6. THE EFFECTS OF SPEED LIMITERS OF HEAVY VEHICLES - A TRAFFIC SIMULATION STUDY

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6.1 BACKGROUND

The EC Commission proposed in 1990 that heavy vehicles operating in the EC countries should be equipped with speed limiters. The maximum speed for lorries should be 80 km/h, and for buses and coaches 100 km/h. The actual adjustment speed should not exceed this value with more than 5 km/h. In 1991, the ministers of Transport, however, agreed on principle about the speed limiters but decided to increase the maximum speed for lorries to 85 km/h (Finnish EC delegation 1991).

The Finnish Ministry of Transport and Communications wanted to find out the effects of the proposed speed limiters on traffic flow, and especially on travel speeds, traffic safety and the operating costs of traffic. The ministry commissioned VTT to carry out the study. The study was mainly based on the EC Commission's proposal, and the significance of the 1991 modifications had to be evaluated after the actual completion of the study.

In 1990, the total vehicle mileage of Finnish public roads was 28 000 million vehicle kilometres. Of these 7900 were driven on roads with a marked 80 km/h speed limit, 8700 on 100 km/h roads, and 710 on 120 km/h roads (Beilinson et al 1992). In Finland, we have a speed limit of 120 km/h on motorways only. Traffic on roads with lower speed limits will probably not be affected by the speed limiters. The composition of traffic on the roads with a speed limit between 80 and 120 km/h is the following:

Cars	80 %
Lorries	10 %
Buses	2 %
Vans and others	8 %

We realised at once that this study can not be carried out with traditional analytical methods, as the changing the maximum speeds of lorries with a speed limiter cause complicated effects on the behaviour of other vehicles travelling in the same flow too. Thus we decided to carry out the study as a simulation study.

6.2 SIMULATION

The Swedish Road and Traffic Institute VTI has developed a simulation model for two-lane roads in the course of the last twenty years. We have calibrated together with VTI the simulation model in Finnish conditions before, and it has been applied in Finland at a number of occasions with satisfactory results. We thus judged that we could rely on the results of the simulation model to a sufficient degree.

The VTI simulation model need the following input data:

- road geometry
- sight distances to both directions at all points
- speed limits
- free speeds (in order to obtain the target speed for every vehicle)
- composition and volume of traffic

We decided to "build" two roads for the simulation. One was a typical 80 km/h road with a width of 9 m, and two 600 m sight distance maximums. The sight distance was more than 300 m for 60 % of the road length, and more than 460 m for 28 % of the length. The other one was a typical 100 km/h road with a width of 9 m, and one 1000 m sight distance maximum. The sight distance was more than 300 m for 70 % of the road length, and more than 460 m for 54 % of the length.

The free speed distribution for the roads were obtained from the automatic traffic measurement stations of the Finnish National Roads Administration on straight 9 m wide road sections at periods of low traffic volume.

The mean and standard deviation of free speeds were (measurements):

	Speed limit	Mean speed	Standard deviation
Cars and vans	80	87.0	11.0
	100	95.0	11,5
Buses 100 km h	80	85.0	10.9
	100	89.7	6,6
Lorries, no trailer	80	83.0	7,2
& buses	100	84,0	7,7
Lorries, trailer	80	83.0	6,1
	100	84,0	6,5

We assumed that the speeds of only the last two groups are affected by the speed limiters, and only those speeds above the threshold value, which is 85 km/h according to the EC proposal and 90 km/h according to the final agreement. The speeds above the threshold value were changed to follow a normal distribution of expected value of 82,5 km/h (87,5 km/h according to the final agreement) and a standard deviation of 1,0 km/h. The percentage of speeds changed to follow this distribution were:

	Speed limit	% vehicles over threshold value of 85 km/h	90 km/h
Lorries, no trailer	80	53.3 %	26,7 %
& buses	100	58,2 %	32,6 %
Lorries, trailer	80	54,0 %	23,0 %
	100	60,0 %	30,0 %

The traffic flows to be simulated were 0, 450 and 1000 vehicles per hour. The flow of 0 vehicles per hour means simulation of free vehicles only, i.e., vehicles which do not encounter other vehicles and the speeds of which depend on their target speed and road geometry only. The flow of 450 vehicles per hour is a typical workingday flow. 75 % of all mileage on roads with a 80 km/h speed limit is driven at flows below 450 veh./h. The flows of 1000 vehicles per hour are encountered on busy roads during Friday and Sunday evenings.

The flows were chosen on the basis of VTTs earlier experiences, as with this values we can quite well interpolate and in some cases also extrapolate the effects for the whole flow range.

The simulated road sections were 10 km long.

6.3 RESULTS OF THE SIMULATION

The simulation model produces the following output data:

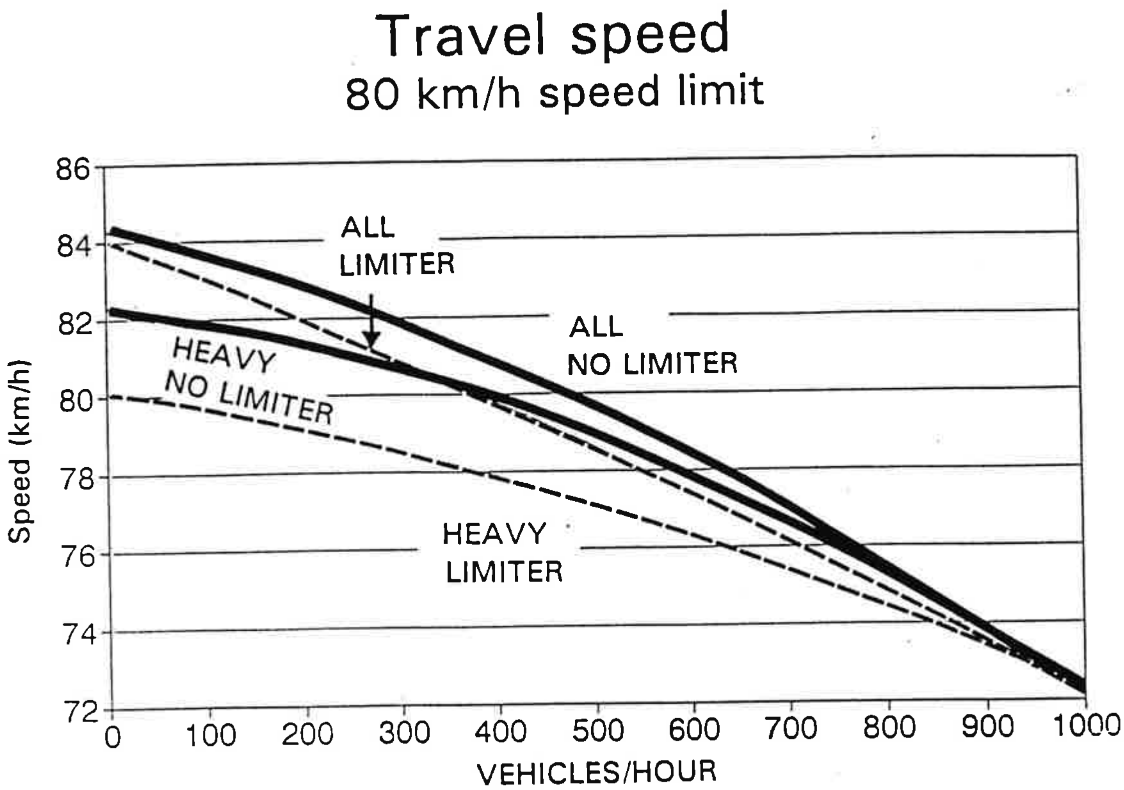
- travel speeds and their distribution
- fuel consumption
- overtakings
- time driven in platoons

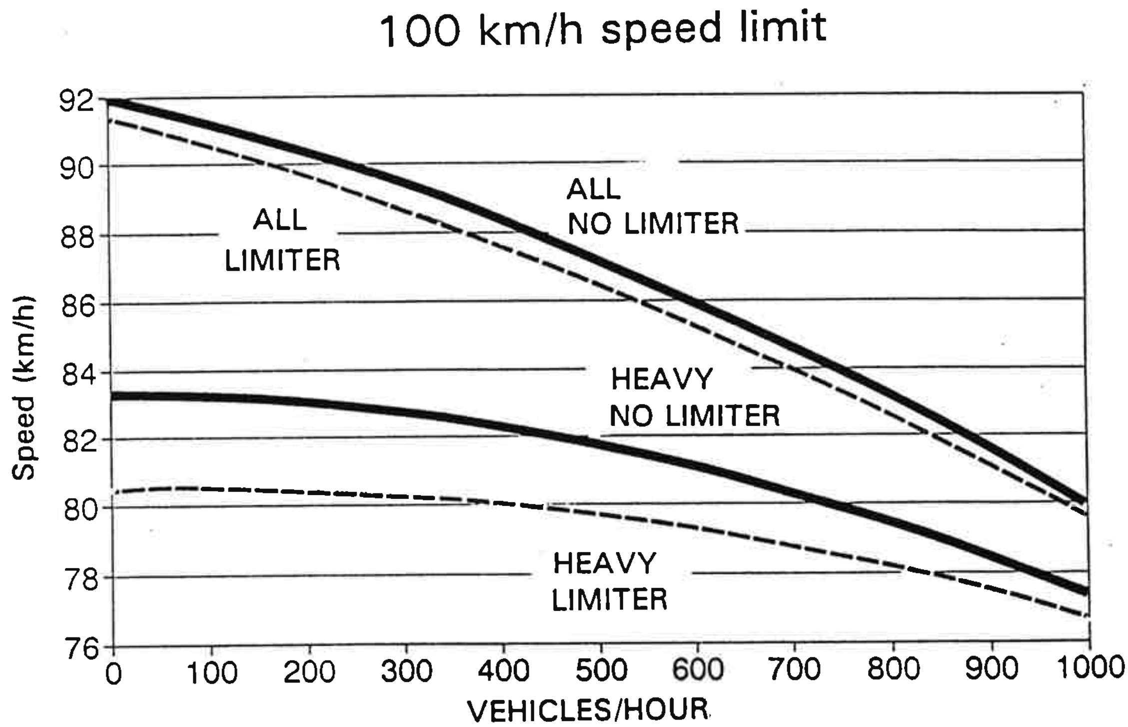
The effects of the speed limiter on the average travel speeds are shown in Table1 and Figure 1.

Table 1. The change in average travel speeds (km/h) caused by the speed limiter of heavy vehicles in different flow conditions.

Vehicle type hourly flow	Speed limit on road 80 km/h	100 km/h
Heavy vehicles		
Free flow	- 2.2	- 2.9
450 veh/h	- 1.9	- 2.1
1000 veh/h	0	- 0.7
Cars and vans		
Free flow	0	0
450 veh/h	- 0.9	- 0.5
1000 veh/h	- 0.1	- 0.4
All vehicles		
Free flow	- 0.3	- 0.6
450 veh/h	- 1.0	- 0.7
1000 veh/h	- 0.1	- 0.4

Figure 1. The effects of the speed limiter on the average travel speeds of heavy and all vehicles for different hourly traffic volumes.





The changes are naturally generally larger for heavy vehicles than for cars. The speed decrease of lorries is largest for free vehicles, and very small for flows of 1000 vehicles/hour. At high flows, the traffic density starts to decrease speeds in any case and thus the speed limiters have less effect. For cars and vans, the effects are nonexistent for free vehicles, and quite small for high flows. The largest speed decreases for cars and vans occur at medium flows.

The effects on the standard deviation of speed are shown in Table 2.

Table 2. The change in the standard deviation of travel speeds (km/h) caused by the speed limiter of heavy vehicles in different flow conditions.

Vehicle type hourly flow	Speed limit on road	
	80 km/h	100 km/h
Heavy vehicles		
Free flow	- 1.6	- 2.3
450 veh/h	- 0.8	- 1.7
1000 veh/h	- 0.4	- 0.5
Cars and vans		
Free flow	0	0
450 veh/h	+0.2	- 0.1
1000 veh/h	0	- 0.2
All vehicles		
Free flow	0	+ 0.2
450 veh/h	+0.2	- 0.1
1000 veh/h	- 0.1	- 0.3

The effects are the greatest for free heavy vehicles. Otherwise, the effects on the standard deviation of speeds are quite small.

According to the simulations, the speed limiters would decrease the fuel consumption of heavy vehicles by ca. 4 % on 80 km/h roads, and by 5 % on 100 km/h roads. The limiters would have very little effect on the fuel consumption of cars and vans.

The overtakings would decrease by 3 overtakings/km and hour on 80 km/h roads, and by 0,5 overtakings on 100 km/h roads. The number of overtakings, where a car overtakes a heavy vehicle, would increase while overtakings of any other type would decrease.

Cars and vans would spend 1 - 2 % more of their time in platoons after the implementation of a speed limiter, whereas the heavy vehicles would spend 0 - 2 % less of their travel time in platoons.

6.4 SAFETY EFFECTS

We divided the safety effects into two categories: primary and secondary effects. The primary effects would result from the effects on accidents involving heavy vehicles. The secondary effects are due to the overall changes in traffic flow caused by the speed limiter.

According to Nilsson (1984), the primary effects are approximately proportional to the change in the kinetic energy of the vehicles involved in accidents. The changes in kinetic energy, and thus the effect on the accidents involving heavy vehicles, are shown in Table 3.

Table 3. The change in the kinetic energy of heavy vehicles caused by the speed limiter of heavy vehicles in different flow conditions i.e. the primary safety effect.

Hourly flow	Speed limit on road	
	80 km/h	100 km/h
Free flow	- 5 %	- 7 %
450 veh/h	- 4 %	- 5 %
1000 veh/h	- 0 %	- 1 %
Average	- 4.5 %	- 6 %

When the effects are converted into annual accident victims, the primary effects would mean an annual saving of 3 dead and 13 injured persons on the Finnish road network.

For the calculation of the secondary effects, we decided to use the general relationships between speed changes and accident changes obtained from the extensive speed limit study carried out by Salusjärvi (1980). The changes in the standard deviation of speed were so small that we estimated the safety effects on the basis of the changes in average travel speeds (Table 1). The resulting safety effects are shown in Table 4.

Table 4. The change in the number of accidents caused by the speed limiter of heavy vehicles in different flow conditions i.e. the secondary safety effect.

Hourly flow	Speed limit on road	
	80 km/h	100 km/h
Free flow	- 1 %	- 3 %
450 veh/h	- 4 %	- 3 %
1000 veh/h	- 0 %	- 2 %
Average	- 2.5 %	- 3 %

When the secondary effects are converted into annual accident victims, the speed limiters would cause an annual saving of 9 dead and 96 injured persons on the Finnish road network. The secondary effects are thus much larger than the primary effects. In all, the speed limiters would have decreased the annual number of fatalities by 12 persons, and the number of injured by 109 persons, if they had been in all heavy vehicles in 1991.

The speed limiters adjusted to the higher value of 85 + 5 km/h (lorries), would have safety effects that are ca. one third of those above i.e. about 4 dead and 36 injured persons.

6.5 COST EFFECTS

The installation of speed limiters in all heavy vehicles is an extensive investment. This is why we also estimated the monetary benefits due to their implementation. As usually, three different cost categories of vehicle, time, and accident costs were taken into account. The unit cost values generally used in cost-benefit analyses for Finnish road projects were applied in our calculations.

The total cost effects would now be:

Vehicle costs	- 9 million FIM / year
Time costs	+ 137 "
Accident costs	- 109 "
Sum of above	+ 19 million FIM / year

Instead of net benefits, the operating costs of road traffic would increase by 19 million FIM on an annual basis. When we made new estimations based on the final EC agreement of 85 + 5 km/h speed limiters for lorries, the cost effects were:

Vehicle costs	- 3 million FIM / year
Time costs	+ 47 "
Accident costs	- 40 "
Sum of above	+ 4 million FIM / year

It should be noted, however, that the environmental effects are not included in the cost estimations. The speed limiter would decrease exhaust emissions, noise and vibration. If the environmental effects were taken into account, the speed limiters would probably decrease the operating costs of road traffic.

6.6 CONCLUSION

The compulsory speed limiters for heavy vehicles will improve traffic safety by decreasing the number of fatalities and injuries caused by road accidents. In cost terms, the accident savings are offset by the time cost increases due to slightly lowered speeds.

It is quite bold to draw conclusions about the safety effects of the speed limiter on the basis of a few simulations on two "typical" roads. The results are not accurate but they probably give a reliable estimate of the general magnitude and direction of the changes, which the speed limiters will cause in the traffic system.

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