IMPACT OF COASTING ON FUEL CONSUMPTION OF HEAVY VEHICLES




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Abstract

Transportation is one of the primary contributors to the global climate emergency, largely due to greenhouse gas emissions from diesel-powered heavy goods vehicles. Promising avenues, such as electrification, offer long-term solutions to fossil fuel dependency. In the short term, however, widespread implementation of existing tools and fuel-efficient practices can mitigate the environmental impact of road freight. Ecodriving is a low-cost, low-complexity solution that can yield significant fuel savings. This study investigates the potential benefits of coasting by using in-service telematics data collected on a 182 km delivery route in the UK. By advising an experienced driver on pre-determined coasting opportunities, the total coasting distance was increased by up to 22 km (47%), leading to a 4.4% decrease in fuel consumption and savings of approximately GBP 3 per trip. For a general stretch of road, a 10% increase in coasting distance accompanied a 2% reduction in fuel consumption. These findings were used to develop practical and straightforward coasting strategies, which drivers can readily implement.

Keywords: Ecodriving, fuel efficiency, coasting, decarbonisation

1. Introduction

Transport is the UK's largest contributing sector to CO_2 emissions (Department for Business & Energy, 2018). In 2019, approximately 4% of the UK's total greenhouse gas emissions were due to heavy goods vehicles (HGVs), up from around 2.5% in 1990 (Department for Transport, 2021). Despite growing interest in alternative fuels and electrification, more than 99% of HGVs in the UK are diesel-powered, compared to 97% in 1994 (Department for Transport, 2021). Figure 1 (adapted from Department for Transport, 2017) shows how fuel consumption of HGVs (in miles per gallon, MPG) changed between 1993 and 2016. For all but $3.5\,t - 7.5\,t$ rigid trucks, average MPG has hardly changed since the introduction of the Euro 4 vehicle emissions standard in 2005[1].

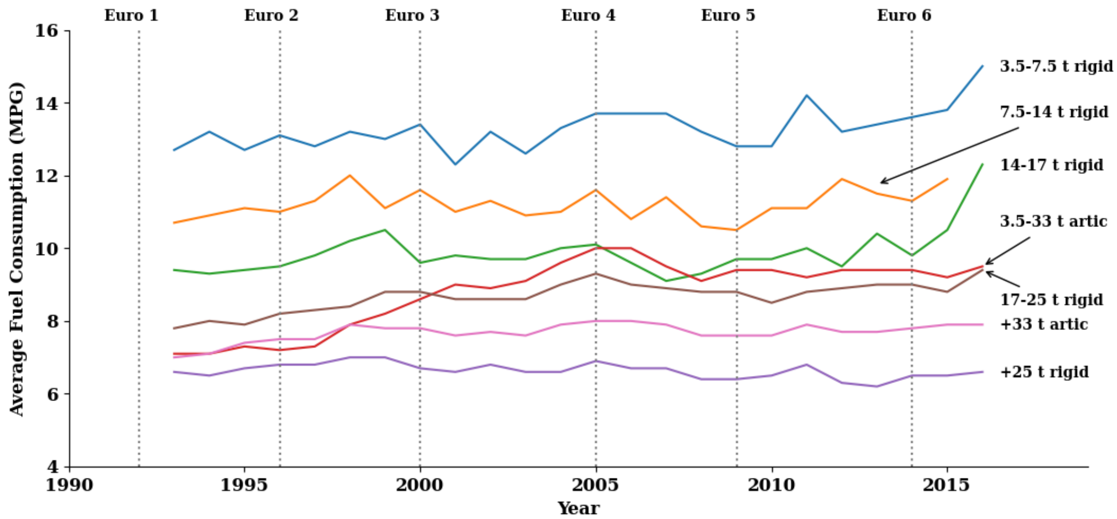


Figure 1: Average fuel consumption of HGVs in the United Kingdom 1993-2016

Fuel consumption of HGVs is often measured using the mass fuel index, $FI_m\left(\frac{l}{t\cdot km}\right)$, to account for differences in vehicle mass and payload. FI_m is given by:

$$FI_m = \frac{Fuel\ Used\ (l)}{Gross\ Vehicle\ Mass\ (t) \times Distance\ Travelled\ (km)} \tag{1}$$

On this basis, the average energy consumption of UK HGVs in 2019 was within 0.2% of that in 2010, despite the emergence of numerous regulations and technologies aimed at curbing emissions (BEIS Energy Statistics, 2020; DfT, 2011 & 2020). The UK aims to reduce HGV emissions by 15%, relative to 2015 levels, by 2025 (Office for Low Emission Vehicles, 2018). To meet this goal, high-impact solutions with low barriers to widespread adoption are critical. Moreover, state-of-the-art technology and know-how must be more widely implemented.

Studies show that driver behaviour strongly impacts fuel efficiency (Allison & Stanton, 2019). Broadly, the concept of 'ecodriving' comprises all operational decisions made by the driver which act to improve fuel efficiency (Ayyildiz et al., 2017). Researchers typically class these decisions into three categories: strategic (vehicle and maintenance), tactical (route and payload), and operational (driving style) (Huang et al., 2018). In this paper, the authors discuss operational aspects.

[1] The large spike in MPG for 14-17 t rigid HGVs is due to the DfT combining 7.5-14 t and 14-17 t rigid vehicles into the same class in 2015.

Recent literature on HGVs claims potential fuel reductions of around 5% through ecodriving training (Strömberg & Karlsson, 2013; Schall & Mohnen, 2017; Barla et al., 2017; Sanguinetti et al., 2020). Some authors, however, claim that driver-related factors can lead to savings from 10% to 45% (Barkenbus, 2010; Sivak & Schoettle, 2012; Thijssen, Hofman, & Ham, 2014; Daun et al., 2013). Ecodriving is thus an important intervention for meeting short-term emissions reduction targets, due to the potential savings and low barriers to adoption,

Although interest in ecodriving emerged as early as the 1990s (Symmons & Rose, 2009), it has had a negligible largescale impact. A possible reason for this is that the definition of ecodriving varies widely, as do opinions on what driving styles lead to improved fuel efficiency (Sanguinetti, Kurani, & Davies, 2017; Strömberg, Karlsson, & Rexfelt, 2015). Consequently, further research into the impact of driving behaviour on fuel efficiency is needed to build a consensus on ecodriving. In particular, Schall & Mohnen (2017) emphasise a need for methodical experimentation to assess individual ecodriving interventions. In this study, in-service telematics data is used to identify key parameters that impact fuel consumption and translate these findings into practical ecodriving strategies.

2. Driving Work and Fuel Consumption

Techniques for estimating fuel consumption vary in both approach and complexity. Although higher complexity can improve accuracy, a simple, intuitive framework is better suited to developing practical ecodriving strategies. Madhusudhanan et al. (2020) and Hunt et al. (2011) showed that fuel consumption could be estimated with errors in the range 2-7%, using the simple energy approach given by:

$$Fuel\ Used = \eta U_f W_d \tag{2}$$

where $W_d (J)$ is the driving work done by the vehicle, $\eta\ (-)$ is the powertrain efficiency and $U_f\ (Jl^{-1})$ is the volumetric energy density of the fuel.

Figure 2 shows the main longitudinal forces acting on a vehicle with mass, $m\ (kg)$, travelling with velocity, $V\ (ms^{-1})$, on a road with gradient θ (°). F_w is the driving force exerted by the vehicle (N) and F_d, F_{rr} and F_g are the aerodynamic drag, rolling resistance and gradient forces acting on the truck.

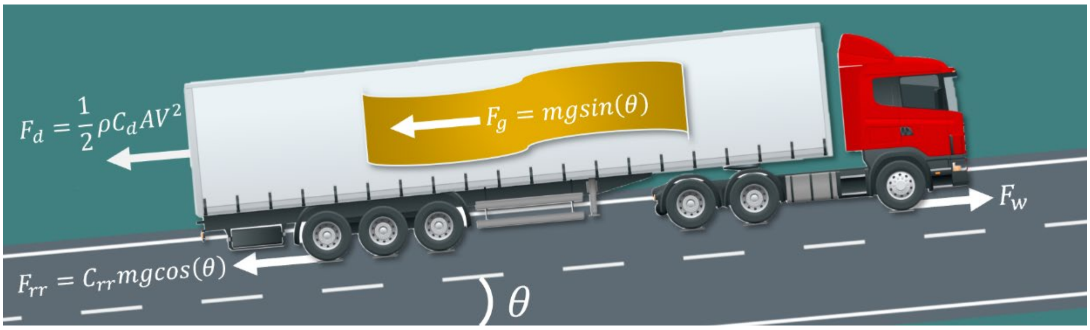


Figure 2: Primary longitudinal forces acting on a heavy vehicle

Applying Newton's second law to the vehicle yields:

$$F_w = F_d + F_g + F_{rr} + m\frac{dV}{dt} \tag{3}$$

where $m\ (kg)$ is the gross vehicle mass and $\frac{dV}{dt}\ (ms^{-2})$ is longitudinal acceleration. Driving work is then calculated by integrating F_w with respect to distance:

$$W_d = \int_0^L \left(\frac{1}{2}\rho C_d A V^2 + mgsin(\theta) + C_{rr}mgcos(\theta) + m\frac{dV}{dt}\right)dx. \tag{4}$$

Here, $L\ (m)$ is the distance driven, $\rho\ (kg/m^3)$ is the density of air, $C_{rr}\ (-)$ is the coefficient of rolling resistance, $C_d\ (-)$ is the coefficient of aerodynamic drag, and $A\ (m^2)$ is the vehicle's frontal area. Some general driving styles are apparent from Equation (4). As aerodynamic losses are proportional to wind speed squared, fuel consumption should increase with increasing average speed. Few ICE vehicles are fitted with regenerative braking, and no regenerative braking system is 100% efficient, so drivers should minimise the number of acceleration/braking cycles to reduce the magnitude of $\frac{dV}{dt}$.

While the remaining terms appear to be independent of velocity, the vehicle will only burn fuel provided $W_d > 0$. Coasting is defined as when speed is non-zero and $F_w \leq 0$. In this state, fuel flow is cut-off[2] , and the vehicle dissipates kinetic energy in overcoming resistive forces or through friction braking. In the absence of braking, the work done on the vehicle by the resistive forces is equal to its change in kinetic energy:

$$V_2^2 - V_1^2 = 2\int_0^{\delta_c}\left(\frac{1}{2m}\rho C_d A V^2 + gsin(\theta) + C_r gcos(\theta)\right)dx \tag{5}$$

where V_1 and V_2 are the truck's initial and final speeds, respectively $(-)$. For any $V_2 < V_1$, the coasting distance, $\delta_c\ (m)$, increases with increasing initial speed. The greater the coasting distance, the less fuel is burned to overcome resistive forces. To increase coasting distance, however, the vehicle must first accelerate to a higher speed ($W_d > 0$) where it will then experience greater drag. The remainder of this article will examine this trade-off between average speed, $\overline{V}$, and coasting distance, δ_c, as it relates to fuel consumption, FI_m.

3. Research Approach

This section details the gathering of in-service telematics data for an articulated vehicle travelling on a standard route. Measurements of the vehicle's speed, position, fuel consumption and driving state (gear, throttle, etc.) were acquired from its telematics system at 1 Hz resolution. Average speed, coasting distance and net fuel consumption were then calculated.

3.1 Testing Programme

Telematics data was collected for 8 journeys at various times on different days. The driver was instructed to avoid coasting on trips 1 and 3 and coast normally on trips 2 and 4. On trips 5 and 6, the driver was accompanied and advised to coast at a set of pre-determined locations, which were selected to increase the total coasting distance. The driver was again accompanied on trips 7 and 8 and advised on additional coasting points to ensure that the dataset comprised a range of coasting distances under different driving conditions.

3.2 Route Overview

Figure 3 shows the selected route spanning 182 km from the Turners (Soham) Ltd headquarters in Newmarket to a Tesco distribution centre in Didcot, UK. The journey is estimated to last

[2] If the clutch is disengaged, the engine will burn fuel at the idling rate.

between 2:20 to 3:30 depending on traffic congestion, implying an average speed of 52 kmh^{-1} to 78 kmh^{-1}. This is a popular delivery route, which is travelled daily by multiple Turners trucks. The vehicle uses a lot of fuel because of the many roundabouts between Milton Keynes and Didcot. However, each roundabout presents an opportunity to coast to a slower speed instead of cruising at a constant speed and braking sharply. There are also long stretches of higher speed driving (a 28 km stretch of the A421 passing by Bedford, for example) where coasting is primarily impacted by traffic and gradients.

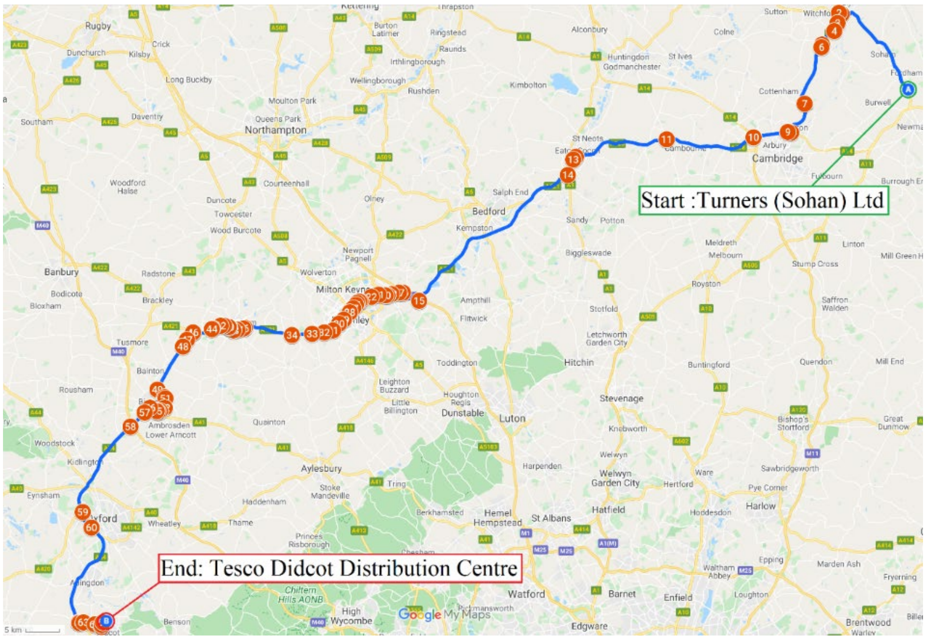


Figure 3: Google Maps depiction of the testing route

3.3 Route Segmentation

While aggregate values – such as total fuel consumption – help quantify the overall impact of driving style, any conclusions are only valid for an individual route. By segmenting the route at locations where the road conditions change (e.g. at roundabouts, new speed limits or different road classes), each segment becomes representative of a particular road type. Figure 4 shows a close-up view of Figure 3, where the route passes through Milton Keynes. The red, numbered circles show the ends of the segments. The marker numbered 15 is located at the exit to a slip road, while the remaining markers are at the entrances to roundabouts. This exemplifies how the segmented data set comprises measurements for multiple roads with different lengths, speed limits, road parameters and traffic conditions. A summary of the individual segments is given in Table 1.

Table 1: Overview of route segments

Parameter	Value
Total segments	68
Average length (m) [min, max]	2676 [37, 29720]
Average gradient (%)[min, max]	0 [-6.0, 4.5]

Since the segments are all different, driving metrics for individual segments cannot be directly compared. A standard cruise controller, for example, can achieve high fuel efficiency on a long stretch of motorway with a flat gradient and no traffic. This is done by minimising acceleration work, ensuring the vehicle has a high average speed and low coasting distance. By contrast, a driver can save fuel on a short stretch of road between two roundabouts by accelerating to a low speed and coasting, rather than accelerating to a high speed, cruising at a constant velocity, and braking sharply to enter the roundabout.

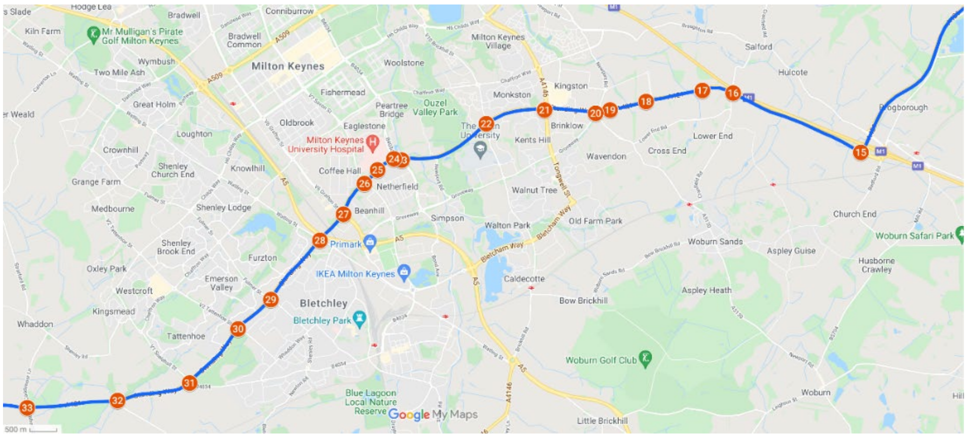


Figure 4: Illustration of route segmentation

Since conflicting driving styles can both be considered fuel-efficient, the vehicle's relative performance on a stretch of road is of interest. It is assumed that, for a specific segment, a driver attempts to follow a similar speed profile each time the segment is traversed. This baseline profile has an associated set of driving metrics, such as $\overline{V}, \delta_c$ and FI_m. Deviations from the baseline speed profile – either deliberately or due to traffic – can be considered changes in driving style. Driving metrics recorded on a segment can thus be normalised with respect to a segment's baseline parameters, illustrating whether changes in driving style lead to higher or lower fuel consumption than is typical for a road segment.

Formally, the *Segment Norm* is defined for a general driving metric, M, recorded on segment j during trip i.

$$\|M\|_s = \frac{M_j^i}{\frac{1}{n}\sum_{i=1}^{n} M_j^i} \tag{6}$$

The numerator and denominator on the right-hand side of Equation (6) are the metric of interest and the baseline, respectively. Here, the baseline is taken as the historical average for n trips completed on the segment. A segment norm greater than 1 thus implies that the metric is higher than is typical of that roadway, whereas a segment norm lower than 1 means the converse.

4. Results and Discussion

This section investigates the impact of average speed and coasting distance on fuel consumption for both individual segments and the entire journey. Insight from this analysis is used to emphasise the importance of coasting in ecodriving and make recommendations on implementing it in practice. Finally, some potential pitfalls of coasting are identified.

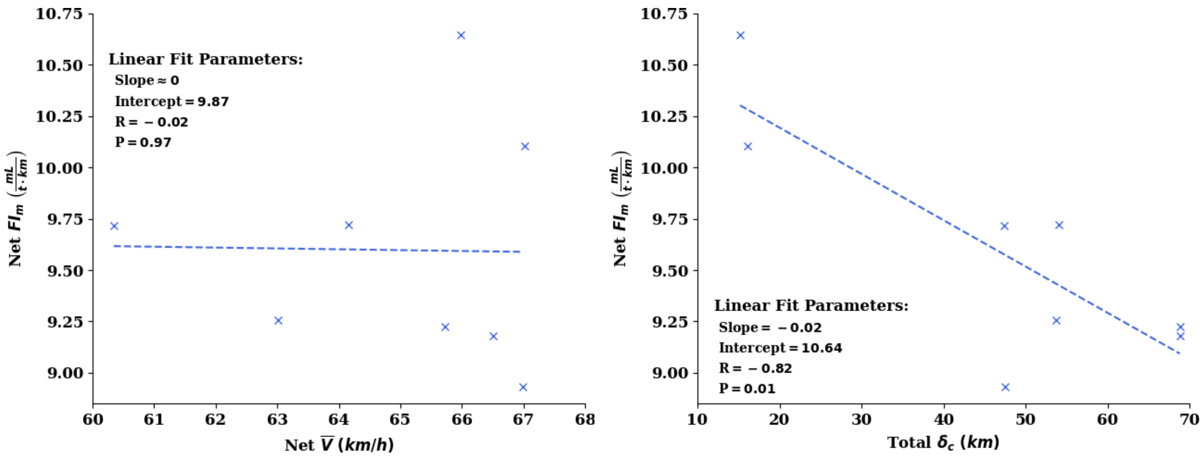
4.1 Metrics for whole journeys

Table 2 lists the metrics for each trip. While coasting distance varied by up to 54 km (between 4% and 38% of the route length), overall average speed differed by approximately 10% (6.7 kmh^{-1}). All durations are on the lower end of the anticipated range due to low traffic, and there is no correlation between coasting distance and trip duration. For instance, trips 1 and 8 have the minimum and maximum coasting distances, respectively, but virtually identical durations. Consequently, for these conditions, trip duration is dominated by traffic congestion – regardless of coasting distance – so any speed lost whilst coasting does not affect a driver's likelihood of completing this assignment on time.

Table 2: Whole journey trip metrics.

Trip	Gross Vehicle Mass (t)	Average Speed (kmh^{-1})	Total Fuel (L)	Coasting Distance (km)	Duration ($HH:MM:SS$)
1	26.48	65.99	51.25	15.20	02:45:19
2	31.78	66.99	51.63	47.45	02:42:53
3	30.66	67.02	56.35	16.11	02:42:52
4	29.60	60.34	52.33	47.41	03:00:54
5	29.58	64.16	52.35	54.04	02:50:15
6	29.66	63.01	49.86	53.70	02:52:54
7	28.06	65.72	47.10	68.87	02:46:08
8	30.30	66.51	50.73	68.89	02:44:33

The vehicle masses and total fuel consumptions in Table 2 were used to calculate the mass fuel index for each trip. Total FI_m is plotted versus average speed in Figure 5(a) and versus coasting distance in Figure 5(b). Each plot is annotated with a line of best fit and the output parameters of the linear regression (R = Pearson correlation coefficient and P = statistical significance test). In Figure 5(a), there is no visible correlation between $\overline{V}$ and FI_m. The small R and large P values of the regression reinforce this, suggesting that any variation in EI_m with $\overline{V}$ is random.



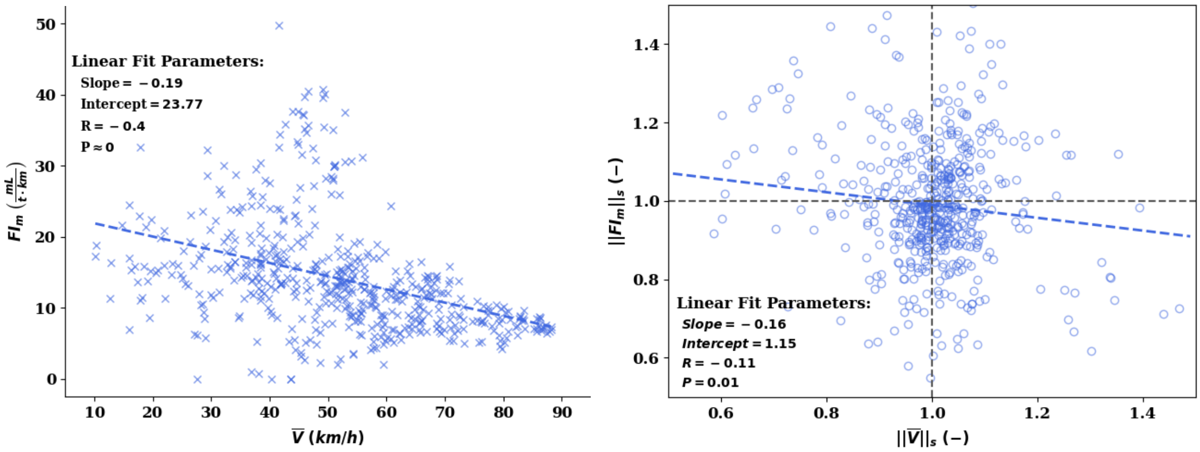
(a) Average speed **(b) Coasting distance**

Figure 5: Impact of overall average speed and coasting distance on mass fuel index

While a linear fit of the data in Figure 5(b) cannot be used to reliably calculate fuel consumption (since $R = -0.2$), there is a visible and statistically significant relationship ($P = 0.01$) suggesting that increasing coasting distance decreases fuel consumption. Using the parameters shown, an experienced driver with historically good coasting performance can improve fuel consumption by 4.4% (on average) if advised on optimal coasting points. If receptive to training, drivers who usually neglect coasting can improve fuel consumption by approximately 10%. For a 30 t vehicle and a diesel price of GBP 1.317 per liter, this translates to savings of GBP 3.08 per trip. However, a larger sample size is needed to draw definitive conclusions about the impact of δ_c on FI_m for this route.

4.2 Metrics for individual segments

$\bar{V}$, δ_c and FI_m were also recorded for the individual segments on each trip. FI_m is plotted versus $\bar{V}$ in Figure 6(a) and versus δ_c in Figure 7(a). The segment-normalised average speed, $\|\bar{V}\|_s$, coasting distance, $\|\delta_c\|_s$, and mass fuel index, $\|FI_m\|_s$, were then calculated using Equation (6). From Equation (4), increasing $\bar{V}$ should increase both aerodynamic and acceleration work. Fuel consumption is thus expected to increase with increasing average speed. Figure 6(a), however, shows that FI_m tends to decrease with increasing $\bar{V}$. Higher-speed roads must therefore have more fuel-efficient driving conditions, to the extent that the additional aerodynamic and acceleration work are outweighed.



(a) Raw metrics **(b) Normalised metrics**

Figure 6: Impact of average speed on segment mass fuel index

As $\bar{V}$ approaches 90 kmh^{-1}, the variance in Figure 6(a) decreases. Since this is the maximum allowable speed of European trucks, $\bar{V} = 90\ kmh^{-1}$ implies that the vehicle is cruising at a constant speed. As $\bar{V}$ decreases, multiple speed profiles which give the same average become viable, and so FI_m becomes harder to predict. It follows that, for average speeds below ~80 kmh^{-1}, fuel efficiency can be significantly impacted by adjusting driving style.

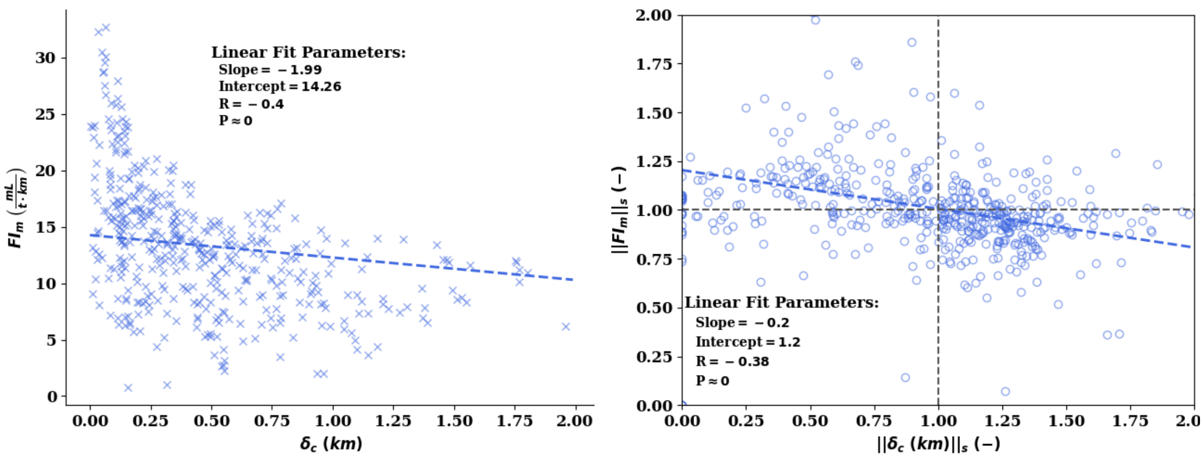
A large portion of the variance in Figure 6(a) can be attributed to acceleration work. Examining the terms of Equation (4), the drag force acting on a typical vehicle travelling at 50 kmh^{-1} are roughly 900 N. This is equivalent to the inertial forces overcome by a 30 t vehicle accelerating at an insignificant rate of 0.03 ms^{-2}, or 0.1 kmh^{-1} per second. For a given average speed, drivers can therefore save fuel by avoiding unnecessary acceleration/braking or letting their speed drift from their target. This is most easily achieved by using a standard cruise controller.

However, on shorter stretches of road, drivers should be encouraged to choose a target speed that can be reached and maintained in the current traffic rather than targeting the speed limit.

Figure 6(b) shows a plot of $\|FI_m\|_s$ versus $\|\overline{V}\|_s$ to illustrate whether travelling faster or slower than average for a stretch of road will lead to higher or lower fuel consumption. While $P = 0.01$ suggests that there may be a statistical relationship between average speed and fuel efficiency, there is too much variance to draw quantitative conclusions. Aerodynamic losses should reflect in Figure 6(b) as a positive correlation between $\|\overline{V}\|_s$ and $\|FI_m\|_s$. However, whatever correlation does exist between $\|\overline{V}\|_s$ and $\|FI_m\|_s$ again implies that fuel consumption decreases with increasing average speed, probably due to traffic congestion.

$At\,\overline{V} \approx 65\,kmh^{-1}$, aerodynamic and rolling resistance forces have similar magnitudes: ~$1.5\ kN$. Gradient forces acting on a $30\,t$ truck exceed this value for slopes steeper than ~0.5% (0.3°). Compared to gradient forces and inertia forces, aerodynamic drag is insignificant unless driving on a flat road at a constant speed. As $\|\overline{V}\|_s$ increases, the vehicle tends towards constant-speed cruising at the speed limit. Conversely, $\|\overline{V}\|_s \ll 1$ implies severe congestion – either stop-start traffic or complete gridlock. Hence, Figure 6(b) again illustrates the impact of traffic on fuel consumption, with high variance caused by aerodynamic drag, gradients and coasting.

Rolling resistance and gradient forces are independent of velocity but can be overcome without burning fuel through coasting. Figure 7(a) shows how fuel consumption (measured by FI_m) decreases with increasing coasting distance, δ_c, for the measured segments. As with average speed, a linear fit givers poor predictive accuracy ($R = -0.4$) due to high variance at low δ_c. As δ_c increases, the variance rapidly diminishes. Hence, coasting even short distances can significantly reduce fuel consumption.



(a) Raw metrics **(b) Normalised metrics**

Figure 7: Impact of coasting distance on segment mass fuel index

It has been established that higher speed roads have more fuel-efficient driving conditions. Long stretches of high-speed road often traverse multiple gradients and end at a node such as a slip-road or roundabout. Accordingly, they tend to have larger baseline coasting distances, so the relative impact of coasting must be investigated.

$\|FI_m\|_s$ is plotted versus $\|\delta_c\|_s$ in Figure 7(b), which again shows fuel consumption decreasing with increasing coasting distance. There is a significantly stronger correlation ($R = -0.38$) and higher statistical certainty ($P \approx 0$) between $\|FI_m\|_s$ and $\|\delta_c\|_s$ than between $\|FI_m\|_s$ and $\|\overline{V}\|_s$. This is because a coasting vehicle will not consume fuel regardless of the speed profile, and so EI_m is less sensitive to disturbances. Using the regression parameters shown in Figure 7(b), a 100% increase in coasting distance, (i.e. a doubling) corresponds to a 20% decrease in FI_m for a general segment of road.

4.3 Practical Coasting Strategies

Figure 8 compares the speed profiles (top) and fuel consumptions (bottom) for trips 2 and 7, which have the same average speed over a 3 km route segment. Initially, the two vehicles followed similar speed profiles, but trip 7 started at a higher initial velocity. Despite this, aerodynamic drag had a negligible impact on fuel consumption which was similar for both trips. At around 1.4 km, the vehicle on trip 7 began coasting (indicated by dotted lines). On trip 2, the driver continued to accelerate to start coasting at ~90 kmh^{-1} (the same speed as trip 7). The continued acceleration burned more fuel so that, although trip 7 had a higher average speed, it used significantly less fuel. Once fuel is burned, it cannot be recovered, so trip 7 would still have used more fuel even if it could coast a greater distance.

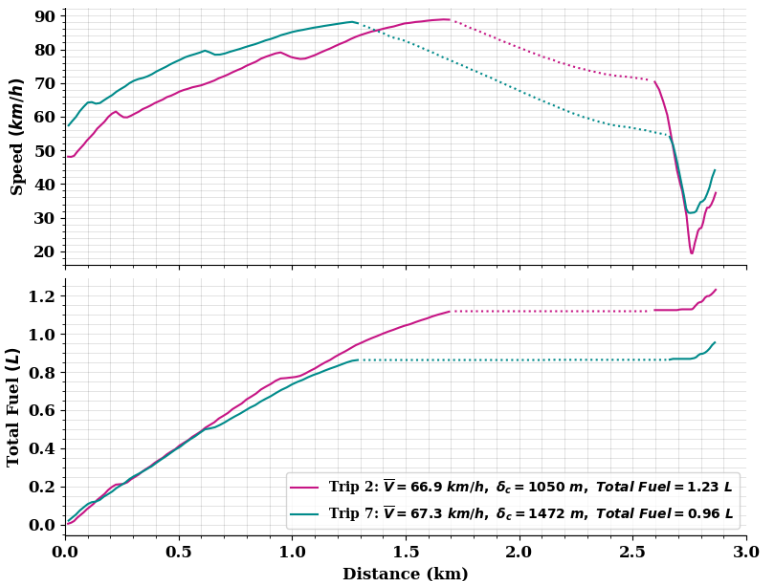


Figure 8: Illustration of the effect of coasting on speed and fuel consumption

The fuel saved on this segment on trip 7 must have been expended on the previous segment to achieve a higher initial speed. The negative correlation between $\|\delta_c\|_s$ and $\|FI_m\|_s$ in Figure 7(b) could therefore be due to the vehicle accelerating to a constant speed on one segment and coasting on the next. The segment norm cannot account for the fact that driving metrics on successive segments are not independent. Still, fuel consumption decreases when:

a) Total coasting distances are large for the entire route (Figure 5(b))
b) Coasting distances are large on individual route segments (Figure 7(a))
c) The driver coasts more than is typical for a specific stretch of road (Figure 7(b))

It can be concluded that drivers can potentially save fuel by maximising coasting distance on any stretch of road. Nevertheless, it is still possible for this to lead to increased fuel consumption. Whatever work is done to accelerate, only a fraction of this energy can be recovered whilst coasting. Therefore, drivers should aim to maintain a constant speed and begin coasting as early as possible in anticipation of braking. However, a driver's ecodriving performance should not be assessed solely on coasting distance since this will encourage drivers to accelerate unnecessarily to inflate their coasting distance. Drivers can also coast on uphill gradients, as long as their minimum speed is not too low for the surrounding traffic and the subsequent downhill allows the vehicle to recover speed without burning fuel.

There are numerous challenges with implementing these strategies. Firstly, coasting distances between 1 km to 2 km make it difficult for the driver to anticipate when to coast correctly. This is further complicated by the impact of payload, aerodynamics and rolling resistance – all of which impact coasting dynamics. If the driver coasts too soon, their speed will drop too low, and they may disrupt traffic. This is unsafe and likely to make drivers distrust the advice. In general, it is best to begin coasting too late rather than too early to avoid disruption to other drivers or having to reaccelerate. Further work is needed on training drivers to coast effectively for the abundance of coasting opportunities encountered in-service.

5. Conclusions

An investigation was undertaken to understand the trade-off between average speed and coasting distance in terms of fuel consumption. In-service telematics data was gathered for 8 trips by an articulated vehicle on a standard route. Analysis of this data using an energy approach to estimating fuel consumption yielded the following conclusions:

1. For the journeys measured, aerodynamic drag has only a small influence on fuel efficiency because the fuel consumption due to starting and stopping swamps the effects of drag.
2. Under the driving conditions measured, acceleration work and gradients dominate fuel consumption. Acceleration and coasting are thus key attributes of ecodriving and have significant potential returns if optimised.
3. Coasting distance can be significantly increased by advising drivers on pre-determined coasting locations. On the 182 km route used in this study, overall coasting distance was increased by up to 22 km (47%) compared to when the driver was unaided. This was accompanied by a decrease in FI_m of 4.4% for the overall route, or approximately GBP 3 per trip.
4. For a general stretch of road, increasing coasting distance by 10% decreases mass fuel index by approximately 2%.
5. The maximum work which can be extracted from a coasting vehicle is equal to the work done on the vehicle to accelerate it. Consequently, accelerating to/cruising at a high speed to increase coasting distance harms fuel efficiency.
6. For short segments of road, the driver should accelerate smoothly and begin coasting as early as feasible. Early coasting can potentially prevent the driver from accelerating to the speed limit, further saving fuel.
7. On long stretches of road, the driver should aim to cruise at a constant velocity and begin coasting as early as possible. Over gradients, the driver should start coasting before the crest of a hill so that the vehicle recovers speed on the subsequent downhill.

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References

- Allison, C. K., & Stanton, N. A. (2019). "Eco-driving: the role of feedback in reducing emissions from everyday driving behaviours," Theor. Issues Ergon. Sci., 85-104.
- Ayyildiz, K., Cavallaro, F., Nocera, S., & Willenbrock, R. (2017). "Reducing fuel consumption and carbon emissions through eco-drive training," Transp Res Part F Traffic Psychol Behav, 96-110.
- Barkenbus, J. N. (2010, February 1). "Eco-driving: An overlooked climate change initiative," Energy Policy, 38, 762-769.
- Barla, P., Gilbert-Gonthier, M., Lopez Castro, M. A., & Miranda-Moreno, L. (2017). "Eco-driving training and fuel consumption: Impact, heterogeneity and sustainability," Energy Economics, 62, 187-194.
- BEIS Energy Statistics. (2020). "Digest of United Kingdom Energy Statistics," Department for Business, Energy and Industrial Strategy. London: Retrieved from https://www.gov.uk/government/statistics/digest-of-uk-energy-statistics-dukes-2020
- Daun, T. J., Braun, D. G., Frank, C., Huag, S., & Lienkamp, M. (2013). "Evaluation of driving behavior and the efficacy of a predictive eco-driving assistance system for heavy commercial vehicles in a driving simulator experiment" in ITSC 2013, (pp. 2379-2386). The Hague.
- Department for Business, Energy & Industrial Strategy. (2018). 2018 UK Greenhouse Gas Emissions. London: Office For National Statistics.
- Department for Transport. (2011, October 27). Domestic activity of GB-registered heavy goods vehicles. Retrieved from: https://www.gov.uk/government/statistics/road-freight-statistics-2010
- Department for Transport. (2017). "Average heavy goods vehicle fuel consumption: Great Britain," Retrieved from: https://www.gov.uk/government/statistical-data-sets/energy-and-environment-data-tables-env#fuel-consumption-env01
- Department for Transport. (2018). "The Road to Zero," Retrieved from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/739460/road-to-zero.pdf
- Department for Transport. (2019). "Transport Statistics Great Britain 2019," London: National Statistics.
- Department for Transport. (2020). "Domestic road freight statistics: 2019 report," Retrieved from: https://www.gov.uk/government/statistics/road-freight-statistics-2019
- Department for Transport. (2021). "Licensed heavy goods vehicles by propulsion and fuel type: Great Britain and United Kingdom,". Retrieved from: https://www.gov.uk/government/statistical-data-sets/veh05-licensed-heavy-goods-vehicles
- Huang, Y., Ng, E. C., Surawski, N. C., Chan, E. F., & Hong, G. (2018). "Eco-driving technology for sustainable road transport: A review," Renew. Sustain. Energy Rev., 93, 596-609.
- Hunt, S. W., Odhams, A. M., Roebuck, R. L., & Cebon, D. (2011). "Parameter measurement for heavy-vehicle fuel consumption modelling," Proc. Inst. Mech. Eng. D, 225, 567-589.
- Madhusudhanan, A. K., Na, X., Boies, A., & Cebon, D. (2020). "Modelling and evaluation of a biomethane truck for transport performance and cost," Transp. Res. D 89.
- Office for Low Emission Vehicles, Office for Zero Emission Vehicles. (2018). "The Road to Zero," Retrieved from: https://www.gov.uk/government/publications/reducing-emissions-from-road-transport-road-to-zero-strategy
- Sanguinetti, A., Kurani, K., & Davies, J. (2017). "The many reasons your mileage may vary: Toward a unifying typology of eco-driving behaviors," Transp. Res. D, 52, 73-84.
- Sanguinetti, A., Queen, E., Yee, C., & Akanesuvan, K. (2020). "Average impact and important features of onboard eco-driving feedback: A meta-analysis," Transp. Res. F, 70, 1-14.
- Schall, D. L., & Mohnen, A. (2017). "Incentivising energy-efficient behavior at work: An empirical investigation using a natural field experiment on eco-driving," Appl. Energy, 185, 1757-1768.
- Sivak, M., & Schoettle, B. (2012). "Eco-driving: Strategic, tactical, and operational decisions of the driver that influence vehicle fuel economy," Transpt. Policy, 96-99.
- Strömberg, H. K., & Karlsson, M. I. (2013). "Comparative effects of eco-driving initiatives aimed at urban bus drivers – Results from a field trial Transp. Res. D, 22, 28-33.
- Strömberg, H., Karlsson, M. I., & Rexfelt, O. (2015). "Eco-driving: Drivers' understanding of the concept and implications for future interventions," Transpt. Policy, 39, 48-54.
- Symmons, M. A., & Rose, G. (2009). "Ecodrive training delivers substantial fuel savings for heavy vehicle drivers," Proc Int Driv Symp Hum Factors Driv Assess Train Veh Des, (pp. 46-53). Montana.
- Thijssen, R., Hofman, T., & Ham, J. (2014). "Ecodriving acceptance: An experimental study on anticipation behavior of truck drivers,". Transp. Res. F 22, 249-260.