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EAST-WEST COOPERATION
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WORKSHOP

"A SIMULATION STUDY WITH FLEXSYT-II-"

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I. INTRODUCTION

In The Netherlands much effort is put in dynamic traffic management. A number of pilot projects have been set up and carried out. For example projects with ramp metering, a reversible lanes, a carpool lane, variable message signs and traffic information on the radio (RDS-TMC) have been implemented and assessed.
The region around the mainport of Rotterdam is also an area where traffic management is necessary, because of the heavy traffic streams and the large amounts of trucks. In cooperation with the municipality of Rotterdam Rijkswaterstaat is carrying out a large project concerned with traffic management in that area. A part of that project is dealing with ramp metering and mainline metering. Ramp metering is the metering of traffic on an on-ramp and mainline metering is the metering of traffic on a motorway.
A location where metering is possible is the Beneluxtunnel. This tunnel is a bottleneck for the traffic going in both directions. A sketch of the ringroad and the location of the Beneluxtunnel is given in figure 1.

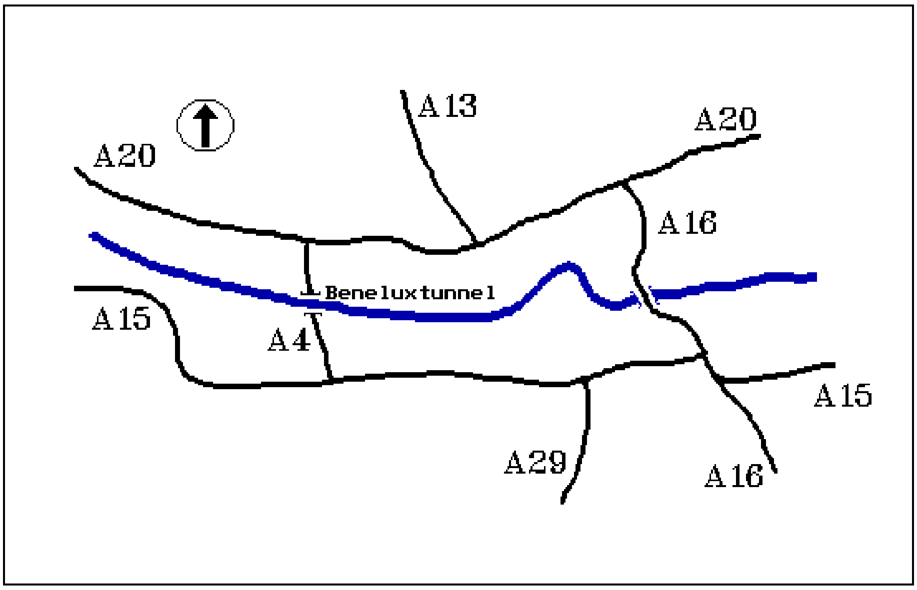

Figure 1: Ringroad round Rotterdam

It was decided to study the possibility of metering on the southside of the Beneluxtunnel. Three goals were distinguished: a better usage of the Beneluxtunnel, favour special users on dedicated lanes (especially trucks) and avoid blockage of the A15 motorway.
This paper describes a study to simulate and analyze the effects of metering and of favouring of special user groups in the neighbourhood of the Beneluxtunnel. First a problem description is given, then the simulation tool is discussed. In paragraph 4 the alternatives are described and finally the results and conclusions are given.

II. PROBLEM DESCRIPTION

The A4 motorway is an important link in the ringroad around Rotterdam. It is a motorway with 2 lanes in both directions. In 1994 more than 90,000 vehicles per 24 hours passed the tunnel during an average working day, leading to recurrent congestion in both peak periods. A

structural solution for this problem (a new tunnel) will not be realised before the year 2000. Rijkswaterstaat has therefore decided to take measures to come to a better usage of this part of the A4 motorway.
This study deals with the part of the A4 south of the Beneluxtunnel and with traffic travelling in northern direction. The current situation is given in figure 2.

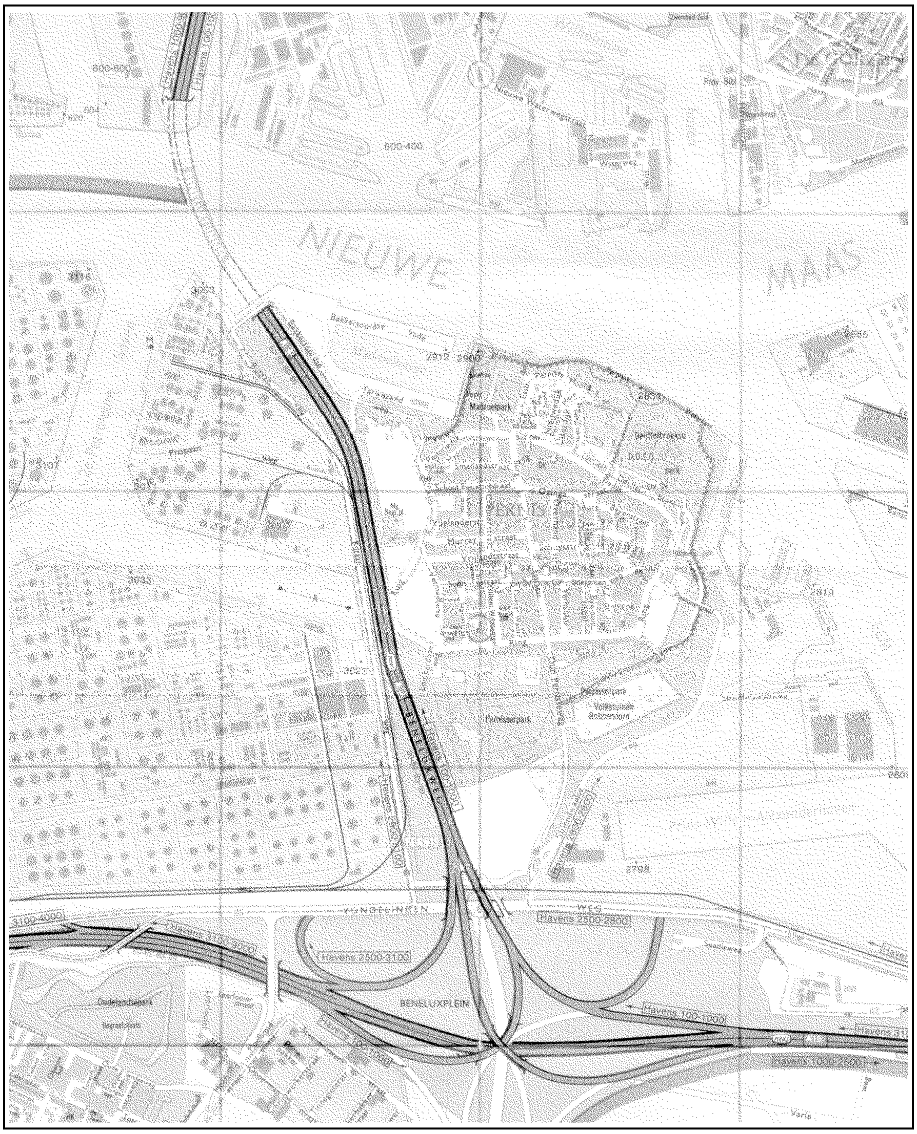

Figure 2: Situation south of the Beneluxtunnel

Almost everyday congestion occurs in both peak periods on the two connective roads from the A15 motorway to the A4 motorway. This congestion also blocks back on the A15 motorway itself.
The main reason for this problem is that each of the two connective roads merge from two lanes into one lane and then these two single lanes come together and continue as a two lane motorway. The branch from the A15-East also has an on-ramp and just before the tunnel a bus lane merges into the traffic stream. A more schematic representation of the situation is shown in figure 3.

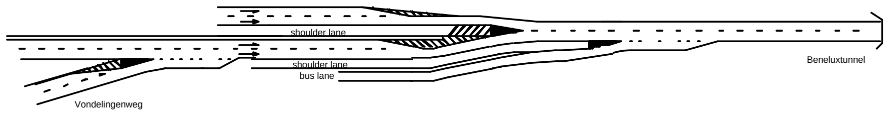

Figure 3: Current situation

Furthermore, problems occur with weaving traffic, for example trucks travelling from the western branch have to change from the left lane to the right lane.

III. FLEXSYT-II-

FLEXSYT was developed in the seventies by Frans Middelham. It is a microscopic simulation program that can be used to study all kinds of traffic management measures, due to its own traffic control programming language, called FLEXCOL-76-. In 1985 the development of FLEXSYT-II- was started. In comparison with the first version FLEXSYT-II- had a more refined vehicle model, more vehicle types and a module for environmental effects.
Examples of applications with FLEXSYT are bus lanes, bus priority, traffic control strategies, ramp metering, mainline metering, tidal flow lanes, HOV lanes, toll-plaza's, etc.

IV. ALTERNATIVES AND INPUT

IV.1 Alternatives

A group of designers prepared a number of geometric alternatives that had to be investigated, including alternatives with and without main-line metering. The first set of alternatives includes a lane for special user groups (SDG lane: same as HOV lane). In this set a distinction is made between one alternative without metering (1a) and two alternatives with metering (1b and 1c). The difference between the alternatives with metering consists of the location of the stop-line. Also a distinction is made between two groups of special users. One group consists of trucks and busses (I) and the other group consists of trucks, busses and carpool vehicles with more than two occupants (II). This set of alternatives includes ramp metering on the on-ramp with an HOV lane. The lay-out of alternative 1a (without stop-line) is shown in figure 4.

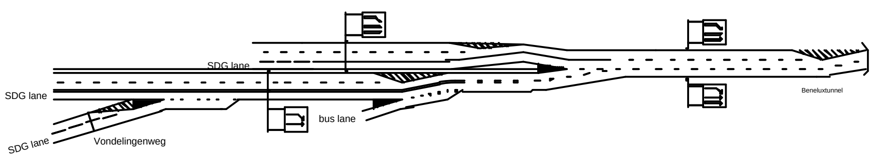

Figure 4: Alternative 1 (with lane for special user groups)

The second set of alternatives also has a lane for special user groups (SDG lane) and is with metering, including ramp metering. For this set of alternatives also a distinction is made between the special user groups and furthermore between alternatives with (A) and without priority of the special users lane (B) in the control plan of the metering system. The lay-out of these alternatives is shown in figure 5.

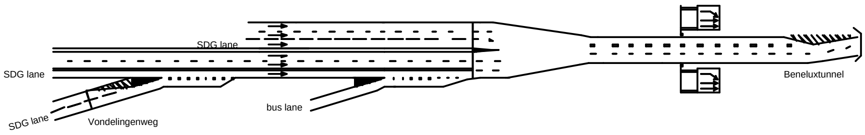

Figure 5: Alternative 2: with main-line metering

The third set of alternatives is divided into three: an alternative with two left merging lanes (3a), an alternative with one left merging lane and a taper (3b) and an alternative with a left and a right merging lane (3c). These alternatives do not have ramp metering on the on-ramp. In the figures 7, 8 and 9 the lay-out is shown.

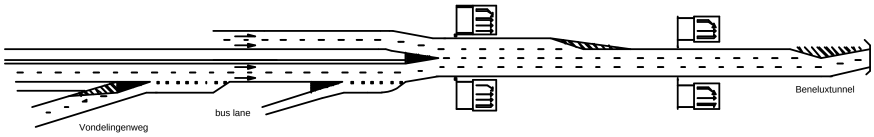

Figure 6: Alternative 3a: with two left merging lanes

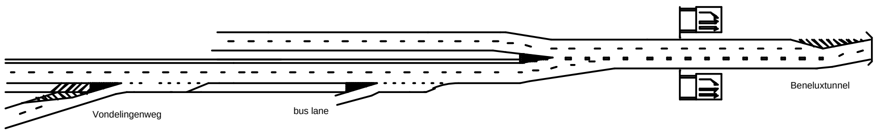

Figure 7: Alternative 3b: with a taper and a left merging lane

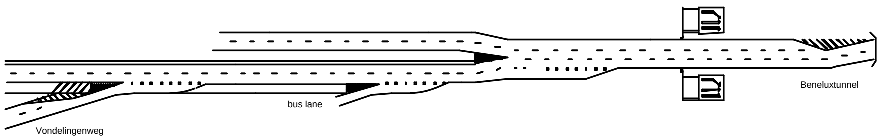

Figure 8: Alternative 3c: with a left and right merging lane

IV.2 Input

First the network input was prepared for the all situations. For the motorway stretches with two lanes a capacity of 4300 veh/hr was used, for stretches with three lanes a capacity of 6700 veh/hr and for stretches with four lanes a capacity of 9000 veh/hr. For a single lane the capacity was 2000 veh/hr or 2200 veh/hr, dependent on the amount of trucks. The capacity of the lane for special user groups (SDG-lane) was set to 1200 veh/hr. These values are normal for the capacity in The Netherlands.
FLEXSYT-II- needs the demand as input for the flow. For this, measurements were used, which were carried out on four days in January 1994, for the morning peak period (06:00 - 10:00 hrs). Unfortunately, for some time the cross-sections which were measured, were congested. That means that not the demand, but the flow was measured. Therefore, some assumptions for the input had to be made. After some calculations the flows as shown in figure 9 were used.

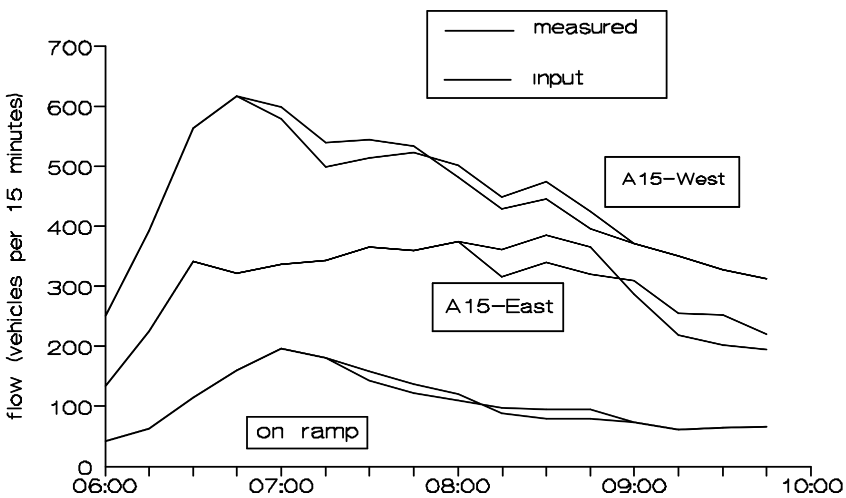

Figure 9: Measured and used flows

The final input consisted of the control strategy for the alternatives with main-line metering. The control strategy consists of an algorithm for the on and off switching of the metering and an algorithm for the calculation of the greentimes. The main-line metering switches on when the smoothed flow on a connecting road (A15-West or A15-East) exceeds the capacity of a single lane. The greentimes are calculated based on the ratio of the flows on the connecting roads. The minimum greentime is 20 seconds and the maximum cycletime is 200 seconds. Some alternatives have priority for the SDG-lane. Based on the presence of vehicles on this lane the greentime is extended with a maximum of 15 seconds.
Also the on-ramp is metered in all alternatives, except alternatives 3a, 3b and 3c. The metering system switches on when the flow exceeds a certain threshold. The minimum and maximum cycletime are 4½ and 9 seconds respectively.

V. RESULTS

V.1 Introduction

To compare the several alternatives the total delay will be considered first. Furthermore, the average delay, the queue length and the flow in the Beneluxtunnel will be discussed. The results of the simulation are average values of 10 simulation runs for the same alternative.

V.2 Total delay

The total delay (vehiclehours per hour) for all vehicles, as a percentage of the current situation, is given in figure 10.

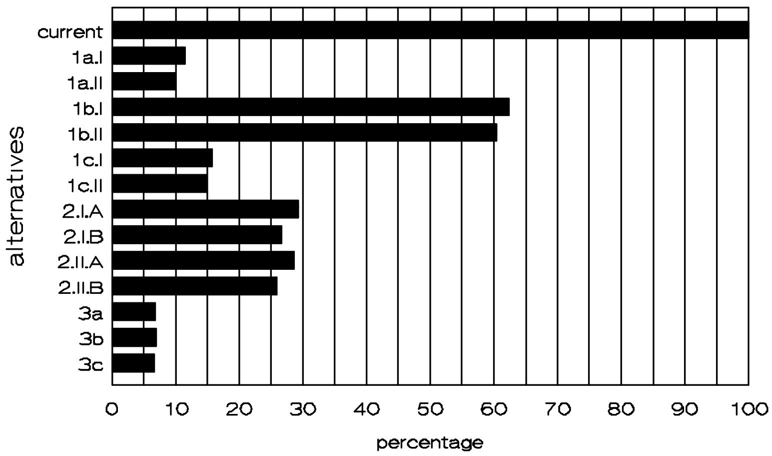

Figure 10: total delay

It can easily be seen that all alternatives are better than the current situation. The alternatives 3 are the best, but also alternative 1a looks good. The difference is due to metering on the on-ramp. The difference between 4c and 4a is due to main-line metering. The total delay for alternative 4b is very large, compared with 4c, but that is caused by the bad location of the stop-line in 4b.

V.3 Average delay

The average delay in seconds per vehicle from the beginning of the network to the end, is displayed for private cars and heavy trucks in the figures 11 and 12.
As can be seen from figure 11, the average delay for private cars decreases from 10 or 12 minutes to 1 or 2 minutes in the alternatives 1 and 3, for both the A15-West and A15-East. In the alternatives 1 the average delay for the on-ramp increases because of ramp metering. That explains the difference with the alternatives 3 which do not have ramp metering. The same conclusions can be drawn from figure 12. The difference between the average delay for private cars and for trucks can be explained from the use of the SDG-lane and the difference in speed.

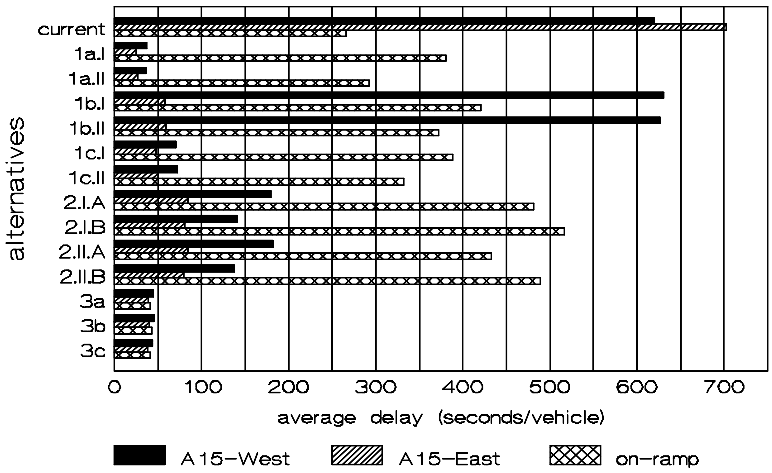

Figure 11: Average delay for private cars

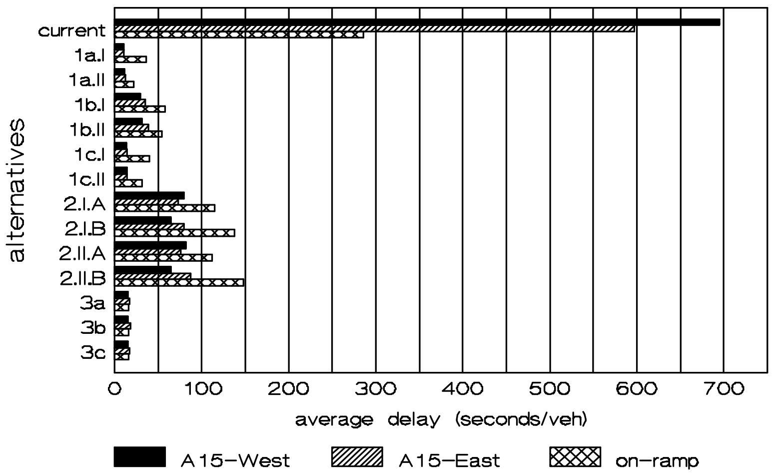

Figure 12: Average delay for heavy trucks

<u>V.4 Flow in the tunnel</u>

For two alternatives the flow in the tunnel was measured. The results are shown in figure 13. Figure 13 shows that in the current situation the capacity of the tunnel is used for a shorter time than in the alternatives. This effect is caused by the location of the congestion and the distribution of the demand on both connecting roads. This distribution is such that congestion occurs at the merging point from two lanes to one lane on both connecting roads at the same time. But the demand for the A15-East is smaller than the demand for the A15-West and therefore the congestion on the A15-East disappears faster. But that means that the stretch after the merging of the two connecting roads is not fully utilized.

For the alternatives, congestion occurs just before the tunnel, leading to a far better utilization.

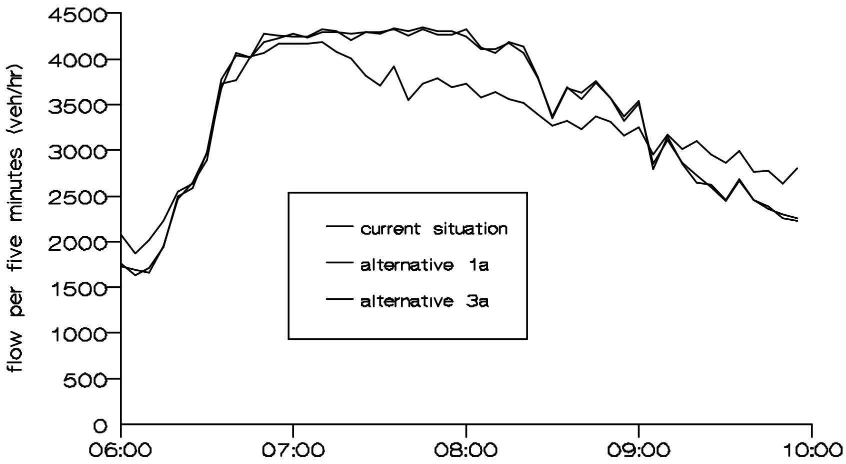

Figure 13: Flow in the Beneluxtunnel

VI. CONCLUSIONS

It can be concluded that the current situation is the worst of all cases. Taking into account the aspects total delay and average travel time, the best alternatives are 3a, 3b and 3c. But these alternatives do not have a SDG-lane for special user groups. If this is desirable, alternative 2a is also possible.
It can also be concluded that in the current situation the tunnel is not fully utilized. It is better to move the location of the congestion to a location downstream of the merging point of the two connecting roads.

VII. FINAL REMARKS AND LITERATURE

Based on the study Rijkswaterstaat decided to investigate the possibilities to adjust the geometry of the current situation to the geometry of the alternatives 3.

[1] *FLEXSYT-II- Manual*, Transport Research Centre (AVV), January 1994

[2] *Analysis of the effects of metering within the Benelux junction with FLEXSYT-II-*, H. Taale, report no. ID 93.304.03/1, August 1994 (in Dutch)