Intelligent Speed Adaptation, Speed Limiter and Speed Regulator

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Please note: The studies included in this synopses were selected from those identified by a systematic literature search of specific databases (see supporting document). The main criterion for inclusion of studies in this synopsis and the DSS was that each study provides *a quantitative effect estimate*, preferably on the number or severity of crashes or otherwise on road user behaviour that is known to be related to the occurrence or severity of a crash. Therefore, key studies providing qualitative information might not be included in this synopsis.

1 Summary

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1.1 COLOUR CODE: LIGHT GREEN

The effects of Intelligent Speed Adaptation (ISA) devices in cars are mostly positive in reducing crash frequency, vehicles' mean speed and drivers exceeding the speed limit. Furthermore, the coded studies encompass several topics and have good levels of quality and consistency. However, there are a number of findings which cannot be strongly supported due to lack of statistical tests. For the reasons mentioned above, the overall impact of speed adaptation is characterised as probably effective.

1.2 KEYWORDS

Speed adaptation; speed limiter; speed regulator; road safety; in-vehicle system; accident; systematic review

1.3 ABSTRACT

In-vehicle systems assist drivers to maintain a safe speed or prevent them from driving above the speed limit. Overall, the impact of Intelligent Speed Adaptation devices on road safety is beneficial. Observational and field experiments showed that this measure affects the level of road safety, causing a reduction in travel speeds, an improvement of safety performance indicators and a reduction in fatal crashes. Six high quality studies regarding field experiments were coded. On the basis of both studies and effect numbers, it can be argued that speed adaptation systems create a generally positive impact on road safety. There were cases, however, where results did not include any statistical tests, and therefore conclusions cannot be strongly supported. The results seem generally transferable with caution.

1.4 BACKGROUND

Definition of speed adaptation systems

Intelligent Speed Adaptation (ISA) is an in-vehicle system that uses information on the position of the vehicle in a network in relation to the speed limit at that particular location. In simple words, they check if road vehicles are complying with the speed limit on roads and prevent excessive speeding. ISA systems can support drivers in helping them to comply with the speed limit everywhere in the network, and consequently decrease speed violations assist other drivers to maintain a safe speed. There are various such systems and each one might be considerably different than the other, but in general, the systems were based on a GPS receiver, which continuously identified the position of the vehicle, and a digital map containing all the current speed limits within the test area. This is an important advantage in comparison to the speed limiters for heavy good vehicles and coaches, which only limit the maximum speed. Overall, the system can be warning or preventive. The former warns the driver (visibly and/or audibly) that the speed limit is being exceeded. The driver him/herself decides whether or not to slow down. The latter can either increase the pressure on the accelerator pedal when the speed limit is exceeded or even limit the speed automatically if the speed limit is exceeded.

How do speed adaptation systems affect road safety?

In-vehicle speed adaptation/speed limiter systems are based on the principle of warning drivers whenever they exceed the speed limit (or exceed the speed limit by a certain amount), by displaying visual or audio messages and warning. By doing so, drivers usually adapt and reduce speeds. Although findings from the studies demonstrate that the presence of such systems leads to a reduction in mean travel speed and crash frequency, an increase in speed compliance and an improvement in driving performance, there are cases where driver workload is increased.

Which safety outcomes are affected by speed adaptation systems?

The reviewed studies focus on various outcomes, however, the main focus is on travel speeds. In one study, there is also a focus on estimating the reduction of the number of fatal crashes due to speed adaptation systems. In addition to this, other studies investigate the number of vehicles travelling over the speed limit. A few studies use surveys to ask respondents their perceived level of safety, driving effort, irritation etc. after implementing these in-vehicle systems.

How is the effect of speed adaptation on road safety studied?

The international literature has not examined very different approaches and ways to study the effect of speed adaptation systems on road safety. The main strategy is to carry out field experiments and surveys (incl. questionnaires) and observe the change in travel speeds and driving performance measures. Often this measure is examined.

1.5 OVERVIEW OF RESULTS

The effects of speed adaptation systems in cars on road safety tend to increase the level of road safety. Usually the various study findings report improved driving performance indicators like irritation scores With regard to vehicle's mean speed the majority of studies shows a significant reduction with a beneficial effect on road safety. Positive effects were also found on the number of vehicles exceeding the speed limit. A major drawback in some studies is the lack of statistical tests, since only before-after differences are reported and they lack standard errors.

Transferability

The coded studies are mainly based on data from a few specific European countries such as Spain, The Netherlands and Sweden. Although this is a good sample for general trends in developed countries, there is a lack of studies representing less motorised countries. Moreover, the totality of studies examines cars, without differentiating for different road users.

1.5 NOTES ON ANALYSIS METHODS

The methodology applied for capturing the impact of speed adaptation systems on road safety does not vary between studies. This is mainly in terms of the method (basically the absolute difference) utilised but also the outcomes evaluated as dependent variables. However, there is also a certain margin for investigating different road user categories and/or other geographical regions. All of the above make the results for this measure generally transferable, though relative caution is always required.

2 Scientific overview

2.1 ANALYSIS OF STUDY DESIGNS AND METHODS

After appropriate use of various search tools and databases, six (6) high quality studies were selected and coded to evaluate the effectiveness of the speed adaptation systems on road safety. Most of studies examined the absolute differences in mean travel speeds. However, fatal and injury crashes were investigated in a few cases as well (Hjälmdahl et al.; 2002; Várhelyi et al.; 2004). In addition, two studies (Várhelyi and Makinen, 2001; Adell and Várhelyi, 2008) used questionnaires and examined change in driving performance measures due to intelligent speed adaptation systems. When examining speed adaptation systems, another somewhat popular outcome is the duration that drivers exceed the speed limit.

In order to examine the relationship between the various exposures and outcome indicators, the majority of the studies used simple before-after measurements and absolute differences. A few studies (Hjälmdahl et al.; 2002) utilise percentage differences. Overall, no statistical modelling takes place. It is also worth mentioning that usually there is no statistical evidence, since no statistical tests are applied. Consequently, no strong conclusions can be made and results must be interpreted with caution.

Limitations

There are few limitations in the current literature examining the effects of speed adaptation on road safety. The first is that the totality of studies comes from developed countries and there is a lack of information concerning the impact of speed adaptation in less motorised countries, such as in South America or Africa. The impact of this measure from similar studies in these environments should also be captured for a more collective approach. Moreover, many of the reported findings lack statistical tests and therefore, conclusions must be drawn carefully.

Overview of main features

An overview of the main features of the coded studies (sample, method, outcome and results) is illustrated in Table 1.

Number	Author(s); Year; Country;	Sampling frame for speed adaptation investigation	Method for speed adaptation investigation	Outcome indicator	Main Result
1	Adell, E., & Varhelyi, A.;2008; Sweden	Driver comprehension and acceptance of the active accelerator pedal (AAP) after long-term use were evaluated in a large-scale Swedish trial held in 2000–2002. The system was installed in the cars of 281 test drivers who then used it for between six months and a year.	Absolute Difference	Irritation score; Stress score; Safety score; Speeding tickets risk score; Speed change score; Driving effort score;	The study has shown that the concept of the AAP was rated positively while the willingness to keep and pay for the system was rather lower. The system was found to be more useful than satisfactory. High ratings such as "good" and "important" indicate a general need for a system like the AAP and high ratings such as "effective", "clear" and "informing" pointed to the fact that the system could fill those needs. The system was reported to be only slightly "pleasant" and slightly "ugly" and neither "soothing" nor "comfortable". While, using the AAP the drivers felt an increase in the "feeling of being an obstacle", "effort" and

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Number	Author(s); Year; Country;	Sampling frame for speed adaptation investigation	Method for speed adaptation investigation	Outcome indicator	Main Result
					"irritation" as well as a reduction in "enjoyment". Notwithstanding, they also felt they were slightly better drivers when using the AAP. The largest effect on the driving outcome was a considerable reduction in the risk of getting speeding tickets. The drivers also felt a slight increase in their safety as well as travel time.
2	Adell et al.;2008; Hungary and Spain	Field experiments with ISA (intelligent speed adaptation) were carried out in Hungary and Spain in 2003 and 2004, respectively. Twenty private vehicles in each country were equipped with two kinds of systems: (1) support via an active accelerator pedal (AAP) and (2) warning via beep signals and a flashing red light when the speed limit was exceeded (BEEP). The test drivers drove for a month with both systems installed in each car.	Absolute Difference	Mean speed; Perceived safety performance	The results show a reduction of mean and 85 percentile speed while the devices were used, followed by an increase after their deactivation to almost that of the before situation in both countries. The speed variance decreased on all the analysed road types, except on motorways with a 120 km/h speed limit in Spain. The AAP system proved to be more effective in reducing speed than the BEEP system; nonetheless the drivers liked it less.
3	Brookhuis, & de Waard; 1999; Netherlands	Twenty-four subjects, both male and female, were randomly selected from an existing subject pool that contains over 1000 subjects and were included in a test of effects of feedback on speed behaviour, mental workload and acceptance.	Absolute Difference	Proportion of time driving above the limit; Proportion of time driving above the limit+10%	The hypothesis that ISA would interact with the road segment was not supported. Although drivers in both the experimental and control group better complied to the speed limit in the built-up area (the display was red 4% of the time as opposed to 18% of the time in the rural area), the interaction with display-feedback was not significant. Apparently, in the present experiment ISA feedback does not add to increased rule compliance in a relevant environment.
4	Hjälmdahl et al.; 2002; Sweden	The effects on speeds and speed distribution were studied in a large scale field trial with an in-car system for speed adaptation in the city of Lund, Sweden. In the trial 290 vehicles were equipped with an "active accelerator pedal" and a data logger for a period of 3–11 months. Data was logged in each test vehicle during the whole trial and was analysed for 3 one-month periods: Before activating the system, after short time use and after long time use	Absolute Difference	Mean speed; Expected decrease in the number of injury accidents; Expected decrease in the number of fatal accidents	The positive effects of the active accelerator pedal on the speed level and speed distribution could be confirmed and it could also be confirmed that the effect was sustained after long time use of the system. The effects were largest on arterial roads where the vast majority of injury accidents occur. In this sense the AAP studied here demonstrated its great traffic safety potential.

Number	Author(s); Year; Country;	Sampling frame for speed adaptation investigation	Method for speed adaptation investigation	Outcome indicator	Main Result
5	Várhelyi et al.; 2004; Sweden	The long-term effects of the active accelerator pedal (AAP) were evaluated in the city of Lund in 2000 and 2001. The system, installed in 284 vehicles, produced a counterforce in the accelerator pedal at the speed limit. It could, however be overridden by pressing the accelerator pedal harder.	Absolute Difference	Mean speed in test area b/a; Mean speed in non-test area b/a; Accident rate; Mean speed (test drivers/non-test drivers); Maximum approach speed at intersection; Turning speed at intersection	The mean speed decreased more where the speed level was highest with the AAP inactive. The initial decrease in speeds was greater than the decrease after long-term usage of the system. Reduction in speed variance could also be shown. In interactions of equipped vehicles with pedestrians no significant differences could be observed between equipped and non-equipped cars.
6	Várhelyi and Makinen; 2001; Netherlands, Spain and Sweden	Field trials in three European countries, the Netherlands, Spain and Sweden were carried out in order to investigate the effects of an in-car speed limiter. The trials were carried out on urban and rural roads including motorways. A so-called unobtrusive instrumented car was used, where all the measuring equipment was hidden.	Absolute Difference	Mean travel speed; Mean time gaps; Giving way to pedestrians; Giving way to cyclists; Giving way to cars; Mental demand score; Physical demand score; Time pressure score; Performance score; Effort score; Frustration level score; Mean turning speeds at intersection	The results suggest that, the more frequently the speed limiter interferes, the more frustrated the driver feels. The highest proportion of interference on urban roads was in the Netherlands, followed by Sweden and the lowest in Spain. On rural roads, the highest proportion of interference was in Sweden, followed by the Netherlands and the lowest in Spain. The proportion of increase in self-reported frustration level follows the same order, with the largest increase for the Dutch drivers (by 104%), followed by the Swedish drivers (by 74%) and with the smallest for the Spanish drivers (by 57%). The main conclusion is that automatic speed limiting via in-car equipment is promising within built-up areas.

Table 1 *Description of coded studies*

2.2 RESULTS FOR SPEED ADAPTATION DEVICES

Introduction

The effects of speed adaptation on road safety can be summarised as follows:

- 1 study with a vast majority of findings of improving performance scores (irritation, stress, effort, safety etc.);
- 1 study with a majority of findings reporting a decrease in travel speeds;
- 1 study with a majority of findings reporting inconsistent effects on travel speeds, moreover without any statistical tests being carried out;
- 1 study with a majority of findings reporting a decrease in travel speeds;
- 1 study also includes a significant reduction of fatal crashes;
- 1 study with inconsistent effects on performance scores (irritation, stress, effort, safety etc.) and without statistical tests being carried out.

The complete detailed results from the coded studies appear on Table 2 which is presented in the supporting document. After the results were reviewed together, in possible consideration of a meta-analysis, the following points were observed:

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a) There is an adequate number of studies, however;
b) Some studies did not use statistical effects but only absolute differences (no statistical tests). Therefore, no standard errors reported.

Description of analysis carried out

Vote count analysis

After considering the previous points it was decided that a meta-analysis could not be carried out in order to find the overall impact of speed adaptation on road safety. Taking the above into consideration, it was decided to carry out a vote count analysis.

Outcome definition	Tested in number of studies	Result (number of effects)			Result (number of effects)-without statistical evaluation		
		↑	-	↓	↑*	-	↓*
Irritation score	1	1	-	-	-	-	-
Stress score	1	-	1	-	-	-	-
Safety score	1	-	-	1	-	-	-
Speeding tickets risk score	1	-	-	1	-	-	-
Speed change score	1	-	-	1	-	-	4
Driving effort score	1	1	-	-	-	-	-
Mean speed	4	2	11	26	3	21	17
Perceived safety performance	1	-	4	-	-	-	-
Proportion of time driving above the limit	1	-	-	-	4	4	1
Expected decrease in the number of fatal accidents	1	-	-	12	-	-	-
Accident rate	1	-	-	1	-	-	-
Mean time gaps	1	-	5	-	-	-	-
Giving way to pedestrians	1	-	-	-	-	1	2
Mental demand score	1	-	-	-	3	-	1
Physical demand score	1	-	-	-		-	4

Time pressure score	1	-	-	-	1	-	3
Performance score	1	-	-	-		-	4
Effort score	1	-	-	-	4	-	-
Frustration level score	1	-	-	-	4	-	-
Total Studies = 6							

Overall estimate for road safety

On the basis of the coded studies, it can be asserted that the implementation of such advance driving systems has an overall positive effect on road safety. However, there are cases when its impact is inconclusive, but these are a minority and occur due to unexpected circumstances. The fact that the results are mostly consistent and show a decrease in the number of accidents, in mean speed and in the number of drivers exceeding the speed limit leads to the assessment of the light green colour code. The variation between indicators, framing and lack of statistical evaluation and reporting of standard errors in some studies made the circumstances for conducting a meta-analysis inappropriate.

Conclusion

The vote count analysis which was carried out showed that speed adaptation/limiter is usually associated with a reduction of mean travel speeds and fatal accidents.

3 Supporting document

3.1 SUPPORTING QUANTITATIVE TABLE

Below follows Table 2, including all quantitative effects from the coded studies for the measure of speed adaptation.

Number	Author(s); Year; Country;	Outcome indicator	Exposure	Quantitative Estimate		Effect on road safety
1	Adell, E., & Varhelyi, A.;2008; Sweden	Irritation score	Active accelerator pedal (AAP)	All drivers; all speed limits	Abs. Diff=0.16; p-value<0.05	↑
		Stress score	Active accelerator pedal (AAP)	All drivers; all speed limits	Abs. Diff=0.08; p-value=0.246	-
		Safety score	Active accelerator pedal (AAP)	All drivers; all speed limits	Abs. Diff=0.220; p-value<0.05	↓
		Speeding tickets risk score	Active accelerator pedal (AAP)	All drivers; all speed limits	Abs. Diff=-1.34; p-value<0.05	↓
		Speed change score	Active accelerator pedal (AAP)	All drivers; all speed limits	Abs. Diff=-1.02; p-value<0.05	↓
				Male drivers; Private drivers; Speed limit=30	Abs. Diff=-1.00	↓*
				Male drivers; Company drivers; Speed limit=30	Abs. Diff=-1.00	↓*
				Female drivers; Private drivers; Speed limit=30	Abs. Diff=-1.00	↓*
				Female drivers; Company drivers; Speed limit=30	Abs. Diff=-1.00	↓*
		Driving effort score	Active accelerator pedal (AAP)	All drivers; all speed limits	Abs. Diff=0.220; p-value<0.05	↑
2	Adell et al.;2008; Hungary and Spain	Mean speed	Use of an active accelerator pedal when the speed limit was exceeded	Speed limit= 30; Data collection=01/02/2003-31/05/2003; Spain	Abs. Diff=-3.9; p-value<0.05	↓
		Mean speed	Use of a beep signal when the speed limit was exceeded	Speed limit= 30; Data collection=01/02/2003-31/05/2003; Spain	Abs. Diff=-2.8; p-value<0.05	↓

		Mean speed	Use of an active accelerator pedal when the speed limit was exceeded/ Use of a beep signal when the speed limit was exceeded	Speed limit= 30; Data collection=01/02/2003-31/05/2003; Spain	Abs. Diff=-1.9; p-value<0.05	↓
		Mean speed	Use of an active accelerator pedal when the speed limit was exceeded	Speed limit= 50; Data collection=01/02/2003-31/05/2003; Spain	Abs. Diff=-2.6; p-value<0.05	↓
		Mean speed	Use of a beep signal when the speed limit was exceeded	Speed limit= 50; Data collection=01/02/2003-31/05/2003; Spain	Abs. Diff=-1.4; p-value<0.05	↓
		Mean speed	Use of an active accelerator pedal when the speed limit was exceeded/ Use of a beep signal when the speed limit was exceeded	Speed limit= 50; Data collection=01/02/2003-31/05/2003; Spain	Abs. Diff=-2.5	↓*
		Mean speed	Use of an active accelerator pedal when the speed limit was exceeded	Speed limit= 80; Data collection=01/02/2003-31/05/2003; Spain	Abs. Diff=-2.5; p-value<0.05	↓
		Mean speed	Use of a beep signal when the speed limit was exceeded	Speed limit= 80; Data collection=01/02/2003-31/05/2003; Spain	Abs. Diff=-1.00	↓

		Mean speed	Use of an active accelerator pedal when the speed limit was exceeded/ Use of a beep signal when the speed limit was exceeded	Speed limit= 80; Data collection=01/02/2003-31/05/2003; Spain	Abs. Diff=-0.2	↓*
		Mean speed	Use of an active accelerator pedal when the speed limit was exceeded	Speed limit= 120; Data collection=01/02/2003-31/05/2003; Spain	Abs. Diff=-3.9; p-value<0.05	↓
		Mean speed	Use of a beep signal when the speed limit was exceeded	Speed limit= 120; Data collection=01/02/2003-31/05/2003; Spain	Abs. Diff=-1.9	↓*
		Mean speed	Use of an active accelerator pedal when the speed limit was exceeded/ Use of a beep signal when the speed limit was exceeded	Speed limit= 120; Data collection=01/02/2003-31/05/2003; Spain	Abs. Diff=-1.8	↓*
		Mean speed	Use of an active accelerator pedal when the speed limit was exceeded	Speed limit= 50; Data collection=01/08/2003-30/11/2003; Hungary	Abs. Diff=-1.1; p-value<0.05	↓
		Mean speed	Use of a beep signal when the speed limit was exceeded	Speed limit= 50; Data collection=01/08/2003-30/11/2003; Hungary	Abs. Diff=-0.7; p-value<0.05	↓

		Mean speed	Use of an active accelerator pedal when the speed limit was exceeded/ Use of a beep signal when the speed limit was exceeded	Speed limit= 50; Data collection=01/08/2003-30/11/2003; Hungary	Abs. Diff=0.2; p-value<0.05	↑
		Perceived safety performance	Use of an active accelerator pedal when the speed limit was exceeded	All speed limits; Spain & Hungary	Abs. Diff=0.47; CI [95%]= [-0.84, 0.11]	-
		Perceived safety performance	Use of a beep signal when the speed limit was exceeded	All speed limits; Spain & Hungary	Abs. Diff=0.66; CI [95%]= [-0.89, 0.42]	-
		Perceived safety performance	Use of an active accelerator pedal when the speed limit was exceeded/ Use of a beep signal when the speed limit was exceeded	All speed limits; Hungary	Abs. Diff=0.63; CI [95%]= [-0.99, 0.27]	-
		Perceived safety performance	Use of an active accelerator pedal when the speed limit was exceeded/ Use of a beep signal when the speed limit was exceeded	All speed limits; Spain	Abs. Diff=0.5; CI [95%]= [-0.86, 0.14]	-
3	Brookhuis, & de Waard; 1999; Netherlands	Proportion of time driving above the limit+10%	Speed adapter (ISA)	Speed limit=50	Abs. Diff=3	↑*
				Speed limit=50	Abs. Diff=-5	↓*
				Speed limit=70	Abs. Diff=0	-

				Speed limit=70		Abs. Diff=0	-
				Speed limit=80		Abs. Diff=0	-
				Speed limit=80		Abs. Diff=0	-
				Speed limit=100		Abs. Diff=12	↑*
				Speed limit=100		Abs. Diff=11	↑*
				Speed limit=120		Abs. Diff=1	↑*
				Speed limit=120		Abs. Diff=-1	↓*
4	Hjälmdahl et al.; 2002; Sweden	Mean speed	Active Accelerator Pedal (AAP)	Speed limit=70; Arterial road	Short time use vs without AAP	Abs. Diff=-7	↓
		Mean speed		Speed limit=50; Arterial road	Short time use vs without AAP	Abs. Diff=-5.4	↓
		Mean speed		Speed limit=50; Arterial road	Short time use vs without AAP	Abs. Diff=-4.7	↓
		Mean speed		Speed limit=50; Main street	Short time use vs without AAP	Abs. Diff=-1.5	↓
		Mean speed		Speed limit=50; Main street/mixed traffic	Short time use vs without AAP	Abs. Diff=-1	-
		Mean speed		Speed limit=30; Central street	Short time use vs without AAP	Abs. Diff=-2	↓
		Mean speed		Speed limit=70; Arterial road	Long time use vs without AAP	Abs. Diff=-4.9	↓
		Mean speed		Speed limit=50; Arterial road	Long time use vs without AAP	Abs. Diff=-5	↓
		Mean speed		Speed limit=50; Arterial road	Long time use vs without AAP	Abs. Diff=-3.7	↓
		Mean speed		Speed limit=50; Main street	Long time use vs without AAP	Abs. Diff=-2	↓
		Mean speed		Speed limit=50; Main street/mixed traffic	Long time use vs without AAP	Abs. Diff=-1	-
		Mean speed		Speed limit=30; Central street	Long time use vs without AAP	Abs. Diff=-1.7	↓
		Expected decrease in the number of fatal accidents		Speed limit=70; Arterial road	Long time use vs without AAP	Percentage diff.=18	↓
		Expected decrease in the number of fatal accidents		Speed limit=50; Arterial road	Long time use vs without AAP	Percentage diff.=25	↓

		Expected decrease in the number of fatal accidents		Speed limit=50; Arterial road	Long time use vs without AAP	Percentage diff.=20	↓
		Expected decrease in the number of fatal accidents		Speed limit=50; Main street	Long time use vs without AAP	Percentage diff.=13	↓
		Expected decrease in the number of fatal accidents		Speed limit=50; Main street/mixed traffic	Long time use vs without AAP	Percentage diff.=8	↓
		Expected decrease in the number of fatal accidents		Speed limit=30; Central street	Long time use vs without AAP	Percentage diff.=17	↓
		Expected decrease in the number of fatal accidents		Speed limit=70; Arterial road	Long time use vs without AAP	Percentage diff.=23	↓
		Expected decrease in the number of fatal accidents		Speed limit=50; Arterial road	Long time use vs without AAP	Percentage diff.=32	↓
		Expected decrease in the number of fatal accidents		Speed limit=50; Arterial road	Long time use vs without AAP	Percentage diff.=25	↓
		Expected decrease in the number of fatal accidents		Speed limit=50; Main street	Long time use vs without AAP	Percentage diff.=17	↓
		Expected decrease in the number of fatal accidents		Speed limit=50; Main street/mixed traffic	Long time use vs without AAP	Percentage diff.=10	↓
		Expected decrease in the number of fatal accidents		Speed limit=30; Central street	Long time use vs without AAP	Percentage diff.=22	↓
5	Várhelyi et al.; 2004; Sweden	Mean speed in test area b/a (Mean speed [km/h] at mid-block; unweighted average for all stretches.)	Installation of an AAP	Speed limit=70;Dual carriageway; Arterial		Abs. diff.=-3.7, p-value<0.05	↓
		Mean speed in test area b/a (Mean speed [km/h] at mid-block; unweighted average for all stretches.)		Speed limit=50;Dual carriageway; Arterial		Abs. diff.=-3.5, p-value<0.05	↓
		Mean speed in test area b/a (Mean speed [km/h] at mid-block; unweighted average for all stretches.)		Speed limit=50; Single carriageway; Arterial		Abs. diff.=-2.7, p-value<0.05	↓

		Mean speed in test area b/a (Mean speed [km/h] at mid-block; unweighted average for all stretches.)		Speed limit=50; Main road	Abs. diff.=-2.7	-
		Mean speed in test area b/a (Mean speed [km/h] at mid-block; unweighted average for all stretches.)		Speed limit=50; Main road/mixed traffic	Abs. diff.=-0.9	↓
		Mean speed in test area b/a (Mean speed [km/h] at mid-block; unweighted average for all stretches.)		Speed limit=30; Central street	Abs. diff.=0.1	-
		Mean speed in non-test area b/a (Mean speed [km/h] at mid-block; unweighted average for all stretches.)		Speed limit=30; other; other	Abs. diff.=-2.2	-
		Mean speed in non-test area b/a (Mean speed [km/h] at mid-block; unweighted average for all stretches.)		Speed limit=50;other;other	Abs. diff.=-0.4	-
		Mean speed in non-test area b/a (Mean speed [km/h] at mid-block; unweighted average for all stretches.)		Speed limit=70; other;other	Abs. diff.=1.8	-
		Mean speed in non-test area b/a (Mean speed [km/h] at mid-block; unweighted average for all stretches.)		Speed limit=90; other;other	Abs. diff.=0.3	-
		Mean speed in non-test area b/a (Mean speed [km/h] at mid-block; unweighted average for all stretches.)		Speed limit=110; other;other	Abs. diff.=1.7	-
		Accident rate (Injury accidents per driver and per passenger car in traffic and per year)		Other;other;other	Abs. diff.=-0.0534	↓

		Mean spead (test drivers/non-test drivers, Long term mean speed [km/h] of test vehicles and of other drivers)		Other;other;other	Abs. diff.=-2.4	↓
		Maximum approach speed at intersection (Maximum approach speed [km/h] at intersections evaluated 80 m before the yield line.Unweighted mean of the profiles of the mean speeds.)		Other;other;other	Abs. diff.=-0.7	-
		Turning speed at intersection (Minimum approach speed [km/h] at intersections evaluated 80 m before the yield line. Unweighted mean of the profiles of the mean speeds.)		Other;other;other	Abs. diff.=-0.9	-
6	Várhelyi and Makinen; 2001; Netherlands, Spain and Sweden	Mean travel speed	Speed limiter	All test drives, inclusive of platoon driving; all countries, speed limit=30	Abs. diff.=-2	↓*
		Mean travel speed		All test drives, inclusive of platoon driving; all countries, speed limit=40	Abs. diff.=-16.1	↓*
		Mean travel speed		All test drives, inclusive of platoon driving; all countries, speed limit=50	Abs. diff.=-3	↓*
		Mean travel speed		All test drives, inclusive of platoon driving; all countries, speed limit=60	Abs. diff.=-6.9	↓*
		Mean travel speed		All test drives, inclusive of platoon driving; all countries, speed limit=70	Abs. diff.=-4.3	↓*
		Mean travel speed		All test drives, inclusive of platoon driving; all countries, speed limit=80	Abs. diff.=2.4	
		Mean travel speed		All test drives, inclusive of platoon driving; all countries, speed limit=90	Abs. diff.=-1.9	↓*
		Mean travel speed		All test drives, inclusive of platoon driving; all countries, speed limit=110&120	Abs. diff.=0.5	↑*
		Mean travel speed		Free driving; all countries, speed limit=30	Abs. diff.=-1.5	↓*
		Mean travel speed		Free driving; all countries, speed limit=40	Abs. diff.=-27.4	↓*
		Mean travel speed		Free driving; all countries, speed limit=50	Abs. diff.=-4.3	↓*
		Mean travel speed		Free driving; all countries, speed limit=60	Abs. diff.=-12.5	↓*
		Mean travel speed		Free driving; all countries, speed limit=70	Abs. diff.=-4.4	↓*
		Mean travel speed		Free driving; all countries, speed limit=80	Abs. diff.=1.4	↑*

		Mean travel speed		Free driving; all countries, speed limit=90	Abs. diff.=-4.5	↓*
		Mean travel speed		Free driving; all countries, speed limit=110&120	Abs. diff.=-3.7	↓*
		Mean turning speeds at intersection		Free driving; Netherlands; Intersection N1T1	Abs. diff.=1.1	-
		Mean turning speeds at intersection		Free driving; Netherlands; Intersection N1T2	Abs. diff.=-0.4	-
		Mean turning speeds at intersection		Free driving; Netherlands; Intersection N1T6	Abs. diff.=0.8	-
		Mean turning speeds at intersection		Free driving; Netherlands; Intersection N1T11	Abs. diff.=1.3	-
		Mean turning speeds at intersection		Free driving; Netherlands; Intersection N1T15	Abs. diff.=2.8	-
		Mean turning speeds at intersection		Free driving; Netherlands; Intersection N1T16	Abs. diff.=-15	-
		Mean turning speeds at intersection		Free driving; Netherlands; Intersection N1T18	Abs. diff.=-0.6	-
		Mean turning speeds at intersection		Free driving; Spain; Intersection SpT1	Abs. diff.=-0.1	-
		Mean turning speeds at intersection		Free driving; Spain; Intersection SpT7	Abs. diff.=-2.6	-
		Mean turning speeds at intersection		Free driving; Spain; Intersection SpT13	Abs. diff.=-2.6	-
		Mean turning speeds at intersection		Free driving; Spain; Intersection SpT15	Abs. diff.=-2.6	-
		Mean turning speeds at intersection		Free driving; Spain; Intersection SpT17	Abs. diff.=-3.4	-
		Mean turning speeds at intersection		Free driving; Sweden; Intersection SwT1	Abs. diff.=0.6	-
		Mean turning speeds at intersection		Free driving; Sweden; Intersection SwT2	Abs. diff.=-1	-
		Mean turning speeds at intersection		Free driving; Sweden; Intersection SwT3	Abs. diff.=-1.5	-
		Mean turning speeds at intersection		Free driving; Sweden; Intersection SwT4	Abs. diff.=-2	-
		Mean turning speeds at intersection		Free driving; Sweden; Intersection SwT8	Abs. diff.=0.5	-
		Mean turning speeds at intersection		Free driving; Sweden; Intersection SwT9	Abs. diff.=2.3	-
		Mean turning speeds at intersection		Free driving; Sweden; Intersection SwT15	Abs. diff.=1.4	-
		Mean turning speeds at intersection		Free driving; Sweden; Intersection SwT16	Abs. diff.=-1	-
		Mean turning speeds at intersection		Free driving; Sweden; Intersection SwT19	Abs. diff.=-4.5	-
		Mean turning speeds at intersection		Free driving; Sweden; Intersection SwT20	Abs. diff.=19.1	↑

		Mean time gaps		All countries; Speed limit=0-30	Abs. diff.=-0.05, p-value=0.839	-
		Mean time gaps		All countries; Speed limit=30-50	Abs. diff.=0.09, p-value=0.094	-
		Mean time gaps		All countries; Speed limit=50-70	Abs. diff.=-0.03, p-value=0.407	-
		Mean time gaps		All countries; Speed limit=70-90	Abs. diff.=-0.1, p-value=0.083	-
		Mean time gaps		All countries; Speed limit=90-140	Abs. diff.=-0.02, p-value=0.626	-
		Giving way to pedestrians		All countries	Abs. diff.=4	↓*
		Giving way to pedestrians		All countries	Abs. diff.=1	↓*
		Giving way to pedestrians		All countries	Abs. diff.=0	-
		Mental demand score		Netherlands	Abs. diff.=-2.2	↓*
		Mental demand score		Spain	Abs. diff.=7.3	↑*
		Mental demand score		Sweden	Abs. diff.=3.5	↑*
		Mental demand score		All countries	Abs. diff.=2.8	↑*
		Physical demand score		Netherlands	Abs. diff.=8.6	↑*
		Physical demand score		Spain	Abs. diff.=2.4	↑*
		Physical demand score		Sweden	Abs. diff.=2.3	↑*
		Physical demand score		All countries	Abs. diff.=4.4	↑*
		Time pressure score		Netherlands	Abs. diff.=4.5	↑*
		Time pressure score		Spain	Abs. diff.=-9.4	↓*
		Time pressure score		Sweden	Abs. diff.=-3.8	↓*
		Time pressure score		All countries	Abs. diff.=-2.7	↓*
		Performance score		Netherlands	Abs. diff.=-5.4	↓*
		Performance score		Spain	Abs. diff.=-18.1	↓*
		Performance score		Sweden	Abs. diff.=-10.9	↓*
		Performance score		All countries	Abs. diff.=-11.3	↓*
		Effort score		Netherlands	Abs. diff.=10.9	↑*
		Effort score		Spain	Abs. diff.=6.4	↑*
		Effort score		Sweden	Abs. diff.=0.8	↑*
		Effort score		All countries	Abs. diff.=6	↑*
		Frustration level score		Netherlands	Abs. diff.=17.1	↑*
		Frustration level score		Spain	Abs. diff.=13.5	↑*
		Frustration level score		Sweden	Abs. diff.=7.8	↑*
		Frustration level score		All countries	Abs. diff.=12.8	↑*

↓	denotes positive road safety effects	-	denotes unclear or marginal road safety effects
↑	denotes negative road safety effects	*	denotes that no statistical analysis was conducted for the significance of the effects

Table 2 *Quantitative results of coded studies*

3.2 IDENTIFYING RELEVANT STUDIES

Literature search strategy

The search strategy aimed at identifying recent studies regarding the implementation of intelligent speed adaptation systems. The main database that was consulted was Scopus. In general, only recent (after 1990) journal studies were considered. However, high quality conference papers and reports were also considered. Moreover, reference lists of individual studies were also examined.

Limitations/ Exclusions:

- Search field: TITLE-ABS-KEY
- Published: 1990 to current
- Document Type: "Review" and "Article"
- Language: "English"
- Source Type: "Journal"
- Only Transport Journals were considered
- Subject Area: "Engineering and Psychology"

Database: Scopus **Date:** 28th March 2017

search no.	search terms / operators / combined queries	Hits
#1	(„intelligent speed adaptation")	954

3.2.1 Results of Literature research

Database	Hits
Scopus	954
Total number of studies to screen title	954

3.3 SCREENING

The abstracts of relevant studies from the initial literature search results were examined to narrow the scope and to detect studies that would be more appropriate at a first stage. Those abstracts gave hints as to whether the full text warranted close examination for coding and inclusion in the project.

Total number of studies to screen title	954
Number of articles remaining after screening of the title = Total number of studies to screen abstract	768
Remaining studies after abstract screening	389
Total number of studies to screen full text	389

3.4 ELIGIBILITY

Total number of studies to screen full-text	389
Full-text could be obtained	389
Reference list examined Y/N	Yes
Eligible papers prioritised	11

3.5 PRIORITISING CODING

- Prioritising Step A (existing meta-analyses)

- Prioritising Step B (most recent studies)

- Prioritising Step C (Journals over conferences and reports)

- Prioritising Step D (Prestigious journals over other journals and conference papers)

- Prioritising Step E (Studies from Europe)

3.6 REFERENCES

List of coded studies

1) Adell, E., Varhelyi, A. (2008). Driver comprehension and acceptance of the active accelerator pedal after long-term use. Transportation Research Part F: Traffic Psychology and Behaviour, 11(1), 37-51.
2) Adell, E., Várhelyi, A., Hjälmdahl, M. (2008). Auditory and haptic systems for in-car speed management – A comparative real life study. Transportation Research Part F, 11, 445-458. Doi:10.1016/j.trf.2008.04.003.
3) 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.
4) Hjälmdahl, M., Almqvist, S., Varhelyi, A. (2002). Speed regulation by in-car active accelerator pedal - Effects on speed and speed distribution. IATSS Research, 26(2). Doi: 10.1016/S0386-1112(14)60044-3.
5) 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, 36, 729-737. Doi:10.1016/j.aap.2003.06.001.
6) Várhelyi, A., Mäkinen, T. (2001). The effects of in-car speed limiters: field studies. Transportation Research Part C: Emerging Technologies, 9(3), 191-211.