Technical Note

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Subject:	Paramics Model Review and Sensitivity Testing		
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Client signoff

Client	
Project	Cyber Parks Phase 1 Paramics Modelling
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1. Introduction

This Technical Note documents the review and sensitivity testing carried out on the of M5 Junction 11 and 12 Paramics Discovery Model developed by Amey. The purpose of the Paramics model review is to ensure that the model had been coded and developed to an acceptable standard prior to further modelling of the proposed schemes on the A40 and M5 in Gloucester. Further sensitivity testing was carried out to understand how the proposed changes to Arle Court Roundabout in Phase 1 of the scheme may be improved.

2. Paramics Model Review

2.1. Introduction

This chapter contains a review of the Paramics Discovery Model of the A40 and M5 Junction 11 and 12 between Gloucester and Cheltenham developed by Amey. The purpose of this Technical Note is not intended to be a full audit, however aims to review parameters for key locations in the model, including Arle Court Roundabout. The following files have been provided by Amey:

- Base, Do Minimum and Do Something Paramics Models for 2021 and 2031;
- Local Model Validation Report (LMVR) and Paramics Forecasting Report; and
- Calibration / Validation results spreadsheet

The following sections cover the individual elements of the model, highlighting and potential issues which could impact future modelling of the proposed schemes.

2.2. Assignment, zones, and portals

2.2.1. Generalised Cost Equation (GCE)

Individual GCE values have been used for individual vehicle types, with time having a coefficient of 1 for all types, and varying distances. The source and reason for using these GCE values in the model has not been detailed in the report.

2.2.2. Link Categories

2.2.2.1. Major and Minor Links

Road hierarchy is used to inform route choice in the traffic model. Major links are those that new drivers in the area will tend to use in order to reach their destination. Minor links tend to be residential streets, access roads, and older roads of a lower standard which experience low levels of through traffic.

The use of major and minor links in the model appears to be mostly appropriate. A mini-roundabout on Fiddler's Green Lane (nodes 2068, 2069 and 389) has been coded as minor, whereas the surrounding roads leading to it are all major.

2.2.2.2. Highway and Urban Links

On highway links, vehicles are able to go faster in the outside lane than the inside lane. Urban links however have the same distribution of speeds across all lanes. Vehicles on urban links also make lane choice decisions based on the movement they want to take at the junction ahead. Short sections of dual carriageways and motorways likely to exhibit this behaviour. If vehicles are unable to get into the correct lane on an approach to a junction, this can have a major impact on the junction's capacity.

Urban links have been used for the majority of the model, with highway links representing the entirety of the M5, the A40 to the west of Junction 11 until the roundabout with Tewkesbury Road where it becomes a single-carriageway, and the A417 to the southwest. The use of urban links on the approach to junctions has been used which is typically best practice. The A40 to the east of Arle Court Roundabout is divided into several smaller sections by junctions and roundabouts, therefore not requiring highway classification as this would impact lane choice behaviour, as has been coded in the model.

At M5 Junction 11, all links have been classified as urban. While the A40 off-slips leading to the roundabout should be minor links, it is recommended that the on-slips and A40 mainline should remain as highway up until the Arle Court Roundabout, as traffic behaviour is not expected to change until this point.

2.2.2.3. Categories

12 different link categories have been used in the model, of which two are duplicate categories with no apparent differences. These are:

- "Urban 20mph" – Index 9, Urban, minor link with 20mph speed limit; and
- "Urban 20mph" – Index 23, Urban, minor link with 20mph speed limit

While there is no impact on the running of the model, it is recommended that one of these categories is removed and the link types updated.

The A40 has been coded using the "Urban 70mph" link category. This category is actually coded as a Highway link, except where manually changed, with 60mph speeds. It is unclear whether the category name is incorrect or the coding, as the A40 is expected to be a Highway link at 70mph. This could therefore have an impact on modelling and results for the schemes and may need addressing.

2.2.3. Category and Link Cost Factors

Further structuring of the road hierarchy can be achieved through using category and link cost factors. In this, a particular route may contain a lot of on-street parking, making the route more difficult to navigate.

No category cost factors have been used in the model. Link cost factors of 2.0 have been used on Shelley Road (west), nodes 1030 and 1037. This is justifiable due to heavy on-street parking and speed bumps on this link which is located by a nursing home.

2.2.4. Familiarity

Familiarity is used to describe the behavioural characteristics in the driving population. Drivers are either familiar or unfamiliar depending on whether they perceive major and minor roads differently.

Familiarity has been applied by vehicle type using the following values which are considered appropriate:

- Car and LGV – 50%
- OGV1 and OGV2 – 10%
- Coach – 0%

2.2.5. Dynamic Assignment

In Paramics Discovery models, dynamic assignment assumes that familiar drivers have the opportunity to re-route based on their knowledge of the current traffic conditions which are fed back to them. This is achieved by taking real time information from the model and using this data to update the routeing calculations.

Dynamic Assignment is enabled, with parameters set to default (Interval: 2mins, Smoothing factor: 0.5) which is in line with good practice.

2.2.6. Zones

Zones represent the points of origin and destination for journeys within the model. A zone must cover at least one link and should not release vehicles directly onto junctions. The following zones release vehicles directly onto junctions: 105, 106, 109, 113, 114, 118, 128, 136, 160, 161, 162 and 165.

None of the junctions onto which vehicles are released directly are included in any analysis, therefore there is no anticipated impact on the results. Additionally, none of these zones are notably close to Arle Court Roundabout and the region of interest, thus these zones are considered acceptable.

2.2.6.1. Zone Portals

Zone portals have been used to split traffic between loading points where zones are associated with more than one loading link. Some zones connecting to more than one link have not been assigned portals, typically in areas where entry points are linked in reality but not modelled, therefore this is justified.

Zone 106 has been assigned a portal where 5% is loading onto link 124:123, which is both part-way through a road and directly below another zone (167). In reality, there is no connection between these two roads.

2.3. Demands and Profiles

2.3.1. Release Profiles and Matrix Levels

Two demand sets have been used in the model, one for each of the AM and PM periods. Traffic demand is not consistent and varies during the modelled period, this variability defined by the release profile. Release profiles can be set up for different vehicle types and different OD movements. Profiles are disaggregated into 5-minute periods for the whole day and should be based on observed turning count and queue data.

The AM and PM demand sets appear to have profiles assigned correctly. In some cases, profiles sum to above or below 100%, however this is usually within 0.5% and is therefore not expected to impact vehicle releases.

2.4. Public Transport and Vehicle Types

2.4.1. Public Transport

A wide number of bus stops, routes, schedules and services with associated dwell times have been coded in the model. These appear to be coded correctly, although the accuracy of the services could not be checked due to 2017 timetables being used which was correct at the time of model construction.

A bus dwell time of 30 seconds has been used across all periods. This may be considered relatively high unless they are busy, frequently used services, however this has not been justified in the LMVR.

Additionally, bus stops on the following route numbers were found to have a dwell time of 0 seconds, although these are not expected to impact the modelling:

- C_Cheltenham_FiddlersGreen
- C_FiddlersGreen_Cheltenham
- F_OB
- G_SWAN_HC4_O_396_228
- G_SWAN_HC4_I_379_223
- 511_Cheltenham_ArleCourtRide

2.4.2. Vehicle Types

In microsimulation models, different vehicle types can be associated with different demand matrices with individual dynamic characteristics. There are three matrix levels in the model, one for car, one for LGV's and one with a combination of OGV1 and OGV2.

The OGV1 and OGV2 vehicle type proportions in matrix level 3 are an even 50:50 split. This has not been justified in the LMVR and does not appear to be based on survey data, thus may not be entirely accurate.

Vehicle top speed limits have also been changed from default for the OGV1 and OGV2 vehicle types, from 65mph to 56mph. This reflects the typical maximum speed limit these vehicles can travel and is justifiable.

2.5. Network Coding

2.5.1. Node and Link Structure

No overlay has been provided, however node positions and link structure appear appropriate. The model contains a large number of redundant "stub" links where there is no connection to zones. While this may have been done for visual effect, these are generally unnecessary.

2.5.2. Speed Limits on Links

Throughout the model, speed limits do not appear to match signposted speed limits. This has not been documented or appropriately justified in the LMVR. Table 2-1 below documents where issues have been identified which may have a notable impact on modelling of the LEP schemes.

Table 2-1 - Speed Limit Discrepancies

Location	Description	Comments
Cheltenham residential roads (St Mark's, Rowanfield, Alstone, Arle, Hester's Way)	Speed limit inconsistencies - classified as 20mph. These roads are 30mph zones apart from by schools.	Relatively narrow residential streets with cars parked on-street thus reduced limit may be appropriate – **potential big impact on phase 3 and 4 modelling**
The Reddings and area south of Arle Court Roundabout	1926:1681:1507 – Grovefield Way south of roundabout as 30mph	Link should be 40mph – could be impacting routing to Arle Court Roundabout
	The Reddings (238:579:1665:1927) and N Road W (577:235) as 40mph	The Reddings should be 30mph. N Road W is 30mph to the halfway point (westbound) where it changes to 50mph.
	South link of Arle Court Roundabout (Hatherley Lane) as 40 mph	This link is actually 30mph from the P&R roundabout until just before the Arle Court roundabout where it changes to 40mph (node 572)
Arle Court Roundabout	Roundabout gyratory coded as a 30mph limit	The roundabout should be 40mph – **this could be significantly impacting vehicle flows and movements on this roundabout**
	Northwest joining link (B4063), nodes 206:1098:1746 as 40mph	This link should be 50mph as with the rest of the road
M5 Junction 11	Motorway and A40 on-slips as 40mph until merge point	These should be 70mph to represent vehicles speeding up to match main carriageway speeds, otherwise it is affecting their ability to merge – **could impact phase 2 modelling**
Bamfurlong Lane	Changes from 50mph to 40mph back to 50mph again	Should be 50mph all the way along
	Link from zone 139 until it meets Bamfurlong Lane as 40mph	This should be 20mph all along
A40 / A417 / B4063 Roundabout	Roundabout gyratory coded as a 30mph limit	The roundabout should be 40mph
Fiddler's Green Way / Telstar Way mini-roundabout	All joining links 30mph but roundabout coded at 20mph	The mini-roundabout should also be 30mph – **may affect phase 3 modelling**

2.5.3. Link Properties

2.5.3.1. Visibility

Visibility is calculated from the node position and extends back along one entry link only. It should be applied consistently throughout the base model to ensure that any future year models or design scenarios can adopt the same methodology as the calibrated base model.

In the model, visibility has been set between 20m and 30m at roundabouts, and between 10m and 20m at priority junctions, as documented in the LMVR. While this is a consistent approach, visibility values are missing from a large number of links with give way approaches, including roundabouts and junctions. It is recommended that visibility is applied on all links with a give way priority unless there is good reason not to, such as at stop signs.

2.5.3.2. Look Through

The Look Through modifier allows vehicles to look beyond the end of the link when assessing gaps in an opposing stream of traffic. Look Through has been applied at a number of locations in the model, and the application appears to be correct.

2.5.3.3. Gap Acceptance Parameters

Vehicles make decisions based on the physical layout of the road network and their interactions with other vehicles. The position of multiple other vehicles is considered, and when a vehicle calculates gaps it assesses how long it will take for its tail to clear the collision point. It then adds to this a buffer zone defined by the Gap Acceptance Parameters.

Gap Acceptance Parameters (lane merge, lane cross and path cross) have been reduced from default at multiple junctions, justified in the LMVR by using real observations of how these junctions operate. Some of the reduced gap acceptance locations have not been included in the model report however.

2.5.4. Signalised Junctions / Crossings

A large number of signal-controlled junctions and crossings have been included in the model. Signal controller information from Gloucestershire County Council was obtained and replicated in the model using fixed or demand actuated signals.

Whilst not necessarily incorrect, the signals located at the following nodes were found to have slight discrepancies in the phases taking place in the same stages across the AM and PM periods: 145, 161, 885, 1679 and 1682.

Additionally, the following nodes have signal junctions with differing intergreens between time frames:

- 142 – Stage 2
- 156 – Stage 2
- 861 – Stage 4
- 885 – Stage 3
- 1682 – Stage 2
- 1731 – Stage 1

In reality, it is unlikely that intergreens will vary between time periods. Despite this, both of the above issues do not impact any junctions within close proximity to the modelled schemes, and therefore are not expected to impact their modelling.

The signalised crossing at node 1490 has assigned medium priority to vehicle phase A westbound. This is causing unnecessary slowing of vehicles at the approach to the crossing, leading to congestion and preventing the release of vehicles at zone 212. This may be delaying vehicles from reaching the road network, especially the A40 westbound, potentially impacting journey times and vehicle count calibration and validation.

2.5.5. Roundabouts

The use of roundabout lanes has been reviewed. There are some examples of vehicles making unrealistic lane choices or movements at roundabouts. For example, at the roundabout with node J6, vehicles wishing to turn onto the A417 south from the A40 east can use the rightmost (outside) lane, impeding/crossing traffic heading to the B4063 west, which can also use the outside and middle lanes. Additionally, traffic on the Arle Court Roundabout (node 351 etc.) can only use the righthand lane from Hatherley Lane south to head northbound onto Fiddler's Green Lane, but can use both the middle and righthand lanes to turn right onto the A40 east, therefore appearing inaccurate as it causes issues with crossing traffic.

The central bus-only lane on the A40 eastbound approach to the roundabout with Princess Elizabeth Way has been observed in the model simulation to be used by vehicles when congestion is present. This may be a limitation of the modelling software itself, however may also be due to the proceeding roundabout link not having the restriction present, leading to vehicles moving across into the restricted lane when stationary on the approach. This could impact the queueing capacity of the A40 eastbound approach, and may therefore also affect how the Arle Court Roundabout operates which traffic has the potential of blocking back towards.

The give way to all feature has been used at roundabout approaches in the model, all using the value of 100%.

2.5.6. Highway Coding

It is recommended by Systra to use a reduced Headway Factor of 0.6 at merges and diverges to assist in replicating merge behaviour and reducing the severity of modelled shockwaves. No Headway Factor has been used at merges and diverges in the model which may cause vehicles to wait at the end of the ramp.

2.5.7. Hazard Signposting and Hazard Overrides

Hazard signpost distances have been changed from default at 157 locations, however this has not been documented in the model report. The location of these changes in the model seem justified.

2.5.8. Defined Routes

Defined Routes are used to force vehicles to take prescribed routes in the model. A number of defined routes have been used in the model, not documented in the LMVR, however they all appear to be appropriate in preventing unrealistic vehicle routeing choices, such as “rat run” routes through residential streets rather than using main roads, for example at Princess Elizabeth Way in Cheltenham.

2.6. Model Calibration and Validation

2.6.1. Calibration

Overall, the match between modelled and observed traffic is good across all periods. Individual calibration counts at 72 links and 253 turns were compared to modelled flows, with >90% of turn flows passing the flow or GEH criteria in the AM and PM, and 85% of AM and 90% of PM link flows passing. Of the counts at Arle Court Roundabout, only the movement from the A40 west to Hatherley Lane south did not meet the GEH or flow criteria in the AM period, with modelled flow too light in comparison to the observed flow.

In the AM, only 67% of the 6 screenlines passed WebTAG +/-5% flow criteria, however the failing screenlines were all within 3% or less of the WebTAG criteria.

2.6.2. Validation

The overall journey time validation is good, with the vast majority of journey time routes meeting the WebTAG criteria. Out of 18 routes, 16 are passing in both the AM and PM periods, with an overall success rate of 89%. As the two failing routes in the AM and PM are different, it is not considered to be a concurrent issue.

In the PM period, it should be noted that Route 3 westbound is failing WebTAG criteria, with a 20% difference in modelled journey time from the observed. This is a key route in the model, following the A40 from the roundabout with Princess Elizabeth Way in the east, to where it ends in the model by Gloucester to the west. If this route is failing in the base model, the forecast models may less accurately represent future conditions, and therefore not respond as expected. As this route met WebTAG criteria in the AM, it is unlikely to be a coding issue and may be related to demand or vehicle routeing.

2.7. Do Minimum and Do Something 1 Models

Changes to the Do Minimum (DM) and Do Something 1 (DS1) model links appear to be in line with what has been documented in the Forecast Model Report. It is important to note that issues with the Base Model identified in the above sections have been carried over to the DM and DS1 models.

In terms of coding of the Phase 1 scheme at Arle Court Roundabout, some minor issues have been identified. Next lane movements are used to define the direction of travel from one link with multiple lanes to another, in order to prevent unrealistic movements or crossing of traffic. In the Do Minimum and Do Something models, defined next lanes have been used on the Arle Court Roundabout entry and gyratory links. While this is not necessarily an issue, the defined lanes have caused some of the other lanes to become redundant where no traffic is able to access them due to being forced to use other lanes instead. This is unrealistic, and some vehicles have been observed to “hop” across lanes when stationary in order to be able to take the desired trajectory.

The DM and DS1 model have the same signal timings at Arle Court for both 2021 and 2031. It is expected that the additional demand in 2031 will impact the flow of vehicles to / on the roundabout, therefore potentially requiring revised timings between the two forecast years. In addition, it is noted the two signals on the Arle Court Roundabout for the DM model have been changed from a 60-second phase cycle in the Base Model AM

to an 80-second one. This change has not been documented in the Forecasting Report and only implemented in the AM and unchanged in the PM peak with no other signal modification across the rest of the model. Given the pivotal impact this scale of,signal setting would have on overall network statistics, it is felt the AM peak Do Minimum signal settings should be addressed.

The Hatherley Lane northbound approach to the Arle Court Roundabout has the capability to turn left onto the A40 westbound from both the middle and left lanes in the Do Minimum model. This lane discipline is carried over from the 2017 base model. In reality on the ground and confirmed by the lane markings, this left turn movement is only signed from the left lane, however local knowledge of the operation of this roundabout suggests that people also use the middle lane for this movement despite it being undesignated, therefore this coding is considered appropriate to follow through into the 2020 Do Minimum.

When undertaking initial model forecasting, an additional issue was discovered that was carried over from the Base model to the Do Minimum and Do Something models. This affects the M5 J11 slip road onto the A40 eastbound. Vehicles are currently only using only one of the two lanes on the slip in anticipation of it becoming a single lane before the A40 merge. In addition, the hazard signpost distance is coded at the default value of 250 metres, with this stretching back to the M5 and A40 mainlines, meaning vehicles are making their lane choice decision unrealistically far in advance. Sensitivity tests on the base model were run and localised traffic flow and journey time checks were made to assess the scale of impact on the 2017 validation. Flows using J11 remained stable and none of the journey time validation routes pass through this part of the network so there was no measurable detriment to the either AM or PM validation as a result of modifying the merge characteristics. Due to the impact on vehicle behaviour found in Do Minimum and future phases of the project, it is recommended that the modified merge characteristics is adopted for all forecasting scenarios.

2.7.1. Demand Forecasting

As per the Forecast Model Report, the Base 2017 demand matrices for the AM and PM periods were scaled to the opening year of 2021 and assessment year of 2031. This was carried out using National Trip End Model growth factors for car demand, and the National Traffic Model (NTM) for LGV and HGV demand growth. Income and fuel factors were also applied as per WebTAG unit M4 7.4.13 guidance. Blanket factors were applied to zones categorised under 5 different local areas: Gloucestershire, Cheltenham, Gloucester, Tewkesbury and Stroud. This process has not been documented or justified in the Forecasting Report. The method used may be considered inaccurate as it does not take into account planned developments where individual growth is planned, and also may therefore be overestimating growth in other areas of the model.

2.8. Summary

A number of issues were identified in this review of the Paramics models provided by Amey. It was considered that the minimal impact of these on the Base, Do Minimum and Do Something models was acceptable. Only those issues anticipated to potentially impact the modelling of Phases 1 to 4 of the scheme were considered for further addressing. The coding of the hazard signpost distance on the M5 J11 slip road affecting all models as discussed in Section 2.7 was reduced to 120 metres to prevent the observed unusual lane choice behaviour.

2.8.1. DS1 Model Changes

Based on the review, the following changes were applied to the Do Something 1 model prior to modelling and generating outputs for TUBA analysis:

- Forced next lane movements identified in section 1.7 for the Arle Court Roundabout approaches and gyratory were removed to prevent unrealistic lane choice behaviour and queueing across exit arms;
- Signal timings for 2021 and 2031 were individually optimised in LinSig for the AM and PM peaks using traffic flows from the Paramics models;
- Detectors used to trigger signal phases on the roundabout gyratory when queuing occurs were removed (believed to not be scripted in the model); and
- A second lane on the Hatherley Lane southbound link between the Arle Court Roundabout and the Park and Ride roundabout was added following further scoping discussions.

The other issues outlined previously were believed to not have a significant effect on the modelling or outputs, and therefore were not addressed further.

2.8.2. DM Model Changes

The only change made to the Do Minimum Models for 2021 and 2031 was to the two AM signal timings at Arle Court Roundabout discussed in section 2.7, reverting the cycle time to 60s. As with the Do Something model, these signals were individually optimised.

3. Do Something Model Sensitivity Testing

3.1. Introduction

When modelled, the original DS1 option was found to experience severe congestion on the Hatherley Lane northbound approach to the Arle Court Roundabout. This resulted in a high number of unreleased vehicles in both the AM and PM peaks from nearby zones, including the Park and Ride site and Golden Valley Retail Park, shown in Figure 3-1 below. Therefore, two additional options were presented for sensitivity testing to assess whether these could improve queueing and journey times at the roundabout. The DS1 layout at Arle Court Roundabout is shown in Figure 3-2, but with the addition of the second lane on Hatherley Lane southbound.

Figure 3-1 - DS1 2031 PM Peak (18:00)

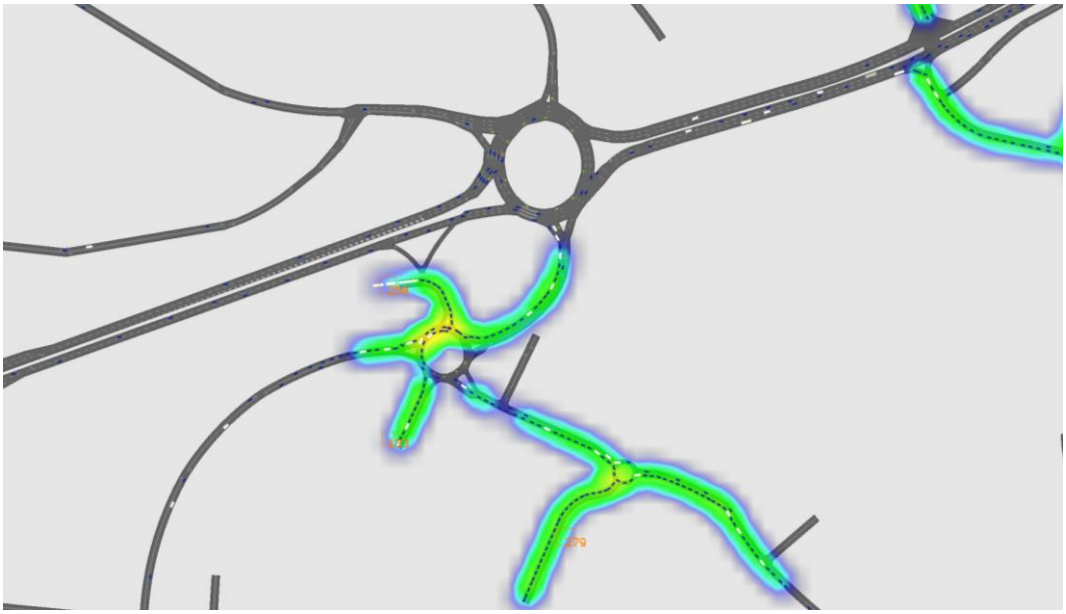
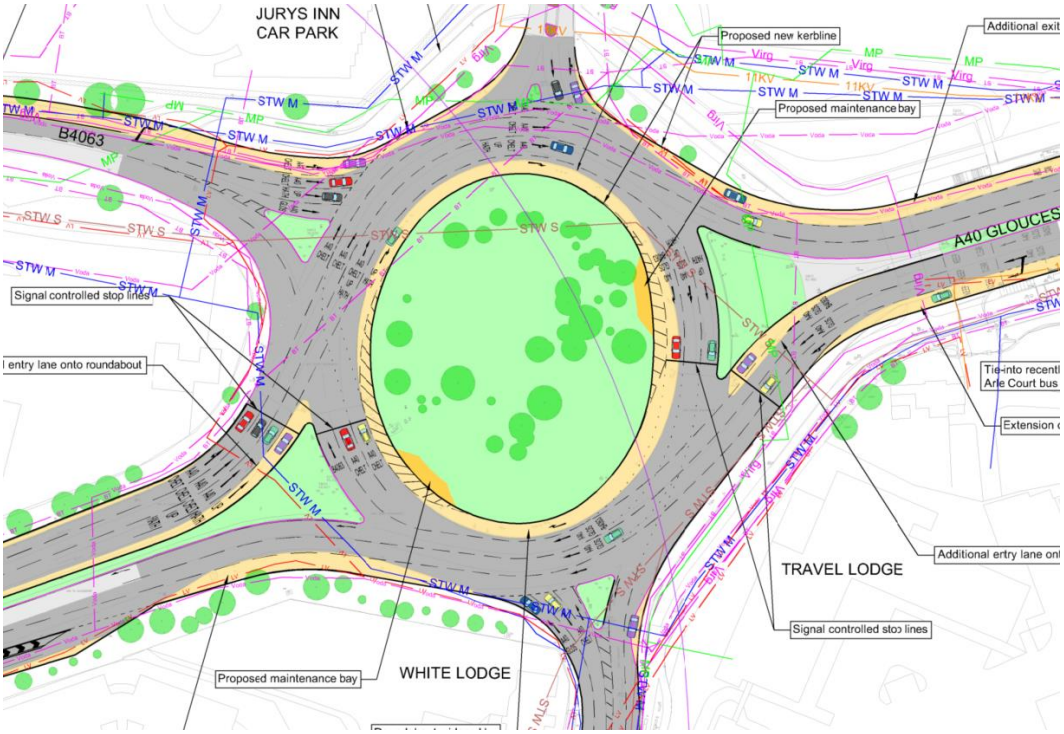


Figure 3-2 – DS1 Arle Court Roundabout Layout Lane Allocation Extract



3.2. Do Something 2 Option

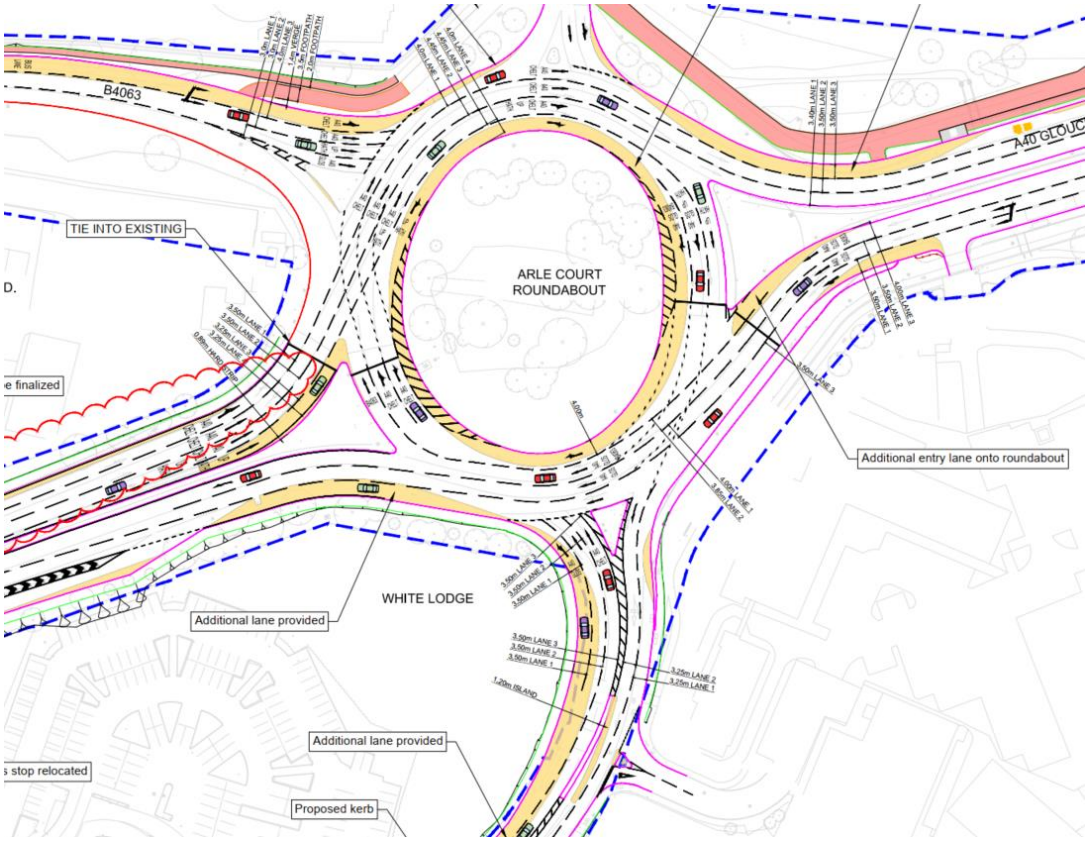
The Do Something 2 (DS2) model option consists of an identical network to the DS1 model, with changes only to the lane allocations of the Hatherley Lane approach arm to the Arle Court Roundabout, allowing the left turn from the middle lane towards the A40 westbound, shown in Figure 3-3 below.

Figure 3-3 - Changes to DS2 Hatherley Lane approach allocations

3.3. Do Something 3 Option

The Do Something 3 (DS3) model option consists of the DS2 Hatherley Lane option shown in Figure 3-3, but with the third rightmost lane on the Hatherley Lane approach arm extended back to allow further queueing capacity, shown in Figure 3-4. This may help to alleviate traffic and queueing at Arle Court, particularly in the PM peak.

Figure 3-4 - DS3 Option for the Arle Court Roundabout



3.4. Journey Times

As with the model Forecast Report produced by Amey, journey times were collected for two key routes on the network for the AM and PM single validated peak hours (08:00-09:00 and 17:00-18:00 respectively), shown in

Figure **3-5** and Figure 3-6 below:

- **Route 1** – A40 east and westbound between the A40 / Tewkesbury Road Roundabout and the A40 / Princess Elizabeth Way Roundabout; and
- **Route 2** – A4013 Princess Elizabeth Way north and southbound between the A40 / A4013 roundabout and the A4019 / A4013 / Kingsditch Lane Roundabout.

Results were taken as an average of 10 random seed runs of the DS1, DS2 and DS3 Paramics models for 2021 and 2031. These results are displayed in Table 3-1 to Table 3-4.

Figure 3-5 - Journey Time Route 1

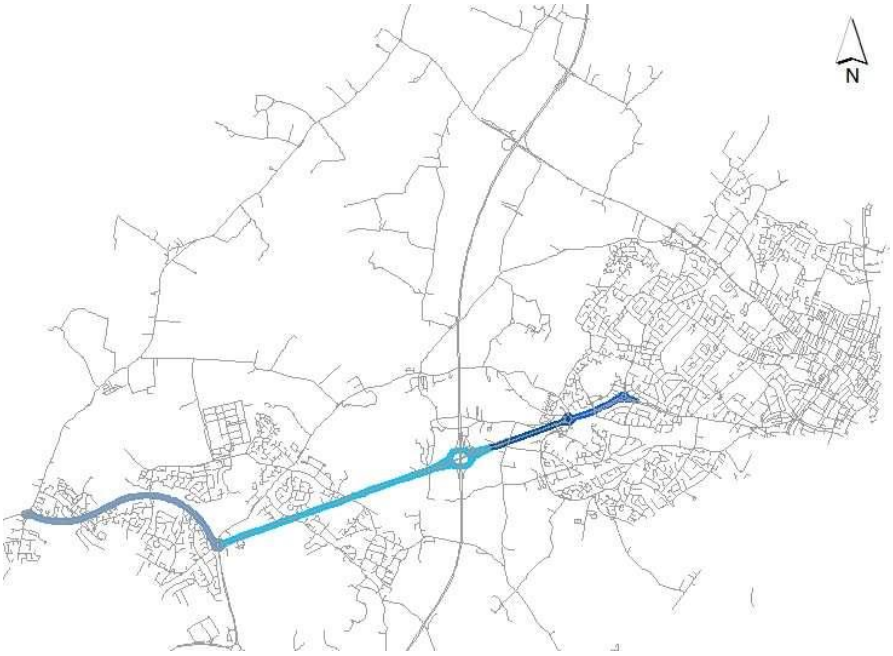


Figure 3-6 - Journey Time Route 2

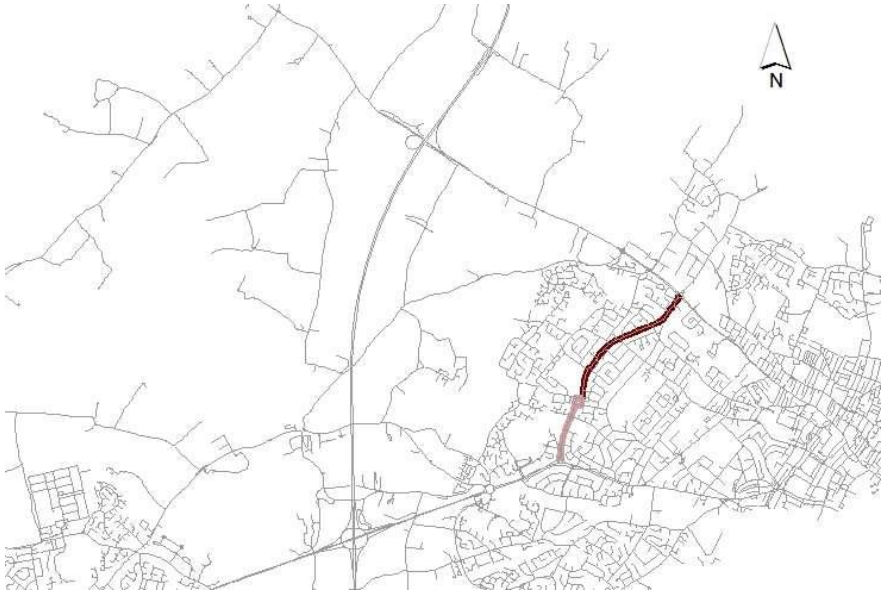


Table 3-1 - 2021 AM (08:00-09:00) Journey Time Comparison for the DS1, DS2 and DS3 options

Route	Direction	2021 AM (08:00-09:00) Journey Time			
		Do Minimum	Do Something 1	Do Something 2	Do Something 3
1	Eastbound	00:10:43	00:11:01	00:10:38	00:10:57
	Westbound	00:10:52	00:11:40	00:11:52	00:12:00
2	Northbound	00:05:58	00:06:06	00:05:56	00:05:51
	Southbound	00:05:38	00:05:48	00:05:47	00:05:43

Table 3-2 - 2021 PM (17:00-18:00) Journey Time Comparison for the DM, DS1, DS2 and DS3 options

Route	Direction	2021 (17:00-18:00) PM Journey Time			
		Do Minimum	Do Something 1	Do Something 2	Do Something 3
1	Eastbound	00:13:57	00:11:32	00:11:21	00:11:14
	Westbound	00:09:55	00:09:49	00:09:32	00:09:37
2	Northbound	00:05:38	00:05:38	00:05:39	00:05:38
	Southbound	00:07:05	00:06:56	00:06:51	00:06:51

For the 2021 AM Peak, travel times across all routes are shown to remain relatively consistent across all three options tested. The Do Something 2 and 3 options (DS2 and DS3 respectively) demonstrated an overall slight improved performance in journey time when compared to the Do Something 1 (DS1) scenario, with option 3 performing best for route 2, and option 2 best for route 1. Signal timings at the Arle Court Roundabout may need further revising between the tested options and therefore may account for the small increase in Route 1 Westbound journey times.

For the 2021 PM Peak, travel times experienced a similar minimal level of change as shown in the AM Peak. The Do Something 3 option consistently performed the best across all of the three tested scenarios, with the maximum benefit to journey time a reduction of 18 seconds to Route 1 Eastbound when compared to the DS1 scenario. There was little to no observed change in travel time for Route 2 in both directions over the three model scenarios.

Table 3-3 - 2031 AM (08:00-09:00) Journey Time Comparison for the DM, DS1, DS2 and DS3 options

Route	Direction	2031 AM (08:00-09:00) Journey Time			
		Do Minimum	Do Something 1	Do Something 2	Do Something 3
1	Eastbound	00:17:47	00:18:45	00:20:42	00:20:13
	Westbound	00:10:26	00:12:45	00:13:07	00:13:19
2	Northbound	00:06:58	00:06:51	00:06:52	00:06:53
	Southbound	00:06:17	00:06:06	00:06:09	00:06:16

Table 3-4 - 2031 PM (17:00-18:00) Journey Time Comparison for the DM, DS1, DS2 and DS3 options

Route	Direction		2031 (17:00-18:00) PM Journey Time		
		Do Minimum	Do Something 1	Do Something 2	Do Something 3
1	Eastbound	00:30:20	00:14:20	00:20:42	00:20:27
	Westbound	00:11:07	00:10:27	00:12:00	00:11:33
2	Northbound	00:06:05	00:07:33	00:07:01	00:07:00
	Southbound	00:09:24	00:08:29	00:09:02	00:08:52

In the 2031 AM Peak, the DS1 scenario consistently performed the best across all routes and directions when compared to the DS2 and DS3 options. Despite this, the maximum difference in journey time for Route 2 was only 10 seconds, showing a relatively consistent travel time over all the modelled options. Route 1 Eastbound increased by almost 2 minutes from the DS1 to the DS2 option, and approximately 1 minute 30 seconds in the DS3 option. While this may be considered notable, it is likely that a reduction to the severe congestion on the Hatherley Lane approach to Arle Court shown in the DS1 scenario is therefore allowing more vehicles to reach the road network, potentially leading to more congestion elsewhere and thus slowing journey times.

In the 2031 PM Peak, Route 1 Eastbound experiences the most notable increase in travel time of over 6 minutes from the DS1 scenario to the DS2 and DS3 options. As with before, this may be due to more vehicles being able to enter the network where the severe congestion on Hatherley Lane northbound has been reduced, potentially shifting traffic further down the network. Additionally, the Do Minimum model experienced a travel time of 00:30:20 for Route 1 Eastbound. Therefore, while the improvements to travel time may not be as great as in the DS1 model, the DS2 and DS3 models are still significantly lower than the Do Minimum.

3.5. Queue Routes

Average and maximum queue lengths were collected for each approach arm to the Arle Court Roundabout to understand the impact of the DS2 and DS3 options on congestion in comparison to the DS1 scenario. Paramics queue results are output in terms of individual lanes on each approach arm. Due to some of these lanes experiencing significantly less usage than others, the maximum average queue value from across all lanes was taken. Figure 3-7 through to Figure 3-11 shows the 5 queue routes used, consistent with the Model Forecasting Report produced by Amey. The queue results are shown in Table 3-5 through to Table 3-8.

Figure 3-7 - Queue Route: Fiddler's Green Lane

Figure 3-8 - Queue Route: A40 East

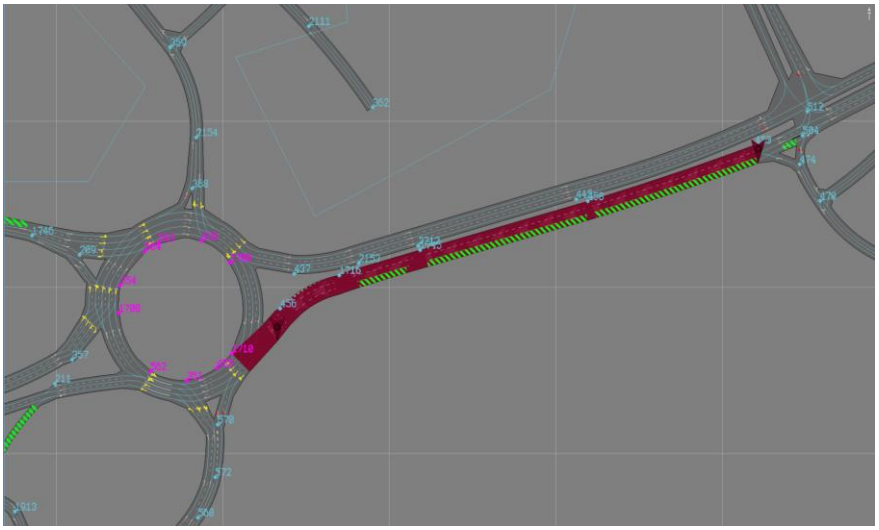


Figure 3-9 - Queue Route: Hatherley Lane

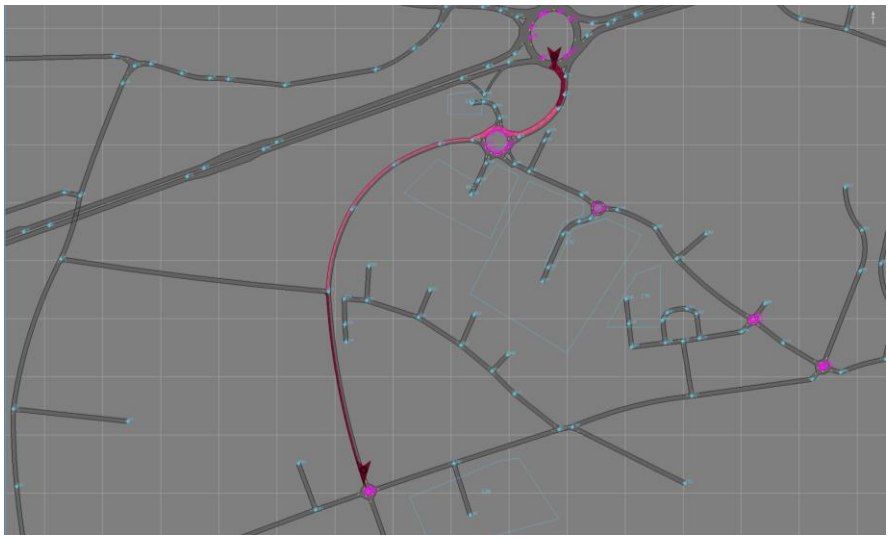


Figure 3-10 - Queue Route: A40 West

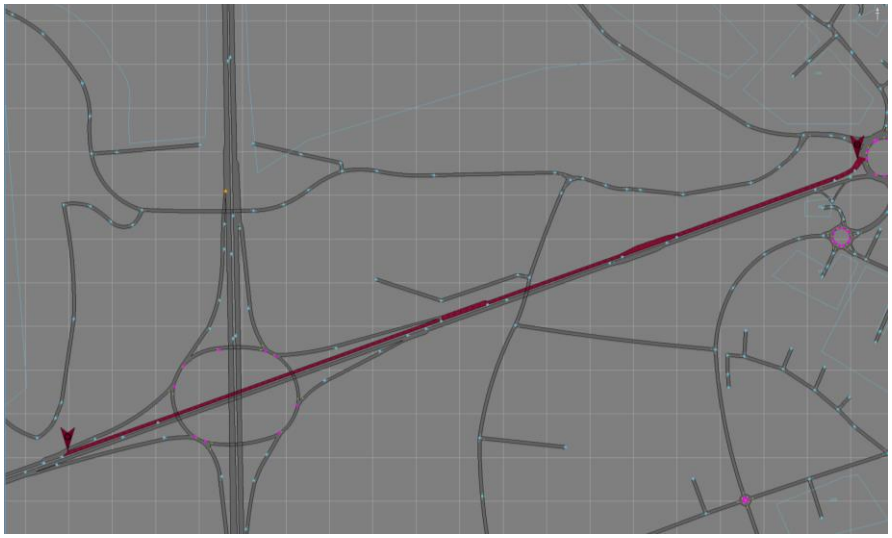


Figure 3-11 - Queue Route: B4063

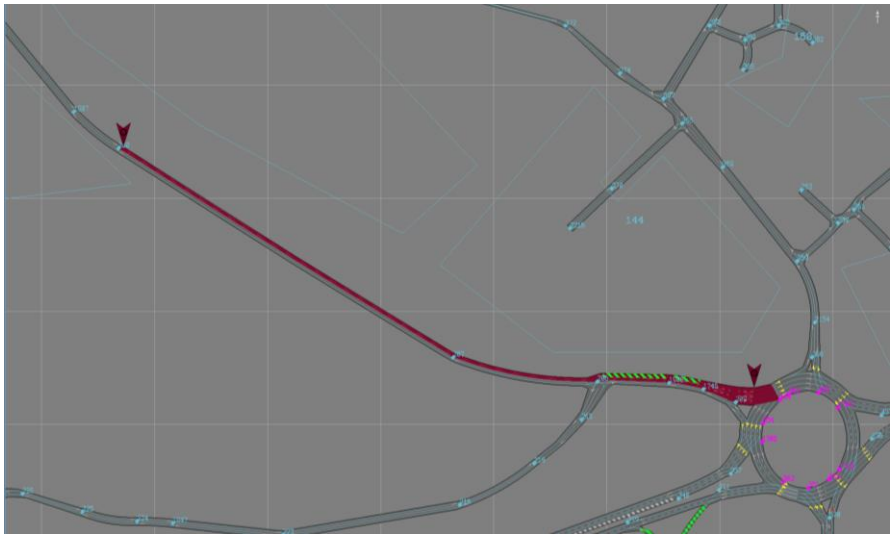


Table 3-5 - 2021 AM (08:00-09:00) Queue Route Comparison for the DM, DS1, DS2 and DS3 options

	2021 AM (08:00-09:00) Queue Results (m)							
	Do Minimum		Do Something 1		Do Something 2		Do Something 3	
Approach	Average	Max.	Average	Max.	Average	Max.	Average	Max.
Fiddler's Green Lane	42	106	32	55	32	52	32	49
A40 East	122	354	85	282	74	231	71	219
Hatherley Lane	75	311	144	532	54	156	46	120
A40 West	359	1101	55	221	53	208	55	231
B4063	40	101	42	92	39	72	41	78

	2021 AM (08:00-09:00) Queue Results Difference from DS1 (m)			
	Do Something 2		Do Something 3	
Approach	Average	Maximum	Average	Maximum
Fiddler's Green Lane	0	-4	0	-6
A40 East	-11	-51	-13	-64
Hatherley Lane	-89	-376	-98	-412
A40 West	-2	-13	0	10
B4063	-3	-20	-1	-14

The DS2 and DS3 options are shown to improve the average and maximum queue lengths on all approach arms to the Arle Court Roundabout in the 2021 AM Peak. The only exception to this is the A40 eastbound approach (A40 West), which shows a 10-metre increase in maximum queue length in the DS3 option. Both the DS2 and DS3 options significantly improve queueing on the Hatherley Lane link, as well as an additional notable improvement to the A40 Eastern approach when compared to the DS1 scenario. In most cases, the DS3 option performed better than the DS2 option for the 2021 AM Peak.

Table 3-6 - 2021 PM (17:00-18:00) Queue Route Comparison for the DM, DS1, DS2 and DS3 options

	2021 PM (17:00-18:00) Queue Results (m)							
	Do Minimum		Do Something 1		Do Something 2		Do Something 3	
Approach	Average	Max.	Average	Max.	Average	Max.	Average	Max.
Fiddler's Green Lane	151	246	32	47	34	62	47	74
A40 East	114	350	84	277	72	217	72	222
Hatherley Lane	107	333	158	365	53	161	46	114
A40 West	227	770	76	308	67	278	77	282
B4063	186	409	38	61	44	68	54	86

	2021 PM (17:00-18:00) Queue Results Difference from DS1 (m)			
	Do Something 2		Do Something 3	
Approach	Average	Maximum	Average	Maximum
Fiddler's Green Lane	2	15	15	27
A40 East	-12	-60	-12	-55
Hatherley Lane	-105	-204	-112	-251
A40 West	-8	-29	1	-26
B4063	6	7	16	25

As with the AM Peak, the DS2 and DS3 options show strong improvements to the DS1 scenario for the 2021 PM Peak. The most notable decrease in queue length is for the Hatherley Lane approach, with average queues decreasing by 105 and 112 metres for the DS2 and DS3 options respectively. Both the DS2 and DS3 options show an increase in average and maximum queues on the Fiddler's Green Lane and B4063 approaches. This may be due to the give way nature of these approach roads. Additional traffic now able to enter Arle Court Roundabout from Hatherley Lane through improvements made in the DS2 and DS3 options means that vehicles on the B4063 and Fiddler's Green Lane may have to wait longer for gaps in the opposing traffic.

Table 3-7 - 2031 AM (08:00-09:00) Queue Route Comparison for the DM, DS1, DS2 and DS3 options

	2031 AM (08:00-09:00) Queue Results (m)							
	Do Minimum		Do Something 1		Do Something 2		Do Something 3	
Approach	Average	Max.	Average	Max.	Average	Max.	Average	Max.
Fiddler's Green Lane	73	173	106	182	146	234	140	234
A40 East	125	367	97	347	81	236	83	265
Hatherley Lane	105	998	172	873	117	317	65	205
A40 West	368	1122	72	343	87	395	104	476
B4063	46	127	53	117	77	167	109	243

	2031 AM (08:00-09:00) Queue Results Difference from DS1 (m)			
	Do Something 2		Do Something 3	
Approach	Average	Maximum	Average	Maximum
Fiddler's Green Lane	40	52	34	52
A40 East	-16	-111	-14	-82
Hatherley Lane	-55	-556	-107	-668
A40 West	16	52	33	134
B4063	25	49	56	126

The 2031 AM Peak shows an overall increase in both average and maximum queue lengths for all Arle Court Roundabout approach arms except for Hatherley Lane and the A40 East. While the maximum lengths have increased by a more substantial amount, the increase to average queue length remains relatively low. Additionally, despite being higher than the DS1 scenario, both the DS2 and DS3 options have queue lengths lower than the Do Minimum scenario for the majority of the approach arms (see Figure 3-12). The DS3 option on average performs better than the DS2 option when compared to the DS1 model, although experiences slightly greater queueing on the A40 West and B4063 approaches.

Table 3-8 - 2031 PM (17:00-18:00) Queue Route Comparison for the DM, DS1, DS2 and DS3 options

	2031 PM (17:00-18:00) Queue Results (m)							
	Do Minimum		Do Something 1		Do Something 2		Do Something 3	
Approach	Average	Max.	Average	Max.	Average	Max.	Average	Max.
Fiddler's Green Lane	222	279	32	47	98	129	70	117
A40 East	135	374	84	288	98	238	70	216
Hatherley Lane	165	481	167	395	217	389	87	224
A40 West	554	1287	53	217	251	569	76	387
B4063	353	608	37	55	116	200	57	107

	2031 PM (17:00-18:00) Queue Results Difference from DS1 (m)			
	Do Something 2		Do Something 3	
Approach	Average	Maximum	Average	Maximum
Fiddler's Green Lane	66	82	38	70
A40 East	14	-49	-14	-72
Hatherley Lane	50	-5	-80	-170
A40 West	198	352	23	169
B4063	79	145	20	52

As with the AM Peak, the 2031 PM Peak shows an increase in average and maximum queue lengths, with the exception of Hatherley Lane and the A40 East. The overall increase in average queue length from the DS1 option is relatively low, with the DS3 scenario performing the best out of the two proposed options with the greatest reduction to queueing. While average and maximum queue lengths are expected to increase slightly with the DS2 and DS3 options for some approaches, they still demonstrate a significant improvement to the Do Minimum results, shown in Figure 3-13 below. As experienced with previous time periods and years, the DS3 option is shown to be the better of the two potential improvement options to the DS1 scenario.

Figure 3-12 – 2031 AM (08:00-09:00) Modelled Average Queue Length Comparison (m)

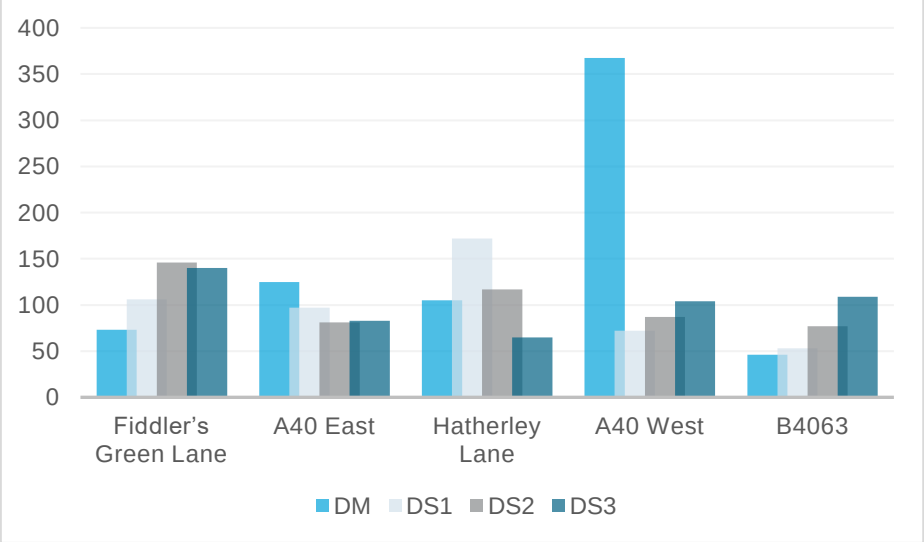
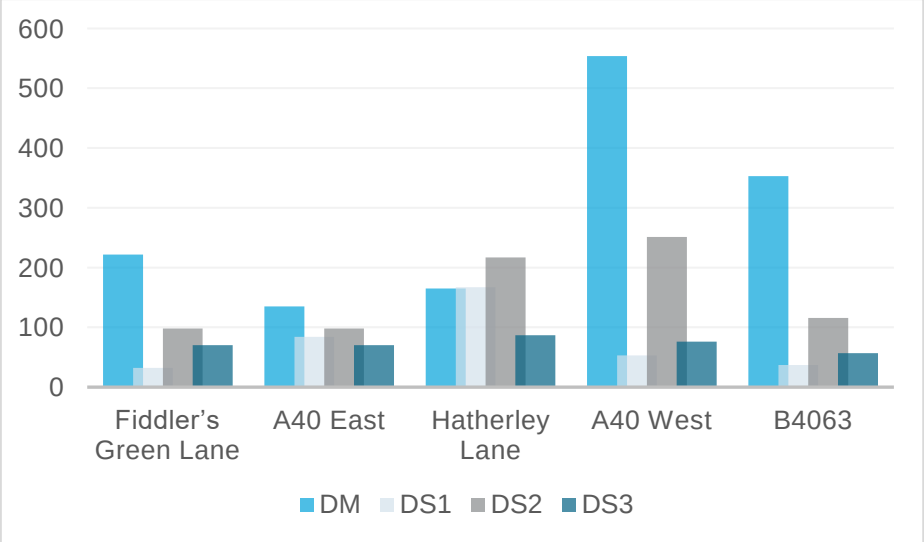


Figure 3-13 – 2031 PM (17:00-18:00) Modelled Average Queue Length Comparison (m)



3.6. Summary

This section of the report looked at two potential options for the existing DS1 model in order to reduce heavy congestion experienced on the Hatherley Lane approach to the Arle Court Roundabout. The Do Something 2 option enabled an additional lane to be used for the left-turn movement onto the A40 westbound, while the Do Something 3 option consisted of the same network but with the third lane on the inside of the Hatherley Lane northbound approach extended back to allow further queueing capacity. It was found that both options marginally improved journey times in the 2021 AM and PM Peaks when compared to the original DS1 scenario, however showed more significant improvements to queueing on almost all the approach arms to the Arle Court Roundabout. For the 2031 AM and PM Peaks, journey times were shown to mostly stay the same for Route 2 in both DS options in comparison to the DS1 scenario, but typically increased for Route 1. This may reflect traffic previously congested along Hatherley Lane northbound being released onto the wider network, and therefore potentially leading to more queueing elsewhere. Queue lengths for the 2031 peak periods were shown to improve on Hatherley Lane and the A40 East approaches, however increased for the other three arms. Despite this, the majority of these were still significantly under the reported Do Minimum results. On average the DS3 option was found to perform better than the DS2 option across the majority of the modelled times and years, and was therefore taken forward as the basis for the Phase 1 scheme.

4. Economics Model Development

This chapter outlines the steps taken in order to convert the Paramics models into ones suitable for producing outputs for economics analysis. Table 4-1 lists the parameters defined by Systra which are essential to undertaking fixed trip matrix economic assessments.

Table 4-1 - Paramics and TUBA Parameters

Parameter	Setting / Comment
Seed Value	It is essential to undertake both the Do Minimum and Do Something model runs using the same random seed values in each case. This ensures consistency of the number of trips released and in their modelled characteristics.
Preserve Choice	The “preserve choice” option must be toggled on in all models. This ensures consistency of release link within a zone where multiple options exist.
Simulation Time	The simulation must be run for long enough to ensure that all trips that are released between 07:00 and 19:00 complete their journey and are recorded in the outputs.

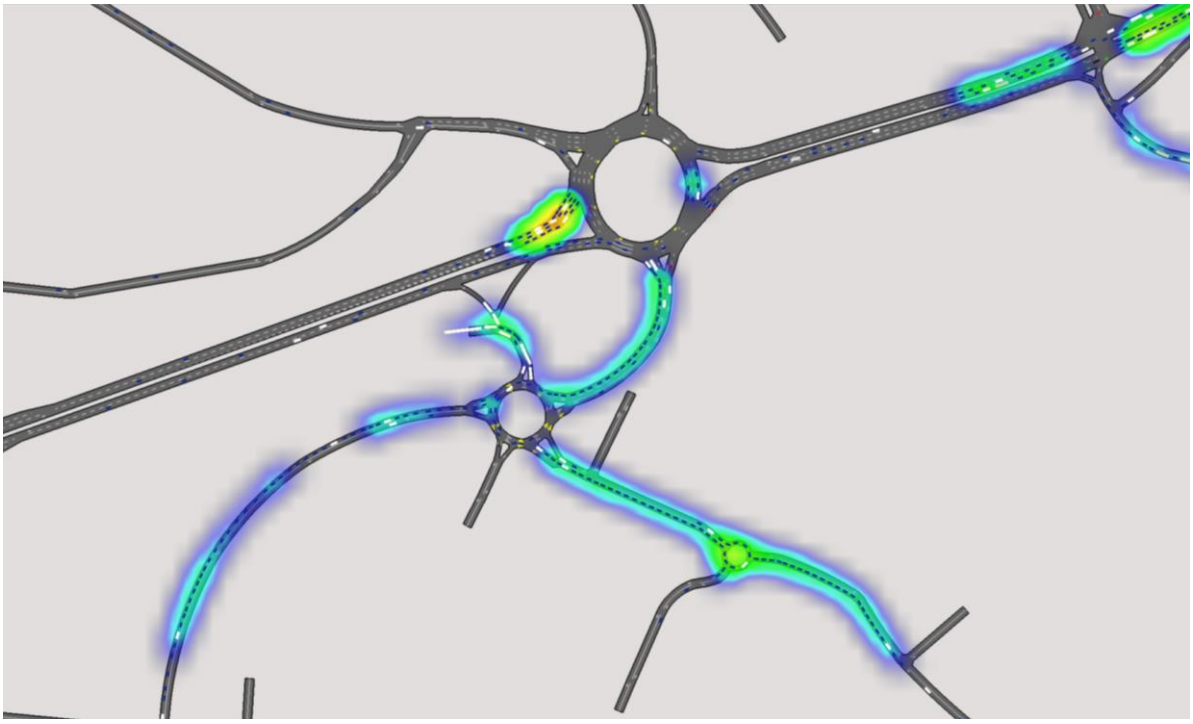
New Base, Do Minimum and Do Something 3 Paramics models were therefore set up following these settings, whilst keeping the original models separate for other forms of analysis. Additionally, with regards to the simulation time parameter, it was decided to carry out a total of 30 runs for the 2021 models and 40 runs for the 2031 models, with an extra cool-down hour without demand. This was to ensure that there are enough model runs where the additional simulated traffic during the AM and PM peaks was able to completely leave the network over the modelled period.

The runs were further filtered by removing those where the mean difference in distance and travel time from the average exceeded 15%. This was to remove runs which experienced extreme changes from the average and were therefore potentially skewing the results.

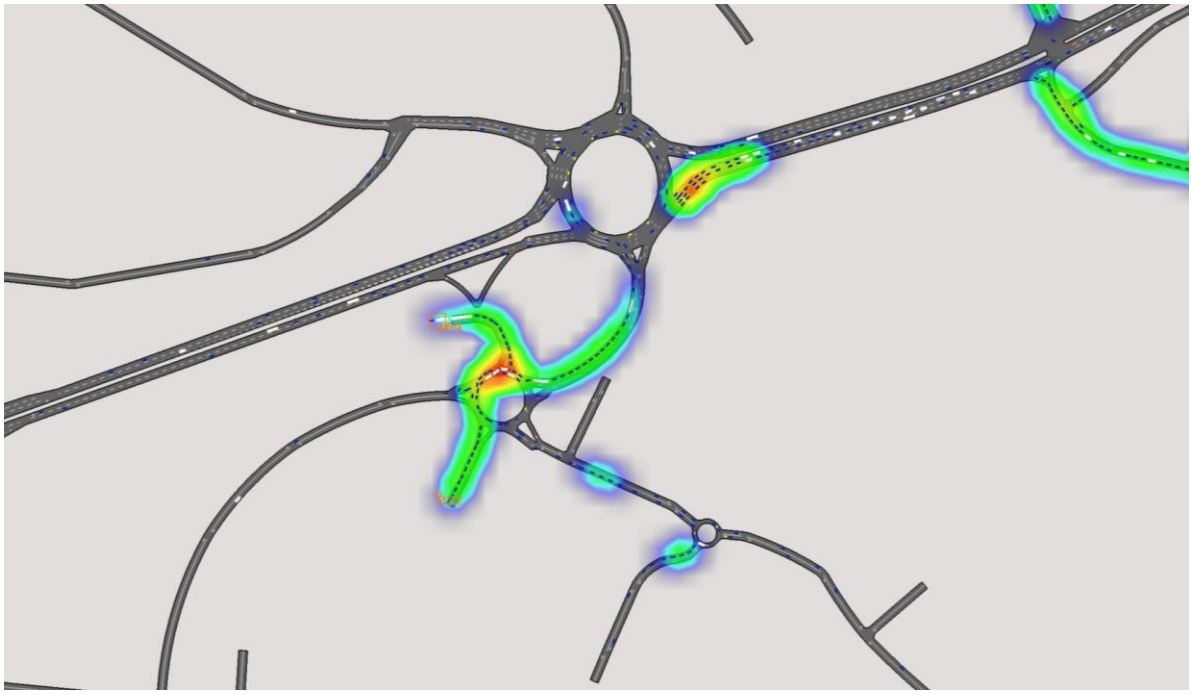
Despite the same demand matrices being used across the DM and DS3 models, and due to how Paramics assigns trips, there are occurrences where a trip may occur for a particular Origin-Destination (OD) movement in one model and not the other. For TUBA modelling, these OD pairs need to be consistent across all modelled years for the AM and PM peaks separately, else TUBA flags a serious warning. Therefore, the model outputs were filtered across the years for the AM and PM peaks individually to contain only OD pairs which occurred across the Base, DM and DS models.

Appendix A.

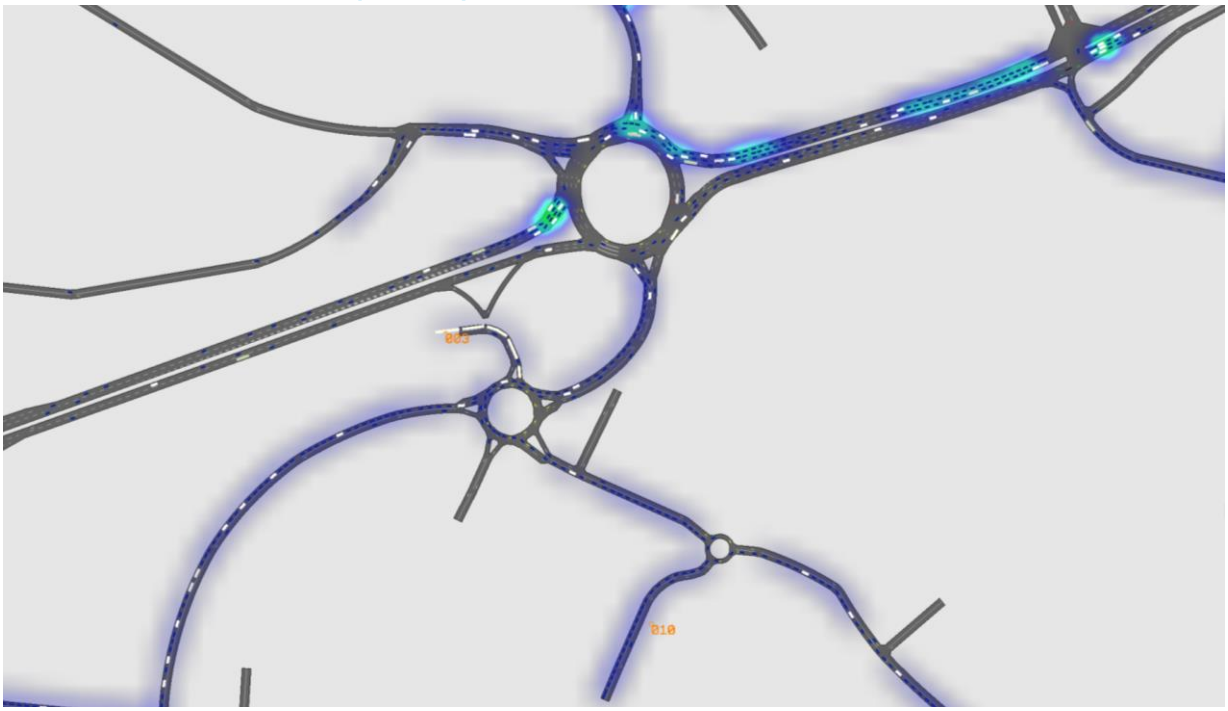
A.1. DS1 2021 AM (09:00)



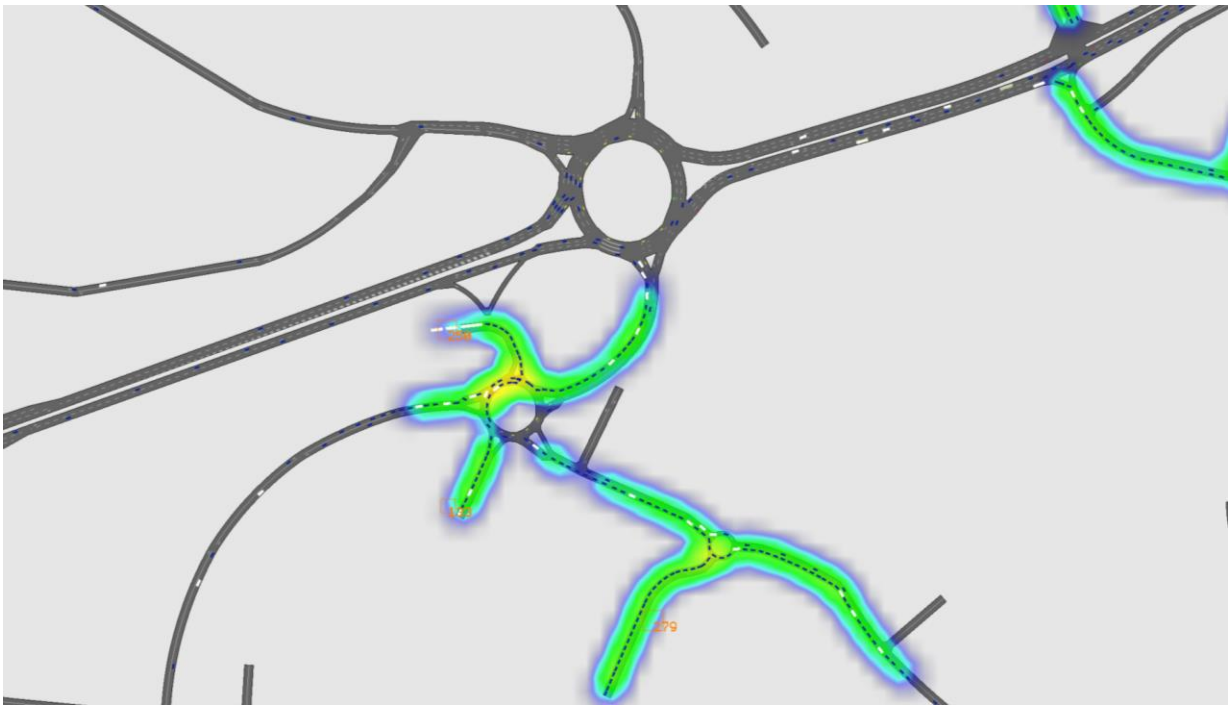
A.2. DS1 2021 PM (18:00)



A.3. DS1 2031 AM (09:00)

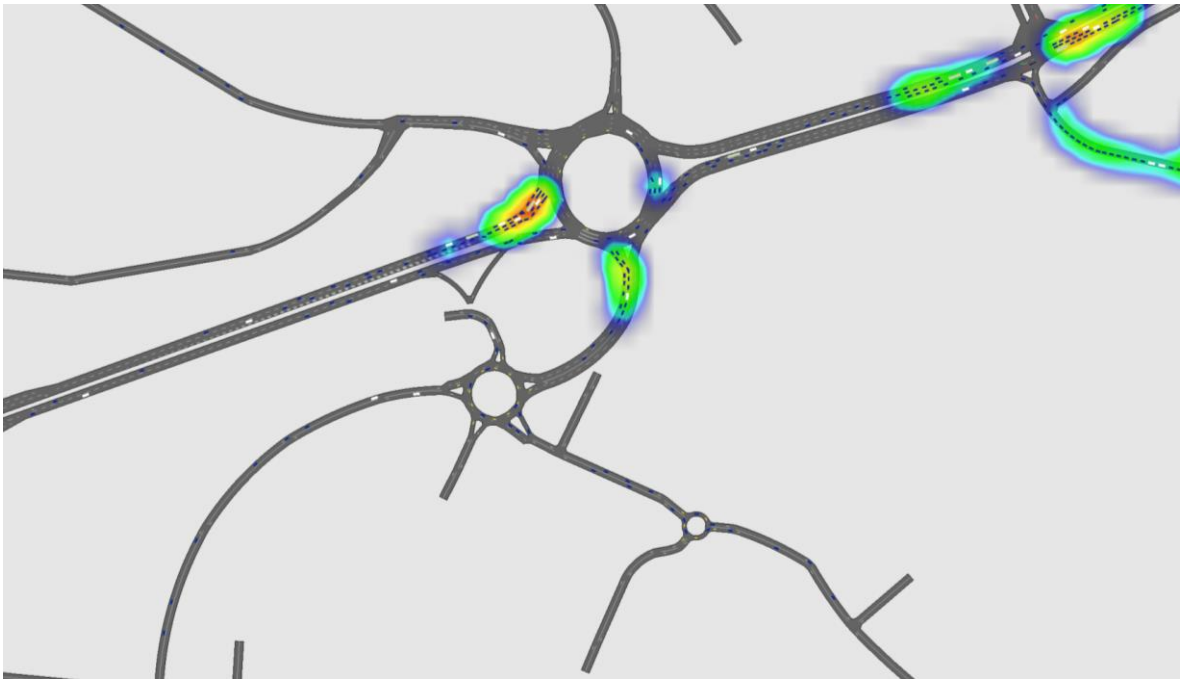


A.4. DS1 2031 PM (18:00)

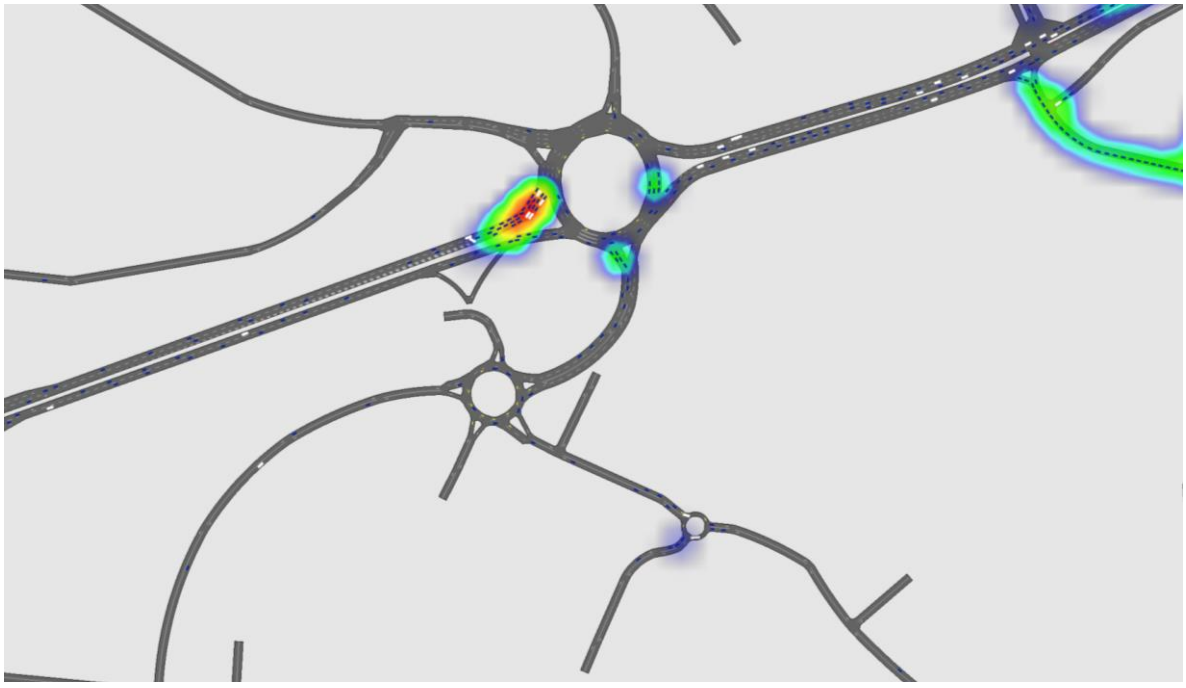


Appendix B.

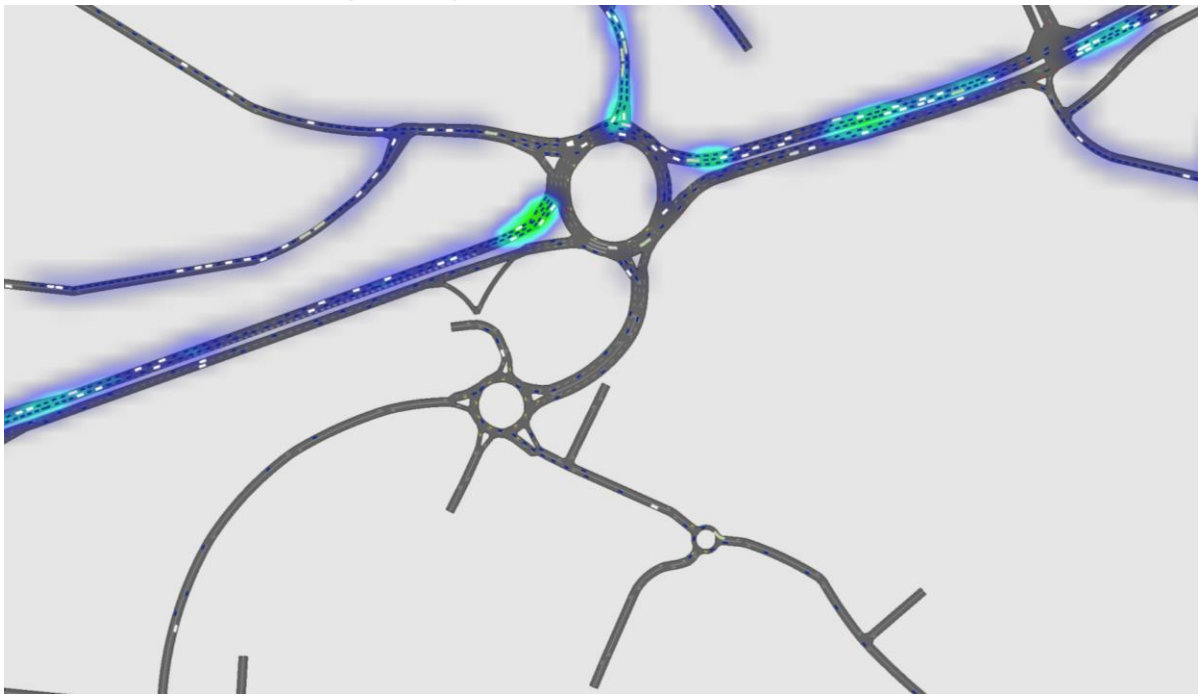
B.1. DS2 2021 AM (09:00)



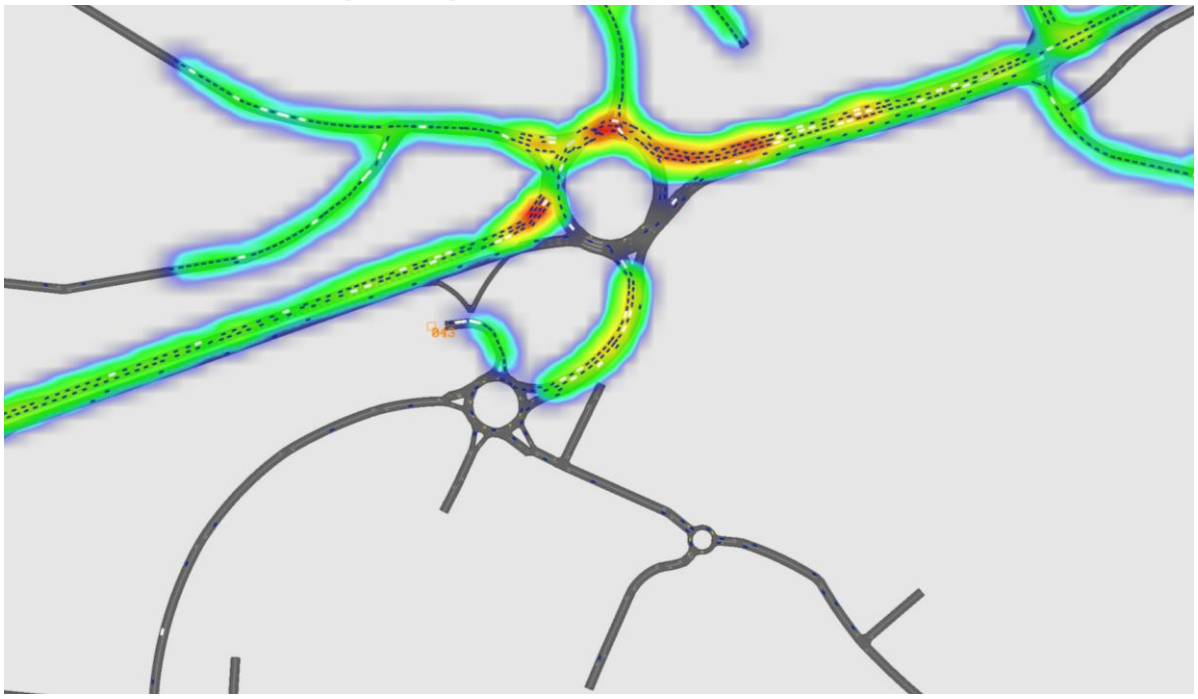
B.2. DS2 2021 PM (18:00)



B.3. DS2 2031 AM (09:00)



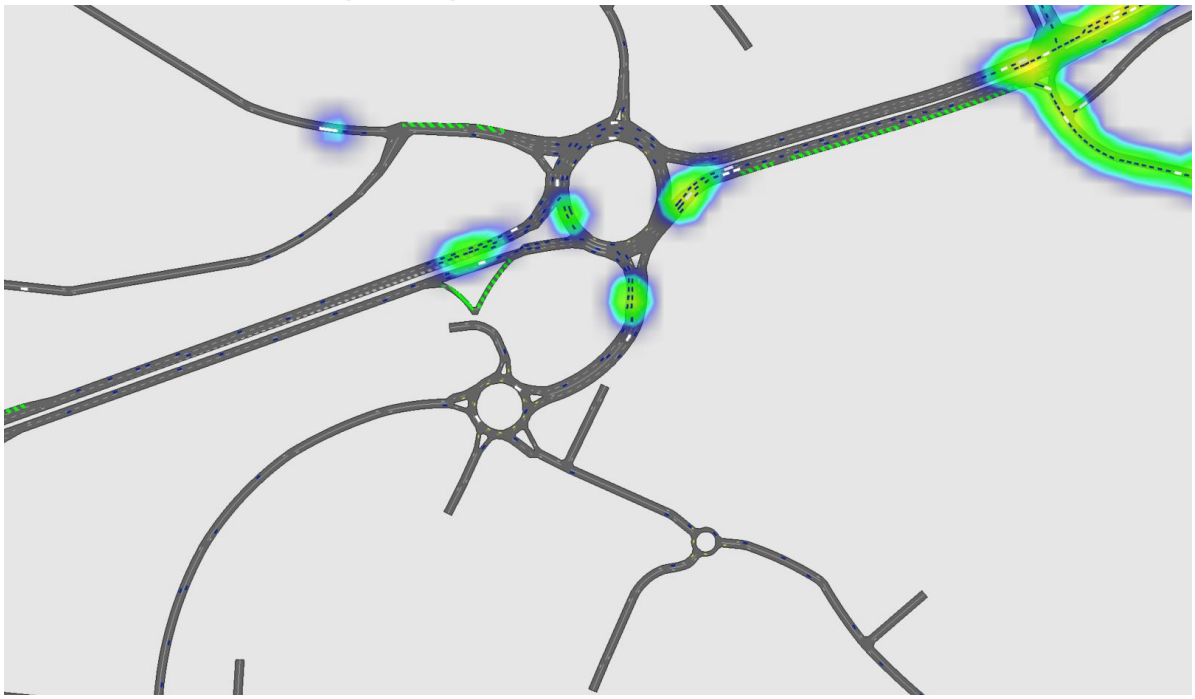
B.4. DS2 2031 PM (18:00)



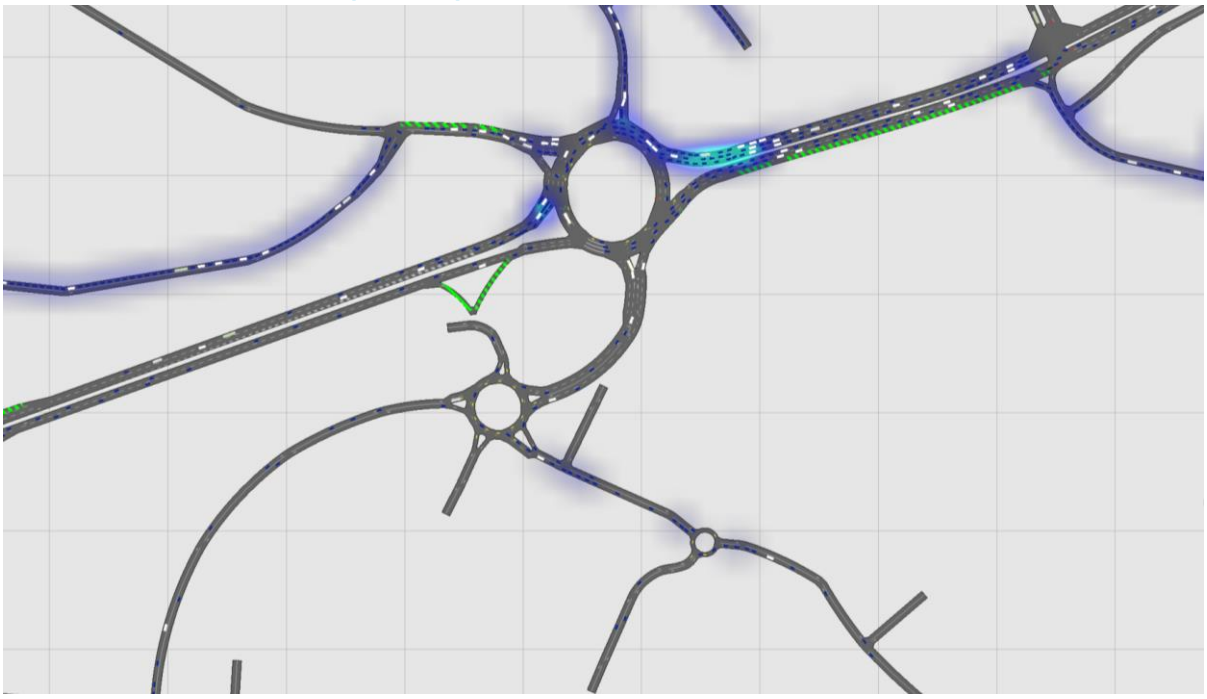
Appendix C.

C.1. DS3 2021 AM (09:00)

C.2. DS3 2021 PM (18:00)



C.3. DS3 2031 AM (09:00)



C.4. DS3 2031 PM (18:00)