SWOV Fact sheet

Intelligent Speed Assistance (ISA)

Summary
Speeding is one of the most important causes of road crashes. Speed control of individual vehicles is expected to improve traffic safety and efficiency significantly. Intelligent Speed Assistance (ISA) is the most promising type of Advanced Driver Assistance System, and 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 the drivers. At the same time, however, the more intruding and controlling, the larger the effects on speed and on traffic safety in general. A successful implementation of ISA is largely dependent on the willingness of drivers to buy and use these systems correctly, the public's attitudes, and the possible ways of a gradual implementation.

What is Intelligent Speed Assistance (ISA)?
Intelligent Speed Assistance (ISA) is the general term for advanced driver assistance systems that aim at improving compliance with speed limits by drivers of motorized vehicles. In general, ISA systems establish the position of a vehicle, compare the speed of the vehicle with the posted speed limit at a given location, and 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 they give to the driver, see *Table 1*.

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 applying sufficient force, it is possible to driver 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. Driver's request for speeds beyond the speed limit is simply ignored.

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

ISA systems can use three types of speed limits:
1. Fixed speed limits – The driver is informed of the posted speed limits.
2. 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. Therefore the speed limits are dependent on the location.
3. Dynamic speed limits - The dynamic ISA system uses speed limits that take account of the actual road and traffic conditions (weather, traffic density). Therefore, besides being determined by location, the dynamic speed limits are also dependent on time.

What are the effects of ISA on speed?
Since the early 1980's, the effects of ISA on driving performance and traffic safety have increasingly been researched. ISA research uses different methodologies 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*). The size of these reductions depends on the type of ISA, with more controlling ISA types being more effective. Only one study found an increase in average speed. (Peltola & Kumala, 2000) who 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 possisble explanation could be that the ISA speed advice exceeded the speed that drivers would have chosen themselves.

Study	Methodology	Country	Effect on mean speed	Effect on standard deviation of speed	Speed violations
Comte (2000)	Driving simulator	UK	↓	↓	?
Peltola & Kumala (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	↓	↓	↓
Paatalo 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	↓	↓	↓
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)*

In a SWOV driving simulator experiment (Van Nes et al., 2007), the effects of warning ISA on speed behaviour was investigated in combination with credible speed limits. As in previous 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. In addition there were fewer speed violations and smaller differences in speed when driving with ISA.

Testing by Veilig Verkeer Nederland and Senter Novem of one particular warning ISA system named SpeedAlert, also shows that it is effective in reduction of driving speed. In 80% of the situations where the speed limit was exceeded, participants adjusted their driving speed after being warned by the SpeedAlert system (www.veiligverkeernederland.nl).

What are the effects of ISA on traffic crashes?
It is not simple to determine the effect of ISA on traffic crashes. The proportion of vehicles equipped with ISA in the field trials was relatively small, while, in order to measure the effect on traffic crashes, a substantial number of ISA vehicles is required. Therefore, studies making use of a driving simulator and traffic simulation studies are used for effect estimates based on current best knowledge.

Based on the found reductions of mean speed, speed distribution and the percentage of speeding, ISA systems are assumed to achieve substantial reductions in the incidence and severity of road crashes (Varhelyi, 1996; Kievit & Hanneman, 2002; Louwerse & Hoogendoorn, 2004; Carsten & Tate, 2005). There is a large variation 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 mandatory systems. In addition, the effect of ISA based on fixed or variable speed limits is smaller than 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'. The results study by Carsten and Tate (2005) gives an expected estimate of a 36% reduction of injury crashes and a 59% reduction of fatal crashes from mandatory forms of ISA and dynamic speed limits.

System type	Type of speed limit	Best estimate of injury accident reduction	Best estimate of fatal and serious accident reduction	Best estimate of fatal accident reduction
Advisory	Fixed Variable Dynamic	10% 10% 13%	14% 14% 18%	18% 19% 24%
Driver select (voluntary)	Fixed Variable Dynamic	10% 11% 18%	15% 16% 26%	19% 20% 32%
Mandatory	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 (source: Carsten & Tate, 2005)*

Similarly, assuming all vehicles being equipped with an ISA system that would not allow exceeding the (fixed) speed limit, Oei (2001) estimated the reduction in annual fatalities and injuries in the Netherlands. Based on detected speed violations on different road types and using Nilsson's formula on the relation between driving speed and the number of traffic victims (Nilsson, 1981), Oei estimated the reduction to be 25% which is well in line with the estimated 29% for mandatory ISA with fixed speed limits in *Table 3*.

It is not yet clear whether these large effects would also be realised in reality. Although limited, there is evidence that drivers could develop certain risky driving behaviour like adapting closer following distances, accepting smaller gaps when merging or braking relatively late when driving with ISA (Comte, 2000). Furthermore, the long-term ISA effects on driving behaviour are as yet unknown, as is the behavioural response of other drivers towards ISA drivers.

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

The results of micro-simulation modelling of the ISA effect on network efficiency showed that in high traffic density conditions, ISA would not have a significant effect on network total travel time because driving speeds are already largely limited 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 about 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, 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 the other road types there were no significant changes and on arterial streets with a 70 km/h speed limit emissions increased (Varhelyi et al. 2004).

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 users accept an ISA system?
In 2002, over 24,000 European drivers were questioned about how useful they find a system which prevents exceeding the speed limit (Cauzard, 2004). More than 50% of the drivers questioned found that such a system would be very of fairly useful and an even higher percentage of drivers were in favour of fitting such devices to a car.

Acceptance is critical 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 the road environment and the driver's character.

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 traffic safety in general. Evidently, there is the trade-off between the effectiveness and the acceptance by drivers of the ISA systems. The characteristics of the specific feedback given by the ISA system are also important for the acceptance. In general, continuous visual and auditory feedback are preferred over the haptic feedback.

It seems that drivers, whose speed behaviour would benefit most from ISA, accept it least. Hence, there is a danger of a self-selection bias when ISA is introduced on a voluntary basis. Drivers who "need" ISA most would be least willing to use it.

The acceptance of ISA differs for different road types, their related speed limits and the driving speeds. The acceptance is the highest for urban roads with 30 and 50 km/h speed limits (AVV, 2001b; Wiethoff, 2003).

In general, 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 testing 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 economic 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 which assessed road speed management methods (www.prosper-eu.nl), 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.

Because of the complexities and uncertainties surrounding the implementation of ISA, one of the suggested approaches is flexible or adaptive policy making (Marchau & Walker, 2003). This adaptive approach suggests taking some actions immediately and creating a framework for future actions that allows for adaptations over time as knowledge about ISA accumulates and critical events for ISA implementation take place (Marchau & Walker, 2003).

For the short term, gradual market-driven ISA implementation is probably the most realistic scenario. At present, systems are already in use. They are linked to navigation systems and they provide 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, though still to a very limited extent. The next step would be making exceeding the speed limit physically difficult. In the first instance, all these developments could be implemented on a voluntary basis.

In the meanwhile, considering the large ISA safety potential, the government would need to think over the potentials 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 frequent speed violators or inexperienced drivers.

Further development of speed limits that elicit ISA support is also necessary. In order to set a speed limit, it is necessary to establish the safe driving speed. Next important thing is that safe speed limits are also credible speed limits (Wegman & Aarts, 2006).

The ISA systems that are presently on the market work with fixed speed limits. The next step would be to add location-dependant 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 of weather conditions, should be the final goal in ISA development. Because dynamic speed limits can be better 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 developments are necessary to make the system sufficiently reliable.

The role of the government is to stimulate the implementation of informing/warning ISA actively by facilitating the development of a central speed limit database for the benefit of ISA. First attempts are made as shown by www.maximumsnelheden.info.

Also the insurance companies could help by, for example, reducing insurance contributions for ISA users, like in the Danish project 'Traffic Safe Young Car Drivers' (Schmidt Nielsen & Lahrmann, 2004).

Conclusions

ISA is 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 reductions. Besides the reduction in the number of traffic crashes, there are also indications of a reduction in fuel consumption and harmful emissions. This is especially the case for built-up areas, because of a lower and more homogenous speed when driving with ISA.

The European drivers are reasonably to very positive about ISA, especially towards informing/warning ISA systems (Cauzard, 2004). Field trials also showed that the actual driving experience with the system, positively affects the attitude towards ISA. Although mandatory types of system are shown to be more effective, the acceptance of such systems is still low.

Generally, Dutch policy makers are positive towards voluntary forms of ISA. Regarding short term large-scale implementation, a voluntary market-driven approach seems to be most realistic, beginning with the informing/warning system based on the fixed speed limits. However, the potential drawback of this approach could be the self-selection bias for the voluntary use of ISA.

References

AVV (2001a). *Evaluatie Intelligent SnelheidsAanpassing (ISA): het effect op het rijgedrag in Tilburg*, AVV, Nieuwegein.

AVV (2001b). *Eindrapportage praktijkproef Intelligent Snelheidsaanpassing*, AVV, Rotterdam.

Biding, T. & Lind, G. (2002). *Intelligent Speed Adaptation (ISA); Results of large-scale trials in Borlänge, Lidköping, Lund and Umeå during 1999-2002*. Publication 2002:89 E. Swedish National Road Administration SNRA, Borlänge, Sweden.

Brookhuis, K. & de Waard, D. (1999). *Limiting speed, towards an intelligent speed adapter (ISA),* Transportation Research F, Vol. 2, No. 2, pp. 81 – 90.

Carsten, O.M.J. & Tate F.N .(2005). *Intelligent speed adaptation: accident savings and cost–benefit analysis*, Accident Analysis & Prevention, 37 (3) pp.*407-416.*

Cauzard, J.-P. (ed.) (2004) *European drivers and road risk. Part1, report on principal results*. Project on Social Attitudes to Road Traffic Risk in Europe, SARTRE 3. INRETS, Paris, France.

Comte, S.L. (2000). *New systems: new behaviour?* Transportation Research Part F 3 (2), 95-111.

Goldenbeld, C. (2004). *Political support for Intelligent Speed Adaptation (ISA); Interview study among representatives of Netherlands political parties*. R-2004-5. Stichting Wetenschappelijk Onderzoek Verkeersveiligheid SWOV, Leidschendam.

Hogema, J.H. & Rook, A.M. (2004). *Intelligent speed adaptation: the effects of an active gas pedal on driver behaviour and acceptance*. On request of the Dutch Ministry of Transport, Public Works and Water Management, Transport Research Centre AVV and the European Commission.TNO report TM-04-D011.

Kievit de, E. & Hanneman. F. (2002). Setting up an ISA trial from a traffic safety perspective methodology research in the Netherlands, proceedings of the ICTCT workshop, Nagoya, Japan. www.ictct.oprg/workshops/02-Nagoya/Kiewit.pdf.

Lahrmann, H., Madsen, J.R. & Boroch, T. (2001). *Intelligent Speed Adaptation - development of GPS based System and Field Trial of the System with 24 test Drivers*, Proceedings of the 8th World Congress on Intelligent Transport Systems, Sidney, Australia, Sept 30 – Oct 4 2001.

Liu, R., Tate, J. & Boddy, R. (1999). Simulation modelling on the network effects of EVSC. Deliverable 11.3. of External Vehicle Speed Control Project. Institute for Transport Studies, University of Leeds, Leeds.

Louwerse, W.J.R. & Hoogendoorn, S.P. (2004). *ADAS safety impacts on rural and urban highways*. In: Intelligent Vehicle Symposium 2004 IEEE, 14-17 June 2004, Parma, Italy. pp. 887-890.

Marchau, V.A.W.J. & Walker, W.E. (2003). *Dealing with uncertainty in implementing advanced driver assistance systems (ADAS) : an adaptive approach.* Integrated Assessment, vol. 4, no. 1, pp. 35-45.

Nes, C.N. van, Schagen, I.N.L.G. van, Houtenbos, M. & Morsink, P.L.J. (2007) *De bijdrage van geloofwaardige limieten en ISA aan snelheidsbeheersing*. Stichting Wetenschappelijk Onderzoek Verkeersveiligheid SWOV, Leidschendam.

Nilsson, G. (1981). *The effects of speed limits on traffic accidents in Sweden*, OECD Proceedings of the International Symposium on the effects of speed limits on traffic accidents and transport energy use, Dublin.

OECD/ECMT (2006). *Speed management*. OECD/ECMT Joint Transport Research Committee, Parijs.

Oei, H-I. (2001). *Veiligheidsconsequenties van Intelligente Snelheidsadaptatie ISA*, R-2001-11, Leidschendam: Stichting Wetenschappelijk Onderzoek Verkeersveiligheid SWOV.

Paeaetalo, M.,.Peltola, H. & Kallio, M. (2001). *Intelligent speed adaptation – effects on driving behaviour*, Proceedings of Traffic safety on three continents conference, Moscow, 19-21 September 2001, pp. 772-783.

Peltola, H. (2000). *Weather related ISA – experience from a simulator*, Proceedings 7th World Congress on Intelligent Transport Systems, 6-9 November Turin, Italy, pp. 54-61.

Regan, M. Triggs, T. Young, K. Tomasevic, N. Mitsopoulos, E. Stephan, K. & Tingvall, C. (2006). *On-road evaluation of Intelligent Speed Adaptation, Following Distance Warning and Seatbelt Reminder Systems: Final results of the TAC SafeCar project*, Monash University Accident research Centre.

Várhelyi, A., Hjälmdahl, M., Hydén, C. and Draskóczy, M. (2004). *Effects of an active accelerator pedal on driver behaviour and traffic safety after long-term use in urban areas*. Accident Analysis & Prevention, 36 (5), pp. 729-737.

Varhelyi, A. (1996). *Dynamic speed adaptation based on information technology; a theoretical background*, Lund Institute of Technology, Lund, Sweden.

Vlassenroot, S., Broekx, S., Mol, J. de, Int Panis, L., Brijs, T. & Wets, G. (2007). *Driving with intelligent speed adaptation: Final results of the Belgian ISA-trial*, Transportation Research A, vol 41 (3), pp. *267-279.*

Wegman, F. & Aarts, L. (eds) (2006). *Advancing Sustainable Safety*, Stichting Wetenschappelijk Onderzoek Verkeersveiligheid SWOV, Leidschendam.

Wiethoff, M. (2003). *Technologieën voor snelheidsbeheersing*, R-2003-12, Leidschendam: Stichting Wetenschappelijk Onderzoek Verkeersveiligheid SWOV.

Websites:
www.prosper-eu.nl
http://sartre.inrets.fr/
www.veiligverkeernederland.nl