Consideration of the role of speed limiters in light commercial vehicle CO_2 regulation

Final report for:

DG Climate Action
24 Avenue de Beaulieu
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Date: 9 March 2016

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Summary

Objective, context and methodology

Regulation 253/2014 defines the modalities for reaching the 2020 target to reduce CO_2 emissions from new light commercial vehicles (LCV's) and requests the European Commission to carry out a review of this Regulation for the period beyond 2020 by the end of 2015. One of the issues debated during the legislative process for this Regulation was the potential use of speed control devices as a low-cost tool for reducing fuel consumption and CO_2 emissions from LCV's.

This study focuses on both the traditional speed limiters as well as the more advanced Intelligent Speed Adaptation (ISA) systems for **new** LCV's. The current situation is explored (costs, fitting rates and compliance). Furthermore, the study explores competition of LCV's with HDV's, evaluates the co-benefits of implementation of speed control devices (traffic safety and air pollutant emissions) and explores legislative options for incentivising speed control devices.

The analysis builds upon a review of vehicle brochures, literature review, a survey among stakeholders and Member States, interviews, mystery shopping, data analysis and modelling.

Overview costs and fitting rates of speed control devices

Two systems of speed control devices are the most prominent offered for LCV's: separate speed limiters and cruise control with speed limiters. The separate speed limiter is installed by the OEM and generally cannot be adjusted by the driver. For the cruise control with speed limiter, however, the speed limiter is a functionality of the cruise control system which can always be adjusted by the driver. ISA is currently not yet on the market for LCV's.

The combination of speed limiter and cruise control is an option in the price range of €150-€347 excluding taxes. For separate speed limiters, the speed limit is set either at the dealer or in the factory; and the driver cannot turn it off. If the speed limiter is placed at the dealer using a designated computer, it can also be removed at the dealer quite easily and at low cost. If the speed limiter is set in the factory, it is protected by a factory code and it can only be removed at considerable costs. This type of separate speed limiters (i.e. without cruise control) is installed at the factory for a price in the range of €25-€139 excluding taxes. All prices are based on the brochure review for the Netherlands, Germany, Italy and the United Kingdom. The costs for the OEM to install a separate speed limiter were given qualitatively to be low.

Currently, ISA systems are not being sold for LCV's in the Netherlands, Germany, or the United Kingdom. Open ISA systems are ubiquitous in current navigation systems. Carsten et al (2008) expected prices to drop to £60(€80) for advisory ISA and £160 (€222) for voluntary/mandatory ISA systems if fitted in new vehicles by 2015.

There is no data on EU level available on the fitting rates of speed limitation devices for new LCV's. Unfortunately, the survey supporting this report did not yield information on fitting rates. Therefore fitting rates were explored through interviews with trade associations from the Netherlands, Germany, the UK and Italy, as well as lease companies and distributors. It was found that trade associations don't have information on the fitting rates. For lease companies there can be a high variation in the fitting rates. Distributors of LCV's seem to have the best data available.

Speed limiter compliance

This analysis did not just focus on LCV's but also on HDV's. There is much more experience with speeds limiters, the possibilities for tampering and how this could be prevented in that segment. For this task some experts from specialised companies were interviewed. These were companies that offer speed limiter adjustment or removal. The companies claimed that they can delete the speed limiter completely for virtually all new vans. The price for adjusting the speed limiter is relatively high compared to the price of a separate speed limiter. A range around 260-435 euro was indicated in the interviews. The companies had no experiences with ISA.

Enforcement of speed limiter compliance for HDV's is organised in two ways: via the Periodical Technical Inspections (PTI) and via roadside inspections. During the PTI, a visual inspection could be insufficient and an acceleration test would be necessary to spot a tampered speed limiter. Roadside inspections are more effective for HDV's. For LCV's this would be different as not all types can be easily distinguished from passenger cars. Moreover, if the speed limiters are only optional for vans it would be impossible to recognise tampering only from speed measurement. Overall, very little data on fraud with HDV's was available. The data available does suggest that fraud is relatively low (0.2-2%) for HDV's.

Legislation outside the EU

We checked the legislation in other parts of the world, requiring OEMs to fit LCV's with speed control devices. The experience of other countries could provide valuable insights or lessons on the implementation of LCV requirements in the EU. We found that there are no countries with legislation requiring OEMs to fit speed limiters for LCV's. The US heavy-duty GHG Phase 1 regulations (and the Phase 2 proposal) include credits for speed limiters, but they are not required.

Exploration of competition with HDV's

In general LCV's are less regulated than HDV's – think for example of the requirement of drivers with Certificates of Professional Competence and the fact that speed limiting devices are mandatory for HDV's. It is sometimes argued that this has led to an uneven level playing field between HDV's and LCV's. It might be possible that this has led to a shift towards more frequent use of LCV's as they are subject to fewer limitations. Such a shift might have consequences such as increased number of vehicle km, fuel consumption and hence CO_2 emissions.

The literature review and stakeholder survey led to mixed results. On the one hand, there has been an increase in the sales and stock of LCV's, while the stock of HDV's decreased. There might also be some competition on certain submarkets – especially for the larger N1 vans (class III). On the other hand, it is difficult to link these evolutions to the speed limiter obligation for HDV's.

Evaluation of co-benefits

Next, we focussed on the potential co-benefits of speed control devices – especially on safety and air pollutant. For this task four scenarios were analysed. In all cases the speed control device is not mandatory for LCV's. We analysed two speed limiters - with a limit set at 110 km/h and a limit set at 120 km/h; and two ISA scenarios – one half open and one closed system, both using fixed speed information. Using the impact of the speed control device on the average speed, the speed distribution and a speed-accident relationship the effect on safety was calculated. This calculation takes into the differences between the EU countries with respect to the set speed limit at different types of roads and the number of accidents happening with LCV's. The table below summarizes the results.

Table 1: Potential safety effect of speed control devices (fatalities)

		Urban	Rural	Motorways	Total number of fatalities
Scenario 1	Speed limiter (120 km/h)	0%	0%	-7.7%	-12
Scenario 2	Speed limiter (110 km/h)	0%	-2.1%	-19.9%	-40
Scenario 3	ISA (half open-fixed)	-30%	-11%	-11%	-111
Scenario 4	ISA (closed-fixed)	-31%	-12%	-12%	-119

This result is also relevant for the work currently being done in the framework of the review of the General Safety Regulation (EC) No 661/2009 on the monitoring of technical developments in the field of enhanced passive safety requirements, the consideration and possible inclusion of new and enhanced safety features as well as enhanced active safety technologies. In this context Intelligent Speed Adaptation is amongst those that are identified as potential cost-effective safety measures.

The effect on the emissions was calculated using the impact of the speed control device on the average speed and speed profiles using the VERSIT+ model.

Table 2: Emission reductions resulting from various speed control devices

	Speed limiting device	Road type	average velocity	Reductions CO_2	Reductions NO_x	Reductions PM10	Share of driving	Reductions CO_2	Reductions NO_x	Reductions PM10
Reference	No limiter	Urban	17.5	0%	0%	0%	13%	0.0%	0.0%	0.0%
	No limiter	Rural	80.0	0%	0%	0%	10%			
	No limiter	Rural	90.0	0%	0%	0%	10%			
	No limiter	Motorway	107.0	0%	0%	0%	33%			
	No limiter	Motorway	115.0	0%	0%	0%	33%			
Scenario 4	ISA (Closed - fixed)	Urban	17.4	1%	1%	1%	13%	1.7%	3.6%	1.7%
	ISA (Closed - fixed)	Rural	77.1	7%	10%	7%	10%			
	ISA (Closed - fixed)	Rural	86.0	9%	21%	9%	10%			
	ISA (Closed - fixed)	Motorway	106.8	0%	1%	0%	33%			
	ISA (Closed - fixed)	Motorway	115.0	0%	0%	0%	33%			
Scenario 2	speed limiter (110 km/h)	Urban	17.5	0%	0%	0%	13%	6.4%	17%	6%
	speed limiter (110 km/h)	Rural	80.0	0%	0%	0%	10%			
	speed limiter (110 km/h)	Rural	90.0	2%	5%	2%	10%			
	speed limiter (110 km/h)	Motorway	104.7	5%	15%	5%	33%			
	speed limiter (110 km/h)	Motorway	107.2	14%	35%	14%	33%			
Scenario 1	speed limiter (120 km/h)	Urban	17.5	0%	0%	0%	13%	0.9%	2.2%	0.9%
	speed limiter (120 km/h)	Rural	80.0	0%	0%	0%	10%			
	speed limiter (120 km/h)	Rural	90.0	0%	0%	0%	10%			
	speed limiter (120 km/h)	Motorway	107.0	0%	0%	0%	33%			
	speed limiter (120 km/h)	Motorway	113.5	3%	6%	3%	33%			

Given that the simulations in this study result in only limited effect of closed ISA systems on motorways, the effect of half open ISA systems is expected to be similar to what is found for closed ISA systems.

Exploration of legislative options

Given the positive effects of both ISA and speed limiters on greenhouse gas emissions, pollutants and safety it is worthwhile to investigate how they could be incentivised. In the current and future (WLTP) legislation the CO_2 emissions will (partly) be based on a type approval test dynamometer test. For as long as the CO_2 emission targets that manufacturers have to comply with are solely based on this dynamometer test there are two ways in which speed control devices could be rewarded and therefore incentivised, i.e.

1. Allow the speed control device during the drive cycle on the dynamometer during the type approval test or;
2. Account for the reduced CO_2 emissions separately from the test procedure via;
    a. Via the 'eco-innovations' system that is currently in place.
    b. However, future regulation is not necessary similar to the current setup and the use of speed limiters could be incentivised in multiple ways. For example, a simplified eco-innovations system could be implemented to credit emission reductions.

We considered the pros and cons of these two options with respect to three categories, i.e. Incentive, Flexibility and Administrative burden. We found that accounting for speed control devices via the type approval test is likely to result in a considerable incentive and will additionally lower the administrative burden. However, this is only possible for speed limiters and it is at the cost of flexibility to correct for 'real world' use of LCV's compared to the type approval test. Accounting separately from the type approval test and not purely based on theoretical emission reduction does provide such flexibility, i.e. as the amount of credits granted can be chosen by the regulator in such a way that implementation is cost-effective for LCV manufactures. As a result, the incentive for this option can be greater than when accounting via the type approval test. The only drawback of this option is the higher administrative burden compared to accounting via the type approval test.

Policy discussion and conclusion

The table below summarizes the impact on emissions, safety and the potential of the two main incentive policies possible.

Table 3: Multiple-criteria decision analysis

				Flexibility			Administrative burden		Safety	CO2	Air pollu-tants
			Incentive (apart from incentive resulting from 'flexibility')	Ability to correct for tampering	Ability to correct for specific LCV use	Ability to incentivise even if not cost effective on type approval	For commission	For manufacturer			
Apply in type approval test		Speed limiter	X	X	X	X	X	X	+	++	++
		ISA	+	-	-	-	++	++	++	+	+
Account for the reduced CO2 emissions separate from the type approval test	Via the 'eco-innovations' system	Speed limiter	X	X	X	X	X	X	+	++	++
		ISA*	+/-	+	+	+	- -	- -	++	+	+
	Not purely based on theoretical emission reduction	Speed Limiter	+/-	++	++	++	-	+	++	++	++
		ISA	+/-	++	++	++	-	+	++	+	++

Speed control devices have been mandatory for HDV's for many years. We found that speed control devices might be a cost-effective way to reduce green-house gas emissions from LCV's; especially in the case of a speed limiter set at 110 km/h or an ISA system. The use would also positively impact the emissions of other air pollutants and traffic safety. There could be a problem of enforcement; as fraud would not be easily detected.

A speed limiter set at 110 km/h has the highest effect on CO_2 emissions and air pollutants. If the choice would be between a speed limiter set at 110 km/h or one at 120 km/h, it is clear that the first is much more cost-efficient. It does however have a much lower impact on safety than the ISA systems as ISA has an impact on all road types. Given that ISA systems have a much higher impact on traffic safety, impact CO2 emissions and air pollutants positively, do not impose lower speed limits for LCVs and hence are much more acceptable, **the best option seems to incentivise the use of ISA**. This means that the only option to incentivise the use would be to account for the reduced CO_2 emissions separately from the test procedure as ISA cannot be included into the test procedure. It is also not clear if ISA would classify as an eco-innovation. However, currently consideration is being given to the post 2020 regime for regulating car and light commercial vehicle CO2 emissions. As part of this, the eco-innovation-like system could change or even be replaced with a different approach. Depending on the final regulation, such a system could incentivise the implementation of technologies more easily. This may lower the administrative burden on both the regulatory authority as well as LCV manufacturers. Hence the best option seems to be to **incentivise the use of ISA granting credits under a new system**.

1 Introduction

1.1 Preamble

Regulation 253/2014 to define the modalities for reaching the 2020 target to reduce CO_2 emissions from new light commercial vehicles (LCV's) requests the European Commission to carry out a review of this Regulation for the period beyond 2020 by the end of 2015.

One of the issues debated during the legislative process for this Regulation was the potential use of speed limiters as a low-cost tool for reducing fuel consumption and CO_2 emissions from LCV's. The potential of speed limiters to reduce CO_2 emissions from LCV's was estimated by (CE Delft, 2010) to be around 4-5% for 110 km/h speed limiters and 6-7% for the 100 km/h speed limiters. (Transport & Mobility Leuven, 2013) took into account the speed limits in the different EU member states and estimated the potential to be around 3-8% on motorways and 0-1% on rural roads for 110 km/h speed limiters and 9-14% on motorways and 0-5% on rural roads for the 100 km/h speed limiter.

There seems to be a market interest in fitting speed limiters to LCV's. They are available as optional extras for many LCV's at a reasonable cost (around 25-139 euro). There also appears to be a substantial after-market with different companies offering to fit speed limiters with illustrative prices around 260-435 euro (excluding VAT).

Companies offering to fit speed limiters claim that the fuel savings are in the range of 25% and hence that the fitting costs are recuperated in a few months use. (IMPROVER study, 2006) estimated a benefit-cost ratio of fitting speed limiters to LCV's of 1.65 to 1.

Apart from the expected fuel savings and the effect on CO_2 emissions one can also expect additional benefits in the form of reduced air pollutant emissions and improved road safety. The European Commission is currently in the process of preparing a report covering the review of the General Safety Regulation (EC) No 661/2009 (OJ L 200, 31.7.2009, p. 1) on the monitoring of technical developments in the field of enhanced passive safety requirements, the consideration and possible inclusion of new and enhanced safety features as well as enhanced active safety technologies. These commitments are laid down in Article 17 of the Regulation. The named report will be in the form of a Communication with a targeted finalisation date by the end of June 2016. The Communication will outline the methodology to be used in the identification of the next measures and way forward in terms of vehicle safety. Measures are identified in terms of whether or not the benefits outweigh the cost of regulation. In this context Intelligent Speed Adaptation is amongst those that are identified as potential cost-effective safety measures. A Commission proposal will follow, to be adopted before June 2017. At this stage, more information is available in the preparatory research that has been carried out by TRL on behalf of the Commission: "Benefit and feasibility of a range of new technologies and unregulated measures in the field of vehicle occupant safety and protection of vulnerable road users[1]".

[1] http://bookshop.europa.eu/en/benefit-and-feasibility-of-a-range-of-new-technologies-and-unregulated-measures-in-the-field-of-vehicle-occupant-safety-and-protection-of-vulnerable-road-users-pbNB0714108/;pgid=Iq1Ekni0.1lSR0OOK4MycO9B0000BAJ9tQVy;sid=OT_-Ap3uO3P-V8j2wGFgpf_Lm_yCUpo9P-w=

Stakeholders also argue that the absence of speed limiters in LCV's leads to unfair competition between LCV under and over 3.5 GVW, leading to an overuse of LCV, leading on its turn to a greater overall fuel consumption.

It is also desirable to understand whether there are differences between Member States which lead to greater or less benefits from speed control devices or bring other considerations.

Note that the EU legislation regulating LCV CO_2 emissions cannot require the fitting of a technology. If that were desired, it would need to be carried out through type approval legislation. Nevertheless, in view of the potential CO_2 benefits, it is desirable to consider whether the legislation could incorporate a mechanism to encourage fitting speed limiters as original equipment to LCV's. While speed limiters do not qualify under the eco-innovation regime, one possible mechanism might be to give credit to OEMs who fit speed limiters which are proven to be tamper-proof and are in permanent operation. Intelligent Speed adaptation on the other hand is, depending on the system, far more subject to driver behaviour. An open system would hence, in the eco-innovation regime, call into question any granting of credits. A key issue if OEMs were to receive any benefits under legislation from fitting speed control devices is that the device should remain in continuous operation and be tamper proof.

1.2 Objective

The objective of this study is to gather information on the market for speed control devices (both on traditional speed limiters as well as more advanced Intelligent Speed Adaptation (ISA)), the implications of their use and to explore the potential for using speed limitation devices in the EU on **new** light commercial vehicles to reduce their CO_2 emissions. More precisely, we will

- Provide an overview of original equipment LCV speed control devices costs and their variations
- Explore fitting rates of LCV speed control devices in major EU member states and their use.
- Provide an overview for major world LCV markets of any requirements to fit LCV speed control devices or if any account is taken of them in fuel economy or CO_2 legislation
- Explore the degree to which the absence of speed limiters in LCV's of less than 3.5 tGVW may contribute to a traffic shift to LCV's and hence an increase in vkm travelled (because of their lower load carrying capacity) and higher fuel use and CO_2 emissions
- Evaluate the value of co-benefits quantitatively– especially traffic safety and air pollutant emissions from fitting speed control devices
- Explore the legislative options through which speed control device fitment could be incentivised for LCV's.
- Seek relevant stakeholder input on all pertinent aspects of the work.

1.3 Structure of the report

This report is structured as follows. In chapter 2 the general methodology of the project and the approach, responses and results of the survey are presented.

In Chapter 3 the first task is discussed; the overview of the prices, costs and fitting rate of speed control devices. Chapter 4 focusses on speed limiter compliance. An overview of the requirements for LCV's outside the European Union is given in Chapter 5. Chapter 6 explores the potential competition between LCV's and HDV's while in Chapter 7 an evaluation is made of possible co-benefits of speed control devices. Chapter 8 explores the legislative options to incentivise the use of speed control devices. Finally, the main conclusions and recommendations of the study are presented in chapter 9.

2 Methodology

In this chapter we first discuss the definition of the different speed control devices we consider in this work. Next we outline the main methodology and the different tasks. We end with a description of the stakeholder survey which is used as an input in all other tasks.

2.1 Definitions

2.1.1 Speed control devices

There are different speed control devices on the market, and we have to be clear about the definitions we use. We mainly distinguish between speed limiters and Intelligent Speed Adaptation (ISA).

A **speed limiter** is a system installed in a vehicle that limits the speed at which it can travel. This can be achieved in several ways, such as through accelerator control, direct fuel control, and electronic control. Speed limiters can also be divided in voluntary systems (when it can be turned off by the driver), and mandatory systems (when it cannot be turned off by the driver). The speed limit is fixed at a certain value, at the dealer, or in the factory. Directive 92/6/EEC required speed limiters to be installed on large Heavy Goods Vehicles and buses (N3 and M3 vehicles). In 2002, this "Speed Limitation Directive" was amended by Directive 2002/85/EC, which obliged all Heavy Commercial vehicles, so also N2 and M2 vehicles, to be equipped with speed limiters. The two most prominent systems offered for LCV's are separate speed limiters and cruise control with speed limiters. The separate speed limiter is installed by the OEM and generally cannot be adjusted by the driver. For the cruise control with speed limiter, however the speed limiter is a functionality of the cruise control system which can always be adjusted by the driver. It can also be easily set and unset without undue distraction to the driver. Moreover, these systems can actively prevent from driving faster than the speed limit or simply warn the driver when the speed is above the set maximum.

With **Intelligent Speed Adaptation** (ISA), the speed limit changes while driving. Intelligent Speed Assistance (ISA) is an example of an advanced driver assistance system (ADAS). An ADAS is a system that aims at supporting the driver during the driving process through the use of safe human-machine interfaces. ISA systems focus on supporting drivers' speed choices. Different types of ISA exist and have potentially different impacts on speed choice, safety, emissions, driving comfort and road usage. An ISA system typically exists of three components. These components can be built into the vehicle, or be provided as an after-market system.

- Component 1: speed and location monitoring system
- Component 2: set speed information comparison
- Component 3: a feedback system

The speed monitoring system (component 1) is responsible for providing information on the current location of the vehicle as well as the speed that the vehicle is running at. This information is typically provided by a GPS system (location) in combination with vehicle data input (CANBUS or similar).

This information is compared to a set speed (component 2). This set speed can be provided through the combination of GPS coordinates with map information containing mandatory speed limits, vertical road sign recognition (speed signs) or other sources of information.

The driver receives information on the set speed through visual, auditory or haptic channels (component 3). A comparison between set speed and driven speed can take place before the feedback is presented. ISA systems can be **open/passive**, when they only provide speed limit information, as in most navigation systems. They can be **semi-open**, providing tactile feedback e.g. through a heavier accelerator pedal when the limit is exceeded. An ISA system is called **closed or active** when it actually restricts the speed of the vehicle.

2.1.2 LCV's and HDV's

In this work we focus on speed limitation devices for **Light Commercial Vehicles** (**LCV's)** or N1 vehicles. Light Duty Vehicles (LDV's) are understood to include both M1 and N1 (LCV's) categories, but this analysis does not address M1 vehicles. Heavy Duty Vehicles (HDV's) are understood to include M2, M3, N2 and N3 vehicles. These categories of vehicles are defined as follows:

- Category M1: Vehicles designed and constructed for the carriage of passengers and comprising no more than eight seats in addition to the driver's seat.
- Category M2: Vehicles designed and constructed for the carriage of passengers, comprising more than eight seats in addition to the driver's seat, and having a maximum mass not exceeding 5 tonnes.
- Category M3: Vehicles designed and constructed for the carriage of passengers, comprising more than eight seats in addition to the driver's seat, and having a maximum mass exceeding 5 tonnes.
- Category N1: Vehicles designed and constructed for the carriage of goods and having a maximum mass not exceeding 3.5 tonnes.
- Category N2: Vehicles designed and constructed for the carriage of goods and having a maximum mass exceeding 3.5 tonnes but not exceeding 12 tonnes.
- Category N3: Vehicles designed and constructed for the carriage of goods and having a maximum mass exceeding 12 tonnes.

2.2 Overall project methodology and structure of the work plan

The overall project approach consists of three phases. In a first phase we set the scene by making an overview of the types of speed control devices offered as original equipment and their costs and the fitting rates (Task 1). Next, we explore the data on deactivation and tampering and how far it is possible to prevent this (Task 2). In task 3, we provide an overview of legislation in other parts of the world, requiring (OEMS) to fit speed limiters.

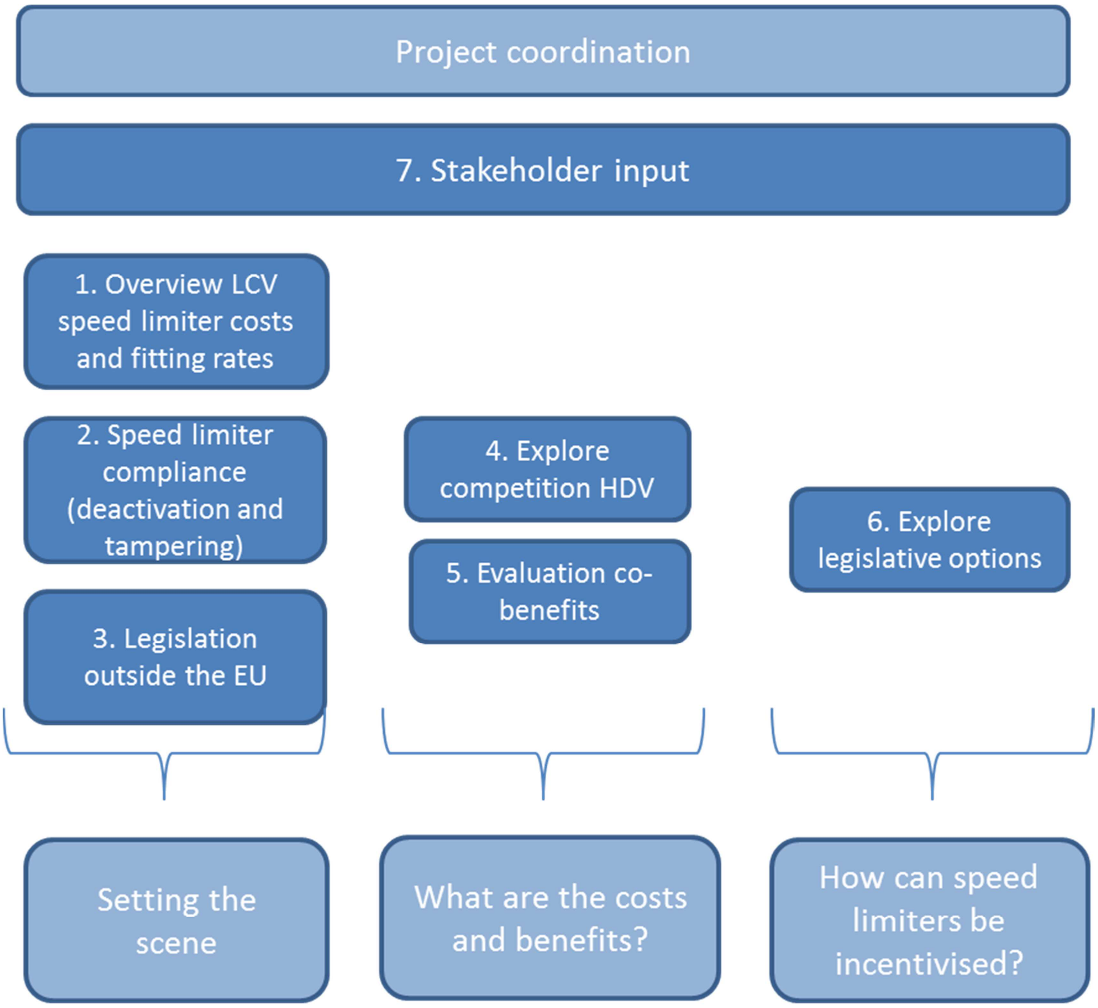
In a second phase we focus on the possible consequences of (not) fitting LCV's with speed control devices. Has the fact that LCV's are not equipped with a speed limiter led to a modal shift from HDV's to LCV's? And consequently to more km driven and hence a higher fuel consumption and CO_2 emissions (Task 4)? Apart from reducing fuel use and CO_2 emissions, what are the additional benefits on traffic safety and air pollutants from fitting LCV's with speed control devices (Task 5)?

In a final phase we explore the legislative options to incentivise the use of speed control devices by LCV's (Task 6).

Stakeholder input (task 7) is used throughout the different tasks.

The figure below illustrates this set-up.

Figure 1: Overall project methodology.



As the stakeholder input is used in all tasks we discuss our approach in the following paragraph. The actual outcome from the stakeholder input is integrated in the other tasks. The goal, approach and outcome of the other tasks are discussed in the next chapters.

2.3 Stakeholder input

Stakeholder input is important in this work. The goal of their input is not only to use the information they have, but also to collect their view on the use of speed control devices for LCV's as a mean to reduce the CO_2 emissions.

Input was gathered via different interviews and a stakeholder survey.

2.3.1 Interviews

Several individual interviews were conducted, mainly to gather information on

- The costs and prices of speed limiter devices: several dealers were approached
- The possibilities of tampering: experts from specialised companies were interviewed. These were companies that offer speed limiter adjustment or removal. They were

sometimes approached as 'mystery shoppers' and therefore they are presented anonymously in this report.
- The experience with speed control devices in other countries: specialists were interviewed.
- Fitting rates of speed control devices: interviews with trade associations and lease companies.

2.3.2 Stakeholder survey

An online survey was set up in the first stage of the project. The questions were composed in consultation with the Commission. An extract from the survey can be found in Annex 1.

The main objective of this survey was to gather information which fed into the different tasks of the project. Given this main objective, two sub-objectives were identified for the current survey:

1. Receiving hard input data on prices, vkm, possibilities of tampering, fitting rates;
2. Gathering the view of stakeholders on certain aspects such as policy options to stimulate the use of speed limit devices.

Practical implementation

- The questionnaire was available in English in the format of an on-line survey using LimeSurvey[2](hosted by TML).
- There were different sets of questions and the interviewees first had an option of indicating the subject groups they have knowledge of (to avoid that people have to go through a very long survey indicating "no information")
- Umbrella organisations received a shorter version and were not asked about prices/costs of speed control devices.
- The stakeholders first received a mail indicating the main purpose of the survey, including the supporting letter written by DG CLIMA. Following this mail, we received some replies requesting for the survey in a pdf/word format, which was also given.
- The survey was online in the period 10 November 2015-31 December 2015
- The survey was sent out to 58 stakeholders[3] and representatives of the 28 Member States. Umbrella organisations indicating that they would ask their individual members to fill in the survey received a separate link which could be forwarded. This way five additional people accessed the survey. Hence, in total 91 contacts were made of which 20 filled in the survey, although only eight completely. Two people opted to send information without filling in the survey.
- We received one "position paper" as a reply to the survey. We refer to the content of this paper in task 5.

[2] http://www.limesurvey.org/

[3] Stakeholders included vehicle OEMs, relevant umbrella organisations, safety institutes, countries outside the EU, components manufacturers and companies offering speed limiters

3 Task 1: Overview LCV speed limiters costs and fitting rates

3.1 Introduction

This chapter gives an overview of the types of speed limiters and ISA offered as original equipment, their prices and costs, and their fitting rates.

In this chapter, the distinction between separate speed limiters and cruise control with speed limiters is important. These systems are the two most prominent that are offered for LCV's. As said, the separate speed limiter is installed by the OEM and generally cannot be adjusted by the driver. For the cruise control with speed limiter, however the speed limiter is a functionality of the cruise control system which can always be adjusted by the driver.

3.2 Approach

The data has been acquired through review of vehicle brochures, literature review, and a survey and interviews with several dealers, trade associations, lease companies and automotive distributors (ie. the companies that import and supply vehicles from the OEMs to the local dealers). The focus of this approach is aimed at Netherlands, Germany, Italy and United Kingdom (which represent 46% of the EU new LCV market).

3.3 Results

3.3.1 Speed limiter prices and costs

Speed limiters for new LCV's offered by the vehicle OEM, are sold in two variations:

1. cruise control system with speed limiter
2. separate speed limiter.

Currently all speed limiters use electronic control, controlling the engine through the motor management system (also called electronic control unit or ECU).

In the first variation, the speed limiter is sold as a package with cruise control, which is installed at the factory. The driver can also choose to turn the speed limiter off. The speed limiter has a different function compared to the cruise control. The speed limiter allows all speeds up to the speed limit where it will not respond to the accelerator pedal anymore. Cruise control fixes the speed at a certain single value (eliminating the need for using the accelerator pedal), but this value can be exceeded by pushing the accelerator pedal again (or, naturally, the speed can be reduced by pushing the brake). The combination of speed limiter and cruise control is an option in the price range of €150-€347 excluding taxes, based on the brochure review for the Netherlands, Germany, Italy and the United Kingdom.

In the second variation, the speed limit is set either at the dealer or in the factory; and the driver cannot turn it off. If the speed limiter is placed at the dealer using a designated computer, it can also be removed at the dealer quite easily and at low cost. If the speed limiter is set in the factory, it is protected by a factory code and it can only be removed at considerable costs. This type of separate speed limiters (i.e. without cruise control) is installed at the factory for a price in the range of €25-€139 excluding taxes, based on the brochure review for the Netherlands, Germany, and the United Kingdom.

The available speed limiting systems and their prices in the Netherlands, Germany, the United Kingdom and Italy are displayed in the following tables. Table 4 shows the results for speed limiters in combination with cruise control. Table 5 gives an overview for separate speed limiters (i.e. without cruise control). For some model (types), the price of the speed limiting system is already included in the price of the LCV as it is standard installed, and therefore the price is unknown. Here, 'std' refers to standard installation of the speed limiter, 'n/a' means that the speed limiter is not available on some or all types of that model.

Table 4: Overview of prices (without taxes) for speed limiters in combination with cruise control offered as original equipment in the Netherlands, Germany, the UK, and Italy

Manufacturer	Model	Share of EU LCV sales	Voluntary	Price (€) NL	Price (€) DE	Price (€) UK*	Price (€) IT
Mercedes	Sprinter	4.5%	yes	274	n/a	std	134
	Vito	2.0%	yes	287	n/a	std	137
Volkswagen	Transporter	4.5%		n/a	n/a	n/a	n/a
	Caddy	3.6%	yes	305	295 / std	327 / std	n/a
Renault	Kangoo	4.5%	yes	195 / std	n/a	278	200
	Master	3.6%	yes	195	250	347	280
	Trafic	3.2%	yes	195	200	208 / std	200
Citroën	Berlingo	4.2%	yes	200 / std	200 / 150 / std	n/a / 208 / std	only in package
Ford	Transit	2.7%	yes	n/a / 150 / 200	n/a / 180 / 200	n/a / 208 / std	300

Source: brochures of OEMs (per country)
**conversion rate €1.39 EUR:GBP (3-12-2015)*
Std: standard installation of speed limiter
n/a speed limiter not available on some or all types of that model
Multiple prices for a model point to different prices for different types of the model, where the speed limiter can be not available or standard for some types. Because used type names differ between countries and some manufacturers use packages instead of types, the prices are not differentiated with respect to type name in the table for clarity.

Table 5: Overview of prices (without taxes) for separate speed limiters offered as original equipment in the Netherlands, Germany and the UK

Manufacturer	Model	Share of EU LCV sales	Voluntary	Price (€) NL	Price (€) DE	Price (€) UK*
Mercedes	Sprinter	4.5%	yes and no	131 / 117	n/a / 123	n/a
	Vito	2.0%	no	138	139	n/a
Volkswagen	Transporter	4.5%		n/a	n/a	n/a
	Caddy	3.6%	yes	n/a / std	n/a	n/a
Renault	Kangoo	4.5%	no	n/a / 75	n/a	70
	Master	3.6%	no	100	100 / std	83
	Trafic	3.2%	no	100	n/a	83
Citroën	Berlingo	4.2%		n/a	n/a	n/a
Ford	Transit	2.7%	yes and no	n/a / 0	25	n/a / 70 / 62 / std

Source: brochures of OEMs (per country)
**conversion rate €1.39 EUR:GBP (3-12-2015)*
Std: standard installation of speed limiter
n/a speed limiter not available on some or all types of that model
Multiple prices for a model point to different prices for different types of the model, where the speed limiter can be not available or standard for some types. Because used type names differ between countries and some manufacturers use packages instead of types, the prices are not differentiated with respect to type name in the table for clarity.

These prices are for installation at the factory, which is much cheaper than a retrofit installation. The price for retrofitting a speed limiter was approximately €700 in 2002 according to (CE Delft, 2002), but has become cheaper because nowadays a speed limiter can be installed by changing the computer settings of a vehicle. Based on some interviews with specialised companies in the Netherlands the price of installing the speed limiter as a setting in the ECU nowadays are €260-€435 (see also paragraph 4.3.1).

The costs for the OEM to install a separate speed limiter were given qualitatively to be low. Technically, it is a simple procedure, only involving a change in the software controlling the motor management system. In the survey that was conducted for this study, the costs for the OEM to install the speed limiter as a percentage of the price of LCV speed limiters were given different values by two respondents: 40-50% and 70-80%. Interviews with specialised companies however suggested that the costs for the OEM should be negligible (see also 4.3.1), because the speed limiter can be installed by setting a maximum speed in the engine computer of the vehicle. Besides, the HDV market could be taken as a comparison. TRB (2008) distributed a survey to the commercial motor vehicle industry. The survey was comprised of 27 questions and distributed to approximately 1,500 recipients with a response rate of 7 percent (103 responses) and every fleet interviewed agreed that the cost to implement speed limiters for a HDV was negligible. A report from the US Department for Transportation (Hanowski, 2012) also argues that for HDV the cost to implement the speed limiter is negligible because this capability is standard.

3.3.2 ISA prices and costs

Currently, ISA systems are not being sold for LCV's in the Netherlands, Germany, or the United Kingdom. One of the interviewees did state that next year's models will have a closed ISA system based on GPS, which can be manually switched off by the driver. Open ISA systems are ubiquitous in current navigation systems.

For ISA prices, a 2006 study resulted in a range of £300-800 (equivalent to €450-€1200) for an open and £1100-1300 (equivalent to €1650-€1950) for a closed ISA system (Jamson, 2006). Another study predicted the prices to be in the range of £293-372 (equivalent to €428-€543) in 2010 (Carsten and Tate, 2005). (Carsten & ea, 2008) expected prices to drop to £60 (€80) for advisory ISA and £160 (€222) for voluntary/mandatory ISA systems if fitted in new vehicles in 2015. For retrofit prices are higher with £233 (€324-advisory) and £333 (€463 - voluntary/mandatory) because of the required labour. They expect that beyond 2020 costs will not decline further. Most likely, current systems are significantly less expensive than indicated in 2005 and 2006 due to advances in navigation systems and the electronic control of the engine through motor management systems.

A first indication for the price of ISA systems was derived from the first available models in passenger cars. According to ETCS (ETCS, 2015) ISA has started to 'hit the showrooms'. The latest version of Ford's S-Max and Galaxy, and Volvo's XC90 passenger cars can come factory-fitted with camera and GPS-based systems that alert the driver to the current speed limit and help prevent him or her from exceeding it. The prices of the ISA systems for these models are shown as an example in Table 6. It was found that ISA is not sold separately but offered as part of (non-comparable) safety packages, the prices of which are presented. The price of the ISA system itself could not be distinguished from the prices of the other safety package options (such as navigation systems, parking assistance). It must be noted that only the Ford ISA systems are closed systems; the Volvo ISA systems are traffic sign recognition systems that are also offered in passenger cars from other manufacturers at this moment.

Table 6: Overview of prices (without taxes) for ISA systems offered as original equipment in the Netherlands, Germany, the UK and Italy

Manufacturer	Model	ISA system	Package/standard	Price (€) NL	Price (€) DE	Price (€) UK*	Price (€) IT
Ford	Galaxy	closed/active	option: safety package	€ 1,281	€ 1,095	€ 3,197	not in brochure
Ford	S-Max	closed/active	option: safety package	€ 1,281	€ 1,095	€ 2,572	not in brochure
Volvo	XC60	open/passive	option: safety package	€ 1,814	€ 1,000	€ 2,200	n/a
Volvo	XC90	open/passive	standard included	-	-	-	€ 1,549

Source: brochures of OEMs (per country)
*conversion rate €1.39 EUR:GBP (3-12-2015)

3.3.3 Fitting rates

As this study aims to explore the potential for using speed control devices in the EU on new light commercial vehicles, information of the current fitting rates of new LCV's are important. However, there is no data on EU level available on the fitting rates of speed control devices for new LCV's Unfortunately, the survey supporting this report (Task 7) did not yield information on fitting rates. Therefore fitting rates were explored through interviews with trade associations from the Netherlands, Germany, the UK and Italy, as well as lease companies and automotive distributors (ie. the companies that import and supply vehicles from the OEMs to the local dealers on a national level) . It was found that trade associations don't have information on the fitting rates and that for companies there can be a high variation in the fitting rates. Distributors of LCV's seem to have the best data available.

Trade associations RAI (NL), RMIF, SMMT (UK) and leasing companies LeasePlan (NL) and Volkswagen Leasing Germany (D) were very willing in their effort to provide information, but unfortunately do not record the number of LCV's fitted with speed limiters. They have also set out a data request to a part of their members for the purpose of this study, but this did not yield any responses within the requested time frame. One of the members of RAI responded that they do not sell LCV's with a speed limiter. We did not receive a response from trade associations VDA (D) and ANFIA (IT).

Distributors have information on fitting rates for the new LCV's that they have supplied to dealers.

An interview with one of the larger distributors of LCV's in the Netherlands revealed specific data on the share of LCV's that were fitted with a separate speed limiter. For this distributer 91% of the sold LCV's were closed and 9% were open LCV's (i.e. LCV's that are not delivered with a closed cargo space but only with a chassis). Approximately 4% or 400 per year of their newly sold closed LCV's was fitted with a separate speed limiter. For open LCV's, this number was 30% or 300 vehicles per year. This high number can be explained by the requirements for type approval. Half of the latter LCV's had a total weight exceeding 3.5 ton, making a 90 km/h speed limiter mandatory. Which would in fact require even more open LCV's to be equipped with speed limiters. Another large Dutch distributor reported that the combination of cruise control and speed limiter is almost always requested but the separate speed limiter is seldom requested.

For lease companies there seems to be a high variation in the fitting rates of their fleets, which may be explained by company policies. One of the larger Dutch lease companies stated in an interview that 37% of their 5000+ LCV's was fitted with a speed limiter. Of those 37%, 70% had a fixed speed limit set at 120 or 130 km/h and 30% was equipped with a system setting per gear the most efficient speed and engine revolutions with a fixed speed limit between 98 and 115 km/h. The interviewee estimated that their percentage of fitted speed limiters was higher than at other lease companies or for non-leased LCV's due to their active policy. The aim of their policy is to use speed limiters as a means to reduce CO_2-emission, reduce fuel costs for them and their clients, and reduce the number of accidents (and damage costs). Another large Dutch lease company stated that 900 of their 16.000 LCV's (6%) have a speed limiter, of which the type is unknown. We did not receive a response from leasing companies Lex Autolease (UK) and UniCredit Leasing (IT).

Separate speed limiters for LCV's are mostly requested by rental companies and other fleet owners. Independent contractors rarely request speed limiters, because removing the speed limiter is very difficult and expensive (as stated before); they lose flexibility during use and when selling the vehicle. An important factor preventing the choice for a separate speed limiters by independent contractors is the European Union type-approval system. Since manufacturers are responsible for ensuring conformity of the vehicle with the type of vehicle approved through the European Union type-approval system following Directive 2007/46/EC, they make sure an installed separate (i.e. mandatory) speed limiter cannot be removed. For this reason, a factory code is installed to protect the speed limiter, which can only be removed at the factory. The interview with a second distributor yielded that the combination of cruise control and the speed limiter is almost always requested.

We have not found ISA systems being sold as options for current LCV's (only for passenger cars). In the near future ISA systems will be introduced only in niche markets (closed fleets). ETSC reports that 47 London buses will be fitted with ISA systems (ETSC, 2015). Also, in Sweden 4,000 cars of the Swedish Road Administration, vehicles of several companies and 50-60 local authorities, and local buses have been fitted with open, informative ISA, whereas in the United Kingdom companies such as UK Royal Mail and Centrica have installed closed ISA systems (ETSC, 2009).

Regarding fitting rates, we have found that distributors and lease companies in general have high quality data, whereas trade associations currently do not. The number of LCV's fitted with a speed limiter may vary greatly from company to company, where active policy and the type approval for >3.5t vehicles play a large role. To get a complete overview of fitting rates of speed limitation devices in new LCV's further research is required, for which it would be best to approach distributors.

4 Task 2: Speed limiter compliance (deactivation and tampering)

4.1 Introduction

In this task we explore the possibilities for deactivation and tampering. This is important, because the effect of speed limiter requirement could be severely reduced if the speed limiters are deactivated or tampered with.

The analysis will not just focus on LCV's but also on HDV's. In that segment there is much more experience with speeds limiters, the possibilities for tampering and how this could be prevented. At the moment, there is no requirement to fit LCV's with speed limiters. Hence the experience with deactivation and tampering is much more limited.

4.2 Approach

For this task some experts from specialised companies were interviewed. These were companies that offer speed limiter adjustment or removal. They were sometimes approached as 'mystery shoppers' and therefore they are presented anonymously in this report.

Additionally, we performed a limited literature review to identify analyses/studies (Surveys, Impact Assessment, Evaluation studies, etc.) on speed limiter compliance for HDV's. This presented additional information on the possibilities for tampering.

Research questions:

- What options are there for deactivation and tampering of speed limiters and ISA systems?
- What options are there for preventing or limiting deactivation and tampering of speed limiters and ISA systems?

4.3 Experiences with tampering and deactivation of speed limiters from the HDV

4.3.1 *Options for deactivation and tampering*

To explore the options for deactivation and tampering some technical experts were interviewed from specialised companies.

The main activity of these companies is the so called 'chip tuning'. **Chip tuning** refers to changing or modifying the motor management system of a vehicle. The motor management system is also referred to as the electronic control unit (ECU). The settings from the ECU are downloaded from the engine onto the computer. The technical experts can adjust then it and re-install it in the engine. They claim that the engine manufacturer generally uses a conservative electronic control unit map to allow for individual engine variations as well as infrequent servicing and poor-quality fuel. Vehicles with a remapped electronic control unit may be more sensitive to fuel quality and service schedules. They may also have higher pollutant emissions; the reason why driving a vehicle that has been tuned is illegal (the act of chip tuning itself by the specialised companies is not illegal).

One of the services provided by the chip-tuning companies is the adjustment or removal of the speed limiter. The companies claimed that they can reprogram the ECU to delete the speed limiter completely. All the interviewees stated that they can do this for virtually all new vans (that were built after 2008/2009). According to the companies, the vehicle manufacturers are making more and more efforts to prevent chip tuning / speed limiter adjustment. The engine can be damaged and the car will emit a much higher level of pollutants. Often, the warranty of the engine expires immediately. Therefore the security of the ECU is getting more advanced. This causes the companies in this sector to evolve as well, because it gets harder to break into the motor management system.

The price for adjusting the speed limiter or chip tuning the engine are relatively high (compared to the price of a separate speed limiter as described in paragraph 3.3.1). The prices of speed limiter adjustment and chip tuning are shown in Table 7. The companies that were interviewed indicated a range of €260-€435. Some price indications from brochures also suggested lower costs of €50-€100. It is however unclear if the latter indicated prices only apply in combination with chip tuning. Interviewed companies explained that a combination of chip tuning and speed limiter adjustment resulted in a lower extra price for the speed limiter removal.

Table 7: Price estimations from interviews and brochures for speed limiter adjustment and chip tuning (incl 21% VAT)

Chip tuning company	Adjustment of speed limiter	Price of adjusting speed limiter	Price of chip tuning of Vans	Price of chip tuning of HDV's
1	Yes	€435	€435	n/a
2	Yes	€260	€499	n/a
3	Yes	€300	n/a	n/a
4	Yes	€400	€450	€1399
5	Yes	n/a	€400	n/a
6	Yes	€99*	n/a	€699
7	Yes	n/a	n/a	n/a
8	Yes	n/a	€599	€1999
9	Yes	€100*	€549	n/a
10	Yes	€50*	€249	n/a
11	No	n/a	€450	€1250

*these prices have been taken from brochures/internet search and the companies were not separately interviewed. It is unclear if the prices also apply when only the speed limiter is adjusted (no chip-tuning).

The chip tuning companies in Table 7 are only Dutch companies. Additionally, specialised companies from Germany and the UK were also found on the internet. The conclusion and price range was similar for these companies. In Germany one company charges €249 for speed limiter removal and €499 for chip tuning. In the UK one company charges €273 for speed limiter removal and €342 for chip tuning. Another company from the UK that is solely specialised in the removal of speed limiters, charges €110 for removal of the speed limiter[4].

The prices for chip tuning of HDV's seem to be much higher than that of vans. Two specialised companies have been asked what causes this difference. One stated that the equipment for chip tuning of HDV's is more expensive; the other complemented that the ratio of investments in the equipment and software to the sales rate of chip tuning for HDV's is less favourable.

[4] Conversion rate €1.39 EUR:GBP (3-12-2015)

The companies disagreed on the topic of re-approval of the engine. One company argued that it was necessary to get a new type approval after installing or adjusting the speed limiter. But another company advised us against it, as it was no obligation. These companies had no experience whatsoever with ISA systems. They indicated that they had not seen any vehicle with this technology yet.

Besides tampering with the speed limiter itself, there are several other ways of circumventing the imposed speed limit. A HDV is fitted with a tachograph, which records the speed at all times. If the tachograph indicates that the maximum speed is frequently overrun, the speed limiter is likely to be tampered with. To prevent the tachograph recording an excessive speed the driver can interrupt its fuse for a moment, use two tachographs, install a second set of sensors in the wheels, or manipulate the digital tachograph with a computer. Also, the motor management system can be fooled by installing larger wheels. By installing wheels with a circumference larger than is stored in the motor management system, a larger speed can be accomplished while not increasing the number of pulses per second (and thereby the calculated speed).

In the interviews with the chip tuning companies it was indicated that for HDV's speed limiter removal occurs very rarely. It is unlikely that individual truck drivers are willing to pay the cost of often more than €100 to even €435. Also because many transport companies have strict policies on tampering and they would risk their job. Chip-tuning companies said that they had much more experience with lowering the maximum speed of speed limiters of trucks. This is because transport companies wished to lower the maximum speed of their trucks, most often, to about 85 km/h. They expected some fuel efficiency gains but mostly less accidents.

4.3.2 Enforcement of speed limiter compliance in HDV market

Besides options for deactivation and tampering of LCV speed limiters, experiences with deactivation and tampering from the HDV market are useful to get some insights in the possible challenges for enforcement of LCV speed limiters.

Generally Member States have organised the enforcement of speed limiter compliance for HDV's in two ways: Via roadside inspections and via the Periodical Technical Inspection (PTI). Roadside inspections are often also targeted at various other offences such as the proper functioning of the tachograph. They provide a random sample check during the year. The PTI is generally required once a year.

Periodical Technical Inspection

For Heavy Duty Vehicles the functioning of the speed limiter is checked during PTI. During the check-up the presence of the speed limiter itself is verified, along with the presence of a tag with the correct speed limit and the intactness of all seals. Also, the maximum speed is measured (if the diagnostics equipment is available). If the speed limiter does not comply with regulations, the only consequence is that the vehicle will not be approved. Reporting to the police department does not take place.

According to the chip tuning companies it is difficult to recognise tuning of the engine ECU, or any adjustments of the speed limiter without advanced equipment. The dealer would only be able to spot this if they have an engine power bench at their disposal. During the PTI, visual inspection could be insufficient and an acceleration test would be necessary. If the functioning of the speed limiter is inspected during PTI it is unlikely that individual drivers or transport companies will remove the speed limiter. They would have to adjust it before and after the PTI, which would be expensive. (Fuetsch, 2009) reports that enforcement will check speed limiters settings primarily at weigh stations and public officials estimated 2 to 5 minutes will be added to inspection times.

Roadside inspections

Roadside inspections are an effective instrument for enforcement of speed limiter compliance in the HDV market. A roadside inspection can be general or specifically aimed at the speed limiter. In both cases the speed limiter itself is checked for the presence of a tag with the correct speed limit and the intactness of all seals as during the PTI. In the inspection aimed at speed limiters, the software for the motor management system and the tachograph are checked. The circumference of the wheels is checked by having the HDV drive five wheel rotations. If tampering is suspected, the HDV is taken to the workshop and tested on a dynamometer. It is important to note that the Heavy Duty Vehicles that have their speed limiter removed and are speeding are very easy to spot on the highways. They are the only HDV's driving faster than the other HDV's.

For vans, all this would be different. It is not so easy to distinguish all types of vans from large passenger cars. Moreover, if the speed limiter would be optional for vans then it would be impossible to recognise tampering from only speed measurements. Roadside inspections would always have to be combined with speed tests and even then tampering would be harder to recognise (because vehicles that can drive faster than the maximum speed will not do so all of the time) or a tachograph would have to be required next to the speed limiter.

4.3.3 Data on frauds

Very little data on fraud with HDV speed limiters was available. For Poland, the Netherlands and the UK some data was found and reported in this paragraph.

Poland has provided some data on roadside inspections and frauds detected for the period of 2008-2011. This data is presented in Table 8.

Table 8: Data on frauds for HDV's in Poland

Year	Number of HDV inspected	Number of frauds detected	Percentage frauds detected
2011	8,227	15	0.2%
2010	12,595	40	0.3%
2009	6,296	40	0.6%
2008	4,557	34	0.7%

Source: Background information available in the stakeholder survey from (Transport & Mobility Leuven, 2013).

It must be noted that total number of detected defects does not just consists of frauds but also cases where speed limiters were found malfunctioning or where plaques or seals were missing.

In the Netherlands, roadside inspections are frequently performed. Some data on roadside inspections were made available from the Human Environment and Transport Inspectorate (ILT) for the years 2005-2007. The results from these inspections are shown in Table 9.

Table 9: Data on frauds for HDV's in the Netherlands

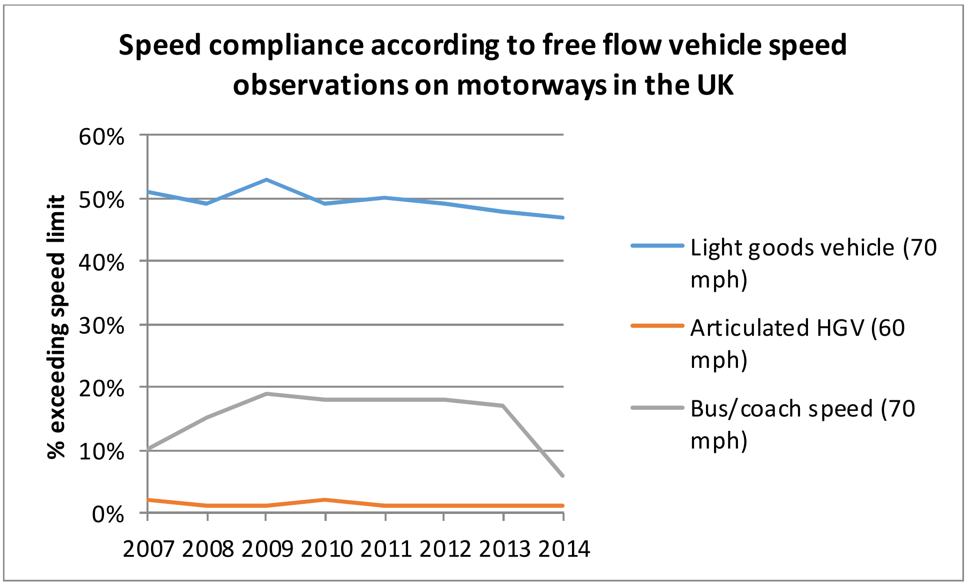
Date	Number of vehicles inspected	Type of vehicles inspected	Number of frauds detected	Of which speed limiter compliance frauds	Percentage SL frauds
Coaches					
25-7-2005	157	Coaches	21	4	2.5%
29-8-2005	200	Coaches		4	2.0%
14-2-2005	85	Coaches	22	6	7.1%
1-8-2006	98	Coaches	17	2	2.0%
20-6-2006	43	Coaches		4	9.3%
26-2-2007	64	Coaches	20	1	1.6%
Trucks					
25-9-2006	848	Trucks	211	9	1.1%
22-3-2006	323	Trucks	76	2	0.6%
28-9-2007	139	Trucks	22	1	0.7%

Overall, in less than 2% of the vehicles was fraud with the speed limiter detected. More recent data is also available for the Netherlands, where 11.375 HDV's were inspected during roadside inspections in 2014 (Ministry of Infrastructure and Environment, 2014). Of the inspected HDV's, 18% were found to have committed fraud on the tachograph, and about a dozen specifically on the speed limiter (less than 1%). The fine for a non-functional speed limiter is €2000 while the fine for tampering with the speed limiter and the digital tachograph, is €4400.

In the UK many speed measurements are performed. Based on the measured free flow vehicle speeds on motorways in Great Britain an estimation can be given of the rate of compliance for articulated HGVs and buses/coaches. The speed limit for buses and coaches on motorways in Great Britain is 70 mph (112 km/h) and 60 mph (96 km/h) for HGVs.

The data from the Department for Transport Statistics (2015) shows that on motorways a very small percentage of HGVs exceed the speed limit (1%), while a larger share of the buses and coaches exceed their speed limit (10-20%).

Figure 2: Speed compliance of HGVs and buses/coaches in the UK on motorways



Both data from the UK and the Netherlands suggest that there seems to be a difference between speed compliance of trucks and coaches. However, it is not clear what could cause the difference. No explanation was found in the literature for this observation.

Overall, the data sources that are presented in this paragraph indicate that fraud with speed limiters for heavy trucks is relatively small (0.2 – 2%).

4.3.4 *Literature review on speed limiter compliance for HDV's*

A literature study showed that historically, tampering with speed limiters was a major concern.

The studies that were found mainly relate to the US market for speed limiters. The major difference between the US market and the European market is that speed limiters are not mandated in the US. If the vehicles are equipped with a speed limiter in the US, the owner of the truck can often adjust the speed limiter, while in the EU this is not possible.

Historical problems with speed limiter compliance

The literature study showed that historically, tampering with speed limiters was a major concern. Transport Canada (2008) reports that tampering is a significant problem in Australia, Sweden, and the UK. Heavy vehicle drivers tamper with their speed limiters to increase the maximum speed of their vehicles, thus increasing their competitive advantage. Tampering can take many forms including simply pulling the fuse out of the speed limiter device, changing the settings in the engine control module (ECM), and adjusting the tire size or transmission gear ratio. In Australia, between 10–30% of heavy vehicles were estimated to have tampered speed limiters. No official compliance rates were available from the UK or from Sweden.

TRB (2008) also indicates that tampering with speed limiters is a problem. Based on the survey of ATRI and their own survey, TRB concludes that tampering has been cited by some as a concern with speed limiters. Depending on the survey, 22%–27% of respondents reported such tampering. These percentages do not directly represent the rate of tampering, because the surveys were conducted amongst key safety managers of transport companies (which represent many drivers).

In contrast to the studies above, a more recent study from the US Department of Transportation (Hanowski, 2012) argues that historical problems related to driver tampering have been alleviated by the current electronic systems. For these software-based speed limiters, the speed setting cannot be adjusted without the proper OEM-supplied equipment (interface, software, etc.). The speed limit setting is secured with a password unique to the vehicle that is given to the owner of the vehicle. The owner of the vehicle can then change the password as desired. The vehicle owner controlling and limiting access to the password is a key principle in preventing improper changes.

The study from US DoT (2012) describes that historically, speed limiters existed as distinct, mechanical parts. These parts generally did not function very well, and were fairly easy to bypass. Over time, the trucking industry moved toward electronic engine management systems for a number of reasons, including durability and lower maintenance costs. Newer trucks are built to be vertically integrated, with significant interaction between all the system components. In these systems the speed limiter concerns the maximum speed as one of the settings on the ECM contained within every engine.

For some speed limiters, the settings can be altered by a fleet using a simple computer service tool connected to a standard data bus (e.g., maximum speed, etc.), but other speed limiters are designed to be set by the manufacturer and not modified by the owner. If the speed limiter is credited under the GHG Phase 1 regulations (Environmental Protection Agency standards, see also par 5.3.1) then the maximum speed settings needs to be set by the manufacturer and cannot be modified by the owner.

In the US, currently most speed limiters are not set by the manufacturer (and thus not credited under the GHG Phase 1 regulations) and the owner can adjust the speed settings themselves. For these speed limiters, many owners have software that allow them to change the speed limiters settings for their own fleet as desired, other operators do not have this ability and must rely on the dealer to access the settings if changes are desired. Generally, this service is not performed without an associated charge. The cost of the software and hardware to enable changes by the owner is estimated to be between $500 and $1,000. This is consistent with the prices found in paragraph 4.3.1.

Owner / operator perspective

From the operator perspective, tampering with the speed limiter is unlikely. Although in the US, the installation of speed limiters is not mandatory, many operators have them installed and clearly must perceive benefits for their company. In the surveys, fuel savings and safety were named as the most important benefits of speed limiters in trucks and motorcoaches.

For company-owned trucks in the US, the surveys conducted by OOIDA (2007), ATRI, and the TRB (2008) study indicated that 60 to 63 percent use speed limiters (with variations across sectors). The investigation in the report of US DoT (2012) yielded much higher estimates for fleets, in the range of 75 to 80 percent. However for owner-operators, OOIDA contends that owner-operators (truck drivers that own their own truck) typically do not employ speed limiters.

Truck driver perspective

Individual truck drivers could have other motivations to tamper with the speed limiter, as it may improve their driving experience when they are not limited in their driving speed. For example, overtaking will be easier when the speed limiter is turned off.

In a survey conducted by the OOIDA Foundation (2007), questionnaires were sent to the company driver portion of their membership (approximately 15,000 drivers). Survey responses from 3,422 drivers represented 2,080 trucking companies. The OOIDA Foundation Survey (2007) found that more than 80 percent of the truck drivers would rather drive for a carrier that did not require a speed limiter. According to drivers, this was due to the fact that it reduced the driver's ability to complete a delivery on time, especially when traveling in congested areas. In addition, more than 80 percent admitted that, in areas where the posted speed limit was lower than the speed limiter setting, they travelled at faster rates than was legal.

However, tampering by truck drivers is unlikely. Both surveys from ATRI and TRB found that, in most cases, the consequence for tampering was immediate termination of their contract. Moreover, for drivers speed limiters are difficult to tamper with, as they take special software and electronic equipment to change. Also, every fleet interviewed used a password to secure the maximum speed setting.

5 Task 3: Overview requirements LCV speed control device fitting outside the EU

5.1 Introduction

In this chapter we will provide an overview of legislation in other parts of the world, requiring OEMs to fit LCV's with speed limiters. The experience of other countries could provide valuable insights or lessons on the implementation of LCV requirements in the EU.

5.2 Approach

The main source for information on non-EU requirements for LCV speed control device fitting was interviews with non-EU policy experts. Additionally, other relevant legislation and literature was reviewed (with a focus on the US, Canada, Japan and China).

The survey that was put out for this study did not yield any results regarding legislation in countries outside the EU.

5.3 Results

Transport Canada (2008) and OECD (2006) give an overview of the international legislation on speed limiters. These are combined into Table 10. Based on these studies, it can be concluded that there are no countries with legislation requiring OEMs to fit speed limiters for LCV's.

Table 10: Overview of international jurisdictions with Speed Limiter Legislation (non-EU countries)

Jurisdiction	Speed limiter compulsory	Vehicle Types/Classes	Effective Date	Other Details
Australia	Yes	Heavy trucks > 12 t Buses > 5 t For new trucks/buses, model year 1990	1990	Federal Legislation: Australian Design Rule (ADR 65) Maximum Road Speed Limiting for Heavy Goods Vehicles and Heavy Omnibuses
Canada	No			
Japan	Yes	Heavy trucks > 8 t	2003	
Mexico	No	HDV		Tachographs are used as a speed control measure.
Russia	No			
United States	No			
Zambia	Yes	All intercity and long distance buses	2005	

Additionally, relevant information was found for USA, Canada, Japan and China based on available literature and interviews with experts from ICCT. These are described in the following paragraphs.

5.3.1 US and Canada

There are no requirements or incentives for speed limiters for light-duty vehicles in the US or Canada, which includes vans and pickup trucks up to 3,900 kg gross vehicle weight (maximum weight with payload). Vans and pickups over 3,900 kg GVW are regulated under the heavy-duty rules.

There are fuel consumption standards for light-duty vehicles, but they do not require or incentivise the use of speed limiters.

However, the US heavy-duty GHG Phase 1 regulations (and the Phase 2 proposal) include credits for speed limiters, but they are not required. As this credit system might provide important background information for comparable legislation in the EU, the next paragraphs describe the highlights of the legislation.

US CO_2 and Fuel Consumption Standards

In 2011 the U.S. Environmental Protection Agency (EPA) and the Department of Transportation's National Highway Traffic Safety Administration (NHTSA) have introduced a program to reduce greenhouse gases (GHGs) and improve fuel efficiency of medium- and heavy-duty vehicles (ICCT 2011). Canada published its finalized standards for new on-road heavy-duty vehicles, designed to align with the U.S. national standard, in 2013 (ICCT 2013).

The standards on GHG-emissions and fuel efficiency apply to three categories of vehicles: Combination tractors (semi-trucks that typically pull trailers), heavy-duty pickup trucks and vans and vocational vehicles. The regulation covers model years (MY) 2014-2018 and applies to all on-road vehicles rated at a GVW≥8,500 lbs (3,900 kg). The standards are defined as a percentage reduction in fuel consumption compared to the baseline in 2010.

For tractors, manufacturers must demonstrate compliance with the standards using the Greenhouse gas Emissions Model (GEM), which is computer simulation program that was developed by the U.S. EPA and NHTSA. Inputs to the model include data on aerodynamics, tire rolling resistance, weight reduction, extended idle reduction, and vehicle speed limiting. For heavy-duty pickup trucks and vans and vocational vehicles this is not an option.

Manufacturers must manage truck sales specification to balance the sales weighted average against the targets in each size class. Unless sufficient credits can be generated, manufacturers need to force customers to accept features with credits that add up to EPA targets (Grezler 2012).

Impact on the uptake of speed limiters

Speed limiters are one of the technology options to get credits for tractors. Tractor manufacturers can specify the speed limiter to be used in the GEM to modify fuel use and emissions calculation. If the top speed is limited to below 65 mph an alternate test cycle will be used to reflect this lower top speed. This feature of the regulation can be considered as an incentive for speed limiters. Grezler (2012) states that all long-haul tractors are currently already equipped with an owner programmable speed limiter.

However, an owner programmable speed limiter cannot be used to gain credits. In order to gain GHG emissions credits, the speed limiter must be hard-programmed to a maximum speed less than 65 mph (101 km/h) at the moment of production and the OEM also has to make sure there is no way to disable the speed limiter. Some fleet owners see the benefits of using speed limiters, but they want the option to deactivate it. These concerns from fleet owners indicate that tampering with speed limiters is difficult or costly. The fuel consumption standards for light-duty vehicles do not require or incentivise the use of speed limiters.

The potential benefits in the US are high, because the maximum speeds on freeways are high. In 35 of the 50 states the maximum speed is 70 mph (112 km/h) or higher, and in 13 states even 75 mph (120km/h) or higher. Grezler (2012) gives an example of the potential of the speed limiters for CO_2 credits compared to the EPA baseline vehicle MY 2010 and the % of needed reduction of the 2017 improvement from the MY 2010 baseline value based on calculations with the GEM.

Table 11: Example of credits for speed limiters in GEM (Grezler 2012)

Speed limiter	Class 8 mid roof sleeper cab	Class 8 high roof sleeper cab
63 mph (101 km/h)	3.1 CO_2 gram/ton mile (22% of needed reduction)	2.8 CO_2 gram/ton mile (32% of needed reduction)
60 mph (96.5 km/h)	7.2 CO_2 gram/ton mile (51% of needed reduction)	6.5 CO_2 gram/ton mile (74% of needed reduction)
Needed reduction vs conventional tractor (MY 2010 – MY 2017)	14.1 CO_2 gram/ton-mile	8.8 CO_2 gram/ton-mile

There is not any data available at the moment to see if the regulation has had any impact on the uptake of hard programmed speed limiters. A heavy-duty expert from ICCT estimates that probably not many speed limiters are getting credited under the Phase 1 GHG regulations since it is likely that most manufacturers could comply with the standards without the use of speed limiters (however, this may change for the Phase 2 standards which will be more stringent). The main concerns that have been expressed by end users are that speed limiters could reduce operator flexibility (such as completing routes within hours-of-service limits and avoid extended rest stops), may drive up operating cost, and may impact resale value.

5.3.2 Japan

All new vehicles in Japan have had speed limiters for some time. The default setting is for 180 km/hr. The vehicle manufacturers in Japan have limited independently the maximum speed of vehicles to 180 km/h, and the power to 280 hp since 1990. This was a voluntary agreement and applies only to domestic manufacturers. There had been no limits of speed performance in vehicles until then. Social pressure by an association of children whose parents had been killed in traffic accidents worked as a trigger for this self-regulation (Tanigushi, 2000)

Starting in MY 2003 this was reduced to 90 km/hr for heavy duty vehicles above 8 tonnes GVW. Used vehicles were required to retrofit speed limiters between 2003 and 2006.

In conclusion, all domestic LCV's have speed limiters but set at a rather high level (180 km/hr). No additional legislation is announced to reduce the maximum speed for LCV's at this moment.

5.3.3 China

In China there are no speed limiter requirements or incentives for LCV's. Certain HDV's are required to install speed limiters, as part of a safety mandate (not the fuel economy mandate), the rule is GB7258-2012. According to an expert from ICCT there are no plans to extend the legislation to LCV's at this moment.

5.3.4 India

Many uncertainties exist around speed limiter legislation in India. In 2008, the Karnataka State imposed speed limiters on all transport vehicles (Transport Canada, 2008). However, after being faced with one protest after the other by truckers the Karnataka government has cancelled the regulation (India Today, 2008). According to (The Times of India, 2015) all new transport vehicles must have a speed governor, but it is questioned if the legislation is enforced (Express, 2015)

6 Task 4: Exploration of competition between LCV's and HDV with GVW>3.5t

6.1 Introduction

It is sometimes argued that, given that speed limiting devices are mandatory for HDV's and not for LCV's, this has led to an uneven level playing field between HDV's and LCV's. It might be possible that this has led to a shift towards more frequent use of LCV's as they are subject to fewer limitations. Such a shift might have consequences such as increased number of vehicle km, fuel consumption and hence CO_2 emissions. The goal of this task is to assess if this is indeed a real problem.

6.2 Approach

A first logical step would be to make a comparison of the data for the years before and after 2006- the year of the implementation of the Speed Limitation Directive for HDV's. However for this, we need to bear in mind two important conditions under which the freight transport market has evolved over the last years:

- The economic crisis and the consequent reactions and adaptations of the operators,
- The development of the road transport market towards higher fragmentation of flows (less stocks, just in time, dedicated shipments, etc.), inducing a more differentiated vehicle choice.

Given these trends, it will be difficult and often even impossible to quantify the impacts on the basis of a statistical analysis of time series. Moreover, the (Transport & Mobility Leuven, 2013) study showed that often detailed data on LCV's is or was missing. This has not changed.

Therefore this analysis will be based on the findings of the data analysis, stakeholder input and literature review. Where possible we will focus on specific markets instead of the market for freight as a whole. For long distance, low value/high volume goods, the level of competition between LCV's and HDV's is likely to be small, but competition might be relevant for certain submarkets.

6.3 Results

6.3.1 Data-analysis

Data with respect to LCV's is scarce and often not complete. Eurostat does not provide any data on LCV's and actually uses different weight classes. ACEA does provide data on sales and also on stocks. The table below summarizes the results.

Table 12: Vehicles in use

		2006	2011	% change
LCV	EU15	19.444.616	25.300.509	30%
	EU23	21.721610	28.141.638	30%
Light and Medium trucks (3.5-6t)	EU15	86.499	105.329	22%
	EU23	97.695	105.374	8%
3.5-16 Tonnes	EU15	1.751.998	1.501.896	-14%
	EU23	1.839.034	1.502.245	-18%
Heavy trucks (+16 tonnes)	EU15	1.984.280	1.781.642	-10%
	EU23	2.043.959	1.705.260	-17%

Source: (ACEA, 2013) – note that data is not complete for all countries

We see an increase in the use of LCVs and the lighter trucks (3.5-6 tonnes). At the same time there is a rather sharp decrease in the fleet of heavier trucks.

This evolution is also reflected in the sales figures. From the table below it is clear that over time (2009-2014) the sales of LCV's increased rapidly in countries such as the UK, Ireland, Germany, Sweden, Austria and Denmark. In other countries the level is more constant or even decreasing – especially in the years in between. At first sight it seems that the economic crisis still plays a role in these figures.

Table 13: LCV total sales/registrations

Member State	2009	2010	2011	2012	2013	2014
EU-28	1,313,122	1,218,114	1,552,007	1,368,349	1,370,998	1,552,706
France	368,644	366,804	426,475	381,116	364,814	370,129
United Kingdom	184,701	200,041	258,537	239,247	270,782	322,650
Germany	166,678	177,895	232,587	218,690	211,895	227,289
Italy	164,011	148,828	141,319	101,775	88,973	106,027
Spain	105,515	96,322	100,862	76,754	85,402	113,825
Netherlands	47,313	41,397	56,408	56,544	50,553	51,749
Belgium	48,415	2,718	63,485	56,049	54,444	54,280
Sweden	26,397	33,935	46,266	39,358	37,395	42,008
Austria	23,946	21,524	33,507	32,698	31,933	32,524
Denmark	11,886	5,217	24,281	24,077	23,712	28,470
Portugal	38,004	39,236	34,204	16,011	18,202	26,166
Finland	7,471	9,360	14,490	11,470	10,411	10,625
Ireland	7,173	6,408	11,109	10,601	10,863	16,458
Greece	13,402	7,636	6,332	3,710	3,433	4,904
Luxembourg	1,888	1,467	3,539	3,421	3,268	3,527
EU-13	97,678	59,326	98,606	96,828	104,918	142,075

Source: http://eupocketbook.theicct.org/data/lcv-data-eu-member-state-0

Looking at the distribution of sales of LCV's between the classes, we see that the LCV-class III is most dominant. If there is a modal shift from HDV's towards LCV we would expect that N1 class III is most relevant for this.

Table 14: Distribution of LCV's over weight classes (2012 data – 148629 sales in EU)

Class	Weight	Number	% in sales
Class I	Reference mass ≤1305 kg	83.374	7.6%
Class II	1305 kg<reference mass ≤1760 kg	360.984	32,8%
Class III	1760 kg<reference mass ≤3560 kg	655.025	59,6%

Own calculations based on http://www.eea.europa.eu/data-and-maps/data/vans

6.3.2 Use of LCV's

Little information is available on the actual use of LCV's. LCV's vary significantly in size, type and degree of specialist use. This reflects the complexity of the requirements and the many roles LCV's play in economic activity. Their use would give us some information on whether they are indeed used as a replacement for HDV's. (RAC Foundation, 2014) does provide detailed information, but only for Great Britain. In Great Britain they are usually used in urban areas, where they might have replaced some of the HDV's. On the other hand LCV's make much more drops over less distance than HDV's. Moreover, 84% of the distance for journeys are starting and ending in the same region. Hence most of them drive local.

In Great Britain 53% of LCV's are privately owned, but probably mostly used for business purposes while 47% are commercially owned. The table below shows the use. The primary use is the carriage of equipment to provide a service (utility & construction, plumbers and electricians). Second came the deliveries of goods, home deliveries, mail and courier services.

Table 15: use of LCV's in Great Britain(%)

	Share of mileage (%)	Share of LCV numbers (%)
Delivering/collecting goods	28	21
Carriage of equipment to provide a service	51	50
Providing transport	3	3
Private and domestic	9	18
Not specified	8	9

Source: (RAC Foundation, 2014) based on DfT (2008) data

Considering the primary and secondary use of LCV's and the location where they drive (urban) it seems that, if there is a shift from HDV to LCV, this would mainly be for the urban distribution.

6.3.3 LCV mileage trends

(Ricardo-AEA, 2014) found that LCV's driver on average 15.500 km per year – much more than normal petrol cars (10.800 km), but less than diesel cars (16.800). The annual mileage in the first three years is higher and assumed to be around 33.800 km in this study. This range was also found in a study currently ongoing on second hand LCV's by TML. Assuming 200 working days, this means that LCV's are driving around 80 to 150 per working day. (Ricardo-AEA, 2014) also shows the spread for different mass classes and show that there are few LCV's with high mileages.

This is consistent with the data on use indicating that LCV's are mostly used for urban regional transport.

6.3.4 Stakeholder input and literature review

Stakeholders and literature state that there are reasons to expect some level of competition between the heavily regulated HDV market and the LCV market. None of them however can prove that this link really exists.

(Ricardo-AEA, 2015) state that in some Member States there is evidence that operators are choosing to replace HDV with large LCV's as they are significantly cheaper to operate and more suitable for the current market conditions. HDV drivers require a specialist driver licence, and specific training or an operator's licence. They also state that the wages for LCV drivers are around 40% lower than for HDV drivers, and that businesses have found it difficult to find and attract suitable HDV drivers. Furthermore, increasing levels of restrictions on the operation of HDVs in urban areas (based on size, height, width, emissions,…) means that larger LCV's are now often more practical for use in these locations. They do not prove these statements.

(RAC Foundation, 2014) find that in the UK the number of HDVs are decreasing, while at the same time the number of LCV's increased from 2.5 million in 2002 to 3.3 million in 2012 – a period of severe recession. They state that there are different reasons for this, but that they do not fully know the actual reason for the increase. Possible reasons listed are

- The increase in online shopping. This increase is expected to lead to an increase in home deliveries and hence van use. But they did not find research which proved this relationship.
- The costs associated with training HDV drivers, the increased environmental standards for HDVs, etc. which make the less regulated LCV's increasingly attractive. But they did not have evidence to prove this.

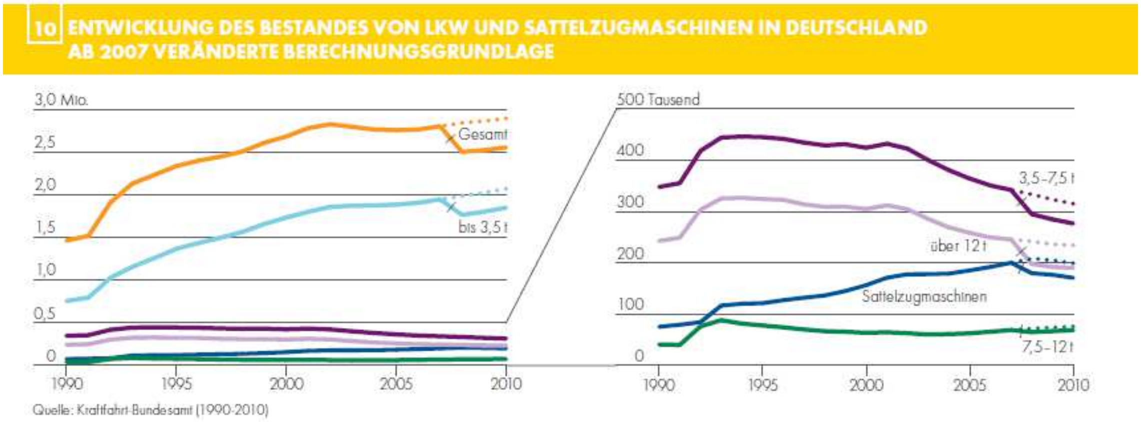
Taking into account the use of LCV's (RAC Foundation, 2014) conclude that the greatest driver in the increase of LCV's is probably the growth in home deliveries and is probably not caused by a modal shift away from HDV's – although regulation of HDV's plays a role.

(ETSC, 2014) also acknowledges that van use in Europe is on the increase, particularly following the rise in the home delivery sector and the recent developments in urban freight logistics. They also state that more vans are being used during office hours in central urban areas as heavier vehicles face increasingly restricted access to city centers. Night time van deliveries are also increasing, extending supermarket deliveries to evenings or early mornings. In addition, the online shopping phenomenon has led to a large increase in next-day deliveries of small items to households in particular. This reasoning, again, seems to suggest that other reasons, not linked to the speed limiter obligation for HGVs, are the source for the increase in the use of vans.

At the same time, (ETSC, 2014) do state that "vans weighing less than 3.5 tons are not subject to the same legal scrutiny as heavy goods vehicles (HGVs). HGV regulations require operators to be licenced and the drivers require Certificates of Professional Competence (CPC)."

This was echoed in the stakeholder survey. It was noted that large N1 vans (class III) operate in the same segment as small N2 (up to ca. 7,5t). It was stated that whilst weight limited in theory, in reality class III LCV's are often overloaded and loaded up to 5 or even 7 tonnes. Given that for a van you do not need a specific driving license, there is not always "driving and-rest time" regulation and almost no weight enforcement, it was concluded that a big van would be infinitely more attractive than a small truck. This would hold in particular for the express and delivery market. This can also be seen in (Shell LKW-studie, 2010) in which a clearly decreasing trend and stock for the 3.5-7.5 t vehicles is shown (as can be seen in the figures below). On the other hand this was not echoed in the data of ACEA (Table 11) for Europe. It is important to note that the German Mautsystem gives a cost advantage to the smaller trucks (<12 tonnes) as they are not tolled (since 2005).

Figure 3: Change in vehicle stock in Germany



Source: (Shell LKW-studie, 2010) – in 2007 the calculation methods changed

In the stakeholder survey it was acknowledged that the speed limiter may not be the determining advantage (lack of social legislation is likely a bigger factor) but is part of the picture and one of the easiest discrepancies to remedy.

The (Transport & Mobility Leuven, 2013) study stated that it is difficult to measure the influence of speed limiters on HGVs on the competitiveness as many other factors played a role at the same time of the implementation such as

- The implementation of other European regulation such as EURO emission standards, the tachograph, working&rest times, road charging, etc.
- The economic crisis and measures taken to reduce the cost of transport
- The increase of e-commerce

At the time, the stakeholders surveyed in the 2013 study did not see a correlation or evidence of a shift or a change in vehicle stock.

In the (TNO, 2012) study, the expected impact of a regulation on the potential shift from vans to cars (for passenger transport) and from LCV's to HDV's (for freight) was calculated using the TREMOVE model. Note that the regulation in fact would lead to a price decrease of LCV's as the expected decrease in fuel costs was higher than the expected increase in purchase cost. No real shift from LCV to either cars or HDV's was found. They found a small increase in vehicle km as – on average- the overall price decreased as a consequence of the regulation.

In the (NEA, 2010) study on LGVs the cost calculation exercises showed that there is no substantial cost price based competition between LGVs and the heavier and larger freight vehicles overall. Even though HDV's >3.5 tonnes are heavily regulated, the freight cost price per tonne or per cubic metre of the latter is at least 25% lower than that of an LGV. The cost of the trip on the other hand is cheaper with LGVs, but not when you take the volume into account. The analysis of the bilateral freight flows (in tonnes) between the Member States has shown that on average the maximum share of LGVs in international goods transport is less than 5% of the total goods flow.

The result of their survey was mixed. Some countries did indicate that there "might be a problem" (in certain situations). The study concluded that there is no substantial unfair competition between HGVs and LGVs in international commercial road freight transport – over a long distance (+200 km) transport. This shows that it is not likely that competition between HDV's and LCV's would occur on the international transport market, but rather on the local/regional transport market. This matches the previous finding that LCV's operate in urban areas and remain rather local.

6.4 Conclusion

From the data it is clear that the market for LCV's has increased over time. At the same time sales in HDV's declined. It is however difficult to link both trends. The literature review and stakeholder survey led to mixed results. On the one hand, it is true that the HDV market is more heavily regulated than the LCV market (emission regulation, working and rest times, speed limiter, but also urban restrictions on height, weight, etc.) This might have led to some modal shifts – most likely for urban distribution. On the other hand, the increase in the use and sales of LCV's is probably more linked to the increase in e-commerce. UK data also showed that about half of the LCV's were used for the carriage of equipment to provide a service (utility & construction, plumbers and electricians). Consistent with this observation, data on mileage indicate travel distances of around 70-150 km per day.

Moreover, it is not possible to link these evolutions solely to the speed limiter obligation for HDV's. Although installing speed control devices in LCV's would probably be one of the easiest discrepancies to be remedied (compared to social regulation for example).

Do note that any changes on the N1 market might have an impact on the M1 market. Especially for the smaller LCV's a change in registration could happen if speed limitation devices would become obligatory. For example, in Belgium about 50-60% of the leisure activity vehicles like Citroen Berlingo, Renault Kangoo, Peugeot Partner, etc. are registered as M1[5]. And as said, also in the UK 53% of the LCV's are privately owned, but probably mostly used for business purposes.

[5] Own calculations based on vehicle registration database. Taxes and conditions do play a role in the registration. For example certain luxury cars are also registered as N1 in the database.

7 Task 5: Evaluation of the co-benefits

7.1 Introduction

The goal of this task is to evaluate the co-benefits- especially on safety and air pollutant emissions for an individual vehicle from fitting speed control devices to reduce fuel consumption and CO_2 emissions.

7.2 Approach

To perform this task, we first briefly discuss the existing literature. Next we calculate the effects on safety and CO_2. For this calculation we first define the scenarios to be analysed. Given these scenarios, we need to assess the effect of the speed control devices on the actual speed driven. Given the effect on the speed (average speed and standard deviation) we then calculate the effect on emissions and safety. Hence we will not calculate quantitatively other possible benefits such as a possible reduction in the level of noise.

7.3 Literature

Most literature on speed limiters focusses on HDV's, while literature on ISA[6] focusses on passenger vehicles. Literature on speed control devices for LCV's is rather limited.

(Transport & Mobility Leuven, 2013) took into account the speed limits in the different EU member states and estimated the potential to be around 3-8% on motorways and 0-1% on rural roads for 110 km/h speed limiters and 9-14% on motorways and 0-5% on rural roads for the 100 km/h speed limiter. The effect of ISA was estimated to be close to zero. With respect to safety, introducing an ISA system for LCV's showed a reduction in the number of accidents in the EU with LCVs involved of about 25% for fatal accidents, 18-19% for serious injury accidents and 11% for all injury accidents. The scenario with a speed limiter set at 100 km/h leads to a decrease in fatal accidents with LCV's involved of about 5%.

(CE Delft, 2010) investigated the impact of extending the Speed Limitation Directive towards LCV's with N1 vehicles (LCV's). The potential reduction of CO2 of a speed limiter for LCV's was estimated at about 4-5% for a speed limiter set at 110 km/h and at about 6-7% for a speed of 100 km/h. Overall, limiting the top speed of LCV's in the EU to 100 and 110 km/h would reduce fatalities by about 190 and 110 per year, respectively.

[6] Brookhuis, K, & de Waard, D. (1999). Limiting speed, towards an intelligent speed adapter (ISA). Transportation Research Part F 2 (1999), pp. 81-90. Carsten, O.M.J., & Tate, F.N. (2005). Intelligent speed adaptation: accident savings and cost-benefit analysis. Accident Analysis and Prevention, 37, pp 407-416. Vlassenroot, A., Broeckx, S., De Mol, J., Int Panis, L., Brijs, T. & Wets, G. (2007). Driving with intelligent speed adaptation: Final results of the Belgian ISA-trial. Transportation Research Part A, 41, pp. 267-279. Monash university (2006). On-road evaluation of intelligent speed adaptation, following distance warning and seatbelt reminder systems: Final results of the TAC SafeCar Project. Varhilyi, A., Hjälmdahl, M., Hydén, C., & Draskoczy, 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, pp. 729-737. Päätalo, M., Peltola, H., & Kallio, M. (2001). Intelligent speed adaptation – effet on driving behaviour. In: Proceedings of the European Working Group on Speed Control, Aalborg.

(European Parliament - Directorate-General for Internal Policies, 2009) described the collation and analysis of a wide range of European data on the safety of LCV's. They quote the results of the IMPROVER project in which it was shown that speed limiters for LCVs were not considered economically viable. This was linked to a UK study which showed that- over all road types- only in 2% of the accidents was speeding seen as a contributory factor. In (BAST ea , 2013), on the other hand, it was shown that on motorways speed played an important role in 28% of the cases.

Most field trials mention the potential safety related effect of ISA systems, but given the relative low number of participants it is difficult to present statistically significant differences[7]. Paine M. et al. (2009)[8] made a review of several ISA trials and estimated the potential road safety benefits for Australia. They estimate that top-speed limiting of cars can reduce 1% of all serious crashes (the number of crashes happening at a speed larger than 120 km/h).

In their final report, (Carsten & ea, 2008) find the following expected reduction of accidents as a result of ISA systems.

Table 16: Safety impacts of various types of ISA systems

Type of ISA	Accident Severity			Total
	Fatal	Serious	Slight	
Advisory	9%	4%	2%	2%
Voluntary	25%	19%	10%	11%
Intervening	44%	40%	25%	27%

Source: Carsten et al. (2008)

The table below shows the effect of the type of ISA on CO2 emissions. The highest reduction -6% can be found back in this table for a mandatory ISA system on motorways with a posted speed limit of 112 km/h.

Table 17: Results CO_2 emission analysis

Posted speed limit	**Baseline CO2 (mean g/km)**	**Voluntary ISA - change**	**Mandatory ISA change**
32 km/h	222.1	0.0 ±0.5%	0.1 ±0.6%
48 km/h	185.1	-0.4 ±0.3%	-0.4 ±0.3%
64 km/h	164.0	-1.2 ±0.1%	-1.2 ±0.3%
96 km/h	148.2	0.3 ±0.1%	0.3 ±0.1%
112 km/h	170.8	-3.4 ±0.3%	-5.8 ±0.7%

Source: Carsten et al. 2008

[7] SWOV (2010). SWOV Fact sheet: Intelligent Speed Adaptation (ISA)

[8] Paine, M. ea (2009), Speed limiting trials in Australia

7.4 Scenario definition

The first step of this task is to clearly define the different parameters for which the calculations will be done. In cooperation with the Commission we developed 4 **scenarios**. With these 4 scenarios we are able to provide a good overview of the ranges of impact of the different options, especially as we can also use the results of previous research. Hence we first discuss the scenarios which have been calculated before in previous studies.

7.4.1 Scenarios used in previous studies.

Two studies are of relevance. In (CE Delft, 2010) two scenarios were constructed for speed limiters for vans:

- A speed limiter set at 110 km/h
- A speed limiter set at 100 km/h

The effects were calculated on fuel consumption, CO_2 emissions, air pollutant emissions and safety. Both the effect on motorways and on rural roads was taken into account. No assumption was made on the level of fraud.

In the (Transport & Mobility Leuven, 2013) study scenarios were constructed for both HDV's and LCV's. The effects of both a speed limiter as of an ISA system were calculated. The effects taken (quantitatively) into account were speed, safety, emissions and fuel consumption. These effects were calculated for motorways, rural roads and urban roads. The tables below summarize the scenarios used for LCV's.

Table 18: Summary of the scenarios for the ex-ante analysis for LCV's – TML,2013

Scenario	**Speed limiter LCV's (type N1)**	**ISA system**
Reference	no	No
LCV1	110 km/h	No
LCV2	100 km/h	No
LCV3	no	Advisory/open – variable speed limit information
LCV4	no	Half-open – fixed speed limit information

7.4.2 Definition scenarios

For this project we only consider LCV's. The main parameters and choices which need to be taken into account are

- Only new vehicles or also retrofit? In this project we only focus on speed control devices fitted for new vehicles and hence do not consider retrofit.
- Inclusion of all LCV's or certain subclasses? As the use of a speed control device will not be mandatory in our scenarios we opt to include all LCVs. If creating a level playing field is important, it might be reasonable to consider mandatory speed control devices for the LCV class III as competition is more likely with HDV's. We will not consider this option in this work.

- Assumed penetration rate? if only new vehicles are affected this will affect the penetration rate of the park. The uptake will also greatly depend on the incentives. We will assume that the effects are linear[9] and hence the effects can be easily extrapolated.
- Assumed level of fraud? This is important if we want to calculate the total effect. Given that we assume linearity of effects, this can be easily taken into account.
- For speed limiters: which would be the set maximum speed level for LVCs?
    - Most realistic options are 120 kmh/ 110 kmh/ 100 kmh
    - A lower speed limit, for example of 90 km/h or lower, would result in relatively high differences in speed between N1 and M1 and was assessed as not to be realistic[10] in (Transport & Mobility Leuven, 2013). 120 kmh was not studied before as it was thought that the effects would be small. It would however be an acceptable solution and it is worthwhile to see how small the effects would be.
- For ISA: two main parameters play a role: the feedback given by the system and the information on speeds
    - Feedback: a distinction can be made between
        - Open system. In this case only information on the actual speed and the speed limit is given.
        - Voluntary or half-open systems in which some tactile feedback is given
        - Closed system in which you cannot driver faster than the imposed speed limit.
    - Information on speeds:
        - Fixed information, which changes between road types but is not updated.
        - Variable information, in which case the system "reads" the posted speed limits
        - Dynamic systems, in which case the system will adapt the speed limits if there is congestion on the road, road works, bad weather, etc.
    - Practical feasibility is another important parameter when considering ISA systems. We need to take into account
        - What is available (or will be available in a short time span)?
        - Possible liability issues?
        - Acceptance (as currently there is no mandatory application of speed limiters for LCV's, scenarios with both speed limiters and ISA (closed system) would take two steps at once)?

      This means that most likely are
        - open or voluntary (half open) systems
        - using fixed speed information.

      Dynamic speed information systems are not foreseen in the next 5 years, while variable systems are also not yet available. There might be a liability issue with the closed systems. But if it is a matter of incentives (and no obligation) a scenario including a closed system is interesting (and has not been studied before). An open system is less interesting as an option for a scenario as navigation systems are already widely used.

Given this information we ended with the following four scenarios. Given the assumed linearity the level of penetration and fraud are less important in the analysis.

[9] (Carsten & ea, 2008) did not find a "critical mass" effect of ISA. They concluded that the impact of penetration is linear.

[10] If only LCV class III are considered it might be an option to consider a speed limit of 90 kmh.

Table 19: Scenarios to assess

Scenario	Which LCV	Speed limiter	ISA
Scenario 1	All LCV's can get credits	120 km/h	
Scenario 2	All LCV's can get credits	110 km/h	
Scenario 3	All LCV's can get credits		Half open – fixed
Scenario 4	All LCV's can get credits		Closed - fixed

7.5 Results

7.5.1 Data used

Data on speed limits

The geographical scope of the evaluation is EU28. Data on speed limits for each country is available on the European Commission Road Safety Going Abroad Website[11]. The resulting table for LCV's can be found in Annex 2. Note that the speed limit set can be higher or lower than the speed of the speed limiter.

For urban roads, the speed limit is in general the same for all types of vehicles and set at 50 km/h. Only in Malta and the UK the speed limits are lower. Furthermore, in some countries such as for example in Belgium and the Netherlands, different speed limits apply on certain parts of the urban road network ranging from 30 km/h up to 70 km/h.

For non-urban roads there is much more variation between the different countries with speed limits varying between 60 and 100 km/h, but with most speed limits set at 90 km/h for M1/N1 vehicles and 90 or 80 for N2/N3 vehicles and M2/M3 vehicles.

On motorways and expressways the largest differences can be found between different types of vehicles. For M1/N1 vehicles most speed limits vary between 120-130 km/h, for N2/N3 vehicles around 80/90 km/h and for M2/M3 vehicles around 90/100 km/h.

Given the differences in speed limits between countries, the analysis of impacts on speeds was carried out at country level.

Data on accidents

Data on accidents were taken from the CARE database. To take into account fluctuations we took an average for the years 2011-2014 (or shorter if data for 2014 was not available). We considered

[11] http://ec.europa.eu/transport/road_safety/going_abroad/index_en.htm

the number of fatalities and the number of seriously injured in accidents with LCV's involved – making a distinction with respect to the type of road (urban, rural, motorway). Note that for some countries no accident data was available for LCV's (BG, EE, LT and PL).The accident data used in shown in annex 3.

Given that there is no data available on the vkm driven by LCV's in each country[12], we opted to work with total fatalities and injured and not with the accident risks.

7.5.2 Impacts on speed

In this assessment, the key question is how speed was and will be affected by the introduction of a speed control device. The impacts on vehicle speeds and speed profiles are not as straight forward as one might expect.

This requires data on speeds and speed profiles in both situations. There is data is available in some Member States on vehicle speed levels and speed profiles on various road types (mainly motorways). Those data are often gathered by traffic detecting systems in roads, as part of traffic management or information systems. Unfortunately, the number of vehicle types that can be distinguished in these data is usually rather limited. Therefore, following the methodology of TML (2013) we propose to make use of a theoretical speed distribution. More information on this can be found in annex 4. The speed distribution is assumed to be normally distributed around the average speed with the speed deviation. The average speed that is driven on the road is different for different road types and for different posted speed limits and hence for the different Member States.

For ISA, almost all laboratory and field trials indicate that a speed reduction effect can be found[13]. This effect increases according to the level of intrusion that the system is allowed to have[14]. In some field trials however, an adverse effect on acceleration is reported. It is suspected that drivers use the haptic feedback that is presented as a secondary source of information on vehicle speed and anticipate on this. As such, this is potentially an unwanted effect of the chosen human-machine interaction[15]. Detailed speed profiles or speed distributions are seldom presented. In some cases, a Gaussian curve is presented where the mean average speed is lower as well as the spread of vehicle speeds ran (smaller standard deviations) [16].

We will assume that without a speed limiter the speed distribution follows a normal distribution around the mean (= the reference scenario). This average speed used in this calculation is based on real speed distributions (discussed in (Transport & Mobility Leuven, 2013)) and shown in Annex 2. If a speed limiter is introduced, it is assumed that drivers that are speeding reduce their speeds to the level of the speed limiter, so that speeds above the speed limit become very rare. To illustrate

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[12] Another option would be to use model estimates for vkm as a proxy. For example the vkm listed in the TREMOVE model.

[13] ETSC (2009). Speed fact sheet: ITS and speed: accelerating the deployment of intelligent transport systems for speed management.

[14] DTV Consultants (2012). Snelheidsslot en snelheidsmonitor: evaluatierapport.

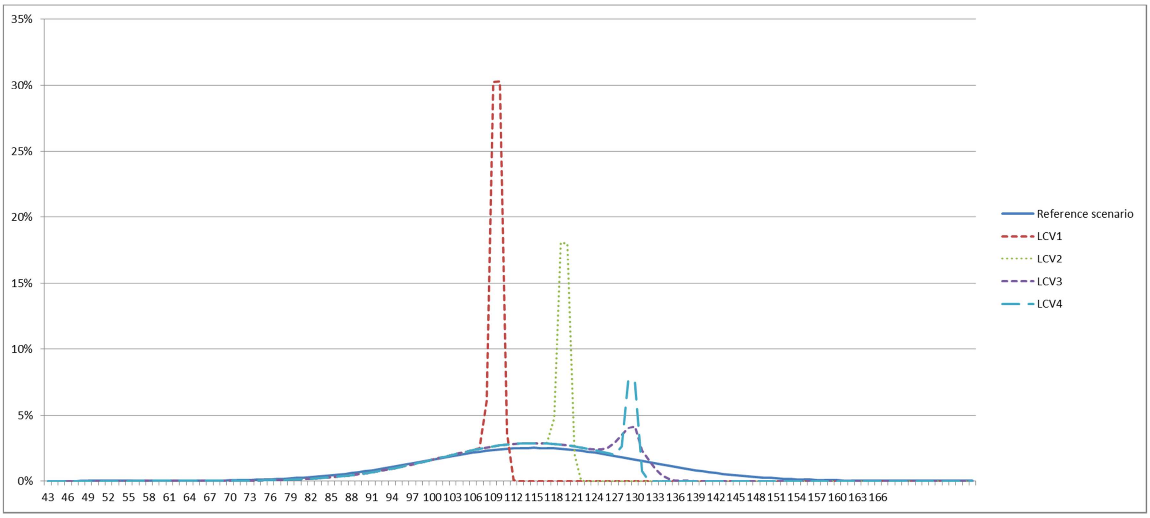
15 Vlassenroot, S. (2008). Speed management through vehicle measures, Intelligent Transport Systems and Intelligent Speed Assistance.

[16] Saint Pierre, G., & Ehrlich, J. (2008). Impact of Intelligent Speed Adaptation systems on fuel consumption and driver behaviour. In proceedings of 15th World Congress on Intelligent Transport Systems and ITS America's 2008 Annual Meeting.

the approach, we show the distributions used in the different scenarios. The blue line shows the situation if there is no speed control device and the speed limit is set at 130 km/h. The red line shows the distribution of scenario LCV1 (speed limiter set at 110 km) which corresponds to the distribution of LCV4 (ISA – closed system) – in light blue. The green line shows the distribution of a speed limiter set at 120 km/h (LCV2) which is higher than the set speed limit (110 km). The purple line shows the distribution of scenario LCV3 – a half open ISA system and the light blue line the distribution of LCV4 (ISA- closed system)

For each speed limit and each type of road these distributions were calculated and attributed to the different countries.

Figure 4: Speed distribution with and without a speed limiter (LCVs)



Source: own calculations.

7.5.3 *Impacts on safety*

Given these speed distributions we can calculate the effect on safety as there is a strong relationship between speed and road safety. The impacts on road safety are the result of two mechanisms:

- Speed control devices generally lower the average vehicle speeds, which lower the accident rates. Furthermore, lower average speeds reduce the energy that needs to be absorbed in case of collision and therefore reduce the damage.
- Speed control devices may smoothen the traffic and reduce speed differences between vehicles. This has also an impact on both the damage in case of collisions and on the accident rates. Furthermore, the road capacity is larger in case of smooth traffic flows.

Literature[17]

In the literature one can find different power functions describing the relationship between accidents and speed. Very well-known Scandinavian studies that are still often quoted in this context are those carried out by Nilsson (1982; 2004), Elvik, Christensen & Amundsen (2004) and

[17] Part of this literature overview was taken over from annex 12 from (Transport & Mobility Leuven, 2013), but updated with the most recent studies.

Elvik (2009). These studies examined the effects on the number of crashes of the increases and decreases of average speeds on a road section mostly due to changes in speed limit.

Nilsson (1982) developed the following formula to describe the effects of a speed change on the number of injury accidents:

$$A_2 = A_1 \left(\frac{v_2}{v_1}\right)^2$$

with A2 as the number of injury crashes after a speed change; A1 as the number of injury crashes before the speed change; v1 as the average speed before the change, and v2 as the average speed after.

He derived this relation based on the notion that when speed increases, the kinetic energy increases, Because kinetic energy is determined by the square of the vehicles speed, the probability of injury and the severity of injuries increase exponentially with vehicle speed.

The absolute speed also has an impact on injury severity. For any given road, there is a relationship between increased injury severity and increased speed. When the collision speed increases, the amount of kinetic energy that is released increases as well. Part of this energy will need to be absorbed by the vulnerable human body. This is particularly true for occupants of light vehicles when colliding with more heavy vehicles, and for unprotected road users, such as pedestrians and cyclists when colliding with motorized vehicles. Generally, the more kinetic energy to be dissipated in a collision, the greater the potential for injury to vehicle occupants.

Nilsson reasoned that the severe injury crash rate would be affected more by a change in speed than the overall crash rate. Based on empirical data of the effects on crashes after a speed limit change on Swedish roads, he increased the power of the function to calculate the number of severe injury (I) and fatal crashes (F) to respectively 3 and 4:

$$I_2 = I_1 \left(\frac{v_2}{v_1}\right)^3$$

$$F_2 = F_1 \left(\frac{v_2}{v_1}\right)^4$$

With I_1 and I_2 as the number of severe injuries before and after the speed change and F_1 and F_2 the number of fatalities before and after the speed change.

Elvik (2009) made it possible to refine this quantitative relationship. He defined the general power function as shown below and specified different exponents relating to the type of accident. The general function is:

$$\frac{Accidents_{after}}{Accidents_{before}} = \frac{Speed_{after}}{Speed_{before}}^{Exponent}$$

The exponent depends on the severity of accident that is considered. In general, the exponent is higher for more severe accidents. He also made a distinction between urban and rural roads. This showed that the effect of an increase or decrease of speed on rural roads is relatively greater than the effect on urban roads. The exponent is higher for motorways in comparison to urban roads. The table below shows the exponents for different accident severities for rural roads/motorways and for urban/residential roads, based on the latest empirical data (Elvik, 2009).

Table 20: The exponents of the power functions for the relationship between speed and crashes/casualties with different injury severity (Elvik, 2009)

Crash/injury severity	Rural roads/motorways		Urban/ residential roads	
	Best estimate	95% Confidence interval	Best estimate	95% confidence interval
Fatal crashes	4.1	(2.9-5.3)	2.6	(0.3-4.9)
Fatalities	4.6	(4.0-5.2)	3.0	(-0.5-6.5)
Serious injury crashes	2.6	(-2.7-7.9)	1.5	(0.9-2.1)
Serious injuries	3.5	(0.5-5.5)	2.0	(0.8-3.2)
Slight injury crashes	1.1	(0.0-2.2)	1.0	(0.6-1.4)
Slight injuries	1.4	(0.5-2.3)	1.1	(0.9-1.3)

As the power functions of Nilsson were extensively evaluated (Nilsson, 2004; Elvik et al., 2004) and fitted the speed and crash data of very different road types, Aarts and van Schagen (2006) consider that these functions describe this relationship best. They are based on a fairly sound before–after study design and describe the effect of changes in average speed on different crash severities levels.

The speed-crash-rate-relation is further complicated by the fact that the crash-rate is not only related to the absolute speed, but also to the speed dispersion. If on a particular road, the vehicles travel at different speeds, the probability of an encounter is higher than if they drive at similar speeds (Hauer, 1971; Elvik et al., 2004). Faster traffic will be catching up with and passing slower vehicles. Higher speed variance this will result in less predictability, more encounters, more overtaking manoeuvres, etc. Many studies emphasized speed variance, rather than absolute speed, as the primary culprit in the incidence of crashes (ERSO, 2006).

The effect that speed differences between vehicles have on the crash-rate is studied in two ways. The first type of studies (e.g. Taylor et al., 2000) are those that compare the crash rates between roads that have a large speed variance (large differences in vehicle speeds during a 24 hour period) and roads that have a small speed variance. These studies mostly conclude that roads with a large speed variance are less safe (Aarts & Van Schagen, 2006).

The second type of studies are those that concentrate on the speed differences between the individual vehicles that were involved in a crash and all the other vehicles. The first studies of this type were conducted in the United States in the 1950s and 1960s, e.g. Solomon (1964). These studies always found a U-curve: the slower or faster a car drives compared with most of the vehicles on that road, the more the risk of being involved in a crash increased. However, more recent studies, especially those carried out in Australia (e.g. Kloeden et al., 1997; 2001; 2002) that used more modern measuring instruments and used a more accurate research design, reached a different conclusion. They still indicate that vehicles that drive faster than average on that road have a higher crash rate; vehicles that drive slower, however, were found not to have an increased risk.

Both the older and the more recent studies provide evidence that driving faster than the surrounding traffic increases the risk of a crash. With regard to driving slower than average, the evidence is less conclusive.

Concluding, when speed differences increase, the crash risk increases as well. Hence, a measure that results in lower average speed, but in larger speed differences may not have the expected positive effect on road safety. Given the scenarios with speed limiters set at 110 km/h and 120 km/h it is however not expected that intruding speed limiters for LCV's will lead to larger speed differences.

As mentioned before, Taylor et al. examined speed variance at road section level. They performed a cross-sectional study, by comparing the crash rates (hospital admission or more) between roads that have a large speed variance and roads that have a small speed variance. They use both the speed deviation and the average speed at the same time as explanatory variables for the accident rates.

Taylor et al. (2000) found that traffic speed variance is related to the crash frequency. They collected aggregated 24 h spot speed data of 300 urban single carriageway roads in the UK and linked this to 1590 injury crashes at these roads. The researchers distinguished four road types: congested roads in town, inner city link roads, suburban link roads, and outer suburban fast roads. The results show that the crash frequency increased more with increasing average speed. At a more detailed level, congested roads both had a higher absolute crash frequency and a larger increase in crash frequency with higher average speeds than fast roads. Lower average speeds coincide with a larger speed variance and both were found to be related to crash frequency.

Taylor et al states that road safety is both related to the average speed and to the speed dispersion on the road section. Taylor developed the following formula for the relationship between accident rate and average speed and speed variance:

$$Accident\ rate(V, SD) = 0{,}000435 \cdot V^{2{,}252} \cdot e^{5{,}893 \cdot \frac{SD}{V}}$$

with v as the average speed (km/h) and SD as s the standard deviation of the speed distribution (km/h)

Most other studies indicate either a relationship between average speed and accident rate or just the relationship between speed dispersion and accident rate. Only Taylor et al (2000) and Baruya and Finch (1994), use both the speed deviation and the average speed at the same time as explanatory variables for the accident rates. The type of study that was used to derive the relationships are cross-sectional, and less suitable to estimate the effect.

(Cameron & Elvik, 2010) focusses on urban roads and on estimating new functions. They conclude that the power function is a good match for rural roads and motorways. However, it is not a good match for urban roads, but that more information is needed to estimate a better func2tion than currently available.

(Elvik, 2013) focusses on the function to be used. He states that the function should also depend on the initial speed and hence an exponential function might be more useful than an power function. Using an exponential function he estimated the AMF (Accident Modification Factor) which can be associated with a certain change in speed. He finds that the exponential function fits particularly well for injury accidents.

Power function used

Even though the exact relationship between speed and crash rate depends on a large number of different factors, clear relationships between road safety and absolute speed and speed dispersion have been established. The literature is inconclusive on which one is more important. We have chosen to follow the coefficients to be used in a power function[18] as listed in (Elvik, 2013). These coefficients depend on the type of accident (fatality versus seriously injured) and the type of road. The table below shows the coefficients used.

Table 21: Estimates of the exponents in the Power model.

Accident or injury severity	Summary estimates of exponents by traffic environment					
	Rural roads/freeways		Urban/residential roads		All roads	
	Best estimate	95% confidence interval	Best estimate	95% confidence interval	Best estimate	95% confidence interval
Fatal accidents	4.1	(2.9, 5.3)	2.6	(0.3, 4.9)	3.5	(2.4, 4.6)
Fatalities	4.6	(4.0, 5.2)	3.0	(−0.5, 6.5)	4.3	(3.7, 4.9)
Serious injury accidents	2.6	(−2.7, 7.9)	1.5	(0.9, 2.1)	2.0	(1.4, 2.6)
Seriously injured road users	3.5	(0.5, 5.5)	2.0	(0.8, 3.2)	3.0	(2.0, 4.0)
Slight injury accidents	1.1	(0.0, 2.2)	1.0	(0.6, 1.4)	1.0	(0.7, 1.3)
Slightly injured road users	1.4	(0.5, 2.3)	1.1	(0.9, 1.3)	1.3	(1.1, 1.5)
Injury accidents – all	1.6	(0.9, 2.3)	1.2	(0.7, 1.7)	1.5	(1.2, 1.8)
Injured road users – all	2.2	(1.8, 2.6)	1.4	(0.4, 2.4)[a]	2.0	(1.6, 2.4)
Property-damage-only accidents	1.5	(0.1, 2.9)	0.8	(0.1, 1.5)	1.0	(0.5, 1.5)

[a] Confidence interval specified informally.

The exponents for fatalities and seriously injured were applied to each individual country and each road type. The country results[19] can be found in annex 5. Summing over all countries, we found the following results:

Table 22: Potential safety effect of speed control devices (fatalities)

		Urban	Rural	Motorways	Total (#)
Scenario 1	Speed limiter (120 km/h)	0%	0%	-7.7%	-12
Scenario 2	Speed limiter (110 km/h)	0%	-2.1%	-19.9%	-40
Scenario 3	ISA (half open-fixed)	-30%	-11%	-11%	-111
Scenario 4	ISA (closed-fixed)	-31%	-12%	-12%	-119

[18] It was not possible to use the exponential model as the article did not list all relevant AMFs.

[19] Note that for some countries, the number of accidents is rather low. This means that the results are probably more reliable when looking at relative changes for all countries together than when considering countries one by one.

Table 23: Potential safety effect of speed control devices (seriously injured)

		Urban	Rural	Motorways	Total (#)
Scenario 1	Speed limiter (120 km/h)	0%	0%	-6.00%	-74
Scenario 2	Speed limiter (110 km/h)	0%	-2%	-15%	-230
Scenario 3	ISA (half open-fixed)	-21%	-8%	-9%	-466
Scenario 4	ISA (closed-fixed)	-22%	-9%	-9%	-498

Using a value of 1.870.000 euro for one fatality and 243.100 euro for one seriously injured[20], the safety effects have a value of about -40 million euro (total for speed limiter set at 120 km/h) up to -343 million euro (total for ISA-closed)

Table 24: Total effect and value of safety for speed control devices.

		Fatalities (#)	Seriously injured (#)	Fatalities (million euro)	Seriously injured (million euro)
Scenario 1	Speed limiter (120 km/h)	-12	-74	-22.44	-17.99
Scenario 2	Speed limiter (110 km/h)	-40	-230	-74.8	-55.91
Scenario 3	ISA (half open-fixed)	-111	-466	-207.57	-113.28
Scenario 4	ISA (closed-fixed)	-119	-498	-222.53	-121.06

7.5.4 Impacts on CO_2 and pollutant emissions

Introduction

Speed limitation devices also impact the emissions levels. At the vehicle level, fuel efficiency and resulting CO_2 emissions are strongly affected by speed. Higher speeds result in higher friction of air and tyres and so a higher energy demand. At the same time the energy efficiency of the drivetrain of the vehicle is also dependent on the speeds, generally being suboptimal at low speeds and very high speeds and having an optimum somewhere in between. The combination of both effects makes that there is an optimal vehicle speed for fuel consumption and CO_2 emissions (for cars generally a constant speed in the range of 70-100 km/h).

For pollutant emissions, a similar relation between speed and emissions exists, although with generally even larger differences between optimal and suboptimal emission levels.

Apart from the average vehicle speed, also the speed dynamics have a significant impact on CO_2 and pollutant emissions. Generally, the higher the speed dynamics are, the higher the emissions. The more technology is installed on vehicles, the larger the role of throttle movements on pollutant emissions is. Regarding fuel consumption and CO_2, braking and accelerating results in energy losses and temporarily high fuel consumption.

[20] (Ricoardo-AEA, 2014)

The estimation of the impacts on energy use and emissions will start from the impacts on speed and speed profiles. With the relation between speed and speed profile on the one hand and energy use and emissions on the other, the impacts will be estimated using the VERSIT+[21] (see Annex 5) emission model of TNO. As these relations depend on vehicle type and road type and therefore, the relations need to be differentiated to these parameters. Note that the emissions in VERSIT+ are based on measurements of real vehicles in real world conditions. It takes into account of the recent evidence of the exceedance of NO_x emissions in real driving conditions compared to test conditions. As there are few Euro 6 LCV's on the market, we will derive emission maps based on the available Euro 6 emission maps from passenger cars. The emission-after treatment systems of current (passenger car) Euro 6 reduce pollutant emissions relatively well at high velocities. Therefore, the introduction of the WLTP is not expected to have a significant impact on the pollutant emission reduction by speed limiters. Even the introduction of a 'real driving emissions' test is expected to have only limited effect. In order to analyse the sensitivity of potentially changed emission maps, the Euro 5 emission map (which differs significantly from the Euro 6 emission map) of LCV's will be translated to Euro 6 levels. Pollutant emission reductions resulting from speed limiters will be compared for the two cases with different emission maps.

Tested scenarios

The effect of speed limiting devices on vehicle emissions is assessed for 20 scenarios as shown in Table 25. The scenarios without speed limiting device and the ones based on two speed limiter settings for rural and motorway conditions (12 in total) are equal to the ones assessed in 2013 (Transport & Mobility Leuven, 2013).

Table 25: Scenarios for which effects of speed limiting devices on emissions are assessed

Scenario	Road type	Speed limiting device	Average velocity	
			Low	High
Reference	Urban	No speed limiter	17.5	-
ISA (Closed - fixed)	Urban	ISA	17.4	-
speed limiter (110 km/h)	Urban	speed limiter (110 km/h)	17.5	-
speed limiter (120 km/h)	Urban	speed limiter (120 km/h)	17.5	-
Reference	Rural	No speed limiter	80	90
ISA (Closed - fixed)	Rural	ISA	77.1	86
speed limiter (110 km/h)	Rural	speed limiter (110 km/h)	80	89.4
speed limiter (120 km/h)	Rural	speed limiter (120 km/h)	80	90
Reference	Motorway	No speed limiter	107	115
ISA (Closed - fixed)	Motorway	ISA	106.8	115
speed limiter (110 km/h)	Motorway	speed limiter (110 km/h)	104.7	107.2
speed limiter (120 km/h)	Motorway	speed limiter (120 km/h)	107	113.5

[21] [TNO 2007] A new modelling approach for road traffic emissions: VERSIT+. Smit, R., Smokers R., Rabe E. Transporation Research Part D, 12 (2007), pp. 414–422.

Drive cycles

To assess the effects of speed limiting devices on emissions, the Artimis Urban Cycle was used for urban conditions. The cycles used for rural and motorway conditions are equal to the ones used in (Transport & Mobility Leuven, 2013). All cycles are depicted in Annex 6.

Emission maps

The emission maps used to determine the CO_2, NO_x and PM10[22] emissions are updated and are now based on modern Euro 6 LCV's. Emissions are determined for 'light' (representative for Class I and II LCV's) and 'heavy' (representative for Class III LCV's) LCV's. Based on 2014 sales distribution, based on the Monitoring database, the reductions are sales weighted to derive an average reduction value for average LCV's (Class I, II and III).

Emission reductions

Table 26: Emission reductions resulting from various speed limiting devices

	Speed limiting device	Road type	average velocity	Reductions			Share of driving	Reductions		
				CO_2	NO_x	PM10		CO_2	NO_x	PM10
Reference	No limiter	Urban	17.5	0%	0%	0%	13%	0.0%	0.0%	0.0%
	No limiter	Rural	80.0	0%	0%	0%	10%			
	No limiter	Rural	90.0	0%	0%	0%	10%			
	No limiter	Motorway	107.0	0%	0%	0%	33%			
	No limiter	Motorway	115.0	0%	0%	0%	33%			
Scenario 4	ISA (Closed - fixed)	Urban	17.4	1%	1%	1%	13%	1.7%	3.6%	1.7%
	ISA (Closed - fixed)	Rural	77.1	7%	10%	7%	10%			
	ISA (Closed - fixed)	Rural	86.0	9%	21%	9%	10%			
	ISA (Closed - fixed)	Motorway	106.8	0%	1%	0%	33%			
	ISA (Closed - fixed)	Motorway	115.0	0%	0%	0%	33%			
Scenario 2	speed limiter (110 km/h)	Urban	17.5	0%	0%	0%	13%	6.4%	17%	6%
	speed limiter (110 km/h)	Rural	80.0	0%	0%	0%	10%			
	speed limiter (110 km/h)	Rural	90.0	2%	5%	2%	10%			
	speed limiter (110 km/h)	Motorway	104.7	5%	15%	5%	33%			
	speed limiter (110 km/h)	Motorway	107.2	14%	35%	14%	33%			
Scenario 1	speed limiter (120 km/h)	Urban	17.5	0%	0%	0%	13%	0.9%	2.2%	0.9%
	speed limiter (120 km/h)	Rural	80.0	0%	0%	0%	10%			
	speed limiter (120 km/h)	Rural	90.0	0%	0%	0%	10%			
	speed limiter (120 km/h)	Motorway	107.0	0%	0%	0%	33%			
	speed limiter (120 km/h)	Motorway	113.5	3%	6%	3%	33%			

In [Casten et al 2008] it was found that the ISA half open (or voluntary) system results in a very similar amount of emission reduction compared to a closed (mandatory) system up to maximum velocities of 112 km/h (or 70 mph). At higher posted speed limits, the effect is reduced by approximately 40% compared to a closed (mandatory system. Given that the simulations in this

[22] Emission maps for PM10 are not available and as a result, the relative PM10 emission reduction is assumed to be equal to the relative CO2 emission reduction.

study result in only limited effect of closed ISA systems on motorways, the effect of half open ISA systems is expected to be similar to what is found for closed ISA systems.

Caveats

The relative emission reductions shown in Table 26 are the result of an analysis based on a single drive cycle (with limited length). Given that the (average) driving behaviour between countries and between individuals varies significantly, the share of distance driven at velocities at which speed limiting devices actually affect the driving speed is likely to deviate from the cycle used in this analysis. Therefore the emission reduction resulting from speed limiting devices may also differ significantly between countries and from individual to individual.

For instance, devices limiting speeds to a maximum of 120 km/h are found not to have a significant effect on vehicle emissions when the average motorway speed is 107 km/h. This is the case because the maximum velocity of the (scaled) drive cycle (shown in Figure 13) is not higher than 120 km/h. As a result the speed limiting device does not affect the velocity and does therefore not affect the emissions. In reality however, it is very well possible that the maximum velocity of LCV's is higher than 120 km/h on certain roads at which the average velocity of LCV's is 107 km/h.

Moreover, the emission maps used for the emission reduction analysis are based on real world emission measurements of a large number of light duty vehicles, resulting in a weighted average emission map. However, as the emission maps deviate significantly between vehicle makes and models, the effect of speed limiting devices of a certain vehicle make or model may deviate from the relative emission reductions found in this study.

7.5.5 Other impacts

There is a relationship between speed and noise, although this is not a simple linear relationship. Noise from road traffic comprises engine-related propulsion noise and rolling noise from the interaction between tyre and road. At higher speeds, rolling noise is predominant, while at speeds less than 30 km/h, engine noise becomes dominant. This means that at higher speeds, a speed reduction can lead to a noise reduction, but at low speed limits a reduction can lead to an increase as you can go from a situation where rolling noise is dominant to a situation where engine noise dominates. The UKNA report[23] states that in urban areas with speeds of between 30 and 56 km/h, reducing speeds by 10 km/h could cut noise levels by up to 40%, while reducing 112 km/h and 96 km/h on urban motorways would cut noise by up to 50%.

With the introduction of speed limiters/ISA we do not expect that average speeds will drop by so much. (Carsten & ea, 2008) state that regarding noise, the implementation of ISA systems is likely to make a negligible contribution towards reducing overall noise levels. Any benefits would not be noticed by the human observer. This is probably also true for speed limiters.

It is sometimes also argued that speed control devices might have a beneficial impact on the capacity of roads as there would be less accelerating and less variation in speeds. (Carsten & ea,

[23] Referred to on http://www.roadtraffic-technology.com/features/feature126199/

2008) tried to assess this effect using network models and microsimulation. They did not find consistent results

7.6 Conclusion

For this task four scenarios were analysed. In all cases the speed control device is not mandatory for LCV's. We analysed two speed limiters - with a limit set at 110 km/h and a limit set at 120 km/h; and two ISA scenarios – one half open and one closed system, both using fixed speed information.

Using the impact of the speed control device on the average speed, the speed distribution and a speed-accident relationship the effect on safety was calculated. This calculation takes into the differences between the EU countries with respect to the set speed limit at different types of roads and the number of accidents happening with LCV's. We found that the closed ISA system had the largest effect (value of 343 million euro)–as it impacts the speed on all types of roads. When only comparing the speed limiters, the speed limiter set at 110 km/h had the highest effect and also affected accidents on rural roads in some countries.

The effect on the emissions was calculated using the impact of the speed control device on the average speed and speed profiles using the VERSIT+ model[24]. The speed limiter set at 110 km/h had the highest impact on emissions. The ISA systems did impact emissions but only marginally better than a speed limiter set at 120 km/h.

The table below summarizes the results. While ISA has the highest safety effects, the speed limiter set at 110 km/h has the highest effect on emissions.

Table 27: Summary co-benefits speed control devices

	Safety effect						Emissions		
	Fatalities			Seriously injured			CO2	NOx	PM
	Urban	Rural	Motorway	Urban	Rural	Motorway			
LCV 1 (speed limiter 120 km/h)	0%	0%	-8%	0%	0%	-6%	-1%	-2%	-1%
LCV 2 (speed limiter 110 km.h)	0%	-2%	-20%	0%	-2%	-15%	-6%	-17%	-6%
LCV 3 (Half open ISA)	-30%	-11%	-11%	-21%	-8%	-9%	-2%	-4%	-2%
LCV 4 (Closed ISA)	-31%	-12%	-12%	-22%	-9%	-9%	-2%	-4%	-2%

[24] More information on the VERSIT+ model can be found in annex 7.

8 Task 6: Exploration of the legislative options

8.1 Way in which implementation of CO_2 reducing technologies are currently incentivised

There are multiple ways in which OEMs are rewarded for implementing CO_2 reducing technologies in their LCV. For technologies that affect the CO_2 emissions under type approval test procedure (Directive 2007/46/EC) conditions, i.e. on the coast down test or on the standardised drive cycle driven on a dynamometer, the effect is automatically accounted for in the type approval emissions of the vehicle. However, certain technologies that lower emissions in real world use of a vehicle, have no effect on the CO_2 emissions in the test procedure, e.g. energy efficiency improvement of the air conditioning system. In order to incentivise manufacturers to implement such technologies, known as 'eco-innovations', under the current regulation manufacturers can be granted emission credits equivalent to a maximum emissions saving of 7 g/km per year for their fleet (under Regulation (EU) No 333/2014) if they equip vehicles with innovative technologies, based on independently verified data.

The goal of this chapter is to provide insight in the way in which the implementation of speed limiting devices can be incentivised by means of legislation. Such incentives can be provided in multiple ways that will be analysed in section **Error! Reference source not found.**.

8.2 Approach

In order to determine the possible legislative options available to further incentivise the implementation of speed limiters, the current regulation will be assessed. This assessment provides information on the current ways in which the implementation of CO_2 emission reducing technologies is incentivised. Moreover, other legislative options to incentivise the implementation of speed limiters are proposed based on questionnaire results, expert views and consultation with the commission. The various options will be analysed and pros and cons described.

8.3 Possible legislative ways in which speed limiters can be incentivised

In the current and future (WLTP) legislation the CO_2 emissions will (partly) be based on a type approval test dynamometer test. For as long as the CO_2 emission targets that manufacturers have to comply with are solely based on this dynamometer test there are two ways[25] in which speed limiting devices could be rewarded and therefore incentivised, i.e.

1. Allow the speed limiting device during the drive cycle on the dynamometer during the type approval test or;
2. Account for the reduced CO_2 emissions separately from the test procedure;
    a. Via the 'eco-innovations' system that is currently in place.

[25] In the end all options can be classified in the described two ways

b. However, future regulation is not necessary similar to the current setup and the use of speed limiters could be incentivised in multiple ways. For example, a simplified eco-innovations system could be implemented to credit emission reductions.

We now discuss these two options in more detail.

8.3.1 Account for effect of speed limiting devices by using them on the dynamometer during the type approval test

Ways in which vehicle emissions are effected by accounting for speed limiters via the dynamometer test

As speed limiters limit the maximum speed of a vehicle, using such a device on the type approval test will limit the upper speed of the LCV on the dynamometer. This affects the CO_2 emissions in two ways

- Energy use (and therefore CO_2 emissions) are highest at the highest velocities. As explained in section **Error! Reference source not found.**, for conventional ICE vehicles, the energy use per kilometre increases significantly with an increasing velocity above approximately 70 to 100 km/h (depending on the engine power and number of gears) as the air drag increases with the velocity. Limiting the maximum velocity at a value higher than this range of 70 - 100 km/h therefore results in lower overall energy use and CO_2 emissions during the type approval test.
- Speed limiters reduce driving dynamics, i.e. the amount of decelerations and accelerations. These dynamics increase the energy use and CO_2 emissions of a vehicle. Limiting such dynamics therefore reduces the overall CO_2 emissions during the type approval test.

The current NEDC type approval procedure (Directive 2007/46/EC) will in 2017 be replaced by the WLTP. Therefore, the effects of allowing speed limiters to be used during type approval will be based on the WLTP situation rather than the existing NEDC type approval test.

Effect of implementation of the WLTP

In the new type approval test WLTP, three different test cycles are defined. Depending on vehicle class based on the power-to-weight ratio, rated engine power divided by kerb weight in [kW/tonne]:

- Class 1: low powered vehicles (ptw <= 22);
- Class 2: medium powered vehicles (22 < ptw <= 34);
- Class 3: high powered vehicles (ptw > 34);

As shown in Table 28, the LCV models with the highest market shares, i.e. Ford Transit, Mercedes Sprinter and Volkswagen Transporter, are all available in Class 2 and Class 3.

Table 28: Power-to-weight for LCV's with highest market shares

Model	Power-to-weight [kW/tonne]
Ford Transit	33 – 55
Mercedes Sprinter	28 – 63
VW Transporter	30 – 79

Table 29 shows that the vast majority of LCV's registered in 2013 had a power-to-weight ratio higher than 34 kW/tonne (class 3), i.e. 97.9%. A small share had a power-to-weight ratio below 34 kW/tonne, i.e. 2.1%. These are mainly the larger LCV's, i.e. Class III. Finally, the number of LCV's in Class 1 (< 22 kW/tonne) was very limited (0.1%) and only included one single electric small van model. Given that the average energy use over the Class 3 cycle is significantly higher than that over the Class 2 cycle, the CO_2 emissions will also be significantly more. For LCV models that currently have a power-to-weight ratio just higher than 34 kW/tonne, it is very well possible that the power-to-weight ratio will be slightly reduced in order to lower the type approval CO_2 emissions.

Table 29: Power-to-weight for LCV's with highest market shares (based on monitoring database 2013)

LCV class	sales share of LCV classes	Class 1 (ptw ≤ 22 kW/tonne)	Class 2 (22 < ptw ≤ 34 kW/tonne)	Class 3 (ptw > 34 kW/tonne)
Class I (≤ 1305 kg)	11%	0.1%	0.1%	99.9%
Class II (1305 - 1760 kg)	30%	0.0%	1.4%	98.6%
Class III (> 1760 kg)	59%	0.0%	2.8%	97.2%
Total	**100%**	**0.0%**	**2.1%**	**97.9%**

Figure 5: WLTC class 3 cycle

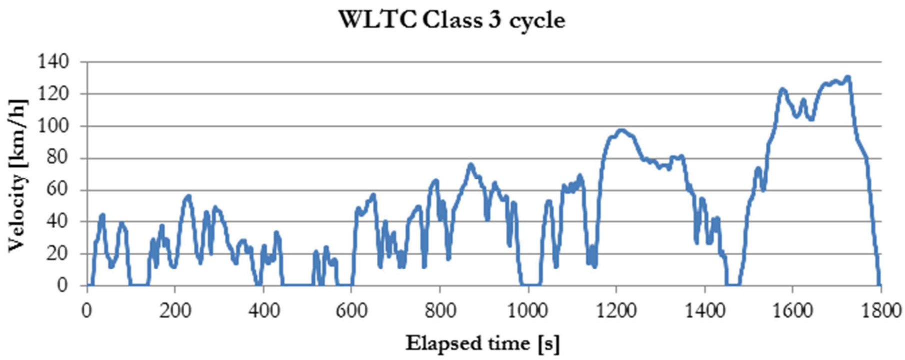
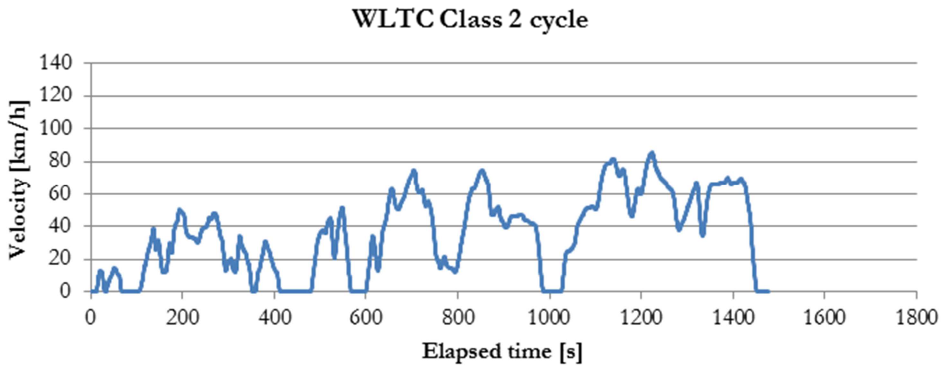


Figure 6: WLTC class 2 cycle



As the maximum velocity of the Class 2 WLTP drive cycle is below 110 km/h, the speed control devices assessed in this study will not affect the type approval CO_2 emissions of these lower powered vehicles (as shown in Table 29). As a result, the use of speed control devices will not be incentivized on LCV's with power-to-weight ratios below 34 kW/tonne. Despite the limited power-to-weight ratio, the real driving maximum velocities of these vehicles could well be higher than 110 km/h meaning that a speed limiter would lower the real driving CO_2 emissions.

On the Class 3 cycle, the maximum velocity is significantly higher. As a result speed limiters set at 110 km/h and 120 km/h affect the cycle and therefore CO_2 emissions. Speed limiters set at 120 km/h are expected to lower emissions by approximately 1%, while Speed limiters set at 110 km/h are expected to lower emissions by approximately 2% to 4% (as shown in Table 29).

Vehicle's emissions on a certain drive cycle can be simulated using the VERSIT+ model. Therefore, the characteristics of the cycle in terms of velocity and acceleration are combined with the velocity and acceleration dependent emission maps of various vehicle types that are available in VERSIT+[26]. By determining the emissions of Class I, II and II LCV's on WLTC drive cycle Class 2 and 3, the relative emissions as shown in Table 30 can be determined.

Based on these VERSIT+ velocity and acceleration based emission maps, the CO_2 emissions of LCV's on the Class 2 cycle are expected to be approximately 10% lower than those of comparable LCV's on the Class 3 cycle, which is a significantly greater emissions difference than the difference between applying a speed limiter at 110 km/h or not. In case speed limiters would be allowed in the type approval test, for LCV models with power-to-weight ratios just above 34 kW/tonne, slightly reducing the power-to-weight ratio is a more effective way of reducing type approval CO_2 emissions than implementing a speed limiter. Since the implementation of speed limiters would then not further reduce the type approval emissions, speed limiters would not be incentivized for the models below, and possibly just above, 34 kW/tonne.

Table 30: Class 3 WLTP CO_2 emission of LCV's with various speed limiter configurations relative to Class 3 WLTP CO_2 emissions without speed limiter and Class 2 WLTP CO_2 emission of LCV's with and without various speed limiter configurations relative to Class 3 WLTP CO_2 emissions without speed limiter. All is derived using VERSIT+ emission maps.

		Simulated CO_2 emissions relative to Class 3 without speed limiter		
Drive cycle	N1 class	No limiter	speed limiter (110 km/h)	speed limiter (120 km/h)
Class 3	Class I	100%	96%	99%
Class 3	Class II	100%	96%	99%
Class 3	Class III	100%	98%	99%
Class 2	Class I	90%	90%	90%
Class 2	Class II	90%	90%	90%
Class 2	Class III	89%	89%	89%

The effect of an ISA system on a vehicle's emissions during type approval cannot be assessed in this way as not posted speed limits are available for the different WLTC sections. The WLTC is a combination of many parts of trips from different regions of the world with different posted speed limits. Therefore, the speed limit of every part of which the WLTC was constructed could be different. Selecting velocity limits for the ISA system is therefore very arbitrary and the effect of an ISA system on the type approval procedure cannot be determined objectively.

8.3.2 Account for the reduced CO_2 emissions separate from the type approval test

A technology can qualify as an eco-innovation under current rules (Regulation (EC) 443/2009) if it is new to the market, contributes to significant CO_2 savings and is not otherwise taken into account in determining the level of CO_2 emissions from vehicles. The technology should also aim at

[26] These emission maps have been derived by TNO by measuring emission behaviour of well over 12000 real vehicles. See also: Refined vehicle and driving-behaviour dependencies in the VERSIT+ emission model- Norbert E. Ligterink and Ronald De Lange and Annex 7.

improving vehicle propulsion or the energy consumption of devices that are mandatory, without compromising vehicle safety.

Currently, manufacturers can be granted credits for equipping their vehicles with CO_2-reducing technologies for which it has been independently verified that it reduces the actual real world CO_2 emissions and it is not accounted for in the type approval procedure. The Commission assesses applications submitted by car manufacturers and component suppliers and adopts decisions approving generic eco-innovations. The actual CO_2 savings from the eco-innovations for each specific vehicle will be certified as part of the vehicle type approval procedure. In order for speed limiters or ISA systems to be rewarded credits under the eco-innovations system, the Commission would have to determine that they are innovative and do not compromise vehicle safety.

For speed limiters it is not likely that they could be rewarded under this eco-innovation system, since they are not 'new to the market'. For ISA systems this chance is larger, however, with current information, it is not possible to unarbitrarily apply an ISA system in the WLTP type approval procedure as posted speed limits are not available for the WLTC. This WLTC is constructed out of many parts of trips form different regions in the world with different posted speed limits. Therefore the maximum velocity that would be required for the ISA settings is unknown.

Currently consideration is being given to the post 2020 regime for regulating car and light commercial vehicle CO2 emissions. As part of this, the eco-innovation-like system could change or even be replaced with a different approach. For example, it could be decided to grant a fixed amount of credits, e.g. only 1 gCO_2/km credit even though the emission testing or modelling might suggest that the effect of a technology is larger. Depending on the final regulation, such a system could incentivise the implementation of technologies more easily. Also technologies that are not necessarily innovative but do reduce real driving CO_2 emissions could be granted credits. This may lower the administrative burden on both the regulatory authority as well as LCV manufacturers.

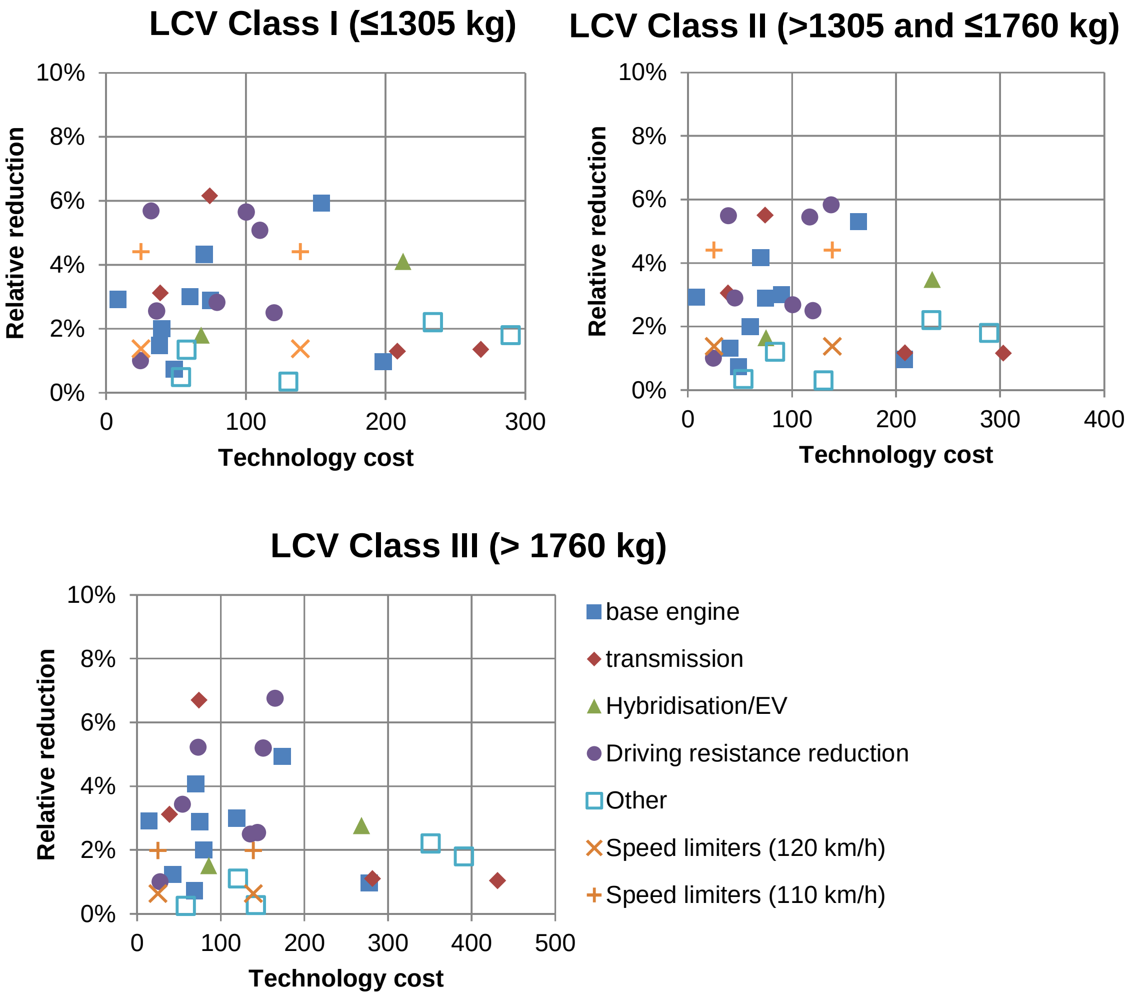
In order for this system to be an actual incentive, the avoided costs, resulting from not having to implement technologies that do have a direct effect on the type approval CO_2 emissions, should be equal to or greater than the cost of implementing a speed limiter. In a new study for the EC[27], the costs and reduction potentials (on the WLTP) of several CO_2 reducing technologies for LCV's were determined.

In Figure 7 the cost and (WLTP)) reduction potential for several CO_2 reducing technologies are shown, divided into five categories, i.e. engine, transmission, hybridization, driving resistance and other technologies. The combinations of cost (assumed between €25 and €139 from Table 4) and WLTP reduction potentials (taken from Table 30) of speed limiters are shown as well in orange. The high reduction values represent the use of speed limiters at 110 km/h, the lower reduction potentials represent the use of speed limiters at 120 km/h. For Class I and II LCV's, speed limiters set at 110 km/h are compared to other technologies quite effective for CO_2 reduction. From a manufacturer perspective, this type of speed limiter at the lower part of the price range (i.e. €25) is a very cost effective technology to reduce type approval CO_2 emissions. Even at higher cost, the cost and reduction potential are very close to other technologies. The cost of a speed limiter set at 120 km/h is more towards the upper end of the price range (i.e. €139). However, it is still close to the

[27] http://ec.europa.eu/clima/policies/transport/vehicles/docs/technology_results_web.xlsx

cost effectiveness of other CO_2 reducing technologies, such as "Aerodynamics improvement 2 (Cd reduced by 20%)" and "Low rolling resistance tyres 2".

Figure 7: Cost and (WLTP) reduction potential for several technologies including possible costs and reductions for speed limiting devices. Reductions of speed limiting devices based on values found in section ***Error! Reference source not found.***



8.4 Pros and cons of legislative ways in which speed limiters can be incentivised

1a) Accounting for effect of speed limiting devices by using them on the type approval test

Pros:

+ the emission reduction is representative for the specific LCV it is used on

+ low administrative burden as the emission credits to be granted do not have to be determined for all available speed limiting devices individually

+ as long as end users cannot tamper with the speed limiting device, emissions at velocities higher than the maximum velocity on the test cycle (85 km/h and 131 km/h for respectively Class 2 and 3), which may be high as the vehicle is not optimised on these high velocities, will not occur.

+ safety effect with a value of 40 to 130 million euro (depending on the speed limit set).

Cons:

- since speed limiters have no effect on LCV's with power-to-weight ratios below 34 kW/tonne, the use of such devices will not be incentivized for vehicles with low power-to-weight ratios.
- in case speed limiting devices are allowed on the type approval test, vehicle's emission behaviour at velocities higher than the speed limiting device's limit is not tested, in case the speed limiting device is switched off by the end user, vehicle emissions may become very high as the LCV is not optimised for these high velocities.
speed limiting devices that can be switched off by the user,
- extra emissions resulting from switching off the speed limiting device cannot be accounted for by granting only a certain share of the emission reduction that the speed limiting device instigates when in use.
- the effect of the speed limiting device increases significantly with a decreasing maximum velocity set on the device which may result in low maximum velocities set, increasing the incentive for end users to obstruct the correct use of the speed limiting device
- the light duty type approval cycles are based on predefined shares driven in 'low', 'medium', 'high' and 'extra high' conditions. In case the share of 'extra high' conditions, the part where speed limiters have (highest) effect, is higher in the type approval cycle (35%, Table 31) than in reality, the effect of the speed limiting device is overestimated.
- as speed limiting devices may become a relatively cost effective way to reduce type approval CO_2 emissions (up to 4% reduction at 25 and 347 euros) they may decrease the incentive to implement other CO_2 reducing technologies.
- currently, the use of ISA systems cannot be accounted for in the WLTP type approval procedure as the posted speed limits are not available since the WLTC was constructed of many different parts of trips with many different unknown posted speed limits.
- speed limiters mainly have a safety effect on motorways and on some rural roads. They do not impact safety on urban roads.

Table 31: Shares of the class 2 and class 3 WLTP cycles driven in 'low', 'medium', 'high' and 'extra high' conditions

	Low	**Medium**	**High**	**Extra high**
Class 3	13%	20%	31%	35%
Class 2	21%	32%	47%	0%

2) Account for the reduced CO_2 emissions separate from the type approval test

2a) Via the 'eco-innovations' system that is currently in place

Pros:

+ flexibility in terms of credits granted depending on
  + share of vehicle use in situation in which the speed limiting device actually affects the velocity (highways with posted speed limits higher than the limit of the device)

Cons:

- granted absolute or relative emission reductions are not vehicle specific
- higher administrative burden to determine the credits grated for every type/model of speed limiting device available
- higher administrative burden to assess innovativeness of every type/model of speed limiting device available
- 'conventional' speed limiters are unlikely to be granted credits because this technology is not 'new to the market'. For ISA systems this is more likely as they are currently not available on LCVs.

2b) Granting credits under a new system that is still to be developed

Pros:

+ flexibility in terms of credits granted depending on
  + likeliness of tampering with the device (higher likeliness → less credits)
  + share of vehicle use in situation in which the speed limiting device actually affects the velocity (highways with posted speed limits higher than the limit of the device)
  + the cost effectiveness compared to other CO_2 reducing technologies in order to change the relative cost effectiveness and therefore incentive for manufacturers to implement speed limiting devices
+ no necessity to assess innovativeness in order to be able to grant emission credits
+ both 'conventional' speed limiters as well as ISA systems could be granted credits since the criteria that technologies would have to comply with in order to be granted credits are still to be defined.

Cons:

- granted absolute or relative emission reductions are not vehicle specific
- higher administrative burden to determine the credits grated for every type/model of speed limiting device available.

8.4.1 *Conclusion*

These identified pros and cons can be divided into three categories, i.e. Incentive, Flexibility and Administrative burden. Hereafter the extent to which the three options contribute to incentivising the implementation of speed limiting devices via legislation can be summarised as shown in Table 32. From this table can be derived that accounting for speed limiting devices via the type approval test is likely to result in a greater incentive and will lower the administrative burden. However this is at the cost of flexibility. This flexibility in option of accounting separate from the type approval test and not purely based on theoretical emission reduction can greatly increase the extent to which the implementation of speed limiters is incentivised. As a result, the incentive is for this option can be greater than when accounting via the type approval test. The only resulting drawback of this option is the higher administrative burden compared to accounting via the type approval test.

Table 32: Multiple-criteria decision analysis for the extent to which the three options contribute to incentivising the implementation of speed limiting devices via legislation

			Incentive (apart from incentive resulting from 'flexibility')	**Flexibility**			**Administrative burden**		**Safety**	**CO2**	**Air pollu-tants**
				Ability to correct for tampering	Ability to correct for specific LCV use	Ability to incentivise even if not cost effective on type approval	For commission	For manufacturer			
Apply in type approval test		Speed limiter	X	X	X	X	X	X	+	++	++
		ISA	+	-	-	-	++	++	++	+	+
Account for the reduced CO2 emissions separate from the type approval test	Via the 'eco-innovations' system	Speed limiter	X	X	X	X	X	X	+	++	++
		ISA*	+/-	+	+	+	- -	- -	++	+	+
	Not purely based on theoretical emission reduction	Speed Limiter	+/-	++	++	++	-	+	++	++	++
		ISA	+/-	++	++	++	-	+	++	+	++

9 Conclusions and recommendations

This study focused on the role of speed control devices for **new** LCV's. We considered both the traditional speed limiters as the more advanced Intelligent Speed Adaptation (ISA) systems. The study explored

- the current situation (costs, fitting rates and compliance);
- the legislation outside the EU
- the possibility of competition between LCV's and HDV's
- the co-benefits of implementation of speed control devices (traffic safety and air pollutant emissions)
- the legislative options for incentivising speed control devices.

The analysis built upon a review of vehicle brochures, literature review, a survey among stakeholders and Member States, interviews, mystery shopping, data analysis and modelling.

We found that speed control devices are a cost-effective way to reduce green-house gas emissions from LCV's. Their use would also positively impact the emissions of other air pollutants and traffic safety. Hence, unless the administrative would be very high, it is worthwhile to incentivise the use of speed control devices. The relative changes are shown in the table below. There could be a problem of enforcement; as fraud would not be easily detected.

Table 33: Summary co-benefits speed control devices

	Safety effect						Emissions		
	Fatalities			Seriously injured			CO2	NOx	PM
	Urban	Rural	Motorway	Urban	Rural	Motorway			
LCV 1 (speed limiter 120 km/h)	0%	0%	-8%	0%	0%	-6%	-1%	-2%	-1%
LCV 2 (speed limiter 110 km.h)	0%	-2%	-20%	0%	-2%	-15%	-6%	-17%	-6%
LCV 3 (Half open ISA)	-30%	-11%	-11%	-21%	-8%	-9%	-2%	-4%	-2%
LCV 4 (Closed ISA)	-31%	-12%	-12%	-22%	-9%	-9%	-2%	-4%	-2%

A speed limiter set at 110 km/h has the highest effect on CO_2 emissions and air pollutants. If the choice would be between a speed limiter set at 110 km/h or one at 120 km/h, it is clear that the first is much more cost-efficient. It does however have a much lower impact on safety than the ISA systems as ISA has an impact on all road types. Given that ISA systems have a much higher impact on traffic safety, impact CO2 emissions and air pollutants positively, do not impose lower speed limits for LCVs and hence are much more acceptable, **the best option seems to incentivise the use of ISA**. This means that the only option to incentivise the use would be to account for the reduced CO_2 emissions separately from the test procedure as ISA cannot be included into the test procedure. It is also not clear if ISA would classify as an eco-innovation. However, currently consideration is being given to the post 2020 regime for regulating car and light commercial vehicle CO2 emissions. As part of this, the eco-innovation-like system could change or even be replaced with a different approach. Depending on the final regulation, such a system could incentivise the implementation of technologies more easily. This may lower the administrative burden on both the regulatory authority as well as LCV manufacturers. Hence the best option seems to be to **incentivise the use of ISA granting credits under a new system**.

In the following paragraphs we briefly summarize the findings of the study.

Two systems of speed control devices are the most prominent offered for LCV's: separate speed limiters and cruise control with speed limiters. The combination of speed limiter and cruise control is an option in the **price range** of €150-€347 excluding taxes. Separate speed limiters (i.e. without cruise control) are installed at the factory for a price in the range of €25-€139 excluding taxes. The costs for the OEM to install a separate speed limiter were given qualitatively to be low. Currently, ISA systems are not being sold for LCV's in the Netherlands, Germany, or the United Kingdom. Open ISA systems are ubiquitous in current navigation systems. Expected prices are €80 for advisory ISA and €222 for voluntary/mandatory ISA systems (if fitted in new vehicles).

There is no data on EU level available on the **fitting rates** of speed limitation devices for new LCV's. It was found that trade associations don't have information on the fitting rates. For lease companies there can be a high variation in the fitting rates. Distributors of LCV's seem to have the best data available.

To assess the **possibilities of tampering** experts from specialised companies were interviewed. These were companies that offer speed limiter adjustment or removal. The companies claimed that they can delete the speed limiter completely for virtually all new vans. The price for adjusting the speed limiter is relatively high compared to the price of a separate speed limiter. A range around 260-435 euro was indicated in the interviews. The companies had no experiences with ISA.

We also checked the **legislation in other parts of the world**, requiring OEMs to fit LCV's with speed control devices. We found that there are no countries with legislation requiring OEMs to fit speed limiters for LCV's.

With respect to the question of **competition** we did find that the market for LCV's was increasing, while the market for HDV's is decreasing. On the one hand it might be possible that the heavy regulation for HDV's has led to a shift towards more frequent use of LCV's as they are subject to fewer limitations. This might especially be true for certain submarkets – such as urban delivery. On the other hand, it is difficult to link these evolutions to the speed limiter obligation for HDV's and the increased use of LCV's is most probably more linked to the increase in e-commerce. Moreover, most of the LCV's are used for delivering services (plumbers and building).

Next, we focussed on the **potential co-benefits** of speed control devices – especially on safety and air pollutant. For this task four scenarios were analysed. In all cases the speed control device is not mandatory for LCV's. We analysed two speed limiters - with a limit set at 110 km/h and a limit set at 120 km/h; and two ISA scenarios – one half open and one closed system, both using fixed speed information. Using the impact of the speed control device on the average speed, the speed distribution and a speed-accident relationship the effect on safety was calculated. We found that the safety effect is largest for the ISA systems (as they also impact urban roads and more rural roads). This corresponds to the findings of work currently being done in the framework of the review of the General Safety Regulation (EC) No 661/2009 on the monitoring of technical developments in the field of enhanced passive safety requirements, the consideration and possible inclusion of new and enhanced safety features as well as enhanced active safety technologies. In this context Intelligent Speed Adaptation is amongst those that are identified as potential cost-effective safety measures. The effect on the emissions was calculated using the impact of the speed control device on the average speed and speed profiles using the VERSIT+ model. The speed limiter set at 110 km/h had the highest impact on emissions.

With respect to **possible legislation** there are two ways in which speed control devices could be rewarded and therefore incentivised, i.e.

1. Allow the speed control device during the drive cycle on the dynamometer during the type approval test – this option is only possible for speed limiters - or;
2. Account for the reduced CO_2 emissions separately from the test procedure via;
    a. Via the 'eco-innovations' system that is currently in place – this option is not possible for speed limiters as they are not innovative.
    b. However, future regulation is not necessary similar to the current setup and the use of speed limiters could be incentivised in multiple ways. For example, a simplified eco-innovations system could be implemented to credit emission reductions.

We found that accounting for speed limiters via the type approval test is likely to result in a considerable incentive and will additionally lower the administrative burden. However this is at the cost of flexibility. This flexibility in option of accounting separate from the type approval test and not purely based on theoretical emission reduction can greatly increase the extent to which the implementation of speed limiters is incentivised. As a result, the incentive is for this option can be greater than when accounting via the type approval test. The only resulting drawback of this option is the higher administrative burden compared to accounting via the type approval test.

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Annex 1: extract survey

Consideration of the role of speed limiters in LCV CO2 regulation

This survey fits within the framework of a study on "**Consideration of the role of speed limiters in light commercial vehicle CO2 regulation**".

The study is carried out by a consortium of consultancy and research firms: Transport & Mobility Leuven, CE Delft and TNO under a contract with the European Commission.

The overall objective of the study is to gather information on the market for speed control devices, the implications of their use and to explore the potential for using speed control devices in the EU on new light commercial vehicles to reduce their CO2 emissions.

For this work speed control devices include both

- Speed limiters, which are mandatory for N2,M2, N3 and M3 vehicles (Directive 92/6/EEC, as amended by Directive 2002/85/EC) *
- Intelligent Speed Assistance (ISA) devices **

We kindly ask you to fill in this survey by the 10th of December, 2015.

Thank you in advance for your effort,

The project team.

*Please note that figures for vehicle categories M1, N1, M3, M2, N3, N2 will be asked.

Light Commercial Vehicles (LCV) are understood to include the M1 and N1 categories

Heavy Duty Vehicles (HDV) are understood to include M2,M3 and N2 and N3.

The categories of vehicles shall be understood to be:

- Category M3: Vehicles designed and constructed for the carriage of passengers, comprising more than eight seats in addition to the driver's seat, and having a maximum mass exceeding 5 tonnes.
- Category M2: Vehicles designed and constructed for the carriage of passengers, comprising more than eight seats in addition to the driver's seat, and having a maximum mass not exceeding 5 tonnes.
- Category M1: Vehicles designed and constructed for the carriage of passengers and comprising no more than eight seats in addition to the driver's seat.
- Category N3: Vehicles designed and constructed for the carriage of goods and having a maximum mass exceeding 12 tonnes.
- Category N2: Vehicles designed and constructed for the carriage of goods and having a maximum mass exceeding 3.5 tonnes but not exceeding 12 tonnes.
- Category N1: Vehicles designed and constructed for the carriage of goods and having a maximum mass not exceeding 3.5 tonnes.

**Intelligent Speed Assistance (ISA) is an example of an advanced driver assistance system (ADAS). An ADAS is a system that aims at supporting the driver during the driving process through the use of safe human-machine interfaces. ISA systems focus on supporting drivers' speed choices. Different types of ISA exist and have potentially different impacts on speed choice, safety, emissions, driving comfort and road usage.

An ISA system typically exists of three components. These components can be built into the vehicle, or be provided as an after-market system.

- Component 1: speed and location monitoring system
- Component 2: set speed information comparison
- Component 3: a feedback system

The speed monitoring system (component 1) is responsible for providing information on the current location of the vehicle as well as the speed that the vehicle is running at. This information is typically provided by a GPS system (location) in combination with vehicle data input (CANBUS or similar).

This information is compared to a set speed (component 2). This set speed can be provided through the combination of GPS coordinates with map information containing mandatory speed limits, vertical road sign recognition (speed signs) or other sources of information.

The driver receives information on the set speed through visual, auditory or haptic channels (component 3). A comparison between set speed and driven speed can take place before the feedback is presented.

There are 85 questions in this survey

Identification of the respondent

Which authority/organisation do you represent? (eg. Ministry of Transport of Italy, Volkswagen, Safety Institute of ...)

Please write your answer here:

This is a:

Please choose **only one** of the following:

- Ministry
- Umbrella organisation (ie. CLEPA, ETSC, ...)
- Vehicle manufacturer (Volvo, Renault,...)
- Component supplier
- Other

Please provide your contact details

Please write your answer(s) here:

- Your name
- Your e-mail
- Your phone number

Administrative Address

Please write your answer(s) here:

- Country
- Postcode + City
- Street + Streetnumber

Available information

The survey is structured in 7 sections:

- Part 1: Overview of LCV speed control devices, prices and costs
- Part 2: Fitting rates of LCV speed control devices
- Part 3: Speed control device compliance (tampering and deactivation)
- Part 4: Legislation on LCV speed control devices outside Europe
- Part 5: Impacts of speed control devices (speed, market, safety)
- Part 6: Exploration of legislative options
- Part 7: Data requests

The time series required in this survey is very detailed and often split into specific categories (eg. Vehicle categories, categories of roads and types of accidents). In case you are not able to provide detailed data, we would very much appreciate your effort to provide summary figures (eg. Data for all roads, data regarding accidents without further classifications, etc.)

Thank you very much in advance for filling out this survey.

The survey consists of 7 sections.

Can you provide any information on the following sections:

Please choose the appropriate response for each item:

	Yes	Uncertain	No
Overview of LCV speed control devices, prices and costs			
Fitting rates of LCV speed control devices			
Speed control device compliance and enforcement			
Legislation on LCV speed control devices outside Europe			
Impacts of speed control devices (emissions, market, safety)			
Exploration of legislative options			
Data requests			

Overview of LCV speed control devices, prices and costs

In this section we focus on the speed limiter devices offered and their prices.

We will make a distinction between "traditional" speed limiters and ISA systems.

Do you offer speed limiters and/or ISA for LCV (multiple answers are allowed)

Please choose **all** that apply:

- Speed limiters
- ISA
- None

Overview of LCV speed control devices, prices and costs

You indicated that you sell speed limiters. Which types of speed limiters do you offer?

Please choose **all** that apply:

- Accelerator control
- Direct fuel control
- Electronic control
- Not applicable
- Other:

Are they offered separately or as part of a(n) (environmental) package?

Please choose **all** that apply:

- Separately
- Part of environmental package
- Other:

Can the speed limiter device be switched on/off?

Please choose **only one** of the following:

- Yes
- No

Please explain by whom

Please choose **all** that apply:

- Driver
- Vehicle owner
- Mechanic
- Other:

Could you give any information on the price range of speed limiters?

Please write your answer here:

Are the costs for the OEM of speed limiters typically x% of the price of LCV speed limiters?

Please choose **only one** of the following:

- 100-90%
- 90-80%
- 80-70%
- 70-60%
- 60-50%
- 50-40%
- Other

Do the costs of installing speed limiter devices depend on the volume sold? Please elaborate in the comment box.

Please choose **only one** of the following:

- Yes
- No

Make a comment on your choice here:

Overview of LCV speed control devices, prices and costs

Nine different types of ISA systems can be identified based on two characteristics:

- Type of feedback given:
  - Advisory/informing: speed limits are visually presented to the driver (mostly when changes in speed regimes are present). The driver is only informed on the speed limits. The driver is free to adjust his speed. This systems is currently being offered as an option in some passenger cars.
  - Voluntary (Driver select):
    - Warning (open): a warning is presented to the driver through visual or auditory means when the driven speed exceeds the posted speed limit. The driver is free to adjust his speed.
    - Intervening (half-open): the driver is present with tactile feedback through the accelerator pedal when exceeding the speed limit. The driver experiences a higher pressure required on the operation of the accelerator pedal to increase driving speed.
    - Mandatory (closed): the maximum speed of the vehicle is automatically limited to the posted (set) speed that is in force on that particular location. Remaining driver input is ignored. Additional feedback can be presented to the driver by limiting throttle input (strong haptic feedback or dead throttle).
- Speed limit type:
  - Fixed: the basis for the speed comparison is the posted speed limit. The driver is informed thereof.
  - Variable: in addition to the fixed speed limits, the basis for the speed comparison is extended to variable speed information for special situations (road works, dangerous areas, black spots, etc.). The driver is informed thereof.
  - Dynamic: In addition to fixed speed limits, the basis for the speed comparison is extended to location specific situations (road works, traffic density, etc.) and time specific situations (weather, lighting, etc.). The driver is informed thereof.

You indicated that you sell ISA systems.

For these systems, what type of feedback is given? If you offer more than one system, please explain in the "other" box.

Please choose **only one** of the following:

- Advisory/informing
- Voluntary
- Mandatory
- Other

Speed limit type

Please choose **only one** of the following:

- Fixed
- Variable
- Dynamic
- Other

Can the ISA system be switched on/off?

Please choose **only one** of the following:

- Yes
- No

Please explain by whom

Please choose **all** that apply:

- Driver
- Vehicle owner
- Mechanic
- Other:

Could you give any information on the price range of ISA systems?

Please write your answer here:

Are the costs for the OEM of ISA typically X% of the price of the ISA system?

Please choose **only one** of the following:

- 100-90%
- 90-80%
- 80-70%
- 70-60%
- 60-50%
- 50-40%
- Other

Do the costs of installing ISA systems depend on the volume sold? Please elaborate

Please write your answer here:

Overview of LCV speed control devices, prices and costs

Could you give an indication how often clients request a speed control device?

Please write your answer here:

What types of clients are requesting this?

Please choose **all** that apply:

- Lease
- Private
- Other:

Is the speed control device more popular in some markets than others (eg. distribution sector, construction sector, etc.)? Please elaborate.

Please write your answer here:

Fitting rates of LCV speed control devices

In this section we focus on the fitting rates of speed control devices.

Do you have data on how many LCV's are equipped with a speed control device at the time of production (by the OEM)?

Please choose **only one** of the following:

- ○Yes
- ○No

Please elaborate if possible on the data you have available and, if available, please upload the information (below).

Please elaborate, if possible, per:

- **Segment in the LCV market**
- **Vehicle brand**
- **Type of speed control device**

Please write your answer here:

Kindly attach any document you wish to share in your reply mail to this survey.

Fitting rates of LCV speed control devices

Do you have data on how many LCV's are retrofitted with a speed control device (by a mechanic)?

Please choose **only one** of the following:

- Yes
- No

Please elaborate if possible on the data you have available and, if available, please upload the information (below).

Please elaborate, if possible, per:

- **Segment in the LCV market**
- **Vehicle brand**
- **Type of speed controler device**

Please write your answer here:

Kindly attach any document you wish to share in your reply mail to this survey.

Speed limiter compliance and/or enforcement

In your country, is the use of speed limiters for N2/N3 (Heavy Duty Vehicles) enforced by law?

Please choose **only one** of the following:

- Yes
- No

Who is responsible for enforcement of the speed limiter devices for N2/N3 (HDV's)?

Please write your answer here:

Is there data available on the number and type of frauds detected?

Please choose **only one** of the following:

- Yes
- No

Please elaborate and if possible provide us with time series data (1999/2000 - 2015) or an analysis of such data.

If this data is available, please also indicate where these can be found.

Please write your answer here:

Please upload the information you have available.

Kindly attach any document you wish to share in your reply mail to this survey.

Are there available analyses/studies (pilot studies, surveys, impact assessment, evaluation studies, etc.) on speed limiter compliance (tampering/deactivation) at a national scale?

Please choose **only one** of the following:

- Yes
- No

Please elaborate.

Please write your answer here:

Kindly attach any document you wish to share in your reply mail to this survey.

Can you suggest other analyses/studies/reports that have evaluated speed limiter compliance (tampering/deactivation)? *

Please choose **only one** of the following:

- Yes
- No

Please elaborate.

Please write your answer here:

Kindly attach any document you wish to share in your reply mail to this survey.

Do you have any information on possibilities of <u>deactivation</u> of speed limiters with N2/N3 (HDV's)? *

Please choose **only one** of the following:

- Yes
- No

Please elaborate

Please write your answer here:

Kindly attach any document you wish to share in your reply mail to this survey.

Do you have any information on possibilities of <u>tampering</u> of speed limiters with N2/N3 (HDV's)? *

Please choose **only one** of the following:

- Yes
- No

Please elaborate.

Please write your answer here:

Kindly attach any document you wish to share in your reply mail to this survey.

Speed limiter compliance and/or enforcement

Do you have any information on possibilities of deactivation of speed limiters with N1 (passenger car)/M1 (Light Commercial Vehicles)?

Only answer this question if the following conditions are met:

Please choose **only one** of the following:

- Yes
- No

Please elaborate

Please write your answer here:

Kindly attach any document you wish to share in your reply mail to this survey.

Do you have any information on possibilities of deactivation of ISA with N1 (passenger car) / M1 (Light Commercial Vehicles)?

Please choose **only one** of the following:

- Yes
- No

Please elaborate

Please write your answer here:

Kindly attach any document you wish to share in your reply mail to this survey.

Legislation of LCV speed control devices outside Europe

Are you familiar with legislation in countries outside of the EU (e.g. US, Canada, Japan, China) regarding speed control devices for LCV's? *

Only answer this question if the following conditions are met:

Please choose **only one** of the following:

- Yes
- No

Could you please indicate which countries?

Please write your answer here:

Could you refer us to contact persons that have more information on these topics?

Please write your answer here:

Impacts of speed control devices (emissions, market, safety)

Are there available analyses/studies (pilot studies, surveys, impact assessments, evaluation studies, etc.) on the impact of speed control devices on:

- **shifts between heavy goods vehicles and light commercial vehicles**
- **transport demand**
- **changes in vehicle stock**

Please choose **only one** of the following:

- Yes
- No

What are the key results and conclusions from these studies?

Please write your answer here:

If you have other document types you want to share, please mail them directly to speedlimiters@tmleuven.be.

In your opinion, which market is most sensitive for competition between LCV's and HDV's? *

Please write your answer here:

Do you have any information on the impact of different speed control devices on accident rates - especially for LCV's? *

Please choose **only one** of the following:

- Yes
- No

Please elaborate

Please write your answer here:

If you have other document types you want to share, please mail them directly to speedlimiters@tmleuven.be.

Do you have information on accident causes with LCV's on motorways/rural roads?

Please choose **only one** of the following:

- Yes
- No

Please elaborate

Please write your answer here:

Kindly attach any document you wish to share in your reply mail to this survey.

Are there available analyses/studies (pilot studies, surveys, impact assessments, evaluation studies, etc.) on the impacts of speed control devices on vehicle speed and speed profiles for different vehicle types?

Please choose **only one** of the following:

- Yes
- No

What are the key results and conclusions from these studies?

Please write your answer here:

If you have other document types you want to share, please mail them directly to speedlimiters@tmleuven.be.

Kindly attach the aforementioned documents along with the survey

Exploration of legislative options

Do you see any policy options to incentivise the use of speed control devices?

Please write your answer here:

How could the use of speed control devices be incorporated in the type approval procedure?

Please write your answer here:

In what way would the incorporation of speed control devices in the type approval procedure affect the choice for implementation?

Please write your answer here:

Data requests

The time series required in this survey is very detailed and often split into specific categories (e.g. vehicle categories, categories of roads and types of accidents, long time series). In case you are not able to provide detailed data, we would very much appreciate your effort to provide summary figures (e.g. data for all roads, data regarding accidents without further classifications, data for a shorter time period, etc.

Do you have data on vkm and/or tonkm driven by LCV's over the period 2004 to today? *

Please choose **only one** of the following:

- Yes
- No

Please elaborate.

Please write your answer here:

Kindly attach any document you wish to share in your reply mail to this survey.

Do you have data on vkm and/or tonkm driven by HDV's over the period 2004 to today? *

Please choose **only one** of the following:

- Yes
- No

Please elaborate.

Please write your answer here:

Kindly attach any document you wish to share in your reply mail to this survey.

Do you have any information on the average speed and speed distribution, preferably making a distinction between:

- **rural road/motorway**
- **vehicle type**

(but any data, even aggregated, would be useful).

Please choose **only one** of the following:

- Yes
- No

Please elaborate.

Please write your answer here:

Kindly attach any document you wish to share in your reply mail to this survey.

Is there more detailed data available on accidents recorded than the data reported in the CARE database? When available, please provide us with time series of this data (1999/2000 - 2014) or an analysis of such data. In particular the following data differentiation would be important:

- **Number and severity of accidents per vehicle category (N3, N2, N1) and type of road (motorways and interurban roads)**
- **Number and severity of accidents provoked by the excessive heavy vehicle speed differentiated per type of road (motorways and interurban roads).**

Please choose **only one** of the following:

- Yes
- No

Please elaborate.

Please write your answer here:

Kindly attach any document you wish to share in your reply mail to this survey.

Final page

This is the final page of the survey.

By pressing "submit" you will finalise the survey and make a final (and irreversible) submission of data and information.

If you wish to correct data, you can still press the "prevous" button.

Thank you for completing this survey. It is possible that we will contact you again for a short follow-up.

12-31-2015 – 00:00

Submit your survey.
Thank you for completing this survey.

Annex 2: Speed limits, classification and average speeds

	Maximum speed (km/h)			Classification country (high/low)			Average speed (km/h) - reference		
	urban roads	non-urban	Motorways/expre	urban roads	non-urban	Motorways/expre	urban roads	non-urban	Motorways/expre
	M1, N1	M1, N1	M1, N1	M1, N1	M1, N1	M1, N1	M1, N1	M1, N1	M1, N1
BE	50	90	120		H	L	50	80	110
BG	50	90	140/120		H	H	50	80	110
CZ	50	90	130		H	H	50	80	115
DK	50	80	130		L	H	50	70	115
DE	50	100	130		H	H	50	90	115
EE	50	90	90		H	L	50	80	80
IE	50	80/100	120		H	L	50	70	110
GR	50	90	110/130		H	H	50	80	105
ES	50	70	90		L	L	50	60	90
FR	50	90	110/130		H	H	50	80	105
IT	50	90	130		H	H	50	80	115
CY	50	80	100		L	L	50	70	100
LV	50	90	100		H	L	50	80	100
LT	50	70/90	100/130		H	H	50	60	100
LU	50	90	130		H	H	50	80	115
HR	50	90	130		H	H	50	80	115
HU	50	90	110/130		H	H	50	80	105
MT	40	60	60		L	L	40	55	55
NL	50	80	100/120/130		L	H	50	70	110
AT	50	100	130		H	H	50	90	115
PL	50	90	120/140		H	H	50	80	110
PT	50	90	100/120		H	L	50	80	100
RO	50	90/100	130		H	H	50	80	115
SI	50	90	110/130		H	H	50	80	105
SK	50	90	130		H	H	50	80	115
FI	50	80	80/100*		L	L	50	70	80
SE	50	70	110		L	L	50	60	100
UK	48	96	112		H	L	48	86	105
Average low	50	80	110				17.5	80	107
Average high	50	90	130				17.5	90	115

Annex 3: Accident data LCV's

	number of fatal accidents (average 2011-2014)			number of fatalities (average 2011-2014)			number of seriously injured (average 2011-2014)		
	urban roads	**non-urban**	**Motorwa ys/expre**	**urban roads**	**non-urban**	**Motorwa ys/expre**	**urban roads**	**non-urban**	**Motorwa ys/expre**
	LCV	**LCV**	**LCV**	**LCV**	**LCV**	**LCV**	**LCV**	**LCV**	**LCV**
BE	17	45	15	4	17	9	22	98	558
BG									
CZ	17	32	3	2	10	1	12	30	4
DK	4	20	4	0	9	2	7	38	9
DE	79	141	58	10	43	26	219	547	279
EE									
IE	3	22		1	13	0	3	22	
GR	40	57	6	10	35	2	12	29	3
ES	47	128	48	5	59	24	42	239	109
FR	78	246	31	16	107	16	157	519	139
IT	134	203	59	27	56	29			
CY	2	2	2	1	1	1	14	9	3
LV	4	8		1	4		3	3	12
LT									
LU	1	2	1	0	0	0	2	4	1
HR	16	7	2	6	2	0	22	20	4
HU	30	58	6	4	17	2	36	111	16
MT									
NL	21	27	8	1	10	3	7	27	13
AT	26	26	7	1	7	4	23	65	20
PL									
PT	75	53	11	23	29	7	81	92	14
RO	194	123	6	32	32	3	137	146	4
SI	5	9	4	1	1	2	4	4	5
SK									
FI	5	16	2	1	9	0			
SE	6	17	3	1	8	1	20	58	72
UK	48	108	12	4	27	5	99	221	32

Source: own calculations based on CARE data

Annex 4: Speed profiles[28]

Introduction

In this study, a key question is how the speed was and will be affected by the introduction of a speed control device – either a speed limiter or an ISA system. The effect on speed determines the impact on road safety and emissions. In this section, the relevant aspects on speed are introduced and it is explained how these can be modelled.

Both the speed distribution and speed profiles with and without a speed control device are relevant. Important characteristics of the speed distribution are the absolute speed and speed dispersion. By the absolute speed we mean either the speed of an individual vehicle, or the average speed of the traffic flow. The speed dispersion is a measure for the differences in speeds between individual vehicles that are part of the traffic flow or is the variation in speeds for all vehicles over a road segment. The speed profile is the speed as a function of time of a specific vehicle.

For the assessment, data is required on the speed distribution and speed profile per combination of road type, vehicle type and speed limit. Speed distributions and speed profiles with and without a speed limiter are determined. In (Transport & Mobility Leuven, 2013) this was done by analysing information on actual speed distributions for various EU Member States. It should be noted that data on speed distributions is scarce and this has not changed. Hence we will work, as in 2013 with theoretically distributions. We do however, take into account the different speed limits set at different roads in different countries.

In the following sections we first introduce some definitions of the different concepts used. Next , more information is the data on average speeds, speed distributions and speed profiles with and without a speed control devices are presented.

Definition and use of speed distribution

For the analysis of impacts, both the average speeds and distribution of speeds are important.

The **speed distribution** is the arrangement of speeds driven according to their frequency of occurrence on the road. It can be modelled by assuming that, in the case without a speed control device, the desired driving speed is normally distributed. Many studies[29] use this approach for modelling the speed of vehicles. For each vehicle type, the speed distribution is different depending on the road type and speed limit. An example of the speed distribution for one vehicle category is given in the figure below.

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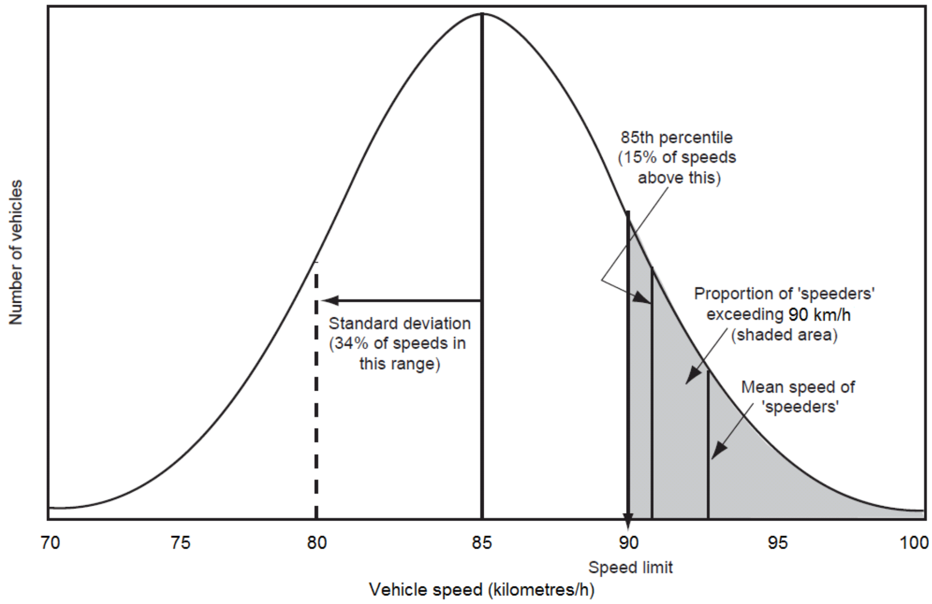
[28] Given that the same approach has been used as in (Transport & Mobility Leuven, 2013), most of the text in this annex is based on this report. Note however that in 2013 we estimated the effect of ISA based on literature. In this study we also use speed profiles to estimate the result of ISA on safety and emissions.

[29] e.g. Roszbach, R. & Blokpoel, A. (1991) Veiligheidseffecten van de invoering van 100- en 120 km/uur snelheidslimieten op autosnelwegen: vervolg van de evaluatiestudie. R-91-95 SWOV , Taylor ea (2000), The effects of drivers' speed on the frequency of road accidents, TRL Report No 421, , Hohnscheid (2006) Impact assessment of the measures concerning the improvement of road safety of light goods vehicles (LGV), Final report of Subproject 2. IMPROVER project

Figure 8: A typical speed distribution for one vehicle category showing commonly used parameters, adopted from Taylor et al. (2000)



The speed distribution has two main speed characteristics, the absolute speed and the speed dispersion. The **absolute speed** is either the speed of an individual vehicle, or the **average speed** (or mean) of the traffic flow. In the example the latter is 85 km/h. The **speed dispersion** (or speed variance) relates to the differences in speeds between individual vehicles that are part of the traffic flow. The measure used for the speed dispersion is the **speed deviation** (or the standard deviation of speed). This is a statistical measure (standard deviation) of the spread in values, applied to speeds. In the example this is 5 km/h. Other measures concerning the speed dispersion are the 85th percentile (15% of the speeds are above this speed), the proportion of speeders and the mean speed of speeders. For this study the average speed and speed deviation are important.

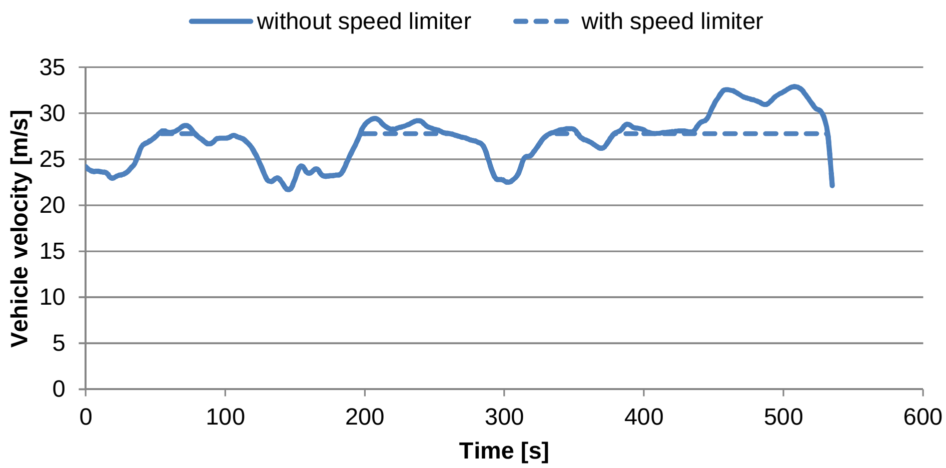
Definition and use of speed profiles

The **speed profile** shows the variation in speed for an individual vehicle over time. In reality, every vehicle will have a different speed profile. This depends on many factors such as the driving behaviour, weather, traffic lights, congestion, etc. The speed profiles are important for assessment of the emission impacts of speed and therefore one or more speed profiles have to be assumed to be representative for the real-world driving speeds. Annex 6 shows the drive cycles used in this report.

The figure below shows an example of a speed profile. On the horizontal axis the time is shown. The graph displays the speed of the vehicle in meters per second (m/s). A speed profile can be characterized by an average speed and a deviation.

It should be noted that for a given combination of vehicle type and road type, the deviation of the speed distribution and the deviation of the speed profile can be different. The first one is a measure of the differences in speeds between various users, while the second is a measure for the variation in speed over time for a single average user. On motorways (without congestion), the deviation in the speed profile will generally be low, while the deviation in speed distributions can be quite large because of the difference between slow vehicles (HGVs) and faster vehicles (cars). On the other hand, on urban and rural roads, the deviation in speed profiles is generally relatively large because of the much more frequent braking and accelerating. At the same time, on these roads the deviation in the speed distribution can be smaller than on motorways, because of the smaller speed differences between the various road users.

Figure 9: Example of a speed profile of a passenger car with and without a speed limiter on a motorway without congestion



Speed distributions with and without a speed control device

The application of a speed control device has an effect on the speed distribution. A speed limiter or a closed ISA system will force drivers exceeding the speed limit to decrease their speed. With a half-open ISA system, the driver will be able to override the system and drive faster than the speed limit. However, given the tactile feedback, he will be less likely to do so.

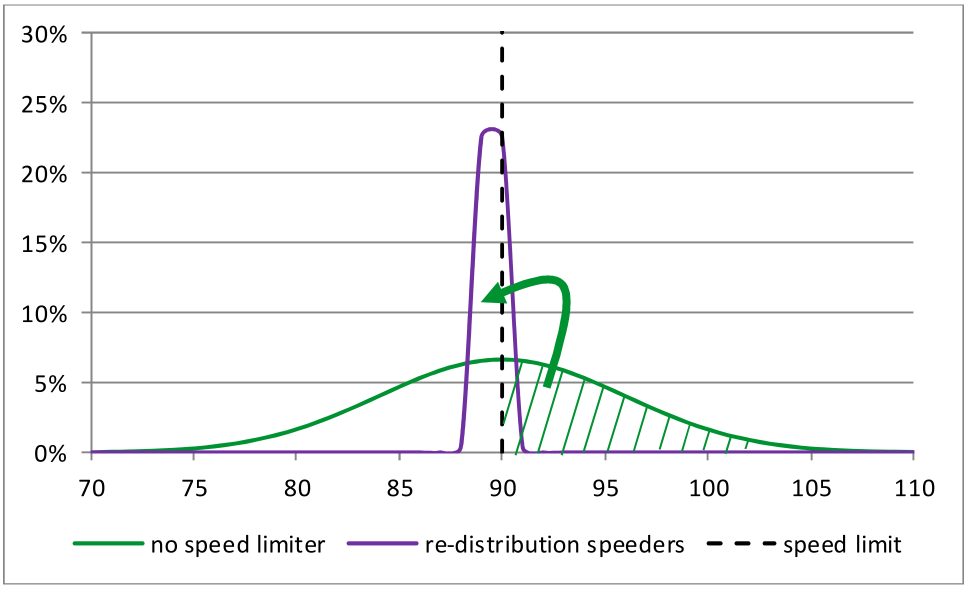
We start from the situations without the speed control device. Given the data limitations explained above we start from a theoretical speed distribution. The speed distribution is assumed to be normally distributed around the average speed with the speed deviation. The average speed that is driven on the road is different for different road types and for different posted speed limits. The average speeds and speed deviations of the speed distributions used for the situations **without a speed limiter** are shown in the table below. Using the information sources collected in (Transport & Mobility Leuven, 2013) the average speeds and standard deviation were calculated for different vehicles and different speed limits (Annex 16). This information then forms the base for the figures shown in the table below.

Table 0-1: Average speeds and speed deviations without a speed limiter

	Average speed LCV without limiter (km/h)		
Posted speed limit (km/h)	Motorway	Rural road	Urban
50			50
60			55
70		60	60
80	90	70	70
85			75
90	95	80	80
96		86	86
100	100	90	90
110	105		105
112	106	102	106
120	110		110
130	115		115
140	120		120
Speed deviation (in km/h)	16	14	10

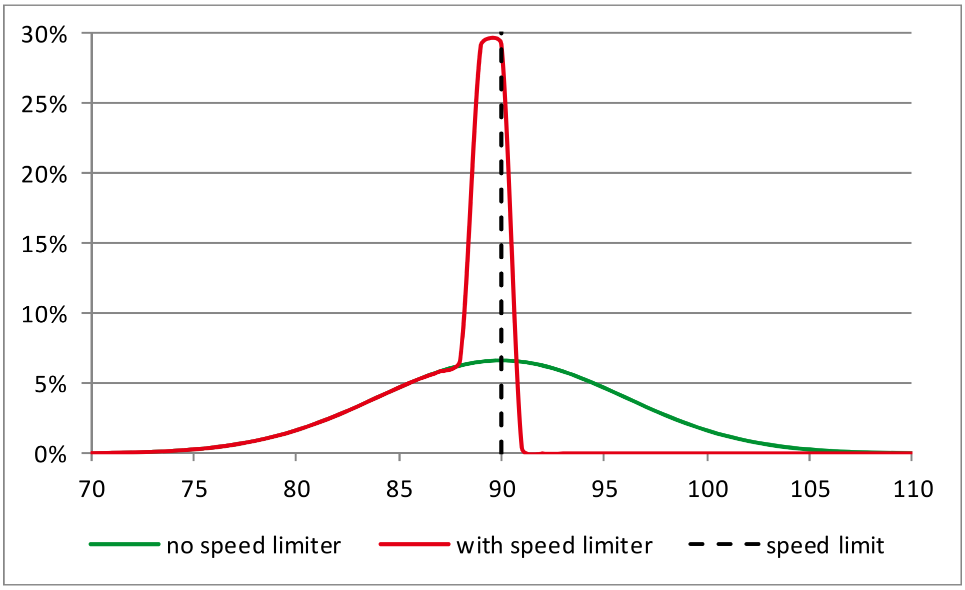
It is assumed that without a speed control device the speed distribution follows a normal distribution around the mean. If a speed limiter or a closed ISA is introduced, it is assumed that drivers that are speeding reduce their speeds to the level of the speed limiter, so that speeds above the speed limit become very rare. To illustrate the approach, an example is given. A fictional speed distribution for LCV's on a rural road with a speed limit of 90 km/h is shown in the figure below. The green line shows the distribution if there is no speed limiter. We use the distributions to capture the effect of the speed limiters on driver behaviour. The installation of speed limiters changes the shape of the distribution, since in each case all vehicles with speed limiters that that would otherwise have a desired speed that is higher than the limiter set speed, will be constrained to the limiter speed. The figure shows the percentage of vehicles driving at the different speeds and the speed limit, for an example.

Figure A - 1: Re-distribution of the speed distribution due to the speed limiter



Below you can find the new speed distribution due to the speed limiter.

Figure A - 2: Changed speed distribution due to the speed limiter



The assumptions on the speed distributions differ per road type, vehicle type, scenario and posted speed limit.

For the speed limiters set at 110 km/h and 120 km/h we fix the maximal speed for all road types to the same number. In the case of a closed ISA, we in fact redo the exercise above for each road type as such a system in fact imposes a different speed limiter for each type of road. For the half-open system we increase the variance, such that more drivers drive above the speed limit (but still less than without ISA)[30].

[30] See for example (Servin, 200X) and (Carsten & ea, 2008) for more information on speed profiles under ISA.

Annex 5: Country results- safety

As speed limits and the safety level are different between the different countries, all calculations were made at country level. The tables below show the expected relative changes in fatalities and seriously injured.

Table 2: Effect on fatalities – per country

	Change in fatalities- scenario 1			Change in fatalities- scenario 2			Change in fatalities- scenario 3			Change in fatalities- scenario 4		
	urban roads	**non-urban**	**Motorways/expre**	**urban roads**	**non-urban**	**Motorways/expre**	**urban roads**	**non-urban**	**Motorways/expre**	**urban roads**	**non-urban**	**Motorways/expre**
	M1, N1	**M1, N1**	**M1, N1**	**M1, N1**	**M1, N1**	**M1, N1**	**M1, N1**	**M1, N1**	**M1, N1**	**M1, N1**	**M1, N1**	**M1, N1**
BE	0%	-3%	-22%	0%	0%	-8%	-30%	-10%	-8%	-31%	-12%	-8%
BG												
CZ	0%	-3%	-31%	0%	0%	-14%	-30%	-10%	-4%	-31%	-12%	-4%
DK		0%	-31%		0%	-14%		-12%	-4%		-13%	-4%
DE	0%	-3%	-31%	0%	-1%	-14%	-30%	-9%	-4%	-31%	-10%	-4%
EE												
IE	0%	0%		0%	0%		-30%	-12%		-31%	-13%	
GR	0%	-3%	-15%	0%	0%	-5%	-30%	-10%	-14%	-31%	-12%	-15%
ES	0%	0%	-3%	0%	0%	-1%	-30%	-14%	-9%	-31%	-15%	-10%
FR	0%	-3%	-15%	0%	0%	-5%	-30%	-10%	-14%	-31%	-12%	-15%
IT	0%	-3%	-31%	0%	0%	-14%	-30%	-10%	-4%	-31%	-12%	-4%
CY	0%	0%	-11%	0%	0%	-3%	-30%	-12%	-23%	-31%	-13%	-24%
LV	0%	-3%		0%	0%		-30%	-10%		-31%	-12%	
LT												
LU												
HR	0%	-3%		0%	0%		-30%	-10%		-31%	-12%	
HU	0%	-3%	-15%	0%	0%	-5%	-30%	-10%	-14%	-31%	-12%	-15%
MT												
NL	0%	0%	-22%	0%	0%	-8%	-30%	-12%	-8%	-31%	-13%	-8%
AT	0%	-3%	-31%	0%	-1%	-14%	-30%	-9%	-4%	-31%	-10%	-4%
PL												
PT	0%	-3%	-11%	0%	0%	-3%	-30%	-10%	-23%	-31%	-12%	-24%
RO	0%	-3%	-31%	0%	0%	-14%	-30%	-10%	-4%	-31%	-12%	-4%
SI	0%	-3%	-15%	0%	0%	-5%	-30%	-10%	-14%	-31%	-12%	-15%
SK												
FI	0%	0%		0%	0%		-30%	-12%		-31%	-13%	
SE	0%	0%	-11%	0%	0%	-3%	-30%	-14%	-23%	-31%	-15%	-24%
UK	0%	-2%	-15%	0%	0%	-5%	-31%	-10%	-14%	-32%	-11%	-15%

Table 3: Change in seriously injured – country results

	Change in seriously injured road users- scenario 1			Change in seriously injured road users- scenario 2			Change in seriously injured road users- scenario 3			Change in seriously injured road users- scenario 4		
	urban roads	**non-urban**	**Motorways /expresswa**	**urban roads**	**non-urban**	**Motorwa ys/expre**	**urban roads**	**non-urban**	**Motorwa ys/expre**	**urban roads**	**non-urban**	**Motorwa ys/expre**
	M1, N1	**M1, N1**	**M1, N1**	**M1, N1**	**M1, N1**	**M1, N1**	**M1, N1**	**M1, N1**	**M1, N1**	**M1, N1**	**M1, N1**	**M1, N1**
BE	0%	-3%	-15%	0%	0%	-6%	-21%	-8%	-5%	-22%	-9%	-6%
BG												
CZ	0%	-3%	-21%	0%	0%	-9%	-21%	-8%	-3%	-22%	-9%	-3%
DK	0%	0%	-21%	0%	0%	-9%	-21%	-9%	-3%	-22%	-10%	-3%
DE	0%	-2%	-21%	0%	0%	-9%	-21%	-7%	-3%	-22%	-8%	-3%
EE												
IE	0%	0%		0%	0%		-21%	-9%		-22%	-10%	
GR	0%	-3%	-10%	0%	0%	-3%	-21%	-8%	-9%	-22%	-9%	-10%
ES	0%	0%	-2%	0%	0%	0%	-21%	-11%	-6%	-22%	-12%	-7%
FR	0%	-3%	-11%	0%	0%	-4%	-21%	-8%	-11%	-22%	-9%	-11%
IT												
CY	0%	0%	-9%	0%	0%	-2%	-21%	-9%	-18%	-22%	-10%	-19%
LV	0%	-3%	-9%	0%	0%	-2%	-21%	-8%	-18%	-22%	-9%	-19%
LT												
LU	0%	-3%	-24%	0%	0%	-11%	-21%	-8%	-3%	-22%	-9%	-3%
HR	0%	-3%	-24%	0%	0%	-11%	-21%	-8%	-3%	-22%	-9%	-3%
HU	0%	-3%	-11%	0%	0%	-4%	-21%	-8%	-11%	-22%	-9%	-11%
MT												
NL	0%	0%	-17%	0%	0%	-7%	-21%	-9%	-6%	-22%	-10%	-7%
AT	0%	-2%	-24%	0%	0%	-11%	-21%	-7%	-3%	-22%	-8%	-3%
PL												
PT	0%	-3%	-9%	0%	0%	-2%	-21%	-8%	-18%	-22%	-9%	-19%
RO	0%	-3%	-24%	0%	0%	-11%	-21%	-8%	-3%	-22%	-9%	-3%
SI	0%	-3%	-11%	0%	0%	-4%	-21%	-8%	-11%	-22%	-9%	-11%
SK												
FI												
SE	0%	0%	-9%	0%	0%	-2%	-21%	-11%	-18%	-22%	-12%	-19%
UK	0%	-1%	-11%	0%	0%	-4%	-22%	-8%	-11%	-23%	-8%	-11%

Annex 6: drive cycles

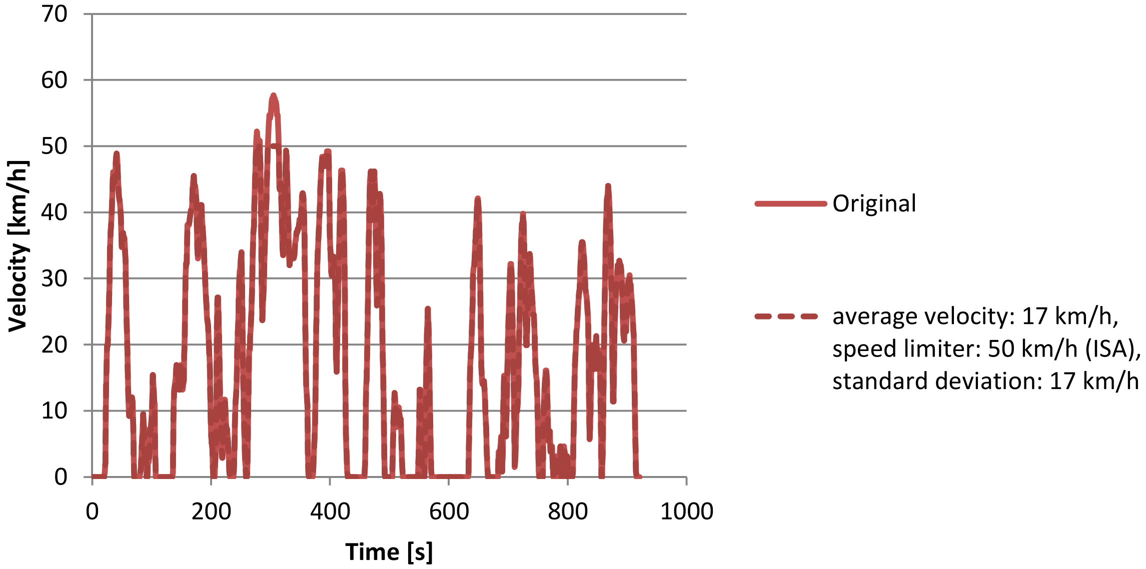


Figure 10: Artemis Urban Cycle without and with ISA system (limiting at 50 km/h)

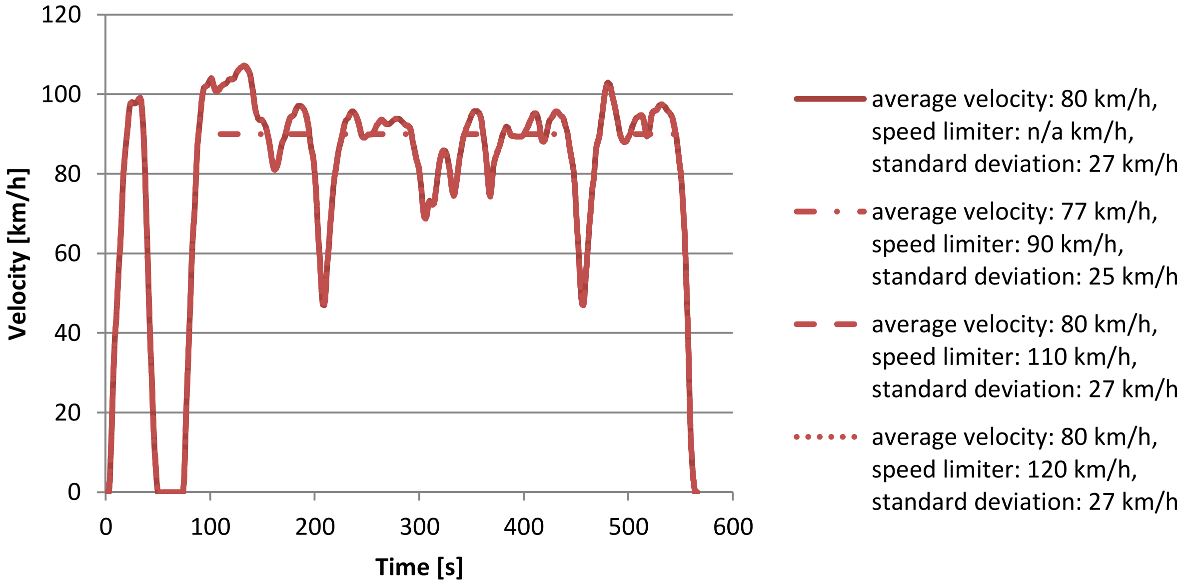


Figure 11: Rural cycle scales to average velocity of 80 km/h without and with speed limiter (at 110 and 120 km/h) and ISA system (limiting at 90 km/h)

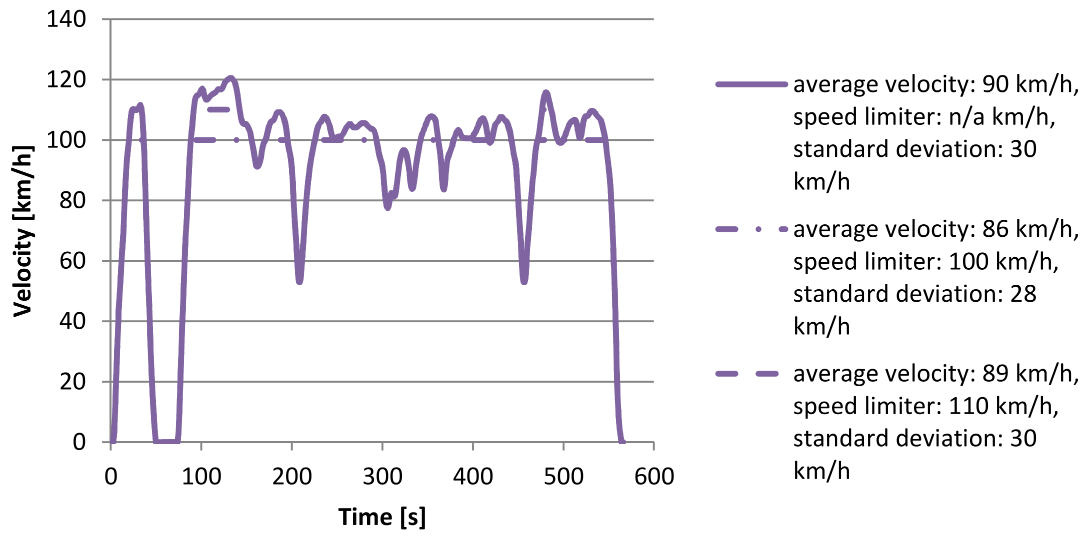


Figure 12: Rural cycle scales to average velocity of 90 km/h without and with speed limiter (at 110 and 120 km/h) and ISA system (limiting at 100 km/h)

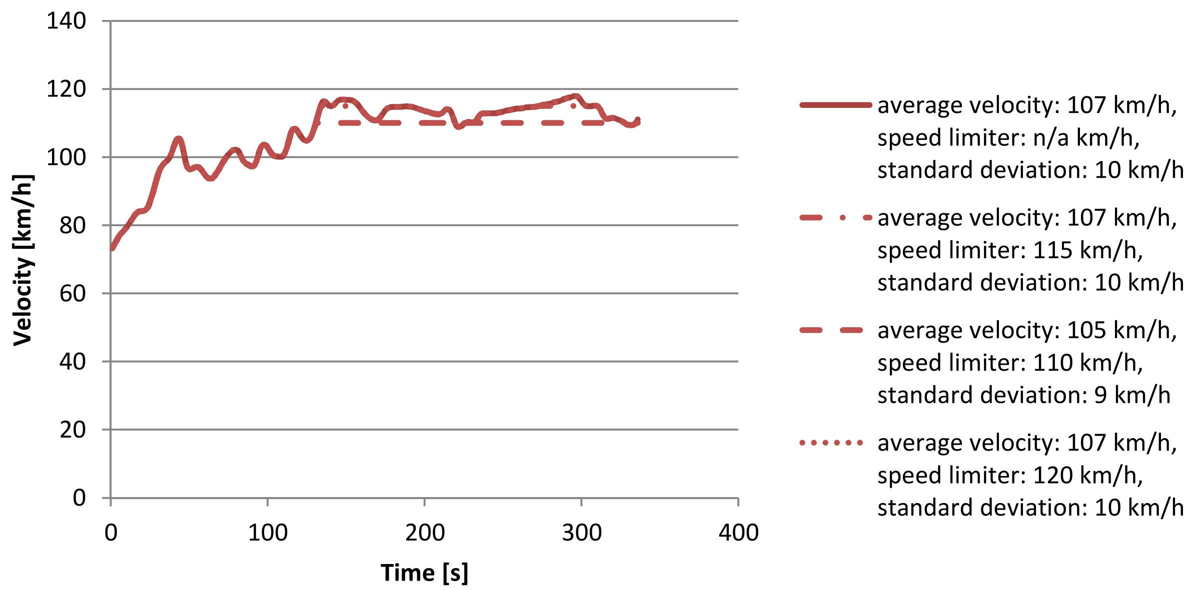


Figure 13: Motorway cycle scales to average velocity of 107 km/h without and with speed limiter (at 110 and 120 km/h) and ISA system (limiting at 115 km/h)

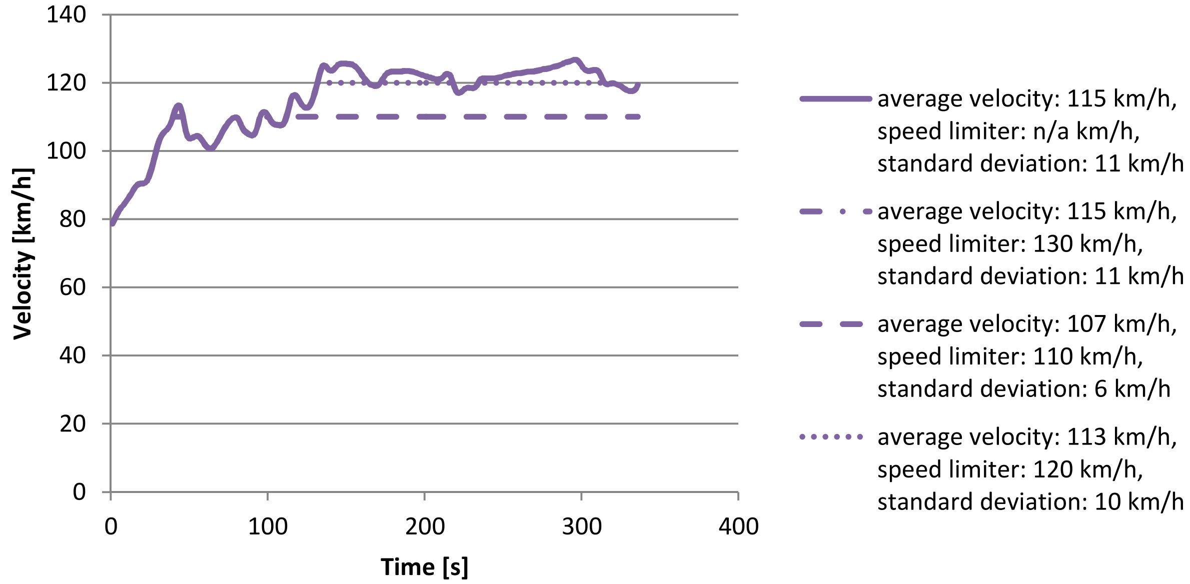


Figure 14: Rural cycle scales to average velocity of 115 km/h without and with speed limiter (at 110 and 120 km/h) and ISA system (limiting at 130 km/h)

Annex 5: The VERSIT+ model

Introduction to the VERSIT+ model

The VERSIT+ model of TNO is used to calculate the emissions for specific speed profiles. The VERSIT+ modal has been developed to estimate the CO_2 and pollutant emissions of specific driving patters and has been built upon a large amount of data from real world driving patterns.

Road traffic emission models serve a variety of purposes. They may be used in for instance emission inventory studies, to determine the total, annual and national emissions of all vehicles, and relate these numbers to the average emission of a fleet-average vehicle in a generic category, like a passenger car or a heavy-duty HGV. Another purpose is to test the compliance with emission regulations. Beyond this compliance lies a further goal to make the regulations fitting for the problems they are meant to solve.

A completely different purpose of emission models is to assist the development of new technology, by precise knowledge of the circumstances of the vehicle and the engine at which the unwanted emissions may occur. These emission models are meant to supply a direct, experimental link between vehicle operation and emissions.

Another application is the direct link between emissions and local air quality. In many urban areas where the air pollution exceeds the limit, there is a substantial traffic-related contribution. Therefore, the wish to monitor and to take effective measures has grown. The emission models are one part of the missing link between road traffic and the deterioration of air quality. The other part is the dispersion model; how the exhaust gases spread in the air.

The VERSIT+ emission model has been the Dutch road traffic emission model for many years for mainly the first goals: the average emissions in a variety of circumstances, for present and future fleet decomposition. The effects of planned government policies lead to changes in fleet composition, fleet usage and age, with corresponding effect in the gross emissions. These emission factors form part of the basis of the environment reports submitted by the local governments. A simple dispersion model links the daily traffic intensities with air-quality, which is for instance done in the Dutch CAR model.

The results produced by these models, are largely based on averages and they produce as many questions as answers if used to estimate the effect of traffic related measures. Many variations in the traffic situations, local road planning, or fleet composition will not be visible in these results.

Emission models

VERSIT+ is a statistical emission model able to calculate real-world HC, CO, NO_x, NO_2, PM10 and CO_2 emissions of road vehicles. It is best seen as an analysis tool of a large set of emission measurements of the Dutch fleet, mainly performed in the in-use compliance program. Over 20.000 measurements with warm and cold engines on over 3.200 different vehicles have been performed in a period over twenty years. The vehicles were randomly selected from the commonly sold models and were requested from their owners, to participate in the testing program. The average maintenance state of the vehicles should therefore correspond to the Dutch situation. Furthermore, new technology has always been included in the VERSIT+ model to be able to estimate their effects of their mass introduction.

The emission results themselves are already representative of the Dutch situation, since besides type approval tests like the NEDC and the FTP, in most cases real world driving cycles, like the CADC, OSCAR and Dutch F&E cycles, are used to characterize the driving behaviour for which the emissions are determined. Every vehicle is tested typically on five different tests, but some on many more, as in the cases of durability testing.

To develop an emission model for a given driving behaviour and vehicle type from the large set of vehicles, driving cycles and emission measurements a detailed statistical analysis is used. Two main ingredients are the distinction of relevant vehicle categories, with similar emission characteristics, and the characterization of driving behaviour in relevant parameters on which the emission actually depend.

The vehicle categories are generally straightforwardly based on fuel, emission standard, injection technology, after-treatment technology, and transmission. The disadvantage of making such a detailed distinction is insufficient data in some of the categories, while on the other hand automatic transmission and older injection technology will strongly affect certain emissions, of these cars.

The characterization of driving behaviour has evolved continuously. The average velocity was one of the first parameters to be used. Once it became clear that this was insufficient for an accurate emission prediction, a power variable, like average acceleration was added. More and more parameters, like trip fraction of idling, were added, and eventually there was a list of over fifty parameters for each trip, from which the relevant ones were selected, by checking for the dependencies. For every vehicle category and emission component this process was repeated. Therefore, generating the emission model VERSIT+ had become a cumbersome process.

Trip parameters versus instantaneous parameters

The trip parameters are only valid for a trip, which consist of at least several hundred meters of driving, from stop to stop. This is also closely tied to the measurement data, which yields a total emission in grams per test, for a particular driving cycle or trip. The actual time-dependence of the emissions, as the result of driving at that moment, or a few seconds before, has become available only in the last ten years with modal mass, or time-dependent, measurements. The quality of such data in the laboratory has increased in the last years. Hence it is possible to construct a second-by-second model from the data.

Velocity and acceleration dependence

A great part of VERSIT+ is to translate the bag results into velocity acceleration dependent results. The aggregated data per trip makes a full conversion impossible, and from velocities and accelerations combinations have be sought, to construct a robust emission model. Since for each vehicle category between fifteen and twenty five different drive cycles were used in the testing, the emission model can never have more than these fifteen to twenty five degrees of freedom.

Therefore, it is important to choose the degrees of freedom in the emission model appropriately. In a sense, instead of relying on a long list of variables, or models, to find the most appropriate ones, the basic model is selected in advance. Two criteria were used to select the model variables: First, the variables have to be independent to avoid the use of two variables which describe the same effect. Second, the variables have to be relevant to evenly divide the variables such that their share in the total emission is of the same magnitude.

Handling large variations in measurements

Especially for CO and HC emissions only a small fraction of the vehicles, in a small fraction of the traffic situations, produce the majority of the emissions. Only for CO_2, and in lesser extent for PM10 in certain older diesel vehicle technologies, the variation is smaller than the average itself. In all other relevant emission components, the variation inside the same vehicle class is significant. Therefore, emission modelling for a fleet and a wide range of traffic situations requires statistical analysis. Only a few measurements on a few vehicles are insufficient produce a representative national emission model. Several dozens of vehicles are required to produce enough statistics to bring the model uncertainty down to an acceptable value, less than 10 % of the mean emissions.

Also, little less than half the emissions tests are type-approval tests such as the MVEG-A, MVEG-B, and FTP tests, which are less representative for real world driving. To ensure that these tests do not dominate the analysis, a weighted average of the type-approval tests and the real-world driving tests has been used during the model development. The weighting of type-approval test results is one fifth of the real-world test results.

History effects and modal mass data

The most important history effect is cold start. Most of the CO and HC emissions are produced just after the start. Also the CO_2 emission is typically higher during the cold start. The retention of the cold start effects depend on the components, but in VERSIT+ the time-dependence is not taken into account, mainly because it is hard to determine the precise trip in average Dutch driving. It is simpler to assume that in the majority of the cases the engine is warm at the end of the trip, meaning that the full contribution of the cold start emissions were produced during the trip. Depending on the components this may be after less than hundred meters for HC and CO to four to five kilometres for CO_2 emissions and emissions related to the higher fuel consumption.

Modal mass, or second-by-second, data can be treated in the similar manner in the VERSIT+ model as bag data. The prediction of the model depends on the ten parameters q0...q9, which are known for every second. In principle the measurement of every data point counts as a separate test. Some care must be taken, in this case unlike the bag data, to compensate for history effects. The emission may have a delay by some time with respect to the velocity and acceleration.

At TNO modal mass data has be measured intermittently from 1998, during the tests. Some of the older data exhibit misalignment: the CO_2 signal does not coincide with the power demand as determined from velocity and acceleration, but is advanced or delayed with respect with the power demand. Likewise, all other signals are misaligned. Possibly, the delay may vary with exhaust gas velocity. Modal mass data must be analysed both for history and misalignment effects.

Limitations of the VERSIT+ model

As all models VERSIT+ has some limitations, either due to the model data (as derived from measurements) or to the way the model is set up.

- The emission measurements for VERSIT+ are done on a sample of vehicles taken from the Dutch real-world fleet. This sample is for some vehicle categories small and may have insufficient data.
- The VERSIT+ model is primarily designed to model general average driving behaviour, i.e. trip averages, for average vehicles belonging to certain vehicle categories. This implies that it is limited in the velocity dependent detail it can accurately model.

Not a direct limitation but rather a point not to forget in the European context is the following.

- The VERSIT+ database is based on measurements on a sample of vehicles taken from the Dutch vehicle fleet and not from the European vehicle fleet. Thus, for a certain vehicle category the VERSIT+ data will usually accurately model the average Dutch vehicle for that category. This need not be the case for the average European vehicle for that category. This can be overcome by using an adapted weighting over the measured vehicles within each category, which compensates for differences between the Dutch and European fleets.