IMPACTS OF VARIABLE AND PERMANENT TRAFFIC SIGNS ON MOTORWAYS

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ABSTRACT

Uncertainty exists in the evaluation of the contribution of Variable Message Signs (VMS) especially dynamic speed limits for traffic safety in the course of a Motorway Control System (MCS). The use of Permanent Traffic Signs (PTS) in combination with ramp metering to achieve the same positive effects is under increasing discussion. The study describes the effects of PTS and VMS to sign the traffic regulations on motorways. The investigation bases mainly on the evaluation of traffic safety of a long distance motorway in Rhineland-Palatinate. For the long distance motorway the posting of speed limits and other traffic regulations by PTS and VMS was carried out in two steps. In the first step a permanent speed limit of 130 kph and forbidding of over-taking for heavy vehicles were posted. For an accident-prone motorway section of 23 km a MCS was installed three years later to increase traffic safety and to optimise traffic flow conditions. The posting of a permanent speed limit and forbidding of over-taking for heavy vehicles at the long distance motorway cause a reduction of accident and accident costs of about 30 %. The evaluations in more detail show the necessity to differ between accidents influenceable and non-influenceable by a MCS. The implementation of the MCS produced a further light improvement of traffic safety by an overall analysis, but in the case of accidents influenceable to MCS a clear improvement. The evaluation of the metropolitan motorways presents a concentration of the accident occurrence at the access points and interchanges. PTS – here speed limit and forbidding of overtaking of heavy vehicles in combination with ramp metering - seems to be an equivalent alternative to a “classic” MCS for motorways in metropolitan areas. Analysing cost-benefit of MCS a reduction of the accident costs has to take into account carefully in the case of existing speed limits and other traffic regulations by PTS.

KEY WORDS

TRAFFIC SAFETY / MOTORWAY CONTROL SYSTEM / VARIABLE MESSAGE SIGN / PERMANENT TRAFFIC SIGN / RAMP METERING

1. INTRODUCTION

Motorway Control Systems (MCS) are well-accepted modern tools of Intelligent Transportation Systems (ITS) to ensure a high quality of a traffic management operation. The measures are used to get better overall traffic safety and traffic flow conditions on motorways. In benefit-cost-analysis an improvement of traffic safety in a range of 20% to 30% is supposed. The positive effects may be caused especially on one side by a homogenisation of the traffic flow and on the other side by an early warning of the road users of adverse road and traffic conditions by congestion, accidents, fog or rain for instance. The effect of traffic engineering measures for traffic safety evaluated by before-and-after-studies is always depending on the level of the traffic safety situation in the before state with consequence of alterations of the improvement potential according as the evaluation starting-position was chosen. But uncertainty exists in the evaluation of the contribution of VMS for traffic safety in the course of motorway control systems by taking

account the before-situations especially in the case of no regular permanent speed limit on German motorways. A combination of permanent speed limits and ramp metering is often discussed as an alternative to controlled motorways. It is necessary to differentiate between accidents influenceable and non-influenceable to MCS. The study aims to describe the effects of permanent and variable traffic orders and information.

2. METHOD OF EVALUATION

The investigation was conducted at two types of motorways (M) in the German motorway network: the M A61 in the Land Rhineland-Palatinate and the M A1 and A7 in the Land Hamburg. The M A61 represents a long-distance corridor mainly passing rural areas whereas the M A1 and A7 are characterised by a metropolitan area.

The research of the M A61 is characterised by three traffic order actions and time periods in the last 11 years (see Figure 1). The actions are:

1st action: no speed limit (recommended speed of 130 kph) till the 30th June 1991
2nd action: speed limit of 130 kph and no-overtaking of heavy vehicles since 1st July 1991 till August 1994
3rd action: since September 1994 operation of MCS in a 23 km long section of the M A61.

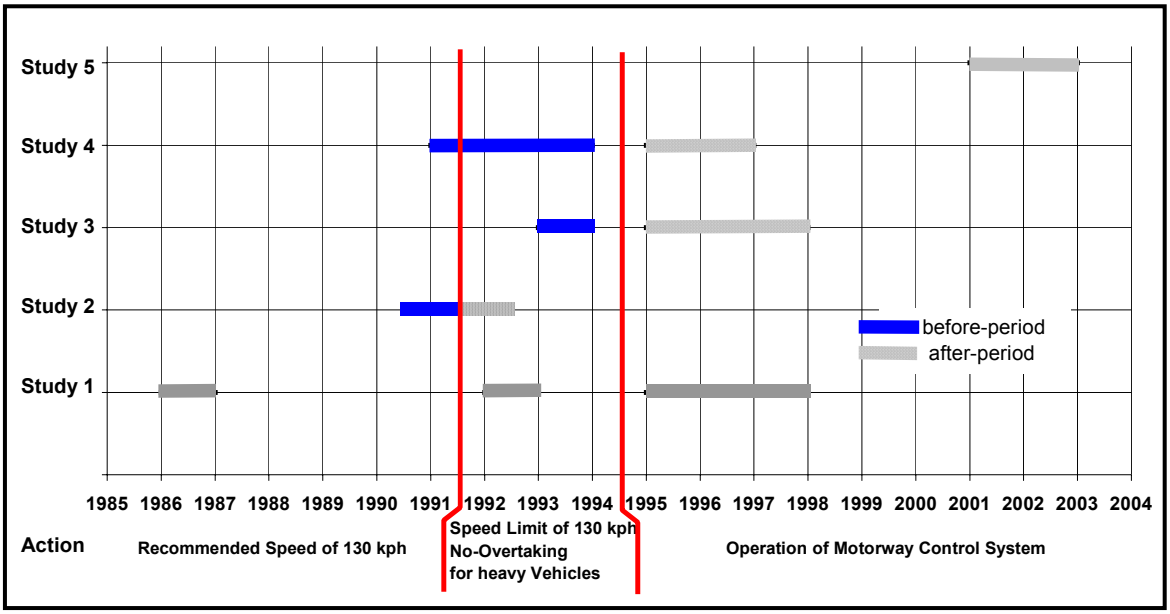

Figure 1 – Traffic order actions and conducted researches

In the past 9 years several studies about the impacts on traffic safety and flow on the M A61 were carried out to assess the different actions. Figure 1 shows the different studies and their investigation periods that deal with a traffic safety evaluation in the section equipped with a MCS (Study 1: ATT, 1998; Study 2: METR, 1993; Study 3: ISAC, 1998; Study 4: Siegener, 2000; Study 5: actual traffic safety and flow evaluation).

The problem in the evaluation of the impacts of a MCS on traffic safety is that only certain types of accidents and accident causes are be touched and influenced by a MCS. Seven different types with two subgroups and 89 causes are taken into account in German traffic safety analysis (FGSV, 1974). In the Central Office of Accident Evaluation of the Authority of Traffic and Transport Engineering of Rhineland-Palatinate (ATT) in 1997 the procedure

was developed to differ in a traffic safety evaluation of MCS between "accidents influenceable to MCS" (AiM) and "accidents not influenceable to MCS". Basically type 1 (driving accident), type 6 (accident between vehicles moving along in carriageway) and type 7 (other accidents) should be integrated in an analysis by taking into consideration special accident causes and weather and road surface conditions. The accidents influenceable to MCS are:

- Speeding, except in the case of winter slipperiness (type 1 or type 6)
- Not adapted speed, except in the case of winter slipperiness (type 1 or type 6)
- Driving accident in the case of wetness (type 1)
- Rear-end collision in the case of wetness (type 60)
- Accidents in the case of fog (type 1 or type 6)
- Accidents by broken down vehicles (type 741 or type 742)
- Rear-end collision by congestion, except in the case winter slipperiness (type 60)

The overall analysis covers ordinarily a period of no less than 10 years. During that time alterations of the general accident occurrence may happen by other driving behaviour, alteration of the road user sample or other used engineering standards. These alterations have to be taken into account like a calibration in the analysis of the results and in the deducing of conclusions. Two kinds of calibration were chosen. The first calibration is the development of the accident occurrence of accidents with personal injury on all motorways in Rhineland-Palatinate (see Figure 2). The other kind of calibration is the interpretation of the results in relation to a control section. Here the control section is a motorway section of about 25 km and it follows directly northern of the MCS.

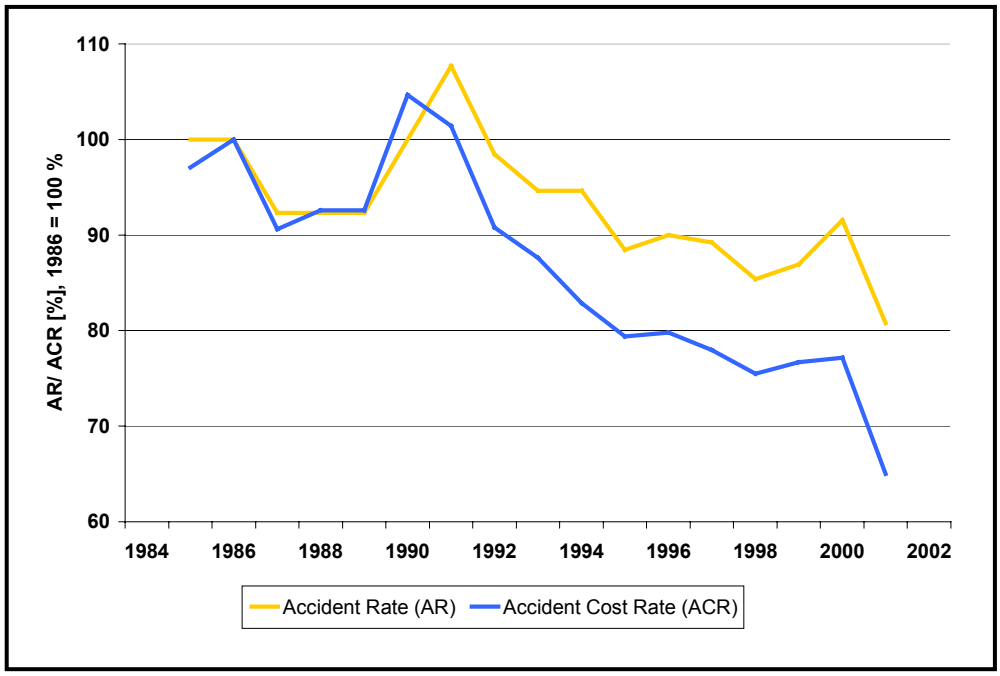

Figure 2 – Accident Rate and Cost Rate of Accidents with personal injury of all motorways in Rhineland-Palatinate

The accidents were evaluated by the accident causes between the access points or interchanges in small sections of 250 m or 500 m as well. The accidents of most interest are those caused by speed, distance/ overtaking and other driving mistakes.

3. RESULTS

The accident cost rate (ACR) decreased by 40 % by introduction of the permanent speed limit (2nd action) for the total number of accidents and the accidents with personal injury (see Table 1). By implementation of the MCS an improvement of about 10 % could be achieved from 1992 (before-period) to 2001. A further decrease of 13 % could be observed for the last evaluation year 2002. The accident occurrence at the control section has another development. By the permanent speed limit an improvement of 30 % could be achieved. The accident occurrence of accidents with personal injury decreased on a level of only 25 % of the beginning of the evaluation so the control-section is on 20 % lower level than the MCS-section. But in 2002 the development changes in favour of the MSC-section.

Table 1 – Accident Cost Rate [%] of the total accidents (1986 = 100%)

	total accidents					accidents with personal injury				
	1986	1992	1997	2001	2002	1986	1992	1997	2001	2002
Motorway Control System	100	59	51	49	36	100	57	45	45	29
Control Section	100	71	42	35	62	100	77	36	24	62

These results are confirmed in principle by the accident rate (AR) (see Table 2). In the calculation of the AR the accident type 1 and 6 were included to focus on the aim of a permanent speed limit and MCS. In contrast to the ACR the AR changes lightly for the better by implementation of the MCS. The AR of 1991/92 improves about 7 % by the MSC-implementation. The decrease of the AR is not so high than the ACR after introduction of the permanent speed limit. Therefore the permanent speed limit and the no-overtaking for heavy vehicles have a favourable effect on the accident severity.

Table 2 – Accident Rate of accident types 1 and 6

	Absolute number					Relative number (1990/91 = 100%)				
	1990/ 91	1991/ 92	1997	2001	2002	1990/ 91	1991/ 92	1997	2001	2002
Motorway Control System	0.522	0.368	0.332	0.371	0.299	100	70	64	71	57
Control Section	0.431	0.212	0.170	0.221	0.215	100	49	39	51	50

The evaluations give an impression of the accident occurrence but without any special consideration of the "influenceable procedure" in the course of a MCS. The “influenceable procedure” was applied for calculation of the accident rate (AR,AiM). Moreover the percentage of the number of accidents influenceable to MSC in relation to the absolute number of accidents was determined (see Table 3). The percentage and the AR,AiM has the same oscillating development since 1992 (implementation of PTS). The percentage drops from 0.42 to an average of 0.24 and the AR,AiM decrease from 0.28 to an average of 0.15.

The evaluation of the accident causes in the course of the MCS shows in the vicinity of some access points an accumulation of accidents. The accident causes speed and distance/ overtaking are the majority. For the metropolitan motorway a clear accumulation can be observed at the access points (see Figure 3).

Table 3 – Accident Rate and Percentage of Accidents susceptible to MSC

	1992	1995	1996	1997	2001	2002
	Motorway Control System					
AR, AsM [acc./1E6 veh.km]	0.285	0.114	0.176	0.113	0.205	0.141
AR, total [acc./1E6 veh.km]	0.675	0.582	0.713	0.691	0.635	0.557
p [%]	42	20	25	16	32	25
	Control Section					
AR, AsM	0.104	0.075	0.097	-	0.102	0.097
AR, total	0.356	0.337	0.358	-	0.346	0.378
p [%]	29	22	27	-	29	26

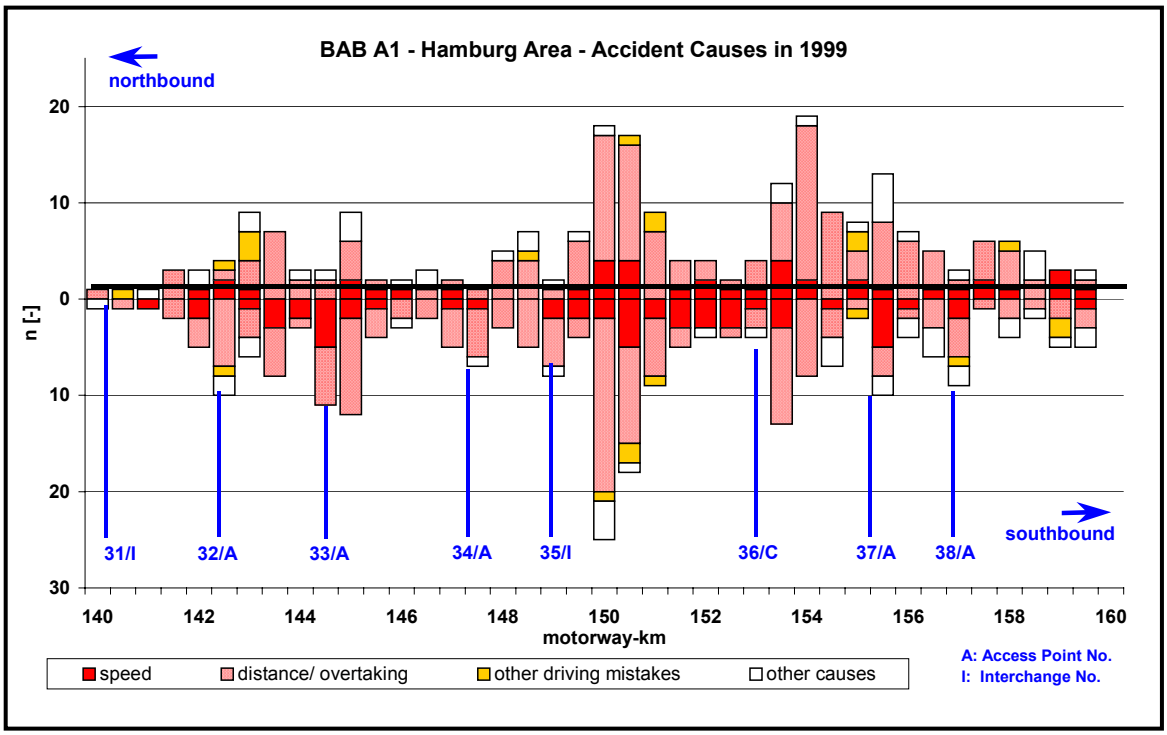

Figure 3 – Accident Causes in 1999 of Motorway A1 in Hamburg metropolitan area

4. DISCUSSION

The permanent speed limit and the no-overtaking for heavy vehicles cause the main basic impact in the improvement of the accident occurrence. The ACR and AR present a constant level during the MCS operation after the distinct decrease of the accident criteria by the permanent traffic orders. A statement of the ATT-internal paper (ATT, 1998) of stabilisation of the AIM in the last years can be confirmed. The improvement of the accident occurrence by permanent traffic orders characterised by the ACR is in a range of 40 %. This value has to be corrected on one side by the general accident cost rates in Rhineland-Palatinate by about -5 % on the other side by consideration of the control section by –10 %. The general development seems to be better for calibration than the direct control section because of the limited comparability evoked of the vertical alignment. So the improvement varies in a range of 35 %. The implementation of the MCS results to an improvement for the accidents of type 1 and 6 of about 10 %. The improvement of 10%

is congruent with the general accident development in Rhineland-Palatinate. The MSC-operation improves the accident occurrence for the AiM on a 60 %-level related to the PTS-situation (before-period). By correction with the general accident development the decrease by MCS-operation is in a range of 30 %.

The reason for the limited impact of the total accident seems to be in the partly extreme exceeding of the speed limit. The V85-speed especially on the overtaking lane is on a very high level both for cars as for heavy vehicles. A V85-speed for cars of 155 kph was measured on the overtaking lane in the late evening hours. The V85-level of cars in combination of V85-speed of heavy vehicles with 30 kph over the speed limit on the overtaking lane represent a high potential risk of accidents because of great speed difference of about 50 kph. The evaluation of accident causes confirms the risk because speed and distance/ overtaking occurs most frequently.

5. CONCLUSIONS

The traffic safety had increased mainly by the permanent traffic orders in a range of 30 %. The implementation of the MCS could contribute only less for the overall traffic safety. Here the improvement potential seems to be in range of 0 to 10 % depending on how the general accident development will be taken into account. In the case of a missing permanent speed limit before implementation of a MCS the improvement potential is expected to be on a higher level. By a MCS-operation the accident rate and the percentage of accidents influenceable to MCS decrease about 30 %. The constant level of traffic safety during the MCS operation is on one side the poor acceptance of the traffic orders and on the other side little knowledge of the MCS purpose. Motorway Control Systems can complete the traffic management especially in the case of transparent and actual traffic information. An accumulation of accidents at access points could be observed at the motorways in a metropolitan area with a high density of access points. The analysis of the accident causes as function of space presents clearly the access points that should have been equipped with ramp metering. Usually the speed limit of metropolitan motorways is on level of about 100 kph to optimise the capacity. By this the impacts of VMS-speed limits is restricted. An alternative might the combination of permanent speed limits and ramp metering in metropolitan area. As the research was conducted for only one MCS-section further MCS-sections have to be researched by this procedure to verify the generalisation of the conclusions. Especially the development of the accidents influenceable to MCS has to be observed. A reduction of the accidents cost has to take into account carefully in the case of existing speed limits and other traffic regulations by PTS in cost-benefit-analyses of MCS.

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