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INVESTIGATION OF SAFETY IMPACT OF DRIVER ASSISTANCE SYSTEMS THROUGH TRAFFIC SIMULATION MODELLING

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GENERAL CONSIDERATIONS

- Advanced driver assistance systems (ADAS) have the potential to improve road safety by influencing exposure to traffic hazards, by reducing the probability of crashes and by reducing injury consequences.

- Driver assistance systems support modification of the driving task by providing information, advice, and assistance. They also influence, directly and indirectly, the behaviour of users of both equipped and non-equipped vehicles and can alleviate accident consequences by in-vehicle intelligent injury reducing systems.

- The EU co-funded project ADVISORS, work is in hand to overall assess the impact from the introduction of advanced driver assistance systems.

OBJECTIVE

The use of microscopic traffic modelling allowing an investigation of safety impact from the introduction of Adaptive Cruise Control and Intelligent Speed Adaptation systems on interurban motorways.

METHODOLOGY

Safety impact was investigated in relation to changes in:

- average speed
- headways
- time-to-collision
- lane changing

Investigation of safety impact sensitivity under different conditions such as traffic level and assumed ADAS penetration.

THE MICROSCOPIC SIMULATION MODELS

- The British model, **SISTM**, can be used to evaluate qualitatively and quantitatively the effect of different layouts or operating conditions on a length of motorway.

- The Dutch simulation model **SIMONE** is designed to analyse traffic flow impacts of a wide variety of driver support system compositions of the vehicle fleet under various roadway configurations and traffic demand conditions.

- The Finnish model **HUTSIM** can deliver traffic indicators, but its main strength is in environmental modelling. Environmental analysis in HUTSIM is divided into emissions and fuel consumption.

FUNCTIONAL CHARACTERISTICS OF SIMULATED ADAS

Assumptions	No ADAS			ACC			ISA			ACC+ISA		
	SIMONE	SISTM	HUTSIM	SIMONE	SISTM	HUTSIM	SIMONE	SISTM	HUTSIM	SIMONE	SISTM	HUTSIM
Minimum speed (km/h)	0	0	0	30	0	0	30	0	0	30	0	0
Maximum speed (km/h)	115	142	No limit	170	142	0	170	142	40 (urban)/ 70 (highway)	170	142	40 (urban)/ 70 (highway)
Acceleration rate (m/s^2)	2,5	0 - 2,68	0 - 1.9	4	0 - 0,28	0 - 1.9	2,5	0 - 2,68	0 - 1,9	4	0 - 0,28	0 - 1.9
Deceleration rate (m/s^2)	-7	-7,86	0 - 2,2	-2,5	-1,25	0 - 2,2	-2,5	-1,25	0 - 2,2	-2,5	-1,25	0 - 2,2
ACC headways (s)	---	---	---	~1-2,5*	1,5-2,0	**	---	---	---	~1-2,5*	1,5-2,0	**
Minimum gaps (s)	Various values for different configurations											
Other	Various values for different configurations											

* function of speed and system control settings

** based on a normal distribution with average 0,7 seconds

SIMULATION MODEL OUTPUTS (SAFETY)

Output	SISTM	SIMONE	HUTSIM
Average speed	X	X	X
Headway	X	X	
Time to collision	X	X	
Lane Change rate	X		

BASIC ASSUMPTIONS

- Increase in speed is associated with an increase in the frequency and severity of accidents.

- Reduction in average headway affords the driver less time to respond to unforeseen events and so must be associated with an increase in the frequency and severity of accidents.

- Headway homogeneity is expected to increase traffic safety.

- Time-to-collision (TTC) has been proposed as an indicator of safety as there needs to be relative speed between vehicles for a collision to occur.

- An increase in lane changing behaviour is associated with reduced safety.

IMPACT ON TRAFFIC SAFETY DUE TO CHANGES ON AVERAGE SPEED

- For ACC scenarios, different findings may be due to the different conditions studied.

- For ISA scenarios, SISTM reports an overall increase in average speed while SIMONE reports a decrease in both situations studied. This difference can be explained by the fact that SISTM imposed a limit of 112km/hr (above the maximum observed average traffic speed of 95km/h) and SIMONE chose a limit of 70km/h (below the previous average speed).

- From a safety point of view it is speed variability and the top-end speeds that have the most profound effects. ISA, by reducing the most excessive speeds and reducing variability, is expected to have a considerable positive effect on safety. The message from the simulations is that it is necessary to choose the speed limit wisely in order to maintain traffic flow at the same time.

IMPACT ON TRAFFIC SAFETY DUE TO HEADWAY CHANGES

- For ACC scenarios, the average headway depends on the proportion of ACC traffic and the ACC set headway. However, from a safety perspective, it is the short headways that are most important to consider.

- SISTM reports the proportion of average headways less than 1 second and ACC is found to reduce this proportion slightly (which is positive for safety). SIMONE reports the proportion of average headways less than 1.5s but does not detect any differences (possible reduction for headways less than 1s).

- If it were found that drivers invariably selected shorter headways than they would without ACC, this would be an important behavioural adaptation that could have negative safety consequences.

- For ISA, SISTM reports no change in the proportion of short headways at low flow but a slight increase at higher flow. SIMONE finds no significant change in short headway.

IMPACT ON TRAFFIC SAFETY
DUE TO CHANGES IN TIME-TO-COLLISION

- SISTM finds reduction in the proportion of TTC values for both ACC and ISA, thus implying improvement in terms of safety
- For ACC and lane drop situations, SIMONE reports reductions in "dangerous" TTC measurements but increases in "uncomfortable" TTC measurements.
- For the on-ramp situation both TTC measures imply decreases in safety.
- Regarding ISA, SIMONE finds positive safety effects in the lane-drop situation and negative effects at the on-ramp.
- There is considerable debate about the use of TTC as an indicator of safety in inter-urban situations.

IMPACT ON TRAFFIC SAFETY
DUE TO CHANGES ON LANE CHANGING

- The unexpected result was that ACC seemed to promote an increase in lane changing behaviour (SISTM).
- For ISA-based scenarios there was an (expected) reduction in lane changing (SISTM).
- According to the SIMONE capacity results (no reduction in capacity) may lead to increasing lane changing behaviour.
- If ACC does promote increased lane changing or under use of one of the running lanes, then these are important effects and should be investigated experimentally.

SYNTHESIS OF SAFETY INDICATORS
ADVANCED CRUISE CONTROL (ACC)

ACC	SAFETY IMPLICATIONS		
Output	SISTM	SIMONE	HUTSIM
Average speed	+	0	–
Headway	+	0	
Time to collision	+	+	
Lane Change rate	–		

SYNTHESIS OF SAFETY INDICATORS - ACC

- There is a disagreement between SISTM and HUTSIM results with respect to average speed, which can probably be attributed to the relatively uncongested traffic prevailing in the HUTSIM simulated scenarios, which allowed for more significant speed increases (interpreted here as safety decreases).

- As the average speed changes are small and TTC is controversial, the most important indicator for safety is likely to be headway. In this regard, driver behaviour is crucial. SIMONE, with a modelled headway of 1.25s, finds safety neutral, whereas SISTM models longer headways and finds safety improvements. A key question is whether drivers choose ACC headways shorter or longer than they would without ACC.

- Finally, the increase in lane changing reported by SISTM is an interesting effect that may warrant further study in driving simulators and field trials.

SYNTHESIS OF SAFETY INDICATORS
INTELLIGENT SPEED ADAPTATION (ISA)

ISA	SAFETY IMPLICATIONS		
Output	SISTM	SIMONE	HUTSIM
Average speed	–	+	+
Headway	–	0	
Time to collision	+	+, –	
Lane Change rate	+		

SYNTHESIS OF SAFETY INDICATORS - ISA

- Average speed produces diverging safety results. This can probably be explained by the choice of the ISA limit in the various models (SISTM used a limit above the average speed while SIMONE and HUTSIM used a limit below).

- Positive safety effect of ISA by decreasing speed variability and reducing "top-end" speeders.

- For ISA the dominant effect is thought to be the reduction in "top-end" speeders and lower speed variability. Both of these factors are very positive for safety. An interesting area where modelling can be employed is in the choice of appropriate ISA limits so that impacts on traffic flow are optimised.

CONCLUSION

- Even though an overall conclusion concerning the safety impact of ADAS systems is not possible due to the complexity of the traffic safety phenomenon, several positive effects on safety were identified. These positive effects varied according to the traffic situations and their presence also depends directly on the penetration level of the ADA systems.

- Application of the proposed methodology showed that extraction of some conclusions about ADAS safety impact is possible through microscopic traffic modelling. Such modelling is also very useful in highlighting areas where further detailed experimental analysis is required to identify changes in driver behaviour.

NEXT STEPS

- Further research using various types of road network and traffic situations with the proposed methodology will allow a clearer picture of ADAS impacts to emerge.

- The results contribute to strategic decisions concerning the importance and urgency of implementation of each ADAS, and can therefore play an important role in their future development.