SUMMARY NOTE

SHEFFIELD AND ROTHERHAM CLEAN AIR ZONE FEASIBILITY STUDY

BEHAVIOURAL RESEARCH – ADDITIONAL ANALYSIS

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1. INTRODUCTION

1.1.1 In July 2018, SYSTRA was commissioned to undertake research on behalf of Sheffield City Council (SCC) and Rotherham Metropolitan Borough Council to provide evidence-based insights into how drivers in Sheffield and Rotherham may respond to a Clean Air Zone (CAZ) charge. In September 2018, SYSTRA produced a draft report summarising this research.

1.1.2 The research was undertaken to produce behavioural response proportions to a CAZ charge. This note describes how the behavioural research results have been incorporated into the traffic modelling work in order to establish a realistic local response to a CAZ, therefore providing a bespoke evidence base which takes into account the likely behavioural change of the local population.

1.1.3 The aim of this analysis is to predict how the frequency of trip-making and the level of the CAZ charge affect the proportions of non-compliant vehicle owners who respond in different ways to the introduction of a CAZ charge.

1.1.4 We start by describing our analysis of the local annual ANPR data, which provides a robust understanding of the distribution of trip frequencies by vehicle type, then provide a summary of the behavioural research, then explain how these two strands are combined to predict the proportion of non-compliant traffic on any given day that will respond in the various different ways to a given level of CAZ charge.

2. ANPR ANALYSIS OF TRIP FREQUENCY

2.1 Introduction

2.1.1 The frequency with which a non-compliant vehicle enters a CAZ Charging area will determine how likely it is to respond in different ways to the introduction of a CAZ charge, with infrequent 'one-off' trips assumed to be less likely to upgrade their vehicle than regular 'almost daily' trips, such as those made by commuters.

2.1.2 The most-interesting choices (ie those which are hardest to predict) are likely to occur in the middle of this range (ie in the 'once per month' to 'twice per week' range).

2.1.3 In particular, it will be important to be able to distinguish between 'once per week' and 'once per year', as the likely responses of these two groups will be very different.

2.1.4 The duration of a bespoke ANPR survey will determine how much the lower frequency trips can be disaggregated. In particular, it is not possible to disaggregate the set of number plates which are identified once in a week-long bespoke ANPR survey between trips which are typically made once per week from those which are made once a year or less. Given the likelihood that these two groups will respond very differently to a local CAZ charge, this limitation makes it difficult to use short-duration bespoke ANPR surveys to calibrate a robust local behavioural response model.

2.1.5 Luckily, Sheffield and Rotherham have an extensive network of their own ANPR cameras which have been operating continuously for a number of years. The associated database of observed number plates provides an invaluable source of data on this crucial area of the trip frequency distributions (ie between weekly and once-per-year trip frequencies.

2.1.6 In particular, for the CAZ Feasibility Study, a year's worth[1] of data from a set of camera clusters illustrated in Figure 1 below.

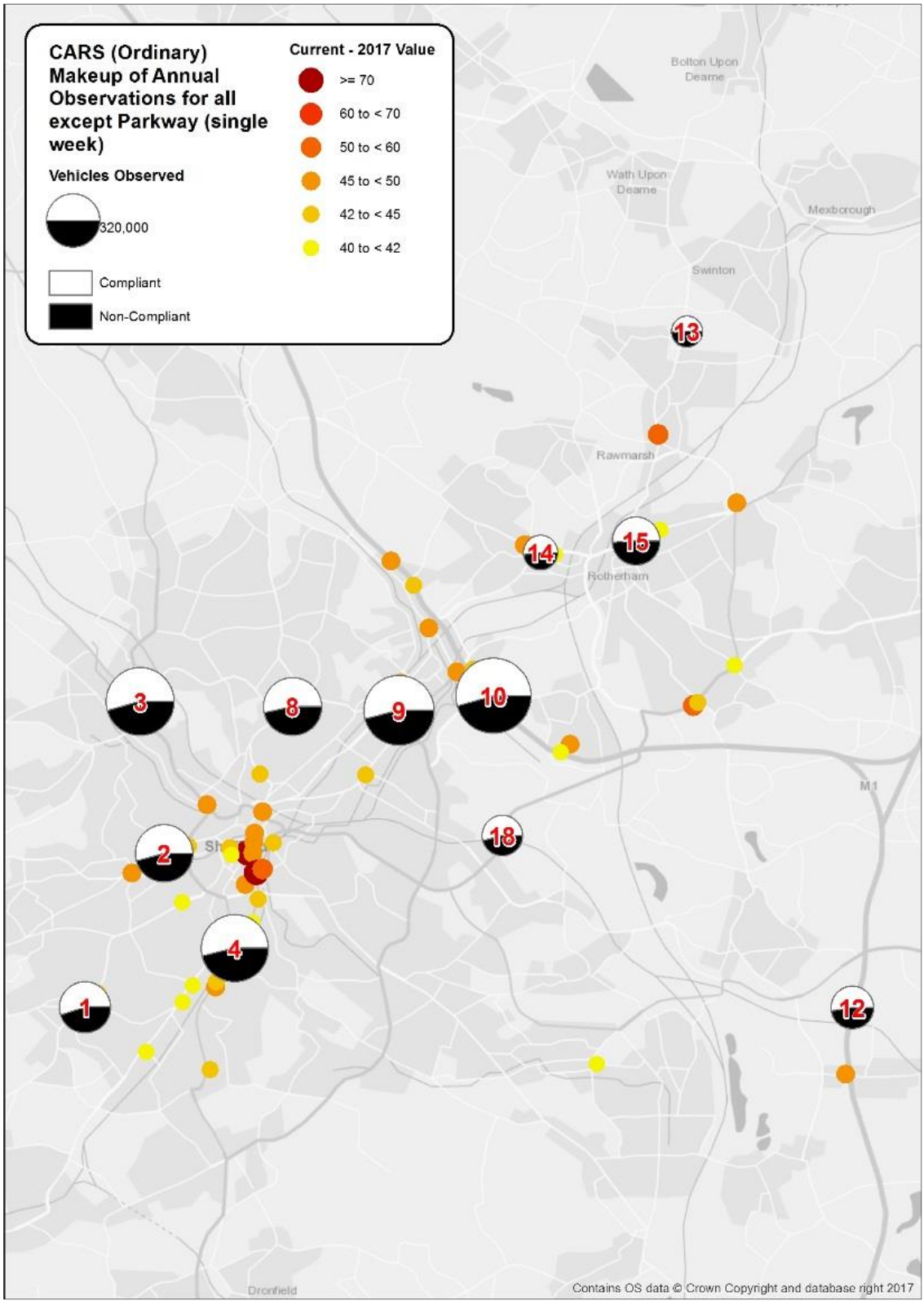

Figure 1 Location of the Camera Clusters

[1] 1 December 2016 – 30 November 2017

2.1.7 The trip frequency distributions (ie the number of days on which the number plate was seen at each camera cluster) by vehicle type[2] and location were generated and aggregated into 5-trip frequency bands (1-5, 6-10, 11-15, …, 196-200, >200), which were further aggregated into four trip frequency categories, as follows:

- Low = 'Less than once per month' (1-5 + 6-10 days per year);
- Low-Medium = 'Between once per month and once per week') (11-15 + … + 45-50)
- Medium-High = 'Between once per week and twice per week' (51-55 + … + 101-105); and
- High = ('More than twice per week') (106-110 + … 196-200 + '>200').

2.2 Analysis of Trip Frequency

2.2.1 The table below summarises the trip frequency distribution of the total fleet of vehicles observed throughout the year, averaged across all 11 camera clusters.

Table 1. Distribution of Trip Frequency – Annual Fleet – All Sites Combined

Distribution of Annual Fleet (by vehicle type and trip frequency) - all ANPR Clusters Combined							
Trip Frequency	BUSES & COACHES	CARS Ordinary	CARS Special	GOODS - HEAVY (ARTIC)	GOODS - HEAVY (RIGID)	GOODS - LIGHT	All Vehicles
Low (<1 per month)	63%	74%	32%	87%	77%	76%	74%
LM (<1 per week)	22%	20%	25%	11%	18%	19%	19%
MH (1 < = x < 2 per week)	8%	4%	18%	1%	3%	4%	4%
High (>2 per week)	7%	3%	25%	1%	2%	2%	3%

2.2.2 This table illustrates that the majority (74%) of vehicles seen across the year passes any particular camera cluster less than once per month, with a further 19% passing any camera cluster less often than once per week.

2.2.3 Buses & coaches and 'Special Cars – ie vehicles registered as hackney cabs or private hire vehicles, are much more likely to be high frequency than the other vehicle types, highlighted the cost-effectiveness of targeting fleet upgrades on these two vehicle types.

2.2.4 When considering the frequency profile of traffic **on any given day**, the high frequency vehicles appear on many more days than the infrequent ones and therefore the distribution of vehicles seen on any particular day swings much more towards the high-frequency category.

2.2.5 The table below shows the corresponding trip frequency for traffic observed on any particular day, generated by multiplying the annual trip frequency distribution reported in the table above by the likelihood that the vehicle will be seen on any particular day.

[2] Buses and Coaches, Cars, 'Special Cars (= Private Hire Cars and Hackney Cabs), HGVs x2 and LGVs

Table 2. Distribution of Trip Frequency – Daily Traffic – All Sites Combined

Distribution of Daily Fleet (by vehicle type and trip frequency) - all ANPR Clusters Combined							
Trip Frequency	BUSES & COACHES	CARS Ordinary	CARS Special	GOODS - HEAVY (ARTIC)	GOODS - HEAVY (RIGID)	GOODS - LIGHT	All Vehicles
Low (<1 per month)	7%	15%	2%	35%	19%	18%	15%
LM (<1 per week)	20%	33%	10%	36%	36%	37%	33%
MH (1 < = x < 2 per week)	23%	22%	21%	15%	22%	22%	22%
High (>2 per week)	50%	30%	68%	14%	23%	22%	30%

2.2.6 This trip frequency-weighted version suggests that the trip frequency of vehicles seen on any particular day are much more -balanced between low and high frequency, with approximately half of all vehicles in the Low or Low/Medium category and the other half in the Medium/High or High categories.

2.2.7 Buses and coaches and 'special' cars (ie taxis) are again much more likely to be high frequency than the other vehicle types.

2.3 Geographic Variation

2.3.1 The table below summaries the share of daily traffic in the Low and Low/Medium trip frequency category at each of the 11 camera clusters.

Table 3. Daily Trip Frequency by Camera Cluster

	Camera Cluster	BUSES & COACHES	CARS Ordinary	CARS Special	GOODS - HEAVY (ARTIC)	GOODS - HEAVY (RIGID)	GOODS - LIGHT	All Vehicles
1	South West Sheffield (outside city centre)	22%	38%	13%	58%	70%	53%	39%
2	SW Sheffield City Centre	54%	48%	10%	73%	70%	60%	48%
3	West of Sheffield City Centre	21%	43%	6%	76%	56%	50%	43%
4	SW Sheffield City Centre	15%	44%	6%	86%	52%	51%	43%
8	North of Sheffield City Centre	37%	65%	13%	78%	66%	70%	63%
9	North-east of Sheffield City Centre	26%	48%	5%	61%	40%	49%	46%
10	M1 - Tinsley	48%	66%	25%	72%	55%	68%	65%
M1 So	M1 - South of J31	83%	56%	100%	66%	59%	64%	58%
13	North Rotherham - not in town centre	33%	41%	16%	76%	59%	58%	42%
14	Rotherham - edge of town centre	48%	56%	30%	93%	78%	70%	57%
15	Rotherham town centre	24%	40%	12%	76%	55%	49%	40%

2.3.2 The key conclusions from this analysis are :

- There is no significant systematic difference between Sheffield sites (at the top of the table) and Rotherham sites (at the bottom);
- There **is** a significant difference between the motorway sites and the area-wide average, with the proportion of low + low/medium frequency trips much higher at the two motorway sites than the area-wide average (presumably because the motorway traffic contains a much higher proportion of infrequent long-distance through trips); and
- Goods vehicles (particularly articulated HGVs) are much more likely to be low frequency than other vehicle types – this will have implications for both the likelihood that a given vehicle owner will decide to upgrade their non-compliant vehicle in response to a CAZ charge and the number of different vehicles which need to be upgraded to achieve a given %reduction in emissions from these vehicle types. However, there is a possibility that goods vehicles may be operating in multiple CAZ areas, which may increase the likelihood that they will be upgraded.

2.3.3 The two tables below compare the trip frequency distribution at Junction 31 on the M1 (which the traffic is likely to be predominantly long-distance 'through' trips and the weighted average of the non-motorway sites (which will consist of a much-higher proportion of local trips).

Table 4. Trip Frequency Differences Between 'Local' and 'Through Trips

M1 South of J31	BUSES & COACHES	CARS Ordinary	CARS Special	GOODS - HEAVY (ARTIC)	GOODS - HEAVY (RIGID)	GOODS - LIGHT	All Vehicles
Low	32%	24%	45%	34%	25%	25%	24%
LM	51%	33%	55%	32%	34%	39%	34%
MH	10%	19%	0%	14%	19%	20%	19%
HIGH	7%	24%	0%	19%	23%	16%	23%
Total	100%	100%	100%	100%	100%	100%	100%
Total excluding motorways	BUSES & COACHES	CARS Ordinary	CARS Special	GOODS - HEAVY (ARTIC)	GOODS - HEAVY (RIGID)	GOODS - LIGHT	All Vehicles
Low	6%	14%	1%	35%	19%	17%	14%
LM	19%	32%	8%	37%	36%	37%	32%
MH	23%	23%	21%	15%	22%	23%	23%
HIGH	52%	31%	70%	13%	23%	23%	32%
Total	100%	100%	100%	100%	100%	100%	100%

2.3.4 The distributions of buses and coaches and 'special cars' (ie taxis) are particularly different between these two types of trip, but ordinary motorway/through-trip cars are also more likely to be low frequency than at the 'local' urban sites (24% vs 14%) and correspondingly less likely to be high frequency (24% vs 31%).

2.3.5 The differences between the trip frequency distribution of these two types of trip are felt to be sufficiently different to warrant analysing their likely responses to charging CAZ schemes separately, particularly for any charging schemes that might be applied to both local and long-distance 'through' trips.

2.3.6 Note that CAZ responses can be implemented in one of two ways, either by applying different Do Something' fleet profiles on a link-by-link basis (where link-based trip frequency patterns are most appropriate) or by applying some of the other behavioural responses (eg mode shift) on a origin-destination (OD) basis, when the concept of 'local' and 'through trips' will be more appropriate.

2.3.7 For the purposes of the analysis of likely responses by particular non-compliant vehicles described later in this note, we have used the following OD-based 'rules':

- Internal zones to internal zones = 'Local trips' – non-motorway average trip frequencies used;
- External zones to external zones = 'Long distance/through trips'- M1 South of J31 trip frequency values used; and
- Internal zones <-> External Zones – arithmetic average of 'Local' and 'Through trip' parameters used.

3. LOCAL BEHAVIOURAL RESEARCH

3.1 Overview

3.1.1 Between July and September 2018, SYSTRA undertook qualitative and quantitative research with black cab drivers, private hire vehicle (PHV) drivers, LGV drivers and private car drivers (quantitative only). The work is discussed in detail in the SYSTRA report *Sheffield and Rotherham Clean Air Zone Feasibility Study – Behavioural Research.*

3.1.2 One of the main aims of this research was to understand how Sheffield/Rotherham residents may respond to a Clean Air Zone charge to be incorporated into the transport modelling work. Only the quantitative research was used to calculate the response proportions and therefore an overview of this research is given in the table below.

Table 5. Quantitative research overview

GROUP	METHOD	NUMBER OF RESPONDENTS
Private car drivers	Online survey	311
LGV drivers	Computer-Assisted Telephone Interview (CATI)	101
Black cab drivers	Paper survey	50
PHV drivers	Paper survey	50

3.2 Questionnaire design

3.2.1 The questionnaires were designed by SYSTRA and reviewed by SCC and RMBC prior to fieldwork commencing. The quantitative research included four CAZ charge scenarios:

- £5 per day
- £10 per day
- £10 per day and subsidy for those that use electric vehicles
- £20 per day

3.2.2 In each scenario, participants were asked to select their response from a list of options:

- Use same vehicle as now & pay the £5 charge every day

- Change to a petrol-based vehicle and avoid the charge
- Change to a Euro 6 diesel vehicle and avoid the charge
- Change to an electric car and avoid the charge
- Convert vehicle to run on LPG and avoid the charge (black cab and LGV only)
- Drive to/work in a different town/city
- Use an alternative mode of transport (car only)
- Drive into Sheffield/Rotherham less frequently (car only)
- Other (please specify)

3.2.3 In addition to the charging scenarios, a frequency question was incorporated into the quantitative questionnaires that would allow the behavioural research results to be combined with the ANPR analysis previously undertaken by SYSTRA (and therefore incorporated into the traffic modelling). This frequency question is outlined below:

How often do you drive it into central Sheffield or central Rotherham?

No more than 11 days a year (i.e. less than once a month)	☐1
12 - 51 days a year (more than once a month but less than once a week)	☐2
52 - 105 days a year (i.e. once or twice a week)	☐3
More than 105 days a year (i.e. three times a week or more)	☐4

3.3 Analysis

3.3.1 Following completion of the fieldwork, SYSTRA analysed the data using SPSS. This analysis included the production of crosstabulations of trip frequency into Sheffield and Rotherham against the CAZ scenario responses.

3.3.2 The details of the various stated responses to the different charging levels by vehicle type and trip frequency were reported in detail in the Local Behavioural Research report and, for brevity, this reporting is not repeated in detail here. The relevant predicted responses are tabulated in Appendix A and the relevant values are discussed and used in Chapter 4 below.

3.3.3 These crosstabulations were combined with the trip frequency profiles provided from the ANPR frequency analysis to generate response proportions for each mode and movement type, the movement types are listed below:

- Internal to internal
- External to external
- Internal to/from external

3.3.4 This disaggregation by mode and trip type was undertaken for car and LGV drivers only.

3.3.5 Only a small proportion of black cab and PHV drivers responded that they travelled into Sheffield/Rotherham less than three times a week or more and therefore the proportions from the behavioural research were used for these groups with no additional frequency analysis.

4. COMBINING TRIP FREQUENCY AND BEHAVIOURAL RESPONSES

4.1 Introduction

4.1.1 In this chapter we combine the distribution of trip frequencies for different vehicle and trip-types with the stated behavioural responses of the relevant vehicle owners (vehicle type and trip frequency)

4.1.2 However, as noted in the previous chapter, the sample size for black cab and PHV owners was not large enough to disaggregate by trip frequency (and almost all were high frequency, with respect to trips into the respective town/city centres). We therefore simply use the average responses for all black cab and PHV owners, regardless of their trip frequency. This assumption would need to be reviewed if we were to consider charging these vehicles on motorways, where the low trip frequencies for individual vehicles are much more common.

4.1.3 For the other vehicle types included in the local behavioural research (private cars and LGVs) we take the weighted average of the four trip frequencies to produce an all-vehicle-type average response to each potential CAZ charge.

4.2 All-Vehicle Averages

4.2.1 Appendix A contains the results of the using a combination of the CAZ charge and the trip frequency in a 'VLOOKUP' to identify the likely response proportions of that vehicle/trip type and weighting these values by the proportion of trip frequencies (Low//LM/MH/High) for that trip-type Internal<->Internal, External<->External etc)

4.2.2 Summing up these weighted proportions gives the weighted average response for each trip type, as shown in the tables below.

Table 6. Behavioural Responses by Trip Type – Private Car

		Scenario	Use same vehicle as now & pay the charge every day	Change to a petrol-based vehicle and avoid the charge	Change to a Euro 6 diesel vehicle and avoid the charge	Change to an electric vehicle and avoid the charge	Work/drive to different town/city	Use an alternative mode of transport (e.g. walk, cycle, public transport)	Drive into Sheffield/ Rotherham less frequently
Car	Internal - Internal	£5	11%	27%	9%	11%	13%	13%	16%
Car	External - External	£5	12%	25%	9%	10%	15%	12%	16%
Car	Internal<->external	£5	11%	26%	9%	11%	14%	13%	16%
Car	Link by link (all site ave.)	£5	11%	27%	9%	11%	13%	12%	16%
Car	Internal - Internal	£10	8%	22%	9%	11%	15%	20%	16%
Car	External - External	£10	7%	21%	9%	10%	17%	19%	17%
Car	Internal<->External	£10	8%	21%	9%	10%	16%	19%	17%
Car	Link by link (all site ave.)	£10	8%	22%	9%	11%	15%	19%	16%
Car	Internal - Internal	£10+Sub	8%	16%	7%	23%	16%	16%	14%
Car	External - External	£10+Sub	8%	16%	7%	22%	18%	15%	14%
Car	Internal<->External	£10+Sub	8%	16%	7%	23%	17%	15%	14%
Car	Link by link (all site ave.)	£10+Sub	8%	16%	7%	23%	16%	15%	14%
Car	Internal - Internal	£20	5%	18%	7%	15%	25%	16%	14%
Car	External - External	£20	4%	18%	7%	14%	27%	16%	14%
Car	Internal<->External	£20	4%	18%	7%	14%	26%	16%	14%
Car	Link by link (all site ave.)	£20	5%	18%	7%	15%	26%	16%	14%

Table 7. Behavioural Response by Trip Type – Taxis

		Scenario	Use same vehicle as now & pay the charge every day	Convert vehicle to run on LPG	Change to a petrol-based vehicle and avoid the charge	Change to a Euro 6 diesel vehicle and avoid the charge	Change to an electric vehicle and avoid the charge	Work/drive to different town/city	Leave trade/retire
PHV	Behavioural research proportions	£5	16%	0%	16%	14%	35%	14%	5%
PHV	Behavioural research proportions	£10	5%	0%	12%	12%	45%	19%	7%
PHV	Behavioural research proportions	£10+Sub	0%	0%	11%	13%	45%	21%	11%
PHV	Behavioural research proportions	£20	3%	0%	13%	8%	39%	21%	16%
Black Cab	Behavioural research proportions	£5	27%	11%	0%	29%	18%	7%	9%
Black Cab	Behavioural research proportions	£10	16%	12%	0%	30%	19%	7%	16%
Black Cab	Behavioural research proportions	£10+Sub	18%	9%	0%	27%	20%	7%	18%
Black Cab	Behavioural research proportions	£20	15%	15%	0%	23%	17%	9%	21%

Table 8. Behavioural Response by Trip Type – Light Goods Vehicles

	Trip Type	Scenario	Use same vehicle as now & pay the charge every day	Convert vehicle to run on LPG	Change to a petrol-based vehicle and avoid the charge	Change to a Euro 6 diesel vehicle and avoid the charge	Change to an electric vehicle and avoid the charge	Work/drive to different town/city
LGV	Internal - Internal	£5	51%	9%	1%	15%	5%	19%
LGV	External - External	£5	50%	10%	1%	14%	6%	19%
LGV	Internal<->External	£5	51%	9%	1%	14%	6%	19%
LGV	Link by link (all site ave.)	£5	51%	9%	1%	14%	5%	19%
LGV	Internal - Internal	£10	43%	4%	0%	18%	6%	29%
LGV	External - External	£10	43%	5%	0%	16%	6%	29%
LGV	Internal<->External	£10	43%	5%	0%	17%	6%	29%
LGV	Link by link (all site ave.)	£10	43%	5%	0%	17%	6%	29%
LGV	Internal - Internal	£10+Sub	38%	8%	0%	12%	18%	24%
LGV	External - External	£10+Sub	37%	9%	0%	12%	17%	25%
LGV	Internal<->External	£10+Sub	37%	8%	0%	12%	17%	25%
LGV	Link by link (all site ave.)	£10+Sub	38%	8%	0%	12%	18%	25%
LGV	Internal - Internal	£20	31%	4%	0%	17%	3%	45%
LGV	External - External	£20	32%	5%	0%	15%	4%	44%
LGV	Internal<->External	£20	31%	4%	0%	16%	4%	45%
LGV	Link by link (all site ave.)	£20	31%	4%	0%	16%	3%	45%

4.2.3 These tables suggest that the predicted behavioural responses for 'local' and 'through' trips for cars and LGVs are not sufficiently different to result in any significantly different responses between these two subsets of vehicle owners. We therefore propose to use the values of behavioural responses based on the all-ANPR-camera-site average when predicting the responses of these two sets of vehicle owners to charging CAZ schemes.

4.2.4 For black cab and private hire car owners (where there was a more-significant difference between the trip frequencies at urban and motorway sites), the behavioural research sample did not contain sufficient low-frequency respondents to predict their responses to a charging CAZ. We therefore propose to use the single average response for these two vehicle types.

4.2.5 This proposed approach would need to be revisited if we were to consider charging taxis at locations (eg on the M1 or other long-distance through routes) where many of the taxis are likely to be low-frequency and therefore less likely to upgrade than for a city centre CAZ scheme.

4.3 Summary of Predicted Responses for a £10/day Charge

4.3.1 The table below summarises the predicted responses of the four vehicle types to a £10/day charge, based on the 'all ANPR camera site average' values reported in the previous section.

Table 9. Predicted Responses to a £10/day Charge

	Daily Charge	Pay to Pollute (or avoid)	Convert vehicle to run on LPG	Change to a petrol-based vehicle and avoid the charge	Change to a Euro 6 diesel vehicle and avoid the charge	Change to an electric vehicle and avoid the charge	Work/drive to different town/city	Mode shift	Drive into Sheffield/ Rotherham less frequently	Leave trade/ retire
Car	£10	8%	0%	22%	9%	11%	15%	19%	16%	
PHV	£10	5%	0%	12%	12%	45%	19%			7%
Black Cab	£10	16%	12%	0%	30%	19%	7%			16%
LGV	£10	43%	5%	0%	17%	6%	29%		0%	

4.3.2 To simplify the comparison with the JAQU default responses, the table below amalgamates the various types of vehicle upgrade responses from the table above.

Table 10. Predicted Amalgamated Responses to a £10/day Charge

	Daily Charge	Pay to Pollute (or avoid)	Upgrade the Vehicle	Mode Shift	Destination Choice or Trip Frequency
Car	£10	8%	41%	19%	32%
PHV	£10	5%	69%	0%	26%
Black Cab	£10	16%	60%	0%	23%
LGV	£10	43%	28%	0%	29%

4.3.3 There are a number of ways of modelling the responses which imply a reduction in trip frequency, as follows:

- **'Pessimistic'** - Assume they are prevented from making these trip-reducing choices and instead have to choose between 'Pay-to-Pollute' and 'Upgrade the Vehicle' (and follow the same proportions as the other owners of the relevant vehicle type) – so, for example the 32% car drivers who stated they would change their trip patterns are returned to the highway matrix and split 8:41 between paying and upgrading, adding 5% and 27% to the 'Pay to Pollute' and 'Upgrade the Vehicle' totals respectively;
- **Pros:** allows these choices to be modelled as a simple fleet change (without requiring a new traffic assignment) and avoids the need to consider the impact of the removed trip on the relevant customers who lose their delivery, plumber, taxi, etc;
  Cons: Is likely to over-estimate the resulting emissions as it under-estimates the reduction in emissions from any net removal of discretionary trips or from trip-consolidation etc;
- '**Conservative**' – assume that the trips formerly made by the non-compliant vehicles are removed and the relevant business is picked up by someone driving a compliant vehicle (and who is therefore not put off by the CAZ charge)
  Pros: allows these choices to be modelled as a simple fleet change (without requiring a new traffic assignment) and avoids the need to consider the impact of the removed trip on the relevant customers who lose their delivery, plumber, taxi, etc;
  Cons: Still more 'conservative' that the stated responses, as it under-estimates the reduction in emissions from any net removal of discretionary trips or trip-consolidation etc (though less so than for the 'Pessimistic' assumptions described above;
- **'Optimistic'** – assume the stated responses are correct and the resulting trips are removed from the travel demand matrices (and not replaced)
  Pros: Consistent with the stated responses;
  Cons: Requires an additional traffic assignment for each CAZ charging scenario being considered (eg if the level of charge is changed) and creates theoretical and/or appraisal difficulties regarding the impact of the removal of trips on the relevant customers – also requires an additional assumption about many trips to remove from the set of drivers who stated they would 'drive less frequently' (as the survey did not ask these respondents to quantify their predicted new trip-making behaviour.

4.3.4 **Our approach used in the modelling of the scheme will be to use the 'Conservative' figures**.

4.3.5 Due to the large number of disadvantages associated with the 'Optimistic' approach, it has been dropped from further consideration here.

4.3.6 The results of the two alternative 'Fixed Demand' assumptions ('Pessimistic' and 'Conservative') are shown in the table below.

Table 11. Predicted responses if total demand assumed to be constant

	Daily Charge	Pay to Pollute		Total Upgrade the Vehicle		Mode Shift
		Pessimistic	Conservative	Pessimistic	Conservative	
Car	£10	13%	8%	68%	73%	19%
PHV	£10	6%	5%	94%	95%	0%
Black Cab	£10	21%	16%	79%	84%	0%
LGV	£10	61%	43%	39%	57%	0%

4.3.7 Finally, we compare these Local Behavioural Research responses with the corresponding values based on the default guidance provided by JAQU (which do not depend on the level of the charge. The results of this comparison are shown in the table below.

Table 12. Comparison between local research and JAQU default responses

		Pay to Pollute			Upgrade the Vehicle			Remove from traffic matrix	
	Daily Charge	Local		JAQU	Local		JAQU	Local (tbc by mode choice)	JAQU
		Pessimistic	Conservative		Pessimistic	Conservative			
Car	£10	13%	8%	18%	68%	73%	64%	19%	18%
PHV	£10	6%	5%	N/A	94%	95%	N/A	0%	N/A
Black Cab	£10	21%	16%	N/A	79%	84%	N/A	0%	N/A
LGV	£10	61%	43%	28%	39%	57%	64%	0%	8%

4.3.8 It can be seen that the pattern of predicted responses for non-compliant private car owners are very similar between the local research and the JAQU defaults, but the local LGV owners appear much more likely to 'Pay to Pollute' than the JAQU defaults would suggest.

4.3.9 This difference will mean that any CAZ C (or above) modelled using these local responses is likely to generate slightly less of a reduction in traffic emissions than would be predicted using the JAQU default values.

Appendix A

Local Behavioural Research - Behavioural Responses by Vehicle Type and Trip Frequency

			Charge	Proportion	Use same vehicle as now & pay the charge every da	Convert vehicle to run on LPG	Change to a petrol-based vehicle and avoid the charge	Change to a Euro 6 diesel vehicle and avoid the charge	Change to an electric vehicle and avoid the charge	Work/ drive to different town/ ci	Use an alternative mode of transport (e.g. walk, cycle, public transport)	Drive into Sheffield/ Rotherham less frequently
Car	External - External	L	£ 5	24%	3%	0%	3%	2%	1%	6%	4%	4%
Car	External - External	HM	£ 5	19%	1%	0%	5%	1%	2%	3%	6%	1%
Car	External - External	LM	£ 5	33%	4%	0%	9%	3%	5%	5%	1%	7%
Car	External - External	H	£ 5	24%	4%	0%	8%	2%	2%	1%	2%	4%
Car	Internal - Internal	L	£ 5	14%	2%	0%	2%	1%	1%	4%	2%	2%
Car	Internal - Internal	HM	£ 5	23%	1%	0%	7%	1%	3%	3%	7%	1%
Car	Internal - Internal	LM	£ 5	32%	4%	0%	9%	3%	5%	5%	1%	7%
Car	Internal - Internal	H	£ 5	31%	5%	0%	10%	3%	3%	2%	2%	6%
Car	Internal<->external	L	£ 5	19%	3%	0%	3%	2%	1%	5%	3%	3%
Car	Internal<->external	HM	£ 5	21%	1%	0%	6%	1%	2%	3%	7%	1%
Car	Internal<->external	LM	£ 5	32%	4%	0%	9%	3%	5%	5%	1%	7%
Car	Internal<->external	H	£ 5	28%	4%	0%	9%	3%	3%	1%	2%	5%
Car	Link by link (all site ave	L	£ 5	15%	2%	0%	2%	1%	1%	4%	2%	3%
Car	Link by link (all site ave	HM	£ 5	22%	1%	0%	6%	1%	3%	3%	7%	1%
Car	Link by link (all site ave	LM	£ 5	33%	4%	0%	9%	3%	5%	5%	1%	7%
Car	Link by link (all site ave	H	£ 5	30%	5%	0%	10%	3%	3%	2%	2%	5%
Car	External - External	L	£ 10	24%	1%	0%	3%	3%	0%	7%	4%	5%
Car	External - External	HM	£ 10	19%	1%	0%	5%	0%	3%	2%	7%	2%
Car	External - External	LM	£ 10	33%	3%	0%	7%	4%	5%	7%	3%	6%
Car	External - External	H	£ 10	24%	2%	0%	5%	3%	2%	2%	5%	5%
Car	Internal - Internal	L	£ 10	14%	1%	0%	2%	1%	0%	4%	3%	3%
Car	Internal - Internal	HM	£ 10	23%	1%	0%	6%	0%	4%	2%	8%	2%
Car	Internal - Internal	LM	£ 10	32%	3%	0%	7%	4%	5%	7%	3%	6%
Car	Internal - Internal	H	£ 10	31%	3%	0%	7%	4%	2%	2%	7%	6%
Car	Internal<->external	L	£ 10	19%	1%	0%	3%	2%	0%	6%	3%	4%
Car	Internal<->external	HM	£ 10	21%	1%	0%	5%	0%	4%	2%	7%	2%
Car	Internal<->external	LM	£ 10	32%	3%	0%	7%	4%	5%	7%	3%	6%
Car	Internal<->external	H	£ 10	28%	3%	0%	6%	3%	2%	2%	6%	5%
Car	Link by link (all site ave	L	£ 10	15%	1%	0%	2%	2%	0%	4%	3%	3%
Car	Link by link (all site ave	HM	£ 10	22%	1%	0%	6%	0%	4%	2%	8%	2%
Car	Link by link (all site ave	LM	£ 10	33%	3%	0%	7%	4%	5%	7%	3%	6%
Car	Link by link (all site ave	H	£ 10	30%	3%	0%	7%	4%	2%	2%	7%	6%
Car	External - External	L	£10+Sub	24%	1%	0%	4%	3%	3%	6%	3%	4%
Car	External - External	HM	£10+Sub	19%	2%	0%	5%	0%	5%	2%	4%	2%
Car	External - External	LM	£10+Sub	33%	4%	0%	5%	2%	8%	8%	3%	5%
Car	External - External	H	£10+Sub	24%	2%	0%	3%	2%	7%	2%	5%	4%
Car	Internal - Internal	L	£10+Sub	14%	1%	0%	2%	1%	2%	4%	2%	2%
Car	Internal - Internal	HM	£10+Sub	23%	2%	0%	6%	0%	6%	3%	4%	3%
Car	Internal - Internal	LM	£10+Sub	32%	3%	0%	4%	2%	7%	7%	3%	4%
Car	Internal - Internal	H	£10+Sub	31%	2%	0%	4%	3%	9%	2%	6%	5%
Car	Internal<->external	L	£10+Sub	19%	1%	0%	3%	2%	2%	5%	3%	3%
Car	Internal<->external	HM	£10+Sub	21%	2%	0%	5%	0%	5%	2%	4%	2%
Car	Internal<->external	LM	£10+Sub	32%	3%	0%	4%	2%	7%	7%	3%	4%
Car	Internal<->external	H	£10+Sub	28%	2%	0%	4%	3%	8%	2%	6%	4%
Car	Link by link (all site ave	L	£10+Sub	15%	1%	0%	2%	2%	2%	4%	2%	3%
Car	Link by link (all site ave	HM	£10+Sub	22%	2%	0%	6%	0%	6%	2%	4%	2%
Car	Link by link (all site ave	LM	£10+Sub	33%	4%	0%	5%	2%	8%	8%	3%	5%
Car	Link by link (all site ave	H	£10+Sub	30%	2%	0%	4%	3%	8%	2%	6%	5%
Car	External - External	L	20	24%	1%	0%	4%	2%	1%	8%	4%	4%
Car	External - External	HM	20	19%	1%	0%	4%	1%	3%	4%	5%	2%
Car	External - External	LM	20	33%	2%	0%	6%	3%	5%	11%	3%	4%
Car	External - External	H	20	24%	1%	0%	4%	1%	5%	4%	4%	5%
Car	Internal - Internal	L	20	14%	0%	0%	2%	1%	1%	5%	2%	2%
Car	Internal - Internal	HM	20	23%	1%	0%	5%	1%	3%	5%	6%	2%
Car	Internal - Internal	LM	20	32%	2%	0%	6%	3%	5%	11%	3%	4%
Car	Internal - Internal	H	20	31%	2%	0%	5%	2%	6%	5%	5%	6%
Car	Internal<->external	L	20	19%	0%	0%	3%	2%	1%	7%	3%	3%
Car	Internal<->external	HM	20	21%	1%	0%	5%	1%	3%	4%	5%	2%
Car	Internal<->external	LM	20	32%	2%	0%	6%	3%	5%	11%	3%	4%
Car	Internal<->external	H	20	28%	1%	0%	5%	1%	5%	5%	5%	5%
Car	Link by link (all site ave	L	20	15%	0%	0%	2%	1%	1%	5%	3%	3%
Car	Link by link (all site ave	HM	20	22%	1%	0%	5%	1%	3%	4%	6%	2%
Car	Link by link (all site ave	LM	20	33%	2%	0%	6%	3%	5%	11%	3%	4%
Car	Link by link (all site ave	H	20	30%	1%	0%	5%	1%	6%	5%	5%	6%

			Charge	Proportion	Use same vehicle as now & pay the charge every da	Convert vehicle to run on LPG	Change to a petrol-based vehicle and avoid the charge	Change to a Euro 6 diesel vehicle and avoid the charge	Change to an electric vehicle and avoid the charge	Work/ drive to different town/ ci
LGV	External - External	L	£ 5	25%	12%	2%	1%	3%	1%	7%
LGV	External - External	HM	£ 5	20%	12%	0%	0%	4%	0%	4%
LGV	External - External	LM	£ 5	39%	16%	8%	0%	5%	5%	5%
LGV	External - External	H	£ 5	16%	10%	0%	0%	2%	0%	3%
LGV	Internal - Internal	L	£ 5	17%	8%	1%	1%	2%	0%	4%
LGV	Internal - Internal	HM	£ 5	23%	14%	0%	0%	5%	0%	5%
LGV	Internal - Internal	LM	£ 5	37%	15%	7%	0%	5%	5%	5%
LGV	Internal - Internal	H	£ 5	23%	15%	0%	0%	3%	0%	5%
LGV	Internal<->external	L	£ 5	21%	10%	2%	1%	2%	1%	6%
LGV	Internal<->external	HM	£ 5	22%	13%	0%	0%	4%	0%	4%
LGV	Internal<->external	LM	£ 5	38%	15%	8%	0%	5%	5%	5%
LGV	Internal<->external	H	£ 5	20%	13%	0%	0%	3%	0%	4%
LGV	Link by link (all site ave	L	£ 5	19%	9%	2%	1%	2%	1%	5%
LGV	Link by link (all site ave	HM	£ 5	22%	13%	0%	0%	4%	0%	4%
LGV	Link by link (all site ave	LM	£ 5	37%	15%	7%	0%	5%	5%	5%
LGV	Link by link (all site ave	H	£ 5	22%	14%	0%	0%	3%	0%	5%
LGV	External - External	L	£ 10	25%	11%	3%	0%	2%	1%	9%
LGV	External - External	HM	£ 10	20%	8%	0%	0%	6%	0%	6%
LGV	External - External	LM	£ 10	39%	17%	3%	0%	6%	6%	8%
LGV	External - External	H	£ 10	16%	8%	0%	0%	3%	0%	5%
LGV	Internal - Internal	L	£ 10	17%	7%	2%	0%	1%	0%	6%
LGV	Internal - Internal	HM	£ 10	23%	9%	0%	0%	7%	0%	7%
LGV	Internal - Internal	LM	£ 10	37%	16%	3%	0%	5%	5%	8%
LGV	Internal - Internal	H	£ 10	23%	12%	0%	0%	4%	0%	8%
LGV	Internal<->external	L	£ 10	21%	9%	2%	0%	2%	1%	8%
LGV	Internal<->external	HM	£ 10	22%	8%	0%	0%	7%	0%	7%
LGV	Internal<->external	LM	£ 10	38%	16%	3%	0%	5%	5%	8%
LGV	Internal<->external	H	£ 10	20%	10%	0%	0%	3%	0%	7%
LGV	Link by link (all site ave	L	£ 10	19%	8%	2%	0%	1%	0%	7%
LGV	Link by link (all site ave	HM	£ 10	22%	8%	0%	0%	7%	0%	7%
LGV	Link by link (all site ave	LM	£ 10	37%	16%	3%	0%	5%	5%	8%
LGV	Link by link (all site ave	H	£ 10	22%	11%	0%	0%	4%	0%	7%
LGV	External - External	L	£10+Sub	25%	11%	1%	0%	1%	4%	9%
LGV	External - External	HM	£10+Sub	20%	5%	1%	0%	5%	5%	4%
LGV	External - External	LM	£10+Sub	39%	12%	6%	0%	6%	6%	9%
LGV	External - External	H	£10+Sub	16%	9%	0%	0%	0%	3%	4%
LGV	Internal - Internal	L	£10+Sub	17%	7%	1%	0%	0%	2%	6%
LGV	Internal - Internal	HM	£10+Sub	23%	6%	1%	0%	6%	6%	4%
LGV	Internal - Internal	LM	£10+Sub	37%	11%	6%	0%	6%	6%	9%
LGV	Internal - Internal	H	£10+Sub	23%	13%	0%	0%	0%	4%	6%
LGV	Internal<->external	L	£10+Sub	21%	9%	1%	0%	1%	3%	7%
LGV	Internal<->external	HM	£10+Sub	22%	5%	1%	0%	5%	5%	4%
LGV	Internal<->external	LM	£10+Sub	38%	12%	6%	0%	6%	6%	9%
LGV	Internal<->external	H	£10+Sub	20%	11%	0%	0%	0%	3%	5%
LGV	Link by link (all site ave	L	£10+Sub	19%	8%	1%	0%	1%	3%	7%
LGV	Link by link (all site ave	HM	£10+Sub	22%	6%	1%	0%	6%	6%	4%
LGV	Link by link (all site ave	LM	£10+Sub	37%	11%	6%	0%	6%	6%	9%
LGV	Link by link (all site ave	H	£10+Sub	22%	13%	0%	0%	0%	4%	6%
LGV	External - External	L	20	25%	7%	2%	0%	2%	1%	14%
LGV	External - External	HM	20	36%	9%	0%	0%	8%	0%	19%
LGV	External - External	LM	20	39%	15%	3%	0%	6%	3%	12%
LGV	External - External	H	20		0%	0%	0%	0%	0%	0%
LGV	Internal - Internal	L	20	17%	5%	1%	0%	1%	1%	9%
LGV	Internal - Internal	HM	20	46%	12%	0%	0%	10%	0%	24%
LGV	Internal - Internal	LM	20	37%	14%	3%	0%	6%	3%	11%
LGV	Internal - Internal	H	20		0%	0%	0%	0%	0%	0%
LGV	Internal<->external	L	20	21%	6%	1%	0%	1%	1%	11%
LGV	Internal<->external	HM	20	41%	11%	0%	0%	9%	0%	22%
LGV	Internal<->external	LM	20	38%	15%	3%	0%	6%	3%	12%
LGV	Internal<->external	H	20		0%	0%	0%	0%	0%	0%
LGV	Link by link (all site ave	L	20	19%	6%	1%	0%	1%	1%	10%
LGV	Link by link (all site ave	HM	20	44%	11%	0%	0%	10%	0%	23%
LGV	Link by link (all site ave	LM	20	37%	14%	3%	0%	6%	3%	11%
LGV	Link by link (all site ave	H	20		0%	0%	0%	0%	0%	0%

				Charge	Proportion	Use same vehicle as now & pay the charge every da	Change to a petrol-based vehicle and avoid the charge	Change to a Euro 6 diesel vehicle and avoid the charge	Change to an electric vehicle and avoid the charge	Work/ drive to different town/ ci	Leave trade/ retire
PHV*All-site average	PHV	All-site average	L	£ 5	2%	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
PHV*All-site average	PHV	All-site average	HM	£ 5	21%	11%	0%	0%	11%	0%	0%
PHV*All-site average	PHV	All-site average	LM	£ 5	10%	0%	0%	6%	0%	4%	0%
PHV*All-site average	PHV	All-site average	H	£ 5	68%	11%	13%	6%	26%	8%	4%
PHV*All-site average	PHV	All-site average	L	£ 10	2%	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
PHV*All-site average	PHV	All-site average	HM	£ 10	21%	0%	0%	0%	21%	0%	0%
PHV*All-site average	PHV	All-site average	LM	£ 10	10%	2%	0%	2%	2%	4%	0%
PHV*All-site average	PHV	All-site average	H	£ 10	68%	2%	10%	8%	31%	12%	6%
PHV*All-site average	PHV	All-site average	L	£10+Sub	2%	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
PHV*All-site average	PHV	All-site average	HM	£10+Sub	21%	0%	0%	0%	21%	0%	0%
PHV*All-site average	PHV	All-site average	LM	£10+Sub	10%	0%	0%	2%	4%	4%	0%
PHV*All-site average	PHV	All-site average	H	£10+Sub	68%	0%	9%	9%	28%	13%	9%
PHV*All-site average	PHV	All-site average	L	20	2%	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
PHV*All-site average	PHV	All-site average	HM	20	21%	0%	0%	0%	21%	0%	0%
PHV*All-site average	PHV	All-site average	LM	20	10%	0%	3%	0%	3%	5%	0%
PHV*All-site average	PHV	All-site average	H	20	68%	2%	8%	6%	25%	13%	13%

APPROVAL					
Version	**Name**		**Position**	**Date**	**Modifications**
1	Author	Olivia Hockney David Connolly	Consultant Director	31/10/2018	
	Checked by	David Connolly	Director	31/10/2018	
	Approved by				
2	Author	Olivia Hockney David Connolly	Consultant Director	05/11/2018	
	Checked by	David Connolly	Director	05/11/2018	
	Approved by				
3	Author	Olivia Hockney David Connolly	Consultant Director	08/11/2018	
	Checked by	David Connolly Chris Robinson	Director Associate	09/11/2018	
	Approved by	Tom Finnegan-Smith	Head of Strategic Infrastructure & Transport at SCC	09/11/2018	