SWOV Fact sheet

Intelligent Speed Assistance (ISA)

Summary
Intelligent Speed Assistance (ISA) has been a promising type of advanced driver support system for some decades. From a technical point of view, large scale ISA implementation is possible in the short term. The different types of ISA are expected to have different effects on behaviour and traffic safety. The more intruding and controlling an ISA system is, the less it will be accepted by drivers. At the same time, however, the more intruding and controlling, the larger the effects on speed and on road safety in general. Successful implementation of ISA is largely dependent on the willingness of drivers to buy these systems and use them correctly, the quality of the maps that are used to indicate maximum speeds, and the possibilities for a gradual implementation. So far there is no substantial implementation of ISA anywhere in the world and ISA threatens to become a very effective road safety measure that is not used widely anywhere.

Background and content
Speeding is a major cause of traffic crashes (see also SWOV Fact sheet *The relation between speed and crashes*). Controlling the speed of individual vehicles is expected to increase road safety considerably. Intelligent Speed Assistance (ISA) is a promising type of advanced driver support system (also called Advanced Driver Assistance Systems (ADAS)) which can play an important role. This fact sheet discusses the different types of ISA, the effects that are to be expected, and the possibilities for implementation. Other speed management measures are discussed in SWOV Fact sheet *Measures for speed management*.

What is Intelligent Speed Assistance (ISA)?
Intelligent Speed Assistance (ISA) is the general term for advanced systems that assist the driver in choosing the correct speed, aimed at compliance with the speed limits.

ISA systems can use three types of legal speed limits (Carsten & Tate, 2005):
1. Fixed speed limits:
   The driver is informed of the posted speed limit at a location.
2. Dynamic speed limits:
   The dynamic ISA system uses speed limits that take account of the actual road and traffic conditions (weather, traffic density) while using the posted limit as the maximum speed limit. Therefore, dynamic speed limits differentiate between both place and time.
3. Variable speed limits:
   The driver is additionally informed about (lower) speed limits at special locations like road construction sites, pedestrian crossings, sharp curves, et cetera, (often as an advisory speed limit). The speed limits are therefore dependent on the location.

In general, ISA systems establish the position of a vehicle and compare the speed of the vehicle with the posted speed limit at a given location using digital maps or reading speed limit signs as a basis. The systems then give in-vehicle feedback about that speed limit to the driver or even restrict the vehicle's speed according to the speed limit in force.

There is a wide range of ISA systems that differ in the level of support and the kind of feedback that is given to the driver, see *Table 1*. Systems are informative, open (just a warning), half-open (intervening) or closed (impossible to go faster than the limit).

Level of support	Type of feedback	Feedback
Informing	Mostly visual	The speed limit is displayed and the driver is reminded of changes in the speed limit.
Warning (open)	Visual/auditory	The system warns the driver when he exceeds the posted speed limit at a given location. The driver himself decides whether to use or ignore this information and to adjust his speed.
Intervening (half-open)	Haptic throttle (moderate/low force feedback)	The driver gets a force feedback through the accelerator if he tries to exceed the speed limit. If sufficient force is applied, it is possible to drive faster than the limit.
Automatic control i.e. speed limiter (closed)	Haptic throttle (strong force feedback) and dead throttle	The maximum speed of the vehicle is automatically limited to the speed limit in force. The driver's attempt to go faster than the speed limit is simply ignored.

Table 1*. Overview of different variants of ISA systems*

What are the effects of ISA on driving speeds?
Since the early 1980's, the effects of ISA on driving performance and traffic safety have increasingly been researched. ISA research uses different methods and data collection techniques among which micro-simulation, driving simulators, instrumented vehicles and field trials.

The results of the studies all point in the same direction. The general conclusion is that ISA systems appear to have a number of positive safety effects on driving speed: ISA equipped vehicles show an average speed reduction of approximately 2 to 7 km/h, as well as a reduction in speed variance and speed violations (see *Table 2*).

Study	Methodology	Country	Effect on mean speed	Effect on standard deviation of speed	Speed violations
Comte (2000)	Driving simulator	UK	↓	↓	?
Peltola & Kulmala (2000)	Driving simulator	FIN	↑	↓	?
Hogema & Rook (2004)	Driving simulator	NL	↓	↓	↓
Van Nes et al. (2007)	Driving simulator	NL	↓	↓	↓
Brookhuis & De Waard (1999)	Instrumented vehicle	NL	↓	↓	↓
Päätalo et al. (2001)	Instrumented vehicle	FIN	↓	?	↓
AVV (2001)	Field trial	NL	↓	↓	?
Lahrmann et al. (2001)	Field trial	DK	↓	?	?
Biding & Lind (2002)	Field trial	S	↓	↓	↓
Regan et al. (2006)	Field trial	AUS	↓	↓	↓
Van der Pas (2012)	Field trial	NL	↓	↓	↓
Vlassenroot et al. (2007)	Field trial	B	↓	↓	↓

Table 2*. Overview of the ISA effects on mean speed and standard deviation of speed in various studies (↓decrease, ↑ increase, ? not investigated). Adapted after Morsink et al. (2006)*

The size of these reductions depends on the type of ISA, with more controlling types of ISA being more effective. Only one study found an increase in average speed (Peltola & Kulmala, 2000); this study investigated the effects of ISA on icy roads. The ISA system gave a speed advice that was lower than the general speed limit in force. It appeared, however, that the mean speed of ISA drivers was higher that that of drivers without ISA. A possible explanation is (of: an explanation could be) that the ISA speed advice exceeded the speed that drivers would have chosen themselves.

A SWOV driving simulator experiment (Van Nes et al., 2007) investigated the effects of warning ISA on speed behaviour in combination with credible speed limits. As did earlier studies, the results of this experiment showed that ISA has a significant speed reducing effect. A new observation in this study was that the effect was especially significant in situations where speed limits were of low credibility. Furthermore, there were fewer speed violations and smaller differences in speed when driving with ISA.

In a study among (serious) traffic offenders (Van der Pas, 2012) participants drove with a speed controlling ISA or with a warning type of ISA that became a speed limiter in the case of prolonged speeding. During the three months of use, both systems led to a large reduction in speed violations. In addition, the participants themselves reported fewer speed-related violations like tailgating and unnecessary driving in the left lane, and an increase in anticipatory behaviour. Other road users, on the other hand, were found to engage more in tailgating and overtaking and participants were much less alert on speed limits.

What effect does ISA have on traffic crashes?

It is not easy to determine the effect of ISA on traffic crashes. The proportion of vehicles equipped with ISA in the field trials was relatively small, while measuring the effect on traffic crashes requires a substantial number of ISA-equipped vehicles. Therefore, making use of the best available knowledge, the effect was estimated based on driving simulator and traffic simulation studies.

Based on the reductions that were found in mean speed, speed distribution and the percentage of speed violations, ISA systems are assumed to achieve substantial reductions in the incidence and severity of road crashes (Carsten & Tate, 2005). There are large variations in effects, depending on the system type, the type of speed limit and the ISA penetration rate in the vehicle fleet. When comparing the effectiveness of various ISA systems, advisory or informative systems have a much smaller effect than intervening systems. In addition, the effect of ISA based on fixed or variable speed limits is more limited than that of ISA based on dynamic speed limits. *Table 3* presents the results of the Carsten & Tate study. Their estimates assume a 100% ISA penetration level and no behavioural adaptation to ISA and therefore they represent a 'best case scenario'.

System type	Type of speed limit	Best estimate of reduction in injury crashes	Best estimate of reduction in crashes with serious road injuries	Best estimate of reduction in fatal crashes
Advisory	Fixed Variable Dynamic	10% 10% 13%	14% 14% 18%	18% 19% 24%
Intervening but voluntary (with on-off switch)	Fixed Variable Dynamic	10% 11% 18%	15% 16% 26%	19% 20% 32%
Intervening and mandatory (no on-off switch)	Fixed Variable Dynamic	20% 22% 36%	29% 31% 48%	37% 39% 59%

Table 3*. Best estimates of crash savings by ISA type and crash severity (Carsten & Tate, 2005)*

Similarly, assuming all vehicles being equipped with an ISA system that prevents exceeding the (fixed) speed limit, Oei (2001) estimated the reduction in annual fatalities and injuries in the Netherlands. Based on observed speed violations on different road types, Oei estimates the reduction to be 25% which is well in line with the estimated 29% for intervening and mandatory ISA with fixed speed limits in *Table 3*.

It is not yet clear whether these large effects would in fact be achieved in real traffic. There is evidence that drivers could develop certain risky driving behaviour when driving with ISA like accepting smaller gaps when merging (Jamson et al., 2012), adapting shorter following distances, or braking relatively late (Comte, 2000). In addition, the reactions of other drivers towards drivers using ISA are not yet sufficiently known. Furthermore, the long-term effects that ISA will have on driving behaviour when used on a large scale are as yet barely known (Van der Pas et al., 2012).

What effects does ISA have on traffic flow and the environment?
The expectations of the effects of ISA on traffic flow and the environment are based on the reduction and the homogenization of driving speeds.

The results of micro-simulation modelling showed that in high traffic density conditions, ISA would not have a significant effect on network total travel time because driving speeds are already considerably reduced by congestion in high traffic density conditions. However, in lower traffic density conditions, the travel time would increase due to lower average speeds, especially with increasing ISA penetration rates (Liu et al., 1999).

The data on the real effect of ISA on the environment is very limited. The Dutch ISA trial (AVV, 2001) resulted in data that was insufficient to come to an indicative conclusion about the ISA effect on emissions. The results of the Swedish trial in the city of Lund (Várhelyi et al., 2004) showed that there were reductions in the emission volumes mainly for dual carriage ways and 50 km/h speed limits. The average reduction for CO volumes was 11%, for NO_x 7% and for HC 8%. On through roads with a 70 km/h speed limit emissions increased. On the other road types no significant changes were found. The results of an English field trial (Carsten et al., 2008) also show a small decrease of the CO_2 emission volumes for motorways. The average decrease was 3.4% for the open system and 5.8% for the closed system. This English trial found no substantial differences on other road types.

The micro-simulation study by Liu et al. (1999) showed that the emissions of CO, NO_x and HC varied by only +/- 2% for all ISA penetration rates. The total fuel consumption gradually decreased with increasing penetration levels of ISA equipped vehicles and a total of 8% reduction in fuel consumption was achieved.

Do drivers accept an ISA system?
Acceptance is essential for the potential success and effectiveness of ISA. Several factors seem to be significant for the users' acceptance of ISA: the type of ISA system, the type of road environment and the type of driver.

Regarding the type of ISA system, the more intruding and controlling a system is, the less it will be accepted by the drivers. At the same time, however, the more intruding and controlling, the larger the effects on speed and on road safety in general. Evidently, there is the trade-off between the effectiveness of the ISA systems and the acceptance by drivers. The characteristics of the specific feedback given by the ISA system are also important for the acceptance. In general, continuous visual and auditory feedback is preferred to the haptic feedback.

The acceptance of ISA differs for different road types, their related speed limits and the driving speeds. The acceptance is highest for urban roads with 30 and 50 km/h speed limits (AVV, 2001).

It seems that drivers whose speed behaviour would benefit most from ISA, least accept it. Hence, there is a danger of a self-selection bias when ISA is introduced on a voluntary basis. Drivers who "need" ISA most will be least willing to use it (Vlassenroot, 2011). Furthermore, there are indications that long-term use leads to more frustration (Lai et al., 2010). However, when, for example, serious offenders are faced with the choice of either losing their licence or installing the system, their acceptance could increase considerably (Van der Pas, 2012).

In the Dutch trial (AVV, 2001) test drivers initially did not have a very positive attitude towards ISA systems and they favoured normal, unsupported driving. However, drivers' attitudes turned out to be more positive after they had tested the system. Especially the "usefulness" and "satisfaction" offered by the system were more appreciated by the test drivers after driving with ISA than before having gained experience with the system. Eventually, a combination of ISA features like less tickets for speeding, more comfortable and economical driving, and optimization of travel times, may increase the product image and improve the attractiveness for individual drivers.

How to get ISA implemented?

The conclusions of the EU PROSPER project (Carsten, 2005) which assessed road speed management methods (www.prosper-eu.nl), mainly focused on the identification of obstacles to ISA implementation. The most important general barriers to the ISA implementation were found to be the technical functioning of the system, the applicability to the whole road network and the benefits to the users. However, for some countries the cost price is also a very important barrier, as well as the public and political acceptance.

For the short term, gradual market-driven ISA implementation is probably the most realistic scenario (Morsink et al., 2008). At present, various systems are being used already. Many navigation systems give information about the (fixed) speed limits. Warning systems like SpeedAlert are also available already. In these systems ISA is an additional function to the navigation system, be it just advisory. The next step could be making exceeding the speed limit physically difficult. Initially, all these developments could be implemented on a voluntary basis.

In the meantime, considering ISA's large safety potential, the government will need to think over the possibilities and the legal consequences of a mandatory form of ISA. This must be done in cooperation with other European countries (OECD/ECMT, 2006). Mandatory ISA could be especially interesting for some specific risk groups like repeat speed offenders or inexperienced drivers. For these groups it is also important to make the systems fraud-proof (Van der Pas, 2012).

The ISA systems that are presently on the market work with fixed speed limits. The next step would be to add location-dependent variable speed limits, like for example lower speed limits in the schools' surroundings. Both fixed and variable speed limits can be communicated to the vehicle by the digital speed limit database in combination with GPS. ISA based on full dynamic limits, depending on time factors like traffic density or weather conditions, should be the final goal in ISA development. Because dynamic speed limits can better be tuned to the actual circumstances, these types of ISA are expected to have the largest safety gain (see *Table 3*). These systems require new ways of determining speed limits and communicating them to road users (e.g. infrastructure to vehicle communication using road side beacons, and/or vehicle to vehicle communication). Although this is technically possible, further development is necessary to make the system sufficiently reliable.

To stimulate the implementation of informing/warning ISA it is important to facilitate the development of a central speed limit database for the benefit of ISA. Van der Pas (2012) believes that in the Dutch maps that were available at the time of his study, the speed limits are correct for 70 to 90 percent of the road length.

In April 2013, the Belgian parliament accepted the proposal by Temmerman et al. (2012) to begin with the actual implementation of ISA in Belgium, starting with vehicles used by the government. The next step is to go to the EC to urge general introduction.

The insurance companies could also be of assistance by, for example, reducing insurance contributions for ISA users, as was done in the Danish project 'Traffic Safe Young Car Drivers' (Schmidt Nielsen & Lahrmann, 2004).

Conclusions

For quite some time now, ISA has been a promising instrument to reduce the number and severity of traffic crashes substantially. This applies mostly to more intervening, closed forms of ISA in combination with dynamic speed limits, but implementation of informing and warning ISA types in combination with fixed limits will also result in substantial crash reductions. Besides the reduction in the number of traffic crashes, there are also indications of a reduction in fuel consumption and harmful emissions. However, as yet ISA has not been introduced on a substantial scale.

Field trials indicate that the actual driving experience with the system, positively affects the attitude towards ISA; in fact drivers already use advisory ISA in their navigation system. Because intervening types of system are considerably more effective, governments need to encourage the implementation of this type of ISA, also because the drivers who need ISA most, are not likely to use ISA on a voluntary basis.

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