Economic Appraisal Methodology Report (E1)

Report for Derby City Council

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Derby Roadside NO_2 Air Quality Feasibility Study

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1 Introduction

This paper sets out the Cost Benefit Analysis (CBA) carried out for Derby's Feasibility Study to assess options in response to non-compliance with the nitrogen dioxide (NO_2) limit values. The scope of options considered covers:

- *Do minimum:* Includes funded measures (the Clean Bus Technology Fund, CBTF) and the A38 improvement scheme introduced in 2025
- *Stafford Street traffic management and wider network management scheme (Traffic management):* this is a targeted set of traffic management measures designed to specifically tackle the exceedance problem identified on Stafford Street.
- *A benchmark Class D Clean Air Zone (CAZ)*: this scheme would apply to all vehicles entering the area within the city's outer ring road.

JAQU have provided detailed guidance regarding the economic appraisal of CAZ options. This provides a steer for many of the key data inputs and assumptions that have framed how the analysis is undertaken. The key guidance documents include:

- Options Appraisal – Guidance (2017)[1] (and preceding versions of this guidance)
- National data inputs for Local Economic Models (2017)[2].

We have based our analysis on this guidance as well as using TUBA to perform analysis of the transport impacts in accordance with Department for Transport's A.1 range of transport appraisal guidance.

The analysis is underpinned by the following general assumptions:

- Each impact is assessed relative to a 'do minimum' counterfactual
- All impacts are presented in real terms with a Price Year of 2018
- All impacts are discounted to 2018 applying Green Book discount factor of 3.5%.

[1] Unpublished – provided directly by JAQU to cities
[2] Unpublished – provided directly by JAQU to cities

2 Definition of modelling option scenarios

2.1 Setting out the options

The analysis is defined by the options that are defined for the Final Business Case (FBC). These options been developed and refined by Derby City Council, using a range of evidence from the transport model, emission runs by ENEVAL (an element of the Transport model) and the baseline air quality assessment. The details of options assessed are set out in Table 1.

Table 1 – Shortlist for assessment

Scenario	Details
Do Minimum	• Includes funded measures (the CBTF) and the A38 improvement scheme introduced in 2025
Traffic Management	• Do min plus: • Targeted set of traffic management measures designed to specifically tackle the exceedance problem identified on Stafford Street
Class D Charging CAZ Scheme	• Do min plus: • Introduced by 2020 • Charging scheme operating within the Outer Ring Road (ORR) of Derby • Compliance with the Charging Scheme is defined in line with JAQU's standard assessment as defined in the national plan: i.e. non-compliant vehicles are petrol Euro 3/III or older and diesel Euro 5/V or older • Applies to Buses, Taxis, Private Hire vehicles, HGVs, Coaches, LGVs and cars.

2.2 Models developed

We have designed our approach to be consistent with HMT's Green Book guidance for appraisal. We draw on guidance provided by the Joint Air Quality Unit (JAQU) to inform the assessment as well as applying TUBA to perform analysis in accordance with Department for Transport's A.1 range of transport appraisal guidance.

The approach to assessing the impacts associated with upgrading vehicles (and associated OPEX, fuel and CO_2 impacts) and air quality impacts has been tested in multiple cities carrying out similar feasibility studies. Congestion, implementation costs, welfare, OPEX, fuel CO_2 impacts associated with additional distances, will be calculated using TUBA. TUBA is deployed because as part of this appraisal we are considering a Traffic Management scheme and are therefore adopting the tools which are standard in this type of analysis. TUBA is used for the impacts identified across all scenarios to ensure coherency of the analysis. The results of TUBA modelling and Ricardo's economic model will be combined in calculating overall NPV.

Table 2 – Economic models used

Option	Modelling Effort
Traffic Management	Use of TUBA which provides an estimate of the economic benefits associated with implementation, congestion impacts, vehicle operating costs (opex, fuel) greenhouse gas emissions. Ricardo's economic model is used to calculate damage costs associated with aggregate reductions in pollutants.
Class D CAZ (Charging Scheme)	Use of Ricardo's Clean Air Zone economics model to calculate upgrade costs (and associated OPEX, fuel and CO_2 impacts) and damage costs associated with aggregate reductions in pollutants associated with a Charging Scheme in Derby. Use of TUBA which provides an estimate of the economic benefits associated with congestion impacts, vehicle operating costs (opex, fuel) and greenhouse gas emissions associated with changes in distance travelled, and user costs (which includes welfare considerations).

The following sections define the response (or take-up) of individuals and businesses to the two options considered in the economic modelling. These critical assumptions determine the number of vehicles affected by each option considered and the associated impacts. Specific modelling assumptions and data inputs are provided in the Appendix of this document.

2.3 Traffic Management Response

The main predicted flow impacts of the preferred scheme are as follows:

- Significant reduction in the use of Stafford Street, realising the main objective of the scheme.
- Significant reductions in traffic on the western and northern parts of the Inner Ring Road between Uttoxeter New Road and the A52 at Eastgate with some of this traffic transferring to the southern and eastern sections of the Inner Ring Road where increases in traffic levels are predicted.
- Large reduction in traffic on Uttoxeter New Road and Ashbourne Road with significant proportions of this traffic transferring to other radial routes such as Kedleston Road and Duffield Road to access the city centre, causing a resultant relatively small increase on sections of the A38.
- Significant increase in traffic on Uttoxeter Old Road which is being enhanced to be an alternative route to Stafford Street as part of the scheme.
- Minor changes to 'rat running' traffic routes through the New Zealand part of the city as a result of the changes in traffic flows, primarily the increases on Uttoxeter Old Road
- Wider increases in traffic on the A50 and A6 in the peak hours only as traffic diverts from travelling through the city centre to the Strategic Road Network that provides an outer southern and eastern bypass of the city. This is generally longer distance movements between the south east of the city and the west where the Strategic Road Network is the most appropriate route rather than the roads within the vicinity of the city centre.
- Peak hour increases in the use of the Outer Ring Road and also Infinity Way as radial routes into the city centre change as a result of the scheme. As the development levels around Infinity Park Way increase the usage of this route for through traffic decreases and therefore the increases along this route are seen as a short-term issue.

Overall the Preferred Scheme is achieving its objective of significantly reducing traffic flow along Stafford Street which is the only predicted air quality exceedance location. It also moderately reduces overall traffic flows in the city centre as a whole because the cumulative increases in traffic flow are outweighed by the cumulative decreases in flows resulting from the scheme.

The main impact areas are Uttoxeter Old Road, Kedleston Road and the southern and western sections of the Inner Ring Road which are considered further in the air quality modelling reporting.

2.3.1 Primary impacts associated with the Traffic Management Scheme

Primary impacts are directly associated with the movement of trips from Stafford Street to two primary routes, although there is also some minor rerouting on other routes in the city centre. The two primary impacts are related to:

- A transfer of trips to Uttoxeter Old Road and Friar Gate as the most immediate parallel alternative to Stafford Street
- A transfer of through traffic to routes outside of the city centre, in particular to the A50/A6 and the A5111 Outer Ring Road.

The level and type of impact and the dis-benefit for drivers is different on each of these alternative routes. An overview of the implications is given below, for each:

- Uttoxeter Old Road / Friar Gate

  This alternative route poses a relatively short increase in distance for trips from Stafford Street; however the current nature of this route would result in a significant increase in journey time. Therefore without improvements to this route there would be significant dis-benefit to vehicles using this route compared to Stafford Street and the measures along Stafford Street would have to provide considerably higher demand constraint than under the present scheme to make enough vehicles relocate.

  However, the proposed scheme also includes capacity improvements at the Ashbourne Road/Uttoxeter Old Road junction which is currently the main congestion issue along Uttoxeter Old Road. This provides a significant level of mitigation in terms of delays and overall journey times for the traffic diverting from Stafford Street which encourages greater transfer to this route but also reduces the dis-benefits to these vehicles that transfer.

  The overall economic impact for the vehicles that transfer to Uttoxeter Old Road is a slight dis-benefit in terms of route distance and also journey time compared to using Stafford Street under its current operation. However, this dis-benefit has been minimised by the mitigation at the Ashbourne Road/Uttoxeter Old Road junction.

  In addition, vehicles that already utilise the Ashbourne Road/Uttoxeter Old Road junction receive a benefit from the capacity improvements at this location though reduced delays and journey times, which has a compensatory impact to the vehicles transferred from Stafford Street.

- Transfer outside the city centre

  Through traffic movements that do not have an origin or destination in the city centre have the opportunity to use routes that do not require the use of the Derby Inner Ring Road, including Stafford Street. The proposed changes to Stafford Street are predicted to result in some of these through traffic movements not entering the city centre at all and utilising the generally faster but longer routes outside of the city centre.

  Compared to their current routing via Stafford Street these diversions will result in dis-benefits to these drivers both in terms of route distance and also to a lesser extent journey times (although they are longer they are also generally higher speed routes). However, the implementation of better signal time optimisation along these routes (especially the ring road) through the upgrade to the UTC system will provide some mitigation in terms of the increased travel times and associated dis-benefits along these wider routes.

In conclusion, the trips that divert from Stafford Street to alternative routes will incur an economic dis-benefit. However this has been minimised by the measures introduced as part of the scheme to manage these impacts, primarily the improvements to the Ashbourne Road/Uttoxeter Old Road junction and the implementation of the UTMC upgrade.

2.3.2 Secondary Impacts associated with the Traffic Management scheme

The removal of traffic from the city centre to outlying main road routes provides additional capacity on the city centre routes for traffic that still uses these routes. This traffic also includes the transfers from Stafford Street that remain in the city centre for the remainder of their journey.

This reduction in traffic flows, primarily on the norther section of the Inner Ring Road leads to general benefits to vehicles in a number of ways:

- Journey times and delays reduce for traffic that currently utilises the routes where traffic flows are reduced;
- Some traffic that is currently diverting to less efficient routes or 'rat running' to avoid the current congestion levels diverts back to primary routes reducing journey time and distances.

The overall reduction in traffic flows in the city centre therefore has a general beneficial economic impact on movements in the city centre and these impacts affect a larger number of vehicles than are being displaced from Stafford Street and have a dis-benefit of the scheme.

In conclusion, considering both primary and secondary impacts associated with the Traffic Management scheme, overall there is generally a dis-benefit in terms of the direct transfer to alternative routes to Stafford Street as a result of the scheme compared to the current approach. However, the removal of through traffic movements from the city centre has a beneficial impact on a wide range of journeys that utilise routes within the city centre area, including the continuing journeys for movements diverted from Stafford Street, in terms of journey times. This secondary wider impact outweighs the dis-benefits associated with the primary transfers from Stafford Street thus providing overall scheme benefits that have been identified, resulting in a moderate positive value for the travel time element of the NPV calculation.

2.4 Charging Scheme responses

The charge levels assumed for the analysis are those consistent with the proposed London ULEZ charges – i.e. £12.50 per day for cars, LGVs, taxis and PH vehicles, and £100 per day for buses, coaches and HGVs. These charge levels are assumed as a placeholder.

An estimate of how vehicle owners respond to this set of charges is required in order to define the different impacts experienced. The economic (along with the transport and air quality) modelling adopts the 'upgrade' behavioural response from the JAQU guidance. These values are based on the responses assumed for the London ULEZ by TfL. No specific evidence for a charge-response relationship is available for Derby. Likewise, no robust evidence exists to suggest that the charge-response relationship in Derby will be different. Hence in lieu of a better assumption, the JAQU assumptions are adopted (these were developed by JAQU to be nationally applicable). These behavioural assumptions are subject to sensitivity testing in section 6.2.

Table 3 defines how many non-compliant vehicles upgrade in response to the introduction of a charging scheme. This percentage is applied to the non-compliant vehicles fleet baseline (as defined in Section 4 of this document). Table 4 defines the specific upgrade response of those vehicles that upgrade, which in turn defines the upgrade costs faced.

Table 3 - % of non-compliant vehicles assumed to upgrade in response to the Charging Scheme

Response	CAR	LGV	HGV	Bus	Coach	Taxis/PH
Upgrade	22%	25%	44%	62%	41%	22%

Table 4 – Second Order Behavioural Responses

	Assumption	Of what
Scrap	25%	upgrade
Buy new	25%	upgrade
Switch fuel	75%	of 75% upgrade
Keep fuel	25%	of 75% upgrade

3 Scope of impacts assessed

Any scheme to tackle air quality will impact different parts of the environment, economy and society. The economic analysis seeks to quantify and value as many of these impacts as possible given the time, resource and modelling methodologies available.

JAQU's guidance sets the basis for the scope of impacts to be assessed for a Charging Scheme appraisal. We have adopted the same approach to the Traffic Management scheme although some of the impacts may not be relevant. In some cases, we have grouped impacts by the methodology taken to appraise them and hence may in places refer to different impacts using different terminology to that set out in the JAQU guidance.

The scope of impacts captured by the CBA, and their correspondence to the impact categories described in the JAQU guidance, are presented in Table 5.

All responses to the options are assumed to occur in 2020 for simplicity. In practice, these upgrades (and their associated impacts) could occur before or after the implementation of the options.

Table 5 - Impact description and mapping

Impact name	Description	JAQU reference
Upgrade costs	The impact on those vehicle owners that respond to Charging Scheme. These are the upfront costs for vehicle owners associated with switching from a non-compliant to a compliant vehicle. This encompasses the vehicle scrappage cost and the consumer welfare impact as described in the JAQU guidance. These will not be considered as part of the Traffic Management Scheme.	'Vehicle scrappage costs' and 'Consumer welfare impact' for 'upgrade vehicle response'
Operating cost impacts	Those savings or additional costs that can result from Charging Scheme or Traffic Management Measure. This includes both changes in fuel consumption and the associated cost, and change in operating and maintenance costs. This can come about through additional distances travelled (handled by TUBA) or change in vehicle type (handled by the Ricardo model).	'Fuel switch costs'
Implementation costs (Investment and Operating Costs)	Cost of upfront and ongoing activity and assets required to implement, monitor and enforce the Charging Scheme, and Traffic Management measure by the administering authority.	'Government costs'
Air quality emissions	The impact on affected populations by a change in NOx and PM emissions as a result of Charging Scheme and Traffic Management implementation	'Health and environmental impact'
Greenhouse Gas impacts	The impact of a change in greenhouse gas emissions that result from Charging Scheme and Traffic Management measure implementation. This can come about through additional distances	'Greenhouse Gas impacts'

	travelled or change in vehicle type.	
Travel Time	The impact of the Charging Scheme and Traffic Management measure on traffic flow and the subsequent impact on travel time experienced by affected populations	'Traffic flow impact'
User Charges	The cost to road users from paying the CAZ charges. This category includes for impact on consumer welfare associated with the user not being able to take their first preference. E.g. in the case of 'cancelled' journeys, the vehicle user will not be able to undertake the activity planned at the destination (e.g. shopping trip to city centre). The vehicle user will miss out on the happiness/value that they would have gained from that trip, which is captured by this impact category.	'Consumer welfare impact'
User Charge Revenues	The revenue generated through charging the non-compliant cars to travel through the CAZ.	'Government costs'
Indirect Tax Revenues	The impact on revenues generated by the VAT, excises and duties levied on goods and services, due to changes in the traffic behaviour.	'Government costs'

Modelling has been split between TUBA and Ricardo's (REE) economic models as shown in Table 6.

Table 6 – Allocation of impact categories

Impacts	Traffic Management	Charging Scheme
Upgrade costs	-	✓ - REE Economic Model
Implementation	✓ - TUBA	✓ - TUBA
Welfare loss (rule of half)	✓ - TUBA	✓ - TUBA
Air quality	✓ - REE Economic Model	✓ - REE Economic Model
Time	✓ - TUBA	✓- TUBA
Opex/Fuel/CO2 (distance)	✓ - TUBA	✓ -TUBA
Opex/Fuel/CO2 (upgrades)		✓ - REE Economic Model

TUBA presents a value for indirect taxation. This is because of the market price unit of account that is used in TUBA. It reflects the relevant indirect taxes paid by different user groups and accrues to public finances. The Ricardo CAZ model adopts the social approach to the CBA which means all costs exclude VAT and therefore have no indirect taxation line.
The only difference between the two approaches is the way in which results are presented. As stated in TUBA manual (emphasis added):

Clearly, adding these three groups of benefits together will result in the payments between the consumer, the producer and the government cancelling out to provide the same overall result as the method of social cost and benefits.

The difference between the two methods is simply a difference in presentation of the results*. Because the willingness to pay method makes clear how a project affects different economic interest groups, it is particularly useful when projects are sponsored by private sector firms."*

Therefore, we do not believe there is an inconsistency in aggregating the social costs approach and the approach adopted by TUBA.

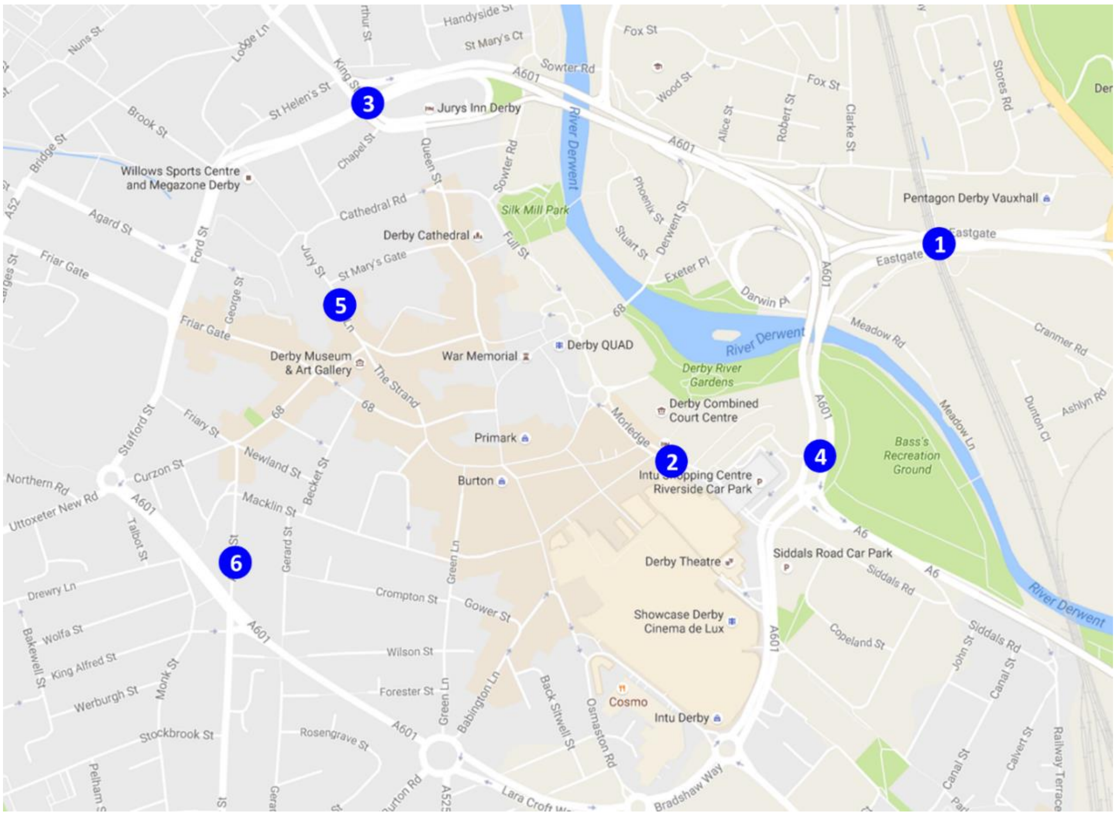
4 Developing the fleet baseline

4.1 Input data

The vehicle fleet baseline is a critical dataset that was utilised in many of the impact calculations. Baseline traffic data for Derby was provided by the Systra transport model for both 2016 and 2020. The assessment was also supported by ANPR data recorded by DCC in 2016 at a number of locations across the city (Figure 1). Data was recorded at sites 1 – 6 on 19th October 2016 and sites 1 – 2 on 22nd October 2016.

A charging scheme would likely be introduced in 2020 and therefore the change in fleet between 2016 and 2020 must be considered. The fleet composition in 2020 was estimated by projecting the basic composition derived from the ANPR data using data on the expected evolution of the fleet ages by vehicle type as reported in the National Atmospheric Emissions Inventory (NAEI).

Figure 1: Locations of ANPR measurement sites across Derby



4.2 Traffic Management

In the Traffic Management scheme, no modifications were made to the baseline fleet assumptions as the scheme does not affect vehicle choices.

4.3 Charging scheme

The number of unique vehicles that would be affected by the charging scheme was estimated using the data sources discussed above and sense checked using licensed vehicle data from the Department for Transport (DfT).

The starting point for calculating unique vehicles was daily trip data from the transport model. In the transport model data (2016), a vehicle was considered to travel into Derby if it crossed the outer ring-road boundary. The data was provided in passenger car units (PCU) for six vehicle types (Car (Work), Car (Commute), Car (Other), Taxi, LGV and HGV) segmented by time period (morning peak, inter-peak and evening peak). These data were converted to trips per day using conversion factors provided by Systra.

Data for the number of trips per day were converted to daily unique vehicles using Derby ANPR data and specifically the derived conversion ratios shown in Table 7. This shows the ratio of unique vehicles to trips observed in the ANPR data for Derby city centre.

Table 7: Ratio between daily trips and daily unique vehicles (Source: Derby ANPR data)

Vehicle Type	Factor
Car Commute	0.65
Car Work	0.65
Car Other	0.65
LGV	0.63
HGV	0.75
PSV	0.20
Taxi	0.33
All	0.61

As previously discussed, two days of ANPR data were recorded by DCC. It was therefore deemed necessary to use another ANPR dataset recorded over a longer time period to more accurately scale from unique vehicles per day to unique vehicles per year.

In this case, ANPR data from Leeds City Council which was previously applied to the economic assessment of the Leeds CAZ was used owing to the two cities being deemed to be adequately similar in size. Table 8 shows the conversion factors used to convert daily trips to weekly trips and subsequently weekly trips to annual trips. These factors were derived from analysis of the Leeds ANPR data combined with expert judgement based on the typical nature of travel patterns per vehicle type.

Table 8: Conversion factors applied to convert daily trips into Derby to annual trips into Derby (Source: Leeds ANPR data)

Vehicle Type	Daily to Weekly Conversion Factor	Weekly to Annual Conversion Factor
Car Commute	1.62	1.5
Car Work	3.25	1.5
Car Other	3.25	1.5
HGV	5.41	2.5
LGV	3.25	1.5
Taxi	2.16	1.0

The fuel type and Euro standard split of the estimated annual unique vehicles was calculated through application of the 2020 fleet composition (Table 9 and Table 10) estimated by projecting the basic composition derived from the Derby ANPR data using data on the expected evolution of the fleet ages by vehicle type as reported in the NAEI. **An upgrade of the main Derby bus fleet to Euro 6 by 2020 is already funded and was therefore assumed to be compliant in the fleet baseline**. All HGVs were assumed to be diesel.

Table 9: Projected 2020 fuel split for selected vehicle types (Source: Derby ANPR and NAEI data)

Fuel type split	Car	LGV	Taxi
Electric	0.4%	0.1%	0.2%
Petrol	48.8%	0.4%	22.5%
Diesel	50.8%	99.5%	77.3%

Table 10: Projected 2020 Euro standard breakdown for selected vehicle types (Source: Derby ANPR and NAEI data)

Euro Standard	Car (petrol)	Car (diesel)	LGV (petrol)	LGV (diesel)	HGV (Rigid)	HGV (Artic)	Taxi (petrol)	Taxi (diesel)
Pre-1/Pre-I	0%	0%	0%	0%	0%	0%	0%	0%
1/I	0%	0%	0%	0%	0%	0%	0%	0%
2/II	0%	0%	0%	0%	0%	0%	0%	0%
3/III	6%	3%	17%	2%	4%	1%	11%	11%
4/IV	19%	14%	51%	25%	9%	6%	56%	57%
5/V	26%	32%	25%	53%	51%	27%	27%	26%
6/VI	48%	51%	7%	20%	36%	65%	6%	6%

As part of the quality assurance of the calculations outlined above, the estimated number of unique cars and LGVs were cross-referenced against the VEH0105 database (Licensed vehicles by body type, by local authority[3]). The 2016 baseline number of unique vehicles modelled entering the Derby outer ring road were compared with the DfT database looking at total licensed vehicles for the zones Derby Urban Area (UA), Derbyshire, Nottingham UA and Nottinghamshire. The modelled car and LGV numbers are approximately 10% greater than the number of registered vehicles in the specified nearby zones. This is considered an acceptable divergence and gives us confidence in the number of vehicles used in our modelling.

Table 11: Comparison of the number of licensed vehicles from the DfT VEH0105 database with estimated annual unique vehicles estimated by the Systra model

	Registered Vehicles (Derby UA + Derbyshire)	Registered Vehicles (Derby UA + Derbyshire + Nott UA + Nottinghamshire)	Modelled unique vehicles 2016
Source	DfT	DfT	Systra
Car	532,685	1,025,775	1,146,431
LGV	110,242	163,567	180,601

5 Approach to assessing the impacts

We describe the methodologies adopted below.

5.1 Appraisal period

This economic assessment covers a five-year period between 2020 and 2025, after which we expect two things to have occurred:

1) The traffic management scheme will no longer be required as Stafford Street will be compliant under business-as -usual conditions as evidenced in the 2025 reference test and therefore there will no longer be any marginal impact of the Traffic Management option.

[3] https://www.gov.uk/government/statistical-data-sets/all-vehicles-veh01

2) The baseline fleet is likely to have caught up with the fleet induced by the Charging Scheme and therefore there will be no marginal impact of the Charging Scheme.

It is for this reason we do not model the period 2025-30 as we anticipate no differences between the baseline and intervention scenarios.

5.2 TUBA

TUBA performs economic appraisal of transport schemes, in line with DfT guidance, published in WebTAG[4]. It is based on the willingness to pay of individuals, for changes in the transport systems, and includes costs and benefits experienced by the consumers, producers and government.

TUBA takes matrix based outputs from a transport model for trips, time, distance and charges (parking costs, fares, tolls). The user can also specify the costs associated with the transport scheme. TUBA then calculates the following:

Monetised user benefits ***from:***

- Journey time - travellers benefit from reductions to their journey time, as they can spend those time savings working or undertaking enjoying leisure activities. Within TUBA, monetary values of time are applied to journey times differences between the Reference and Do Something scenarios, to monetise the travel time (dis)benefits
- Vehicle operating costs – fuel and non fuel - fuel and non fuel – changes in distance travelled between the Reference and Do Something scenarios lead to changes in vehicle operating costs such as the amount of fuel consumed or tyre wear and tear
- Charges - for this modelling, the only charges considered are those levied in relation to the CAZ D. This metric also includes the disbenefit due to increased expenditure and travel time experienced by choosing to avoid the charge by changing mode or destination

Monetised costs relating to:

- Operator revenues - these are the revenues from any modelled charges to the operator. For this modelling, the only operator revenues are those resulting from the CAZ D charges
- Government revenues - changes in taxes paid lead to changes in tax revenue received by the government. Taxes captured in the TUBA relate to duty and VAT on fuel, fares, tolls and non-fuel VOCs.

All user benefits are calculated based on the rule-of-half, apart from the non-fuel VOC benefits for consumer trips. The operator revenues are calculated based on the change in consumption.

Benefits and scheme costs are discounted to the present value year (2018 for this study), and interpolated and extrapolated to cover the required appraisal period.

The outputs from TUBA are reported in perceived costs and market prices and can be disaggregated to fully analyse and understand the impacts of the transport scheme. Summary results are also provided, in the form of the Economic Efficiency of the Transport System table (TEE).

Further information about TUBA is available in the user manuals[5].

5.3 Ricardo's Model

5.3.1 Vehicle Upgrade costs

A vehicle owner upgrading to cleaner vehicles and the resultant impact on air quality is the key output of the Charging Option. The costs associated with this decision are a critical impact category. Our approach to estimating upgrade costs has been tested in a number of cities considering charging schemes and has been applied in Derby when considering the Charging Scheme.

[4] https://www.gov.uk/guidance/transport-analysis-guidance-webtag
[5] https://www.gov.uk/government/publications/tuba-downloads-and-user-manuals

The approach starts by calculating the number of vehicles to be upgraded. This is defined by applying behavioural responses to the non-compliant vehicles in the baseline. It is assumed that the oldest vehicles are the first to upgrade.

The cost to an owner of changing a vehicle is then estimated through consideration of the following:

a. The lost residual value from scrapped vehicles or the resale value of an unwanted vehicle based on the depreciated value of vehicle in 2020

b. New or used vehicle purchase costs in 2020

These input values are combined to give the net cost. Resale costs (if applicable) are netted off the purchase costs and lost residual value associated with each upgrade.

Upgrades will also occur in the baseline and our approach to estimating these costs is very similar to what has been applied when considering the policy option. The general assumption in the baseline is that the same upgrade decision will be undertaken as in the measure but at a later date (defined by useful lives and ownership profiles). This future net cost is discounted (according to how far in the future it occurs) to 2020 to allow comparison with option costs.

The upgrade costs are calculated taking the difference in aggregate upgrade costs for the option and baseline scenarios. Specific modelling assumptions and data inputs are provided in the Appendix of this document.

5.3.2 Air Quality Emissions

The key objective of these policy options is to reduce the emission (and subsequently concentrations) of air pollutant emissions from road transport sources. Reducing air pollutant emissions will have a range of subsequent benefits on human and environmental health, productivity and amenity.

The following approach to valuing the impacts associated with reductions in emissions is as follows:

1. Take quantities (tonnes) of emissions from underlying air quality modelling undertaken by Ricardo for all option scenarios and do minimum baseline
2. Calculate total emissions impact relative to baseline
3. Value impact applying damage costs provided by JAQU
    a. The damage cost 'Urban large' is applied to all emissions reductions under the Traffic Management and Charging Scheme scenarios.

The results of the analysis for 2020 are presented in Table 12. It should be noted that these are only impacts for a single year, and there is no application of extrapolation factors or addition of PM results.

Table 12 – Air pollutant impacts of (original) short-list scenarios in 2020

Option	NOx Emissions (t/ year All vehicles)	Difference from Baseline (t)	Benefits per annum (£m)
Baseline	609		
Traffic Management	556	53	£0.3
Baseline including coach emissions	709		
Charging Scheme	552	157	£0.9

The transport model does not include coaches as a separate category. As a consequence, emissions associated with these vehicles are not represented in the air quality modelling. Coaches will also be charged under a Charging Scheme. Hence to capture the potential size of these impacts, an illustrative run of the DfT has been completed. The outputs of this are shown as part of the results, but are caveated that they do not model emissions in the same level of detail as the core modelling. Also emissions changes are estimated over the total average annual mileage of these vehicles, hence represent total emissions changes nationally, rather than just in the Derby AQ modelling domain as for other vehicle types. This is the reason two counterfactual scenarios are presented – the counterfactual for the charging scheme is the Do minimum plus baseline emissions from coaches.

Coaches are not taken into account for the Traffic Management scheme (or the zero % percent sensitivity).

Emissions under each scenario from the Derby modelling were only available for 2020. To assess the impacts over the course of the appraisal period, some of the impacts in 2020 were extrapolated to 2025 using an extrapolation factor which is discussed in Information Box #1.

Information Box #1: Impact extrapolation factors

Use of an extrapolation factor

For air pollutant (and other) impacts, detailed modelling of the effects was only available for 2020. Where it is expected that the baseline turnover of fleet will *'catch-up'* with the fleet that results from implementation of an option, an extrapolation factor is applied to air quality benefits to reflect the diminishing marginal impact of that option. This will only be the case where it is expected that the baseline *will* in fact catch-up.

For the Charging Scheme and Traffic Management scheme an extrapolation factor was applied to all air quality impacts.

Methodology

The extrapolation factor used was derived from the results of PCM modelling undertaken by JAQU when producing the ***National AQ plans scenarios***[1]. The supporting evidence for the national plans included scenarios run by JAQU presenting resulting concentrations in cities for the baseline and illustrative charging scheme scenarios. This information could be analysed to produce a factor with which impacts can be extrapolated over the appraisal period to simulate the erosion of the impacts of the policy options considered, as the vehicle fleet naturally catches up with the upgrades brought forward as part of the option. The extrapolation factor is the difference in concentrations between baseline and option scenario, expressed as a ratio relative to the difference in 2020.

This approach was adopted (relative to developing a local fleet turnover model) as it was deemed most proportionate, and also given limitations in the availability of local information make it doubtful that a significantly different trend to that observed nationally can be confidently assumed for Derby.

5.3.3 Operating costs and Greenhouse Gas Emissions for Upgraded vehicles

Operating costs and greenhouse gas emissions are calculated as part of the TUBA model. This modelling focuses on the additional impacts associated with any change in distance and therefore fuel consumption associated with a particular option. But TUBA does not take into account any change in fuel consumption (and OPEX and GHG impacts) associated with the upgrades associated with a policy option. Ricardo's model, which has focused on charging schemes that result in a significant change in fleet mix, calculates the changes in fuel costs, OPEX and greenhouse gas emissions.

The estimation of operating costs and greenhouse gas emissions focused on capturing the effect of upgrading vehicles, which switches vkm travelled from one Euro class of vehicles to another. The following approach was taken:

1. Take numbers of vehicles upgraded from fleet upgrade calculations

[1] See 'Baseline and with Measures projections' available: https://uk-air.defra.gov.uk/library/no2ten/2017-no2-projections-from-2015-data

2. Combine numbers of vehicles upgraded by different vehicle type and Euro standards with data around the average annual fuel consumption and average annual operating costs per vehicle type and age[6]
    a. By applying average opex and fuel consumption over the full year and average vkm travelled per annum, this illustrative modelling will likely capture an even wider domain of impacts – i.e. will include the impacts where upgraded vehicles travel outside the AQ modelling domain
3. Changes in fuel consumption are combined fuel costs
4. Changes in fuel consumption are combined with emissions factors from BEIS' Green Book Supplementary Guidance to calculate changes in GHG emissions (tCO_2e)
5. Changes in GHG emissions in each year are combined with carbon values from BEIS' Green Book Supplementary Guidance.

Note: these impacts are not forecast over the period using the extrapolation factor. This is because these impacts are associated with modelled vehicle upgrades. The model depicts the opex and GHG emissions associated with the new vehicle, and with the vehicle replaced to identify the difference. For Charging Scheme it does so over the period which the replaced vehicle was anticipated to remain in the fleet in the baseline. Hence the impacts are already depicted over the appraisal period and the extrapolation factor is not required.

5.4 Discounting

As recommended by JAQU, our model uses a 2018 price year as the basis for all calculations. This means that past costs (for example vehicle costs) are inflated to 2018 values using HM Treasury's GDP Deflator series. Any costs projections are kept in constant 2018 prices and therefore inflation adjustments are not required.

Discounting future costs and benefits considers the time preference of society. Discounting is done in accordance with HM Treasury's Green Book guidance. The model applies a discount rate of 3.5% to all impacts, which are discounted back to 2018.

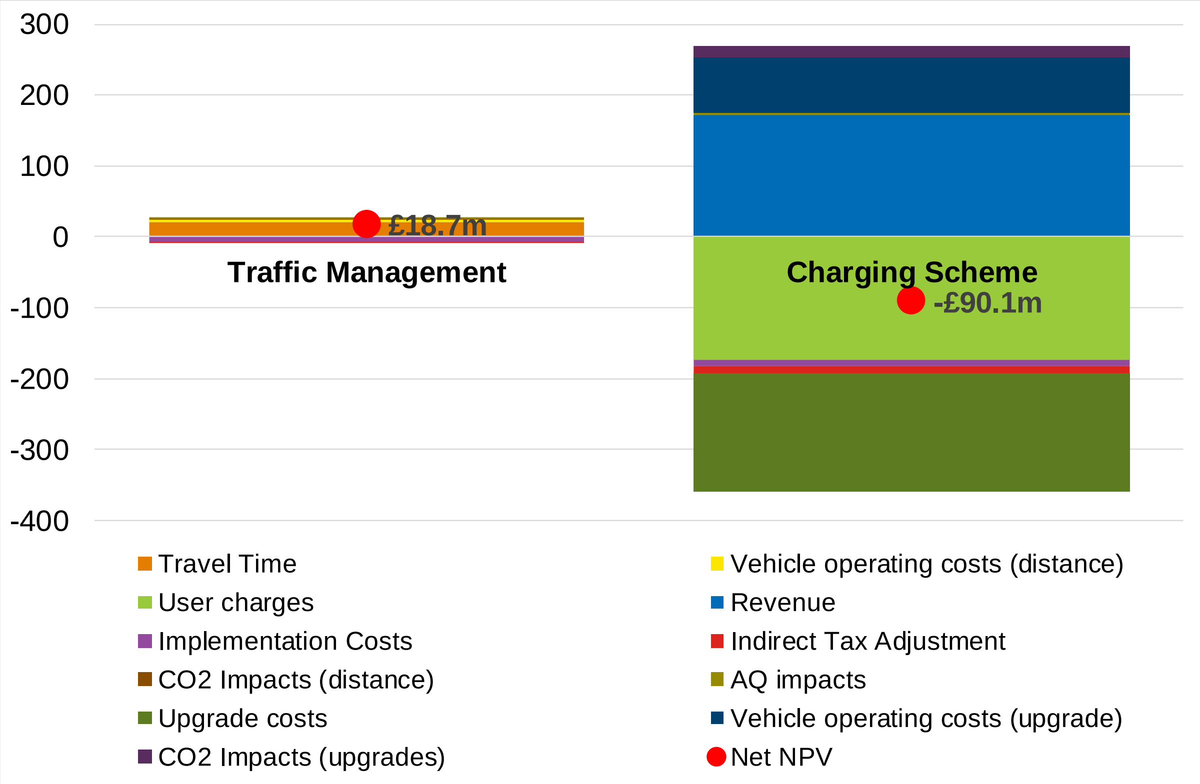
[6] Consumption and opex for general vehicle types came from: Ricardo study for TfL (2014): 'Environmental Support to the Development of a London Low Emission Vehicle Roadmap' (unpublished). Data for hybrid vehicles came from: Ricardo Energy & Environment (forthcoming). Car Choice Model (CCM) summary report.

6 Results

6.1 Summary of results

The results of our economic analysis are summarised in Figure 2 and Table 13.

Figure 2 – PV of impacts and NPV of option scenarios



Note: Bars represent present value (PV) of impacts; dots represent aggregate net present value (NPV) of all impacts associated with CAZ option; all impacts are assessed relative to 'do nothing' baseline; all impacts presented in 2018 prices.

Table 13 - Monetised impacts associated with option scenarios (cumulative discounted impact (PV) from 2020-25 (£m 2018 prices))

	Traffic Management	Charging Scheme
Travel Time	21.0	2.1
Vehicle operating costs (distance)	3.8	0.2
User charges	0.0	-173.4
Revenue	0.0	168.5
Implementation Costs	-6.5	-8.4
Indirect Tax Adjustment	-0.8	-10.3
CO2 Impacts (distance)	0.4	-1.5
TUBA Partial NPV	17.9	-22.7
AQ impacts	0.8	4.7
Upgrade costs		-165.2
Vehicle operating costs (upgrade)		78.5
CO2 Impacts (upgrades)		14.6
REE Partial NPV	0.8	-67.4
Net NPV	18.7	-90.1

Notes: +ve values denote benefit / -ve values denote costs; all impacts are in 2018 prices; all impacts are discounted to 2018

6.1.1 Commentary on results

Travel Time Benefits

- For the charging scheme modest travel time benefits are seen. This is due to the deterrence of non-compliant cars from travelling through the charging zone, which results in a reduction in congestion in this area and travellers receive reductions in their journey times. This journey time benefit for compliant cars is then off-set to some degree by dis-benefits for non-compliant vehicles, caused by congestion outside the charging zone as a result of re-routing to avoid the charge.
- For the traffic management scheme moderate travel time savings are demonstrated through improved signal timings and re-routing of traffic to quicker routes. Overall, road users experience some moderate reductions in congestion and journey times.

Vehicle Operating Costs and CO_2 (distance)

- Overall vehicle operating costs follow a similar pattern to travel time benefits with the Traffic Management scheme resulting in greater operating costs savings than shown in the Charging Scheme.

Charging Disbenefits

- High charging disbenefits are demonstrated for the Charging Scheme as a result of the charges paid by the users of non-compliant vehicles. The transport model does not include mode or destination responses for freight trips, it only permits changes in route for these trips. The charging rate for HGVs is also significantly higher than for other vehicle types. The combination of these factors leads to significant user charge disbenefits for freight trips.

Implementation Costs

- The capital and operating costs provided for the charging scheme do not include a number of important elements, and so are likely to be significantly under estimating the costs associated with the scheme. Costs have not been provided for:
    - Public enquiry
    - System to create the evidence pack - currently SEA APNR camera system creates the evidence pack
    - Server/maintenance costs
    - Interface with central payment portal and database for assessing vehicle compliance (hackney carriage and private hire vehicles identification)
    - TPT adjudicator costs - cost per PCN to support adjudicator (dependant on number of PCNs issued)
    - Charge for use of central payment portal system
    - Recruitment
    - Staff Training costs
    - Printing
    - Telephones
    - Premises costs
    - Financial processing costs / staff including overheads
    - Asset maintenance - signs / lines
    - Income - reimbursement of proportion of CAZ charge from central payment portal
    - PCN fees
    - Costs associated with erection of signs on HE / Derbyshire CC roads
    - Decommissioning costs
- Optimism bias of 44% has been included

Air quality impacts:

- Air quality impacts are one of the smallest impacts feeding through both options, which reflects the challenges of reducing vehicles emissions over such a large area.
- The Charging Scheme achieves the greatest reduction in air quality pollutants and therefore the greatest economic benefit. The benefit for the Charging Scheme is nearly 4 times greater than the Traffic Management scheme.
- The key question underlying these benefit calculations is whether they represent compliance with legal limits. This is explored in the air quality modelling (reported in AQ3) and shows that both options can achieve compliance.

Vehicle Upgrade Costs

- This is the most significant net impact that resulted from the economic analysis (after considering that the user charge costs are mostly netted off by the benefit for the public purse).
- It covers a number of impacts: the scrappage cost of non-compliant vehicles, cost of purchasing new compliant vehicles and the cost of swapping a non-compliant used for a compliant used vehicle.
- This impact is a net effect associated with the option scenarios analysed. The costs of the baseline activity are removed from those of the option to present the net cost. Hence the overall NPV is particularly sensitive to any assumptions made in calculating the upgrade costs.
- There are no upgrades resulting from the Traffic Management scheme and therefore they are not considered.
- The Charging Scheme demonstrates very high upgrades costs. These are driven by the large number of vehicles that are affected. This is especially true for HGVs where approximately 11,000 non compliant HGVs face a very high cost of scrapping and replacing with new HGVs.
- Given the significant number of vehicles upgrading we also see significant operating, fuel consumption and CO_2 emission savings benefits associated with the newer vehicles.

6.2 Sensitivity testing

Economic modelling is only an approximation of the real world and it is inevitable there will be uncertainty and error around the inputs and assumptions that form the model. Failing to accurately predict future states of the world, using input values developed in different locations (i.e. not specific to Derby) or using expert judgement where no data is available are all potential sources of uncertainty in assumptions and input values. We have identified those assumptions and input values where errors are more likely and potentially significant (i.e. could have a material effect on the results of the quantitative analysis and could affect the ranking of options).

To determine whether these uncertainties have a significant impact on the recommendations made in this report a sensitivity analysis was undertaken. The sensitivity analysis involves developing lower and upper bounds around important assumptions and input values used in the analysis. If the recommendations stand up to this 'stress testing', the robustness of the analysis is confirmed.

The sensitivity analysis is conducted around the following key inputs, which covers those sensitivities identified by JAQU as requiring testing:

1. Behavioural assumptions
2. Implementation costs and Optimism bias
3. Damage Costs
4. Carbon prices
5. Welfare cost (rule of half)
6. Scrappage costs and vehicle upgrade assumptions
    - Scrap proportion.
    - Vehicle costs
    - Depreciation

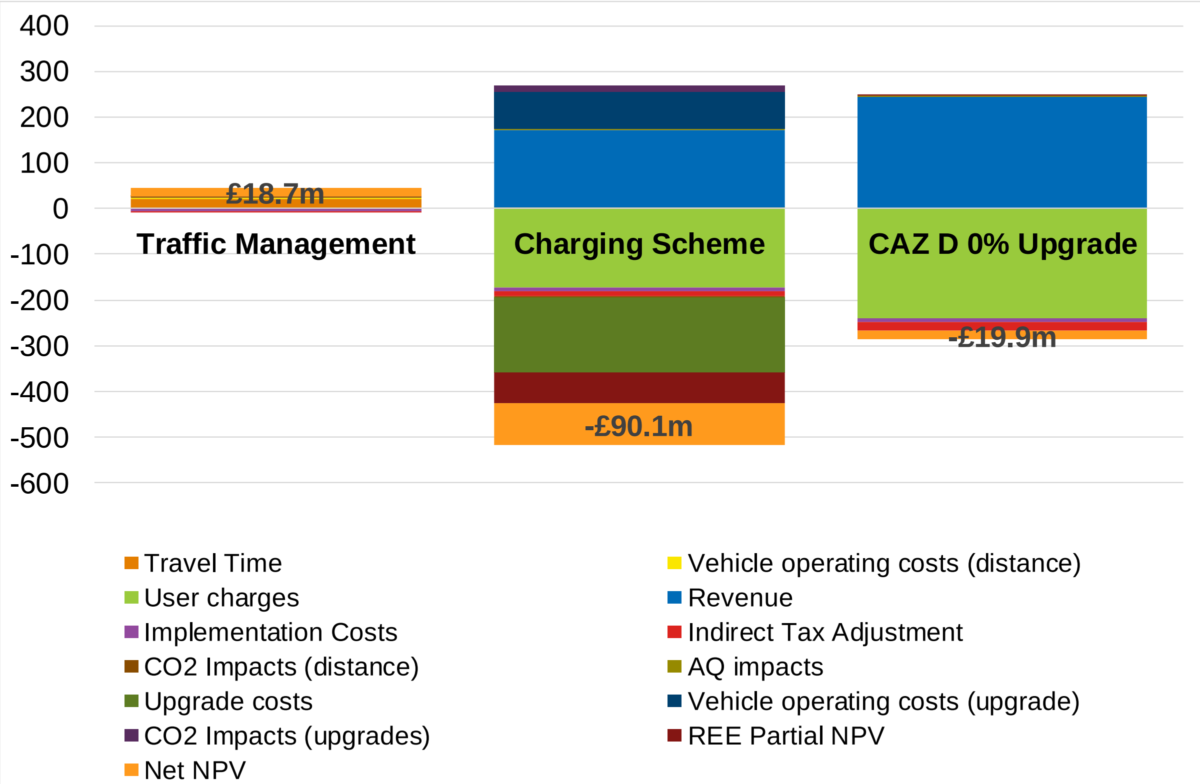
6.2.1 Charging Scheme – 0% Upgrade

The behavioural assumptions define the response of vehicle owners to a particular measure. The impact of the CAZ option will critically depend on the behavioural response of the transport users. This behavioural response determines the number of vehicles that are upgraded, with the associated costs.

As a sensitivity, we have applied a scenario where 0% of vehicles upgrade. We have run only one scenario here, as this requires updates to transport, air quality and economic models.

This unsurprisingly reduces negative NPV associated with the Charging Scheme with the absence of upgrade costs. However, the influence of user costs, reduced air quality benefits, a negative impact on travel time and operating costs means that negative NPV is still apparent and the Traffic Management scheme remains the preferred option.

Figure 3 – PV of impacts and NPV of option scenarios with 0% upgrade scenario



Note: Bars represent present value (PV) of impacts; dots represent aggregate net present value (NPV) of all impacts associated w ith CAZ option; all impacts are assessed relative to 'do nothing' baseline; all impacts presented in 2018 prices.

6.2.2 Optimism Bias

Optimism bias represents a systematic tendency for appraisers to be overly optimistic in their assessment of schemes, in particular regarding the costs (and time) associated with implementing a policy. An adjustment for optimism bias has already been included in the estimation of implementation costs. This is the most important adjustment and hence has been included as part of the core analysis, given costs have been estimated directly for scheme implementation.

As a sensitivity, we vary the adjustment for optimism. The results are presented in the table below. As can be seen from the table, the results and ranking of options remain unchanged whether this adjustment is included or not.

Table 14 – Optimism Bias sensitivity analysis – NPV result (£m 2018 prices)

	Sensitivity	Charging Scheme NPV (£m)	Favoured Scheme
NPV Traffic Management	22%	£20m (5%)	Traffic Management
	44%	£19m	Traffic Management
	88%	£17m (-11%)	Traffic Management
NPV Charging Scheme	22%	-£89m (-1%)	Traffic Management
	44%	-£90m	Traffic Management
	88%	-£93m (3%)	Traffic Management

6.2.3 Damage Costs

The economic costs associated with air quality are driven by the damage costs supplied by JAQU. The damage costs applied in this case are those for 'urban large' and are applied to all PM and NOx emissions reductions under the scenarios. This is not a value that has been tailored to the circumstances in Derby – hence this is one source of uncertainty. Furthermore, there is underlying uncertainty in the methodologies and techniques used to construct the damage costs (e.g. impacts included, valuation of endpoints, etc) which should be reflected in the analysis.

No upper and lower bound for damage costs has been provided in the JAQU guidance on CAZ appraisal. Instead, to test this sensitivity the damage costs are inflated and deflated by 20%.

This analysis demonstrates that both scenarios are not very vulnerable to this given the small contribution that air quality has on overall NPV.

Table 15 – Damage Cost sensitivity analysis – NPV result (£m 2018 prices)

	Sensitivity	Scheme NPV (£m)	Favoured Scheme
NPV – Charging Scheme	-20%	-£91m (1%)	Traffic Management
	Damage Costs	-£90m	
	20%	-£89m (-1%)	Traffic Management
NPV – Traffic Management	-20%	-£19m (1%)	Traffic Management
	Damage Costs	-£19m	
	20%	-£19m (-1%)	Traffic Management

6.2.4 Carbon Prices

The carbon price is used to value the climate-mitigation benefits of reducing Greenhouse Gas emissions as an indirect effect of the air quality measures. The carbon price is based on the BEIS and WebTAG guidance. Where carbon impacts have the greatest impacts, is where the change in carbon price has the greatest effect. For the Charging Scheme, where upgraded vehicles are a significant benefit, changing the carbon price is significant, but immaterial in preference for the scheme.

Table 16 – Carbon Prices sensitivity analysis – NPV result (£m 2018 prices)

	Sensitivity	Scheme NPV (£m)	Favoured Scheme
NPV Traffic Management	Low	£18m (-1%)	Traffic Management
	Central	£19m	Traffic Management
	High	£19m (1%)	Traffic Management
NPV Charging Scheme	Low	-£97m (7%)	Traffic Management
	Central	-£90m	Traffic Management
	High	-£84m (-7%)	Traffic Management

6.2.5 Scrapped vehicles

If vehicles are scrapped as a result of any proposed policies, the impacts of this will depend on vehicle values, depreciation rates and counterfactual upgrade assumptions. All of these values could be very uncertain. As such three sensitivity tests have been run on 'scrappage' and applied only to the charging scheme as the traffic management scheme includes no vehicle replacement.

In this sensitivity analysis we adjust

1. Adjust depreciation rates: If the value of a vehicle falls more quickly, then the cost of scrapping this vehicle will reduce more quickly too. Range tests ±2%.
2. Adjust the values of the vehicles. For this sensitivity we use Ricardo derived for values of vehicles compared to JAQU values.
3. The fixed assumption on the proportion of 'upgraded' vehicles that are scrapped. The CAZ charge could cause the value of a non-compliant vehicle to depreciate by less, leading to fewer vehicles to be scrapped and vice versa. The range tested was 20 to 30% vehicles scrapped.

Table 17 – Scrappage sensitivity analysis – NPV result (£m 2018 prices)

	Sensitivity	Charging Scheme NPV (£m)	Favoured Scheme
Depreciation Rates	Low -2%	-£105m (17%)	Traffic Management
	Central 0%	-£90m	Traffic Management
	High +2%	-£80m (-12%)	Traffic Management
Vehicle Values	Ricardo Values	-£28m (+69%)	Traffic Management
	JAQU Values	-£90m	Traffic Management
Scrappage %	20%	-£49m (-46%)	Traffic Management
	25%	-£90m	Traffic Management
	30%	-£138m (52%)	Traffic Management

Adjustments to scrappage costs have large impacts on the NPV of the Charging Scheme. Increasing depreciation rates reduce the costs of scrappage because the scrapped vehicle is worth less and therefore less value is lost.

Using Ricardo values for vehicle upgrades also has a large impact on the model. The Ricardo derived values significantly lower the vehicles in the model and therefore the upgrade costs faced by individuals drops dramatically.

Reducing the rates of scrappage vastly reduces costs. Reducing scrappage costs increases those vehicles that are sold and replaced. This is a less costly option than scrapping and replacing with new vehicles, and in some cases (where individuals switch fuel) this can result in a net positive for many upgrading and therefore a significant positive pressure on NPV.

6.2.6 Conclusion

Although the sensitivity analysis shows that the NPV assessment of each option is sensitive to the assumptions, it demonstrated that uncertainty around the parameters tested does not influence the ranking of the options in NPV terms.

6.3 Uncertainties

The impact of the policy options considered is critically dependent on the behavioural response of the transport users. The behavioural responses used in our modelling were based on the following:

- **Traffic management scheme** – the behaviour of vehicles in response to the traffic management scheme has been determined by the transport model.
- **Charging Scheme** - Behavioural responses for upgrading the fleet are provided by JAQU and based on TfL modelling associated with introduction of the ULEZ in London. Avoiding the charges by changing mode, route or destination are provided by the transport model. The Transport model has been validated and calibrated to be WebTAG compliant, meaning that its behavioural responses to changes in costs are within the accepted ranges defined in WebTAG.

The vehicle upgrade response is central to the impact of the charging scheme and the following issues can all affect the validity of the responses assumed:

- Modelling how individuals and businesses will respond to economic incentives is uncertain. It is unlikely that vehicle owners will be as rational as the behavioural assumptions and transport and economic models suggest. Therefore, vehicle owners may not respond in a way it has been assumed in the models. Consideration of transaction costs, endowment effects, access to credit, contractual issues may result in behavioural assumptions which bear closer resemblance to 'real' decision making. However, modelling these influences is in itself highly uncertain and beyond the scope of this study.
- The policy options considered are not a binary policy instruments (it is there or it is not). Responses and resultant impact will be determined by the stakeholder engagement, communication, public transport, signs, cameras and enforcement, and complementing policies that go with/alongside implementation.
- The response for the Charging Scheme will also depend on the charge levels set. This analysis is based on the national recommended charges, which are assumed consistent with the JAQU behavioural responses in the Derby context.
- The modelling assumes all responses will occur immediately upon implementation in 2020. However, in practice it may take vehicle owners time to realise the additional costs and select their behavioural response

– Responses will start when the scheme is announced to try and achieve compliance when scheme opens (e.g. London LEZ) so some may react before 2020, but some may do so afterwards.
– Also, vehicle owners may switch between behavioural responses over time, and potentially multiple times.

6.4 Qualitative Assessment

The approach has sought to quantify and monetise the impacts associated with the options considered. However, in some cases due to limitations in data or methodologies available, it has not been possible to assess all impacts quantitatively. In this case, these impacts have instead been assessed qualitatively and the results are presented in this section.

Through the development of the methodology, a number of impacts were identified as being unquantifiable. Specially:

a) AQ impacts outside modelling domain (NOx and PM)
b) Wider GHG/congestion impacts associated with alternative responses to a charging scheme
c) Noise / accidents / infrastructure effects associated with the options

Further several impacts were identified as associated with vehicle upgrades with the charging scheme and wider travel behaviour changes, but were deprioritised for assessment as less significant effects. Specifically:

- Transaction costs: associated with upgrading vehicles.
- Welfare (utility) loss associated with upgrading vehicles.
- Active travel effects.

A summary of impacts is included in Table 18.

Table 18– Summary of impacts assessed qualitatively

Impact category	Traffic Management	Charging scheme
AQ impacts outside modelling domain (NOx and PM, excluding coaches)	-	✓✓
AQ impacts associated with alternative responses of coaches in response to charging CAZ	-	✓
Wider GHG/congestion impacts associated with alternative responses to a charging scheme	-	✓
Noise / accidents / infrastructure effects associated with the options	✓	✓
Transaction costs: associated with upgrading vehicles	-	××
Welfare (utility) loss associated with upgrading vehicles	-	✓/×
Active travel effects.	✓	✓✓

Key: Each impact is assigned a scoring – this attempts to judge the size and direction of impacts between different options, and the overall size / importance of impact relative to other impacts assessed both qualitatively and quantitatively. '✓✓' denotes large benefit associated with option; '✓' denotes small benefit; '-' denotes no significant impact; '×' denotes small cost; '××' denotes large cost; '✓/×' denotes where there are costs and benefits, with no discernible overall net effect.

The qualitative impacts are dominated by those experienced as a result of the charging scheme:

- The Charging Scheme affects a large number of HGVs and coaches, which are likely to travel more widely relative to taxis, cars and LGVs.
- The charging scheme will also have additional benefits associated with GHG emission and congestion reductions associated with cancelled trips.

- Both options will have associated active travel benefits and reductions in levels of noise, accidents and infrastructure replacement requirements through reducing levels of traffic.

7 Summary assessment

The key focus of the options presented is to reduce emissions of air pollutants and meet legal limits for **air pollutant** concentrations. Both options will achieve legal compliance as set out in the Air Quality results report (AQ3). However, the Charging Scheme has the greatest impact on emissions and as a result will deliver much greater associated health benefits.

Alongside greater reductions in air pollutant emissions, the higher level of vehicle upgrades under the Charging Scheme also delivers a higher level of **secondary benefits** – i.e. fuel and operating cost savings, and GHG emission reductions as newer and more efficient vehicles come into the fleet at an earlier stage. The Traffic Management does deliver fuel and GHG savings, as a result of a reduction in distances travelled but these savings are smaller.

However, the high level of vehicle upgrades for the Charging Scheme generates high vehicle upgrade costs which drive an overall highly negative NPV for the scheme. In contrast the Traffic Management scheme achieves a positive NPV driven by considerable time saving benefits associated with the scheme. In light of this, based on NPV alone, the Traffic Management scheme is the favoured option, although it must be said that the air quality benefits are substantially lower than under the charging scheme.

This CBA was facilitated through the use of several simplifying assumptions. When viewing this analysis, it is important to recognise the uncertainty and caveats around these results. Indeed, the sensitivity analysis highlights that the NPV is sensitive to the input assumptions. However, the sensitivity testing carried out indicates that any inaccuracy in input values is unlikely to change ranking of options:

Table 19 – Economic analysis summary options ranking

Rank	Option	Rationale
1	Traffic Management	• Positive NPV • Improvements in travel time and benefits in terms of vehicle operating costs and CO_2. • Relatively small improvement in air quality
2	Charging scheme	• Greatest improvement in mass AQ emissions, • Negative NPV driven by many vehicles upgrading in response to introduction of charge which are partly offset by the fuel, opex and CO_2 benefits associated with new vehicles.

Appendices

Appendix 1 – Key Methodological Assumptions

A.1 Data inputs

A summary of the key assumptions applied in the analysis is set out in Table 20.

Table 20 – Summary of Key Assumptions

Assumption	Assumption	Source
Appraisal Assumptions		
Discount Year	2018	JAQU
Price Year	2018	JAQU
Appraisal Period	5 years (2020 to 2025)	Expert judgement
Discount Rate	3.5%	JAQU
Price Year Adjustment	GDP deflators used in TUBA	GDP Deflators Used in May 2018 Databook[7]
Air Quality		
Damage Costs (air quality and GHGs)	Various values	JAQU Guidance for damage costs; Carbon prices taken from: BEIS Supplementary Green Book Guidance (2018) as used in WebTAG databook (2018)
Impact extrapolation factor	Various values	Derived from analysis of scenario concentration results from Defra Air Quality National Plan
Fleet Assumptions		
Vehicle Types	As defined by JAQU – but the Charging Model combines HGVs (rigid and articulate) and Coaches (coach, minibus) and buses (single and double) into single categories to make the model more manageable.	JAQU/ Expert judgement

[7] 2018-2022 from EFO Mar 2018 supplementary economy table 1.7, published 13/03/2018

Vehicle fleet composition	Various values	ANPR data and air quality model
Fleet projection (vkms/vehicles)	Various values	Transport model, ANPR data and fleet projection tool Ricardo study for TfL (2014): 'Environmental Support to the Development of a London Low Emission Vehicle Roadmap' (unpublished)
Number of vehicles entering the target area	Various values	Transport model and ANPR data, plus supporting assumptions
Annual unique vehicles	Conversion factors to convert ANPR data to annual vehicle numbers	Expert judgement / Systra
Growth in overall vehicle fleet	Growth of the vehicle fleet between 2016 and 2020	Systra transport model
Change in fleet composition projection	Change in the vehicle fleet composition between 2016 and 2020	ANPR data and NAEI national trend in fleet
Annual unique vehicles	Conversion factors to convert ANPR data to annual vehicle numbers	Expert judgement / Systra
Growth in overall vehicle fleet	Growth of the vehicle fleet between 2016 and 2020	Systra transport model
Change in fleet composition projection	Change in the vehicle fleet composition between 2016 and 2020	ANPR data and NAEI national trend in fleet
Behavioural Assumptions		
Upgrade to new (Charging Scheme)	If upgrade response is triggered then 25% of those upgrading will purchase a new vehicle and 75% will replace their non-compliant vehicle with a second-hand compliant vehicle	JAQU
Fuel switch (Charging Scheme)	Of those replacing their vehicle with a second-hand complaint variant, 25% will purchase the cheapest complaint vehicle of the same fuel type, while 75% will purchase the cheapest compliant vehicle (for example, in a charging clean air zone diesel will switch to petrol).	JAQU
Scrappage/Fleet size (Charging	For every vehicle purchased new, due to an upgrade response, another vehicle will be scrapped.	JAQU

Scheme)		
Trips proportional to response	Those vehicles making the most trips into the zone are the most likely to upgrade.	JAQU
TUBA Assumptions		
Value of Time	Default TUBA values by mode, journey purpose and person type	WebTAG data book (May 2018)
Average Indirect Tax Rate	Standard TUBA - 19%	WebTAG data book (May 2018)
Fuel Costs (and CO2e)	Default TUBA values by fuel type	WebTAG data book (May 2018)
Fleet composition (fuel type)	Default TUBA fleet composition by Petrol, Diesel, Electric	WebTAG data book (May 2018)
Fuel Consumption (including change in fleet efficiency through time)	Default TUBA fuel consumption parameters and fleet efficiency by vehicle and fuel type	WebTAG data book (May 2018)
Non Fuel Vehicle Operating costs	Default TUBA non fuel vehicle operating cost parameters by vehicle and fuel type	WebTAG data book (May 2018)
Annualisation factors	AM – 500, Inter Peak – 2500, PM – 500. Based on number of weekdays per year, and time profiles of traffic	Expert judgement / Systra
Vehicle Occupancies	Default TUBA vehicle occupancies by vehicle type, journey purpose and time period	WebTAG data book (May 2018)
Consumer Preference	Impact of welfare loss associated with an avoided, cancelled or mode-shifted trip can be valued as half of the Charging Scheme charge	JAQU
Costs Associated with Upgrades		
Emission factors	Various values	WebTAG data book (May 2018) based on BEIS (2018)
Annual emissions of NOx and other pollutants (baseline and option scenarios)	Various values	Air Quality Model
Ownership profile	A four-year ownership profile is assumed for vehicle users. I.e. on average vehicle users' own vehicles for 4 years, before replacing them. In 2020 vehicles that are resold are expected to be halfway through this profile (2 years remaining).	Expert judgement
Euro standard age	Vehicles of different Euro standards are assumed to the youngest possible age for that standard in 2020 with the exception of used ULEV which in 2020 are assumed to be 3 years old.	Euro standard introduction dates

Remaining life of vehicle	Where the age of the vehicle is greater than the life of vehicle, 2 more years is assumed.	Expert judgement
Resale of used, non-compliant vehicles profile (Charging Scheme)	Different resale profile for different Euro standards – different proportions of vehicles are either scrapped or resold depending on vehicle age. Older vehicles are more likely to be scrapped, newer vehicles likely to be resold.	Expert judgement
Scrappage of non-compliant vehicles replaced by new vehicles (Charging Scheme)	Older vehicles are likely to be scrapped first	Expert judgement
Baseline upgrade response (Charging Scheme)	Assume same upgrade decision will be undertaken in baseline as in the measure but at a later date (defined by useful lives and ownership profiles). This future net cost is discounted (according to how far in the future it occurs) to 2020 to allow comparison with option costs	Expert judgement
Average value of new vehicle by type		JAQU upgrade costs
Vehicle depreciation	Various values	JAQU guidance
Fuel consumption per vehicle	Various values	Ricardo study for TfL (2014): 'Environmental Support to the Development of a London Low Emission Vehicle Roadmap' (unpublished) and Ricardo Energy & Environment (forthcoming): Car Choice Model (CCM) summary report
Fuel costs	Various values	WebTAG data book (May 2018)
CO_2 Emission factors	Various values	BEIS Supplementary Green Book Guidance (2016), as recommended by JAQU
Conversion Factors	Conversion factors to allow conversion from fuel consumption to CO_2 emissions	DECC DUKES Annex A[8]

[8] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/642725/Annex_A.pdf

Operating cost	Various values	Ricardo study for TfL (2014): 'Environmental Support to the Development of a London Low Emission Vehicle Roadmap' (unpublished)
Implementation		
Charging Scheme Charge	£12.50 / day Car, LGV, TAXI, Private Hire £100 / day HGV, Coach, Bus	JAQU/Local Authority
Implementation costs	Costs of implementation (capital costs and operating costs)	Charging scheme from DCC
Optimism Bias	33%	TUBA

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