OPTIMIZATION OF TRAFFIC FLOW THROUGH THE USE OF RUNNING LIGHTS

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Abstract: In tunnel sections, the velocity of individual drivers frequently changes. This uneven driving behaviour can cause density waves in the traffic flow. In crowded traffic this leads to traffic jams. The uneven velocity is caused by the driver's perception, because the environment did not give him any information about the driven speed. Through the use of a running light this lack of information can be avoided. The positive effects on the traffic flow are investigated by the traffic flow simulation programme PELOPS.

Keywords: Driver behaviour, Driver models, Simulation, Guidance systems, Human perception, Traffic Control, Tunnel, Light, Vehicle

1 INTRODUCTION

For the investigation of the traffic flow at a selected tunnel section, with the goal of it's optimisation, the actual traffic state was registered by comprehensive measurements. Based on these measurements, the traffic flow was reproduced in the microscopic traffic flow simulation program PELOPS. By means of the realistic reproduction of the traffic flow by simulation it is possible, to predict the influence of a construction-caused blocked lane. In order to keep the traffic disturbance as small as possible, different optimisation measures have been proposed and evaluated by means of simulation. Thereby, also influencing the driver by running light signals was investigated as very promising measure. For the evaluation of the driver reaction to a running light signal, necessary for the simulation, as well as for the design of the running light itself finally a sight simulation in a drive simulator was done.

2 REGISTRATION OF THE TRAFFIC FLOW AT A TUNNEL

For the registration of the traffic flow at a selected tunnel section different measurements were executed (Fig. 2-1).

On the one hand the traffic with its flow, density and average speed was analysed by means of data from measuring loops over a period of three days. By the measuring loop data speed and distance distributions could also be determined for smaller time intervals. The traffic reproduction was completed by vehicle-specific measurements. These were done by follow-up drives with a vehicle equipped with a sensor for distance and differential speed. Thus, the speed profile of uninfluenced drivers in the observed stretch could be determined.

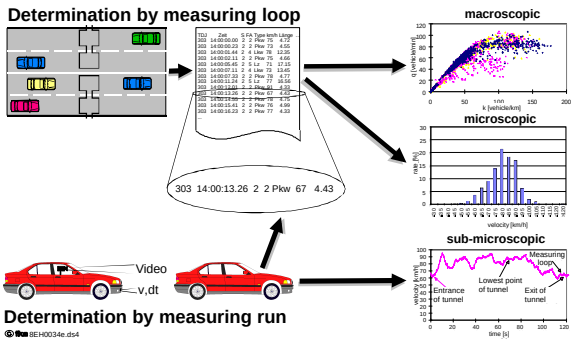

Fig. 2-1. Traffic flow Description

The measurements showed the extremely high traffic strain at the tunnel at certain times of the day, leading to traffic jams. Most of all, they were caused by the uneven speed behaviour of single drivers, which cannot be balanced in platoons in case of dense traffic and thus lead to density waves. These density waves led to hold-ups of the traffic flow up to total still stand.

The uneven driving behaviour occurred on the one hand while entering the tunnel, in which case particularly unpractised drivers reduce their speed. On the other hand the incline within the tunnel also caused a deceleration. In contrast to natural environment, this incline was not perceived due to the identical forming of the tunnel walls.

3 TRAFFIC FLOW SIMULATION WITH PELOPS

The microscopic traffic flow simulation program PELOPS was developed at the Forschungsgesellschaft Kraftfahrwesen Aachen mbH and the Institut für Kraftfahrwesen Aachen of the RWTH Aachen in co-operation with BMW. It stands out for the accurate reproduction of the driver and the vehicle on a certain stretch section. Consequently, it is subdivided into a driver-, a vehicle and a stretch model (Fig. 3-1). (Diekamp, 1995)

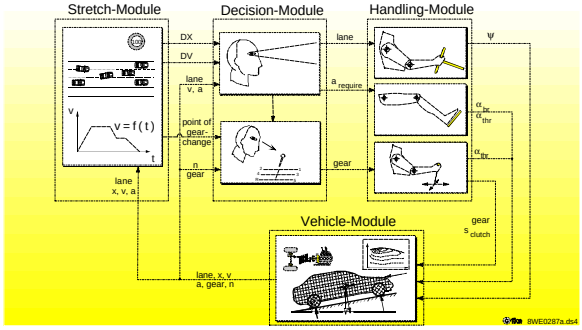

Fig. 3-1. Structure of PELOPS

This detailed modelling (Ludmann, 1998) allows the description of the driving behaviour on special stretch sections, such as, f. e., tunnels. Thus, the traffic flow at the relevant tunnel was simulated according to the executed measurements. The whole traffic as well as the individual driving behaviour in the simulation corresponded to the measured values. (Ehmanns *et al.*, 1998)

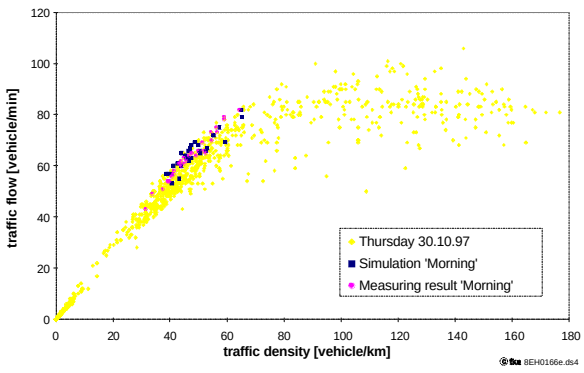

Fig. 3-2. Macroscopic validation (Ehmanns *et al.*, 1998)

On the basis of this validation the following investigations of the influence of new systems could be realised.

4 SIMULATION INVESTIGATION OF MEASURES FOR TRAFFIC MANAGEMENT TOOLS

By means of traffic simulation predictions concerning the effects of different traffic management tools can be made. At the investigated section at the tunnel one of the three lanes is blocked due to construction. This blocking is located between two closely following access points. In order to keep the influence of the lane reduction as small as possible, the following measures were proposed and afterwards evaluated by means of simulation:

- Increasing the distances between commercial vehicles, in order to make the entrance at the access point easier,

- Blocking of an entrance at the tunnel entrance.

By the simulation program PELOPS the effects of these measures could be predicted. No significant differences in the traffic flow as against the unchanged traffic guidance at the construction site could thereby be established.

Beyond this, the investigation of the employment of light signals for the driver assistance remained, which will be presented in the following.

The measurements established the uneven speed profile of single drivers as the main jam causing problem. This is caused on the one hand by the spatial feeling when entering the tunnel and the according uneasiness, on the other hand it is caused by the lack of information about the driven speed from the environment. One possibility to convey this information to the driver consists in generating a running light at the tunnel walls which indicates an even speed level. This optical stimulus - compared to the acoustic announcement - has the advantage that it permanently provides an orientation for the driver. A running light is generated by successive switching of single light sources being placed one behind the other with the proposed speed.

For estimating the influence of such a running light in the traffic flow, PELOPS was employed. The behaviour of the driver was depicted in such a manner that he is trying to keep the running lights' speed, if the surrounding traffic permits such a speed. This means that the driver takes into account an approach to the preceding vehicle when choosing his speed. By means of sight simulations in the drive

simulator it was proofed if these assumptions could be realized.

By the street parallel warning system COMPANION it becomes obvious that drivers reacts to light signals. This system - developed with BMW - implements blinking lights into the beacons. Several field studies, that were executed in the section of the BAB 92 near Munich, showed in case of switched-on lights the positive effect on the speed behaviour by warnings. In the meantime this system has also been installed in Verona and Edinburgh. (Klassen *et al.*, 1999)

Assuming that running light signals do have an influence on the driving behaviour, predictions were made concerning the travel time through the tunnel stretch and the development of traffic jams with and without driver assistance.

Since the uneven velocity of individual drivers is the mean reason for density waves in the traffic flow, the running light's influence on driven velocities should be investigated. The beginning of the ascent is a critical point on the stretch. There cars slow down because of resistance forces. As shown in Fig. 4-1 the running light's effect is a more even velocity on a higher level.

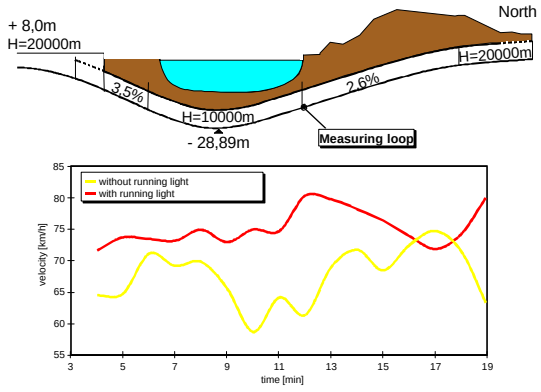

Fig. 4-1. Influence of the running lights on the driven velocity at the beginning of the ascent

As a consequence of the positive influence on the driven velocity, the travel time through the tunnel decreases (Fig. 4-2).

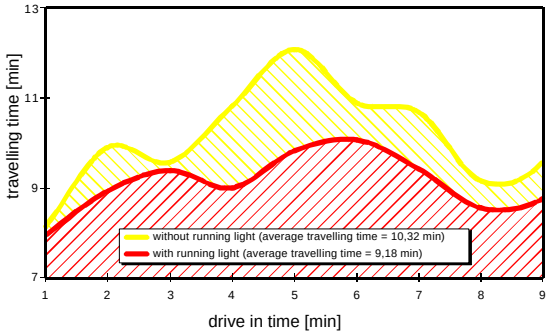

Fig. 4-2. Travel time through the tunnel with and without running lights depending on the entrance time

When using the running light, the average travel time diminishes by 10 %. Furthermore the travel time's variation becomes slighter.

The investigation of the described optimisation measures with light signals resulted in an increased maximum traffic flow of approx. 6 % as well as a raised running off flow at the traffic jam's head of approx. 10%. The evaluation of the traffic flow during the day time resulted in a possible 16 %-reduction of the jam duration in the investigated case. (Ehmanns *et al.*, 2000) These very promising results led to further investigations of the running lights.

5 SIGHT SIMULATION

For the further investigation of the driver reaction to a running light as well as its possible design a drive simulator was employed. The drive simulator was constructed by the Interdisziplinären Zentrum für Verkehrswesen of Prof. Dr. Krüger at the Universität Würzburg and the investigation were done in cooperation with the Institut für Psychologie of the RWTH Aachen. In this drive simulator the sight of a driver in the tunnel was reproduced. The planned running lights were added to the range of vision, so that different blinking patterns, -frequencies and -durance could be observed (Fig. 5-1).

In the tests the lights were designed in such a manner that in one variant the impression of one single running light arises, whereas in another variant a running light package is moving, consisting of several individual lights. It could be established after the tests that the running light package, conveying the impression of a running line, are clearly more suitable as orientation means for the driver as the single lights.

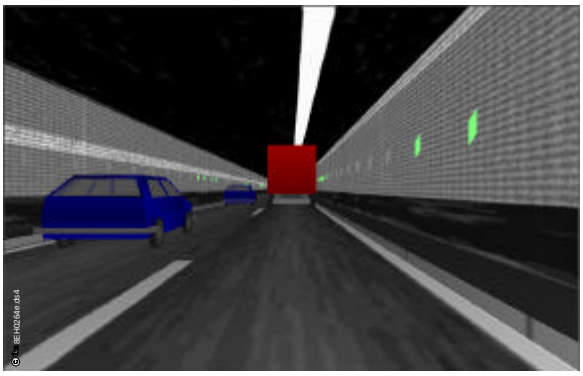

Fig. 5-1. Reproduction of the tunnel in the drive simulator

First investigations of the driving behaviour were added to the subjective impression of the design of the lights. These demonstrate that the drivers can be lead to a more even driving. The investigation of the distance behaviour did not show any safety-relevant influences. The covering of single lights by the surrounding traffic e. g. trucks caused no irritation for the driver.

6 OUTLOOK

The presented results show the improvement potential of the traffic flow by the employment of running lights. Therefore it is sensible to take this system into consideration for the new concepts of traffic manipulation measures at tunnel stretch sections. The necessary preparatory works have been presented here.

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