Draft Report
October 2018

Birmingham CAZ behavioural research

Birmingham City Council
Our ref: 23346301
Client ref:

steer

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1 Introduction

Context

1.1 Air pollution in the UK and the resulting impact on public health has been identified as a priority area by the Government. In particular, the Government has a legal requirement to ensure that all roads with public access do not exceed the legal levels of No2 concentrations in the shortest time possible.

1.2 The setting up of Clean Air Zones (CAZ) is the government's main measure proposed to address this issue. In light of this, a framework for the setting up of CAZs by local authorities was released in 2017[1] (post consultation) and Birmingham was instructed to consider the establishment of this.

1.3 A CAZ can take two forms: charging (where drivers have to pay to enter the CAZ if their vehicle is deemed to be "polluting") or non-charging (where they don't pay): Steer has been working for Birmingham City Council (BCC), assisting in their evaluation of the former. The work undertaken thus far, has involved modelling the response of all vehicle types, to the proposed CAZ. In order to include the behavioural response to the scheme, previous work used a combination of Stated Preference (SP) research carried out for Transport for London (TfL), the regional demand model (PRISM), and guidance from the central governments Joint Air Quality Unit (JAQU).

1.4 This current study will complement the previous work and is aimed at providing further evidence to justify the level of charging to be tested in the modelling suite, in order to achieve compliance with the Government air quality standards. This report comprises the first deliverable, and benchmarks the assumptions used in previous work. Any recommendations set out here (differing from those already employed previously) will then be tested via further model runs, and a set of final recommendations will be issued, in a separate report (the second deliverable).

1.5 Key areas addressed via this report are as follows:

- Benchmarked level of charge and corresponding compliance rate (adjusted for Birmingham demographics and consultation responses);
- Duration of charge (24-hour vs. peak period)
- Benchmarked behavioural response of people who are not expected to upgrade their vehicles – this is modelled using PRISM however we will benchmark these outputs;
- Response of businesses and light/heavy goods vehicles; and
- Additional measures over and above the CAZ, as benchmarked from similar schemes.

[1] https://www.gov.uk/government/publications/air-quality-clean-air-zone-framework-for-england

1.6 The following table summarises how each of these areas was addressed in our previous work. These have been reported for "CAZ D – High" charge, see "Birmingham Clean Air Zone Feasibility Study Modelling – Future Year Traffic Report" (June 2018) for further details.

Table 1-1: Key behavioural assumptions from previous work

	Vehicle type	Assumptions (CAZ D – High)
Level of charge	Cars/taxi/light goods vehicles (LGV)	£12.50
	Heavy goods vehicles (HGV)/bus/coach	£100
Duration of charge	All vehicle types	24-hour
Compliance rates	Cars/LGV	Choice Modelling based on TfL (ULEZ) SP research, adjusted to Birmingham demographics and ANPR data
	Taxis	Taxis and buses assumed to upgrade to compliant vehicles through licencing agreements
	HGV	HGVs users value for money over 5 years period on whether to upgrade
Short term response	Cars/LGV (to/from city centre)	PRISM model used to forecast options (cancel trip/change mode/change route/pay)
	Cars/LGV (through trips)	BCC CAZ assignment model to forecast options (avoid/pay charge)
	Taxis	N/A – all assumed to upgrade to compliant vehicles
	HGV	Trade-off of cost to upgrade over a 5-year period vs. cost of paying a charge throughout this period
Cost to upgrade	Cars	£3,240: JAQU assumptions
	LGV	£6,500: JAQU assumptions
	HGV	£10,073 – 24,816 (depending on HGV type – Rigid/Arctic) and fuel type (Euro 1 – 4): Road Haulage Association Cost Tables

Source: Steer, Birmingham Clean Air Zone Feasibility Study Modelling – Future Year Traffic, June 2018

Contents of this report

1.7 This report has been divided into 7 chapters, including this introduction:

- Chapter 2 includes a summary of similar schemes implemented elsewhere in Europe and their impacts, as well as, research into charging hours (24-hour vs. peak period charge);
- Chapter 3 describes research evaluating charging responsiveness, and drivers' price elasticity, both to proposed CAZ schemes and other relevant road charging schemes;
- Chapter 4 discusses desktop research related to additional/alternative measures;
- Chapter 5 covers the potential response of businesses, to CAZ schemes; and
- Chapter 7 provides recommendations for further sensitivity testing, pulling together the desktop research and consultation analysis recently undertaken in Birmingham.

2 Summary of impacts from implemented low emission zone schemes

Overview

2.1 Several European cities have already established rules to limit the number of high-emissions vehicles entering urban cores. This chapter summarises the impacts of these, covering the type of scheme, charge level, hours of operation, public transport availability, behavioural response and key socioeconomic characteristics of the cities covered.

2.2 Based on evidence from such schemes, this chapter also addresses the issues of effectiveness and time periods, associated with such schemes.

Key findings

2.3 A wide variety of implementation approaches have been attempted – Berlin and Paris bar more polluting vehicles from entering their LEZs but do not impose a fee on permitted vehicles, whereas Oslo charges a differential rate based on the type of fuel and the time of day.

2.4 An 11-14% decrease in vehicle volumes was observed in Milan and Oslo, where a charge was imposed. In contrast, London and Berlin – where there is currently no CAZ entry charge for cars (though the planned Ultra-Low emission zone, ULEZ, for London will apply such a charge in the future) – did not observe a change in vehicle volumes. However, both cities observed a change in the makeup of the fleet, where vehicle owners phased out polluting vehicles at a higher pace, instead replacing them with compliant vehicles – in the case of London, the ULEZ has been widely publicised, which might have had an impact on these decisions. Both sets of examples indicate that CAZ schemes do have a noticeable impact in changing travel patterns.

2.5 Notably, all of the studied cities have extensive public transit systems, including subways, that can substitute for driving into city centres. For example, Oslo observed an increase in transit usage that corresponded with the magnitude of decrease in driving. It is important to note that Birmingham's public transport system is less extensive – this is discussed in further detail in Chapter 4, when considering additional measures, over and above CAZ style schemes.

2.6 The following table summarises the key aspects of the schemes and their impacts. While not all the cities are directly comparable due to the makeup of their population/income levels etc., the research indicates that in most cases, there's been a clear impact of reduction in traffic and/or polluting vehicles.

Table 2-1: Example existing CAZ schemes in Europe

Measure	Birmingham (Proposed)	London	Milan	Oslo	Paris	Berlin
Local Name	Clean Air Zone (CAZ)	Low Emissions Zone (LEZ); Emissions Surcharge (T-Charge)	Area C	Oslo Charging Scheme	Crit'Air	Umweltzone
Year of Implementation	2020	2008 (Low Emissions Zone – excludes cars); 2017 (T-Charge)	2012 (cleaner vehicles exempted from charge until 2017)	Congestion pricing started in 1990; clean air charges added 2017	2017	2008
Cost of entering CAZ (2018 prices)	To be confirmed, but expected to be charged to all non-compliant vehicle types: • Cars • PHV/ taxi • LGV • HGV • Bus/ Coach	LEZ: £100 -£200/day T-Charge: £10/day	Combined daily congestion and clean air charge: Noncompliant vehicles may not enter the CAZ; all non-zero emission vehicles entering must pay €5/day for cars and €40-100 for coaches depending on size (discounts for local vehicles and school buses)	Combined hourly congestion and clean air charge; non-electric/hydrogen vehicles pay between 40.50 – 60 NOK per hour depending on time of day and fuel type (diesel vehicles pay 5 NOK additional) for cars and 94 – 198 NOK for heavy vehicles	N/A – Non-compliant vehicles are not allowed to enter LEZ, else fine of €68 (cars) or €135 (heavy vehicles)	N/A – Non-compliant vehicles are not allowed to enter the LEZ, else fine of €80 plus administrative fee
CAZ operating hours	24/7	LEZ: 24/7 T-Charge: 7am – 6pm, weekdays	7:30am – 7:30pm M-W and F; 7:30am – 6pm on Thursdays	6am – 6pm, weekdays; higher charges during rush hour (6:30-9am and 3-5pm)	Heavy vehicles: 8am – 8pm, daily Light vehicles: 8am – 8pm, weekdays	24/7
Availability of public transport	Bus, regional train, tram	Subway, bus, tram, bikeshare, ferries, regional rail	Subway, bus, tram, bikeshare, regional rail	Subway, bus, tram, ferry, regional rail	Subway, bus, bikeshare, regional rail	Subway, bus, bikeshare, regional rail
Additional measures (e.g. limited downtown parking, etc.)	Removal of free City Centre parking	Central London congestion charge for all vehicles entering the city centre between 7am – 6pm on weekdays	Winter emergency schemes that impose stricter regulations in winter Increased bus lanes and frequency; increased parking restrictions and fees	Reduction in parking provision downtown; expansion of cyclist and pedestrian facilities; portion of charge revenues earmarked for transit improvements	Additional vehicles may be barred from LEZ on days with especially high pollution; some traffic-free zones in city centre on weekends	Truck ban; traffic calming; tax incentives for clean or retrofitted heavy vehicles

Measure	Birmingham (Proposed)	London	Milan	Oslo	Paris	Berlin
Behavioural response	Forecast: • Upgrade to compliant • Travel somewhere else/ not at all • Mode shift • reroute	Temporary increase in the speed at which vehicles were replaced upon introduction of the scheme	14.5% decrease in traffic (most of these changed their routing or time of day of travel)	11% decrease in car travel into the city centre; 11% increase in transit use (combined impact of toll and clean air charge)	Not available	No measurable impact in overall traffic flows; significant drop in number of registered high-polluting vehicles
Metropolitan region population (2017)	1.1 million (Birmingham city); 2.9 million (West Midlands Met County)	14.2 million (Metropolitan area); 8.8 million (London boroughs)	4.3 million	1.3 million	12.2 million	5.2 million
GDP per capita (2015€)	34,905	60,208	44,959	75,007	55,127	32,614

Source: urbanaccessregulations.eu; Eurostat; Office of National Statistics; Brookings Institution Global Metro Monitor 2018

Evaluation of charging hours

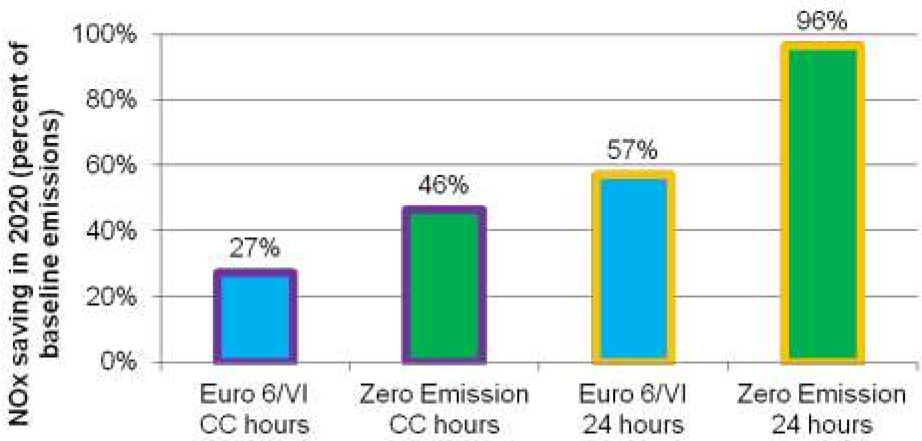
2.7 Most active CAZ/LEZs in Europe (including London's) function on a 24h-a-day basis[2], 7 days a week. Some, such as Lisbon's, are only in place over 12 daytime hours from Monday to Saturday, and some Italian and Greek LEZs vary during the year. These are, however, exceptions.

2.8 TfL monitored[3] daily emission levels to draw a conclusion on the scheduling of the charge, especially since the already active congestion charge doesn't operate 24 hours a day. The data showed that particle concentration levels begin to rise at 4am and start falling just after 7pm. This led to the conclusion that to avoid drivers rescheduling their trips and to capture all emission sources, a 24-hour charging system should be implemented.

2.9 While the research into the effectiveness of a 24-hour charge vs peak hour charging (for the purposes of emissions control) is limited, literature[4] covering the pricing structures of such schemes does indicate that peak period fees primarily impacts commuters, and causes shifts in trip times/home working (while instead, a flat kilometre fee for example, causes total trips to decline)[5], which supports TfL's conclusions on driver rescheduling of trips (discussed above).

2.10 Furthermore, a benchmarking assessment was carried out by TfL (as a part of the same study) to understand the difference between a stronger emission standard active only during working hours and a laxer emission standard active throughout the whole day. The following figure summarises the results of their analysis.

Figure 2-1: NO_x emissions saving for 2020 based on LAEI 2010 – benchmark scenarios



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[2] Holman et al. (2015) *Review of the efficacy of low emission zones to improve urban air quality in European cities.* Atmospheric Environment, vol 111, pages 161-169

[3] Transport for London (2014) *Ultra Low Emission Zone consultation. Supplementary information.*

[4] Ubbels and Verhoef (2005) Behavioural responses to road pricing. Empirical results from a survey among Dutch car owners

[5] Litman (2017), *Understanding Transport Demands and Elasticities. How Prices and Other Factors Affect Travel Behavior*

Source: **https://consultations.tfl.gov.uk/environment/ultra-low-emission-zone/user_uploads/ulez-supplementary-information---final-291014.pdf**

2.11 The conclusion drawn by TfL was that less strict emissions standards over longer periods of time had a similar effect to stricter standards over working hours. They argue that the fact that a lower emissions standard presents lower compliance costs for drivers (since the compliant vehicle's required efficiency is lower and cheaper to upgrade to), resulting in a higher compliance rate, reinforces the idea of a 24-hour charging scheme. Lastly, they hold that a 24-hour scheme may be more easily understood.

2.12 This research was conducted in 2014, and that subsequently, in May 2017 the Government published the Clean Air Zone Framework[6] which sets out the general principles for the operation of Clean Air Zones in England, including allowing authorities to operate a reduced hour CAZ if 'it will still achieve compliance with air quality limit values in the shortest possible time'. The Framework also includes the minimum classes and emission standards required for entry into a charging zone without paying a charge. These are defined to be Euro Class 4 and above for petrol vehicles and Euro Class 6 and above for diesel vehicles which implies that the 'lower standards' scenario recommended by TfL is equivalent to those proposed in the CAZ schemes.

2.13 As such, we recommend a 24-hour charging system, based on the following:

- Analysis indicated the likelihood of rescheduling trips in the face of a peak hour charge;
- TfL's comparison of the results of their tests, suggests the vehicle standard of compliant vehicles would need to be raised significantly as in the "zero emissions" test to compensate for non-compliant vehicles rescheduling their journeys (see Figure 2-1); and
- The stated "better understandability" of a 24-hour charge.

2.14 If necessary, it would be possible to test the impact of a non-24hr CAZ using the TfL research to adjust the responsiveness in the peak model periods and apply different Annual Average Daily Traffic factors to shift non-compliant traffic outside of the peak hours.

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[6] **https://www.gov.uk/government/publications/air-quality-clean-air-zone-framework-for-england**

3 Literature related to charging responsiveness

Overview

3.1 This chapter covers research conducted in London and other CAZ cities, on the proposed implementation of schemes similar to Birmingham's CAZ. In particular, we focus on the stated behavioural response in both cities, to the proposed charge levels.

3.2 We further summarise our desktop research on the price sensitivity of drivers, for road charging schemes. While these schemes are not directly aimed at reducing emissions, they represent monetary policies aimed at inducing behavioural change, and as such, are considered useful in benchmarking the sensitivity of road users, as a proxy for behavioural response to CAZ-like schemes.

Research related to CAZ-like schemes

Stated Preference surveys

3.3 London and a number of second wave CAZ cities identified a need to reduce levels of emissions to improve air quality and reach compliance with relevant European directives. In London's case, this is planned to be achieved via an Ultra Low Emission Zone (ULEZ) in Central London that represents an expansion of the previous Low Emission Zone (LEZ), to cover a wider geographic range as well as a larger range of vehicles, including private cars.

3.4 Stated Preference (SP) surveys studying the likely response of potential users, to the proposed schemes and charge levels have been carried out in a number of ULEZ/CAZ cities. The primary purpose of these surveys was to understand whether people will change their vehicles to become compliant with the ULEZ/CAZ thresholds, and if not, how their use of a non-compliant vehicle might change in the face of the proposed charge. Both surveys recorded over 1,000 responses each, covering a range of ages, demographic groups, and geographic locations within their respective cities.

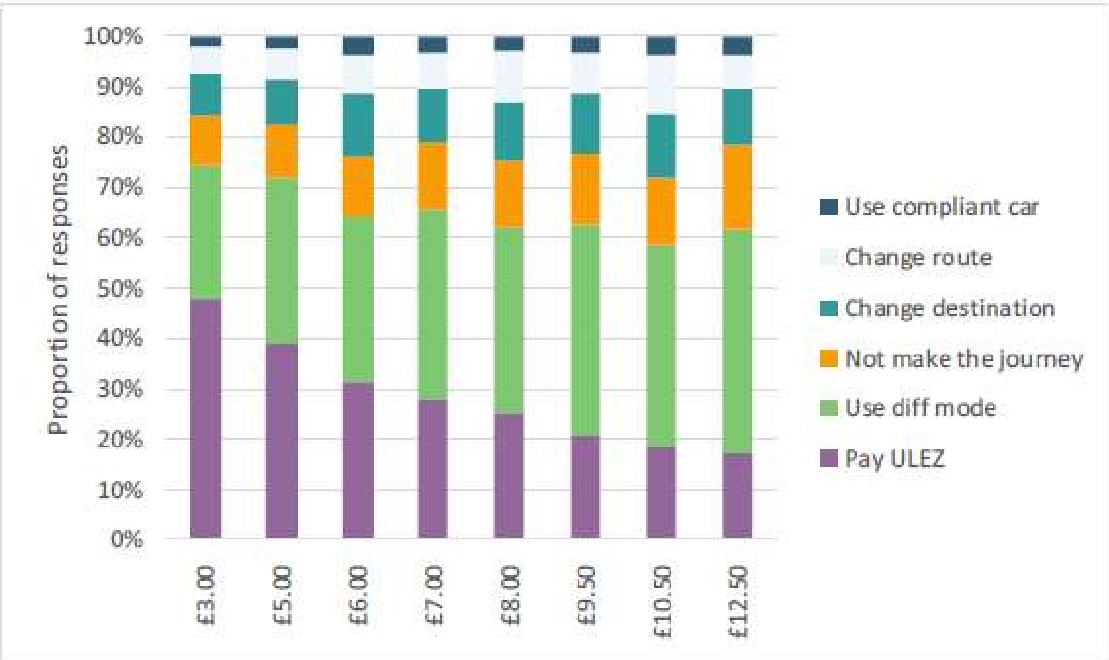
3.5 Our existing modelling of the numbers of car and LGV users upgrading to a compliant vehicle for the Birmingham CAZ, used the ULEZ study carried out in London, but reweighted the results based on Birmingham specific values:

- Trip Frequency
- Income levels
- Cost to upgrade

Short-term response

3.6 The short-term response survey shows how people would respond to a charging CAZ if people had no opportunity to prepare for it, for example by purchasing a new car or moving home/ job. The London SP surveys presented in Figure 3-1, shows the proportion of respondents who were willing to pay the charge decreases swiftly (from approx. 50% at £3.00 to 25% at £8.00), and thereafter, decreases at a slower rate to reach just under 20% at £12.50. The proportion of people choosing to use a different mode increases, while the options of changing destination/route etc., remain relatively stable. Other research in other CAZ cities has revealed similar responses to London.

Figure 3-1: London traveller response to proposed levels of Ultra Low Emissions Zone (ULEZ) charge



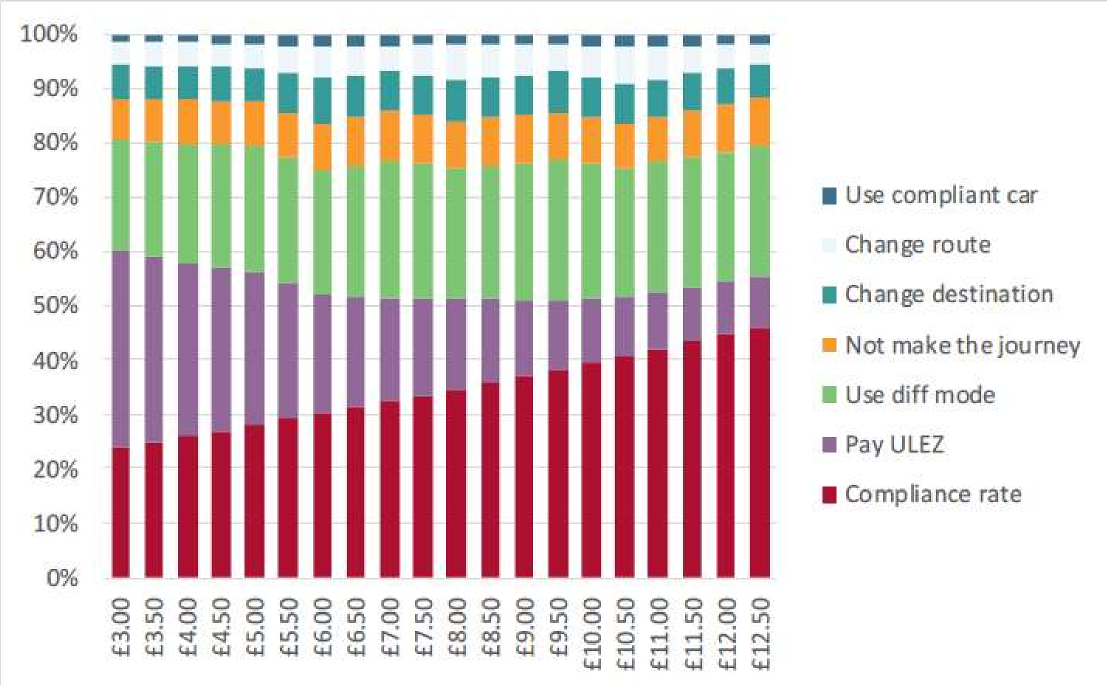
Source: Figure 4.1, Ultra Low Emission Zone Expansion Stated Preference Survey, TfL (August 2017)

Long-term response

3.7 Respondents stated that were more likely to upgrade their vehicle in the long term with higher levels of CAZ charge, and were also sensitive to the upfront cost of upgrading the vehicle. The following two charts indicate the combined short term and long-term responses, as reported in the London survey, for an upgrade cost of £10,000. As can be seen:

- In the case of London:
  - the compliance rate (respondents upgrading their vehicles) starts at a higher level than for other cities and varies from 24% at £3.00 to 46% at £12.50;
  - The proportion of respondents willing to pay the charge decreases till the £7.00-8.00 charge level (as mentioned previously) with the corresponding shares of respondents changing mode increases, after which the combined shares of these two alternatives remain relatively stable;
  - The proportions of people not making the journey or changing route remain stable, across all charge levels, while the proportion of people changing modes increases with increasing charge, and is overall larger than the equivalent group in other cities, as mentioned previously.

Figure 3-2: London traveller response to proposed levels of ULEZ charge, combined for all users



Source: Figure 4.1, Ultra Low Emission Zone Expansion Stated Preference Survey, TfL (August 2017)

Long Term Response Conclusion

3.8 The key differences between the CAZ cities and London SPs in relation to Birmingham is the following:

- Changing route is considerably higher outside of London, compared to London (approx. 3%). The London ULEZ area covers a large area which will have low numbers of through trips, whereas other cities are proposing CAZ's which covers a similar sized area to the Birmingham CAZ. In addition, the change in numbers rerouting is stable between different prices indicating most users with a viable alternative will divert at any toll level.
- The point at which the increase in charge, stops having a significant impact on drivers paying to enter the CAZ flattens at a lower charge level in other cities compared to London. This reflects both the lower disposable income levels outside of London, and the fewer non-car alternatives than in London. We believe that cities outside of London are more comparable to Birmingham than that of London and thus provides a better indication of the possible response to the implementation of the charging scheme.
- All research show that as the charge nears the higher charge levels the numbers of people choosing to pay the charge stabilises, indicating that those remaining users are price insensitive so there will be minimal impacts in increasing the prices above this level.

Transport for London (TfL) ULEZ consultation

3.9 TfL conducted a public consultation exercise to better understand public response to proposed changes to the ULEZ scheme, in particular the expansion of the scheme to a wider geographical area, stricter emissions rules, and the implementation of the scheme at an earlier date than previously scheduled.

3.10 As shown in the table below, individuals who live in the existing Congestion Charge Zone (CCZ) in central London tend to have higher support for an early implementation of the ULEZ, perhaps because they will receive the most benefit from the stricter emissions rules. Respondents who did not drive in the CCZ were also more likely to support the ULEZ rules, which could be driven by easier access to public transport in Central London and hence potential flexibility to avoid ULEZ charges, while still benefiting from the expected air quality improvements.

Table 3-1: Summary of Responses to Proposed ULEZ Early Implementation

Characteristic	Higher support for ULEZ	Lower support for ULEZ
Residency of Congestion Charge Zone (CCZ; in city centre)	CCZ residents	Non-CCZ residents
Whether the respondent drives in the CCZ	Respondents who never drive in the CCZ	Respondents who drive in the CCZ

3.11 In addition, business groups – especially those operating fleet vehicles – were particularly concerned about ULEZ implementation due to the potential impact on their commercial operations as they would need to achieve compliance at an earlier date than previously planned.

Birmingham consultation

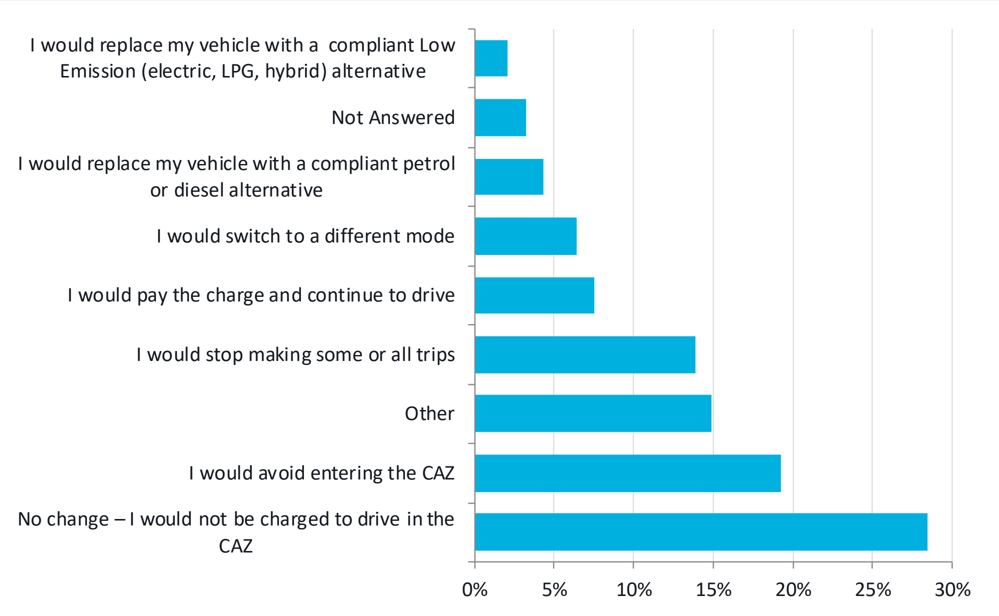
3.12 Birmingham City Council carried out a consultation between 4th July and 17th August 2018 to gather the views of the public on the proposed introduction of a CAZ in January 2020. While this research is different from an SP – in that it does not include any statistical estimation of behavioural responses – it does serve as a useful benchmark into Birmingham specific behaviour.

3.13 The sample size of the consultation was 10,392 individuals. As part of the questionnaire, respondents were asked what they would do if a Clean Air Zone was introduced. Below is a summary of the answers to that question.

Overall

3.14 Most respondents (around 28%) said that they would not be charged. This can be due to either their vehicle being already compliant or because they do not drive in the area. A significant number of respondents indicated that they would avoid entering the area altogether (18%) or that they would stop making some trips (17%), as can be seen in the following figure.

Figure 3-3: Overall responses to the introduction of the CAZ



Source: Birmingham City Council 2018 CAZ Consultation

3.15 To facilitate a comparison between the responses from TfL's ULEZ study and other SPs, the following table summarises the consultation responses, excluding those who stated they wouldn't be charged, those who replied "other" or "not answered".

Table 3-2: Birmingham consultation responses to the introduction of the CAZ (total sample)

Response	No. of respondents	%
Pay charge	778	14%
Change route	1998	36%
Cancel trip	1447	26%
Upgrade to compliant vehicle	661	12%
Change mode	670	12%
Total	5554	100%

Source: Birmingham City Council 2018 CAZ Consultation

3.16 The consultation provides useful context into what the response of individuals in Birmingham will be to the CAZ. However, since it was not set up as a proper trade-off exercise (i.e. respondents did not know the charge level, for instance) and is a self-selecting sample, the results should not be considered as a robust assessment of how users will respond to the CAZ.

3.17 The responses detailed above are more likely to representative of short-term behaviour, which might for example have resulted in a lower proportion reporting they would upgrade their vehicles (compared to benchmarks from TfL's ULEZ study).

3.18 It does therefore provide a useful indication of likely short-term behaviour in the opening weeks of the scheme. The responses provide evidence that people will be slightly slower to upgrade to a compliant car in the short-term, while also pointing at a possible underestimation of mode shift in the modelling work.

Detailed Analysis

3.19 We have analysed the data splitting by main purpose, frequency and place of residence (within or outside of the CAZ) to understand differences between these population segments. The data has been reweighted excluding 'Not Answered' and 'No change' responses and hence the sample size is below the total reported.

Responses by purpose

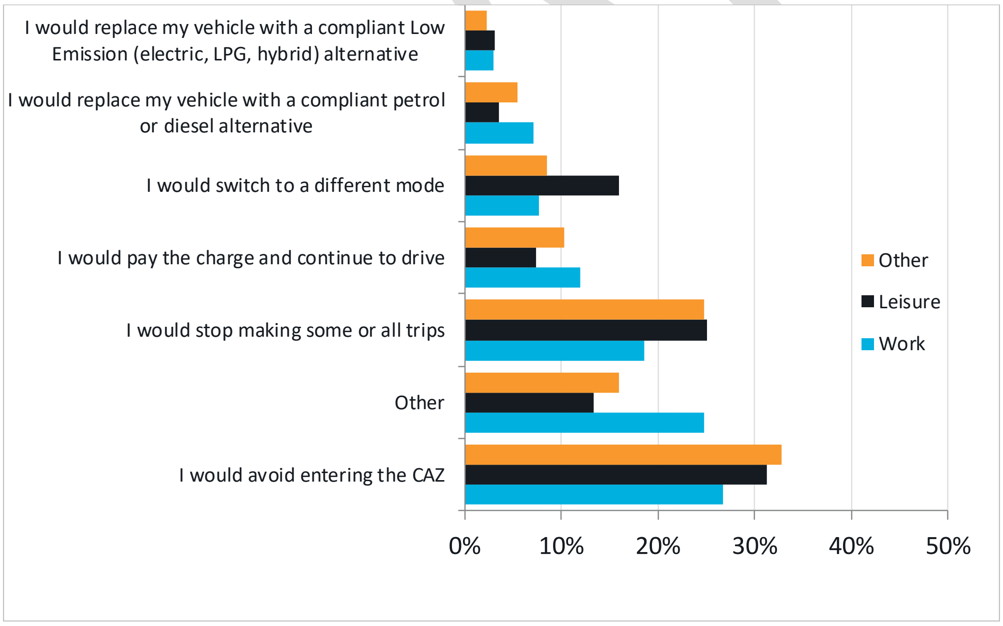
3.20 To assign a main purpose to each respondent, we have cross-checked the frequency of their trips reported to each of the purposes included in the survey: work, leisure, shopping, worship, medical, children-related & other purposes.

3.21 We assumed that the most frequent of them is their main purpose. Some respondents reported the same frequency for work and other purposes' trips into the CAZ. In this case, their main purpose has been classed as 'work' to distinguish them from non-commuters.

3.22 Purposes have been simplified into: work, leisure (including 'leisure' and 'shopping') and other (all other purposes reported). This results in 70% of responses assigned to the 'work' category, 21% to 'leisure' and 9% to 'other'.

3.23 The main differences between the purposes are present in willingness to change mode (higher for leisure trips), as well as reduction of the number of trips and avoidance of the CAZ area (as expected, higher for non-work purposes). Figure 3-4 below shows the responses in detail.

Figure 3-4: Responses to the introduction of the CAZ by journey purpose



Source: Birmingham City Council 2018 CAZ Consultation (N=6,970)

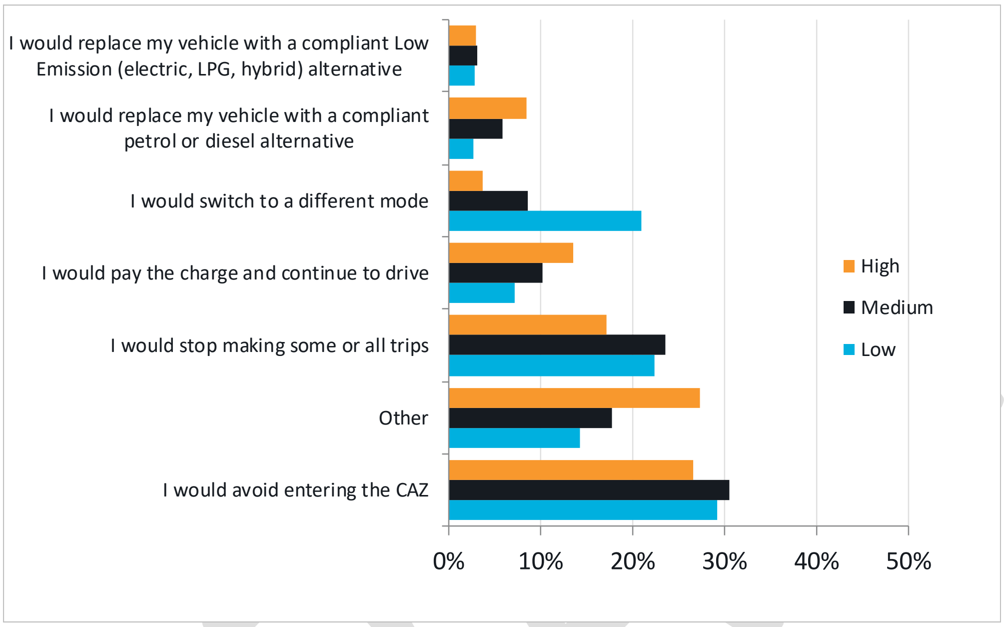
Responses by frequency

3.24 Similarly, since respondents were asked about several trips, we have assigned their highest reported frequency as their main frequency. We have considered 5 or more weekly trips as a 'high' frequency, between 1 and 4 days a week as 'medium' and rarer than once a week as 'low'. As a result, 43% of respondents were classed as high-frequency travellers, 27% as medium-frequency and, lastly, 30% as low-frequency.

3.25 Around 43% of low-frequency travellers reported that they would not change their travel patterns since the CAZ would not make a difference to them, although as noted above these responses have been excluded. This response might be due to them not driving into the designated CAZ zone. This group (low-frequency drivers) is also the most likely to switch to a different mode.

3.26 On the contrary, medium and high-frequency travellers seem more prone to either reducing the number of trips they make into the CAZ or stop making some or all trips.

Figure 3-5: Responses to the introduction of the CAZ by trip frequency

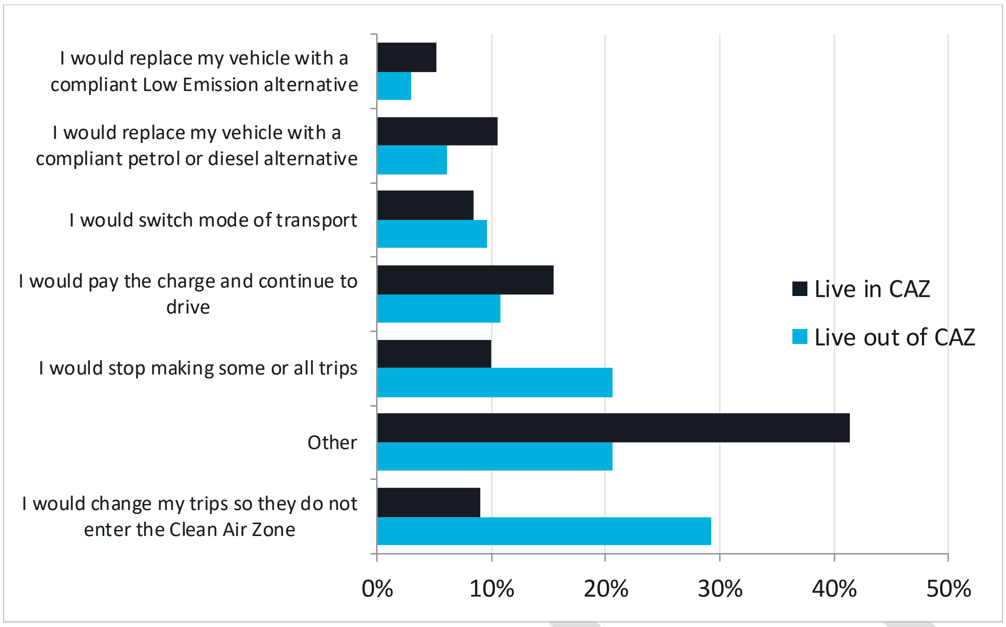


Source: Birmingham City Council 2018 CAZ Consultation (N=6,970)

Responses by place of residence

3.27 Non-residents are more likely to change their journey to avoid going into the CAZ or stop making some or all trips, which is logical as residents would not be able to avoid the CAZ for most journeys. CAZ residents are more likely to upgrade their vehicle or pay the charge emphasising that they have less options compared to non-residents. The largest response category for CAZ residents is 'other' further indicating the additional complexity for residents within the CAZ and highlighting the need for additional support for residents of the CAZ when implementing the scheme.

Figure 3-6: Responses to the introduction of the CAZ by place of residence



Source: Birmingham City Council 2018 CAZ Consultation (N=6,736)

3.28 To conclude, the consultation responses are broadly comparable to the response to the charge forecast by the modelling work. The key takeaways from the consultation analysis are:

- People will be slower to upgrade their vehicle in the short term, although we believe that over the first two years of operation of the scheme, higher compliance rates will be achieved;
- The existing model underestimate mode shift in comparison with consultation responses.

PRISM Do Minimum

3.29 Mode shares into the city centre in the PRISM model have been summarised and grouped by income and journey purpose. This shows:

- Around 30% of car trips are made by lower income users (those earning less than £25k), rising to 50% when including the next income bracket (£25K-£35K) in the PRISM classification.
- Lower income users are more likely to take PT or walk, with 54% using a non-car mode compared to an average of around 45%.
- Lower income drivers are more likely to own a non-compliant vehicle, and will therefore be less able to upgrade to a compliant, and are therefore more likely to switch modes compared to other users.

Table 3-3: Mode share by income - PRISM Do Minimum scenario

Mode	<£25k	£25k-£35k	£35k-£50k	>£50k	Total
Car Driver	15%	11%	10%	12%	48%
Car Passenger	3%	2%	1%	1%	6%
PT	16%	7%	6%	5%	34%
Walk/Cycle	6%	2%	1%	1%	11%
Total	41%	22%	19%	18%	100%

Source: Steer analysis from PRISM Do Minimum scenario

3.30 Work purpose is the largest segment of the demand segment, with nearly 50% of all trips, but with other (including shopping) and leisure around 45% producing a large number of trips. Work trips are likely to be more frequent and less able to change destination in the short term (which is consistent with the consultation responses).

Table 3-4: Mode share by journey purpose - PRISM Do Minimum scenario

Mode	Work	Business	Other	Leisure	Total
Car Driver	7%	2%	2%	1%	13%
Car Passenger	3%	1%	2%	1%	8%
PT	34%	2%	20%	14%	70%
Walk/Cycle	4%	0%	3%	3%	10%
Total	49%	5%	27%	19%	100%

Source: Steer analysis from PRISM Do Minimum scenario

Other studies related to drivers' price sensitivity

3.31 While the impact of the implementation of low emission zones in other areas has been described in Section 2, the following examples include additional research undertaken on the implementation of congestion charging and other charging policies, to assist in the benchmarking of drivers' sensitivity to charging schemes in this section.

3.32 Congestion zone charges (where a cost is implemented to deter drivers from entering areas of high traffic) or tolls (where drivers must pay a fee to use a route that provides faster or more reliable travel) are not dissimilar to CAZs, in that monetary penalties are imposed to influence behaviour change. Below we discuss several case studies of behavioural responses to congestion/road pricing.

Behavioural impacts of the London CCZ

3.33 Research by TfL suggests that the CCZ – currently £11.50 per day – has reduced trips by as much as 36%. The table below presents a summary of the findings from their study:

Table 3-5: Summary of behavioural responses to the introduction of the CCZ in London

Measure	Central Congestion Zone (CCZ)	Western Extension Zone
Reduction in all car and minicab trips	-36%	-23%
Of which: % Diverting around charged area or avoiding charged hours	11%	5%
% Lost to other modes, destinations, or frequency	25%	18%
Elasticity across affected vehicles	-0.47	-0.42

Source: TfL study: "Demand Elasticities for Car Trips to Central London as revealed by the Central London Congestion Charge"

3.34 Further, the study found that the elasticity[7] response was higher to the introduction of a £5 charge (-0.55) than to a £3 price increase (-0.16). Put otherwise, the impact of charges on

[7] An elasticity of -0.55 implies that as the charge is increased by 10%, demand would fall by 5.5%.

travel volumes is not linear; a more modest initial charge often deters a larger amount of people than subsequent price increases. In this case, individuals who continued driving into the CCZ after the initial £5 charge was imposed were much less reactive to further price increases, than drivers who avoided the CCZ upon the introduction of the CCZ scheme. This could suggest that a more modest charge amount could be sufficient to induce a behavioural response among most of the travellers who had alternative routings or modes of transport available to them.

3.35 This is consistent with the findings in the London stated preference surveys and other evidence outside of London, where the proportion of respondents who were willing to pay a CAZ charge decreased at a faster rate till the £7-8 charge level, after which it remained relatively stable till the £12.50 charge level.

Elasticities to toll and congestion charges

3.36 The M6 corridor stated preference study suggests that the value of time in the local area is about £7.54/hour for 30-minute journeys, rising to around £10/hour for longer trips. While this study is based on highway traffic and therefore not directly equivalent to the proposed CAZ charge (which relates to vehicles entering an urban centre), it informs the potential price sensitivity levels of Birmingham-area travellers.

3.37 Research indicates that road users are more sensitive to tolls (including cordon charging schemes such as congestion charging), with an overall elasticity towards tolls tending towards -0.3 (with lower values where there are few alternatives). In particular, cordon tolls are expected to have reduced traffic by 12-22% in five major European cities and Singapore, again supporting the -0.2 to -0.3 elasticity[8].

3.38 Research shows that most congestion charging schemes have led to a reduction in emissions levels (with limited shifting of trips outside the charge zones i.e. rerouting)[9]. As CAZ charges are similar in nature to tolls – drivers pay a fee to use a road or enter an area that they otherwise would not be permitted to use – this could inform the decisions surrounding appropriate CAZ charges in Birmingham.

Petrol Price Elasticities

3.39 There is extensive research into driver price sensitivity with regards to pump prices due to the ubiquitous nature of petrol. The following table presents guidance from the UK Department for Transport (DfT) and the WebTAG appraisal guidance, which point to fuel price elasticities between -0.125 in the short term and -0.3 in the long term, with slight variations depending on local income levels. However, since petrol prices are a decreasing proportion of generalized journey costs (due to increasing fuel efficiency and/or increasing values of time) and also incurred continually in vehicle operation, they should not be directly equated with CAZ pricing which only charged when entering the CAZ and not for all journeys (this would be more relevant for frequency visitors to the CAZ).

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[8] Litman (2017), *Understanding Transport Demands and Elasticities. How Prices and Other Factors Affect Travel Behavior*

[9] UKERC (2009), *What policies are effective at reducing carbon emissions from surface passenger transport? A review of interventions to encourage behavioural and technological change*

Table 3-6: Fuel Price Elasticities from UK Government Guidance

Study	Fuel Price Elasticity
Department for Transport, National Transport Model Working Paper 3	-0.17 to -0.24
WebTAG Unit 3.11.1, Model Structures and Traveller Responses for Public Transport Schemes	-0.125 (short term) -0.3 (long term)

Source: DfT

Birmingham Mode Share Analysis

3.40 The existing modelling used in the CAZ forecasts a low propensity to change mode, when compared to the survey data described above. We have analysed existing mode shares into the City Centre and how this has changed in recent years, to provide analysis of the propensity of transport users in the area to shift to public transport modes.

3.41 Table 3.7 below presents Transport for the West Midland's (TfWM) analysis of mode shares from survey data in Birmingham City Centre (It should be noted that Metro shares should be ignored in 2015 due to construction of extensions and temporary closures of stops artificially supressing Metro demand in this period)[10].

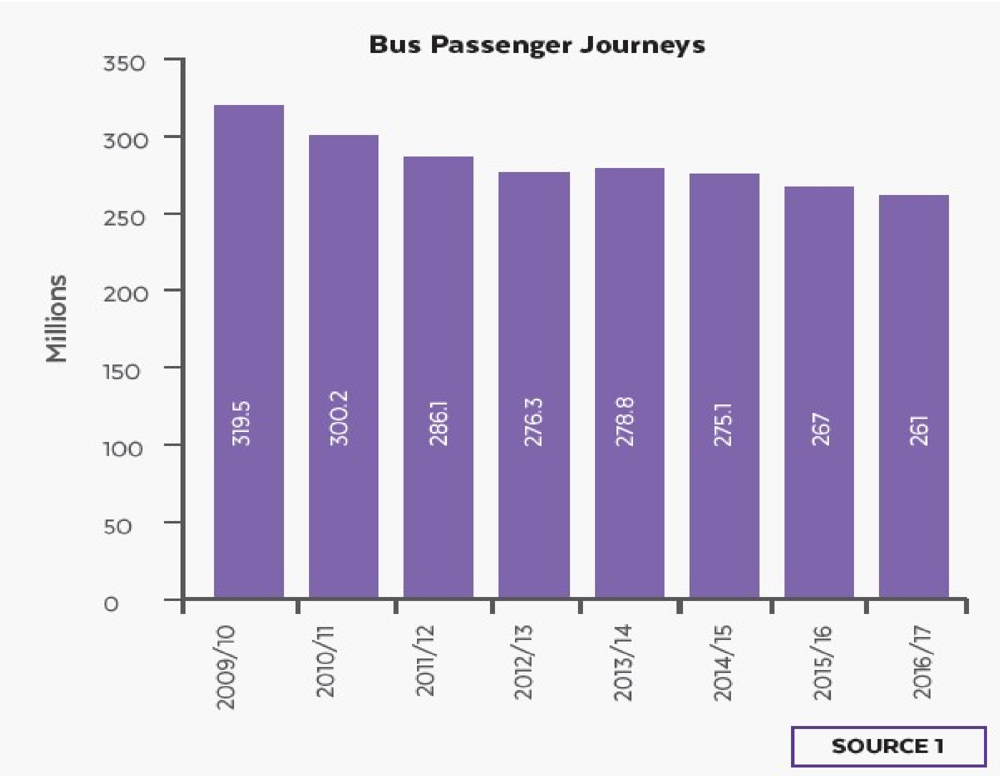
Table 3.7: Mode Shares Entering the City Centre

Mode	2011	2013	2015
Bus	28%	27%	26%
Rail	30%	29%	36%
Metro	2%	2%	0%
Car	40%	42%	37%
Total	100%	100%	100%

Source: West Midlands Travel Trends 2017, Transport for the West Midlands, 2017

[10] West Midlands Travel Trends 2017, Transport for the West Midlands, 2017

Figure 3-7: Bus Passenger Journeys in the West Midlands



Source: West Midlands Travel Trends 2017, Transport for the West Midlands, 2017

3.42 There has been an increase in mode shares in recent years indicating that there is a growing propensity for people to use public transport to access Birmingham and that the CAZ could accelerate this trend. There should be some concern that bus ridership has fallen, as many users may not have access to rail. Ensuring improved bus services will be important in driving this mode shift.

3.43 An important consideration based on the observed trend in increasing PT mode shares in Birmingham City Centre is whether this is reflected in the modelling, and in particular the development the development of the 2022 model which used growth directly from the DfT's TEMPRO software which provides outputs from the National Trip End Model (NTEM). The 2020 models take growth rates from PRISM which includes improvements in public transport and increasing congestion.

3.44 The TEMPRO growth rates in the table below indicate that car mode shares are forecast to increase, which is not consistent with recent trends. There will be significant investment in the public transport network up to 2022, with new 'SPRINT' bus rapid transit routes, the opening of the City Centre Westside Metro extension and improved rail corridors.

Table 3.8: Growth in Demand 2020 to 2022

Mode	Growth
Car	2.0%
Bus	-1.4%
Rail	-0.4%
PT	-1.0%

Key conclusions and comparison to previous work

Compliance rates

3.45 The following table summarises the research into compliance levels and compares it with the modelling already undertaken for Birmingham's CAZ, for cars. As can be seen:

- The compliance rates for outside of London are lower than those for London at the £10,000 cost to upgrade, this could be indicative of the differing patterns of trips in outside of London and lower GDP/capita – it could be argued that Birmingham would follow a pattern more similar to cities outside of London;
- As the cost to upgrade goes down, the compliance rate goes up.

3.46 The current Birmingham process is based on the ULEZ study – but since they have been adjusted for Birmingham's cost to upgrade, income distribution and frequency (based on ANPR data), and overall, they fall within the range indicated by TfL and analysis of cities outside of London, we do not suggest any changes to these assumptions.

Table 3-9: Summary of compliance levels

Upgrade cost	CAZ charge	ULEZ response	BCC modelling
£10,000	£3	24%	N/A
	£12.50	46%	
£7,000	£3	N/A	
	£12.50		
£3,240	£3		N/A
	£12.50		41% (overall), 52% (city centre)

Source: Ultra Low Emission Zone Expansion Stated Preference Survey, TfL (August 2017, Birmingham Clean Air Zone Feasibility Study - Future Year Traffic Modelling (June 2018)

Short term response

3.47 Considering the short-term response, i.e. whether users would pay the charge, change route or mode or destination, or stop travelling:

- The benchmarking indicates that after a charge level of £7-8, the response stabilises;
- The overall proportions of respondents who state that they would change routes in SP studies outside of London is significantly larger than in London, and the corresponding proportion changing modes is smaller – likely driven by the availability of public transport options in London – it could be argued that Birmingham would follow a similar response to other CAZ cities given that its public transport availability is less extensive than in the case of London; and
- Benchmarking of reduction in trips when faced with road tolls/congestion charging schemes indicates a 10%-35% reduction in overall trips, with research into pricing elasticities of congestion (and similar charging schemes), which indicate values around -0.3 (i.e. a 10% increase in pricing results in a 3% fall in traffic). This is consistent with our previous work, which implied an 8% reduction under the £12.50 charge scenario.

3.48 BCC's modelling uses the PRISM model to distribute the short-term responses of users – this is done separately for trips to and from the city centre, and within the city centre. The following table summarises the overall assumptions employed in the modelling (at the "high" £12.50 charge level) vs. benchmarks.

Table 3-10: Car Compliance Response Comparisons at the High Charge Level

Response	TfL (ULEZ Charge)	BCC (High Charge)	Consultation Response	JAQU*
Pay Charge	9%	8%	14%	7%
Change Route	4%	22%	36%	11%
Change Destination	6%	18%		
Cancel Trip	9%	9%	26%	7%
Replace Vehicle	48%	41%	12%	64%
Mode Shift	24%	2%	12%	11%
Total	100%	100%	100%	100%

Source: Ultra Low Emission Zone Expansion Stated Preference Survey, TfL (August 2017), Birmingham Clean Air Zone Feasibility Study - Future Year Traffic Modelling (June 2018)

3.49 Moreover, we have compared responses by journey purpose as well as trip frequency between the Birmingham consultation and the ULEZ study, as follows in the tables below.

Table 3-11: Comparison of ULEZ and BCC responses by purpose

Response	ULEZ Study			BCC Consultation		
	Commuting	Personal	Leisure	Work	Other	Leisure
Pay Charge	20%	19%	12%	16%	12%	9%
Change Destination or Route	19%	16%	25%	36%	39%	36%
Cancel Trip	18%	15%	23%	25%	29%	29%
Replace Vehicle	2%	4%	5%	14%	9%	8%
Mode Shift	42%	45%	35%	10%	10%	18%
Total	100%	100%	100%	100%	100%	100%

Source: Ultra Low Emission Zone Expansion Stated Preference Survey, TfL (August 2017); Birmingham City Council 2018 CAZ Consultation

Table 3-12: Comparison between ULEZ and BCC responses by frequency

Response	ULEZ Study			BCC Consultation		
	High	Medium	Low	High	Medium	Low
Pay Charge	15%	14%	17%	19%	12%	8%
Change Destination or Route	21%	21%	24%	37%	37%	34%
Cancel Trip	15%	23%	25%	24%	29%	26%
Replace Vehicle	2%	4%	7%	16%	11%	7%
Mode Shift	47%	38%	26%	5%	11%	25%
Total	100%	100%	100%	100%	100%	100%

Source: Ultra Low Emission Zone Expansion Stated Preference Survey, TfL (August 2017); Birmingham City Council 2018 CAZ Consultation

3.50 Analysis has been undertaken on two journey purposes (Employers business and Commute/ other) and by income level. In the case of Employer's Business purpose, there is a wide range of reactions to the charge, making it difficult to draw clear conclusions from this journey purpose. However, there is a clear indication that people travelling for this purpose were more prone to pay the charge rather than considering an upgrade, given that they can presumably pass on the charge cost to their employer/ customer. For income levels, in the case of Commute/Other purposes, people with higher household incomes are more willing to upgrade their vehicle, as expected.

3.51 In terms of trip frequency, the evidence shows a decrease in mode shift and a slight increase in the number of 'not travel' responses as trip frequency goes down, which is logical given that sporadic trips are likely to be more discretionary. Other than these patterns, the responses between different frequencies were consistent, and broadly in line with what is seen in Birmingham and London.

3.52 One of the main differences between Birmingham and London responses is the mode shift, which is explained by a greater availability of alternatives to car use in the latter. On the contrary, changing destination or route or cancelling trip is seen as a much more viable option by Birmingham respondents.

3.53 The percentage reporting to pay the charge is higher in London, while Birmingham users seem more prone to upgrade their vehicle, possibly also due to the more limited choice of alternatives.

3.54 The responses by purpose seem to be consistent across studies, with commuters more willing to pay the charge and less likely to reduce the number of (or cancel) trips than leisure travellers.

3.55 When analysing the responses by frequency, in the cases of paying the charge, changing destination or route or cancelling a trip, the same pattern is seen across both studies. However, in the case of replacing a vehicle or shifting to a different mode, the order is reversed: for instance, low-frequency travellers are the most likely to shift modes in Birmingham, while high-frequency travellers are more likely to do so in London.

3.56 All in all, the differences between the Birmingham consultation and the ULEZ show consistent patterns when analysed by purpose and frequency, with obvious differences due to the different dynamics of the cities and the provision of alternatives, which seems to indicate that ULEZ is a reasonable placeholder for assumptions.

3.57 As can be seen in the summary illustrated by Table 3-10, the results of the PRISM run show that mode shift forecast is low in comparison with the redistribution impacts of people switching their car trips to non-city centre zones, compared to the benchmarks (and Birmingham's consultation responses). This is further supported by evidence from the CCZ in London, where, of the 36% reduction in all car and minicab trips, 11% were found to be diverting around charged area or avoiding charged hours and 25% lost to other modes, destinations, or frequency.

Model Updates

Behavioural Responses Adjustment

3.58 Following our review of the research we recommend the following updates to the modelling approach:

Table 3.13: Car Behavioural Responses Recommendations

Response	Conclusion	Change

<table>
<tr><td>Upgrade</td><td>No change in approach to forecasting the compliance rates except introducing a ramp up process that reflects peoples likely initial reluctance to upgrading their vehicle in the short term. This will dampen down the upgrade rates in the early years.
Ramp up is standard practice in forecasting demand in the early years of a transport scheme.
These no upgrading cars will be distributed evenly to the other responsiveness groups (excepting through trips).</td><td>Ramp Up:
2020 – 85%
2021 – 95%
2022 – 100%</td></tr>
<tr><td>Pay Charge</td><td>The benchmarking exercise has shown that the elasticity to the toll at the £12.50 charge is reasonable. However, when comparing to other SP results the change between the £12.50 and up to £7.00 charge, the change in users paying the charge is too steep.
When developing the 'pay charge' forecasts, we ran the PRSIM model at the £12.50 level and developed a set of elasticities to forecast the different toll levels based on changes in generalised costs across all zones pairs.
Therefore, the forecasts for other toll levels are less reliable and we would therefore recommend adopting the elasticities from the other CAZ SP surveys but pivoting off the PRISM £12.5 results.</td><td>We will apply an elasticity of -1.09 assuming the £12.50 PRSIM responsiveness is correct.

In other words, every £1 increase from £7 up to £12.50 results in a 1.09% decrease in users willing to pay the charge. Based on the results below.
<table><tr><th>Fare level</th><th>% respondents who would pay the charge</th></tr><tr><td>£7.00</td><td>8%</td></tr><tr><td>£12.50</td><td>2%</td></tr></table></td></tr>
<tr><td>Through Trips</td><td>The current approach captures the trips diverting around the CAZ affectively, and is in line with other studies.</td><td>No change</td></tr>
<tr><td>Mode Shift</td><td>As described above, the mode shift forecast by PRISM is lower than expected in the short term, as users will have less options to change destination and are more likely to cancel or change mode.

To adjust this, we will use evidence from 'short term' SP surveys to redistribute the 'Mode Shift', 'Cancel Trip' and 'Change distribution', while keeping the total response across all the responses at the same level as currently forecast.

Over the long term (10 years) the responses will return to the PRISM levels. Assuming a reduction in PT mode shares of 1% p.a. to 2025 and CAGR over the next 5 to the PRISM forecasts.</td><td>Increase 'mode shift from car' and 'cancel trip' and reduce 'change destination' using short term SP survey results. This keeps the total response across the three at the same level.</td></tr>
</table>

3.59 The results of these updates to the model are compared in the tables below for a £12.50 and £8.00 charge in the existing and proposed updated model responses. For the updated model there is around a 6% difference in response rate between the two tests, which is only applied to the non-compliant vehicles (23% of total car fleet in 2020 and 16% in 2022) resulting in a

1.4% and 0.9% increase in non-compliant vehicles in 2020 and 2022 respectively. In addition, the higher upgrade rates will result in increases in compliant vehicles entering the CAZ at the higher charge further offsetting some of the benefits of the higher charge. Previous experience in running the AQ model indicates this will have a negligible impact on air quality on the exceedance links.

Table 3.14: Existing Model Response

Response	At £8		At £12.50	
	2020	2022	2020	2022
Pay Charge	32%	32%	8%	8%
Change Route	22%	22%	22%	22%
Change Destination	12%	12%	18%	18%
Cancel Trip	6%	6%	9%	9%
Replace Vehicle	27%	27%	41%	41%
Mode Shift	1%	1%	2%	2%

Table 3.15: Updated Model Response

Response	At £8		At £12.50	
	2020	2022	2020	2022
Pay Charge	14%	14%	8%	8%
Change Route	22%	22%	22%	22%
Change Destination	7%	6%	4%	3%
Cancel Trip	14%	12%	14%	10%
Replace Vehicle	23%	27%	35%	41%
Mode Shift	20%	18%	17%	15%

Traffic Growth to 2022

3.60 As noted above Public transport mode shares have increased in the centre of Birmingham in recent years. TEMPRO (Version 7.2 – most up to date version) which is used to grow the model from 2020 to 2022 does not reflect these increased PT mode shares or the additional investment in public transport in the City is planned by 2022. To improve the plausibility of the forecasts we propose to use the overall TEMPRO growth levels but leave the mode shares constant between 2020 and 2022. This will be a conservative approach as the trend indicates the PT mode share should increase further.

Table 3.16: Change in 2020-2022 Growth Rates

Car Growth	Growth
TEMPRO Forecasts	2.0%
TEMPRO (Assuming Flat Mode Share 2020-2022)	0.4%
Reduction in 2022 Traffic to/from City Centre	-1.5%

4 Additional measures

Overview

4.1 Several cities such as London, Singapore and Stockholm have successfully implemented congestion charging schemes which have been coupled with a series of ancillary measures around public transport provision and changes in mobility policies. Other cities have introduced alternative measures to charging schemes.

4.2 As a part of the modelling work undertaken previously, additional measures such as rapid installation of electric vehicle infrastructure, zero emissions buses, removal of free parking, speed controls, bus route improvement and network changes were assessed. This chapter summarises similar measures from other cities, and their impacts.

Additional measures on top of congestion or LEZ charging

London

4.3 London was the first major European city to introduce a congestion charging scheme, in 2003. Other than reducing congestion, the scheme also aimed at improving air quality and reliability of driving journey times. It operates between 07:00 and 18:00, with a charge of £11.50, Monday to Friday.

4.4 In 2008, as a first step towards addressing the emissions impact of road vehicles, a Low Emission Zone (LEZ) was established, covering most of the Greater London area, and applying to heavy diesel vehicles. The LEZ was extended to cover larger vans and minibuses in January 2012. Each of these schemes are cordon pricing schemes with automatic number plate recognition. The charge is a flat daily fee.

4.5 The implementation of the LEZ charge was also thought of as a mean to create extra funding for public transport improvements. To provide alternatives for commuters not willing to pay the charge, significant improvements to the bus network were made, with over 300 new buses joining the existing fleet as well as updated routes and improved service frequencies. While during the years leading up to the implementation of the charging scheme bus provision in London was vastly improved, this was accelerated upon its implementation. In the first year of congestion charging, bus ridership went up by 37%, half of it attributed to the charge and the other half to the earlier growth trend[11].

4.6 Moreover, nearly 8,500 park-and-ride spaces were created, as well as enhanced infrastructure for pedestrians and cyclists. Additionally, parking was secured for near-boundary residents, since locals and businesses living just outside of the zone are among the most affected in area-based charging systems.

[11] Gardner et al. (2006) The Benefits of Bus Priority Within the Central London Congestion Charging Zone. Bus Priority Team, Transport for London.

Singapore

4.7 In 1998, the Electronic Road Pricing (ERP) was launched to deter private vehicles from driving into Singapore's Central Area. It substituted a cordon pricing system which had been in place since 1975. The scheme is designed to respond to congestion in real time and as such, charges vary by location and the congestion level of the route at different times of the day.

4.8 Shortly after its introduction, parking fees within the designated zone were doubled. 15,000 park-and-ride spaces were created outside of the zone to encourage mode shift[12]. Moreover, the bus fleet was overhauled, with new routes created and improved frequencies.

4.9 It is estimated that traffic fell in the city by 24% due to the introduction of the scheme, with an increase in bus and train usage of 15%[13].

Stockholm

4.10 The city implemented a LEZ in 1996 and a congestion charging scheme in 2007. As in London, the scheme is based around automatic number plate recognition. However, in this case pricing is based on time of day. Taxis and for-hire vehicles pay the charge as well.

4.11 As in the rest of geographies analysed, there was an improvement of the existing public transport infrastructure, with 2,800 new park-and-ride spaces created outside the zone, 197 new buses added to the fleet and 16 new bus routes created[14].

4.12 Trials of the congestion scheme in 2006 indicated a 22% reduction in traffic volumes across the cordon area and a 4.5% increase in public transport usage.

Alternative measures to congestion or LEZ charging

Parking provision management

4.13 Nottingham introduced a £379-a-year (per parking space) Workplace Parking Levy (WPL) in 2012, which applies to circa 25,000 parking spaces (roughly half of available spaces in the city). The revenues generated by the scheme go towards funding public transport improvements in the area.

4.14 It is estimated that only 18% of employers pay the levy[15]. The charge has led to 40% of journeys to work to be done on public transport, reduced carbon emissions and extra revenues for the City Council, which has improved the bus network since the scheme came into place.

4.15 Perth introduced a parking policy in 1999/2000 with limits on the amount of private tenant parking that could be provided for in the city, as well as, parking levies/taxes on non-

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[12] Provonsha et al. (2018) *Road pricing in London, Stockholm and Singapore: a way forward for New York City. Tri-State Transportation Campaign*

[13] Ibid

[14] Wang, Song et al. (2017) *Study on International Practices for Low-Emission Zone and Congestion Charging*. Ross Centre, World Resources Institute.

[15] WWF Scotland (2016) *International Case Studies for Scotland's Climate Plan*

residential parking. In a 10-year review[16], it was found that public transport usage for trips to work increased from 35% in the mid-1990s to 50% in 2010, with traffic volumes falling by 3-20% over the three years following implementation of the policy.

4.16 Research[17] on the impacts of parking prices on user demand (elasticities to parking prices)/implementation of employee parking schemes, etc, found that road users are 1.5-2 times more sensitive to parking price changes than other out-of-pocket expenses (e.g. a £1 parking increase per trip has the same impact on trip reduction as a £1.5-£2 fuel cost increase).

4.17 The following table summarises the estimated elasticities and cross elasticities for different journey purposes, and user types. It further emphasises that the elasticities are meaningless in the case of implementing a parking price when parking was previously free, but in this case, benchmarked experience suggests a 10-30% reduction in solo commuting trips, especially when policies are implemented in conjunction with rideshare programs. Charging employees can similarly reduce solo commuting by 20-40%.

Figure 4-1: Long-term elasticities for relatively automobile-oriented urban regions (Table 27)*

Term/Purpose	Car Driver	Car Passenger	Public Transport	Slow Modes
Trips				
Commuting	-0.08	+0.02	+0.02	+0.02
Business	-0.02	+0.01	+0.01	+0.01
Education	-0.10	+0.00	+0.00	+0.00
Other	-0.30	+0.04	+0.04	+0.05
Total	*-0.16*	*+0.03*	*+0.02*	*+0.03*
Kilometres				
Commuting	-0.04	+0.01	+0.01	+0.02
Business	-0.03	+0.01	+0.00	+0.01
Education	-0.02	+0.00	+0.00	+0.00
Other	-0.15	+0.03	+0.02	+0.05
Total	*-0.07*	*+0.02*	*+0.01*	*+0.03*

Source: Litman (2017), Understanding Transport Demands and Elasticities. How Prices and Other Factors Affect Travel Behaviour. **"This table indicates how parking fees affects various types of trips. For example, a 10% increase in commuter parking prices will reduce automobile trips and parking demand 0.8%, and increase car passenger, public transport, and slow mode travel (walking and cycling) 0.2% each"*

4.18 Parking policies can also result in a shifting of trip destinations, with a 10% increase in parking prices in the central business district (CBD) of an area resulting in an approx. 5% decrease in demand there but a consequent 8% increase in demand in less preferred CBDs. Increase in trips on public transport is similar to that mentioned above[18].

Occupancy rules

4.19 Local authorities in Jakarta, Indonesia implemented high-occupancy vehicle (HOV) lanes in some of the city's key corridors, with a minimum of 3 passengers per vehicle to reduce congestion during the morning and evening peak hours. Unchanged since 2004, the scheme

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[16] Richardson (2010) *Extracting maximum benefit from parkin policy – 10 years experience in Perth, Australia*

[17] Litman (2017), *Understanding Transport Demands and Elasticities. How Prices and Other Factors Affect Travel Behavior*

[18] Ibid.

was discontinued in 2016, among claims that it was not reducing congestion in the city as well as unavailability of reliable public transport alternatives. However, researchers[19] have shown that delays went up across the whole city after the policy was abandoned, even in those areas where no HOV lanes had been introduced.

Key conclusions

4.20 The following table summarises the research on additional measures.

Table 4-1: Summary of additional measures

Measure	London	Singapore	Stockholm	Nottingham	Perth	Jakarta
Existing Scheme	CCZ/LEZ (T-Charge)	Electronic Road Pricing (ERP)	LEZ/Congestion charging scheme	N/A – alternative measure	N/A – alternative measure	N/A – alternative measure
Year of Implementation	2003 (CCZ), 2008 (LEZ), 2017 (T-Charge)	1998	LEZ (1996), congestion charging (2007)	2012	2000	2004-2016
Additional/ alternate measure	• Significant improvements to bus services (300 new buses) • 8,500 park-and-ride spaces created	• Parking fees doubled. • 15,000 park-and-ride spaces created.	• 197 new buses and 16 new routes • 2,800 park and ride spaces	Workplace parking levy applying to 25,000 parking spaces	Parking levy	High occupancy vehicle lanes
Response	In the first year of congestion charging, bus ridership went up by 37% (half due to the charge and half to growth of buses)	24% reduction in traffic and a 15% increase in bus/train usage.	22% reduction in traffic and 4.5% increase in transit usage.	N/A	3-20% reduction in traffic (over 3 years) and 15% increase in transit use over a decade	Scheme was discontinued resulting in larger delays across the city.

Source: listed in previous sections of this Chapter

4.21 Research based on the experience of London, Stockholm, and Singapore[20] indicates that congestion charging schemes have often been complemented by investment in public transport and argues that a part of their success has been driven by the same. In particular, in the case of London, the increase in bus usage was attributed in equal measure to the charge and the increase in bus infrastructure.

[19] Hanna et al. (2017) *Citywide effects of high-occupancy vehicle restrictions: Evidence from "three-in-one" in Jakarta*. Science – Vol 357, Issue 6346.

[20] Provonsha et al. (2018) *Road pricing in London, Stockholm and Singapore: a way forward for New York City. Tri-State Transportation Campaign*

4.22 Policies such as parking restrictions/employee parking/increase in parking prices can also contribute to a reduction/redistribution of trips, as evidenced by research and experience of the implementation of such schemes.

4.23 The research shows that increasing parking controls can have a positive impact of further reducing highway demand, but that for the schemes to be successfully delivered additional investment is required. The following measures are proposed as part of the Birmingham CAZ to ensure that the scheme is effectively implemented:

- Exemptions for residents and lower income users
- Financial support for upgrading to compliant vehicles for specific users (i.e. low income)
- Mobility Package to support low income users to switch to PT
- City Centre Traffic Light investment to improve bus reliability
- Investment in electric vehicle charging infrastructure

4.24 Additional investment in the Birmingham Public Transport Network that will improve accessibility into the City Centre:

- 3 new Bus Rapid Transit Routes to the City Centre in 2022
- Opening of three new stations on the Camp Hill Rail line by 2022
- Closure of Moor Street Queensway to general traffic opening up an new PT/ wall/cycle network through the City Centre

5 Response of businesses to charging schemes

Overview

5.1 Previous chapters considered the response of car users to the introduction of CAZ-like schemes. These responses can range from upgrading vehicles and becoming compliant, keeping non-compliant vehicles and paying the charge, not travelling or changing modes/routes/destinations.

5.2 This chapter considers the response of business, which often have less options available to them. We further discuss the cost of upgrading light and heavy goods vehicles and how that ties in with their responsiveness, when faced with the charge. We lastly compare the assumptions used in previous modelling work, and our recommendations for any additional sensitivity tests, post benchmarking.

Responsiveness of businesses

5.3 In the case of businesses, there are two key considerations to be taken into account: firstly, in the case of heavy goods transport, the opportunities for mode shift or trip frequency reduction are limited, and secondly, if located within the charging zone, businesses could consider the option of relocation (as a trade-off against paying a charge for each of their vehicles, for each trip), which is less of an option for car drivers (i.e. relocation of their homes).

5.4 The Federation of Small Businesses (FSB) and Defra/DfT have studied the potential impact of newly established CAZs on businesses across England[21]. The businesses surveyed as part of their research work answered in the following fashion when asked what their response would be to the introduction of charging CAZs:

Table 5-1: Defra consultation to LGV and HGV-owning businesses

Response	LGVs (%)	HGVs (%)
Upgrade	25%	44%
Pay charge	42%	28%
Cancel/Change mode/Avoid zone	33%	28%

Source: UK Plan for tackling roadside nitrogen dioxide concentrations

[21] Federation of Small Businesses (2017) *Clearing the air: Supporting small businesses in tackling air quality in England*

5.5 Their research[22] suggests that:

- Most businesses that own non-compliant LGVs (42%) will not upgrade their vehicles in the short term to comply with CAZs due to the high cost involved in doing so. Around 25% are willing to upgrade; and
- In the case of HGV owners, 44% are willing to upgrade their vehicle whereas 28% will just pay the charge.

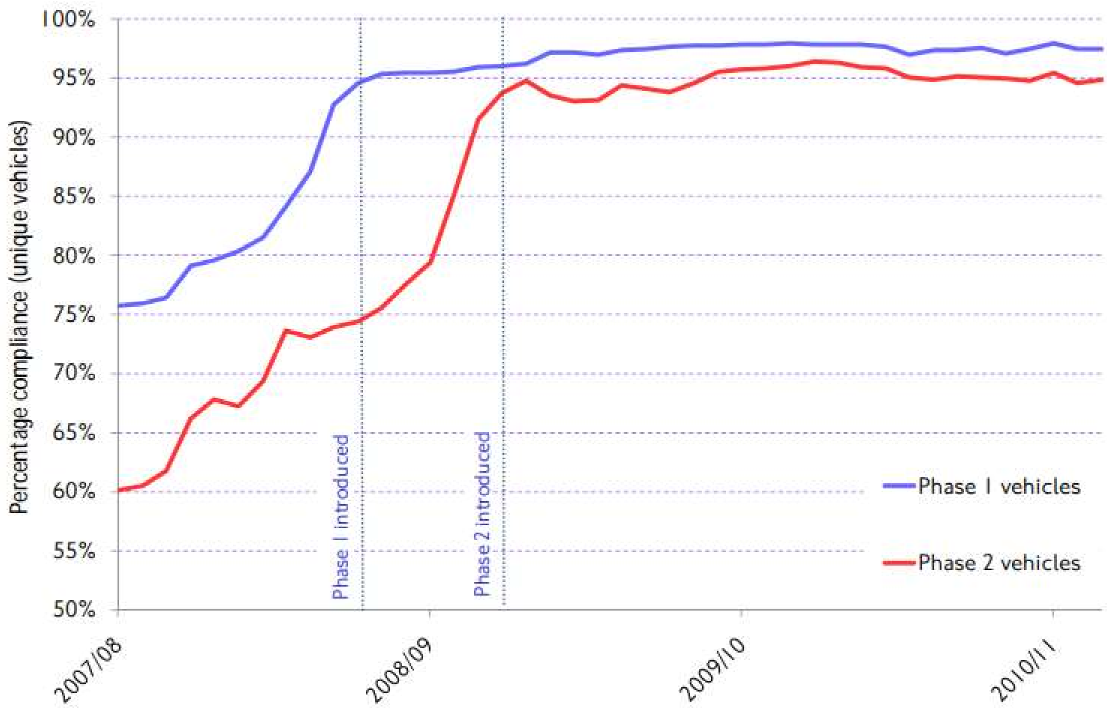
London case study

5.6 Since London is the only city in the UK with an LEZ and congestion charge in place, there has been extensive research around the compliance of businesses with the new regulations around emissions as well as the impact of the charging scheme on businesses within the area.

Compliance with LEZ

5.7 Eight months before the implementation of phase 1 (regulating heavy goods vehicles) of the LEZ scheme in London, only 75% of vehicles were compliant with the LEZ requirements. As the mayor confirmed the introduction of the LEZ, the rate steadily increased, reaching 90% just before the implementation of the scheme. Compliance rates have been steadily increasing, reaching 97%-98% in 2010[23], as can be seen in the following figure.

Figure 5-1: Trend in vehicle compliance (% of vehicles observed in zone) for LEZ phases 1 and 2



Source: Transport for London (2010) Travel in London, Report 3 (Figure 12.3)

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[22] Defra/DfT (2017) *UK Plan for tackling roadside nitrogen dioxide concentrations (technical report)*

[23] Transport for London (2010) *Travel in London, Report 3.*

5.8 As per phase 2 of the scheme (targeting medium goods vehicles), the trend has been very similar. Compliance rates before the introduction of the LEZ stood at around 60% whereas they reached 95%-96% by 2010, marginally lower than phase 1.

Impact of charging on business activity

5.9 Quddus et al.[24] argue that sales at John Lewis on Oxford Street were reduced by 7% after the introduction of the congestion charge solely as an effect of it but the overall impact on the retail industry in London was close to zero. This is due to John Lewis customers showing a higher car mode share than average.

5.10 As part of the study, London First (a group representing businesses in London) surveyed its members to understand their views on the congestion charge. 22% said the charge had been positive while 9% thought it had a negative effect. The overall feeling was that the expense of the extra cost was balanced out by faster travel and quicker delivery times and implied extra productivity.

5.11 Moreover, Steer carried out a study[25] to measure the response of businesses to the introduction of congestion charging through a series of interviews with a wide range of businesses located within and around the congestion zone. Overall, there was broad recognition that travel times inside the zone had been reduced and this had led to more efficient deliveries, although many small businesses lacked the tools to quantify the effect of this on their operations.

5.12 A drop of around 10% in goods vehicles entering the congestion zone had been detected, although there was evidence of changes to the timing of deliveries (i.e. shifted to before or after the charging period) rather than other major changes to the businesses' operational arrangements.

German case study

5.13 LKW Maut is a distance-based toll system for heavy goods vehicles operating at the national level in Germany. Tolls are calculated based on distance driven, vehicle emissions and vehicle category. It aims at reducing the number of empty vehicles on the road network as well as curbing vehicle emissions.

5.14 According to Transport & Environment[26], truck operating costs in Germany stand at around €1/vehicle-km. At the current LKW Maut toll levels, the toll is approximately 10% of this cost. This scheme has led to the renewal of trucks operating in Germany, since the revenue from these tolls has been used to encourage shifting to less polluting vehicles. SMEs get a greater discount than large operators since they work on lower profit margins and as such the cost they face to upgrade is greater in comparison.

5.15 The same author cites statistics from a similar scheme in Belgium, where 85% of toll costs are passed onto clients and as such businesses can withstand the extra cost.

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[24] Quddus, M. et al.(2007) *The impact of the congestion charge on the retail business in London: An econometric analysis.* Transport Policy – volume 14, issue 5, pages 433-444.

[25] Steer Davies Gleave (2003) *London Congestion Charging: Economic & Business Impacts. Freight and Logistics Case Study*

[26] Keeny, Samuel (2017) *The Economic Impacts of Road Tolls*. Transport & Environment

5.16 The effects of the scheme at this price level have been a consolidation of road transport, with fewer trucks running empty on the German road network, as well as a 3.1% increase in use of rail transport[27] among large shippers.

Current BCC assumptions

5.17 We have reviewed ANPR data to obtain a profile of driving frequency (days a year) into the CAZ by vehicle type. Logically, the cost of paying the CAZ goes up as the number of days increases. Regular drivers will most likely upgrade their vehicle, although the trade-off point will depend on the level of charge applied.

5.18 Table 5-2**Error! Reference source not found.** below shows the estimated compliance rate at different charge levels using the methodology described above, considering a 5-year period to assess the costs (i.e. paying the CAZ charge over 5 years versus upgrading to a compliant, second-hand vehicle).

Table 5-2: Estimated rigid and articulated compliance rates at £25, £50 and £75 charge levels (costs over 5 years)

Type	£25/day CAZ charge	£50/day CAZ charge	£75/day CAZ charge	£100/day CAZ charge
Rigid	45%	83%	90%	98%
Articulated	50%	77%	79%	84%
Total	46%	82%	89%	96%

Source: Steer analysis of cost to upgrade HGVs over a 5-year period

5.19 This is, however, not an exhaustive analysis and it's driven by the assumption that businesses will act in the manner described previously (all of them upgrade to a second-hand vehicle if the cost analysis over 5 years suggests a saving). As such, it's a sensitive calculation and should be considered as a placeholder. For instance, the table below illustrates the equivalent compliance rates when comparing costs over a 3-year period instead:

Table 5-3: Estimated rigid and articulated compliance rates at £25, £50 and £75 charge levels (costs over 3 years)

Type	£25/day CAZ charge	£50/day CAZ charge	£75/day CAZ charge	£100/day CAZ charge
Rigid	25%	62%	78%	87%
Articulated	18%	48%	62%	76%
Total	24%	60%	76%	85%

Source: Steer analysis of cost to upgrade HGVs over a 3-year period

Key conclusions

5.20 For LGVs, evidence suggests that sporadic drivers are likely to continue paying the charge, while for regular drivers into the area it is always cheaper to upgrade to a compliant vehicle (considering a time period of 4 years), be it a lease or a second-hand purchase. On the basis of this, we do not suggest changing the previous approach (see Table 1-1) for LGVs.

[27] Gustafsson et al. (2006) *Road User Charging for Heavy Goods Vehicles – an Overview of Regional Impact* BMT Transport Solutions. Swedish Intermodal Transport Research Centre

5.21 For HGVs, while the effects of road pricing in Germany (and Belgium) seem to indicate that a proportion of toll related costs can be passed on to customers, there is still a resulting increase in operating costs at the £50 and £100 charge levels. Evidence from the introduction of the LEZ in London however implies that these vehicles are replaced the rate forecast in the CAZ study but that there is lag of 2 to 3 years before the fleet gets up to its final compliance levels. We therefore recommend implanting an approach that dampens the upgrade rates in the opening years, but with accelerated upgrade response up to 2022.

- Reduction factors applied to upgrade rates as follows:
  - 2020 – 70%
  - 2021 – 90%
  - 2022 – 100%

6 Cost to Upgrade

Cost to upgrade

Cars

Steer assumptions in the modelling

6.1 In order to calculate the cost to upgrade for cars, we have taken the cost of a brand-new Nissan Qashi in 2017 (one of the most popular cars in Britain in 2016), which amounts to £19,000. This value has been depreciated in accordance with JAQU guidelines: loss of 37% of value after the first year and 18% thereafter.

6.2 The cost to upgrade is hence the value of the car to be purchased minus the resale value of the vehicle which is to be replaced. In this regard we have assumed that by 2020 the value of the compliant car in question will remain at £19,000 and the relevant depreciation has been applied to the age of cars with respect to 2020.

6.3 We have assumed average ages by Euro Class by 2020 from ANPR data. It is assumed that the car to be upgraded to will be a second-hand vehicle and hence depreciated. The compliant car will be the eldest (i.e. cheapest) model available within each category, that is, from the year when the emissions standard certification came into place.

6.4 We have assumed that the compliant car to be upgraded to will be of the most similar fuel type to the car for resale, or the closest higher standard.

Table 6-1: Summary of cost to upgrade assumptions

Pre- 2020 Euro Class	Age of resale vehicle	Resale value	Compliant car for upgrade	Purchase cost	Cost to upgrade
Pre-Euro 1	25	£129	Petrol Euro 4	£3,079	£2,950
Euro 1	21	£285	Petrol Euro 4	£3,079	£2,794
Euro 2	17	£629	Petrol Euro 4	£3,079	£2,449
Euro 3	14	£1,141	Petrol Euro 4	£3,079	£1,937
Euro 4	9	£3,079	Petrol Euro 5	£5,584	£2,505
Euro 5	7	£4,579	Diesel Euro 6	£8,304	£3,726

Source: Steer analysis

6.5 A weighted average by number of cars currently on the road by pre-2020 Euro Class (from ANPR data) yields an average cost to upgrade of £3,240.

JAQU assumptions

6.6 A similar rationale has been followed replicating JAQU assumptions to calculate an equivalent cost to upgrade. The depreciation methodology is the same, as well as the assumed ages of the vehicles up for replacement. In this case, the value of a brand-new compliant car by 2020 is £18,000, which is very close to our assumption.

6.7 In this case, several responses are considered when upgrading a vehicle:

- Scrap: A proportion, 25%, of those people taking the upgrade response will scrap their old vehicle. This assumes that the cost to upgrade is equal to the purchase cost, neglecting any resale value. It is assumed that the replacement vehicle is brand new.
- Buy new: A proportion, 25%, of those people choosing to upgrade will buy a brand-new vehicle, selling their former car.
- Switch: A proportion, (75% of 75%), of those people who elect to upgrade will sell their old vehicle and buy the cheapest unaffected one. The purchase cost has been calculated in a similar fashion to the analysis above, plus £200 in transaction costs. It is assumed that all replacement vehicles are the eldest compliant Petrol Euro 4.
- Keep fuel: A proportion, (25% of 75%), of those people who decide to upgrade will sell their old vehicle and buy the cheapest unaffected one of the same fuel type. £200 in transaction costs plus depreciation are included in the estimation of the upgrade cost. This follows the same methodology used by Steer.

6.8 The resulting costs to upgrade, weighted by age of current fleet as per ANPR data, are as follows:

Response	Average cost to upgrade
Scrap	£18,000
Buy new	£14,051
Switch	£401
Keep fuel	£3,187

Source: Steer analysis using JAQU methodology and assumptions

6.9 Applying the shares assumed by JAQU results in an average cost to upgrade of £4,582.

Light Goods Vehicles (LGV)

6.10 In the case of vans, Element studied[28] carried out an analysis of the cost to upgrade from a non-compliant to a CAZ-compliant vans as opposed to paying the CAZ charge (assumed to be £12.50/day). In this case, the compliant vans to be upgraded to were as follows:

- New vehicles: assumed to be on 4-years lease contracts mostly within Birmingham;
- Second hand vehicles: assumed to be purchased outright, more common in surrounding areas.

6.11 The vehicles presented as compliant alternatives were:

- Euro 4 (and above) petrol
- Euro 6 diesel
- Electric

6.12 Over the same 4-year period, the cost comparison is made in the same two scenarios (paying the £12.50 daily charge twice or 5 times a week).

[28] Element Energy (2018): *Birmingham fleet analysis – the case of vans*

6.13 Similar to their analysis for cars, sporadic users wishing to enter the CAZ area just twice a week find it cheaper to just pay the charge rather than upgrading to a compliant vehicle. The exception would be the purchase of a small electric van over the long term, whose running costs come out to be under the forecast incurred cost for paying the non-compliance charge.

6.14 For regular users intending to enter the area 5 times a week, the conclusions were (by vehicle type):

- Small vans: purchasing a compliant vehicle is cheaper than paying the charge;
- Medium vans: purchasing a compliant vehicle is cheaper than paying the charge;
- Large vans: with a longer pay-back period, purchasing a compliant vehicle is cheaper than paying the charge. The optimal choice in the long run is an electric vehicle, although supply in this segment of the second-hand market is limited.

6.15 In every case, a 4-year lease (rather than a second-hand purchase) is cheaper than paying the charge to enter the area 5 times a week (over the 4 year period).

6.16 This analysis is consistent with the observations from London, where Phase 2 vehicles switched to compliant vehicles over a 2-3 year period, prior to implementation of the charge. They did not however reach the compliance levels of heavy goods vehicles. It is important to note that Defra's analysis (Table 5-1) suggests that a lower proportion of light goods vehicles will upgrade in the short term, which is consistent with the assumptions used in the modelling, where the short-term behaviour is assumed to mimic that of cars.

6.17 Moreover, earlier research carried out by Steer[25] seems to point towards the same direction: several small businesses operating mostly through the use of LGVs showed greater cost sensitivity as well as a higher degree of flexibility to consolidate deliveries and reduce their exposure to the charge in this manner, rather than incurring high costs such as major operational arrangements (which, in this case, could be equivalent to a major operation such as fleet replacement).

6.18 Furthermore, Jacobs[29] has engaged with businesses operating in Birmingham and the surrounding area. Operators at the national level raised that they have plans to upgrade vehicles in accordance with current lease agreements, since early termination may result in payment of high fees. As such, compliance rates will vary greatly depending on the composition of the businesses' fleets and their lease agreements, which will delay the ability of companies to respond to the CAZ up to until 2025 in some cases. Companies with existing compliant vehicles have expressed their willingness to move part of such fleets to operate in CAZ cities.

Heavy Goods Vehicles (HGV)

6.19 In order to understand the behaviour of this segment, we have compared the magnitude of CAZ charges with respect to operating costs. Data by the Freight Transport Association[30] is used for this purpose, as it publishes yearly reports analysing operating costs of a wide range of vehicles, including the following variables:

- Running costs, taking into account maintenance, consumption, fuel prices (2017), tyre life;
- Standing costs, including insurance and depreciation;

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[29] Jacobs (March 2018) *Clean Air Zone: Freight & Logistics* – Birmingham City Council

[30] Freight Transport Association (October 2017) *Manager's Guide to Distribution Costs*

- Overheads.

6.20 Two types of heavy good vehicles have been used as placeholder for short and long-distance driving:

- Short-distance vehicles: assumed to be a 7.5-tonne box, annual mileage of 40,000
- Long-distance vehicles: assumed to be a 26-tonne 3-axle vehicle, annual mileage of 60,000

6.21 It is assumed that both types of vehicles are operated over a period of 5 days a week, 48 weeks a year. This results in the following costs:

Table 6-2: Operating costs of short-distance and long-distance heavy goods vehicles

Vehicle	Annual cost (from FTA)	Daily cost	Cost per km-vehicle	% increase in operating costs at £50/day charge	% increase in operating costs at £100/day charge
Short-distance	£60,159	£251	£0.93	20%	40%
Long-distance	£96,931	£404	£1.00	12%	24%

Source: Freight Transport Association (FTA)

6.22 As can be seen from the table above, there is between a 12%-40% increase in operating costs depending on the charge level and distance travelled by the truck. Using the Belgian example, and assuming 80% of these costs are passed on to customers, there is still a remaining 2.4% - 8% increase in operating costs, per day to be borne by heavy goods vehicles.

6.23 Taking into account the observations from London, where Phase 1 vehicles switched rapidly to compliant vehicles over a 2-3 year period, prior to implementation of the charge, reaching higher compliance levels than light goods vehicles and Defra's analysis (Table 5-1) suggesting a higher proportion of light goods vehicles will upgrade in the short term (and the implied impact on operating costs) – we believe that there is evidence to suggest that heavy goods vehicles will upgrade their vehicles over a 2-3 year period. This is faster than the 5-year period assumed in the modelling, and we suggest a sensitivity test on a faster upgrade period.

Comparison between cost to upgrade and payment of CAZ charge

6.24 Using ANPR data as well as JAQU guidelines, a model to predict the compliance rate of HGVs based on a comparison between the cost incurred by paying the CAZ charge and the cost of upgrading to a compliant vehicle was built.

6.25 Several levels of CAZ charge were tested. It is assumed that when upgrading is a cheaper option, every vehicle will be upgraded to a 4-year-old compliant vehicle.

6.26 The assumed cost to purchase a brand-new HGV is shown on **Error! Reference source not found.** below. This is a weighted average of all available vehicles within each type (rigid and articulated) in 2018, which are priced differently according to size and specifications. The weighing has been done according to figures from ANPR, which specify the number of vehicles by specification within each type. We have assumed a 4-year old equivalent vehicle as an option for upgrade, resulting in the cost shown on the rightmost column below.

Table 6-3: Cost to buy brand-new HGVs, 2018

Type	Cost to Buy	Cost to Upgrade
Rigid	£68,000	£24,370
Articulated	£81,000	£29,030

Source: Steer from ANPR data

6.27 These prices are reduced according to JAQU's depreciation guidelines: 35% after one year and 18% a year thereafter. It is assumed that Euro 5 and Euro 6 vehicles will have upgraded before 2020. Therefore, for Euro 1 to Euro 4 standards, these are the calculated resale values for old, non-compliant cars:

Table 6-4: Resale value of rigid and articulated HGVs following JAQU depreciation guidelines

Type	Class	Age	Resale value
Rigid	Euro 1	21	£835
Rigid	Euro 2	17	£1,847
Rigid	Euro 3	14	£3,350
Rigid	Euro 4	9	£9,035
Articulated	Euro 1	21	£995
Articulated	Euro 2	17	£2,200
Articulated	Euro 3	14	£3,990
Articulated	Euro 4	9	£10,762

Source: Steer analysis following JAQU guidelines

6.28 Therefore, the total cost to upgrade will be the cost to buy the second-hand vehicle minus the resale value of the non-compliant one which is meant to be traded in. This cost is then compared against the cost of paying the CAZ charge.

Recommendations

6.29 We will adopt JAQU's assumptions on vehicle costs, depreciation and behavioural assumptions, but based on the observed Birmingham age composition.

7 Conclusions and recommendations for model testing

Conclusions

7.1 This chapter highlights the key conclusions from our desktop research and summarises the behavioural responses to be implemented, in the next phase of this study.

Level of charge

7.2 SP research indicates that proportion of respondents willing to pay the charge decreases swiftly till the £7-8 charge level with the corresponding shares of respondents changing mode/not travelling increasing, after which the combined shares of these two alternatives remain relatively stable. In light of this, we recommend a sensitivity test at the £7-8 mark, for the short-term response related to this test.

7.3 Analysis of the surveys indicate that as the charge level approaches the £12.50 mark there is little impact on the numbers of non-compliant vehicles entering the CAZ. Indeed, our testing of an 'ultra high' charge level, double the TfL ULEZ levels indicates that while there would be a reduction in non-compliant vehicles, it could also increase the total numbers of vehicles entering the CAZ as more infrequent drivers choose to upgrade. This could have a counterproductive approach as the air quality issues are also related to the volume as well as the type of vehicles entering the CAZ.

7.4 For business vehicles that have chosen not to upgrade at the high charge, they would be likely to pass the charge onto their customers rather than upgrade as they are very resistant to upgrade at this higher level.

Table 7.1: CAZ D Ultra High and CAZ D High

CAZ Category	Total vehicles entering CAZ (2020)	Non-compliant vehicles entering CAZ (2020)	No of non-compliant vehicles entering CAZ (2020)
CAZ D 'Ultra High'	197,500	1,300	0.7%
CAZ D 'High'	190,900	6,500	3.4%

Duration of charge

7.5 Most active CAZ/LEZs in Europe (including London's) function on a 24h-a-day basis[31], 7 days a week. Some, such as Lisbon's, are only in place over 12 daytime hours from Monday to

[31] Holman et al. (2015) *Review of the efficacy of low emission zones to improve urban air quality in European cities.* Atmospheric Environment, vol 111, pages 161-169

Saturday, and some Italian and Greek LEZs vary during the year. These are, however, exceptions.

7.6 TfL conducted research into the impacts of implementing a peak charge vs. 24-hour charge and concluded that to avoid drivers rescheduling their trips and capture all emission sources, a 24-hour charging system should be implemented. They further stated that a 24-hour charge is more easily understood. Moreover, earlier research carried out by Steer[25] indicated that there is evidence of a rescheduling of trips being performed by operators after London's congestion charge was implemented so as to avoid being subject to payment.

7.7 As such, we recommend a 24-hour charging system.

Compliance rate

7.8 The compliance rates reported in the SP studies outside of London are lower than those for London at the £10,000 cost to upgrade, this could be indicative of the differing patterns of trips and lower GDP/capita, and it could be argued that Birmingham would follow a pattern more similar to cities outside of London.

7.9 As the cost to upgrade goes down, the compliance rate goes up – at the £7,000 mark, with the SP studies indicating similar compliance rates to those assumed for Birmingham at the £3,240 mark for the city centre, and marginally lower than those assumed overall.

7.10 However, given that the rates for Birmingham were based on the ULEZ study – which are already higher than those for other cities, and since they were adjusted for Birmingham's cost to upgrade, income distribution and frequency (based on ANPR data), and overall, they fall within the range indicated by TfL and other analysis, we do not suggest any changes to these assumptions.

7.11 However, it is likely that the upgrade will take some time to reach the forecast rates. We therefore recommend a 'ramp-up' approach that delays some upgrades in the first two years.

Short-term response

7.12 As mentioned above, benchmarking indicates that after a charge level of £7-8, the response stabilises. The overall proportions of respondents who state that they would change routes SP studies outside of London is significantly larger than in the case of London, and the corresponding proportion changing modes is smaller – likely driven by the availability of public transport options in London – it could be argued that Birmingham would follow a similar response to non-London cities given that its public transport availability is less extensive than in the case of London.

7.13 Benchmarking of reduction in trips when faced with road tolls/congestion charging schemes indicates a 10%-35% reduction in overall trips, with research into pricing elasticities of congestion (and similar charging schemes), which indicate values around -0.3 (i.e. a 10% increase in pricing results in a 3% fall in traffic). This is consistent with our previous work, which implied an 8% reduction under the £12.50 charge scenario.

7.14 BCC's modelling uses the PRISM model to distribute the short-term responses of users – this is done separately for trips to and from the city centre, and within the city centre. The following table summarises the overall assumptions employed in the modelling (at the "high" £12.50 charge level) vs. benchmarks. As can be seen, the results of the PRISM run show that mode shift forecast is low in comparison with the redistribution impacts of people switching their car trips to non-city centre zones, compared to the benchmarks (and Birmingham's consultation responses).

7.15 The rate of increase in people paying to enter the CAZ from reduced charges from the £12.50 charge, is more rapid than seen in the other SPs. As the existing methodology is based on an elasticity to toll from a run of the PRISM demand model at a £12.50 charge, the lower charge levels are less reliable. We therefore recommend using an elasticity to dampen the response to the charge below £12.50.

7.16 As the PRISM model predicts changes over the long term, one mitigation (outlined in our previous work)[32] is to test an 'out of model' adjustment which replaces destination shift with mode shift in the short term, but reverts back to destination shift in the long term, if required.

7.17 We therefore recommend increasing the 'mode shift' and 'cancel' trips, and decreasing the change destination response. This keeps the overall response of the three at the same level, but shifts the population between them.

Cost to upgrade

7.18 We recommend adopting JAQU's cost to upgrade assumptions, which is moderately higher than is currently used in the model. In addition, we have conducted a sensitivity test assuming 0 upgrade rates. This will effectively provide an upper level of the impact of the price to upgrade being underestimated.

Additional measures over and above the CAZ

7.19 Research based on the experience of London, Stockholm, and Singapore[33] indicates that congestion charging schemes have often been complemented by investment in public transport and argues that a part of their success has been driven by the same. In particular, in the case of London, the increase in bus usage was attributed in equal measure to the charge and the increase in bus infrastructure.

7.20 Policies such as parking restrictions/employee parking/increase in parking prices can also contribute to a reduction/redistribution of trips, as evidenced by research and experience of the implementation of such schemes. We will discuss in conjunction with BCC whether additional tests around these are to be considered.

Updated Modelled Testing

7.21 The following table summarises our recommendations for updating the forecasts. In to this work a set of sensitivity tests have been undertaken to demonstrate the impacts of various assumptions which will be reported in subsequent versions of this report.

Table 7-2: Key assumptions summary and sensitivity tests

	Vehicle type	Assumptions (CAZ D – High)	Benchmarking conclusions
Level of charge	Cars/taxi/light goods vehicles (LGV)	£12.50	Test a charge level of £7-8

[32] Steer (2018), *Birmingham Clean Air Zone Feasibility Study - Future Year Traffic Modelling (June 2018) – Appendix A*

[33] Provonsha et al. (2018) *Road pricing in London, Stockholm and Singapore: a way forward for New York City. Tri-State Transportation Campaign*

	Vehicle type	Assumptions (CAZ D – High)	Benchmarking conclusions
	Heavy goods vehicles (HGV)/bus/coach	£100	£50
Duration of charge	All vehicle types	24-hour	24-hour
Compliance rates	Cars/LGV	Choice Modelling based on TfL (ULEZ) SP research, adjusted to Birmingham demographics and ANPR data	Assume a 'ramp up' period (delaying upgrades in the short term)
	Taxis	Taxis and buses assumed to upgrade to compliant vehicles through licencing agreements	No additional tests
	HGV	HGVs users value for money over 5 years period on whether to upgrade	Sensitivity test on a shorter upgrade period
Short term response	Cars (to/from city centre)	PRISM model used to forecast options (cancel trip/change mode/change route/pay)	• Out of model adjustment (as described previously); - Keep Existing Upgrade Rates (with ramp-up) - Dampen increase in paying cars for charges over £7 but using current the £12.50 level as the cap. - Assume increased mode shift - Assume PRISM long term responses by 2030
	Cars/LGV (through trips)	BCC CAZ assignment model to forecast options (avoid/pay charge)	Through trips as currently forecast
	Taxis	N/A – all assumed to upgrade to compliant vehicles	N/A – all assumed to upgrade to compliant vehicles
	HGV	Trade-off of cost to upgrade over a 5-year period vs. cost of paying a charge throughout this period	No additional tests
Cost to upgrade	Cars	£3,240: JAQU assumptions	£4,582: JAQU assumptions
	LGV	£6,500: JAQU assumptions	£6,500: JAQU assumptions
	HGV	£10,073 – 24,816 (depending on HGV type – Rigid/Arctic) and fuel type (Euro 1 – 4): Road Haulage Association Cost Tables	£24,370 – 29,030 (depending on HGV type – Rigid/Arctic) and fuel type (Euro 1 – 4): JAQU Assumptions. Improved Profiling of trip frequencies from ANPR surveys (Previously underestimated trip frequency)

Source: Steer analysis

Control Information

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Complex questions.
Powerful answers.

To	Fiona Waters	**Memo**	
Cc	David Harris		
From	Caulfield, Tom		
Date	13 November 2018		
Project	Birmingham Clear Air Zone	Project No.	23013602

HGV Trip Frequency Analysis

1. This memo is in response to JAQU's note 'Suggested amendment to frequency of journeys estimate in HGV response analysis'. JAUQ acknowledges the overall robustness of Birmingham's approach of assessing trip frequency into the zone to calculate the CAZ charges against the cost of upgrading their vehicle. Birmingham's trip frequency is derived from one week of data from the ANPR surveys, and JAQU has made available analysis of Trafficmaster GPS data over a year.

2. Birmingham's approach to expanding the data to the whole year as follows:

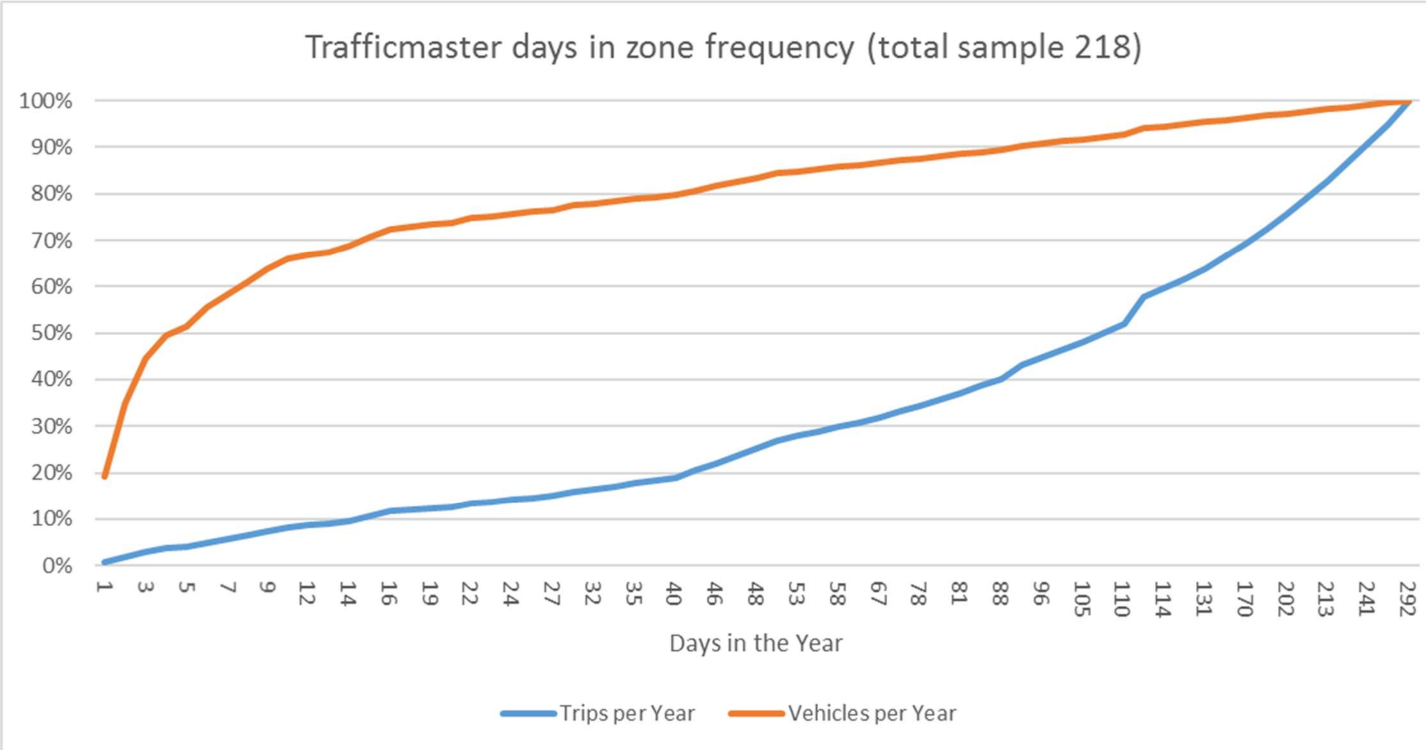
- HGVs captured for 2 days or over are assumed to represent a typical vehicle frequency rate for the year and are multiplied by 52 weeks to get the annual trips into the zone.
- For vehicles captured one day in the week an assumption was made that these vehicles were spread with a reverse distribution as the more frequent users.
- An additional calculation is applied so that only a proportion of the HGV demand in the frequency band close to the 'break even' point is deemed to upgrade.

3. Analysis of the Trafficmaster data provided by JAQU indicates that there is a shallower drop off in trip frequencies than in the approach taken by Birmingham. This could potentially overestimate the number of HGVs upgrading as there is a higher proportion of low frequency trips than currently forecast.

Traffic Master Analysis

4. JAQU provided the underlying Trafficmaster data as shown in figure 1 below. The data is presented as a cumulative proportion of the total HGV fleet from low frequency to high, for individual vehicles and weighted by total trips. This illustrates the impact on vehicle kilometres of the different vehicle frequencies in the CAZ. For example, around 70% of vehicles enter the CAZ for 16 days or less, but this represents around only 15% if total journeys.

Figure 1: Cumulative Distribution of Trip Frequency Into the CAZ (from low to high)



5. JAQU's proposed approach to incorporating the Trafficmaster data into the forecasts is use the ANPR frequency distribution for those vehicles captured twice or more in the week, but to use the Trafficmaster distribution for those captured for 1 week or less.

6. Applying this approach (using the data behind Figure 4 in the JAQU note 'Frequency of journeys in HGV response analysis') the following upgrade rates are derived. Applying this will lead to a 12% reduction in complaint trips in the CAZ. We have also applied the same calculation using the full Trafficmaster data set and this results in a similar (although slightly higher) upgrade rates.

Table 1: Upgrade Rate (By Trip)

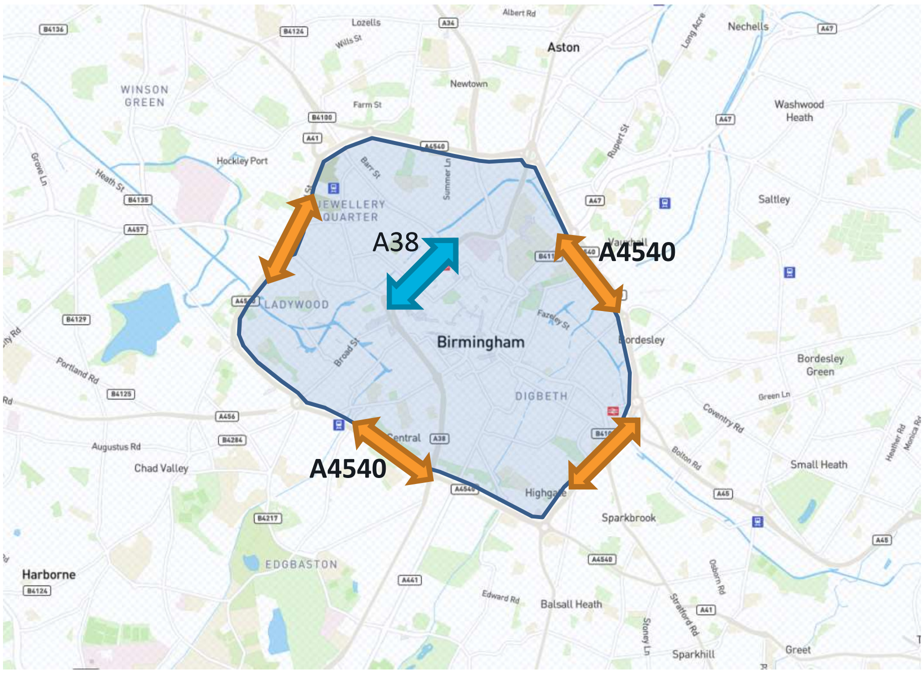
Charge	BCC	JAQU	Difference (JAQU-BCC)
Medium (£50)	**85%**	**73%**	**-12%**
High (£100)	**94%**	**82%**	**-12%**

Through Trips

7. In modelling the impacts of the CAZ on Birmingham the demand matrices (trips) are split into those with an origin or destination in the CAZ and those that are not. The upgrade rates are only applied to those trips with an origin and destination within the CAZ, with all other non-compliant vehicles left non-compliant.

8. The Birmingham CAZ has significant numbers of through trips, due to the A38 (a major trunk road) running through the centre of the city centre. The location of the CAZ boundary offers existing through trips a reasonable alternative to travelling through the City Centre, by utilising the A4050 ring road.

Figure 2: City Centre Routing



9. Trips that avoid the zone through route choice are captured in the assignment model where a penalty is applied to vehicles that enter the zone and those that have an alternative can reroute. For the toll levels proposed for the CAZ it will be more economic to reroute (rather than upgrading or paying the charge) for all through trips.

10. If we include through trips in the calculation, we end up with the upgrade rates shown in table 2. This implies an upgrade rate of 62%, using the existing BCC option and 53% if the Trafficmaster data is included.

Table 2: Upgrade rates including rerouting

Approach	Upgrade Rate (to/ from CAZ)	Rerouting	Total Upgrade Rate
BCC	85%	27%	62%
JAQU	73%	27%	53%

11. While it is reasonable to exclude through trips from the upgrade rates, there are a number of factors that indicates using the Trafficmaster frequencies would underestimate total upgrade rates:

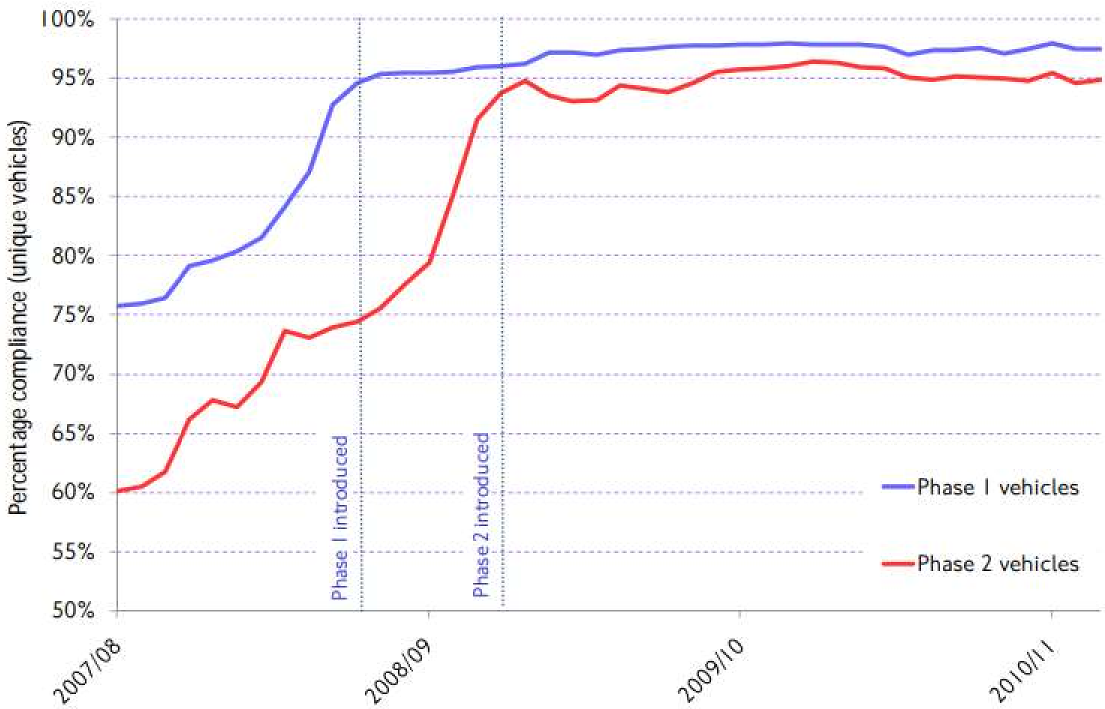
- Through trips are more likely to be lower frequency trips. Trips with a start and end in the City Centre are more likely to be making a regular trip, whereas the through trips will have a mix of long distance irregular trips as well as more the frequent deliveries.
- Additionally, the CAZ would likely be a further increase in frequency of trips for compliant vehicles as these vehicles are more likely to be used for trips that are required to enter the centre.

12. Given that the upgrade assumptions are applied to trips with an origin or destination in the City Centre it is therefore likely that the trip frequency of these movements will have a distribution similar to that used in the BCC forecasts. Using the full distribution of lower frequency trips into the zone, will ignore the fact that many will be through trips that can avoid the zone by changing route.

Summary

13. We would recommend using the existing BCC trip frequencies to calculate upgrade rates in the City Centre. This accounts for the likely higher levels of trip frequencies for trips to and from the City Centre compared to all trips (accounting for through trips). We have benchmarked the results against the observed ULEZ responses, and this results in similar levels of non-compliant HGV reductions. We have also applied a ramp-up effect in the first two years of operation, to build in the likely delay in upgrade rates in the opening years.

Figure 3: Upgrade Rates for HGVs in ULEZ



To	Birmingham City Council	**Technical Note**	
Cc			
From	Caulfield, Tom		
Date	16 November 2018		
Project	Birmingham Clean Air Zone - Final Business Case	Project No.	23013602

Sensitivity Testing

1. Sensitivity tests on the traffic model have been run, to support the development of the CAZ scheme. The tests are summarised in the table below:

Table 1: Sensitivity Tests

Model Elements	Tests
Traffic Growth	1) Low Growth - City Centre traffic is flat + existing model assumptions for outer areas.
	2) High Growth - Apply TEMPRO trip growth to the outer areas on existing City Centre growth.
Behavioural Responses to Charging	1) Apply published JAQU responses
	2) Apply TfL ULEZ responses directly
	3) 0 Vehicle Upgrades
	4) Double Charge
	5) Outer CAZ
Cost to Upgrade	1) Apply JAQU behavioural assumptions on new vehicle upgrades
	2) Assume HGV users assess cost to upgrade over 3 rather than 5 years.
Base Year Correction	1) Scale up HGV flows based on mismatch between base year and observed counts crossing the screenline.
	2) Scale up All PM peak flows by 5%
Congestion	1) Increase delays by 5%
	2) Decrease delays by 5%
Fleet	1) Latest assumptions on when Euro classes enter the fleet tested (this test is underway).
	2) Assume age of fleet increases over time (less compliant vehicles naturally enter the fleet)

Assumptions

OBC Growth Assumptions

1. The growth rates for the 2020 central case are from the PRISM model, which had been updated with TEMPRO demographic data with the following observations:

- City Centre traffic growth is higher in PRISM compared to TEMRPO
- For the rest of the West Midlands traffic growth is lower than the TEMPRO forecasts

steer

Table 2: AM Peak Growth Rates - Central Case (2016 to 2020)

Sector	CAR			LGV			HGV		
	Origin	Destination	Total	Origin	Destination	Total	Origin	Destination	Total
City Centre	7.0%	8.4%	7.9%	10.7%	10.9%	10.8%	3.3%	3.7%	3.5%
Rest of Birmingham	4.2%	3.1%	3.7%	10.7%	10.8%	10.7%	3.1%	3.2%	3.2%
Rest of West Midlands	4.1%	4.7%	4.4%	10.7%	10.6%	10.6%	2.9%	2.9%	2.9%
Total	**4.3%**	**4.3%**	**4.3%**	**10.7%**	**10.7%**	**10.7%**	**3.0%**	**3.0%**	**3.0%**

Table 3: Inter Peak Growth Rates – Central Case (2016 to 2020)

Sector	CAR			LGV			HGV		
	Origin	Destination	Total	Origin	Destination	Total	Origin	Destination	Total
City Centre	8.1%	7.9%	8.0%	10.7%	10.8%	10.8%	3.6%	3.6%	3.6%
Rest of Birmingham	3.7%	3.7%	3.7%	10.7%	10.7%	10.7%	3.1%	3.1%	3.1%
Rest of West Midlands	5.4%	5.3%	5.3%	10.7%	10.7%	10.7%	2.9%	2.9%	2.9%
Total	**4.7%**	**4.7%**	**4.7%**	**10.7%**	**10.7%**	**10.7%**	**3.0%**	**3.0%**	**3.0%**

Table 4: PM Peak Growth Rates – Central Case (2016 to 2020)

Sector	CAR			LGV			HGV		
	Origin	Destination	Total	Origin	Destination	Total	Origin	Destination	Total
City Centre	8.2%	6.3%	7.4%	10.7%	10.8%	10.7%	3.8%	3.4%	3.6%
Rest of Birmingham	3.3%	4.2%	3.7%	10.7%	10.7%	10.7%	3.1%	3.1%	3.1%
Rest of West Midlands	4.8%	4.4%	4.6%	10.8%	10.8%	10.8%	2.9%	3.0%	3.0%
Total	**4.4%**	**4.4%**	**4.4%**	**10.7%**	**10.7%**	**10.7%**	**3.0%**	**3.0%**	**3.0%**

Low Growth

2. For the low growth scenario, the following adjustments to the growth were made:

- Set car growth for trips with an origin or destination in the City Centre to stay flat (0%) from 2016
- LGV and HGV growth is set to be the same as TEMRPO for City Centre trips.
- The rest of the region's growth is left at PRISM levels as it is on the low side compared to TEMPRO

Table 5: AM Peak Growth Rates - Central Case (2016 to 2020)

Sector	CAR			LGV			HGV		
	Origin	Destination	Total	Origin	Destination	Total	Origin	Destination	Total
City Centre	0.0%	0.0%	0.0%	4.1%	4.1%	4.1%	3.1%	3.1%	3.1%
Rest of Birmingham	4.2%	3.1%	3.7%	10.7%	10.8%	10.7%	3.1%	3.2%	3.2%
Rest of West Midlands	4.1%	4.7%	4.4%	10.7%	10.6%	10.6%	2.9%	2.9%	2.9%
Total	**4.0%**	**3.6%**	**3.8%**	**4.1%**	**4.1%**	**4.1%**	**3.0%**	**3.0%**	**3.0%**

Table 6: Inter Peak Growth Rates – Central Case (2016 to 2020)

Sector	CAR			LGV			HGV		
	Origin	Destination	Total	Origin	Destination	Total	Origin	Destination	Total
City Centre	0.0%	0.0%	0.0%	4.1%	4.1%	4.1%	3.1%	3.1%	3.1%
Rest of Birmingham	3.7%	3.7%	3.7%	10.7%	10.7%	10.7%	3.1%	3.1%	3.1%
Rest of West Midlands	5.4%	5.3%	5.3%	10.7%	10.7%	10.7%	2.9%	2.9%	2.9%
Total	**4.3%**	**4.3%**	**4.3%**	**4.1%**	**4.1%**	**4.1%**	**3.0%**	**3.0%**	**3.0%**

Table 7: PM Peak Growth Rates – Central Case (2016 to 2020)

Sector	CAR			LGV			HGV		
	Origin	Destination	Total	Origin	Destination	Total	Origin	Destination	Total
City Centre	0.0%	0.0%	0.0%	4.1%	4.1%	4.1%	3.1%	3.1%	3.1%
Rest of Birmingham	3.3%	4.2%	3.7%	10.7%	10.7%	10.7%	3.1%	3.1%	3.1%
Rest of West Midlands	4.8%	4.4%	4.6%	10.8%	10.8%	10.8%	2.9%	3.0%	3.0%
Total	**3.8%**	**4.1%**	**4.0%**	**4.1%**	**4.1%**	**4.1%**	**3.0%**	**3.0%**	**3.0%**

High Growth

3. For the High growth scenario, the following adjustments to the growth was made:

- City Centre growth is kept the same as PRISM, as it is higher than TEMPRO
- The rest of the region's growth is set at the TEMPRO levels which is higher than PRISM growth

Table 8: AM Peak Growth Rates - Central Case (2016 to 2020)

Sector	CAR			LGV			HGV		
	Origin	Destination	Total	Origin	Destination	Total	Origin	Destination	Total
City Centre	7.0%	8.4%	7.9%	10.7%	10.9%	10.8%	3.3%	3.7%	3.5%
Rest of Birmingham	5.7%	4.3%	5.0%	10.7%	10.8%	10.7%	3.1%	3.1%	3.1%
Rest of West Midlands	4.7%	4.8%	4.8%	10.7%	10.6%	10.6%	3.1%	3.1%	3.1%
Total	5.2%	4.9%	5.0%	10.7%	10.7%	10.7%	3.1%	3.1%	3.1%

Table 9: Inter Peak Growth Rates – Central Case (2016 to 2020)

Sector	CAR			LGV			HGV		
	Origin	Destination	Total	Origin	Destination	Total	Origin	Destination	Total
City Centre	8.1%	7.9%	8.0%	10.7%	10.8%	10.8%	3.6%	3.6%	3.6%
Rest of Birmingham	5.5%	5.6%	5.5%	10.7%	10.7%	10.7%	3.1%	3.1%	3.1%
Rest of West Midlands	4.5%	3.3%	3.9%	10.7%	10.7%	10.7%	3.1%	3.1%	3.1%
Total	**5.1%**	**4.5%**	**4.8%**	10.7%	10.7%	10.7%	**3.1%**	**3.1%**	**3.1%**

Table 10: PM Peak Growth Rates – Central Case (2016 to 2020)

Sector	CAR			LGV			HGV		
	Origin	Destination	Total	Origin	Destination	Total	Origin	Destination	Total
City Centre	8.2%	6.3%	7.4%	10.7%	10.8%	10.7%	3.8%	3.4%	3.6%
Rest of Birmingham	4.5%	5.4%	4.9%	10.7%	10.7%	10.7%	3.1%	3.1%	3.1%
Rest of West Midlands	5.5%	4.2%	4.8%	10.8%	10.8%	10.8%	3.1%	3.1%	3.1%
Total	5.5%	4.2%	4.8%	10.7%	10.7%	10.7%	**3.1%**	**3.1%**	**3.1%**

Behavioural Test

JAQU Response

4. JAQU published a technical report as part of their National Air Quality Plan which included the assumptions on how users would respond to a charging CAZ. These responses are compared to the BCC responses used in the OBC in the table below. The route choice response is forecast within the assignment model rather than being taken directly from JAQU.

Table 11: Car Responses ULEZ

Response	OBC Response	JAQU Responses
Pay Charge	10%	8%
Change Destination	23%	0%
Cancel Trip	10%	8%
Replace Vehicle	54%	72%
Mode Shift	2%	12%
Total	100%	100%

Table 12: LGV Responses ULEZ

Response	OBC Response	JAQU Responses
Pay Charge	53%	22%
Change Destination	0%	0%
Cancel Trip	0%	7%
Replace Vehicle	47%	70%
Mode Shift	0%	2%
Total	100%	100%

Table 13: HGV Responses ULEZ

Response	OBC Response	JAQU Responses
Pay Charge	5%	9%

Change Destination	0%	0%
Cancel Trip	0%	4%
Replace Vehicle	95%	86%
Mode Shift	0%	0%
Total	100%	100%

ULEZ Responses

5. TfL's ULEZ stated preference survey results were used directly to test the car user's responsiveness rates. As with the JAQU test the route choice for non-city centre traffic was taken from the assignment model.

Table 14: ULEZ Car Responses

Response	OBC Response	ULEZ Responses
Pay Charge	10%	9%
Change Destination	23%	6%
Cancel Trip	10%	12%
Replace Vehicle	54%	56%
Mode Shift	2%	17%
Total	100%	100%

0 Vehicle Upgrades

6. For this test all non-compliant car users are assumed not to upgrade to a compliant vehicle. The responsiveness comes directly from the PRSIM demand model CAZ run and is shown in the table below.

Table 15: Car No Upgrade Test

Response	OBC Response	0 Upgrade Responses
Pay Charge	10%	22%
Change Destination	23%	56%
Cancel Trip	10%	17%
Replace Vehicle	54%	0%
Mode Shift	2%	5%
Total	100%	100%

Ultra-High Charge

7. The BCC OBC model was rerun with users charged double what was assumed in the OBC high charge, as follows:

- Car/ Taxi/ LGV - £25
- HGV/ Coaches - £200

Outer CAZ

8. The model was rerun with the CAZ charge applied on traffic crossing the Birmingham outer ring road A4040 rather than applying just to City Centre traffic. This was run on the CAZ D high scenario without further adjusting the demand impacts and compliance rates. This will underestimate the traffic reductions of the scheme but gives a reasonable picture of the route choice impacts.

Cost to Upgrade

Apply JAQU behavioural assumptions on new vehicle upgrades

9. For the OBC the following assumptions where made:

- Users will upgrade to the cheapest available vehicle that is an upgrade (e.g. diesel 4 would upgrade to petrol 5)
- Users will always trade in their old vehicle to offset the cost of their new vehicle.

10. JAQU however have published their research on the cost of a new vehicle, deprecation rates, and the choice users will make when choosing to upgrade. Several responses are considered when upgrading a vehicle:

- Scrap: A proportion, 25%, of those people taking the upgrade response will scrap their old vehicle. This assumes that the cost to upgrade is equal to the purchase cost, neglecting any resale value. It is assumed that the replacement vehicle is brand new.
- Buy new: A proportion, 25%, of those people choosing to upgrade will buy a brand-new vehicle, selling their former car.
- Switch: A proportion, (75% of 75%), of those people who elect to upgrade will sell their old vehicle and buy the cheapest unaffected one. The purchase cost has been calculated in a similar fashion to the analysis above, plus £200 in transaction costs. It is assumed that all replacement vehicles are the eldest compliant Petrol Euro 4.
- Keep fuel: A proportion, (25% of 75%), of those people who decide to upgrade will sell their old vehicle and buy the cheapest unaffected one of the same fuel type. £200 in transaction costs plus depreciation are included in the estimation of the upgrade cost. This follows the same methodology used by Steer.

11. We have tested this both by calculating a new average cost to upgrade and updating the vehicle class splits to take these assumptions into account. Applying the shares assumed by JAQU results in an average cost to upgrade of £4,582, compere to the OBC where £3,100 was assumed.

Assume HGV users assess cost to upgrade over 3 years

12. The central case assumes that HGV users will assess the cost to upgrade against the cost of the CAZ depending on trip frequency over 5 years. This test applied the same approach, but assessed the cost over 3 years.

Base Year Correction

13. The base year correction test involved out of model adjustments. This was focused on HGV flows which were weaker than other vehicle classes and the PM peak which was weaker than the other time periods:

- Scale up HGV flows based on mismatch between base year and observed counts crossing the screenline.
- Scale up All PM peak flows by 5% and HGV by the mismatch on the cordon (which is higher than 5%)

Fleet

Euro 6d Updated Assumptions

14. The year in which Euro 6D vehicles become available is expected to be brought forward since the OBC was developed. This test assumes that new diesel cars forecast to enter the fleet will have better emission levels, and is tested within the air quality rather than the traffic model.

Ageing Fleet

15. The central case assumes that the age of the fleet will remain constant over time so that there is a natural improvement in emissions. The impact of the fleet ageing over time was tested by assuming that the rate of change would effectively half, by taking the existing approach but assuming that the fleet makeup in 2018 would apply to 2020.

Traffic Impacts

1. The impacts of the sensitivities are summarised below, focussing on:

- Change in flows entering the CAZ cordon
- Change in flows on key links in the City Centre

2. The changes in flows entering the CAZ cordon, represents all vehicles forecast to cross the A4540 ring road to enter the CAZ on an average day (AADT).

3. The key links are a selection of links forecast to have air quality issues in 2020, as well some additional links on the ring road that are likely to have traffic diverting onto it to avoid the CAZ. The links analysed are shown in the figure below with the CAZ D High link flows (which are compared against the sensitivities) on the page below. The numbers are two-way average daily flows (AADT).

Figure 1: City Centre Key Links Locations

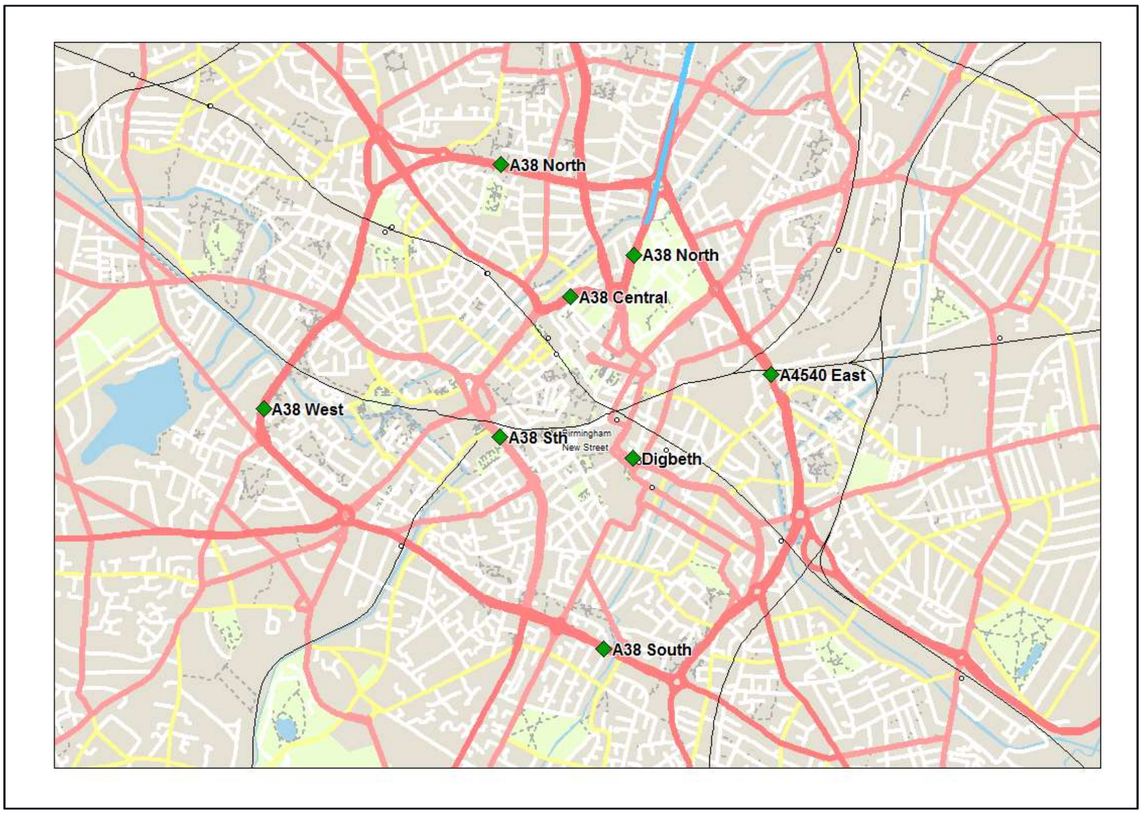


Table 16: 2020 CAZ D High Key Links Inside CAZ (2-way AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Digbeth	21,871	15,613	1,039	1,376	667	653	-	398	12
A38 Sth	55,285	43,000	2,941	5,725	2,182	701	-	715	16
A38 cen	64,689	50,716	3,262	5,872	2,331	1,260	-	1,159	31
A38 Nth	83,164	64,064	5,386	7,310	3,295	1,295	-	1,338	42

Table 17: 2020 CAZ D High Key Links On the A4540 Ring Road (2-way AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Ring Road North	33,249	19,899	1,366	2,134	968	6,549	-	1,781	551
Ring Road South	62,000	39,856	2,735	4,681	2,530	8,497	-	2,661	897
Ring Road West	34,157	19,965	1,396	1,920	608	7,814	-	1,922	390
Ring Road East	53,887	31,087	2,156	4,737	3,083	8,289	-	3,159	1,373

Traffic Growth Tests

Low Growth

Cordon Flows

4. The Low Growth test was run as a CAZ C high test (no charging for cars), to assess to what extent there would still be a need for a CAZ D scheme to sufficiently impact on air quality in Birmingham. The test highlights the importance of cars in improving air quality in Birmingham. Overall a low growth CAZ C

would have an increase in traffic entering the City Centre compared to the CAZ D OBC test, with significant increases in non-compliant cars entering the CAZ.

Table 18: 2020 Cordon Crossing Impact of Low Growth (AADT)

	CAZ D High (OBC – No Additional Measures)					
Compliance	**Car**	**Taxi**	**LGV**	**HGV**	**Bus**	**Total**
Compliant	146,072	9,429	16,848	6,555	5,466	184,371
Non-compliant	2,959	-	3,496	87	-	6,542
Total	149,031	9,429	20,345	6,642	5,466	190,913
	CAZ C High (Low Growth Scenario)					
Compliance	**Car**	**Taxi**	**LGV**	**HGV**	**Bus**	**Total**
Compliant	119,561	9,467	15,571	6,395	5,466	156,460
Non-compliant	35,943	-	3,283	87	-	39,313
Total	155,504	9,467	18,854	6,482	5,466	195,773
	Difference (Sensitivity - CAZ D)					
Compliance	**Car**	**Taxi**	**LGV**	**HGV**	**Bus**	**Total**
Compliant	-26,511	38	-1,278	-160	-	-27,911
Non-compliant	32,984	-	-213	0	-	32,771
Total	6,473	38	-1,491	-160	-	4,860
	% Difference (Sensitivity/CAZ D)					
Compliance	**Car**	**Taxi**	**LGV**	**HGV**	**Bus**	**Total**
Compliant	-18%	0%	-8%	-2%	0%	-15%
Non-compliant	1115%		-6%	0%		501%
Total	4%	0%	-7%	-2%	0%	3%

Key Links Change

5. In terms of key link flows, for city centre links there would be an increase in overall traffic on the A38 links, with significant increases in total flows and non-compliant cars. There would be reductions flows on the ring road, due to the lower growth and increases in A38 car through trips (due to them not being charged to enter the CAZ).

Table 19: 2020 Low Growth CAZ C High Key Links Inside CAZ (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Digbeth	21,871	15,613	1,039	1,376	667	653	-	398	12
A38 Sth	55,285	43,000	2,941	5,725	2,182	701	-	715	16
A38 cen	64,689	50,716	3,262	5,872	2,331	1,260	-	1,159	31
A38 Nth	83,164	64,064	5,386	7,310	3,295	1,295	-	1,338	42

Table 20: 2020 Low Growth CAZ C High Key Links On the A4540 Ring Road (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Ring Road North	32,669	19,896	1,417	2,172	983	5,944	-	1,701	555
Ring Road South	61,669	37,187	2,664	4,372	2,507	11,387	-	2,505	903

Ring Road West	31,849	19,652	1,422	1,842	625	5,959	-	1,816	391
Ring Road East	53,127	29,853	2,135	4,562	3,139	9,035	-	3,008	1,391

Table 21: 2020 Difference (Low Growth CAZ C High – CAZ D High) Key Links Inside CAZ (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Digbeth	-55	-2,907	-103	-90	7	3,063	-	-26	0
A38 Sth	3,363	-6,263	-284	-505	-164	10,633	-	-53	-0
A38 cen	1,262	-8,719	-322	-571	-148	11,102	-	-79	-0
A38 Nth	2,622	-10,699	-408	-673	-154	14,647	-	-90	-0

Table 22: 2020 Difference (Low Growth CAZ C High – CAZ D High) On the A4540 Ring Road (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Ring Road North	-580	-3	51	38	15	-605	-	-81	4
Ring Road South	-332	-2,669	-71	-309	-23	2,890	-	-156	7
Ring Road West	-2,307	-313	26	-77	17	-1,855	-	-105	0
Ring Road East	-760	-1,233	-21	-175	56	745	-	-151	18

Table 23: 2020 % Difference (Low Growth CAZ C High – CAZ D High) Key Links Inside CAZ (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Digbeth	0%	-19%	-10%	-7%	1%	469%		-6%	2%
A38 Sth	6%	-15%	-10%	-9%	-8%	1517%		-7%	-1%
A38 cen	2%	-17%	-10%	-10%	-6%	881%		-7%	0%
A38 Nth	3%	-17%	-8%	-9%	-5%	1131%		-7%	0%

Table 24: % Difference (Low Growth CAZ C High – CAZ D High) Key Links On the A4540 Ring Road (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Ring Road North	-2%	0%	4%	2%	2%	-9%		-5%	1%
Ring Road South	-1%	-7%	-3%	-7%	-1%	34%		-6%	1%
Ring Road West	-7%	-2%	2%	-4%	3%	-24%		-5%	0%
Ring Road East	-1%	-4%	-1%	-4%	2%	9%		-5%	1%

Summary of Impacts

6. A low growth CAZ C scenario is likely to have worse air quality than a CAZ D high central growth scenario within the city centre.

High Growth

Overview

7. There is an increase in traffic entering the CAZ of around 6% in the high growth scenario, with HGVs showing the largest increase. Non-compliant trips have a smaller impact, as the increased traffic growth is focused on the non-city centre areas and the charge causes this traffic to divert away from the CAZ.

Cordon Flows

Table 25: 2020 Cordon Crossing Impact of High Growth (AADT)

Compliance	CAZ D High (OBC – No Additional Measures)					
	Car	Taxi	LGV	HGV	Bus	Total
Compliant	146,072	9,429	16,848	6,555	5,466	184,371
Non-compliant	2,959	-	3,496	87	-	6,542
Total	149,031	9,429	20,345	6,642	5,466	190,913
Compliance	**CAZ D High (High Growth Scenario)**					
	Car	Taxi	LGV	HGV	Bus	Total
Compliant	153,017	9,959	18,426	7,905	5,466	194,772
Non-compliant	3,016	-	3,614	111	-	6,740
Total	156,033	9,959	22,040	8,015	5,466	201,512
Compliance	**Difference (Sensitivity - CAZ D)**					
	Car	Taxi	LGV	HGV	Bus	Total
Compliant	6,945	530	1,577	1,349	-	10,401
Non-compliant	56	-	118	24	-	198
Total	7,002	530	1,695	1,373	-	10,599
Compliance	**% Difference (Sensitivity/CAZ D)**					
	Car	Taxi	LGV	HGV	Bus	Total
Compliant	5%	6%	9%	21%	0%	6%
Non-compliant	2%		3%	27%		3%
Total	5%	6%	8%	21%	0%	6%

Key Links Change

8. The key links show increases in traffic in line with the change in cordon crossings. The non-compliant flows show small reductions, which is caused by the increases in compliant trips within the CAZ pushing the traffic accessing the City Centre onto alternative routes. The ring road links show larger increases in non-compliant vehicles, showing that the growth in through trips will divert away from the City Centre in the CAZ scenario.

Table 26: 2020 High Growth CAZ D High Key Links Inside CAZ (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Digbeth	22,655	16,221	1,072	1,396	809	642	-	390	15
A38 Sth	60,257	46,378	3,216	6,705	2,527	689	-	717	20
A38 cen	69,147	53,711	3,488	6,644	2,777	1,253	-	1,176	39
A38 Nth	90,124	69,006	5,724	8,332	3,885	1,320	-	1,371	52

Table 27: 2020 High Growth CAZ D High Key Links On the A4540 Ring Road (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Ring Road North	34,862	19,853	1,372	2,448	1,003	7,240	-	2,302	641
Ring Road South	67,246	42,161	2,929	5,532	2,783	9,373	-	3,270	1,054
Ring Road West	37,965	21,563	1,533	2,343	701	8,643	-	2,542	498
Ring Road East	57,479	32,065	2,218	5,461	3,295	9,082	-	3,826	1,528

Table 28: 2020 Difference (High Growth CAZ D High – CAZ D High) Key Links Inside CAZ (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Digbeth	785	608	33	20	141	-11	-	-8	3
A38 Sth	4,972	3,378	275	980	344	-12	-	2	4
A38 cen	4,458	2,995	227	772	446	-7	-	17	8
A38 Nth	6,960	4,941	338	1,022	591	25	-	33	9

Table 29: 2020 Difference (High Growth CAZ D High – CAZ D High) On the A4540 Ring Road (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Ring Road North	1,613	-45	6	314	36	691	-	521	91
Ring Road South	5,246	2,305	195	851	253	877	-	608	157
Ring Road West	3,808	1,597	137	423	93	829	-	620	108
Ring Road East	3,592	979	62	724	212	793	-	668	155

Table 30: 2020 % Difference (High Growth CAZ D High – CAZ D High) Key Links Inside CAZ (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Digbeth	4%	4%	3%	1%	21%	-2%		-2%	28%
A38 Sth	9%	8%	9%	17%	16%	-2%		0%	22%
A38 cen	7%	6%	7%	13%	19%	-1%		2%	25%
A38 Nth	8%	8%	6%	14%	18%	2%		2%	22%

Table 31: % Difference (High Growth CAZ D High – CAZ D High) Key Links On the A4540 Ring Road (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Ring Road North	5%	0%	0%	15%	4%	11%		29%	16%
Ring Road South	8%	6%	7%	18%	10%	10%		23%	18%
Ring Road West	11%	8%	10%	22%	15%	11%		32%	28%
Ring Road East	7%	3%	3%	15%	7%	10%		21%	11%

Summary of Impacts

9. Significant increases in vehicle flows, with non-compliant vehicle increases less in the City Centre as the high growth is focused on the non-city centre areas.

Behavioural Responses

JAQU

Cordon Flows

10. The JAQU assumptions results in overall increases in traffic of around 2%, but for cars and LGVs there would be a reduction in non-compliant vehicles. HGVs also show a small decrease in overall vehicles as JAQU assumes that there would be a reduction in HGV trips, whereas BCC assumes that the all HGVs trips will still need to be made. JAQU also assume that there will lower levels of compliance for HGVs, although the numbers of vehicles this affects is relatively small.

Table 32: 2020 Cordon Crossing Impact of JAQU Behavioural Assumptions

	CAZ D High (OBC – No Additional Measures)					
Compliance	Car	Taxi	LGV	HGV	Bus	Total
Compliant	146,072	9,429	16,848	6,555	5,466	184,371
Non-compliant	2,959	-	3,496	87	-	6,542
Total	149,031	9,429	20,345	6,642	5,466	190,913
	CAZ D High (JAQU Scenario)					
Compliance	Car	Taxi	LGV	HGV	Bus	Total
Compliant	149,731	9,410	18,298	6,445	5,466	189,350
Non-compliant	2,464	-	1,918	141	-	4,523
Total	152,195	9,410	20,216	6,586	5,466	193,873
	Difference (Sensitivity - CAZ D)					
Compliance	Car	Taxi	LGV	HGV	Bus	Total
Compliant	3,659	-19	1,449	-110	-	4,979
Non-compliant	-495	-	-1,578	54	-	-2,019
Total	3,164	-19	-129	-56	-	2,960
	% Difference (Sensitivity/CAZ D)					
Compliance	Car	Taxi	LGV	HGV	Bus	Total
Compliant	3%	0%	9%	-2%	0%	3%
Non-compliant	-17%		-45%	63%		-31%
Total	2%	0%	-1%	-1%	0%	2%

Key Links Change

11. The key link changes mirrors the impacts seen on the cordon crossing.

Table 33: 2020 JAQU CAZ D High Key Links Inside CAZ (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Digbeth	22,115	16,242	1,043	1,555	653	325	-	163	22
A38 Sth	55,701	43,776	2,950	6,121	2,083	440	-	295	31
A38 cen	65,510	52,219	3,283	6,423	2,232	756	-	479	58
A38 Nth	84,587	66,014	5,413	7,970	3,178	946	-	553	80

Table 34: 2020 JAQU CAZ D High Key Links On the A4540 Ring Road (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Ring Road North	33,310	20,297	1,371	2,255	962	6,220	-	1,652	552
Ring Road South	62,109	40,377	2,740	4,884	2,517	8,144	-	2,398	906
Ring Road West	33,992	20,203	1,404	1,993	605	7,422	-	1,832	392
Ring Road East	54,033	31,638	2,168	5,019	3,040	7,963	-	2,831	1,371

Table 35: 2020 Difference (JAQU CAZ D High – CAZ D High) Key Links Inside CAZ (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Digbeth	244	629	4	179	-15	-327	-	-235	11
A38 Sth	416	775	9	396	-99	-261	-	-420	14
A38 cen	821	1,503	21	551	-99	-504	-	-680	27
A38 Nth	1,423	1,950	27	661	-117	-349	-	-786	37

Table 36: 2020 Difference (JAQU CAZ D High – CAZ D High) On the A4540 Ring Road (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Ring Road North	61	399	5	121	-6	-329	-	-130	1
Ring Road South	109	521	6	203	-13	-353	-	-264	9
Ring Road West	-165	238	8	73	-3	-392	-	-90	1
Ring Road East	146	552	12	282	-43	-326	-	-328	-2

Table 37: 2020 % Difference (JAQU CAZ D High – CAZ D High) Key Links Inside CAZ (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Digbeth	1%	4%	0%	13%	-2%	-50%		-59%	91%
A38 Sth	1%	2%	0%	7%	-5%	-37%		-59%	88%
A38 cen	1%	3%	1%	9%	-4%	-40%		-59%	88%
A38 Nth	2%	3%	1%	9%	-4%	-27%		-59%	88%

Table 38: % Difference (JAQU CAZ D High – CAZ D High) Key Links On the A4540 Ring Road (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Ring Road North	0%	2%	0%	6%	-1%	-5%		-7%	0%
Ring Road South	0%	1%	0%	4%	-1%	-4%		-10%	1%
Ring Road West	0%	1%	1%	4%	-1%	-5%		-5%	0%
Ring Road East	0%	2%	1%	6%	-1%	-4%		-10%	0%

Summary of Impacts

ULEZ

Cordon Flows

12. The ULEZ test only impacts on cars and would results in a neutral impact on all vehicles, but with an increase in non-compliant vehicles. The numbers of vehicles this would impact is relatively small.

Table 39: 2020 Cordon Crossing Impact of ULEZ Behavioural Assumptions

	CAZ D High (OBC – No Additional Measures)					
Compliance	Car	Taxi	LGV	HGV	Bus	Total
Compliant	146,072	9,429	16,848	6,555	5,466	184,371
Non-compliant	2,959	-	3,496	87	-	6,542
Total	149,031	9,429	20,345	6,642	5,466	190,913
	CAZ D High (ULEZ Scenario)					
Compliance	Car	Taxi	LGV	HGV	Bus	Total
Compliant	146,914	9,405	16,843	6,552	5,466	185,179
Non-compliant	2,424	-	3,496	87	-	6,007
Total	149,338	9,405	20,340	6,639	5,466	191,187
	Difference (Sensitivity - CAZ D)					
Compliance	Car	Taxi	LGV	HGV	Bus	Total
Compliant	842	-24	-5	-4	-	809
Non-compliant	-535	-	0	0	-	-535
Total	307	-24	-5	-4	-	274
	% Difference (Sensitivity/CAZ D)					
Compliance	Car	Taxi	LGV	HGV	Bus	Total
Compliant	1%	0%	0%	0%	0%	0%
Non-compliant	-18%		0%	0%		-8%
Total	0%	0%	0%	0%	0%	0%

Key Links Change

13. There are some significant increases in non-compliant car flows in percentage terms, although the numbers of vehicles this affects is relatively small.

Table 40: 2020 ULEZ CAZ D High Key Links Inside CAZ (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Digbeth	21,827	15,848	1,047	1,382	671	354	-	399	12
A38 Sth	55,175	43,136	2,942	5,709	2,182	474	-	711	16
A38 cen	64,527	50,984	3,271	5,877	2,329	815	-	1,159	31
A38 Nth	83,257	64,435	5,392	7,306	3,297	1,014	-	1,337	42

Table 41: 2020 ULEZ CAZ D High Key Links On the A4540 Ring Road (AADT)

Road	All	Compliant	Non-Compliant

		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Ring Road North	33,214	20,045	1,366	2,135	968	6,365	-	1,781	551
Ring Road South	61,831	39,918	2,738	4,672	2,530	8,273	-	2,659	897
Ring Road West	33,787	19,871	1,389	1,916	609	7,548	-	1,922	390
Ring Road East	53,822	31,217	2,160	4,742	3,080	8,080	-	3,168	1,372

Table 42: 2020 Difference (ULEZ CAZ D High – CAZ D High) Key Links Inside CAZ (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Digbeth	-43	235	7	7	4	-299	-	2	0
A38 Sth	-110	135	1	-16	-0	-226	-	-4	0
A38 cen	-163	268	10	5	-2	-445	-	1	-0
A38 Nth	93	371	6	-4	3	-282	-	-1	-

Table 43: 2020 Difference (ULEZ CAZ D High – CAZ D High) On the A4540 Ring Road (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Ring Road North	-35	146	0	1	0	-183	-	0	0
Ring Road South	-169	62	3	-9	-0	-223	-	-3	1
Ring Road West	-370	-95	-7	-4	1	-266	-	1	-0
Ring Road East	-65	130	5	5	-3	-209	-	9	-1

Table 44: 2020 % Difference (ULEZ CAZ D High – CAZ D High) Key Links Inside CAZ (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Digbeth	0%	2%	1%	0%	1%	-46%		0%	1%
A38 Sth	0%	0%	0%	0%	0%	-32%		-1%	0%
A38 cen	0%	1%	0%	0%	0%	-35%		0%	0%
A38 Nth	0%	1%	0%	0%	0%	-22%		0%	0%

Table 45: % Difference (ULEZ CAZ D High – CAZ D High) Key Links On the A4540 Ring Road (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Ring Road North	0%	0%	0%	0%	0%	0%		0%	0%
Ring Road South	0%	0%	0%	0%	0%	0%		0%	0%
Ring Road West	0%	0%	0%	0%	0%	0%		0%	0%
Ring Road East	0%	0%	0%	0%	0%	0%		0%	0%

No Upgrade Response

Cordon Flows

14. The non-upgrade response test unsurprisingly shows an increase in non-compliant vehicles entering the CAZ. Overall there is a reduction in traffic as some users that are assumed to upgrade in the OBC will choose to avoid the CAZ charge.

Table 46: 2020 Cordon Crossing Impact of No Upgrades Test

	CAZ D High (OBC – No Additional Measures)					
Compliance	**Car**	**Taxi**	**LGV**	**HGV**	**Bus**	**Total**
Compliant	146,072	9,429	16,848	6,555	5,466	184,371
Non-compliant	2,959	-	3,496	87	-	6,542
Total	149,031	9,429	20,345	6,642	5,466	190,913
	CAZ D High (No Upgrades)					
Compliance	**Car**	**Taxi**	**LGV**	**HGV**	**Bus**	**Total**
Compliant	131,436	9,450	13,707	5,592	5,466	165,651
Non-compliant	6,328	-	6,496	1,024	-	13,849
Total	137,764	9,450	20,203	6,616	5,466	179,499
	Difference (Sensitivity - CAZ D)					
Compliance	**Car**	**Taxi**	**LGV**	**HGV**	**Bus**	**Total**
Compliant	-14,636	21	-3,142	-964	-	-18,720
Non-compliant	3,369	-	3,000	938	-	7,307
Total	-11,267	21	-142	-26	-	-11,413
	% Difference (Sensitivity/CAZ D)					
Compliance	**Car**	**Taxi**	**LGV**	**HGV**	**Bus**	**Total**
Compliant	-10%	0%	-19%	-15%	0%	-10%
Non-compliant	114%		86%	1081%		112%
Total	-8%	0%	-1%	0%	0%	-6%

Key Links Change

15. Key links shows a similar pattern as the cordon flows.

Table 47: 2020 No Upgrades CAZ D High Key Links Inside CAZ (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Digbeth	20,954	13,907	1,012	1,074	561	1,402	-	745	137
A38 Sth	53,762	40,625	2,938	5,109	2,031	1,523	-	1,332	198
A38 cen	62,003	46,462	3,226	4,958	2,050	2,719	-	2,162	367
A38 Nth	79,246	58,814	5,084	6,216	2,854	2,778	-	2,494	501

Table 48: 2020 No Upgrades CAZ D High Key Links On the A4540 Ring Road (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Ring Road North	32,758	18,623	1,375	1,973	949	7,224	-	2,001	610
Ring Road South	61,623	38,500	2,735	4,370	2,370	9,382	-	3,075	1,047
Ring Road West	33,891	19,165	1,371	1,748	554	8,453	-	2,033	425
Ring Road East	53,531	29,819	2,137	4,287	2,909	9,165	-	3,658	1,553

Table 49: 2020 Difference (No Upgrades CAZ D High – CAZ D High) Key Links Inside CAZ (AADT)

Road	All	Compliant	Non-Compliant

		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Digbeth	-917	-1,705	-27	-302	-107	749	-	347	126
A38 Sth	-1,524	-2,375	-3	-616	-151	822	-	618	182
A38 cen	-2,686	-4,254	-35	-914	-281	1,459	-	1,003	336
A38 Nth	-3,918	-5,250	-302	-1,094	-440	1,483	-	1,155	459

Table 50: 2020 Difference (No Upgrades CAZ D High – CAZ D High) On the A4540 Ring Road (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Ring Road North	-491	-1,276	9	-160	-19	675	-	219	60
Ring Road South	-377	-1,356	1	-311	-160	885	-	414	150
Ring Road West	-266	-800	-25	-172	-54	639	-	112	34
Ring Road East	-356	-1,268	-19	-450	-174	875	-	499	180

Table 51: 2020 % Difference (Medium Growth CAZ D High – CAZ D High) Key Links Inside CAZ (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Digbeth	-4%	-11%	-3%	-22%	-16%	115%		87%	1082%
A38 Sth	-3%	-6%	0%	-11%	-7%	117%		86%	1110%
A38 cen	-4%	-8%	-1%	-16%	-12%	116%		87%	1084%
A38 Nth	-5%	-8%	-6%	-15%	-13%	115%		86%	1082%

Table 52: % Difference (Medium Growth CAZ D High – CAZ D High) Key Links On the A4540 Ring Road (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Ring Road North	-1%	-6%	1%	-8%	-2%	10%		12%	11%
Ring Road South	-1%	-3%	0%	-7%	-6%	10%		16%	17%
Ring Road West	-1%	-4%	-2%	-9%	-9%	8%		6%	9%
Ring Road East	-1%	-4%	-1%	-9%	-6%	11%		16%	13%

Summary of Impacts

Ultra High Charge

Cordon Flows

16. At the ultra-high charge, the numbers of non-compliant vehicles reduce significantly, although it should be noted that due to the high compliance rates in the OBC scenario the absolute numbers of vehicles are relatively small. In addition, the higher upgrade rates causes an increase in overall trips.

Table 53: 2020 Cordon Crossing Impact of Ultra High Charge

	CAZ D High (OBC – No Additional Measures)					
Compliance	Car	Taxi	LGV	HGV	Bus	Total
Compliant	146,072	9,429	16,848	6,555	5,466	184,371
Non-compliant	2,959	-	3,496	87	-	6,542
Total	149,031	9,429	20,345	6,642	5,466	190,913

Compliance	CAZ D High (Ultra High Charge)					
	Car	Taxi	LGV	HGV	Bus	Total
Compliant	155,236	9,393	19,235	6,522	5,466	195,851
Non-compliant	133	-	1,198	17	-	1,349
Total	155,369	9,393	20,433	6,539	5,466	197,200
	Difference (Sensitivity - CAZ D)					
Compliance	Car	Taxi	LGV	HGV	Bus	Total
Compliant	9,164	-36	2,386	-34	-	11,481
Non-compliant	-2,826	-	-2,298	-69	-	-5,193
Total	6,338	-36	88	-103	-	6,287
	% Difference (Sensitivity/CAZ D)					
Compliance	Car	Taxi	LGV	HGV	Bus	Total
Compliant	6%	0%	14%	-1%	0%	6%
Non-compliant	-96%		-66%	-80%		-79%
Total	4%	0%	0%	-2%	0%	3%

Key Links Change

17. As with the cordon crossings the CAZ links show significant reductions in non-compliant vehicles but an overall increase in vehicles. For the ring road the change in total vehicles is neutral, with a reduction in non-compliant vehicles which is more moderate than for CAZ links.

Table 54: 2020 Ultra High Charge CAZ D High Key Links Inside CAZ (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Digbeth	22,358	16,730	1,046	1,575	664	96	-	133	2
A38 Sth	56,011	44,431	2,954	6,227	2,085	61	-	245	3
A38 cen	66,108	53,411	3,298	6,549	2,261	126	-	396	6
A38 Nth	85,173	67,438	5,429	8,120	3,217	69	-	458	8

Table 55: 2020 Ultra High Charge CAZ D High Key Links On the A4540 Ring Road (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Ring Road North	33,418	20,475	1,377	2,308	967	6,107	-	1,637	544
Ring Road South	62,293	40,785	2,737	4,938	2,542	7,912	-	2,355	880
Ring Road West	34,173	20,422	1,407	2,011	610	7,375	-	1,822	386
Ring Road East	54,190	32,002	2,172	5,091	3,045	7,768	-	2,777	1,331

Table 56: 2020 Difference (Ultra High Charge CAZ D High – CAZ D High) Key Links Inside CAZ (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Digbeth	488	1,118	7	199	-3	-557	-	-265	-9
A38 Sth	726	1,431	13	502	-97	-640	-	-470	-13
A38 cen	1,418	2,695	37	677	-69	-1,133	-	-763	-25

A38 Nth	2,009	3,374	43	811	-78	-1,226	-	-881	-34

Table 57: 2020 Difference (Ultra High Charge CAZ D High – CAZ D High) On the A4540 Ring Road (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Ring Road North	168	577	11	174	-1	-442	-	-145	-7
Ring Road South	293	929	3	257	12	-584	-	-307	-17
Ring Road West	17	456	11	91	2	-439	-	-100	-4
Ring Road East	303	916	17	354	-38	-522	-	-382	-42

Table 58: 2020 % Difference (Ultra High Charge CAZ D High – CAZ D High) Key Links Inside CAZ (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Digbeth	2%	7%	1%	14%	-1%	-85%		-67%	-80%
A38 Sth	1%	3%	0%	9%	-4%	-91%		-66%	-80%
A38 cen	2%	5%	1%	12%	-3%	-90%		-66%	-80%
A38 Nth	2%	5%	1%	11%	-2%	-95%		-66%	-80%

Table 59: % Difference (Ultra High Charge CAZ D High – CAZ D High) Key Links On the A4540 Ring Road (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Ring Road North	1%	3%	1%	8%	0%	-7%		-8%	-1%
Ring Road South	0%	2%	0%	5%	0%	-7%		-12%	-2%
Ring Road West	0%	2%	1%	5%	0%	-6%		-5%	-1%
Ring Road East	1%	3%	1%	7%	-1%	-6%		-12%	-3%

Outer CAZ

Cordon Flows

18. The outer cordon test is a fixed assignment test that looks at the route choice implications of an outer CAZ. This would lead to an increase in non-compliant vehicles and total vehicles entering the City Centre. For trips within the outer cordon there is no disincentive to enter the city centre, as the charging point is not on the ring road. In reality, overall traffic levels would reduce from what is currently forecast, but this is unlikely to undermine the key point that an outer CAZ does not address the main area of AQ concerns.

Table 60: 2020 Cordon Crossing Impact of Outer CAZ

	CAZ D High (OBC – No Additional Measures)					
Compliance	Car	Taxi	LGV	HGV	Bus	Total
Compliant	146,072	9,429	16,848	6,555	5,466	184,371
Non-compliant	2,959	-	3,496	87	-	6,542
Total	149,031	9,429	20,345	6,642	5,466	190,913
	CAZ D High (Outer CAZ Scenario)					
Compliance	Car	Taxi	LGV	HGV	Bus	Total
Compliant	143,172	9,218	16,507	6,381	5,466	180,744

Non-compliant	10,297	-	5,781	674	-	16,752
Total	153,469	9,218	22,288	7,055	5,466	197,496
	Difference (Sensitivity - CAZ D)					
Compliance	Car	Taxi	LGV	HGV	Bus	Total
Compliant	-2,900	-211	-341	-175	-	-3,627
Non-compliant	7,338	-	2,284	588	-	10,210
Total	4,438	-211	1,943	413	-	6,583
	% Difference (Sensitivity/CAZ D)					
Compliance	Car	Taxi	LGV	HGV	Bus	Total
Compliant	-2%	-2%	-2%	-3%	0%	-2%
Non-compliant	248%		65%	677%		156%
Total	3%	-2%	10%	6%	0%	3%

Key Links Change

19. City Centre links show an increase in traffic flows driven by the increase in non-compliant vehicles. On the ring road there is a reduction non-compliant traffic as there is more through trips in the City Centre and longer distance through trips will reroute around the outer CAZ, although most of these trips are likely to already route around the motorway box in the Do Minimum.

Table 61: 2020 Outer CAZ CAZ D High Key Links Inside CAZ (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Digbeth	22,079	15,809	1,041	1,370	678	636	-	388	44
A38 Sth	60,069	40,161	2,747	5,429	1,987	6,527	-	2,655	557
A38 cen	66,691	48,570	3,135	5,601	2,169	4,693	-	2,164	298
A38 Nth	86,731	61,877	5,235	7,021	3,125	5,795	-	2,822	424

Table 62: 2020 Outer CAZ CAZ D High Key Links On the A4540 Ring Road (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Ring Road North	32,811	21,614	1,479	2,344	988	4,665	-	1,302	417
Ring Road South	61,706	39,642	2,744	4,689	2,506	8,484	-	2,571	924
Ring Road West	31,657	20,852	1,458	1,991	641	5,171	-	1,155	247
Ring Road East	53,234	32,590	2,239	4,892	3,154	6,636	-	2,539	1,180

Table 63: 2020 Difference (Outer CAZ CAZ D High – CAZ D High) Key Links Inside CAZ (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Digbeth	208	196	2	-6	10	-17	-	-10	33
A38 Sth	4,783	-2,839	-193	-297	-195	5,826	-	1,941	541
A38 cen	2,001	-2,146	-127	-271	-161	3,433	-	1,006	267
A38 Nth	3,567	-2,188	-151	-289	-170	4,500	-	1,484	382

Table 64: 2020 Difference (Outer CAZ CAZ D High – CAZ D High) On the A4540 Ring Road (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Ring Road North	-438	1,715	113	210	20	-1,884	-	-479	-134
Ring Road South	-295	-214	10	8	-24	-12	-	-90	27
Ring Road West	-2,500	886	62	72	33	-2,643	-	-767	-143
Ring Road East	-653	1,503	83	155	71	-1,653	-	-620	-193

Table 65: 2020 % Difference (Outer CAZ CAZ D High – CAZ D High) Key Links Inside CAZ (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Digbeth	1%	1%	0%	0%	2%	-3%		-3%	280%
A38 Sth	9%	-7%	-7%	-5%	-9%	831%		272%	3303%
A38 cen	3%	-4%	-4%	-5%	-7%	273%		87%	862%
A38 Nth	4%	-3%	-3%	-4%	-5%	347%		111%	900%

Table 66: % Difference (Outer CAZ CAZ D High – CAZ D High) Key Links On the A4540 Ring Road (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Ring Road North	-1%	9%	8%	10%	2%	-29%		-27%	-24%
Ring Road South	0%	-1%	0%	0%	-1%	0%		-3%	3%
Ring Road West	-7%	4%	4%	4%	5%	-34%		-40%	-37%
Ring Road East	-1%	5%	4%	3%	2%	-20%		-20%	-14%

Cost to Upgrade

JAQU Behavioural Responses

Cordon Flows

20. There is a moderate decrease in the number of non-compliant vehicles in the JAQU behavioural response test, as this assumes a higher cost to upgrade than in the central OBC assumptions. However, JAQU assumptions also assumes thatpeople are more likely to upgrade to a new vehicle, so this would assumption would have some positive impacts on air quality.

Table 67: 2020 Cordon Crossing Impact of JAQU Upgrade Behavioural Assumptions

	CAZ D High (OBC – No Additional Measures)					
Compliance	**Car**	**Taxi**	**LGV**	**HGV**	**Bus**	**Total**
Compliant	146,072	9,429	16,848	6,555	5,466	184,371
Non-compliant	2,959	-	3,496	87	-	6,542
Total	149,031	9,429	20,345	6,642	5,466	190,913
	CAZ D High (JAQU Upgrade Behavioural Assumptions)					
Compliance	**Car**	**Taxi**	**LGV**	**HGV**	**Bus**	**Total**
Compliant	145,886	9,101	16,856	6,555	5,466	183,864
Non-compliant	3,052	-	3,496	87	-	6,636

Total	148,939	9,101	20,352	6,642	5,466	190,499
	Difference (Sensitivity - CAZ D)					
Compliance	Car	Taxi	LGV	HGV	Bus	Total
Compliant	-186	-328	8	-1	-	-507
Non-compliant	93	-	0	0	-	94
Total	-92	-328	8	-1	-	-413
	% Difference (Sensitivity/CAZ D)					
Compliance	Car	Taxi	LGV	HGV	Bus	Total
Compliant	0%	-3%	0%	0%	0%	0%
Non-compliant	3%		0%	0%		1%
Total	0%	-3%	0%	0%	0%	0%

Key Links Change

21. The key links show a similar impact within the CAZ, but the ring road links are more or less neutral.

Table 68: 2020 JAQU Upgrade Behavioural Assumptions CAZ D High Key Links Inside CAZ (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Digbeth	21,833	15,537	1,038	1,380	669	685	-	399	12
A38 Sth	55,254	42,948	2,941	5,728	2,181	720	-	714	16
A38 cen	64,608	50,580	3,266	5,879	2,330	1,303	-	1,160	31
A38 Nth	82,322	63,880	4,340	7,313	3,296	1,332	-	1,338	42

Table 69: 2020 JAQU Upgrade Behavioural Assumptions CAZ D High Key Links On the A4540 Ring Road (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Ring Road North	33,213	19,882	1,356	2,126	969	6,547	-	1,780	551
Ring Road South	61,954	39,785	2,737	4,681	2,530	8,520	-	2,660	897
Ring Road West	34,117	19,932	1,394	1,919	608	7,811	-	1,922	390
Ring Road East	53,880	31,060	2,154	4,736	3,083	8,308	-	3,161	1,374

Table 70: 2020 Difference (JAQU Upgrade Behavioural Assumptions CAZ D High – CAZ D High) Key Links Inside CAZ (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Digbeth	-38	-76	-2	5	2	33	-	1	0
A38 Sth	-31	-52	1	2	-1	19	-	-0	0
A38 cen	-81	-136	4	7	-0	43	-	1	-0
A38 Nth	-579	-184	-2	3	1	37	-	-1	-

Table 71: 2020 Difference (JAQU Upgrade Behavioural Assumptions CAZ D High – CAZ D High) On the A4540 Ring Road (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Ring Road North	-36	-17	-10	-7	1	-2	-	-1	1

Ring Road South	-47	-72	2	-0	0	23	-	-1	0
Ring Road West	-39	-33	-2	-1	-0	-3	-	0	-0
Ring Road East	-7	-27	-1	-1	0	18	-	3	1

Table 72: 2020 % Difference (JAQU Upgrade Behavioural Assumptions CAZ D High – CAZ D High) Key Links Inside CAZ (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Digbeth	0%	0%	0%	0%	0%	5%		0%	0%
A38 Sth	0%	0%	0%	0%	0%	3%		0%	0%
A38 cen	0%	0%	0%	0%	0%	3%		0%	0%
A38 Nth	-1%	0%	0%	0%	0%	3%		0%	0%

Table 73: % Difference (JAQU Upgrade Behavioural Assumptions CAZ D High – CAZ D High) Key Links On the A4540 Ring Road (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Ring Road North	0%	0%	-1%	0%	0%	0%		0%	0%
Ring Road South	0%	0%	0%	0%	0%	0%		0%	0%
Ring Road West	0%	0%	0%	0%	0%	0%		0%	0%
Ring Road East	0%	0%	0%	0%	0%	0%		0%	0%

Summary of Impacts

HGV over 3 years

Cordon Flows

22. This scenario results in a reduction in compliant HGVs as is assumes that HGV users will seek to offset the costs of upgrading over a shorter period, meaning the overall perceived savings in upgrading is reduced. This leads to a smaller reduction in compliant vehicles entering the CAZ, although overall this only leads to a 2% increase in non-compliant vehicles.

Table 74: 2020 Cordon Crossing Impact of HGV Test

	CAZ D High (OBC – No Additional Measures)					
Compliance	Car	Taxi	LGV	HGV	Bus	Total
Compliant	146,072	9,429	16,848	6,555	5,466	184,371
Non-compliant	2,959	-	3,496	87	-	6,542
Total	149,031	9,429	20,345	6,642	5,466	190,913
	CAZ D High (HGV Test Scenario)					
Compliance	Car	Taxi	LGV	HGV	Bus	Total
Compliant	146,084	9,430	16,854	6,443	5,466	184,276
Non-compliant	2,959	-	3,496	191	-	6,647
Total	149,043	9,430	20,350	6,634	5,466	190,923
	Difference (Sensitivity - CAZ D)					
Compliance	Car	Taxi	LGV	HGV	Bus	Total
Compliant	12	1	5	-113	-	-94

Compliance	Car	Taxi	LGV	HGV	Bus	Total
Non-compliant	0	-	0	104	-	105
Total	12	1	5	-8	-	10
	% Difference (Sensitivity/CAZ D)					
Compliance	Car	Taxi	LGV	HGV	Bus	Total
Compliant	0%	0%	0%	-2%	0%	0%
Non-compliant	0%		0%	120%		2%
Total	0%	0%	0%	0%	0%	0%

Key Links Change

23. The increase in non-compliant HGV vehicle trips is reflected in the link flows. The overall daily change in vehicle flows is fairly modest with 50 HGVs (2-way flows) the maximum increase.

Table 75: 2020 HGV Test CAZ D High Key Links Inside CAZ (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Digbeth	21,873	15,614	1,039	1,376	654	653	-	398	26
A38 Sth	55,285	42,998	2,940	5,730	2,161	701	-	715	36
A38 cen	64,682	50,709	3,262	5,869	2,296	1,260	-	1,158	68
A38 Nth	83,154	64,064	5,384	7,306	3,242	1,295	-	1,338	93

Table 76: 2020 HGV Test CAZ D High Key Links On the A4540 Ring Road (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Ring Road North	33,263	19,903	1,367	2,135	964	6,553	-	1,783	555
Ring Road South	61,967	39,840	2,736	4,672	2,512	8,496	-	2,656	912
Ring Road West	34,167	19,966	1,397	1,923	604	7,818	-	1,923	395
Ring Road East	53,908	31,111	2,156	4,733	3,063	8,292	-	3,157	1,392

Table 77: 2020 Difference (HGV Test CAZ D High – CAZ D High) Key Links Inside CAZ (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Digbeth	3	2	-1	1	-13	0	-	0	14
A38 Sth	-0	-3	-1	5	-21	-0	-	0	20
A38 cen	-8	-7	1	-3	-35	0	-	-1	37
A38 Nth	-9	-1	-2	-4	-53	0	-	-1	51

Table 78: 2020 Difference (HGV Test CAZ D High – CAZ D High) On the A4540 Ring Road (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Ring Road North	14	4	1	2	-4	5	-	2	4
Ring Road South	-34	-16	1	-9	-18	-1	-	-6	15
Ring Road West	11	1	1	4	-4	4	-	1	4
Ring Road East	21	24	1	-4	-20	3	-	-2	19

Table 79: 2020 % Difference (HGV Test CAZ D High – CAZ D High) Key Links Inside CAZ (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Digbeth	0%	0%	0%	0%	-2%	0%		0%	121%
A38 Sth	0%	0%	0%	0%	-1%	0%		0%	120%
A38 cen	0%	0%	0%	0%	-1%	0%		0%	120%
A38 Nth	0%	0%	0%	0%	-2%	0%		0%	120%

Table 80: % Difference (HGV Test CAZ D High – CAZ D High) Key Links On the A4540 Ring Road (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Ring Road North	0%	0%	0%	0%	0%	0%		0%	1%
Ring Road South	0%	0%	0%	0%	-1%	0%		0%	2%
Ring Road West	0%	0%	0%	0%	-1%	0%		0%	1%
Ring Road East	0%	0%	0%	0%	-1%	0%		0%	1%

Summary of Impacts

Base Year Correction

HGV Adjustment

24. The HGV calibration was not as strong as for the other user classes. To assess the impact of this on the results, the HGV flows have been factored up based on the mismatch between the cordon flows and counts at the CAZ boundary. This, leads to increases in HGV flows across the day, however the overall impact on total vehicles flows into the CAZ is less than 1%.

Cordon Flows

Table 81: 2020 Cordon Crossing Impact of Base Year HGV Test

	CAZ D High (OBC – No Additional Measures)					
Compliance	Car	Taxi	LGV	HGV	Bus	Total
Compliant	146,084	9,430	16,854	6,443	5,466	184,276
Non-compliant	2,959	-	3,496	191	-	6,647
Total	149,043	9,430	20,350	6,634	5,466	190,923
	CAZ D High (Base Year HGV Test)					
Compliance	Car	Taxi	LGV	HGV	Bus	Total
Compliant	146,072	9,429	16,848	8,222	5,466	185,657
Non-compliant	2,959	-	3,496	109	-	6,559
Total	149,031	9,429	20,345	8,331	5,466	192,216
	Difference (Sensitivity - CAZ D)					
Compliance	Car	Taxi	LGV	HGV	Bus	Total
Compliant	-	-	-	1,667	-	1,667
Non-compliant	-	-	-	22	-	22
Total	-	-	-	1,689	-	1,689
	% Difference (Sensitivity/CAZ D)					

Compliance	Car	Taxi	LGV	HGV	Bus	Total
Compliant	0%	0%	0%	25%	0%	1%
Non-compliant	0%		0%	26%		0%
Total	0%	0%	0%	25%	0%	1%

Key Links Change

25. There are similar impacts on the key links as on the cordon crossings

Table 82: 2020 Base Year HGV Test CAZ D High Key Links Inside CAZ (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Digbeth	22,050	15,613	1,039	1,376	844	653	-	398	15
A38 Sth	55,842	43,000	2,941	5,725	2,735	701	-	715	21
A38 cen	65,289	50,716	3,262	5,872	2,922	1,260	-	1,159	39
A38 Nth	84,032	64,064	5,386	7,310	4,152	1,295	-	1,338	54

Table 83: 2020 Base Year HGV Test CAZ D High Key Links On the A4540 Ring Road (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Ring Road North	33,656	19,899	1,366	2,134	1,229	6,549	-	1,781	697
Ring Road South	62,913	39,856	2,735	4,681	3,204	8,497	-	2,661	1,136
Ring Road West	34,414	19,965	1,396	1,920	764	7,814	-	1,922	492
Ring Road East	55,065	31,087	2,156	4,737	3,896	8,289	-	3,159	1,738

Table 84: 2020 Difference (Base Year HGV Test CAZ D High – CAZ D High) Key Links Inside CAZ (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Digbeth	180	-	-	-	177	-	-	-	3
A38 Sth	557	-	-	-	553	-	-	-	4
A38 cen	600	-	-	-	592	-	-	-	8
A38 Nth	868	-	-	-	857	-	-	-	11

Table 85: 2020 Difference (Base Year HGV Test CAZ D High – CAZ D High) On the A4540 Ring Road (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Ring Road North	407	-	-	-	261	-	-	-	147
Ring Road South	913	-	-	-	674	-	-	-	239
Ring Road West	257	-	-	-	156	-	-	-	101
Ring Road East	1,178	-	-	-	813	-	-	-	365

Table 86: 2020 % Difference (Base Year HGV Test CAZ D High – CAZ D High) Key Links Inside CAZ (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV

Digbeth	1%	0%	0%	0%	26%	0%		0%	26%
A38 Sth	1%	0%	0%	0%	25%	0%		0%	26%
A38 cen	1%	0%	0%	0%	25%	0%		0%	26%
A38 Nth	1%	0%	0%	0%	26%	0%		0%	26%

Table 87: % Difference (Base Year HGV Test CAZ D High – CAZ D High) Key Links On the A4540 Ring Road (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Ring Road North	1%	0%	0%	0%	27%	0%		0%	27%
Ring Road South	1%	0%	0%	0%	27%	0%		0%	27%
Ring Road West	1%	0%	0%	0%	26%	0%		0%	26%
Ring Road East	2%	0%	0%	0%	26%	0%		0%	27%

PM Adjustment

Cordon Flows

26. The PM peak calibration is weaker than the other peak. This test adjusted the PM flows post model to show overall impact on the daily figures. This caused an overall increase of 1%.

Table 88: 2020 Cordon Crossing Impact of PM Base Year Adjustment

	CAZ D High (OBC – No Additional Measures)					
Compliance	**Car**	**Taxi**	**LGV**	**HGV**	**Bus**	**Total**
Compliant	146,084	9,430	16,854	6,443	5,466	184,276
Non-compliant	2,959	-	3,496	191	-	6,647
Total	149,043	9,430	20,350	6,634	5,466	190,923
	CAZ D High (PM Base Year Adjustment)					
Compliance	**Car**	**Taxi**	**LGV**	**HGV**	**Bus**	**Total**
Compliant	148,198	9,552	16,886	6,954	5,466	187,056
Non-compliant	2,997	-	3,504	92	-	6,593
Total	151,195	9,552	20,390	7,047	5,466	193,649
	Difference (Sensitivity - CAZ D)					
Compliance	**Car**	**Taxi**	**LGV**	**HGV**	**Bus**	**Total**
Compliant	2,126	123	38	399	-	2,685
Non-compliant	38	-	7	6	-	51
Total	2,164	123	45	404	-	2,736
	% Difference (Sensitivity/CAZ D)					
Compliance	**Car**	**Taxi**	**LGV**	**HGV**	**Bus**	**Total**
Compliant	1%	1%	0%	6%	0%	1%
Non-compliant	1%		0%	6%		1%
Total	1%	1%	0%	6%	0%	1%

Key Links Change

27. Similar impacts were seen on the link flows as in the cordon crossings.

Table 89: 2020 PM Base Year Adjustment CAZ D High Key Links Inside CAZ (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Digbeth	22,006	15,659	1,056	1,379	720	655	-	399	13
A38 Sth	55,615	43,135	2,990	5,740	2,308	703	-	716	17
A38 cen	65,063	50,874	3,314	5,887	2,470	1,264	-	1,161	33
A38 Nth	83,742	64,285	5,482	7,329	3,524	1,300	-	1,342	46

Table 90: 2020 PM Base Year Adjustment CAZ D High Key Links On the A4540 Ring Road (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Ring Road North	33,497	19,968	1,392	2,140	1,047	6,571	-	1,786	592
Ring Road South	62,488	39,983	2,781	4,694	2,728	8,522	-	2,669	968
Ring Road West	34,335	20,022	1,417	1,925	648	7,837	-	1,927	417
Ring Road East	54,382	31,180	2,189	4,749	3,305	8,313	-	3,167	1,476

Table 91: 2020 Difference (PM Base Year Adjustment CAZ D High – CAZ D High) Key Links Inside CAZ (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Digbeth	136	46	17	3	52	2	-	1	1
A38 Sth	330	135	50	15	126	2	-	2	1
A38 cen	373	158	52	15	139	4	-	3	2
A38 Nth	579	220	96	19	229	4	-	4	3

Table 92: 2020 Difference (PM Base Year Adjustment CAZ D High – CAZ D High) On the A4540 Ring Road (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Ring Road North	248	69	25	6	79	22	-	5	41
Ring Road South	488	127	46	13	198	25	-	7	71
Ring Road West	178	56	21	5	40	23	-	5	27
Ring Road East	496	93	34	12	222	24	-	8	103

Table 93: 2020 % Difference (PM Base Year Adjustment CAZ D High – CAZ D High) Key Links Inside CAZ (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Digbeth	1%	0%	2%	0%	8%	0%		0%	8%
A38 Sth	1%	0%	2%	0%	6%	0%		0%	7%
A38 cen	1%	0%	2%	0%	6%	0%		0%	6%
A38 Nth	1%	0%	2%	0%	7%	0%		0%	8%

Table 94: % Difference (PM Base Year Adjustment CAZ D High – CAZ D High) Key Links On the A4540 Ring Road (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV

Ring Road North	1%	0%	2%	0%	8%	0%		0%	8%
Ring Road South	1%	0%	2%	0%	8%	0%		0%	8%
Ring Road West	1%	0%	1%	0%	7%	0%		0%	7%
Ring Road East	1%	0%	2%	0%	7%	0%		0%	7%

Fleet

Older Fleet

Cordon Flows

28. The impact of the older fleet is an increase in non-compliant vehicles, which would be a significant increase in percentage terms, although in absolute numbers the increase is less than 2,400 out of 190'000 total vehicles in the CAZ D High scenario. There will also be a reduction in total vehicles as the higher numbers of non-compliant vehicles means more vehicles avoiding the CAZ than in the OBC.

Table 95: 2020 Cordon Crossing Impact of Older Fleet Assumptions

	CAZ D High (OBC – No Additional Measures)					
Compliance	Car	Taxi	LGV	HGV	Bus	Total
Compliant	146,084	9,430	16,854	6,443	5,466	184,276
Non-compliant	2,959	-	3,496	191	-	6,647
Total	149,043	9,430	20,350	6,634	5,466	190,923
	CAZ D High (Older Fleet)					
Compliance	Car	Taxi	LGV	HGV	Bus	Total
Compliant	140,164	9,405	14,855	6,419	5,466	176,308
Non-compliant	4,030	-	4,713	117	-	8,860
Total	144,194	9,405	20,340	6,639	5,466	186,043
	Difference (Sensitivity - CAZ D)					
Compliance	Car	Taxi	LGV	HGV	Bus	Total
Compliant	-5,908	-24	-1,994	-137	-	-8,062
Non-compliant	1,071	-	1,217	30	-	2,318
Total	-4,837	-24	-5	-4	-	-4,870
	% Difference (Sensitivity/CAZ D)					
Compliance	Car	Taxi	LGV	HGV	Bus	Total
Compliant	-4%	0%	-12%	-2%	0%	-4%
Non-compliant	36%		35%	34%		35%
Total	-3%	0%	0%	0%	0%	-3%

Key Links Change

29. The CAZ key links follows a similar pattern to the cordon crossings, but on the ring road the total flows is neutral so there would be a greater worsening in air quality outside of the CAZ.

Table 96: 2020 Older Fleet CAZ D High Key Links Inside CAZ (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Digbeth	21,521	15,021	1,030	1,250	662	889	-	540	16

A38 Sth	53,068	41,240	2,982	4,842	2,028	976	-	974	22
A38 cen	62,891	48,797	3,278	5,110	2,307	1,730	-	1,567	42
A38 Nth	80,645	61,662	5,378	6,323	3,214	1,772	-	1,807	57

Table 97: 2020 Older Fleet CAZ D High Key Links On the A4540 Ring Road (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Ring Road North	33,345	17,449	1,322	1,706	764	8,955	-	2,407	740
Ring Road South	61,935	36,657	2,692	3,805	2,204	11,621	-	3,610	1,202
Ring Road West	34,931	17,737	1,319	1,503	502	10,625	-	2,582	522
Ring Road East	53,976	28,033	2,084	3,855	2,661	11,257	-	4,249	1,834

Table 98: 2020 Difference (Older Fleet CAZ D High – CAZ D High) Key Links Inside CAZ (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Digbeth	-349	-592	-10	-126	-5	236	-	142	4
A38 Sth	-2,217	-1,760	41	-883	-155	275	-	259	6
A38 cen	-1,799	-1,919	16	-762	-23	470	-	409	11
A38 Nth	-2,519	-2,402	-8	-987	-81	476	-	469	15

Table 99: 2020 Difference (Older Fleet CAZ D High – CAZ D High) On the A4540 Ring Road (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Ring Road North	96	-2,450	-44	-428	-204	2,406	-	626	190
Ring Road South	-66	-3,199	-42	-876	-326	3,125	-	949	305
Ring Road West	774	-2,228	-77	-417	-106	2,811	-	660	131
Ring Road East	89	-3,053	-71	-882	-422	2,968	-	1,090	461

Table 100: 2020 % Difference (Older Fleet CAZ D High – CAZ D High) Key Links Inside CAZ (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Digbeth	-2%	-4%	-1%	-9%	-1%	36%		36%	35%
A38 Sth	-4%	-4%	1%	-15%	-7%	39%		36%	36%
A38 cen	-3%	-4%	0%	-13%	-1%	37%		35%	35%
A38 Nth	-3%	-4%	0%	-14%	-2%	37%		35%	34%

Table 101: % Difference (Older Fleet CAZ D High – CAZ D High) Key Links On the A4540 Ring Road (AADT)

Road	All	Compliant				Non-Compliant			
		Car	Taxi	LGV	HGV	Car	Taxi	LGV	HGV
Ring Road North	0%	-12%	-3%	-20%	-21%	37%		35%	34%
Ring Road South	0%	-8%	-2%	-19%	-13%	37%		36%	34%
Ring Road West	2%	-11%	-6%	-22%	-17%	36%		34%	34%
Ring Road East	0%	-10%	-3%	-19%	-14%	36%		34%	34%