Retrofitting smart tachographs by 2020: Costs and benefits

STUDY

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RETROFITTING SMART TACHOGRAPHS BY 2020: COSTS AND BENEFITS

Study

by Dr Michał Suchanek

This study has been produced at the request of the European Parliament's Committee on Transport and Tourism. It relates to on-going work on the mobility package, presented by the European Commission on 31 May 2017, and in particular to the proposal for a regulation amending Regulation (EC) No 561/2006 as regards minimum requirements on maximum daily and weekly driving times, minimum breaks and daily and weekly rest periods, and Regulation (EU) No 165/2014 as regards positioning by means of tachographs – COM(2017) 277 final - 2017/0122(COD).

Abstract

This research paper presents the main costs and benefits connected with retrofitting smart tachographs in vehicles that belong to enterprises operating on the European transport market by January 2020. The costs connected with the procedure of retrofitting are identified and analysed in regards to the transport enterprises, enforcement agencies and licensed workshops. The potential benefits resulting from the reduction of accidents as well as other benefits are identified and estimated too.

The study also assesses how costs and benefits generated by the early introduction of smart tachographs are likely to be distributed across EU Member States.

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Preface

EU transport market in heavy-duty commercial vehicles

According to the European Commission's 2011 impact assessment, by late 2010 around six million heavy-duty commercial vehicles (buses/coaches or trucks) in the EU had tachographs fitted, out of which just 1.5 million were digital. At that time, the EU tachograph regulations directly affected around 600 000 road haulage operators and 330 000 road passenger carriers.[1] Nearly all of these companies were medium-sized enterprises; among them, 80 % were micro-companies with less than 10 employees, whereas 1 % were companies with more than 50 employees.

Tachograph fraud is a persistent problem in international road transport across the EU. When preparing legislation on smart tachographs, the Commission found that, even under a conservative assumption, up to 45 000 vehicles can be in breach of EU tachograph rules at any one time.[2] Breaches include not adhering to minimum driver rest periods or maximum driving times, which can result in fatigued drivers. This constitutes both a threat to road safety and a breach of road transport and social legislation, both of which are regulated at the EU level.

To prevent heavy-duty commercial vehicle accidents, which are often caused by tiredness and speeding, tachographs were introduced in the EU as an obligatory requirement in 1985. A tachograph can measure, among other information, a vehicle's speed, distance travelled, driver's driving time and rest periods.

Originally an analogue device,[3] it has evolved over time into the so-called 'digital tachograph', undergoing several upgrades.[4] Nevertheless, there is already a newer product that will soon be installed in vehicles – the so-called 'smart tachograph'. Among other benefits, this latter product is expected to deliver real-time information on driving and rest periods through a new feature allowing a connection with satellite navigation systems and remote communication with enforcement authorities.

There is a widespread consensus, both in the Council and in the European Parliament,[5] that the development and deployment of smart tachographs is crucial for improved enforcement of EU road transport legislation. The Council of Transport Ministers meeting of 5 December 2017 underlined the issue in its conclusions on the digitalisation of transport.[6]

The European Parliament, in its resolution of 18 May 2017 on road transport in the EU, called on the Member States to set up checks, in particular in relation to compliance with driving and rest times, in order to tackle the issue of fraud concerning tachographs.[7]

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[1]European Commission, Impact assessment on measures enhancing the effectiveness and efficiency of the tachograph system – revision of Council Regulation (EEC) No 3821/85, Commission Staff Working Paper, SEC(2011) 948, 19 July 2011.
[2]European Commission, impact assessment on measures enhancing the effectiveness and efficiency of the tachograph system..., op.cit.
[3]It is still used in vehicles registered before 1 May 2006.
[4]Digital tachographs are obligatory in vehicles registered after 1 May 2006.
[5]European Parliament resolution of 14 September 2016 on social dumping in the European Union, 2015/2255(INI).
[6]Council of the European Union, Conclusions on the digitalisation of transport, 5 December 2017.
[7]European Parliament resolution of 18 May 2017 on road transport in the European Union, 2017/2545(RSP).

Recent policy developments at EU level

The EU updated its legislation in preparation for the introduction of smart tachographs by adopting Regulation (EU) No 165/2014, according to which the installation of smart tachographs will be obligatory in new heavy-duty commercial vehicles registered for the first time after 15 June 2019. The Commission also estimated that the smart tachograph could save companies up to €515 million per year in administrative costs.[8]

On 18 March 2016, the Commission adopted a more detailed piece of legislation, Implementing Regulation (EU) 2016/799, defining the technical specifications for the smart tachograph. It requires that already existing older generation tachographs in use in international transport should be replaced within 15 years of adoption of the regulation. A full implementation of smart tachograph requirements is therefore envisaged for 2034.

Due to a high level of non-compliance and the manipulation of digital tachographs already in use, there are high expectations related to deployment of smart tachographs, especially regarding their effectiveness.[9] Ex-post analysis of EU road safety and social legislation in road transport conducted by the Commission concluded that control tools and data exchange systems are currently inefficient, including when it comes to tachographs.[10]

Nevertheless, when the European Commission was preparing the smart tachograph legislation in 2011 (which resulted in adoption of Regulation No 165/2014) it did not conduct a fully-fledged cost-benefit analysis.[11]

Therefore, calculations regarding the retrofitting of smart tachographs in vehicles that are already in use are missing.

The estimates of the main budgetary impacts on public authorities are rather rough but suggest a cumulative cost of a maximum of around €46.5 million per year.[12]

The latest EU-level legislative development regarding smart tachographs is the European Commission proposal (COM(2017) 277) for a regulation on driving time and rest periods, which is a part of the mobility package presented on 31 May 2017.[13] It is supposed to remedy the current problems with tachographs. The new smart device should enable enforcement authorities undertaking roadside control checks to detect abnormalities quicker and more efficiently.[14] As a result, it should reduce incidences of tachometer fraud.

Although the Commission had still not assessed the costs of retrofitting smart tachographs when preparing the recent proposal on driving time and rest periods, it is currently doing so.

[8]European Commission, Impact Assessment on measures enhancing the effectiveness and efficiency of the tachograph system... op.cit.

[9]Already digital tachographs were perceived as a big improvement from easy to manipulate analogue ones. Nevertheless, new tampering techniques were found.

[10]European Commission, Staff working document, Final report on ex-post evaluation of the social legislation in road transport, SWD(2017) 184, May 2017; Staff working document, Executive summary of ex-post evaluation of the social legislation in road transport, SWD(2017) 185, May 2017.

[11]European Commission, Impact Assessment on measures enhancing the effectiveness and efficiency of the tachograph system..., op.cit., p.51.

[12]Ibid, pp.45-46.

[13]European Commission, Proposal for a regulation amending Regulation (EC) No 561/2006 as regards on minimum requirements on maximum daily and weekly driving times, minimum breaks and daily and weekly rest periods and Regulation (EU) 165/2014 as regards positioning by means of tachographs, COM(2017) 277, 31 May 2017.

[14]Council of the European Union, Council conclusions on the digitalisation of transport, 15050/17, 5 December 2017.

A study has been commissioned from an external contractor (Ricardo plc) and the final report is expected to be delivered within the first quarter of 2018.

Against this background, the European Parliament's Committee on Transport and Tourism (TRAN) is preparing a report on the Commission proposal for a regulation on driving time and rest periods (rapporteur: Wim van de Camp, EPP, the Netherlands). As estimates regarding economic impacts of accelerated deployment of smart tachographs in vehicles already registered (by 2020) are not available, the TRAN Committee requested a cost-benefit analysis on the matter.

Scope of the study

The scope of this study is to assess the costs and benefits of retrofitting smart tachographs in heavy-duty vehicles operating in international transport by January 2020. Specifically, it addresses economic consequences of a technological upgrade of these vehicles. Moreover, it considers the related economic impacts incurred on national enforcement authorities. It also assesses the costs, which Member States' national enforcement bodies risk to incur, among others, due to retrieving and processing data from smart tachometers. In assessing both the costs and benefits, the study focuses on the EU-level analysis.

Conclusions of the commissioned study

The commissioned study concludes that retrofitting of smart tachographs in all heavy-duty vehicles by 2020 would represent an extensive process likely to generate significant costs for the main actors of the European transport market, notably:

- the cost of purchasing the devices and the cost of labour connected with the service of retrofitting, which is estimated to be between **€6.4 and €15.9 billion**, depending on the real market price of the tachograph;
- the costs of auditing the workshops which are licensed to perform the service of retrofitting, which is estimated to be around **€73 million** per year;
- the cost of training the personnel of the enforcement agencies to collect and analyse data, which is estimated to be around **€11 million**.

However, the process will also generate benefits, notably:

- the benefits of the potential reduction of the costs of accidents estimated to be between **€430 million** and **€4.5 billion**, depending on the chosen methodology;
- the benefits for the licensed EU workshops, which will be able to generate a higher profit during the process, approximately **€182 million**.

High costs will be generated in the short term, but benefits will outweigh them in the longer term.

The study also argues that the **Member States most affected** by the process of retrofitting the smart tachographs would be those with the largest fleet of heavy-duty vehicles participating in international transport, i.e. **Poland, Germany, Italy, the United Kingdom, France and the Netherlands**.

These costs will mostly **affect micro and small transport enterprises,** which would probably be unable to negotiate and benefit from discounts on retrofitting services, unlike enterprises with larger fleets.

Therefore, the **main policy recommendation of the study is that retrofitting of smart tachographs should be pursued, but with a longer horizon than the deadline of January 2020**.

Aleksandra Heflich, European Added Value Unit.

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Executive summary

Despite the introduction of digital tachographs in all heavy-duty vehicles registered in the European Union, there remains a considerable number of road transport policy offences. In light of this, a policy has been proposed in order to retrofit new smart tachographs in heavy-duty vehicles by 2020. This process should considerably decrease the number of road transport policy offences, thus also generating a benefit of accident cost reduction, but is also bound to generate a considerable cost to transport enterprises.

1. Introduction

1.1. Scope and goal

The scope of this study is to perform an economic analysis and provide an assessment of costs and benefits of retrofitting smart tachographs by January 2020. It estimates both the costs incurred to the main agents of the European road transport market, i.e. the transport enterprises, the licensed workshops, the enforcement authorities, as well as the benefits resulting from such a process.

The scope of this study was determined by the Committee on Transport and Tourism (TRAN) of the European Parliament and it based on the assumption that smart tachographs would be introduced in the EU international transport market by 1 January 2020.

The three main research questions addressed by this study are:

1. What would be the cost incurred by main road transport related actors e.g. international transport companies and certified workshops, of upgrading the tachographs to smart tachographs in already registered heavy-duty vehicles by 2020?
2. What would be the potential EU-level benefits (added value) of retrofitting smart tachographs in already registered heavy-duty vehicles by 2020?
3. What would be the costs incurred by Member States' enforcement authorities (e.g. costs related to reading, retrieving and analysing the data from these tachographs), if smart tachographs were retrofitted in already registered heavy-duty vehicles by 2020?

1.2. Methodology

The research methodology is based on the use of reliable data regarding the European transport market, collected among others from the Eurostat database. The data was analysed and, where appropriate statistical methods such as trend analysis, time series analysis and linear regression were used to estimate the costs and benefits. Data analysis was based on an extensive literature review, including the literature on the European transport market and the tachograph system. In addition, market research was conducted in 37 licensed workshops and inquiries were also conducted with the tachograph producers and the enforcement agencies.

Whenever possible, the study presents a quantitative analysis of the possible costs and benefits. When data was not available or not reliable enough, a qualitative analysis is presented.

2. Tachographs – analogue, digital and smart

The need to measure and control the basic parameters of a driver's activity led to an obligatory EU-wide introduction of the tachograph, a device fitted into the vehicle that records data such as: the distance covered by the vehicle, current speed and the periods of driver's labour and rest. In general, the tachograph consists of three parts: a sender unit, the tachograph head, and a recording medium. The tachographs are currently fitted in newly registered vehicles carrying goods with a permissible mass of over 3.5 tonnes and vehicles (buses) carrying more than 9 passengers.

2.1. Analogue tachographs

At first the **tachographs were analogue** (introduced by the Council Regulation (EEC) No 3821/85 of 20 December 1985 on recording equipment in road transport) which means that the data was collected on a wax coated paper disc that rotated throughout the day. Each rotation of the disc showed a 24-hour period of activity. The analogue tachographs could have easily been modified with the use of cheap devices, which allowed an individual to switch off the recording devices or generate additional impulses. The drivers could disturb the work of the device and modify the displacement of the vehicle. This primarily explains why the use of information technology has been proposed to assure the safety and integrity of data to describe the activity of drivers. The new system, based on digital tachographs, was intended to provide easier and more efficient control of drivers' activity time via their employers and control organs. It was also supposed to be less prone to user manipulation (Rychter, 2011).

2.2. Digital tachographs

The introduction of **digital tachographs** (introduced by the Council Regulation (EC) No 2135/98 of 24 September 1998 amending Regulation (EEC) No 3821/85 on recording equipment in road transport and Directive 88/599/EEC concerning the application of Regulations (EEC) No 3820/84 and (EEC) No 3821/85 and later updated by Commission Regulation (EU) No 1266/2009 of 16 December 2009 adapting for the tenth time to technical progress Council Regulation (EEC) No 3821/85 on recording equipment in road transport (OJ L339, 22/12/2009, page 3)) has only slightly diminished the scale of manipulation. Common cases of interference led to a stream of constant research on the methods of manipulation for the digital tachographs. The research has shown that there are various methods that allow an individual to manipulate a digital tachograph, which generate serious dangers for road safety, whilst also creating a negative impact on market competition and driver's working conditions. These manipulations, including the use of magnets, switches or double encoders, can be identified, but this requires the introduction of a constant monitoring system (Herma, 2015). The technical progress leads to an increase in the number of possible interferences with the tachograph system. Moreover, these manipulations have serious effects on transport activity and its associated costs. The lack of the speed signal of the tachograph results in the malfunction of the systems which limit the vehicle speed and performance. This also leads to higher fatigue of drivers, longer reaction times and ultimately to the possibility of falling asleep behind the wheel.

Three generations of digital tachographs have been introduced so far (Table 1).

Table 1. Digital tachograph generations

	I generation	II generation	III generation
Software versions: DTCO 1381 and Stoneridge SE5000	DTCO 1.0-1.3X SE5000 5.0-7.2	DTCO 1.4x SE5000 Exact 7.3	DTCO 2.0-2.1 SE5000 Exact Duo 7.4-7.5
Characteristics		1 minute rule	Second independent signal (IMS), new motion sensor KITAS 2+
Required motion sensor	KITAS 2	KITAS 2	KITAS 2+
Required in vehicles registered after	1.5.2006	1.10.2011	1.10.2012

Source: Herma, 2015.

Digital tachographs differ with respect to the installed software, required motion sensors and other characteristics. The first two tachograph generations, which were obligatory for vehicles registered after the 1 May 2006 (first generation) or after the 1 October 2011 (second generation), were prone to simple interference such as the use of a magnet. They didn't have any additional safety mechanisms apart from a register of errors which occurred after the use of magnet in the memory. Since the 1 October 2012 a second independent signal (IMS) has been introduced into the system with an improved motion sensor. This is a characteristic for the digital tachographs of the third generation. The goal was to make it impossible for the third parties to interfere by verifying the speed and displacement signal from the vehicle (including the Anti-Lock Braking System (ABS) or the Acceleration slip regulation (ASR)) which is simultaneously compared with the signal from the motion sensor. Nevertheless, more advanced distortion methods have been invented, such as devices for the remote disabling of the motion sensor, using a masked switch or remote controls which correspond with an external system.

2.3. Smart tachographs

The above-mentioned deficiencies of the digital tachograph system have led to the development of a new generation of tachographs, the so-called "**smart tachographs**". Such devices are supposed to have a Global Navigation Satellite System (GNSS) module, allowing the automatic recording of the location of the vehicle along with a second motion sensor. The sensor has to be enclosed in a secure box and the signal itself shall be secured between a GNSS receiver and a vehicle unit (VU), while the satellite signal is authenticated. The smart tachographs will also include a dedicated short-range communications (DSRC) module allowing the enforcers to collect data such as (Martinez, 2017):

- latest security breach attempts,
- longest power supply interruption,
- sensor faults,

- motion data errors,
- vehicle motion conflict,
- invalid card, card insertion while driving,
- calibration data,
- vehicle registration number,
- speed.

The smart tachograph will also be fitted with a new cryptography system and an enhanced seal for increased security. The scope of improvement in this new generation of tachograph resulted in the Regulation (EU) No 165/2014[15], repealing Council Regulation (EEC) No 3821/85[16] and amending Regulation (EC) No 561/2006[17]. This implies that **new vehicles** registered **after 15 June 2019** shall be fitted with the smart tachograph.

What is important to understand within the context of this study is that the smart tachograph has **not been commercialised yet** and there is an on-going discussion about the possibility of this happening. The Commission implementing Regulation EU 2016/799 envisages **retrofitting of smart tachographs** in vehicles with older generation tachographs in use in international transport within 15 years from the adoption of the regulation. A full implementation of smart tachograph is therefore foreseen **by 2034**.

3. Road transport market in the European Union

The main features of the European road transport market are presented below in order to understand the impacts that the retrofitting of smart tachographs could have on different actors. Its specific features determine which market participants would be most and least impacted by the potential retrofitting of smart tachographs.

The EU road transport market is characterised by a constant development, which is a result of many factors such as (Mindur, 2010):

- trade liberalisation,
- narrow specialisation, leading to a search for distant markets,
- decrease of production costs due to technological developments,
- corporate strategies concentrated on diversified supply sources,
- increased mobility of citizens,
- globalisation processes,
- changes in customer preferences.

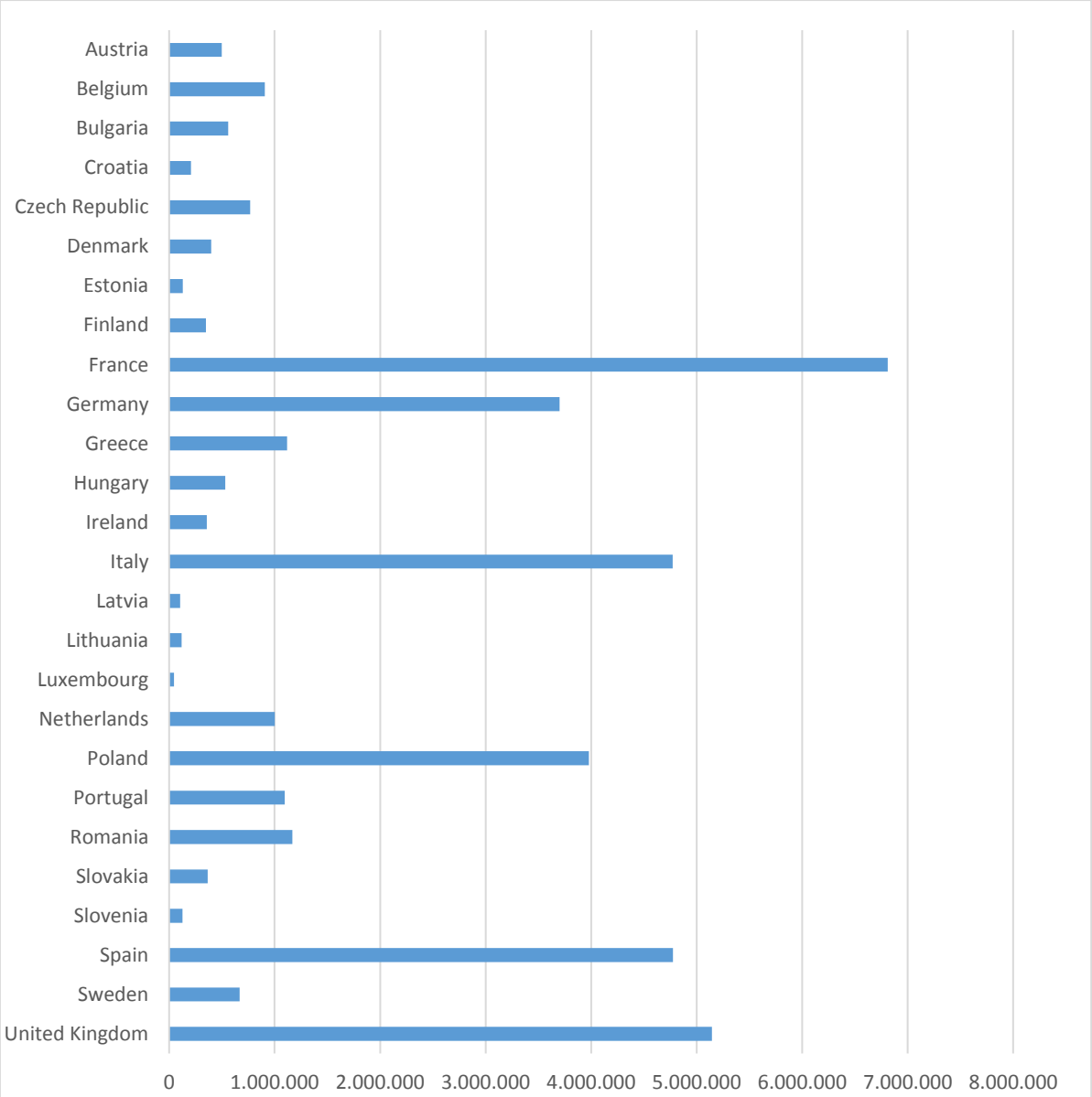
As a result, the freight performance of transport has been steadily increasing in the EU and reached the value of 3 516.5 billion tonne-kilometres in 2015. 49% of this performance has been carried out by road transport and despite the efforts to promote rail and inland-waterways transport, this share is constantly increasing. The passenger transport performance has also been increasing and has reached the value of 5 387.5 billion

[15]Regulation (EU) No 165/2014 of the European Parliament and of the Council of 4 February 2014 on tachographs in road transport.
[16]Council Regulation (EEC) No 3821/85 on recording equipment in road transport.
[17]Regulation (EC) No 561/2006 of the European Parliament and of the Council on the harmonisation of certain social legislation relating to road transport.

passenger-kilometres in 2015. The share of road transport in passenger transport is even higher, amounting to 81.6% of all performance. 10% of this performance is carried out by buses and coaches (DG MOVE 2017).

The development of the market leads to a trend of **growth of the commercial vehicle fleet in the EU** (Figure 1). This trend is true both for the overall number of commercial vehicles as well as for the vehicles with maximum permissible mass of over 3.5 tonnes (Annex, Table 1). It is estimated that there will be a fleet of 39.7 million commercial vehicles in the European Union[18] (Figure 1) by 2020.

Figure 1. Estimated number of total commercial vehicles in EU by 2020



Source: Author's own estimation based on ACEA, 2017.

[18]The number of vehicles by 2020 is a prognosis based on linear regression analysis of the statistical data with the use of ordinary least squares method. Cyprus and Malta are not included in the analysis due to a lack of statistical data and small scale of the transport market.

The transport market is highly dispersed with a high number of enterprises. It is also diversified in form, legal character and spectrum of activity. It is estimated that there are **900 000 road transport enterprises** in the EU, most of which are **micro-enterprises** hiring less than 9 employees (over 80% in all the Member States, over 95% in many of them[19]). Most of these enterprises have a small fleet of vehicles, many often consisting of only one vehicle. However, the fleet distribution (Table 2) proves that a **considerable share of the vehicles belong to transport enterprises with large fleets (over 10 vehicles)** which at times have more than 10 vehicles.

Table 2. Commercial vehicles over 3.5 tonnes distribution structure in EU cross-border road transport

Size of the transport company (according to the size of the fleet)	Share of commercial vehicles
Fewer than 3 vehicles	18%
3-5 vehicles	19%
6-10 vehicles	21%
11-20 vehicles	**23%**
More than 20 vehicles	**19%**

Source: Author's own estimation based on Eurostat, 2017 and Kabashkin, 2014.

These **large fleet operators** – operating over 10 vehicles and representing 42% of companies – have market advantage and can generate a higher efficiency of fleet management due to scale benefits resulting, among others, from **discounts of up to 15%** received for repair and management services (Goyal and Gunasekaran 1992; George and Xia, 2011). These discounts are vital and have to be included in the calculation of the cost of retrofitting the smart tachographs, as they will affect the cost of labour connected with the process of retrofitting.

4. Main costs of retrofitting smart tachographs by 2020

Currently, the digital tachographs are fitted in newly registered commercial vehicles with a maximum permissible mass of more than 3.5 tonnes and buses or coaches carrying more than nine persons. The Regulation (EU) 165/2014 foresees the fitting of a new generation of **smart tachographs** in all **newly registered vehicles** of this type from **15 June 2019** onwards.

As explained above, this research envisages a scenario of accelerated **retrofitting of smart tachographs** in **all EU heavy-duty vehicles operating currently in international**

[19] e.g. Poland, Hungary and the Netherlands.

transport by **1 January 2020**. The potential costs and benefits of such an option are assessed in the subsequent sections.

4.1. Methodology

In order to calculate the cost of retrofitting smart tachographs in the EU, first the number of vehicles subject to retrofitting has to be established. This can be done using a linear regression prognosis, based on the available Eurostat data on the total number of commercial vehicles and the number of light commercial vehicles which are not subject to retrofitting. Each of those vehicles which are subject to the process will generate a cost connected with retrofitting resulting in two main parts:

- ✓ the cost of the device itself (the tachograph) and,
- ✓ the cost of labour connected with the service of retrofitting performed in a licensed workshop.

The smart tachograph itself is not yet available on the market, so its price is based on current market estimates. The cost of labour can be based on the current service of retrofitting connected with the digital tachographs, but it has to be weighted by the cost of labour in different countries. It is assumed that the costs of retrofitting will not differ depending on the current generation of used tachographs because regardless of the generation, the whole device will have to be replaced.

The light commercial vehicles (with a maximum permissible mass of less than 3.5 tonnes) which account for over 80% of all the commercial vehicles, are out of scope of the current legislation and therefore not taken into consideration in this analysis (Table 3). On estimate, by 2020, there will be 32.5 million light commercial vehicles, as their number has been growing since 2011 (Annex, Table 2)[20].

In consequence, by subtracting the number of light commercial vehicles from the number of all commercial vehicles, it can be deduced that by 2020, there will be over 7 million vehicles which have to be retrofitted with a smart tachograph (Table 3).

[20] The number of vehicles by 2020 is a prognosis based on linear regression analysis of the statistical data with the use of ordinary least squares method. Cyprus and Malta are not included in the analysis due to a lack of statistical data and small scale of the transport market. The data for Bulgaria is estimated based on weighted average share of light commercial vehicles.

Table 3. Number of vehicles subject to tachograph retrofitting – projection for 2020[21]

Country	2020P
Austria	75 763
Belgium	151 895
Bulgaria	128 247
Croatia	60 892
Czech Republic	229 907
Denmark	46 855
Estonia	43 875
Finland	106 205
France	655 900
Germany	989 007
Greece	259 943
Hungary	103 830
Ireland	51 674
Italy	906 383
Latvia	35 476
Lithuania	64 566
Luxembourg	13 134
Netherlands	143 493
Poland	1 274 216
Portugal	117 260
Romania	300 343
Slovakia	97 305
Slovenia	38 066
Spain	529 227
Sweden	92 873
United Kingdom	686 392
EU	**7 202 727**

Source: Author's own estimation.

[21] The number of vehicles by 2020 is a prognosis based on linear regression analysis of the statistical data with the use of ordinary least squares method. Cyprus and Malta are not included in the analysis due to a lack of statistical data and small scale of the transport market.

As previously said, each of these vehicles will generate a **retrofitting cost** for their corresponding enterprise (owner/user) which will consist of the cost of the smart tachograph itself - and the cost **of labour** connected with the service of fitting, calibrating and testing the tachograph in a workshop.

While the cost of a smart tachograph itself it is estimated to be approximately constant across the EU, the labour cost varies across the EU and will result in different costs for retrofitting. The annual data on labour costs will be used to calculate a coefficient for the discounted weighted labour cost (Table 5). The labour cost of fitting, calibrating and testing one smart tachometer in a vehicle has been estimated for Poland[22] at **96 EUR** (Kordel and Waśkiewicz, 2013; Gil and Ignaciuk, 2014)[23].

4.2. How do we calculate

The estimated cost of fitting and authorising of a smart tachometer in the EU is prone to be discounted for larger enterprises and has to be adjusted for the labour cost in particular countries. Based on Table 2, which shows the EU road transport fleet distribution structure, it can be estimated that **42% of vehicles** (EU cross-border transport companies with a fleet over 10 vehicles) could be serviced at a **discounted rate**, estimated for the purpose of this calculation **at 15%** (Goyal and Gunasekaran 1992; George and Xia, 2011). This in turn means that the average base labour cost of fitting a tachograph should be discounted for the whole fleet of vehicles to **89.95 EUR**[24]. This base cost will vary in different countries due to a different labour cost (Table 4).

[22] Poland is the Member State with the most commercial vehicles and with the biggest estimated fleet of vehicles subject to retrofitting by 2020.
[23] Figure also based on market research in 37 workshops.
[24] =42% *96 EUR * 0.85 + 58% * 96 EUR.

Table 4. Labour costs annual data (EUR/hour average)

Country	2012	2013	2014	2015	2016	2020P
Austria	29.7	30.6	31.4	32.4	32.7	36.81
Belgium	38	38.8	39	39.1	39.2	41
Bulgaria	3.4	3.6	3.8	4.1	4.4	5.22
Croatia	9.5	9.5	9.4	9.6	10	9.63
Czech Republic	10	9.7	9.4	9.8	10.2	9.14
Denmark	39.4	39.9	40.6	41.2	42	44.24
Estonia	8.6	9.2	9.8	10.3	10.9	13.18
Finland	31.3	32	32.5	33	33.2	35.84
France	34.3	34.4	34.7	35.1	35.6	36.38
Germany	30.5	30.9	31.4	32.2	33	34.89
Greece	15.7	14.5	14.5	14.1	14.2	11.58
Hungary	7.4	7.7	7.7	7.9	8.3	8.65
Ireland	29.8	29.8	29.8	30	30.4	30.24
Italy	27.7	28.1	28.3	28.1	27.8	28.96
Latvia	5.9	6.2	6.6	7.1	7.5	9.05
Lithuania	5.9	6.2	6.5	6.8	7.3	8.3
Luxembourg	33.9	35.1	36.2	36.3	36.6	40.77
Netherlands	32.5	33.2	33.7	34	34.3	36.6
Poland	7.9	8.1	8.3	8.6	8.6	9.72
Portugal	13.3	13.3	13.2	13.4	13.7	13.43
Romania	4.1	4.4	4.6	4.9	5.5	6.19
Slovakia	8.9	9.2	9.7	10	10.4	11.92
Slovenia	15.6	15.3	15.6	15.8	16.2	16.16
Spain	21.1	21.2	21.1	21.2	21.3	21.28
Sweden	37.3	38.2	37.3	37.4	38	37.16
United Kingdom	25	24.1	25.8	29.7	26.7	36.42
EU Average	**20.26**	**20.51**	**20.80**	**21.23**	**21.46**	**22.80**

Source: Author's own estimation based on Eurostat.

Due to the fact that the smart tachograph is not yet in production, there is no reference market price. However, different sources provide different estimated market prices ranging from **675 EUR**[25] through to **800 EUR**[26] and up to a price of **2 000 EUR**[27].

4.3. Findings

The cost of retrofitting the tachographs in all subject vehicles by 2020 varies depending on the variant chosen and ranges from **6.4 billion EUR** (Annex, Table 3) through to **7.3 billion EUR** (Annex, Table 4) to **15.9 billion EUR** (Annex, Table 5). The estimated costs of retrofitting depending on the variant of the price are presented in the Table 5.

Table 5. Estimated cost of retrofitting the smart tachographs depending on the market price

Estimated market price of the smart tachograph	Estimated cost of retrofitting (in EUR)
675 EUR	6 381 503 188.83
800 EUR	7 281 844 104.14
2 000 EUR	15 925 116 891.18

Source: Author's own estimation.

Regardless of the chosen price variant, the three countries in which the highest costs will be generated are Poland, Germany and Italy, as they have the biggest vehicle fleets relative to other Member States.

In the case of the lowest estimated price (675 EUR) Germany would be the country in which the highest cost will occur, due to a relatively higher cost of labour. However, if the price of the device increases, the relative share of the labour cost decreases and therefore the countries with the lower costs of labour increase their share of the overall cost. In the case of both the medium (800 EUR) and the high (2 000 EUR) price of the device, the country in which the highest cost will occur is Poland.

In general, this cost will be harder to bare for the smaller enterprises that cannot expect any discounts due to smaller fleet sizes and lower market strength, resulting in a lack of negotiating power.

[25] A 12.5% based on the current trend of price increase for the digital tachographs; Wieteska and Piechota, 2016.
[26] A 33.3% increase of the current market price of digital tachograph, based on market research including 37 licensed workshops.
[27] A maximum increase of the market price, based on inquiries with producers suggesting that the smart tachograph will include a much more specialised equipment than current digital tachographs including GNSS receiver and will therefore have a proportionately higher price.

5. Main benefits of retrofitting smart tachographs by 2020

Retrofitting the smart tachographs in heavy-duty vehicles and buses will mainly result in reducing the cost of accidents, which constitute the biggest share of all external road transport costs[28]. Assuming the above-mentioned scenario of retrofitting smart tachographs by 2020, the calculations below present the benefits of such an action.

5.1. Methodology

There are two main methods of calculating the cost of accidents:

- based on gross domestic product (GDP),
- based on the value of statistical life (VSL).

Firstly, we need to estimate the cost of accidents in the EU using each of the two methodologies. Secondly, this cost will be corrected based on the share of accidents caused by vehicles fitted with tachographs. Thirdly, based on whether the accident is caused by a factor controllable by the tachograph, the cost will be further corrected.

5.1.1. GDP based method

The first method takes into account all of the costs connected with the accidents i.e.:

- ✓ the expected cost of death and/or injury for the person exposed to the accident,
- ✓ the expected cost for the relatives and friends of the person exposed to the accident and,
- ✓ the costs for the rest of the society such as output loss, material costs, police and medical costs (Lindberg, 2006).

According to a report, 'External costs of transport' produced for the European Environment Agency, they constitute up to 2.5% value of gross domestic product (Table 6).

Table 6. External costs of transport

Factor	% of GDP	% of total external costs
Uncovered infrastructure	0.15	4
Noise	0.4	10
Climate change	0.5	12
Air pollution	0.6	14
Accidents	**2.5**	**60**
Total	4.15	100

Source: European Environment Agency, 2010.

This share remains relatively constant over the years (Ricardo-AEA, 2014) and can be used to estimate the value of road accidents in the future based on the forecasts of GDP. The average GDP growth rate for the EU-28 for the following years varies depending on the source and is

[28] i.e. costs imposed upon a third party when services are produced, such as: pollution, congestion, accidents.

estimated at between 1.8% (International Monetary Fund, 2018) and 2.1% (European Commission, 2017).

This allows us to extrapolate the **cost of road accidents in the EU in 2020** at **402 billion EUR**[29].

5.1.2. VSL based method

A second approach to estimating the value of accidents is to use the estimated number of fatal accidents and the estimates of the value of statistical life (VSL). These estimates vary across different age groups and countries, but also depend on the risk situation. Therefore, the VSL estimates for the EU used in different studies are different and vary from 1.5 million EUR to 3.0 million EUR. The most recent update suggests a VSL estimate of 1.7 million EUR (Ricardo-AEA, 2014)[30]. On average, fatalities have the highest share of the costs of accidents and amount to 88% of the total cost (Table 7).

Table 7. Shares of accident costs in the EU

Fatalities	Severe injury	Slight injury
88%	11%	1%

Source: Ricardo-AEA, 2014.

The number of fatalities in road accidents has been steadily decreasing over time (a 43% decrease between 2005 and 2015; a 17% decrease between 2010 and 2015[31]) and this trend is estimated to continue over the following years (Table 8).

[29] Assuming an average GDP growth rate of 1.9% and cost of accidents of 2.5% of GDP (16 074 billion EUR*2.5%).
[30] Update of the Handbook on External Costs of Transport, Report for the European Commission, Ricardo-AEA, 2014.
[31] CARE, EU road accidents database.

Table 8. Estimated fatalities in road accidents in the EU

Country	Fatalities in 2011	Fatalities in 2015	Fatalities in 2020P[32]
Austria	523	479	351
Belgium	858	732	557
Bulgaria	657	708	758
Croatia	418	348	210
Czech Republic	773	738	632
Denmark	220	178	139
Estonia	101	67	29
Finland	292	266	205
France	4 111	3 459	2 666
Germany	4 009	3 459	2 631
Greece	1 141	793	297
Hungary	638	644	644
Ireland	186	162	167
Italy	3 860	3 428	2 696
Latvia	179	188	224
Lithuania	296	242	173
Luxembourg	33	36	42
Netherlands	661	621	539
Poland	4 189	2 938	1 439
Portugal	932	624	237
Romania	2 018	1 893	1 595
Slovakia	355	310	240
Slovenia	141	120	80
Spain	2 060	1 689	1 134
Sweden	319	259	184
United Kingdom	1 960	1 804	1 656
EU total	**30 930**	**26 185**	**19 523**

Source: Author's own estimation based on Eurostat data and World Health Organization, 2015.

[32] Estimated through linear regression using data from years 2011-2015.

Based on the predicted number of accidents, the share of costs of fatalities and the estimated VSL of 1.7 million EUR, the **cost of accidents in 2020** can be estimated at **37.7 billion EUR**[33]. This value is ten times lower than the previously estimated value based on GDP. However, it does not include the costs that are not directly associated with fatalities and injuries.

5.2. Findings

Regardless of the calculation method, for further calculations it is assumed that only a small part of the total accidents is caused by drivers of vehicles which are supposed to be fitted with smart tachographs (Table 9). An analysis of data from EU Member States police forces shows that only 6% of all the casualties are those killed in accidents caused by vehicles fitted with tachographs, including heavy-duty vehicles (HDVs) and buses.

Table 9. Vehicles causing accidents in EU road transport

Cars and light-duty vehicles (LDVs)	Bicycles	Heavy-duty vehicles (HDVs) and buses	Motorcycles
78%	6%	6%	3%

Source: Data from police forces of Member States, Eurostat, 2017.

Furthermore, not all accidents can be attributed to causes strictly related to the use of tachographs. Factors such as external distractions, mobile phone use, improper overtaking, and driving under the influence of alcohol or drugs, remain beyond the control of the tachographs and will therefore not be affected by the change.

However, driver distraction remains the most important cause of accidents (up to 50% of all accidents) and in 12% of instances, the distraction is caused by the driver's fatigue. This means that in 6% of the accidents, the driver's fatigue is the main cause of the accident (World Health Organization, 2017). However, the **fatigue** is at least an **aggravating factor in up to 40% of all the accidents** according to the National Transportation Safety Board, 1995. Speed does not play as great a role in heavy-duty vehicle crashes as it does in regard to cars and light-duty vehicles (LDVs), but it is said to be the main cause of accident in 13%, and at least a partial cause of accident, in up to 46% of accidents[34].

Currently, the digital tachographs barely help reduce the number of accidents caused by speeding, as they only control the maximum permissible speed of the vehicle and not the incident of speeding at a given location. However, the signal from the smart tachograph, together with the signal from the GNSS, could allow the establishment of the position of the vehicle at any given time and therefore provide an assessment of whether the vehicle is speeding or not. This could prove to be a factor in forcing drivers to control the speed of their vehicle at all times, therefore indirectly increasing safety. Currently, however, it is

[33] =19 523 fatalities * 1.7 million EUR / 0.88 (the share of fatalities costs).
[34] NSW Centre for Road Safety, *Heavy Truck Fatal Crash Trends and Single Vehicle Heavy Truck Crash Characteristics*, 2014; Federal Motor Carrier Safety Administration, *Large Truck and Bus Crash Facts Reports*, 2011-2015.

impossible to assess to what extent the smart tachographs will in fact provide such a functionality.

Overall, it can be assumed that at least 19%[35] of all accidents involving HDVs and buses are caused by factors that are at least partially preventable with the introduction of a smart tachograph.

This means that the value of potential benefits from avoidable accidents in 2020 is equal to **430 million EUR**[36] or **4.5 billion EUR**[37] (depending on the calculation method).

Theoretically, the countries that would benefit the most from these reduced costs of accidents are the countries in which currently there are the most road accidents, i.e. France, Germany, Italy, Poland, Romania, Spain and United Kingdom. It should also be mentioned here that these benefits should be treated with caution, as it is often difficult to distinguish the single dominant factor that leads to an accident – whether it was fatigue or perhaps the bad technical condition of the vehicle.

6. Other costs

6.1. Enforcement costs for public authorities

6.1.1. Fitting workshops auditing costs

The main budgetary cost for public authorities connected with the retrofitting of smart tachographs by 2020 would be to **audit the workshops** that are licensed to retrofit and calibrate smart tachographs, in order to ensure compliance with the standards.

Within the EU, there are currently over 19 thousand workshops and fitters approved by the competent authorities of each Member State who are authorised to carry out calibrations, inspections and repairs to digital tachographs (Table 10). The same authorities would be in charge of supervising the upgrading of tachographs to smart tachographs in the current vehicle fleet. The current number of workshops in the EU Member States is sufficient to perform the procedure of retrofitting the smart tachographs. The estimated maximum fitting capacity of workshops is 8 procedures/daily[38] and the rate of tachographs to be fitted per day in each workshop doesn't exceed 6.7 (Annex, Table 6).

[35] 6% caused directly by the fatigue and 13% caused directly by speeding.
[36] Calculation of road accidents cost based on VSL.
[37] Calculation of road accidents cost based on GDP.
[38] Based on market research in 37 workshops.

Table 10. Number of workshops and fitters approved by the competent authorities as of 2018[39]

Country	Workshops
Austria	288
Belgium	929
Bulgaria	160
Croatia	242
Czech Republic*	164
Denmark	198
Estonia	38
Finland	328
France	517
Germany	4 476
Greece	94
Hungary	476
Ireland	121
Italy	2 794
Latvia	13
Lithuania*	26
Luxembourg	10
Netherlands	3 972
Poland	851
Portugal*	234
Romania	291
Slovakia	33
Slovenia	98
Spain	589
Sweden	269
United Kingdom	2 146
EU total	**19 357**

Source: European Commission, 2018.

These workshops will have to be audited by the authorities in order to assure that they comply with the standards, assuring that the tachographs are properly mounted, calibrated

[39] Data for Czech Republic, Lithuania and Portugal were unavailable and for the purpose of this study is estimated based on the number of vehicles.

and authorised. The cost of such an audit has been estimated at 1 185 EUR per year for Poland[40], which has been chosen as a reference because it is the country with the highest number of vehicles subject to retrofitting, but this calculation has to be weighted according to the average labour cost (Table 5).

Therefore, the resulting **estimated cost of an audit of workshops in the EU** would be **73 million EUR per year** (Table 11). The overall cost will depend on the number of workshops in each Member State, including the cost of labour, and will therefore be the highest for Germany, the Netherlands, Italy and United Kingdom.

[40] Based on audit and consulting market research as well as interviews with authorities.

Table 11. Cost of auditing licensed workshops in the EU in 2020

Country	Workshops	Discount coefficient	Cost of audit (in EUR)
Austria	288	3.79	1 292 440
Belgium	929	4.22	4 643 566
Bulgaria	160	0.54	101 822.2
Croatia	242	0.99	284 114.7
Czech Republic	164	0.94	182 936.3
Denmark	198	4.55	1 067 904
Estonia	38	1.36	61 059.2
Finland	328	3.69	1 433 158
France	517	3.74	2 293 007
Germany	4 476	3.59	19 038 956
Greece	94	1.19	132 705.4
Hungary	476	0.89	501 967
Ireland	121	3.11	446 086.7
Italy	2 794	2.98	9 864 545
Latvia	13	0.93	14 343.13
Lithuania	26	0.85	25 833.37
Luxembourg	10	4.19	49 704.17
Netherlands	3 972	3.77	17 723 211
Poland	851	1.00	1 008 435
Portugal	234	1.38	383 232.6
Romania	291	0.64	219 601.7
Slovakia	33	1.23	47 955.93
Slovenia	98	1.66	193 072.1
Spain	589	2.19	1 528 055
Sweden	269	3.82	1 218 653
United Kingdom	2 146	3.75	9 528 439
EU total	**19 357**		**73 284 803**

Source: Author's own estimation.

It is possible that the retrofitting of smart tachographs will generate **additional costs** to the transport enterprises connected with additional equipment necessary to read and analyse data, as has been the case with digital tachographs. This is estimated to generate an

additional cost of 879 EUR per enterprise, based on a European Commission study produced in 2016[41]. It is worth mentioning that these costs, if incurred, will mostly burden the micro and smaller enterprises, which have relatively small fleet and still have to accept the same cost as larger enterprises. Currently, however, there is no data that would allow a reliable estimate of these costs. Further, at least during the period in which the tachographs are retrofitted, the system of data collection has to accept input from both old and new data sources.

6.1.2. Tachograph data analysis related costs

Under the current legislation (which foresees retrofitting of smart tachographs by 2034 and introducing them only in newly registered vehicles from 15 June 2019), until 2034 national authorities do not have an obligation to get hold of smart tachograph related technology which would allow them to collect data from it.

Nevertheless, the accelerated process of retrofitting smart tachographs by 2020 in all subject vehicles would generate costs to Member States' enforcement authorities connected with reading, retrieving and analysing the data from these tachographs. This cost would consist of two main elements:

- ✓ the cost of the purchase of the necessary technology and,
- ✓ the cost of the training of personnel of the enforcement agencies responsible for the task of reading, retrieving and analysing the data from smart tachographs.

Due to the fact that there is currently no final form of the smart tachograph technology, there is no reliable data which would allow an estimate of the cost of technology necessary to read and retrieve data from them. There is a possibility that technology used currently with the digital tachographs will allow for the collection of part of the data, however, it should be observed that it does not allow the collection of data from the GNSS system, which is supposed to be an integral part of the smart tachograph. Therefore, at the very least, the technology necessary to collect the GNSS signal will have to be purchased.

There are currently devices that allow individuals to monitor data from the GNSS receivers, but the amount of data which would need to be collected means that there is no possibility to reliably estimate the cost of such an extensive system for the enforcement agencies of the Member States. The cost of the data analysis can be minimised as long as the data collected will have a format compliant with that of the currently used data formats.

Regardless of the technology used to collect data, the enforcement agencies will have to train responsible personnel for the collection and analysis of data, in order to enable an effective transition during the process of retrofitting smart tachographs. By 2020, there will be approximately 30 500 enforcement officers who earn an average wage of 23.05 EUR per hour[42]. Each of these officers will require two labour days of training[43] in order to make the transition into the new system. This means that the training costs incurred by the

[41] An additional cost of 879 EUR per enterprise; based on Commission Staff Working Document, Ex-post evaluation of the social legislation in road transport: Regulation (EC) No 561/2006 on driving times, breaks and rest periods of drivers, Directive 2002/15/EC on the working time of road transport mobile workers and directive 2006/22/EC on enforcement requirements.
[42] Based on the tempo of the growth of the sector and the tempo of the growth of wages in the sector.
[43] Based on inquiries with the employees of the enforcement agencies.

enforcement agencies in connection with the process of retrofitting the smart tachographs will amount to around **11 million EUR**[44] in the EU.

6.2. Upgrade of driver card related costs

Merging the driver card with the driver's licence has been identified as a solution for limiting costs and therefore reducing the potential administrative burden by 100 million EUR (European Commission, 2011). This has been calculated based on the assumption that every driver who currently has a driver card also has a driver's licence. The process of retrofitting of smart tachographs could potentially create an opportunity to merge these two documents into one, creating a new form of driver's licence which would also include a chip and all necessary data to be used with the tachograph. However, this benefit seems highly unlikely. First, this is due to the fact that the cost of the new, merged documents would in all probability increase significantly. Second, if a new standard for driver's licences would be introduced across the EU, it would affect all drivers, not only professional drivers. They would have to bear the cost of purchasing a new and more expensive license.

7. Other benefits

It is assumed that the retrofitting of smart tachographs by 2020 will generate a new **market opportunity for the workshops** that will carry out the upgrade of the devices by increasing the demand for their services. The profit for these companies can be estimated based on the labour cost connected with retrofitting the tachographs (Tables 6-8) and the return on sales margin characteristic for the transport services sector, which is on average equal to 11.38%[45]. This will allow the workshops to generate a profit of **18.2 million EUR** across the EU by 2020 (Table 12). This profit is likely to be highest in the Member States with the largest fleet of vehicles combined with relatively high labour costs, i.e. Germany, United Kingdom, Italy and France.

[44] 11 248 800 EUR = 30 500 (employees) * 23.05 EUR (average rate) * 16 labour hours.
[45] Own estimation based on Amadeus database Amadeus.bvdinfo.com

Table 12. Tachograph fitting workshop profits in the EU by 2020

Country	Labour cost (in EUR)	Profit (in EUR)
Austria	25 808 784	2 937 040
Belgium	57 633 089	6 558 645
Bulgaria	6 195 315	705 027
Croatia	5 426 641	617 552
Czech Republic	19 446 567	2 213 019
Denmark	19 182 960	2 183 021
Estonia	5 351 519	609 003
Finland	35 225 529	4 008 665
France	220 823 294	25 129 691
Germany	319 333 804	36 340 187
Greece	27 856 801	3 170 104
Hungary	8 311 579	945 858
Ireland	14 461 003	1 645 662
Italy	242 915 299	27 643 761
Latvia	2 971 172	338 119
Lithuania	4 959 370	564 376
Luxembourg	4 955 441	563 929
Netherlands	48 602 248	5 530 936
Poland	114 618 278	13 043 560
Portugal	14 573 721	1 658 489
Romania	17 204 923	1 957 920
Slovakia	10 733 861	1 221 513
Slovenia	5 692 764	647 837
Spain	104 221 705	11 860 430
Sweden	31 938 149	3 634 561
United Kingdom	231 343 187	26 326 855
EU total	**1 599 787 002**	**182 055 761**

Source: Author's own estimation.

It is worth noting, however, that the services connected with retrofitting smart tachographs will also partially substitute the services connected with authorising and testing the digital tachographs, thus the marginal profit will be substantially lower depending on the pace at which the transport enterprises switch to using smart tachographs.

Furthermore, it is also worth mentioning that the enforcement authorities could potentially benefit from improved **enforcement of EU road transport legislation,** resulting from the introduction of smart tachographs. The tachographs will contain a transmitter which will broadcast technical data (including: speeding event, driving without a valid card, motion data errors, power interruptions, security breach attempts) which will allow officers to quickly identify vehicles that could potentially be in breach of road transport legislation. At present, **26% of heavy-duty vehicles roadside checks show a breach of legislation** (Euro Controle Route, 2017). The new technology, which allows for the collection of some of the data in a wireless manner, without the need to stop the vehicle, should allow for the identification of vehicles that should be investigated in a more effective way, thus **increasing the controlling efficiency of the enforcement authorities**. However, it should be remembered that only part of all roadside checks show breaches of legislation that are identifiable with the tachograph, such as: tachographs offences, drivers' hours offences, tachograph frauds and manipulations. These offences make up approximately 45% of all identified offences[46]. Other offences, such as overweight loads, insecure loads, technical offences or ADR offences, will still only be identifiable during a regular roadside check, as the smart tachographs are not designed to include functionalities that would facilitate the identification of such offences.

[46] Own estimation, based on Euro Controle Route, 2017.

8. Conclusion

The retrofitting of smart tachographs in all relevant vehicles by 2020 is an extensive process, which will certainly generate significant costs for the main actors of the European transport market.

The main cost will be incurred by the transport enterprises, which will be the cost of purchasing the devices and the cost of labour connected with the service of retrofitting. This cost is estimated to be between **6.4 and 15.9 billion EUR** depending on the actual market price of the tachograph. The smart tachographs are not yet available on the market, therefore different price variants ranging from **675 to 2 000 EUR** have been assumed in these estimations.

Other primary identifiable costs connected with the process include: the costs of auditing workshops which are licensed to perform the service of retrofitting by public authorities - **73 million EUR** annually - and the cost of training the personnel of the enforcement agencies to collect and analyse tachograph data - **11 million EUR**.

The main benefits which have been identified and analysed include: the benefits of the potential reduction in the costs of accidents - **430 million EUR** or **4.5 billion EUR** depending on the chosen methodology. Second, the benefits for the licensed workshops, which will be able to generate a higher profit throughout the process -**182 million EUR** in general for the workshops in the EU.

The **cost-benefit ratio** (CBR), which shows the general profitability of the process, calculated for these values ranges from 1.38[47] (borderline profitable) to 26.12[48] (not profitable). However, these values have to be treated as a general approximation, because they have been calculated for a very short period of time, during which most of the costs are generated (mainly from the process of retrofitting), whereas the benefits will be spread over time. This means that, the longer the horizon of analysis, the more profitable the process of retrofitting the smart tachographs.

It is worth mentioning that the process of retrofitting the smart tachographs will mostly affect **Member States in which the largest number of vehicles participate in the European transport market**; Poland, Germany, Italy, United Kingdom, France and the Netherlands.

These changes will largely be a **burden for the micro and small transport enterprises**, which operate using a small fleet of vehicles, as they will not be able to negotiate and take benefit from discounts on services of retrofitting which are available for the enterprises with larger fleets.

Regardless of the high overall cost of the process of retrofitting smart tachographs, it should be stated, that **in the long term, the benefits of the process outweigh the costs**. However,

[47] Calculated for the most optimistic variant – the highest estimated values of benefits from the reduction of accident costs and workshop profits and the lowest estimated values of retrofitting, personnel training and auditing costs. Timeline – 2020.

[48] Calculated for the most pessimistic variant – the lowest estimated values of benefits from the reduction of accident costs and workshop profits and the highest estimated values of retrofitting, personnel training and auditing costs. Timeline – 2020.

the proposal to retrofit the smart tachographs by 2020 implies a very short period of time with in which the process must be fulfilled. This is likely to generate a steep initial cost of purchasing and retrofitting the smart tachograph, which becomes especially severe for the micro and small enterprises. Consequently, it can be stated that **the policy to retrofit smart tachographs should be pursed**, as the benefits resulting from it are likely to outweigh the cost. However, perhaps it might be **advisable to reconsider the very short period of less than two years to retrofit** the tachographs, especially when one considers that the device is not currently available on the market.

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10. Annex

Table 1. Number of commercial vehicles (over 3.5 tonnes) in EU by 2020.

Country	2011	2012	2013	2014	2015	2020P
Austria	417 000	426 081	434 331	444 500	453 702	499 399
Belgium	778 745	791 033	801 722	817 089	838 424	907 192
Bulgaria	347 600	367 000	388 000	411 800	444 400	558 640
Croatia	145 586	152 494	159 336	166 441	173 152	207 757
Czech Republic	702 499	705 147	714 043	721 432	732 045	767 797
Denmark	480 154	466 000	452 174	448 267	445 934	398 185
Estonia	87 416	92 356	96 675	101 240	106 539	129 836
Finland	470 145	407 814	409 928	411 877	415 394	349 224
France	6 517 000	6 538 000	6 550 000	6 608 000	6 652 177	6 811 283
Germany	3 055 708	3 107 000	3 163 469	3 244 457	3 355 885	3 701 772
Greece	1 075 445	1 079 290	1 083 064	1 088 498	1 094 851	1 117 844
Hungary	459 309	458 474	465 466	478 034	494 065	533 420
Ireland	337 926	326 280	335 732	333 202	348 627	356 180
Italy	4 953 778	4 921 712	4 867 000	4 865 167	4 890 701	4 771 782
Latvia	73 510	79 136	84 762	87 945	85 520	105 155
Lithuania	193 595	196 175	194 420	100 626	103 578	118 338
Luxembourg	37 934	39 254	40 230	40 725	41 683	46 244
Netherlands	1 092 000	1 072 000	1 053 000	1 044 485	1 059 999	1 000 235
Poland	3 177 221	3 277 863	3 345 086	3 446 673	3 537 809	3 979 921
Portugal	1 351 000	1 310 100	1 273 200	1 251 500	1 243 700	1 094 660
Romania	701 726	753 539	806 343	855 187	909 970	1 168 048
Slovakia	300 791	307 917	315 877	320 504	330 130	364 929
Slovenia	85 261	90 011	94 916	99 200	104 416	128 010
Spain	5 319 109	5 232 813	5 130 066	5 085 343	5 107 427	4 775 368
Sweden	562 219	571 024	579 168	595 197	610 328	667 861
United Kingdom	4 269 641	4 279 078	4 364 718	4 500 576	4 677 162	5 143 813
EU total	**36 644 718**	**36 680 592**	**36 814 726**	**37 156 165**	**37 813 218**	**39 702 893**

Source: Author's own estimation based on ACEA, 2017.

Table 2. Number of light commercial vehicles (up to 3.5 tonnes)

Country	2011	2012	2013	2014	2015	2020P
Austria	336 322	346 397	355 214	365 686	375 163	423 636
Belgium	613 343	627 692	640 253	656 691	678 801	755 297
Bulgaria	267 801	282 748	298 927	317 263	342 379	430 393
Croatia	110 938	114 930	119 411	121 935	127 395	146 865
Czech Republic	495 639	502 164	504 388	509 378	515 263	537 890
Denmark	427 484	414 725	401 874	398 074	395 645	351 330
Estonia	49 698	54 139	57 414	61 233	66 297	85 961
Finland	361 499	299 088	301 012	304 255	307 706	243 019
France	5 867 000	5 896 000	5 915 000	5 965 000	5 995 177	6 155 383
Germany	2 085 258	2 141 457	2 196 265	2 274 261	2 374 822	2 712 765
Greece	818 818	822 492	825 956	830 935	836 685	857 901
Hungary	354 203	355 042	361 706	373 162	389 980	429 590
Ireland	291 241	281 122	287 587	286 294	299 609	304 506
Italy	3 861 167	3 853 329	3 831 774	3 844 429	3 874 452	3 865 399
Latvia	39 762	43 119	46 477	50 531	52 612	69 679
Lithuania	97 214	98 459	95 854	44 856	46 342	53 772
Luxembourg	24 800	26 089	27 046	27 635	28 521	33 110
Netherlands	922 000	906 000	890 000	885 000	901 026	856 742
Poland	2 237 729	2 303 433	2 334 415	2 399 323	2 447 764	2 705 705
Portugal	1 206 000	1 170 000	1 137 000	1 118 000	1 110 000	977 400
Romania	516 071	555 141	591 978	637 750	670 119	867 705
Slovakia	208 877	215 404	222 464	227 395	235 519	267 624
Slovenia	57 455	61 065	64 751	68 132	71 971	89 944
Spain	4 696 898	4 636 062	4 550 076	4 508 276	4 520 616	4 246 141
Sweden	467 533	477 094	486 052	501 661	516 168	574 988
United Kingdom	3 614 664	3 631 595	3 706 351	3 842 017	4 007 331	4 457 421
EU total	**29 761 613**	**29 832 038**	**29 950 318**	**30 301 909**	**30 844 984**	**32 500 166**

Source: Author's own estimation based on ACEA, 2017.

Table 3. Tachograph retrofitting cost (price of smart tachograph = 675 EUR)

Country	Discount coefficient	Discounted weighted labour cost (in EUR)	Number of vehicles	Total estimated cost (in EUR)
Austria	3.79	340.65	75 763	76 948 808.80
Belgium	4.22	379.43	151 895	160 162 213.54
Bulgaria	0.54	48.31	128 247	92 762 257.37
Croatia	0.99	89.12	60 892	46 528 740.91
Czech Republic	0.94	84.58	229 907	174 633 792.22
Denmark	4.55	409.41	46 855	50 810 084.92
Estonia	1.36	121.97	43 875	34 967 144.33
Finland	3.69	331.67	106 205	106 913 903.95
France	3.74	336.67	655 900	663 555 794.36
Germany	3.59	322.88	989 007	986 913 528.59
Greece	1.19	107.17	259 943	203 318 326.22
Hungary	0.89	80.05	103 830	78 396 828.68
Ireland	3.11	279.85	51 674	49 340 953.35
Italy	2.98	268.01	906 383	854 723 824.00
Latvia	0.93	83.75	35 476	26 917 471.94
Lithuania	0.85	76.81	64 566	48 541 420.26
Luxembourg	4.19	377.30	13 134	13 820 890.69
Netherlands	3.77	338.71	143 493	145 460 023.30
Poland	1.00	89.95	1 274 216	974 714 077.63
Portugal	1.38	124.29	117 260	93 724 221.35
Romania	0.64	57.28	300 343	219 936 447.57
Slovakia	1.23	110.31	97 305	76 414 736.11
Slovenia	1.66	149.55	38 066	31 387 313.72
Spain	2.19	196.93	529 227	461 449 930.43
Sweden	3.82	343.89	92 873	94 627 423.71
United Kingdom	3.75	337.04	686 392	694 657 786.68
EU	**2.35**	**210.98**	**7 202 727**	**6 381 503 188.83**

Source: Author's own estimation

Table 4. Tachograph retrofitting cost (price of smart tachograph = 800 EUR)

Country	Discount coefficient	Discounted weighted labour cost (in EUR)	Number of vehicles	Total estimated cost (in EUR)
Austria	3.79	340.65	75 763	86 419 183.80
Belgium	4.22	379.43	151 895	179 149 088.54
Bulgaria	0.54	48.31	128 247	108 793 172.69
Croatia	0.99	89.12	60 892	54 140 240.91
Czech Republic	0.94	84.58	229 907	203 372 167.22
Denmark	4.55	409.41	46 855	56 666 959.92
Estonia	1.36	121.97	43 875	40 451 519.33
Finland	3.69	331.67	106 205	120 189 528.95
France	3.74	336.67	655 900	745 543 294.36
Germany	3.59	322.88	989 007	1 110 539 403.59
Greece	1.19	107.17	259 943	235 811 201.22
Hungary	0.89	80.05	103 830	91 375 578.68
Ireland	3.11	279.85	51 674	55 800 203.35
Italy	2.98	268.01	906 383	968 021 699.00
Latvia	0.93	83.75	35 476	31 351 971.94
Lithuania	0.85	76.81	64 566	56 612 170.26
Luxembourg	4.19	377.30	13 134	15 462 640.69
Netherlands	3.77	338.71	143 493	163 396 648.30
Poland	1.00	89.95	1 274 216	1 133 991 077.63
Portugal	1.38	124.29	117 260	108 381 721.35
Romania	0.64	57.28	300 343	257 479 322.57
Slovakia	1.23	110.31	97 305	88 577 861.11
Slovenia	1.66	149.55	38 066	36 145 563.72
Spain	2.19	196.93	529 227	527 603 305.43
Sweden	3.82	343.89	92 873	106 236 548.71
United Kingdom	3.75	337.04	686 392	780 456 786.68
EU	**2.35**	**210.98**	**7 202 727**	**7 281 844 104.14**

Source: Author's own estimation.

Table 5. Tachograph retrofitting cost (price of smart tachograph = 2 000 EUR)

Country	Discount coefficient	Discounted weighted labour cost (in EUR)	Number of vehicles	Total estimated cost (in EUR)
Austria	3.79	340.65	75 763	177 334 783.80
Belgium	4.22	379.43	151 895	361 423 088.54
Bulgaria	0.54	48.31	128 247	262 689 959.73
Croatia	0.99	89.12	60 892	127 210 640.91
Czech Republic	0.94	84.58	229 907	479 260 567.22
Denmark	4.55	409.41	46 855	112 892 959.92
Estonia	1.36	121.97	43 875	93 101 519.33
Finland	3.69	331.67	106 205	247 635 528.95
France	3.74	336.67	655 900	1 532 623 294.36
Germany	3.59	322.88	989 007	2 297 347 803.59
Greece	1.19	107.17	259 943	547 742 801.22
Hungary	0.89	80.05	103 830	215 971 578.68
Ireland	3.11	279.85	51 674	117 809 003.35
Italy	2.98	268.01	906 383	2 055 681 299.00
Latvia	0.93	83.75	35 476	73 923 171.94
Lithuania	0.85	76.81	64 566	134 091 370.26
Luxembourg	4.19	377.30	13 134	31 223 440.69
Netherlands	3.77	338.71	143 493	335 588 248.30
Poland	1.00	89.95	1 274 216	2 663 050 277.63
Portugal	1.38	124.29	117 260	249 093 721.35
Romania	0.64	57.28	300 343	617 890 922.57
Slovakia	1.23	110.31	97 305	205 343 861.11
Slovenia	1.66	149.55	38 066	81 824 763.72
Spain	2.19	196.93	529 227	1 162 675 705.43
Sweden	3.82	343.89	92 873	217 684 148.71
United Kingdom	3.75	337.04	686 392	1 604 127 186.68
EU	**2.35**	**210.98**	**7 202 727**	**15 925 116 891.18**

Source: Author's own estimation.

Table 6. Fitting capacity of workshops

Country	Workshops	Vehicles subject to tachograph retrofitting	Vehicles/ Workshops	Vehicles per workshop daily
Austria	288	75 763	263	0.60
Belgium	929	151 895	164	0.37
Bulgaria	160	128 247	802	1.83
Croatia	242	60 892	252	0.57
Czech Republic	164	229 907	1400	3.19
Denmark	198	46 855	237	0.54
Estonia	38	43 875	1155	2.63
Finland	328	106 205	324	0.74
France	517	655 900	1269	2.89
Germany	4 476	989 007	221	0.50
Greece	94	259 943	2765	6.30
Hungary	476	103 830	218	0.50
Ireland	121	51 674	427	0.97
Italy	2 794	906 383	324	0.74
Latvia	13	35 476	2729	6.22
Lithuania	26	64 566	2529	5.76
Luxembourg	10	13 134	1313	2.99
Netherlands	3 972	143 493	36	0.08
Poland	851	1 274 216	1497	3.41
Portugal	234	117 260	501	1.14
Romania	291	300 343	1032	2.35
Slovakia	33	97 305	2949	6.72
Slovenia	98	38 066	388	0.88
Spain	589	529 227	899	2.05
Sweden	269	92 873	345	0.79
United Kingdom	2 146	686 392	320	0.73
EU	**19 357**	**7 202 727**	**372**	**0.85**

Source: Author's own estimation based on the assumption that there are 439 labour days in the period Q2 2018-Q4 2019.

The scope of this study is to assess the costs and benefits of retrofitting smart tachographs in heavy-duty vehicles operating in international transport by January 2020. Specifically, it addresses economic consequences of a technological upgrade of these vehicles. Moreover, it considers the related economic impacts incurred on national enforcement authorities. It also assesses the costs, which Member States' national enforcement bodies risk to incur, among others, due to retrieving and processing data from smart tachometers. In assessing both the costs and benefits, the study focuses on the EU-level analysis with consideration of the European Added Value aspect in particular.

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