

# Modelling and assessing the effects of traffic safety measures



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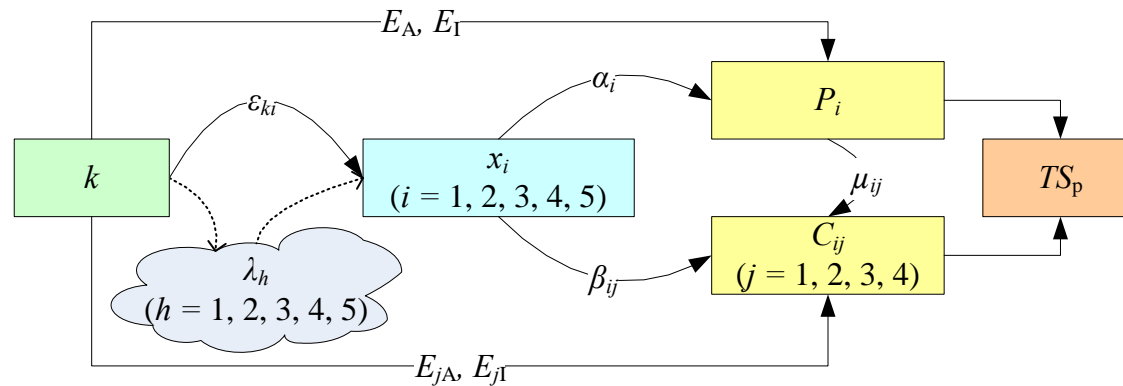
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## Abstract

The nature and the effects of improving road traffic safety by infrastructure redesign and Advanced Driver Assistance Systems (ADAS) are different. This makes comparison of such measures difficult, especially because relevant effect data for ADAS are not yet available. To address this issue, a conceptual model is presented for the effects of road traffic safety measures, based on a breakdown in underlying components of road traffic safety (probability and consequence), and five (speed and conflict related) variables that influence these components, and are influenced by traffic safety measures. The model allows estimating relative effects, and together with available data on absolute effects of infrastructure measures, to estimate absolute effects for ADAS based measures. It may in general help to improve insight in the mechanisms between traffic safety measures and their effects. The model is illustrated by a case study concerning rural roads in the Netherlands.

**Keywords:** ADAS, infrastructure design, traffic safety determinant, effectiveness index



### Causal chain process for the influence of traffic safety measures on traffic safety

$k$  - measure

$TS_p = f_p(P, C)$  - traffic safety in terms of probability

$P_i$  - accident probability

$C_{ij}$  - accident consequence ( $j=1,2,3,4$  represents fatality, hospitalisation, slight injury and damage-only respectively)

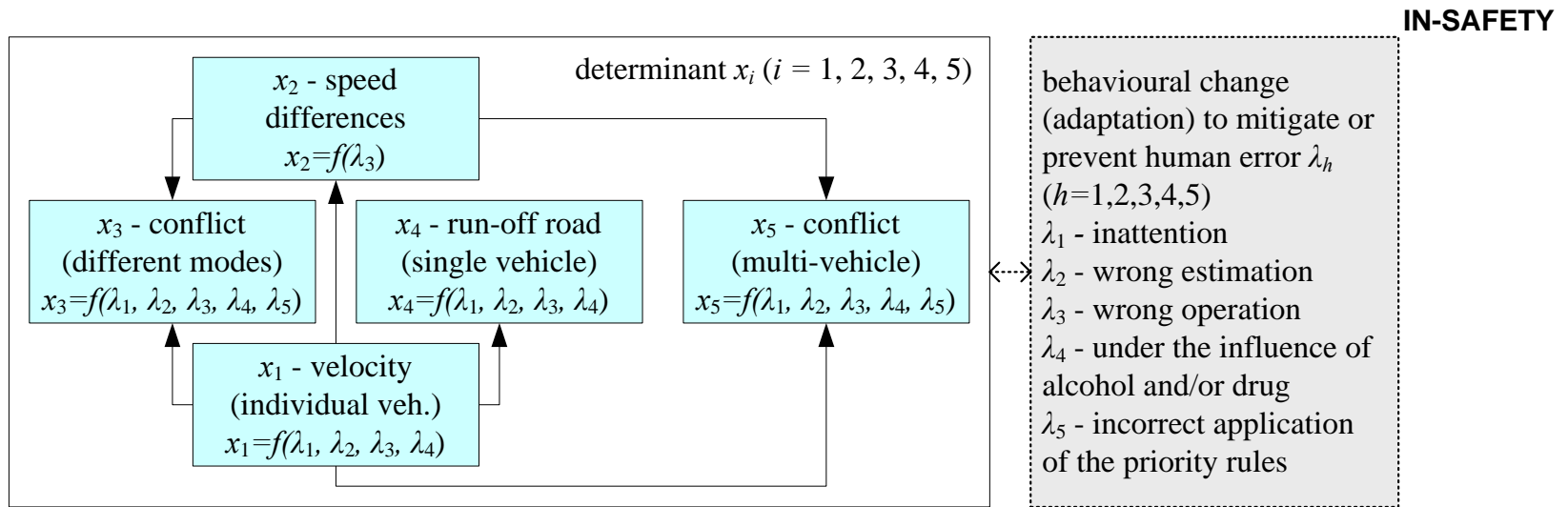
$\varepsilon_{ki}, \alpha_i, \beta_{ij}, \mu_{ij}$  - coefficient

$\lambda_h$  - human error

$x_i$  - (speed or conflict related) traffic safety determinant

$E_j$  - absolute effect of a measure on consequence of type  $j$

$E$  - absolute effect of a measure on risk (A - ADAS, I - infrastructure)



### Traffic safety determinants and relationships, related categories of human error

- $x_1$  - velocity ( $\vec{v}$ , speed and direction) of individual vehicle as compared to the legal speed limit or the safe speed limit, and to logical driving direction
- $x_2$  - velocity differences ( $\Delta\vec{v}$ ) of traffic participants, vehicle-vehicle or vehicle-VRU (vulnerable road user), where vehicle is to be understood as a motor vehicle
- $x_3$  - conflict between different modes, especially between motor vehicles and VRUs, in mixed traffic situations
- $x_4$  - single vehicle run-off road by loss of lateral control or by wrong manoeuvring
- $x_5$  - multi-vehicle conflict, i.e. vehicle-vehicle collision situations, including sub-determinant  $x_{5.1}$  run-off lane,  $x_{5.2}$  intersection conflict,  $x_{5.3}$  rear-end,  $x_{5.4}$  head-on and  $x_{5.5}$  other conflict, e.g. U-turn related and sideswipe

## Estimated values of influence coefficients

determinant	probability influence coefficient	direct consequence influence coefficient		indirect consequence influence coefficient	
		$j = 1$ (fatality)	$j = 2$ (hospitalisation)	$j = 1$ (fatality)	$j = 2$ (hospitalisation)
$x_1$	$\alpha_1 = 0.021$	$\beta_{11} = 0.026$	$\beta_{12} = 0.009$	$\mu_{11} = 0.071$	$\mu_{12} = 0.193$
$x_2$	$\alpha_2 = 0.030$	$\beta_{21} = 0.009$	$\beta_{22} = 0.007$	$\mu_{21} = 0.016$	$\mu_{22} = 0.096$
$x_3$	$\alpha_3 = 0.176$	$\beta_{31} = 0.009$	$\beta_{32} = 0.038$	$\mu_{31} = 0.003$	$\mu_{32} = 0.088$
$x_4$	$\alpha_4 = 0.109$	$\beta_{41} = 0.077$	$\beta_{42} = 0.016$	$\mu_{41} = 0.038$	$\mu_{42} = 0.059$
$x_5$	$\alpha_5 = 0.591$	$\beta_{51} = 0.056$	$\beta_{52} = 0.011$	$\mu_{51} = 0.049$	$\mu_{52} = 0.073$

## Measure effect coefficients & potential safety improvement on rural roads, NL

#	DVI ( <i>k</i> )	$\varepsilon_{ki}$	$E_{1I}$ (%)	$E_{2I}$ (%)	#	ADAS ( <i>k</i> )	$\varepsilon_{ki}$	$E_{1A}$ (%)	$E_{2A}$ (%)
D1	separate bicycle lane	$\varepsilon_{k3} = 0.85$	10.1	6.9	A1	anti-collision	$\varepsilon_{k3} = 0.05$	0.6	0.4
D2	road category recognisable	$\varepsilon_{k3} = 0.05$ $\varepsilon_{k4} = 0.05$ $\varepsilon_{k5} = 0.05$	0.1	0.2	A2	navigation	$\varepsilon_{k3} = 0.20$ $\varepsilon_{k4} = 0.20$ $\varepsilon_{k5} = 0.20$	0.4	0.8
D3	plateau	$\varepsilon_{k1} = 0.65$	35.0	25.0	A3	speed assistance	$\varepsilon_{k1} = 0.75$ $\varepsilon_{k2} = 0.30$	46.0	38.1
D4	parallel roads	$\varepsilon_{k3} = 0.60$ $\varepsilon_{k5} = 0.85$	24.8	17.9	A4	anti-collision	$\varepsilon_{k3} = 0.05$ $\varepsilon_{k5} = 0.05$	1.4	0.7
D5	carriageway separate	$\varepsilon_{k5} = 0.70$	9.8	7.2	A5	lane keeping	$\varepsilon_{k5} = 0.85$	11.9	8.7
D6	pedestrian crossing	$\varepsilon_{k3} = 1.00$	5.1	4.2	A6	anti-collision	$\varepsilon_{k3} = 0.05$	0.3	0.2
D7	semi-shoulder	$\varepsilon_{k4} = 0.65$	20.0	14.0	A7	lane keeping	$\varepsilon_{k4} = 0.85$	26.2	18.3
D8	obstacle free zone	$\varepsilon_{k4} = 0.70$	55.1	39.2	A8	lane keeping	$\varepsilon_{k4} = 0.85$	66.9	47.6
D9	roundabout	$\varepsilon_{k1} = 0.90$	75.0	53.0	A9a	speed assistance	$\varepsilon_{k1} = 0.75$ $\varepsilon_{k2} = 0.30$	17.8	7.4
		$\varepsilon_{k2} = 0.95$			A9b	intersect. support	$\varepsilon_{k5} = 0.60$	38.6	17.4
		$\varepsilon_{k3} = 0.60$ $\varepsilon_{k5} = 0.70$			A9c	anti-collision	$\varepsilon_{k3} = 0.05$ $\varepsilon_{k5} = 0.05$	3.6	2.9
D10	reducing crossing	$\varepsilon_{k5} = 0.75$	80.0	57.0	A10	intersect. support	$\varepsilon_{k5} = 0.60$	64.0	45.6
D11	guard-rail	$\varepsilon_{k4} = 0.75$	54.8	38.7	A11	lane keeping	$\varepsilon_{k4} = 0.85$	62.1	43.9

## Conclusion

The paper presents a model for quantitative analysis of the effects of road traffic safety measures, based on a breakdown of the causal chain between measures and effects. The focus is on probabilities rather than on historical statistics. Two stochastic components of traffic safety, and five (speed and conflict related) determinants that influence them are determined. The determinants may in turn be influenced by traffic safety measures. The relationships between the identified elements of the causal chain are modelled by coefficients. The relationships between measures and determinants have a more subjective character, and their coefficients need to be estimated based on expert judgement. The other relationships have a more technical character, and although their coefficients are estimated from accident statistics, more sophisticated estimation methods may be developed that better comply with their stochastic character. In general the proposed breakdown increases the understanding of the whole process, and thereby facilitates the estimation. Based on the model a method is developed for structured comparative analysis of traffic safety measures. It enables estimating absolute effects for a measure based on the absolute effects of another measure. This is particularly helpful for assessing the effects of ADAS based measures, for which few data exist, by using existing data for infrastructure based measures. This method is illustrated with a case study for a part of a rural road in The Netherlands.