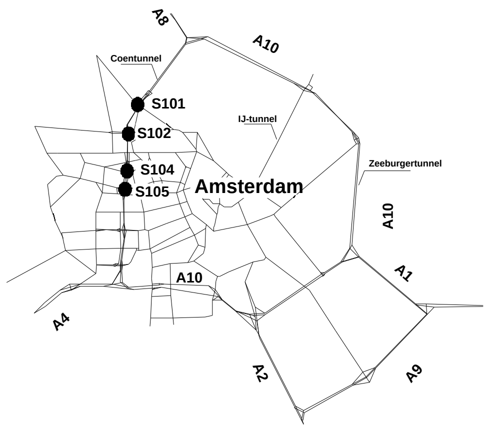

Figure 1. The location of the ramp metering systems

DATA COLLECTION

Data Collected

The data was derived from several sources: electronic systems, visual observations and other sources. The following gives a brief description of the sources and the data used.

Electronic data collection. The national monitoring network was used to collect data from a location near the Zeeburgertunnel to assess an effect in route choice due to the metering systems. This system gives hourly counts of

flows and speeds. The same type of data was collected in the IJtunnel, another IJ-crossing. These data were provided by the municipality of Amsterdam.
In addition the Motorway Control and Signalling System (MCSS) was used as a data source. This system gives flows and speeds per minute for cross-sections with a spacing of approximately 500 meters. In figure 2 the induction loops of the signalling system are indicated as e.g. M 191, where the M stands for MARE being the application of the signalling system which provides the data. This data was used for the 'before' period. The system also gives information about speed measures (e.g. "50 km/hr" signs) that were in effect during the measuring periods, the so-called AID (Automatic Incident Detection) messages. This information was used to calculate queue lengths.
For the period with ramp-metering the logs of the ramp-metering systems were used as the source for flows and speeds per minute. Also the flows on the on-ramps were available from these logs (see figure 2 for the location of the loops). In the before period the flows on the on-ramps were counted per five minutes with pneumatic cables.

Visual observations. A license plate survey was conducted to be able to determine travel times. License plates of white vehicles (a manageable subset) and time of passage were recorded on the entrances of the S101, S102, S104 and S105 on-ramps, on the motorway upstream of the S105 and on a location downstream of the Coentunnel.
Furthermore, queue lengths on the on-ramps on the surface street network were observed visually. Also the appearance of incidents, weather conditions and other relevant events and circumstances was paid attention to.

Other information. During the assessment the logs of the nearby traffic control centre were used to obtain relevant information about the occurrence of incidents like road accidents and height detector alarms. The latter always lead to a temporary closure of the motorway for all traffic. Finally, during the after period use was made of the detailed weather forecast of Schiphol Airport for efficient short-term planning of the measurements.

Data Collection Periods

For the assessment data was collected during two periods. For the situation without ramp-metering (except on the S101 on-ramp) data was collected between April 18th and June 1st 1994. For the situation with ramp-metering on all four on-ramps data was collected between September 13th and October 6th. For the after period a distinction was made between metering with the Rijkswaterstaat strategy and metering with the ALINEA strategy. The Rijkswaterstaat strategy is a feed-forward strategy assigning the remaining motorway capacity to the on-ramp traffic. ALINEA is a feed-back strategy which controls the entering traffic towards a preset occupancy.
From these periods days were selected for the analysis. Only days with dry weather conditions and without incidents were chosen. Due to the large number of height detector alarms before the Coentunnel only five days in the 'before' situation and seven days in the after situation could be used (see table 1).

Table 1. Days selected for analysis

Before	Tuesday	19 April 1994
	Wednesday	27 April 1994
	Thursday	28 April 1994
	Wednesday	18 May 1994
	Wednesday	25 May 1994
After (Rijkswaterstaat)	Tuesday	13 September 1994
	Monday	26 September 1994
	Wednesday	28 September 1994
	Thursday	29 September 1994
After (ALINEA)	Wednesday	21 September 1994
	Thursday	22 September 1994
	Thursday	6 October 1994

TRAFFIC ASPECTS

This section describes the traffic aspects that were studied. A distinction is made between motorway traffic and traffic on the on-ramps and surrounding network.

Motorway Traffic

For motorway traffic the following aspects were considered: flow, speed, total day flow, queue length, travel time, delay, total distance travelled and total delay.

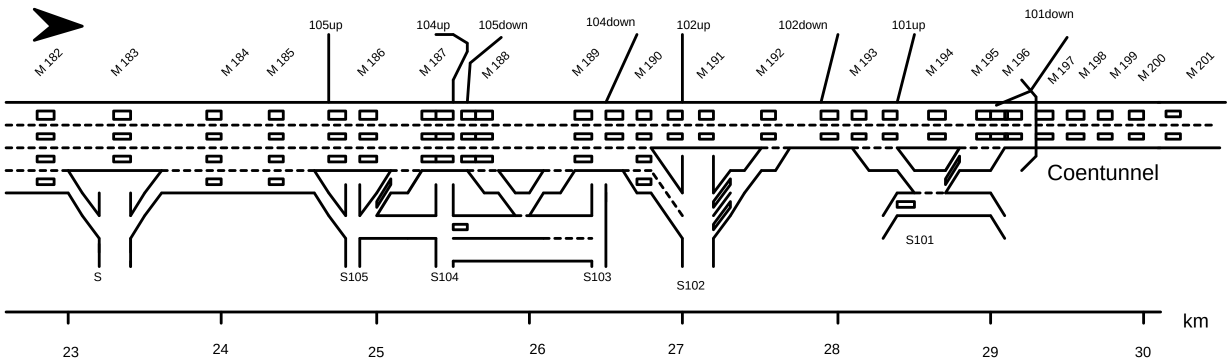

Figure 2. Schematic presentation of the road geometry and the location of the loop detectors

The flows and speeds could directly be adopted from the measured data. Queue lengths were obtained from the MCSS system by drawing contour diagrams of the speed for two different speed classes: speed drops below 80 km/hr and speed drops below 50 km/hr.
The travel times of individual vehicles were aggregated over 5 minute intervals, from which 15 minute averages were calculated and compared. Delay was defined as travel time minus free flow travel time, the latter being determined for each route as the travel time which is exceeded by 95% of the individual trips.
The total distance travelled was calculated by summing the product of link lengths with the corresponding flows and the total delay was calculated by summing up the delays, weighted with the flows on each route.

Traffic on the Ramps and Surrounding Network

For traffic on the on-ramps and the surrounding network the following aspects were considered: flows; queue lengths and route choice.
The flows could be directly determined from the data just like the queue lengths. Remarks about route choice were made based on traffic counts.

RESULTS OF THE ANALYSIS

Operation of the Ramp Metering Systems

Essential for achieving effects through ramp metering is that the systems, in reaction to motorway conditions are actually switched on. An example of the operation periods during the days involved in the analysis is depicted in figure 3.

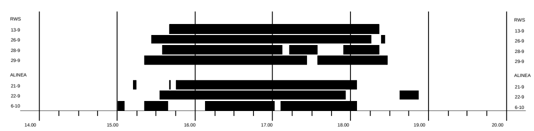

Figure 3. Metering periods for the S102 on-ramp

This figure shows that the system on the S102 is mainly active from about 15.30 to about 18.30 hours, and incidentally outside this time interval. The latter mostly in cases of height detector alarms. Clearly, the Rijkswaterstaat strategy continues metering until 18.30 hours, while the ALINEA on the average stops already at 18.00 hours. For the other on-ramps it can be seen that ALINEA starts a little earlier on the S101. The system on the S104 has been active during a shorter interval, and also switches off more frequently. Also here, it is seen that the ALINEA strategy switches on less often. The ramp metering system on the S105 has only switched on twice while running Rijkswaterstaat, and never during the ALINEA days. These activation times could be interpreted as the ALINEA strategy being more alert and more efficient.
During the period the system is in operation, cycle times range between 4 seconds and 9 seconds. The cycle time behaviour of the S102 differs from the S101, S104 and S105. The S102 cycle time varies from one minute to the other, while all other cycle times remain at the same value for several minutes

Motorway Traffic

In the following some results of the analysis are shown and discussed. Attention is paid to flows and speeds and travel times.

Flows and speeds. The average flow and speed curves for the motorway upstream the S102 on-ramp are drawn in the figures 4 and 5.

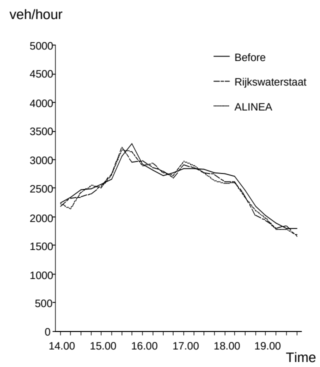

Figure 4. Average flow upstream the S102 on-ramp

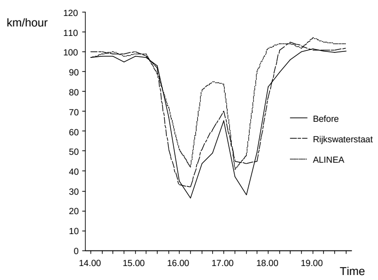

Figure 5. Average speed upstream the S102 on-ramp

Upstream from S102 the flow does not show a clear difference for the three situations. Speeds have changed, however: in the ALINEA situation they have increased considerably with respect to the 'before' situation. The peak periods are shorter and less severe: the average minimum speed has increased (approximately from 30 km/h to 50 km/h). In the middle of the peak period speeds recover almost to free flow. We will call this the two-peak mechanism. As can be seen from the data the rush-hour is divided in two peak periods: one from 16:00 to just before 17:00 hrs and one starting just after 17:00 hrs.

Travel times. The figures 6 and 7 show the travel times from the beginning of the motorway and from the S102 on-ramp to a location downstream the Coentunnel.

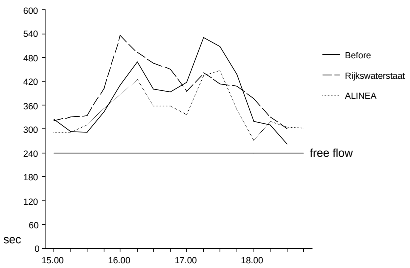

Figure 6. Travel time on the A10-West

A strange effect can be seen in figure 6. In the first part the situation with metering with the Rijkswaterstaat strategy is worse than the situation without ramp-metering. After 17:00 hrs. this changes in favour of Rijkswaterstaat. ALINEA performs best during the whole period

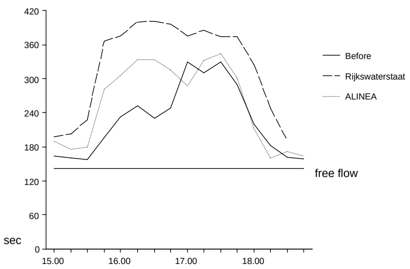

Figure 7. Travel time from the S102 on-ramp

In figure 7 is shown that with the introduction of ramp-metering the travel times from the S102 on-ramp have increased as expected. From this figure it is also clear that the ALINEA algorithm performs better than the Rijks-waterstaat algorithm. With ALINEA the situation after 17:00 hrs. is much the same as the before situation

.**Traffic on the Ramps and Surrounding Network**

For this traffic it is interesting to see if the flows on the on-ramps have changed and how the queues have evolved. Furthermore the aspect of route choice is considered.

On-ramp flows. As an example the S102 on-ramp flow is shown in figure 8.

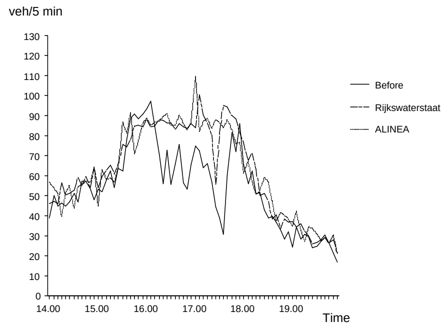

Figure 8. On-ramp flow S102

It is clear that the total amount of traffic using the S102 on-ramp has increased. On the other hand the flow on the S104 on-ramp has decreased. On the other on-ramps no large effects were visible. This effect, which is confirmed by table 2, was unexpected and should be further investigated.

Queue lengths. Figure 9 shows the queue lengths on the S102 on-ramp. From this figure it is clear that the queues have increased considerably due to metering.

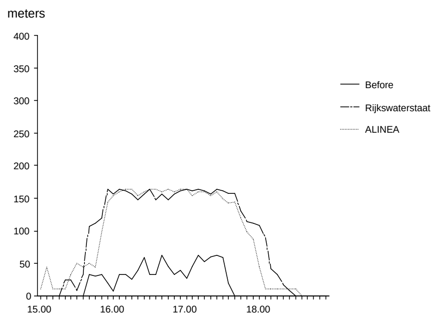

Figure 9. Queue length on the S102

Figure 10 shows the queue lengths on a branch of the intersection leading to the S102 on-ramp. The figure shows that the queues have not changed.

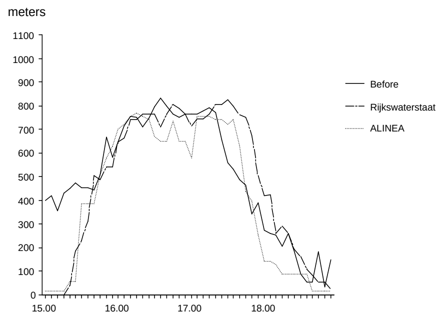

Figure 10. Queue length on a connecting road

The same conclusion can be drawn for the other on-ramps and connecting roads that are assessed. Due to ramp-metering the queue lengths on the on-ramps have increased or have come into existence, except of course for the S101 on-ramp, because this ramp was already being metered. The queues on the surrounding network have not changed much.

Route choice. Route choice behaviour was analysed on two scales: the redistribution of traffic over the on-ramps and the use of other IJ-crossings. In table 2 the total amount of traffic using the on-ramps is shown.

Table 2. Total amount of traffic using the on-ramps between 14:00 and 20:00 hrs.

ramp	Before	Rijkswaterstaat	ALINEA
S101	3019	2941 (97%)	3113 (103%)
S102	4064	4522 (111%)	4534 (112%)
S104	2519	2250 (89%)	2411 (96%)
S105	3398	3303 (97%)	3367 (99%)
S106	5162	5228 (101%)	5174 (100%)
Total	18162	18244 (100%)	18599 (102%)

From table 2 it can be concluded that metering with the Rijkswaterstaat strategy results in a shift of traffic from the S101, S105 and most strongly from the S104 on-ramp to the S102 on-ramp. While metering with ALINEA the S102 on-ramp also increases its share, but not with a strong decrease for the other on-ramps. That means that with ALINEA the total amount of traffic has increased. The cause of this effect is not certain, but possibly due to the small amount of measuring days. It should be further investigated.
The analysis of the flows for the other IJ-crossings: the IJ-tunnel and the Zeeburgertunnel showed that it is very difficult to draw conclusions on such a scale. There is a slight increase in the use of the Coentunnel and a slight decrease in the use of the IJ-tunnel when the on-ramps were metered, but this could also be due to seasonal influences or influences of other dynamic traffic management measures in the same area.

CONCLUSIONS

A major problem encountered in the field work was the high rate of height detector alarms. Hence, a considerable deal of the gathered data could not be used for the analysis. So, the amount of data used for the assessment study is rather small: five days for the before situation, four days for the Rijkswaterstaat situation, of which two days only up to 17.00 hrs, and only three days for the ALINEA situation. Therefore the conclusions, outlined below, should be considered with some care.
The differences for the control strategies are shown in form of the delays which are experienced both on the on-ramps and the motorway. With ramp metering in operation, delays on the on-ramps were expected to increase, being a direct effect of the traffic management tool under consideration. Delays on the motorway, however, should decrease.

- The results for the ALINEA strategy are promising. A reduction of delays by 19 % has been achieved for all traffic on the motorway and the on-ramps. This figure is much higher than expected and is possibly due to the small amount of days that was used for the analysis.

- For the Rijkswaterstaat control strategy, however, traffic conditions have worsened with respect to the before situation and this manifests itself both in the delays and in the speeds. Delays have increased by 35% for the Rijkswaterstaat strategy. It must be emphasised that mainly the first half of the rush period, i.e. from 16.00 to 17.00 hours is responsible for the increase in delays. During the rest of the evening peak, the Rijkswaterstaat strategy improves upon the before situation, although slightly less than the ALINEA strategy.

A full description of the analysis and all results can be found in Grontmij (3) and Middelham et al (4).

REFERENCES

1. Taale, H., Schouten, W.J.J.P. and Kooten, J. van, 1994, "The design of a coordinated ramp-metering system near Amsterdam", Seventh International Conference on Road Traffic Monitoring and Control, London
2. Middelham, F., 1994, "State of the Art in Dynamic Traffic Management in The Netherlands", 7th IFAC/IFORS Symposium on Transportation Systems, Tianjin, China
3. Grontmij, "An assessment of multiple ramp metering on the Amsterdam ring road", Transport Research Centre (AVV), 1995
4. Middelham, F., Taale, H., Van Velzen, G.A., "Experimental Results and Comparative Analyis", Deliverable 11A of the EUROCOR project, March 1995