Road network efficiency and environmental impact assessment of Driver Assistance Systems

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Outline

- Objective
- Methodology
- Microscopic simulation results
- Macroscopic simulation results
- Conclusions

Objective

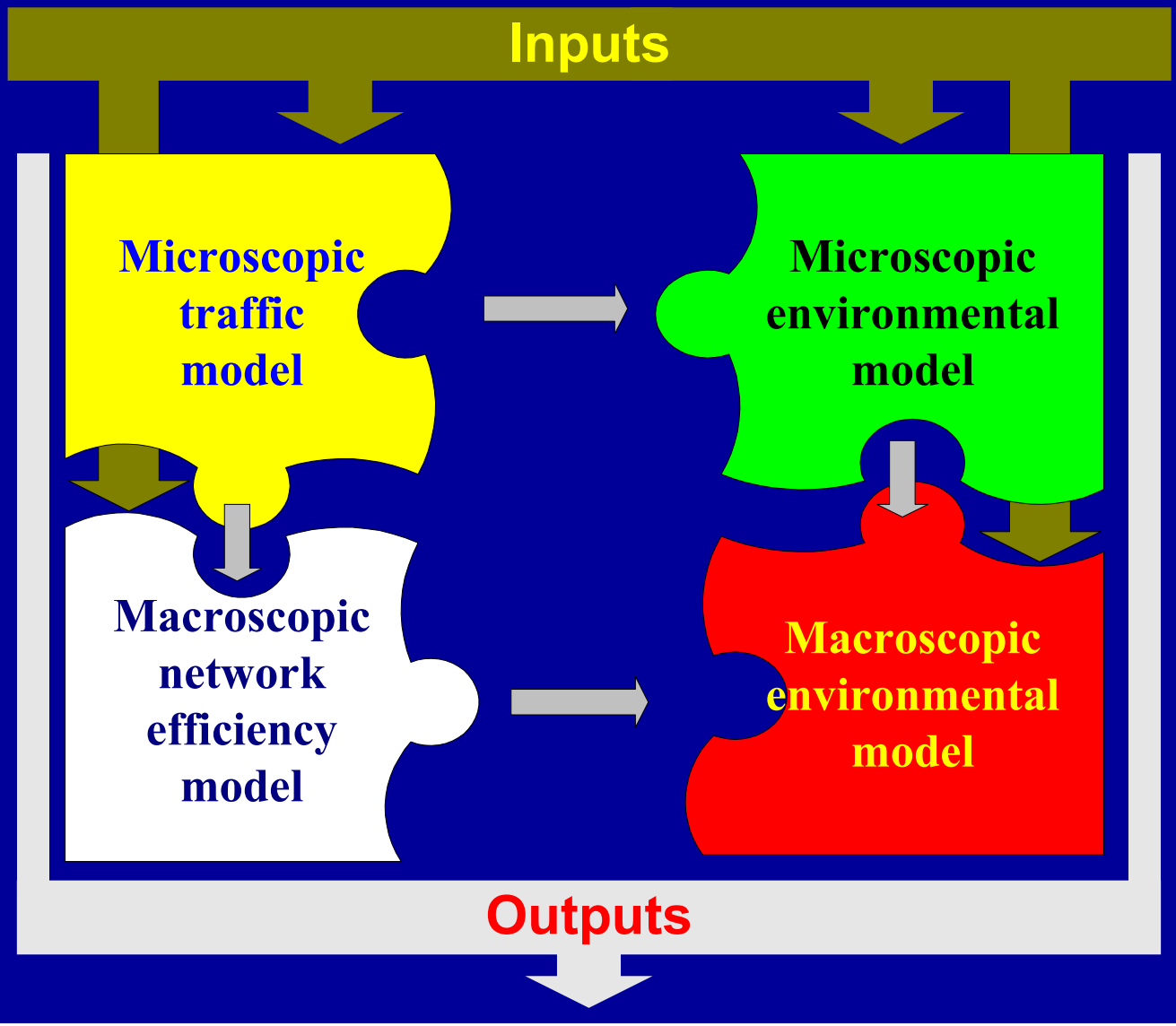
Indicative assessment of:

- Road network efficiency and
- Environmental impact

of selected Driver Assistance Systems at:

- Local scale (micro-models) and
- Network level (macro-models).

Methodology



Simulation models

Microscopic

- HUTSIM (Helsinki U. of Technology) [traffic, environmental]
- SIMONE (TRAIL/U. of Delft) [traffic]
- SISTM (TRL) [traffic, environmental]

Macroscopic

- SATURN (University of Leeds) [traffic]
- TEMAT (The VITO) [environmental]

Considered scenaria

- Type of impact [Traffic/network efficiency, Environmental]
- Level of impact [Microscopic, Macroscopic]
- Type of ADAS [ACC, ISA]
- Penetration levels [0→100%]
- Network parameters [urban/interurban (micro), urban (macro)]

Microscopic models

Functional characteristics, including

- Minimum speed
- Maximum speed
- Acceleration range
- Deceleration range
- Gap acceptance

Microscopic / Traffic

	SIMONE		SISTM		HUTSIM	
	ACC	ISA	ACC	ISA	ACC	ISA
Average speed	0, (+)	0	0, +	0, (-)	+	+
Headway	+	0	+	+, -		
Capacity	+	0, (-)	+	+		

Impact on average speed

- Impact of ACC increases with system penetration and traffic flow.
- As traffic volume increases, the speed at capacity is higher for the ACC.
- ACC and ISA systems combined provide better results (but not as good as the cumulative impact of the two systems.)

Impact on headways

- If ADAS headway parameter is 1.8s, flow falls; with short headway, flow increases.
- Reducing headway variability will:
  - increase the stability of traffic,
  - reduce lane changing and overtaking and
  - allow increased flows.
- Headway distribution is more uniform at higher ACC penetration levels.

Impact on traffic capacity

- ACC has positive impact on capacity
- ISA has a small effect on capacity

Microscopic / Safety

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

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

Impact on traffic safety due to changes on average speed

- **ACC**: small reduction in average speed is expected to have a direct impact on traffic safety.
- **ISA:** expected to have a great effect on safety.
- 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 changes on headway

- **ACC:** reduction of **headways** less than 1 second ➔ positive impact.
- **ACC**: Avoidance of **very short headways** ➔ positive safety impact.
- **ISA**: the change in the proportion of short headways for higher flow levels can lead to positive impact on traffic safety.

Impact on traffic safety due to changes on time-to-collision

- **ACC and ISA:** The reduction in the proportion of low time-to-collision values implies improvement in terms of traffic safety.

Microscopic / Environmental

	SISTM		HUTSIM	
	ACC	ISA	ACC	ISA
Fuel consumption			++	+
CO emissions	+	++	++	+
CO_2 emissions	0	0		
PM emissions	+, (-)	+, (-)		
HC emissions	0, -	0, -	++	+
NOx emissions	-	-	++	+
Noise	0	0		

Impact on the emissions

- **Speed** generally increases and becomes smoother with ADA systems ➔ positive environmental impacts.
- **CO emissions** decrease directly proportionally to the penetration level.
  - ACC results in almost twice as steep a decrease than ISA, while
  - ACC+ISA is slightly better that ACC alone.

Impact on fuel consumption and noise level

- Improvements in **fuel consumption** become more significant at higher ADAS penetration levels.
- It cannot be claimed that ADAS will have a significant noise reduction impact.

Macroscopic

- Network efficiency
  - Average speed
- Environmental
  - Emissions

Impact on average speed

- Impact **increases proportionally** to the ADAS penetration level.
- Higher traffic flow level relates to lower **average speed** increase.
- ACC systems offer better **network efficiency** results than ISA systems.
- The benefits of a **combined ACC and ISA** system are only marginally better than the ACC system.

Impact on emissions

- ADAS systems **reduce** the fuel consumption and the emissions of PM, CO_2, Pb, SO_2, THC, CO, and NOx. (in this order, urban environment)
- **ACC** use leads to higher emission reduction.
- Larger emission reduction for higher ADAS **penetration levels**.

Conclusions

- Indicative results: overall positive (ACC > ISA)
- Trends should be universal but magnitude of impacts is expected to be case-specific
- Methodology should be applicable to variety of network/population/system combinations
- More research is needed, e.g.
  - Improper use of the systems
  - Behavioral models for ADAS use