Aalborg Universitet

Intelligent Speed Adaptation for involuntary drivers

Final results

Agerholm, Niels; Tradisauskas, Nerius; Juhl, Jens; Berthelsen, Kasper Klitgaard; Lahrmann, Harry

Published in:
ITS World Congress

Publication date:
2012

Document Version
Early version, also known as pre-print

Intelligent Speed Adaptation for involuntary drivers – Final results

Niels Agerholm[1*], Nerius Tradisauskas[1], Jens Juhl[2], Kasper Berthelsen[3], Harry Lahrmann[1]

1 Traffic Research Group, Department of Development and Planning, Aalborg University, Fibigerstraede 11, DK-9220 Aalborg OE, Denmark, +4520650455, agerholm@plan.aau.dk

2 Geoinformatics, Department of Development and Planning, Aalborg University, Denmark

3 Department of Mathematical Sciences, Aalborg University, Denmark

Abstract

The Danish Intelligent Speed Adaptation (ISA) trial *ISA C* included 26 commercial cars and 51 drivers a number of whom were involuntary. After a baseline period, ISA was activated for one year. The drivers should identify themselves with a personal key ID before driving. As well as being informative and warning, the ISA had an incentive in the form of rewards for speeding avoidance and social control - the latter, however, did not work sufficiently. When a key ID was used, the proportion of speeding was low while driving with ISA. Without key ID there was virtually no change in driving behaviour regardless of ISA. Also, a statistical model showed that drivers *sensitive* to ISA sped significantly less in baseline than *insensitive* drivers. Moreover, on the basis of questionnaires it was found that drivers could be categorised as either *green* drivers (not positive to speeding) or *red* (more positive to speeding). A high correlation between the use of key ID, sensitivity to ISA, and the driver's colour was found: *green* drivers would use the key ID while *red* virtually never did. Hence ISA, as used in this trial, has virtually no effect on the driving behaviour of involuntary drivers.

KEYWORDS

Intelligent Speed Adaptation, Advanced Driver Assistance Systems, Road Safety

Introduction

Speed violations and road safety

Road safety is a major issue regarding loss of years of life [1]. Despite a significant improvement in the road safety level in the last decade more than 34,000 people were killed on the European roads in 2009 [2]. A significant risk factor in traffic is inappropriate speeds while driving [3,4]. Despite many years' constant focus on speed limit violation it is still very widespread. Even in countries with a high road safety level, such as Sweden and Norway, the proportion of drivers who drive too fast is about 50% [5]. The frequency of speeding can be due to the immediate reward of speeding: the drivers experience reduced transportation time although the reality is that the transportation time virtually remains unchanged [6]. Also, most drivers misjudge which speed the road conditions allow. The result is a higher speed than if drivers were fully aware of the risks [7]. Furthermore, many drivers feel joy when driving at high speeds - this applies to young male drivers among others [8,9]. Several groups of drivers are overrepresented in accident statistics. One of these groups are drivers of commercial cars, who have a bad reputation among other road users due to their speed behaviour. The Danish road accident statistics show that commercial cars are approximately 125% more likely to be part of fatal accidents than are passenger cars [10]. Commercial cars are often bigger than the average car, and when accidents occur they are more severe [11]. Commercial cars account for 30% more fatalities and seriously injured per accident than passenger cars [12].

A speeding prevention solution: Intelligent Speed Adaptation
Hence, increasing road safety regarding commercial cars is crucial. Intelligent Transport Systems (ITS) and Intelligent Speed Adaptation (ISA) in particular seem to be efficient measures to increase road safety [13]. The key issue regarding ISA is real time map matching between the current position of a car and the speed limit on that particular road. The driver will receive feedback related to the actual speed and the current speed limit. There are various forms of feedback connected to driving behaviour. The response can be visual, auditory or haptic via the accelerator pedal. Response may be available to the driver even though no speeding occurs (informative ISA). There may be a response in case of speeding (warning ISA). A third response is recording ISA in which every speed limit violation is logged allowing the recordings to be subsequently used to reward/punish driving behaviour (incentive ISA). Finally, ISA can make it impossible to speed (intervening ISA) [14,15]. Over 30 ISA trials have been evaluated and the conclusion is clear; ISA reduces speeding considerably [16]. E.g. the reduced proportion of the driving above the speed limit underpin the effect of ISA. In the Belgian *Ghent* ISA trial, the proportion of the distance driven above the speed (or a set) limit (PDA) was reduced by up to 9.7% while in *Lund,* Sweden it was reduced by up to 13.9%. [17,18]. In the Danish *PAYS* PDA (the proportion of the distance driven above the speed limit + 5 km/h) went from 14 to 4%, however, in this trial speeding avoidance was linked to significant incentives [6].

Despite the positive effects on speeding, most ISA trials, where reported, have shown decreasing effect of ISA over time. Thus in the *Lund* trial it was found that the effect decreased over time, although speeding was still less prevalent than before activation of ISA [19,23]. Similar patterns were found in Borlänge, where the effect decreased to a third over time on some road types [18]. Likewise, in the *Ghent,* the Dutch *Belonitor trial, PAYS* and the Norwegian *Karmøy* trials a decreasing effect of ISA was found [6,17,19,20]. To address the problem of decreasing effect various incentives can be brought into play. Even small incentives tend to increase the willingness to change driving behaviour [21], and a Swedish ISA trial and *PAYS* showed that a more lasting effect is created when ISA is linked to incentives [6,22]. However, to the best knowledge of the authors no ISA trials have included involuntary drivers so far, and it is not clear if the promising effects of ISA can be reached for this type of drivers. To study the effect of ISA on commercial drivers in general and involuntary drivers in particular, the Danish ISA trial *ISA Commercial* (*ISA C*) was carried out.

Project specification
ISA C was carried out in cooperation between Vejle Municipality and Aalborg University. The trial was in general based on the same technology as that of the concurrent ISA trial *PAYS* [6,15] and is described in [23,24]. *ISA C* involved 26 commercial cars and 51 drivers from six companies. While the companies were voluntarily involved in the trial, the same was not true of all drivers. Hence it was to be expected that a group of drivers would be keen to avoid speeding, while other drivers would not be much affected by ISA. To distinguish between more than one driver per car, each driver was given a personal key ID. Before initiating a trip, the driver would register by briefly touching a display with his key ID. Information about the speed limit was always available in a display. If the speed limit was exceeded by more than 5 km/h, the driver would be given a verbal warning by a female voice, for example '*50 - you are driving too fast'*, on a 50 km/h road (50 km road etc.) every 6 seconds. The third and later warnings would result in penalty points. Each driver had a

personal webpage, which would show any penalty points on a speed limit map immediately after the end of a trip. The webpage allowed the driver to check possible penalty points. In case of disagreement regarding penalty points a hotline could be contacted. The amount of penalty points compared to the distance driven was calculated for each driver and those of the drivers who had driven more than 500 km per month competed to be *driver of the month*. The results were calculated monthly for each driver and for each company. The company results included all driving, also driving without use of the personal key ID. These results were available on a webpage as the overall results, the name of the driver of the month, and a table on a webpage with restricted access, displaying the results for each driver and on which the drivers could see each colleague's results while the results of the drivers from other companies were anonymous.

In *ISA C* incentive for avoiding speeding was included. The driver of the month, who was drawn among the group of drivers with few speed violations, would receive a gift basket worth around € 40. In addition, at the end of the trial, the overall best 10 drivers were rewarded with GPS navigators for their private cars. The rewards, monthly and final, and especially the social control facilitated by the information on the webpages of each company were incentives supplementary to the informative and warning feedback of ISA. The two first months were a baseline period during which ISA was inactive, however, driving behaviour was recorded to establish the drivers' normal driving behaviour. In this period was the key ID not used. Afterwards the ISA equipment was activated and driving behaviour was recorded for one year. Concurrently, the drivers' attitudes to ISA and traffic behaviour in general were collected by web-based questionnaires. Focus in the paper is on the development in driving behaviour during the ISA trial and the drivers' attitudes to risky driving behaviour in traffic.

Data and methods

Experimental set-up

Driving behaviour was analysed on the basis of Floating Car Data (FCD) recorded during the trial. Data from baseline are compared with the subsequent 6 two-month periods, denoted as ISA 1 - ISA 6. FCD was logged at 1 Hz resulting in 65 million observations and a distance driven of 391,000 km. Most driving was carried out on 50 and 80 km roads (76%). Hence, when considering individual road types, attention is restricted to 50 and 80 km/h roads. Still, when considering the total effect, data from all road types are included.

To measure the participating drivers' attitudes to various driving-related topics, questionnaire data were collected using web-based questionnaires. 42 out of the 51 drivers filled in a questionnaire. On the basis of questionnaire data concerning attitudes towards speeding and risky driving behaviour each driver was classified as being either *red* or *green*. A *green* driver tries to avoid speeding and is positive towards ISA while a *red* driver speeds more often and has a negative view on ISA. The analyses of questionnaire data presented in this paper are about the difference between the *red* and *green* drivers' attitudes.

Methods

In working with effect studies and FCD two approaches can be used: a *system approach* and an *individual approach*. The *system approach* makes it possible to include the effects of different drivers'/cars' different amounts of driving. The system approach consists in pooling FCD across cars and considering them as one. As a consequence, the longer distance an individual driver covers during the trial, the more this driver will affect the overall result. The *individual approach* weights each driver's/car's driving behaviour equally regardless of the distance driven and allows a direct comparison of driving behaviour and questionnaire data.

Furthermore, the individual approach makes it possible to estimate the average effect of ISA on a (typical) driver. When measuring e.g. the effect of ISA on speeding, it is often found that drivers covering long distances tend to speed more than drivers covering short distances [15]. Hence, the *system approach* will yield more significant results than the *individual approach*. To handle both FCD and questionnaire data collectively the *individual approach* is used.

Although the trial included FCD from cars with one driver only as well as cars with more than one driver, test results of statistical significance cannot be made for the cars with more than one driver. Hence results can preferable be presented in different ways, and results on driving behaviour are therefore shown in two ways: 1: all FCD are included, but tests of statistical significance are not carried out, and 2: trimmed data, which are suitable for statistical analyses, but with a reduced amount of FCD as a basis. The approaches are elaborated on below.

Analyses of all FCD
The effect of ISA on driving behaviour is calculated by four methods to clarify the various effects of the system. PDA (the proportion of the distance driven above the speed limit + 5 km/h) offhand reflects the effect of ISA directly. A straightforward calculation of mean speed may give a misleading picture of the speeding behaviour and the effect of ISA, as mean speed is affected by external factors like congestion and traffic lights. Speed measurements below a certain threshold are discarded accordingly, leaving so-called Mean Free Flow Speed (MFFS). The thresholds were selected arbitrarily, albeit after careful consideration. Regarding 50 km roads all driving ≤ 35km/h was removed. The equivalent threshold for 80 km roads is ≤ 65km/h. The standard deviation of the Free Flow Speed (FFSD) reflects the variation in speed measurements in FCD included in the thresholds used for MFFS. The time used for driving a certain distance indicates if ISA causes changes in transportation times. As baseline was driven without the use of key ID comparisons between driving with and without the use of key ID are made for the ISA periods only, while more general comparisons include driving in all seven periods.

Statistical tests on trimmed data
The purpose of the formal statistical analysis is to assess the effect of the ISA system on PDA, MFFS and FFSD. As no information about key ID during baseline was available, the analysis was restricted to cars associated with exactly one key ID. It was our assumption that each of these cars had been driven by one driver only during the trial. The statistical analysis is performed using linear mixed effects models with cars as the random effects. The model's error terms are then weighted according to the distance driven during the corresponding period. Furthermore, the statistical analysis is restricted to 80 km roads where ISA is expected to have the best effect. To obtain a reasonable fit for the models an additional grouping of the individual cars was introduced. A car (and hence the corresponding single driver) was classified as *sensitive* if that driver had a PDA below 3% during at least one ISA period. It should be emphasised that the statistical analysis considers the cars at the individual level, whereas the results summarised in the table are obtained by accumulating data across several cars. For this reason the results obtained in the statistical analysis are not necessarily consistent with the results presented in the tables.

Results

Driving behaviour
Table 1 shows the proportion of the distance driven with/without use of key ID. In the first part of the ISA trial, the use of key ID was extensive, however, it decreased over time. The reduced use was due to an increasing number of users boycotting it.

Table 1 - The proportion of the distance driven with/without use of key ID

	ISA 1	ISA 2	ISA 3	ISA 4	ISA 5	ISA 6
With key ID	65%	67%	49%	43%	33%	27%
Without key ID	35%	33%	51%	57%	67%	73%

Table 2 shows the effects of ISA by means of PDA. In baseline PDA was 15%. During ISA, PDA showed virtually no speeding with key ID - a level, which remained unchanged. Without key ID PDA was significantly higher than with key ID and virtually returned to the same level as in baseline. On 50 km roads, PDA was 20% in baseline. Although increasing over time, with key ID, PDA still continued to be significantly lower than in baseline. Without key ID there were less significant changes during the ISA trial. More clear effects appeared for 80 km roads. With key ID activated PDA was low (3-5%) and remained virtually unchanged. Without key ID the same pattern as for 50 km roads is found.

Table 2 - The proportion of the distance driven above the speed limit + 5 km/h with and without key ID

Speed limit	Key ID	Baseline	ISA 1	ISA 2	ISA 3	ISA 4	ISA 5	ISA 6
Total	With key ID	15%	3%	4%	3%	4%	5%	5%
	Without key ID		10%	10%	12%	12%	15%	13%
50 km/h	With key ID	20%	5%	6%	5%	6%	6%	12%
	Without key ID		13%	14%	19%	15%	17%	16%
80 km/h	With key ID	15%	3%	4%	2%	3%	5%	4%
	Without key ID		10%	8%	12%	11%	15%	13%

For the statistical analysis of PDA a logit transform of the FCD is used, i.e. the analysis is concerned with ln(PDA/(1-PDA)). The first analysis compares the (logit) Total PDA from baseline with the Total PDA with ISA when a key ID is used. The estimated change in Total PDA is -1.87 on the logit scale ($p < 0.0001$). For 80 km roads it is -2.46 ($p < 0.0001$). A further analysis indicates that both the total PDA and the PDA on 80 km roads slowly increase during the ISA periods suggesting that the effect of ISA wears off over time. Also, an analysis of the combined PDA, i.e. with and without key ID, shows that the *sensitive* drivers were much more affected by the ISA than the *insensitive* ones. This is true of both Total PDA and PDA on 80 km roads. The observations are not so surprising since *sensitive* drivers, by definition, have a low PDA (at least during one ISA period). Of greater interest is that compared to the insensitive drivers, the *sensitive* drivers have a much lower PDA during the baseline. This suggests that the drivers who respond to ISA in the intended way (i.e. reducing their PDA) are the ones who are relatively more careful drivers even without ISA.

Table 3 shows the effects of ISA by means of MFFS. On 50 km roads, the MFFS was significantly lower with key ID compared to the result in baseline. Without key ID no changes due to ISA are found. A similar result can be found regarding 80 km roads.

The statistical analysis of MFFS is analogue to the analysis of PDA. Comparing MFFS during the baseline with MFFS during the ISA periods the estimated change in MFFS on 80 km roads is -2.02km/h ($p < 0.0001$). Considering the combined MFFS, i.e. combining data collected when driving both with and without key ID, no significant difference between baseline and ISA was found. It is worth noticing that the *sensitive* drivers have an average MFFS around 7km/h lower than the *insensitive* drivers.

Table 3 - Mean Free Flow Speed with and without key ID (km/h)

Speed limit	Key	Baseline	ISA 1	ISA 2	ISA 3	ISA 4	ISA 5	ISA 6
50 km/h	With key ID	49,1	46,5	47,2	46,7	47,3	47,1	48,7
	Without key ID		48,6	48,9	51,4	49,5	49,5	49,6
80 km/h	With key ID	78,5	75,0	75,9	75,6	75,5	75,5	76,0
	Without key ID		78,8	77,4	79,4	78,6	80,1	79,2

Table 4 shows the effects of ISA by means of FFSD. On 80 km roads the FFSD was significantly lower with key ID compared to baseline. Without key ID no changes due to ISA can be found. A similar although less significant tendency can be found regarding 50 km roads.

The statistical analysis of the difference in standard deviation for the FFS between the baseline and the ISA periods with key ID is carried out as in the cases of PDA and MFFS. The analysis shows a change in standard deviation of -1.86km/h ($p < 0.0001$) for the *sensitive* drivers.

Table 4 - Free Flow Standard Deviation with and without key ID (km/h)

Speed limit	Key	Baseline	ISA 1	ISA 2	ISA 3	ISA 4	ISA 5	ISA 6
50 km/h	With key ID	8,1	6,4	6,6	6,0	6,1	6,2	6,5
	Without key ID		8,1	8,3	8,4	8,8	8,9	8,8
80 km/h	With key ID	8,2	5,8	6,3	5,4	5,5	5,6	5,9
	Without key ID		7,8	7,1	8,6	7,8	8,9	8,3

Table 5 shows the effects of ISA on transportation time. There are no significant differences in time use, either between baseline and ISA or with or without key ID. Thus, significant speeding among the drivers without key ID did not result in less time per km driven. Hence increased time consumption is not a reason for not using ISA in commercial cars, as also found in several recent ISA trials, where studied. See e.g. [25,26].

Table 5 - The time used to drive 100 km with and without key ID (minutes)

	Baseline	ISA 1	ISA 2	ISA 3	ISA 4	ISA 5	ISA 6
With key ID	126	128	130	123	126	119	118
Without key ID		130	130	121	119	119	119

Attitudes and driving behaviour

There is a high correlation between the use of key ID and the colour of the driver. All *green* drivers used the key ID while only a small, decreasing number of *red* drivers did. Thus the *green* drivers' driving behaviour virtually amounts to driving with the key ID and the *red* drivers' to driving without it.

Table 6 shows the drivers' two most important reasons for speeding. Regardless of the type of driver the most common reasons for speeding were lack of awareness of their current speed and the desire to follow the flow of traffic. Pressure from other cars was more important for the *green* drivers than for the *red* drivers. In contrast to this, the *red* drivers sped more often than the *green* drivers (32% vs. 11%) because they wanted to and were busy.

Table 6 - The drivers' two most important reasons for speeding

	Green	Red
	Share	
I wish to follow the traffic	67%	64%
I am not aware of my speed	56%	55%
I feel pressure from other cars	22%	12%
I intend to speed	11%	32%
I am not aware of speed limit	22%	18%
I feel an urge to speed	22%	15%

Figure 1 shows *green* and *red* drivers' attitudes to speed and risk on different road types. Regardless of road type the drivers found it safe rather than dangerous to drive at speeds in accordance with the posted limits. Regarding 50 and 80 km roads there was virtually no difference between the drivers' attitudes while there was a small difference regarding 130 km roads. When it came to moderate speeding (10 km/h) there was a minor although more clear connection between the type of driver and the attitude. Regarding heavy speeding (20 km/h) the *red* found it neither dangerous nor safe, while the *green* generally found it dangerous.

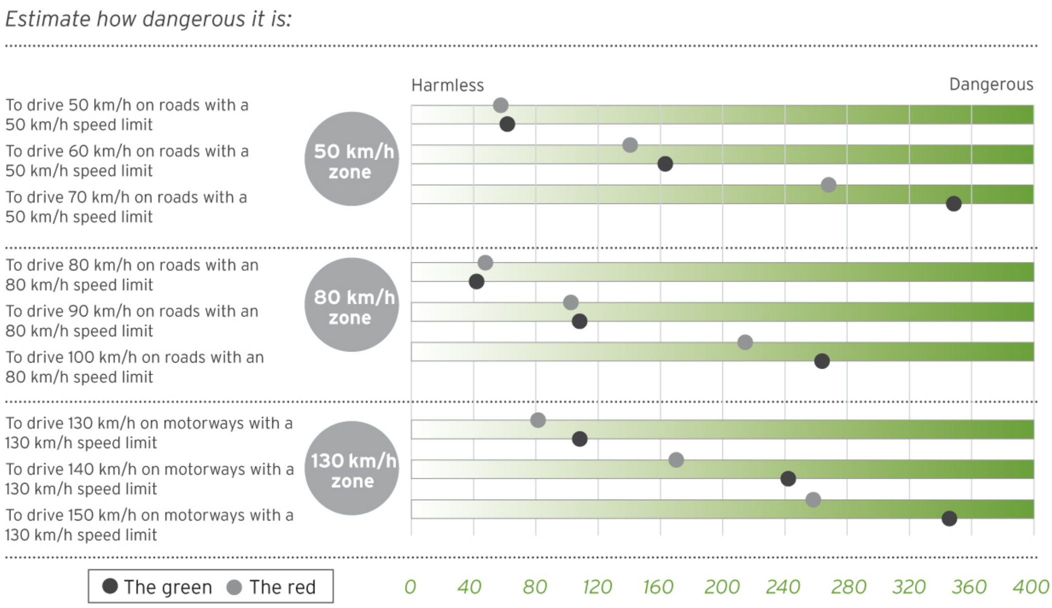

Figure 1 - Green and red drivers' attitudes to speed and risk on different road types

Figure 2 shows *green* and *red* drivers' assessment of their driving behaviour in commercial and private cars. The differences are clearer although they are not statistically significant. Without exception, the *green* had a more positive assessment than the *red* ones. Also, both groups rated their driving behaviour in all parameters a bit higher when driving in private cars compared to driving in commercial cars and they all found their driving behaviour positive rather than negative. The latter was to be expected regardless of their real behaviour - most drivers generally find their own driving behaviour better than the average driving behaviour [27].

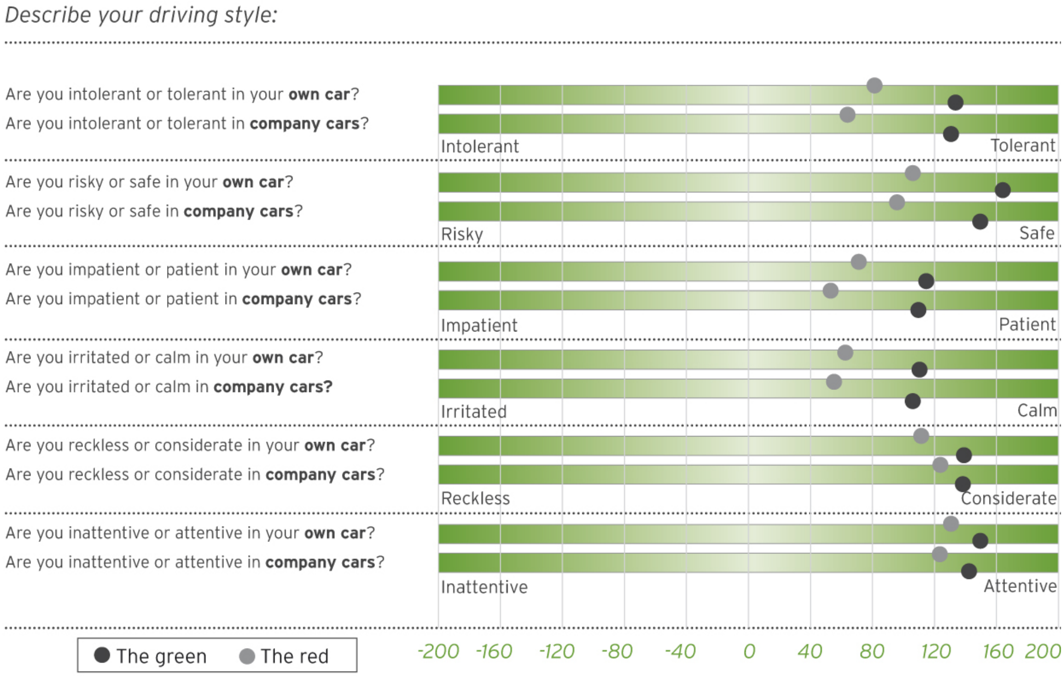

Figure 2 - The drivers' assessment of their behaviour in commercial and private cars

Figure 3 shows *green* and *red* drivers' attitudes to a specific risk related to various traffic activities. In a few cases all drivers found a certain activity dangerous and the drivers agreed on the risk related to the activity. Beyond that, *red* drivers generally assess traffic activities as less dangerous than do *green*. This is particularly significant when it comes to traffic activities, which are generally considered to be illegal rather than really dangerous, such as red light driving at nighttime on an empty street or illegal parking.

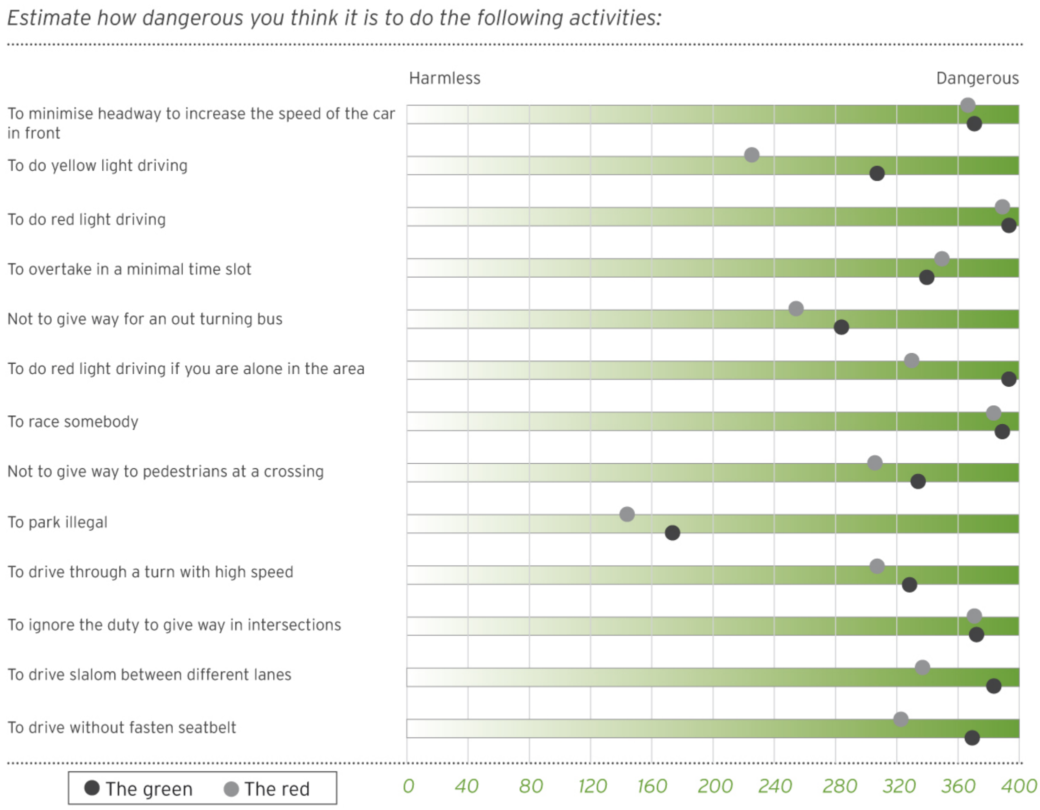

Figure 3 - Drivers' estimated level of danger in connection with traffic activities

Figure 4 shows *green* and *red* drivers' attitudes to various types of ISA equipment. Both groups' attitude to ISA is in general more positive regarding commercial cars than regarding private cars. As for a haptic accelerator pedal, the *green* were less negative than the *red* ones. On the other hand, there was virtually no difference between the two groups' negative attitudes to a hard accelerator pedal (i.e. speeding is made impossible). The *green* were positive to *ISA C* ISA equipment, while the *red* were negative (commercial car) and neutral (private car).

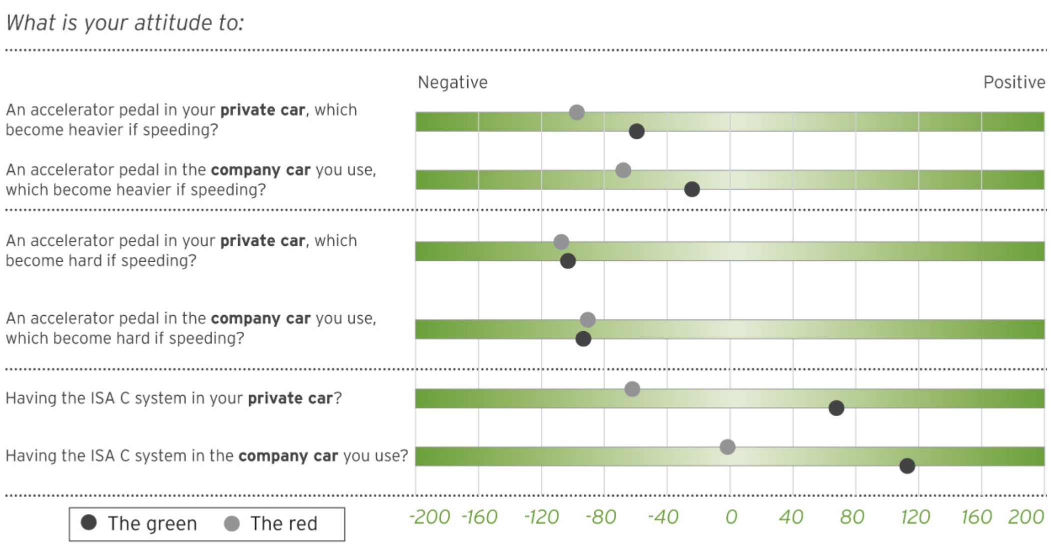

Figure 4 - The drivers' attitudes to various types of ISA equipment

The effect of the incentives selected
Besides informative and warning ISA an element of incentive ISA was included in the ISA trial. The incentives were small monthly, bigger final rewards, and social control in each company. Together the incentives were intended as a mean to keep the less positive drivers from speeding. While the final rewards were given for good driving behaviour to drivers using their key ID, the monthly awards were randomly drawn among the drivers with few or no speed violations. Research has shown that the effect of incentives diminishes significantly when incentives or information about them is given late compared to real time feedback [15,19]. Also, it is plausible that the arbitrary distributed monthly rewards reduced the effect. Moreover, it was found that none of the management teams of the companies had followed up on the driving behaviour. They saw participating in the ISA trial as a private issue. Also, the social control among the drivers during lunch breaks was weak or non-existent, since they mainly discussed the functionality and possible errors of the ISA rather than the penalty points obtained [28]. Overall, the incentives were weak and did not have as great an impact as expected.

Conclusion
The Danish ISA trial *ISA C* included 26 commercial cars and 51 drivers a number of which was involuntary. After a baseline period, ISA was active for one year. Reward incentive for speeding avoidance and social control were added to informative and warning ISA. The effect of ISA, however, was slight or non-existent as far as the drivers using no key ID were concerned, while the system reduced speeding among drivers with key ID. However, the latter did speed significantly less in baseline than the drivers using no key ID. Most of the drivers who applied their key ID were *green* drivers who kept a low level of speeding during the trial. Hence the effect of ISA as used in *ISA C* was only maintained if the drivers were favourable to ISA. The incentives used were insufficient to maintain the effect of ISA over time. However, it should be noted that social control was not used as anticipated. The drivers who did not use the key ID were keener on speeding, finding speeding less dangerous, and were less calm while driving. Also, they were less favourable to ISA. The results regarding the drivers applying the key ID were retrieved in most other ISA trials, which to the knowledge of the authors included voluntary drivers only. Informative and Warning ISA, as tested in *ISA C*, does not prevent speeding among the *red* drivers, the less speed-averse, who have greatest need of it. Opposite, ISA has significant effect on the driving behaviour among the speed-averse drivers, and the safety effect when removing unintended speeding is significant. However, to influence involuntary drivers a more intervening ISA system is required.

Acknowledgements
The authors would like to thank Martin Hellung Larsen of the former Danish Road Safety and Transport Agency, now the Danish Transport Authority and Jesper Sølund of The Danish Road Safety Council, for their input and support.

References
1. World Health Organization (2009). *Global status report on road safety: time for action*. World Health Organization, Geneva, Switzerland.
2. European Commission (2010). *EU - Road Safety - Trends*. Available at: http://ec.europa.eu/transport/road_safety/specialist/statistics/trends/index_en.htm.
3. Kloeden, C., McLean, A., Moore, V., Ponte, G. (1997). *Travelling speed and the risk of crash involvement - Volume 1 - Findings*. Adelaide, Australia: NHMRC Road Accident Research Unit

4. Elvik, R., Christensen, P., Amundsen, A. (2004). *Speed and road accidents - An evaluation of the Power Model*. Oslo: Institute of Transport Economics.
5. Eksler, V., Popolizio, M., Allsop, R. (2009). *How far from Zero? - Benchmarking of road safety performance in the Nordic countries*. Brussels: European Transport Safety Council.
6. Lahrmann, H. et al. (2011). Pay as You Speed, ISA with incentive for not speeding: Results and interpretation of speed data. *Accident Analysis & Prevention*. In press.
7. Várhelyi A. (1996). *Dynamic speed adaptation based on information technology: a theoretical background.* Lund, Sweden: University of Lund.
8. Harms, L. et al. (2008). Controlled Study Of ISA-effects: Comparing Speed Attitudes Between Young Volunteers And External Controls And Effects Of Different ISA-treatments On The Speeding Of Volunteers. *IET Intelligent Transport Systems*.
9. Mogensen, K. (2002). *Livet begynder ved 150 km/t - En ungdoms -psykologisk og -kulturel undersøgelse af unge trafikanters motivation for at foretage risikohandlinger i trafikke*n *(Life begins at 150 km/h - a youth, psychological, and cultural study of young drivers reasons for risky behaviour in the traffic)*. Roskilde, Denmark: Roskilde Universitetscenter.
10. Brems, C. & Munch, K. (2008) *Risiko i trafikken 2000-2007 (Traffic risk 2000-2007)*. Copenhagen: DTU Transport.
11. Færdselssikkerhedskommissionen (2007). *Hver ulykker er én for meget - Trafiksikkerhed begynder med dig - Mod nye mål 2001-2012 - Revision af strategier og indsatser (Every accident is one too many - Road safety begins with you - Revision of strategies and efforts).* Copenhagen: Færdselssikkerhedskommissionen.
12. Havarikommissionen for vejtrafikulykker (2005). *Ulykker med store varebile*r (*Accidents with big vans*). Copenhagen: Færdselssikkerhedskommissionen.
13. Carsten, O.M.J., Tate, F.N. (2005). Intelligent speed adaptation: Accident savings and cost-benefit analysis. *Accident Analysis and Prevention*. vol. 37, no. 3.
14. Jamson, S., Carsten, O.M.J., Chorlton, K., Fowkes, M. (2006). *Intelligent Speed Adaptation - Literature Review and Scoping Stud*y. Leeds, United Kingdom.
15. Agerholm, N. (2011). *Speed regulating Effects of Incentive-based Intelligent Speed Adaptation in the short and medium term*, Aalborg, Denmark: Aalborg University.
16. Paine, M. (2009). Low Range Speeding and the Potential Benefits of ISA. *Australasian Road Safety Research, Policing and Education Conference*. Sydney, Australia.
17. Vlassenroot, S. et al. (2006). Driving with intelligent speed adaptation: Final results of the Belgian ISA-trial. *Transportation Research Part A-Policy and Practice,* vol. 41, no. 3.
18. 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, Sweden: Swedish National Road Administration.
19. Mazureck, U., v Hattem, J. (2006). Rewarding Safe Driving Behavior: Influencing Following Distance and Speed. *Journal of the Transportation Research Board.* vol. 1980.
20. Berg, C., Bayer, S.B. Thesen, G. (2008), *Ungtrafikk. Resultater fra et ISA-forsøk med unge førere i Karmøy (Ungtrafikk. Results from an ISA trial with young drivers on Karmøy)*. Stavanger, Norway: International Research Institute of Stavanger.

21. Litman, T. (2008). *Distance-Based Vehicle Insurance Feasibility, Costs and Benefits – Comprehensive Technical Report*. Victoria, Canada: Victoria Transport Policy Institute.

22. Hultkrantz, L., Lindberg, G. (2009). *Working Paper*. Örebro, Sweden: Swedish Business School.

23. Agerholm, N., Tradisauskas, N., Waagepetersen, R., Lahrmann, H. (2008). Intelligent Speed Adaptation in Company Vehicles. *IEEE Proceedings: Intelligent Transport Systems.* Intelligent Vehicles Symposium. Eindhoven, the Netherlands.

24. Agerholm, N., Tradisauskas, N., Lahrmann, H. (2009). How Intelligent Speed Adaptation affects company drivers' attitudes to issues related to traffic. *ITS World Congress*. Stockholm.

25. Regan, M. et al. (2006). Impact on driving performance of intelligent speed adaptation, following distance warning and seatbelt reminder systems: Key findings from the TAC SafeCar project. *IEE Proceedings: Intelligent Transport Systems*.

26. Várhelyi, A., Hjälmdahl, M., Hydén, C., Draskóczy, M. (2004). Effects of an active accelerator pedal on driver behaviour and traffic safety after long-term use in urban areas. *Accident Analysis and Prevention.* vol. 36, no. 5.

27. Cauzard, J. P. et al. (2004). *Større sikkerhed for vore bilister og veje - Udvalgte resultater fra en europæisk interview-undersøgelse (Enhanced road safety for drivers and roads - selected results from an European interview survey)*. Paris: INRETS.

28. Lahrmann, H., Agerholm, N. & Tradisauskas, N. 2011. *Spar på Farten - et forsøg med Intelligent Farttilpasning og firmabiler i Vejle (ISA C - a trial with Intelligent Speed Adaptation and commercial cars in Vejle)*. Aalborg, Denmark: Aalborg University.