GCC LEZ TRAFFIC MODELLING

SYSTRA

GLASGOW CITY CENTRE LOW EMISSION ZONE

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1. INTRODUCTION

1.1.1 SYSTRA Ltd. (SYSTRA) was commissioned by Glasgow City Council (GCC) to test the traffic related effects of the proposed Low Emission Zones (LEZ) in Glasgow City Centre. This testing was to be carried out primarily using the Glasgow City Centre Paramics Discovery Model, supported by the Strathclyde Regional Transport Model (SRTM).

1.1.2 This report details the development of the test models and presents a comparison of the outputs.

2. LOW EMISSION ZONE PROPOSALS

2.1.1 A Low Emission Zone (LEZ) is an area inside which only vehicles which meet specified standards for exhaust emissions are allowed to drive. The Scottish Government has committed to introducing LEZs in Scotland's four largest cities (Glasgow, Edinburgh, Dundee and Aberdeen).

2.1.2 Glasgow City Council (GCC) provided details of two proposed LEZ boundaries to be tested by SYSTRA. These have been termed LEZ1 and LEZ2 for the purposes of this report and the drawings provided by GCC are shown in Figure 1 and Figure 2.

2.1.3 The LEZ1 and LEZ2 boundaries cover a similar area of Glasgow city centre broadly bounded by the M8, Broomielaw and High Street. The difference between the two proposals is that High Street and Broomielaw are within the LEZ boundary for LEZ1 and outside the boundary for LEZ2.

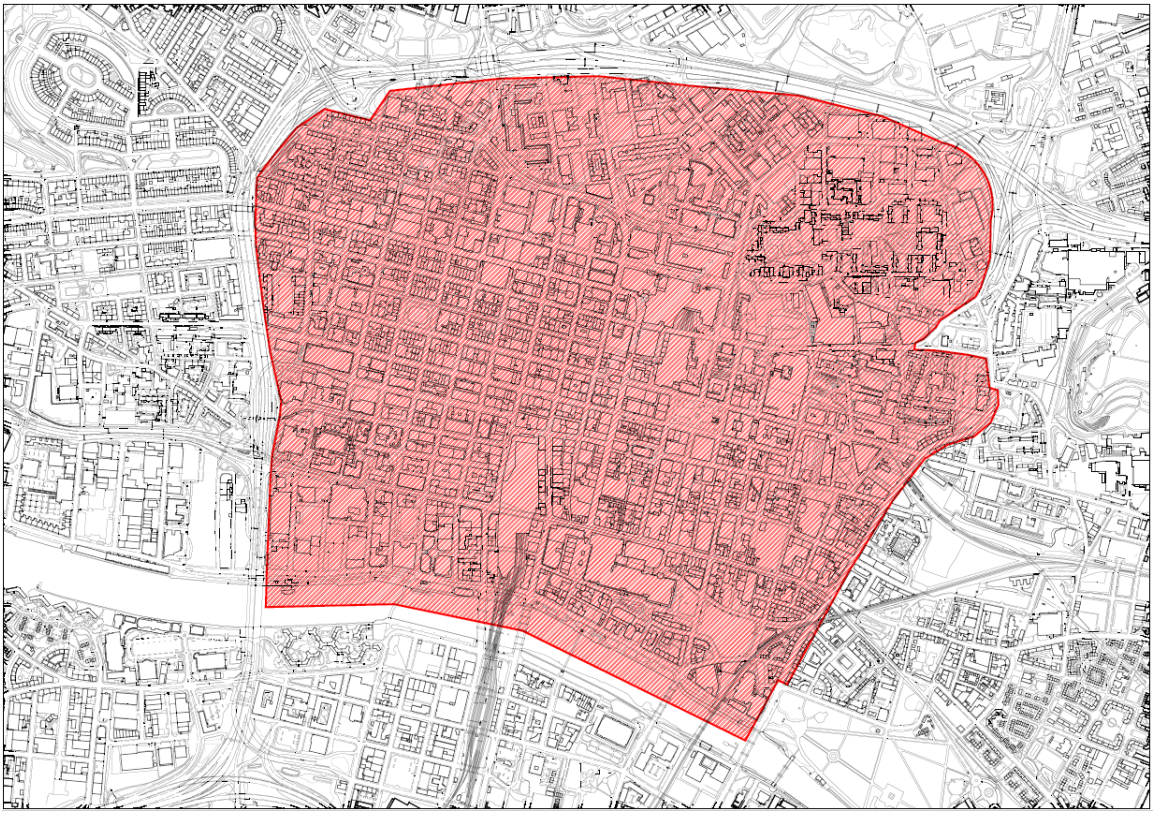

Figure 1. Glasgow LEZ1 Proposed Boundary

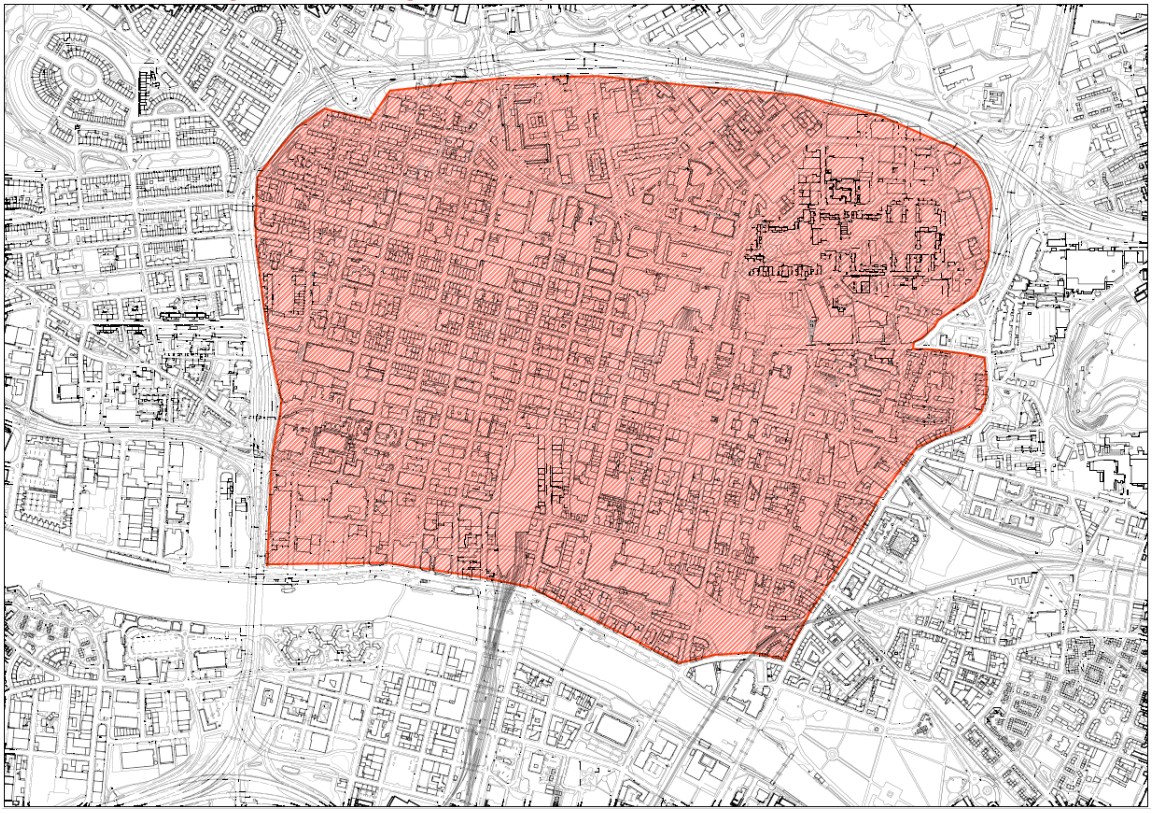

Figure 2. Glasgow LEZ2 Proposed Boundary

3. MODELLING APPROACH AND ASSUMPTIONS

3.1.1 The modelling required for the two proposed LEZ boundaries has two objectives:

- To understand the impacts of displaced vehicles on traffic conditions within the city centre and wider area
- To provide traffic flows for the city centre reflecting the proposed LEZ boundaries for input to the city centre air quality model

3.1.2 Whilst the coverage of the city centre Paramics model encompasses fully both proposed LEZ boundaries, the coverage does not include fully routes which non-compliant vehicles may be displaced onto. The modelling approach therefore utilises SRTM to consider the impacts of the LEZ on traffic conditions out with the city centre model area, and to establish changes to external movements within the Paramics model as a result of vehicles being displaced onto non city centre routes.

3.1.3 The basic assumptions agreed with GCC for the testing are as noted below:

- Operation of the LEZ to be considered for the first year of full enforcement, 2022
- All vehicles making trips starting and/or ending within the LEZ boundary are assumed to become compliant (non-compliant vehicles assumed to either become compliant, or be replaced by an equivalent compliant trip)
- All non-compliant vehicles assumed to adhere to the LEZ boundary, and re-route accordingly

3.1.4 GCC requested that the LEZ proposals would be tested using two differing vehicle fleet assumptions representing a likely best and worst case in terms of compliance levels . The fleet assumptions were provided by the Scottish Environmental Protection Agency (SEPA). Forecast fleets for 2020 and 2023 were provided, based on the latest available National Atmospheric Emissions Inventory dataset.

3.1.5 **Error! Reference source not found.** shows the forecast splits between Petrol, Diesel and Other engine types for the 2020 and 2023 fleets.

Table 1. Engine type splits for 2020 and 2023

	2020			2023		
	Petrol	Diesel	Other	Petrol	Diesel	Other
Car	51.8%	47.9%	0.3%	51.9%	47.5%	0.5%
LGV	2.2%	97.2%	0.4%	1.8%	97.2%	1.0%
HGV	0.0%	100.0%	0.0%	0.0%	100.0%	0.0%

3.1.6 Petrol and diesel engines have differing levels of compliance with the proposed LEZ regulations, which allow Petrol engines of Euro class 4 and above, and Diesel engines of Euro Class 6 and above. SEPA provided the percentage compliance of vehicles by engine type for 2020 and 2023, these are shown in Table 2. In addition it has been assumed that all 'Other' vehicle types (e.g. hybrid vehicles) are fully compliant in both years.

Table 2. Engine type compliance splits for 2020 and 2023

Vehicle Type	Engine Type	2020 Compliance %	2023 Compliance %
Car	Petrol	97.3%	99.6%
	Diesel	60.3%	78.1%
LGV	Petrol	95.2%	99.1%
	Diesel	63.6%	81.4%
HGV	Diesel	96.1%	98.8%

3.1.7 Combining the engine type splits and the compliance levels by engine type gives the overall compliance levels adopted by vehicle type shown in Table 3.

Table 3. Engine type compliance splits for 2020 and 2023

Vehicle Type	2020 Overall Compliance %	2023 Overall Compliance %
Car	79.6%	89.3%
LGV	64.4%	81.9%
HGV	96.1%	98.8%

4. SRTM LEZ TESTING

4.1.1 During the development of the Paramics model 2022 reference case network (see section 5), an SRTM network variant was developed including the committed infrastructure identified by GCC to be in place by the end of 2022. This network was adopted as a start point for the LEZ runs required.

4.1.2 The infrastructure included in this network is detailed in the reference case report (*Glasgow City Centre Paramics Model – Reference Case, SYSTRA, August 2019).* The schemes included are as noted below:

- Oswald Street Bus Gate – also permitting LGV, HGV and taxi
- Union Street Bus Gate – also permitting LGV, HGV and taxi
- Renfield Street bus improvements
- Hope Street bus improvements
- South City Way
- Argyle Street Avenue
- The Underline Avenue
- Sauchiehall Precinct Avenue
- Glasgow City Centre Paramics Model Reference Case
- Glasgow City Centre Paramics Model Reference Case GB01T19D20_RefCase
- Reference Case Model Development Report 27/08/2019 Page 13/20
- North Hanover Street/Kyle Street Avenue
- Cathedral Street to Bath Street Avenue
- Holland Street/Pitt Street Avenue
- Elmbank Street/Elmbank Crescent

4.1.3 Considering the requirement of the LEZ modelling to examine the worst case, short term impacts of the LEZ proposals (given that longer term responses such as fleet change and mode shift would likely result in improved traffic conditions and air quality from this point), highway assignment only runs were undertaken.

4.1.4 SRTM does not include a 2022 forecast year. Model runs were therefore undertaken for both the 2020 and 2027 forecasts, with the intention of combining the results appropriately to reflect 2022.

4.1.5 The 2022 and 2027 networks were amended to create LEZ variants, for both the 2020 and 2023 fleets, and for the two LEZ boundary options. This created 8 LEZ scenarios as below:

- 2020 LEZ Option 1, 2020 fleet assumptions
- 2020 LEZ Option 1, 2023 fleet assumptions
- 2020 LEZ Option 2, 2020 fleet assumptions
- 2020 LEZ Option 2, 2023 fleet assumptions
- 2027 LEZ Option 1, 2020 fleet assumptions
- 2027 LEZ Option 1, 2023 fleet assumptions
- 2027 LEZ Option 2, 2020 fleet assumptions
- 2027 LEZ Option 2, 2023 fleet assumptions

4.1.6 Demand associated with zones out with the LEZ boundaries was split into compliant and non-compliant vehicle types in consideration of the assumption that vehicles originating and/or destinating within the LEZ boundary would all become compliant.

4.1.7 Restrictions were coded to the networks to reflect the LEZ boundaries, and prevent the non-compliant vehicles from routeing through the LEZ area.

4.1.8 Initial runs of the AM and PM periods for each scenario were undertaken, and flow comparisons undertaken between each scenario and the reference case network for each year. These showed a negligible impact on flows in the wider area as a result of the addition of the LEZ restrictions, suggesting that the number of vehicles being displaced is relatively low.

4.1.9 The assumptions adopted mean that only non-compliant vehicles which previously routed through the LEZ area are displaced with the LEZ in place. To understand the number of vehicles being affected, cordon matrices for the LEZ boundaries were generated for the AM and PM peak hours for the basic reference case networks, and the total number of through trips identified. Applying the compliance levels to this number of trips establishes the total number of model trips affected by the LEZ boundaries. Table 4 details the results of this analysis.

Table 4. SRTM, LEZ boundary through trips

			Displaced		Displaced as % of LEZ trips	
	Total Trips	Through Trips	2020 Fleet	2023 Fleet	2020 Fleet	2023 Fleet
AM, Option 1 Boundary						
2020	14925	2552	518	295	3.5%	2.0%
2027	21234	2723	540	305	2.5%	1.4%
PM, Option 1 Boundary						
2020	16146	2842	587	328	3.6%	2.0%
2027	23632	3325	698	374	3.0%	1.6%
AM, Option 2 Boundary						
2020	13592	1526	284	168	2.1%	1.2%
2027	19561	2269	384	160	2.0%	0.8%
PM, Option 2 Boundary						
2020	14785	1732	319	181	2.2%	1.2%
2027	22021	2197	378	215	1.7%	1.0%

4.1.10 This analysis shows that of all trips associated with the LEZ boundaries, very few are through trips, and so the absolute number of vehicles being forced to re-route is relatively small, particularly given that these are spread around the LEZ boundaries, rather than focussed on one point.

4.1.11 The impact of displacing these non-compliant vehicles onto wider routes to avoid the LEZ area is therefore negligible in the context of considering wider impacts. As such, no further SRTM analysis was undertaken.

5. GLASGOW CITY CENTRE PARAMICS MODEL TESTING

5.1 Background

5.1.1 The 2022 Glasgow City Centre Reference Case Paramics Discovery model was used as a baseline for this testing. This model was developed in 2019 based on the 2017 Glasgow City Centre Paramics Model. Development of the Reference Case model is documented in *'Glasgow City Centre Paramics Model Reference Case – Model Development Report'*, August 2019 and of the Base model in *'Glasgow City Centre Base Paramics Model Development plus Scenario Testing – Model Development Report'*, November 2018.

5.1.2 The Glasgow City Centre Paramics Model is a microsimulation model, the coverage of which is shown in Figure 3.

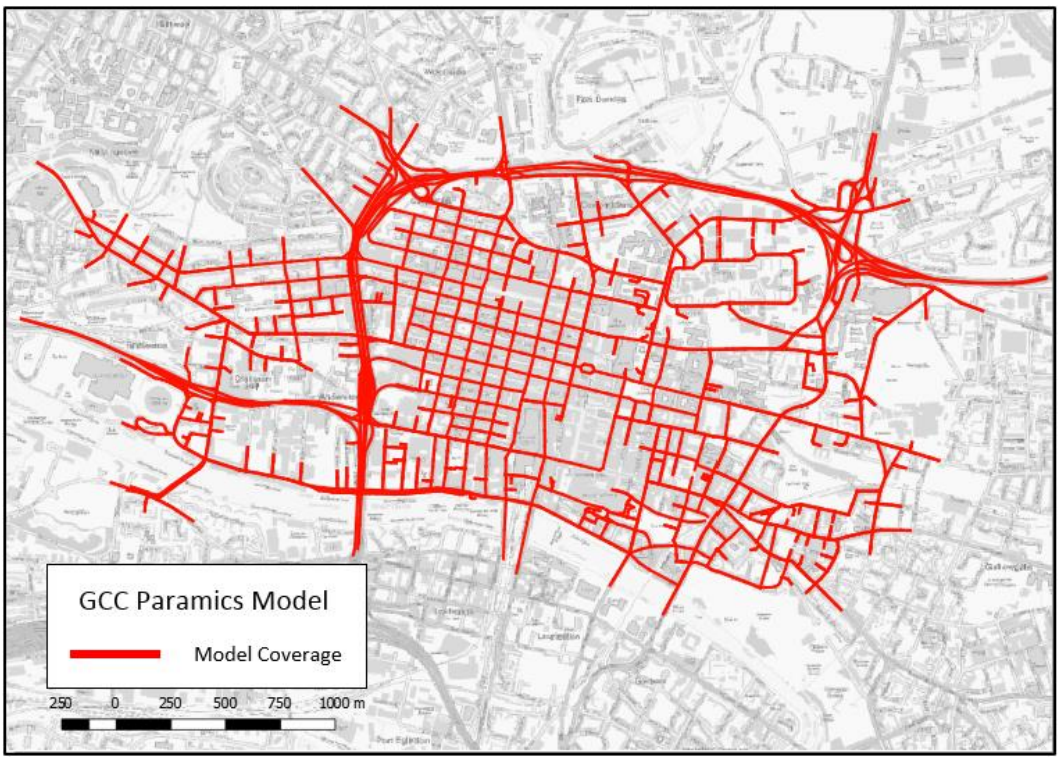

Figure 3. Model Coverage

5.1.3 For the purposes of this study, the Glasgow City Centre Paramics Model was used in this project to test the impacts of local rerouting in the model area resulting from the LEZ proposals.

5.2 LEZ Model Development

5.2.1 In order to test the LEZ proposals four test model variants were created based on the differing LEZ proposals and fleet forecasts;

- LEZ1 2020 fleet
- LEZ1 2023 fleet
- LEZ2 2020 fleet
- LEZ2 2023 fleet

5.2.2 As no significant rerouting out with the model area was found in the SRTM tests, no changes were made to the initial matrix totals.

5.2.3 In order to create the test models, the 2022 Reference Case model was used as a starting point. To create the LEZ test demand matrices, the Reference Case matrices were split out into Compliant and Non-Compliant Vehicle types based on the percentages provided by SEPA and shown in Table 3. It has been assumed that all vehicle trips which start and/or end their trip within the LEZ boundary are be made by compliant vehicles, as per the assumptions set out previously.

5.2.4 For comparison with the SRTM work, and to understand the volumes affected by the boundaries in the Paramics model, analysis was undertaken to establish the volumes of

car traffic associated with the boundaries, those routeing through, and the volume of through trips which would be non-compliant and thus displaced. Table 5 presents this information for car trips only, for the AM and PM periods.

Table 5. Paramics model, LEZ boundary through trips (car only)

			Displaced		Displaced as % of LEZ trips	
	Total Trips	Through Trips	2020 Fleet	2023 Fleet	2020 Fleet	2023 Fleet
AM, Option 1 Boundary	30948	5677	1159	608	3.7%	2.0%
PM, Option 1 Boundary	41425	6618	1351	709	3.3%	1.7%
AM, Option 2 Boundary	29629	3118	637	334	2.1%	1.1%
PM, Option 2 Boundary	39150	3162	646	339	1.6%	0.9%

5.2.5 The analysis shows, when the differences between peak hour and peak period numbers are accounted for, a broadly consistent proportion with SRTM of LEZ boundary trips being displaced due to non-compliance in each fleet assumption. This is to be expected – SRTM provided the trip distributions for the development of the Paramics model, and as such a consistent level of through trips within the area results.

5.2.6 As with SRTM, the absolute number of trips being affected is relatively low, especially when it is considered that these are spread around the boundary, and not concentrated.

5.2.7 Due to the proposed boundary of LEZ1 and the extents of the model, non-compliant through trips entering/exiting the model at King George V Bridge, Glasgow Bridge or Gorbals Street and some at Albert Bridge are not able to make their trip and as a result are assumed to reroute outside the model area, and thus have been removed from the model. The number of trips removed in LEZ1 2020 and LEZ1 2023 are shown in Table 6.

Table 6. Vehicle trips removed in LEZ1, all vehicle types

	LEZ1 2020 Trips Removed	LEZ1 2023 Trips Removed
AM	-584	-304
IP	-860	-447
PM	-587	-307

5.3 LEZ Test Model Findings

5.3.1 The LEZ test models were run 12 times for AM, IP and PM and the model runs were reviewed to ensure the operation was acceptable and any gridlocked runs were discarded. The outputs from the remaining runs were averaged and results were extracted.

5.3.2 A general network operational comparison is presented in 7, this shows the average speed of vehicles in the network across the whole modelled period in mph.

Table 7. Average Speed (mph)

	Ref Case	LEZ1 2020	LEZ1 2023	LEZ2 2020	LEZ3 2023
AM	14.2	14.1	14.3	13.5	14.5
IP	20.0	20.3	20.2	20.1	20.3
PM	9.0	8.8	8.6	8.6	8.6

5.3.3 Table 7 shows that there is little variation in average speed across the scenarios due to the small amount of rerouting traffic due to the LEZ proposals.

5.3.4 Journey time outputs were also extracted for key routes in the city centre. The journey time routes used match those used in the Base Model validation and were originally specified by GCC.

5.3.5 The routes used for comparison are:

- Route 1 – Sauchiehall Street/Bath Street Loop
- Route 2 – Argyle Street Loop
- Route 3 – New City Road/Cowcaddens Road
- Route 4 – Cathedral Street/North Hanover Street
- Route 5 – High Street/Saltmarket
- Route 6 – George Street/Ingram Street Loop
- Route 7 – Broomielaw/Clyde Street
- Route 8 – Renfield Street/West Campbell Street Loop
- Route 9 – Bothwell Street/Waterloo Street Loop
- Route 10 – St Vincent Street/West George Street Loop

5.3.6 The AM, IP and PM peak hour comparisons are shown in Tables 8-10.

Table 8. Journey Time Comparison AM 08:00-09:00

Route	RefCase	LEZ1 2020	LEZ1 2023	LEZ2 2020	LEZ2 2023
Route 1 Eastbound	177	174	174	175	176
Route 1 Westbound	209	205	210	214	211
Route 2 Eastbound	415	327	353	331	372
Route 2 Westbound	347	345	348	342	343
Route 2 Southbound	107	107	106	105	108
Route 3 Eastbound	361	357	355	356	356
Route 3 Westbound	367	373	365	364	374
Route 4 Eastbound	449	444	447	452	443
Route 4 Westbound	747	705	742	687	731
Route 5 Northbound	591	534	554	614	605
Route 5 Southbound	579	502	551	544	547
Route 6 Eastbound	573	536	561	522	585
Route 6 Westbound	194	186	187	185	188
Route 7 Eastbound	721	683	698	708	695
Route 7 Westbound	481	462	477	495	485
Route 8 Northbound	596	589	612	599	609
Route 8 Southbound	287	287	287	288	287
Route 9 Eastbound	88	87	88	86	87
Route 9 Westbound	142	140	140	143	141
Route 10 Eastbound	687	659	777	678	757
Route 10 Westbound	543	510	534	524	533
Route 10 Southbound	413	403	409	395	400

Table 9. Journey Time Comparison IP 1300-1400

Route	RefCase	LEZ1 2020	LEZ1 2023	LEZ2 2020	LEZ2 2023
Route 1 Eastbound	156	155	156	156	159
Route 1 Westbound	180	180	179	181	181
Route 2 Eastbound	164	163	162	165	160
Route 2 Westbound	327	322	324	324	326
Route 2 Southbound	57	55	56	55	56
Route 3 Eastbound	326	326	325	326	324
Route 3 Westbound	272	273	273	273	273
Route 4 Eastbound	462	460	451	451	458
Route 4 Westbound	397	387	393	385	391
Route 5 Northbound	405	406	405	415	413
Route 5 Southbound	373	358	368	370	368
Route 6 Eastbound	282	282	283	279	283
Route 6 Westbound	172	170	172	172	171
Route 7 Eastbound	527	538	539	526	525
Route 7 Westbound	438	445	443	441	437
Route 8 Northbound	525	521	519	530	518
Route 8 Southbound	277	275	279	278	279
Route 9 Eastbound	100	100	100	100	100
Route 9 Westbound	140	138	140	139	140
Route 10 Eastbound	626	596	568	616	614
Route 10 Westbound	321	317	317	320	319
Route 10 Southbound	366	355	359	364	362

Table 10. Journey Time Comparison PM 1700-1800

Route	RefCase	LEZ1 2020	LEZ1 2023	LEZ2 2020	LEZ2 2023
Route 1 Eastbound	174	174	188	189	183
Route 1 Westbound	337	313	344	336	331
Route 2 Eastbound	976	834	930	1083	1062
Route 2 Westbound	498	463	481	502	501
Route 2 Southbound	126	110	119	127	122
Route 3 Eastbound	479	471	490	490	487
Route 3 Westbound	335	325	353	351	361
Route 4 Eastbound	753	757	815	734	749
Route 4 Westbound	722	704	825	707	704
Route 5 Northbound	536	571	562	546	591
Route 5 Southbound	430	410	432	426	429
Route 6 Eastbound	455	459	469	472	471
Route 6 Westbound	231	246	251	236	244
Route 7 Eastbound	818	714	768	960	964
Route 7 Westbound	646	561	613	695	683
Route 8 Northbound	801	814	820	795	791
Route 8 Southbound	454	449	462	465	461
Route 9 Eastbound	143	167	151	148	157
Route 9 Westbound	422	443	382	407	470
Route 10 Eastbound	963	810	901	855	948
Route 10 Westbound	761	708	783	791	785
Route 10 Southbound	411	392	427	451	446

5.3.7 Overall the results show very little impact on the journey times across the city. Some routes adjacent to the LEZ boundaries do exhibit increases in journey times in some periods (for example Route 2 Eastbound in the PM under LEZ2), however it is possible that these impacts could be reduced through signal optimisation or other localised improvements to the road network.

6. SUMMARY AND CONCLUSIONS

6.1 Summary

6.1.1 SYSTRA Ltd. (SYSTRA) was commissioned by Glasgow City Council (GCC) to test the traffic related effects of the proposed Low Emission Zones (LEZ) in Glasgow City Centre. This testing was to be carried out using both the Strathclyde Regional Transport Model (SRTM) and the Glasgow City Centre Paramics Discovery Model.

6.1.2 LEZ test models were created using SRTM to test the impacts of the proposals on the wider area.

6.1.3 Due to the low level of non-compliant vehicles, the SRTM testing showed that the LEZ proposals had a negligible impact on the wider area.

6.1.4 The LEZ Paramics model tests were developed based on the 2022 Reference Case Model and were developed for two test years 2020 and 2023 with differing compliance levels between the two years.

6.1.5 Network average speed and localised average journey times results were extracted from the models for the Reference Case and LEZ test models.

6.1.6 The results showed some local variation in journey times for areas around the LEZ boundaries but little overall effect on the operation of the model area as a whole with the LEZ proposals in place. It is suggested that consideration is given to examining localised optimisation for the preferred boundary option in any follow up work.

6.2 Conclusions

6.2.1 Based on the assumptions used in this testing, the LEZ proposals have little overall effect on traffic operation in either the wider Glasgow area or in the City Centre.

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