Greater Manchester's Outline Business Case to tackle Nitrogen Dioxide Exceedances at the Roadside

Local Plan Transport Model Validation Report (T4 AppendixA)

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Version Status:	DRAFT FOR APPROVAL	**Prepared by:**	Transport for Greater Manchester on behalf of the 10 Local Authorities of Greater Manchester
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1 Introduction

In July 2017 the Government published the UK plan for tackling roadside nitrogen dioxide (NO2) concentrations. This set out how the Government would bring UK concentrations of NO2 within the statutory annual limit of 40 micrograms per cubic metre (µg/m3) in the shortest possible time. The plan sets out a number of national and local measures that need to be taken.

Transport for Greater Manchester (TfGM) is considering options to reduce emissions from transport sources within Greater Manchester, to help meet the target values for NO2 concentrations as soon as possible.

The Demand Sifting Tool has been developed as part of the Greater Manchester (GM) Clean Air Plan (CAP) to test potential measures that could form part of the final GMCAP and to help with the assessment of these measures in terms of performance.

2 Purpose of Demand Sifting Tool

At the time of development TfGM did not have an appropriate off the shelf variable demand model that could be used to model behavioural response. Therefore, a decision was made to develop a Demand Sifting Tool.

The purpose of the Demand Based Sifting Tool is to provide a relatively quick and efficient way of assessing the likely impact of potential measures to improve air quality at key areas in Greater Manchester, making use of modelling tools that TfGM already have access to such as their County Wide SATURN highway and CUBE Public Transport Models.

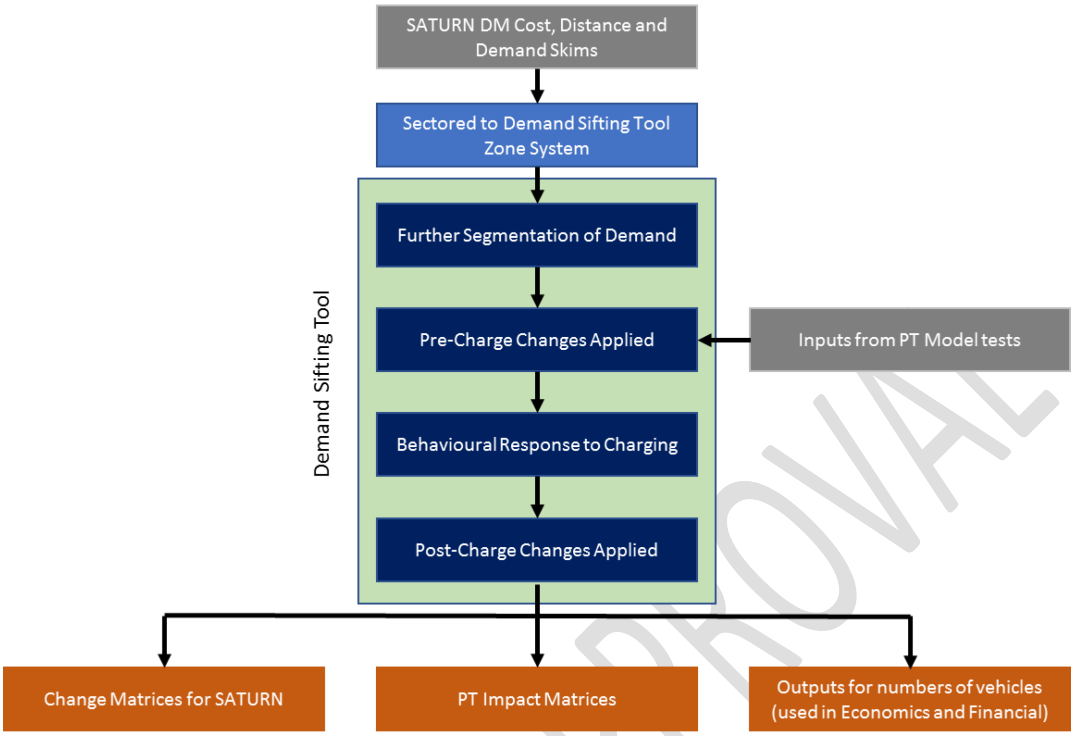
The tool is not an alternative to a fully-fledged variable demand model, as it makes numerous assumptions and can only model a limited number of responses without the ability to represent aspects such as Destination Change that could significantly impact air quality.

Initially the tool was developed using Microsoft Excel, however, as additional responses were incorporated, and a more detailed sector system adopted run times became too time consuming and therefore the tool now uses SQL Server to run a number of calculations in a database, vastly reducing the run time.

3 Overview of Process

The Demand Sifting Tool makes use modelling carried out to inform the Do Minimum scenario in SATURN. The tool then uses inputs from the GM Public Transport Model, accounts for pre-CAZ changes, models behavioural response to charging and accounts for post-CAZ additional responses. The diagram below (Figure 3- 1 shows an overview of the process and what inputs and outputs are produced.

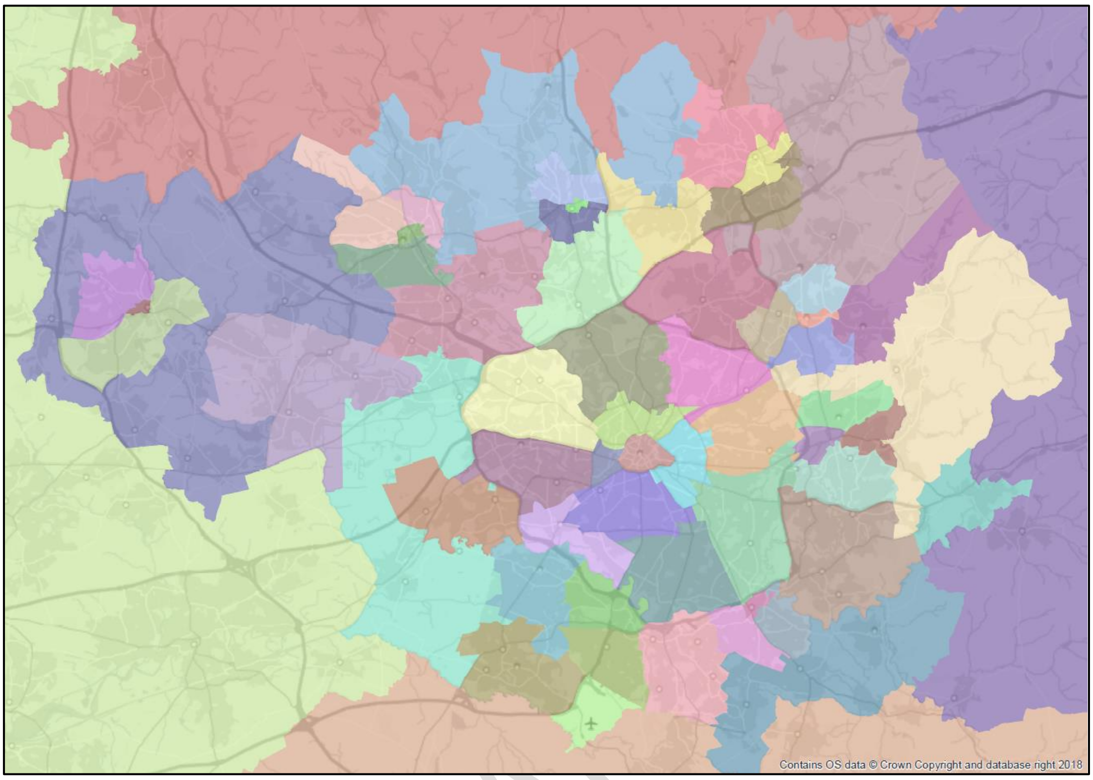
Figure 3- 1: Demand Sifting Tool Overview



4 Sector System

The SATURN model has 1,034 zones, meaning there are 1,069,156 different OD pairs, to speed analysis these zones have been converted to a 62-sector system, the sectors are largely focused on urban and suburban centres as shown in Figure 4- 1: Sector System with a higher level of aggregation in rural and Non-GM areas, a full list of sectors is provided in Appendix X. To add more granularity (given the aggregated nature of the sector system) every zone to zone pair has also been assigned a distance band in line with the National Travel Survey (NTS), as there are 12 bands this means there are potentially 46,128 different sector to sector by distance band movements.

Figure 4- 1: Sector System



5 Segmentation of Demand

Within the demand sifting tool the 8 user classes from the SATURN model have been further segmented by petrol and diesel and the car user class has been segmented to allow for 4 parking types (paid on-street, paid car park, park and ride or unpaid/resident parking). The 32 segments of demand are shown in Table 5- 1. Given the approach adopted to behavioural change for cars (explained later in this note) it is important that the base parking cost of a trip is considered.

Table 5- 1:Demand Sifting Tool Segmentation

Vehicle Class	Compliance	Fuel	Parking
Car	Compliant	Petrol	On Street – Paid
			Car Park – Paid
			Park and Ride
			Free/Residential
		Diesel	On Street – Paid
			Car Park – Paid
			Park and Ride
			Free/Residential

Vehicle Class		Compliance	Fuel	Parking
		Non-Compliant	Petrol	On Street – Paid
				Car Park – Paid
				Park and Ride
				Free/Residential
			Diesel	On Street – Paid
				Car Park – Paid
				Park and Ride
				Free/Residential
LGV		Compliant	Petrol	N/A
			Diesel	N/A
		Non-Compliant	Petrol	N/A
			Diesel	N/A
HGV		Compliant	Petrol	N/A
			Diesel	N/A
		Non-Compliant	Petrol	N/A
			Diesel	N/A
Taxi	PHV	Compliant	Petrol	N/A
			Diesel	N/A
		Non-Compliant	Petrol	N/A
			Diesel	N/A
	Hackney	Compliant	Petrol	N/A
			Diesel	N/A
		Non-Compliant	Petrol	N/A
			Diesel	N/A

6 Pre-CAZ Changes

6.1 Inputs from PT Model

The Demand Sifting Tool has been developed to allow it to account for potential changes to the PT network that could impact highway demand. As mentioned this is not a full variable demand model that includes the ability to loop between highway, PT and slow modes but TfGM have done previous work that has enabled them to develop elasticities that estimate the number of car trips removed from the highway network as a result of a reduction in travel cost on the PT network.

The PT demand zone system is nested within the 1,034 highway zones which have already been sectored to 62 zones used in the Demand Sifting Tool, as such it is possible to convert information from the PT model to the Demand Sifting Tool's sector system.

Should a public transport improvement result in a reduction in highway demand the reduction of trips is applied to all car demand segments, however, it is assumed to only account for trips with distances of less than 50 miles.

6.2 Other changes

Other measures proposed as part of the GM CAP could also result in changes to the fleet regardless of any charging clean air zone (CAZ), for example Local Authority (LA) owned vehicles would be expected to upgrade as LAs will be required to take a lead in cleaning up their fleet.

As such the Demand Sifting Tool provides the functionality to apply a percentage switch to compliant vehicles, public transport or active modes for specific sector to sector movements by demand segment.

7 Behavioural Response to Charging

7.1 Background

One of the measures being considered as part of the GM CAP is the introduction of charging CAZs, in these vehicles that are considered non-compliant are subject to a daily charge to drive within a designated area. A CAZ is intended to force behavioural change as a driver has several different options:

- Pay the charge
- Upgrade their vehicle (so they don't pay the charge)
- Cancelling their trip
- Changing Mode
- Changing where they drive to/from
- Changing the route they use to avoid charged areas

The National Plan presents data adjusted from the modelling of Ultra-Low Emmission Zone (ULEZ) in London to provide an indication of what sort of responses are expected following the introduction of a charging CAZ. These responses were also provided in JAQU's Evidence Package document with a recommendation that responses should be locally adjusted where possible.

In developing the GM CAP to Outline Business Case it was identified that sufficient local information was not available to develop bespoke response curves for GM and there was no scope to include Stated Preference (SP) suveys that could help inform them. Therefore, initial versions of the Demand Sifting Tool made use of the figures from guidance.

In addition, it was identified that inclusion of Destination Choice could not be included at this stage as it added a level of complexity to the tool that would impede performance and require broader assumptions. Changing Route was also not included as this was assumed to be covered by the SATURN assignment, where link charges ensured that traffic routed away from travelling through CAZs unless they had an origin or destination within them.

7.2 Use of Bristol Data

Following work completed elsewhere JAQU requested that available SP data from London or Bristol be used to provide a better estimate of behavioural response to charging.

An exercise was carried out to assess which data was most appropriate to base responses in GM upon and it was identified that Bristol was far more similar to GM than London in terms of income, employment, car availability and method of travel to work, as such a decision was made to use the data from Bristol to estimate behavioural responses for GM.

Working with the team in Bristol it was possible to provide sufficient data to produce behavioural response relationships to the cost of charge weight to the characteristics of GM using:

- Income data
- Frequency data
- Fleet information
- Journey Purpose Data

This weighted response data has been used to estimate the impact of a charging CAZ as shown in the following sections. Further detail on the methodology used to weight the Stated Preference data is provided in Appendix A.

7.3 Vehicle Upgrade Price

The results of weighted stated preference work from Bristol are heavily dependent on what the average upgrade price is (accounting for scrappage and incentive schemes), i.e. how much must a non-compliant vehicle owner spend to buy a compliant vehicle and how much of this is offset by what they can get for selling their vehicle.

In order to derive an average upgrade price of a car, the current asking prices for 10 examples of the UK's top 10 best selling cars were identified, based on fuel type. The prices were then projected forward to the assessment years – for example the value of a 1 year old car in 2021 is assumed to be the same as a 1 year old car in 2018. The ANPR data was then used to estimate the average buy and sell price for compliant and non-compliant vehicles.

For LGV's, a similar approach was adopted but with the vehicles broken down further to small, medium and large sized vans.

7.4 Cars

The weighted stated preference data gives the following expected responses when using our estimated car upgrade cost.

Tabele 7- 1: Car response to CAZ Charge from weighted SP Data

Charge level	Pay Charge	Change Mode	Cancel Trip	Upgrade Vehicle
£3.00	28.3%	9.9%	10.3%	51.4%
£3.50	25.0%	10.6%	11.2%	53.3%
£4.00	21.8%	11.1%	11.9%	55.1%
£4.50	18.9%	11.6%	12.7%	56.8%
£5.00	16.2%	12.1%	13.3%	58.5%
£5.50	13.7%	12.4%	13.8%	60.1%
£6.00	11.6%	12.6%	14.3%	61.5%
£6.50	9.7%	12.8%	14.6%	62.9%
£7.00	8.1%	12.8%	14.9%	64.2%
£7.50	6.7%	12.8%	15.1%	65.4%
£8.00	5.5%	12.8%	15.2%	66.5%

Charge level	Pay Charge	Change Mode	Cancel Trip	Upgrade Vehicle
£8.50	4.5%	12.7%	15.2%	67.6%
£9.00	3.7%	12.5%	15.2%	68.6%
£9.50	3.0%	12.3%	15.2%	69.5%
£10.00	2.4%	12.1%	15.1%	70.4%
£10.50	2.0%	11.8%	14.9%	71.3%
£11.00	1.6%	11.5%	14.8%	72.1%
£11.50	1.3%	11.2%	14.6%	72.9%
£12.00	1.0%	10.9%	14.4%	73.6%
£12.50	0.8%	10.6%	14.2%	74.4%

The behavioural change attributed to a charging CAZ on cars has been estimated using an “Own-Cost Elasticity” relationship to get a response for “paying the charge” where a greater proportional increase in cost due to the charge leads to a stronger response in line with the formula below:

$$T_{ij} = g_{ij} * \ {}_0T_{ij} * \left(\frac{G_{ij}}{{}_0G_{ij}}\right)^A$$

Where:

T_{ij} is the forecast number of trips between i and j

G_{ij} is the forecast disutility or generalised cost

g_{ij} is the forecast growth rate relative to an earlier base year

${}_0T_{ij}$ is the number of trips in the earlier or base year

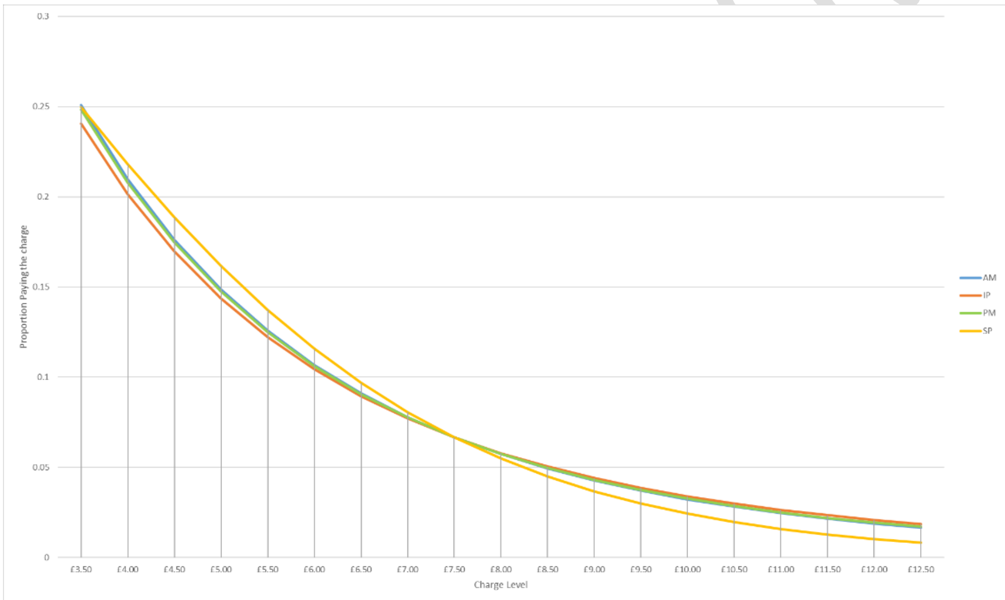
${}_0G_{ij}$ is the disutility or generalised cost in the earlier or base year

A is the elasticity, which should be negative

An own cost elasticity has been applied as it gives some level of base cost sensitivity, where shorter cheaper trips are the most likely to be affected. WebTAG recommends that own-cost elasticity models are not used instead of full variable demand models as they cannot recreate the changes in travel patterns or trip length that could be produced. However, given the lack of an available variable demand model capable of testing the affect of a charging CAZ it has been decided that it is appropriate for Option testing.

The elasticity has been estimated using the weighted stated preference data to attempt to match the response to charging expected from the stated preference work to the response curve for the average trip cost in the model (including parking costs) as shown in the graph below calibrated where the proportion of cars paying the charge at our modelled charge level (£7.50) matches the SP curve exactly as shown in Figure 7- 1

Figure 7- 1: Car Elasticities



This gives 3 separate elasticity values for each time-period that are very different to those proposed in WebTAG for car elasticities, however, using WebTAG elasticities gives very different responses to the weighted SP work and so the calculated values have been used.

Other responses for “Upgrade vehicle”, “change mode” and “cancel trip” have been then been proportioned in line with the proportions in the weighted SP results.

It should be noted that rather than applying a “cost-damping” approach a manual cut off has been applied where trips of longer than 50 miles are assumed to be infrequent and therefore are not subject to any behavioural response.

For the change mode response it has been assumed that trips of less than 5 miles in length have the option to change to Public Transport or to Active Modes (walking and cycling), with the proportion switching to each being estimated using 2011 Census Journey to Work data for Greater Manchester. For trips of longer than 5 miles it is assumed that there is no active mode switch given the distance.

7.5 LGVs

LGVs are difficult to assess given the variety reasons one could be used, for example a charge would affect a self-employed plumber differently to a delivery driver for a multi-national logistics company or someone who uses a van for personal trips. As such it has been decided that an elasticity response is not appropriate and responses to charging for LGVs are directly taken from the weighted SP responses when further weighted towards employer's business. The responses to charging are shown in Tabele 7- 2.

Tabele 7- 2: LGV Response to Charging

Charge level	Pay Charge	Change Mode	Cancel Trip	Upgrade Vehicle
£3.00	24.5%	4.4%	5.1%	66.0%
£3.50	22.5%	4.8%	5.5%	67.2%
£4.00	20.6%	5.1%	5.8%	68.5%
£4.50	18.8%	5.5%	6.1%	69.6%
£5.00	17.0%	5.9%	6.4%	70.7%
£5.50	15.3%	6.2%	6.6%	71.8%
£6.00	13.7%	6.6%	6.9%	72.8%
£6.50	12.3%	6.9%	7.1%	73.7%
£7.00	10.9%	7.2%	7.3%	74.6%
£7.50	9.6%	7.5%	7.5%	75.4%
£8.00	8.5%	7.8%	7.6%	76.1%
£8.50	7.4%	8.1%	7.7%	76.8%
£9.00	6.5%	8.3%	7.8%	77.5%
£9.50	5.6%	8.5%	7.8%	78.1%
£10.00	4.9%	8.6%	7.8%	78.7%
£10.50	4.2%	8.8%	7.8%	79.2%
£11.00	3.6%	8.9%	7.7%	79.8%

Charge level	Pay Charge	Change Mode	Cancel Trip	Upgrade Vehicle
£11.50	3.1%	9.0%	7.6%	80.3%
£12.00	2.6%	9.0%	7.5%	80.8%
£12.50	2.2%	9.0%	7.4%	81.3%

As with cars, LGV trips of less than 50 miles have been deemed in scope to be subject to behavioural change, trips of longer than this distance are assumed to be unaffected and to just pay the charge.

7.6 HGVs

HGV is arguably the market that we have the least information about how they will react to the charge and as such a theoretical relationship has been developed as to how they might respond to a charging CAZ.

WebTAG does not provide any typical values for cost elasticities for freight travel so it is not possible to use an "Own Cost Elasticity" approach as used for cars. For the testing of schemes considered as part of the GM CAP an inverse S-Curve has been developed based on the proportion of people willing to pay the charge, however, to do so two data points need to be identified.

JAQU's guidance on expected responses to a charging CAZ (as described in the "Evidence Package") appear to be based on charges from the London LEZ as presented in the National Plan. In London non-compliant HGVs are set to be charged £100, therefore at £100 the curve developed will achieve the same "pay charge" proportion as presented in guidance[1].

The Victoria Transport Policy Institute (Litman, 2018) presents a summary of research around freight response to increased cost (Bjorner, 1999) where a 10% increase in freight costs leads to a 8% reduction in freight volume. The average daily cost of an HGV trip has been estimated at £185.74 based on SATURN skims for average trip duration, assumptions around the working day and loading/unloading time and WebTAG values of time as outlined below:

- The average HGV trip duration is 0.7 hours in the AM, 0.6 hours in the IP and 0.7 hours in the PM
- If we assume that an HGV trip requires 1 hour of loading/unloading/rest time per trip and the average working day for HGVs is 9 hours (EU daily driving limit) an that the 9 hours is split 1.5 hours in the AM peak, 6 hours in the Inter-peak and 1.5 hours in the PM peak then HGVs can make 0.9 trips in the AM, 3.7 trips in the IP and 0.9 trips in the PM.

[1] It should be noted that it has been assumed that HGVs cannot change mode so this response has been removed

- If we multiply this by WebTAG Values of Time for HGVs we get a total running cost £185.74

Therefore, we assume that an increase in cost of £18.57 leads to 92% of HGVs paying the charge in our response cure.

The equation of the curve is:

$$y = \frac{1}{(1 + e^{(bx-a)})}$$

Where:

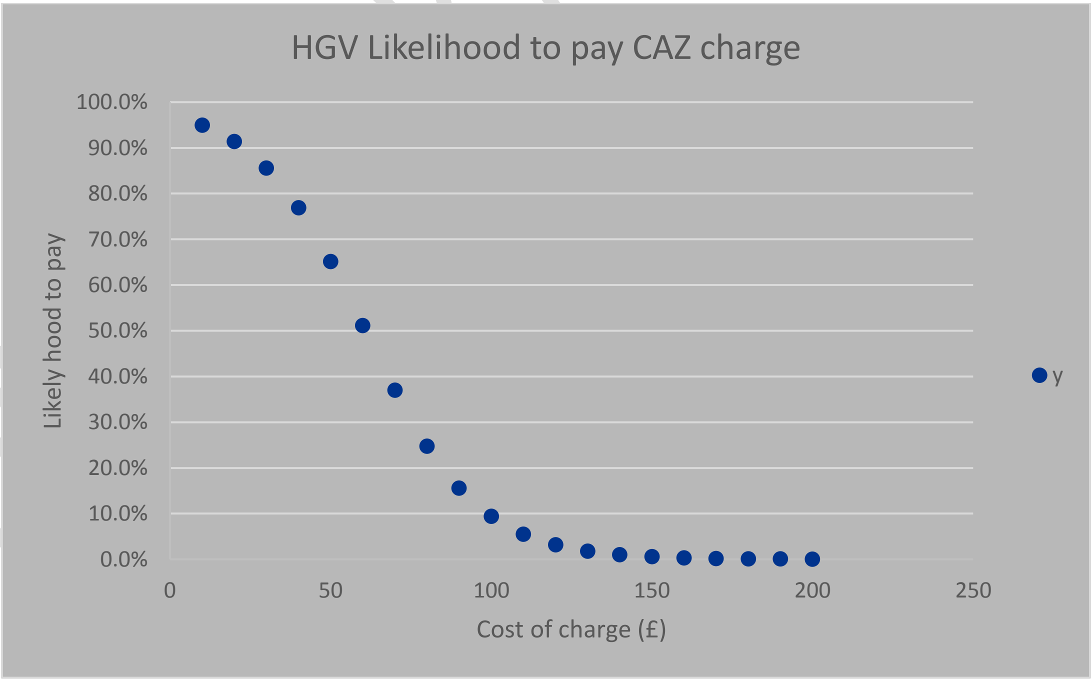
x is the Charge price

y is the proportion of LGVs/HGVs paying the charge

a and b are variables to shape the curve

Figure 7- 2 below shows the curve developed for HGVs. This curve is entirely theoretical, but it is believed that the lower update at a low cost then the sudden increase at a level where it becomes more cost effective to upgrade your vehicle before flattening out as the proportion paying the charge trends to zero is logical.

Figure 7- 2: HGV Response to Charge



We have used figures from national guidance and apart from journey time skims from the GM SATURN model this is not locally adjusted to the characteristics of GM for a number of reasons:

- Given the number of CAZs likely to be introduced in the next 5 years it is likely that schemes will overlap achieving a more national level of compliance.
- The option being progressed as part of the GM CAP is on a much bigger scale than other CAZs being developed. This will be a county wide charge Greater Manchester, as the biggest economic centre in the North of England this is likely to impact traffic across the region rather than just locally.

7.7 Taxis

Within the SATURN model taxis are modelled as a single vehicle class, in reality there are many different types of taxi and for the purposes of assessment on GM CAP they have been split into:

- Hackney Cabs
- Private Hire Vehicles (PHVs)

Each vehicle type is expected to respond differently to charge and Local Authorities have more influence over Hackney Cabs (who are registered in GM) than PHVs who may be licensed outside of GM but operate within it.

PHVs have been assumed to react in a similar way to LGVs, however, as the upgrade price is significantly higher due to the mileage on used PHVs essentially giving them no re-sale market the responses are different. Originally the “cancel trip” and “change mode” responses were included but this led to very high numbers of trips being removed from the network which was not considered to be likely, in later tests it was assumed that if a PHV trip was assigned a response of “change mode” or “cancel trip” then in reality another PHV would take the fare and so these responses were removed as shown below.

Tabele 7- 3

	Initial Tests				Later Tests			
Charge level	**Pay Charge**	**Change Mode**	**Cancel Trip**	**Upgrade Vehicle**	**Pay Charge**	**Change Mode**	**Cancel Trip**	**Upgrade Vehicle**
£3.00	49.8%	9.0%	10.5%	30.7%	53.7%	0.0%	0.0%	46.3%
£3.50	46.9%	9.9%	11.4%	31.8%	51.3%	0.0%	0.0%	48.8%
£4.00	43.9%	10.9%	12.3%	32.9%	48.7%	0.0%	0.0%	51.3%
£4.50	40.9%	12.0%	13.3%	33.9%	46.1%	0.0%	0.0%	53.9%
£5.00	37.9%	13.1%	14.2%	34.8%	43.5%	0.0%	0.0%	56.5%
£5.50	35.0%	14.2%	15.2%	35.6%	40.8%	0.0%	0.0%	59.2%
£6.00	32.1%	15.4%	16.1%	36.4%	38.1%	0.0%	0.0%	61.9%

	Initial Tests				Later Tests			
Charge level	**Pay Charge**	**Change Mode**	**Cancel Trip**	**Upgrade Vehicle**	**Pay Charge**	**Change Mode**	**Cancel Trip**	**Upgrade Vehicle**
£6.50	29.4%	16.6%	17.0%	37.1%	35.4%	0.0%	0.0%	64.6%
£7.00	26.7%	17.7%	17.9%	37.6%	32.8%	0.0%	0.0%	67.2%
£7.50	24.2%	18.9%	18.7%	38.2%	30.2%	0.0%	0.0%	69.8%
£8.00	21.8%	20.1%	19.5%	38.6%	27.6%	0.0%	0.0%	72.4%
£8.50	19.6%	21.2%	20.2%	39.0%	25.2%	0.0%	0.0%	74.8%
£9.00	17.5%	22.3%	20.9%	39.3%	22.8%	0.0%	0.0%	77.2%
£9.50	15.6%	23.4%	21.5%	39.5%	20.5%	0.0%	0.0%	79.5%
£10.00	13.8%	24.5%	22.0%	39.7%	18.4%	0.0%	0.0%	81.6%
£10.50	12.2%	25.4%	22.5%	39.9%	16.4%	0.0%	0.0%	83.6%
£11.00	10.7%	26.4%	22.9%	40.0%	14.5%	0.0%	0.0%	85.5%
£11.50	9.4%	27.2%	23.2%	40.1%	12.8%	0.0%	0.0%	87.2%
£12.00	8.2%	28.0%	23.5%	40.3%	11.2%	0.0%	0.0%	88.8%
£12.50	7.2%	28.8%	23.6%	40.4%	9.8%	0.0%	0.0%	90.2%

As with other user classes trips of over 50 miles are assumed to continue paying the charge and not have a behavioural response.

Hackneys have been considered separately through the option assessment process and it has been decided that the response will simply be a percentage upgrade response for non-compliant cabs that has been made outside of the tool regardless of the level of charge.

8 Charging Assumptions

Charge levels modelled within the core assessments are as follows:

- Non-Compliant Cars - £7.50/day
- Non-Compliant LGVs - £7.50/day
- Non-Compliant HGVs - £100/day
- Non-Compliant taxis - £7.50/day

These charge levels have been selected based on research around social and economic characteristics of Greater Manchester as outlined in (Wendy's Note)

9 Post CAZ Changes

The Demand Sifting tool also offers the ability to model any changes expected on top of a CAZ behavioural response, e.g. as a result of additional measures such as early incentive schemes for phased introductions of the schemes or the implementation of improved travel planning along certain corridors.

This is carried out similarly to the impact of other changes prior to the estimation of response to a CAZ charge and is achieved through assigning a percentage to switch to active modes, public transport or to upgrade based on information provided outside of the Demand Sifting Tool.

10 Outputting of Results

As the ultimate performance of an option is decided through its ability to reduce NO2 levels the results of the demand sifting tool need to be output in a format that is compatible with the GM SATURN model for assignment.

The Demand Sifting Tool has been developed to produce change factors for each sector to sector movement by distance band and modelled user class in each time period. These factors are then applied to all zone to zone movements in the SATURN matrix with the same sector to sector O-D, distance band and user class to give updated matrices. Given the size of the GM SATURN model zoning system this has been carried out in an external database and then matrices are re-created using the MX function in SATURN.

The Demand Sifting Tool has also been developed to provide similar change matrices for the GM Public Transport model to assess the impact of the "change mode" response on public transport in GM. However, as the Do Minimum Public Transport model matrices are not included in the tool this is output with increased numbers of trips rather than factors.

Outputs from the Demand Sifting Tool have also been used to inform the financial case where trips in the AM, IP and PM have been converted into numbers of vehicles per day ito estimate the number of vehicles likely to pay the charge and therefore the revenue generated in the following process:

- AM, IP and PM flows are converted to AADT using expansion factors by user class
- AADT in trips is converted to unique vehicles through using an average trips per day factor calculated from observed ANPR data (further methodology presented in Appendix B)
- Through analysis of the number of compliant and non-compliant in the Do Minimum and Do Something scenarios we can estimate the number of vehicles upgrading and paying the charge to inform the financial impact of the scheme. It should be noted that it is not appropriate to look at the number of "vehicles" impacted by change mode and cancel trip as it is possible that these vehicles will still be in use for other trips outside of any charging zone.

Appendix A – Weighting of Bristol Stated Preference Survey Data

Appendix B – Observed Average Trip Rate Calculations

Estimation of average daily trip frequency using ANPR cordon sample

Trip frequency, i.e. the amount of times a vehicle travels into central Manchester per day was estimated using a sample of ANPR data for the week beginning 12/05/2016 and ending 18/05/2016, which was provided by GMP. (Info about the dataset – confidential?)

Given that the ANPR cordon is not covering all trips entering and exiting the city centre, only number plates for which both an inbound and outbound movement has been captured (i.e. the vehicle has entered and left the area at least once) have been considered.

The ANPR data sample has been imported into an SQL database and the number of movements per number plate has been calculated. An average number of trips per day has then been derived for all seven user classes (Car, private taxi, Hackney, van, bus, HGV and motorcycle).

Trips per day are understood to be the sum of movements registered for the same number plate on the same day on any count site that contain at least one outbound

The following database queries were used to determine the trips per day:

1. **Select all inbound movements and group by vehicle type, date and number plate**
   ```
   SELECT FinalTripTable.Field1, FinalTripTable.Field7,
   FinalTripTable.Field8
   FROM FinalTripTable
   WHERE (((FinalTripTable.Field4) Like "*IB*"))
   GROUP BY FinalTripTable.Field1, FinalTripTable.Field7,
   FinalTripTable.Field8;
   ```
2. **Select all outbound movements and group by vehicle type, date and number plate**
   ```
   SELECT FinalTripTable.Field1, FinalTripTable.Field7,
   FinalTripTable.Field8
   FROM FinalTripTable
   WHERE (((FinalTripTable.Field4) Like "*OB*"))
   GROUP BY FinalTripTable.Field1, FinalTripTable.Field7,
   FinalTripTable.Field8;
   ```

3. **Join inbound and outbound movements obtained from 1) and 2) for the same vehicle type, date and number plate to obtain daily trips with in- AND outbound movement**

   ```
   SELECT [Tab-query1-IB].Field1, [Tab-query1-IB].Field7, [Tab-query1-IB].Field8
   FROM [Tab-query1-IB] INNER JOIN [Tab-query1-OB] ON ([Tab-query1-IB].Field8 = [Tab-query1-OB].Field8) AND ([Tab-query1-IB].Field7 = [Tab-query1-OB].Field7)
   GROUP BY [Tab-query1-IB].Field1, [Tab-query1-IB].Field7, [Tab-query1-IB].Field8;
   ```

4. **Count trips per day per number plate by vehicle type and day where in- and outbound movements exist**

   ```
   SELECT [Tab-Common-Plates].Field1, [Tab-Common-Plates].Field7, Count([Tab-Common-Plates].Field8) AS CountOfField8
   FROM [Tab-Common-Plates]
   GROUP BY [Tab-Common-Plates].Field1, [Tab-Common-Plates].Field7;
   ```

Finally, the total number of trips per day is then divided by the total number of unique plates per day for the entire time period to obtain the total number of trips per day by vehicle class.

The trip frequencies (number of trips per vehicle per day) obtained from the ANPR sample are presented for each user class in Tabele 1- 1:

Tabele 1- 1 Daily trip frequency by vehicle type obtained from the ANPR sample

User Class	Total	Car	Private Hire Taxi	Hackney Cab	Van	Bus	HGV	Motorcycle
Trips per day	2.82	2.63	6.14	9.65	2.79	7.75	2.95	n/a

The calculated trip frequencies differ by vehicle type as would be expected, e.g. cars would have a bit more than one return trip, vans and HGV a somewhat higher trip rate of close to three trips, whereas private taxis and hackneys as well as buses show a much higher trip frequency. The number of captured plates for motorcycles was too small to calculate a meaningful trip rate.