Magnus Hjälmdahl
Swedish National Road and Transport Research Institute (VTI)
magnus.hjalmdahl@vti.se

Who needs ISA anyway?
An ISA system's safety effectiveness for different driver types

Introduction

In-vehicle speed-adapters, which have been researched for almost 20 years in various systems, have been ascribed great safety potential; ranging from a 10 % reduction in injury accidents for a system informing the driver of the speed limit, up to a 40 % reduction for a limiting dynamic system, i.e. where the highest appropriate speed is changed due to traffic, weather and road conditions etc. (Almqvist et al. 1991; Persson et al. 1993; Almqvist and Nygård 1997; Várhelyi 1997; Brookhuis and de Waard 1999; Carsten and Fowkes 2000; Varhelyi and Makinen 2001; Várhelyi et al. 2002). These calculations are based on the assumption that all vehicles on the road have a system installed, or at least that the number of equipped vehicles is high enough to affect all the others. If systems like this are implemented, it is likely that it will take quite a long time to reach an implementation rate that is high enough to obtain the safety effects indicated above. According to the recommendations from the Swedish Large Scale Trial with Intelligent Speed Adaptation (ISA), carried out in 1999 – 2002, ISA-equipment should be available as an option in new cars or to be retrofitted in existing cars by 2005. ISA should become compulsory in new vehicles by 2010 and by 2020 80 % of all vehicles in Sweden should have ISA (Biding and Lind 2002). Carsten and Fowkes (2000) presented a similar implementation strategy where usage of the system would be mandatory on all vehicles in the UK by 2019.

To maximise the safety effect of ISA during the implementation period it is important to target those groups of drivers for whom the system will be most beneficial. Decision-criteria could for instance be drivers who have had accidents, young drivers, or high mileage groups such as fleet car drivers (high mileage groups would affect other drivers to a high degree due to high exposure; they also tend to drive faster than the average driver (Fields et al., 1991; Webster and Wells, 2000)).

This study aims at analysing preferred driving speeds for various groups of drivers and drivers with different attitudes to speed and traffic safety, thereby establishing the potential safety benefit for a speed-adapting system. It further aims to analyse the effect of an advisory ISA system on these drivers. Different implementation strategies of ISA are likely to affect different groups of drivers. For instance may an implementation strategy based on company cars affect one group while a voluntary implementation or implementation by legislation are likely to affect other drivers. By comparing the speeds, with and without an ISA system, for drivers of different groups the effectiveness of these strategies can be estimated.

Method

Study design

The data used for this analysis was collected during a trial with 284 vehicles equipped with an Active Accelerator Pedal (AAP) for up to one year in the city of Lund in 1999-2002. The AAP was a haptic pedal with kick-down possibilities, which did not physically limit the speed of the vehicle. If the driver so wished, he could exceed the speed limit by pressing the accelerator pedal harder. The pressure required for a kick-down was three to five times the normal pedal pressure which was high enough to make it impossible to speed inadvertently.

Driver selection and classification

In the AAP trial in Lund there were both private drivers and drivers of fleet vehicles. The private drivers were selected randomly from the vehicle registry, the intention being to have an even distribution of drivers with regard to sex, age and initial attitude towards the AAP. (During the recruitment the drivers were asked: *"What do you think of having the following equipment in your car? A system that gives a counter force in the accelerator when the vehicle has reached the speed-limit, and the speed-limit can not be over-ridden except in an emergency; "Good"; "Not good"; "Neither"?"* The drivers were then classified as positive, negative or neutral according to their answers.) However, since we could not force the drivers to participate there was a bias towards drivers with a positive attitude towards the system. Due to vehicle-ownership demography there was also a bias towards middle-aged men. Still, all the above groups were well represented in the driver population, see Table 1. For the drivers of the fleet vehicles the selection method was somewhat different; a number of companies were contacted and asked whether they wanted to participate, and those that agreed selected the participating drivers.

Table 1 The number of test subjects according to age group, gender and initial attitude towards the AAP.

	Age group											
	18-24			25-44			45-64			65<		
	pos	neutr	neg	pos	neutr	neg	pos	neutr	neg	pos	neutr	neg
Male	4	1	2	41	7	8	61	13	12	28	3	1
Female	5	0	0	26	3	12	28	12	5	5	0	1

During the trial the participants had to complete four different questionnaires from which data was extracted to classify the drivers. Besides the variables, sex, age, annual driven mileage and driver type (driver of a fleet car or private car), they were classified according to their attitudes to traffic safety, the AAP and their experience of the AAP. These variables were based on the participants' agreement on the following statements: *"think there is a correlation between speed and risk", "joy of driving when driving with the AAP", "experience of stress when driving with the AAP" "physical effort when driving with the AAP", "if they ever wanted to turn the AAP off"* and *"if they wanted to keep the AAP"*. The number of respondents for each questionnaire decreased over time as some participants chose to have their equipment removed. However, the response rate stayed fairly constant at around 80 % of the remaining participants at the time of each questionnaire (except for the first questionnaire which was for recruitment and therefore had a 100 % response rate among the drivers in this trial).

For various reasons some drivers chose to have the equipment removed after they had tried the AAP for a period of time. They were then classified as early finishers since the rest of the drivers participated in the trial until it was completed. The drivers were also classified according to self-reported accident involvement.

Speed data

All vehicles were equipped with data-loggers, and variables logged and used in this study were time, position, vehicle ID and speed, from which drivers' speeds on different road sections were collected. Data logging of the vehicles in the trial started one month before the AAP was activated and continued throughout the entire trial. Data was sampled with a 5 Hz frequency and matched with a map over the city of Lund. Further, attributes such as direction of travel and speed-limit were added to the data.

For the speed analysis, 32 sections of the road network were selected and classified into different road types, see table 2. Most of the sections had two-way traffic, which gave 60 speed measurement spots. For each of the measured sections data was extracted over a stretch of five meters for 30 & 50 kph roads and 10 meters on 70 kph roads. The reason for this was to make sure that even the fastest vehicles were included in the analysis. (Vehicles driving faster than 90 kph, i.e. 25 metres / second would have more than five metres between each stamp in the log-file with a 5 Hz sampling frequency, and too short sections could lead to a bias towards slower vehicles. The reason for having only five metres on 30 and 50 kph-roads was to minimise the amount of data; the number of vehicles travelling over 90 kph on these roads were deemed to be too few to affect the analysis).

Table 2 The various street types included in the analyses

Street type / Speed limit (kph)	Description	N measured points	N measured directions
Arterial road / 70	Dual carriageway	4	8
Arterial road / 50	Dual and single carriageway	11	22
Main street / 50	Low volume of pedestrians and cyclists	5	10
Main street, mixed traffic / 50	High volume of pedestrians and cyclists	6	12
Central street / 30	Frequent interactions between different road users	6	8
$\sum$		32	60

In the AAP-trial in Lund (Várhelyi et al., 2002) it was concluded that the AAP had a large initial effect but decreased somewhat over time. The speed data was therefore analysed for three periods; before using the AAP, the first month of use and the last month of the trial (after 6-11 months of use). These periods were then classified as “without AAP”, “short term use” and “long term use”.

Data from drivers who used the car less than 50 % of the cars’ total usage time was excluded. More than 60 % of the drivers used the car for more than 90 % of the time and 45 % used the car 99 % of the time or more (self-reported). The average usage rate was 87.3 %.

In total, data from 200 vehicles was included in this study and these vehicles generated 64,675 spot-speed measurements. The discrepancy with the 284 vehicles included in the trial was partly due to drivers aborting the trial before the AAP was activated and partly to problems with some of the data-loggers. Of the 200 drivers, 28 were classified as early finishers and they produced 7.9 % of the spot-speeds.

Validity of data

The data used in this study was validated by Várhelyi et al. (2002) when they showed that the mean speeds logged in the vehicles in the study did not differ from the mean speeds of other vehicles measured with pneumatic tubes at 21 spots in the city of Lund. The validity of the data was further analysed in this study by comparing the speeds of drivers with regard to their sex, age, annual driven mileage and comparing drivers of private cars with drivers of fleet vehicles. Studies have shown that men, young persons, drivers who have a high annual mileage and drivers of fleet vehicles usually choose a higher speed than their counterparts (Cowley 1983; Fields et al. 1991; Webster and Wells 2000; Kaufmann 2002).

Analysis

The analysis is done in two parts, where the first part analyses speeds when driving without the AAP. It is carried out for drivers of different sex, age, annual driven mileage and driver type (drivers of private cars or fleet vehicles); this is to check whether the speed behaviour of the drivers in this study is comparable with what has been reported in other studies. Speeds without the AAP are also analysed for drivers with different attitudes and experience of the AAP to see whether there is a relationship between attitude and preferred driving speed. The second part analyses how effective the AAP has been for different types of drivers; the driver groups tested represent drivers that may be affected by different implementation scenarios. Four different implementation scenarios are considered: implementation in all vehicles, in fleet vehicles only, a driver select system (i.e. mandatory installation but voluntary use) and a market introduction (i.e. the systems offered as an option in vehicles and users having to pay for it themselves). There are different implementation strategies discussed in terms of ISA, but these four, or varieties of them, are the most commonly discussed.

For all the speed comparisons the statistical significance of differences in mean speed is tested by t-test or one way ANOVA on the $p<0.05$ level.

Results

Drivers' speed-choice without the AAP

A comparison of drivers' speeds without the AAP showed that men, young persons, fleet car drivers and high mileage drivers had a higher mean speed than their counterparts, see table 3. The data was also tested against accident involvement (self-reported), but no differences could be found between drivers who reportedly had had an accident and those who had not. A comparison, between those who agreed that there was a strong correlation between speed and risk and those who did not agree, did not show any difference, possibly due to the fact that most drivers agreed that there was a strong correlation (only 3 % did not agree). It should also be noted that high mileage correlated at $p<0.01$ with sex and driver type, i.e. men and fleet car drivers had a higher annual mileage than women and drivers of private cars, respectively.

Table 3 The mean speed (kph) with regard to sex, vehicle type, age and mileage

Street type /	Sex		Vehicle type		Age		Mileage	
Speed limit (kph)	Men	Women	Private	Fleet	<45	>=45	<1000	>=1000
Arterial road, 70	74.6	74.2	74.1	76.4*	76.9*	73.9	73.9	74.9*
Arterial road, 50	51.2	51.0	51.3*	50.6	51.9*	50.6	50.7	51.2*
Main street, 50	45.1*	44.1	44.6	45.9*	45.0	44.7	44.6	44.7
Main street, mixed traffic, 50	36.4	36.8	36.5	36.5	37.4	36.0	36.9	36.4
Central street, 30	24.4	23.3	23.3	27.1*	22.4	24.8*	24.0	24.0

* Significantly higher mean speed according to t-test, $p<0.05$

A comparison of speeds, without the AAP, between drivers classified as positive and drivers classified as negative showed that the negative drivers had a significantly higher speed, see table 4. The mean speed was up to 2.4 kph higher for the drivers negative to the AAP.

The drivers were asked whether their "enjoyment of driving" had increased or decreased (in the before study: would increase/decrease) when driving with the AAP. This question was asked before they tested the equipment, after one month's use and at the end of the trial. The responses had a high correlation between the periods ($p<0.001$) and hence a mean value for each driver was used. The advantage of using the mean value was that respondents who had failed to complete all of the questionnaires could also be included in the analysis. The question was answered on a five-grade scale where one represented "increased a lot"; three represented "unchanged" and five represented "decreased a lot". In the analysis the mean speeds for those who thought that their enjoyment of driving had decreased were compared with the mean speeds for those who thought it had not changed or even increased. The analysis showed that the former had a higher mean speed than the latter, see table 4. Of the drivers, approximately 35 percent thought it had decreased, 50 percent thought it was unchanged and the rest thought it had increased.

Table 4 The mean speed (kph) for drivers with regard to their attitude to and experience of the AAP.

		Initial attitude		Joy of driving		Stress		Completed trial		Wished to turn off the AAP		Wants to keep the AAP	
		Positive	Negative	Unchanged/ Increased	Decreased	Unchanged / Decreased	Increased	Yes	No	Not often	Often	Yes	No
Arterial road 70 kph	Without the AAP	74.9+	77.3*+	72.7+	76.3*+	72.8+	74.9*+	73.9	78.7*	73.4+	75.3*+	72.4+	74.0*+
	After long term use	69.7	72.2*	69.9	71.0*	70.8	70.5	-	-	70.0	71.5*	70.4	70.1
Arterial road 50 kph	Without the AAP	51.0*	52.7*+	50.6+	51.7*+	50.3+	51.4*+	50.9	52.3*	50.7+	51.3*+	50.7+	50.7+
	After long term use	47.8	49.0*	48.1	48.1	48.0	48.2	-	-	48.0	48.3	48.6*	47.7
Main street 50 kph	Without the AAP	45.2+	45.3	44.3+	45.5*	45.4*	44.5	44.7	45.3	44.7+	45.2	44.1	44.9+
	After long term use	44.3	45.9*	43.2	45.2*	45.0*	44..1	-	-	43.3	45.7*	43.9	43.8
Main street, mixed traffic 50 kph	Without the AAP	36.5+	36.9+	35.7	37.8*+	36.1	37.1*+	36.4	37.4*	36.4+	37.1	33.6+	37.6*+
	After long term use	35.5	34.8	35.1	36.1*	36.5*	35.3	-	-	35.4	36.1	35.6	35.8
Central street 30 kph	Without the AAP	24.6+	24.8	24.3+	24.2	23.7	24.4	23.9	24.8	23.8	24.8	23.7	24.9
	After long term use	23.4	26.3*+	23.0	25.6*+	24.0	24.2	-	-	23.0	25.9	23.6	24.0

* Significantly higher mean speed than their horizontal counterpart according to t-test, $p<0.05$

+ Significantly higher mean speed than their vertical counterpart according to t-test, $p<0.05$

Questions regarding workload when driving with the AAP were asked both after one month of driving and in the final questionnaire. The response options were on a five-grade scale ranging from much “less/better” (one) to much “more/worse” (five) with three representing “unchanged”. The answers to these questions, correlated between the two questionnaires ($p<0.001$) and a data reduction of the variables (eight variables in two questionnaires) using “Principal Component Analysis” (Rotation Method: Varimax with Kaiser Normalization), resulted in the same two variables for the two questionnaires, where one has to do with stress / frustration and the other has to do with physical effort, see table 5. If they had become better or worse drivers had approximately the same weight for both variables and was therefore left out. In the analysis, data from the two questionnaires was aggregated into the two variables for each driver; the driver population was then divided into one group that felt that stress / frustration had increased and one that thought it had decreased or was unchanged. The variable “physical effort” was divided in the same way. The analysis of the mean speeds of these groups showed that the mean speed without the AAP was higher for the drivers who felt stressed and frustrated by the AAP, see table 4. A similar comparison for physical effort did not show any differences.

Table 5 The questions regarding workload and the variables after the data reduction by principal components analysis.

	Rotated Factor Loadings			
When driving with the AAP,	Questionnaire after one month		Final questionnaire	
	Stress	Physical effort	Stress	Physical effort
do you have to be more attentive?	-0.048	0.757*	-0.001	0.781*
do you have to accelerate and brake more often?	0.236	0.673*	0.133	0.654*
do you feel more pressured for time?	0.759*	0.133	0.752*	0.023
are you a better driver?	-0.393	-0.446	-0.520	-0.414
is the driving more tiring?	0.676*	0.404	0.605*	0.467
do you feel more frustrated?	0.814*	0.257	0.850*	0.234
do you feel as if you are in the way of others?	0.634*	-0.021	0.695*	-0.136
do you look at the speedometer more often?	0.199	0.736*	0.054	0.759*

* Indicates into which variable the question is fitted

Of the 200 drivers included in this study, 28 asked to have the equipment removed from their vehicles before the trial was completed. A comparison showed that those drivers who wanted to finish beforehand had a significantly higher mean speed without the AAP than those who completed the trial. The mean speed was up to 4.9 kph higher on the arterial roads, see table 4.

The drivers were also asked whether they had wanted to turn the system off at anytime. The question was on a five grade scale where one represented “never”, two “once or twice”, three “sometimes”, four “often” and five “all the time”. A comparison of the speeds of those who wanted to turn the AAP off only once or twice or less and those who wanted to turn it off more often showed that the higher the speed the drivers chose without the AAP, the more often they wanted to turn the system off.

In the final questionnaire the drivers were asked whether they wanted to keep the system or not. Note that this means that the drivers who did not complete the trial were excluded from this analysis. A comparison of the speeds without the AAP for these two groups showed that those who wanted to keep the system had a lower mean speed than those who wanted to end the trial: the difference, however, was not as evident as for the comparison with the early finishers. This means that those who disliked the AAP the most, i.e. the fastest drivers, had already decided that they did not want to keep the system and aborted the trial.

The effectiveness of the AAP for drivers with different characteristics

The above findings show that there is a strong relation between preferred speed and attitude towards the AAP; the less the AAP is liked, the higher the chosen speed. This confirms the finding from previous studies of ISA, which states that those who need it the most like it the least (Várhelyi et al. 2002). The above finding also confirms results that suggest that on central streets, and to a certain extent even on main streets, the infrastructure and surrounding traffic have a greater impact on speed than the drivers’ preferred speed (Ekman 2000; Várhelyi et al. 2002). Várhelyi et al. (2002) also concluded that the AAP had little or no effect on these types of roads. In the analysis of the effectiveness of the AAP there was a focus on arterial roads, but it was carried out for all the different road types; table 4 shows the mean speeds with and without the AAP for the various driver groups and road types.

The AAP tested in this trial was an advisory system, or supporting system as it is sometimes called. If the driver so wished, he could exceed the speed limit by pressing the accelerator pedal harder. An analysis of the AAP’s effectiveness over time shows, as has been established previously (Várhelyi et al. 2002), that it has a large initial effect and that the effect diminishes somewhat over time. Figures 1 and 2 show this graphically for arterial roads: 70 kph and 50 kph.

Figure 1 The effectiveness of the AAP on arterial roads with 70 kph speed limit for all the test drivers.

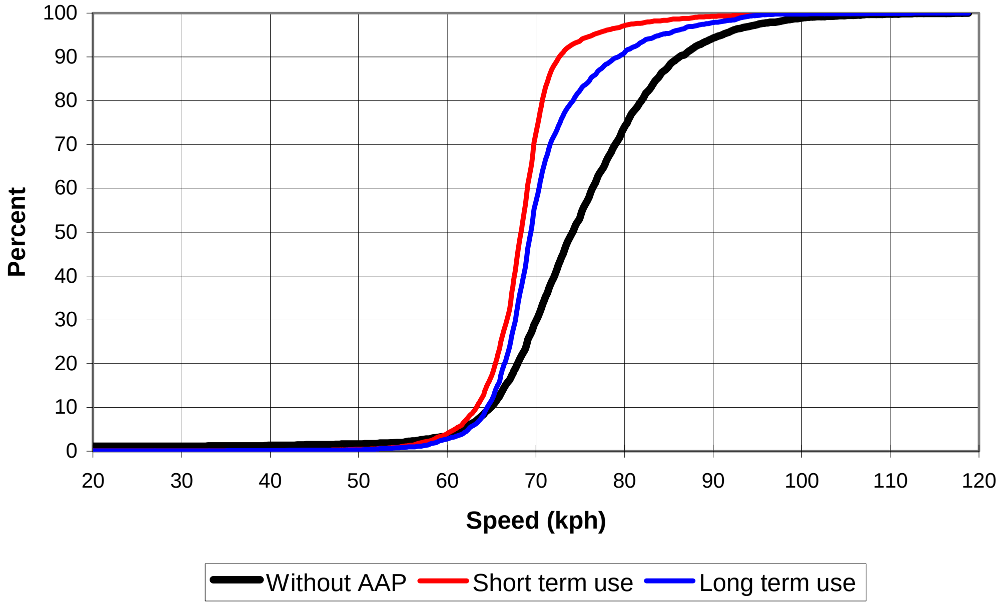
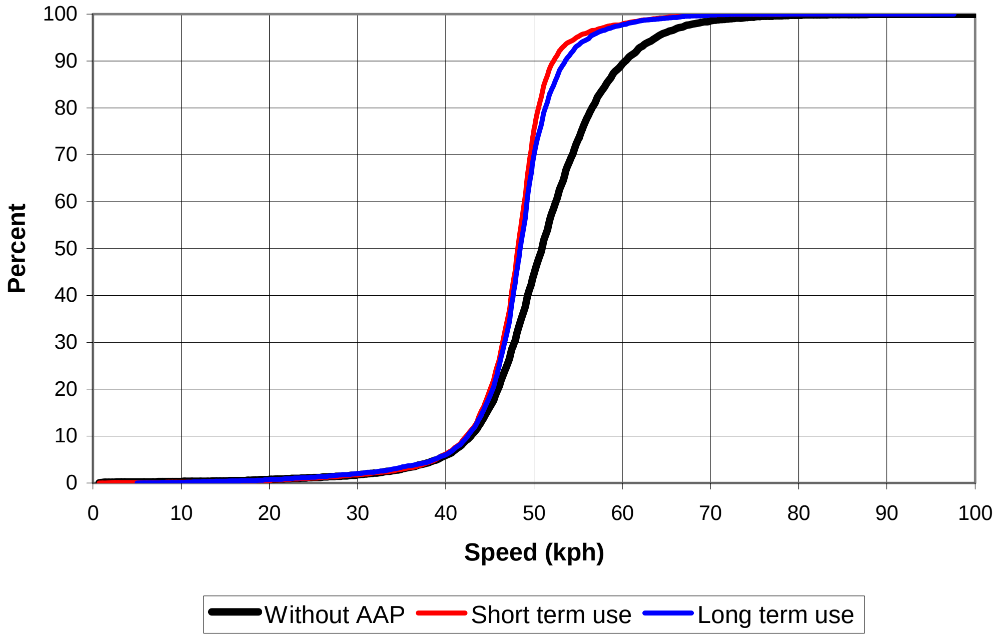


Figure 2 The effectiveness of the AAP on arterial roads with 50 kph speed limit for all the test drivers.



As figures 1 & 2 show, the mean speeds in the three periods differ for arterial roads (statistically significant; $p<0.05$; One way ANNOVA, Tukeys' Post hoc), and there is also a statistically significant difference for the main road with mixed traffic. For main streets and central streets no difference could be found. Table 6 shows the effectiveness of the AAP for the different road types. It is worth mentioning here that, since the AAP is only activated at speeds above the speed limit, it is for the highest speeds that the greatest difference can be found. This is illustrated in figures 1 & 2 and it implies, with reference to knowledge about the importance of speed variance and highest speeds for traffic safety (see e.g. Pasanen et al. 1993; Finch et al. 1994; Wheeler et al. 2000), that even a small difference in mean speed can have a great effect on traffic safety.

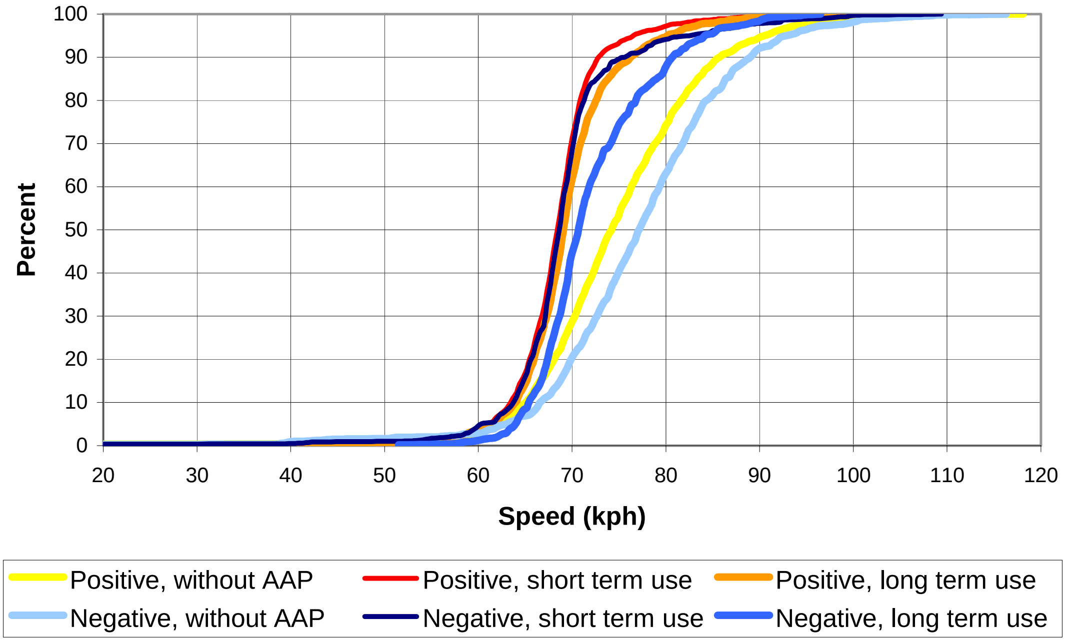
Table 6 The mean speed (kph) during the three measurement periods for the different road types

Street type / Speed limit (kph)	Without AAP (W)	Short term use (S)	Long term use (L)
Arterial road, 70	74.5^{SL}	68.5^{WL}	70.8^{WS}
Arterial road, 50	51.2^{SL}	47.8^{WL}	48.2^{WS}
Main street, 50	44.8	44.6	44.4
Main street, mixed traffic, 50	36.5^{SL}	34.7^{WL}	35.6^{WS}
Central street, 30	24.0	24.2	24.1

W = Statistically significant mean speed from the "Without AAP" period
S = Statistically significant mean speed from the "Short term use" period
L = Statistically significant mean speed from the "Long term use" period

The main difference between short-term use and long-term use of the AAP is to be found at speeds above the speed limit, as figure 1 illustrates clearly. This would indicate that most of the drivers initially tried to give the AAP a chance and follow its recommendations. After using it for a time, however, some started to use the kick down function to a higher extent. When data is broken down into more detail, it is clearly (and not surprisingly) shown that the drivers who had a higher mean speed without the AAP were more inclined to use the kick-down function than their counterparts. An example of this is illustrated in figure 3, where the accumulated speed frequencies for drivers who had an initial positive or negative attitude to the AAP are displayed.

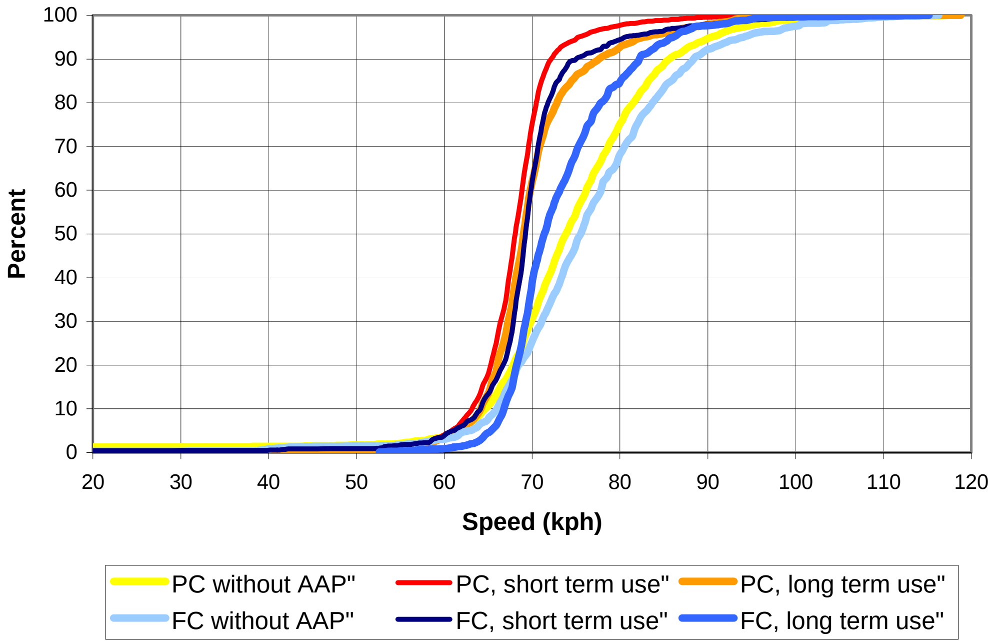
Figure 3 The effectiveness of the AAP for drivers positively and negatively inclined towards the system.



A study of the AAP's effectiveness for fleet car drivers compared to drivers of private cars shows an even more noteworthy difference, see figure 4. Fleet car drivers are often young males with high annual mileage and to a high degree negatively inclined to the system. They might also have financial incentives to speed so, with regard to the above findings, it is not surprising that they are affected by the AAP to a lesser extent.

It is important to note, though, that after long-term use of the AAP the speed did not go back to the same level as without it, for any of the analysed groups.

Figure 4 Fleet car drivers(FC) compared to drivers of private cars (PC).



Discussion

The results have shown that there is a difference in the speed choice of different types of drivers and these findings are in line with those from other studies characterising a speeding driver. One example is Fields et al. (1991), who interviewed a number of drivers for whom they had measured speeds. The study showed that there was a clear correlation between speed and demographic variables. Some of the variables that correlated with a fast driver were young age, fleet vehicles and the notion that high speeds were not dangerous. Kaufmann (2002) came to similar conclusions when he studied drivers on an Austrian motorway. He found that young drivers, male drivers and drivers of large cars exceeded the speed-limit to a higher degree than their counterparts. Cowley (1983) studied police data on speeding and accident speed and he also found that high speeds were associated with young male drivers. He further found that new, high powered cars and long trips were probably associated with high speeds. Webster and Wells (2000), in conducting a literature study of the characteristics of the speeding driver, found that young male drivers, company car drivers, drivers of large cars and high mileage drivers were more likely to speed.

The above findings, based on studies of the characteristics of a speeding driver, show that the speed behaviour of the drivers in this study complies with what has been found in other studies. This, together with the findings from Várhelyi et al. (2002), where they established that the mean speed for the drivers included in this study did not differ from the mean speed for the general public, augurs well for valid results in this study.

The analysis of the drivers' speeds without the AAP showed that those who thought that the AAP was a bad idea had a higher mean speed than those who thought it was a good idea. It also showed that the faster drivers found themselves feeling more stressed when driving with the AAP, and that they also thought that their enjoyment of driving had decreased. A similar pattern could be found for those who were less eager to use the system. The drivers who asked to have the system removed before the trial was completed had a mean speed of up to 4.8 kph faster than those who stayed on, and up to 6.3 kph faster than the drivers who wanted to keep the system after the trial was finished. Similarly, drivers who often wanted to turn the system off had a higher mean speed than those who gladly kept the system on.

These findings indicate that the safety potential for Intelligent Speed Adaptation systems varies a lot for different groups of drivers. The difference in speed without the AAP for some groups is greater than the difference with and without the AAP for the general population of drivers. This means that an implementation strategy aimed at drivers who are quite willing to accept or even buy such a system will have a considerably lower safety benefit than a mandatory implementation in, for instance, fleet vehicles. To obtain the greatest safety benefit from ISA-systems, those drivers who do not want the system have to be targeted. There is however a scope for a voluntary implementation of advisory systems to reduce speed since a certain degree of speeding is inadvertent. Carsten et al. (2001) came to the same conclusion in their study on the effect of new technologies on speed distribution.

The tested system did not limit the speed of the driver, which means that speeds above the speed limit prevailed even when driving with the AAP. When comparing the effectiveness of the system for different drivers, it was found that more or less all the drivers initially reduced their speed to the speed limit. However, after driving with the system for a while, the drivers who had a high speed without the AAP started to speed up again, thereby reducing the safety benefit from the system. This suggests that an advisory system, such as the tested AAP, is efficient in reducing the speed of drivers who initially had a speed at or near the speed limit. It is not as efficient, however, in reducing the speed of drivers who initially had a high speed.

The results of this study suggests that the AAP has the effect of reducing the speeds of drivers who want to comply with the speed limit, but for drivers who deliberately exceed the speed limit the effect is much less, which suggests that a limiting system is necessary to make these drivers comply with the speed limit.

References

Almqvist, S., Hydén, C., Risser, R. (1991). *Hastighetsbegränsare i bil. Effekter på förares beteende och interaktion.* (Speed limiters in cars. Effects on drivers' behaviour and interaction, In Swedish) Lund, Department of Traffic Engineering, Lund University.

Almqvist, S., Nygård M. (1997). *Dynamic Speed Adaptation. Field trials with automatic speed adaptation in an urban area*. Lund, Department of Traffic Engineering, Lund University.

Biding, T., Lind, G. (2002). *Intelligent Speed Adaptation (ISA), Results of large-scale trials in Borlänge, Lidköping, Lund and Umeå during the period 1999-2002.* Borlänge, Vägverket.

Brookhuis, K., de Waard, D. (1999). *"Limiting speed, towards an intelligent speed adapter (ISA)."* Transportation Research Part F: Traffic Psychology and Behaviour 2(2): 81-90.

Carsten, O. M. J., Fowkes, M. (2000). *External Vehicle Speed Control. Executive Summary of Project Results* University of Leeds, Leeds.

Carsten, O. M. J., Tate, F. N., Lai, F. (2001). *The Effect of New Technologies on Speed Distrubutions, Final report* University of Leeds, Leeds

Cowley, J. E. (1983). *Characteristics of the speeding driver.* Hawthorn, Victoria, Road Traffic Authority.

Ekman, L. (2000). *Sänkt hastighet i bostadsområden - önskan eller verklighet.* (Lowered speed in residential areas, In Swedish) Lund, Department of Traffic Engineering, Lund University.

Falk, E., Hjälmdahl, M., Risser, R. (2002). *Testförarnas attityd till ISA : resultat från enkätundersökningar.* (Test drivers attitude to ISA: results from questionnaire studies, In Swedish) Lund, Department of Traffic Engineering, Lund University.

Fields, B., Rumbold, G., Leening, A. (1991). *Speed behaviour and drivers' attitude to speeding.* Melbourne, Monash University Accident Research Centre.

Finch, D. J., P. Kompfner, P., Lockwood, C. R., Maycock, G. (1994). *Speed, speed limits and accidents*. Crowthorne, TRL.

Kaufmann, C. (2002). *Behaviour of car drivers on Austrian motorways on weekends.* ICTCT workshop, Nagoya, Japan.

Pasanen, E., Salmivaara, H. (1993). "*Driving speeds and pedestrian safety in the city of Helsinki*." Traffic Engineering and Control 34(6): 308-310.

Persson, H., Towliat, M., Almqvist, S., Risser, R., Magdeburg, M. (1993). *Hastighetsbegränsare i bil. Fältstudie av hastigheter, beteenden, konflikter och förarkommentarer vid körning i tätort.* (Speed-limiters in cars. On-road study on speeds, behaviour, conflicts and drivers comments when driving in built up areas, in Lund, In Swedish) Lund, Department of Traffic Engineering, Lund University.

Regan, M., Mitsopoulos, E., Haworth, N., Young, K. (2002). *Acceptability of in-vehicle intelligent transport systems to Victorian car drivers.* Royal Automobile Club of Victoria (RACV).

Várhelyi, A. (1997). *Dynamic speed adaptation based on information technology - a theoretical background.* Lund, Department of Traffic Engineering, Lund University.

Várhelyi, A., Hydén, C., Hjälmdahl, M., Almqvist, S., Risser, R., Draskóczy, M. (2002). *Effekterna av aktiv gaspedal i tätort. Sammanfattande rapport LundaISA.* (The effects of Active Accelerator Pedal in built-up areas. Summary report, In Swedish) Lund, Department of Traffic Engineering, Lund University.

Varhelyi, A., Makinen, T. (2001). *"The effects of in-car speed limiters: field studies."* Transportation Research Part C: Emerging Technologies 9(3): 191-211.

Webster, D. C., Wells, P. A. (2000). *The characteristics of speeders* TRL report 440, Transport Research Laboratory, Crowthorne, UK.

Wheeler, A. H., Taylor, M. C. (2000). *Changes in accident frequency following the introduction of traffic calming in villages* TRL report 452, Transport Research Laboratory, Crowthorne, UK.