Private Vehicles & Public Roads – A Review of Trends and Effects

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Introduction

As traffic signals engineers we may take a view rather like the view that teachers take about teaching, i.e. that it would be great if it weren't for all those annoying pupils. Traffic engineering would be great if it weren't for all those annoying vehicles trying to get through the network.

Starting with the premise that the vehicles are annoying because we have so little control over how many there are, and their characteristics, this paper looks at how vehicles are changing and the increasing impact this has on the capacity of the network, which is unable to change at the same rate or with the same level of flexibility. It addresses various changes and for each one offers some reflection on the effect of the change on the network and the ability of the network to convey the traffic.

After setting out some general observations on roads the main focus of this paper is on the vehicles.

The Roads – An Overview

Roads are in the main a public facility operated and managed by local or national highway authorities. They are capital intensive assets and typically are constrained and bounded by land ownership, planning and other institutional constraints. That is, it is neither easy nor quick to alter road capacity nor extent.

Further the condition or quality of the road affects traffic capacity, and traffic modality. For example, poor road surfaces both deter cyclists but also reduce traffic speeds. Break-up of the surface at the edge of the carriageway reduces the effective width.

Against this background of constraint operators of roads are also limited in the ways that they can adapt available road space to achieve best network operation. This reduces to the allocation of carriageway and pavement lane allocation, the provision of one-way routes, and/or the use of signals.

The Vehicles

The majority of the vehicles, the motorcycles, cars, vans and lorries on our roads are privately owned, either by individuals or by businesses. They are bought from businesses and used largely for private, or business uses. While there is a level of

regulation about certain characteristics, (vehicle registration, placement and colours of lighting, maximum dimensions and weight, and more recently emissions,) they are in many ways uncontrolled, and one only has to stand by the roadside for a few minutes to assess the variety of characteristics.

So why are there these differences? Clearly freight carrying vehicles will differ from personal transport. For freight, the overall description of a vehicle is that it is a box or tank in which things can be loaded, moved and unloaded.

Figure 1 Porsce 911 (Image © Porsche UK)

But why so much variety in private vehicles?

Figure 2 Isetta Bubble Car (Image Courtesy of Wikipedia)

A bubble car and a Porsche 911 both only convey two people and a shoebox sized suitcase. This is about status, and social standing, for many of us cars are a part of our identities. For others (petrol-heads) they are a recreation.

This sounds simple enough, we live in an economy where freedom of choice is recognised, and we love our cars.

But there are consequences.

How Many Vehicles

There are a lot of cars on GB roads. (The DfT publishes separate data for Northern Ireland.)

Year	No of GB vehicles
1895	1
1900	750
1930	1,000,000 *
1967	10,000,000 *
1995	21,394,103
2010	28,420,877
2022	32,169,932

* These values interpolated from graphical data.

Table 1 Registered Vehicles in GB

And ownership is pervasive.

Year	No of GB vehicles	Population	Car ownership 1 car per N
1895	1	37800000	37800000.00
1900	750	38200000	50933.33
1930	1,000,000	46000000	46.00
1967	10,000,000	54000000	5.40
1995	21,394,103	58300000	2.73
2010	28,420,877	62000000	2.18
2022	32,169,932	70000000	2.18

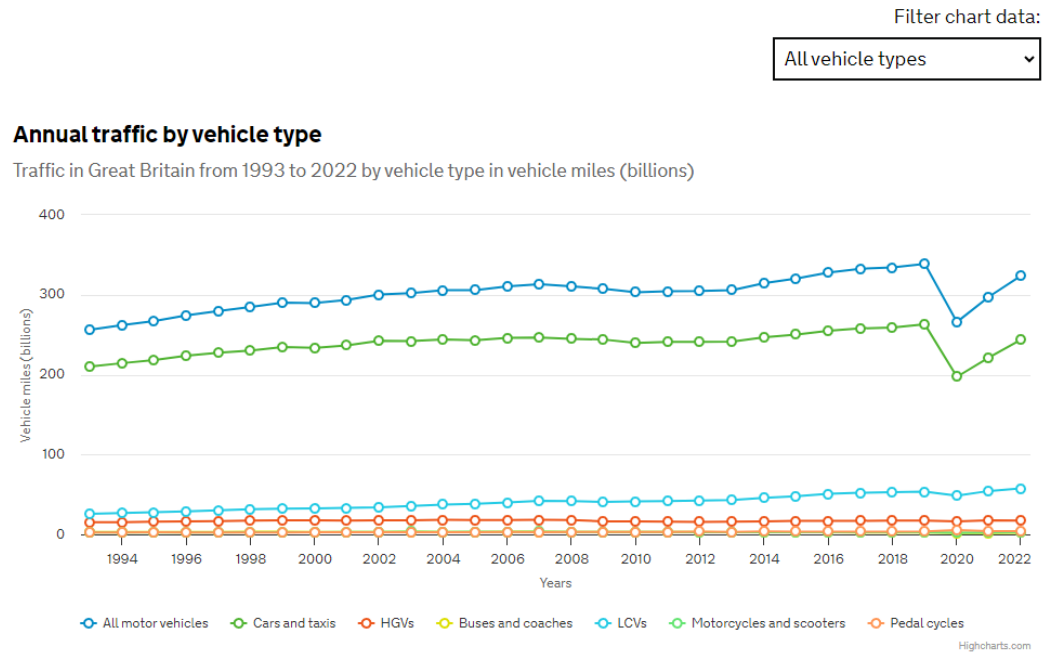
Table 2 Relative accessibility to a vehicle

There is one vehicle for every 2.18 people in the country. Even allowing for the fraction that are freight vehicles then if those under 17 are excluded from the data then a very large fraction of the population own a vehicle. More may have access to a car even if they do not own one.

Mileage Driven

We don't just like having cars, we like driving them too. DfT data offers the following total driven miles in GB.

- 2012: 305 billion vehicle miles
- 2022: 325 billion vehicle miles



Whilst historically significant, the long term trends can be misleading in most cases due to the extraordinary circumstances observed as a result of the coronavirus pandemic. Vehicle miles travelled in Great Britain have had year-on-year growth in each year between 2011 and 2019. Following a sharp decline in 2020, traffic levels in 2021 and 2022 increased, but 2022 levels still remain lower than the 2016 levels. Therefore, to say traffic has fallen since 2016 would misconstrue as the overall decrease is entirely due to the decline in traffic levels observed during the pandemic.

Figure 3 Average Annual Driven Mileage by Vehicle Type[1]

Duty

While thinking about numbers of vehicles we make a segue to the Government position on traffic. A tax on vehicles was introduced in 1888 and tax on petrol introduced in 1908. In 1920 vehicle excise revenues were hypothecated for road improvements. This hypothecation ended in 1937 with the revenues going into general Government funds.

An order of magnitude calculation taking average vehicle tax at £200 suggests that Government receive ~£6.4B (£6,400,000,000.00) a year from vehicle tax. There is also the revenue income from MOT fees and fuel duty.

Roads On Which To Drive

In 2016 there were 246,500 miles of GB roads an increase of 600 miles (0.25%) from 2016 and an increase of 6000 miles (~2.5%), from 1995[2], during which period vehicle numbers increased by ~ 50%. Put differently, if everyone headed out on the August bank

1 https://roadtraffic.dft.gov.uk/summary#:~:text=Motor%20vehicle%20traffic%20on%20Great,to%20323.8%20billion%20vehicle%20miles.

2 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/611185/road-lengths-in-great-britain-2016.pdf

holiday there would be approximately ~ 128 vehicles per mile of roads. The key point here is that the levels of increase in roads are substantially lower than the increases in vehicle over the same period.

What are the consequences of more cars being driven more miles? If the road length is not increasing significantly then there is more wear on the existing roads, i.e. a worsening of the road condition. We revisit this idea when looking at changes in vehicle weights below.

Vehicle Dimensions – Permitted Limits

The applicable legislation that limits vehicle dimensions is Road Vehicles (Construction and Use) Regulations 1986 (as amended)[3]. The following data are extracted from this regulation.

Width

With one or two exceptions the maximum width of a vehicle on UK roads is 255 cm.

Height

The maximum height 503cm for clearance under (most) highway bridges (busses not to exceed 4.57m).

Length

For a rigid bodied vehicle 12m long (except busses which may be up to 13.5m, although the Department seems to be silent on why busses are allowed an extra 1.5m.) There is of course more, but for the purposes of this paper the interesting point is that there is no specific constraint on the width of vehicles below this maximum.

Weight

And weight: A motor car with no more than four wheels, can weigh in at up to 14,230kg and a fully loaded HGV (tractor and trailer) 44,000 kg.

Trends in Size & Weight

Vehicles are getting wider. On average European vehicles are increasing in width by 1cm every 2 years (10 cm 2003 – 2023). US data 2013 – 2023 suggests a higher figure of 2.5 cm p.a. increase in vehicle width.

Wider vehicles have a more insidious effect. In the last 20 years for a single carriageway road with parking on one side the parked cars have consumed 10cm extra width and two lanes of moving traffic have taken up a further 10cm each, so the road has

[3] https://www.legislation.gov.uk/uksi/1986/1078/contents

effectively got narrower by 30cm. This leads to a reduction in vehicle speeds and an increase in congestion.

And they are getting longer, US data indicates ~ 5cm p.a. (over the period 2013 – 2023).

So how many vehicles are in a 30m queue now compared with 20 years ago? Are our traffic engineering equations still valid?

Larger vehicle put pressure on packing spaces meaning less vehicles can park on any give length of road.

Weight

It is generally accepted that road wear increases as the fourth power of the weight[4].

If vehicle weights have increased by 15% since 2001[5] then the corresponding road wear has increased by $1.15^4 = 1.749$, i.e. a 75% increase in road wear.

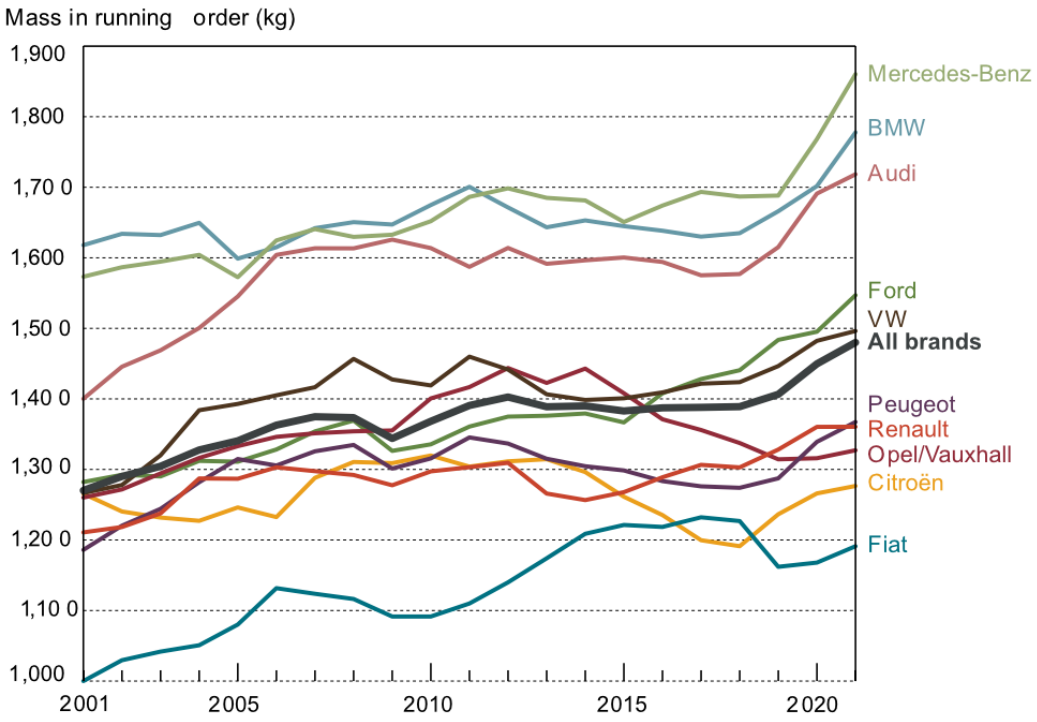


Figure 4 Changes in Vehicle Weights

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https://www.pure.ed.ac.uk/ws/portalfiles/portal/313811988/Read_wear_EV_CTEP_Publishers_Copy.pdf

5 https://ecf.com/news-and-events/news/eus-motor-vehicles-need-go-diet

"In 2020, the average mass of new cars in the EU and the UK increased to 1,457 kg, 3% higher than in 2019 and 15% above 2001 levels."

However, comparatively it is the HGVs and other large vehicles that cause the majority of the wear. A 44 tonne HGV causes 3.7 million x as much wear as a 1 tonne Kia Picanto

Electric HGVs are likely to weight more at around 48 tonnes so will increase wear over their internal combustion predecessors by a further 41%.

This largely affects the arterial network, which is designed for this mix of traffic. But busses run on a much wider range of road types. Electric busses weight in comparably to HGVs. With more and heavier vehicles driving over the same aging road network it is perhaps no surprise that we see as many potholes as we do, with the consequent effects on traffic movement.

Energy Use

While not of directly relevant to the interaction of vehicles with roads, a quick study of the energy used in the life of a vehicle can reveal some interesting factors that might indirectly inform modal choice of transport by the public and may affect future car ownership or use.

Green NCAP[6] is the recognised independent body that assesses the environmental credentials of new vehicles.

Summaries below are the credentials for a Kia Picanto and a Tesla Model S

	Kia Picanto	**Tesla Model S**	**Notes**
Weight (kg)	1019	2095	
Energy per km over whole life (kW.hr/km)	0.78	0.78	240,000 km over life of vehicle

Table 3 A Comparison of Modern Vehicles

It is also interesting to look at the Green NCAP analysis of how that energy is used over the whole lifecycle of the vehicle.

[6] https://www.greenncap.com/lca-tool/

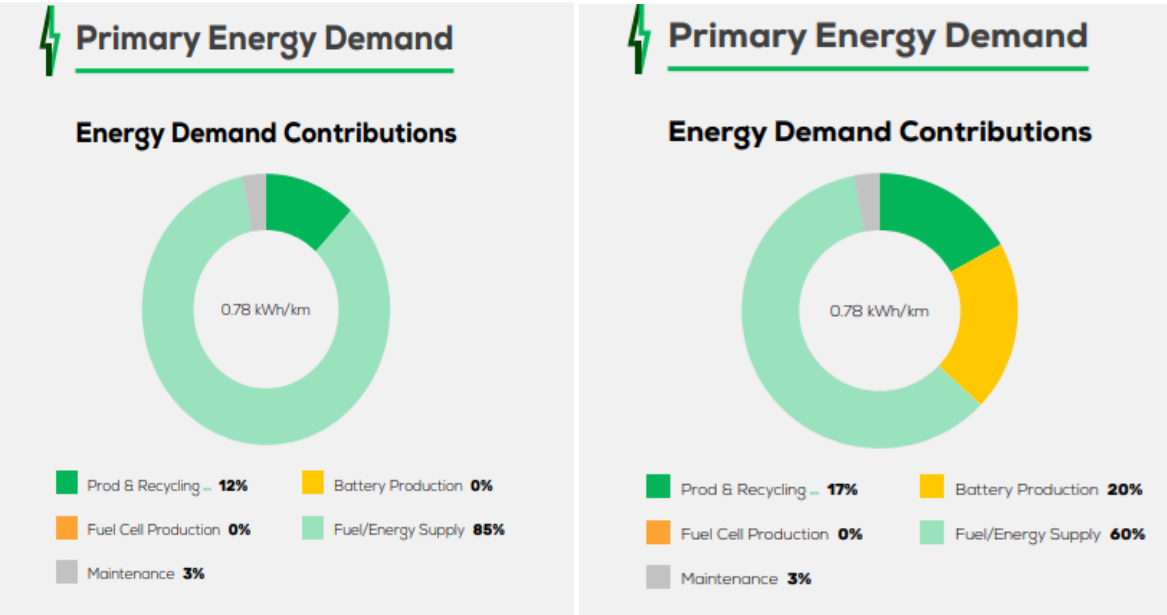

Figure 5 Green NCAP Data Kia Picanto (left) Tesla Model S (right)

The Tesla has used ~ 1/3 of its total energy (= money) in production, battery production and recycling. For these same processes the Kia has used only ~ 1/8 of the total energy. Consequently, at the point of sale the manufacturer of the Tesla needs to recover far more cost than the Kia.

As internal combustion is legislated against the entry cost to private mobility will increase and inevitably less people will be able to afford their own vehicles.

Will this mean less vehicles on the road?

Given the vehicle ownership data, probably not.

New Modalities – Electric Scooters

The last area this paper briefly considers is the recent advent of electric scooters and the issues around their regulation. Current scooter rental schemes are similar to bike rental schemes being largely an urban phenomenon and increasing the number of road users. While there are health benefits arising from cycling, e-scooters seem to offer the opposite effect with many authorities seeing significant increases in KSI data on their networks with the increase being attributed to e-scooters.[7] STATS19 data July 2022 – June 2023 recorded 1269 e-scooter collisions, with 7 fatalities and 390 serious injuries.

[7] https://www.theguardian.com/world/2024/jan/14/tiny-proportion-of-e-scooter-injuries-appear-in-official-uk-data#:~:text=DfT%20analysis%20of%20reported%20road,killed%20and%20390%20seriously%20injured.

It is suggested that these data are only about 25% of the real levels. Even the reported levels represent ~ 1% of the total UK road KSI levels[8].

If there is an emergent mobility poverty challenge in the UK then e-scooters offer some sort of solution, but with adverse consequences not yet fully understood. This topic warrants a review of its own in the context of traffic control, road space, and safety.

Summary

This paper is intended to assist traffic engineers not with any specific scheme or technology, but to offer a view of the changing context and the effects that can have on traffic control.

It sets out the trends in the key characteristics of vehicles on our roads, and how and to some extend why these are changing. It reflects, albeit briefly, on how these changes may affect he movement of traffic, network capacity and network speed, and the modalities of the traffic as these are all input factors when considering traffic control strategies and calibration.

[8] https://www.gov.uk/government/statistics/reported-road-casualties-great-britain-annual-report-2022/reported-road-casualties-great-britain-annual-report-2022#:~:text=In%20reported%20road%20collisions%20in,of%2012%25%20compared%20to%202019