THE BENEFITS OF VEHICLE REPAIR AND MAINTENANCE ON SAFETY AND SUSTAINABILITY

Report for The European Automotive Data Publishers' Association (ADPA)

Ref. 7722534

Ricardo ref. ED21000 Issue: 02-00 13/02/2025

Customer:
The European Automotive Data Publishers' Association (ADPA)

Customer reference:
7722534

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Contact:
Ed Eyton,
Ricardo,
30 Eastbourne Terrace, London,
W2 6LA, UK

T: +44 (0) 1235 753 234
E: ed.eyton@ricardo.com

Author:
Ed Eyton, Ho-Yee Lee, Michael Campbell

Approved by:
Sujith Kollamthodi

Signed

Date:
13/02/2025

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CONTENTS

Appendices

1. INTRODUCTION

Vehicle repair and maintenance activities (R&M) are essential for safeguarding against accidents caused by vehicle defects, avoiding time and money lost in nuisance breakdowns, and maximising the useful life of the vehicle. By ensuring that vehicle components are operating to the safety and environmental standards enshrined in European law, automotive workshops support drivers to keep vehicles on the road safe and sustainable. For many consumers, these activities also help to maintain the vehicle's resale value on the second-hand market, where 44% of the EU's passenger cars are bought and sold (BCG, 2023).

However, the associated costs - ranging from cheaper routine services like oil changes to more expensive repairs of critical mechanical or digital elements - can lead some to defer maintenance, prioritizing immediate savings over long-termer benefits. These affordability concerns have grown in the post-Covid inflationary period, where prices rose sharply across the spectrum of goods and services (ECB, 2024) and particularly for automotive R&M. This tension stresses the importance of accessible and affordable R&M options to encourage more regular and extensive uptake.

To underscore the importance of affordable R&M, Ricardo has been commissioned to highlight the **benefits of vehicle repair and maintenance on safety and sustainability**. Given that passenger cars comprise 87% of the European road vehicle fleet (ACEA, 2024) and petrol and diesel vehicles are expected to remain 74% of the EU's passenger car stock in 2030 (European Commission, 2024), the focus of this report is on the benefits of R&M on petrol and diesel passenger cars, commonly referred to as internal combustion engine vehicles (ICEVs). However, some commentary is also provided on the increasing importance of the battery electric vehicle (BEV) transition in automotive R&M.

The report draws upon an extensive literature review of academic and industry publications to outline the current policy and market context for the European automotive aftermarket (see Sections 1.1 and 1.2), highlight the benefits of vehicle repair and maintenance on safety and sustainability (see Section 0 and Section 2.2 respectively), and present trends in affordability of repair and maintenance in the EU (see Section 3). The report concludes with policy implications on maintaining the affordability of repair and maintenance in the EU to improve sustainability and safety outcomes (Section 4).

1.1 POLICY CONTEXT

There are two main strands of regulation in the EU road transport sector that act as the mechanism to achieve its twin overarching goals of zero road transport fatalities ('Vision Zero') and climate neutrality by 2050:

1. Minimum safety and environmental requirements for all vehicles on EU roads; and
2. Competition in the automotive aftermarket so that consumers can afford R&M to meet these standards.

For manufacturers selling vehicles on the EU market for the first time, they must first receive certification under Vehicle Type Approval Regulation (EC) 2019/2144. From a safety perspective, vehicle manufacturers (OEMs) must demonstrate that their vehicles are adequately crash tested and have a minimum requirement of safety components, such as tyre pressure monitoring devices and functioning brake systems. Periodic updates to the legislation extend these requirements as new technologies come to market that can support these goals further, such as Delegated Regulation 2021/1958 that mandates the use of intelligent speed assistance systems in new vehicles from July 2024. The type approval process also ensures that new vehicles meet stringent environmental standards, where the limits are set in separate supporting legislation. The CO_2 Emissions Regulation (EC) 2023/851 sets the tailpipe carbon dioxide (CO_2) limits that a manufacturer must meet across its fleet offering. Non-CO_2 pollutant limits on emissions like nitrogen oxides (NOx) and particulate matter (PM) are currently set under the Euro 6 Standards Regulation (EC) 2023/443, but from November 2026 the Euro 7 standards will be implemented, also setting standards on PM emissions from tyres and brakes, and minimum requirements on battery durability for electrified vehicles.

Legislation is also in place to ensure that relevant limits are met across the vehicle's entire lifetime, not just when it is first produced and sold. Periodic technical inspection (PTI) Directive 2014/45/EU requires signatory Member States (MS) to perform inspections on passenger cars in the fourth year after new registration and every 2 years thereafter as a minimum, with actual testing even more frequent in many MS

(Ricardo, 2019)[1]. During these inspections, various checks are performed with many related to safety, including checking the proper function of brakes, steering, lights, tyres, and suspension, while others focus on exhaust systems to check that harmful pollutants are below safe thresholds. The directive also requires inspectors to check for any active on-board diagnostics warnings, which indicate potential malfunctions in the vehicle's emissions control systems. Where vehicles do not pass the test requirements, the inspections raise regular opportunities for repair and maintenance activities to correct the proper functioning of vehicles back to legislative (safe and sustainable) levels. **R&M is critical in maintaining the safety and pollutant emission thresholds defined by regulation at the start of a vehicle's life.**

However, R&M is not subsidised by national governments; to empower consumers to meet these thresholds later into a vehicle's life, it is therefore necessary to ensure that R&M on private markets is affordable. Active competition in the vehicle aftermarket is one way to ensure private businesses do not charge prices that are excessive for consumers. The European Union's competition law prohibits anti-competitive agreements or practices (Article 101 of the Treaty on the Functioning of the European Union) but it offers exemptions from the application of competition law where certain benefits arise – for example, where efficiencies are generated, and/or where consumers experience a fair share of resulting benefits.

The Motor Vehicle Block Exemption Regulation (MVBER) represents a key pillar of the European Union's legislative framework for competition in the automotive aftermarket sector, keeping R&M affordable for consumers. A block exemption has been in place for the sale of spare parts and other R&M services since 1985, after the adoption of the Regulation (CEE) 123/85. This has since been renewed and amended four times (Regulation (EC) 1475/1995, Regulation (EC) 1400/2002, Regulation (EU) 461/2010 and Regulation (EU) 2023/822), showing the continuous need for such legislation due to structural imbalances in the automotive aftermarket. This was underlined by several contributions from representatives of consumers and of the independent automotive aftermarket during public consultations launched in 2019 and 2024 to gather stakeholder views on whether the MVBER remained fit for purpose. Many respondents, including consumer groups and independent repairers, emphasized the need for updated provisions to address technical information and digital data accessibility. In May 2022, the EC adopted the current MVBER (Regulation (EU) 2023/822), extending the validity of the MVBER until May 2028 and allowing more time to assess its relevance and adapt to changing market dynamics (European Commission, 2023). The MVBER is supported by sector-specific Supplementary Guidelines, which were also updated in 2023. This sector-specific legislation is complementing the more general Vertical Block Exemption Regulation (VBER), which was further amended in Regulation (EU) 2022/720.

The MVBER and its Supplementary Guidelines aim to address competition in the automotive aftermarket through recognising that the independent aftermarket increases choice for potential customers and ensures that the price of repair and maintenance work remains competitive. The price of R&M is partially determined by repair and maintenance information (RMI), which includes the detailed technical data that are needed to perform the repair and maintenance procedures, such as wiring diagrams, diagnostic trouble codes, and the repair procedures themselves. **One of the most significant items in the Supplementary Guidelines is that OEMs are required to provide access to various operators at different levels in the value chain to a specific list of RMI (provisions 62-68).** This list of specific RMI is periodically updated to adapt to current trends, such as the adoption of connected and electric mobility. Such an update occurred in 2023. However, no improvement was made to further prevent the misuse or abuse of warranties in discouraging or penalising consumers from using independent repairers rather than OEMs and their associated repairers (ADPA, 2023).

Together, regulations on vehicle type approval, periodic technical inspections, and the block exemption set the benchmark for safe and sustainable vehicles in the EU and ensure that these benchmarks are kept throughout vehicles lifetimes.

1.2 MARKET CONTEXT

Opportunities for repair and maintenance are driven not only by legislative PTI requirements but also through additional voluntary maintenance. This is often triggered by fault lights on the dashboard that notify drivers that a repair is needed, service indicator lights showing that the car is due a routine service, and/or when drivers are already in workshops to buy a new tyre, for example. Accidents on the road can also generate the need for more extensive repairs. Around 900.000 crashes happen in the EU each year (ERSO, 2024). Crash

[1] At time of publication, (Ricardo, 2019) indicate that seven European Member States conduct annual PTI testing after cars reach 5 years of age (Austria, Belgium, Bulgaria, Finland, Malta, Poland, Sweden).

incidents on roads leading to death or personal injury have fallen 5% between 2019 and 2022 (European Commission, 2024), but this does not capture other less severe crashes that may also require extensive body repair. On the contrary, other trends point to **an increase in the volume of R&M in the EU – the car parc has grown by 6% between 2018-2022** (ACEA, 2024) **and the average age of vehicles is also increasing, from 11 years in 2013 to over 12 years in 2022** (EEA, 2024)**.** Ageing ICEVs commonly require more maintenance and repair as mechanical wear and tear accumulates.

The complexity of R&M activities is also high and increasing year on year, generating challenges for workshops to stay on top of appropriate fixes to maintain vehicle safety and sustainability. Around 100,000 different vehicle makes and models have been sold in Europe since 2000, all with different repair and maintenance requirements (Roland Berger, 2024). **New technologies are also increasingly penetrating the market that are key to vehicle safety and emissions control, but simultaneously increasing the useable life of the vehicle and bring new and complex RMI**. These include: advanced driver assistance systems (ADAS), digital functions associated with increasingly connected and autonomous vehicles, and mobility as a service (MaaS) (Ricardo, 2021). In particular, the transition to hybrid and electric vehicles will bring a whole new raft of repair and maintenance information and processes. While BEVs have no tailpipe emissions control and have fewer moving parts, repairs could be more complex and costly and require more specialist training and RMI. McKinsey argues that in combination with an ageing ICEV fleet, this could generate an additional $80 billion in gross value added across the EU (McKinsey, 2024).

Capacity from R&M workshops will need to evolve proportionally to volume and complexity requirements to maintain vehicle safety and minimise emissions on European roads. **Service providers in the EU can broadly be split into workshops that have direct affiliations with the OEMs and those that have no affiliations, servicing vehicles from multiple OEMs ('independent workshops').** The latter is otherwise referred to as the independent automotive aftermarket (IAM). This distinction is important to note in the context of R&M affordability because these workshops have different price setting powers, depending on the prices they themselves are offered by OEMs or other market operators (e.g. data publishers, tool and diagnostic equipment manufacturers, parts distributors) on essential inputs like technical information and spare parts (see Section 3 for more discussion). Altogether, 3.2 million jobs are reported to be directly created by or related to the automotive aftermarket in the EU (Roland Berger, 2024). For the first 3 years of a vehicle's life, R&M is typically performed by OEMs and their associated workshops. This is either indirectly required under the vehicle's warranty or otherwise incentivised by OEMs through servicing packages on new vehicles (particularly to commercial fleets or leasing companies that pass vehicles onto the second hand market around 3-4 years old), or the offering of 'goodwill' payments to customers using contracted dealers (Ricardo, 2021). **For vehicles over four years old, representing around 70% of vehicles on European roads, the IAM is typically the preferred service provider. Overall, the IAM services the majority of the almost 280 million vehicles on European roads [62% in 2023]** (Roland Berger, 2024)**.**

2. BENEFITS OF VEHICLE MAINTENANCE

This section of the report focuses on the benefits that vehicle maintenance can provide for enhancing the safety of European road users (see Section 2.1) and in improving environmental and social outcomes (see Section 2.2).

2.1 SAFETY

There is significant evidence presented in existing literature on the safety benefits provided by regular R&M of vehicles, through:

1) **Ensuring the effectiveness of components that contribute to safety**, both traditional mechanical (e.g. tyres, brakes) and more modern electronic technologies (e.g. automated braking systems). Even minor misalignments can significantly impair the functionality of advanced driver-assistance systems (ADAS), necessitating professional calibration by technical experts in workshops.
2) **Identifying and resolving technical defects** that could otherwise lead to road accidents, improving overall vehicle safety.

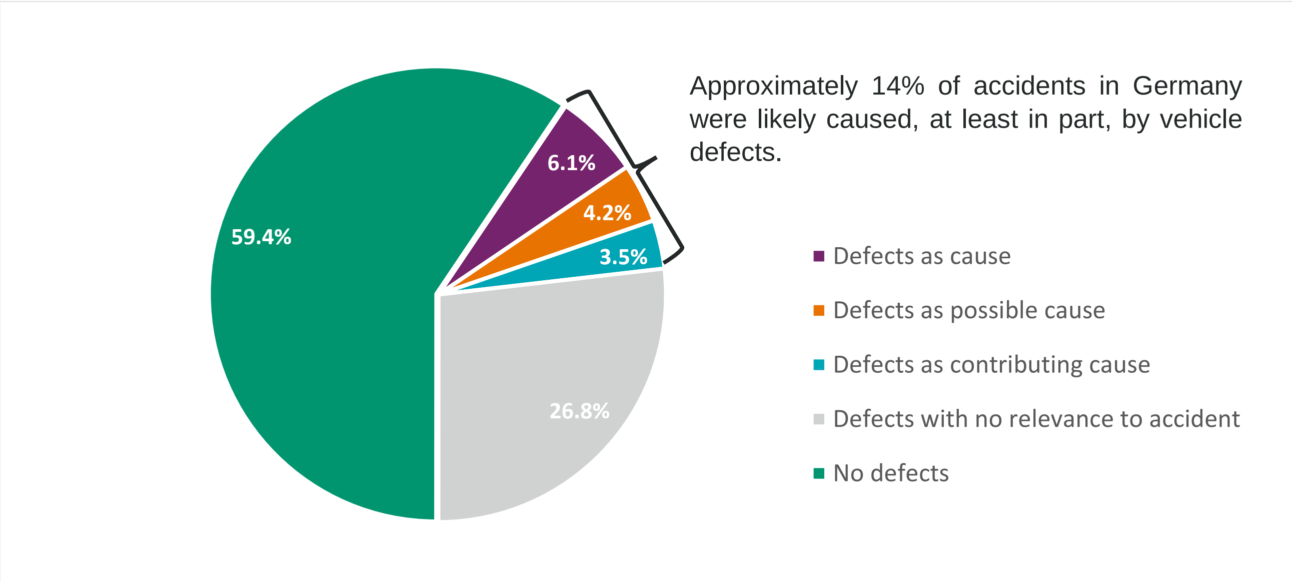
The implementation of PTI in many countries serves as a regulatory measure to ensure that vehicles are maintained properly, thereby reducing the share of cars with technical defects on the road, and therefore the likelihood of accidents. Regular maintenance between mandated PTIs could further mitigate accidents associated with mechanical failures, particularly as advanced vehicle technologies become increasingly complex and integral to safety.

The following sections outline the evidence from the literature supporting these benefits. An overview of the impact of vehicle defects on safety is provided, followed by a discussion of each benefit.

2.1.1 Overview of the impact of vehicle defects on safety

In 2022, road crashes in the EU resulted in 20,634 fatalities and over a million injuries (EC, 2024). While most crashes are attributed to driver behaviour or road conditions, a small proportion are caused by vehicle defects. A systematic review by (Martín-delosReyes, et al., 2021) found that vehicle defects contribute to 3-19% of crashes in developed countries, rising to 27% in developing countries. In Germany, for example, accident-relevant defects were found in 14% of passenger cars inspected by the German Motor Vehicle Inspection Association (DEKRA) following road accidents and traffic checks between 1977 and 2017 (Figure 2-1). Defect rates also correlate with vehicle age: DEKRA's 2020 vehicle inspections found that 8% of vehicles up to three years old had defects, rising to 20% for those five to seven years old, and 40% for vehicles over nine years, of which 25% had serious defects.

Figure 2-1 – Pie chart showing the proportion of accidents related to defects in passenger cars inspected by DEKRA in Germany following road accidents and traffic checks between 1977 and 2017.



Source: (DEKRA, 2017)

The prevalence of accidents attributed to vehicle defects is likely underestimated due to variations in how defect-related accidents are defined and investigated. In Slovakia, for example, a defect is only considered the main cause of the traffic accident if it occurred suddenly, was entirely beyond the driver's control, and this is verified by a court-appointed expert. Typically, crashed vehicles must be subject to detailed investigations in order to identify pre-existing technical defects. Most published studies on the effects of vehicle technical defects are based on registries maintained by police agencies, who often lack sufficient resources to conduct detailed post-crash analyses (Martín-delosReyes, et al., 2021). Furthermore, road accidents caused by technical defects are typically excluded from road accident statistics if they do not cause injuries, fatalities, or significant property damage (Hudec & Šarkan, 2022). Another cause for under-estimation is that often, only the primary cause of the accident is registered, while in many cases, crashes are caused by a combination of factors.

Aside from survey results on the roadworthiness of randomly selected commercial vehicles in Great Britain, there are no systematic investigations into the roadworthiness of in-service vehicles across EU member states. However, data from roadside inspections (primarily targeting vehicles likely to be defective) and PTIs suggest a high prevalence of defective vehicles in use. Beyond the minimum PTI requirements defined in Directive 2014/45/EU, member states are allowed to apply stricter standards, resulting in considerable variation across Europe including in the age at which vehicles must be first tested and the frequency of testing (Cairns, Rahman, Anable, Chatterton, & Wilson, 2014). A review of inspections found that average defect rates have not significantly decreased over the years, continue to rise with vehicle age, and show limited improvement despite advancements in vehicle technology and manufacturing (CITA, 2007).

A case study in Norway found that the accident rate increased with the number of technical defects identified in vehicles during the year before first technical inspection. The likelihood of an accident was found to increase by around 3% for each defect identified, while cars were found to have an average of 2.18 defects, corresponding to an approximate 7% higher accident rate. (Christensen & Elvik, 2007). These findings underscore the critical role of R&M for checking the condition of failure-components even before the mandated PTI intervals to prevent accidents.

2.1.2 Maintaining functionality of safety-critical vehicle components

The most common defects resulting in PTI failures include lights, brakes, tyres, and steering components (Klemenc, Šeruga, Svetina, & Tršelič, 2023) (Hudec, Šarkan, & Cződörová, 2021). In the UK, for example, poor tyre conditions consistently account for the highest percentage of vehicle defects during roadside inspections (DVSA, 2024). Nearly 20% of PTI failures in Germany in 2008 were associated with tyres and related faults; and, of these failures, nearly 25% were due to worn tyres and 12% to tyres being at the legal wear limit. It is a well-established fact that worn tyres increase stopping distances, significantly raising the risk of accidents in critical traffic situations and amplifying the severity of injuries, even at low speeds. A USA study found that PTI implementation was associated with a 2.5% reduction in rates of tyre failure; in Sweden, it was found that 7-8% of vehicles with serious defects were replaced after the introduction of PTI (Rechnitzer, Haworth, & Kowadlo, 2000). Regular R&M of the mechanical components most likely to fail, even between scheduled inspections, is crucial to pre-emptively identifying and repairing components that have significantly deteriorated with use to reduce the likelihood of accidents.

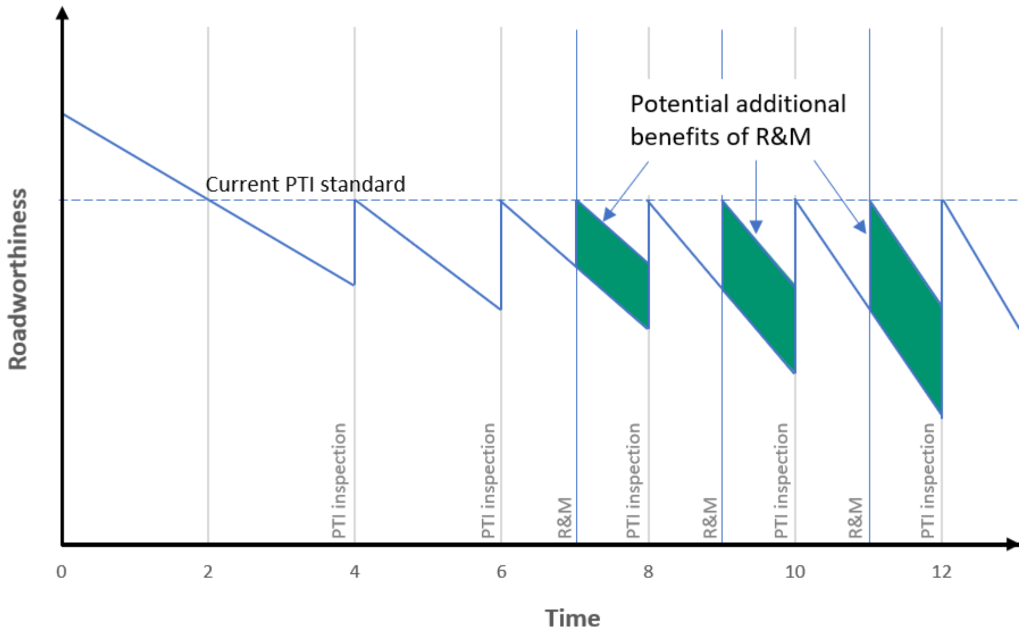
Ensuring the functionality of safety-relevant electronic systems, sensors, and software is also essential as drivers become increasingly reliant on these components in modern vehicles. These systems, such as cameras, sensors, and control algorithms, often vary in design, functionality, and calibration requirements between car brands. Research indicates that the more the system intervenes the more significant the safety benefits (European Commission, 2018). For example, the EU PROSPER project analysed the impact of technology relating to speed limitation devices on safety, and predict reductions in fatalities between 19-28%, depending on the country, in a market-driven scenario. This increases to 26-50% for a regulated scenario (Carsten, Tate, & Liu, 2006).

However, these electronic systems have been found to exhibit failure rates similar to mechanical safety systems, with the likelihood of failure similarly increasing with vehicle age and mileage (CITA, 2002). Testing, maintaining, and repairing these systems is vital because visual checks and self-diagnosis alone cannot reliably detect malfunctions. A DEKRA study demonstrated that even slight misalignments in cameras or radars can cause critical malfunctions in key safety systems like blind spot assistance and automated emergency braking (DEKRA, 2023). As vehicle safety increasingly depends on these systems, existing inspection intervals may become inadequate requiring skilled technicians with access to brand-specific RMI. In particular, independent workshops may have limited ability to invest in all the necessary tools and training to service a wide range brands and vehicle types. Affordable and accessible multi-brand RMI will be essential to be able to maintain these increasingly complex safety systems effectively.

Studies on the effect of PTI on accident rates vary significantly between countries, from no effect to reductions by up to 50% (Hudec & Šarkan, 2022). A comprehensive study in the USA (Acharya, AitBihiOuali, Matthews, & Grahams, 2023) assessed the impact of state-mandated vehicle inspections across all 50 states across 44 years. The study found a 5.5% reduction in roadway fatalities per 100,000 registered vehicles in states with these programs compared to states without. A case study in New Zealand found that vehicles without a current inspection certificate were over three times more likely be involved in crashes resulting in injuries or fatalities, while those without a tyre pressure check in the past three months were nearly twice as likely, after adjusting for other factors such as driver demographics, behaviour, and driving exposure (Blows, Ivers, Connor, Ameratunga, & Norton, 2003). In an analysis of traffic accidents in the Slovak Republic between 2016-2020 (passenger cars undergo PTI 4 years after first registration and then every 2 years), the likelihood of accidents caused primarily by vehicle defects increased as the validity of the inspection certificate approached its end: 35% occurred in the first half of the validity period compared to 65% in the second half. For vehicles over 10 years old, 13% of defect-related accidents occurred in the first year, while 87% occurred in the second year. (Hudec & Šarkan, 2022).

A large proportion of vehicle owners rely on PTIs as their primary form of R&M. The number of passenger cars on the roads with defects could be reduced further through additional R&M between inspection intervals. This has been illustrated in several case studies on increasing the frequency of PTIs. Analyses on inspections and crash data in New Zealand found that an increase from annual to half-yearly inspections that occur six years after the car's manufacture date decreased crash rates by 8% and the rate of vehicle faults by 13.5% (Keall et al., 2012). Similarly, the doubling of inspection frequency was predicted to decrease the number of heavy vehicles involved in injury accidents by 5-10% in Norway (Elvik, 2002). The additional benefits by increasing the frequency of inspections (and therefore repair and maintenance checks) are demonstrated in the figure below:

Figure 2-2 – Potential benefits of increasing PTI inspection frequency



Source: Ricardo adaptation of (CITA, 2007)

However, it has also been suggested that associations between technical defects and increased accidents may stem from driver attitudes, with less safety-conscious owners neglecting vehicle upkeep also exhibiting more dangerous driving behaviours (Christensen & Elvik, 2007). As such, these car owners might have had a higher accident rate than other car owners irrespective of the technical condition of the car. The lack of systematic studies encompassing the wider European Union presents a current literature gap.

Assuming that the observed reduction in crash rates associated with the implementation of PTIs across case studies can be applied across the broader EU fleet, our analysis suggests that, without R&M conducted at a frequency equivalent to that of PTIs at a minimum (typically every 1-2 years in Europe), the EU could experience approximately **an additional 8700 to 18300 defect-related passenger car crashes annually**. This estimate is based on the percentage of defect-related accidents in Germany (DEKRA, 2017), assuming that this trend is representative of the EU as a whole. This figure is likely underestimated, as cars in Germany are typically newer (therefore fewer defects), and the road fatality rate in 2022 (34 deaths per million inhabitants) was below the EU average (Eurostat, 2024). Based on observations by (Keall et al., 2012) and (Elvik, 2002), **doubling the time between R&M checks could further increase crashes by ~8%, corresponding to a further ~700 – 1,500 crashes**.

Our calculation assumes the middle-ground approach by using estimates for the percentage of crashes caused by both direct and contributory factors related to vehicle defects. While our estimates could be higher or lower depending on the inclusion/exclusion of the effect of cars with defects that were "possible" or “contributory” causes to crashes, we believe this approach provides a reasonable estimate that strikes a balance between being overly conservative and overly inclusive. Please see Appendix 1 for more details on how these figures were derived.

As discussed earlier in the report, due to inconsistencies in data reporting on vehicle crashes across EU member states (see Section 2.1.1), research on defect-related road accidents remains limited. Furthermore, as demonstrated by the variation in consensus among literature, PTIs are one of many factors influencing road safety, making it challenging to isolate their specific impact on overall trends in road safety in the EU. Nevertheless, PTIs conducted at the typical 1-2 year intervals cannot address defects that arise between inspections that could lead to an accident. As suggested in Figure 2-2, more frequent inspections could identify defects that may lead to accidents. However, if there is no PTI obligation and the cost of R&M is high, owners may forgo regular maintenance, increasing the risk of safety-related defects and vehicle deterioration. Therefore, ensuring R&M is affordable, widely accessible, and convenient is essential to improving vehicle safety standards.

The accessibility and convenience of R&M is arguably even more crucial on rural roads, which account for over half of traffic fatalities in 17 countries in 2022 (ITF, 2023). Drivers in these areas face heightened safety risks due to higher driving speeds, uneven road surfaces, and limited streetlighting. Independent workshops, which tend to have a higher network density compared to OEMs and affiliated dealers in rural areas, play a vital role in providing regular servicing. As such, they need to be able to properly service a wide variety of vehicle types and brands. Limited options in rural areas may deter drivers from regular R&M due to the inconvenience of traveling long distances to OEM-affiliated workshops, thereby increasing the risk of safety-critical defects going unnoticed.

It is recommended that future studies investigate vehicle maintenance habits across EU member states, focusing on the frequency of preventative check-ups conducted between PTIs. Understanding these practices is crucial for evaluating the role of R&M in vehicle safety.

2.2 SUSTAINABILITY

In addition to benefits on vehicle safety, R&M also benefits the environment through two important avenues:

1) **Reducing lifecycle CO_2 and other greenhouse gases (GHGs)**, through maintenance of engine combustion efficiency and extension of vehicle lifetimes towards optimal replacement periods.
2) **Controlling air quality pollutants like NO_x and PM to improve public health,** through ensuring proper function of emissions control systems to counteract deterioration effects.

Sections 2.2.1 and 2.2.2 present the evidence from literature underlying each of these benefits respectively.

It would be remiss to explore the environmental benefits of vehicle R&M without also considering some of the trade-offs. Counterarguments include (a) keeping older and more polluting vehicles on the road for longer increases tailpipe emissions compared to a scenario where it is replaced with a newer and less polluting model (particularly with zero emission vehicles), and (b) the embedded emissions associated with replaced parts. Point (a) is explored fully within Section 2.2.1 below. Point (b) is not explored in detail in this study given that lifecycle impacts associated with individual parts are much smaller than those embedded in the entire vehicle that would otherwise be required[2]. In addition, it is anticipated that these spare parts will increasingly be reused, remanufactured, refurbished or recycled, reducing this contribution further (Roland Berger, 2024).

2.2.1 Reducing lifecycle CO_2

Repair and maintenance practices ensure that a vehicle's components remain in optimal working condition and prevent minor issues from escalating into major problems. Repairs, particularly those conducted promptly when faults arise, also prevent the degradation of interconnected components. **By adhering to regular upkeep and timely repairs, vehicle owners can reduce spending on future repairs and extend the functional life of their cars.**

There is an environmental trade-off in extending vehicle lifetimes. On one hand, fewer vehicles will need to be produced on a fleet level if vehicles are lasting longer. The production phase accounts for around 15% of the total GHG emissions of typical ICEV cars in Europe (Ricardo, 2020), meaning that a considerable proportion of a car's emissions can be avoided entirely by negating the need for its production. Notably, this proportion is much higher for BEVs – around 66% of total vehicle lifecycle emissions (Ricardo, 2020) – meaning that extension of vehicle lifetimes will be particularly important for electric vehicles. On the other hand, older cars will remain on roads for longer, causing an increase in tailpipe emissions across the fleet. In the EU, ICCT analysis shows that between 2008 when the first CO_2 standards were introduced and 2020[3], the average CO_2 intensity of new cars across Europe fell from around 155g/km to 110g/km (ICCT, 2024). Increasingly stringent Euro standards from Euro 1 in 1992 to Euro 6 from 2014 have reduced tailpipe pollutant emissions (Ricardo EMLEG, 2024). This shows that emissions of newer vehicles are typically lower than the older vehicles they are replacing.

Considering passenger cars already on EU roads, Ricardo analysis indicates that the lifecycle impacts of running a car for one year longer (+ 1-2 tonnes CO_2e) is far smaller than the production impacts of replacing it with a new model (9 tonnes CO_2e for ICEVs, 12 tonnes CO_2e for BEVs). **Extension of vehicle lifetimes can reduce the per-year environmental impacts of vehicles on the road, contributing to broader sustainability goals.** This small relative additional impact is demonstrated in Figure 2-3 below. Use-phase emissions, indicated by the combination of emissions from fuel/electricity used in propulsion (tank-to-wheel, or TTW) and from the prior production of that fuel/electricity (well-to-tank, or WTT), increase by the dashed region, which is relatively small compared to the total lifecycle impact. Given that BEVs have zero tailpipe emissions, there is near-zero downside to extending their lifetimes where possible, reducing to zero when grids become fully decarbonised.

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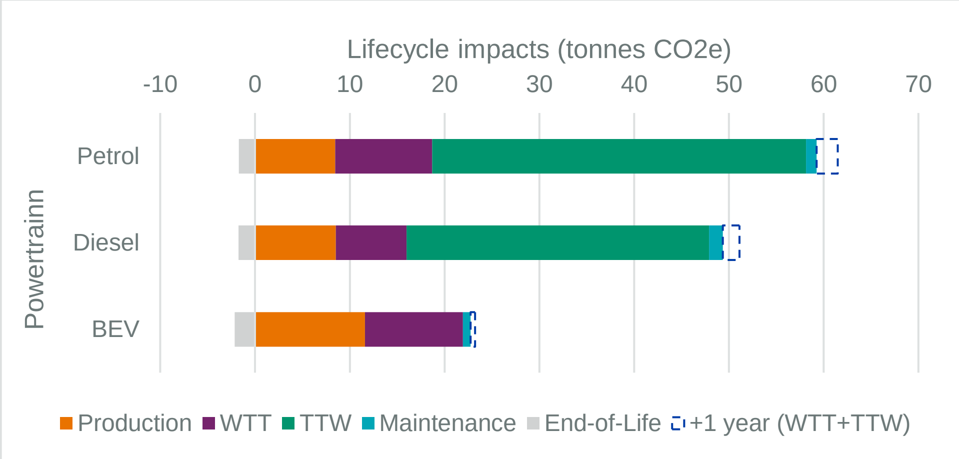
[2] Danilecki et al perform a detailed LCA analysis on Ford focus vehicles in Poland, investigating the specific contribution of repair and maintenance on vehicle lifecycle impacts. Comparing Ecoindicator scores of a baseline reference vehicle against one that needed a number of parts replaced, where the parts were chosen based on analysis of the most commonly replaced parts following accidents, they find that the replaced parts comprise 6-8% of the total lifecycle environment impact of the vehicle (Danilecki et al., 2023)

[3] In 2020 the test procedure in the EU changed from the NEDC to WLTP, changing the benchmark and making comparability of results before and after this point more challenging.

Figure 2-3: Lifecycle GWP impacts of lower medium passenger cars in the EU by lifecycle stage (2024), highlighting the additional impact of extending vehicle lifetimes by 1 year, based on (Ricardo, 2020)



Source: Ricardo analysis based on (Ricardo, 2020)

Notes: WTT – Well-to-tank, TTW – Tank-to-wheel. Total vehicle lifetime assumed at 225,000km. Extension of vehicle lifetimes by 1 year assumed to increase lifetime mileage by 10,000km.

Incidentally, assuming drivers replace expired vehicles with brand new ones, these results point to BEVs being the more environmentally friendly choice. Starting from a Euro 3 petrol car, Montaya-Torres et al. (2023) find that the vehicle choice with lowest lifecycle emissions is a BEV, where the optimal time of replacement is after 9 years of ownership to 'pay off' the embedded carbon of the ICEV (Montoya-Torres, Akizu-Gardoki, & Iturrondobeitia, 2023). This period before replacement can even be as little as 3 years when the BEV utilises multiple occupancy and is charged by a fully renewable electricity grid. However, many consumers may be financially constrained from buying a BEV. BEVs are typically more expensive to buy than comparable ICEVs and have even risen in price since 2020 despite falling battery production costs (EAFO, 2024) (T&E, 2024), although this varies across Member States and vehicle segments (IEA, 2024).

Danilecki et al. (2023) further support extension of vehicle lifetimes by assessing a wide range of lifecycle social and environmental factors beyond GHG emissions to compare short- and long-term replacement strategies for ICEVs, where the latter involves more repair and maintenance activity. They leverage industry-leading data on repair and maintenance of Ford Focus cars in Poland to compile representative life cycle inventories for input to this analysis. Their results show that EU vehicle lifetimes are less than optimal from an environmental perspective. **In a long-term replacement policy that minimises environmental impact, the optimal lifespan of an ICEV may be 20–30 years** (Danilecki, Smurawski, & Urbanowicz, 2023), which aligns with another contemporary estimate of 27 years (Montoya-Torres, Akizu-Gardoki, & Iturrondobeitia, 2023)**. Given that current vehicle lifetimes in the EU are around 22 years on average** (Held et al. , 2021)**, repair and maintenance plays an important role in extending EU vehicle lifetimes to their environmental optimum.**

Across an entire fleet, the benefits are potentially substantial. An extensive life cycle analysis from (Nakamoto, Nishijima, & Kagawa, 2019) across 15 countries finds that **following vehicle lifetime extension, net CO_2e savings are possible for all countries,** reinforcing the findings of (Kagawa, et al., 2011) in Japan. **Benefits are particularly large where vehicle lifetimes are short.** In the U.S.A., Germany, and Japan, where vehicle stock and flow are high (and lifetimes short), extending passenger vehicle lifetime by 5 years compared to the baseline footprints reduced the lifecycle passenger vehicle carbon footprints by 13.3 Mt-CO_2-eq. (−2%), 8.1 Mt-CO_2-eq. (−4%), and 7.2 Mt-CO_2-eq. (−5%), respectively. This implies that any potential interventions aiming to lengthen vehicle lifetimes (for example, by supporting R&M) could be targeted at countries with short vehicle replacement rates. Notably however, their analysis did not include non-CO_2 emissions like NO_x and PM, which could offset these benefits (see more commentary on non-CO_2 emissions in Section 2.2.2)[4].

[4] In addition, it is not clear if the authors considered whether their vehicle lifetimes reflect vehicles being scrapped, or simply exported abroad. It is widely known that Germany and Japan export their older vehicles to Eastern Europe or to the Middle East/Africa respectively. To the extent that replaced German vehicles are still being used within Europe until later scrappage, the benefits may not be as pronounced as indicated.

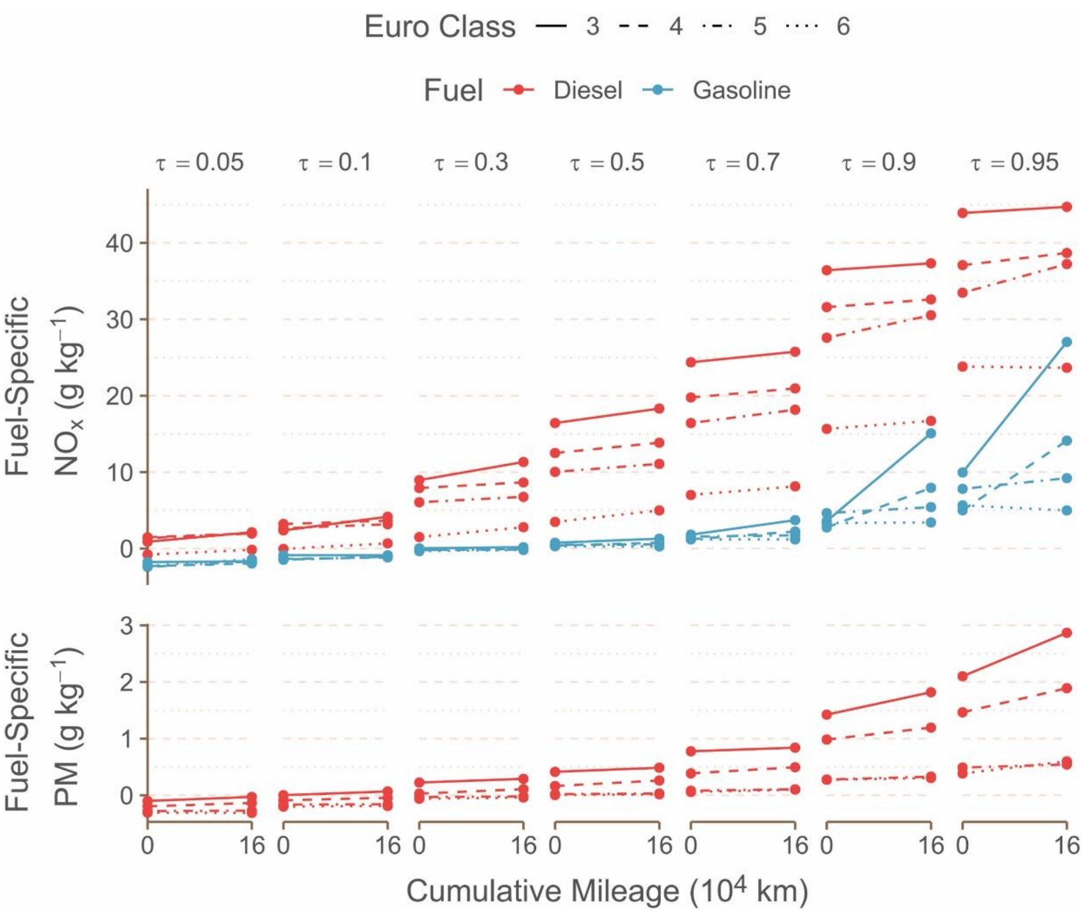
In summary, R&M of the current ICEV fleet can extend the maximum useful lifetime of vehicles, moving them towards environmentally optimal lifetimes, maximising the utilisation of the resources, and minimising the per-year lifetime impact of the vehicle.

2.2.2 Reducing air quality pollutants (NO_x, PM)

The biggest contributing factors to reducing non-CO_2 emissions from passenger cars over the past 20 years have been the introduction of emissions control systems. Selective catalytic reduction (SCR) is one of the most common forms of NO_x control technologies employed in Europe (ICCT, 2015). It can reduce NO_x by up to 95% in laboratory testing (AECC, 2020), and in real world conditions can achieve reductions of between 83-92% (JRC, 2020). NO_x absorbers or Lean NO_x traps (LNT) were also common before the introduction of the Euro 6 standards and reduced NO_x to a lesser extent, after which SCR was effectively required because of the lower emissions limit. Control technologies for PM were also introduced, such as diesel and gasoline particulate filters (DPFs and GPFs respectively). DPFs became mandatory from Euro 5 (2013) onwards and reduce exhaust PM by up to 95% (Rypos, 2024).

The reductions in air quality pollutants from emissions control technologies quoted above only reflect the position when the vehicle is first placed on the road. To take DPFs as an example, the 95% reduction is only realised if the filter is regularly cleaned, or 'regenerated'. Results from roadside testing of vehicle emissions in the UK demonstrates that air quality emissions from vehicles grow over time, particularly for older vehicles that conform to earlier Euro standards. For vehicles that are more than 11 years old (pre-Euro 5), analysis suggests that NO_x and CO emissions grow exponentially with vehicle mileage for petrol cars (Borken-Kleefeld & Chen, 2015). **Vehicles conforming to Euro 5 or later appear to have much more durable NO_x and PM control than Euro 3 or 4 vehicles over the same range of cumulative mileage** (Carslaw, et al., 2022)**, but there is still non-zero deterioration indicating a continuous need for vehicle R&M to maintain local air quality.**

Figure 2-4: Deterioration rate of NO_x and PM emissions factors by Euro class, fuel type, and bracket of emissions performance (τ)

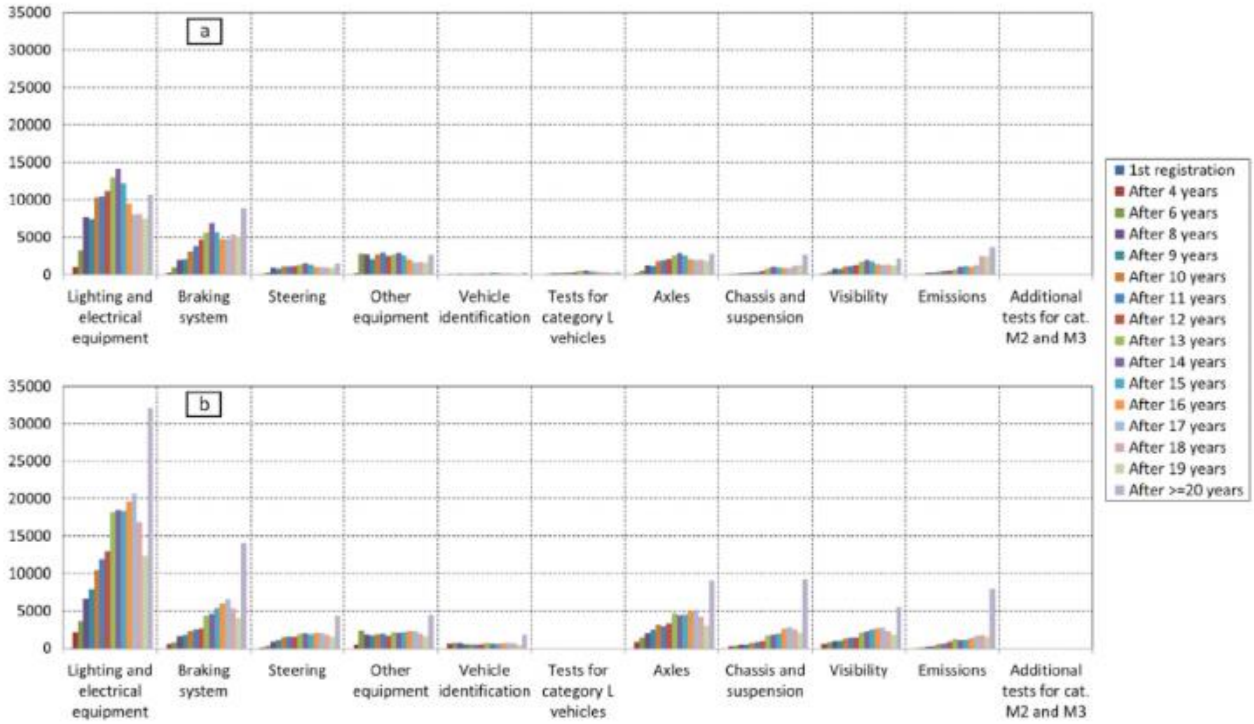


Source: (Carslaw, et al., 2022)*, based on 197,000 vehicle emission remote sensing measurements in the UK between 2017 and 2020.*

Notes: Columns represent brackets of emissions performance. For example, τ=0.05 indicates the top 5% of vehicles with the lowest emissions, τ=0.95 indicates the bottom 5% of vehicles with the greatest emissions.

PTI aims to ensure that these standards are maintained throughout vehicle lifetimes by testing exhaust gases of stationary vehicles regularly. **Analysis of the prevalence and causes of PTI failures in Slovenia between 2016 and 2022 showed that vehicles were failed on emissions grounds in around 2% of the one million annual inspections made (see Appendix 2), which is far lower than for safety reasons** (Klemenc, Šeruga, Svetina, & Tršelič, 2023)**. Each of these failures indicates a case where vehicle R&M could improve its environmental performance.** Recent JRC analysis shows that NO_x emissions from a defective SCR system in a diesel passenger car are 8 to 28 times higher compared to those obtained with a functioning SCR system, and 3 to 6 times the relative Euro 6d emission limit (JRC, 2024). Not all defects are caused by SCR degradation, but this gives an upper bound of the emissions savings that could be expected.

Figure 2-5: Cause of vehicle PTI failure as a function of vehicle age for two data years – (a) 2018 and (b) 2021



Source: (Klemenc, Šeruga, Svetina, & Tršelič, 2023)

Note: total number of inspections in each year (2018, 2021) across Slovenia total slightly more than one million. PIT tests occur every 2 years after a vehicle reaches 3 years old in Slovenia, which is consistent with most EU countries (European Commission, 2012)*.*

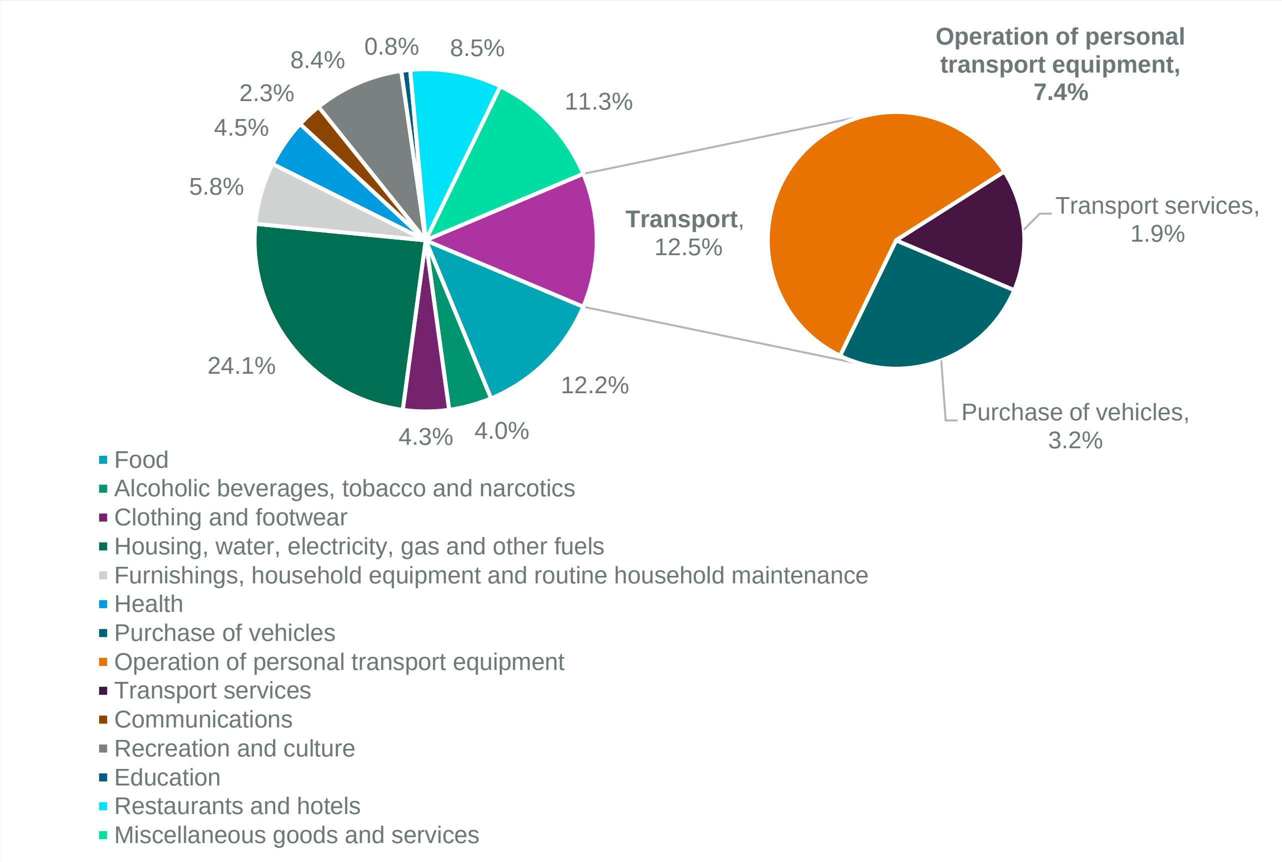
Assuming (a) that repair and maintenance reverses all of the deterioration effects observed by (Carslaw, et al., 2022), and (b) the number of poorly maintained vehicles in the EU are consistent with the proportion of observed PTI failures on emissions grounds in (Klemenc, Šeruga, Svetina, & Tršelič, 2023), **our analysis suggests that proper vehicle maintenance could save around 22,000 tonnes in NO_x emissions (3% of 2024 NOx emissions)[5] and around 1,500 tonnes in PM emissions over the next six years** (see Appendix 2 for more details on how these figures were derived).

[5] Around 830,000 tonnes of NOx is estimated to be produced by passenger cars in 2024 (ACEA, 2023).

3. FALLING AFFORDABILITY OF VEHICLE MAINTENANCE

In 2022, transportation expenses constituted a significant portion of household budgets in Europe, with one in every eight euros spent by the average European allocated to this category (see Figure 3-1 below). Within transportation expenditures, the operation of personal transport equipment dominates, encompassing costs associated with fuel, lubricants, R&M (including spare parts and accessories), and other related services.

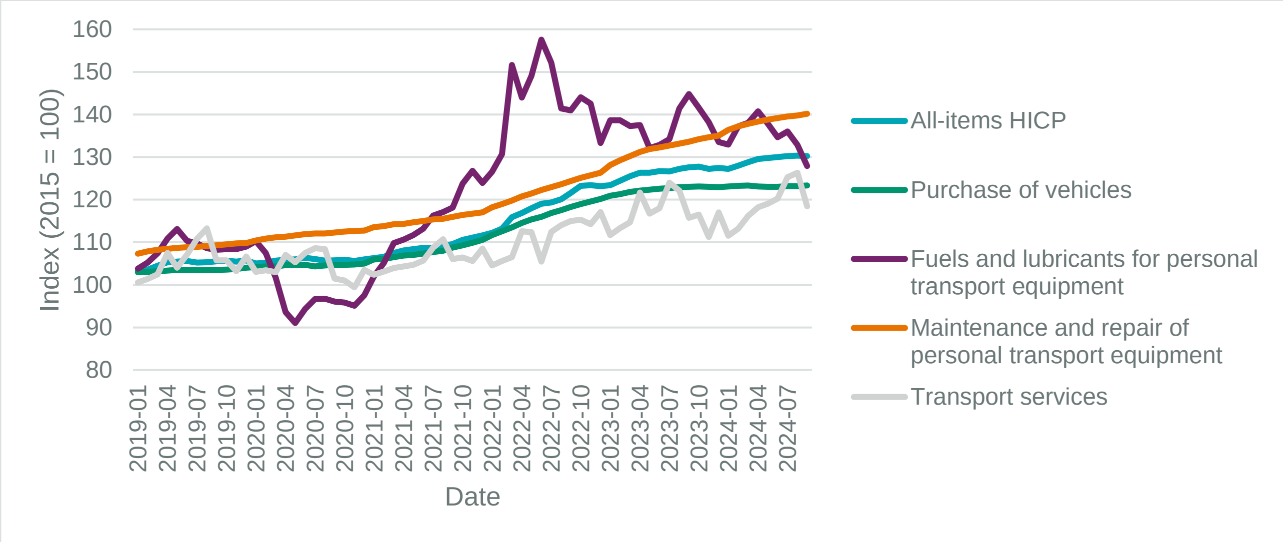
Figure 3-1: Consumption expenditure of European households in 2022 by consumption purpose.



Source: Eurostat, nama_10_co3_p3

These costs have been climbing steadily, with inflationary pressures particularly pronounced in the maintenance and repair sector. Even as general inflation pressures slowed post-COVID in 2023, as measured by the Harmonised Index of Consumer Prices (HICP), **the cost of vehicle maintenance and repair continued to outpace overall inflation every month for the past five years** (see Figure 3-2).

Figure 3-2: Price development of transport-related consumption since 2019, compared to inflation (HICP)



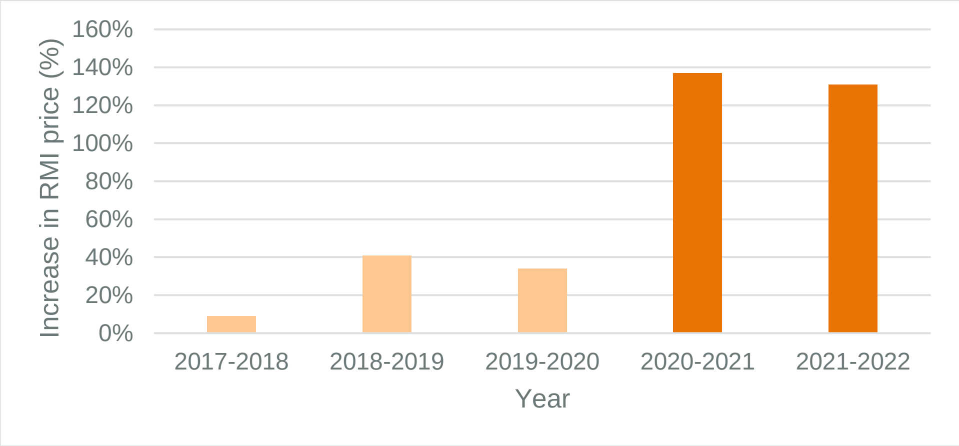
Source: Eurostat, prc_hicp_midx

Diving deeper into the causes of these price increases, the costs incurred by workshops for maintenance and repair services, which are ultimately passed down to consumers, can be divided into three main components:

- **Labour** – representing the mechanic's time required to perform maintenance or repair activities.
- **Materials** – reflecting the cost of spare parts needed to replace faulty or damaged components.
- **Other overheads** – including repair and maintenance information (RMI), tools, specialist equipment, and investments in technician training.

A major driver of increasing R&M costs is the soaring costs of RMI. Between 2017 and 2022, prices demanded from data publishers by four OEMs increased by between 341% and 4,400% depending on the OEM. **Across all OEMs, prices for RMI have spiked dramatically in recent years, rising to over 130% in 2021 and 2022** as shown in Figure 3-3 below (ADPA, 2022). While workshops directly affiliated with an OEM only need to acquire RMI from that single manufacturer, data publishers and independent workshops need to procure RMI to service a large variety of vehicle makes and models and must therefore buy RMI from many OEMs. Cost increases across all OEMs therefore have a multiplicative effect that disproportionately affect smaller enterprises in the IAM. These issues are compounded further by the fact that RMI provided by OEMs is often difficult to access and/or incomplete once accessed (Ricardo, 2021). For example, rather than providing a complete dataset of diagnostic trouble codes, OEMs often provide independent data publishers with a search function via the OEM portal, which requires a manual search and often the entry of a vehicle identification number to execute the search, which may be simply unavailable to independent operators working upstream in the supply chain. Delays in RMI provision, the embedding of RMI in OEMs' proprietary diagnostics tools, and lack of notifications when updates to RMI are made present further examples where the IAM face additional internal costs that compound the direct costs presented below (Ricardo, 2021).

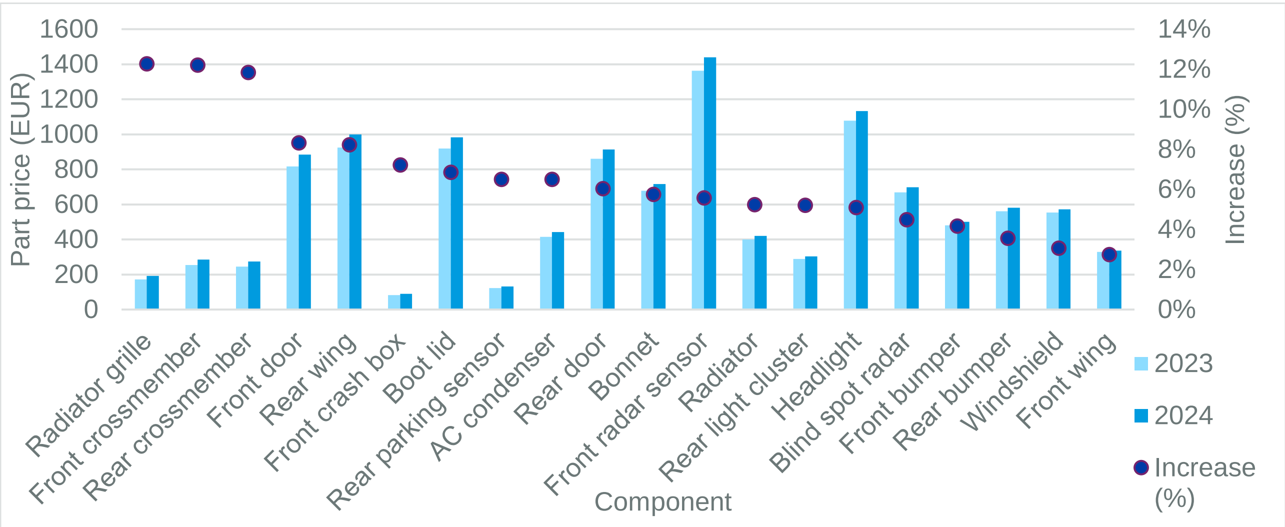
Figure 3-3: Average increase in the price of RMI faced by a data publisher across four OEMs



Source: (ADPA, 2022)

Another key determinant is the escalating price of spare parts. The German association of insurers - GDV - reports that spare part prices have risen over 6% in the past year alone (see Figure 3-4below). Prices for essential components like headlights, taillights, and trunk lids have surged, with trunk lids now costing twice as much as they did a decade ago. This trend has not only increased repair costs but also driven up insurance premiums (GDV, 2024). Meanwhile, labour costs have risen in line with broader wage trends, providing no counterbalance to the rising costs of spare parts and RMI.

Figure 3-4: Increase in part prices for representative vehicle types in Germany between 2023 and 2024



Source: (GDV, 2024)

Collectively, these surging costs are putting pressure both on independent workshops and the EU households, the businesses and the public authorities that they serve. The independent workshops generate business by being more local to customers than dealerships directly associated with OEMs and having comparable or lower prices. Price hikes in RMI for independent data publishers are likely to compel SMEs to raise prices, reducing their competitiveness in the market (Ricardo, 2021). A tipping point may eventually be reached where customers may be forced to use OEMs and their associated workshops, or otherwise choose to reduce maintenance activities. **Rising costs limit the ability of EU households and other corporate and institutional customers to afford necessary vehicle repair and maintenance. This trend poses safety and sustainability concerns, as insufficient maintenance can compromise vehicle performance and longevity, ultimately increasing environmental and safety risks.**

4. CONCLUSIONS

This report has consulted a wide range of academic and industry literature to investigate the benefits and challenges of repair and maintenance (R&M) in the EU passenger car market. **The evidence presented shows that affordable R&M is crucial to maintain the standards set at vehicle type approval towards the achievement of EU policy goals for safety and sustainability, while continuing to provide the consumer with choice and value.**

Modern vehicles feature increasingly complex safety systems, incorporating advanced electronics, sensors, and software essential for safety. While these systems provide significant safety benefits, their failure rates are comparable to mechanical systems and tend to rise as vehicles age. Regular maintenance and testing are critical as defects may not be detectable through visual checks or self-diagnosis alone. Even minor sensor misalignments can have fatal consequences, underscoring the need for skilled technicians having all the necessary resources at their hand. Evidence suggests that failures affecting vehicle safety and likelihood of accidents increase with vehicle age. While periodic technical inspection (PTI) identifies many safety defects, inspections only typically occur every 2 years in Europe. Regular R&M can further reduce accident risks between inspections. Assumptions-based estimates suggest that R&M conducted at the typical 1-2 year frequency of PTIs could help to prevent around 8,700 to 18,300 defect-related car crashes annually across the EU. Defects can accumulate between inspections, highlighting the additional role that R&M can play in reduce crashing rates on top of PTIs. Evidence suggests that doubling the frequency of R&M checks (beyond the minimum set by PTIs) could further reduce accident rates by ~8%, corresponding to a further 700 – 1,500 reduction in crashes.

R&M also helps mitigate emissions deterioration due to mechanical wear, clogged filters, and failing sensors and control systems, which worsen as vehicles age. Older vehicles risk excessive emissions that may not be identified via on-board diagnostics sensors and PTI checks. Deterioration can be rectified through proper R&M. Under some simplifying assumptions, we estimate that proper R&M can prevent failure of key emissions control systems, with the potential to address some of the estimated 22,000 tonnes of NOx and 1,500 tonnes of PM emissions from petrol and diesel cars with emissions system faults in the EU over the next five years. Cost-effective R&M is also crucial in extending the lifetime of vehicles. Evidence suggests EU vehicles are scrapped prematurely, despite one additional year of operation emitting far less GHGs (1–2 tonnes CO_2e) than producing a new vehicle (9–12 tonnes CO_2e). This shows that R&M can play a pivotal role in reducing the average annual emissions of the European fleet.

Recent sharp increases in the costs of R&M are deeply concerning, in that they have the potential to limit the amount of R&M performed by European customers and prevent the benefits explored above from occurring. Costs increases for repair and maintenance information (RMI) and to a lesser extent for spare parts have considerably accelerated in recent years. This is likely to disproportionately impact data publishers and independent workshops, many of them SMEs, because unlike OEMs and their associated workshops, they must purchase more expensive RMI across many vehicle manufacturers. Costs may soon increase to the point where independent workshops will be unable to compete, limiting the choice of and access to R&M across the EU. Proper R&M requires complete access to RMI, specialist tools, diagnostics equipment, and will increasingly require training to service new technologies.

To improve affordability of R&M, EU policymakers could promote more effective competition in the automotive aftermarket. This could be done by removing undue commercial or technical restrictions that (a) prevent new entrants on the market, or (b) restrict the ability of the IAM to compete on an equal footing with vehicle manufacturers and associated workshops that have direct access to the information and parts provided by the original vehicle manufacturer. Given that European public budgets are under extremely high pressure, subsidies or tax rebates to consumers and/or business in the aftermarket are unlikely. Some specific mechanisms through which this can be achieved include:

- **Improve enforcement of existing legislation:** currently, there is limited enforcement of aftermarket provisions in Type Approval Regulation 2018/858 and the Motor Vehicle Block Exemption Regulation 2023/822. A more proactive commitment of enforcement authorities could help, whether the European Commission itself or national Type Approval Authorities and National Competition Authorities. While, individual cases can sometimes be dismissed in isolation, when put together they may create a picture of a systematically unbalanced market where more powerful market players may be misusing or abusing their position. Prompt investigation and sanctions where non-compliance is demonstrated could provide a greater deterrent.

- **Upgrade of existing legislation**: The existing legislative framework could be further adapted to reflect new market realities and ensure that R&M remains a possible and affordable option for European customers. Ongoing discussions on the Delegated Act amending Article 61 of the Type Approval Regulation 2018/858 could include clear restrictions to ensure that fees to access technical information don't become deterrent. The Motor Vehicle Block Exemption Regulation 2023/822 is expiring in 2028 and is due for evaluation in the next years. Its prolongation and upgrade could further strengthen competition in the automotive aftermarket and ensure that the IAM can continue to provide a competitive alternative to vehicle manufacturers and their networks. Other legislation addressing specific items of technical information in the automotive sector (e.g. the "circularity vehicle passport" mentioned in the proposal for an End-of-Life Vehicle Regulation), should similarly ensure that fees for accessing such information may not hamper competition.
- **Introduction of new legislation**: The uptake of vehicles equipped with a growing number sensors and other electronic equipment is profoundly changing R&M. RMI is currently mainly relying on static information, while data generated "in-vehicle" (e.g. built-in diagnostics) could serve to individualise RMI for each vehicle depending on the actual status of its various parts and components. Access to the technical data generated by these equipment will therefore be key to propose new predictive and remote services and solutions. With proprietary telematics systems deployed by vehicle manufacturers, there is however a risk that such information will not be available, or accessible only through potentially deterrent conditions, limiting the ability of the IAM to innovate and to compete. A sector-specific legislation which complements the Data Act (and as foreseen by it) should remedy this, and has been called for by the automotive sector, consumers, and insurers.

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APPENDICES

APPENDIX 1: CALCULATION OF POTENTIAL ACCIDENT REDUCTIONS

This Appendix contains the methodology and assumptions used to estimate the total number of avoided crashes in the EU due to implementation of PTI as a proxy for regular vehicle maintenance (see Section 2.1).

- **Determine the average number of crashes in the EU**. Using data from the European Commission's latest statistical report on road safety, the average number of road crashes annually over the last 10 years was calculated to be 907,482. (European Commission, 2024). EU statistics do not include damage-only crashes, and do not disaggregate crashes by road user type.
- **Determine the average number of defect-related passenger car crashes in the EU**. Based on data from DEKRA (2017), vehicle defects are the main cause or a contributory cause to 9.6% of crashes (6.1% and 3.5% respectively). Assuming these are reflective across the EU fleet, this corresponds to roughly 87,118 of the 907,482 crashes being from passenger cars with defects.
- **Determine the percentage reductions in accident rates correlated to R&M (using PTI as a proxy).** Estimated percentages of accident reduction were taken from across 10 studies conducted between 1984 – 2019. Due to slight differences in methodology and context between studies (e.g. variation in PTI standards across countries), the interquartile range of 10 - 21% was used to account for variability in the data.
- **Calculate the increase in number of passenger crashes in the absence of regular R&M (at the typical 1-2 year frequency of PTIs).** Based on the 10-21% reduction in accident rates associated with PTIs, it is estimated that if vehicle owners do not conduct regular R&M, at a minimum of typical PTI frequencies, this could result in an at least additional 8,712 to 18,294 passenger car crashes annually in the EU.

APPENDIX 2: CALCULATION OF AIR POLLUTANT EMISSIONS SAVINGS

This Appendix contains the methodology and assumptions used to estimate the total air quality pollutant savings that could be realised in the EU as a result of proper vehicle maintenance (Section 2.2.2).

- **Determine proportion of vehicles with excessive emissions based on PTI failures**. Failure rates are assumed at 2% consistent with (Klemenc, Šeruga, Svetina, & Tršelič, 2023). They find a marked increase in PTI failure caused by emissions after vehicles reach 20 years old - which is roughly when the Euro 4 standards are introduced (2006). The fleet is therefore split into pre-Euro 4 and Euro 4+.
- **Apply excessive emissions rate to current EU fleet, deriving current vehicles that are poorly maintained**. The size and fuel split (petrol, diesel) of the current fleet is taken from (ACEA, 2024). The age split of the fleet by Euro standard is taken from (ACEA, 2023).
- **Determine the lifetime (years) and travel distance (km) remaining until these poorly maintained vehicles are scrapped**. As above, current vehicle lifetimes are assumed at 22 years consistent with (Held et al. , 2021). Given that Euro 4 applied from 2006-2010, then taking the midpoint this implies that Euro 4 vehicles have 6 useful years left. Pre-Euro 4 vehicles were assumed to have only 1 year remaining. Vehicle mileage tends to get smaller with age – we therefore assume an annual distance travelled of 10,000km for an older vehicle as reported in (Ricardo AEA, 2015), which is lower than the European average.
- **Combine remaining distance with emissions factors to calculate baseline emissions until scrappage**. COPERT 5.8 emissions factors for ‘Small’ petrol and diesel vehicles were used (EMEP/EEA, 2024). Only NOx and PM are considered as they are the most significant of the controlled pollutants for human health impacts. Given that the poorly maintained fleet is split into pre-Euro 4 and Euro 4+, Euro 2 emissions factors were used for the former and Euro 4 factors for the latter.
- **Determine the emissions that could be saved (%) after proper maintenance**. We take the observed emissions deterioration rates in (Carslaw, et al., 2022) from the top 5% of vehicles with the greatest emissions (τ = 0.95), because the observed failure rate in (Klemenc, Šeruga, Svetina, & Tršelič, 2023) is less than 5%. Effective R&M is assumed to restore emissions performance to that of an average vehicle within the same Euro class.
- **Multiply baseline emissions by the savings rate to determine total emissions savings.**

APPENDIX 3: ACRONYMS

ADAS – Advanced Driver Assistance System

ADPA – Automotive Data Publishers' Association

AECC – Association for Emission Control and Climate

BCG – Boston Consulting Group

BEV – Battery Electric Vehicle

CITA – International Motor Vehicle Inspection Committee

DPF – Diesel Particulate Filter

DVSA – Driver and Vehicle Standards Agency (UK)

EAFO – European Alternative Fuels Observatory

ECB – European Central Bank

EC – European Commission *or* European Community

EEA – European Environment Agency

ERSO – European Road Safety Observatory

EU – European Union

GDV – Gesamtverband der Versicherer (German insurance association)

GHG – Greenhouse Gas

GPF – Gas Particulate Filter

IAM – Independent Automotive Aftermarket

ICCT – International Council on Clean Transportation

ICEV – Internal Combustion Engine Vehicle

ITF – International Transport Federation

JRC – Joint Research Centre

LNT – Lean NOx Trap

MaaS – Mobility as a Service

MS – Member State

MVBER – Motor Vehicle Block Exemption Regulation

OEM – Original Equipment Manufacturer (vehicle manufacturer)

PM – Particle Matter

PTI – Periodical Technical Inspection

R&M – Repair & Maintenance

RMI – Repair and Maintenance Information

SCR – Selective Catalyst Reduction

SMEs – Small- and Medium- sized Enterprises

T&E – Transport & Environment

TTW – Tank-To-Wheel

VBER – Vertical Block Exemption Regulation

WTT – Well-To-Tank

T: +44 (0) 1235 75 3000

E: info@ricardo.com

W: www.ricardo.com