

EFFECTS, ACCEPTANCE AND IMPLICATIONS OF ISA – RESULTS FROM RESEARCH IN LUND

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Speed limiting via an in-car device has been studied at the Department of Technology and Society since 1986. The device used provides a gas pedal counter-force whenever the driver tries to depress the pedal beyond a pre-set speed limit. The pedal resistance is sufficient to remind drivers of the speed limit, and the extra effort required to go faster is sufficient to deter them from speeding. However, in case of emergency, the driver can overcome the pedal resistance by pressing with great force. At speed levels below the pre-set maximal speed the performance of the vehicle is not affected.

The first field study with subjects from the public was carried out in 1993 (Persson et al. 1993). Seventy five test drivers drove with- and without an in-car speed limiter on a test route. The results showed that:

- When driving with the speed limiter, speeds were lower on stretches, while speeds were somewhat higher on approaches to intersections and when turning at intersections.
- Driving time along the test route was on average 2% (33 seconds) longer when driving with the speed limiter.
- The calculated average amount of emissions (based on speed and acceleration levels in each second) was 5% less for NO_x and 1.4% less for CO when driving with the speed limiter.
- The proportion of driving against red/amber at traffic lights was smaller when driving with the speed limiter.
- The proportion of keeping inappropriate distance to the car ahead was smaller when driving with the speed limiter.
- The proportion of inappropriate behaviour in interactions with other road users – especially vulnerable road users - was larger when driving with the speed limiter.
- The number of conflicts with other road users was lower when driving with the speed limiter.
- When driving with the speed limiter the test drivers were passed by other cars 62% more often than when driving without.
- Some of the test drivers who were negative to the idea before the test drive, became positive after driving with the speed limiter.

- Most of the drivers were positive to the speed limiter with regard to general impression, feeling of hindrance and stress, but negative about whether the speed limiter try the patience of the driver or not. The most often mentioned advantage for drivers was smoother rhythm in traffic and better preparedness for unprotected road-users. The most commonly meant disadvantages for drivers were that it would be impossible to accelerate and sometimes exceed the speed limit.

When it comes to the introduction of different in-car systems, driver acceptance is of a great importance. Therefore, a nation-wide survey among 1000 Swedish holders of driving licence was carried out in 1995. The results showed that the majority of the respondents were positive to a device which automatically lowers the maximum possible speed of the car in slippery conditions and poor visibility, as well as to a device which warns the driver or reduces the speed automatically if the car is about to collide with another road-user. A general speed limiter which prevents exceeding the prevailing speed limit is accepted by one third.

Table 2. Driver acceptance of different systems for influence of speed behaviour.*

	Speed limiter			Collision risk	
	generally	on slippery road	in poor visibility	Warning	Intervention
For	34%	59%	59%	80%	65%
Against	48%	23%	23%	7%	19%
Neither	16%	16%	16%	11%	14%

* Measured by answering the questions: "What do you think of a system 1) which prevents the driver from exceeding the speed limit or automatically reduces the maximal possible speed of the vehicle 2) on slippery roads / 3) in conditions of poor visibility or 4) warns the driver / 5) brakes automatically if the car is about to collide with another road-user"?

In 1996, theoretical work on the concept of dynamic speed adaptation was carried out. In order to define critical situations in which speed adaptation is unsatisfactory a number of traffic safety researchers from 20 countries were asked to rate the seriousness of various situations. The proportion of injury accidents in the different situations were also considered. Expert judgements, the high proportion of injury accidents and the increased accident risks compared to "normal" conditions show that road surface, visibility and weather dependent situations are most critical considering speed adaptation. Consequently, improved speed adaptation has the largest safety potential in the following situations:

- Road surface-, visibility and weather affected situations (e.g. slippery road, fog, darkness).
- Places, where drivers after prolonged driving at high speeds have to adapt the speed to a lower level to be able to negotiate the situation (e.g. motorway exits, sharp bends).
- Encounters with crossing-course both between motor vehicles and between motor vehicles and pedestrians/cyclists (e.g. at intersections, at zebra crossings).

A system algorithm was proposed, which calculates the appropriate highest speed for different conditions, such as:

- Speed limit. The input for the static speed limiting function is the prevailing speed limit.

- Wet/slippery roads with decreased friction. The criterion for speed adaptation in conditions with decreased friction is that the driver should be able to stop the vehicle within the same distance on wet or slippery roads as on dry roads. The input for this function are friction, gradient and “constant stopping distance” in dry conditions at the speed limit.
- Decreased visibility because of fog, haze, rain, snow. The criterion for speed adaptation in decreased visibility is that the driver should be able to stop the vehicle within half of the visibility distance on roads with oncoming traffic, and within the visibility distance on motorways. The input for this function are friction, gradient and visibility distance.
- Darkness. The criterion for speed adaptation in darkness is that the driver should be able to stop the vehicle within the lit-up visibility distance. The input for this function are friction, gradient and lit-up visibility distance (low beam / high beam).

The possible safety effects of a system with dynamic speed adaptation were estimated. In a scenario where all vehicles are equipped with speed limiters and therefore do not exceed the prevailing speed limit and adapt their speeds in adverse conditions to the level of the “appropriate highest speed” (with the assumption that vehicle mileage remains unchanged) the proposed speed adaptation system would lower the number of police-reported injury-accidents by between 20% and 40% in Sweden.

In 1997, in order to test the concept on all types of roads and compare driver reactions in different regions of Europe, field trials were carried out within the framework of the EU-financed project MASTER in three “region-typical” countries: Sweden, The Netherlands and Spain. Twenty subjects from the public in each country test drove an instrumented car along a test route with different speed limits. A so-called unobtrusive instrumented car was used, where all the measuring equipment was hidden. All the speed limit categories in the respective countries, ranging from 30 km/h to 120 km/h were included. The results revealed that:

- High speeds were decreased effectively, which resulted in less variation of speeds.
- Approach speeds at roundabouts, intersections and curves became smoother,
- Time-gaps in car following situations increased slightly in the speed interval between 30 and 50 km/h indicating that following behaviour became safer when driving with the speed limiter. On the other hand, in the speed interval between 70 and 90 km/h time-gaps decreased which indicates a less safe following behaviour.
- Behavioural observations could not show any negative adaptation effect in form of incorrect giving-way behaviour towards other road-users. The proportion of pedestrians, cyclists and cars which got priority did not change when driving with the speed limiter compared to driving without.
- Travel time invcreased on average by 6.6%.
- A subjective measurement of the drivers’, carried out with help of RTLX (Raw Task Load Index) method revealed that the test drivers on average reported statistically significant **increases in frustration level** and **decreases in performance** when driving with the speed limiter. The changes in these aspects of workload, however, may be expected when first driving with a new equipment. (workload aspects: mental demand, physical demand, time pressure, performance, effort, frustration level)
Dutch drivers reported more significant *increase in frustration level* than the subjects

in the other two countries.

Spanish drivers reported more significant *decrease in performance* than the subjects in the other two countries. No statistically significant differences could be found for Swedish drivers.

- The majority of the subjects accepted the speed limiter as a driver-operated system.
- Half of the drivers would accept the limiter voluntarily in their own cars. (Esp: 14 no of 20; Sw: 15 yes of 24; Nl: even).

In 1997, another field trial was carried out – on a bit larger scale - in the town of Eslöv. 25 passenger cars were provided with speed limiters for a period of 2 months. All entry roads to the town have been equipped with radio transmitters on the 50 km/h speed limit sign which activated the speed limiter of entering cars and deactivated of those leaving the town. When the driver started the car, the 50 km/h limit was set automatically.

In order to evaluate driver reactions to and acceptance of the system behaviour observations and interviews were carried out both before and 2 months after having used the system. The results revealed that:

- Clear reductions in speed and in speed variation in traffic environments that permitted driving at high speed (major arterials).
- Travel time increased by approximately 5% when driving with the speed limiter.
- The calculated average amount of emissions (based on speed and acceleration levels in each second) decreased by 15% for NO_x and increased by 1% for CO when driving with the speed limiter.
- Improved behaviour in interactions with other road users (more frequently giving the right of way to pedestrians).
- The acceptance of the device increased after the subject had become accustomed to it. (Three-fourth of the subjects thought more positively of the speed limiter than they had expected they would).
The test subjects experienced the speed limiter as provider of safety and support and did not experience it as either an unwelcome control or a source of irritation. The subjects gave no indication of experiencing any problem in connection with overtaking in the urban area.
The majority of the test drivers expressed a preference for the use of in-car speed limiter compared to physical speed reducing measures in form of humps, narrowing of the road, mini-roundabouts, etc.

In a new, large scale demonstration project in Lund, a large number of cars (about 300) are being equipped with speed limiters and computer memories with the road network system with speed limits in form of a digital map. The vehicles' position will be defined via GPS and the speed limiter be set on the current speed limit.