Birmingham Clean Air Zone Feasibility Study - Future Year Traffic Modelling

David Harris

Report
June 2018

Our ref: 23013602

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Executive Summary

Overview

As one of the local authorities identified in the UK Plan for Tackling Roadside Nitrogen Dioxide Concentrations[1], the Government has directed Birmingham City Council (BCC) to develop a plan to deliver compliance with legal limits for nitrogen dioxide in the shortest possible time, as locations in the City exceed legal levels of NO2. The legal limits for all the road links with public access meet the following air quality (AQ) limits are as follows:

Figure1: Statutory limit values for NO2[2]

Averaging period	NO_2 limit value[10]
One hour	200 $\mu g/m^3$ not to be exceeded more than 18 times a calendar year
Calendar year	40 $\mu g/m^3$

To support the delivery of legal clean air levels, in May 2017 the Government published the Clean Air Zone Framework[3] which sets out the general principles for the operation of Clean Air Zones in England. For authorities that adopt Clean Air Zones (CAZ), they have the option to implement a charging CAZ, where the more polluting vehicle types must pay a charge to enter the zone. There framework sets out four levels of CAZ:

- Class A - Buses, coaches, taxis and private hire vehicles (PHVs)
- Class B - Buses, coaches, taxis, PHVs and heavy goods vehicles (HGVs)
- Class C - Buses, coaches, taxis, PHVs, HGVs and light goods vehicles (LGVs)
- Class D - Buses, coaches, taxis, PHVs, HGVs LGVs and cars

The Framework also sets out the minimum classes and emission standards required for entry into a charging zone without paying a charge. Compliance standards for different vehicle types are shown in Table 1.

Table 1: Compliant Vehicles[4]

Vehicle	Petrol	Diesel
Car	Euro Class 4 and above	Euro Class 6 and above
Taxi	Euro Class 4 and above	Euro Class 6 and above
Light Goods Vehicle	Euro Class 4 and above	Euro Class 6 and above
Heavy Goods Vehicle		Euro Class 6 and above
Bus/ Coach		Euro Class 6 and above

[1] UK Plan for tackling roadside nitrogen dioxide concentrations, DEFRA/ DfT, 2017

[2] Air Quality Standards Regulations 2010

[3] Clan Air Zone Framework, DEFRA/ DfT, 2017

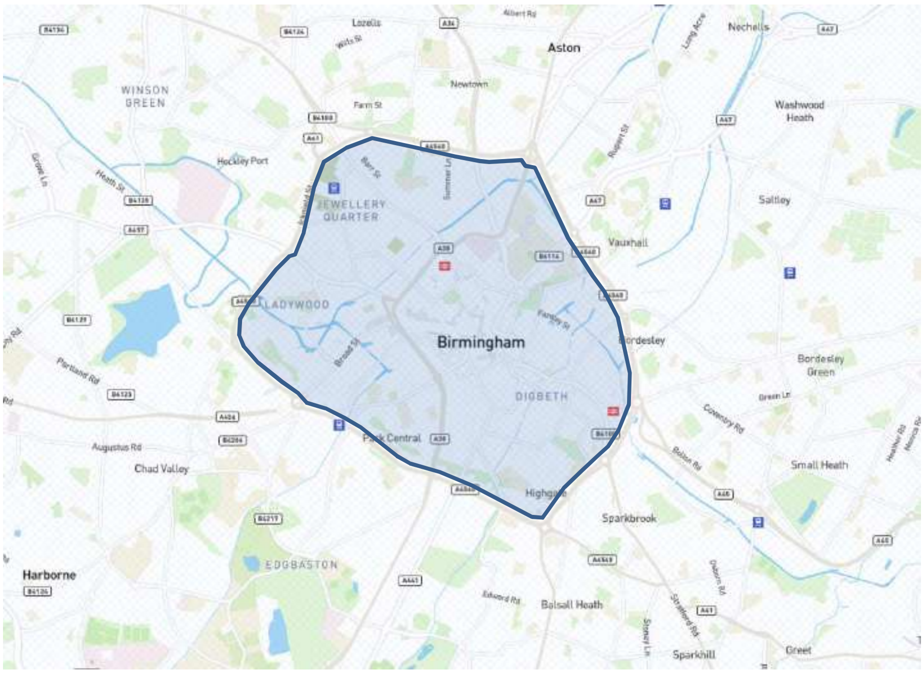
[4] Clan Air Zone Framework, DEFRA/ DfT, 2017

Given the exceedance levels in Birmingham CAZ C and D charging scheme has been developed. The following CAZ charging scenarios have been tested, with non-compliant vehicles crossing the Inner Ring Road towards the City Centre charged the following:

Table 2: CAZ Charging Levels Tested in the Traffic Models

CAZ	CAZ C			CAZ D		
	Low	Medium	High	Low	Medium	High
Car	£0.00	£0.00	£0.00	£2.00	£6.00	£12.50
Taxi	£2.00	£6.00	£12.50	£2.00	£6.00	£12.50
LGV	£2.00	£6.00	£12.50	£2.00	£6.00	£12.50
HGV	£25.00	£50.00	£100.00	£25.00	£50.00	£100.00
Bus/ Coach	£25.00	£50.00	£100.00	£25.00	£50.00	£100.00

Figure 2: CAZ Charing Cordon



Additional Measures

Measures to improve the air quality other than charging non-compliant vehicles have also been tested and are reported here.

Outline Business Case

This report includes a description of the schemes/ options included in the outline business case (OBC) and the impact on traffic in Birmingham.

Transport Model

To support the development of the CAZ a traffic model has been developed to provide traffic flows and speed data into the Air Quality (AQ) model, as well as supporting other assessments of the CAZ, such as the economic assessment. The model has been developed to forecast 2020 conditions without a CAZ, and to test the impact of various CAZ measures on traffic. The model outputs are used to assess the extent to which CAZ policies can solve Birmingham's clean air problem. Outputs from the model are used:

- To forecast compliant/ non-compliant link flows so that the AQ model can demonstrate levels of compliance
- Inputs into the impact assessment (IA) to show the cost benefit analysis (CBA) of the scheme and the distributional impacts.

This modelling methodology applied is based on that outlined in 'Birmingham Clean Air Zone - Model Development'[5] report issued to JAQU in September 2016, with further refinements as new guidance has emerged.

Modelling Tools

The main tools used in forecasting traffic flows in 2020 are as follows:

Table 3: Data/ Modelling Tools

Source	Description
BCC SATURN Model	SATURN assignment model: • 2016 base year and 2020 with and without CAZ scenarios • AM, IP and PM peak weekday periods • Car (taxis included in 2020 scenarios), LGV, HGV and Bus User Classes, split into compliant and non-compliant. • Covers CAZ zone in detail, with network covering the "motorway box". Much of the network outside the CAZ is fixed speed (approx. 2km from ring road) • Feeds traffic link flow data into the air quality models
PRISM Demand Model	Regional demand model covering the West Midlands, maintained by Mott MacDonald on behalf of Transport for the West Midlands, BCC and other stakeholders. Inputs from PRISM are: • Base year prior matrices • Traffic Growth from PRISM, having been updated with TEMPRO V7.0 demographic data (with post model adjustments to account for v7.2 changes). TEMPRO is a DfT software that provides data from their National Trip End Model (NTEM). • To calculate non-route choice responsiveness to charging
ANPR Surveys	A large programme of ANPR surveys carried out in the CAZ area. This has been used to: • Validate base year through trip proportions • Calculate Euro Class fleet mix
TfL Ultra Low Emission Zone (ULEZ) Behavioural Research	TfL carried out a stated preference survey on car drivers in the extended ULEZ area covering an area not in the current congestion charging zone. Used to forecast vehicle upgrade rates from CAZ charging.
WebTAG	Modelling follows WebTAG guidance and uses various data sources
JAQU Guidance	JAQU guidance and data sources used as appropriate

Base Year Model

The forecasting is built off the 2016 base year BCC SATURN model, which has recently been calibrated to 2016 data. The 2016 model results have been reported to JAQU in the 'Birmingham City Centre Clean Air Zone - Transport Model review' issued in August 2017. The

[5] Birmingham Clean Air Zone Feasibility Study - Future Year Traffic Modelling, Steer Davies Gleave, October 2016

model was passed as fit for purpose by JAQU for the forecasting stage, with some questions/ caveats which have been responded to.

2020 Do Minimum

Network

Changes to the highway network have been and are due to be implemented between 2016 and 2020. These changes, which are focused on the City Centre CAZ area were agreed with BCC highways and transportation team and coded into the highway model. Discussions with Highways England indicated that there would not be any significant changes to the strategic road network that would affect the CAZ, so no adjustments were made to the regional motorway network.

Growth

The PRISM model's forecast of traffic growth has been used for background traffic growth. It has been recently updated with TEMPRO V7.0 demographic forecasts, and the latest development locations and network assumptions. A minor adjustment was made to account for changes between TEMPRO V7.0 and V7.2.

The sites of specific major developments within Birmingham were agreed with BCC development planners. A process has been devised to ensure the demand from these developments is loaded in the correct locations, while also ensuring that there is no double counting of developments already included in PRISM. The table below shows the overall growth rates that resulted from this process. Taxi are included within the car vehicle class in PRISM and are then split based on observed proportions from the ANPR survey in the BCC model.

Table 4: BCC Growth 2016 - 20202

Sector	AM Peak			Inter Peak			PM Peak		
	Car/ Taxi	LGV	HGV	Car/ Taxi	LGV	HGV	Car/ Taxi	LGV	HGV
City Centre	7.9%	10.8%	3.5%	8.0%	10.8%	3.6%	7.4%	10.8%	3.6%
Rest of Birmingham	3.7%	10.7%	3.2%	3.7%	10.7%	3.1%	3.7%	10.7%	3.1%
Birmingham (Total)	**4.2%**	**10.7%**	**3.2%**	**4.2%**	**10.7%**	**3.2%**	**4.1%**	**10.7%**	**3.2%**
Rest of West Midlands	4.4%	10.6%	2.9%	5.3%	10.7%	2.9%	4.6%	10.8%	3.0%
Total	**4.3%**	**10.7%**	**3.0%**	**4.7%**	**10.7%**	**3.0%**	**4.4%**	**10.7%**	**3.0%**

Compliance

JAQU guidance on forecasting future year compliance rates was followed. This involved using the existing age profile of vehicles derived from the ANPR survey and deriving new compliance rates assuming the overall age profile remains constant. An additional adjustment was made increasing the diesel car fleet in line with JAQU guidance.

Table 5: 2016 and 2020 Do Minimum Compliance Rates

Vehicle	Compliance Status	2016	2020
Car/ PHV	Compliant	55%	77%
Car/ PHV	Non-Compliant	45%	23%
LGV	Compliant	23%	59%
LGV	Non-Compliant	77%	41%
HGV	Compliant	34%	61%
HGV	Non-Compliant	66%	39%
Bus	Compliant	38%	60%
Bus	Non-Compliant	62%	40%
Taxi	Compliant	17%	29%
Taxi	Non-Compliant	83%	71%

CAZ Charging

A methodology was developed in consultation with JAQU to model the various expected responses to charging as shown in Table 6.

Table 6: CAZ Responses

Hierarchy	Response	Method
1	Upgrade to compliant/ switch to already owned compliant vehicle (for households with more than one car)	Choice Modelling based on TfL Stated Preference Research for Cars and LGV Taxis and buses assumed to upgrade through licencing agreements HGVs users value for money over 5 years period on whether to upgrade
2 (Car only)	Cancel – do not make a journey	Elasticity to charge derived from PRISM run to apply to Do Minimum trips to/ from the City Centre.
	Change Mode to non-highway PT/ Walk/ Cycle option	
	Avoid (Change destination from City Centre to non-City Centre trips)	
	Pay (with a city centre origin/ destination)	
3	Avoid (through trips change route to non-City Centre route).	BCC CAZ assignment model to forecast diversion due to charge for through trips.
	Pay (through trips use City Centre)	

Additional Measures

As part of the OBC preferred option a number of additional measures have been selected to include in the CAZ D and CAZ D high charge scenarios, and included in the final version of the model to feed into the air quality model and economic assessment. Table 7 shows the measures included.

Table 7: CAZ Responses

Type	Summary
Fleet (low emission)	Increase LPG refuelling for Hackney Carriages and the installation of rapid EV infrastructure for taxi and private hire vehicles. Retrofitting of black taxis to LPG **Assumptions tested:** • 85 taxis upgraded to Electric vehicle • 441 PHVs upgraded to Electric Vehicle • 65 taxis retrofitted to LPG
	Zero emission buses (new Hydrogen buses)
Parking	Remove all free parking from BCC controlled areas. Replaced with paid parking spaces. Assume cost of parking in line with BCC off-street parking.
Network Changes	Ban traffic entering (SB) or leaving (NB) Suffolk Street Queensway (A38) from Paradise Circus, other than local access.
	Close Lister Street and Great Lister Street at the junction with Dartmouth Middleway. This allows, more green time for the A4540.

CAZ OBC Results

Table 7 below shows the reduction in non-compliant vehicles in the clean air zone as a result of the OBC CAZ C with Additional Measures scheme, and Table 8 the impact on daily flows entering the CAZ zone.

Table 7: CAZ C Overall Non- Compliant Vehicle Change Percentage

Charge	Car	LGV	HGV
CAZ C High OBC Results	-1%	-61%	-96%

Table 8: 2020 CAZ C Annual Average Daily Flows – Entering the Clean Air Zone

Do Minimum	Car	Taxi/ PHV	LGV	HGV	Bus	Total
Compliant	125,900	2,700	13,100	4,600	3,300	149,500
Non-compliant	37,100	6,500	9,100	2,500	2,200	57,400
Total	163,000	9,200	22,200	7,000	5,500	206,900
OBC	**Car**	**Taxi/ PHV**	**LGV**	**HGV**	**Bus**	**Total**
Compliant	122,600	9,500	17,200	6,700	5,500	161,500
Non-compliant	36,800	-	3,600	100	-	40,500
Total	159,400	9,500	20,800	6,800	5,500	201,900

Table 9 below shows the reduction in non-compliant vehicles in the clean air zone, as a result of the OBC CAZ D with Additional Measures scheme, and Table 10 the impact on daily flows entering the CAZ zone.

Table 9: Overall Response Reduction CAZ D

	Car	LGV	HGV
CAZ D High OBC	-92%	-61%	-96%

Table 10: 2020 CAZ D Annual Average Daily Flows – Entering the Clean Air Zone

Do Minimum	Car	Taxi	LGV	HGV	Bus	Total
Compliant	125,900	2,700	13,100	4,600	3,300	149,500
Non-compliant	37,100	6,500	9,100	2,500	2,200	57,400
Total	163,000	9,200	22,200	7,000	5,500	206,900
OBC	**Car**	**Taxi**	**LGV**	**HGV**	**Bus**	**Total**
Compliant	142,700	9,500	17,200	6,700	5,500	181,500
Non-compliant	2,900	-	3,600	100	-	6,600
Total	145,600	9,500	20,800	6,800	5,500	188,100

Report Structure

This report describes the modelling in more detail and is structured as follows:

- Chapter 1: Do Minimum Without CAZ Scenario Model Development – Describes the process in creating the 2020 without CAZ scenario
- Chapter 2: Do Something With CAZ Charging Scenario Model Development - Describes the process to forecast the impact of charging non-compliant traffic
- Chapter 3: Do Something With CAZ Additional Measures Scenarios Model Development - Describes the methodology to test additional measures.
- Chapter 4: Results – Presents analysis of the model results and the impacts on the highway network
- Chapter 5: Summary – A summary of findings, caveats and potential next steps

1 Do Minimum Without CAZ Scenario Model Development

Overview

1.1 This chapter describes the process of updating the model from 2016 to 2020 to produce a baseline without CAZ scenario (Do Minimum)

Network

1.2 The highway network was updated with proposed changes to the highway network between 2016 and 2020.

City Centre

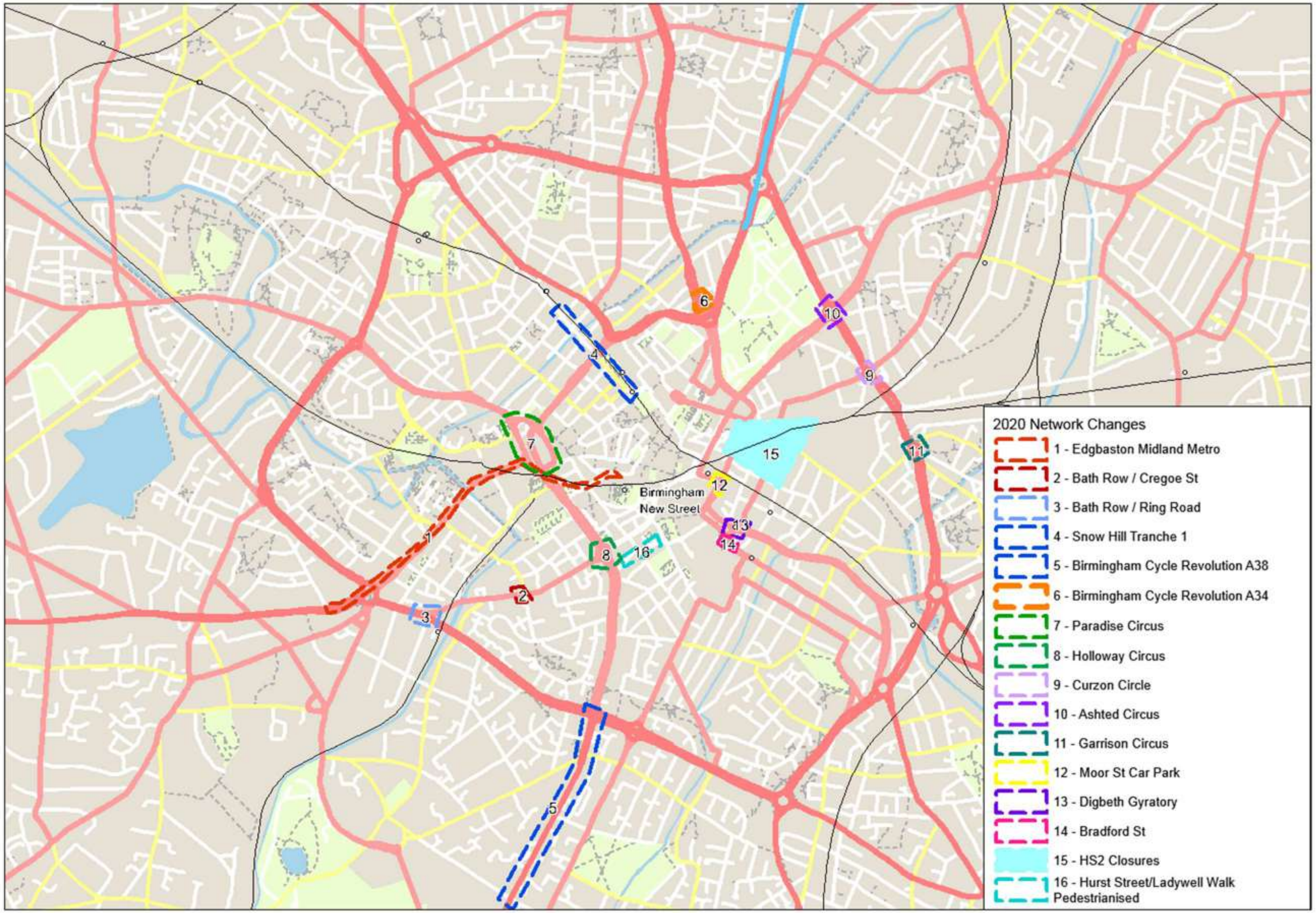
1.3 The majority of changes to the highway network are focused on the City Centre within the CAZ zone or on the A4540 inner ring road. A list of schemes to be included was agreed with BCC streets team and are described in Table 1.1 and shown on the map in Figure 1-1 below. Given the short timescales all schemes are certain or near certain. However, it should be noted that several schemes are in development in the City Centre, so additional schemes may be implemented before 2020, and there may be a requirement to update the model as the project develops.

Table 1.1: City Centre Network Schemes

Scheme ID	Scheme Name	Description
1	Midland Metro (Centenary Sq. / Edgbaston)	Extension of the metro line from Grand Central to Centenary Square and Edgbaston (Hagley Road) via Broad Street with associated re-routeing of private vehicles. Grand Central to Centenary Square will be complete by 2020. Centenary Square to the Five Ways junction will be under construction, with the assumption, taken that the highway impacts will affectively be the same as when the Metro is in operation.
2	Bath Row / Cregoe St	Signalisation of junction to complement Midland Metro works
3	Bath Row / Ring Road	Signalised right turn from Bath Row onto A4540 Ring Road.

Scheme ID	Scheme Name	Description
4	Snow Hill Tranche 1	Closure of right turn from Livery Street to Colmore Row with changes to lane allocations, re-routeing of bus routes and reconfiguring junctions. Livery Street partially made 2-way and bus gate added on Lionel Street.
5	Birmingham Cycle Revolution A38 Improvements	Changes to several junctions including addition of right turn from Bristol Road to Wellington Road and southbound lane reallocation at Lee Bank Middleway Junction. Conversion of Wrentham Street to a 1-way arrangement and Gooch Street to a 2-way arrangement.
6	Birmingham Cycle Revolution A34 Improvements	Narrowing of Newtown Row northbound exit from Lancaster Circus junction. Majority of other scheme works are offline.
7	Paradise Circus	Temporary construction traffic management arrangement re-coded to represent final arrangement, opening access up to Spring Hill and including new access points for underground car park. Broad Street re-opened to buses.
8	Holloway Circus	Installation of a left slip road on the Holloway Head approach.
9	Curzon Circle	Part of HS2 mitigation. Roundabout removed and replaced with signalised junction. Signal staging timings based on designs provided by HS2.
10	Ashted Circus	Roundabout removed and replaced with signalised junction.
11	Garrison Circus	Part of HS2 mitigation. Roundabout removed and replaced with signalised junction. Signal staging timings based on designs provided by HS2.
12	Moor St Car Park Left Turn Only	Left turn only out of Moor St car park.
13	Digbeth Gyratory SE Loop	Bus only turn implemented banning eastbound general traffic from turning right towards Barford Street.
14	Bradford St	Right turn into Barford Street removed.
15	HS2 Closures	Road closures associated with HS2 Curzon Street Station. Includes partial removal of Park Street, Fazeley Street, Banbury Street. Under construction, but closures relating to
16	Hurst Street/Ladywell Walk – Pedestrianised (Follow on from the closure of Hurst Street)	This includes the reversal of Thorpe Street direction.

Figure 1-1: Network Schemes



External Fixed Speed Network

1.4 The fixed speed network has been updated using assumptions of changes in average speeds on the network, using the same approach as in the BCC 2026 model updated, where “changes have been applied based on the proportional change in average speed taken from NRTF core scenario 1 for the West Midlands”[6]. The table below shows the assumed reduction in speeds of 5% which was applied to the 2016 model speeds. It should be noted that the speeds shown are those from the NRFT data used to calculate the adjustment factor rather than the actual modelled speeds in the study area.

Table 1.2: Change in Average Speeds derived from the NRTF data

Year	Average Speed in NRTF
2016	31.9 kph
2020	30.3 kph
% Change 2016-20	-5%

Highways England

1.5 We have discussed with HE whether there any changes or planned roadworks to the strategic network are likely to have an impact on traffic flows in Birmingham. Our understanding, based on the table of assumptions describing the Smart Motorways Programme (SMP) including ‘start of works’ and ‘open for traffic’ dates for the SMP programme is that these works will not affect Birmingham in 2020, as they either occur post 2020 or is geographically out of scope for this study.[7]

1.6 Road schemes that are proposed to be in construction in the period from the end of 2020 are:

- M40-M42 Interchange
- M5/M42 Birmingham Box 4

1.7 While these roads are on the Birmingham Motorway Box, they are some miles outside of Birmingham and to the south where there are less air quality issues. The roadworks are therefore not likely to have any impacts on air quality within Birmingham, but we will work with HE to ensure that any issues with these roadworks are considered when implementing the scheme.

Assignment Parameters

1.8 WebTAG guidance on adjusting values of time and vehicle operating costs were applied to the 2016 values. The updates follow guidance in Unit 3.5.6/ Unit A 1.3 and the associated databook from the July 2017 release v1.8[8]. The 2016 and adjusted 2020 values as input into the BCC model are shown in Table 1.3 and Table 1.4.

Table 1.3: 2016 and 2020 Values of Time in Pence per Minute

User Class	AM		IP		PM	
	2016	2020	2016	2020	2016	2020

[6] Birmingham City Centre Model Traffic Forecasting Report Birmingham City Council 5 May 2017

[7] “PROGRAMME SCHEDULE OVERVIEW”, attached in email from HE 09/08/2017

[8] WebTAG Databook, A1.3.2, A1.3.11 and A1.3.11, July 2017

Car Business/ Taxi	30.20	31.57	30.90	32.30	30.63	32.02
Car Other	17.30	18.09	15.70	16.41	17.29	18.07
LGV	21.30	22.27	21.30	22.27	21.34	22.31
HGV	43.30	45.27	43.30	45.27	43.34	45.31

Table 1.4: 2016 and 2020 Vehicle Operating Costs in Pence per Kilometre

User Class	AM		IP		PM	
	2016	2020	2016	2020	2016	2020
Car Business/ Taxi	15.20	14.94	15.20	14.94	15.20	14.94
Car Other	6.83	6.63	6.83	6.63	6.83	6.63
LGV	14.19	14.44	14.19	14.44	14.19	14.44
HGV	49.32	51.54	49.32	51.54	49.32	51.54

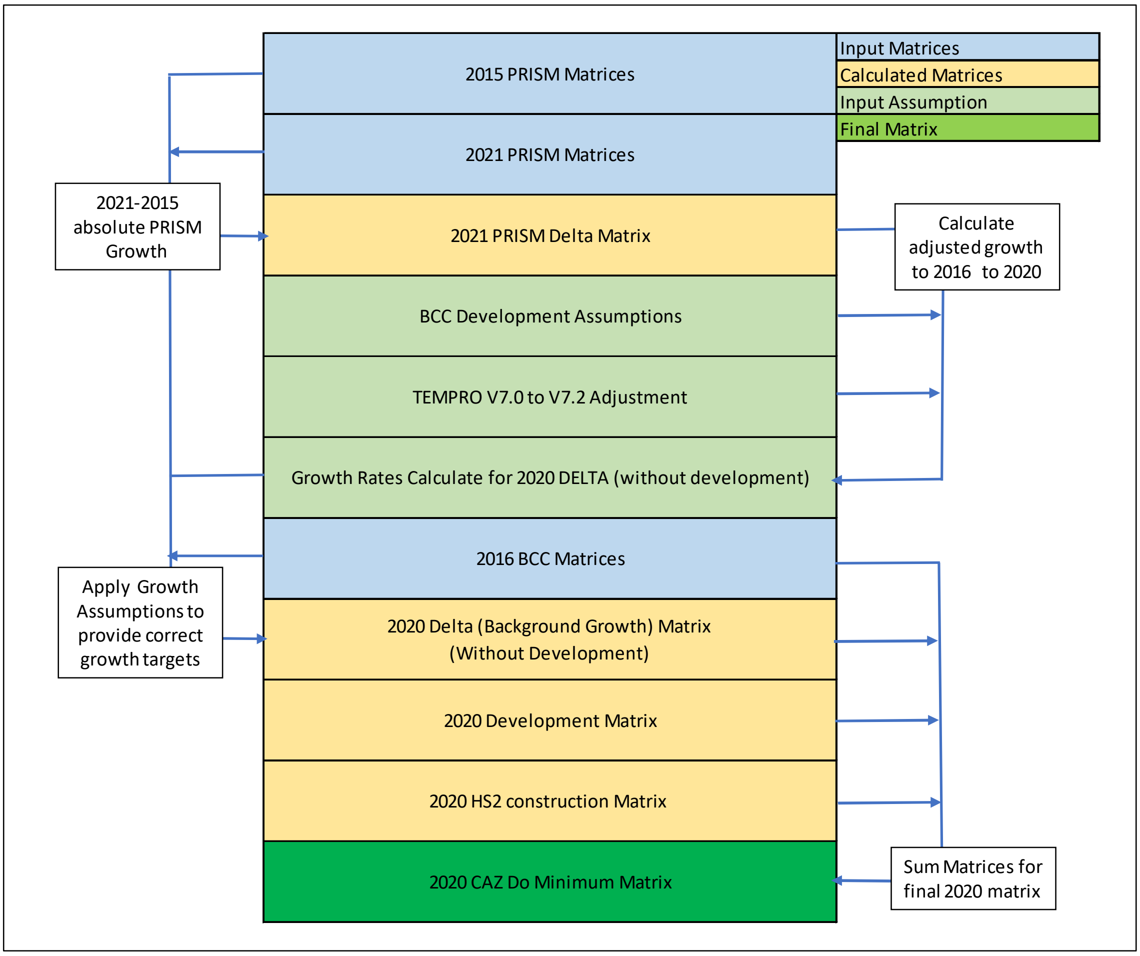
Traffic Growth

Method

1.9 Figure 1-2 below gives an overview of the methodology applied to produce the 2020 CAZ Do Minimum matrices. This involves the following steps which are described in more detail below:

- Creating a delta matrix by subtracting the 2015 PRISM matrices from the future 2021 PRISM matrices.
- Calculating the compound annual growth rates (CAGR) at a sector level and adjusting the overall growth to represent 2016 to 2020 levels.
- Ensuring that specific major development's traffic demand, are located in the correct places
- Include traffic related to HS2

Figure 1-2: Traffic Growth Methodology



PRISM Delta Matrix

1.10 Overall traffic growth is derived from the regional PRISM[9] model. The PRISM model is a full demand model forecasting the growth in journeys across all modes and has been used on major scheme bids in the West Midlands and by Transport for the West Midlands in their regional planning. PRISM has the following advantages:

- WebTAG compliant demand model, including forecasts of mode share
- Recently updated using planning data from TEMPRO version 7.0
- Areas of new developments are more spatially accurate than TEMPRO
- Provides consistency with the CAZ forecasting, which uses behavioural responses to user charging in PRISM.

1.11 The Delta Matrix is created by subtracting the 2015 matrix from the 2021. This creates the absolute growth to 2021 as forecast by the PRISM model. However further processing is required to ensure that the growth forecasts represent a 2016 to 2020 period and that the development trips are included in the correct locations.

[9] http://217.206.77.231/prism/pages/About.aspx

Background Growth

1.12 As described above the overall growth has been implemented using a pivot point/ delta approach, by applying the growth implied by the PRISM forecast 2021 (*Sf*) and base 2015 (*Sb*) year matrices to the CAZ model 2016 base year matrices (*B*) to estimate the 2020 forecast year matrices (*F*). This includes a linear adjustments (*a*) to reflect that the base and future year of the CAZ model is different from the PRISM forecast year, and to reflect that PRISM was updated using TEMPRO V7.0 rather than V7.2. The exact calculations followed the formula shown below.

$$F = B \times \frac{S_f}{S_b} \times a$$

1.13 To ensure that development trips are located in the correct locations, a separate process was undertaken to derive demand related to specific development sites (described below in this chapter). Where developments had been included in PRISM trips were removed and the overall growth scaled so that it equals the correct level once the development trips are added back in.

1.14 As mentioned above the starting PRISM year is 2015 compared to the BCC base of 2016. Therefore, analysis of TEMPRO was carried out to check growth between 2015 and 2016 before applying the adjustment. Growth rates in TEMPRO v7.2 indicated that car traffic remained flat between 2015 and 2016 in Birmingham.

1.15 To address the flat traffic growth, a new growth rate was calculated assuming that the demand matrices would remain at the same level between 2015 and 2016. Therefore, the annual growth rates were calculated over a 5-year rather than a 6-year period, but assuming the overall growth would get to the same level by 2021, although starting from 2016.

1.16 LGV and HGV growth is assumed to be less volatile and therefore the growth rates were applied directly with no similar adjustment made to these vehicle classes.

TEMPRO V7.0 to V7.2 Adjustment

1.17 An additional adjustment factor was applied to the demand based on the difference in the planning data between the two versions of TEMPRO, to ensure the overall model growth is reflecting the latest government forecasts. We extracted the data from TEMPRO, as shown in Table 2 below, which shows the difference in growth rates between the two versions. To adjust the demand, we took a simplified approach and factored down the demand by 0.2% across the model.

Table 1.5: Difference in Growth Rate 2015 to 2021 for Population and Workers (TEMPRO V7.0 to V7.2)

Sector	Population	Workers
City Centre	-0.2%	-0.7%
Birmingham West (3)	-0.2%	-0.7%
Birmingham North (4)	-0.2%	-0.7%
Birmingham South West (5)	-0.2%	-0.8%
Birmingham East/South East (6)	-0.2%	-0.7%
Total	-0.2%	-0.7%

Developments

1.18 To verify the locations of growth implied by PRISM matrices on the CAZ model future growth, the distribution of incremental trip ends during the modelled periods was compared against trip generation data from city centre developments.

1.19 While producing the 2026 BCC model, Atkins went through an exercise of reviewing transport assessments (TA) to derive the incremental demand for the various developments in Birmingham. These were reviewed by ourselves and BCC development planners who confirmed which developments should be included in the model by 2020 (given the short timescales to 2020, only those developments considered to be 'near certain' are included).

1.20 Adjustments were made during the process to ensure that the development trips were incorporated correctly:

- Where new developments replace existing sites, trips related to the old developments were removed from the new target totals.
- Comparisons were made against the PRISM matrix growth in the development locations with trips removed from the Delta matrix so that these locations were not overloaded by double counting the sites trip generation.

1.21 The total trips derived for each employment and residential site are shown in two tables on the following page respectively, and their locations in Figure 1-3 (sites 20 and 21 are related to HS2 construction and are discussed later in the chapter). In creating the development matrix, the distribution for the development sites were taken from the 2026 BCC model, which are based on the distribution of similar neighbouring land uses.

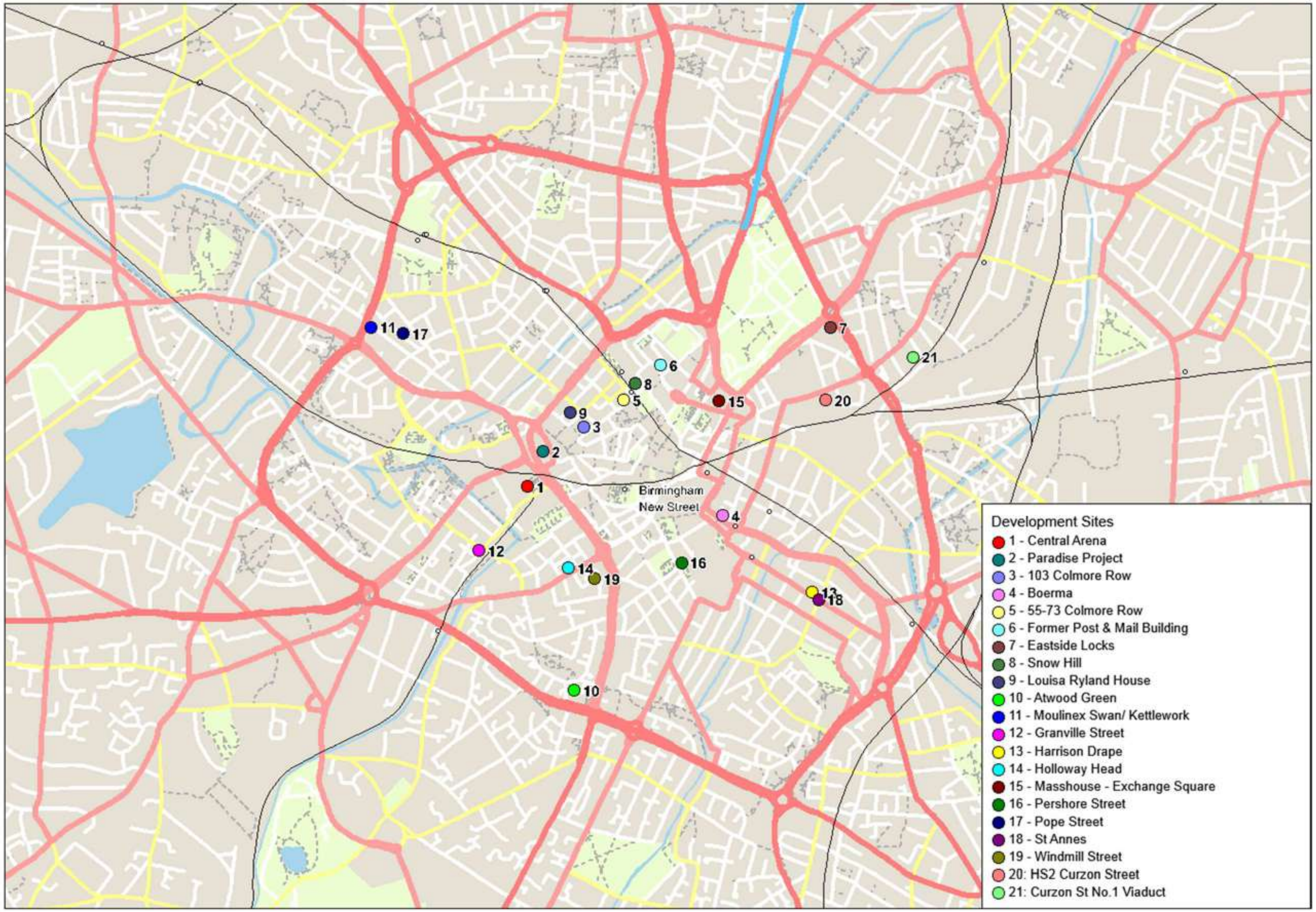
Table 1.6: Developments' Employment Vehicle Trips

Development Site	Map ID	AM Peak		Inter Peak		PM Peak	
		In	Out	In	Out	In	Out
ARENA CENTRAL PLOT D	1	83	5	4	3	6	66
ARENA CENTRAL PLOT A	1	86	5	4	3	6	68
ARENA CENTRAL PLOT C	1	128	8	6	5	9	102
PARADISE PROJECT	2	468	42	61	25	93	419
103 COLMORE ROW	3	161	31	46	38	38	136
55-73 COLMORE ROW	5	35	22	30	26	26	39
'BOERMA' - PHASE 2	4	9	2	4	3	3	7
FORMER POST & MAIL BUILDING	6	161	32	22	19	33	134
EASTSIDE LOCKS PHASE1	7	12	6	8	7	7	13
EASTSIDE LOCKS PHASE 1(BUILDING 5)	7	14	1	0	0	1	12
SNOW HILL SITE 3	8	85	13	8	7	13	76
LOUISA RYLAND HOUSE	9	46	7	1	4	2	45

Table 1.7: Developments' Residential Vehicle Trips

Development Site	Map ID	AM Peak		Inter Peak		PM Peak	
		In	Out	In	Out	In	Out
ARENA CENTRAL PLOT G.	1	18	40	18	24	27	21
ATTWOOD GREEN ZONE 11	10	13	34	26	20	39	22
FORMER MOULINEX SWAN / KETTLEWORKS	11	33	62	44	37	68	41
GRANVILLE STREET	12	5	15	8	9	13	7
HARRISON DRAPE	13	17	21	14	12	22	20
HOLLOWAY HEAD PHASE 1	14	3	12	8	7	12	4
MASSHOUSE: "EXCHANGE SQUARE"	15	12	37	31	22	47	28
PERSHORE STREET	16	18	22	7	13	11	14
SGUV-1: POPE STREET	17	25	47	34	28	51	31
ST.ANNES	18	10	30	25	18	39	16
WINDMILL STREET	19	8	39	26	23	40	14

Figure 1-3: Development Sites



HS2 Construction Traffic

1.22 The TA for HS2 published by DfT and HS2 ltd[10] has forecasts of construction traffic across all the development compounds across the HS2 route. The two main sites relevant to Birmingham city centre (see Figure 1-3 above for site location) are at Curzon Street and another just outside the ring road.

1.23 While other sites are listed they tend to be operational for a shorter time, and may not cover the 2020 modelled year. To avoid the HS2 forecasts being too conservative we have assumed that the two sites will be operating at their busiest period during 2020.

1.24 The TA publishes traffic at the daily level as shown in Table 1.8, with Table 1.9 showing the factors used convert to the modelled periods assuming predominant arrivals departures of car/LHV trips are in the morning and evening peak respectively, with HGV arrivals and departures timed to avoid the peak traffic periods where possible. Industry standard assumptions were taken on how this demand would be distributed across the day. Table 1.9 to Table 1.11 show the traffic levels generated using these assumptions.

Table 1.8: Daily Vehicles Busiest Period

Location	Map ID	Car	HGV
Curzon Street No. 1 viaduct (Duddeston Mill Rd)	21	60	25
Curzon Street No. 3 viaduct (Curzon St)	20	150	40

Table 1.9: Daily to Model Period Factors

Time period	Car/ LGV		HGV		Hours
	IB	OB	IB	OB	Hours
AM	0.70	0.10	0.30	0.05	2
IP	0.20	0.20	0.65	0.65	6
PM	0.10	0.70	0.05	0.30	3.5

Table 1.10: AM Peak HS2 Additional PCUs

Location	Car/ LGV		HGV	
	Inbound	Outbound	Inbound	Outbound
Curzon Street No. 1 viaduct (Duddeston Mill Rd)	21	3	4	1
Curzon Street No. 3 viaduct (Curzon St)	53	8	6	1
Total	**74**	**11**	**10**	**2**

[10] London-West Midlands ENVIRONMENTAL STATEMENT, Volume 5 | Technical Appendices

Transport Assessment (TR-001-000) Part 8: West Midlands assessment Traffic and Transport, HS2 Ltd, November 2013

Table 1.11: Inter Peak HS2 Additional PCUs

Location	Car		HGV	
	Inbound	Outbound	Inbound	Outbound
Curzon Street No. 1 viaduct (Duddeston Mill Rd)	2	2	3	3
Curzon Street No. 3 viaduct (Curzon St)	5	5	4	4
Total	**7**	**7**	**7**	**7**

Table 1.12: PM Peak HS2 Additional PCUs

Location	Car		HGV	
	Inbound	Outbound	Inbound	Outbound
Curzon Street No. 1 viaduct (Duddeston Mill Rd)	2	12	0	2
Curzon Street No. 3 viaduct (Curzon St)	4	30	1	3
Total	**6**	**42**	**1**	**6**

Final Growth Rates

1.25 The process described above resulted in 3 demand matrices in each time period:

1. Delta Matrix scaled to correct 2016-20 growth at the sector level with development trips removed
2. Development Trip matrix
3. HS2 matrix

1.26 These matrices are summed together to create the final do minimum matrices, which results in the following growth rates for the different time periods.

Table 1.13: AM Peak Growth Rates

Sector	CAR			LGV			HGV		
	Origin	Destination	Total	Origin	Destination	Total	Origin	Destination	Total
City Centre	7.0%	8.4%	7.9%	10.7%	10.9%	10.8%	3.3%	3.7%	3.5%
Rest of Birmingham	4.2%	3.1%	3.7%	10.7%	10.8%	10.7%	3.1%	3.2%	3.2%
Birmingham (Total)	***4.5%***	***3.9%***	***4.2%***	***10.7%***	***10.8%***	***10.7%***	***3.2%***	***3.2%***	***3.2%***
Rest of West Midlands	4.1%	4.7%	4.4%	10.7%	10.6%	10.6%	2.9%	2.9%	2.9%
Total	**4.3%**	**4.3%**	**4.3%**	**10.7%**	**10.7%**	**10.7%**	**3.0%**	**3.0%**	**3.0%**

Table 1.14: Inter Peak Growth Rates

Sector	CAR			LGV			HGV		
	Origin	Destination	Total	Origin	Destination	Total	Origin	Destination	Total
City Centre	8.1%	7.9%	8.0%	10.7%	10.8%	10.8%	3.6%	3.6%	3.6%
Rest of Birmingham	3.7%	3.7%	3.7%	10.7%	10.7%	10.7%	3.1%	3.1%	3.1%
Birmingham (Total)	***4.2%***	***4.2%***	***4.2%***	***10.7%***	***10.7%***	***10.7%***	***3.2%***	***3.2%***	***3.2%***
Rest of West Midlands	5.4%	5.3%	5.3%	10.7%	10.7%	10.7%	2.9%	2.9%	2.9%
Total	**4.7%**	**4.7%**	**4.7%**	**10.7%**	**10.7%**	**10.7%**	**3.0%**	**3.0%**	**3.0%**

Table 1.15: PM Peak Growth Rates

Sector	CAR			LGV			HGV		
	Origin	Destination	Total	Origin	Destination	Total	Origin	Destination	Total
City Centre	8.2%	6.3%	7.4%	10.7%	10.8%	10.7%	3.8%	3.4%	3.6%
Rest of Birmingham	3.3%	4.2%	3.7%	10.7%	10.7%	10.7%	3.1%	3.1%	3.1%
Birmingham (Total)	**3.9%**	**4.4%**	**4.1%**	**10.7%**	**10.7%**	**10.7%**	**3.2%**	**3.1%**	**3.2%**
Rest of West Midlands	4.8%	4.4%	4.6%	10.8%	10.8%	10.8%	2.9%	3.0%	3.0%
Total	**4.4%**	**4.4%**	**4.4%**	**10.7%**	**10.7%**	**10.7%**	**3.0%**	**3.0%**	**3.0%**

Comparison With NTEM

1.27 As a benchmarking exercise, the outcome of this process has been compared against the DfT's National Trip End Model's (NTEM) forecasts. For LGV and HGVs results are very similar (see Figure 1-4 below) with growth rates within 0.5% of the NTEM forecasts, but there are some differences with the car forecasts.

1.28 Table 1.15 to Table 1.18 shows a comparison of all car trips between NTEM (v7.2) and BCC. These totals have then been aggregated to 3-sector level showing the CAZ zone, rest of Birmingham and rest of the modelled area for 2016-20.

Table 1.16: AM Peak Growth Rates 2016 to 2020 Car – Comparison of BCC and NTEM

City Centre	BCC	NTEM	Difference
City Centre	7.9%	4.6%	3.3%
Rest of Birmingham	3.7%	5.1%	-1.4%
Birmingham (Total)	***4.2%***	***5.0%***	***-0.8%***
Rest of West Midlands	4.4%	4.8%	-0.4%
Total	**4.3%**	**4.8%**	**-0.6%**

Table 1.17: Inter Peak Growth Rates 2016 to 2020 Car – Comparison of BCC and NTEM

City Centre	BCC	NTEM	Difference
City Centre	8.0%	5.1%	2.9%
Rest of Birmingham	3.7%	5.5%	-1.8%
Birmingham (Total)	***4.2%***	***5.5%***	***-1.3%***
Rest of West Midlands	5.3%	3.8%	1.5%
Total	4.7%	4.8%	-0.1%

Table 1.18: PM Peak Growth Rates 2016 to 2020 Car – Comparison of BCC and NTEM

City Centre	BCC	NTEM	Difference
City Centre	7.4%	4.5%	2.8%
Rest of Birmingham	3.7%	4.9%	-1.2%
Birmingham (Total)	***4.1%***	***4.9%***	***-0.7%***
Rest of West Midlands	4.6%	4.8%	-0.2%
Total	**4.4%**	**4.8%**	**-0.5%**

1.29 The main differences between the forecasts are at the spatial level with PRISM forecasting larger levels of traffic growth within the City Centre compared to the rest of the city. This is plausible given that the main development sites within the City over the next few years are scheduled for the City Centre. In addition, the City Centre has had major works around Paradise Circus in recent years which has caused disruption to traffic flows, with this work scheduled to finish by 2020 there is the potential for better traffic management at this key part of the city centre allowing for some traffic growth.

1.30 To summarise the overall Birmingham growth rates are similar between TEMPRO and those applied in the BCC model particularly in the AM and PM peaks with total growth within 1%. In addition, the higher growth in the City Centre is in line with the locations of growth in Birmingham in terms of population and job development sites. We therefore adopted the growth rates derived from the processes set out above for the 2020 modelling of the CAZ.

Figure 1-4: Matrix Totals, Growth and Comparison with NTEM Forecasts

2016 _Base Year

AM Peak

	1	1		2	2		3	3	
	Car			LGV			HGV		
Sector	Origin	Destination	Total	Origin	Destination	Total	Origin	Destination	Total
City Centre	7,559	14,792	22,351	1,234	1,586	2,820	1,287	1,584	2,871
Rest of Birmingham	84,066	83,422	167,488	13,067	13,668	26,735	9,084	9,508	18,592
Birmingham Total	91,625	98,214	189,840	14,302	15,253	29,555	10,371	11,092	21,463
Rest of Model	110,035	103,446	213,481	21,261	20,309	41,570	20,949	20,227	41,176
Total	201,660	201,660	403,321	35,562	35,562	71,125	31,320	31,320	62,639

Inter Peak

	1	1		2	2		3	3	
	Car			LGV			HGV		
	Origin	Destination	Total	Origin	Destination	Total	Origin	Destination	Total
City Centre	9,943	10,293	20,237	1,279	1,294	2,573	1,029	1,077	2,106
Rest of Birmingham	84,083	81,663	165,746	11,697	11,272	22,969	9,034	9,331	18,365
Birmingham Total	94,026	91,956	185,983	12,976	12,566	25,542	10,063	10,408	20,471
Rest of Model	89,022	91,093	180,115	16,519	16,929	33,448	25,775	25,430	51,205
Total	183,049	183,049	366,098	29,495	29,495	58,990	35,838	35,838	71,676

PM Peak

	1	1		2	2		3	3	
	Car			LGV			HGV		
	Origin	Destination	Total	Origin	Destination	Total	Origin	Destination	Total
City Centre	14,880	10,748	25,628	934	686	1,621	485	418	903
Rest of Birmingham	104,089	101,467	205,556	11,154	10,714	21,868	4,164	4,688	8,853
Birmingham Total	118,969	112,215	231,184	12,088	11,400	23,489	4,649	5,107	9,756
Rest of Model	118,255	125,010	243,266	15,605	16,293	31,897	13,810	13,352	27,163
Total	237,225	237,225	474,450	27,693	27,693	55,386	18,459	18,459	36,918

2020 Do Miniumum

AM Peak

	1	1		2	2		3	3	
	Car			LGV			HGV		
Sector	Origin	Destination	Total	Origin	Destination	Total	Origin	Destination	Total
City Centre	8,087	16,031	24,118	1,366	1,758	3,125	1,330	1,643	2,973
Rest of Birmingham	87,626	85,978	173,603	14,464	15,143	29,607	9,370	9,808	19,178
Birmingham Total	95,713	102,009	197,721	15,830	16,901	32,731	10,699	11,451	22,151
Rest of Model	114,572	108,276	222,848	23,530	22,459	45,990	21,565	20,814	42,379
Total	210,285	210,285	420,569	39,360	39,361	78,721	32,265	32,265	64,530

Inter Peak

	1	1		2	2		3	3	
	Car			LGV			HGV		
	Origin	Destination	Total	Origin	Destination	Total	Origin	Destination	Total
City Centre	10,746	11,104	21,850	1,416	1,434	2,850	1,066	1,116	2,181
Rest of Birmingham	87,185	84,703	171,887	12,948	12,478	25,426	9,318	9,624	18,942
Birmingham Total	97,931	95,806	193,737	14,363	13,913	28,276	10,383	10,740	21,123
Rest of Model	93,806	95,931	189,737	18,283	18,734	37,017	26,534	26,178	52,712
Total	191,737	191,737	383,474	32,647	32,647	65,293	36,917	36,918	73,835

PM Peak

	1	1		2	2		3	3	
	Car			LGV			HGV		
	Origin	Destination	Total	Origin	Destination	Total	Origin	Destination	Total
City Centre	16,097	11,421	27,517	1,034	760	1,794	503	432	935
Rest of Birmingham	107,559	105,692	213,251	12,347	11,856	24,203	4,295	4,834	9,129
Birmingham Total	123,656	117,113	240,769	13,380	12,617	25,997	4,798	5,267	10,065
Rest of Model	123,927	130,470	254,396	17,289	18,053	35,342	14,217	13,748	27,965
Total	247,582	247,583	495,165	30,670	30,670	61,340	19,015	19,015	38,030

2020 - 2016 Growth (CAZ Model)

AM Peak

	1	1		2	2		3	3	
	Car			LGV			HGV		
Sector	Origin	Destination	Total	Origin	Destination	Total	Origin	Destination	Total
City Centre	7.0%	8.4%	7.9%	10.7%	10.9%	10.8%	3.3%	3.7%	3.5%
Rest of Birmingham	4.2%	3.1%	3.7%	10.7%	10.8%	10.7%	3.1%	3.2%	3.2%
Birmingham Total	4.5%	3.9%	4.2%	10.7%	10.8%	10.7%	3.2%	3.2%	3.2%
Rest of Model	4.1%	4.7%	4.4%	10.7%	10.6%	10.6%	2.9%	2.9%	2.9%
Total	4.3%	4.3%	4.3%	10.7%	10.7%	10.7%	3.0%	3.0%	3.0%

Inter Peak

	1	1		2	2		3	3	
	Car			LGV			HGV		
	Origin	Destination	Total	Origin	Destination	Total	Origin	Destination	Total
City Centre	8.1%	7.9%	8.0%	10.7%	10.8%	10.8%	3.6%	3.6%	3.6%
Rest of Birmingham	3.7%	3.7%	3.7%	10.7%	10.7%	10.7%	3.1%	3.1%	3.1%
Birmingham Total	4.2%	4.2%	4.2%	10.7%	10.7%	10.7%	3.2%	3.2%	3.2%
Rest of Model	5.4%	5.3%	5.3%	10.7%	10.7%	10.7%	2.9%	2.9%	2.9%
Total	4.7%	4.7%	4.7%	10.7%	10.7%	10.7%	3.0%	3.0%	3.0%

PM Peak

	1	1		2	2		3	3	
	Car			LGV			HGV		
	Origin	Destination	Total	Origin	Destination	Total	Origin	Destination	Total
City Centre	8.2%	6.3%	7.4%	10.7%	10.8%	10.7%	3.8%	3.4%	3.6%
Rest of Birmingham	3.3%	4.2%	3.7%	10.7%	10.7%	10.7%	3.1%	3.1%	3.1%
Birmingham Total	3.9%	4.4%	4.1%	10.7%	10.7%	10.7%	3.2%	3.1%	3.2%
Rest of Model	4.8%	4.4%	4.6%	10.8%	10.8%	10.8%	2.9%	3.0%	3.0%
Total	4.4%	4.4%	4.4%	10.7%	10.7%	10.7%	3.0%	3.0%	3.0%

2020 - 2016 Growth (TEMPRO)

AM Peak

	1	1		2	2		3	3	
	Car			LGV			HGV		
Sector	Origin	Destination	Total	Origin	Destination	Total	Origin	Destination	Total
City Centre	6.0%	4.1%	4.6%	10.2%	10.2%	10.2%	3.1%	3.1%	3.1%
Rest of Birmingham	5.7%	4.3%	5.1%	10.2%	10.2%	10.2%	3.1%	3.1%	3.1%
Birmingham Total	5.8%	4.3%	5.0%	10.2%	10.2%	10.2%	3.1%	3.1%	3.1%
Rest of Model	4.7%	4.8%	4.8%	10.2%	10.2%	10.2%	3.1%	3.1%	3.1%
Total	5.1%	4.6%	4.8%	10.2%	10.2%	10.2%	3.1%	3.1%	3.1%

Inter Peak

	1	1		2	2		3	3	
	Car			LGV			HGV		
	Origin	Destination	Total	Origin	Destination	Total	Origin	Destination	Total
City Centre	4.9%	5.3%	5.1%	10.2%	10.2%	10.2%	3.1%	3.1%	3.1%
Rest of Birmingham	5.5%	5.6%	5.5%	10.2%	10.2%	10.2%	3.1%	3.1%	3.1%
Birmingham Total	5.4%	5.5%	5.5%	10.2%	10.2%	10.2%	3.1%	3.1%	3.1%
Rest of Model	4.5%	3.3%	3.8%	10.2%	10.2%	10.2%	3.1%	3.1%	3.1%
Total	5.1%	4.6%	4.8%	10.2%	10.2%	10.2%	3.1%	3.1%	3.1%

PM Peak

	1	1		2	2		3	3	
	Car			LGV			HGV		
	Origin	Destination	Total	Origin	Destination	Total	Origin	Destination	Total
City Centre	4.1%	5.4%	4.5%	10.2%	10.2%	10.2%	3.1%	3.1%	3.1%
Rest of Birmingham	4.5%	5.4%	4.9%	10.2%	10.2%	10.2%	3.1%	3.1%	3.1%
Birmingham Total	4.4%	5.4%	4.9%	10.2%	10.2%	10.2%	3.1%	3.1%	3.1%
Rest of Model	5.5%	4.2%	4.8%	10.2%	10.2%	10.2%	3.1%	3.1%	3.1%
Total	5.1%	4.6%	4.8%	10.2%	10.2%	10.2%	3.1%	3.1%	3.1%

2020 - 2016 Growth (TEMPRO)

AM Peak

	1	1		2	2		3	3	
	Car			LGV			HGV		
Sector	Origin	Destination	Total	Origin	Destination	Total	Origin	Destination	Total
City Centre	1.0%	4.3%	3.3%	0.5%	0.7%	0.6%	0.3%	0.6%	0.5%
Rest of Birmingham	-1.5%	-1.3%	-1.4%	0.4%	0.6%	0.5%	0.1%	0.1%	0.1%
Birmingham Total	-1.3%	-0.4%	-0.8%	0.4%	0.6%	0.5%	0.1%	0.1%	0.1%
Rest of Model	-0.6%	-0.1%	-0.4%	0.4%	0.3%	0.4%	-0.1%	-0.2%	-0.2%
Total	-0.8%	-0.3%	-0.6%	0.4%	0.4%	0.4%	-0.1%	-0.1%	-0.1%

Inter Peak

	1	1		2	2		3	3	
	Car			LGV			HGV		
	Origin	Destination	Total	Origin	Destination	Total	Origin	Destination	Total
City Centre	3.2%	2.6%	2.9%	0.4%	0.6%	0.5%	0.5%	0.5%	0.5%
Rest of Birmingham	-1.8%	-1.8%	-1.8%	0.4%	0.5%	0.5%	0.1%	0.1%	0.1%
Birmingham Total	-1.3%	-1.3%	-1.3%	0.4%	0.5%	0.5%	0.1%	0.1%	0.1%
Rest of Model	0.9%	2.1%	1.5%	0.4%	0.4%	0.4%	-0.1%	-0.1%	-0.1%
Total	-0.3%	0.1%	-0.1%	0.4%	0.4%	0.4%	-0.1%	-0.1%	-0.1%

PM Peak

	1	1		2	2		3	3	
	Car			LGV			HGV		
	Origin	Destination	Total	Origin	Destination	Total	Origin	Destination	Total
City Centre	4.1%	0.8%	2.8%	0.4%	0.5%	0.5%	0.7%	0.3%	0.5%
Rest of Birmingham	-1.1%	-1.2%	-1.2%	0.5%	0.4%	0.4%	0.0%	0.0%	0.0%
Birmingham Total	-0.5%	-1.0%	-0.7%	0.4%	0.4%	0.4%	0.1%	0.0%	0.1%
Rest of Model	-0.8%	0.2%	-0.2%	0.6%	0.6%	0.6%	-0.1%	-0.1%	-0.1%
Total	-0.7%	-0.3%	-0.5%	0.5%	0.5%	0.5%	-0.1%	-0.1%	-0.1%

2022 Scenario Growth

1.31 In addition to the core 2020 scenario, a 2022 model has been created to assess air quality beyond this initial modelled year. Growth rates were extracted from TEMPRO V7.2 and applied to the matrices as shown in table 1.19. The same behavioural responses to the change in fleet composition (age of fleet remaining constant), and behavioural responses to clean air measures were applied.

Table 1.19: 2020 to 2022 Growth Rates (applied across the whole model)[11]

Vehicle Type	Growth (2020-2022)
Car/ Taxi/ PHV	2.0%
LGV	4.7%
HGV	1.13%

Fleet Mix

1.32 An additional step in creating the do minimum is in deriving compliant and non-compliant vehicle splits. This is important for the AQ modelling and is also a key input into the CAZ forecasting

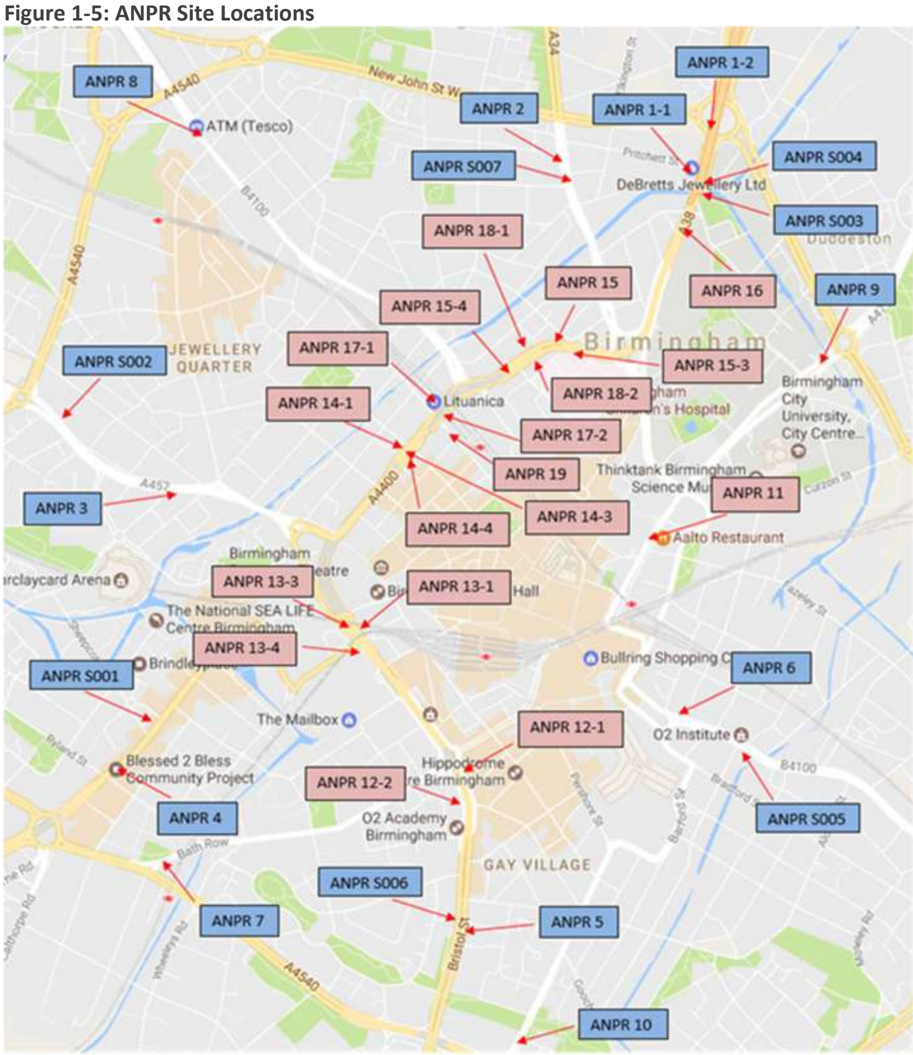
1.33 The base year fleet mix data was derived from ANPR surveys in and around the city centre undertaken by specialist data collection company, Intelligent Data Collection (ID)[12], for a 7-day period commencing Tuesday 8th November 2016. ID installed cameras at 29 unique locations and these were supplemented by a further 7 existing sites which are managed by Amey on behalf of BCC. The following diagram shows the location of each site, with pink sites representing the city centre and blue sites representing a cordon of entry/exit points to the city centre.

1.34 The collection of vehicle registration plate data was then matched to the DVLA database providing various information about the vehicle. This includes providing a breakdown of different Euro Class emission standards by vehicle class.

[11] NTEM Version 7.2, Department for Transport

[12] City Centre Data Collection Report (QU043), Reference: ID02908, 11/04/2017, Issue 2.0

Figure 1-5: ANPR Site Locations



1.35 JAQU guidance on how to forecast future year traffic was followed. This is then used to derive a compliant and non-compliant traffic fleet for future year CAZ testing. The following assumptions were applied:

- National forecasts on change in petrol verses diesel proportions of cars were applied to the local fleet proportions observed in the ANPR surveys. Conventional hybrid vehicles are included in petrol and diesel car numbers when deriving these proportions.
- For other vehicle classes the petrol verses diesel splits remain as observed in the ANPRs.
- The age distribution of vehicles remains the same but increasing in line with each additional year. This causes a natural increase in compliance vehicles i.e. a five-year-old car in 2020 will be of a higher Euro standard than a five-year-old car in 2016.
- There is no change in electric vehicle fleet – plug in hybrids, battery electric or hydrogen vehicles (but this can be included if data becomes available)

Table 1.20: Compliance Rates

Vehicle	Compliance Status	2016	2020
Car	Compliant	55%	77%
Car	Non-Compliant	45%	23%
LGV	Compliant	23%	59%
LGV	Non-Compliant	77%	41%
HGV	Compliant	34%	65%
HGV	Non-Compliant	66%	35%
Bus	Compliant	38%	60%
Bus	Non-Compliant	62%	40%
Taxi	Compliant	17%	29%
Taxi	Non-Compliant	83%	71%

2 Do Something With CAZ Charging Scenario Model Development

Summary

2.1 This chapter sets out the approach used to model the impact of charging non-compliant vehicles to enter the Birmingham Clean Air Zone (CAZ). The impacts reported are only applied to those vehicles forecasted to be non-compliant in 2020. Additional measures that effect all users will have been tested using different approaches and is described in Chapter 3. Table 2.1 shows the compliance rate assumed in 2020 for the without CAZ scenario.

Table 2.1: 2020 Without CAZ Scenario Forecast Compliance Rate

Percentage	Compliance Status	2020
Car	Compliant	77%
Car	Non-Compliant	23%
LGV	Compliant	59%
LGV	Non-Compliant	41%
HGV	Compliant	65%
HGV	Non-Compliant	35%
Bus	Compliant	60%
Bus	Non-Compliant	40%
Taxi	Compliant	29%
Taxi	Non-Compliant	71%

Cars

2.2 There are various responses to the introduction of charging for trips made by non-compliant vehicles entering the CAZ. This has been modelled hierarchically in the order shown in Table 2.2.

Table 2.2: Demand Response Hierarchy

Hierarchy	Response	Method
1	Upgrade to compliant/ switch to already owned compliant vehicle (for households with more than one car)	Choice Modelling based on TfL Stated Preference Research
2	Cancel – do not make a journey	Elasticity to charge derived from PRISM run to apply to Do Minimum trips to/ from the City Centre.
	Change Mode to non-highway PT/ Walk/ Cycle option	

Hierarchy	Response	Method
	Avoid (Change destination from City Centre to non-City Centre trips)	
	Pay (with a city centre origin/ destination)	
3	Avoid (through trips change route to non-City Centre route.	BCC CAZ assignment model to apply to through trips.
	Pay (through trips use City Centre)	

2.3 The model has been developed at the journey rather than individual user level, so is comparable to the vehicle kilometre table shown in the JAQU technical reports (rather than the vehicle tables).

Compliance

2.4 Users that choose to upgrade to a compliant vehicle have been represented in the model by using Transport for London's behavioural research for the extended Ultra Low Emission Zone – see Appendix B for the stated preference report. Stated preference is a survey exercise used to extract the value for different attributes of alternatives based the respondents' choice behaviour. In this case the exercise was aimed at understanding how much people were willing to pay to upgrade their vehicle in response to different charge levels.

2.5 This research is relevant to Birmingham as it covers an area of London that is currently free to drive in (rather than the congestion charging area), and therefore captures individuals that do not currently pay a charge.

2.6 To ensure that the forecasts reflect local conditions the TfL research was reweighted with local data in the following ways:

- Frequency from the ANPR City Centre survey by grouping into Low, Medium and High frequency as follows:
  - High 4-7 days a week
  - Medium 2-3 days a week
  - Low 1 day a week
- Income grouping size from the PRISM model into Low, medium and High as defined in PRISM (Low <-£35k, Medium £35k-£50k, High >£50k)
- Journey Purposes from the PRISM model

2.7 The cost to upgrade is an input to the model, which was calculated based on assumptions published in JAQU's technical appendix[13] to the national air quality plan, resulted in an average upgrade cost of £3,100 as shown in Table 2.4 below. The following assumptions were applied:

- Users will upgrade to the cheapest vehicle that is an upgrade (i.e. a diesel Euro 5 would upgrade to a Euro 6 rather than a petrol Euro 4)
- The starting cost of a new car is taken as the most popular car in 2016 the Nissan Quasqai, costing £19,080 new,
- Depreciation rates applied to derive:
  - Cost of compliant cars for different Euro Classes
  - Value of non-compliant car for the different Euro classes

[13] UK Plan for tackling roadside nitrogen dioxide concentrations, Technical report, Section E, JAQU, July 2017

- An average sell cost and buy cost for Birmingham users was derived by using the age profile of the fleet taken from the ANPR survey (rolled forward to 2020 as described above in Chapter 2).

Table 2.3: Depreciation Assumptions

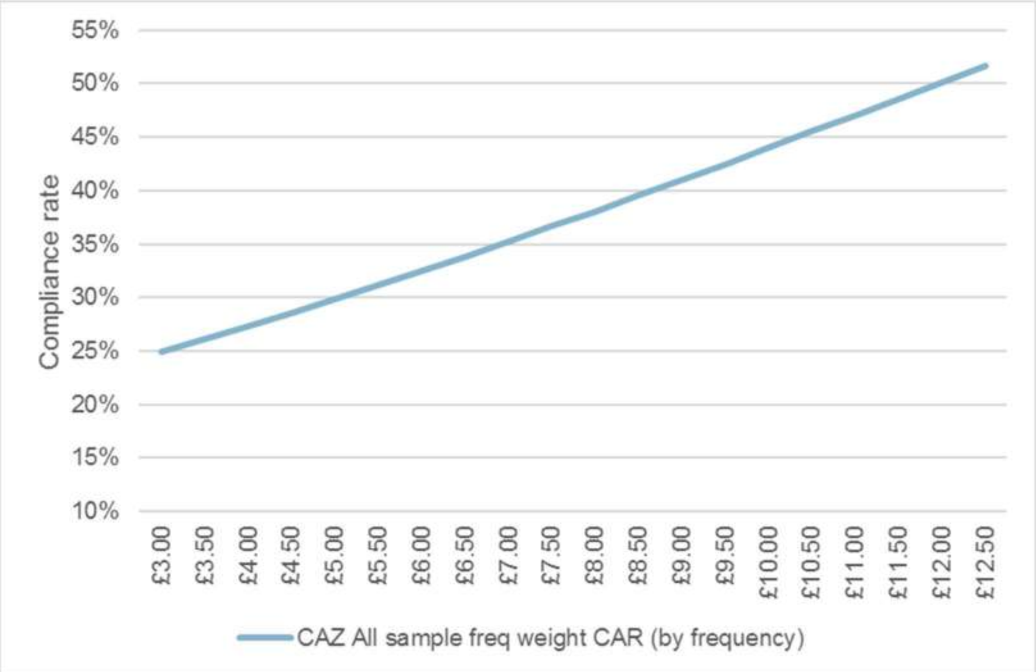
Year	Depreciation Rate per Year
1	0.37
2	0.18
3+	0.16

Table 2.4: Cost to Upgrade Car

Element	Cost
Average sell value	£4,300
Average buy value	£7,400
Net Cost	**£3,100**

2.8 This resulted in the following compliance rates to apply to non-compliant trips to/from the CAZ in the Do Minimum model, with the proportion of compliant vehicles increasing as the charge for entering the city is increased.

Figure 2-1: Upgrade Rates for City Centre Trips



Other City Centre Response

2.9 For the remaining proportion of users that will not upgrade to a new vehicle the PRISM[14] model was used to estimate what proportion of users with an origin or destination in the city centre would respond by:

- Paying the charge;

[14] http://www.prism-wm.com/

- Shift to a new mode;
- Cancel their trip; or
- Avoid the zone by travelling somewhere else.

2.10 It is worth noting that this final option is not applicable to those trips with a home origin in the city centre.

2.11 The PRISM model was run with the charges set to the ULEZ value of £12.50. The charges were coded on the centroid connectors of City Centre zones to isolate the impacts on the City Centre and to not impact through trips. The PRISM model is not set up to be able to separate compliant and non-compliant vehicles so could not be used directly to forecast the full responsiveness to the charge.

2.12 The PRISM demand model outputs provide a large set of demand responses across different:

- Income segments
- Journey purposes
- Origin/ destination pairs with
  - Different highway;
  - public transport; and
  - walk/ cycle times

2.13 An average elasticity to charge was calculated by analysing the changes in demand between Do Minimum and CAZ scenarios against the change in generalised costs of each potential City Centre journey. The generalised costs were calculated as a sum of journey time costs, vehicle operating costs, charges and parking charges to ensure that costs other than the CAZ charge were considered in the choice.

2.14 Within PRISM different responsiveness to charges due to journey purposes' is represented through values of time, taking into attributes issues such as trip frequency (for commuters this will be high), whether the costs can be passed on (business trips) or shared (vehicle occupancy). The adjustment to the matrices are carried out on the two journey purpose levels within the BCC model, using an average responsiveness weighted across the different journey purposes. The two BCC purposes are shown below, aggregating across a large number of purposes in PRISM:

- In Work; and
- Other

2.15 The city centre demand was also analysed in 3 different geographical segments depending on where the trip was generated. Trip generation refers to the home end of a trip unless it is part of a trip chain in which case it is modelled in origin/ destination format.

2.16 The BCC assignment model is in origin/ destination format, where journeys cannot be directly linked to the home end of the trip, so an average response across the day was calculated. The different responsiveness by geographical area is weighted by the relative size of that segment with the following assumptions applied:

Table 2.5: Geographical responses

Geography	Response
Trips Generated in the City Centre to a destination outside the City Centre (CC to Non CC)	These trips can be cancelled, pay the charge or change mode. No change in destination assumed.

Trips Generated in the City Centre which complete their journey within the City Centre (CC to CC)	For home based trips, no change assumed as there would no way to charge them. For non-home based trips, mode shift or cancelled trip assumed.
Trips Generated outside of the City Centre to inside the City Centre (Non CC to CC)	Pay the charge, mode choice, cancel trip, and change destination is modelled.

2.17 The following responses to different charge rates are shown in Figures 3.2 to 3.6, which includes the upgrade to compliant vehicle response discussed earlier. It should be noted that these results apply only to those vehicles forecast to be non-compliant vehicles in 2020 without any CAZ interventions and does not included through trips route choice. The overall model response in terms of the proportion of the fleet that will pay the charge or change mode, for example, will be smaller than presented in the figures below.

Figure 2-2: NCC to CC Non work

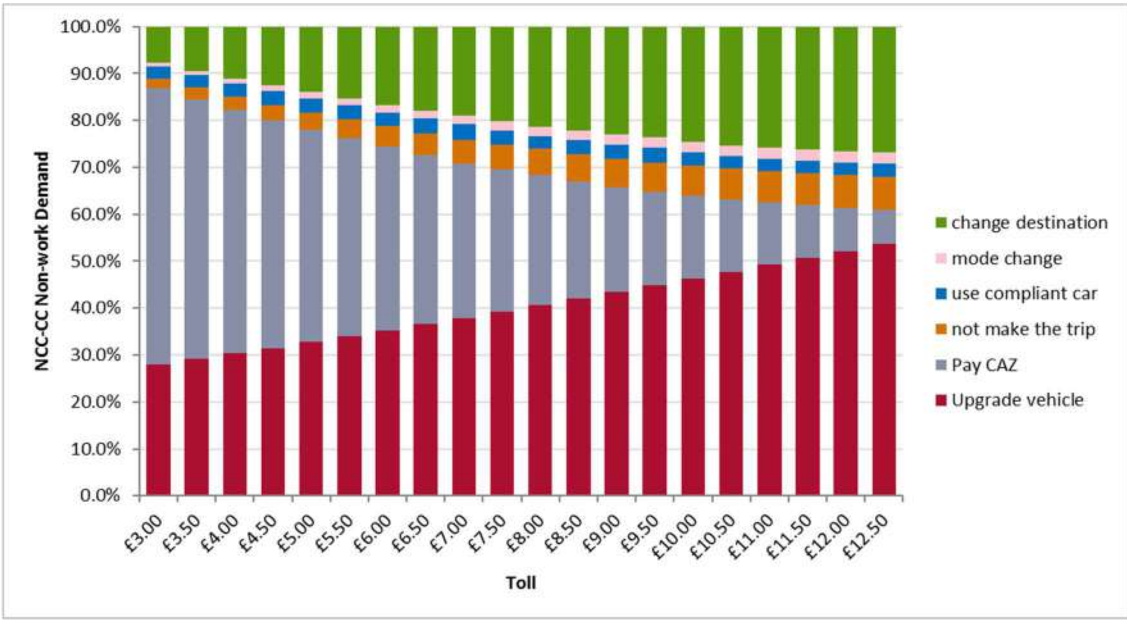


Figure 2-3: NCC to CC In Work

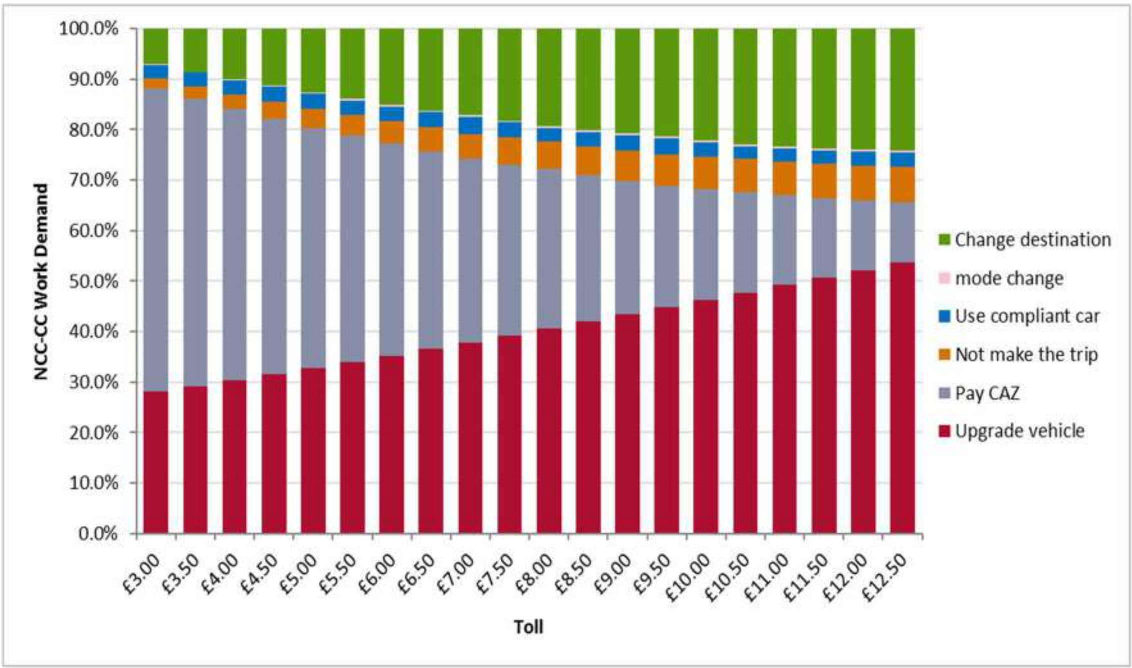


Figure 2-4: CC to CC Non Home based

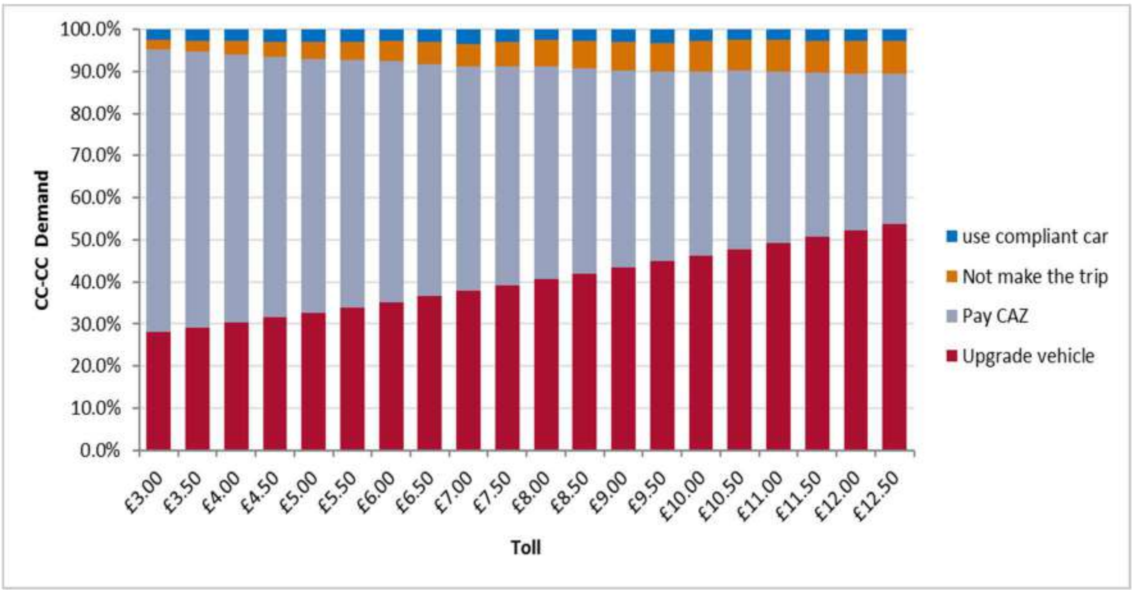


Figure 2-5: CC to NCC Non work

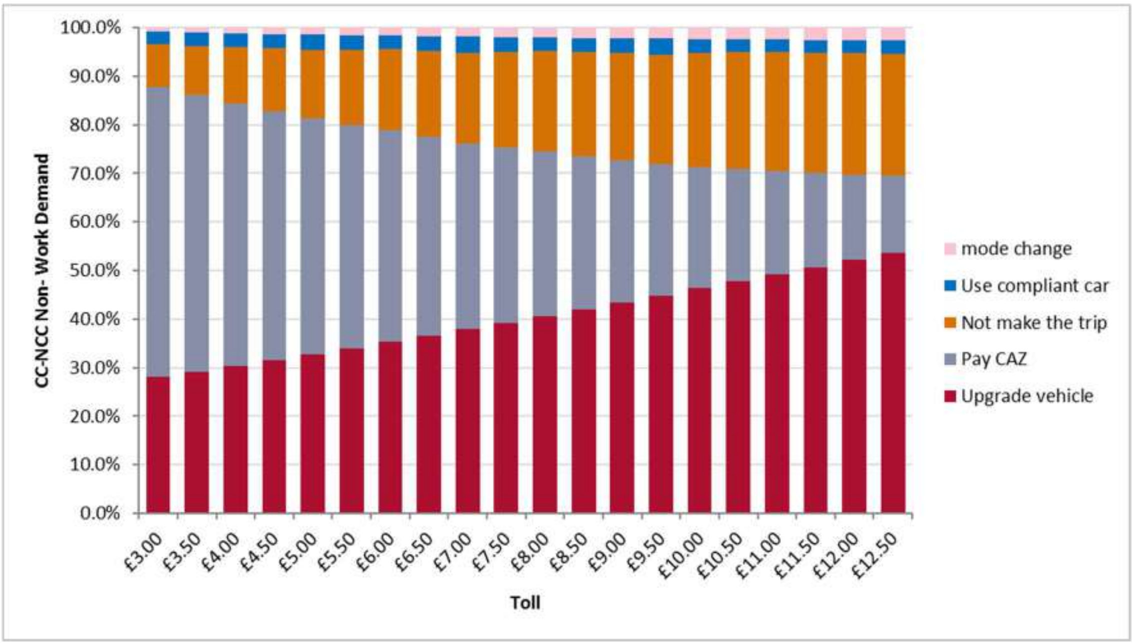
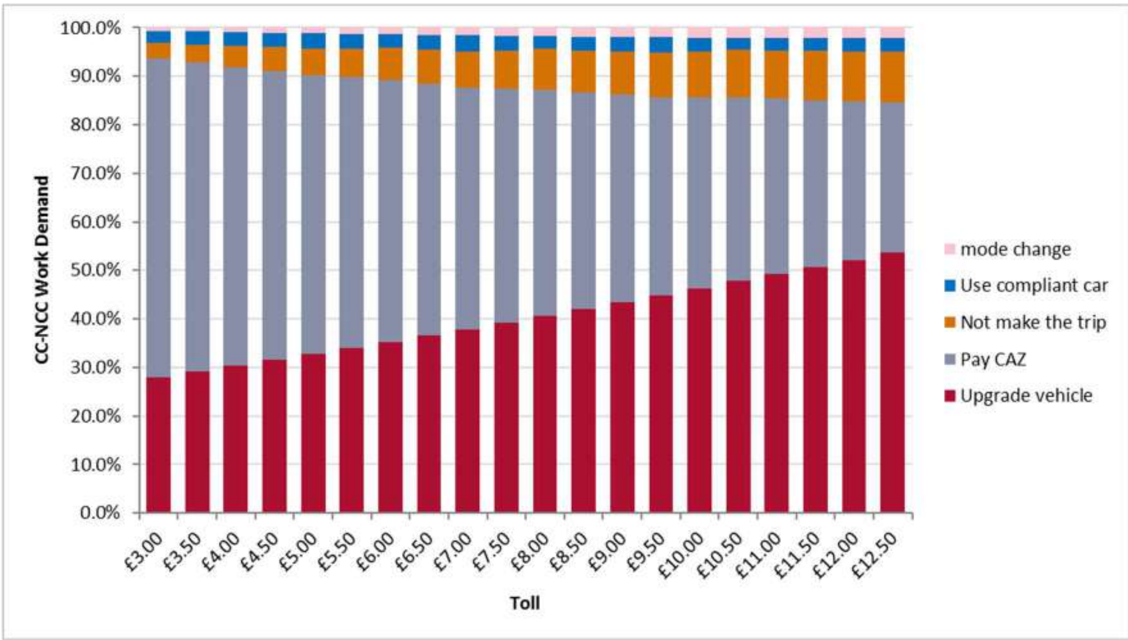


Figure 2-6: CC to NCC in work



2.18 Overall the model responds sensibly with more people prepared to pay the charge at lower levels. The mode shift response is small, which indicates that many existing car users either do not have a good public transport alternative or have a strong preference using the car. The challenge therefore will be ensuring that, within the additional measures programme, high quality public transport alternatives are explored.

2.19 To apply these responses to the City Centre assignment model the following adjustments are made:

Table 2.6: Application of Responses to Assignment Model

Response	Modelled
Upgrade Vehicle	The compliant user class is uplifted and the non-compliant reduced
Mode Shift	The non-compliant car trips to/ from the City Centre are reduced
Cancel Journey	The non-compliant car trips to/ from the City Centre are reduced
Change Destination	The non-compliant trips to/ from the city centre are redistributed to outside so that neither trip end is in the City Centre, using the existing demand distribution from the appropriate origin/destination zone outside the city centre

Through Trips

2.20 Non-compliant through trips are modelled using route choice in the assignment model. Charges are coded onto links forming a cordon into the City Centre. As the charge is only used for route choice it is only applied in the inbound direction to avoid double charging. Values of time are used (described above in chapter 2), converting charges into a generalised journey time, with the model forecasting whether users are prepared to pay for the time savings of making a through trip.

Taxi/ PHV

2.21 We assume that all Birmingham registered taxis and PHVs will upgrade to compliant vehicles, based on policy being developed by Birmingham City Council.

LGV

2.22 Light goods vehicles are assumed to respond by:

- upgrading their vehicle;
- pay the charge and continuing to drive into the CAZ; or
- route choice for through trips by bypassing the CAZ

2.23 We have used TfL's ULEZ behavioural model to forecast the response to upgrading the vehicle. We have assumed that LGV users' behaviour will more closely reflect car users than heavy goods users, as:

- the charges and upgrade costs are similar.
- The costs used are based on JAQU costings published in their technical report to the National Air Quality Plan[15]

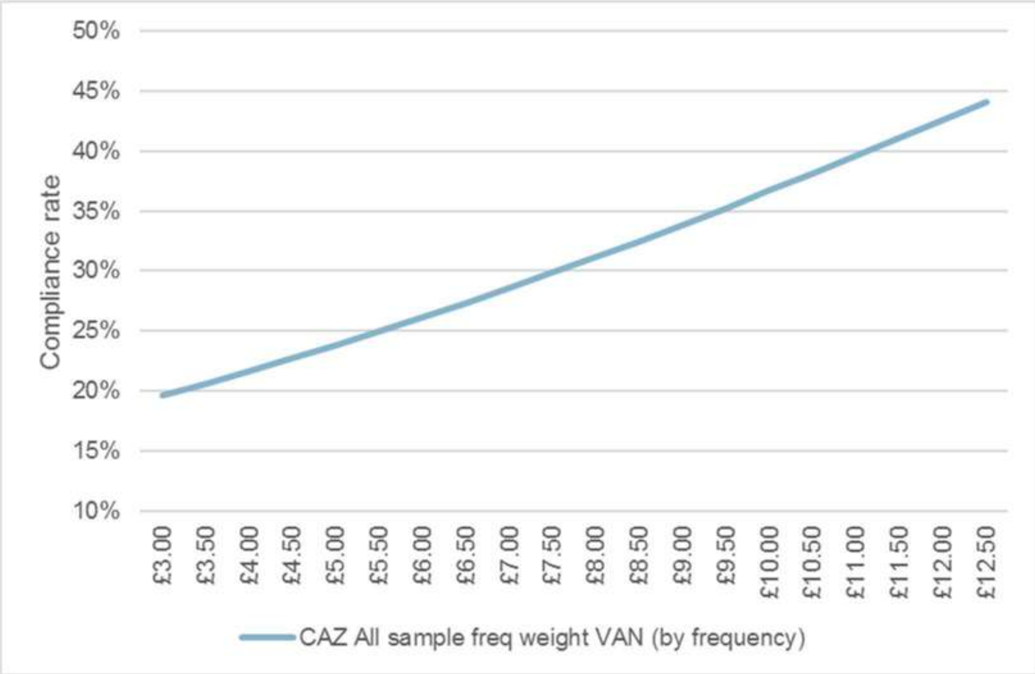
Table 2.7: Cost to Upgrade LGV

Element	Cost
Average sell value	£3,500
Average buy value	£10,000
Net Cost	**£6,500**

2.24 The modelled response for the proportion of compliant LGVs against increasing charges is illustrated below:

[15] UK Plan for tackling roadside nitrogen dioxide concentrations - Technical report, DEFRA/ DfT July 2017

Figure 2-7: LGV Compliance Rate



HGV

2.25 The approach to modelling HGVs has been to consider the cost to upgrade over a 5-year period against the cost of paying a charge throughout this period. The costs involved both in upgrading, the charge paid, and the value of the business being carried out is considerably higher than for the lighter vehicle classes. Users are therefore likely to take a longer-term outlook on whether to upgrade their vehicle.

2.26 Compliance rates were calculated by applying the following assumptions:

- Depreciation Rates from JAQU
- Users will upgrade to cheapest available option
- Frequency taken from the ANPR survey data, with assumptions of how the vehicle counted once in the week are distributed across the year.
- The costs were taken from the Road Haulage Association Cost Tables publication
- Costs were calculated for rigid and artic separately with proportions in the ANPR surveys used to derive the fleet proportions to apply these assumptions to.

Table 2.8: HGV Costs

Type	Cost to Buy	5 Years Interest	Total Cost (over 5 years)
Rigid	£44,700	£6,700	£51,300
Arctic	£71,700	£8,400	£80,100

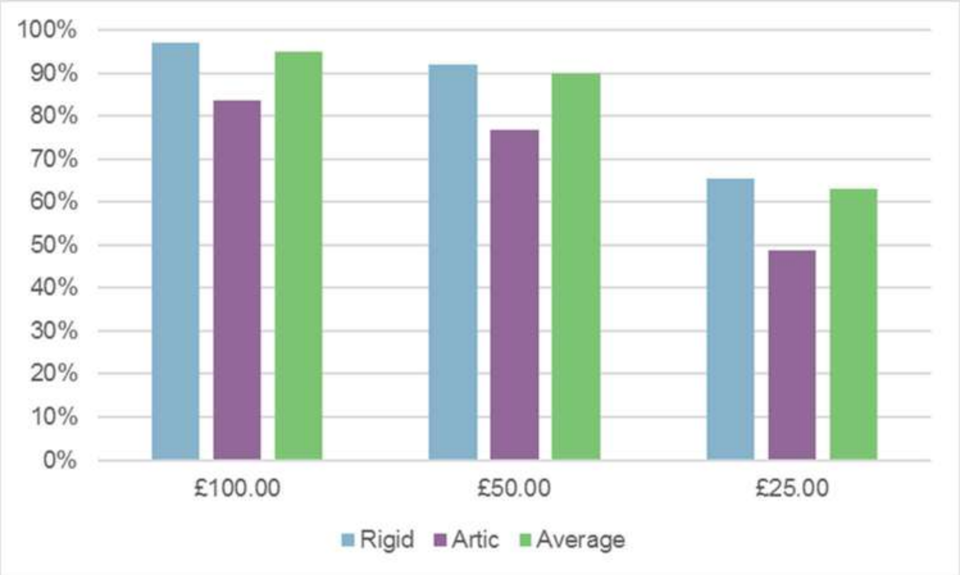
Table 2.9: Depreciation Assumptions

Year	Depreciation Rate per Year
1	0.37
2	0.18
3+	0.18

Table 2.10: Cost to Upgrade HGV

HGV Type	Euro Class	Resale Cost	Cost of Compliant Vehicle	Cost to Upgrade
Rigid	Euro 1	£548	£16,008	£15,460
	Euro 2	£1,213	£16,008	£14,795
	Euro 3	£2,200	£16,008	£13,808
	Euro 4	£5,935	£16,008	£10,073
Arctic	Euro 1	£880	£25,697	£24,816
	Euro 2	£1,947	£25,697	£23,749
	Euro 3	£3,532	£25,697	£22,165
	Euro 4	£9,527	£25,697	£16,170

Figure 2-8: Compliance Rate at 3 levels of charge



Bus

2.27 The effect of CAZ charges on buses is not explicitly modelled as its assumed that all buses in the CAZ will be compliant, with an out of model adjustment made when applying the results in the AQ model.

Birmingham City Council Fleet

2.28 We have assumed that the full Birmingham fleet will be made compliant. However, using number plate data provided by Birmingham City Council and matching against the ANPR surveys showed that the proportion of the fleet within the traffic model was too small to include specifically within the modelling. Measures for staff owned vehicles would be an additional measure, and would be considered at a later stage in the study.

Results

2.29 Full model runs have been completed for CAZ C and CAZ D for three pricing levels for both CAZ types. Full analysis of the model results is contained in Chapter 4, with the following section describing the overall responsiveness. The analysis focuses on car, LGV and HGV, as the assumption for bus and taxi is that they will all upgrade.

2.30 The charges are summarised in Table 2.1 below, with CAZ D run with high HGV charges for all tests.

Table 2.11: Scenarios Tested

CAZ	CAZ C			CAZ D		
	Low	Medium	High	Low	Medium	High
Car	£0.00	£0.00	£0.00	£2.00	£6.00	£12.50
Taxi	£2.00	£6.00	£12.50	£2.00	£6.00	£12.50
LGV	£2.00	£6.00	£12.50	£2.00	£6.00	£12.50
HGV	£25.00	£50.00	£100.00	£100.00	£100.00	£100.00
Bus/ Coach	£25.00	£50.00	£100.00	£100.00	£100.00	£100.00

2.31 Table 2.12 shows the overall response rates for CAZ C non-compliant vehicles in the CAZ zone. This represents the change in non-compliant vehicle numbers within the CAZ compared to the Do Minimum scenario, and is the combined effects of the various responses including the diversion of through trips.

2.32 The non-compliant car numbers increase slightly due to the charging of LGVs and HGVs. Non-Compliant LGVs and HGV through trips divert away from the City Centre making the City Centre less congested and increasing traffic on the ring road. This makes through trips more attractive for those vehicles that are not charged.

2.33 HGVs are shown to have high response rates to charging particularly at the higher charge rates compared to LGVs.

2.34 Table 2.13 below shows in detail how the individual behavioural responses of users contribute to the overall change. The “pay charge” for cars in CAZ C refers to non-compliant cars entering the CAZ (they do not need to pay), as described above.

Table 2.12: CAZ C Overall Non- Compliant Vehicle Change Percentage

	Car	LGV	HGV
Low	+1%	-39%	-72%
Medium	+1%	-45%	-91%
High	+1%	-59%	-96%

Table 2.13: CAZ C Response of Non-Compliant Vehicles to the Charge

Response	Low			Medium			High		
	Car	LGV	HGV	Car	LGV	HGV	Car	LGV	HGV
Pay Charge*	102%	56%	26%	102%	51%	7%	102%	38%	4%
Avoid Zone	-2%	27%	29%	-2%	27%	29%	-2%	27%	29%
Cancel Trip	0%	0%	0%	0%	0%	0%	0%	0%	0%
Replace Vehicle	0%	16%	45%	0%	21%	63%	0%	35%	67%
Mode Shift	0%	0%	0%	0%	0%	0%	0%	0%	0%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%

*Cars do not need to pay in CAZ C

2.35 Responses for CAZ D are found in Table 2.14 and Table 2.15. At the high charge level, the forecasts are for high levels of compliance within the CAZ, with only 12% of cars paying the charge.

Table 2.14: Overall Response Reduction CAZ D

	Car	LGV	HGV*
Low	-46%	-39%	-96%
Medium	-64%	-45%	-96%
High	-88%	-59%	-96%

* HGVs charged at the high rate for the CAZ D tests

Table 2.15: CAZ D Response of Non-Compliant Vehicles to the Charge

Response	Low			Medium			High		
	Car	LGV	HGV	Car	LGV	HGV	Car	LGV	HGV
Pay Charge	46%	56%	4%	32%	51%	4%	8%	38%	4%
Avoid Zone (Change Route)	22%	27%	29%	22%	27%	29%	22%	27%	29%
Avoid Zone (Change Destination)	6%	0%	0%	12%	0%	0%	18%	0%	0%
Cancel Trip	3%	0%	0%	6%	0%	0%	9%	0%	0%
Replace Vehicle	22%	16%	67%	27%	21%	67%	41%	35%	67%
Mode Shift	1%	0%	0%	1%	0%	0%	2%	0%	0%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%

2.36 Table 2.16 compares the response rates with those from TfL's ULEZ study and those published by JAQU in the National Air Quality Plan (for full details see

2.37 Figure 2.9 and Figure 2.10 on the following pages). The National Air Quality Plan does not state the charge levels assumed, but as the research is based on TfL's studies we have assumed it is based on the ULEZ charge.

2.38 The overall response rate of those who will still pay the charge is in line with the National Air Quality and TfL assumptions. This provides evidence that the change in compliance rates within the CAZ zone are plausible, and therefore the flows used in the AQ models are reasonable.

2.39 The main differences occur in the mode shift assumptions where low rates of mode shift are forecast compared to the other studies with two observations:

- London has higher public transport use and more options compared to Birmingham, so people are more likely to change mode in London
- CAZ is to be implemented in the short term, so it will be challenging for people to avoid the zone by changing their destination to areas outside the City Centre, particularly for those who currently work there, so the reality may be higher rates of mode shift in the short term.

2.40 For "replacement of vehicles", the BCC study in in line with TfL forecasts but significantly higher than forecast by JAQU. Given the short timescales while the response is reasonable, it may be difficult to achieve these upgrade rates by 2020, without government support.

Table 2.16: Car Compliance Response Comparisons at the High Charge Level

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

* JAQU only publishes avoid zone, not separately for change destination/ change route.

2.41 LGV and HGV responses are shown in Table 2.17 and compared to the National Plan assumptions. For LGVs a higher proportion is assumed to pay the charge than assumed in the national plan. However, for HGVs higher upgrade rates are assumed than by JAQU, although these are more in line with JAQUs assumptions in comparison to LGVs.

Table 2.17: LGV and HGV Compliance Response Comparisons

Response	LGV		HGV	
	BCC	JAQU	BCC	JAQU
Pay Charge	41%	20%	4%	9%
Avoid Zone	12%	8%	1%	4%
Cancel Trip	-	6%	-	4%
Replace Vehicle	47%	64%	95%	83%
Mode Shift	-	4%	-	-

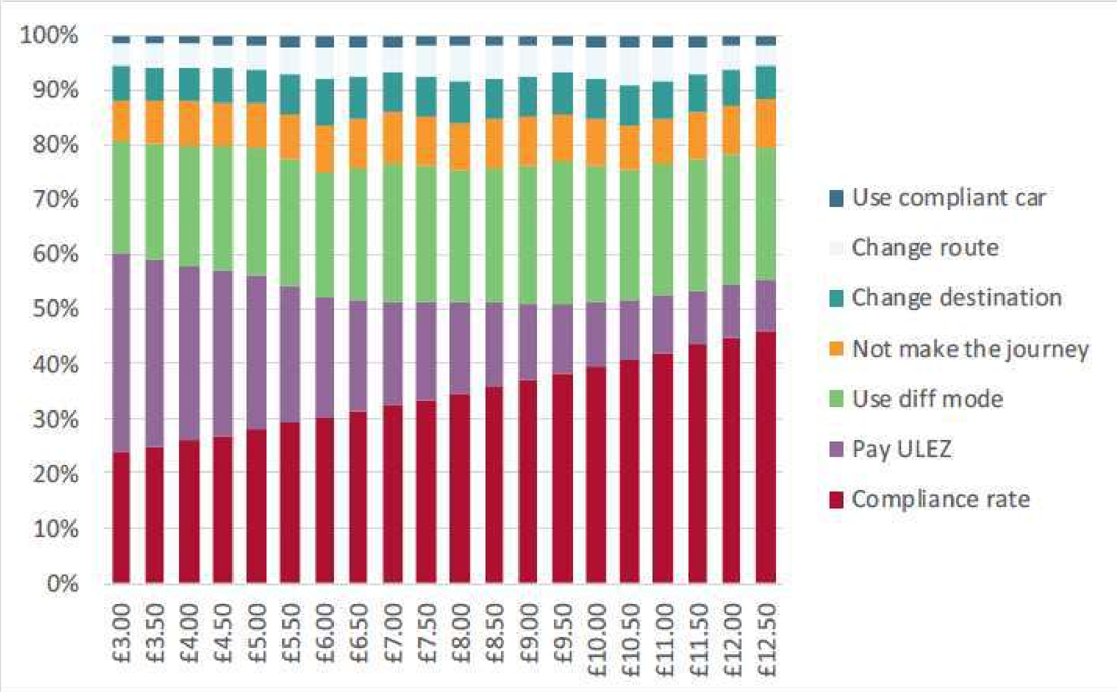
Figure 2.9: National Air Quality Plan Technical Report Assumed Responses[16]

Table 3.3: Proportions of non-compliant vehicle kilometres (VKM) and non-compliant vehicles (V) by response to the presence of a charging CAZ

Response	Cars		LGVs		HGVs		Buses		Coaches	
	VKM	V	VKM	V	VKM	V	VKM	V	VKM	V
Upgrade	64%	22%	64%	25%	83%	44%	94%	62%	72%	41%
Cancel	7%	16%	6%	12%	4%	13%	6%	38%	13%	26%
Change mode	11%	23%	2%	4%	0%	0%	0%	0%	0%	0%
Avoid	11%	23%	8%	17%	4%	13%	0%	0%	0%	0%
Pay	7%	16%	20%	42%	9%	29%	0%	0%	16%	32%

[16] UK Plan for tackling roadside nitrogen dioxide concentrations, Technical report, Section E, JAQU, July 2017

Figure 2.10: Ultra Low Emission Zone Expansion Stated Preference Survey Model Results[17]



[17] Ultra Low Emission Zone Expansion Stated Preference Survey Report, Steer Davies Gleave, 2017

3 Do Something With CAZ Additional Measures Scenarios Model Development

Summary

Overview

3.1 Additional measures have been tested in the traffic model to assess their impact on reducing emissions, and to assist in the process of choosing which options should be included in the OBC. The chapter is structure as follows:

- Measures Tested – give an overview of the measures tested in the model
- Methodology – A summary of the approach taken in modelling the schemes
- OBC Responses – A summary of the changes in traffic as a result of the preferred OBC option.

Measures Tested

3.2 Table 3.2 below described the options tested and a summary of their impacts, and whether they were selected for inclusion in the preferred scheme for OBC.

3.3 In addition to the schemes tested, the closure of Moor Street Queensway between Masshouse and Park Street to general traffic (open to Public Transport, Hackneys and cycles) has been adopted as Birmingham City policy to be implemented by 2020, separate from the Clean Air project. This has benefits, in significant reductions in emissions at Digbeth gyratory, which is one of the links forecast to exceed legal limits in 2020. It will also improve bus reliability and times in this corridor supporting model shift. However, this pushes additional traffic onto the A38 and A4050 links which are forecast to exceed the legal limits.

Table 3.1: Additional Measures Tested

Type	Test ID	Summary	Results	OBC
Fleet (low emission)	Fleet 1	Increase LPG refuelling for Hackney Carriages and the installation of rapid EV infrastructure for taxi and private hire vehicles. Retrofitting of black taxis to LPG **Assumptions tested:** • 85 taxis upgraded to Electric vehicle • 441 PHVs upgraded to Electric Vehicle • 65 taxis retrofitted to LPG	Electric Vehicle upgrade estimated to remove 1.0% of total vehicle kilometres from the City Centre network in a CAZ D scenario. Given that taxi and PHVs are predominately diesel vehicles the AQ impacts are likely to be amplified and provide a significant reduction in NO2 emissions. LPG retrofit has a less significant impact on overall AQ levels, but will provide benefits at locations with high taxi flows.	Include in OBC
	Fleet 2	Zero emission buses (new Hydrogen buses)	Reduction in emissions focused on key corridors	Include in OBC
Parking	Parking 1	Remove all free parking from BCC controlled areas. Replaced with paid parking spaces. Assume cost of parking in line with BCC off-street parking.	Around 15% of traffic parking in the City Centre currently parks on free on street parking. The modelling indicates that this will reduce car demand with free parking by around 30%. This leads to around a 2.5% reduction in overall vehicles KMs in the CAZ, resulting in a relatively significant reduction in emissions, although this is limited in the key locations (those failing the legal limits) as the impacts are focused on the outer areas of the City Centre. An additional benefit is that it raises revenues of the City Centre which will be re-invested in mitigating the effects of the CAZ.	Include in OBC
Network Changes	Network 1	Ban traffic entering (SB) or leaving (NB) Suffolk Street Queensway (A38) from Paradise Circus (except for local access).	Provides a reduction in overall traffic levels and reduces delays on the A38 at a key location, forecast to exceed legal emission levels. Reduces traffic through Paradise Circus, an area with high pedestrian flows linking Birmingham's main cultural quarter, to the shopping/ business district and New Street Station. Paradise is the focus of one the city centre's main masterplan areas, so removing traffic will support this regeneration.	Include in OBC
	Network 2	Close Lister Street and Great Lister Street at the junction with Dartmouth Middleway. This allows, more green time for the A4540.	Reduction in delay on the A4540 ring road, including less traffic needing to stop (and accelerate away from the junction) due to the removal of the signal stage for traffic crossing the ring road. This also provides a mitigation for the increase in traffic on the A4540 caused by the CAZ charge, by increasing capacity at this junction.	Include in OBC

	Network 3	Ban on CAZ through trips for all vehicle types.	Provides significant improvement to air quality in the City Centre. However, this causes significant increases on the Eastern section of the ring road which exceeds the legal NO2 limits. In addition, the model shows large increases on local roads outside of the CAZ area which worsens AQ on these local residential roads. There are also issues with the practicality of implementing this option on the ground.	Exclude from OBC
	Network 4	Ban on CAZ through trips for LGV and HGV vehicles.	As above	Exclude from OBC
	Network 5	CAC C or D on the ring Eastern section of the ring road.	Significant diversion to local roads outside the CAZ increasing emissions on these smaller residential roads. There is a need to reduce overall traffic (not just non-compliant traffic) to meet AQ compliance, so the CAZ charge does not solve the AQ issue and therefore given the problems with implementing the charge on this section	Exclude from OBC
Public Transport	PT_1	Highway/infrastructure changes to provide bus priority 4 corridors were tested, as agreed with TfWM who said they could delivered by 2020.	Impact on mode shift forecast to be small, less than 1% reduction in overall trips into the City Centre, with high costs to implement.	Exclude from OBC

3.4 In addition to the modelling tests undertaken above another of other options where shortlisted, but further analysis indicated that these would not be practical options to implement to 2020 and were excluded prior to modelling.

Table 3.2: Other Measures Considered

Type	Tests	Reason to Exclude	Additional Testing
Network	Average speed enforcement near to Dartmouth Circus to manage traffic and smooth flows.	Analysis of modelled speeds indicated that average speeds were lower than the optimal speeds for limiting emissions, so no benefit in reducing the speed limit.	Non
	Average speed enforcement along the A38 to manage traffic and smooth flows	Analysis of modelled speeds indicated that average speeds were lower than the optimal speeds for limiting emissions, so no benefit in reducing the speed limit.	Non
CAZ Variations	Ban on HGV and LGVs on the Eastern section of the ring road (A4050)	The reconfiguration of junctions along on the A4050, as a result of HS2 construction means that HGVs cannot be U-turned on the ring road. This would prevent access to the HS2 construction site and freightliner terminal which means it is not a feasible option.	Non

	Outer CAZ C Charge (Within A4040)	The options tested already increases traffic on the A4040 and on Highways England motorway network. An additional CAZ will worsen these impacts to an unacceptable level. A City Centre CAZ results in a relatively high number of vehicles to be bought/ swapped. An additional outer CAZ will affect a significantly larger number of vehicles with significant likelihood that this would put pressure on the 2nd hand market. The levels of compliance within the City Centre will not be affected by the outer CAZ, and therefore this would not fix the issues on the A38. The cost and practicality of implementing the option will be prohibitive.	An updated SATURN model is being produced adding network detail outside of the City Centre allowing for a more robust assessment of impacts outside of the City Centre. An outer CAZ will be tested in this model to assess the impacts of removing through traffic on AQ in the City Centre. This could help support policies, such as signage to remove through traffic.
	Outer CAZ D Charge (Within A4040)	The options tested already increases traffic on the A4040 and on Highways England motorway network. An additional CAZ will worsen these impacts to an unacceptable level. A City Centre CAZ results in a relatively high number of vehicles to be bought/ swapped. An additional outer CAZ will affect a significantly larger number of vehicles with significant likelihood that this would put pressure on the 2nd hand market. The levels of compliance within the City Centre will not be affected by the outer CAZ, and therefore this would not fix the issues on the A38. The cost and practicality of implementing the option will be prohibitive.	As above.
	Higher charges during the peaks.	Legal AQ limits cannot be achieved when applied across the whole day so no little benefit likely in reducing charges in the off peak.	This can be considered when more detailed implementation of the scheme is considered for FBC.
	Incentivisation of petrol over diesel	No practical/ legal process to do this has been identified.	To be considered if sensitivity testing indicates that this will provide benefits and if a practical solution can be identified.
Public Transport	Incentivise or subsidise sustainable travel by up to 50% to improve public transport patronage	Ongoing work with TfWM and operators to develop an option that can deliver mode shift for reasonable costs.	Ongoing
Car Sharing	Incentivise Car Sharing	Ongoing work with TfWM to develop a car sharing policy	Ongoing

Approach to Testing

3.5 The section below provides additional detail on the additional measures tested and the approach taken.

Fleet Upgrades

Taxi and PHV

3.6 Birmingham Council have undertaken taxi/ PHV studies, investigating the numbers of vehicles expected to upgrade to cleaner vehicles due to the cities' clean air policies. We have directly adopted these forecasts of the number of vehicles that will upgrade to Electric or LPG retrofitting.

3.7 These assumptions do not affect the numbers of taxi/ PHV vehicles in the CAZ scenarios, but assumes they will be less polluting vehicles. Therefore, the adjustments were made to the link level Air Quality inputs rather than adjusting the model demand and running the full modelling process. The adjustments were made to the traffic model outputs:

- For electric vehicles, they are removed from the AQ inputs as they are assumed to have 0 emissions.
- For taxis retrofitting to LPG, they were removed from diesel and added into petrol, assuming to be the equivalent to a petrol Euro Class 4.

3.8 To adjust the flows input to the AQ model, we analysed the numbers of individual vehicles entering the CAZ zone during the week that the ANPR surveys were undertaken. The numbers of vehicles upgrading, was used to calculate a factor to apply to the AQ inputs as shown in Table 3.3 below.

Table 3.3: Upgrade Assumptions

Vehicle Upgrade	Numbers of Diesel Taxis Entering CAZ	Numbers of Vehicles Upgraded	Taxi VKM Reduction
Taxi to Electric	1985	85	4.3%
Taxi to LPG		65	3.3%
Vehicle Upgrade		**Numbers of Vehicles**	**PHV VKM Reduction**
PHV to Electric	1289	441	34%

Network Tests

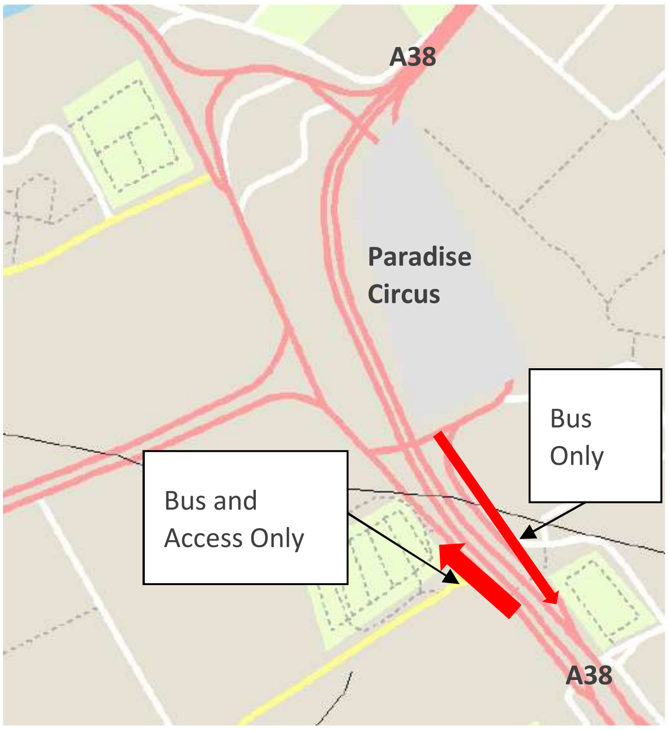
3.9 Changes to the network were tested through coding changes into the SATURN highway model and the new route choices and change in link delay past into the AQ model. The section below describes the changes tested.

Paradise to A38

3.10 Traffic entering (SB) or leaving (NB) Suffolk Street Queensway (A38) from Paradise Circus (except for local access), is banned as in figure 3.1 below. This causes a reduction in traffic on the section of A38 just to the south of Paradise Circus which is a link which exceeds the legal AQ limits. It will also remove weaving movements on the A38 reducing acceleration/ deceleration on this key section of road.

3.11 Implementing these changes also reduces traffic through Paradise Circus, which is an important area of regeneration within the City Centre with a major masterplan currently in construction.

Figure 3.1: Paradise Access Changes



Lister Street Closure

3.12 Access from Lister Street and Great Lister Street to and from the A4050 Dartmouth Middleway is removed. This allows more green-time to be provided for the A4540 at the traffic light junction, reducing delay on this link mitigating against the increase in flows caused by the CAZ charging and reducing emissions.

Ban on all CAZ through trips

3.13 Bans on CAZ through trips for all vehicle types was coded by adding a high toll onto links into the City Centre. This will only affect through trips within the assignment, as trips destined to the City Centre are "forced" to reach their destination within the network model. This test was run banning all vehicles and separately for LGV and HGVs.

3.14 These tests resulted in significant reductions in traffic within the ring road, with resulting AQ improvements. However, this caused significant increases in traffic on the Eastern section of the A4540, which exceeds the AQ levels, and adds rat-running movements on local roads parallel to the Ring Road.

CAZ on the A4050 Ring Road (Eastern Section)

3.15 A charge was applied to the eastern section of the ring road between Bordesley Circus and Dartmouth Circus. This was run for a CAZ C and CAZ D option. The option was rejected as it did not reach compliance, and also increased rat-running traffic on local roads.

Parking

3.16 According to the Birmingham City Centre Parking[18] study undertaken by JACOBS on behalf of Birmingham City Council in 2016 over 12% of parking spaces within Birmingham City Centre are free on-street parking. Once average utilisation, is considered this increases to 16% as shown in table 3.4 below.

[18] Birmingham City Centre Parking Study, JACOBS, 2016

Table 3.4: Parking Supply Birmingham City Centre

Parking Type	Spaces	Free % of Total
Public On-Street (Free Parking Spaces)	6,300	12%
Total Parking Spaces	51’800	
Public On-Street (Average Peak Utilised Spaces)	6,100	16%
Total Parking (Average Peak Utilised Spaces)	38,500	

3.17 As a means of reducing traffic entering the City Centre Birmingham Council have proposed removing all free parking within the zone. A test has therefor been developed to assess the impacts on overall traffic levels of parking charges. The following assumptions have been applied:

- The charge will be capped at the average charge of a Birmingham City Council controlled car park (£4.94). There is spare capacity in the Cities’ car parks with users switching to these car parks if the price exceeds this charge.
- For non-compliant vehicles currently using free parking the charge experienced will be £12.5 plus £4.94
- This is applied to cars only, with freight and taxi assumed to pass on charges or have alternatives to on-street parking.
- PRSIM elasticity to charge used in the CAZ charge testing applied to all users to calculate the responsiveness to removing the parking charge.
- The changes are only applied to the proportion of the demand that has free parking and disaggregated to the areas of the City with free parking.
- Controlled parking will be introduced on the edge of the City Centre if needed to prevent users parking for free (but this has not been explicitly modelled).

Table 3.5: Removal of Free Parking Responsiveness

Response	Non-Compliant	Compliant
Pay Charge	2%	64%
Avoid Zone (Change Destination)	70%	26%
Cancel Trip	21%	7%
Mode Shift	6%	2%
Total	100%	100%

3.18 Applying the assumptions above results in a 5.5% reduction in car traffic with an origin and destination in the City Centre. When taking through trips and other vehicle types a reduction in flows is around 2.5%.

3.19 More detail on the assumptions applied can be found in Appendix F.

Bus Corridors

3.20 Transport for the West Midland (TfWM) identified four potential bus corridors that could implemented by 2020;

- A435 Alcester Road - Kings Heath to Birmingham
- A41 Hollyhead Road/Soho Road to Birmingham
- A5127 - Erdington to Birmingham City Centre
- Pershore Road - Stirchley to Birmingham City Centre

3.21 These have been tested forecasting mode shift using research carried out by Transport Research Laboratory (TRL) [19], which forecasts an uplift on existing demand in a public transport corridor based on an elasticity to public transport journey time improvements and a diversion factor from car to forecast the mode shift proportion.

3.22 In addition, we assumed that non-compliant trips in the corridor with a start or end point in the CAZ would have a mode shift response as forecast by TfL's ULEZ study (weighted to Birmingham values), which is at a higher level than forecast by PRISM. This assumes that the corridor improvements will bring the PT access and in line with London conditions.

Table 3.6: Parameters Applied to Corridor Demand

Parameter	Value
Elasticity to JT	-0.58
Diversion Factor from Car	0.31
Non-Compliant Response	15%
Car Occupancy	1.2

3.23 Work by TfWM provided a high-level assessment of potential journey time improvements and existing patronage to feed into the calculations. However, the limited coverage of the bus corridors resulted in a small mode shift into the City Centre, of only 0.5%. Given the high costs to implement the scheme the interventions cannot be justified in AQ terms.

3.24 The detailed assumptions applied when developing this test can be found in Appendix F.

[19] The demand for public transport: a practical guide (TRL593), 2004, TRL

OBC Behavioural Responses

3.25 The OBC scenarios have been run with a CAZ C High and CAZ D High Charges, with following additional measures.

- Increase LPG refuelling for Hackney Carriages and the installation of rapid EV infrastructure for taxi and private hire vehicles and Retrofitting of black taxis to LPG
  - 85 taxis upgraded to Electric vehicle
  - 441 PHVs upgraded to Electric Vehicle
  - 65 taxis retrofitted to LPG
- Zero emission buses (new Hydrogen buses)
- Remove all free parking from BCC controlled areas. Replaced with paid parking spaces. Assume cost of parking in line with BCC off-street parking.
- Ban traffic entering (SB) or leaving (NB) Suffolk Street Queensway (A38) from Paradise Circus (except for local access).
- Close Lister Street and Great Lister Street at the junction with Dartmouth Middleway. This allows, more green time for the A4540.

3.26 The effects of these tests (other than the fleet upgrades) which are only applied to the AQ inputs (as described above) are shown in the tables and figure on the following pages for CAZ C and CAZ D showing the following:

- Change in flows crossing the cordon – combined impact of route choice and behavioural impacts on flow entering the CAZ cordon.
- Car behavioural impacts, as a result of CAZ charging and parking charges
- Other vehicle’s behaviour as a result of CAZ charging.

Figure 3.2: Cordon Crossings CAZ C High (OBC)

	Car	Taxi	LGV	HGV	Bus	Total
DM						
Compliant	125,900	2,700	13,100	4,600	3,300	149,500
Non-compliant	37,100	6,500	9,100	2,500	2,200	57,400
Total	163,000	9,200	22,200	7,000	5,500	206,900
CAZ C High (OBC)						
Compliant	122,900	9,200	17,200	6,700	5,500	161,500
Non-compliant	36,800	-	3,600	100	-	40,500
Total	159,600	9,200	20,800	6,800	5,500	201,900
Change from Do Minimum (absolute)						
Compliant	-3,000	6,500	4,100	2,100	2,200	12,000
Non-compliant	-300	-6,500	-5,500	-2,400	-2,200	-16,900
Total	-3,400	-	-1,400	-200	-	-5,000
Change from Do Minimum (%)						
Compliant	-2%	243%	32%	47%	67%	8%
Non-compliant	-1%	-100%	-61%	-96%	-100%	-30%
Total	-2%	1%	-6%	-3%	0%	-2%

Table 3.7: CAZ C High OBC - Car Response

Response	Parking Response	Non-Compliant Change as % of Total Car Flows	Compliant Change as % of Total Car Flows
Pay Parking Charge	64%	2.3%	7.6%
Avoid Zone (Change Destination)	26%	0.9%	3.1%
Cancel Trip	7%	0.3%	0.9%
Replace Vehicle	0%	0.0%	0.0%
Mode Shift	2%	0.1%	0.3%
Total	100%	3.6%	11.8%

Table 3.8: CAZ C High OBC - Non-Car Behavioural Responsiveness

Response	LGV	HGV	Taxi	Bus
Pay CAZ Charge	39%	4%	0%	0%
Avoid Zone (Change Route)	27%	29%	0%	0%
Cancel Trip	0%	0%	0%	0%
Replace Vehicle	34%	67%	100%	100%
Total	100%	100%	100%	100%

Figure 3.3: Cordon Crossings CAZ D High (OBC)

	Car	Taxi	LGV	HGV	Bus	Total
DM						
Compliant	125,900	2,700	13,100	4,600	3,300	149,500
Non-compliant	37,100	6,500	9,100	2,500	2,200	57,400
Total	163,000	9,200	22,200	7,000	5,500	206,900
CAZ D High (OBC)						
Compliant	142,700	9,500	17,200	6,700	5,500	181,500
Non-compliant	2,900	-	3,600	100	-	6,600
Total	145,600	9,500	20,800	6,800	5,500	188,100
Change from Do Minimum (absolute)						
Compliant	16,800	6,800	4,100	2,100	2,200	32,000
Non-compliant	- 34,200	- 6,500	- 5,500	- 2,400	- 2,200	- 50,800
Total	- 17,400	300	- 1,400	- 200	-	- 18,800
Change from Do Minimum (%)						
Compliant	13%	251%	32%	47%	67%	21%
Non-compliant	-92%	-100%	-61%	-96%	-100%	-89%
Total	-11%	3%	-6%	-3%	0%	-9%

Table 3.9: Compliant Car Response

Response	Compliant Car Response (or all cars in CAZ C Scenario)	Response as Proportion of Total Car Fleet
Pay Parking Charge	64%	7.6%
Avoid Zone (Change Destination)	26%	3.1%
Cancel Trip	7%	0.9%
Replace Vehicle	0%	0.0%
Mode Shift	2%	0.3%
Total	100%	11.8%

Table 3.10: Non-Compliant Car Response

Response	Response of Compliant Vehicles	Response as Proportion of Total Car Fleet
Pay CAZ Charge	8%	1.8%
Pay CAZ Charge and Parking*	0%	0.0%
Upgrade and Pay Parking	5%	1.2%
Avoid Zone (Change Route)	22%	5.1%
Avoid Zone (Change Destination)	17%	4.0%
Cancel Trip	8%	2.0%
Replace Vehicle	38%	8.8%
Mode Shift	2%	0.4%
Total	100%	23.3%

* less than 0.1%

Table 3.11: Non Car Behavioural Responsiveness

Response	LGV	HGV	Taxi	Bus
Pay CAZ Charge	39%	4%	0%	0%
Avoid Zone (Change Route)	27%	29%	0%	0%
Cancel Trip	0%	0%	0%	0%
Replace Vehicle	34%	67%	94%	100%
Total	100%	100%	100%	100%

4 Model Results

Overview

4.1 This section describes the impact of the forecasts described in the proceeding chapters on the SATURN assignment models. A summary of the model runs are as follows:

- The models have been run for the following time periods:
  - AM Peak Weekday Average Hour (07:30-09:30)
  - Inter Peak Weekday Average Hour (08:30-16:30)
  - PM Peak Weekday Average Hour (16:30-19:00)
- And the following scenarios
  - 2016 Base Year
  - 2020 Do Minimum
  - 2020 CAZ C High with Additional Measures (OBC)
  - 2020 CAZ D High with Additional Measures (OBC)

4.2 The detailed reporting in this chapter focuses on the AM Peak hour, and the high CAZ C and D charge scenarios. The effects are similar across the time periods and the CAZ high charge scenario has the more significant impacts and is therefore more useful in illustrating the potential impacts of the scheme. Network plots and changes in network statistics are included in appendices for all scenario.

4.3 The key metrics we have used to assess the impacts of the CAZ are as follows:

- Annual Average Daily Flows (AADT) entering the CAZ for compliant and non-compliant flows. This shows the numbers of vehicles driving across the CAZ boundary each day by vehicle type in the different scenarios.
- Network Plots – Showing change in flows graphically across the modelled links to see where flows are increasing and decreasing. Also includes analysis of change in link delay.
- Key Link Analysis – Tables showing changes in flows at key network links at the all day level
- Network Statistics – Change in vehicle kilometres and average network speed. This provides an aggregate measure of change in network conditions and has been provided by different modelled areas.

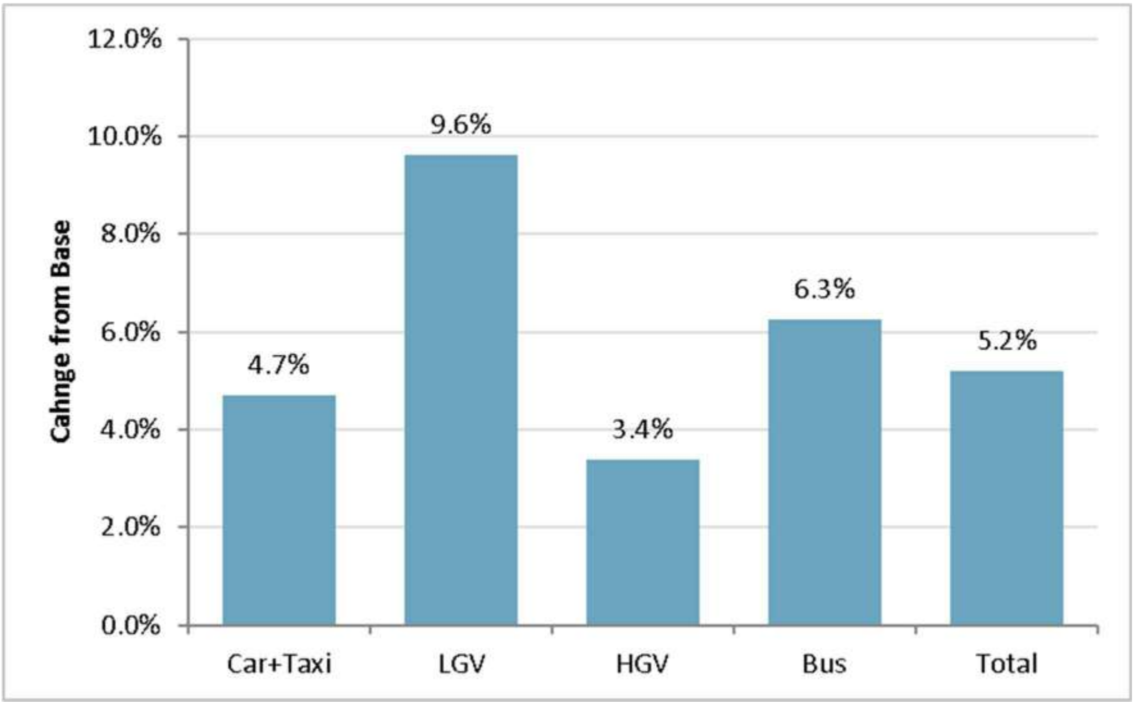
4.4 An important caveat when analysing these results is that the model detailed is focused on the City Centre. Changes to the model outside of the CAZ should be treated with caution.

Base Year to Do Minimum Changes

Clean Air Zone

4.5 Figure 4.1 shows the forecast growth in vehicles entering the CAZ between 2016 to 2020, including both through trips and those with a destination in the City Centre. Overall traffic growth is 5.2% with the largest increase in LGVs, with an increase of 9.6%. This is line with recent trends showing rapid growth in "white van" traffic.

Figure 4.1: Growth by Vehicle Type – Average Annual Daily Traffic



4.6 Figure 4.2 below, shows the changes in compliance rates for the different vehicle classes, supported by the detailed information in Table 4.1 to Table 4.4 below. Overall there is an increase in 10,000 vehicles entering the zone, but with a reduction in non-compliant vehicles of around 33,000 vehicles.

Figure 4.2: Growth by Compliance Rate

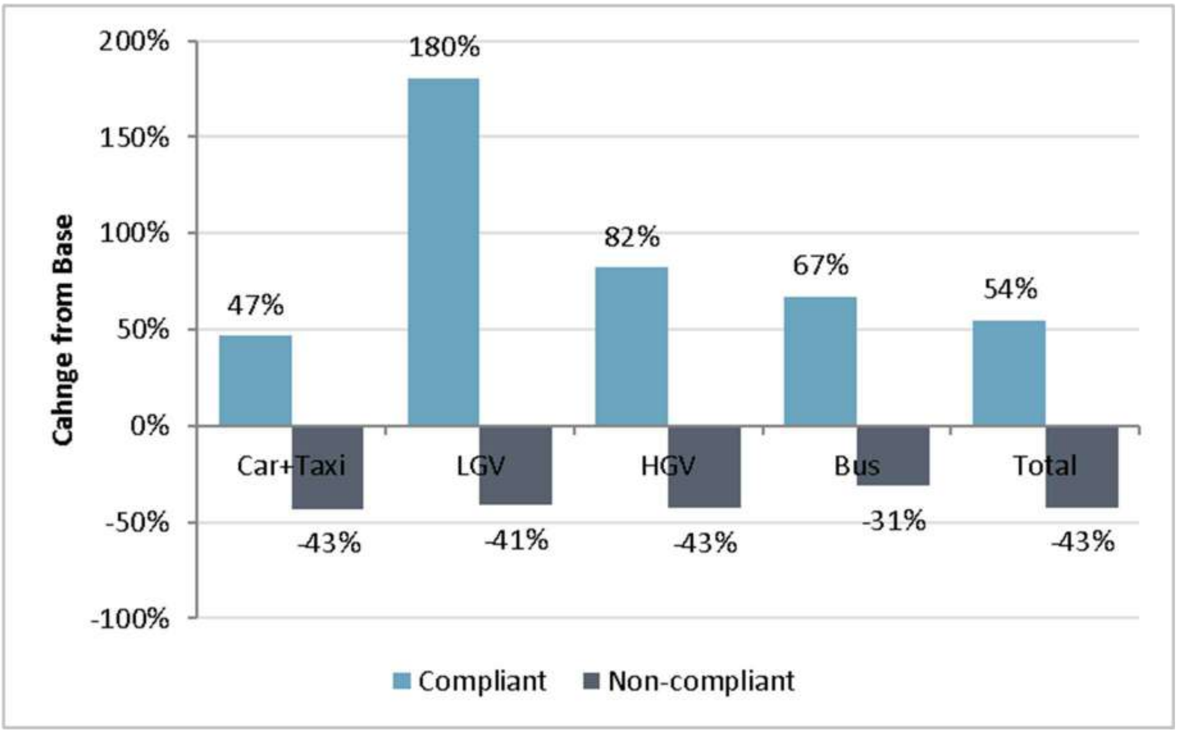


Table 4.1: Screenline AADT Flows – 2016 Base Year

Compliance	Car+Taxi	LGV	HGV	Bus	Total
Compliant	87,700	4,700	2,500	2,000	96,800
Non-compliant	76,800	15,600	4,300	3,200	99,900
Total	164,500	20,300	6,800	5,100	196,700

Table 4.2: Screenline AADT Flows - 2020 Do Minimum

Compliance	Car+Taxi	LGV	HGV	Bus	Total
Compliant	128,600	13,100	4,600	3,300	149,600
Non-compliant	43,600	9,200	2,500	2,200	57,400
Total	172,200	22,200	7,000	5,500	207,000

Table 4.3: Screenline AADT Flows Difference (2020 Do Minimum – 2016 Base Year)

Compliance	Car+Taxi	LGV	HGV	Bus	Total
Compliant	40,900	8,400	2,100	1,300	52,800
Non-compliant	-33,200	-6,400	-1,800	-1,000	-42,500
Total	7,700	1,900	200	400	10,300

Table 4.4: Screenline AADT Flows % Difference (2020 Do Minimum – 2016 Base Year)

Compliance	Car+Taxi	LGV	HGV	Bus	Total
Compliant	47%	180%	82%	67%	54%
Non-compliant	-43%	-41%	-43%	-31%	-43%
Total	5%	10%	3%	6%	5%

Network Changes

4.7 Figure 4-3 to Figure 4-5 illustrate changes in AM peak city centre traffic flows between the 2016 Base Year and the modelled 2020 Do-Minimum, with:

- Green links showing an increase in traffic with the thicker the line the bigger the increase
- Blue links showing a decrease in traffic with the thicker the line the bigger the decrease

4.8 Figure 4-3 shows the change in total traffic, with impacts varying depending on the location of new developments and the impact of changes to the road network. Outside of the CAZ zone there is general increase in traffic reflecting the forecast growth in background traffic. Decreases in traffic can be seen to the East of the City Centre with traffic reducing due to road closures associated with HS2 construction. There are also decreases on Moor Street corridor as the introduction of the Edgbaston Metro further removes capacity for general traffic.

4.9 Significant increases in traffic are seen on the A38 through the City Centre as traffic diverts from the corridors described above, and following the completion of the Paradise Circus scheme which reopens the link to Summer Hill Road increasing accessibility to the corridor compared to 2016 conditions. This also increases traffic on Summer Hill Road while reducing rat-running traffic on the side streets in the area. The closure of the roads linked to HS2 construction also leads to increases in traffic on Moor Street/ Deritend High Street corridors.

4.10 Figure 4-5 shows the changes in compliant and non-compliant vehicle traffic respectively. This demonstrates the reduction in non-compliant vehicles due to the natural upgrading of the vehicle fleet, despite the general increases in total traffic.

Figure 4-3: Total Flow Change (2020 Do Minimum – Base) - AM

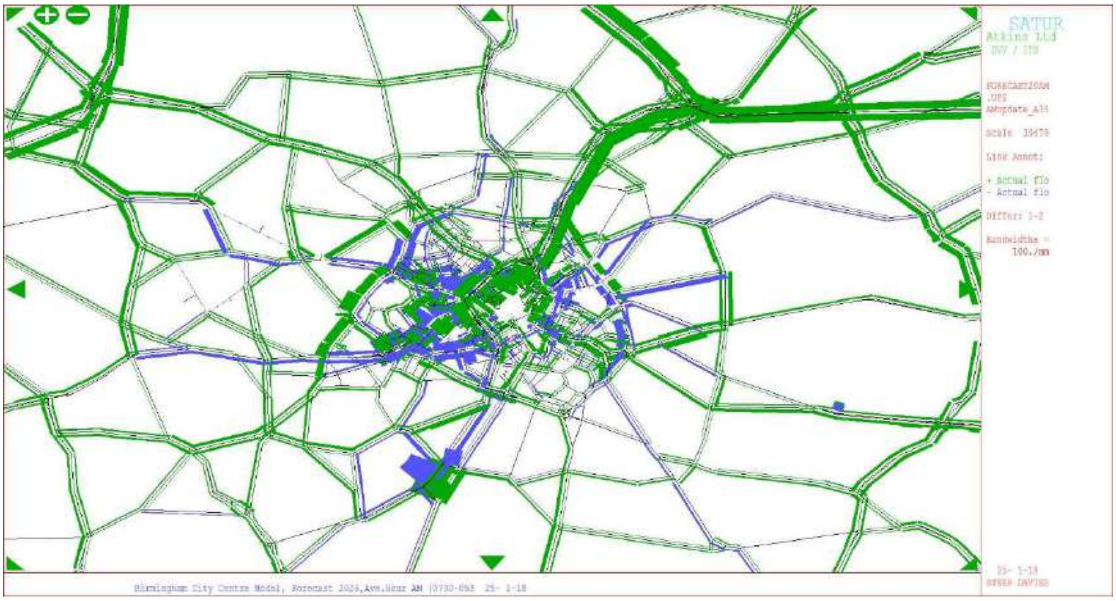


Figure 4-4: Compliant Flow Change (2020 Do Minimum – Base) – AM

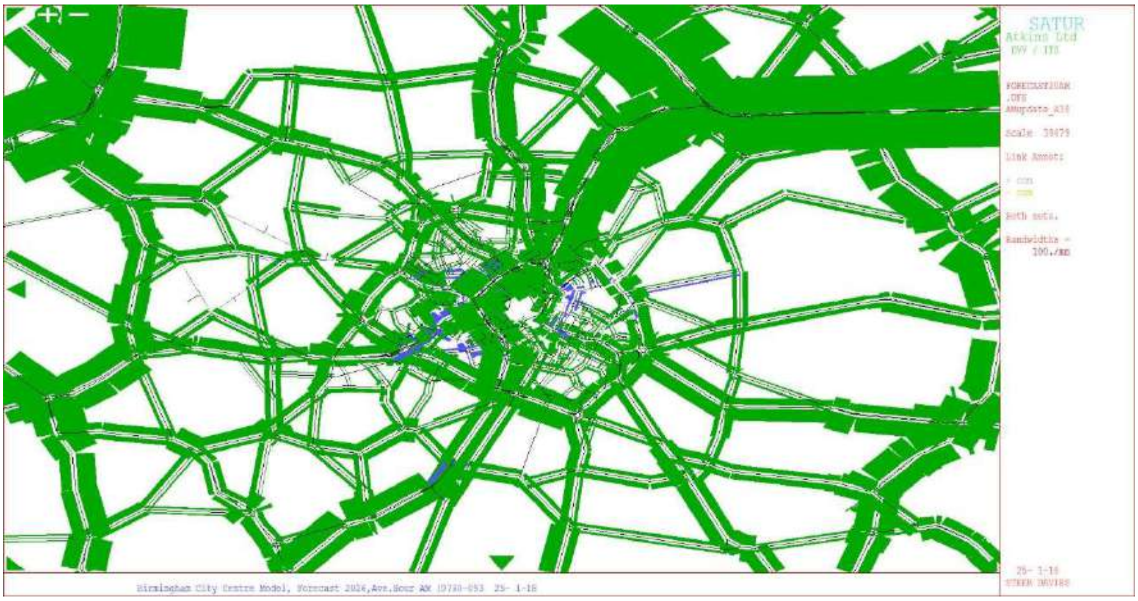
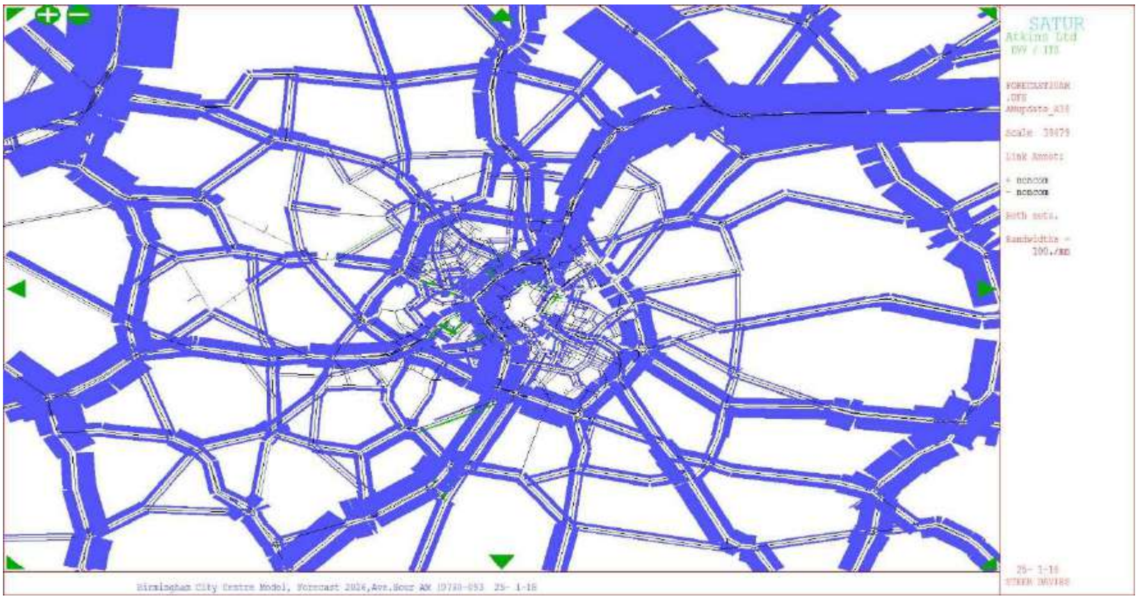


Figure 4-5: Non-compliant Flow Change (2020 Do Minimum – Base) - AM



CAZ Scenario C

Clean Air Zone Changes

4.11 Under CAZ Scenario C there are no charges applied to cars and therefore no significant change in compliance rates within the CAZ. Buses and taxis are assumed to be all upgrade through licencing and agreements with operators.

4.12 The change in compliance for LGV and HGV traffic entering the CAZ is shown for the three charge levels in 4.6 below. At these high charge levels, the compliance rates for HGVs are very high with nearly all vehicles entering the CAZ forecast to be compliant. LGVs have lower compliance rates in comparison.

4.13 The high proportion of car vehicles in the CAZ is demonstrated by the overall impact on total traffic resulting in a 30% reduction in non-compliant vehicles despite high levels of compliance response for the other vehicle types.

Table 4.5: Compliance Rates for CAZ C – Crossing the CAZ Cordon

Scenario	Compliance	Car	Taxi and PHV	LGV	HGV	Bus	Total
DM	Compliant	77%	30%	59%	65%	60%	72%
	Non-compliant	23%	70%	41%	35%	40%	28%
CAZ C (OBC)	Compliant	77%	100%	83%	99%	100%	80%
	Non-compliant	23%		17%	1%	0%	20%

4.14 Table 4.6 below shows the forecast CAZ cordon crossing flows. Within the model Private Hire Vehicles (PHVs) are included within the car matrices with adjustments to the compliance rates made to account for the differing response rates outside of the model for presentation purposes. Because it is an out of model adjustment the balance between car and PHV in the tables may not be 100% accurate, however in terms of total compliance and the fleet mix in the AQ model these numbers are correct.

4.15 The following impacts are shown in the model results:

- There is a reduction in overall car trips caused by removing free parking.
- A reduction of around 17,000 non-compliant vehicles entering the CAZ.

Table 4.6: CAZ C Screenline AADT flows by Vehicle Type

Do Minimum	Car	Taxi and PHV	LGV	HGV	Bus	Total
Compliant	125,900	2,700	13,100	4,600	3,300	149,600
Non-compliant	37,200	6,400	9,100	2,500	2,200	57,400
Total	163,100	9,100	22,200	7,000	5,500	206,900
High	**Car**	**Taxi and PHV**	**LGV**	**HGV**	**Bus**	**Total**
Compliant	122,900	9,200	17,200	6,700	5,500	161,500
Non-compliant	36,800	-	3,600	100	-	40,500
Total	159,600	9,200	20,800	6,800	5,500	201,900
Change from Do Minimum (Abs)	**Car**	**Taxi and PHV**	**LGV**	**HGV**	**Bus**	**Total**
Compliant	-3,100	6,500	4,100	2,100	2,200	12,000
Non-compliant	-400	-6,500	-5,600	-2,400	-2,200	-16,900
Total	-3,400	100	-1,400	-200	-	-5,000
Change from Do Minimum (%)	**Car**	**Taxi and PHV**	**LGV**	**HGV**	**Bus**	**Total**
Compliant	-2%	243%	32%	47%	67%	8%
Non-compliant	-1%	-100%	-61%	-96%	-100%	-30%
Total	-2%	1%	-6%	-3%	0%	-2%

Network Changes

4.16 Figures 4.6 to 4.9 illustrate changes in AM peak city centre traffic flows between the modelled 2020 Do-Minimum and CAZ C High scenario with

- Green links showing an increase in traffic in CAZ C compared to the Do-Minimum with the thicker the line the bigger the increase
- Blue links showing a decrease in traffic in CAZ C compared to the Do-Minimum with the thicker the line the bigger the decrease

4.17 In total, there is decrease crossing the city centre and increase on some sections of the Ring Road which is used as a detour for through trips entering the zone. The effect of closing Moor Street Queensway to general traffic can be seen with reductions on Digbeth High Street/ Moor St corridors and increases on the A4050 Ring Road.

Figure 4.6: Total Flow Change (CAZ C High – Do Minimum) – AM

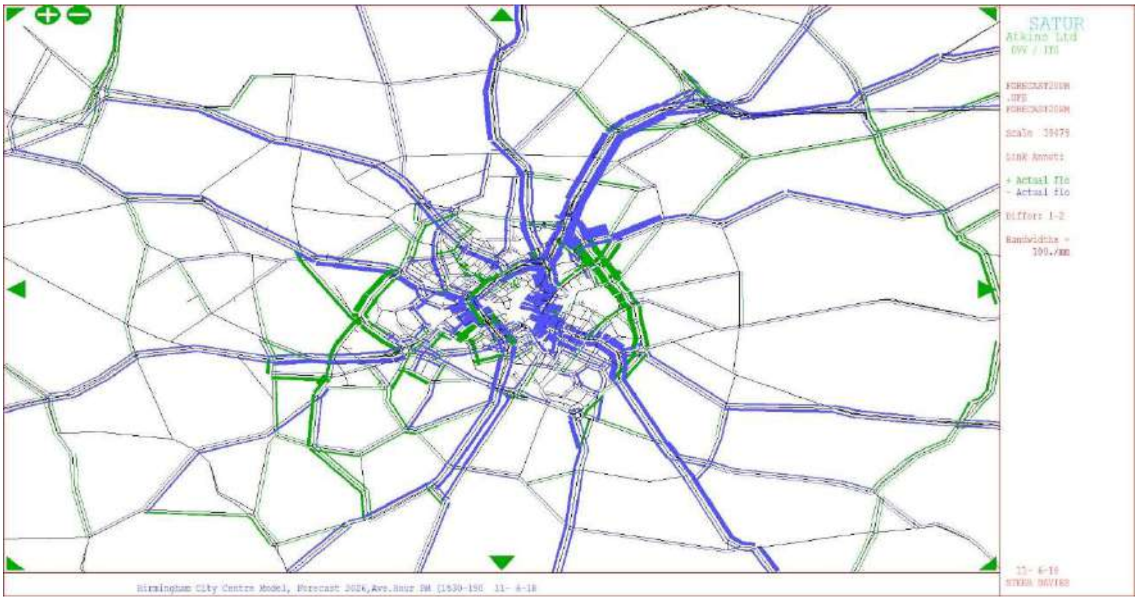


Figure 4.7: Compliant Flow Change (CAZ C High – Do Minimum) – AM

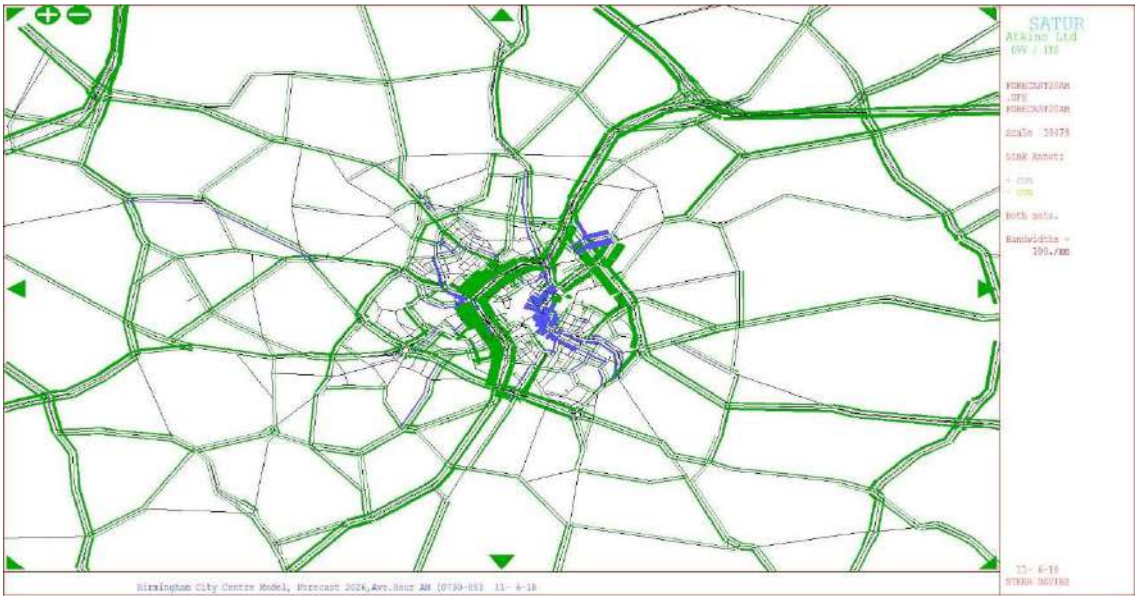
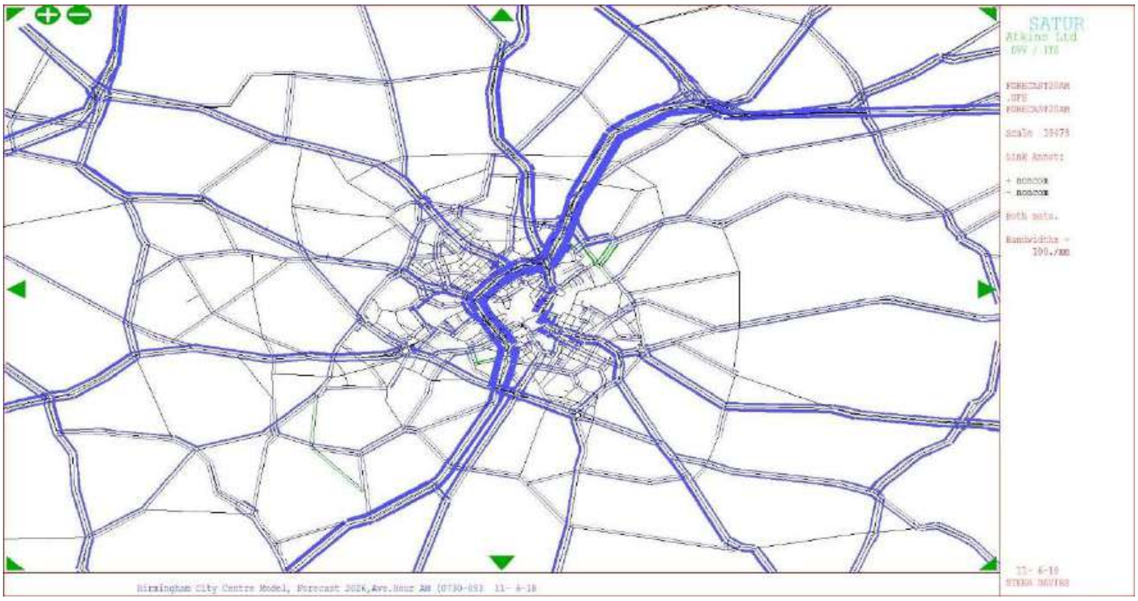


Figure 4.8: Non-compliant Flow Change (CAZ C High – Do Minimum) – AM



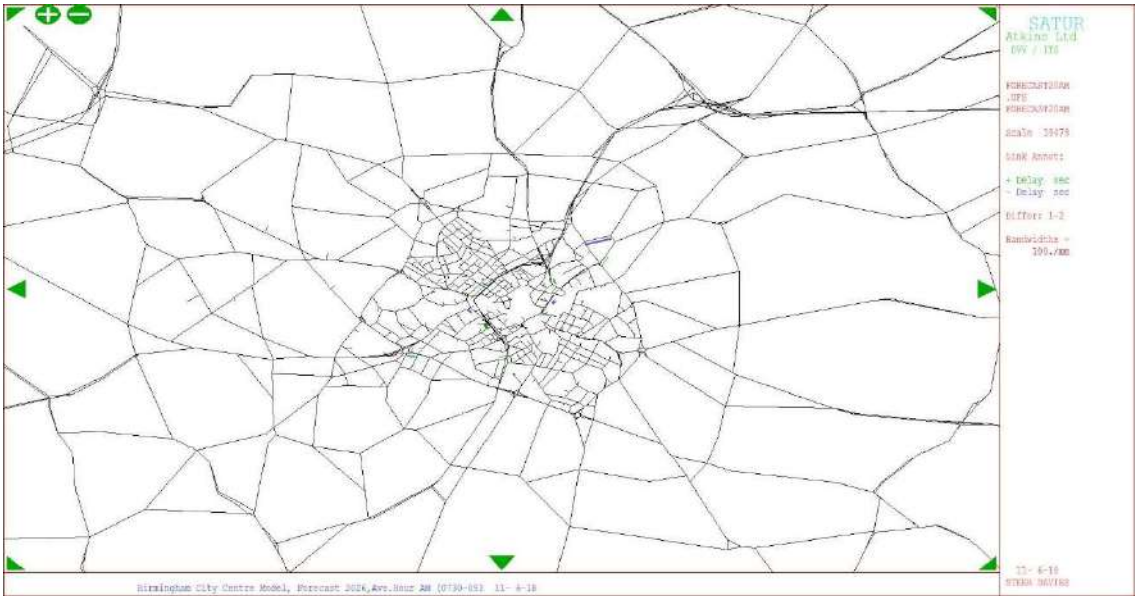
Link Delays

4.18 Figure 4.9 shows the change in average link delay as a result of CAZ C in the AM Peak:

- Green links showing an increase in delays in CAZ C compared to the Do-Minimum with the thicker the line the bigger the increase
- Blue links showing a decrease in delays in CAZ C compared to the Do-Minimum with the thicker the line the bigger the decrease

4.19 The scheme has minor impacts on link delay with minor decreases on links with reduced through trips, and some increases on links to which traffic diverts. The largest increase in delays is around 4 seconds.

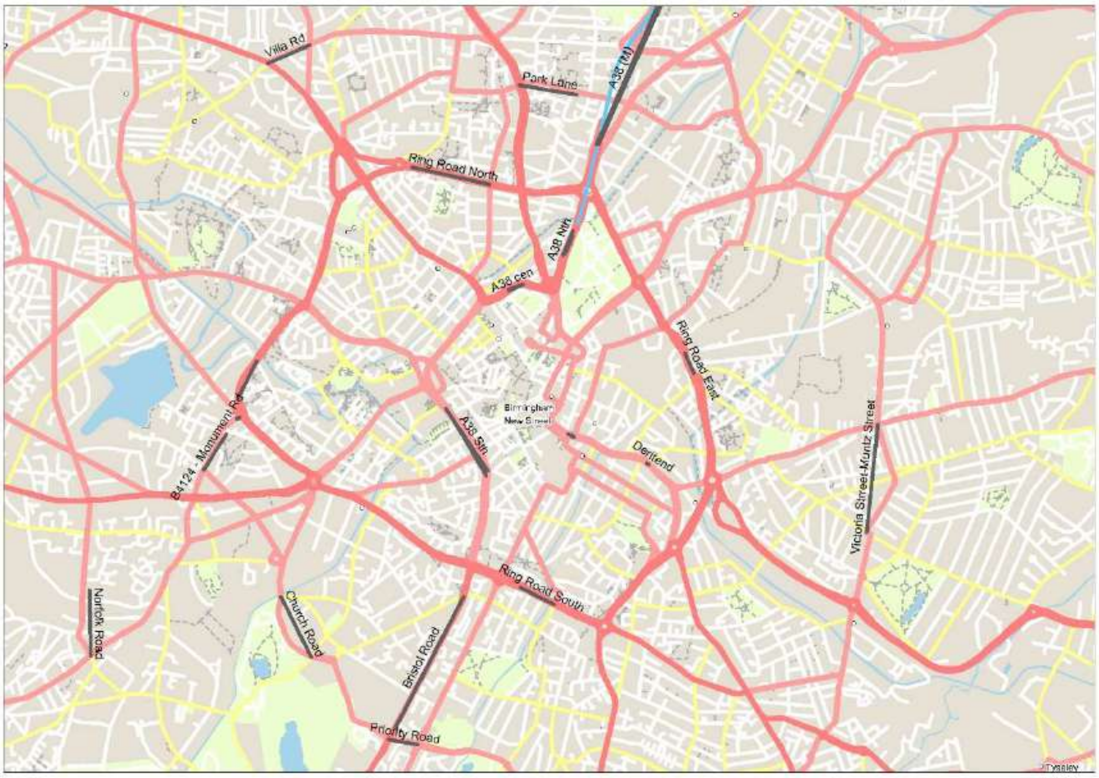
Figure 4.9: AM Peak – Change in Average Link Delay in Seconds – (CAZ C High – Do Minimum)



Key Link Analysis

4.20 To have a more detailed understanding of changes to the network a number of individual links have been analysed. The worst links in the City Centre in terms of Air Quality have been identified as well as selecting four links on the ring road, and change in flows between scenarios analysed. Figure 4.10 shows the links chosen for more detailed analysis.

Figure 4.10: City Centre Key Links



4.21 Table 4.7 and Table 4.8 below show changes in total and HGV traffic respectively for City Centre links, with the following observations for traffic growth between the base year and the Do Minimum:

- These links show significant growth due to parallel road closures (described at the start of this chapter) due to:
  - HS2 Curzon Street construction; and
  - Edgbaston Metro

4.22 The CAZ C compared to the Do Minimum show:

- That CAZ C has a limited impact on overall traffic levels, due to LGV and HGV through trips being a low proportion of the total traffic.
- HGVs impacts of the CAZ C are more significant in % terms, although they are a relatively small proportion of total traffic so in terms of impact on daily flows the maximum reduction is around 500 vehicles.
- Impact of the closure of Moor St can be seen with reductions in Deritend and Digbeth.

Table 4.7: City Centre Links AADT All Vehicles

Road	2016 Base	2020 Do Minimum	Growth (DM-Base) (Abs)	Growth (Base to DM %)	CAZ C High	CAZ C Change (CAZ C - DM)	CAZ C Change (DM to CAZ C %)
Deritend High St	24,300	28,700	4,400	18.1%	24,600	-4,100	-14.4%
Digbeth Gyratory	17,500	22,900	5,400	30.6%	18,300	-4,600	-20.2%
A38 South	56,400	61,100	4,700	8.4%	61,500	400	0.6%
A38 Central	61,500	68,800	7,300	11.7%	70,600	1,800	2.6%
A38 North	84,000	89,900	5,900	6.9%	89,300	-600	-0.6%

Table 4.8: City Centre Links AADT HGVs

Road	2016 Base	2020 Do Minimum	Growth (DM-Base) (Abs)	Growth (Base to DM %)	CAZ C High	CAZ C Change (CAZ C - DM)	CAZ C Change (DM to CAZ C %)
Deritend High ST	610	690	80	12.2%	500	-200	-25.6%
Digbeth Gyratory	420	700	280	64.8%	500	-200	-29.6%
A38 South	2,360	2,520	160	6.7%	2,200	-400	-14.5%
A38 Central	2,460	2,470	10	0.2%	2,400	-100	-2.7%
A38 North	3,540	3,540	-	0.0%	3,100	-400	-11.7%

4.23 For the ring road, changes in traffic levels are as shown in Table 4.9 and Table 4.10 below:

- In terms of traffic growth between base year and the Do Minimum, overall growth is in line the with general traffic growth across the model, despite reduced traffic on the Eastern section.
- There are significant increases in traffic caused by the CAZ measures on the Eastern and Western sides of the Ring Road compared to the Do Minimum.

Table 4.9: Ring Road City Centre Links AADT All Vehicles

Road	2016 Base	2020 Do Minimum	Growth (DM-Base) (Abs)	Growth (Base to DM %)	CAZ C High	CAZ C Change (CAZ C - DM)	CAZ C Change (DM to CAZ C %)
Ring Road North	32,800	33,100	300	0.9%	32,900	-200	-0.5%
Ring Road South	59,600	62,300	2,700	4.6%	62,800	600	0.9%
Ring Road West	30,900	32,200	1,300	4.2%	34,700	2,500	7.7%
Ring Road East	54,900	53,700	-1,200	-2.3%	58,400	4,700	8.8%

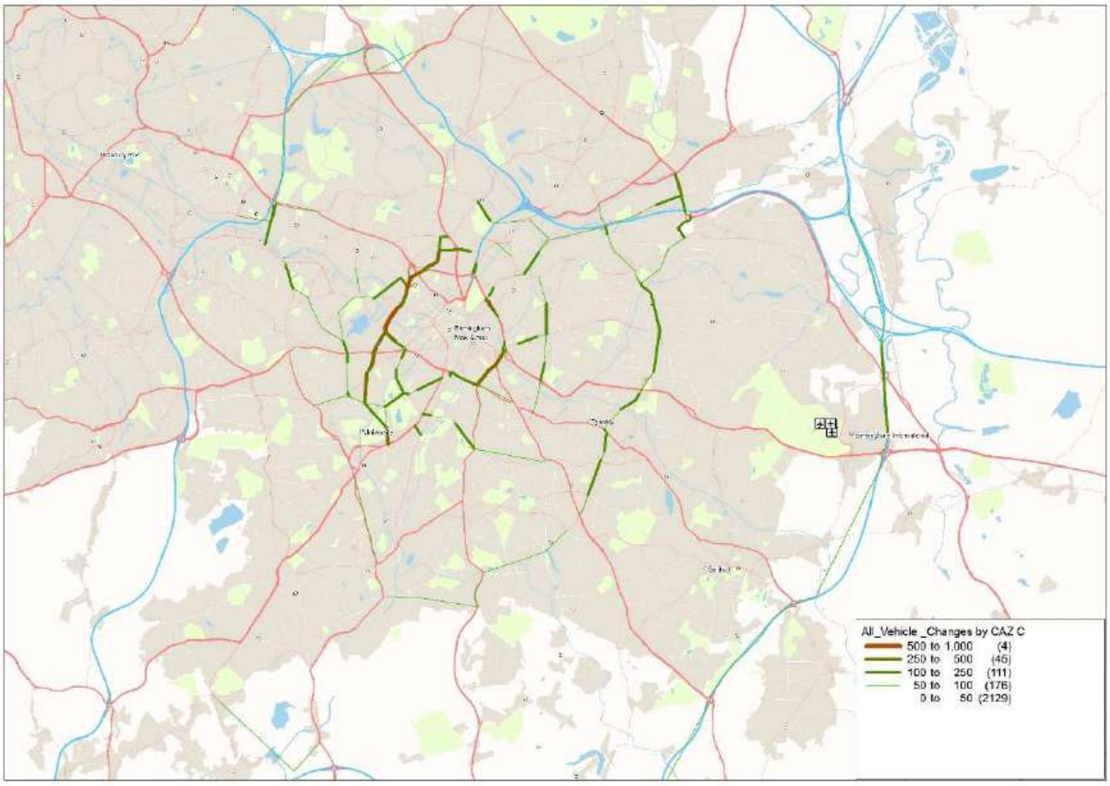
Table 4.10: Ring Road City Centre Links AADT HGVs

Road	2016 Base	2020 Do Minimum	Growth (DM- Base) (Abs)	Growth (Base to DM %)	CAZ C High	CAZ C Change (CAZ C - DM)	CAZ C Change (DM to CAZ C %)
Ring Road North	1,380	1,390	10	0.5%	1,500	100	8.1%
Ring Road South	3,250	3,420	170	5.0%	3,400	-	-1.3%
Ring Road West	780	870	90	11.8%	1,100	200	20.7%
Ring Road East	4,140	4,250	110	2.7%	4,600	400	9.4%

4.24 In terms of the wider network impacts of the CAZ increases in traffic due to diversion away from the CAZ area is shown in Figure 4.11 below, showing links where traffic increase from the Do Minimum. This shows:

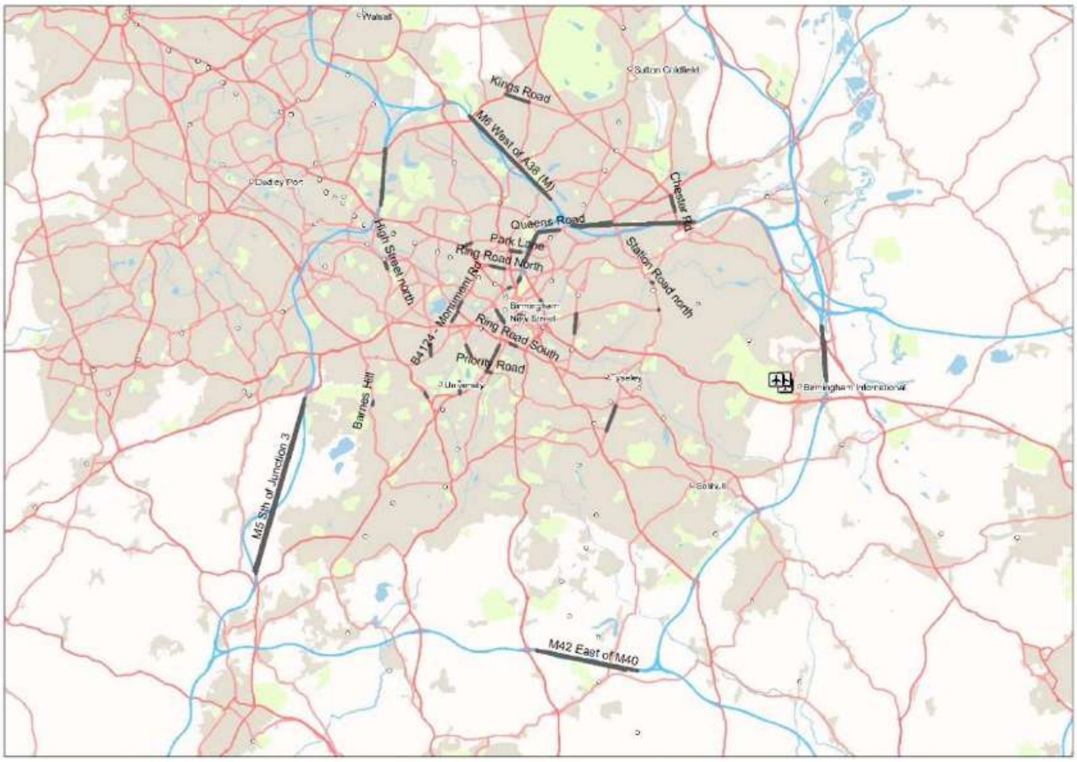
- Increases are generally small at less than 100 vehicles a day
- The most significant increases occur on the Ring Road
- There is diversion to the South East of the City as through trips avoid the A38 and find alternative routing to the Ring Road.

Figure 4.11: Increase in AADT Vehicles Outside the CAZ – CAZ Scenario C



In addition, the links with the largest changes in flows in the CAZ D scenario have also been identified and analysed below. These then represent the full list of links impacted by the two CAZ scenarios and there is duplication of the key links identified in Figure 4.11. The relevant links selected are shown in Figure 4.12 below.

Figure 4.12: Links Selected for Analysis



4.25 Traffic changes on the motorway box links identified for analysis are shown in Table 4.11 and 4.12 below:

- Traffic growth between the base year and the Do Minimum:
  - Is higher than for general traffic particularly on the M42 south of the M6 which is forecast to have highest levels of growth.
- For CAZ C compared to Do Minimum:
  - The impact of CAZ C high is minimal with around a 0.5% change in flows on average.
  - Similar patterns are seen for HGVs with minimal changes caused by CAZ C.

Table 4.11: Motorway Box Links AADT All Vehicles

Road	2016 Base	2020 Do Minimum	Growth (DM- Base) (Abs)	Growth (Base to DM %)	CAZ C High	CAZ C Change (CAZ C - DM)	CAZ C Change (DM to CAZ C %)
M5 South of Junction 3	125,100	130,800	5,700	4.6%	131,000	200	0.1%
M5 South of Junction 8	166,000	173,200	7,200	4.3%	173,900	700	0.4%
M42 East of M40	140,300	148,500	8,200	5.8%	148,900	500	0.3%
M6 East of A38 (M)	115,800	122,200	6,400	5.6%	122,100	-200	-0.1%
M42 South of M6	131,800	141,400	9,600	7.3%	142,100	800	0.6%
M6 West of A38 (M)	156,500	164,700	8,200	5.2%	164,800	100	0.1%

Table 4.12: Motorway Box City Centre Links AAD HGVs

Road	2016 Base	2020 Do Minimum	Growth (DM- Base) (Abs)	Growth (Base to DM %)	CAZ C High	CAZ C Change (CAZ C - DM)	CAZ C Change (DM to CAZ C %)
M5 South of Junction 3	15,840	16,390	550	3.5%	16,400	100	0.3%
M5 South of Junction 8	17,280	17,910	630	3.6%	18,000	100	0.3%
M42 East of M40	17,820	18,590	770	4.3%	18,600	100	0.3%
M6 East of A38 (M)	24,460	24,410	-50	-0.2%	24,400	-	0.1%
M42 Sth of M6	18,360	19,290	930	5.1%	19,500	200	0.9%
M6 West of A38 (M)	27,070	27,080	10	0.0%	27,100	-	0.0%

4.26 For the wider road network within the motorway box the traffic numbers for all traffic are shown in Table 4.13 below. For the base year to Do Minimum traffic growth:

- Growth rates vary across the network with high levels of traffic growth on some links particularly on:
  - B4124 - Monument Rd
  - Alston Street
  - Villa Rd
- There are significant reductions on Park Lane

4.27 For the Do Minimum to CAZ C changes:

- There are generally only relatively minor increases in overall traffic due to diversion, but some reasonably significant increases seen on:
  - Church Road
  - Edgbaston Park Road
  - B4124 - Monument Rd
  - Alston Street
- There is a minor reduction on A38 (M) due to longer distance trips rerouting away from the City Centre.

Table 4.13: Wider Network Links AADT Change in All Vehicles

Road	Growth (Base to DM %)	CAZ C Change (CAZ C - DM)	CAZ C Change (DM to CAZ C %)
Tyburn Rd	7.2%	-300	-0.4%
Chester Rd	4.3%	500	1.0%
A38(M)	7.4%	-2,800	-2.8%
Norfolk Road	6.5%	200	1.4%
Church Road	1.5%	300	2.7%
Edgbaston Park Road	3.2%	800	3.3%
Bristol Road	0.5%	-800	-1.3%

Road	Growth (Base to DM %)	CAZ C Change (CAZ C - DM)	CAZ C Change (DM to CAZ C %)
Priority Road	-12.6%	300	1.0%
Park Lane	1.5%	200	1.1%
B4124 - Monument Rd	21.7%	800	4.9%
Alston Street	14.4%	900	3.5%
Barnes Hill	3.5%	100	0.1%
Harborne Lane	1.5%	400	1.4%
High Street (A4030)	6.2%	300	0.4%
Villa Rd	0.7%	100	0.3%
Fox Hollies Road	3.1%	300	0.6%
Victoria Street-Muntz Street	12.6%	300	1.5%
Queens Road	6.3%	700	2.0%
Kings Road	2.7%	200	0.3%

4.28 HGV changes are shown in Table 4.14. CAZ C causes some significant % increases in HGVs, (however in absolute terms the maximum increase is around 100 vehicles on an average day) on the following roads:

- Church Road
- Edgbaston Park Road
- B4124 - Monument Rd
- Alston Street

4.29 There are reductions in HGV flows on:

- the A38 (M)
- Bristol Road

Table 4.14: Wider Network Links AADT Change in HGVs

Road	Growth (Base to DM %)	CAZ C Change (CAZ C - DM)	CAZ C Change (DM to CAZ C %)
Tyburn Rd	4.7%	-100	-0.9%
Chester Rd	2.5%	100	1.3%
A38(M)	-6.2%	-400	-7.1%
Norfolk Road	10.2%	-	1.3%
Church Road	-4.4%	100	19.3%
Edgbaston Park Road	3.7%	100	21.6%
Bristol Road	-8.0%	-600	-26.3%
Priority Road	-23.1%	100	3.7%
Park Lane	-1.4%	-	3.3%
B4124 - Monument Rd	26.1%	100	17.2%

Alston Street	18.4%	100	10.7%
Barnes Hill	0.9%	-	0.4%
Harborne Lane	-0.1%	-	0.6%
High Street north	2.7%	100	1.7%
Villa Rd	11.2%	-	3.2%
Fox Hollies Road	4.5%	-	1.8%
Victoria Street-Muntz Street	4.6%	-	0.3%
Queens Road	5.4%	100	3.3%
Kings Road	2.8%	-	0.1%

Network Statistics

4.30 Table 4.15 to Table 4.18 below displays the total vehicle kilometres for the Do-Minimum and CAZ C, across the different vehicle types. This provides an aggregate network wide assessment of the impact of CAZ C High on the road network. It should be noted that PHVs are included within cars in the assignment model, so their responses are included within this data.

4.31 The analysis has been split to look at four separate areas:

- Across the whole network:
  - Minimal change in overall vehicle KMs
  - 8% reduction in non-compliant vehicles, driven to a large extent by taxi compliance
- In the Clean Air Zone only:
  - Reduction in overall traffic of 4%
  - Greater reductions in total LGV and HGV traffic of over 8%
  - Close to 30% reduction in total non-compliant traffic
- and for the area outside the CAZ:
  - on the Ring Road,
    - Total traffic increases by less than 1%
    - There is a total reduction in car and taxi traffic
    - LGV and HGV traffic increases in total with HGV non-compliant trips increasing by 5%
    - The overall impact on non-compliant vehicles is a reduction of around 10%
  - Outside the CAZ,
    - Total traffic is flat
    - An overall reduction in non-compliant vehicles of over 7%.

4.32 The increases in vehicle kilometres across the whole network is less than 0.05%. This is driven by the assumption that freight trips will still make the journey into the City Centre, with the only response being whether they upgrade. Diversion caused by through trips are a sufficiently small proportion of the total journeys that no discernible impact is seen on the network.

Table 4.15: Vehicle KMs (whole network)

Do Minimum	Car/ PHV	Taxi	LGV	HGV	Total
Compliant	16,143,303	240,274	2,450,333	3,482,024	22,315,933
Non-compliant	4,905,726	611,606	1,709,811	1,858,001	9,085,144
Total	21,049,029	851,880	4,160,144	5,340,025	31,401,077
CAZ C High	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**

Compliant	16,146,708	852,093	2,497,745	3,537,864	23,034,409
Non-compliant	4,879,531	0	1,666,619	1,806,578	8,352,728
Total	21,026,239	852,093	4,164,364	5,344,442	31,387,137
(CAZ C High – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	3,406	611,820	47,412	55,840	718,476
Non-compliant	-26,195	-611,606	-43,192	-51,423	-732,415
Total	-22,790	214	4,220	4,417	-13,939
(CAZ C High – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	0.0%	254.6%	1.9%	1.6%	3.2%
Non-compliant	-0.5%	-100.0%	-2.5%	-2.8%	-8.1%
Total	-0.1%	0.0%	0.1%	0.1%	0.0%

Table 4.16: Change in Vehicle KMs (CAZ)

Do Minimum	Car	Taxi	LGV	HGV	Total
Compliant	354,776	5,306	33,729	25,940	419,751
Non-compliant	108,688	13,507	23,624	13,900	159,719
Total	463,464	18,813	57,353	39,840	579,470
CAZ C High	**Car**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	347,989	19,235	42,475	35,919	445,618
Non-compliant	102,341	0	9,471	532	112,344
Total	450,330	19,235	51,947	36,451	557,962
(CAZ C High – Do Minimum)	**Car**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	-6,787	13,929	8,746	9,979	25,867
Non-compliant	-6,347	-13,507	-14,153	-13,368	-47,375
Total	-13,134	422	-5,407	-3,389	-21,508
(CAZ C High – Do Minimum)	**Car**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	-1.9%	262.5%	25.9%	38.5%	6.2%
Non-compliant	-5.8%	-100.0%	-59.9%	-96.2%	-29.7%
Total	-2.8%	2.2%	-9.4%	-8.5%	-3.7%

Table 4.17: Change in Vehicle KMs (Ring Road)

Do Minimum	Car	Taxi	LGV	HGV	Total
Compliant	218,018	3,268	24,829	26,022	272,136
Non-compliant	65,917	8,319	17,306	13,854	105,396
Total	283,934	11,587	42,134	39,876	377,532
CAZ C High	**Car**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	222,620	11,315	28,779	30,069	292,783
Non-compliant	65,623	0	18,784	12,597	97,003

Total	288,242	11,315	47,562	42,666	389,786
(CAZ C High – Do Minimum)	**Car**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	4,602	8,047	3,950	4,047	20,647
Non-compliant	-294	-8,319	1,478	-1,257	-8,392
Total	4,308	-272	5,428	2,790	12,254
(CAZ C High – Do Minimum)	**Car**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	2.1%	246.2%	15.9%	15.6%	7.6%
Non-compliant	-0.4%	-100.0%	8.5%	-9.1%	-8.0%
Total	1.5%	-2.3%	12.9%	7.0%	3.2%

Table 4.18: Change in Vehicle KMs (Outside CAZ)

Do Minimum	Car	Taxi	LGV	HGV	Total
Compliant	15,591,245	232,009	2,393,552	3,431,498	21,648,303
Non-compliant	4,737,422	590,568	1,670,116	1,831,008	8,829,114
Total	20,328,667	822,577	4,063,667	5,262,506	30,477,417
CAZ C High	**Car**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	15,596,139	822,640	2,428,843	3,474,029	22,321,650
Non-compliant	4,717,356	0	1,639,025	1,793,499	8,149,880
Total	20,313,494	822,640	4,067,868	5,267,528	30,471,530
(CAZ C High – Do Minimum)	**Car**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	4,894	590,631	35,292	42,531	673,347
Non-compliant	-20,067	-590,568	-31,091	-37,509	-679,234
Total	-15,173	63	4,201	5,022	-5,887
(CAZ C High – Do Minimum)	**Car**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	0.0%	254.6%	1.5%	1.2%	3.1%
Non-compliant	-0.4%	-100.0%	-1.9%	-2.0%	-7.7%
Total	-0.1%	0.0%	0.1%	0.1%	0.0%

Network Speeds

4.33 The impact on speeds on the CAZ C high scenario compared to the Do Minimum are neutral across the network.

CAZ Scenarios D

4.34 Under CAZ Scenario D, cars are subjected to charges as described in Table 2.11 in Chapter 2. Compliance rates across all vehicle types increasing with the higher charges. The greatest change in compliance is again seen for HGVs, where the high charge has been set for all CAZ D scenarios. Buses and taxis are assumed to all upgrade. Our analysis is therefore focused on car, as the responses for the other vehicles are very similar to in CAZ C.

4.35 The change in compliance for car, LGV and HGV traffic entering the CAZ is shown in table 4.19 and Table 4.20 below. At the higher charge level, the overall compliance rates for car are high with only 2% of cars entering the CAZ being non-compliant.

4.36 The importance of cars on overall vehicle numbers can be seen with overall compliance rates being to a large extent driven by changes in car compliance. Although the same charge is modelled for cars and LGVs, the change in compliance rates are different due to different options available for LGV users.

Table 4.19: Compliance Rates for CAZ D – Crossing the CAZ Cordon

		Car	Taxi	LGV	HGV	Bus	Total
DM	Compliant	77%	30%	59%	65%	60%	72%
	Non-compliant	23%	70%	41%	35%	40%	28%
High	Compliant	98%	100%	83%	99%	100%	96%
	Non-compliant	2%	0%	17%	1%	0%	4%

4.37 Table 4.20 below shows the forecast CAZ cordon crossing flows. Within the model Private Hire Vehicles (PHVs) are included within the car matrices with adjustments to the compliance rates made to account for the differing response rates outside of the model for presentation purposes. Because it is an out of model adjustment the balance between car and PHV in the tables may not be 100% accurate, however in terms of total compliance and the fleet mix in the AQ model these numbers are correct.

4.38 The following impacts are shown in the model results:

- A reduction of over 50,000 non-compliant vehicles entering the CAZ
- A total reduction of around 16,000 vehicles

Table 4.20: CAZ D Screenline AADT flows by Vehicle Type

Do Minimum	Car	Taxi and PHV	LGV	HGV	Bus	Total
Compliant	125,900	2,700	13,100	4,600	3,300	149,600
Non-compliant	37,200	6,400	9,100	2,500	2,200	57,400
Total	163,100	9,100	22,200	7,000	5,500	206,900
High	**Car**	**Taxi and PHV**	**LGV**	**HGV**	**Bus**	**Total**
Compliant	142,700	9,500	17,200	6,700	5,500	181,500
Non-compliant	2,900	-	3,600	100	-	6,600
Total	145,600	9,500	20,800	6,800	5,500	188,100
Change from Do Minimum (Abs)	**Car**	**Taxi and PHV**	**LGV**	**HGV**	**Bus**	**Total**
Compliant	20,500	6,400	3,700	2,000	2,200	34,900
Non-compliant	-34,200	-6,400	-5,600	-2,400	-2,200	-50,900
Total	-13,700	0	-1,900	-400	0	-16,000
Change from Do Minimum (%)	**Car**	**Taxi and PHV**	**LGV**	**HGV**	**Bus**	**Total**
Compliant	13%	251%	32%	47%	67%	21%
Non-compliant	-92%	-100%	-61%	-96%	-100%	-89%
Total	-11%	3%	-6%	-3%	0%	-9%

4.39 Figures 4.13 to 4.15 illustrate changes in AM peak city centre traffic flows between the modelled 2020 Do-Minimum and CAZ D High scenario with:

- Green links showing an increase in traffic in CAZ D compared to the Do Minimum with the thicker the line the bigger the increase.
- Blue links showing a decrease in traffic in CAZ D compared to the Do Minimum with the thicker the line the bigger the decrease.

4.40 In total, there is decrease crossing the city centre with a clear reduction trips on the A38. Increases can be seen on sections of the Ring Road as well as some additional parallel roads further out from the CAZ, which are used as a detour for through trips entering the zone.

Figure 4.13: Total Flow Change (CAZ D High – Do Minimum) – AM

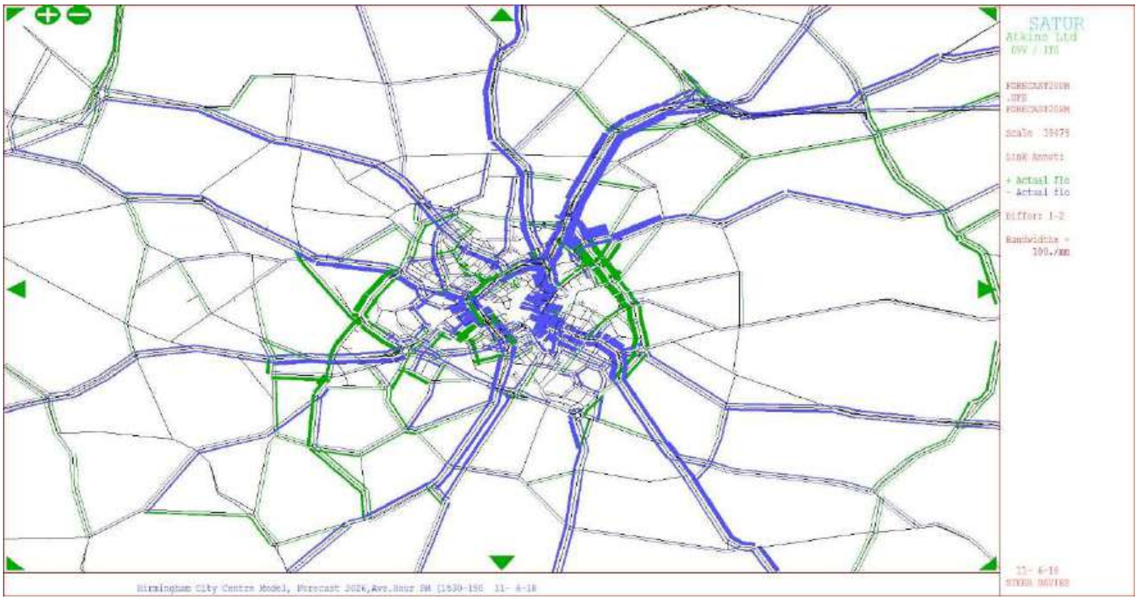


Figure 4.14: Compliant Flow Change (CAZ D High – Do Minimum) – AM

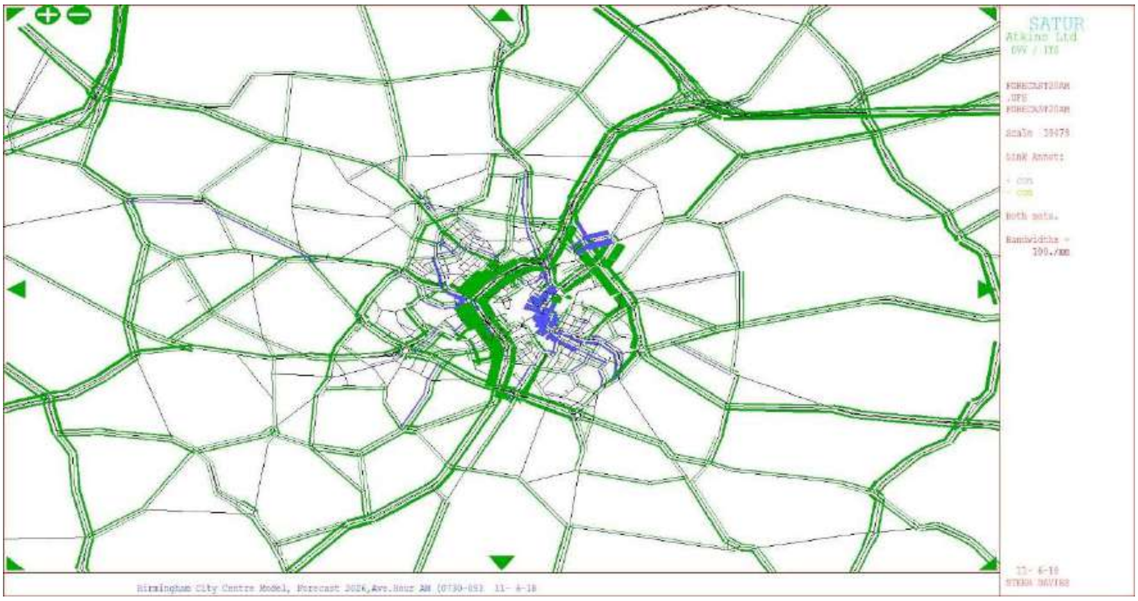
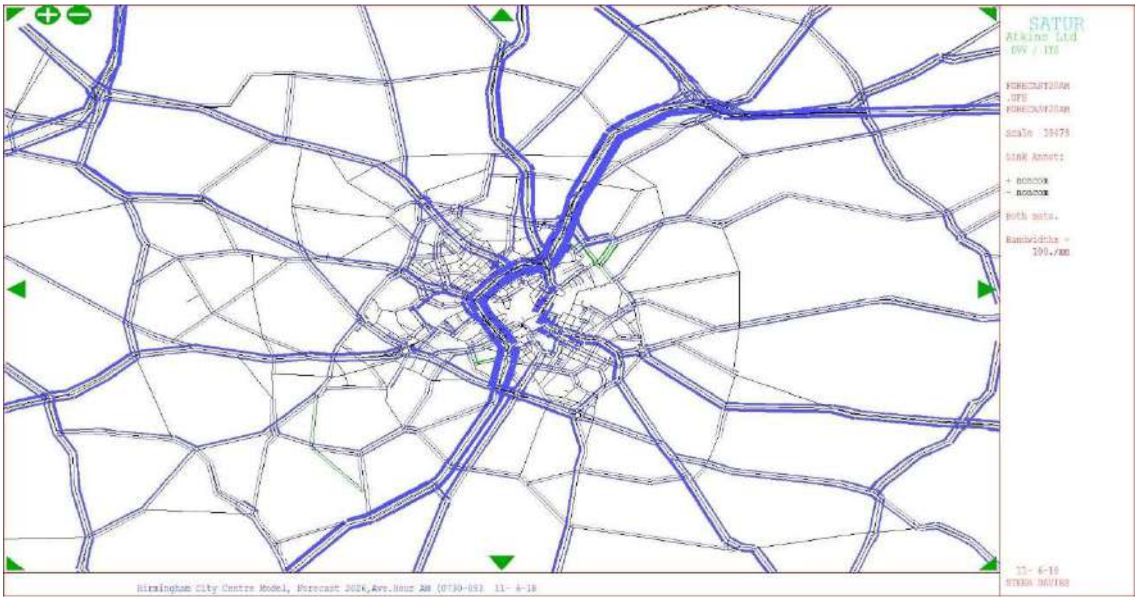


Figure 4.15: Non-compliant Flow Change (CAZ D High – Do Minimum) – AM

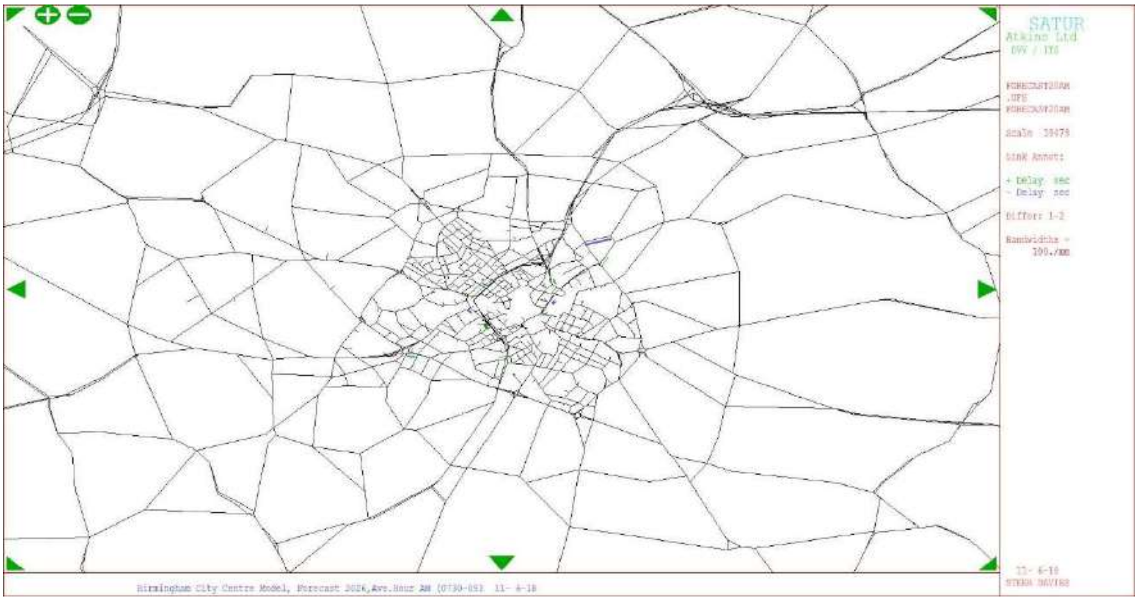


4.41 CAZ D does not have a significant impact on links delays, as can be seen in Figure 4.16 below, with:

- Green links showing an increase in delay in CAZ D compared to the Do Minimum with the thicker the line the bigger the increase.
- Blue links showing a decrease in delay in CAZ D compared to the Do Minimum with the thicker the line the bigger the decrease.

4.42 There have been minor reductions in delays across many City Centre links and on radial routes into the CAZ reflecting the reduction in traffic levels caused by cancelled trips. The effects of diversion have caused minimal increases in delay at a small number of links on parallel routes.

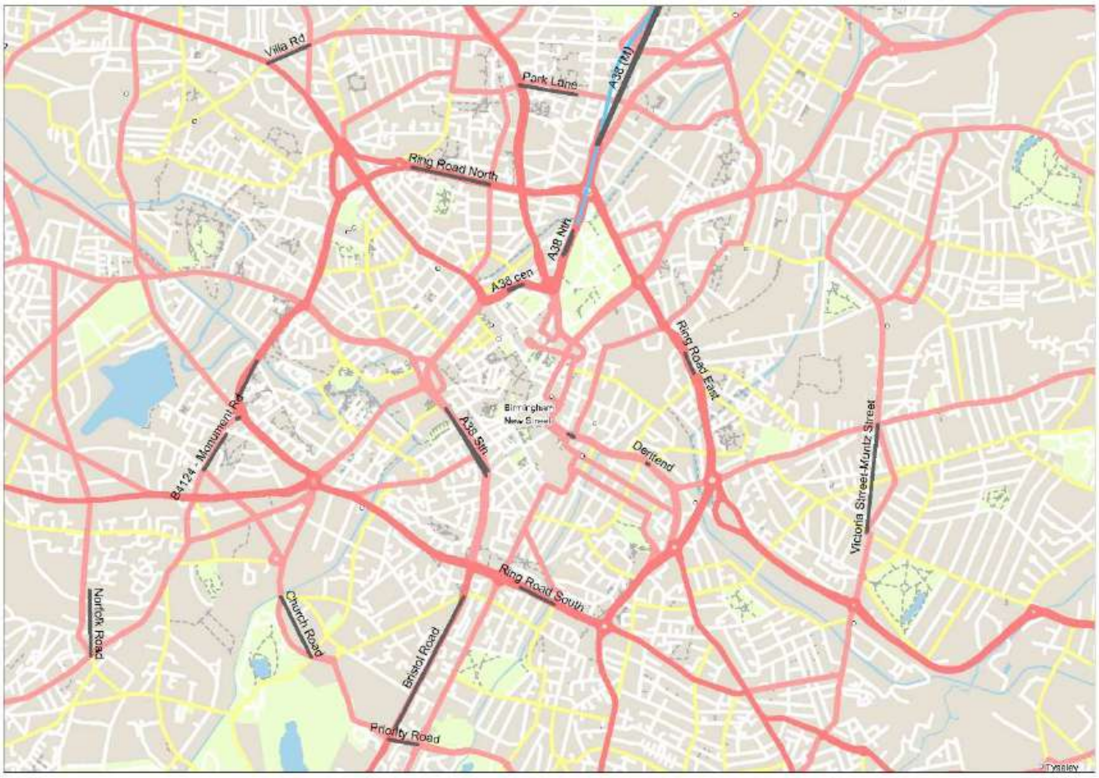
Figure 4.16: Link Delay Change (CAZ D High – Do Minimum) – AM



Key Link Analysis

4.43 To have a more detailed understanding of changes to the network many individual links have been analysed. The worst links in the City Centre in terms of Air Quality have been identified as well as selecting four links on the ring road, and change in flows between scenarios analysed. Figure 4.17 shows the links chosen for analysis.

Figure 4.17: AADT Increases in Total Link Flows CAZ D High



4.44 Table 4.21 below shows changes in total, with the following observations for traffic growth between base year and the Do Minimum:

- These links show significant growth due to parallel road closures (described at the start of this chapter) due to:
  - HS2 Curzon Street construction; and
  - Edgbaston Metro

4.45 The changes between CAZ D and the Do Minimum shows:

- There are significant reductions on each of the roads identified, with flows on the A38 forecast to reduce to below 2016 levels, except for the central section which still shows a 3% reduction from the Do Minimum.

Table 4.21: City Centre Links AADT All Vehicles

Road	2016 Base	2020 Do Minimum	Growth (DM-Base) (Abs)	Growth (Base to DM %)	CAZ D High	CAZ D Change (CAZ D - DM)	CAZ D Change (DM to CAZ D %)
Deritend High ST	24,300	28,700	4,400	18.1%	22,900	-5,700	-20.0%
Digbeth Gyratory	17,500	22,900	5,400	30.6%	17,500	-5,400	-23.7%
A38 South	56,400	61,100	4,700	8.4%	56,200	-4,900	-8.0%
A38 Central	61,500	68,800	7,200	11.7%	66,600	-2,100	-3.1%
A38 North	84,000	89,900	5,800	6.9%	83,600	-6,300	-7.0%

4.46 For the ring road, changes in traffic levels are as shown in Table 4.22:

- In terms of traffic growth between the base year and the Do Minimum, overall growth is in line the with general traffic growth across the model, despite reduced traffic in the East.
- For CAZ D to Do Minimum changes, there are significant increases on the Eastern and Western sections of the ring road.

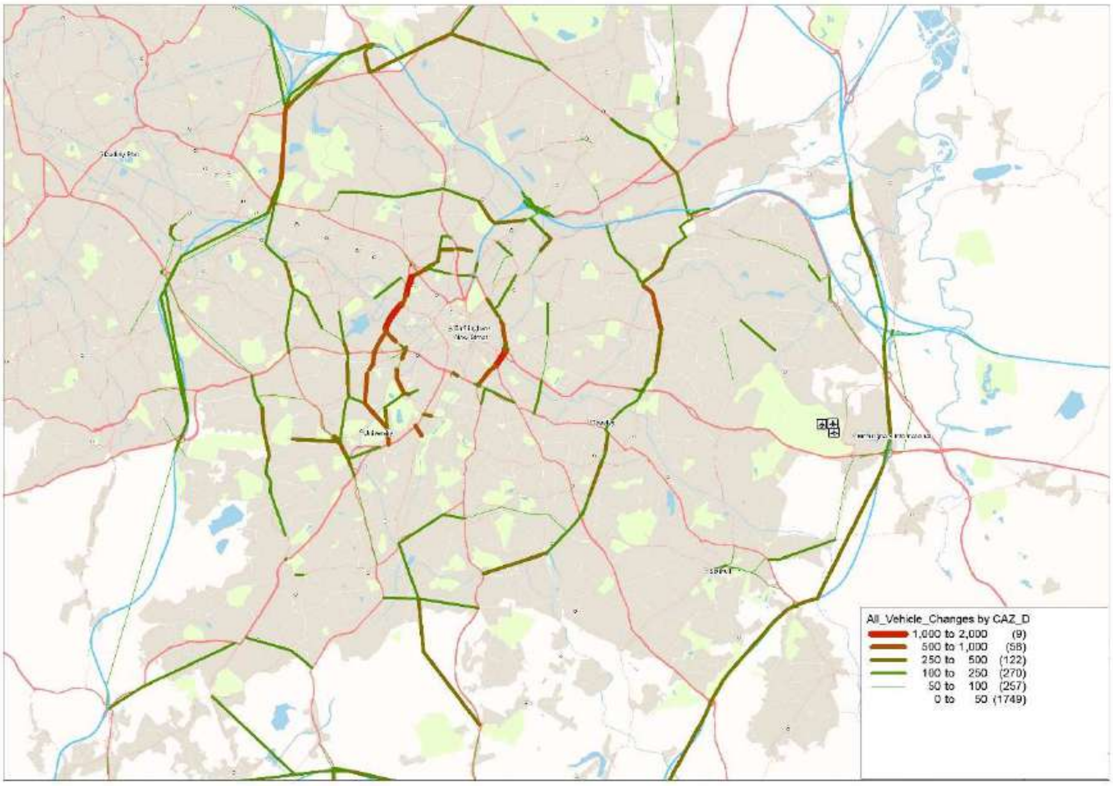
Table 4.22: Ring Road City Centre Links AADT All Vehicles

Road	2016 Base	2020 Do Minimum	Growth (DM- Base) (Abs)	Growth (Base to DM %)	CAZ D High	CAZ D Change (CAZ D - DM)	CAZ D Change (DM to CAZ D %)
Ring Road North	32,800	33,100	300	0.9%	33,100	-	-0.1%
Ring Road South	59,600	62,300	2,700	4.6%	62,500	300	0.4%
Ring Road West	30,900	32,200	1,300	4.2%	35,800	3,600	11.1%
Ring Road East	54,900	53,700	-1,200	-2.3%	58,300	4,600	8.6%

In terms of the wider network the impact of diversion away from the CAZ area is shown in Figure 4.18 below. This shows:

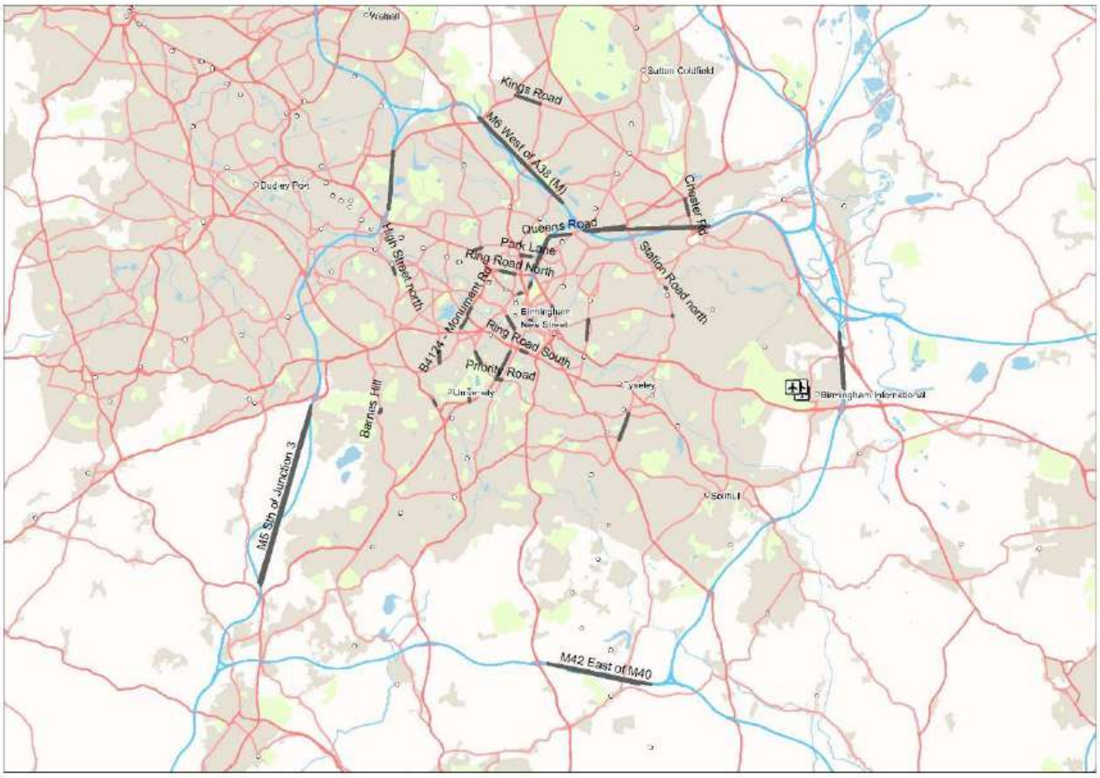
- The most significant increases occur on the Ring Road
- There is diversion to the South East of the City as through trips avoid the A38 and find alternative routing to the Ring Road.
- There are a number of parallel routes with increases in traffic
- Other than the ring road no link increases by more than 1000 vehicles a day, with typical values less than 250 a day

Figure 4.18: Change in AADT Vehicle Flows DM to CAZ D High



4.47 The links with the largest changes in flows in the CAZ D scenario have been identified and analysed. The links selected are shown in Figure 4.19.

Figure 4.19: Links Selected for Analysis



4.48 Traffic changes on the motorway box links selected for analysis are shown in Table 4.23 below.

- For traffic growth between the base year and the Do Minimum:
  - Is higher than for general traffic, in particular on the M42 south of the M6 which is forecast to have higher levels of growth.
- For CAZ D compared to Do Minimum
  - The impact of CAZ D high is minimal with below 1% change in flows, however a section of the M5 (1,300 vehicles) and the M42 (800 vehicles) have increases in absolute terms.

Table 4.23: Motorway Box Links AADT All Vehicles

Road	2016 Base	2020 Do Minimum	Growth (DM- Base) (Abs)	Growth (Base to DM %)	CAZ D High	CAZ D Change (CAZ D - DM)	CAZ D Change (DM to CAZ D %)
M5 South of Junction 3	125,100	130,800	5,700	4.6%	130,900	100	0.1%
M5 South of Junction 8	166,000	173,200	7,200	4.3%	174,500	1,300	0.8%
M42 East of M40	140,300	148,500	8,200	5.8%	149,300	800	0.6%
M6 East of A38 (M)	115,800	122,200	6,400	5.6%	121,500	-800	-0.6%
M42 Sth of M6	131,800	141,400	9,600	7.3%	142,200	800	0.6%
M6 West of A38 (M)	156,500	164,700	8,200	5.2%	164,500	-200	-0.1%

4.49 For the wider road network within the motorway box the traffic numbers for all traffic are shown in Table 4.24 below. For the base year to Do Minimum traffic growth:

- Growth rates vary across the network with high levels of traffic growth on some links particularly on:
  - B4124 - Monument Rd
  - Alston Street
  - Victoria Street-Muntz Street
- There are significant reductions on Park Lane

4.50 The impact of CAZ D High compared with Do Minimum are as follows:

- There are generally only relatively minor increases in overall traffic due to diversion. There are some significant percentage increases on a number of links, although these are less than 1000 vehicles in a day:
  - Church Road
  - Edgbaston Park Road
  - B4124 - Monument Rd
  - Alston Street
- There is a reduction of aver 7% on the A38 (M) and on A38 Bristol Rd of over 7% due to longer distance trips rerouting away from the City Centre.

Table 4.24: Wider Network Links AADT All Vehicles

Road	Growth (Base to DM %)	CAZ D Change (CAZ D - DM)	CAZ D Change (DM to CAZ D %)
Tyburn Rd	7.2%	-1,600	-1.9%
Chester Rd	4.3%	800	1.6%
A38(M)	7.4%	-6,800	-6.8%
Norfolk Road	6.5%	400	2.8%
Church Road	1.5%	900	7.4%
Edgbaston Park Road	3.2%	1,300	5.4%
Bristol Road	0.5%	-4,600	-7.0%
Priority Road	-12.6%	600	1.6%
Park Lane	1.5%	500	2.8%
B4124 - Monument Rd	21.7%	1,500	9.1%
Alston Street	14.4%	1,400	5.9%
Barnes Hill	3.5%	300	0.4%
Harborne Lane	1.5%	900	2.8%
High Street (A4030)	6.2%	500	0.8%
Villa Rd	0.7%	100	0.4%
Fox Hollies Road	3.1%	500	0.9%
Victoria Street-Muntz Street	12.6%	400	1.8%
Queens Road	6.3%	900	2.6%
Kings Road	2.7%	600	0.9%

Network Statistics

4.51 Table 4.25 to Table 4.28 display the total vehicle kilometres for the Do-Minimum and CAZ D, across the different vehicle types and This provides an aggregate network wide assessment of the impact of CAZ D High on the road network. It should be noted that PHVs are included within cars in the assignment model, so their responses are included within this data.

4.52 The analysis has been split to look at four separate areas:

- Across the entire network:
  - Low reduction in overall vehicle KMs of less than 0.5%
  - Around 12% reduction in non-compliant vehicles
- Clean Air Zone only:
  - A reduction of 6% in overall traffic
  - A reduction in total LGV and HGV traffic of around 7% and 5% respectively
  - Significant reduction in total non-compliant traffic of 85%
- the area outside the CAZ:
  - The Ring Road,
    - Total traffic increases by less than 1%
    - There is a total reduction in car and taxi traffic

  - LGV and HGV traffic increases in total with LGV non-compliant trips increasing by over 6%
  - The overall impact on non-compliant vehicles is a reduction of around 10%
- Outside the Ring Road,
  - Total traffic is flat with less than 0.2% reduction
  - A reduction of 9% in non-compliant cars
  - An overall reduction in non-compliant vehicles of almost 11%.

4.53 Changes in overall vehicle kilometres travelled across the modelled area is low. This is because there is a reduction in car trips caused by the CAZ, which offsets any diversion caused by the charge. In addition, the majority of trips in the model do not go through or into the CAZ, so are not affected by the scheme.

Table 4.25: Change in Vehicle KMs (whole network)

Do Minimum	Car	Taxi	LGV	HGV	Total
Compliant	16,143,303	240,274	2,450,333	3,482,024	22,315,933
Non-compliant	4,905,726	611,606	1,709,811	1,858,001	9,085,144
Total	21,049,029	851,880	4,160,144	5,340,025	31,401,077
CAZ D High	**Car**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	16,414,324	851,946	2,497,506	3,536,921	23,300,696
Non-compliant	4,529,453	0	1,666,513	1,806,356	8,002,322
Total	20,943,776	851,946	4,164,019	5,343,277	31,303,018
(CAZ D High – Do Minimum)	**Car**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	271,021	611,673	47,173	54,897	984,763
Non-compliant	-376,273	-611,606	-43,298	-51,645	-1,082,822
Total	-105,252	67	3,875	3,252	-98,058
(CAZ D High – Do Minimum)	**Car**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	1.7%	254.6%	1.9%	1.6%	4.4%
Non-compliant	-7.7%	-100.0%	-2.5%	-2.8%	-11.9%
Total	-0.5%	0.0%	0.1%	0.1%	-0.3%

Table 4.26: Change in Vehicle KMs (CAZ)

Do Minimum	Car	Taxi	LGV	HGV	Total
Compliant	354,776	5,306	33,729	25,940	419,751
Non-compliant	108,688	13,507	23,624	13,900	159,719
Total	463,464	18,813	57,353	39,840	579,470
CAZ D High	**Car**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	404,346	19,758	43,576	37,035	504,716
Non-compliant	12,898	0	9,559	534	22,991
Total	417,244	19,758	53,135	37,570	527,707
(CAZ D High – Do Minimum)	**Car**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	49,571	14,452	9,847	11,095	84,965
Non-compliant	-95,790	-13,507	-14,065	-13,365	-136,727
Total	-46,219	945	-4,218	-2,270	-51,763
(CAZ D High – Do Minimum)	**Car**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	14.0%	272.4%	29.2%	42.8%	20.2%
Non-compliant	-88.1%	-100.0%	-59.5%	-96.2%	-85.6%
Total	-10.0%	5.0%	-7.4%	-5.7%	-8.9%

Table 4.27: Change in Vehicle KMs (Ring Road)

Do Minimum	Car	Taxi	LGV	HGV	Total
Compliant	218,018	3,268	24,829	26,022	272,136
Non-compliant	65,917	8,319	17,306	13,854	105,396
Total	283,934	11,587	42,134	39,876	377,532
CAZ D High	**Car**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	230,065	10,986	28,062	29,860	298,973
Non-compliant	58,423	0	18,763	12,720	89,905
Total	288,488	10,986	46,825	42,580	388,878
(CAZ D High – Do Minimum)	**Car**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	12,047	7,718	3,233	3,838	26,837
Non-compliant	-7,494	-8,319	1,457	-1,135	-15,490
Total	4,553	-601	4,691	2,703	11,346
(CAZ D High – Do Minimum)	**Car**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	5.5%	236.2%	13.0%	14.7%	9.9%
Non-compliant	-11.4%	-100.0%	8.4%	-8.2%	-14.7%
Total	1.6%	-5.2%	11.1%	6.8%	3.0%

Table 4.28: Change in Vehicle KMs (Outside CAZ)

Do Minimum	Car	Taxi	LGV	HGV	Total
Compliant	15,591,245	232,009	2,393,552	3,431,498	21,648,303
Non-compliant	4,737,422	590,568	1,670,116	1,831,008	8,829,114
Total	20,328,667	822,577	4,063,667	5,262,506	30,477,417
CAZ D High	**Car**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	15,803,037	822,299	2,428,218	3,472,172	22,525,725
Non-compliant	4,459,288	0	1,638,855	1,793,155	7,891,297
Total	20,262,325	822,299	4,067,073	5,265,326	30,417,022
(CAZ D High – Do Minimum)	**Car**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	211,792	590,290	34,666	40,674	877,421
Non-compliant	-278,134	-590,568	-31,261	-37,854	-937,816
Total	-66,343	-278	3,406	2,820	-60,395
(CAZ D High – Do Minimum)	**Car**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	1.4%	254.4%	1.4%	1.2%	4.1%
Non-compliant	-5.9%	-100.0%	-1.9%	-2.1%	-10.6%
Total	-0.3%	0.0%	0.1%	0.1%	-0.2%

4.54 The introduction of CAZ D High will increase speeds within the City Centre, particularly in the PM peak which is the most congested time period. There will also be reductions in speeds on the Ring Road, but this only causes relatively small changes in average speeds.

Table 4.29: Change in average speed

Scenario	AM				IP				PM			
	Whole Network	CAZ	RING	REST	Whole Network	CAZ	RING	REST	Whole Network	CAZ	RING	REST
DM	58.2	23.8	26.0	60.8	58.9	25.4	27.3	61.2	55.7	17.1	26.1	59.1
CAZ D	58.5	24.2	26.0	61.0	59.1	26.6	26.8	61.3	56.3	18.9	26.0	59.2
Change %	0%	1%	0%	0%	0%	5%	-2%	0%	1%	11%	0%	0%

Convergence

4.55 The models converge to WebTAG standards, with details found in appendix E

5 Summary

5.1 The key conclusions from the traffic modelling are as follows:

- There are some significant changes to the network and traffic demand in Birmingham City Centre between 2016 and 2020 which affects the traffic levels at some key links and particularly on the A38.
- For CAZ C plus additional measures:
  - There is a 2% reduction in traffic entering the Clean Air Zone, and 30% reduction in non-compliant vehicles
  - There are some significant impacts on the A4050 Ring Road, however many of these increases are caused by the closure of Moor Street Queensway which is now a committed Birmingham City Council scheme and also solves the clean air issues on Digbeth gyratory.
  - Only minor impacts outside of the CAZ and Ring Road.
- CAZ D has more significant impacts with:
  - A 9% reduction in traffic entering the CAZ
  - A 90% reduction in non-compliant vehicles.
  - There are some significant impacts on the A4050 Ring Road, however many of these increases are caused by the closure of Moor Street Queensway which is now a committed Birmingham City Council scheme and, also solves the clean air issues on Digbeth gyratory.
  - There are more significate increases on roads on the wider network.
  - However, beyond the ring road these impacts are not too severe, with network speeds outside of the CAZ zone not noticeably affected.

Conclusion

5.2 The modelling approach applied has resulted in a WebTAG compliant 2020 baseline model that incorporates agreed land use and network changes in Birmingham. In addition, we have developed and applied a modelling methodology to forecast the impact of CAZ charging and additional measures in line with the guidance issued by JAQU incorporating forecasts of:

- Vehicle Upgrade
- Mode Shift
- Cancelled journeys: and
- Avoiding the zone

5.3 Data from these models have been supplied to the AQ economic and IA teams in the format they require to demonstrate the impacts of the CAZ charging schemes.

5.4 The model therefore provides robust forecasts of changes in vehicle flows and network conditions for compliant and non-compliant vehicles and can be reasonably used to develop and assess the CAZ schemes.

5.5 As in all models there are various uncertainties with the assumptions underpinning the results, and some key issues with these assumptions are discussed in 'Appendix A – Caveats' below. In addition, a set of sensitivity tests have been developed to provide further assurance that the results of the model are robust and to further highlight any risks in the modelling process, these are also reported in Appendix A.

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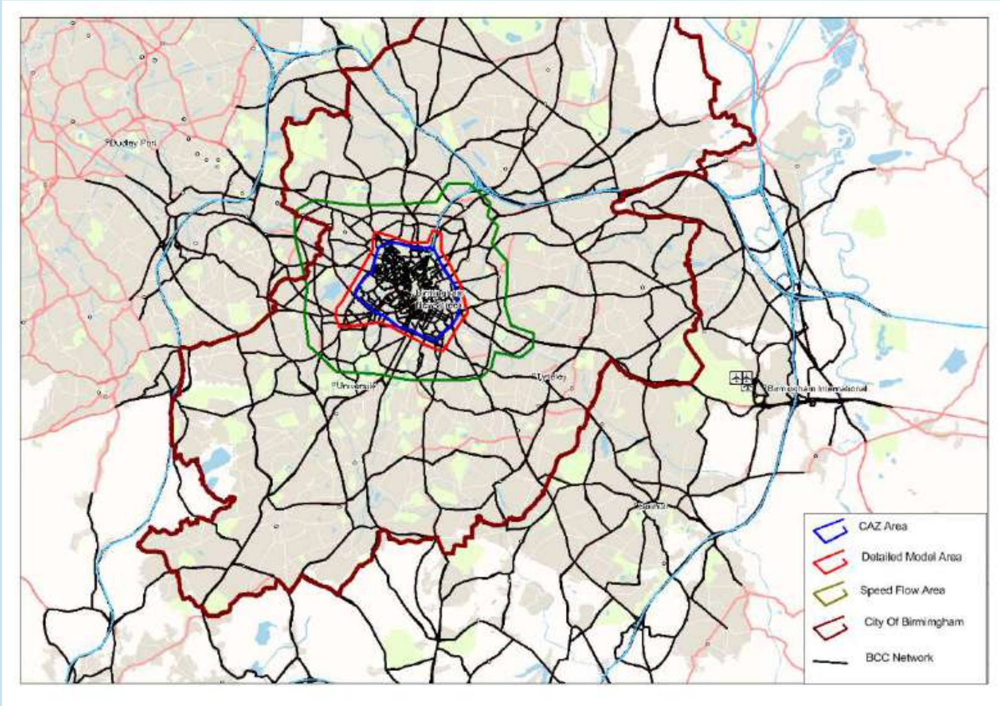
Appendices

A Caveats

Figure A.1: Birmingham City Centre Clean Air Zone - Feasibility Study Traffic Modelling Caveats

Issue	Description

Network Detail:
• Detail
• Responsiveness
• Bus
	Overview
	The model is designed to focus on the City Centre, with less detail in terms of the network and calibration data as the model moves further out from the City Centre. The fiigure below shows the extent of the road network, with:
	BCC – Network Structure
	
	• Detailed Model Area, within the red area (covers the ring road):
	  ◦ Simulation coding – detailed junction coding (lane allocations, junction types, queing represented)
	  ◦ Fine zoning system to reprsent where traffic accesses the network in more detail
	  ◦ Fully calibrated/ validated, with counts, screenlines and journey time surveys
	  ◦ Buses coded along fixed routes
	• Speed Flow Curve Area, within the green area
	  ◦ No junction modelling, but network speeds respond to changes in flow on links.
	  ◦ Zoning less fine but still reasonably detailed, taken from the strategic PRISM model
	  ◦ Calibration not detailed, no screenlines or journey time surveys, but individual counts included in the matrix estimation and calibration statistics.
	  ◦ Buses coded along fixed routes
	• Fixed Speed Area, outside the green area:
	  ◦ Speeds are fixed and will not respond to changes in flows.
	  ◦ Average speeds are based on congested speeds from the Higways England model
	  ◦ No bus route coding
	  ◦ Zoning less fine but still reasonably detailed, taken from the strategic PRISM model
	Issues
	• Forecasts are less reliable outside of the simulation area.

- Where diversion of traffic to the fixed speed area occurs, changes in network conditions are not modelled so could overesimate the network capacity and underestimate the dis-benefits of the scheme.
- Bus flows are not represented outside the speed flow area

Mitigation

- Areas of exceedence and policy levers are focused on the City Centre and therefore in the area of detail, with full responsiveness
- Diversion is fairly limited, minimal change in vehicle kilometers outside of the simulation area is flat between scenarios, so unlikely that the model is underestimating dis-benefits of the CAZ to a significant degree.
- While the model is not calibrated outside of the speed flow curve area the demand matrices are sourced from the PRISM model which has been calibrated across the West Midlands so the overall demand and distribution can be replied upon.
- Bus flows tend to be a lower proportion of total flows outside of the Central area so impact on the AQ results are limited
- Opportunity to carry out corridor studies at specific areas of concern.
- Model detail can be extended if required in reasonabe timescales

All Users

Vehicle Upgrade

- Cost
- Frequency
- Timescales

Timescales

Issue

The modelled year of the CAZ for the central scenario reported here is 2020 so in less than 2 years. The assumptions for users is that they will have time to assess their options and prioritise their spending towards buying a new car. Given that there still needs to be a consultation, and agreement on whether a charge should be implemented and what the level of the charge would be, it may be difficult for people to make these decisions in time for 2020.

This is particularly relevant for LGV and HGV users, where engagement with users as part of this study indicates that many will pass the costs onto their customers in the short term and may not have the capacity to upgrade their vehicle.

Mitigation

In developing the Clean Air Zone, local and central Government needs to ensure that users are well informed of the changes proposed. Any incentives, for example scrappage schemes, will aid the ability and likelihood of people upgrading.

Frequency

Issue

Frequency of journey into the CAZ zone is a key criterion in whether users will upgrade. The data used to define trip frequency is based on the ANPR survey data which was undertaken over one week and is therefore limited in the number of observations, particularly for the vehicles only captured once in the week. These users could potentially be entering the CAZ 52 times in a year or just once, and therefore the average trip frequency over a longer period is an assumption and not observed.

Mitigation

For car and LGV users the input to the choice model is low, medium or high frequency, in line with the groupings within the Stated Preference exercise underpinning the model, so the one week of data allows a reasonable estimate of frequency within these groupings. For HGVs assumptions were made to distribute the frequencies across the year.

Cost to Upgrade

Issue 1

Assumed costs to upgrade were published after the modelling was completed for HGVs. In addition, the cost for car upgrade published by JAQU was considered too low. Therefore, assumptions were developed (described in detail in chapter 2). Since the modelling was completed JAQU published updated assumptions on the typical costs of a new vehicle for each vehicle type. The table below shows the assumptions used in this study against the JAQU assumptions. These values are different than assumed by JAQU and would therefore haven an impact on the results if incorporated.

Compare	Petrol Cars	Diesel Cars	Petrol LGVs	Diesel LGVs	Rigid HGV	Articulated HGV
JAQU	£18,000	£18,000	£25,000	£25,000	£68,000	£81,000
Model	£19,080	£19,080	£25,233	£25,233	£44,700	£71,700
Difference	£1,080	£1,080	£233	£233	-£23,300	-£9,300
Difference (%)	6.0%	6.0%	0.9%	0.9%	-34.3%	-11.5%

Mitigation

Modelled Car and LGV costs are close enough to JAQU values to be considered in line with JAQU. HGVs vary by more, however once the depreciation rates have been applied this would only lead to a 6% reduction in compliance at the higher toll, which is the level that the AQ model has been run. Given that HGVs are a small proportion of total vehicle trips in the City Centre this will not affect the overall conclusions.

The numbers used in the study were based on real cost of HGVs.

Issue 2

Vehicle upgrade response and therefore cost to upgrade is based on different assumptions than in the latest JAQU behavioural guidance.

Mitigation

JAQU behavioural responses includes the assumption that 25% will buy a new vehicle, and of the remaining 75%, 75% will switch to the cheapest compliant vehicle which is not older than their existing vehicle and that the remaining 25% would upgrade within the same fuel group. Our modelling however is that that people would upgrade to the cheapest vehicle that is a newer model than their existing vehicle (e.g. diesel 4 to petrol 5 and not petrol 4). Applying these assumptions to the average upgrade costs higher than the assumptions we've made so far (assuming they haven't updated since 14 of December) would lead to around a £4.5k average upgrade cost rather than £3,100). Below, under 'JAQU Upgrade Assumptions', are the assumptions applied to get to this cost.

An alternative approach would be to assume for the behavioural modelling that people will make their decision based on the cheapest possible option (that is not an older vehicle) which would result in a lower average upgrade cost of around £1,000, which would then cause higher upgrade rates.

We believe that the assumption applied to our model is therefore reasonable, as it incorporates people's desire to truly upgrade if changing cars (i.e. newer than existing), without unduly skewing the costs with the assumption that 25% will buy a brand- new car.

Impact on results

In addition, the impact of the cost to upgrade is not linear as it includes journey purpose, trip frequency, income segmentations, and the possibility of other responses to the charge. Our analysis indicates that applying the lower cost would result in an additional 6% of compliant vehicles on the network than currently modelled. In addition, the evidence from the AQ modelling is that getting higher compliance does not solve the AQ issues by itself. For example, in the CAZ D high scenario only around 3% of all vehicles entering the CAZ are non-compliant. Applying these assumptions will bring more traffic into the City Centre and result in the compliant vehicles being older than currently modelled (more petrol Euros 4 and 5s). Therefore, the conclusion that additional measures are needed on top of a charging CAZ is correct and will be of a similar scale.

Benchmarking

Below shows a comparison of our responses to JAQU's national plan at the high charge level. Our upgrade proportions are lower than JAQU assumptions (but within a plausible range), and with similar proportion of vehicles who would still pay the charge.

Benchmarking Cars

Response	BCC (High Charge)	TfL (ULEZ Charge)	JAQU
Pay Charge	10%	9%	7%
Replace Vehicle	51%	48%	64%

For LGVs it is reasonable to assume that diesel users will need to upgrade to diesel 6 as the petrol fleet is a small proportion of the total vehicle fleet. This is even more relevant for HGVs.

JAQU Upgrade Assumptions

£18,000 for a new car

£200 transaction cost

Assume scrappage is neutral

Table 1: JAQU Responses

Response	Assumption	Explanation
Scrap	25% of upgrade	A proportion, 25%, of those people taking the upgrade response will scrap their old vehicle
Buy new	25% of upgrade	A proportion, 25%, of those people choosing to upgrade will buy a new vehicle
Switch	75% * 75% of upgrade	A proportion, (75%*75%), of those people who elect to upgrade will sell their old vehicle and buy the cheapest unaffected one
Keep fuel	25% * 75% of upgrade	A proportion, (25%*75%), of those people who decide to upgrade will sell their old vehicle and buy the cheapest unaffected one of the same fuel type

Table 2: Deprecation

	Year 1	Year 2	Year 3	Year 4+
Cars	37%	18%	16%	16%

Non-City Centre Trips

Changes to the fleet are only applied to the City Centre trips and not to through trips without an origin or destination in the City Centre. However, users who upgrade their vehicle are also likely to make trips that are not to or from the City Centre. This is therefore a conservative assumption, so as not to overestimate the impact of upgrade rates beyond the CAZ.

	Stated Preference Research **Issue** Upgrade rates are based on stated preference research in London, which has different levels of public transport access, income levels, etc. These effects will therefore not be completely relevant to Birmingham conditions. In, addition the same assumptions have been applied to business users and LGV users, but the research was applied to all users. **Mitigation** There are limited numbers of studies on responsiveness to charging, so this is the best evidence available. In addition, the assumptions were updated with local assumptions including: • Frequency data from the ANPRs • Income distribution from the PRISM model
Demand Responsive to charge – PRISM	**Issue** The results of the PRISM run show that mode shift forecast is low in comparison with the redistribution impacts of people switching their car trips to non-city centre zones. However, given the short timescales in implementing the CAZ it may be difficult for people to change their destination, particularly for the journey to work demand segment. The PRISM model predicts changes over the long term, and assumes a “steady state” where people have the chance to choose to look for new jobs. In addition, PRISM has not been specifically calibrated for responsiveness to road charging, so any specific responses to road charging is not reflected in the modelling, above the responsiveness seen in other monitory costs (i.e. parking or fares). **PRISM Overview** • The CAZ charge is converted into a generalised cost in time and then fed into the choice model. This adds over an hour to each trip in Generalised Costs. • The model estimation process results in the relative sensitivity of mode choice and destination choice being determined based on the choices observed in household travel diary data and the skim costs that are fed into it from the network model. A standard way of representing mode and destination choice sensitivity is with Lambda and Theta values as described in WebTAG M2 section 5.6. PRISM does not explicitly use these values; however a set of implicit values have been calculated and are shown below. • The scale of sensitivity varies with “others and shopping” trip purposes having greater sensitivity of destination choice relative to mode choice as compared to work trip purpose. • The results are plausible with mode choice coming out to be less sensitive than destination choice for most trip purposes, as is described in WebTAG.

Table 4.17: Destination choice lambdas

Purpose	λ_d	WebTAG min	WebTAG median	WebTAG max
Commute	0.064	0.054	0.065	0.113
Business	0.036	0.038	0.067	0.106
Shopping	0.166	0.074	0.090	0.160
Other travel	0.080	0.074	0.090	0.160

Source: RAND Europe

Table 4.18: Mode choice thetas

Purpose	θ_{M_D}	WebTAG min	WebTAG median	WebTAG max
Commute	1.00	0.50	0.68	0.83
Business	0.79	0.26	0.45	0.65
Shopping	0.40	0.27	0.53	1.00
Other travel	0.32	0.27	0.53	1.00

Source: RAND Europe

- The models are estimated for the entire WM region, within the city centre zones parking charges are included in the generalised cost for the urban centres. Otherwise the city centre attractiveness is calculated in the same way as everywhere else from a combination of network costs/accessibility and attraction variables (i.e. jobs etc). One difference is that rail is considered to be a more attractive choice, compared to other zones outside the city centre.

Mitigation

The PRISM demand model has been calibrated to a high standard. It has been used successfully in a number of major scheme bids where mode shift is an important scheme justification. Edgbaston extension was tested using PRISM 4.1 and the Final Business Case was approved by DfT in September 2017. Birmingham Eastside Extension and East Birmingham to Solihull Metro are also being tested.

The model is constrained by input levels of employment, retail, and jobs. As such, there is a limit to the switch in destination choice and therefore a limit to the changes that can occur to the destination end of the journey. This limits the sensitivity of trips diverting away from the City Centre.

If the model was adjusted to change the mode-choice sensitivity compared to destination choice the overall demand response and hence change in vehicle trips to the CAZ would also change. However, this would not change significantly in terms of impact on people driving into the City Centre as the overall utility of continuing to drive into the City Centre would not change. We therefore believe that the overall responsiveness of the model in terms of change in car trips to the City Centre is plausible, although the split between mode shift and destination choice may be less certain in the short term.

Given the high penalty for driving and that PRISM forecasts people will still drive, it indicates that the PT alternatives for many users are poor. In addition, the City Centre will generate more high value of time trips, with higher income jobs and more business trips. These users will be less responsive to the charge. Therefore, there is reason to believe that the low mode shift response is reasonable, without further investment in public transport alternatives or changing attitudes to car use that may be difficult to achieve by 2020.

An ‘out of model’ adjustment for the work based trip/tour matrices could be developed by using a ramp-up process which replaces destination shift with mode shift in the short term (3-5 years) but reverts back to destination shift in the medium/long term, if required.

A.1 The sensitivity tests have been discussed with JAQU and agreed in principal, but may be updated/ changed as guidance is developed.

Table 5.1: Sensitivity Tests

Model Elements	Tests	Purpose	Method
Traffic Growth	1) Low Growth - City Centre traffic is flat + existing model assumptions for outer areas. 2) Low/ Medium Growth - TEMPRO trip growth for City Centre (rather than PRSIM growth updated with TEMPRO demographic/ land use), with PRISM growth for outer areas (lower than TEMPRO directly). 3) High Growth - Apply TEMPRO trip growth to the outer areas on existing City Centre growth.	Impact of different levels of traffic growth. Uncertainty around growth of the city and highway mode share. PRISM forecasts higher City Centre growth and lower wider Birmingham growth highway trip growth than taken directly from TEMPRO, so this will test the difference between the two models. NB - PRISM is updated with TEMPRO demographic growth and trip generation/ mode share generated by PRISM based on locally calibrated data.	Mixture of quantitative assessment of likely impacts and Full model rerun.
Behavioural Responses to Charging	1) Apply published JAQU responses 2) Apply TfL ULEZ responses directly 3) Apply responses derived from benchmarking/ SP exercise above.	Uncertainty around response to charge tested by using other projects research looking at Clean Air Charging.	Mixture of quantitative assessment of likely impacts and Full model rerun.
Cost to Upgrade	1) Assume JAQU latest, new vehicle costs to current assumptions. 2) Apply JAQU behavioural assumptions on new vehicle upgrades 3) Apply cost to upgrade responses based on benchmarking exercise. 4) Assume HGV users assess cost to upgrade over 3 rather than 5 years.	Uncertainty around cost to upgrade, people's choice of upgrade vehicle and impact on secondary market in large increase in vehicle purchasing/ sales.	Mixture of quantitative assessment of likely impacts and Full model rerun.
Base Year Correction	1) Scale up HGV flows based on mismatch between base year and observed counts crossing the screenline. 2) Scale up PM peak flows by 5% 3) Scale down PM peak flows 5%	Impact of errors in base year model assessed, particularly the PM peak models overall impact on results.	Post model Factoring

Model Elements	Tests	Purpose	Method
Taxi	1) Develop test that does not force an upgrade to compliant vehicle based on licensing rules. 2) Factor flows at key locations based on traffic counts/ ANPR to ensure that taxi/ PHV proportions are correctly captured, and that any benefits to the policy is correctly captured.	Impact of Taxi Assumptions.	Full model rerun (only taxis changed)
Congestion	1) Increase delays by 5% 2) Decrease delays by 5% 3) Assess Delays at key locations and if applicable increase modelled speeds by more than above.	Impact of congestion on AQ. Risk that over/ underestimation of delay is impacting AQ results and where to focus policy.	Post model Factoring
Fleet	Depending on available time/ budget changes in demand/ distribution will be assessed by: • Benchmarking sensitivity • Rerun of PRISM demand model	Check removal of highway capacity and increased cost to drive is reflected in traffic growth.	Mixture of quantitative assessment of likely impacts and Full model rerun.

B Transport Model Forecasting Methodology

C SATURN Plots

Figure C.1: Total Flow Change (2020 Do Minimum – Base) - AM

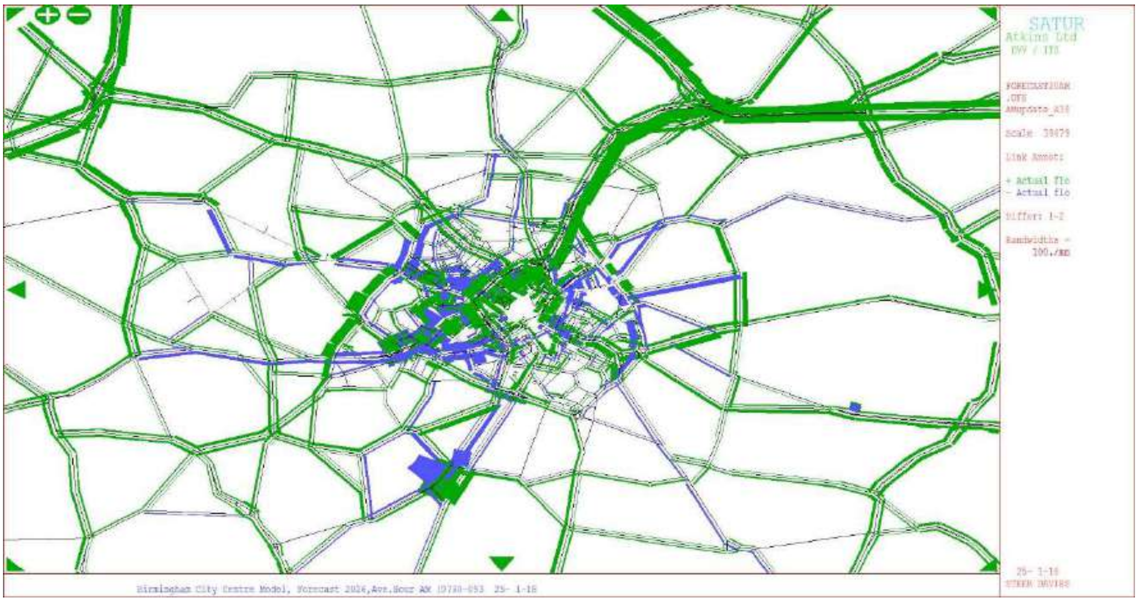


Figure C.2: Compliant Flow Change (2020 Do Minimum – Base) – AM

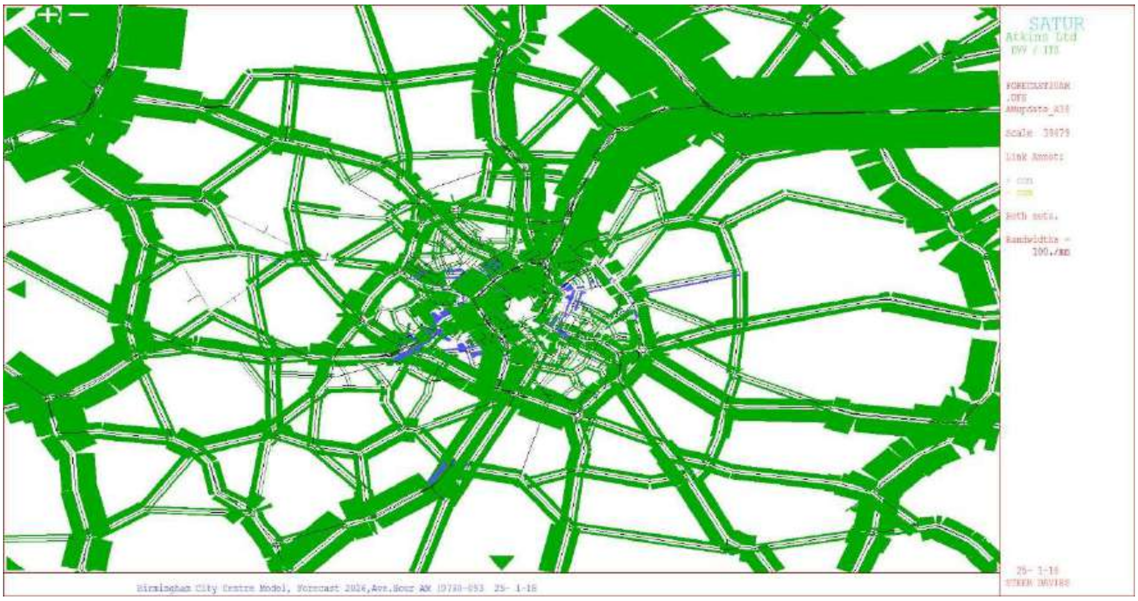


Figure C.3: Non-compliant Flow Change (2020 Do Minimum – Base) - AM

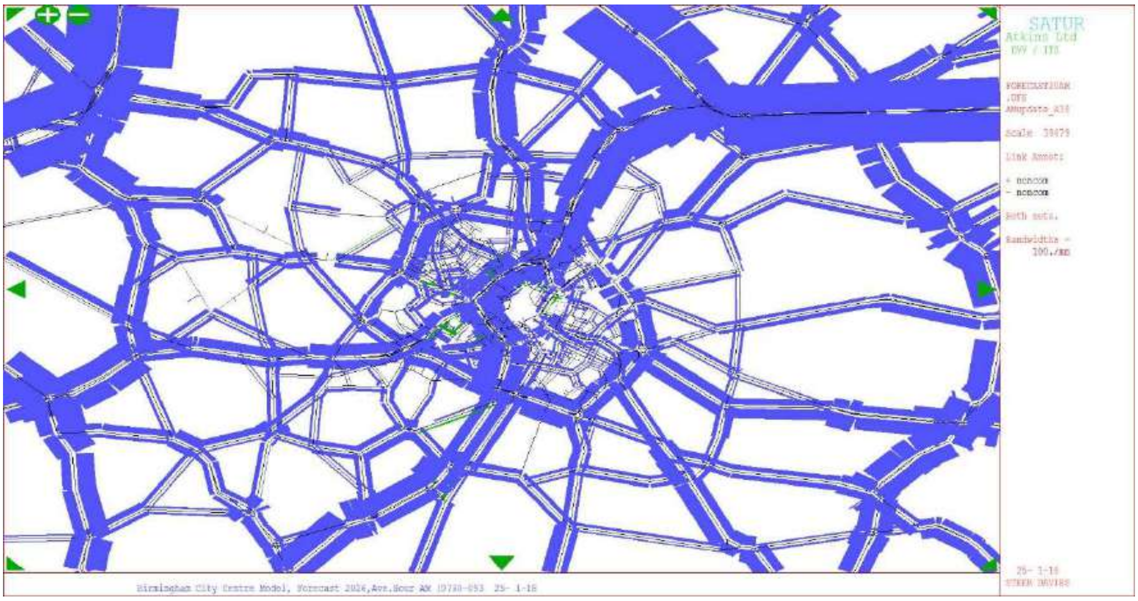


Figure C.4: Link Delay Change (202 Do Minimum – Base) - AM

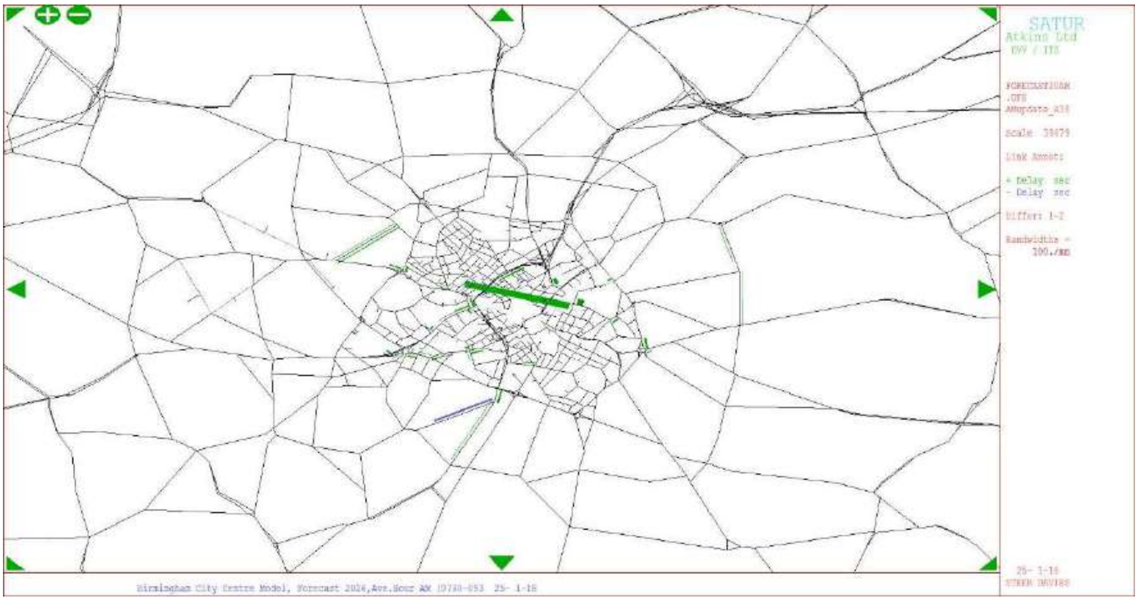


Figure C.5: Total Flow Change (2020 Do Minimum – Base) – IP

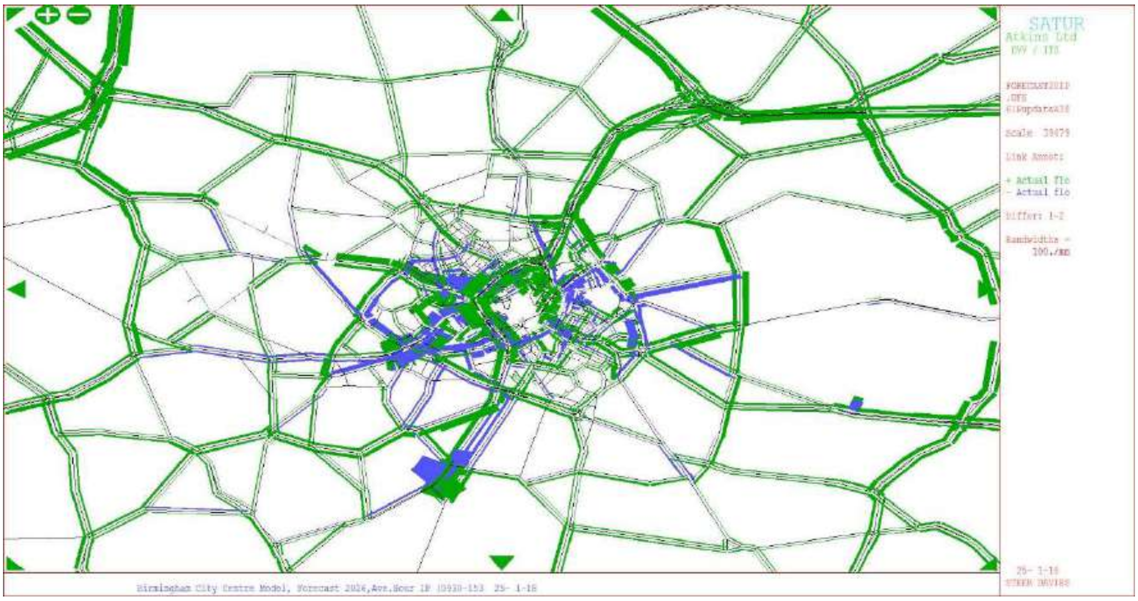


Figure C.6: Compliant Flow Change (2020 Do Minimum – Base) – IP

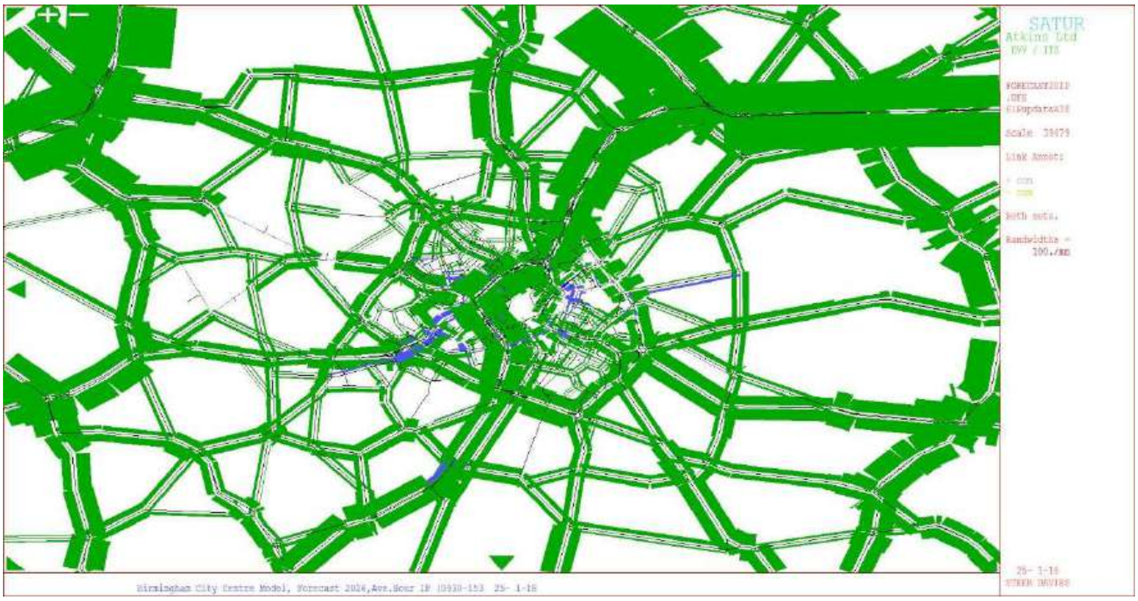


Figure C.7: Non-compliant Flow Change (2020 Do Minimum – Base) – IP

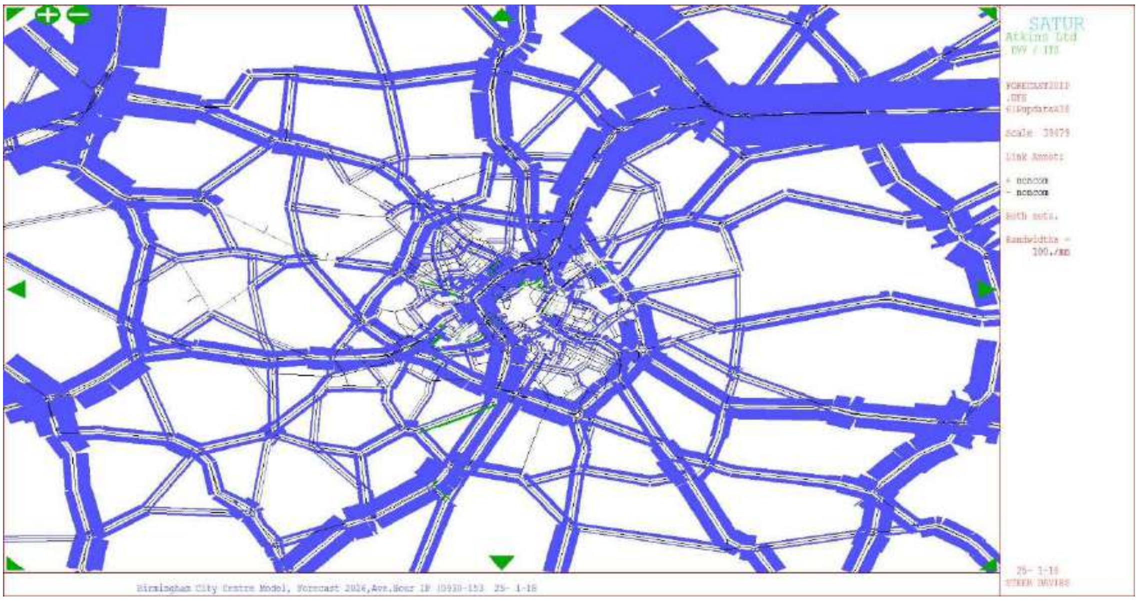


Figure C.8: Link Delay Change (202 Do Minimum – Base) – IP

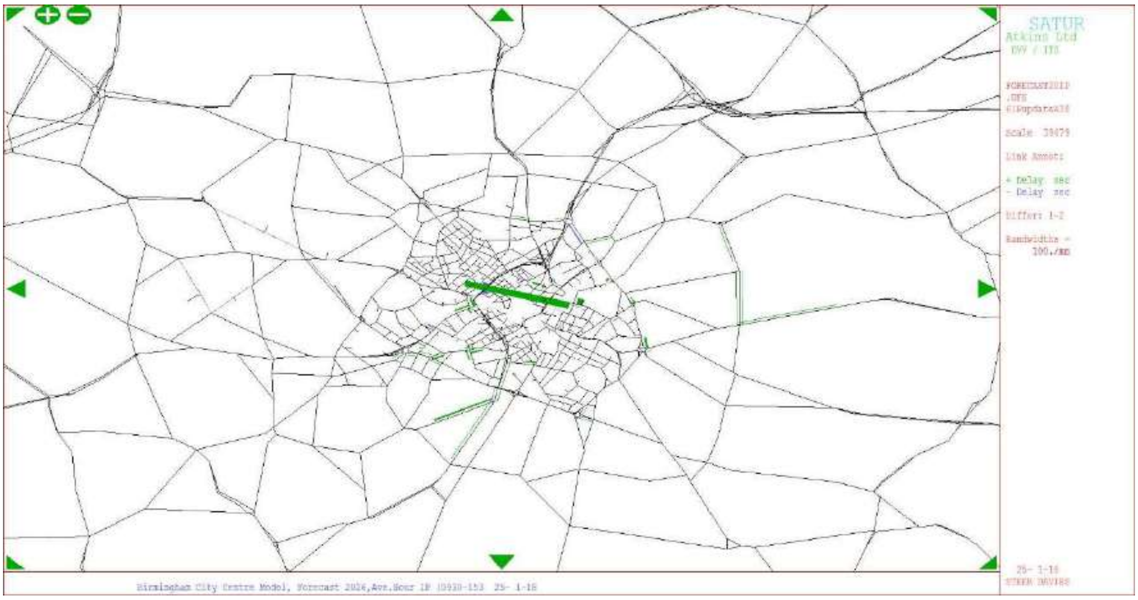


Figure C.9: Total Flow Change (2020 Do Minimum – Base) – PM

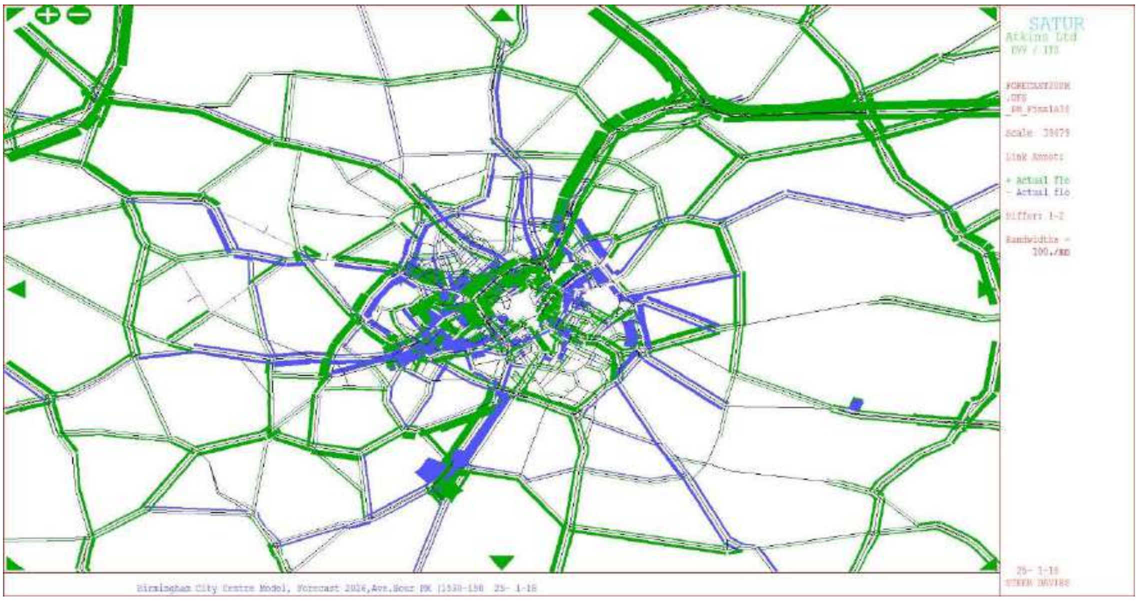


Figure C.10: Compliant Flow Change (2020 Do Minimum – Base) – PM

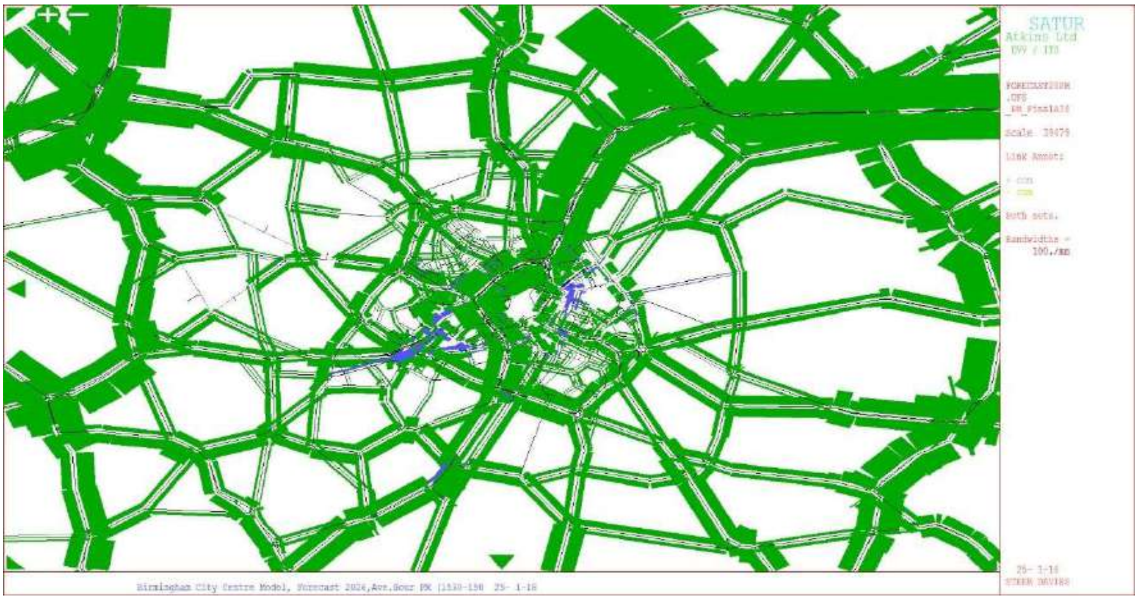


Figure C.11: Non-compliant Flow Change (2020 Do Minimum – Base) – PM

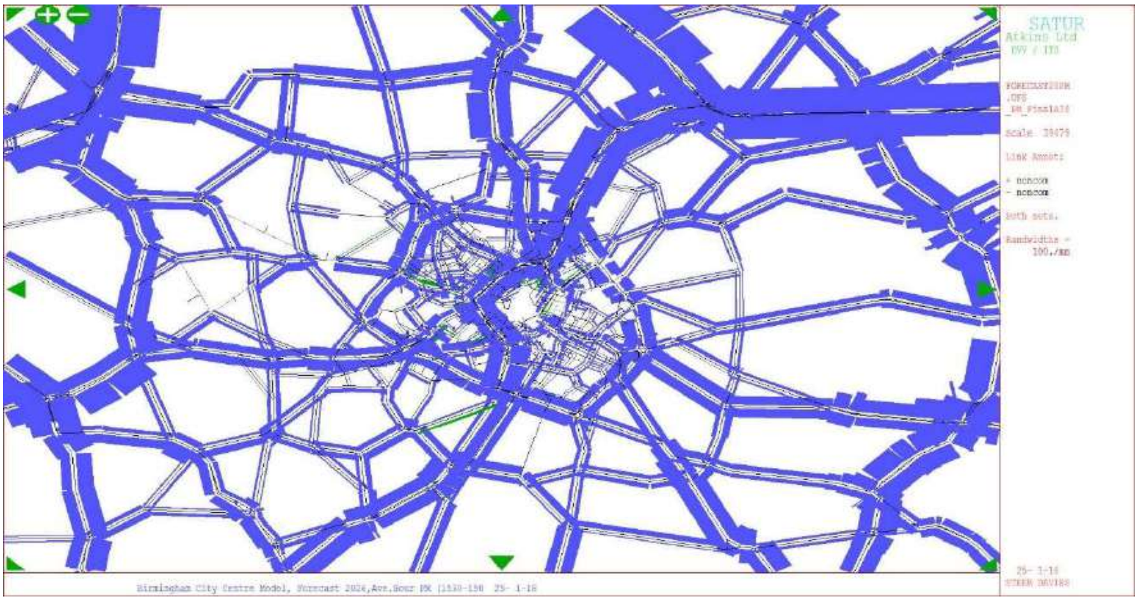
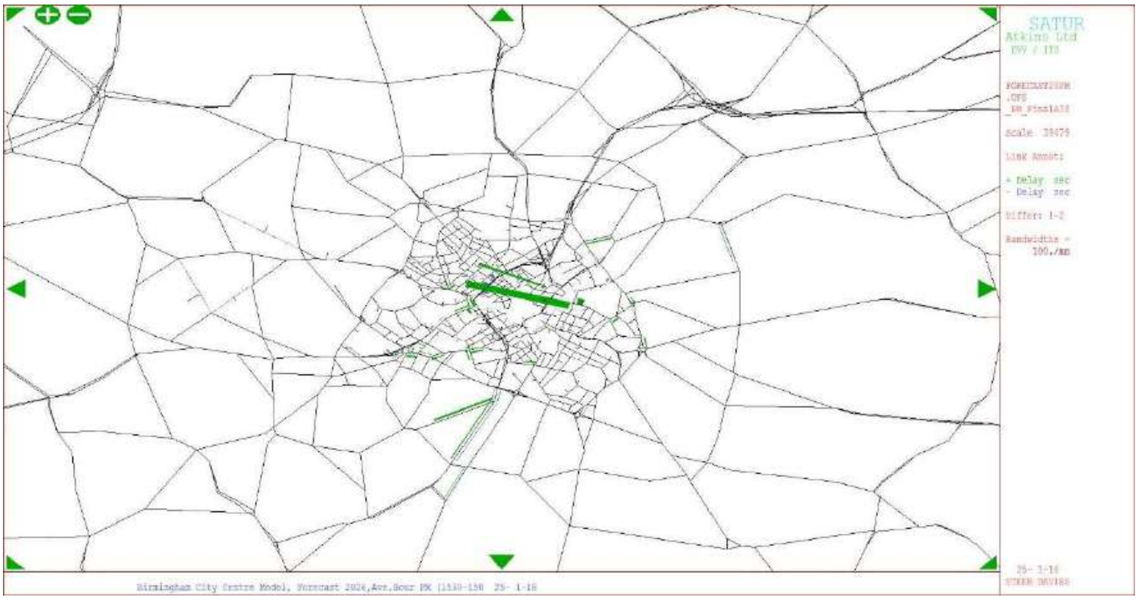


Figure C.12: Link Delay Change (202 Do Minimum – Base) - PM



All CAZs – DM

Figure C.13: Total Flow Change (CAZ C Low – Do Minimum) - AM

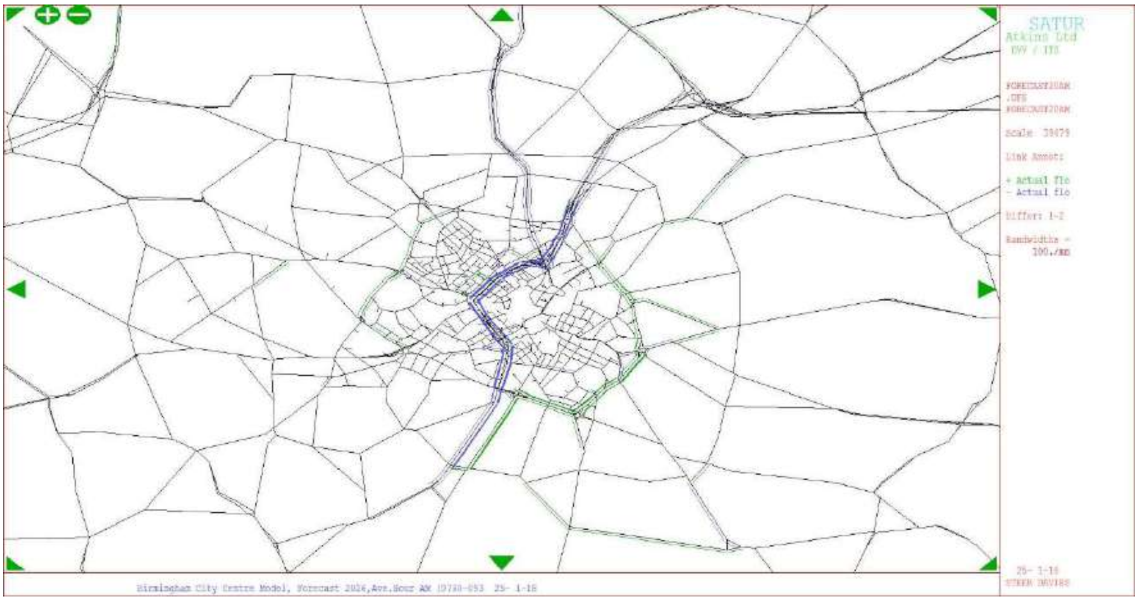


Figure C.14: Compliant Flow Change (CAZ C Low – Do Minimum) – AM

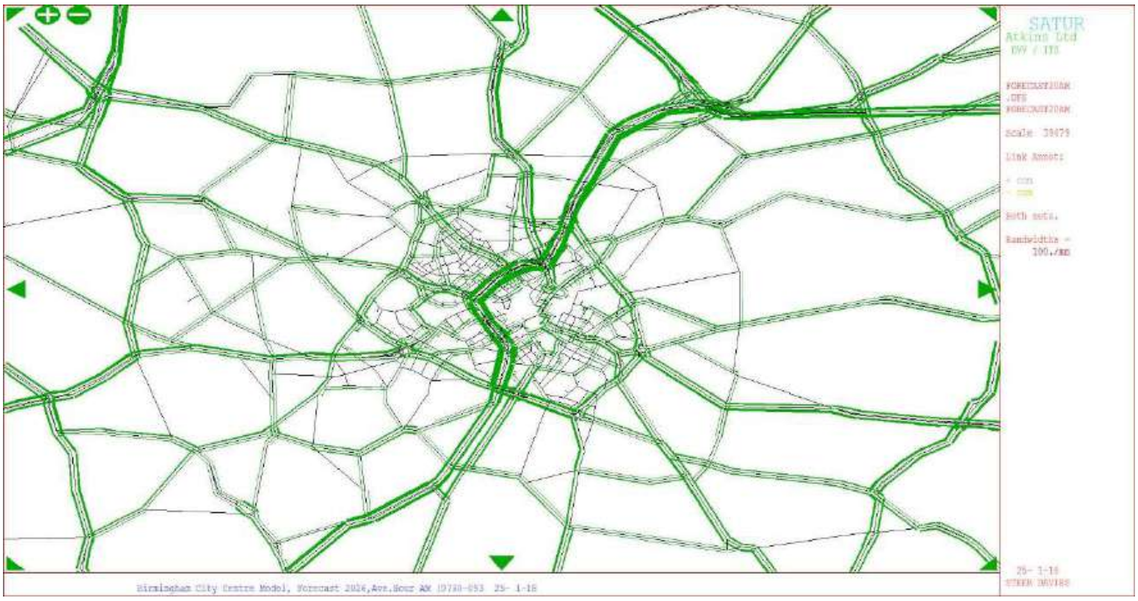


Figure C.15: Non-compliant Flow Change (CAZ C Low – Do Minimum) – AM

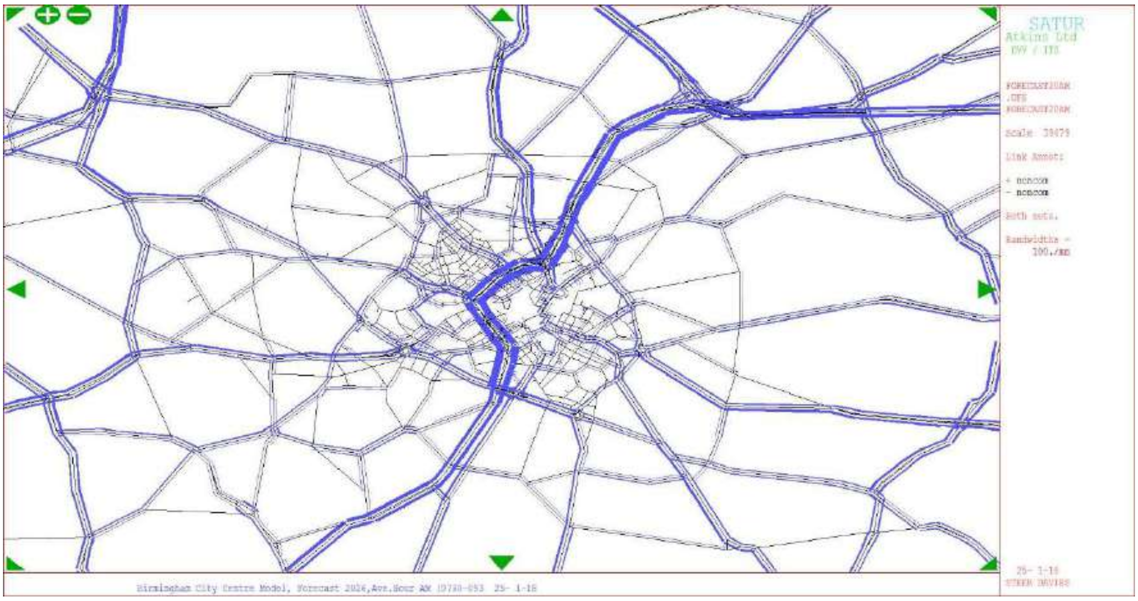


Figure C.16: Link Delay Change (CAZ C Low – Do Minimum) - AM

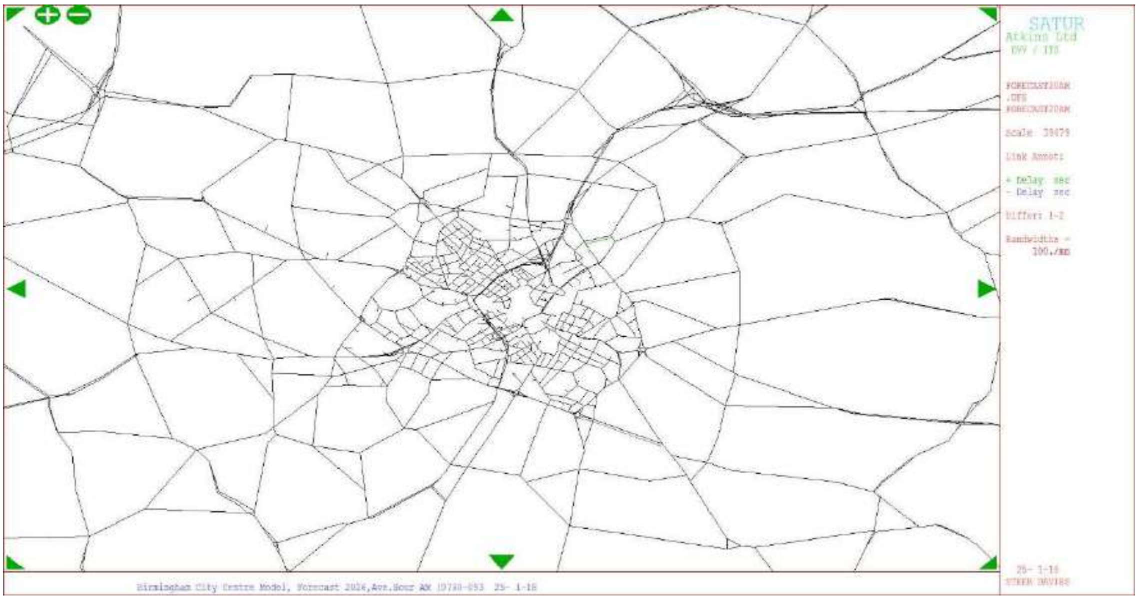


Figure C.17: Total Flow Change (CAZ C Low – Do Minimum) – IP

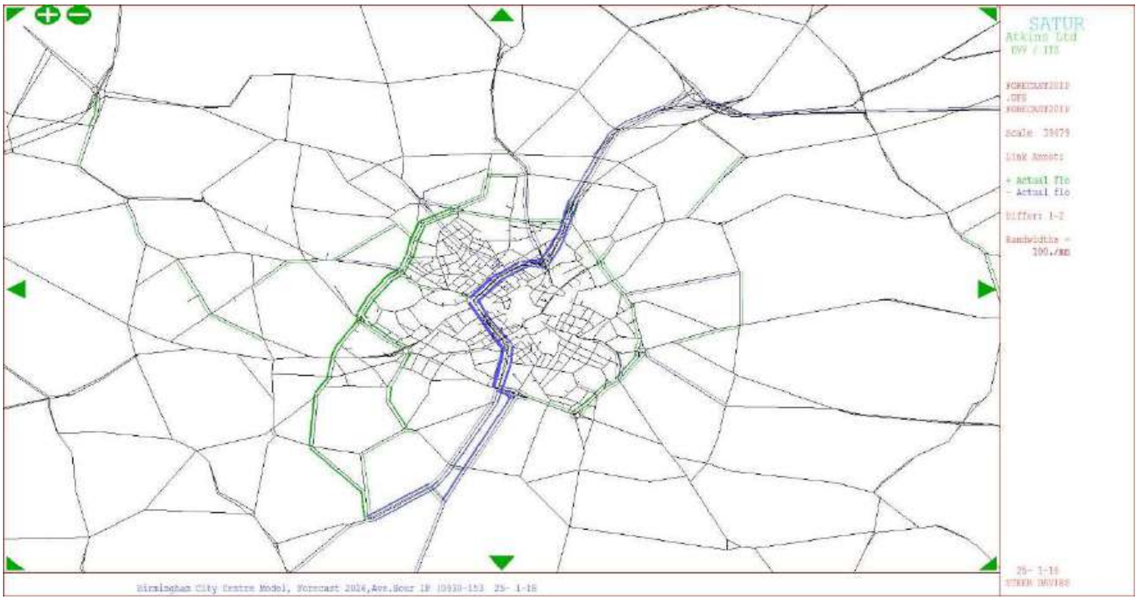


Figure C.18: Compliant Flow Change (CAZ C Low – Do Minimum) – IP

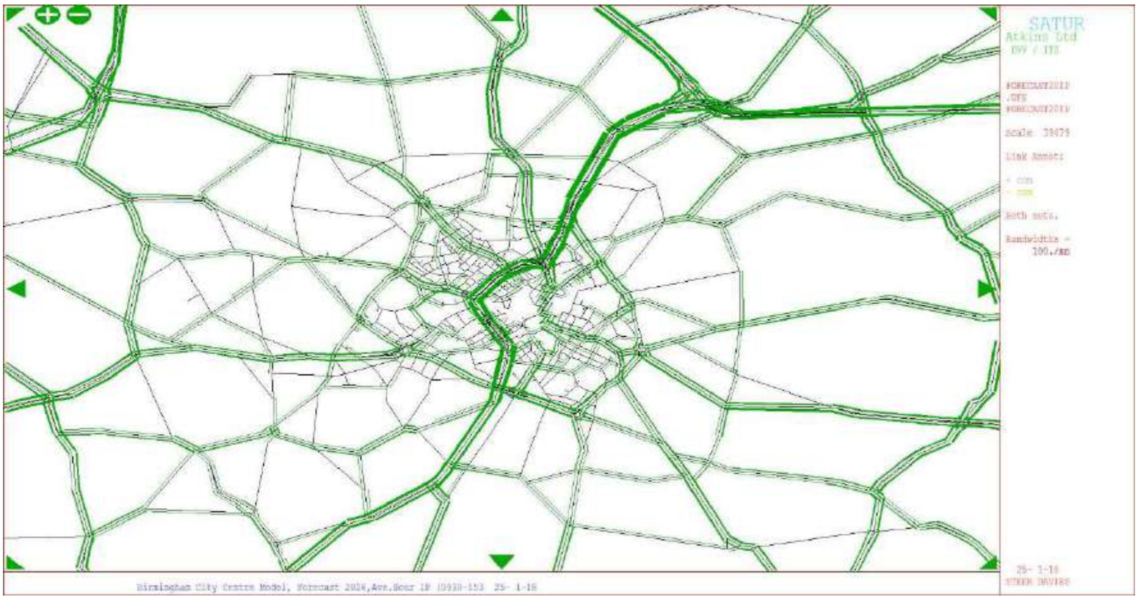


Figure C.19: Non-compliant Flow Change (CAZ C Low – Do Minimum) – IP

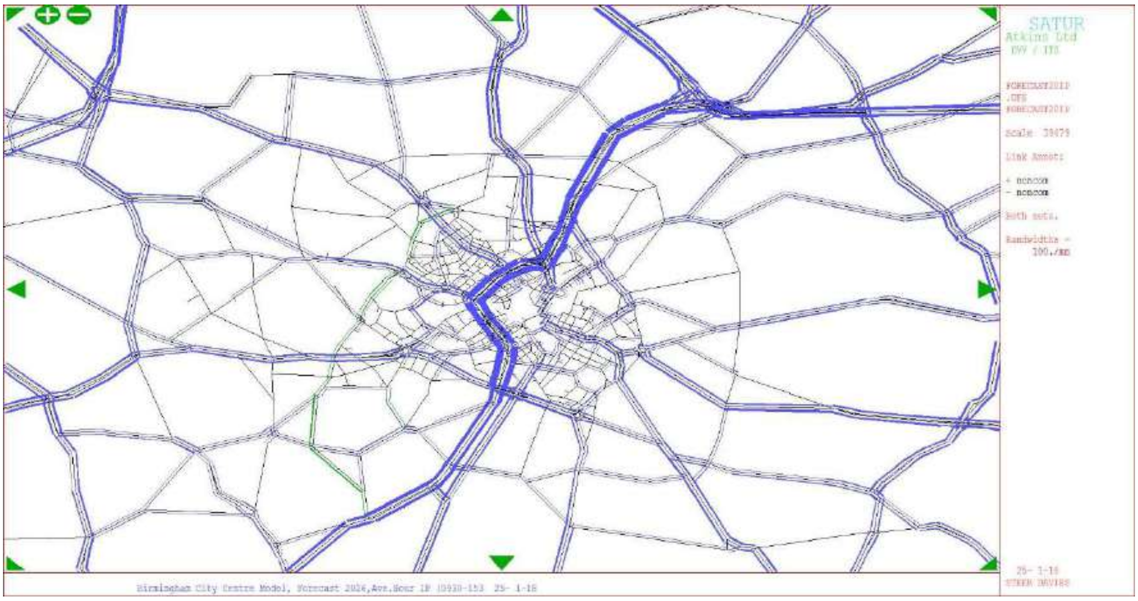


Figure C.20: Link Delay Change (CAZ C Low – Do Minimum) – IP

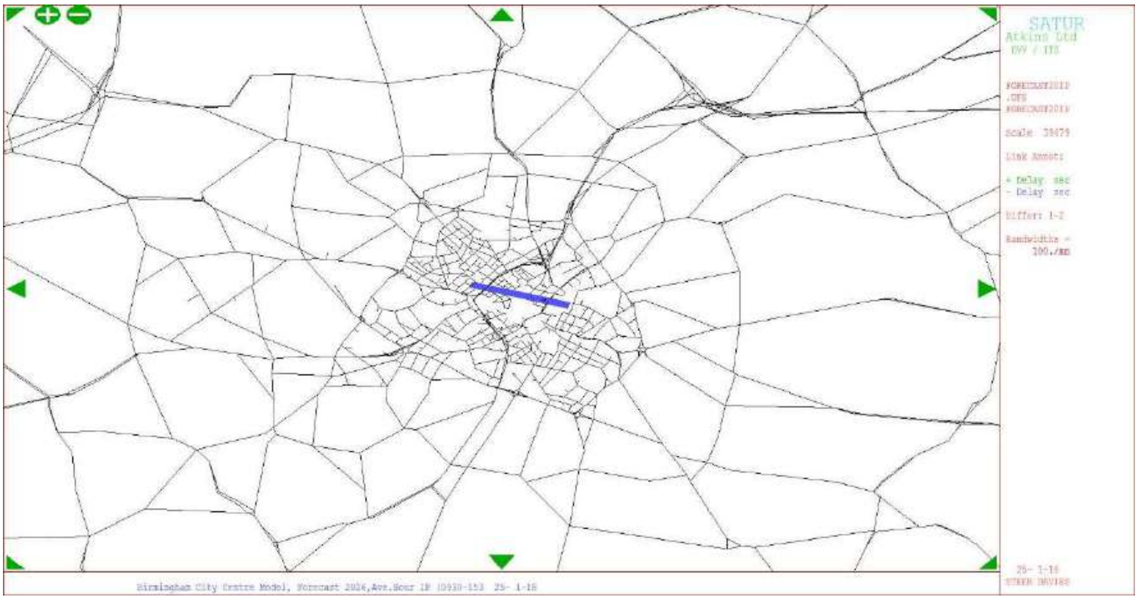


Figure C.21: Total Flow Change (CAZ C Low – Do Minimum) – PM

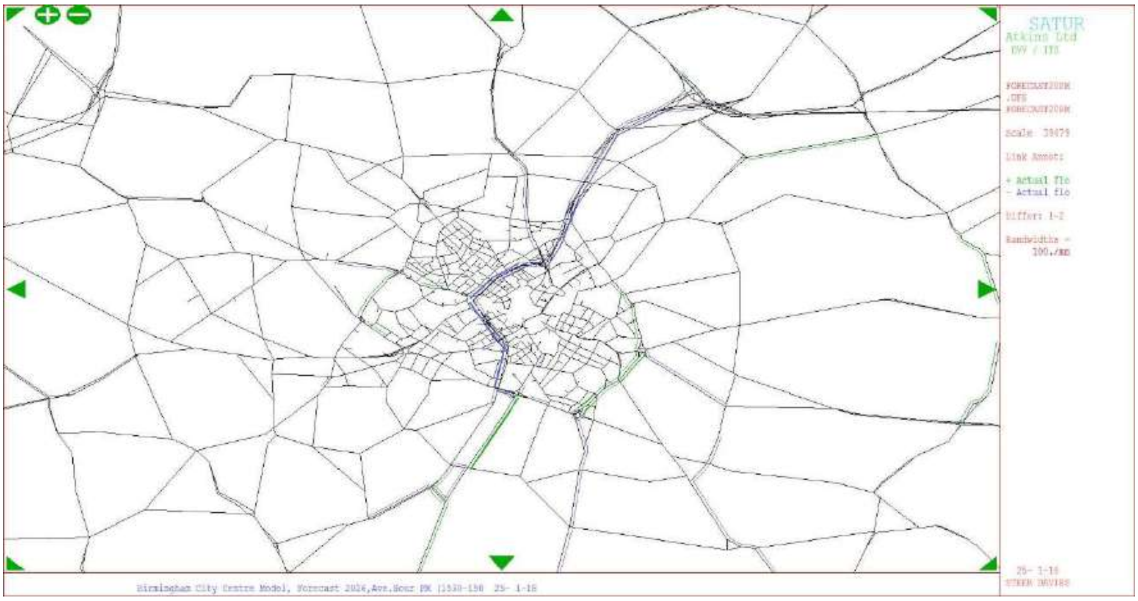


Figure C.22: Compliant Flow Change (CAZ C Low – Do Minimum) – PM

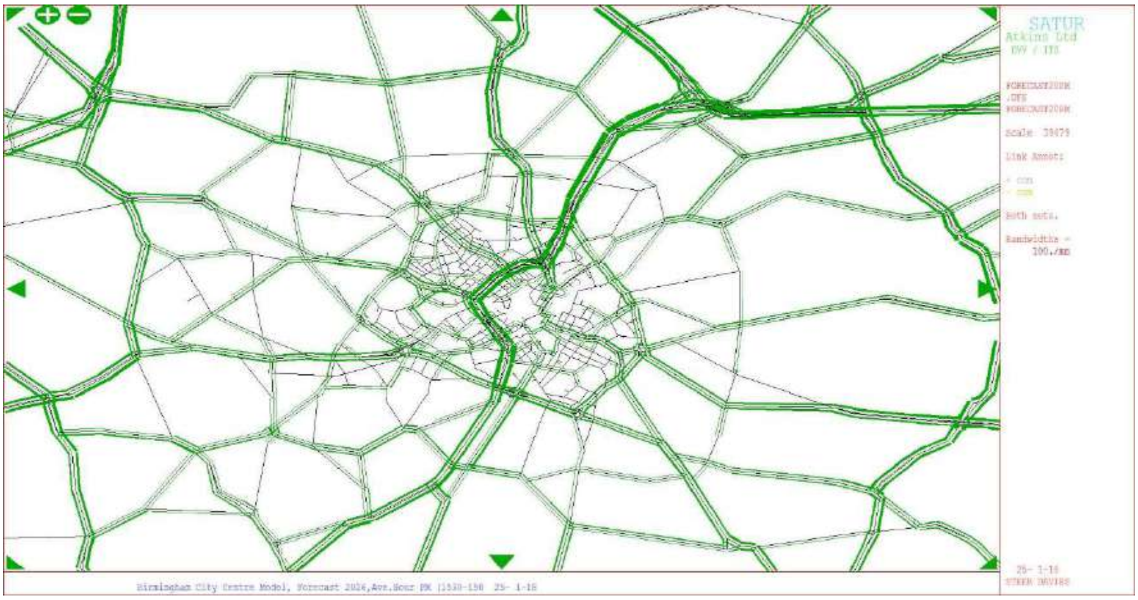


Figure C.23: Non-compliant Flow Change (CAZ C Low – Do Minimum) – PM

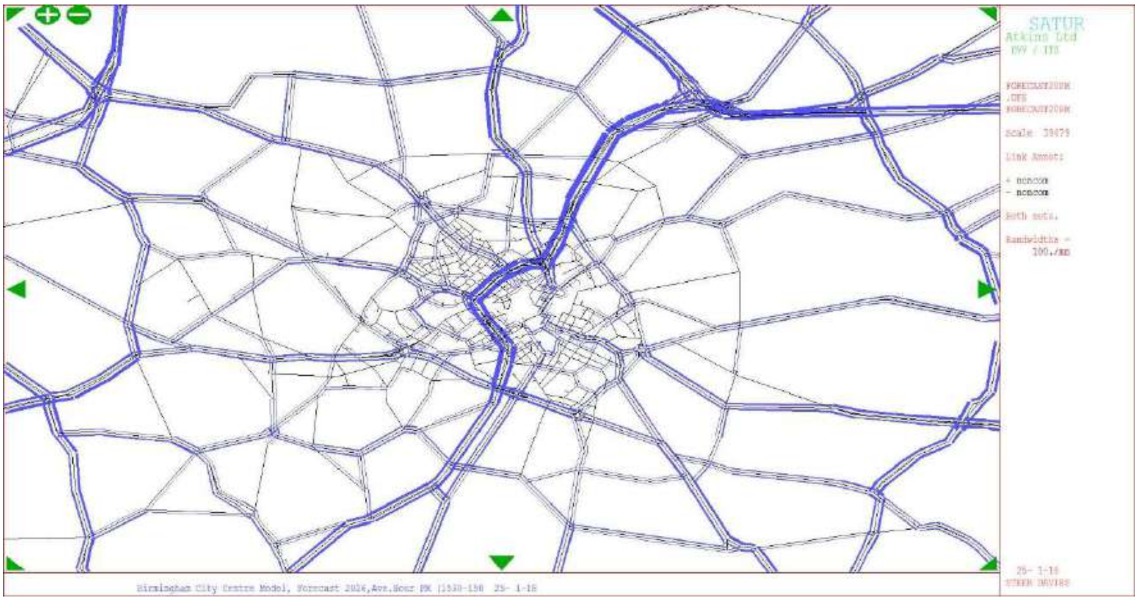


Figure C.24: Link Delay Change (CAZ C Low – Do Minimum) – PM

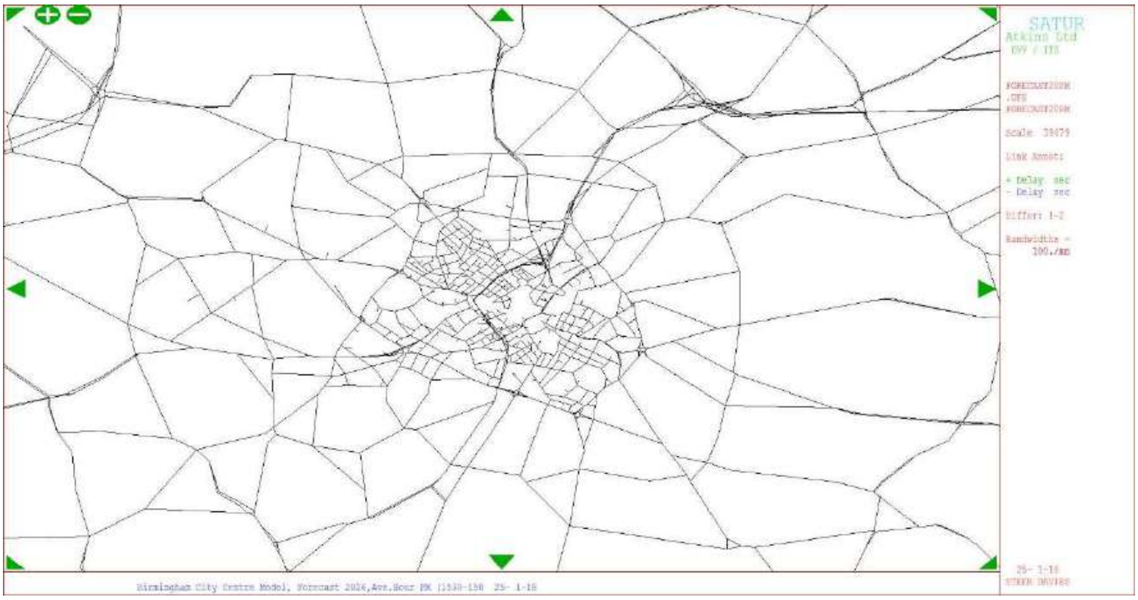


Figure C.25: Total Flow Change (CAZ C Medium – Do Minimum) – AM

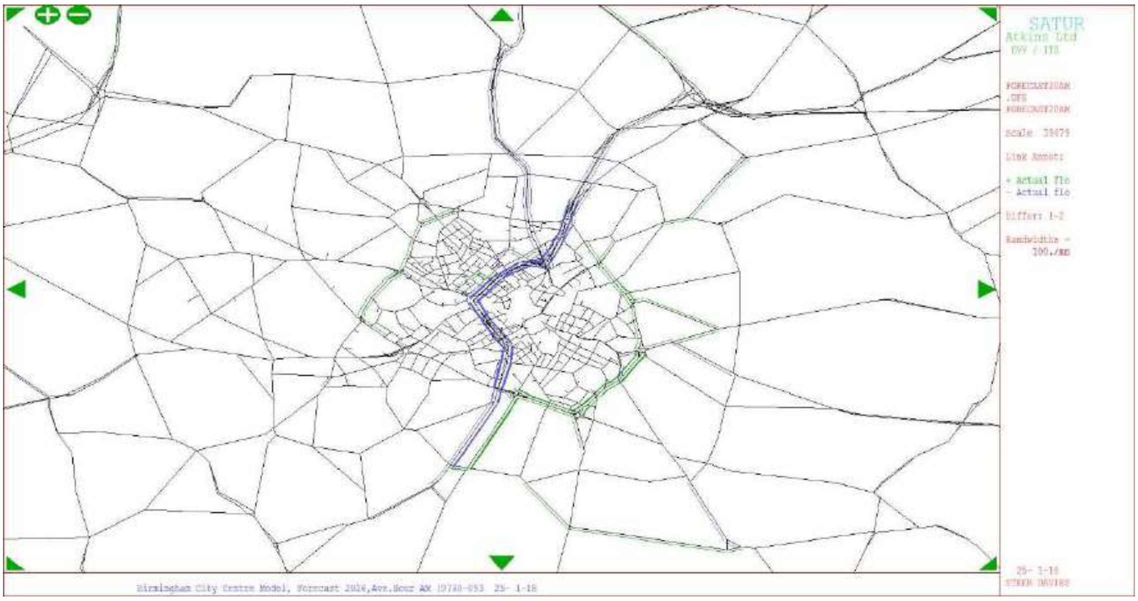


Figure C.26: Compliant Flow Change (CAZ C Medium – Do Minimum) – AM

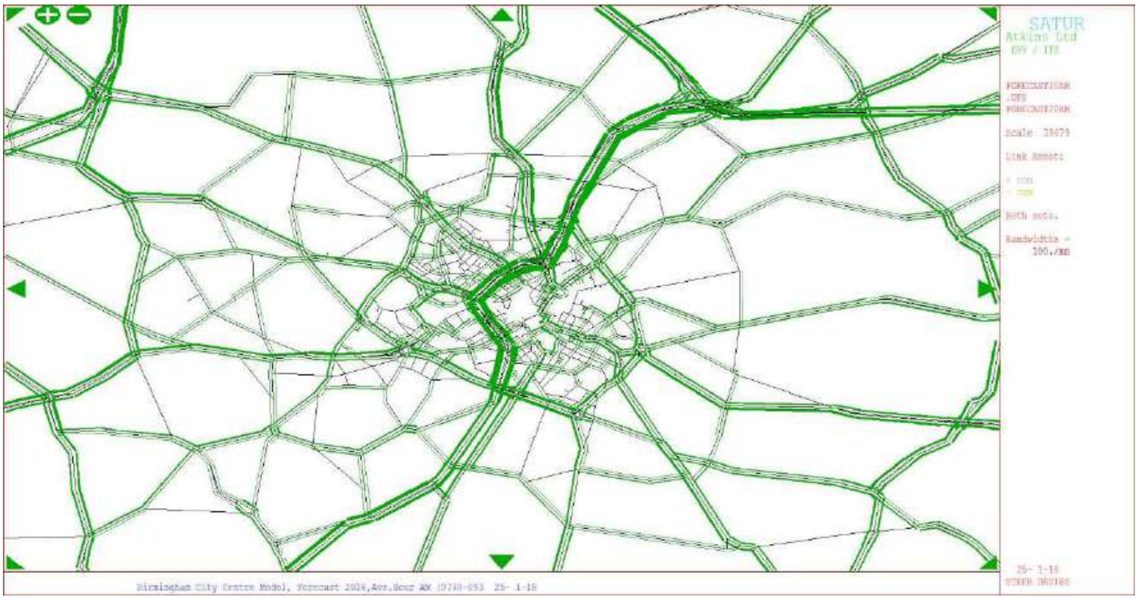


Figure C.27: Non-compliant Flow Change (CAZ C Medium – Do Minimum) – AM

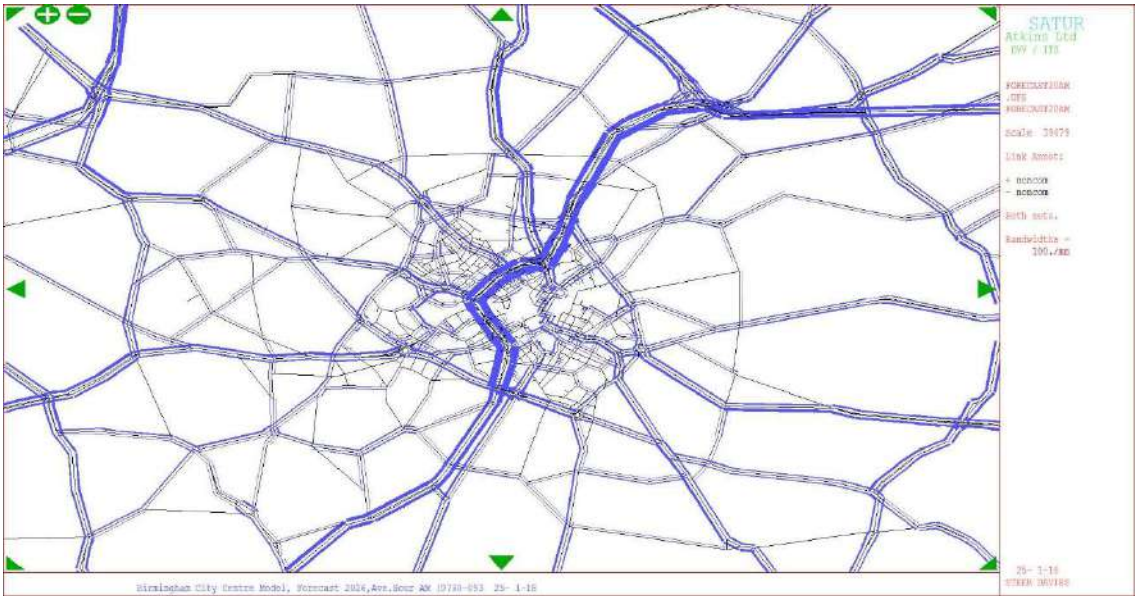


Figure C.28: Link Delay Change (CAZ C Medium – Do Minimum) – AM

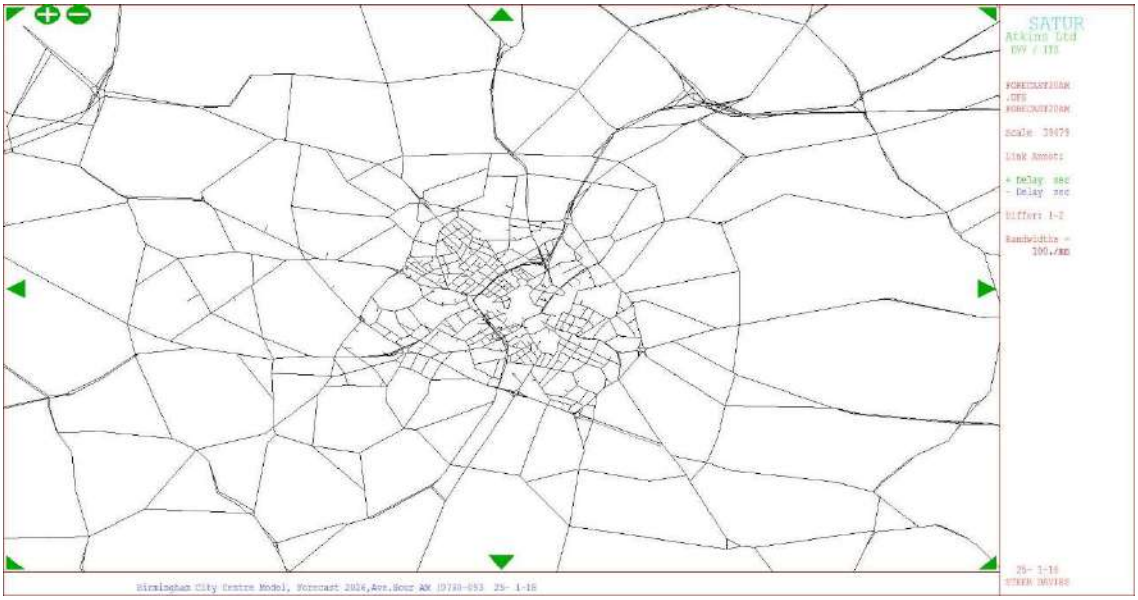


Figure C.29: Total Flow Change (CAZ C Medium – Do Minimum) – IP

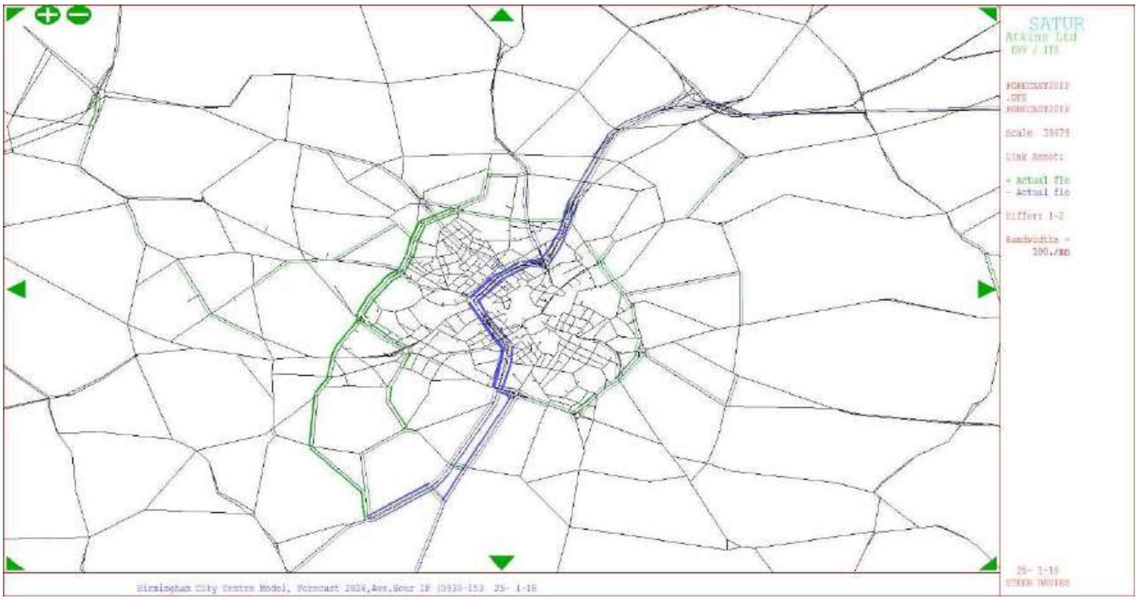


Figure C.30: Compliant Flow Change (CAZ C Medium – Do Minimum) – IP

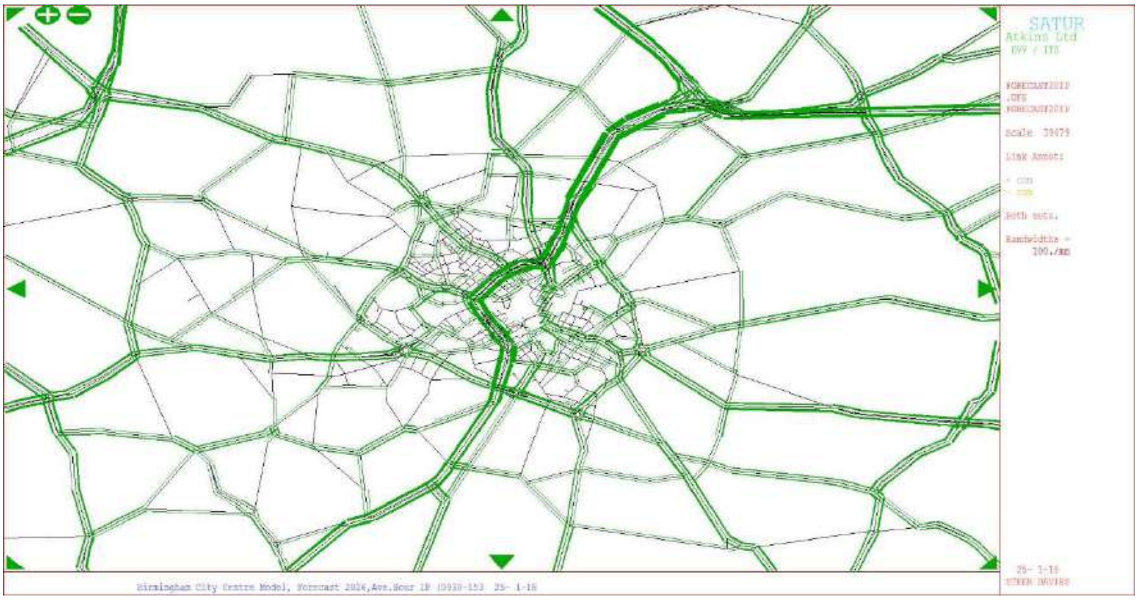


Figure C.31: Non-compliant Flow Change (CAZ C Medium – Do Minimum) – IP

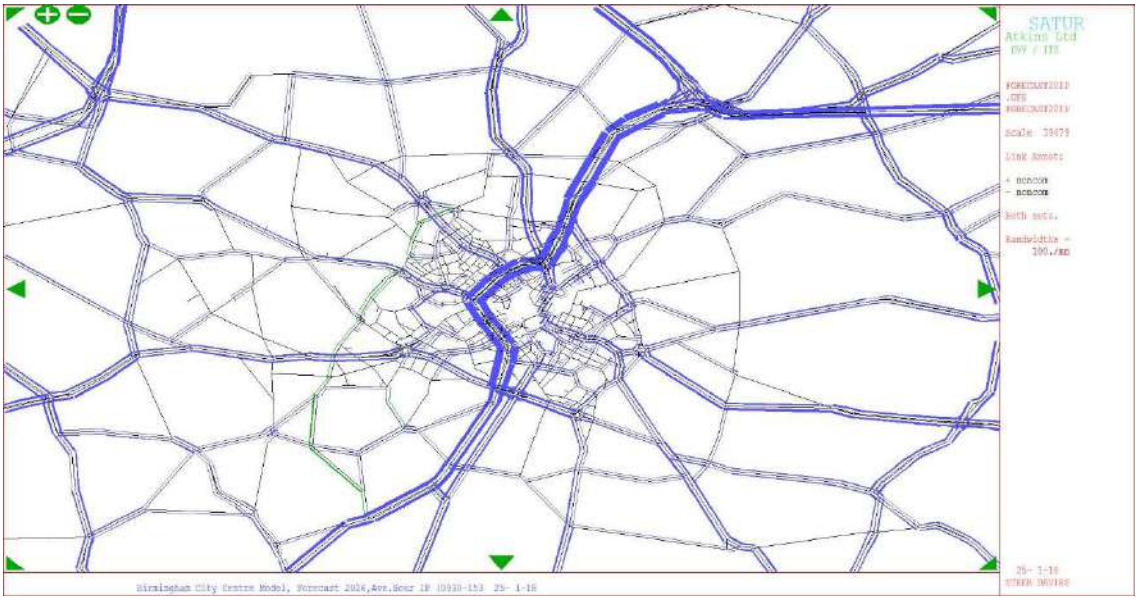


Figure C.32: Link Delay Change (CAZ C Medium – Do Minimum) – IP

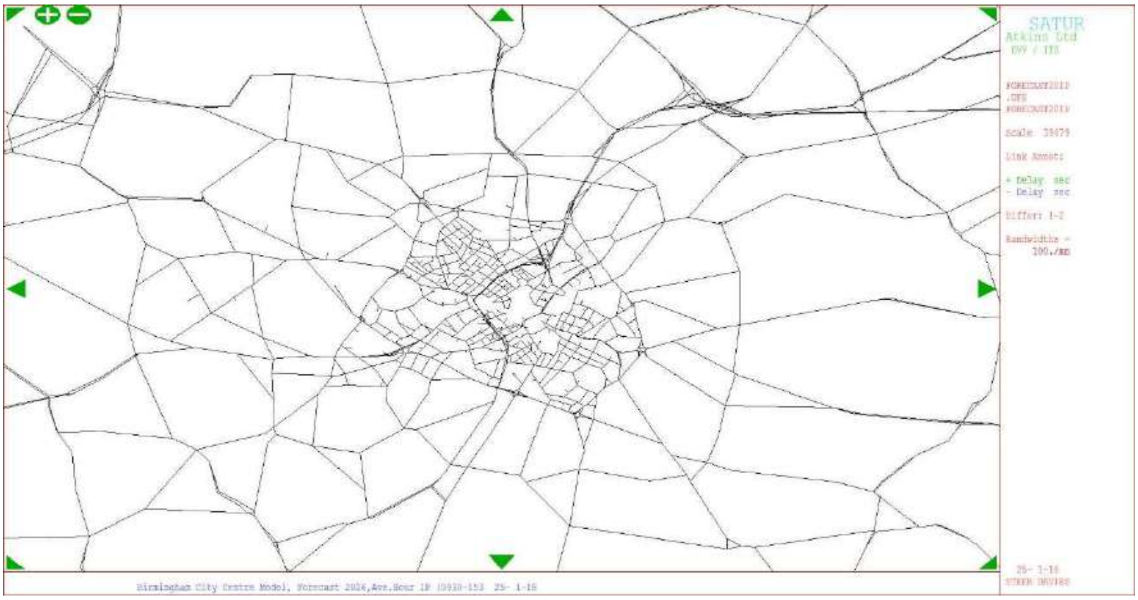


Figure C.33: Total Flow Change (CAZ C Medium – Do Minimum) – PM

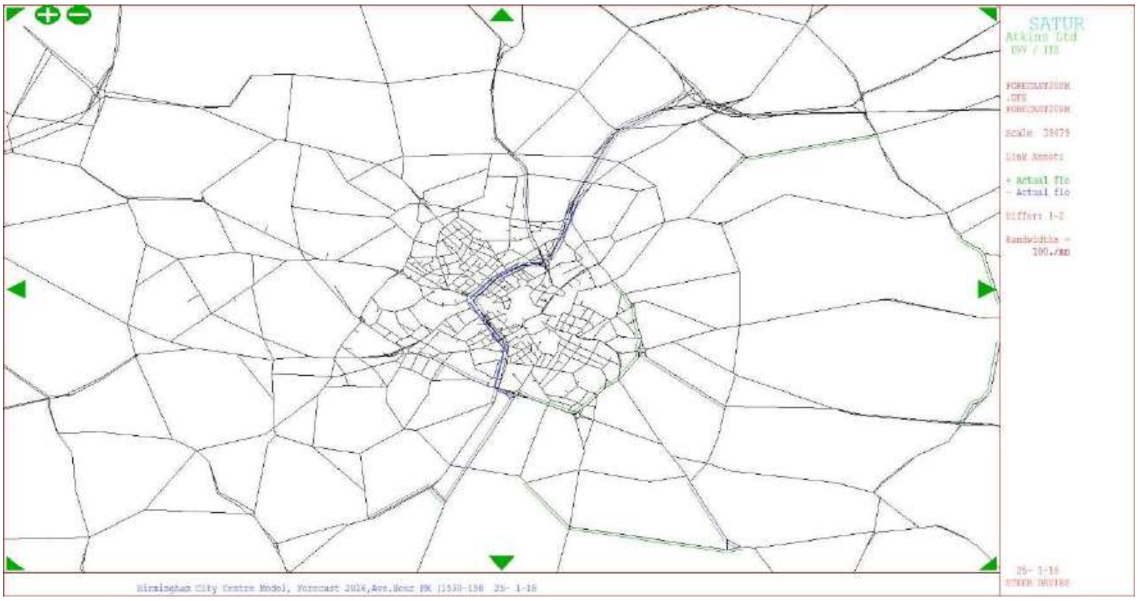


Figure C.34:Compliant Flow Change (CAZ C Medium – Do Minimum) – PM

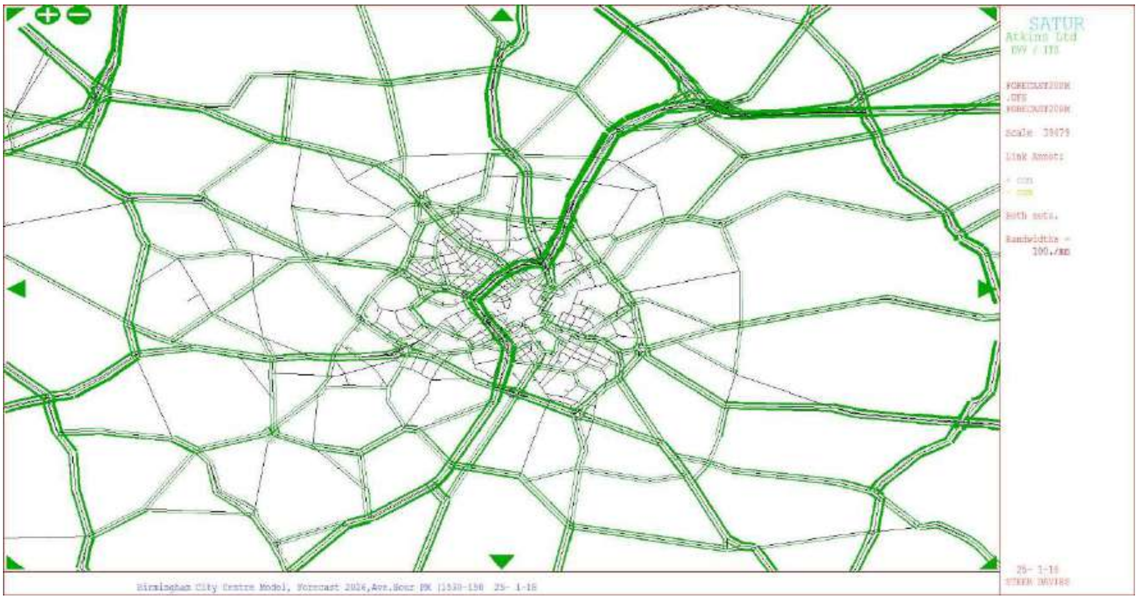


Figure C.35: Non-compliant Flow Change (CAZ C Medium – Do Minimum) – PM

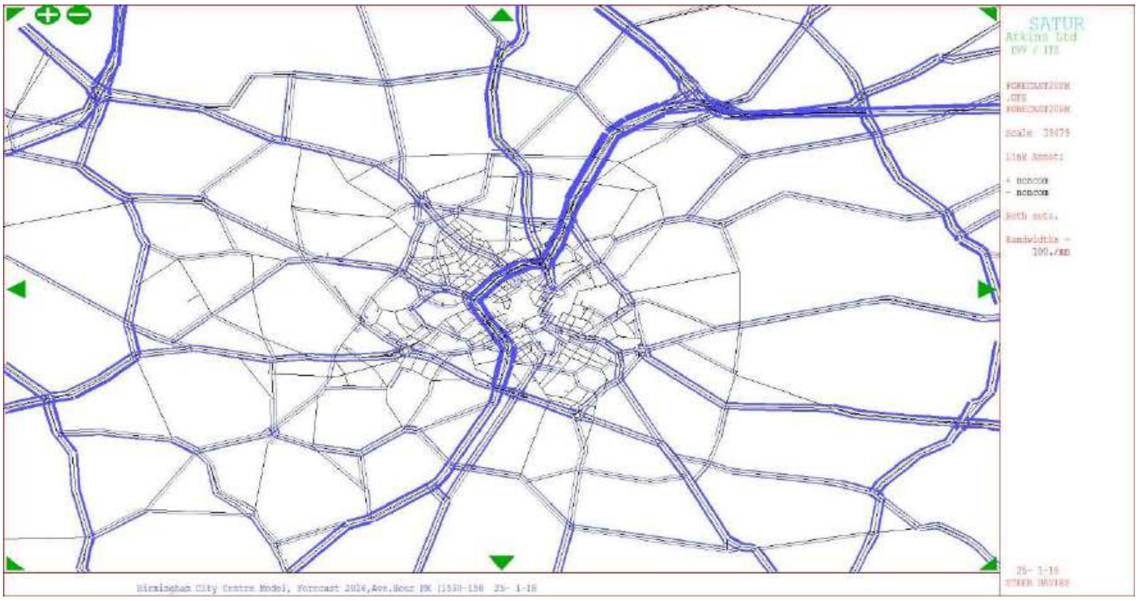


Figure C.36: Link Delay Change (CAZ C Medium – Do Minimum) – PM

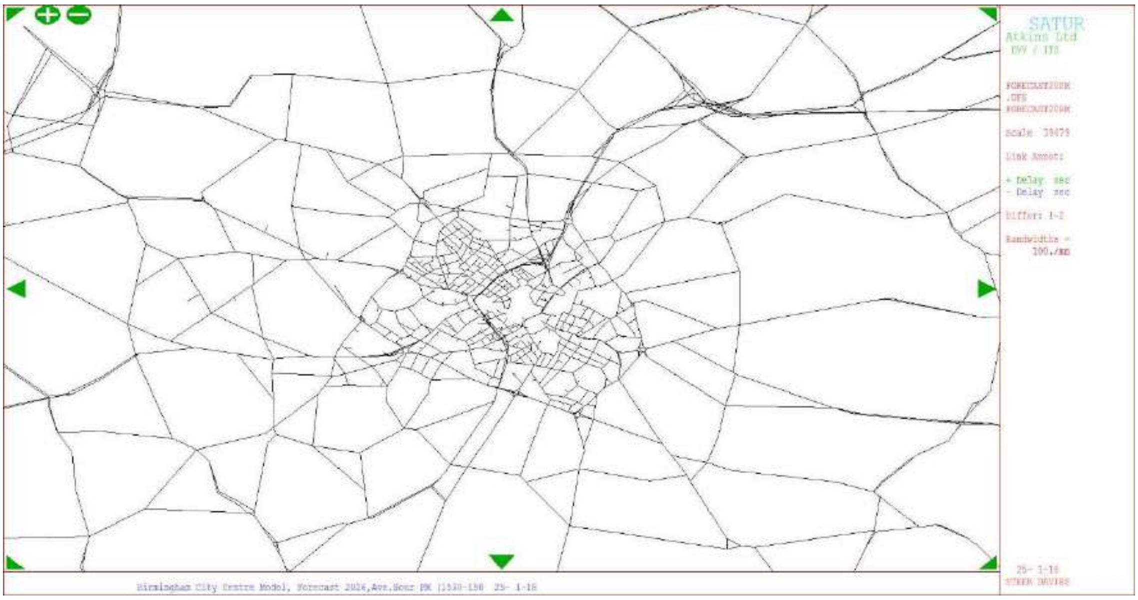


Figure C.37: Change (CAZ C High – Do Minimum) – AM

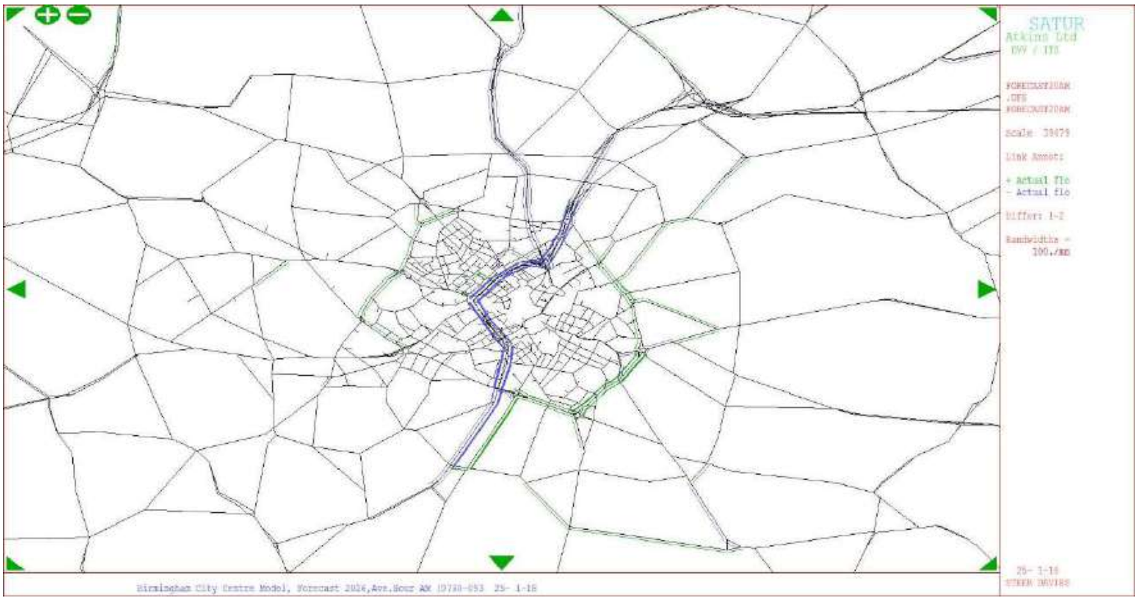


Figure C.38: Compliant Flow Change (CAZ C High – Do Minimum) – AM

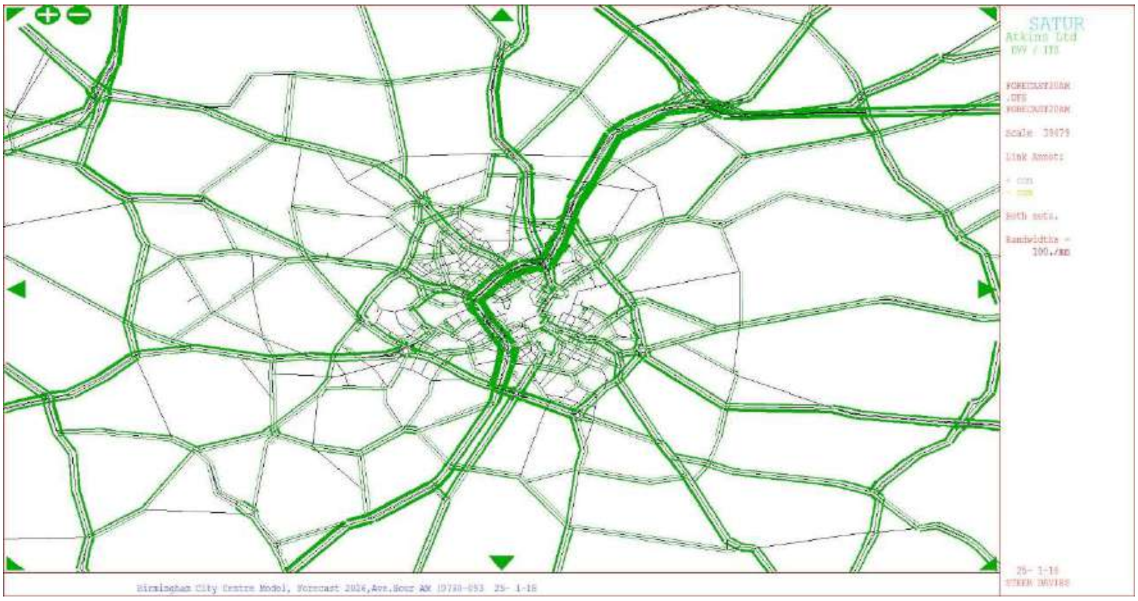


Figure C.39: Non-compliant Flow Change (CAZ C High – Do Minimum) – AM

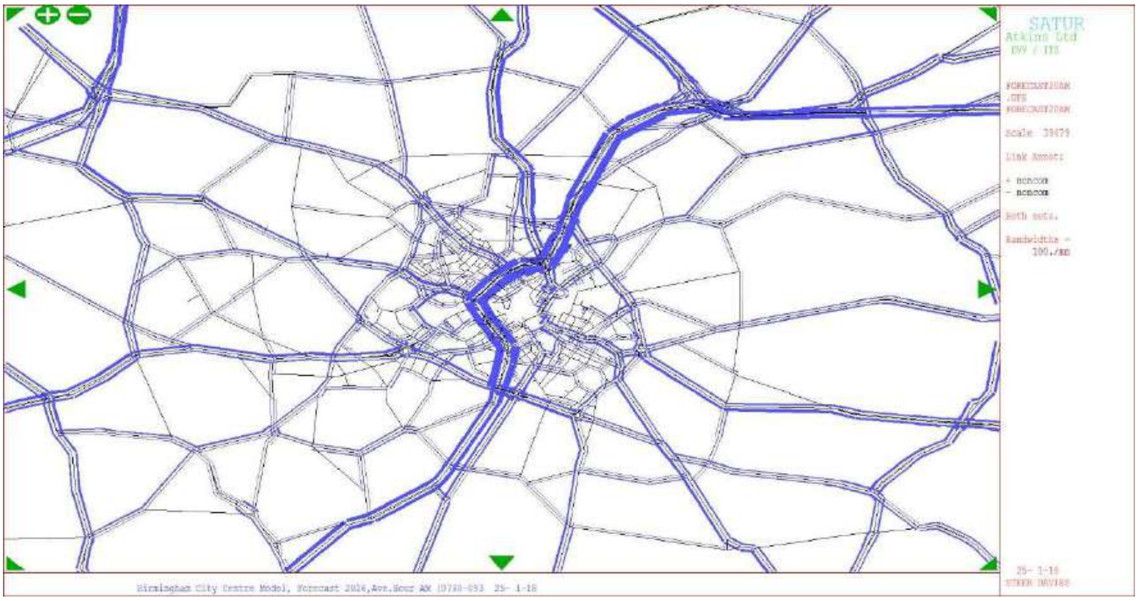


Figure C.40: Link Delay Change (CAZ C High – Do Minimum) – AM

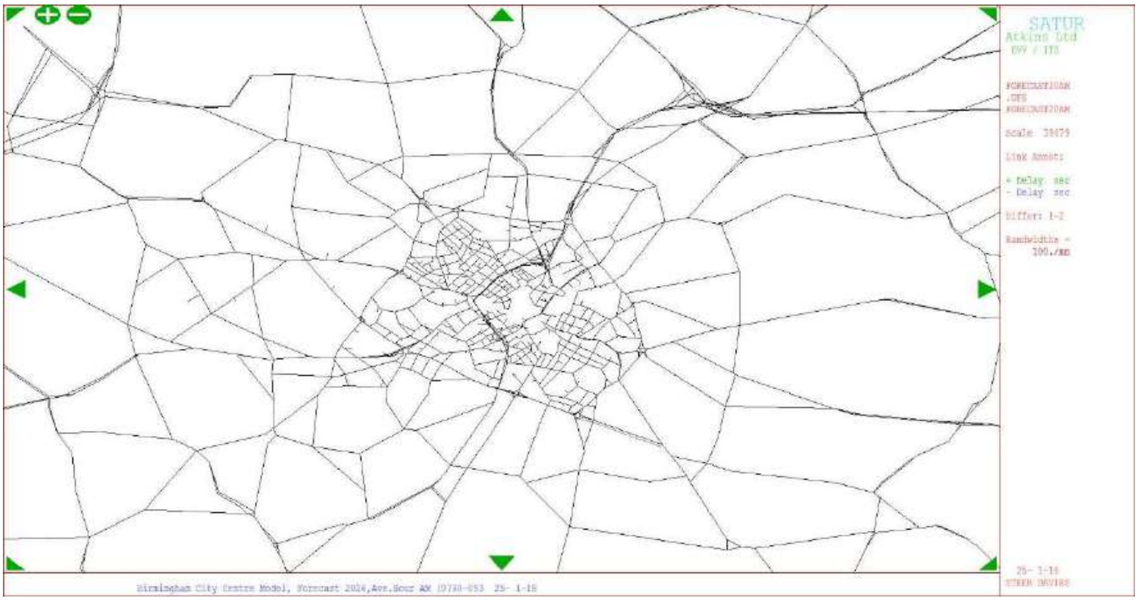


Figure C.41: Total Flow Change (CAZ C High – Do Minimum) – IP

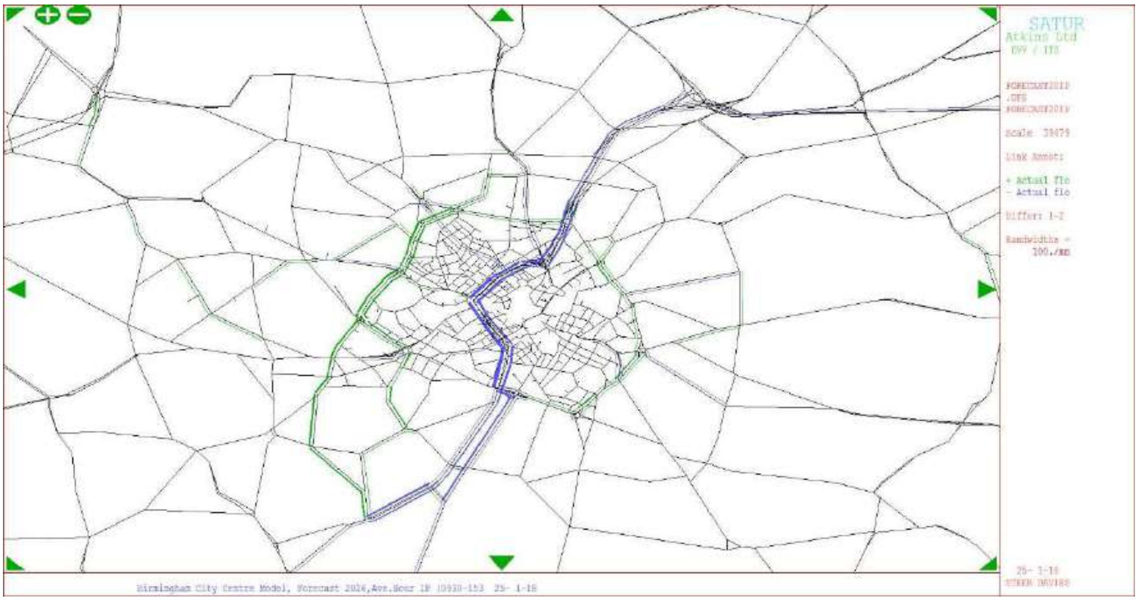


Figure C.42: Compliant Flow Change (CAZ C High – Do Minimum) – IP

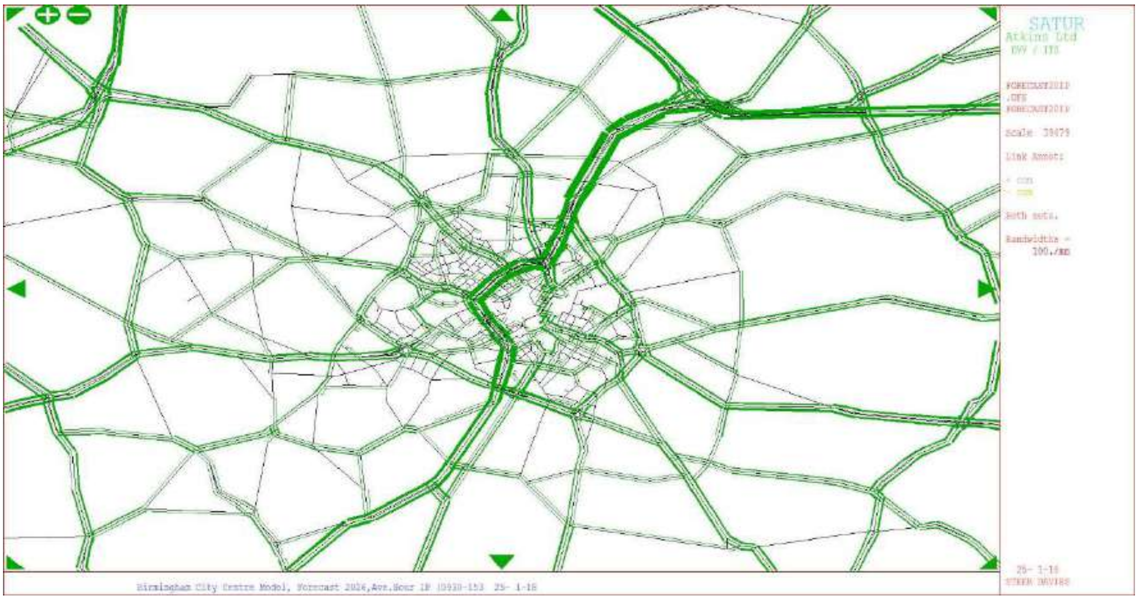


Figure C.43: Non-compliant Flow Change (CAZ C High – Do Minimum) – IP

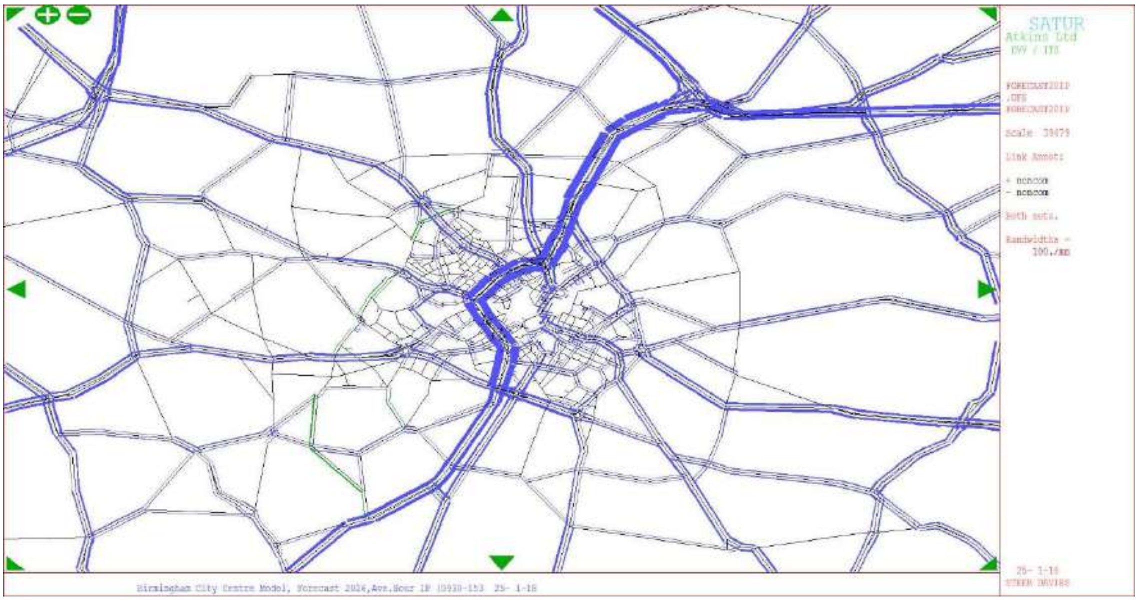


Figure C.44: Link Delay Change (CAZ C High – Do Minimum) – IP

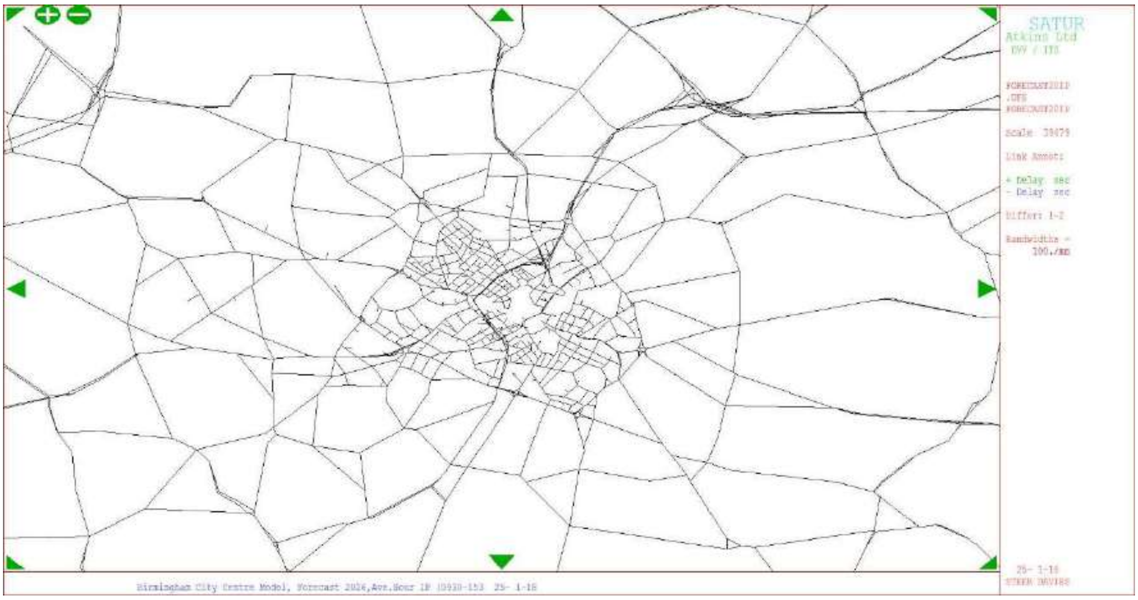


Figure C.45: Total Flow Change (CAZ C High – Do Minimum) – PM

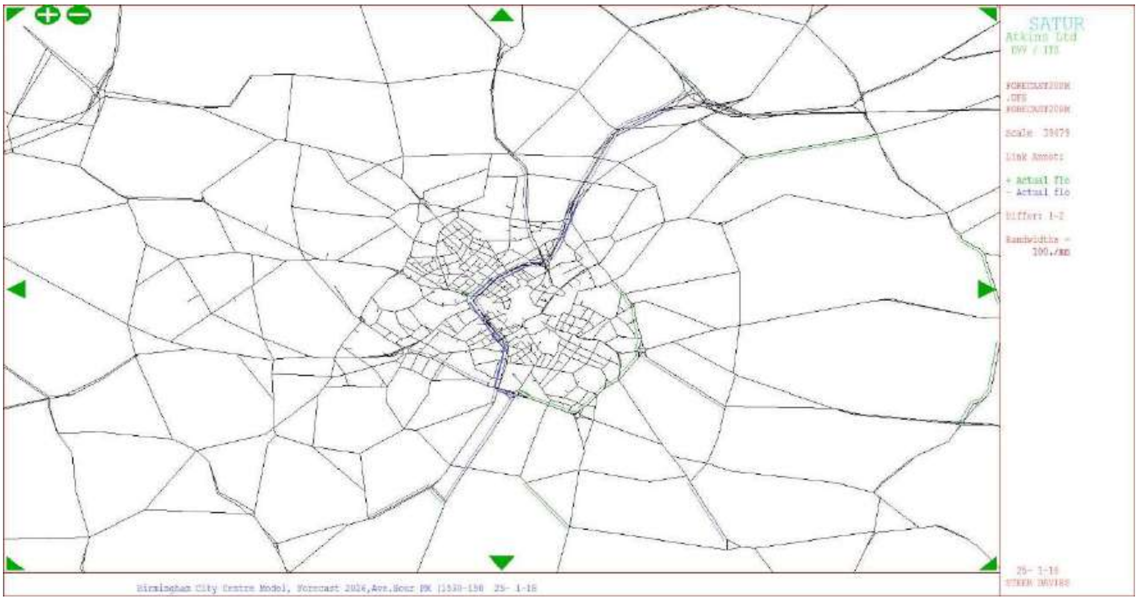


Figure C.46: Compliant Flow Change (CAZ C High – Do Minimum) – PM

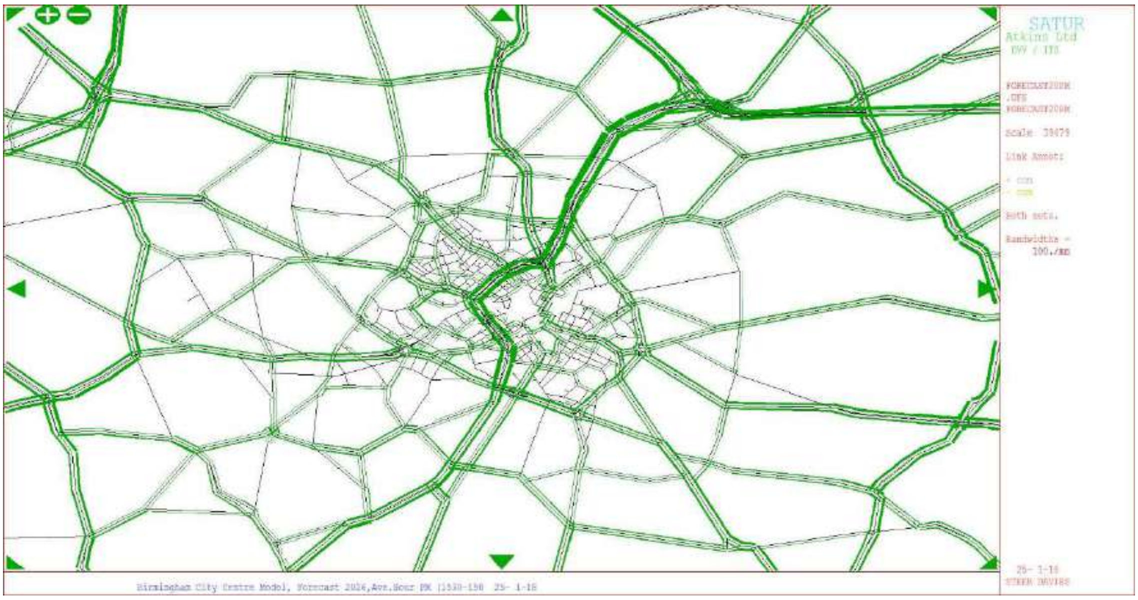


Figure C.47: Non-compliant Flow Change (CAZ C High – Do Minimum) – PM

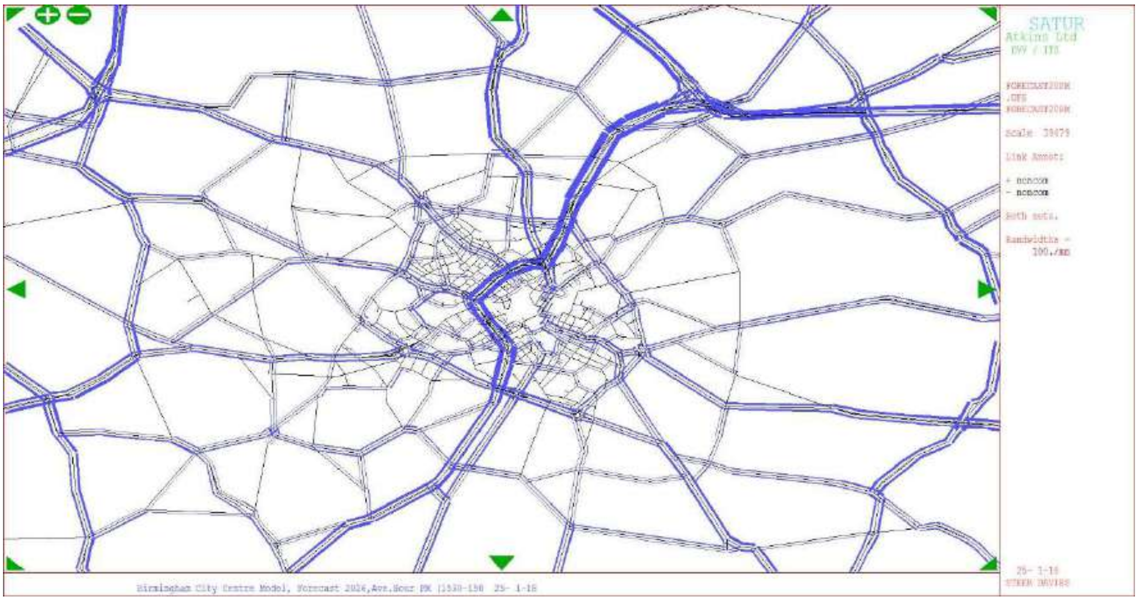


Figure C.48: Link Delay Change (CAZ C High – Do Minimum) - PM

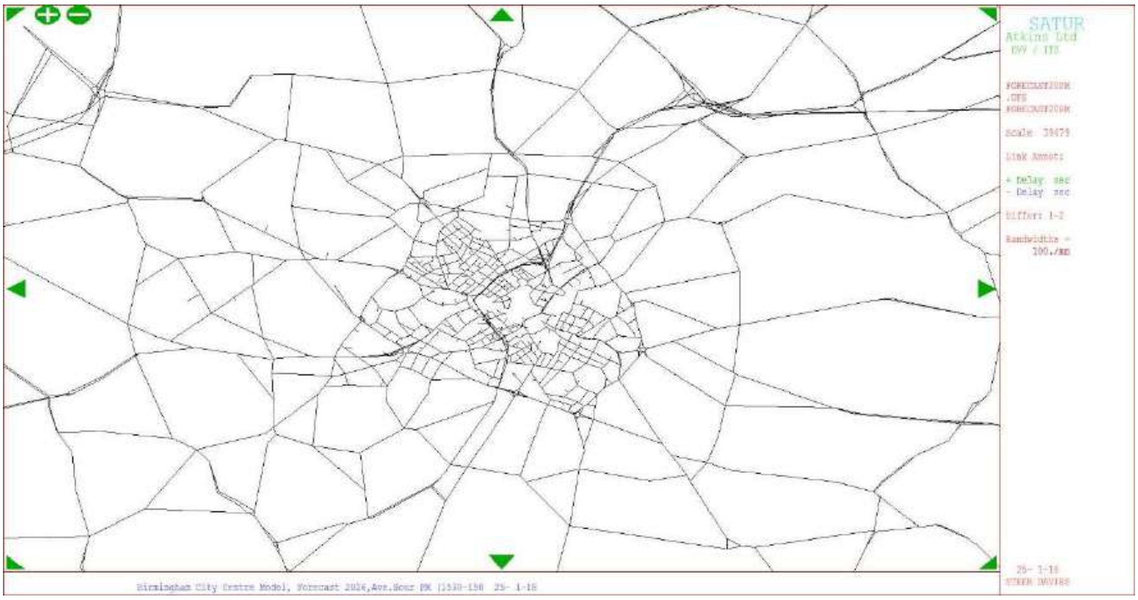


Figure C.49: Total Flow Change (CAZ D Low – Do Minimum) - AM

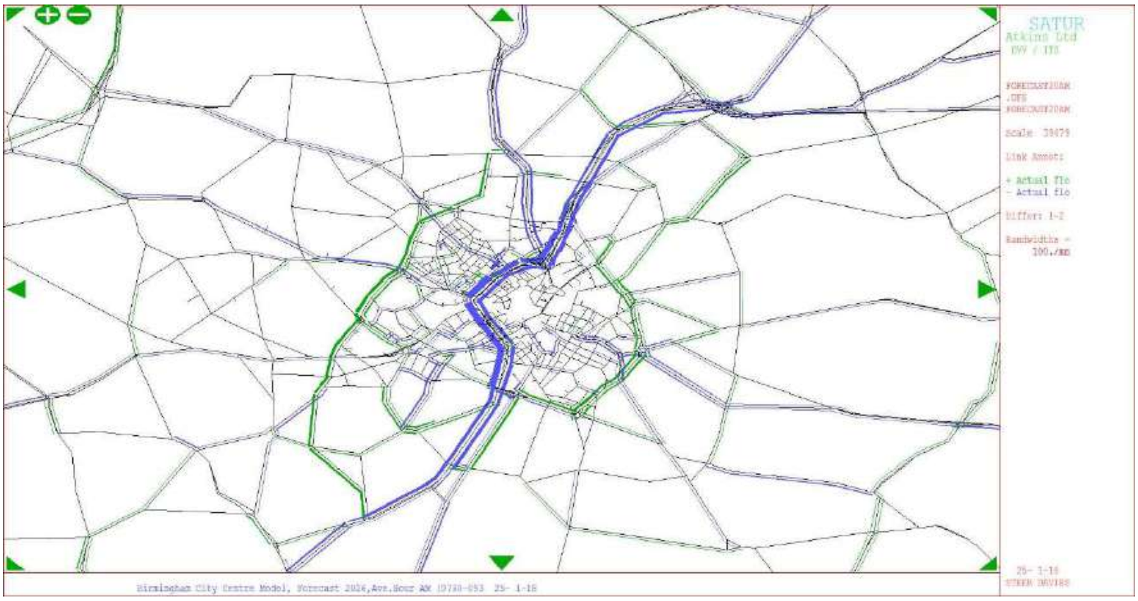


Figure C.50: Compliant Flow Change (CAZ D Low – Do Minimum) – AM

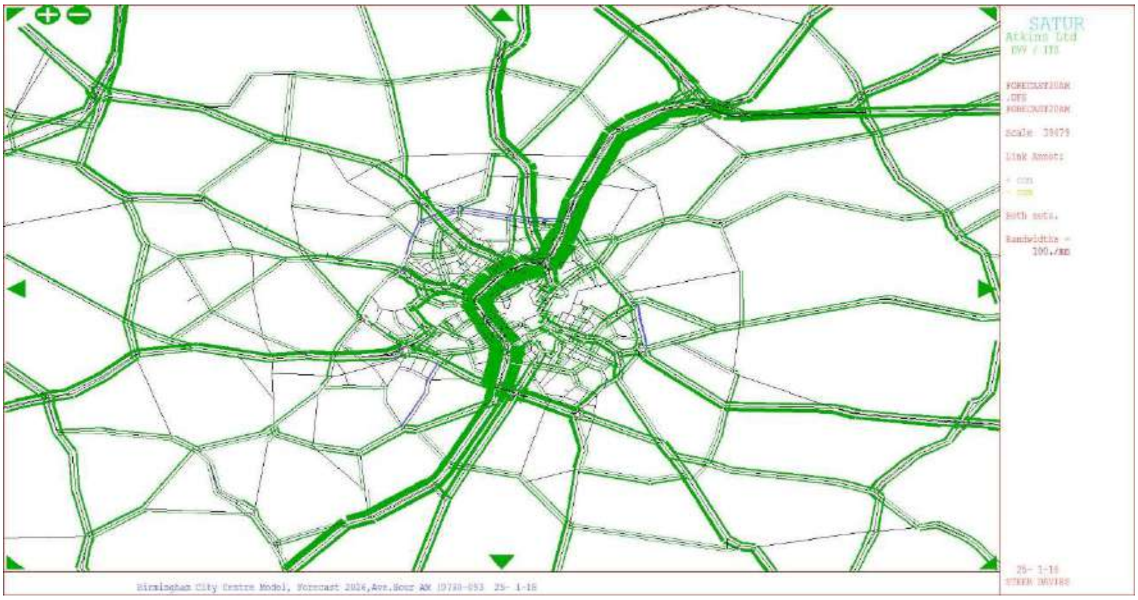


Figure C.51: Non-compliant Flow Change (CAZ D Low – Do Minimum) – AM

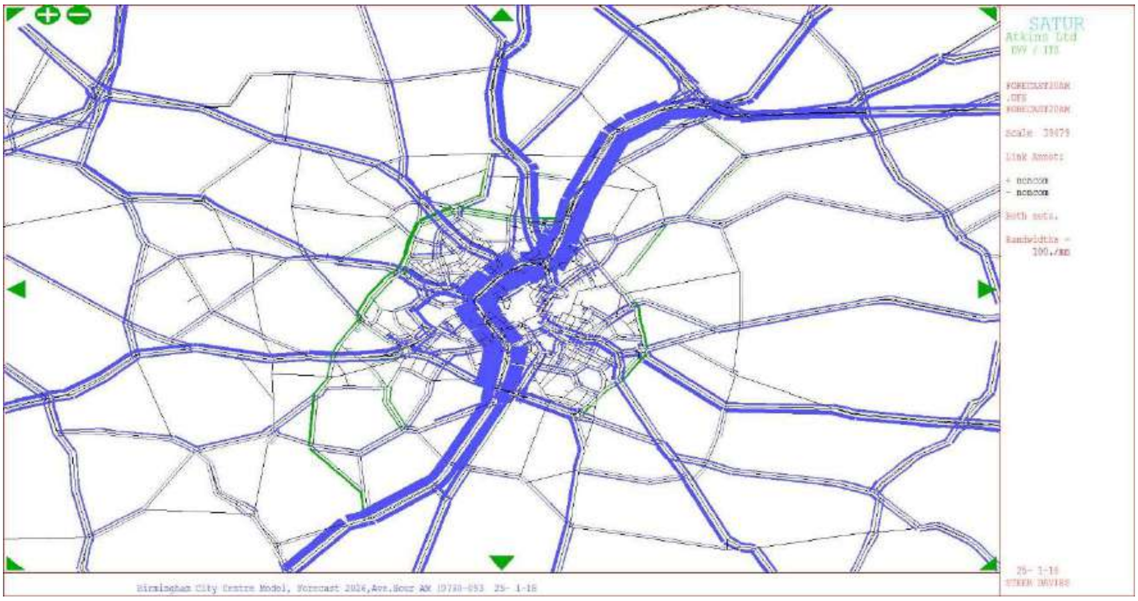


Figure C.52: Link Delay Change (CAZ D Low – Do Minimum) - AM

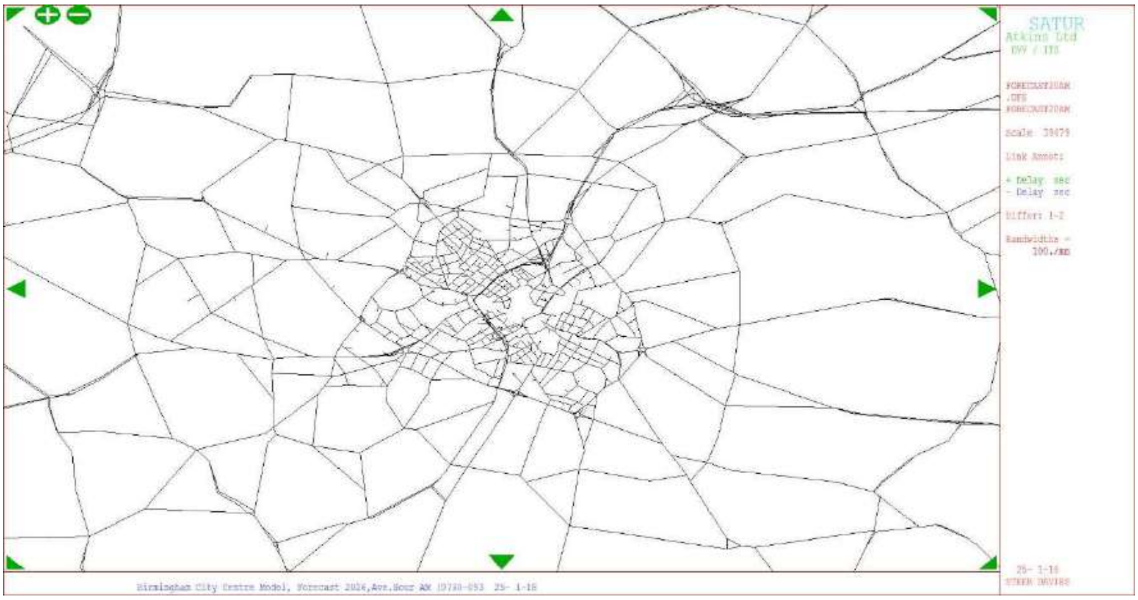


Figure C.53: Total Flow Change (CAZ D Low – Do Minimum) – IP

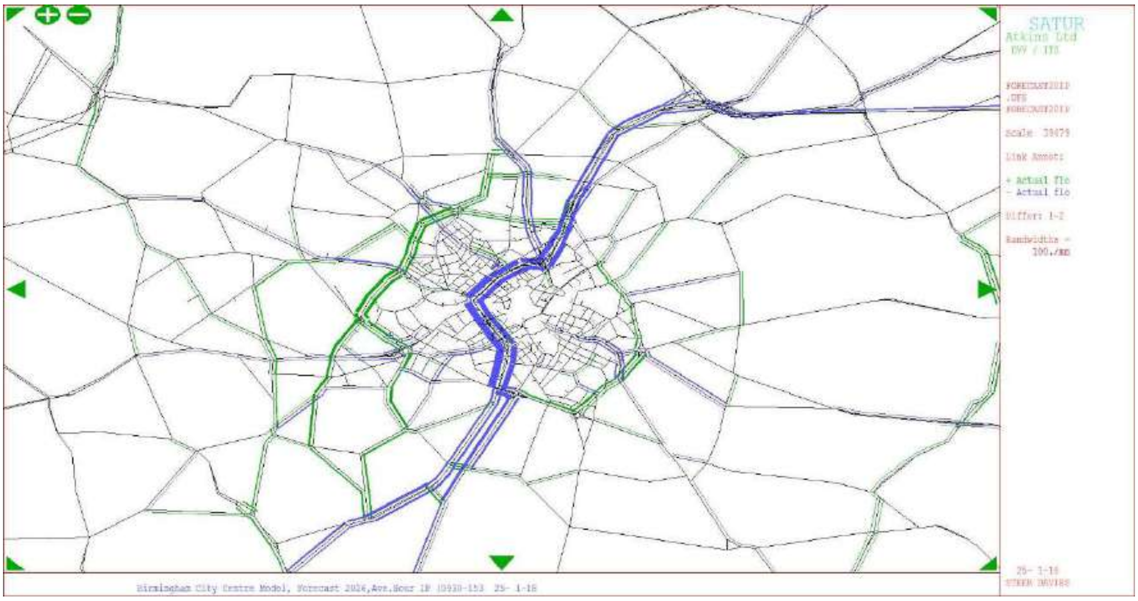


Figure C.54: Compliant Flow Change (CAZ D Low – Do Minimum) – IP

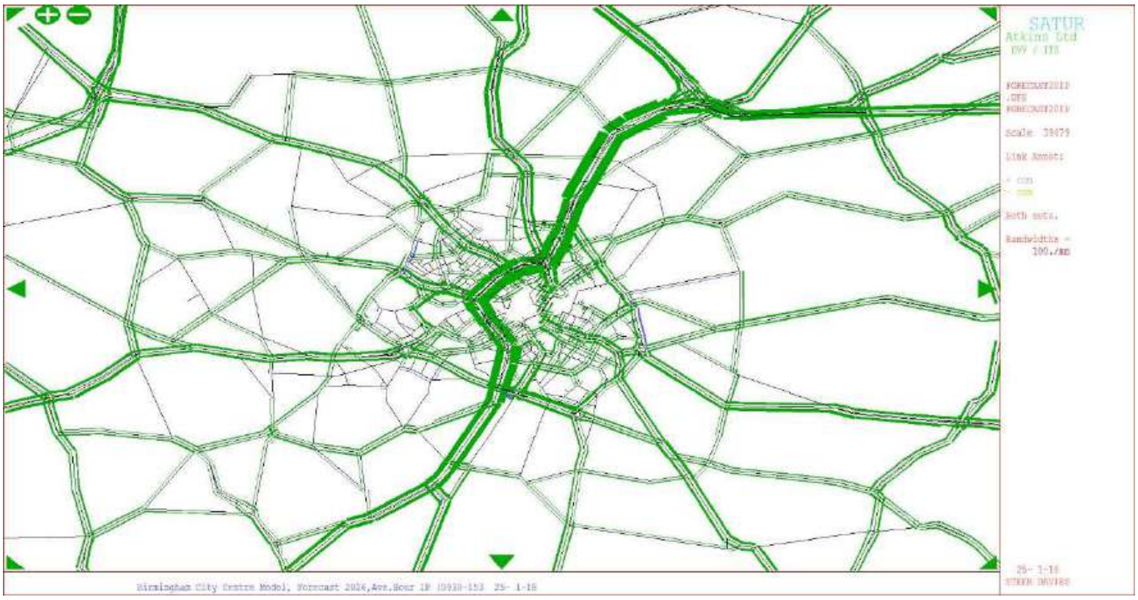


Figure C.55: Non-compliant Flow Change (CAZ D Low – Do Minimum) – IP

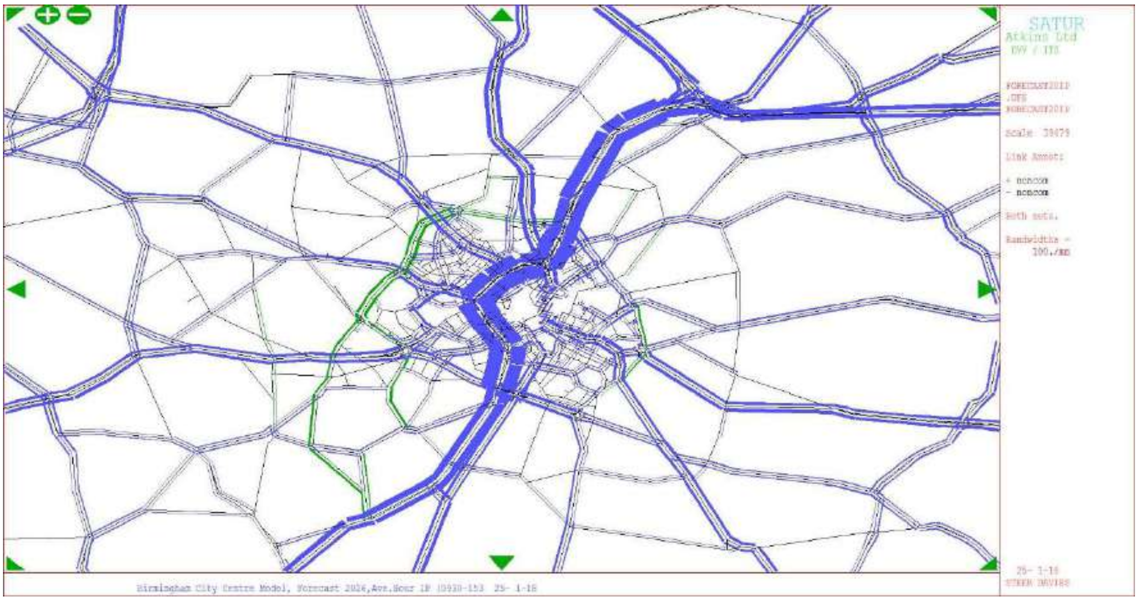


Figure C.56: Link Delay Change (CAZ D Low – Do Minimum) – IP

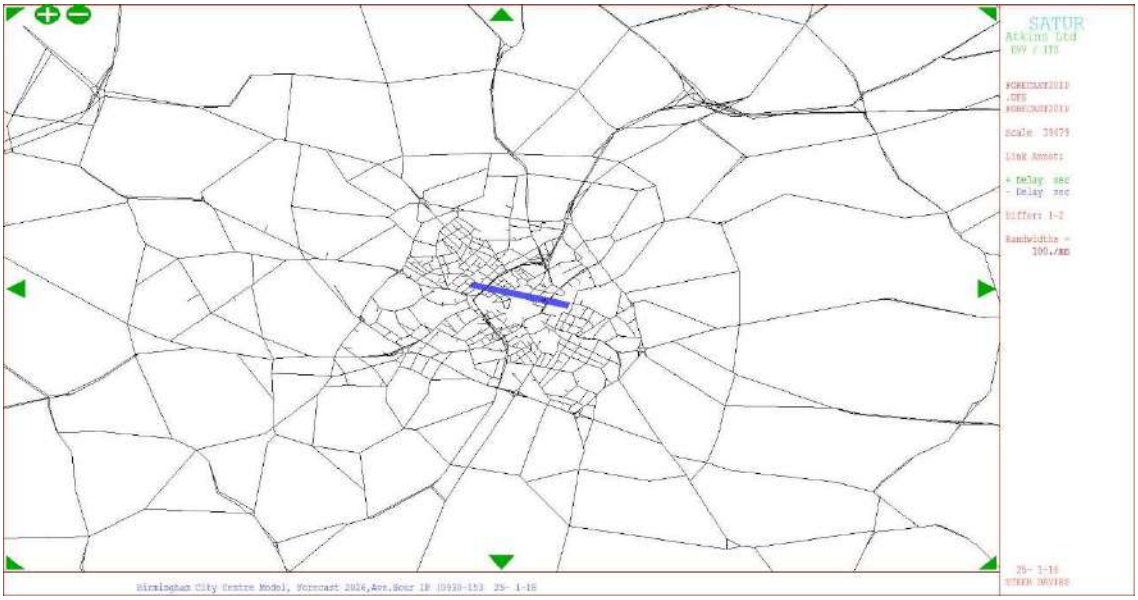


Figure C.57: Total Flow Change (CAZ D Low – Do Minimum) – PM

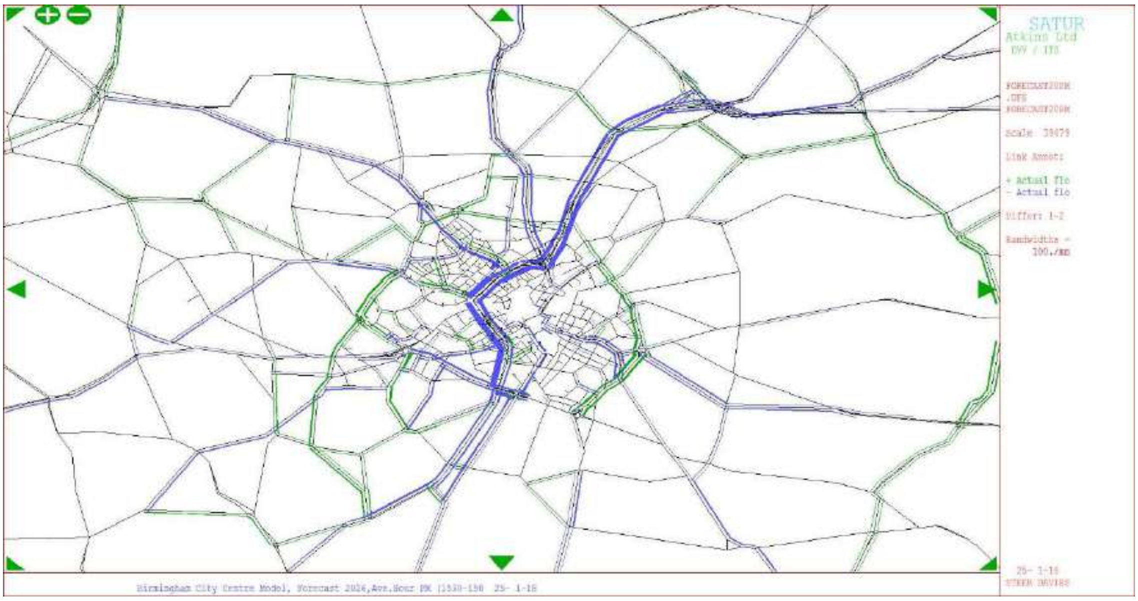


Figure C.58: Compliant Flow Change (CAZ D Low – Do Minimum) – PM

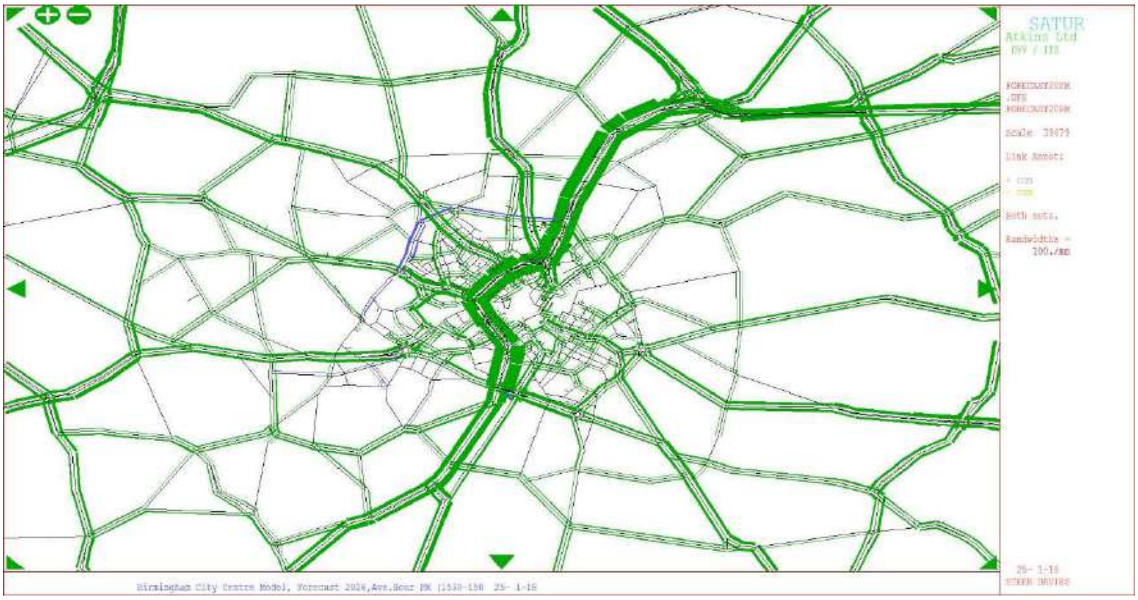


Figure C.59: Non-compliant Flow Change (CAZ D Low – Do Minimum) – PM

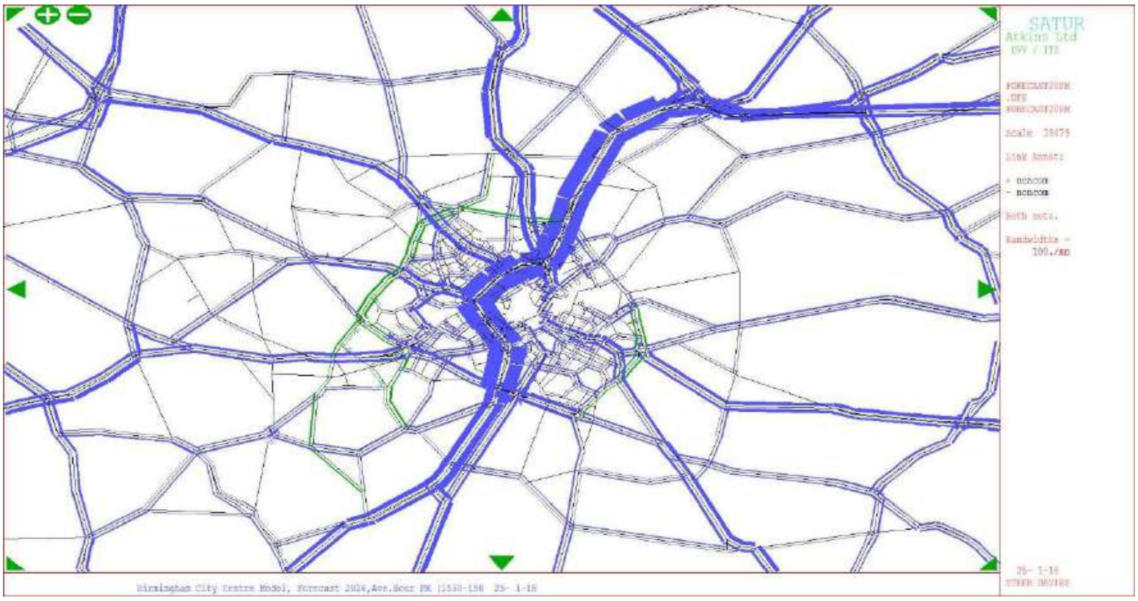


Figure C.60: Link Delay Change (CAZ D Low – Do Minimum) – PM

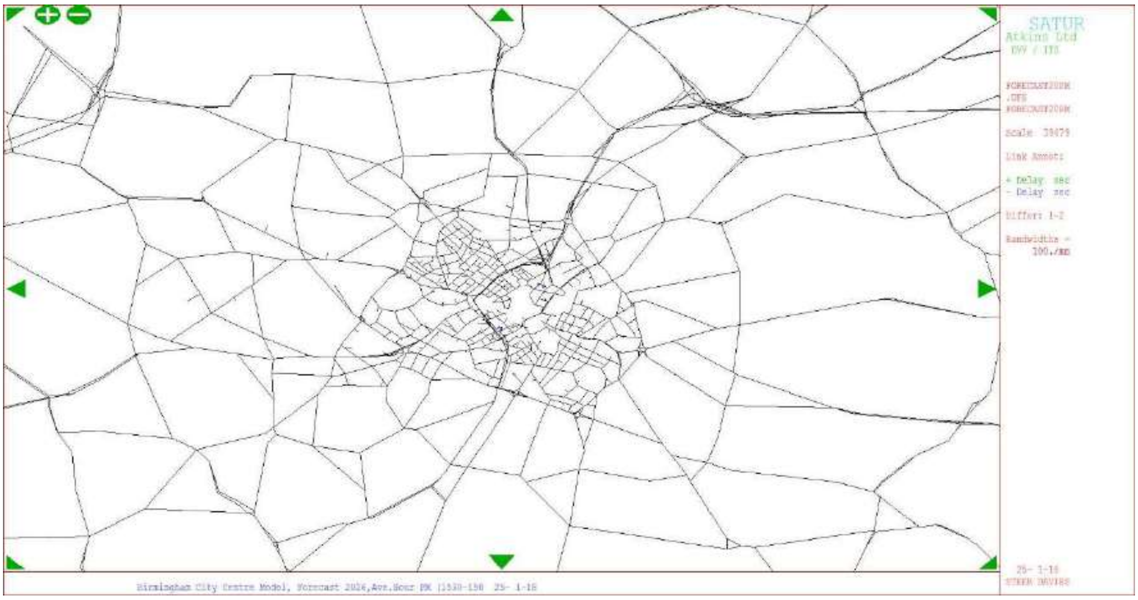


Figure C.61: Total Flow Change (CAZ D Medium – Do Minimum) – AM

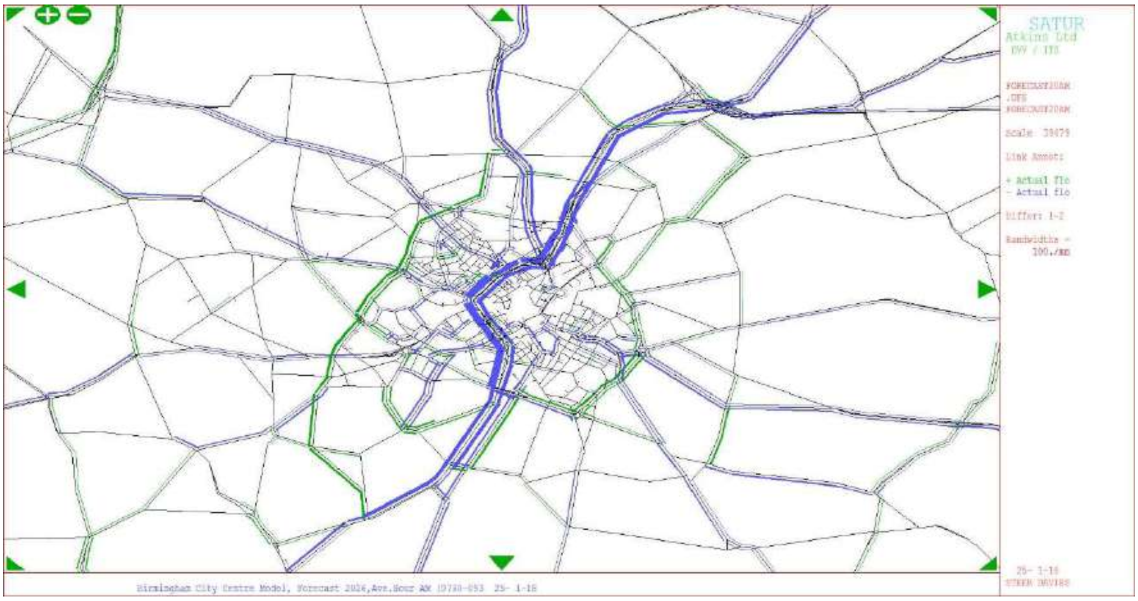


Figure C.62: Compliant Flow Change (CAZ D Medium – Do Minimum) – AM

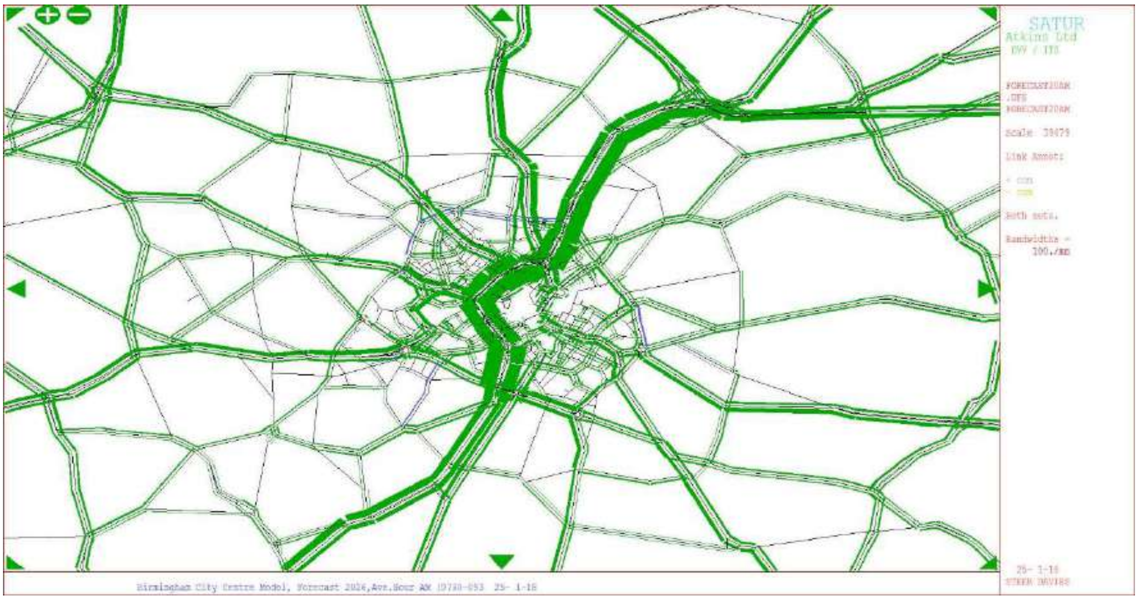


Figure C.63: Non-compliant Flow Change (CAZ D Medium – Do Minimum) – AM

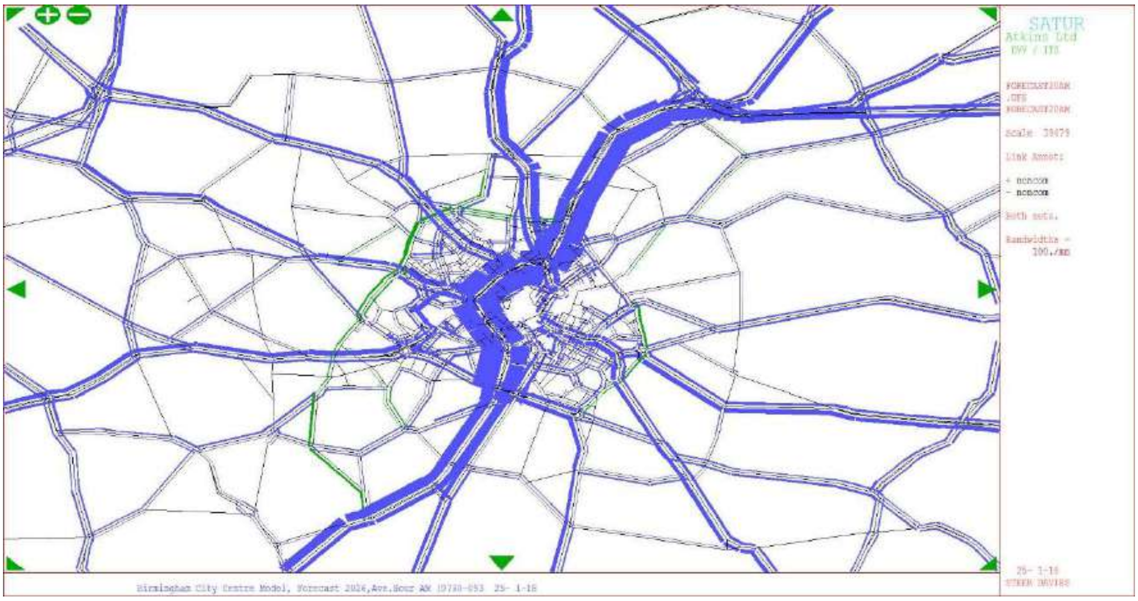


Figure C.64: Link Delay Change (CAZ D Medium – Do Minimum) – AM

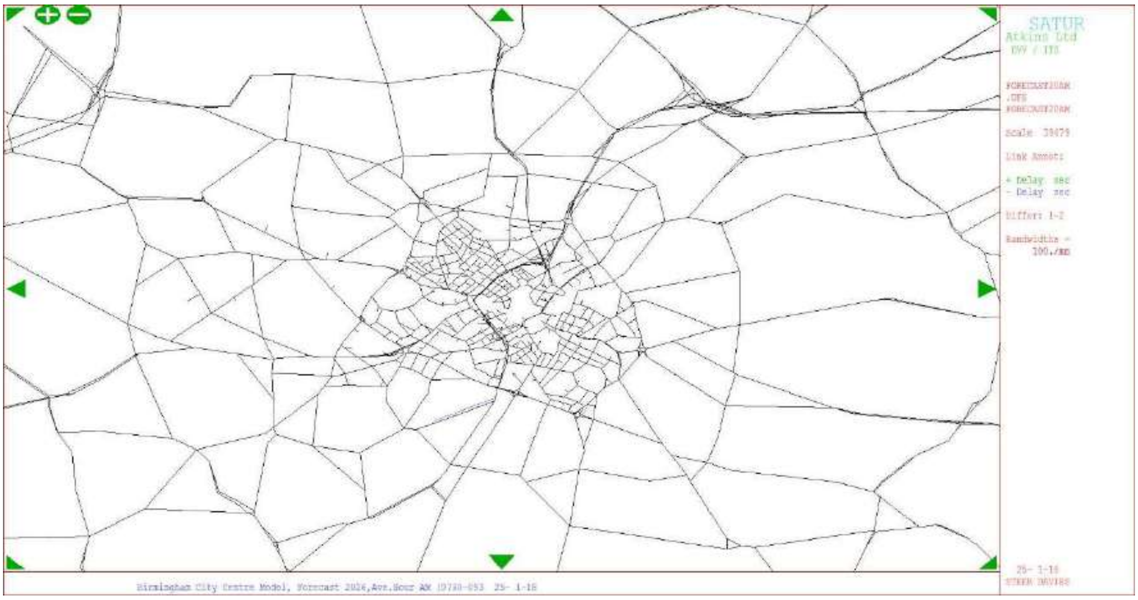


Figure C.65: Total Flow Change (CAZ D Medium – Do Minimum) – IP

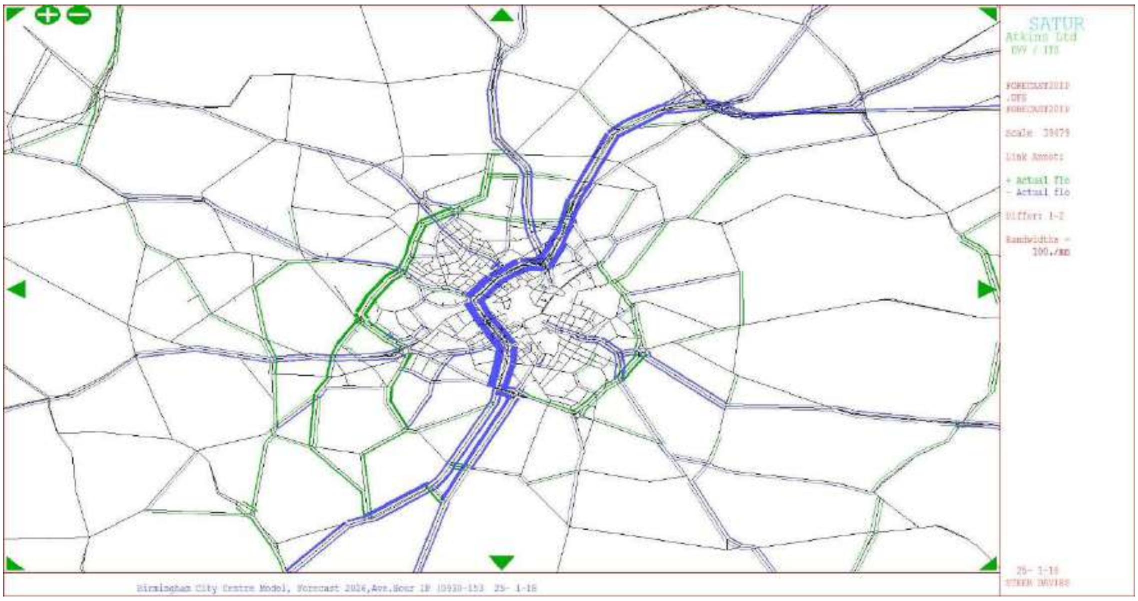


Figure C.66: Compliant Flow Change (CAZ D Medium – Do Minimum) – IP

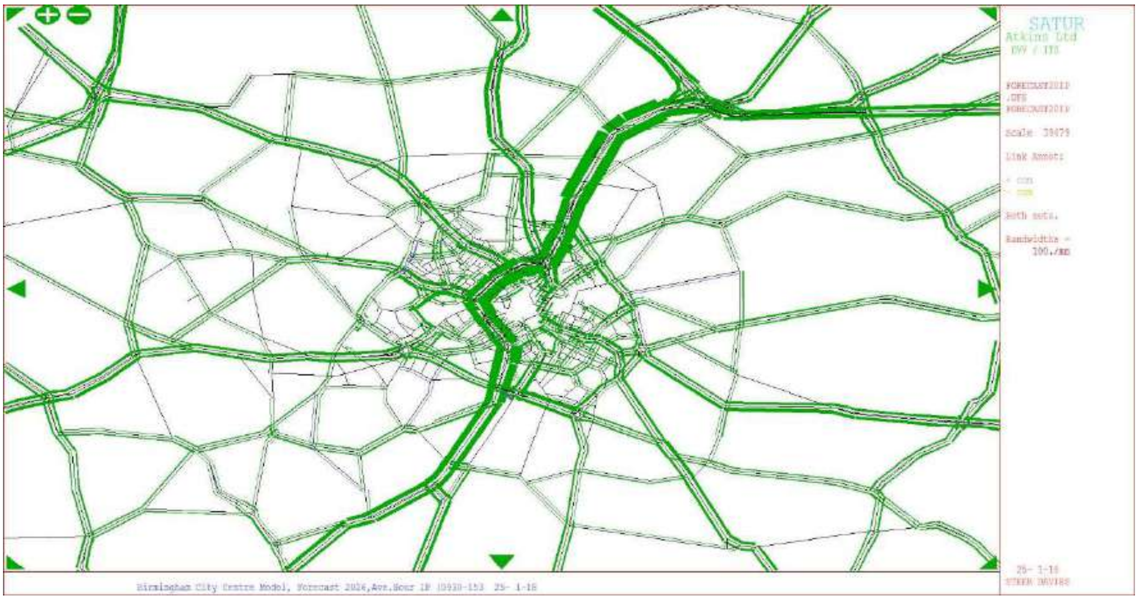


Figure C.67: Non-compliant Flow Change (CAZ D Medium – Do Minimum) – IP

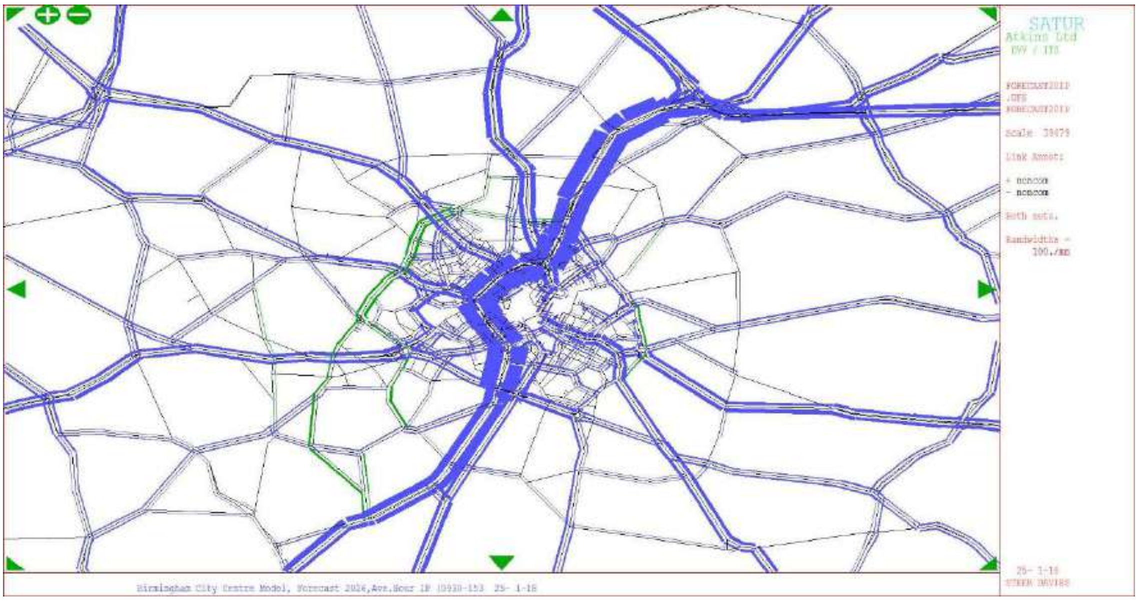


Figure C.68: Link Delay Change (CAZ D Medium – Do Minimum) – IP

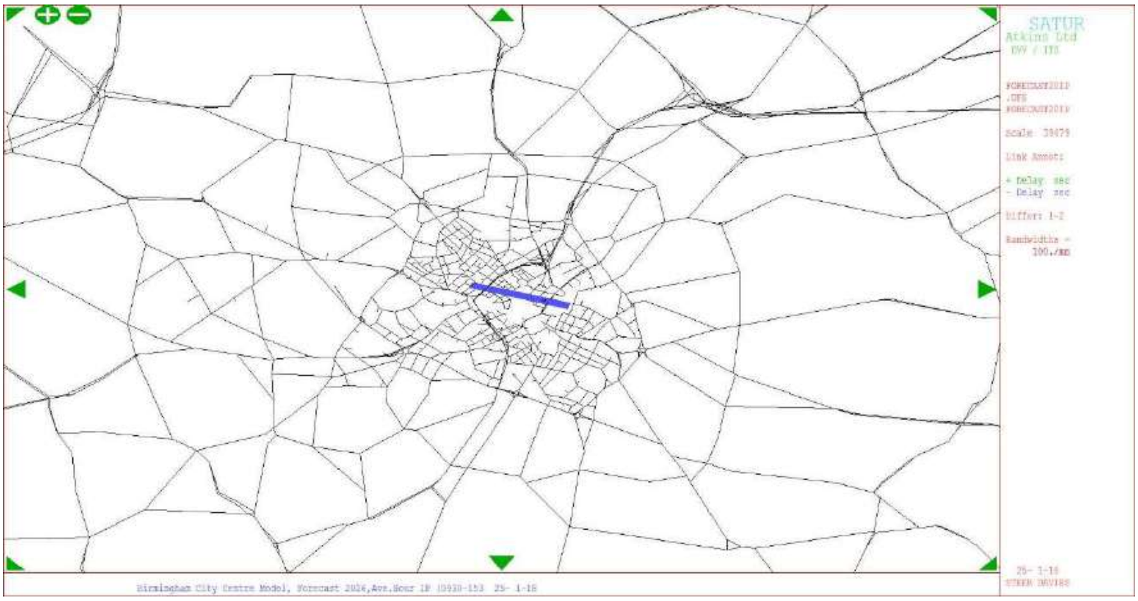


Figure C.69: Total Flow Change (CAZ D Medium – Do Minimum) – PM

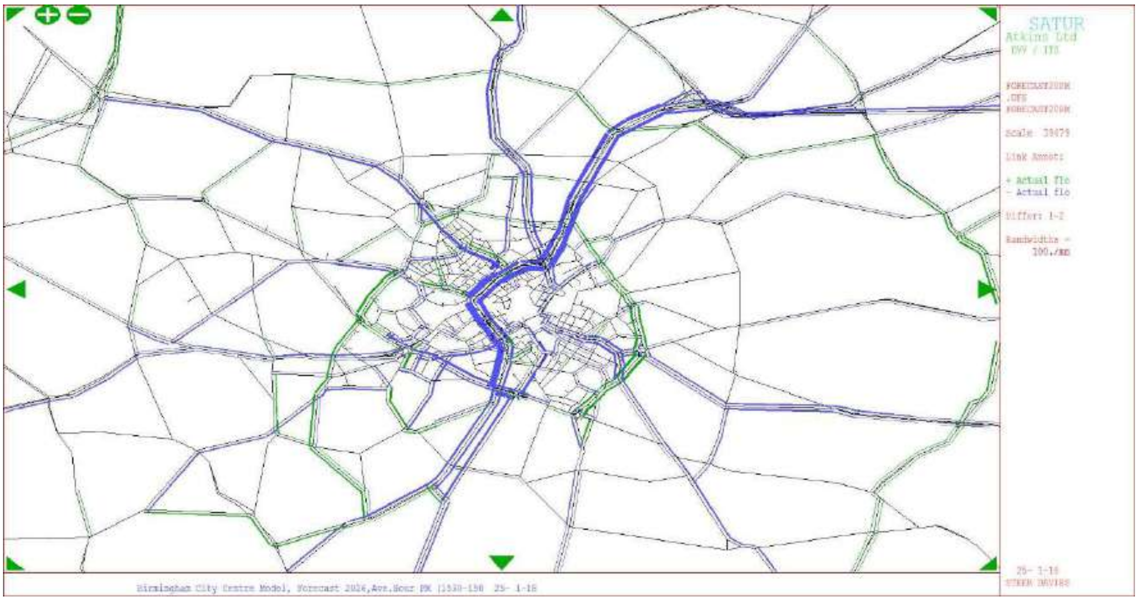


Figure C.70: Compliant Flow Change (CAZ D Medium – Do Minimum) – PM

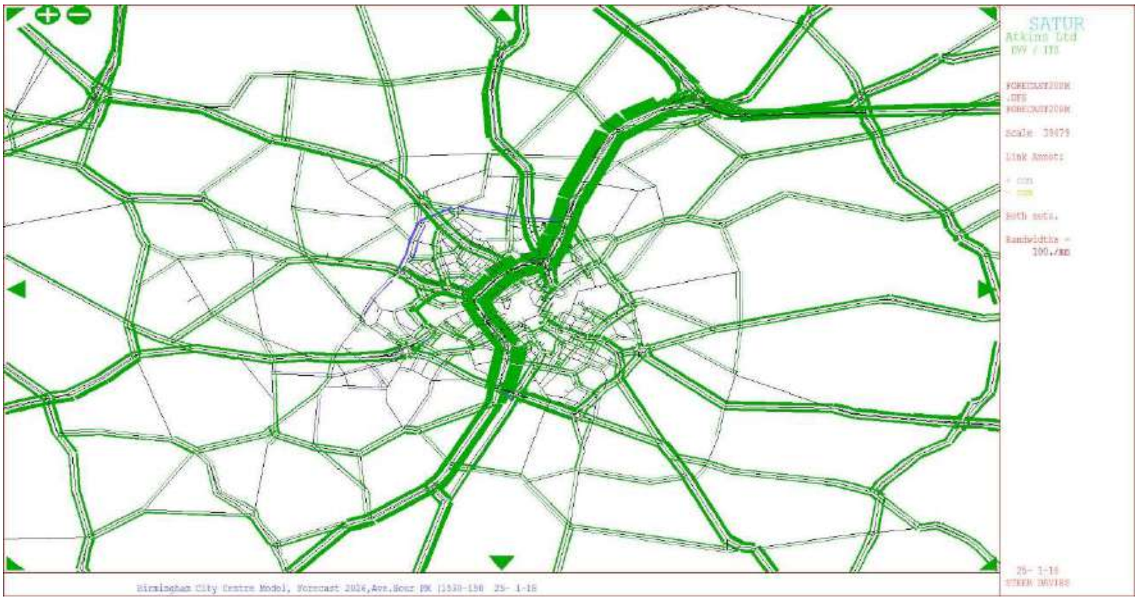


Figure C.71: Non-compliant Flow Change (CAZ D Medium – Do Minimum) – PM

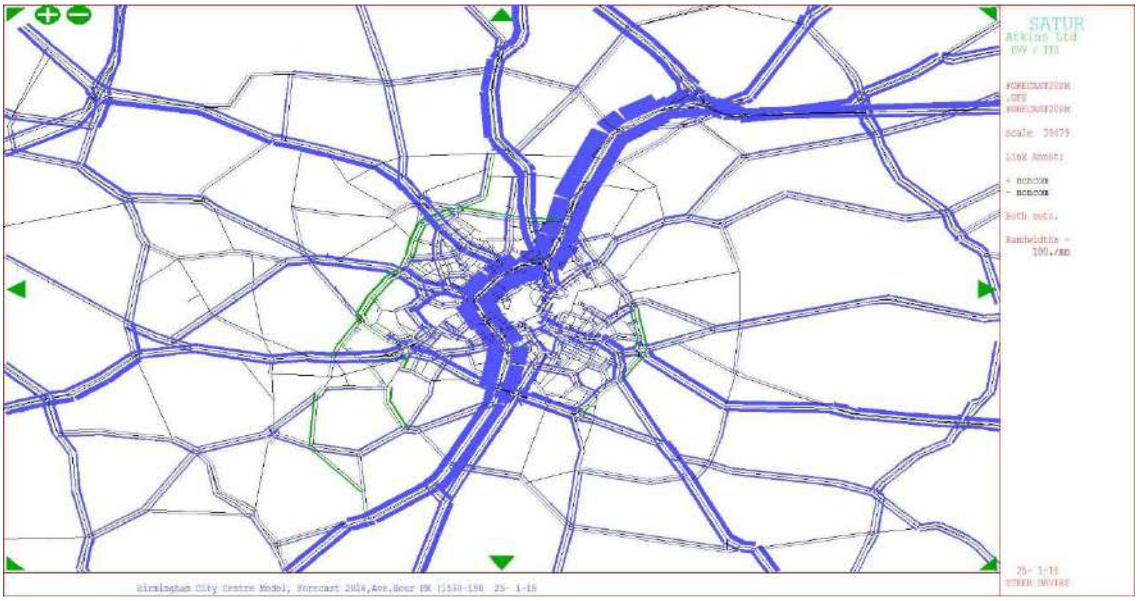


Figure C.72: Link Delay Change (CAZ D Medium – Do Minimum) – PM

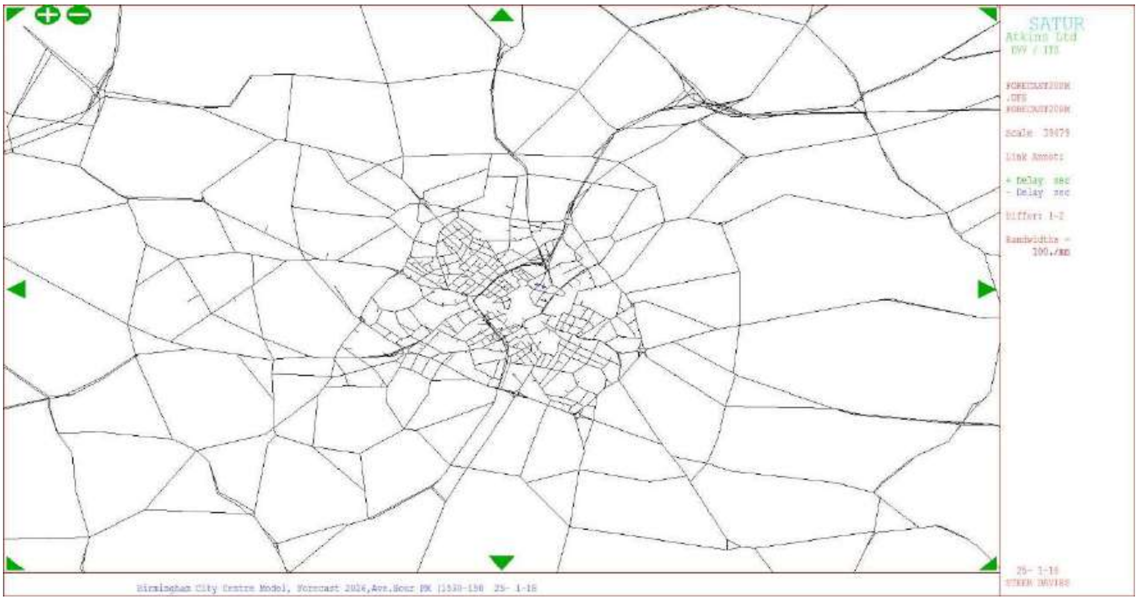


Figure C.73: Total Flow Change (CAZ D High – Do Minimum) – AM

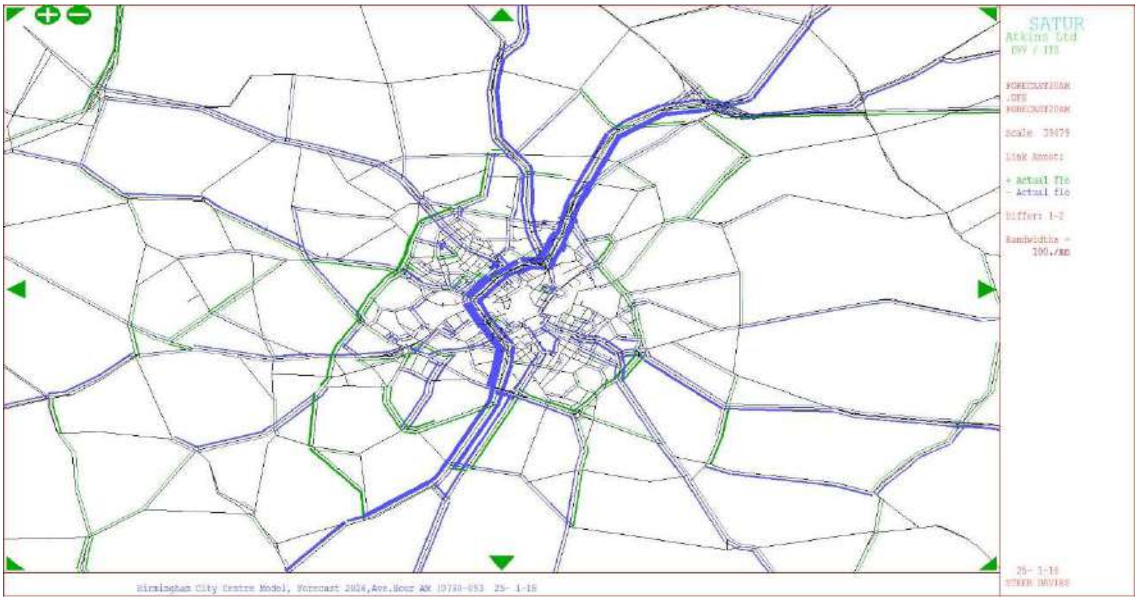


Figure C.74: Compliant Flow Change (CAZ D High – Do Minimum) – AM

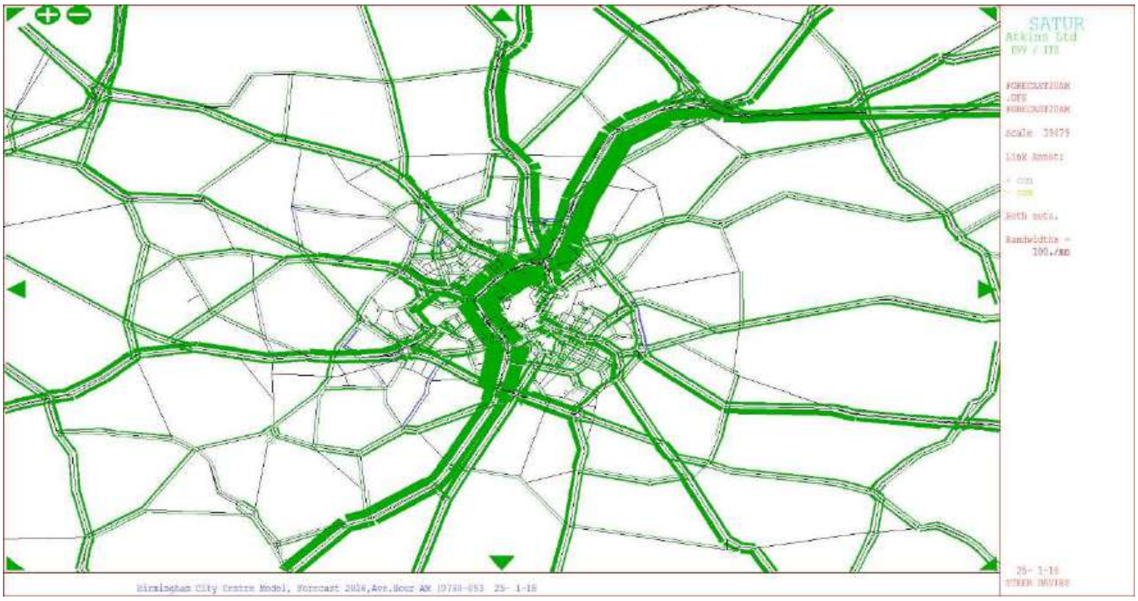


Figure C.75: Non-compliant Flow Change (CAZ D High – Do Minimum) – AM

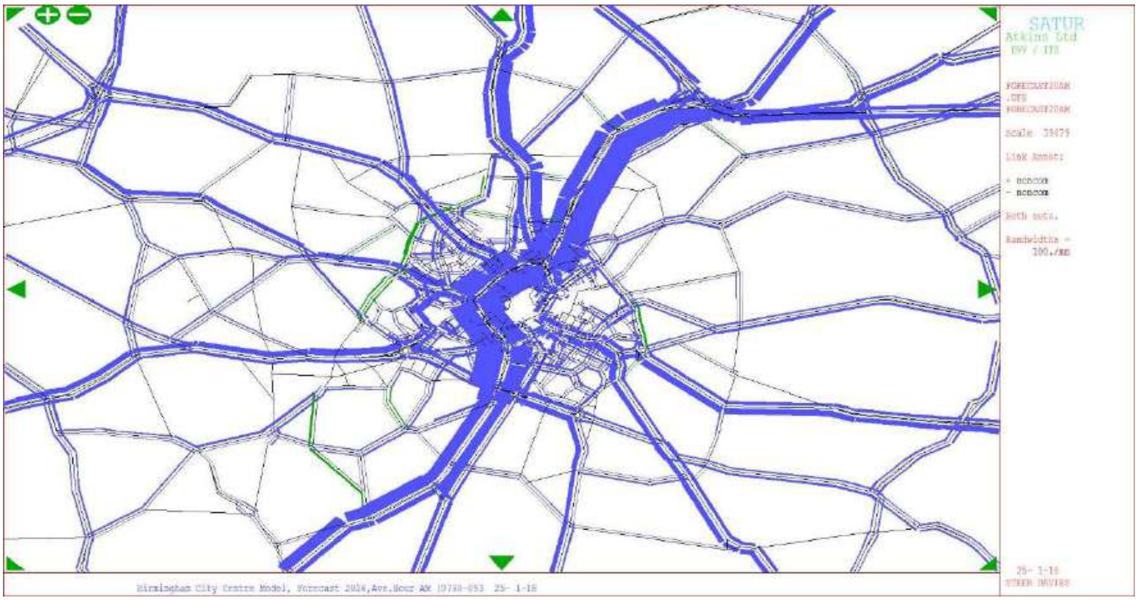


Figure C.76: Link Delay Change (CAZ D High – Do Minimum) – AM

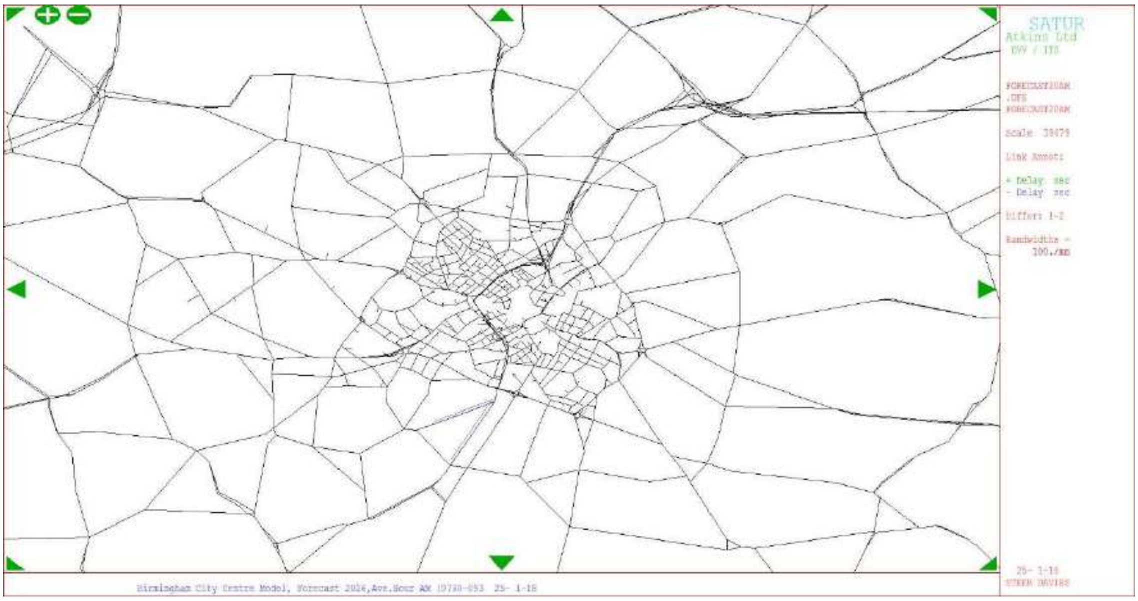


Figure C.77: Total Flow Change (CAZ D High – Do Minimum) – IP

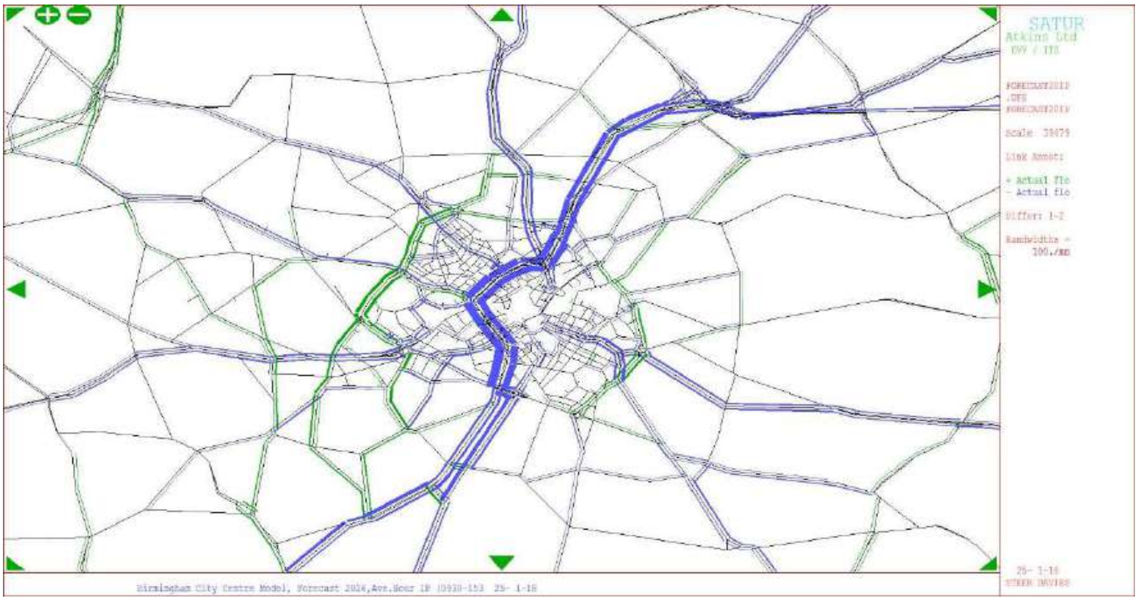


Figure C.78: Compliant Flow Change (CAZ D High – Do Minimum) – IP

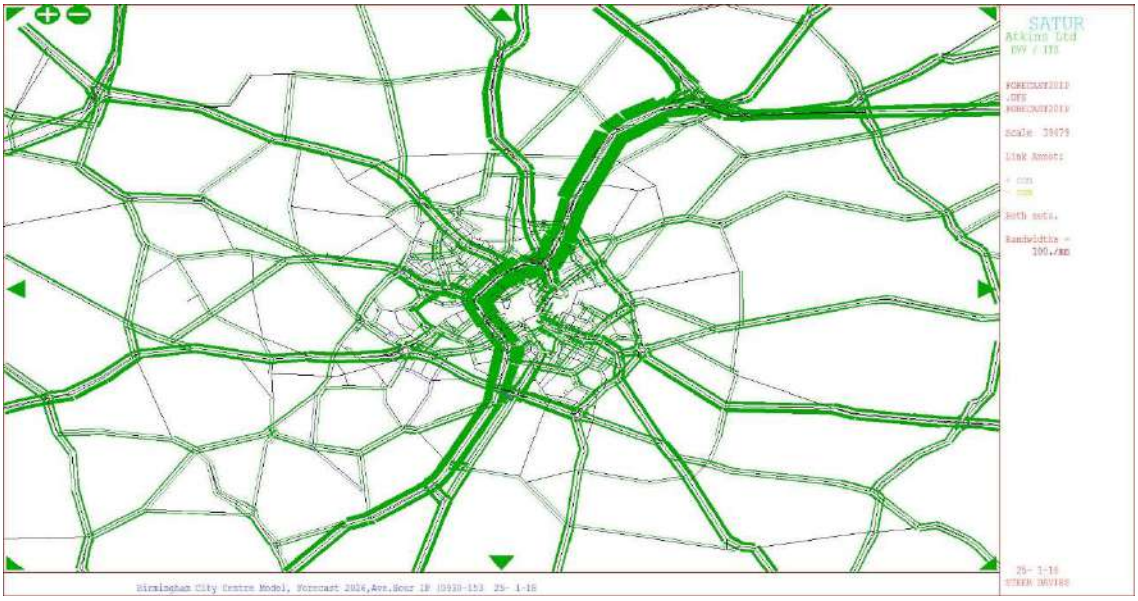


Figure C.79: Non-compliant Flow Change (CAZ D High – Do Minimum) – IP

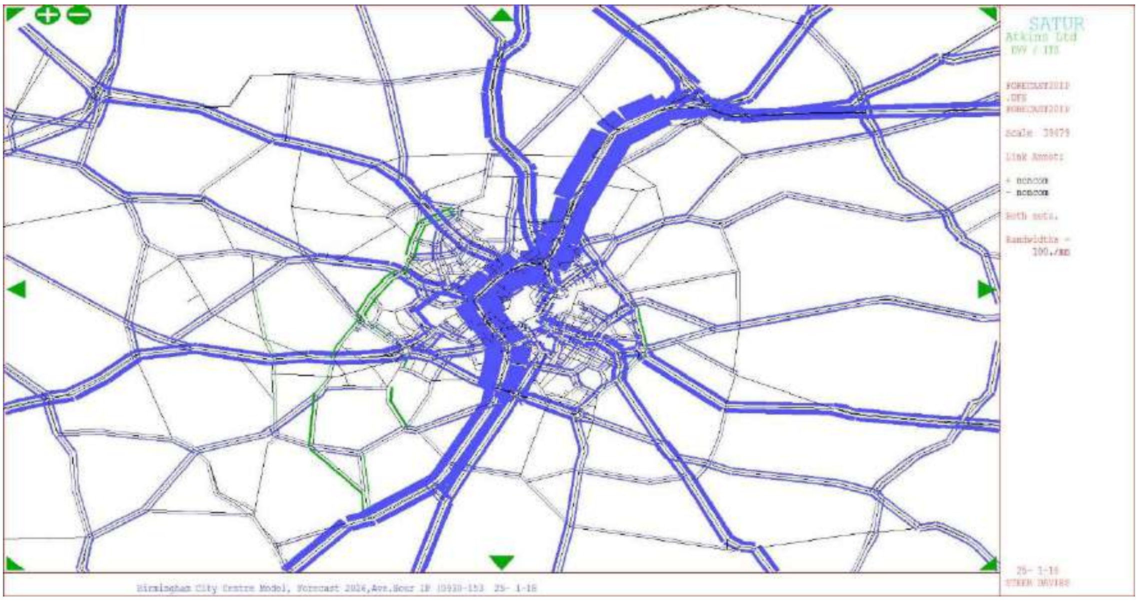


Figure C.80: Link Delay Change (CAZ D High – Do Minimum) – IP

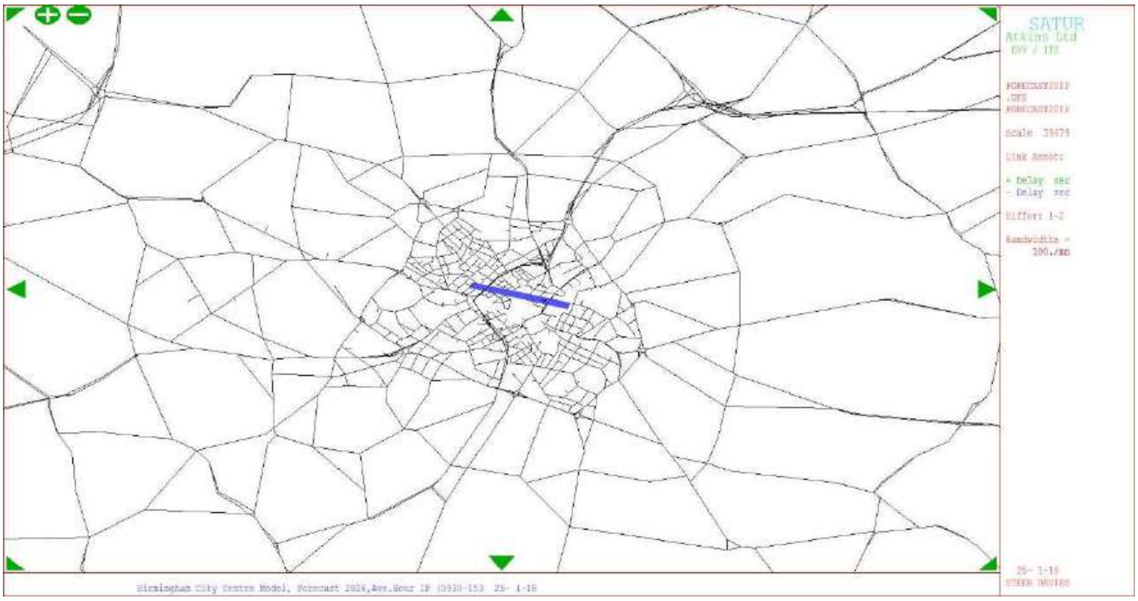


Figure C.81: Total Flow Change (CAZ D High – Do Minimum) – PM

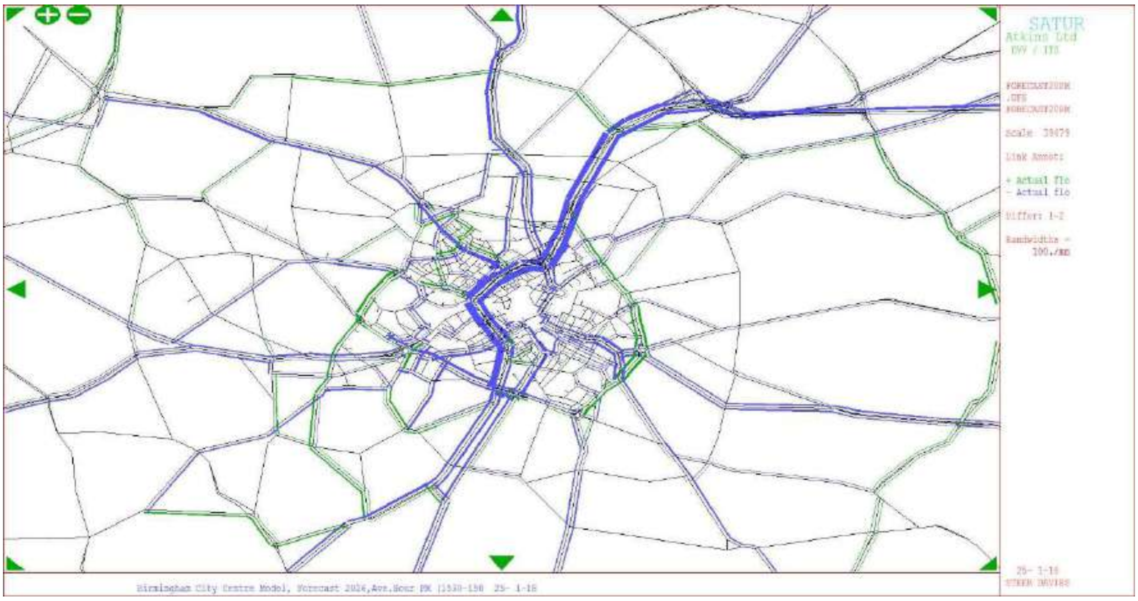


Figure C.82: Compliant Flow Change (CAZ D High – Do Minimum) – PM

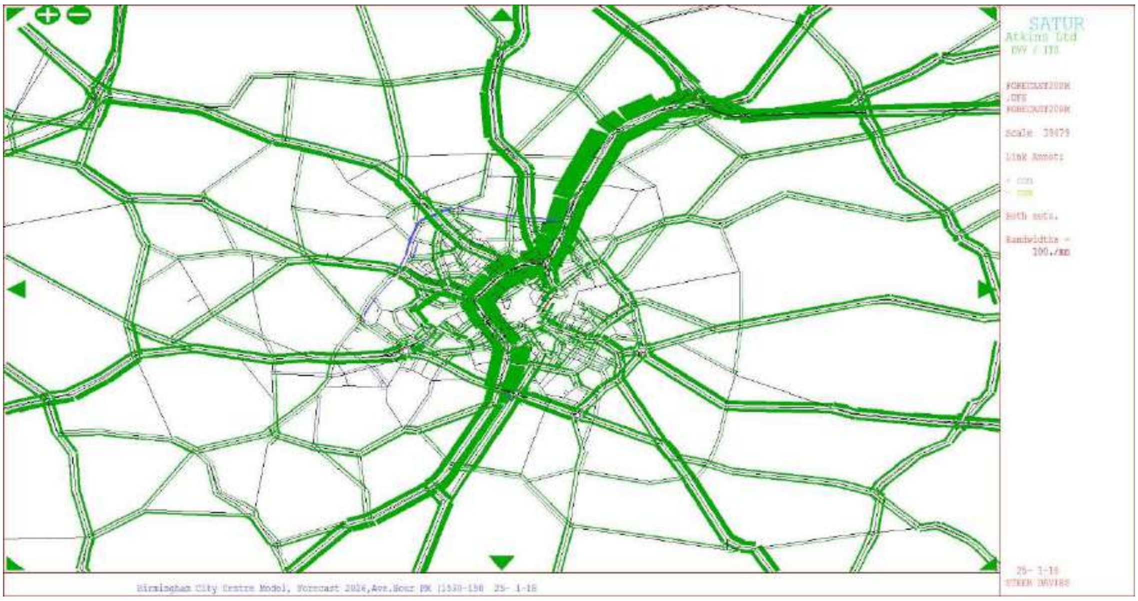


Figure C.83: Non-compliant Flow Change (CAZ D High – Do Minimum) – PM

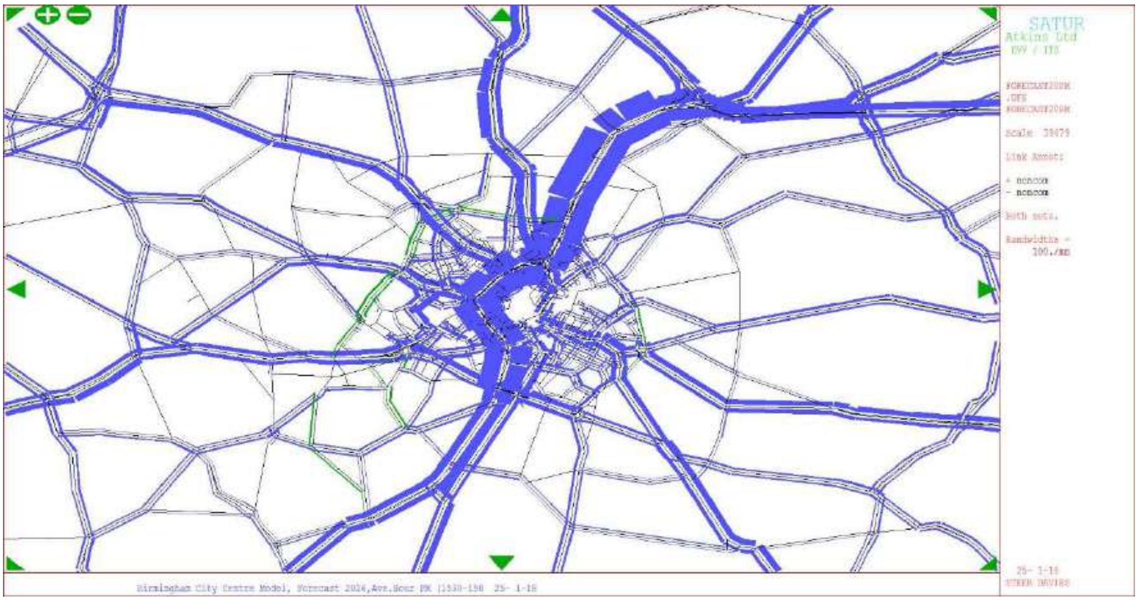
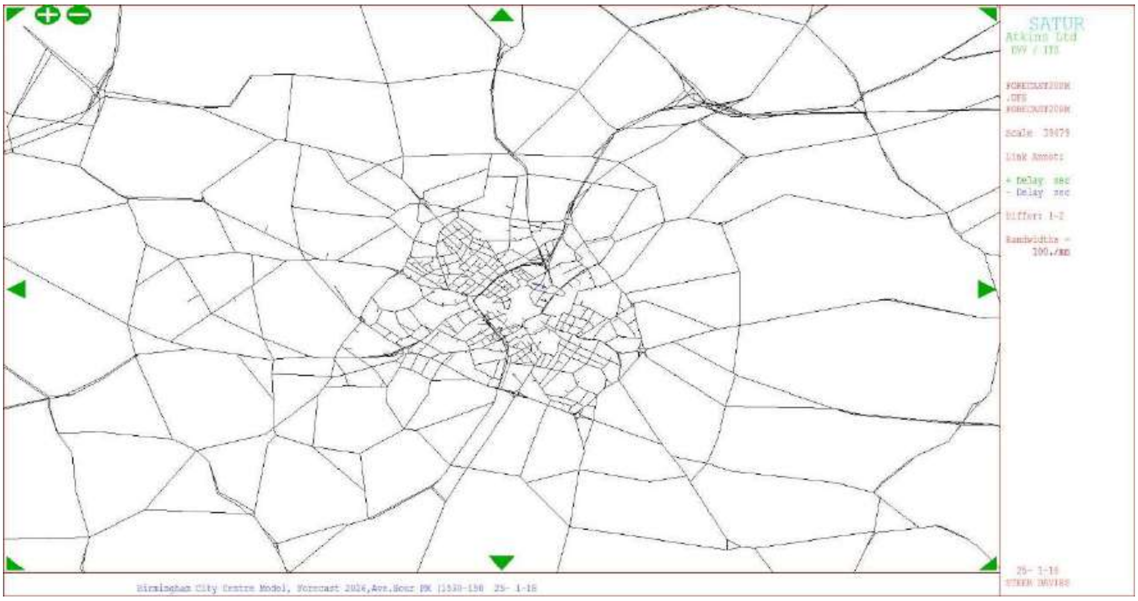


Figure C.84: Link Delay Change (CAZ D High – Do Minimum) – PM



All CAZs – DM

Figure 5-1: Total Flow Change (CAZ C Low – Do Minimum) - AM

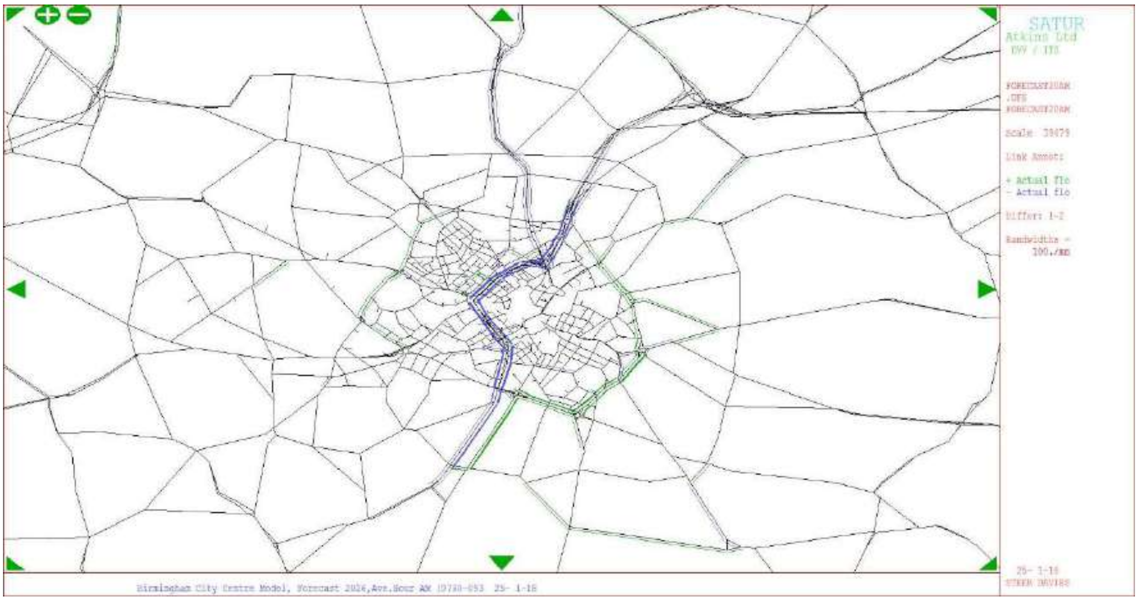


Figure 5-2: Compliant Flow Change (CAZ C Low – Do Minimum) – AM

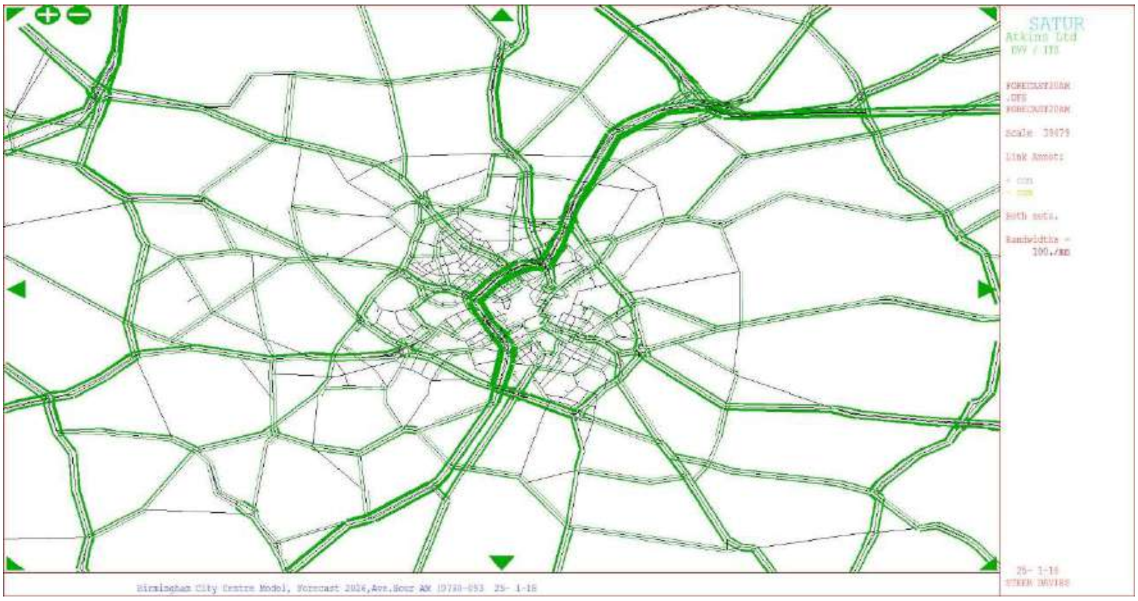


Figure 5-3: Non-compliant Flow Change (CAZ C Low – Do Minimum) – AM

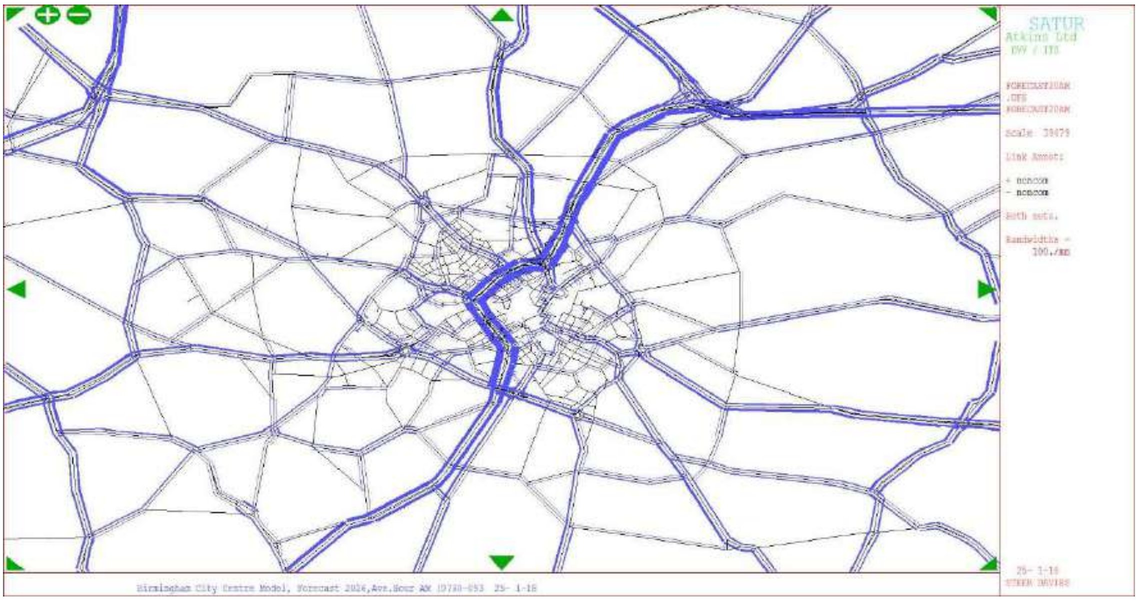


Figure 5-4: Link Delay Change (CAZ C Low – Do Minimum) - AM

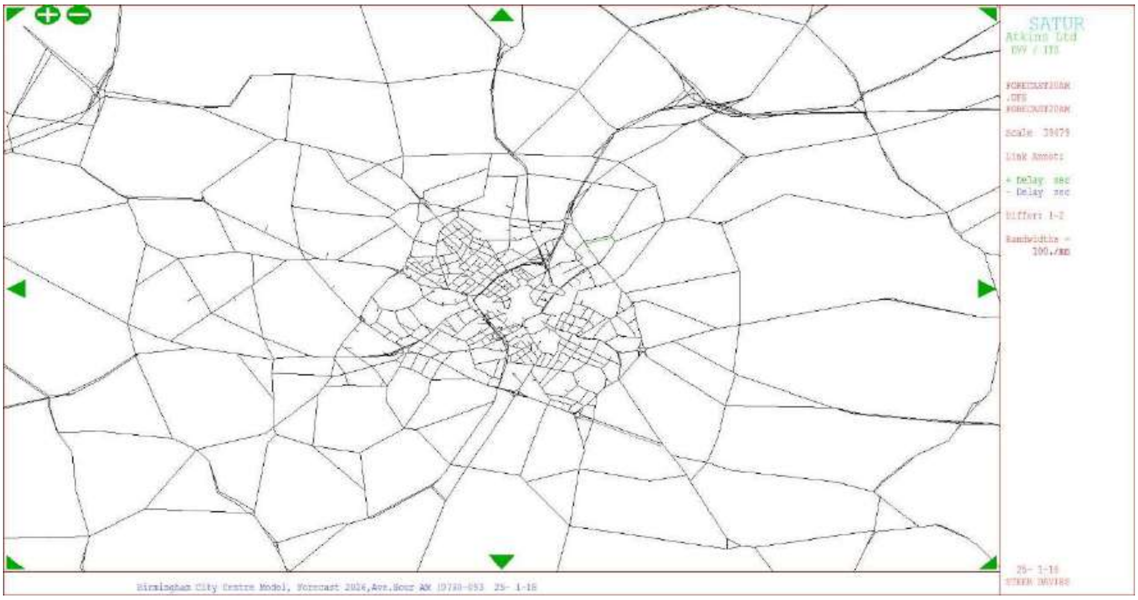


Figure 5-5: Total Flow Change (CAZ C Low – Do Minimum) – IP

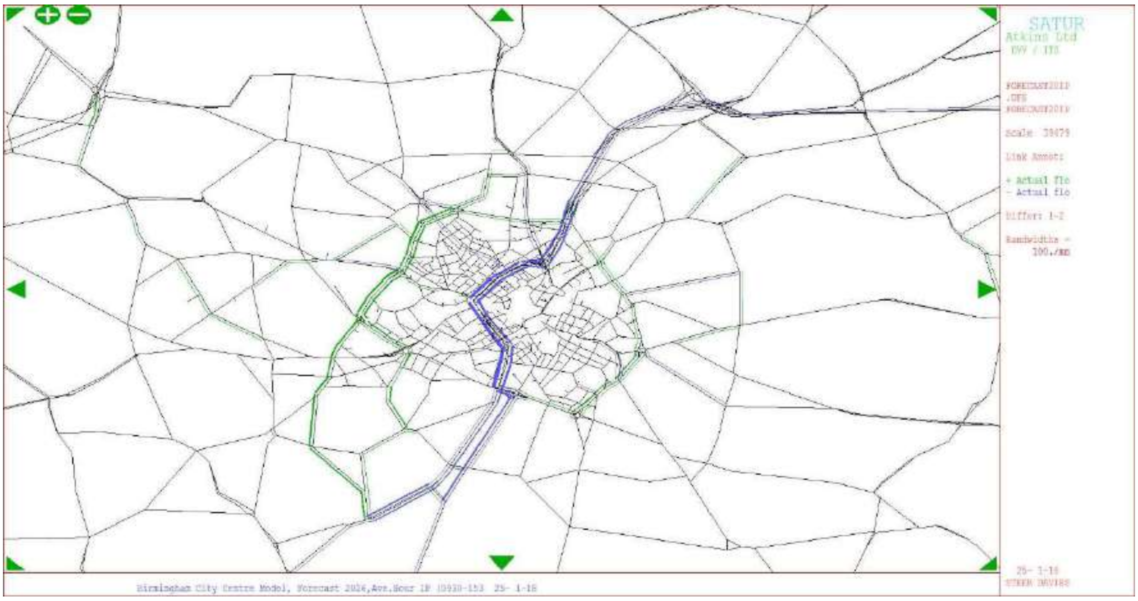


Figure 5-6: Compliant Flow Change (CAZ C Low – Do Minimum) – IP

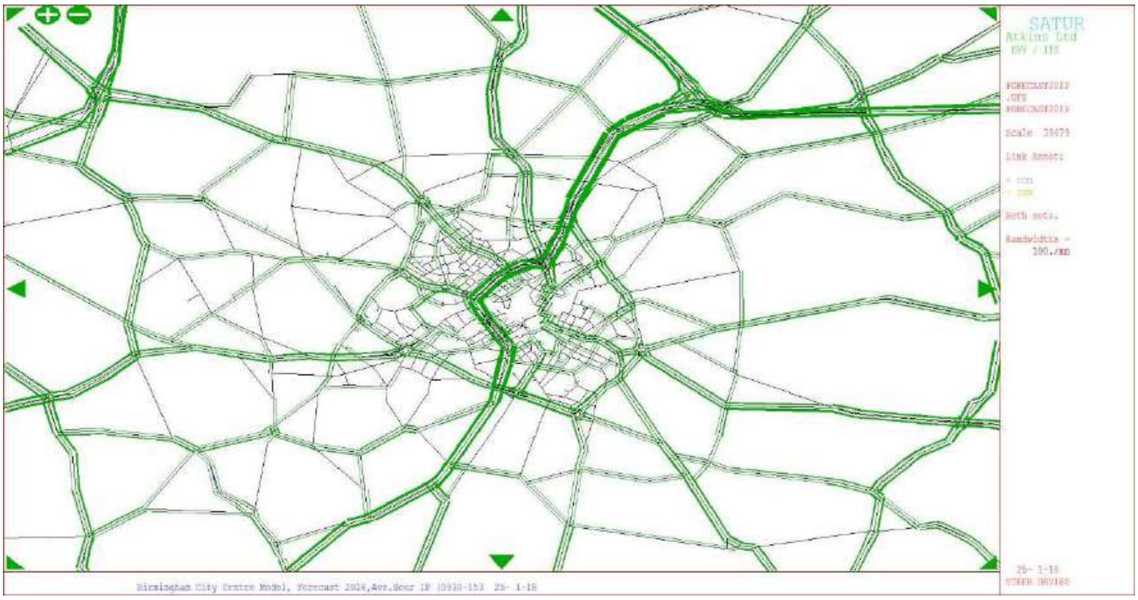


Figure 5-7: Non-compliant Flow Change (CAZ C Low – Do Minimum) – IP

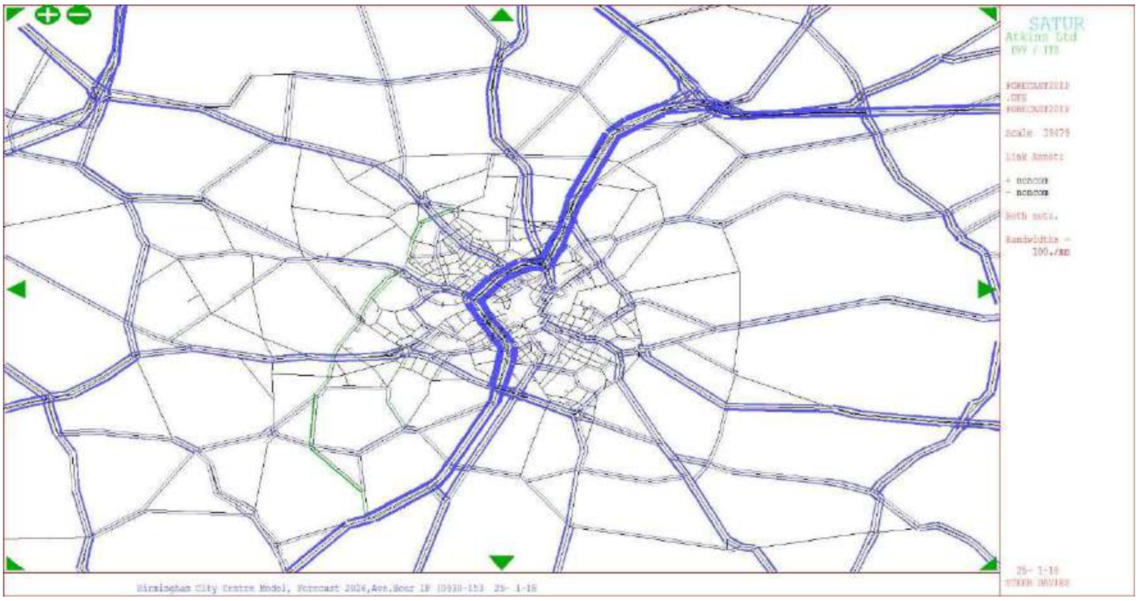


Figure 5-8: Link Delay Change (CAZ C Low – Do Minimum) – IP

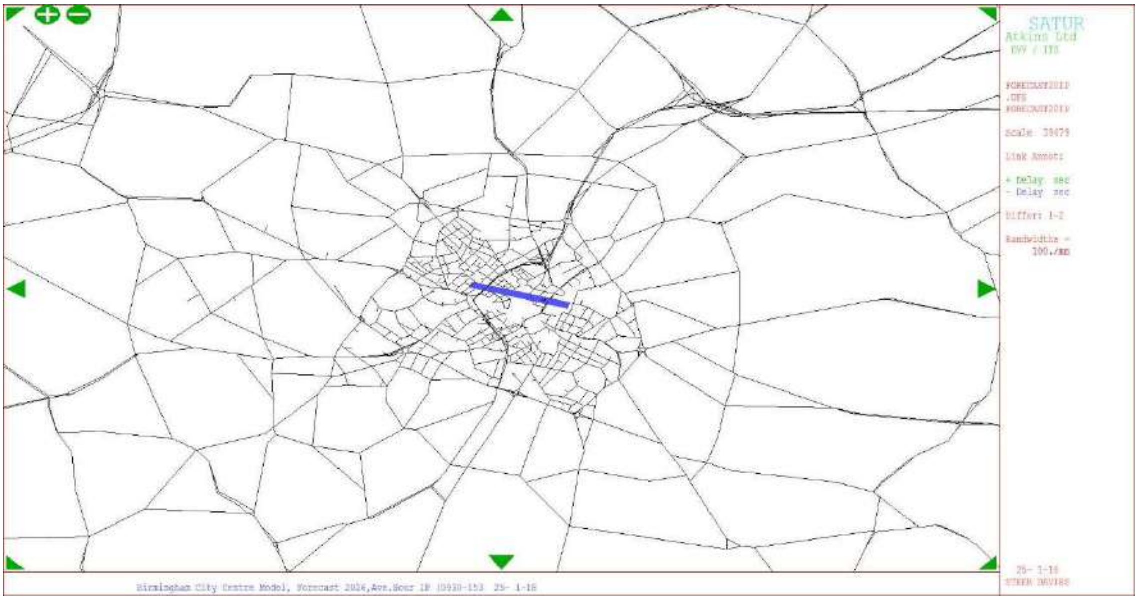


Figure 5-9: Total Flow Change (CAZ C Low – Do Minimum) – PM

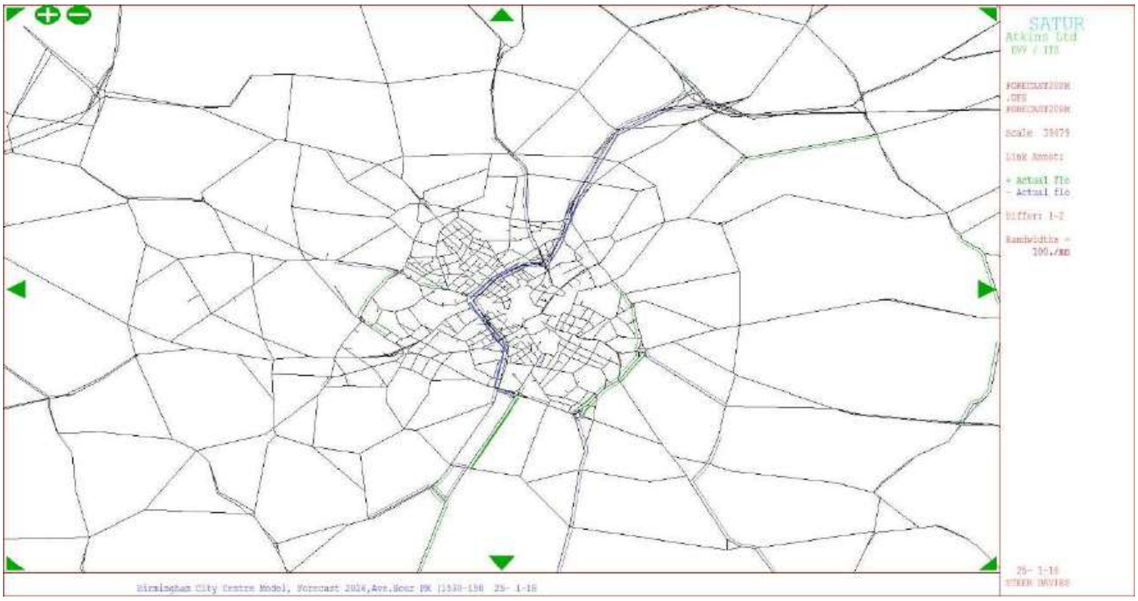


Figure 5-10: Compliant Flow Change (CAZ C Low – Do Minimum) – PM

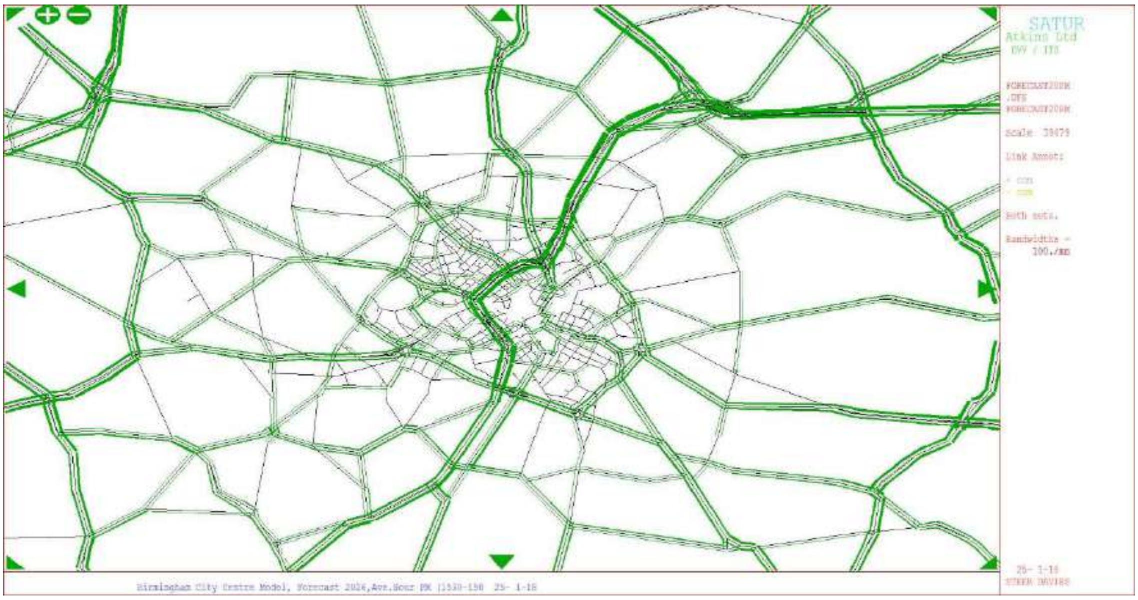


Figure 5-11: Non-compliant Flow Change (CAZ C Low – Do Minimum) – PM

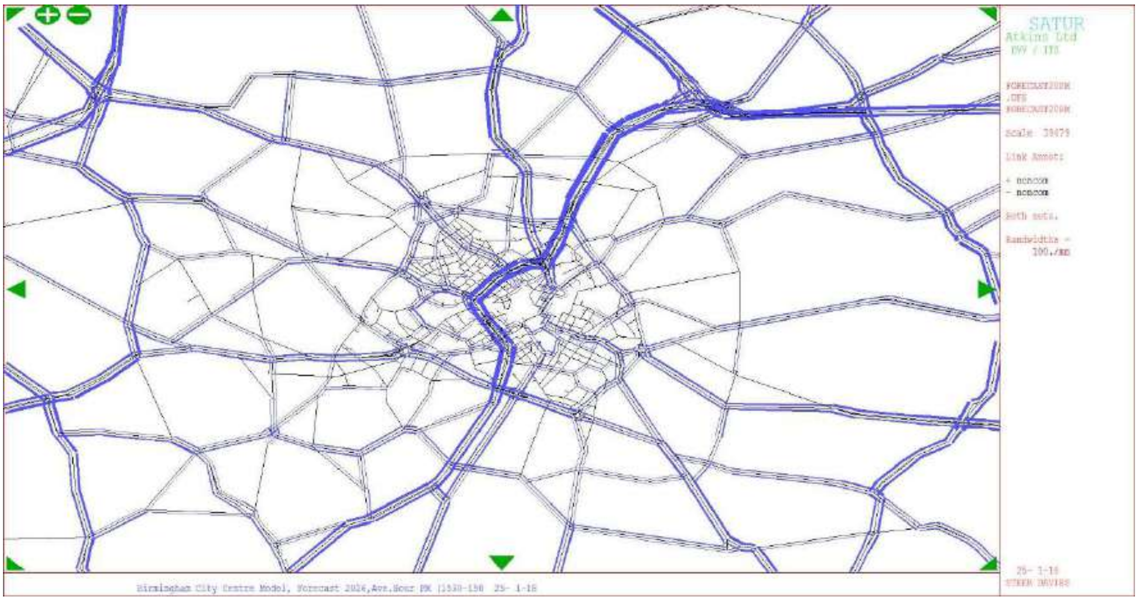


Figure 5-12: Link Delay Change (CAZ C Low – Do Minimum) – PM

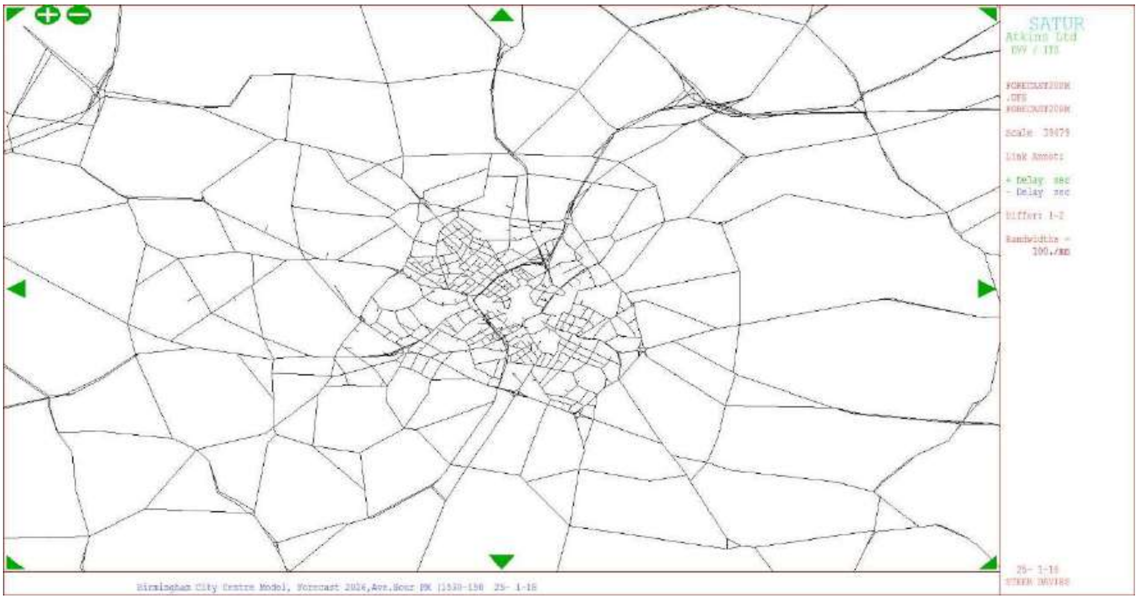


Figure 5-13: Total Flow Change (CAZ C Medium – Do Minimum) – AM

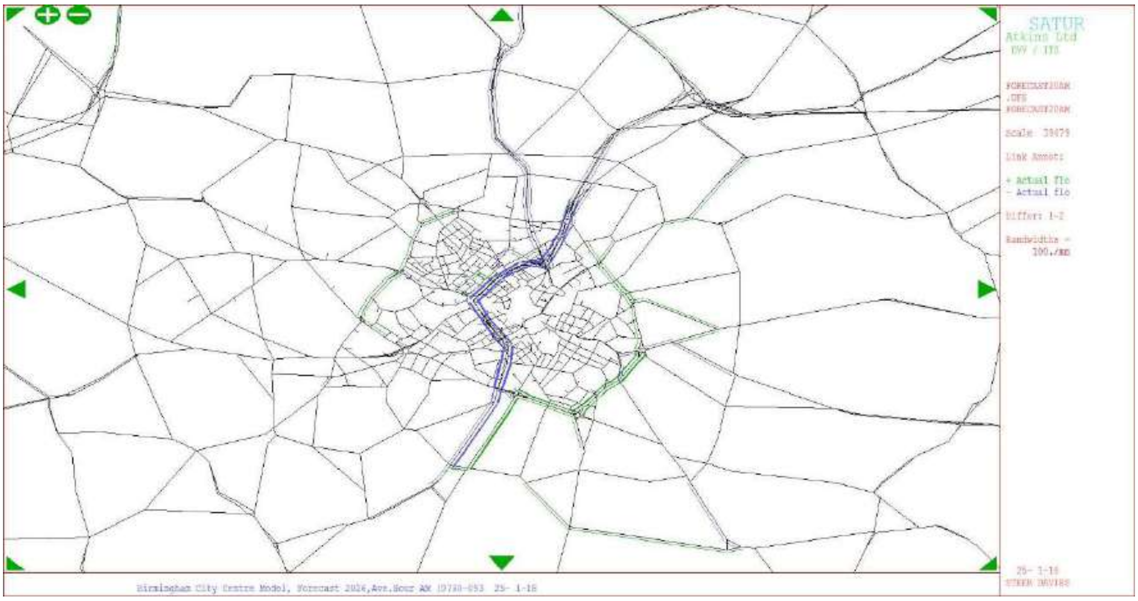


Figure 5-14: Compliant Flow Change (CAZ C Medium – Do Minimum) – AM

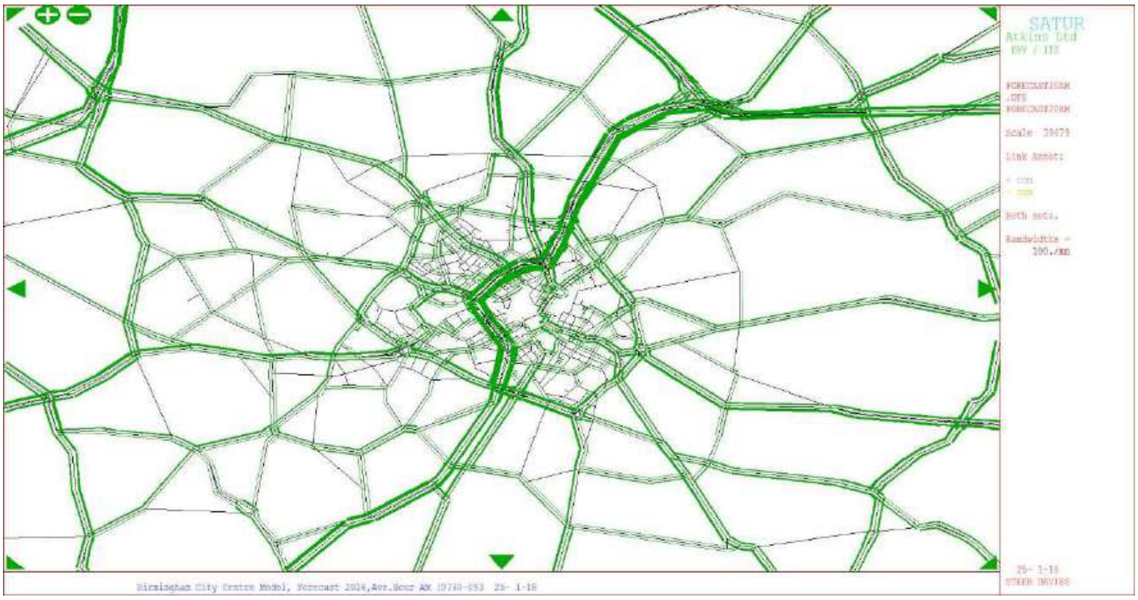


Figure 5-15: Non-compliant Flow Change (CAZ C Medium – Do Minimum) – AM

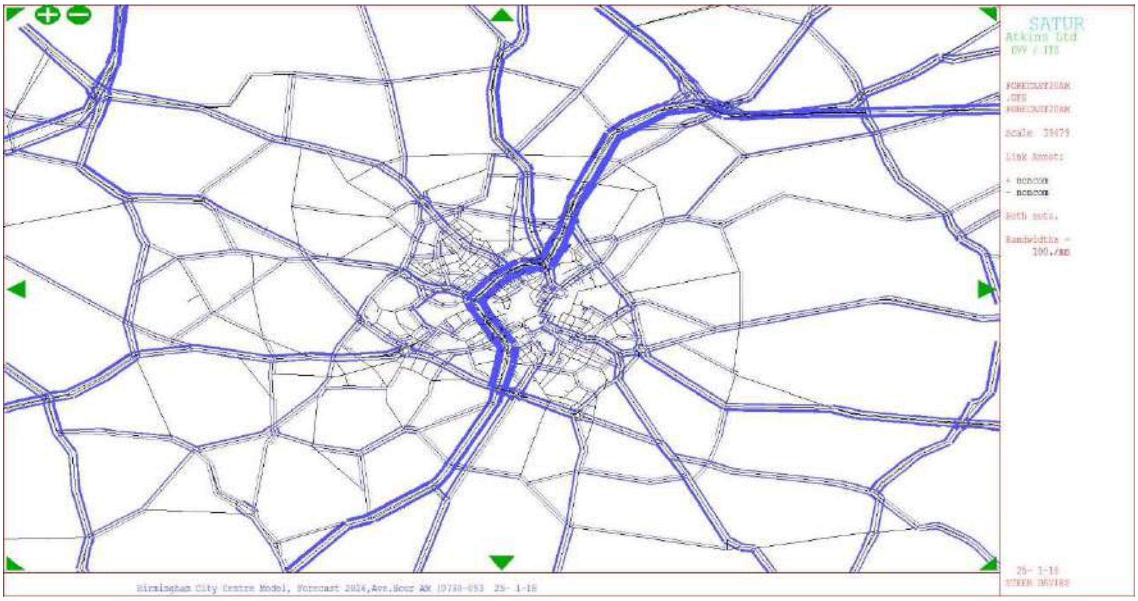


Figure 5-16: Link Delay Change (CAZ C Medium – Do Minimum) – AM

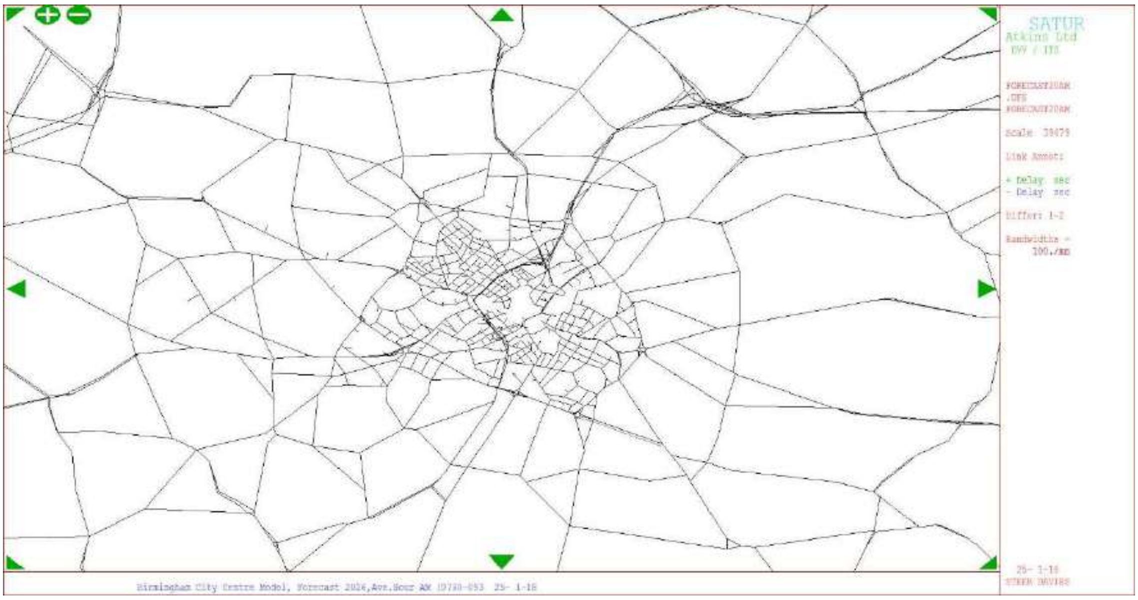


Figure 5-17: Total Flow Change (CAZ C Medium – Do Minimum) – IP

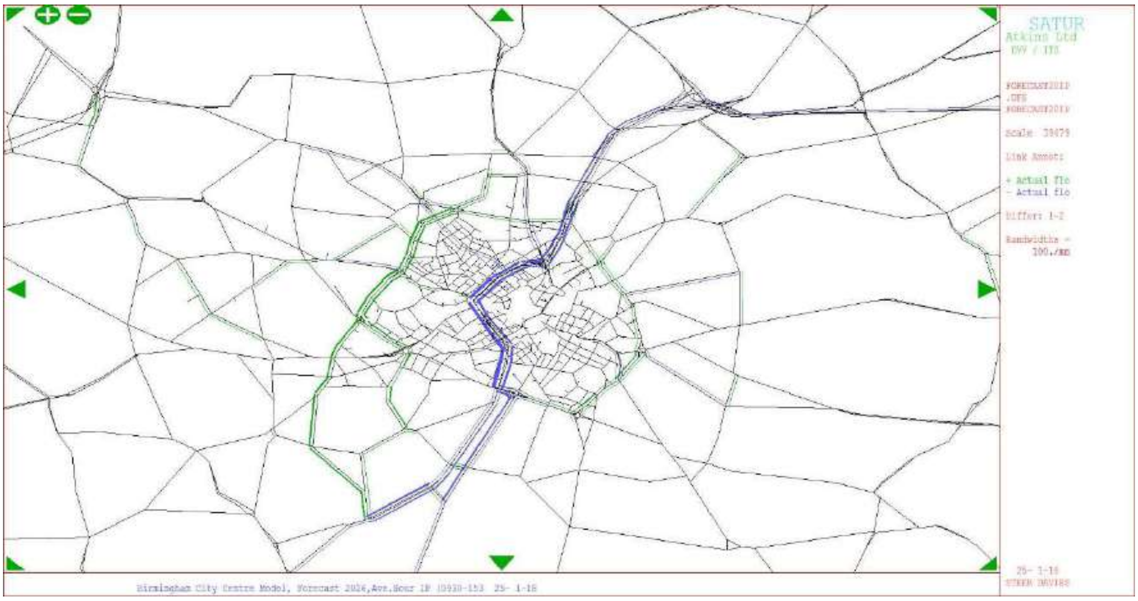


Figure 5-18: Compliant Flow Change (CAZ C Medium – Do Minimum) – IP

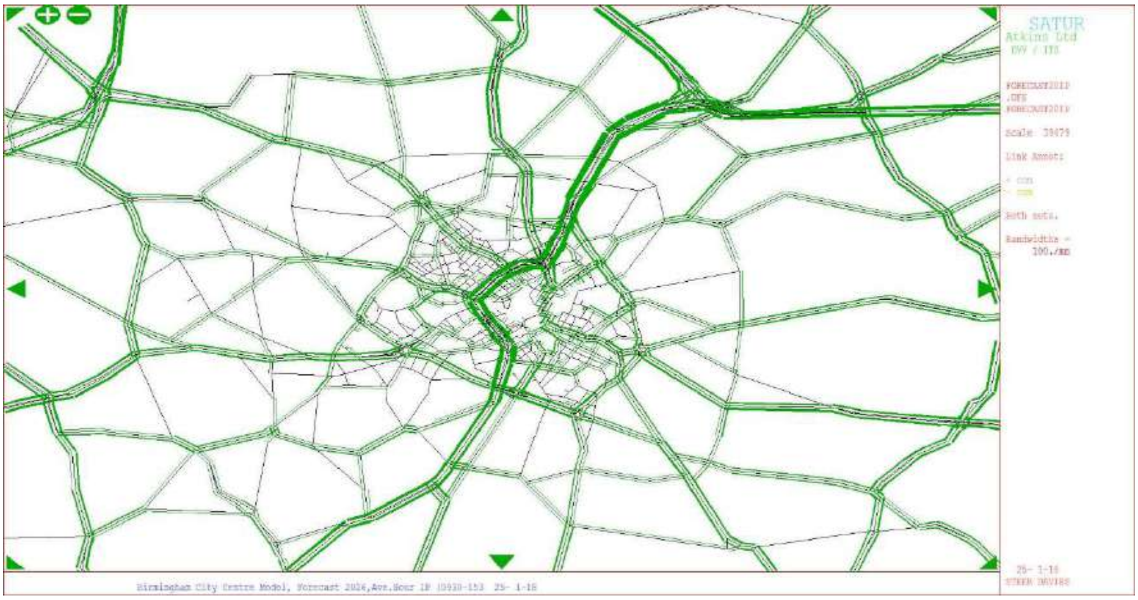


Figure 5-19: Non-compliant Flow Change (CAZ C Medium – Do Minimum) – IP

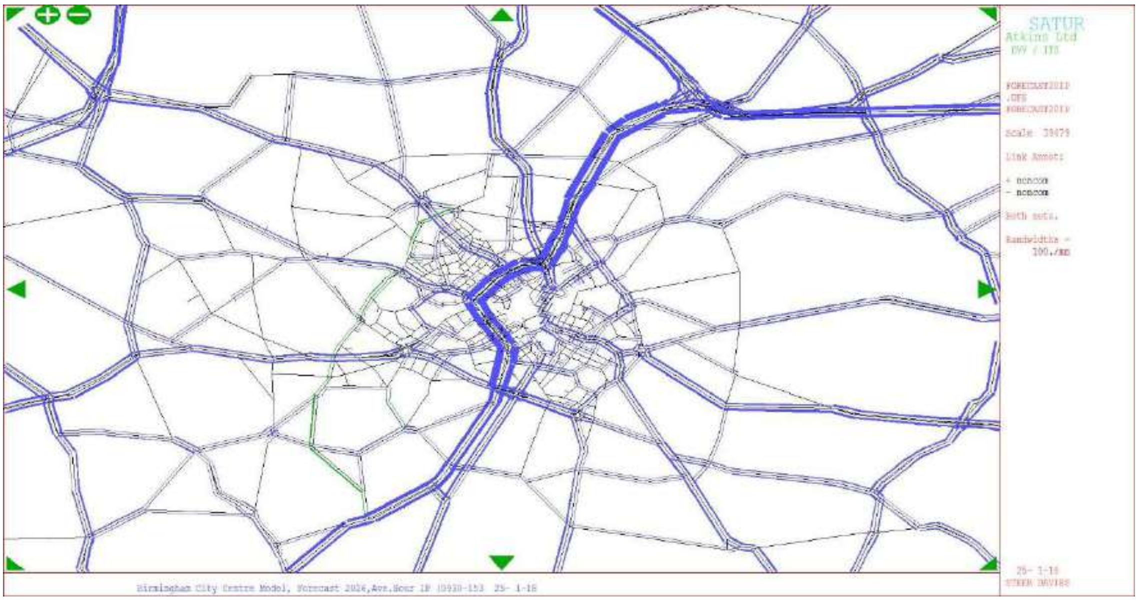


Figure 5-20: Link Delay Change (CAZ C Medium – Do Minimum) – IP

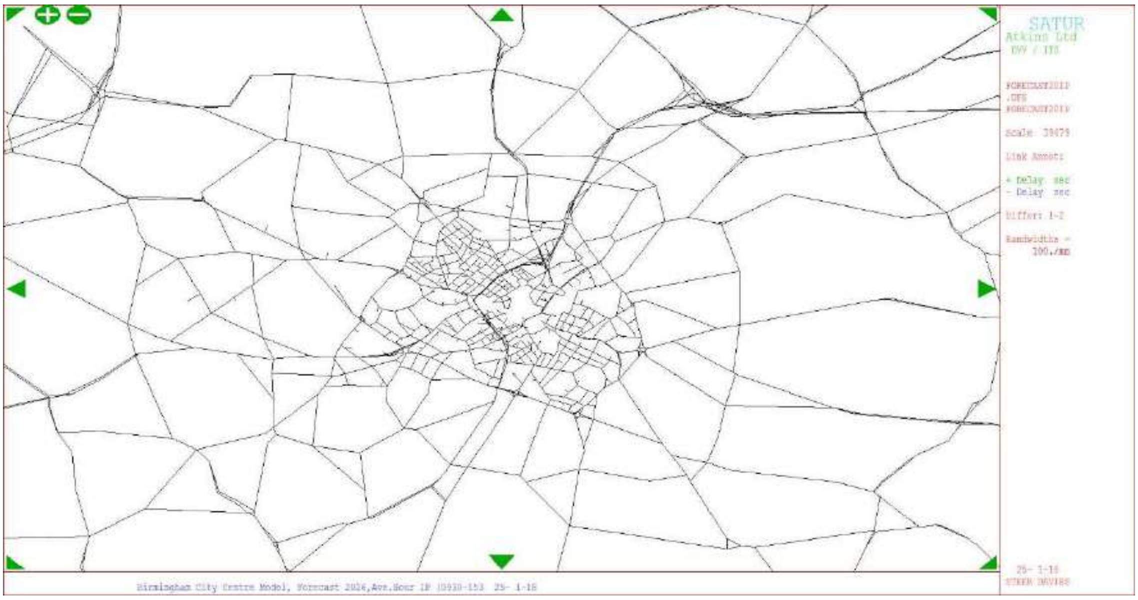


Figure 5-21: Total Flow Change (CAZ C Medium – Do Minimum) – PM

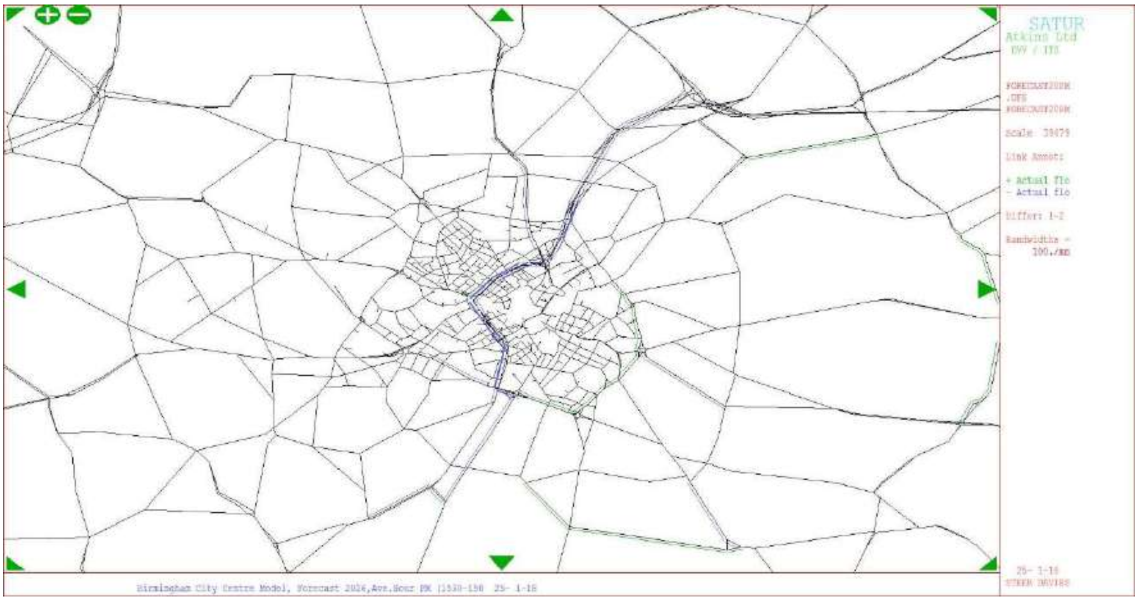


Figure 5-22: Compliant Flow Change (CAZ C Medium – Do Minimum) – PM

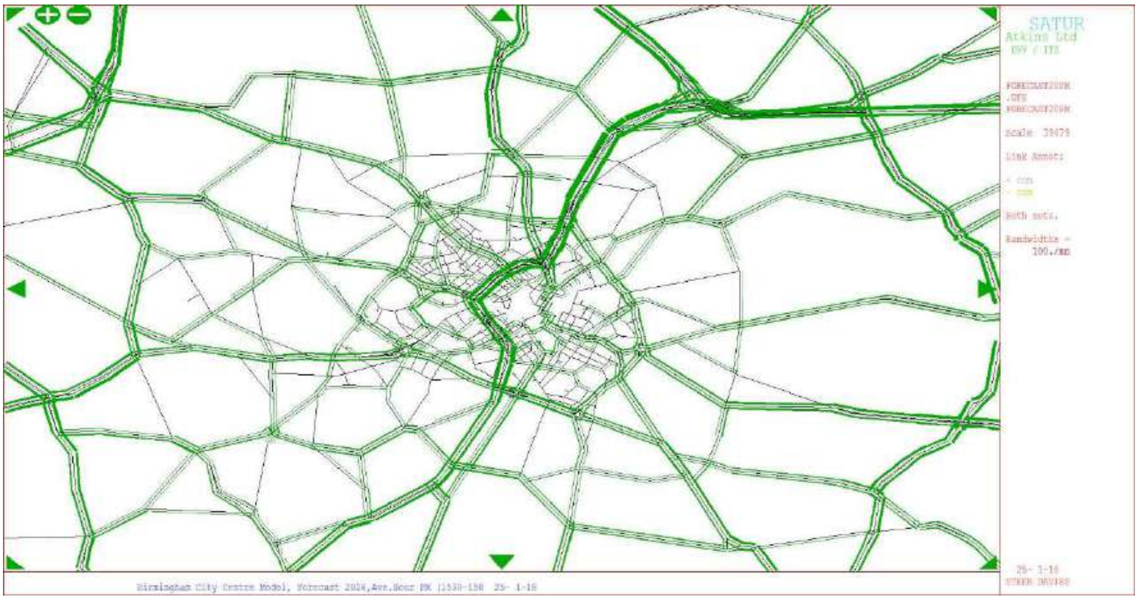


Figure 5-23: Non-compliant Flow Change (CAZ C Medium – Do Minimum) – PM

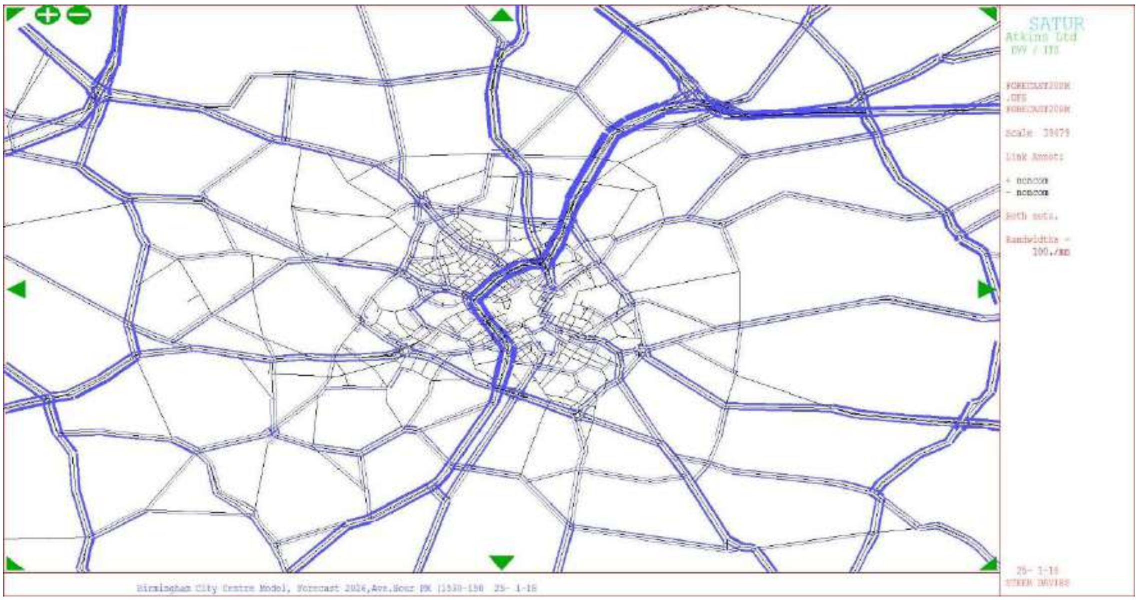


Figure 5-24: Link Delay Change (CAZ C Medium – Do Minimum) – PM

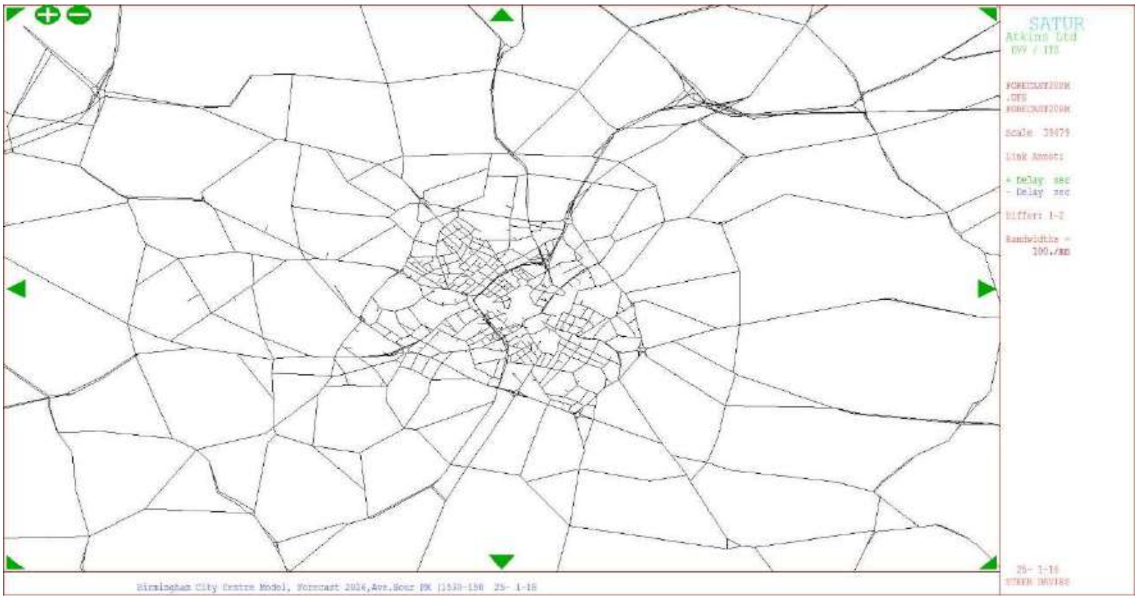


Figure 5-25: Total Flow Change (CAZ C High – Do Minimum) – AM

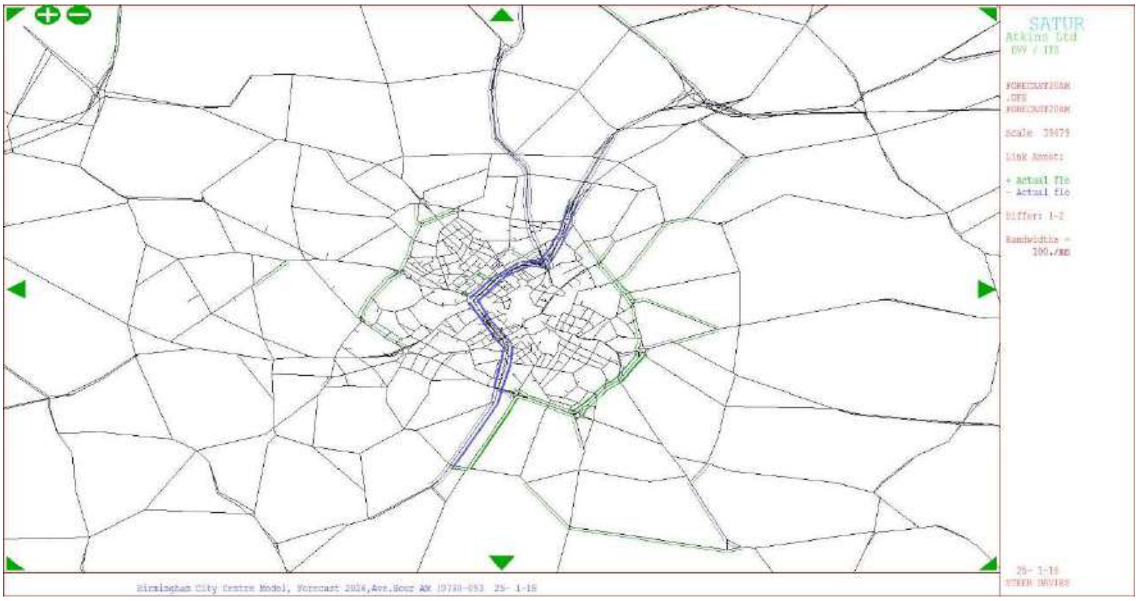


Figure 5-26: Compliant Flow Change (CAZ C High – Do Minimum) – AM

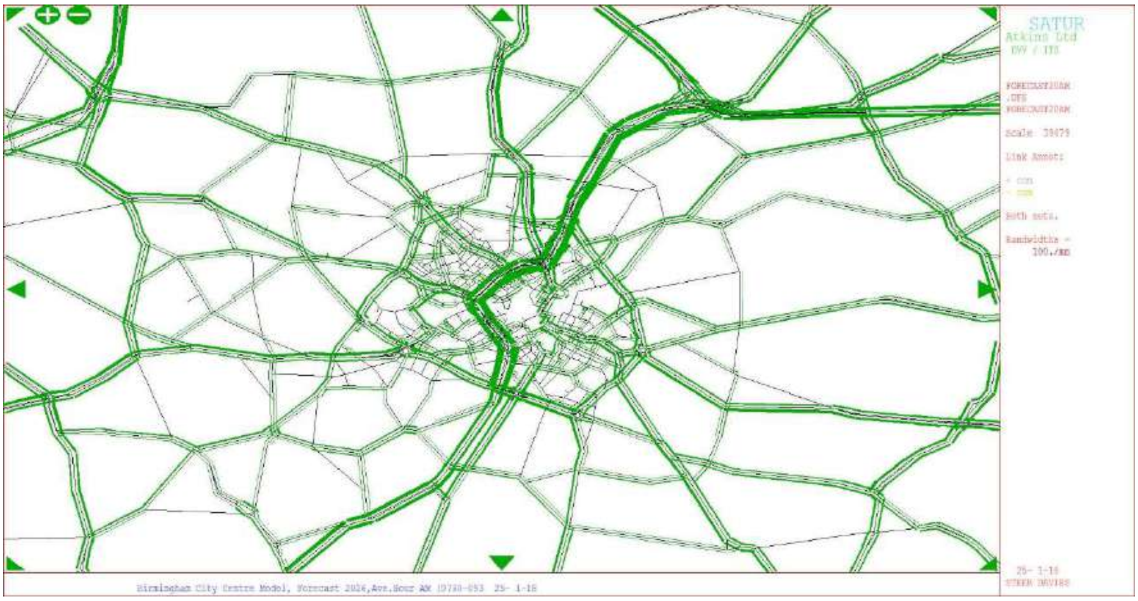


Figure 5-27: Non-compliant Flow Change (CAZ C High – Do Minimum) – AM

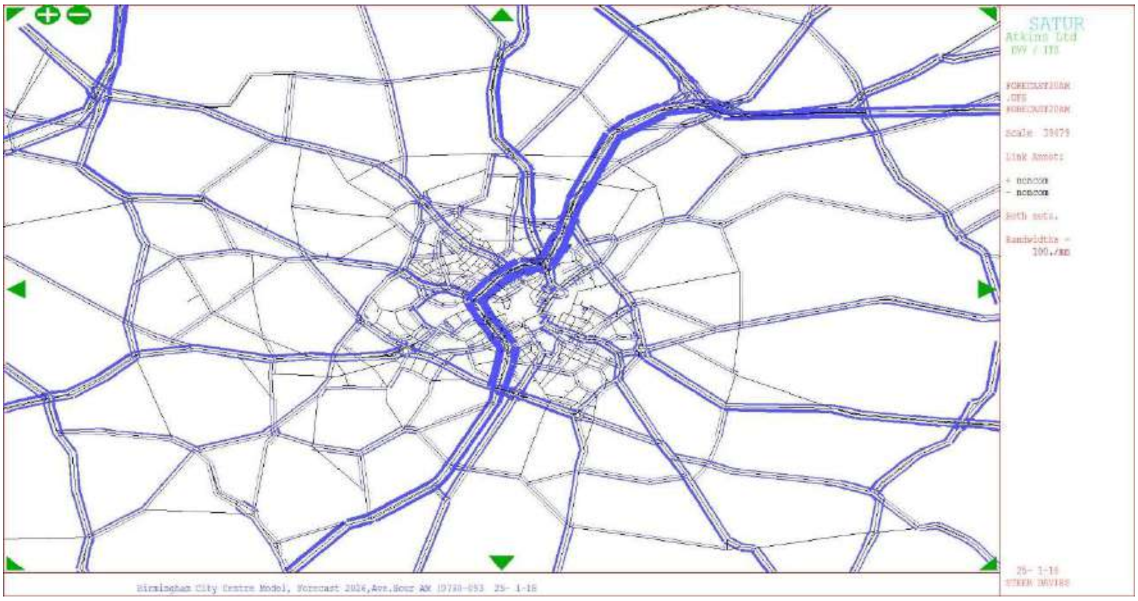


Figure 5-28: Link Delay Change (CAZ C High – Do Minimum) – AM

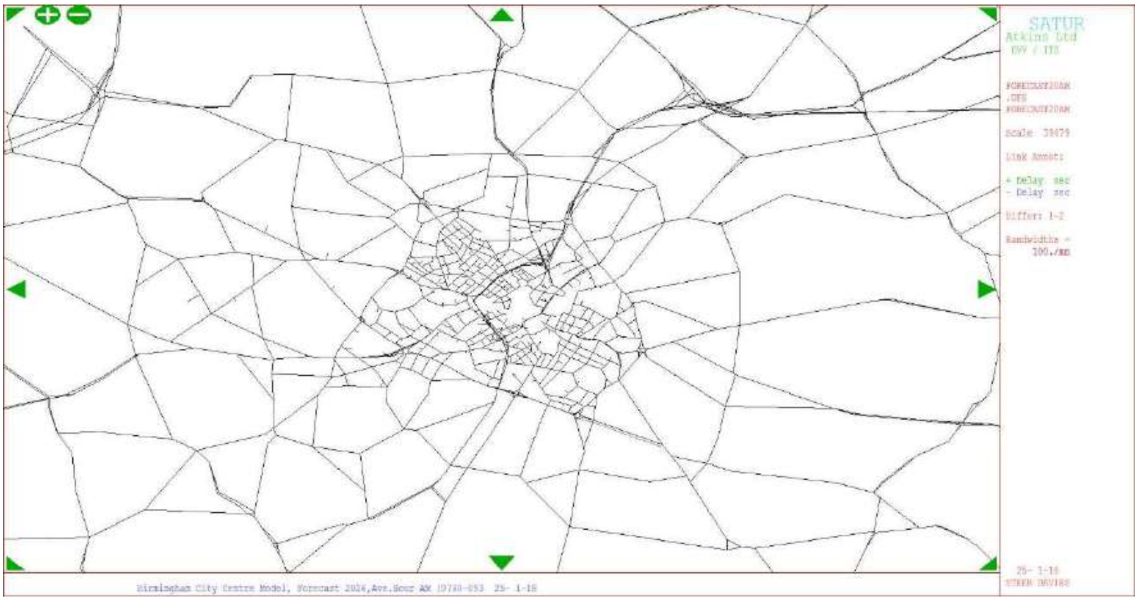


Figure 5-29: Total Flow Change (CAZ C High – Do Minimum) – IP

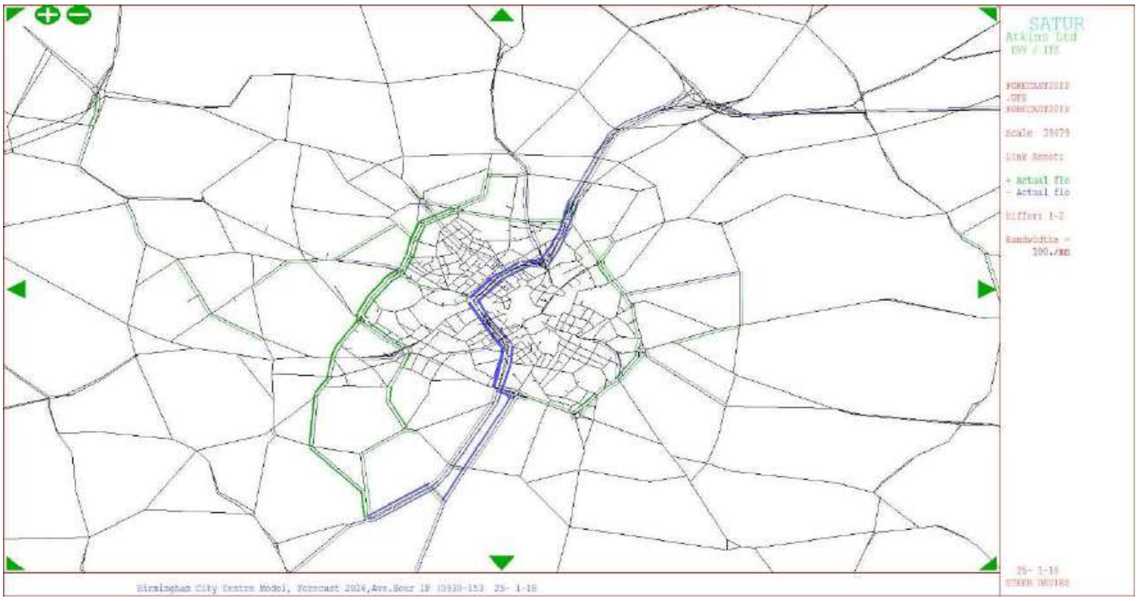


Figure 5-30: Compliant Flow Change (CAZ C High – Do Minimum) – IP

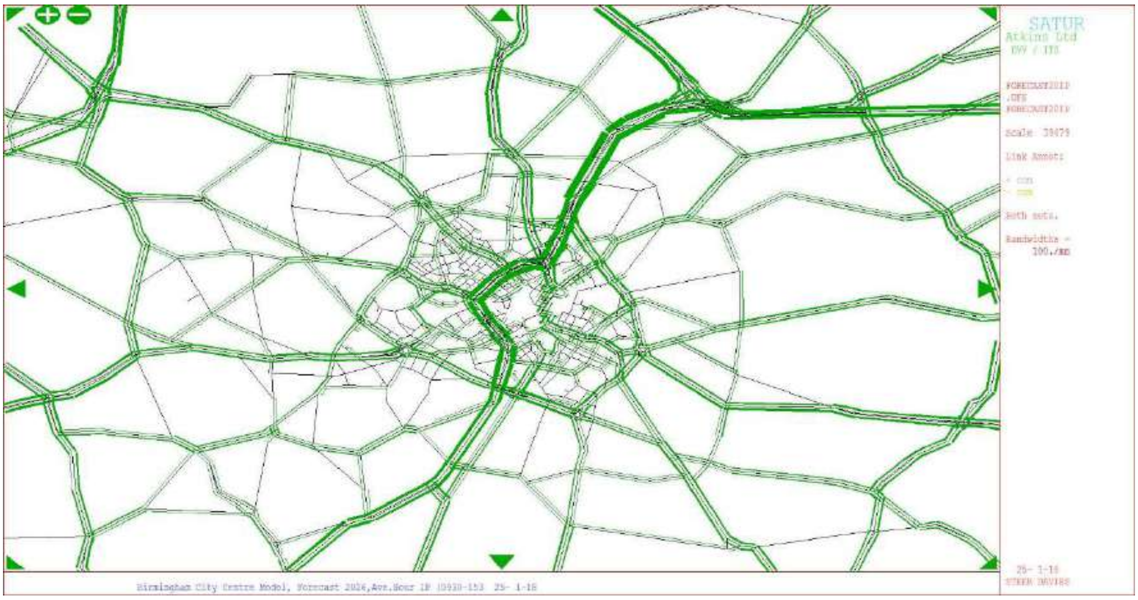


Figure 5-31: Non-compliant Flow Change (CAZ C High – Do Minimum) – IP

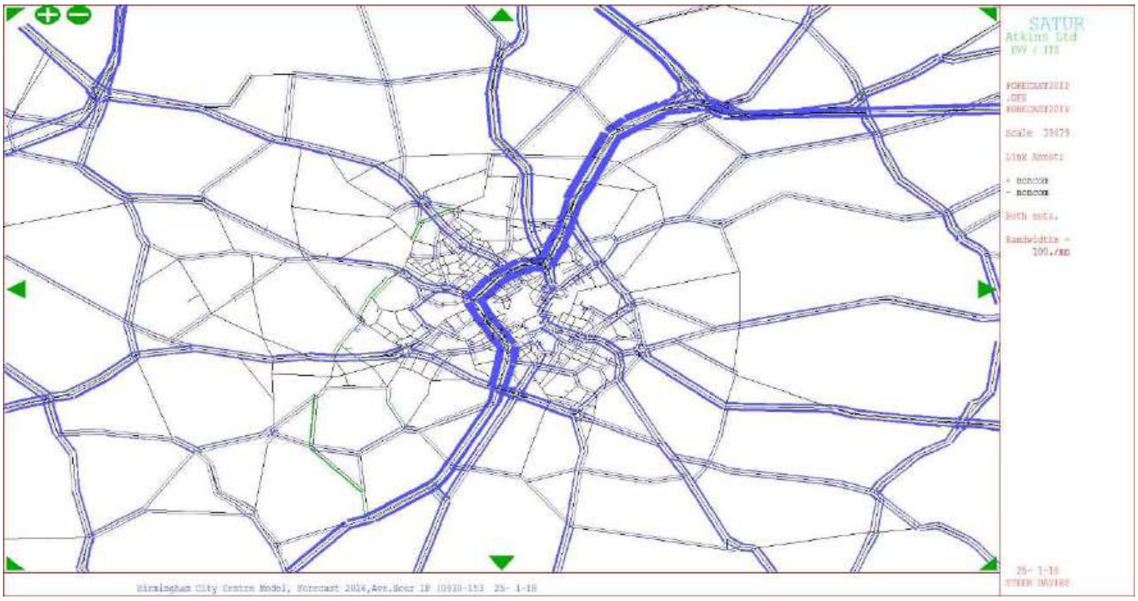


Figure 5-32: Link Delay Change (CAZ C High – Do Minimum) – IP

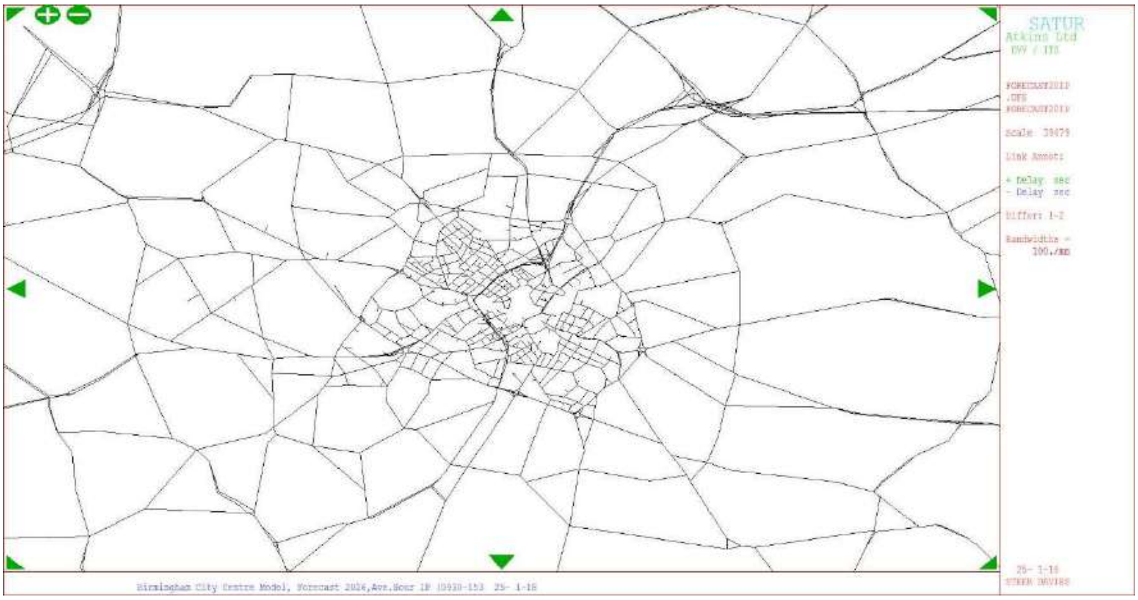


Figure 5-33: Total Flow Change (CAZ C High – Do Minimum) – PM

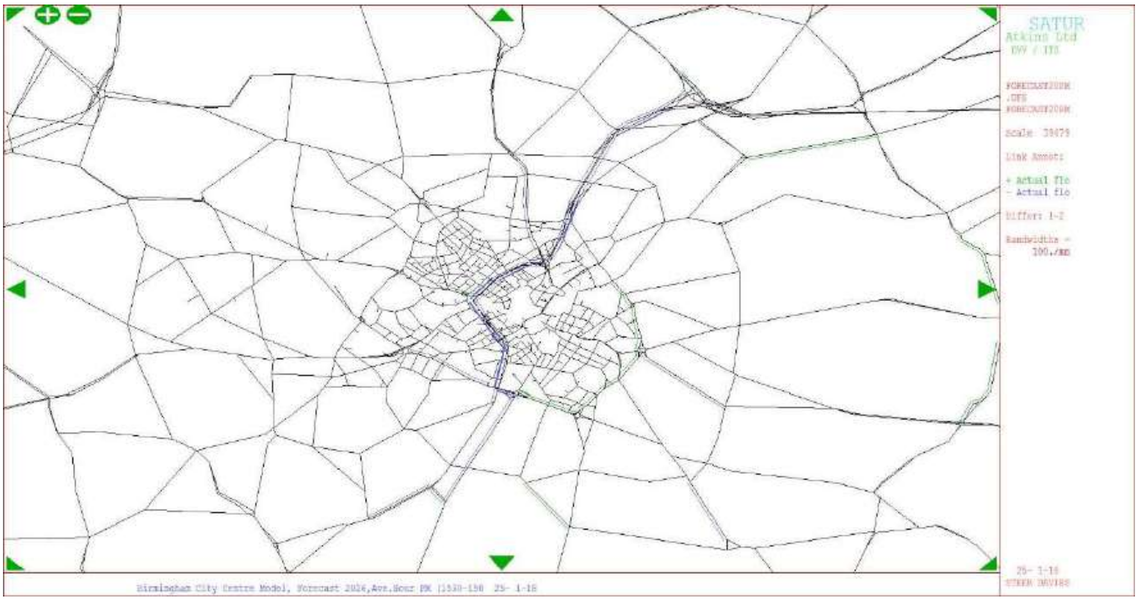


Figure 5-34: Compliant Flow Change (CAZ C High – Do Minimum) – PM

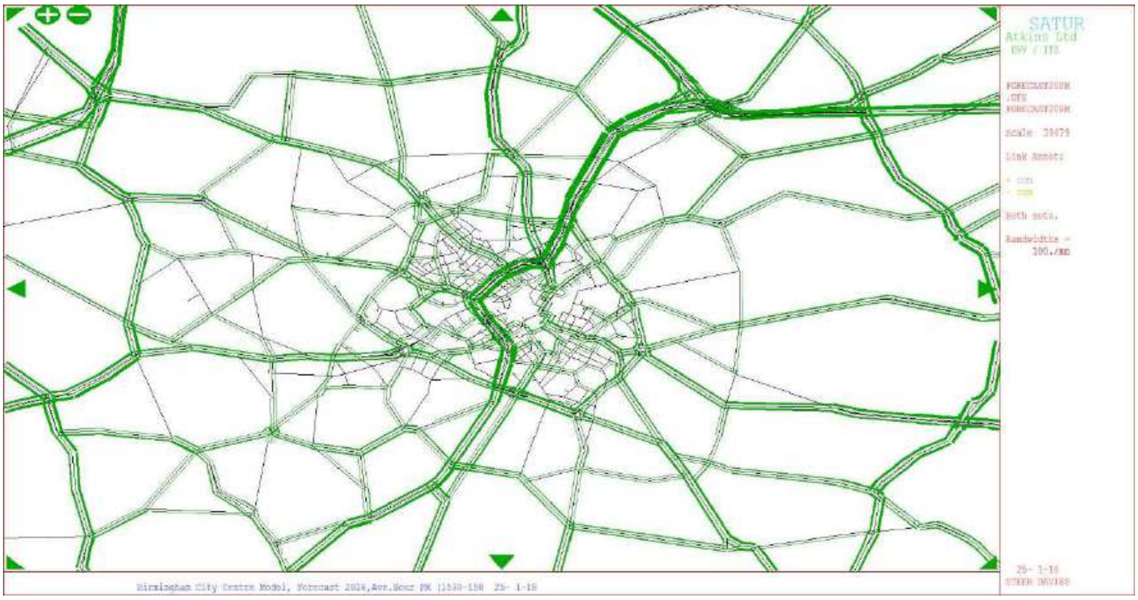


Figure 5-35: Non-compliant Flow Change (CAZ C High – Do Minimum) – PM

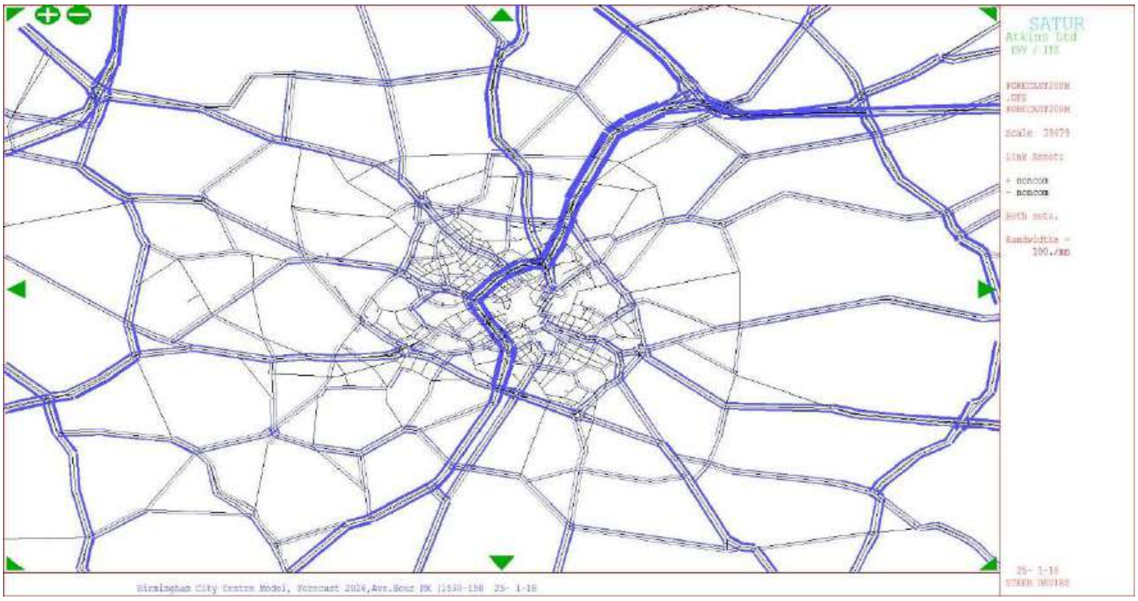


Figure 5-36: Link Delay Change (CAZ C High – Do Minimum) - PM

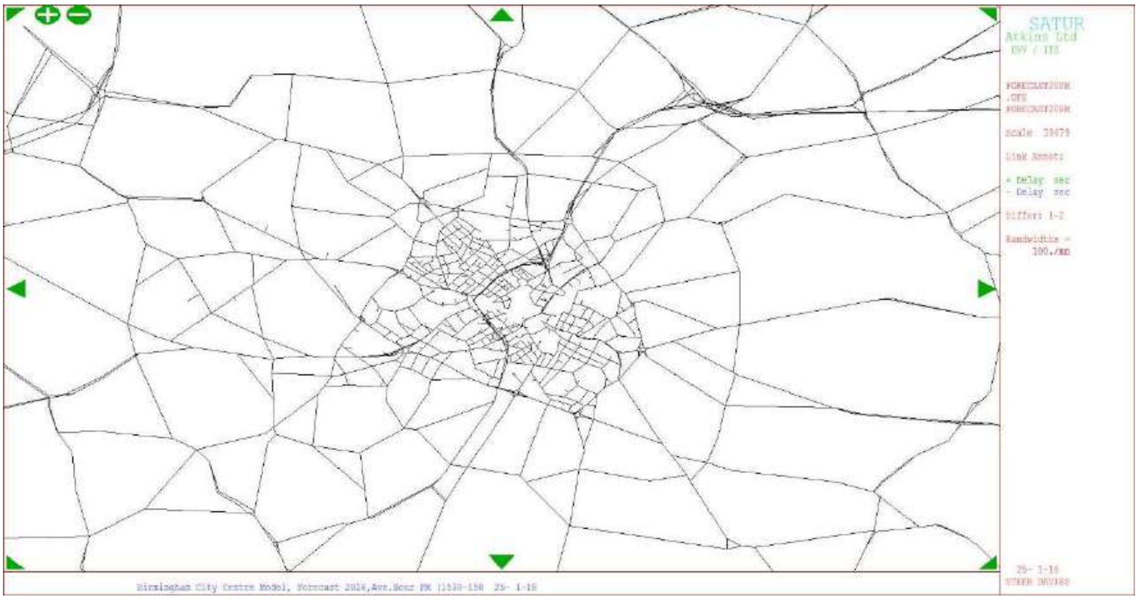


Figure 5-37: Total Flow Change (CAZ D Low – Do Minimum) - AM

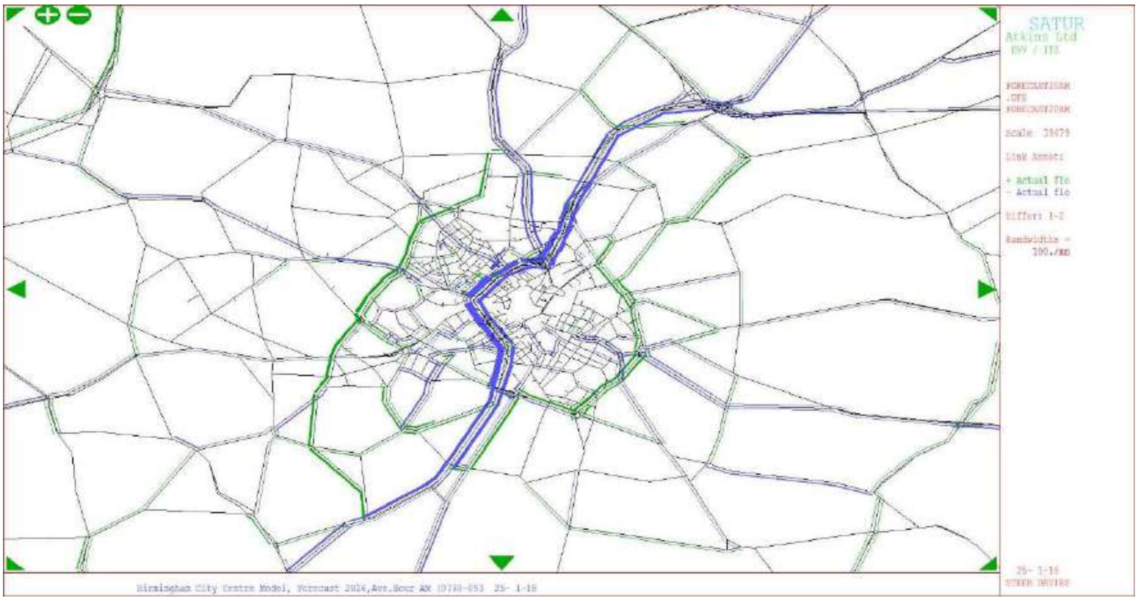


Figure 5-38: Compliant Flow Change (CAZ D Low – Do Minimum) – AM

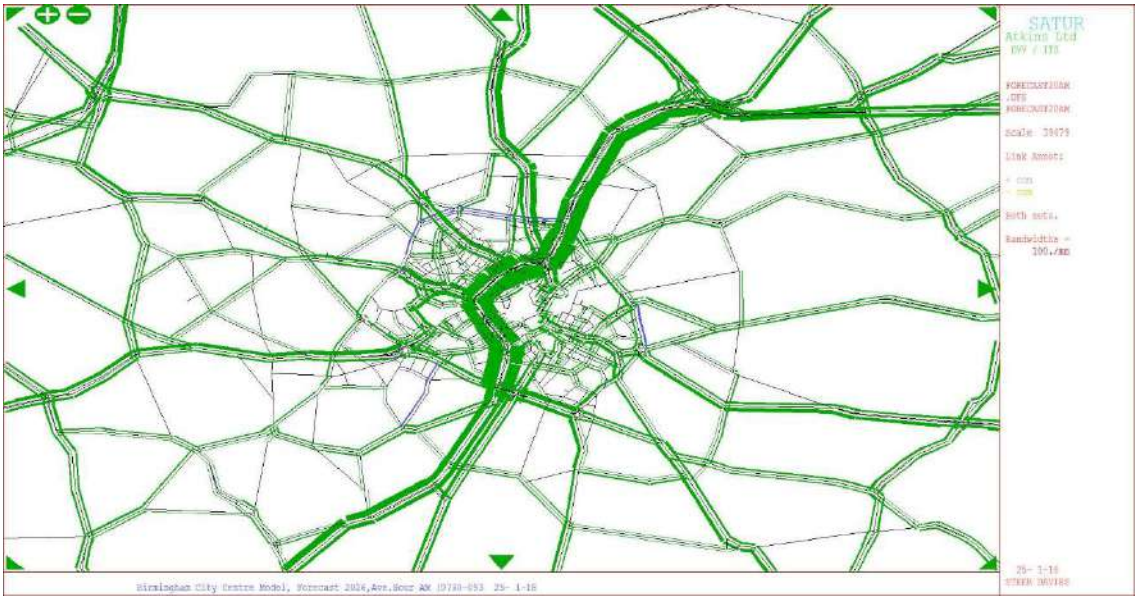


Figure 5-39: Non-compliant Flow Change (CAZ D Low – Do Minimum) – AM

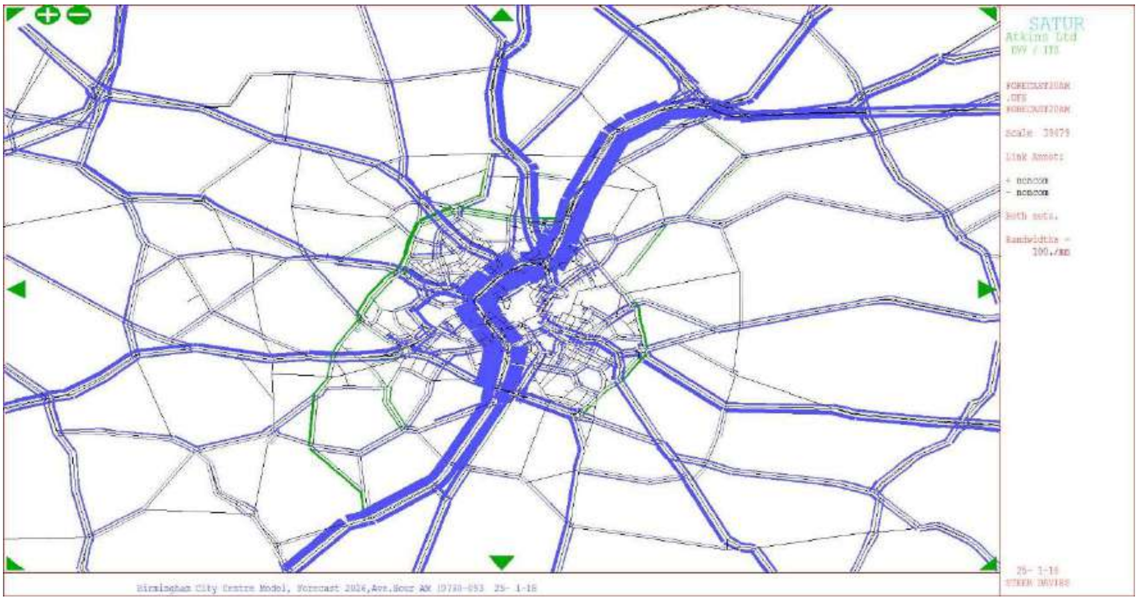


Figure 5-40: Link Delay Change (CAZ D Low – Do Minimum) - AM

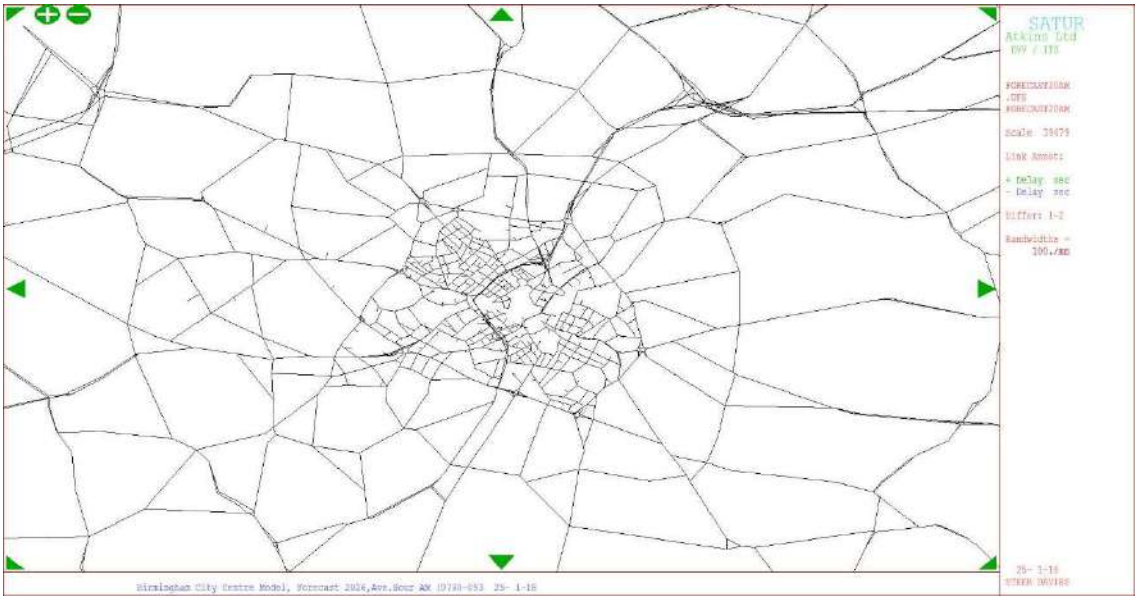


Figure 5-41: Total Flow Change (CAZ D Low – Do Minimum) – IP

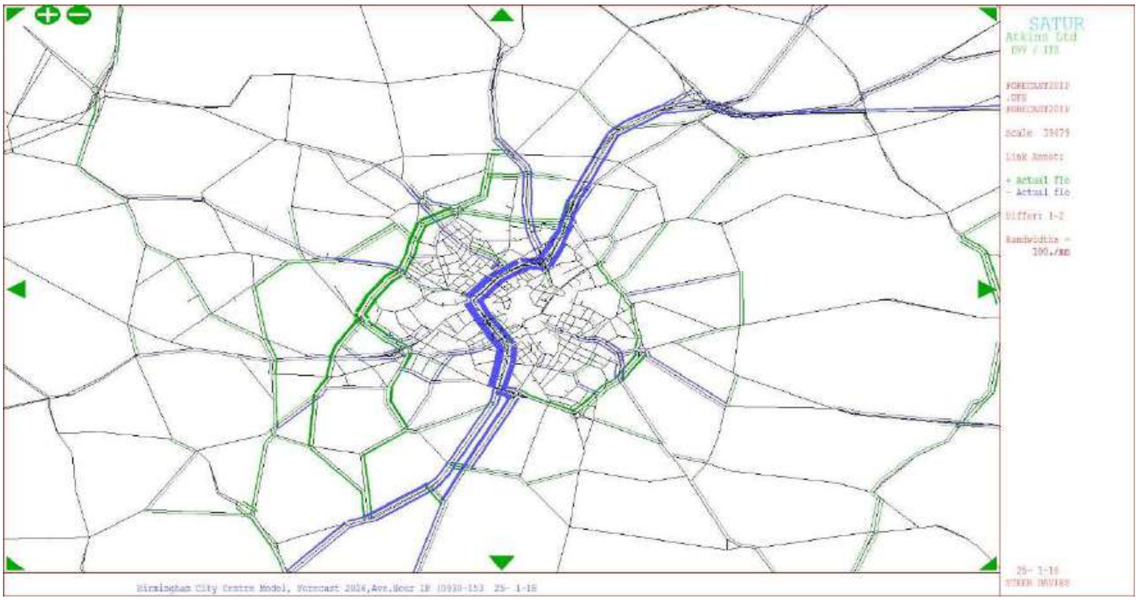


Figure 5-42: Compliant Flow Change (CAZ D Low – Do Minimum) – IP

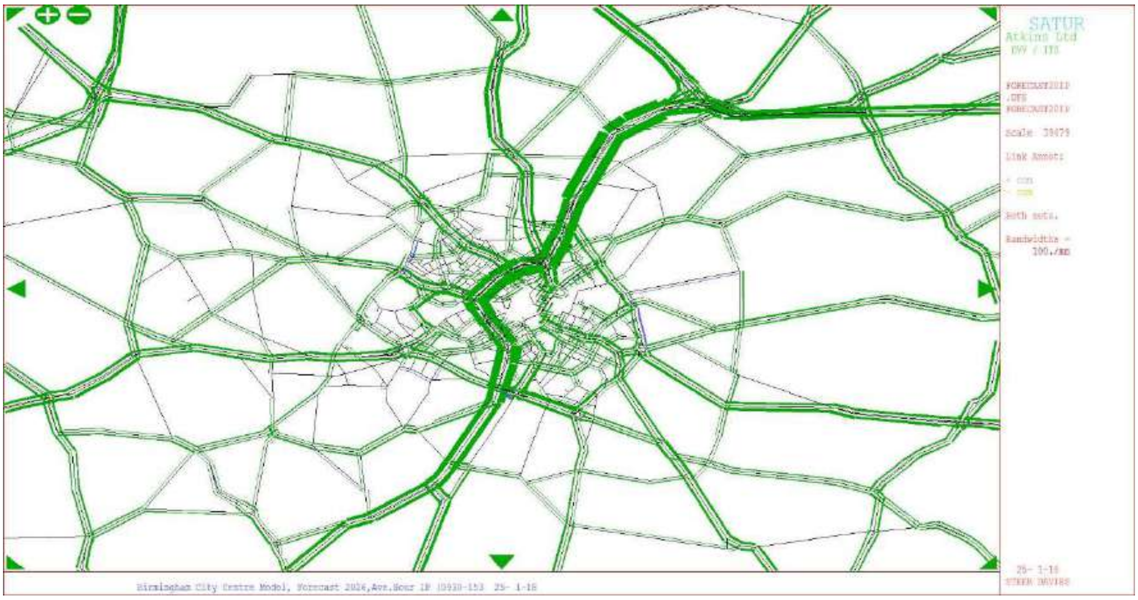


Figure 5-43: Non-compliant Flow Change (CAZ D Low – Do Minimum) – IP

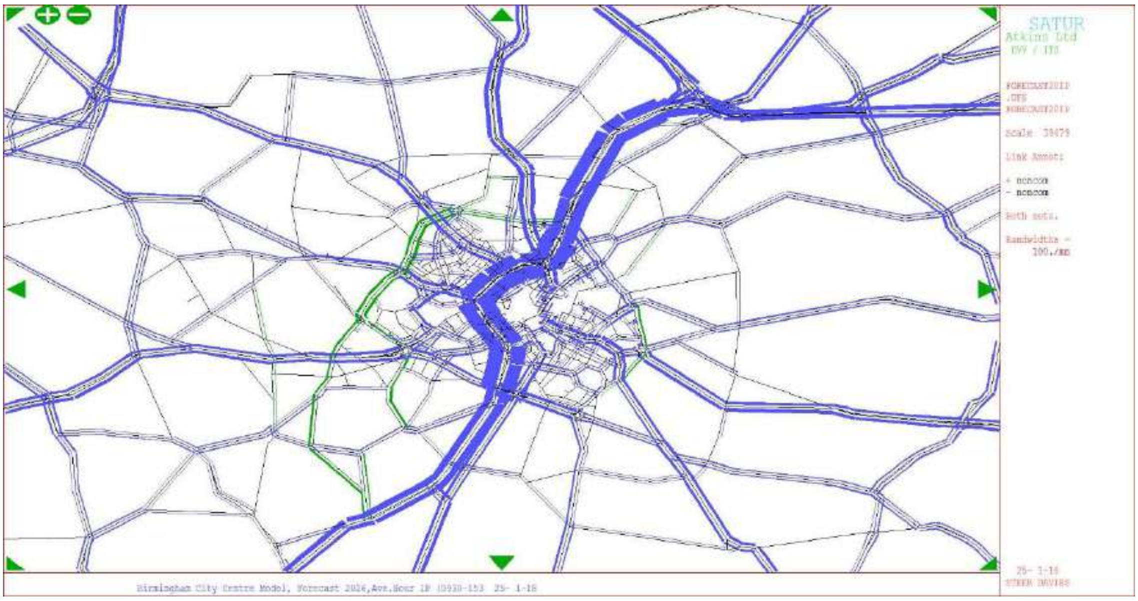


Figure 5-44: Link Delay Change (CAZ D Low – Do Minimum) – IP

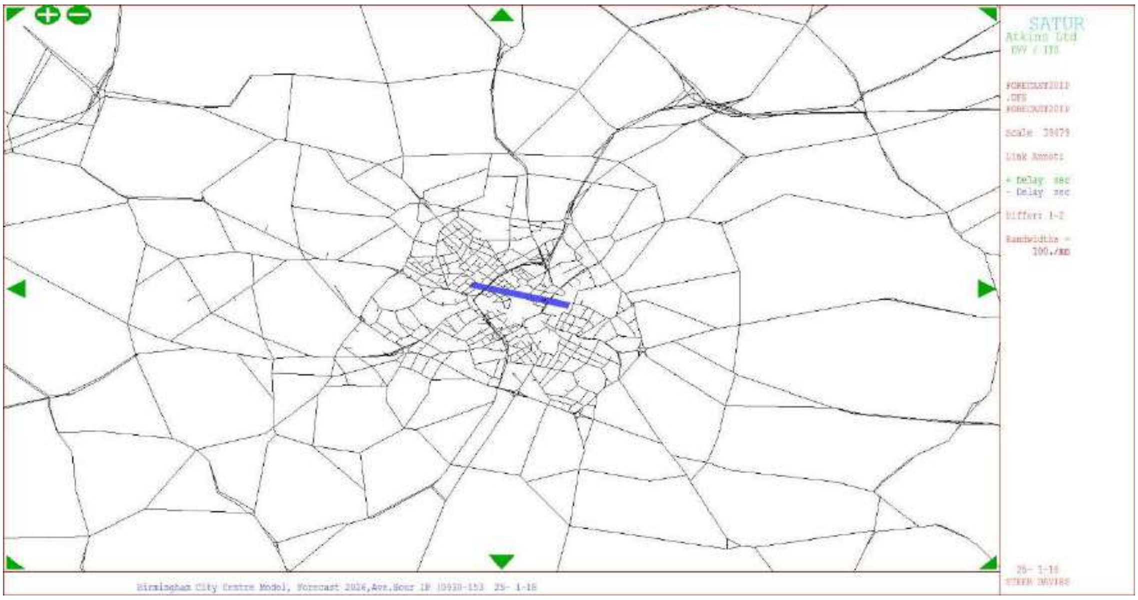


Figure 5-45: Total Flow Change (CAZ D Low – Do Minimum) – PM

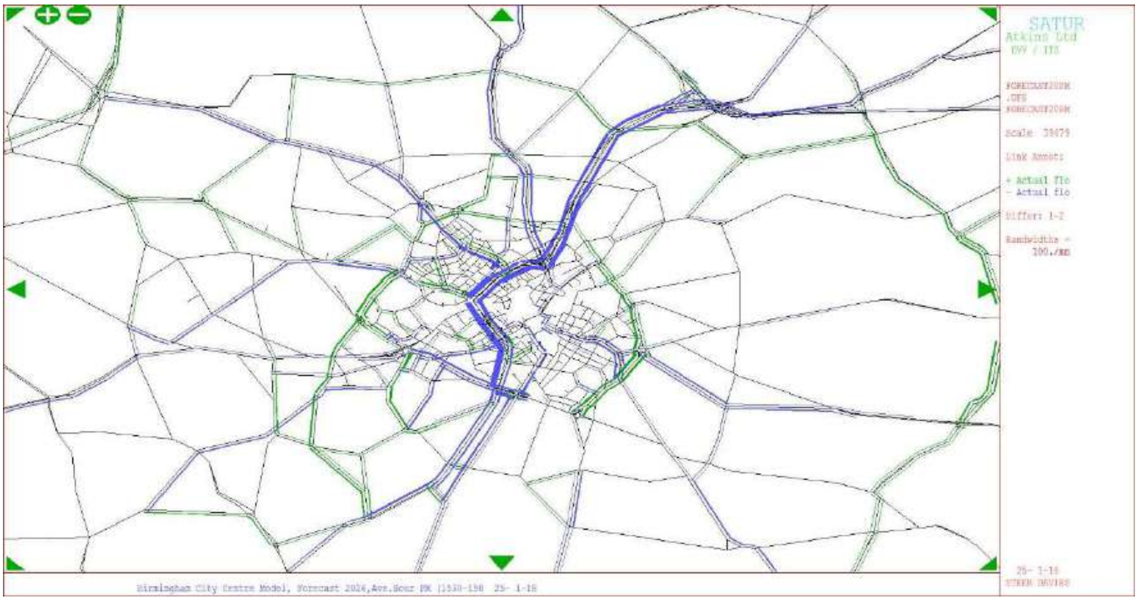


Figure 5-46: Compliant Flow Change (CAZ D Low – Do Minimum) – PM

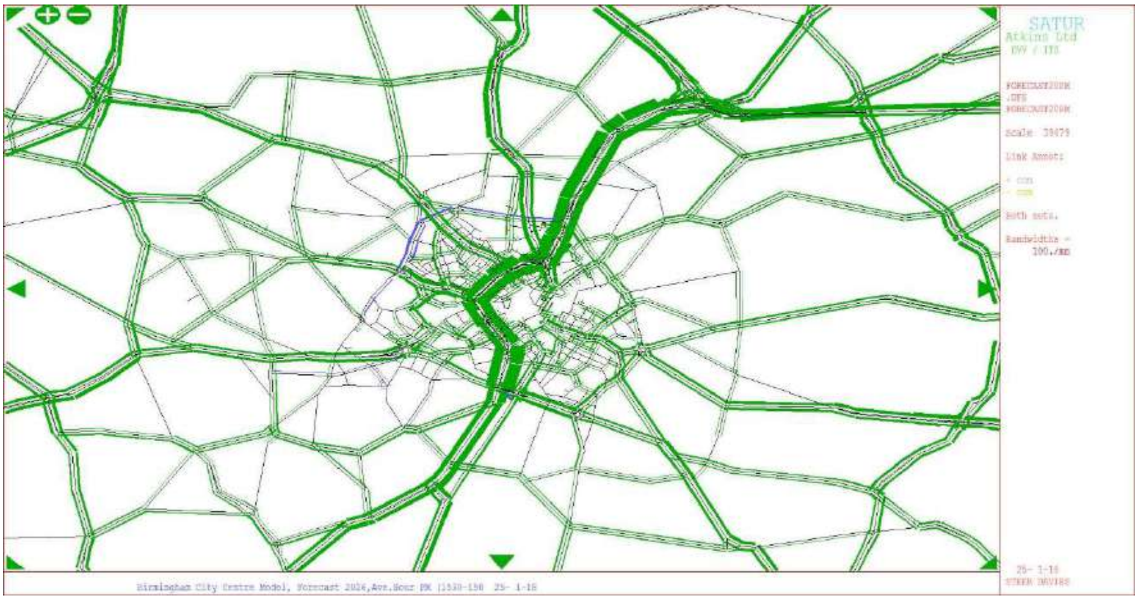


Figure 5-47: Non-compliant Flow Change (CAZ D Low – Do Minimum) – PM

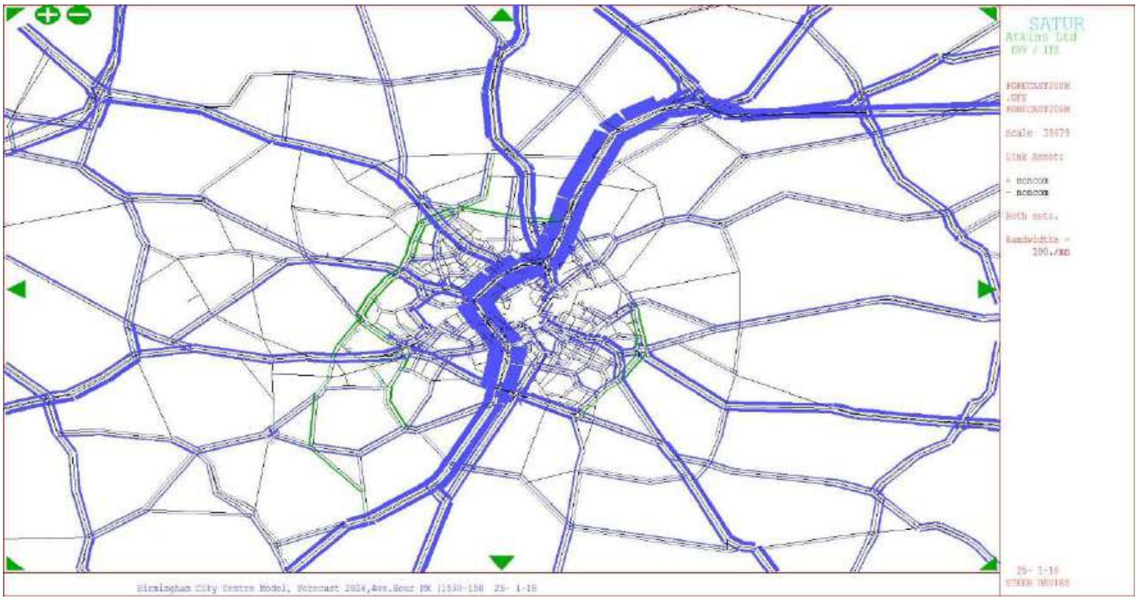


Figure 5-48: Link Delay Change (CAZ D Low – Do Minimum) – PM

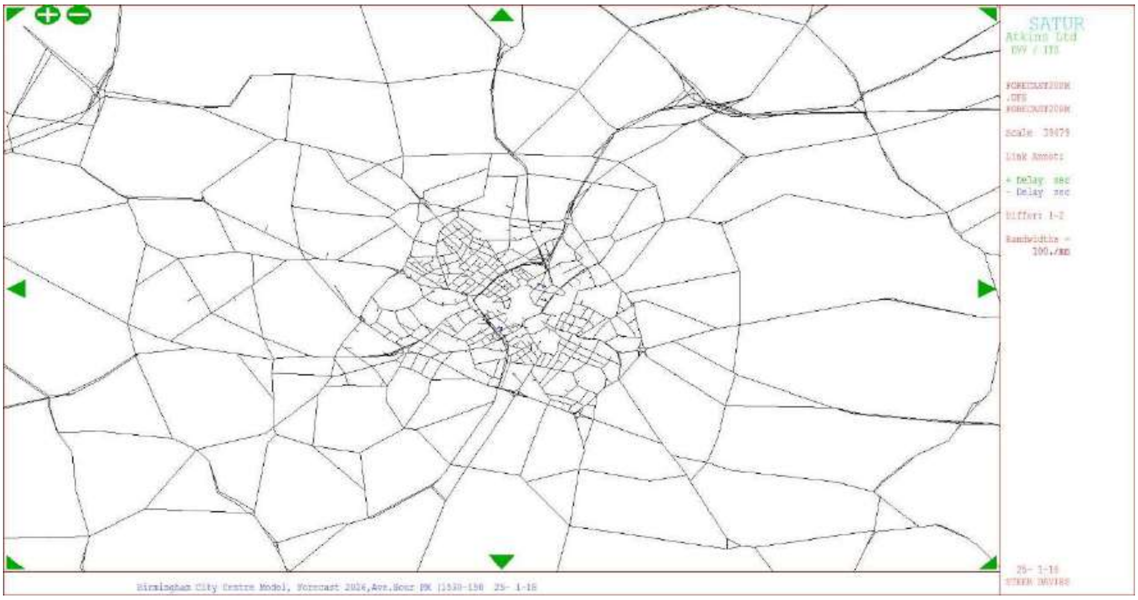


Figure 5-49: Total Flow Change (CAZ D Medium – Do Minimum) – AM

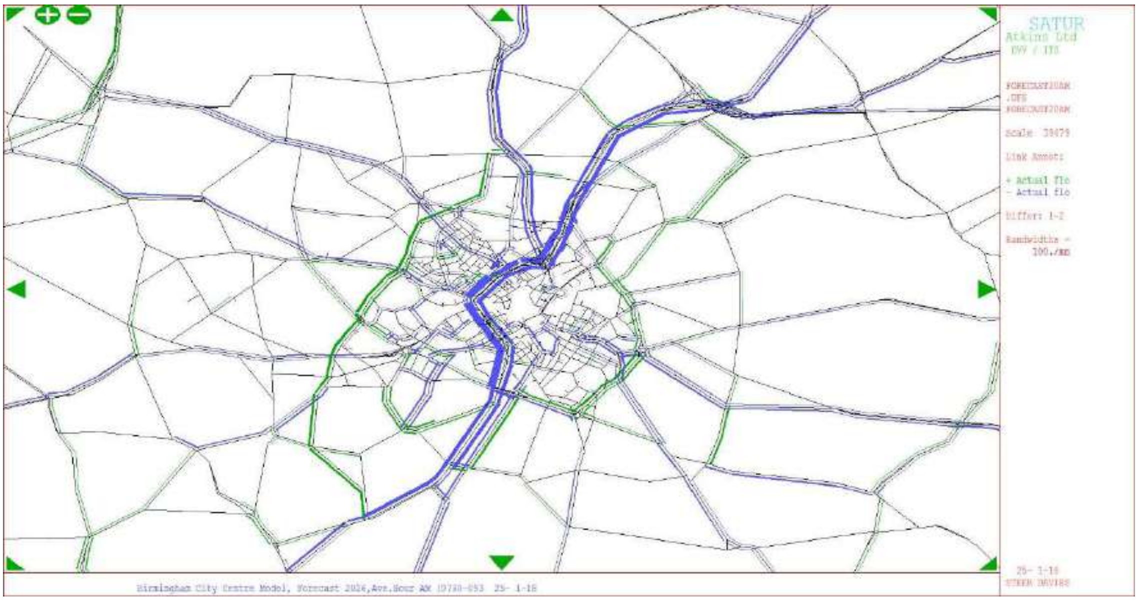


Figure 5-50: Compliant Flow Change (CAZ D Medium – Do Minimum) – AM

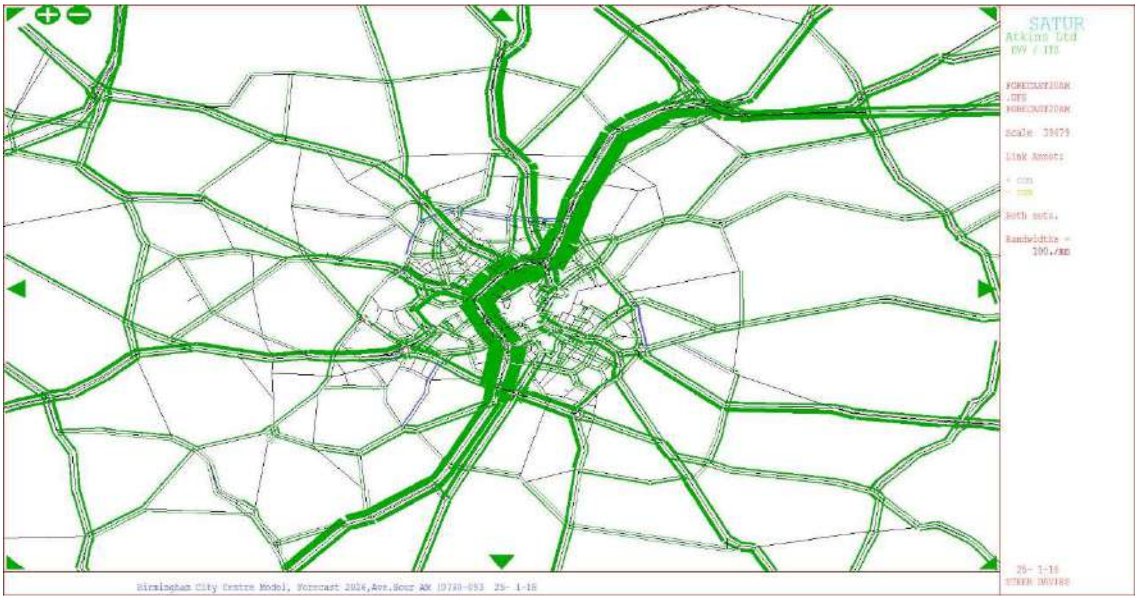


Figure 5-51: Non-compliant Flow Change (CAZ D Medium – Do Minimum) – AM

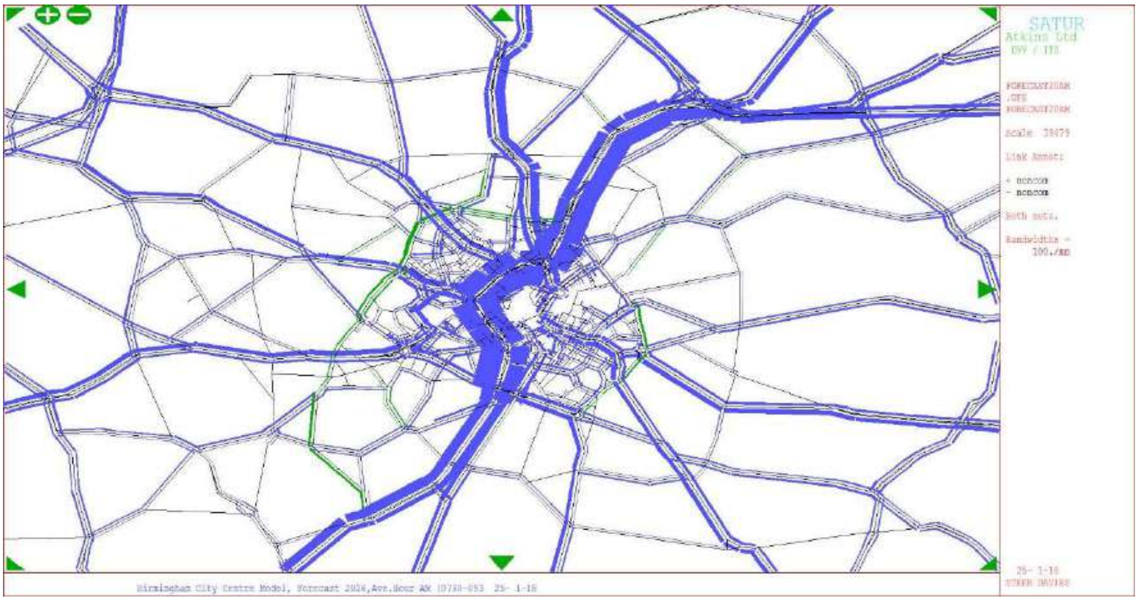


Figure 5-52: Link Delay Change (CAZ D Medium – Do Minimum) – AM

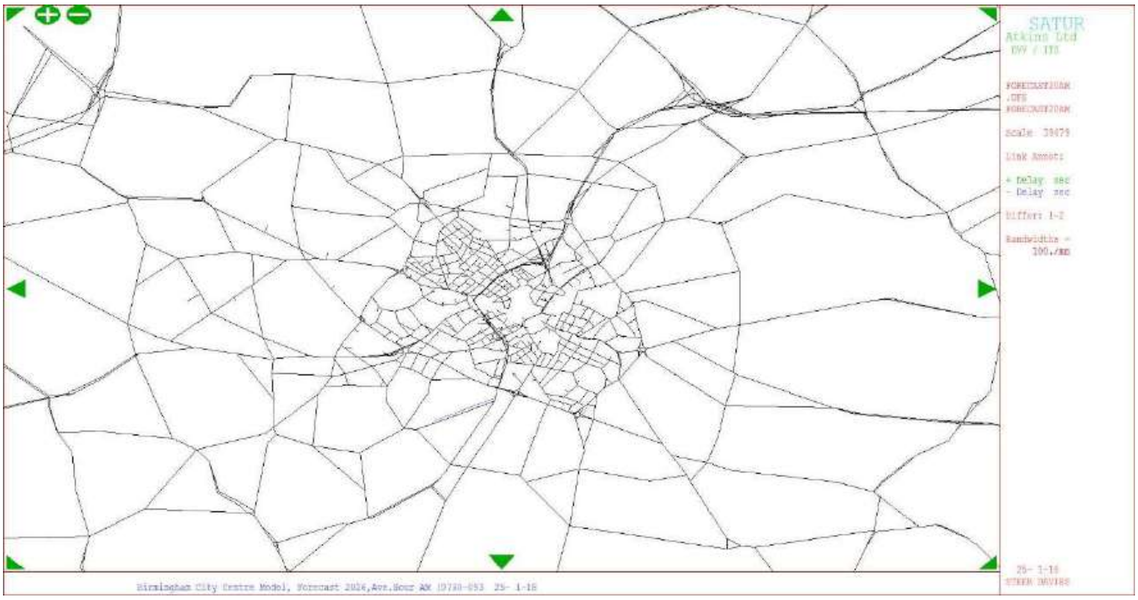


Figure 5-53: Total Flow Change (CAZ D Medium – Do Minimum) – IP

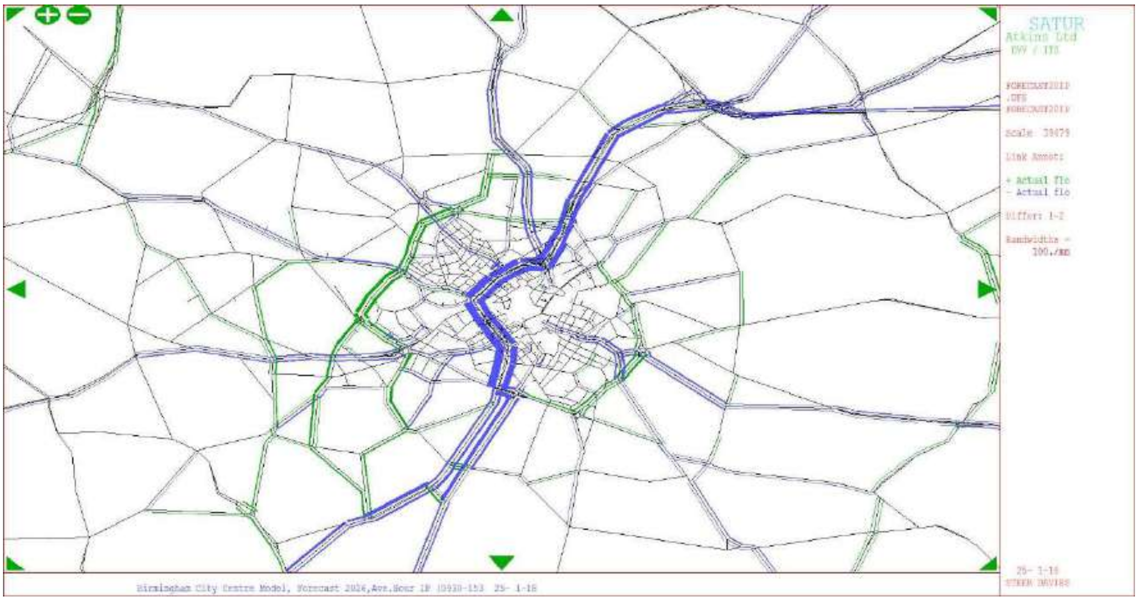


Figure 5-54: Compliant Flow Change (CAZ D Medium – Do Minimum) – IP

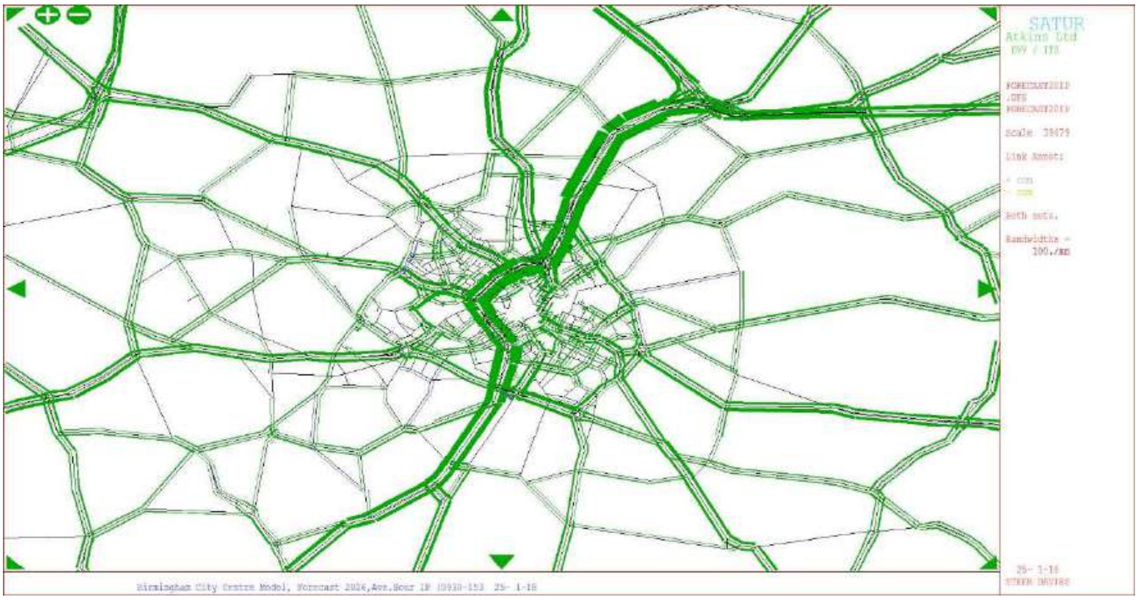


Figure 5-55: Non-compliant Flow Change (CAZ D Medium – Do Minimum) – IP

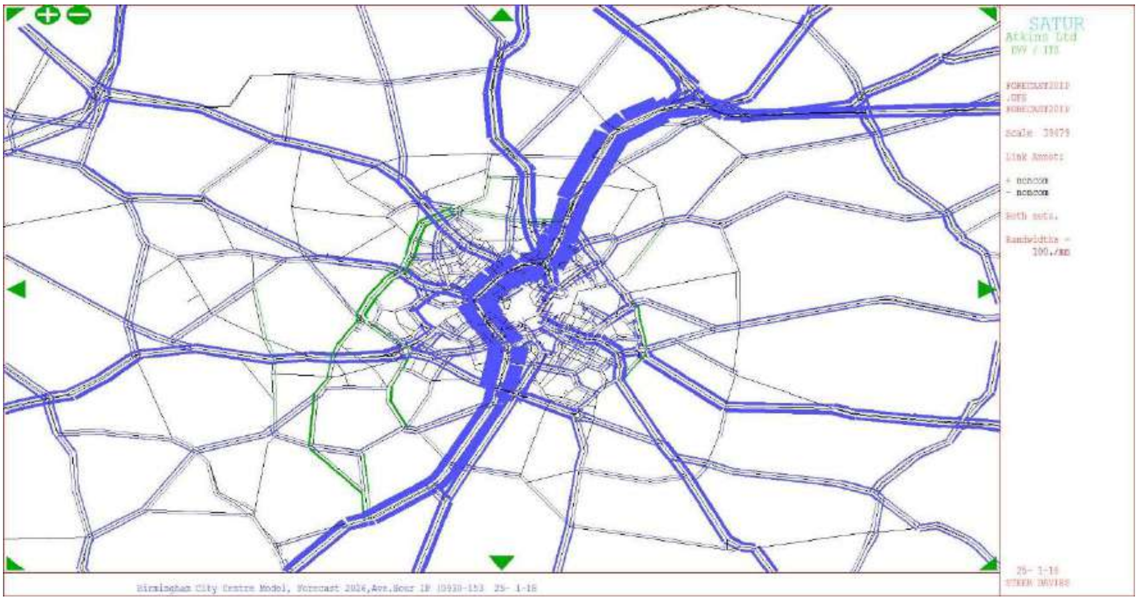


Figure 5-56: Link Delay Change (CAZ D Medium – Do Minimum) – IP

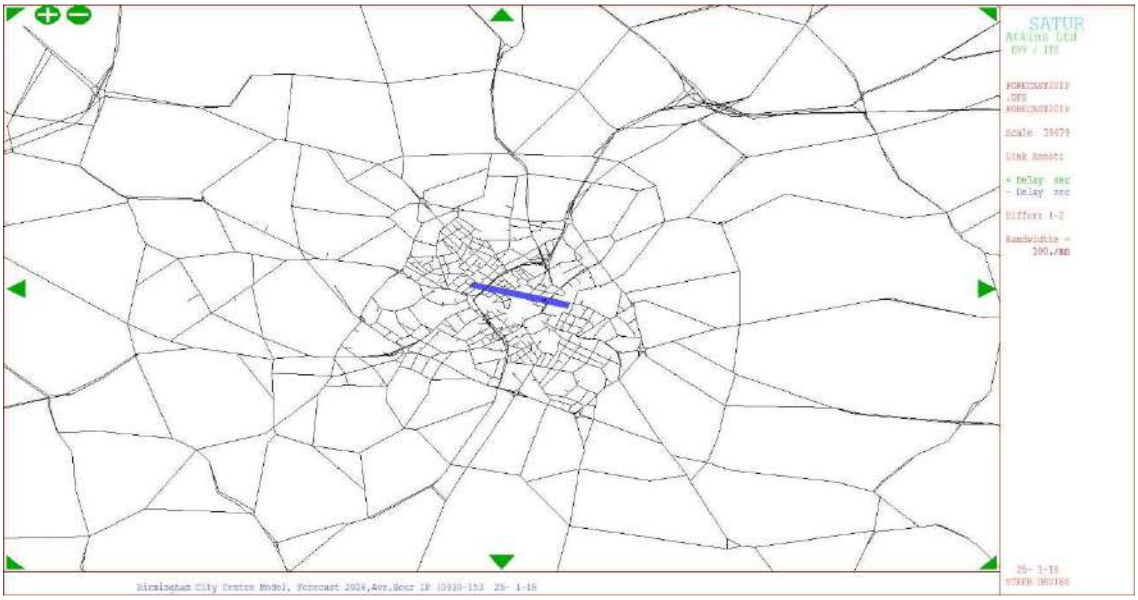


Figure 5-57: Total Flow Change (CAZ D Medium – Do Minimum) – PM

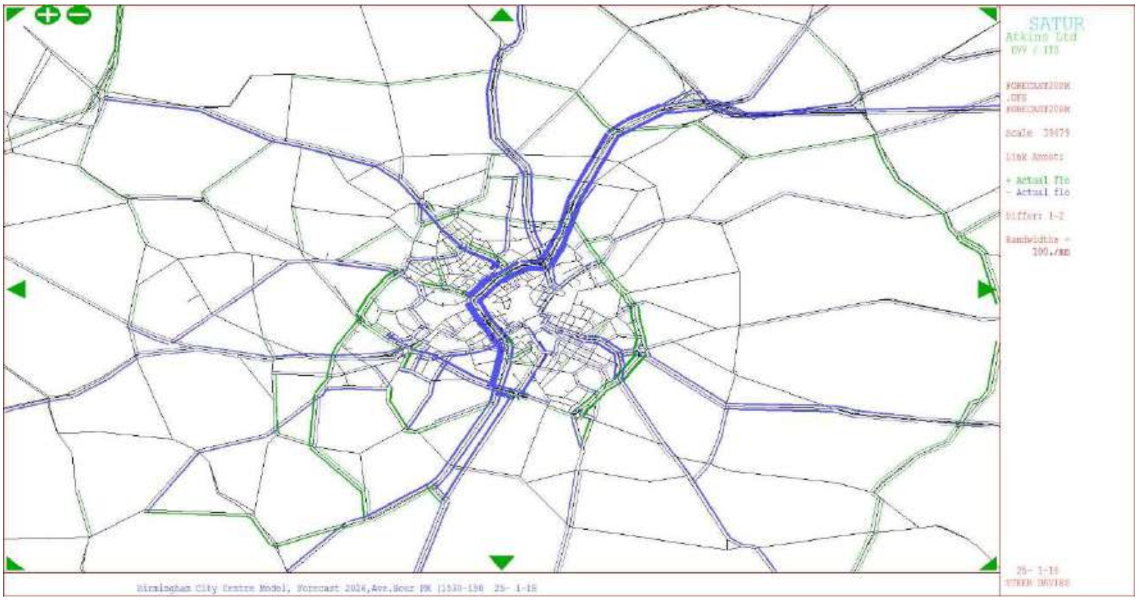


Figure 5-58: Compliant Flow Change (CAZ D Medium – Do Minimum) – PM

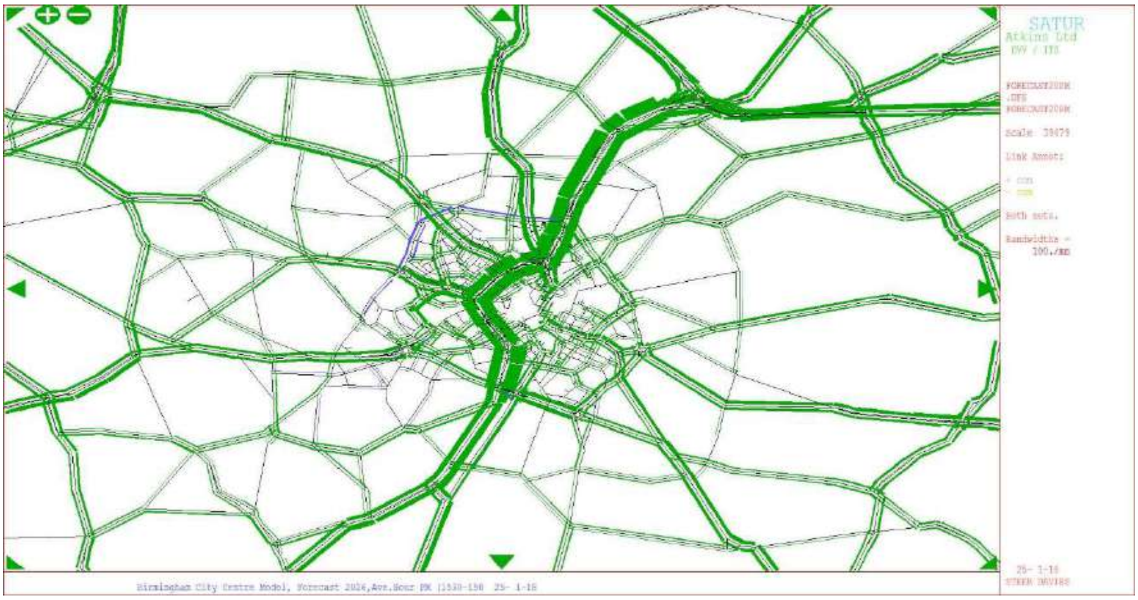


Figure 5-59: Non-compliant Flow Change (CAZ D Medium – Do Minimum) – PM

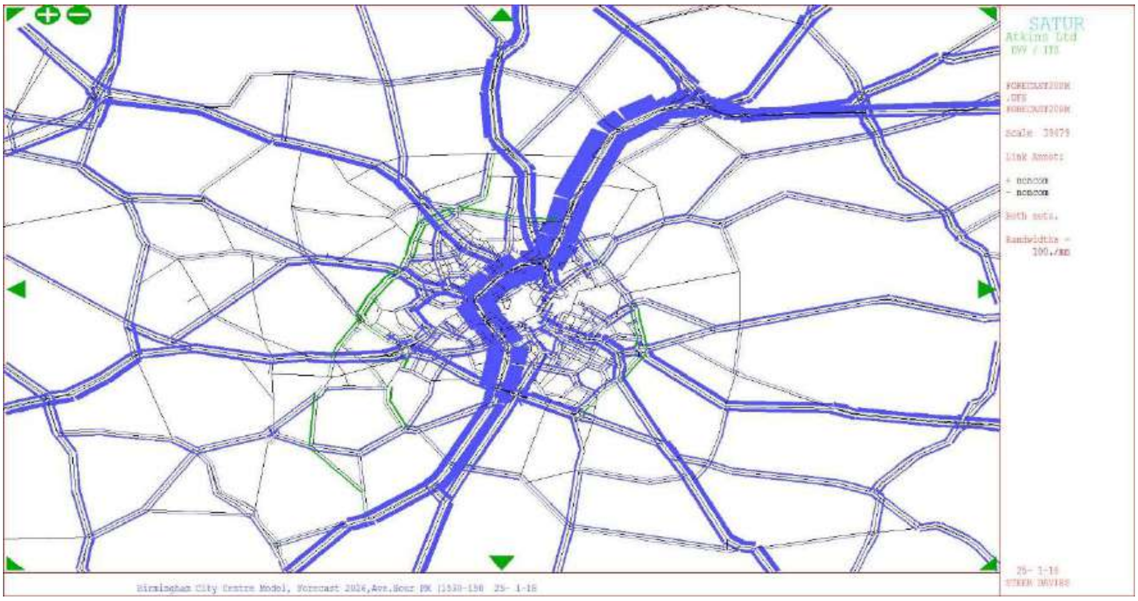


Figure 5-60: Link Delay Change (CAZ D Medium – Do Minimum) – PM

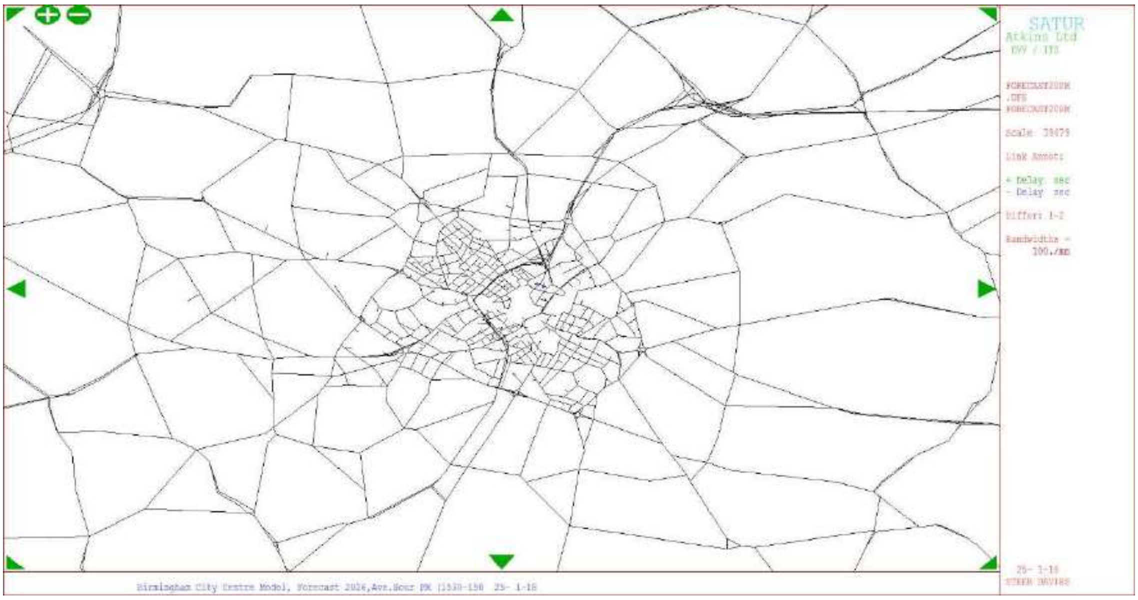


Figure 5-61: Total Flow Change (CAZ D High – Do Minimum) – AM

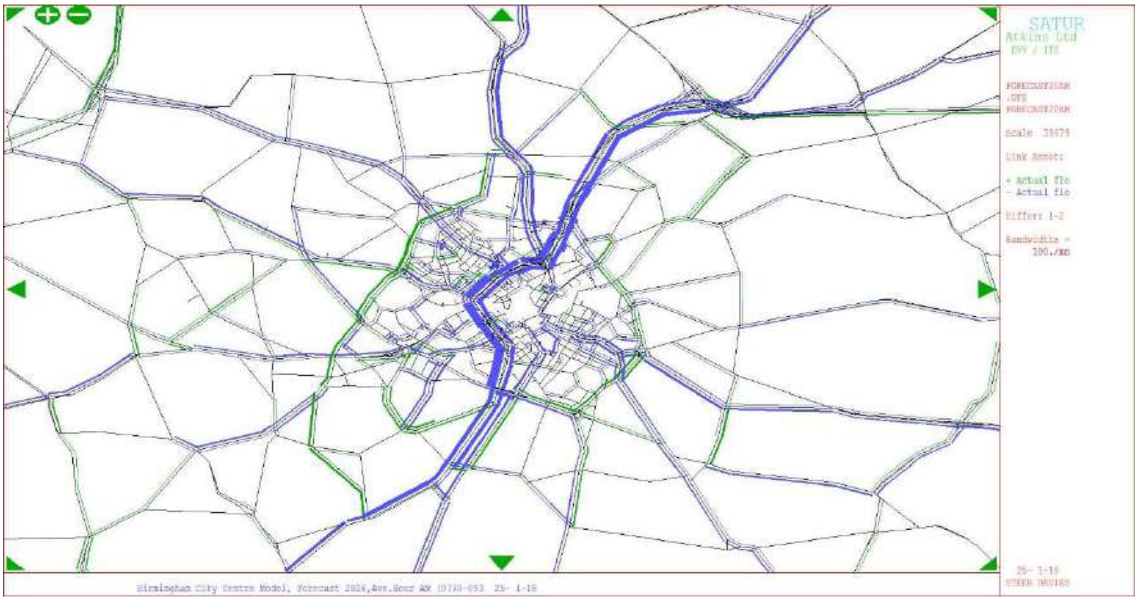


Figure 5-62: Compliant Flow Change (CAZ D High – Do Minimum) – AM

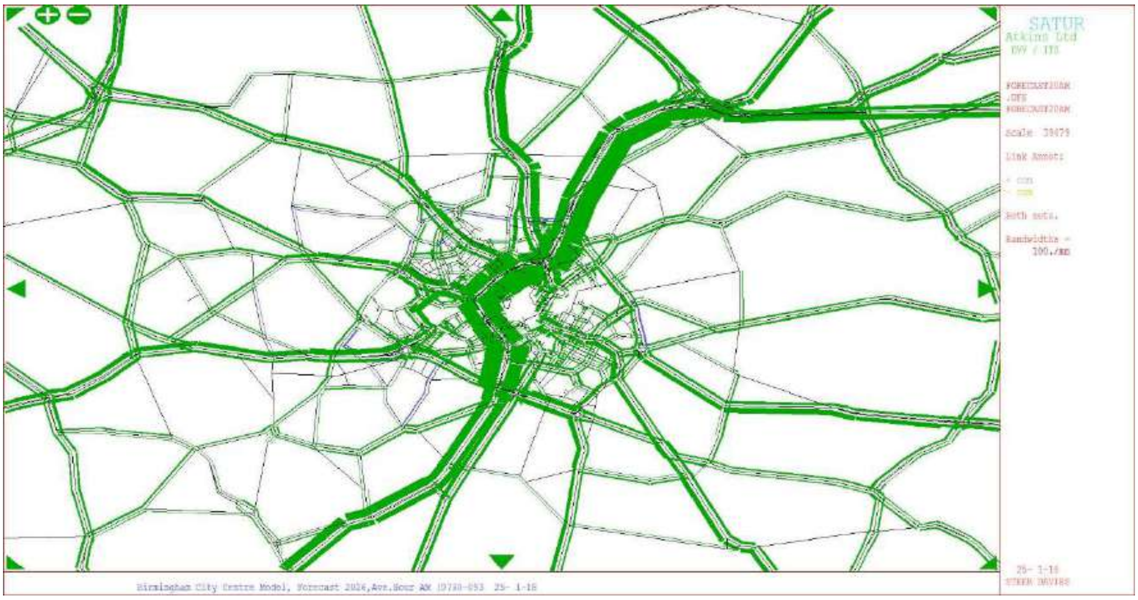


Figure 5-63: Non-compliant Flow Change (CAZ D High – Do Minimum) – AM

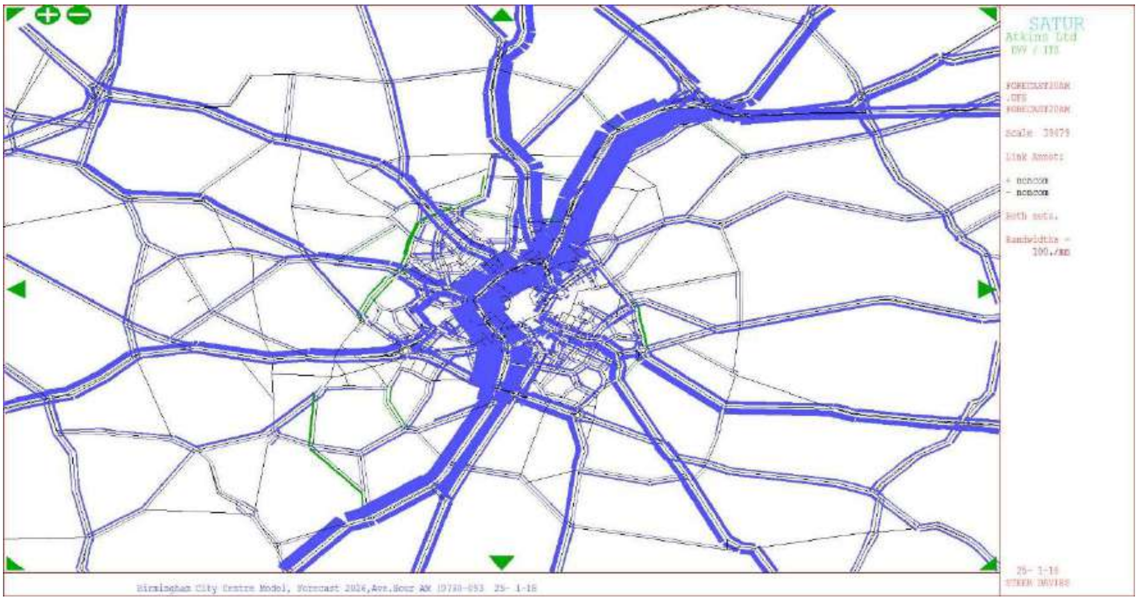


Figure 5-64: Link Delay Change (CAZ D High – Do Minimum) – AM

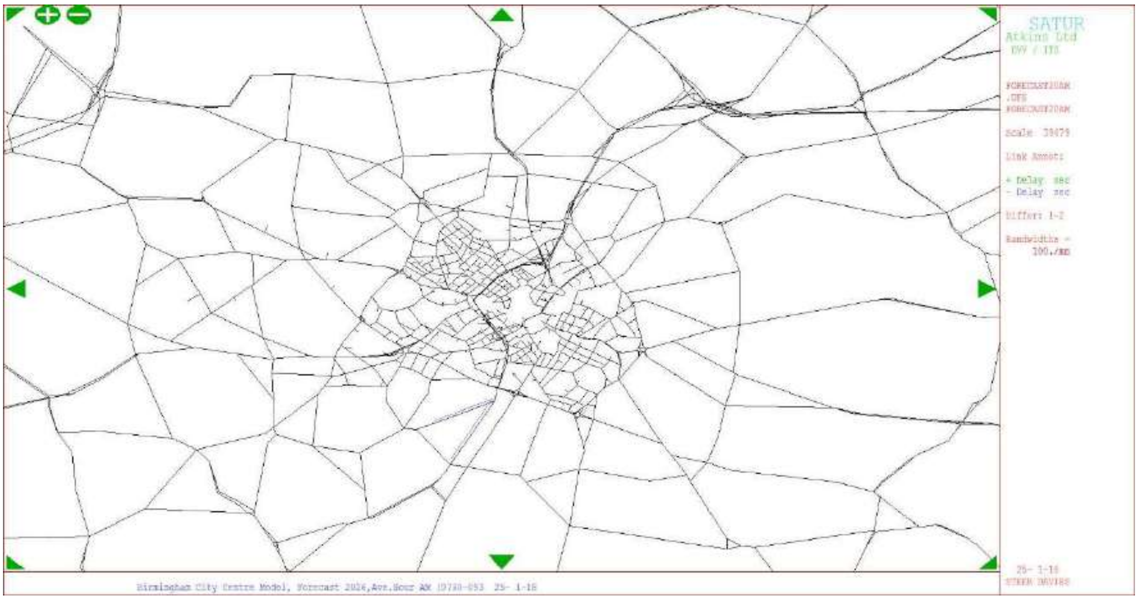


Figure 5-65: Total Flow Change (CAZ D High – Do Minimum) – IP

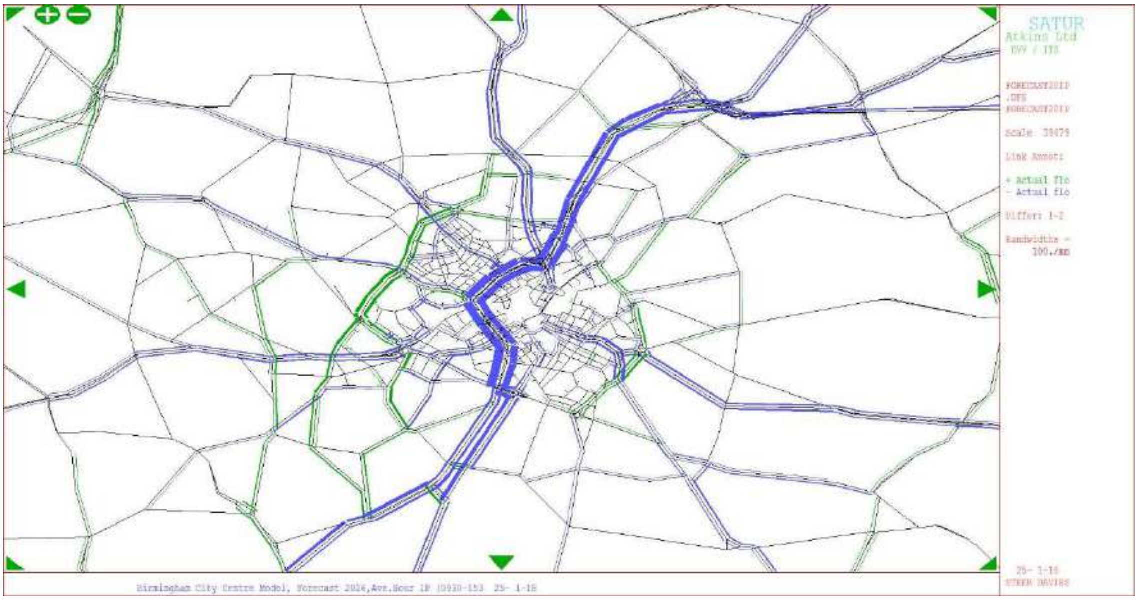


Figure 5-66: Compliant Flow Change (CAZ D High – Do Minimum) – IP

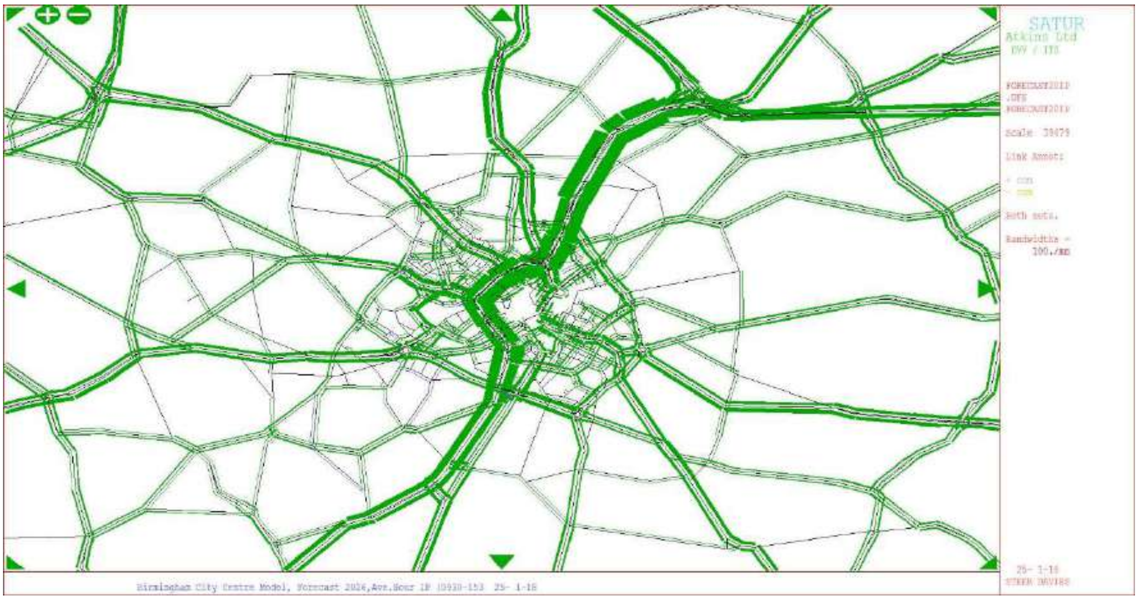


Figure 5-67: Non-compliant Flow Change (CAZ D High – Do Minimum) – IP

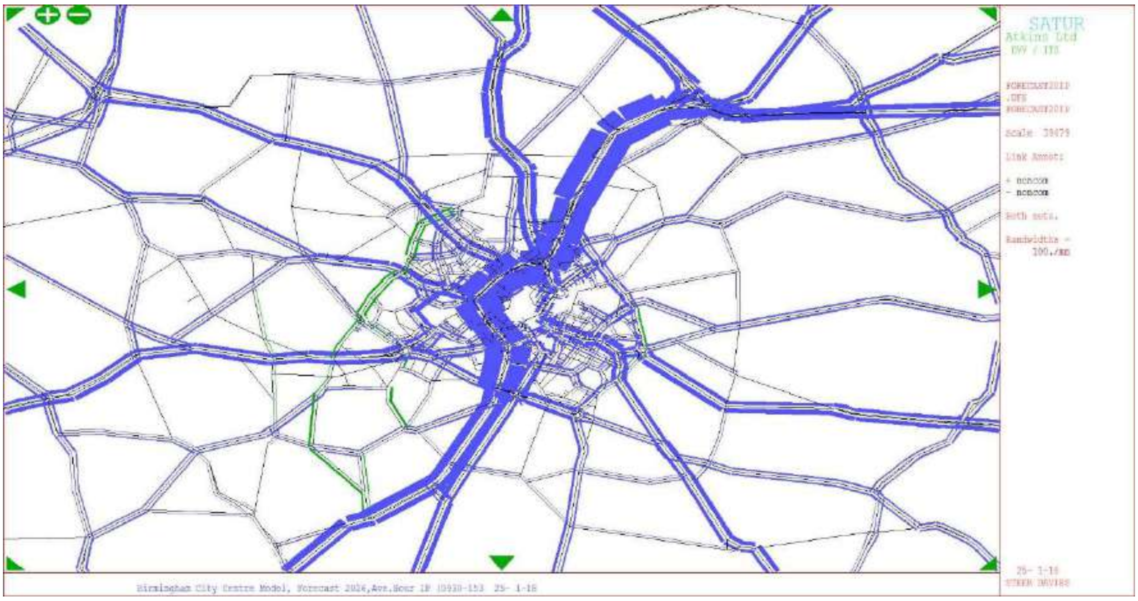


Figure 5-68: Link Delay Change (CAZ D High – Do Minimum) – IP

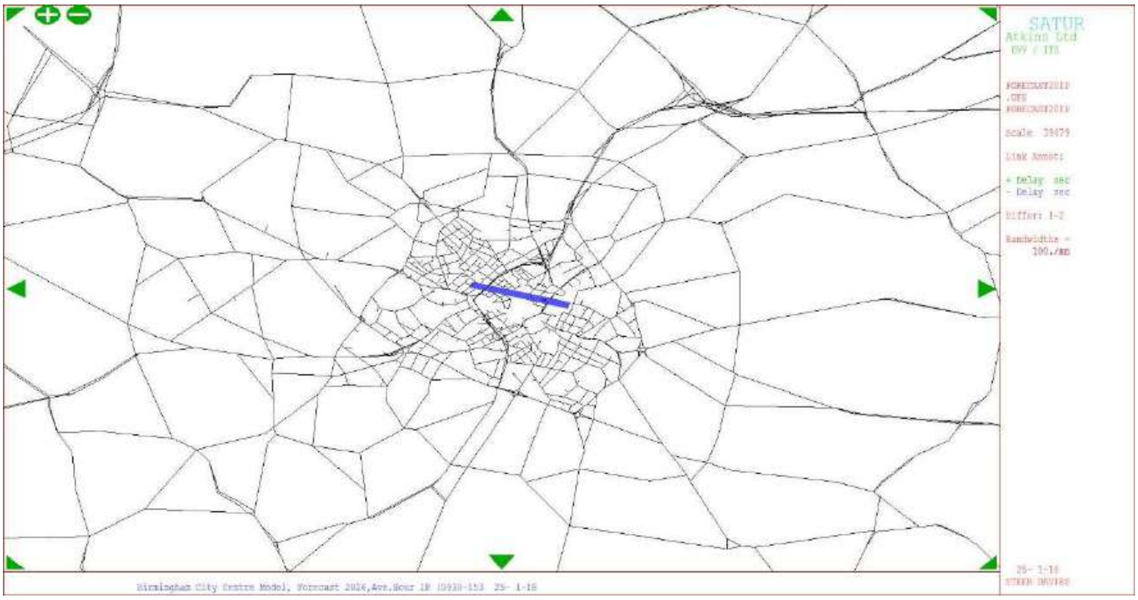


Figure 5-69: Total Flow Change (CAZ D High – Do Minimum) – PM

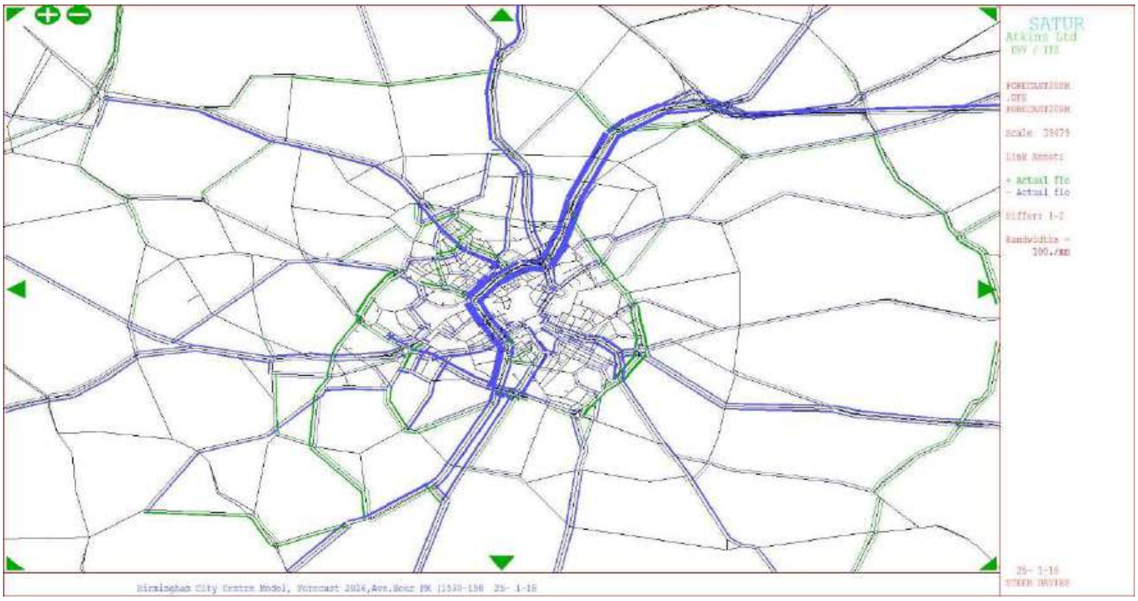


Figure 5-70: Compliant Flow Change (CAZ D High – Do Minimum) – PM

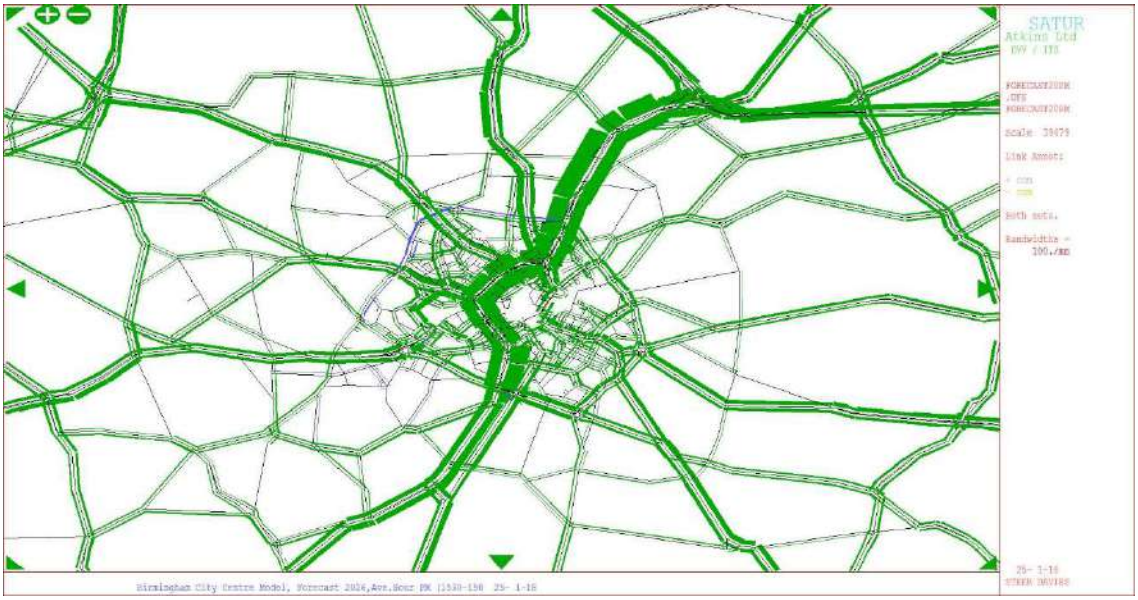


Figure 5-71: Non-compliant Flow Change (CAZ D High – Do Minimum) – PM

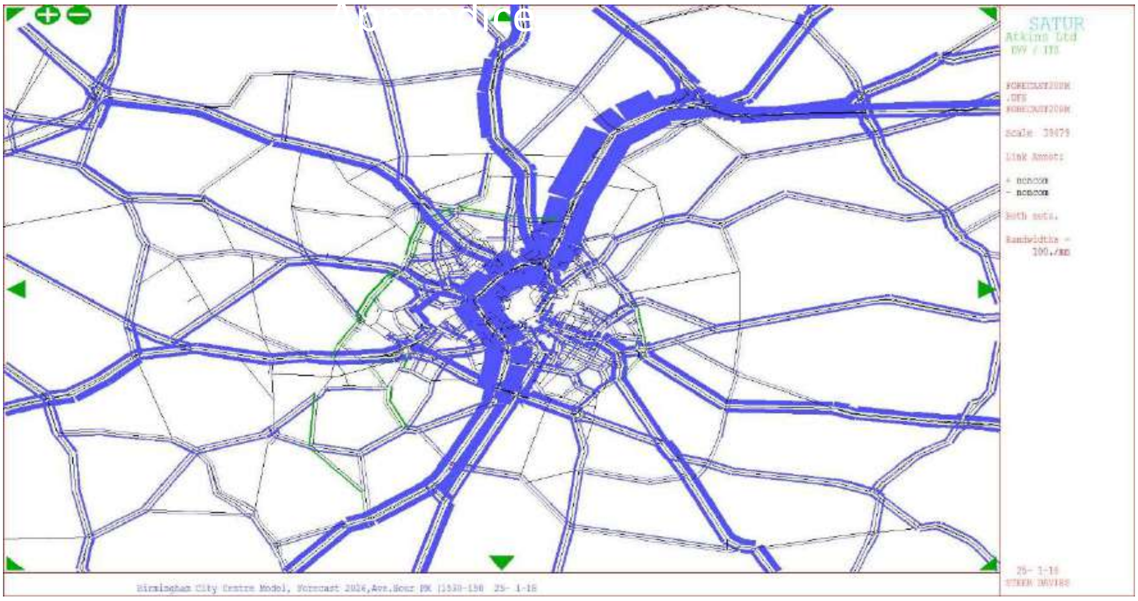
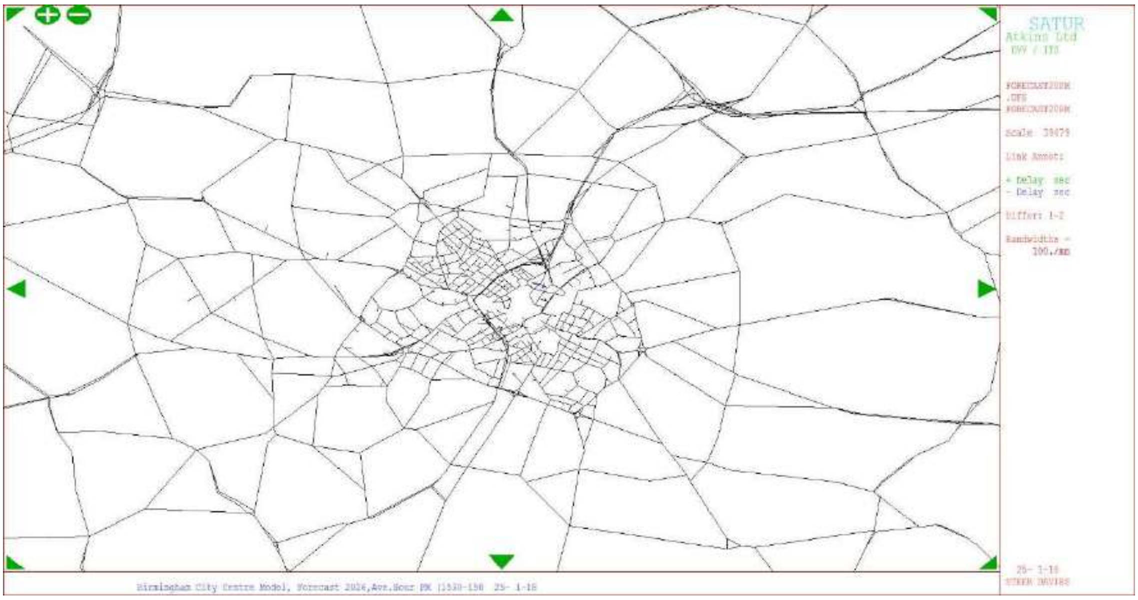


Figure 5-72: Link Delay Change (CAZ D High – Do Minimum) – PM



D Network Statistics Tables

Table D.1: Vehicle KMs (whole network) – CAZ C Low

Do Minimum	Car/ PHV	Taxi	LGV	HGV	Total
Compliant	16,143,303	240,274	2,450,333	3,482,024	22,315,933
Non-compliant	4,905,726	611,606	1,709,811	1,858,001	9,085,144
Total	21,049,029	851,880	4,160,144	5,340,025	31,401,077
CAZ C Low	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	16,165,047	851,921	2,471,779	3,517,535	23,006,281
Non-compliant	4,884,478	0	1,689,773	1,824,088	8,398,338
Total	21,049,524	851,921	4,161,552	5,341,622	31,404,620
(CAZ C Low – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	21,744	611,648	21,446	35,511	690,348
Non-compliant	-21,249	-611,606	-20,038	-33,913	-686,805
Total	496	42	1,408	1,598	3,543
(CAZ C Low – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	0.1%	254.6%	0.9%	1.0%	3.1%
Non-compliant	-0.4%	-100.0%	-1.2%	-1.8%	-7.6%
Total	0.0%	0.0%	0.0%	0.0%	0.0%

Table.2: Vehicle KMs (CAZ) – CAZ C Low

Do Minimum	Car/ PHV	Taxi	LGV	HGV	Total
Compliant	354,776	5,306	33,729	25,940	419,751
Non-compliant	108,688	13,507	23,624	13,900	159,719
Total	463,464	18,813	57,353	39,840	579,470
CAZ C Low	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	360,922	18,957	38,088	32,642	450,609
Non-compliant	105,756	0	14,206	3,963	123,925
Total	466,678	18,957	52,294	36,605	574,534
(CAZ C Low – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	6,146	13,650	4,359	6,702	30,858
Non-compliant	-2,932	-13,507	-9,418	-9,937	-35,794
Total	3,215	143	-5,059	-3,235	-4,936
(CAZ C Low – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	1.7%	257.2%	12.9%	25.8%	7.4%
Non-compliant	-2.7%	-100.0%	-39.9%	-71.5%	-22.4%
Total	0.7%	0.8%	-8.8%	-8.1%	-0.9%

Table D.2: Vehicle KMs (Ring Road) – CAZ C Low

Do Minimum	Car/ PHV	Taxi	LGV	HGV	Total
Compliant	218,018	3,268	24,829	26,022	272,136
Non-compliant	65,917	8,319	17,306	13,854	105,396
Total	283,934	11,587	42,134	39,876	377,532
CAZ C Low	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	217,143	11,464	25,841	28,052	282,499
Non-compliant	64,304	0	19,697	13,761	97,761
Total	281,446	11,464	45,538	41,812	380,260
(CAZ C Low – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	-875	8,195	1,012	2,030	10,362
Non-compliant	-1,613	-8,319	2,391	-94	-7,634
Total	-2,488	-124	3,404	1,936	2,728
(CAZ C Low – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	-0.4%	250.8%	4.1%	7.8%	3.8%
Non-compliant	-2.4%	-100.0%	13.8%	-0.7%	-7.2%
Total	-0.9%	-1.1%	8.1%	4.9%	0.7%

Table.3: Vehicle KMs (Non-CAZ) – CAZ C Low

Do Minimum	Car/ PHV	Taxi	LGV	HGV	Total
Compliant	15,591,245	232,009	2,393,552	3,431,498	21,648,303
Non-compliant	4,737,422	590,568	1,670,116	1,831,008	8,829,114
Total	20,328,667	822,577	4,063,667	5,262,506	30,477,417
CAZ C Low	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	15,607,966	822,599	2,409,898	3,458,748	22,299,210
Non-compliant	4,720,465	0	1,656,837	1,806,649	8,183,951
Total	20,328,431	822,599	4,066,735	5,265,397	30,483,161
(CAZ C Low – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	16,721	590,590	16,347	27,250	650,907
Non-compliant	-16,957	-590,568	-13,279	-24,359	-645,163
Total	-236	22	3,068	2,891	5,744
(CAZ C Low – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	0.1%	254.6%	0.7%	0.8%	3.0%
Non-compliant	-0.4%	-100.0%	-0.8%	-1.3%	-7.3%
Total	0.0%	0.0%	0.1%	0.1%	0.0%

Table D.3: Vehicle KMs (whole network) – CAZ C Medium

Do Minimum	Car/ PHV	Taxi	LGV	HGV	Total
Compliant	16,143,303	240,274	2,450,333	3,482,024	22,315,933
Non-compliant	4,905,726	611,606	1,709,811	1,858,001	9,085,144
Total	21,049,029	851,880	4,160,144	5,340,025	31,401,077
CAZ C Medium	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	16,164,965	851,909	2,478,367	3,532,445	23,027,686
Non-compliant	4,884,469	0	1,683,210	1,809,052	8,376,731
Total	21,049,434	851,909	4,161,577	5,341,497	31,404,416
(CAZ C Medium – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	21,663	611,636	28,034	50,421	711,753
Non-compliant	-21,257	-611,606	-26,601	-48,949	-708,413
Total	405	30	1,433	1,472	3,340
(CAZ C Medium – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	0.1%	254.6%	1.1%	1.4%	3.2%
Non-compliant	-0.4%	-100.0%	-1.6%	-2.6%	-7.8%
Total	0.0%	0.0%	0.0%	0.0%	0.0%

Table.4: Vehicle KMs (CAZ) – CAZ C Medium

Do Minimum	Car/ PHV	Taxi	LGV	HGV	Total
Compliant	354,776	5,306	33,729	25,940	419,751
Non-compliant	108,688	13,507	23,624	13,900	159,719
Total	463,464	18,813	57,353	39,840	579,470
CAZ C Medium	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	360,921	18,954	39,335	35,477	454,688
Non-compliant	105,813	0	12,946	1,108	119,868
Total	466,734	18,954	52,282	36,585	574,555
(CAZ C Medium – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	6,145	13,648	5,606	9,537	34,937
Non-compliant	-2,875	-13,507	-10,678	-12,791	-39,851
Total	3,270	141	-5,072	-3,254	-4,914
(CAZ C Medium – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	1.7%	257.2%	16.6%	36.8%	8.3%
Non-compliant	-2.6%	-100.0%	-45.2%	-92.0%	-25.0%
Total	0.7%	0.8%	-8.8%	-8.2%	-0.8%

Table D.4: Vehicle KMs (Ring Road) – CAZ C Medium

Do Minimum	Car/ PHV	Taxi	LGV	HGV	Total
Compliant	218,018	3,268	24,829	26,022	272,136
Non-compliant	65,917	8,319	17,306	13,854	105,396
Total	283,934	11,587	42,134	39,876	377,532
CAZ C Medium	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	216,959	11,447	26,238	28,961	283,604
Non-compliant	64,215	0	19,298	12,898	96,411
Total	281,174	11,447	45,536	41,858	380,015
(CAZ C Medium – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	-1,059	8,179	1,409	2,938	11,468
Non-compliant	-1,702	-8,319	1,992	-956	-8,985
Total	-2,760	-140	3,402	1,982	2,483
(CAZ C Medium – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	-0.5%	250.2%	5.7%	11.3%	4.2%
Non-compliant	-2.6%	-100.0%	11.5%	-6.9%	-8.5%
Total	-1.0%	-1.2%	8.1%	5.0%	0.7%

Table D.5: Vehicle KMs (Non-CAZ) – CAZ C Medium

Do Minimum	Car/ PHV	Taxi	LGV	HGV	Total
Compliant	15,591,245	232,009	2,393,552	3,431,498	21,648,303
Non-compliant	4,737,422	590,568	1,670,116	1,831,008	8,829,114
Total	20,328,667	822,577	4,063,667	5,262,506	30,477,417
CAZ C Medium	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	15,608,069	822,605	2,414,924	3,470,117	22,315,714
Non-compliant	4,720,496	0	1,651,847	1,795,139	8,167,481
Total	20,328,564	822,605	4,066,770	5,265,256	30,483,195
(CAZ C Medium – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	16,824	590,596	21,372	38,619	667,410
Non-compliant	-16,926	-590,568	-18,269	-35,870	-661,633
Total	-103	28	3,103	2,750	5,778
(CAZ C Medium – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	0.1%	254.6%	0.9%	1.1%	3.1%
Non-compliant	-0.4%	-100.0%	-1.1%	-2.0%	-7.5%
Total	0.0%	0.0%	0.1%	0.1%	0.0%

Table D.6: Vehicle KMs (whole network) – CAZ C High

Do Minimum	Car/ PHV	Taxi	LGV	HGV	Total
Compliant	16,143,303	240,274	2,450,333	3,482,024	22,315,933
Non-compliant	4,905,726	611,606	1,709,811	1,858,001	9,085,144
Total	21,049,029	851,880	4,160,144	5,340,025	31,401,077
CAZ C High	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	16,164,889	851,909	2,495,610	3,535,424	23,047,831
Non-compliant	4,884,447	0	1,665,953	1,806,082	8,356,482
Total	21,049,335	851,909	4,161,563	5,341,506	31,404,312
(CAZ C High – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	21,586	611,636	45,277	53,400	731,898
Non-compliant	-21,280	-611,606	-43,858	-51,919	-728,662
Total	306	30	1,419	1,481	3,235
(CAZ C High – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	0.1%	254.6%	1.8%	1.5%	3.3%
Non-compliant	-0.4%	-100.0%	-2.6%	-2.8%	-8.0%
Total	0.0%	0.0%	0.0%	0.0%	0.0%

Table D.7: Vehicle KMs (CAZ) – CAZ C High

Do Minimum	Car/ PHV	Taxi	LGV	HGV	Total
Compliant	354,776	5,306	33,729	25,940	419,751
Non-compliant	108,688	13,507	23,624	13,900	159,719
Total	463,464	18,813	57,353	39,840	579,470
CAZ C High	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	360,954	18,957	42,621	36,022	458,555
Non-compliant	105,822	0	9,631	542	115,994
Total	466,776	18,957	52,252	36,564	574,549
(CAZ C High – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	6,178	13,651	8,892	10,082	38,804
Non-compliant	-2,866	-13,507	-13,994	-13,358	-43,724
Total	3,312	144	-5,101	-3,276	-4,921
(CAZ C High – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	1.7%	257.3%	26.4%	38.9%	9.2%
Non-compliant	-2.6%	-100.0%	-59.2%	-96.1%	-27.4%
Total	0.7%	0.8%	-8.9%	-8.2%	-0.8%

Table D.8: Vehicle KMs (Ring Road) – CAZ C High

Do Minimum	Car/ PHV	Taxi	LGV	HGV	Total
Compliant	218,018	3,268	24,829	26,022	272,136
Non-compliant	65,917	8,319	17,306	13,854	105,396
Total	283,934	11,587	42,134	39,876	377,532
CAZ C High	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	216,966	11,446	27,294	29,147	284,853
Non-compliant	64,219	0	18,278	12,726	95,222
Total	281,185	11,446	45,572	41,872	380,075
(CAZ C High – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	-1,051	8,178	2,466	3,125	12,717
Non-compliant	-1,698	-8,319	972	-1,129	-10,173
Total	-2,749	-141	3,438	1,996	2,543
(CAZ C High – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	-0.5%	250.2%	9.9%	12.0%	4.7%
Non-compliant	-2.6%	-100.0%	5.6%	-8.1%	-9.7%
Total	-1.0%	-1.2%	8.2%	5.0%	0.7%

Table D.9: Vehicle KMs (Non-CAZ) – CAZ C High

Do Minimum	Car/ PHV	Taxi	LGV	HGV	Total
Compliant	15,591,245	232,009	2,393,552	3,431,498	21,648,303
Non-compliant	4,737,422	590,568	1,670,116	1,831,008	8,829,114
Total	20,328,667	822,577	4,063,667	5,262,506	30,477,417
CAZ C High	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	15,607,952	822,603	2,428,044	3,472,406	22,331,004
Non-compliant	4,720,456	0	1,638,707	1,792,866	8,152,028
Total	20,328,407	822,603	4,066,751	5,265,272	30,483,033
(CAZ C High – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	16,707	590,594	34,493	40,908	682,701
Non-compliant	-16,966	-590,568	-31,409	-38,142	-677,085
Total	-260	27	3,084	2,766	5,616
(CAZ C High – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	0.1%	254.6%	1.4%	1.2%	3.2%
Non-compliant	-0.4%	-100.0%	-1.9%	-2.1%	-7.7%
Total	0.0%	0.0%	0.1%	0.1%	0.0%

Table D.10: Vehicle KMs (whole network) – CAZ D Low

Do Minimum	Car/ PHV	Taxi	LGV	HGV	Total
Compliant	16,143,303	240,274	2,450,333	3,482,024	22,315,933
Non-compliant	4,905,726	611,606	1,709,811	1,858,001	9,085,144
Total	21,049,029	851,880	4,160,144	5,340,025	31,401,077
CAZ D Low	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	16,302,963	851,922	2,471,729	3,535,564	23,162,178
Non-compliant	4,725,996	0	1,689,817	1,806,157	8,221,969
Total	21,028,959	851,922	4,161,546	5,341,721	31,384,147
(CAZ D Low – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	159,661	611,649	21,396	53,540	846,245
Non-compliant	-179,730	-611,606	-19,995	-51,844	-863,174
Total	-20,070	43	1,402	1,696	-16,930
(CAZ D Low – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	1.0%	254.6%	0.9%	1.5%	3.8%
Non-compliant	-3.7%	-100.0%	-1.2%	-2.8%	-9.5%
Total	-0.1%	0.0%	0.0%	0.0%	-0.1%

Table D.11: Vehicle KMs (CAZ) – CAZ D Low

Do Minimum	Car/ PHV	Taxi	LGV	HGV	Total
Compliant	354,776	5,306	33,729	25,940	419,751
Non-compliant	108,688	13,507	23,624	13,900	159,719
Total	463,464	18,813	57,353	39,840	579,470
CAZ D Low	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	392,610	19,392	38,857	36,451	487,311
Non-compliant	56,770	0	14,295	544	71,609
Total	449,380	19,392	53,153	36,995	558,919
(CAZ D Low – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	37,835	14,086	5,128	10,511	67,560
Non-compliant	-51,918	-13,507	-9,329	-13,356	-88,110
Total	-14,083	579	-4,201	-2,845	-20,550
(CAZ D Low – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	10.7%	265.5%	15.2%	40.5%	16.1%
Non-compliant	-47.8%	-100.0%	-39.5%	-96.1%	-55.2%
Total	-3.0%	3.1%	-7.3%	-7.1%	-3.5%

Table D.12: Vehicle KMs (Ring Road) – CAZ D Low

Do Minimum	Car/ PHV	Taxi	LGV	HGV	Total
Compliant	218,018	3,268	24,829	26,022	272,136
Non-compliant	65,917	8,319	17,306	13,854	105,396
Total	283,934	11,587	42,134	39,876	377,532
CAZ D Low	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	218,192	11,133	25,270	28,842	283,437
Non-compliant	67,486	0	19,532	12,672	99,691
Total	285,678	11,133	44,803	41,514	383,128
(CAZ D Low – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	174	7,865	442	2,820	11,301
Non-compliant	1,570	-8,319	2,227	-1,182	-5,705
Total	1,744	-454	2,668	1,638	5,596
(CAZ D Low – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	0.1%	240.7%	1.8%	10.8%	4.2%
Non-compliant	2.4%	-100.0%	12.9%	-8.5%	-5.4%
Total	0.6%	-3.9%	6.3%	4.1%	1.5%

Table D.13: Vehicle KMs (Non-CAZ) – CAZ D Low

Do Minimum	Car/ PHV	Taxi	LGV	HGV	Total
Compliant	15,591,245	232,009	2,393,552	3,431,498	21,648,303
Non-compliant	4,737,422	590,568	1,670,116	1,831,008	8,829,114
Total	20,328,667	822,577	4,063,667	5,262,506	30,477,417
CAZ D Low	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	15,714,766	822,494	2,409,645	3,472,419	22,419,323
Non-compliant	4,605,692	0	1,656,950	1,792,995	8,055,637
Total	20,320,458	822,494	4,066,595	5,265,414	30,474,960
(CAZ D Low – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	123,521	590,485	16,093	40,921	771,020
Non-compliant	-131,731	-590,568	-13,166	-38,013	-773,477
Total	-8,210	-83	2,928	2,908	-2,457
(CAZ D Low – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	0.8%	254.5%	0.7%	1.2%	3.6%
Non-compliant	-2.8%	-100.0%	-0.8%	-2.1%	-8.8%
Total	0.0%	0.0%	0.1%	0.1%	0.0%

Table D.14: Vehicle KMs (whole network) – CAZ D Medium

Do Minimum	Car/ PHV	Taxi	LGV	HGV	Total
Compliant	16,143,303	240,274	2,450,333	3,482,024	22,315,933
Non-compliant	4,905,726	611,606	1,709,811	1,858,001	9,085,144
Total	21,049,029	851,880	4,160,144	5,340,025	31,401,077
CAZ D Medium	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	16,340,898	851,892	2,478,231	3,534,900	23,205,920
Non-compliant	4,658,562	0	1,683,161	1,805,972	8,147,695
Total	20,999,460	851,892	4,161,392	5,340,871	31,353,615
(CAZ D Medium – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	197,596	611,618	27,898	52,876	889,987
Non-compliant	-247,164	-611,606	-26,650	-52,029	-937,449
Total	-49,569	12	1,248	847	-47,462
(CAZ D Medium – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	1.2%	254.6%	1.1%	1.5%	4.0%
Non-compliant	-5.0%	-100.0%	-1.6%	-2.8%	-10.3%
Total	-0.2%	0.0%	0.0%	0.0%	-0.2%

Table D.15: Vehicle KMs (CAZ) – CAZ D Medium

Do Minimum	Car/ PHV	Taxi	LGV	HGV	Total
Compliant	354,776	5,306	33,729	25,940	419,751
Non-compliant	108,688	13,507	23,624	13,900	159,719
Total	463,464	18,813	57,353	39,840	579,470
CAZ D Medium	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	400,459	19,428	40,263	36,657	496,807
Non-compliant	40,834	0	13,042	544	54,420
Total	441,293	19,428	53,305	37,201	551,227
(CAZ D Medium – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	45,683	14,122	6,534	10,717	77,056
Non-compliant	-67,854	-13,507	-10,582	-13,356	-105,298
Total	-22,170	615	-4,048	-2,639	-28,242
(CAZ D Medium – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	12.9%	266.1%	19.4%	41.3%	18.4%
Non-compliant	-62.4%	-100.0%	-44.8%	-96.1%	-65.9%
Total	-4.8%	3.3%	-7.1%	-6.6%	-4.9%

Table D.16: Vehicle KMs (Ring Road) – CAZ D Medium

Do Minimum	Car/ PHV	Taxi	LGV	HGV	Total
Compliant	218,018	3,268	24,829	26,022	272,136
Non-compliant	65,917	8,319	17,306	13,854	105,396
Total	283,934	11,587	42,134	39,876	377,532
CAZ D Medium	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	219,801	11,145	25,664	28,925	285,536
Non-compliant	64,188	0	19,224	12,762	96,174
Total	283,990	11,145	44,888	41,687	381,710
(CAZ D Medium – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	1,784	7,877	836	2,903	13,400
Non-compliant	-1,728	-8,319	1,918	-1,092	-9,222
Total	55	-442	2,754	1,811	4,178
(CAZ D Medium – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	0.8%	241.0%	3.4%	11.2%	4.9%
Non-compliant	-2.6%	-100.0%	11.1%	-7.9%	-8.7%
Total	0.0%	-3.8%	6.5%	4.5%	1.1%

Table D.17: Vehicle KMs (Non-CAZ) – CAZ D Medium

Do Minimum	Car/ PHV	Taxi	LGV	HGV	Total
Compliant	15,591,245	232,009	2,393,552	3,431,498	21,648,303
Non-compliant	4,737,422	590,568	1,670,116	1,831,008	8,829,114
Total	20,328,667	822,577	4,063,667	5,262,506	30,477,417
CAZ D Medium	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	15,743,702	822,415	2,414,433	3,471,469	22,452,019
Non-compliant	4,556,489	0	1,651,776	1,792,722	8,000,986
Total	20,300,191	822,415	4,066,209	5,264,191	30,453,005
(CAZ D Medium – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	152,457	590,406	20,882	39,971	803,716
Non-compliant	-180,934	-590,568	-18,340	-38,287	-828,128
Total	-28,477	-162	2,542	1,685	-24,412
(CAZ D Medium – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	1.0%	254.5%	0.9%	1.2%	3.7%
Non-compliant	-3.8%	-100.0%	-1.1%	-2.1%	-9.4%
Total	-0.1%	0.0%	0.1%	0.0%	-0.1%

Table D.18: Vehicle KMs (whole network) – CAZ D High

Do Minimum	Car/ PHV	Taxi	LGV	HGV	Total
Compliant	16,143,303	240,274	2,450,333	3,482,024	22,315,933
Non-compliant	4,905,726	611,606	1,709,811	1,858,001	9,085,144
Total	21,049,029	851,880	4,160,144	5,340,025	31,401,077
CAZ D High	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	16,434,816	851,828	2,495,437	3,533,515	23,315,596
Non-compliant	4,531,929	0	1,665,889	1,805,782	8,003,600
Total	20,966,745	851,828	4,161,326	5,339,297	31,319,196
(CAZ D High – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	291,514	611,555	45,104	51,491	999,663
Non-compliant	-373,797	-611,606	-43,922	-52,219	-1,081,543
Total	-82,284	-51	1,182	-728	-81,880
(CAZ D High – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	1.8%	254.5%	1.8%	1.5%	4.5%
Non-compliant	-7.6%	-100.0%	-2.6%	-2.8%	-11.9%
Total	-0.4%	0.0%	0.0%	0.0%	-0.3%

Table D.19: Vehicle KMs (CAZ) – CAZ D High

Do Minimum	Car/ PHV	Taxi	LGV	HGV	Total
Compliant	354,776	5,306	33,729	25,940	419,751
Non-compliant	108,688	13,507	23,624	13,900	159,719
Total	463,464	18,813	57,353	39,840	579,470
CAZ D High	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	418,641	19,458	43,722	37,246	519,067
Non-compliant	13,738	0	9,718	544	24,001
Total	432,379	19,458	53,440	37,791	543,068
(CAZ D High – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	63,865	14,152	9,993	11,306	99,316
Non-compliant	-94,950	-13,507	-13,906	-13,355	-135,718
Total	-31,085	645	-3,913	-2,049	-36,402
(CAZ D High – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	18.0%	266.7%	29.6%	43.6%	23.7%
Non-compliant	-87.4%	-100.0%	-58.9%	-96.1%	-85.0%
Total	-6.7%	3.4%	-6.8%	-5.1%	-6.3%

Table D.20: Vehicle KMs (Ring Road) – CAZ D High

Do Minimum	Car/ PHV	Taxi	LGV	HGV	Total
Compliant	218,018	3,268	24,829	26,022	272,136
Non-compliant	65,917	8,319	17,306	13,854	105,396
Total	283,934	11,587	42,134	39,876	377,532
CAZ D High	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	223,625	11,133	26,692	28,995	290,446
Non-compliant	58,274	0	18,291	12,860	89,426
Total	281,900	11,133	44,983	41,856	379,872
(CAZ D High – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	5,608	7,865	1,863	2,973	18,310
Non-compliant	-7,643	-8,319	985	-994	-15,970
Total	-2,035	-454	2,849	1,980	2,340
(CAZ D High – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	2.6%	240.7%	7.5%	11.4%	6.7%
Non-compliant	-11.6%	-100.0%	5.7%	-7.2%	-15.2%
Total	-0.7%	-3.9%	6.8%	5.0%	0.6%

Table D.21: Vehicle KMs (Non-CAZ) – CAZ D High

Do Minimum	Car/ PHV	Taxi	LGV	HGV	Total
Compliant	15,591,245	232,009	2,393,552	3,431,498	21,648,303
Non-compliant	4,737,422	590,568	1,670,116	1,831,008	8,829,114
Total	20,328,667	822,577	4,063,667	5,262,506	30,477,417
CAZ D High	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	15,816,738	822,334	2,427,379	3,469,424	22,535,874
Non-compliant	4,461,138	0	1,638,541	1,792,431	7,892,110
Total	20,277,876	822,334	4,065,920	5,261,855	30,427,984
(CAZ D High – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	225,493	590,325	33,827	37,926	887,571
Non-compliant	-276,284	-590,568	-31,575	-38,578	-937,004
Total	-50,792	-243	2,253	-652	-49,433
(CAZ D High – Do Minimum)	**Car/ PHV**	**Taxi**	**LGV**	**HGV**	**Total**
Compliant	1.4%	254.4%	1.4%	1.1%	4.1%
Non-compliant	-5.8%	-100.0%	-1.9%	-2.1%	-10.6%
Total	-0.2%	0.0%	0.1%	0.0%	-0.2%

E Convergence

Ass. - DELTA FUNCTION (%) / NUMBER OF ITERATIONS

Sim. - FINAL AVER ABS CHANGE IN OUT CFP (PCU/HR) / NUMBER OF ITERATIONS

A/S Step - Step Length used on Ass/Sim Loop / Simulation Iterations

%FLOWS - LINK FLOWS DIFFERING BY < 1% BETWEEN ASS-SIM LOOPS

%DELAYS - TURN DELAYS DIFFERING BY < 1% BETWEEN ASSIGNMENT & SIMULATION

%V.I. - VARIATIONAL INEQUALITY - SHOULD BE > 0

%GAP - WARDROP EQUILIBRIUM GAP FUNCTION POST SIMULATION

Table E.1: Summary of Convergence Measures and Acceptable Values in WebTAG 5

Measure of Convergence	Base Model Acceptable Values
Delta and %GAP	**Less than 0.1% or at least stable with convergence fully documented and all other criteria met**
Percentage of links with flow change (P)<1%	**Four consecutive iterations greater than 98%**
Percentage of links with cost change (P2)<1%	**Four consecutive iterations greater than 98%**
Percentage change in total user costs (V)	**Four consecutive iterations less than 0.1%b(SUE only)**

Table E.2: Convergence statistics of last 4 iterations - DM AM

LOOP	Ass.	Sim.	A/S Step	%FLOWS	%DELAYS	%V.I.	%GAP
45	0.0028/10	0.000/ 3	0.050/ 8	98.6	99.8	0	0.0031
46	0.0019/10	0.000/ 3	0.102/ 5	99	99.8	0.00011	0.004
47	0.0027/10	0.000/ 3	0.017/ 9	98.8	99.8	0.00005	0.0049
48	0.0025/10	0.002/ 4	0.343/ 2	99	99.8	0.00001	0.0061

Table E.3: Convergence statistics of last 4 iterations - DM IP

LOOP	Ass.	Sim.	A/S Step	%FLOWS	%DELAYS	%V.I.	%GAP
17	0.0004/12	0.000/ 7	1.000/ 1	98.5	99.8	0.00004	0.0022
18	0.0004/ 5	0.000/ 4	0.718/ 2	99.1	99.9	0	0.00039
19	0.0003/16	0.000/ 7	1.000/ 1	99.4	99.9	0.00004	0.0016
20	0.0006/16	0.000/ 7	1.000/ 1	99.1	99.9	0	0.00043

Table E.4: Convergence statistics of last 4 iterations - DM PM

LOOP	Ass.	Sim.	A/S Step	%FLOWS	%DELAYS	%V.I.	%GAP
40	0.0020/ 7	0.001/ 7	1.000/ 1	99	99.7	0	0.0037
41	0.0018/10	0.001/ 7	1.000/ 1	99	99.7	0.00003	0.0031
42	0.0017/12	0.001/ 7	1.000/ 1	99	99.8	0.00004	0.0047
43	0.0019/12	0.000/ 3	0.084/ 8	98.8	99.7	0	0.0024

Table E.5: Convergence statistics of last 4 iterations - CAZ C Low AM

LOOP	Ass.	Sim.	A/S Step	%FLOWS	%DELAYS	%V.I.	%GAP
39	0.0026/ 9	0.000/ 3	0.025/ 9	98.7	99.7	0	0.0031
40	0.0019/ 9	0.000/ 3	0.054/ 6	99	99.7	0.00002	0.0072
41	0.0023/ 9	0.000/ 3	0.038/ 9	98.8	99.7	0.00001	0.0031
42	0.0033/ 9	0.001/ 4	0.342/ 2	99.1	99.8	0.00001	0.014

Table E.6: Convergence statistics of last 4 iterations - CAZ C Low IP

LOOP	Ass.	Sim.	A/S Step	%FLOWS	%DELAYS	%V.I.	%GAP
20	0.0006/15	0.000/ 7	1.000/ 1	99	99.9	0.00006	0.00033
21	0.0002/10	0.000/ 7	1.000/ 1	99.2	99.8	0.00001	0.00034
22	0.0002/15	0.000/ 7	1.000/ 1	99.4	99.9	0.00002	0.0002
23	0.0001/11	0.000/ 7	1.000/ 1	99.6	99.9	0.00001	0.00016

Table E.7: Convergence statistics of last 4 iterations - CAZ C Low PM

LOOP	Ass.	Sim.	A/S Step	%FLOWS	%DELAYS	%V.I.	%GAP
30	0.0041/ 8	0.001/ 7	1.000/ 1	99.2	99.8	0.00015	0.0037
31	0.0032/ 8	0.006/ 7	1.000/ 1	98.9	99.7	0.00014	0.0053
32	0.0036/ 8	0.001/ 7	1.000/ 1	99.2	99.7	0.00005	0.0058
33	0.0037/ 8	0.001/ 3	0.568/ 4	98.6	99.7	0	0.0042

Table E.8: Convergence statistics of last 4 iterations - CAZ C Medium AM

LOOP	Ass.	Sim.	A/S Step	%FLOWS	%DELAYS	%V.I.	%GAP
41	0.0021/ 9	0.001/ 3	0.203/ 5	98.6	99.7	0.00001	0.0045
42	0.0023/ 9	0.001/ 7	1.000/ 1	99.3	99.9	0.0001	0.0032
43	0.0019/ 9	0.001/ 4	0.419/ 2	99.4	99.8	0.00006	0.013
44	0.0026/ 9	0.000/ 3	0.033/ 7	98.8	99.8	0.00039	0.011

Table E.9: Convergence statistics of last 4 iterations - CAZ C Medium IP

LOOP	Ass.	Sim.	A/S Step	%FLOWS	%DELAYS	%V.I.	%GAP
18	0.0003/17	0.000/ 7	1.000/ 1	99.1	99.8	0.00006	0.00042
19	0.0002/13	0.000/ 7	1.000/ 1	99.3	99.9	0.00003	0.00028
20	0.0002/17	0.000/ 7	1.000/ 1	99.2	99.8	0.00001	0.00057
21	0.0001/16	0.000/ 7	1.000/ 1	99.5	99.9	0.00001	0.00031

Table E.10: Convergence statistics of last 4 iterations - CAZ C Medium PM

LOOP	Ass.	Sim.	A/S Step	%FLOWS	%DELAYS	%V.I.	%GAP
34	0.0028/13	0.001/ 7	1.000/ 1	99.2	99.8	0.00013	0.0024
35	0.0026/13	0.002/ 7	1.000/ 1	99.1	99.7	0.0001	0.0021
36	0.0015/13	0.001/ 7	1.000/ 1	99.2	99.8	0.00009	0.0027
37	0.0015/13	0.001/ 7	1.000/ 1	99.3	99.7	0.00001	0.0025

Table E.11: Convergence statistics of last 4 iterations - CAZ C High AM

LOOP	Ass.	Sim.	A/S Step	%FLOWS	%DELAYS	%V.I.	%GAP
54	0.0019/ 9	0.001/ 3	0.129/ 4	99.1	99.7	0.00014	0.0028
55	0.0016/ 9	0.000/ 3	0.017/ 9	99.2	99.7	0.00002	0.0069
56	0.0018/ 9	0.002/ 4	0.341/ 2	98.9	99.8	0.00003	0.0041
57	0.0029/ 9	0.002/ 4	0.256/ 2	99	99.7	0.00004	0.0052

Table E.12: Convergence statistics of last 4 iterations - CAZ C High IP

LOOP	Ass.	Sim.	A/S Step	%FLOWS	%DELAYS	%V.I.	%GAP
16	0.0003/19	0.000/ 7	1.000/ 1	98.7	99.9	0.00009	0.00036
17	0.0002/19	0.000/ 7	1.000/ 1	99.3	99.9	0.00005	0.00025
18	0.0002/19	0.000/ 7	1.000/ 1	99.4	99.9	0.00003	0.00033
19	0.0002/10	0.000/ 7	1.000/ 1	99.6	99.9	0	0.00025

Table E.13: Convergence statistics of last 4 iterations - CAZ C High PM

LOOP	Ass.	Sim.	A/S Step	%FLOWS	%DELAYS	%V.I.	%GAP
36	0.0023/14	0.001/ 7	1.000/ 1	99.5	99.7	0.00008	0.0022
37	0.0022/14	0.001/ 7	1.000/ 1	99.3	99.7	0.00006	0.0043
38	0.0022/14	0.001/ 3	0.037/ 7	98.8	99.8	0.00015	0.0033
39	0.0020/14	0.001/ 3	0.348/ 5	99.2	99.7	0	0.002

Table E.14: Convergence statistics of last 4 iterations - CAZ D Low AM

LOOP	Ass.	Sim.	A/S Step	%FLOWS	%DELAYS	%V.I.	%GAP
53	0.0031/ 9	0.000/ 3	0.015/ 8	98.8	99.7	0.00027	0.0075
54	0.0038/ 9	0.001/ 3	0.082/ 7	98.9	99.7	0	0.0034
55	0.0023/ 9	0.001/ 3	0.167/ 4	99.1	99.8	0.00006	0.0031
56	0.0024/ 9	0.001/ 3	0.185/ 4	99.3	99.8	0.00005	0.013

Table E.15: Convergence statistics of last 4 iterations - CAZ D Low IP

LOOP	Ass.	Sim.	A/S Step	%FLOWS	%DELAYS	%V.I.	%GAP
18	0.0002/16	0.000/ 3	0.618/ 3	98.7	99.9	0	0.00024
19	0.0002/16	0.000/ 7	1.000/ 1	99	99.9	0.00001	0.00028
20	0.0002/16	0.000/ 3	0.391/ 4	98.8	99.9	0	0.00015
21	0.0001/13	0.000/ 7	1.000/ 1	99.6	99.9	0.00001	0.0002

Table E.16: Convergence statistics of last 4 iterations - CAZ D Low PM

LOOP	Ass.	Sim.	A/S Step	%FLOWS	%DELAYS	%V.I.	%GAP
29	0.0032/ 9	0.001/ 7	1.000/ 1	99.4	99.8	0.00016	0.0041
30	0.0030/ 9	0.001/ 7	1.000/ 1	99.1	99.7	0.00005	0.0058
31	0.0029/ 9	0.001/ 3	0.304/ 6	99	99.7	0.00001	0.0038
32	0.0023/ 9	0.001/ 7	1.000/ 1	99.2	99.8	0.00004	0.0057

Table E.17: Convergence statistics of last 4 iterations - CAZ D Medium AM

LOOP	Ass.	Sim.	A/S Step	%FLOWS	%DELAYS	%V.I.	%GAP
53	0.0041/ 9	0.000/ 3	0.149/ 6	98.9	99.8	0	0.0034
54	0.0019/ 9	0.001/ 3	0.277/ 3	98.8	99.7	0.00008	0.0039
55	0.0025/ 9	0.002/ 4	0.329/ 2	99.1	99.8	0.00004	0.013
56	0.0022/ 9	0.001/ 3	0.046/ 6	98.5	99.7	0.0004	0.011

Table E.18: Convergence statistics of last 4 iterations - CAZ D Medium IP

LOOP	Ass.	Sim.	A/S Step	%FLOWS	%DELAYS	%V.I.	%GAP
21	0.0002/17	0.000/ 7	1.000/ 1	99.4	99.9	0.00003	0.00021
22	0.0001/13	0.000/ 3	0.098/ 7	98.9	99.9	0	0.00012
23	0.0002/ 7	0.000/ 7	1.000/ 1	99.8	100	0	0.00012
24	0.0001/18	0.000/ 7	1.000/ 1	99.5	99.9	0.00002	0.00017

Table E.19: Convergence statistics of last 4 iterations - CAZ D Medium PM

LOOP	Ass.	Sim.	A/S Step	%FLOWS	%DELAYS	%V.I.	%GAP
25	0.0032/12	0.002/ 7	1.000/ 1	98.5	99.7	0.00023	0.0091
26	0.0029/ 6	0.001/ 3	0.526/ 4	99	99.7	0.00002	0.0046
27	0.0025/12	0.001/ 7	1.000/ 1	98.7	99.7	0	0.0086
28	0.0024/12	0.002/ 7	1.000/ 1	98.7	99.8	0.00022	0.0056

Table E.20: Convergence statistics of last 4 iterations - CAZ D High AM

LOOP	Ass.	Sim.	A/S Step	%FLOWS	%DELAYS	%V.I.	%GAP
57	0.0039/ 9	0.000/ 3	0.098/ 5	99.1	99.7	0.00003	0.0042
58	0.0026/ 9	0.000/ 3	0.044/ 9	98.9	99.7	0.00012	0.0031
59	0.0024/ 9	0.000/ 3	0.052/ 7	99.1	99.8	0.00001	0.0089
60	0.0039/ 9	0.000/ 3	0.026/ 8	98.8	99.7	0.00002	0.0028

Table E.21: Convergence statistics of last 4 iterations - CAZ D High IP

LOOP	Ass.	Sim.	A/S Step	%FLOWS	%DELAYS	%V.I.	%GAP
19	0.0004/ 9	0.000/ 7	1.000/ 1	98.9	99.8	0.00001	0.00067
20	0.0002/ 6	0.000/ 7	1.000/ 1	99.3	99.9	0	0.00024
21	0.0001/10	0.000/ 7	1.000/ 1	99.4	99.9	0.00002	0.00022
22	0.0001/14	0.000/ 7	1.000/ 1	99.3	99.9	0	0.00032

Table E.22: Convergence statistics of last 4 iterations - CAZ D High PM

LOOP	Ass.	Sim.	A/S Step	%FLOWS	%DELAYS	%V.I.	%GAP
27	0.0024/ 8	0.001/ 3	0.506/ 4	98.7	99.7	0	0.0066
28	0.0022/ 6	0.001/ 3	0.427/ 3	99.3	99.8	0	0.0032
29	0.0024/13	0.001/ 7	1.000/ 1	99.2	99.7	0.00007	0.0059
30	0.0033/13	0.001/ 4	0.746/ 2	99	99.7	0.00001	0.0034

F Parking and Bus Corridor Assumptions

G Reporting of CAZ Only Testing

CONTROL INFORMATION

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SDG project/proposal number	Client contract/project number
23013602	Click here to enter text.

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Version control/issue number Draft Final	Date 11/06/2018