Technical Note

Project:	WCTIS Phase 3 & 4 Paramics Modelling Note		
Subject:	Paramics Model Option Testing		
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Document history

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Client signoff

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1. Introduction

This Technical Note documents the steps undertaken to analyse and select the optimal Phase 3 and 4 network design to be taken forward to WCTIS Phases 3 and 4 Full Business Case. As with the previous phases of the improvements scheme, a Paramics Discovery v19 micro-simulation model was used for this assessment.

2. Phase 3 Model Development

This section details the steps undertaken to develop the Phase 3 Paramics Discovery models for the three individual network options agreed to be tested. All networks assume construction for the Phase 1 and 2 schemes has been completed, acting as a continuation of the WCTIS improvements scheme. The Do Minimum model used in the Phase 3 analysis is consistent with the Phase 2 Do Something model, assuming no further development has taken place.

One change was applied to the Phase 3 Do Minimum model from the Phase 2 Do Something assessment, carried over to the Phase 3 Do Something models. Previously, vehicles waiting to turn right into Granley Road from the A40 would block all eastbound traffic flow. However, from local knowledge and on-site observations, it was found that blocked vehicles would use the adjacent bus lane to undertake those waiting. This was found to have a significant impact on the results of the Phase 3 assessment, therefore the model was updated to reflect these localised observed conditions.

2.1. Phase 3 Modelling Options

The aim of the Phase 3 scheme is to reduce congestion on the A40 eastbound between the Arle Court Roundabout and Benhall Roundabout, shown in Figure 2-1, with additional focus on improving access into and out of GCHQ at the Telstar Way junction. The existing network layout is shown in Figure 2-2 below, with two lanes for the A40 eastbound movement, a dedicated third left-turn lane to Telstar Way, widening from two to three lanes on the approach to Benhall Roundabout, and a two-lane roundabout gyratory.

Figure 2-1 - Phase 3 & 4 Scheme Location

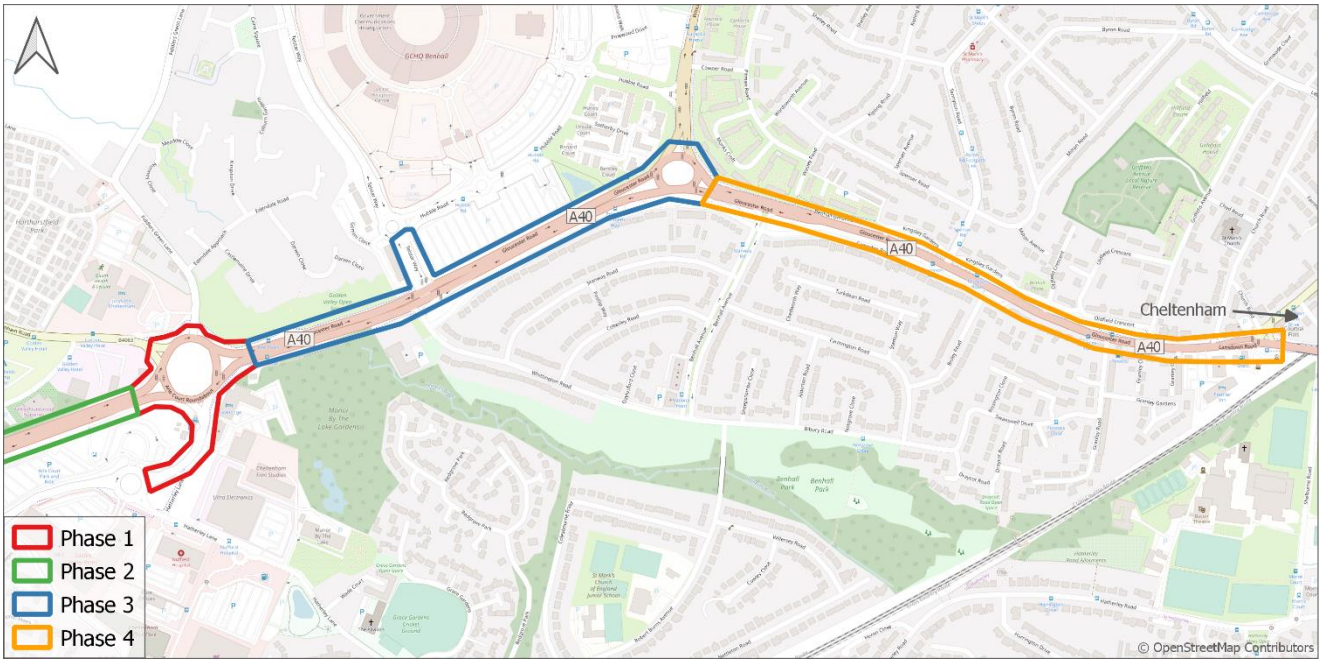
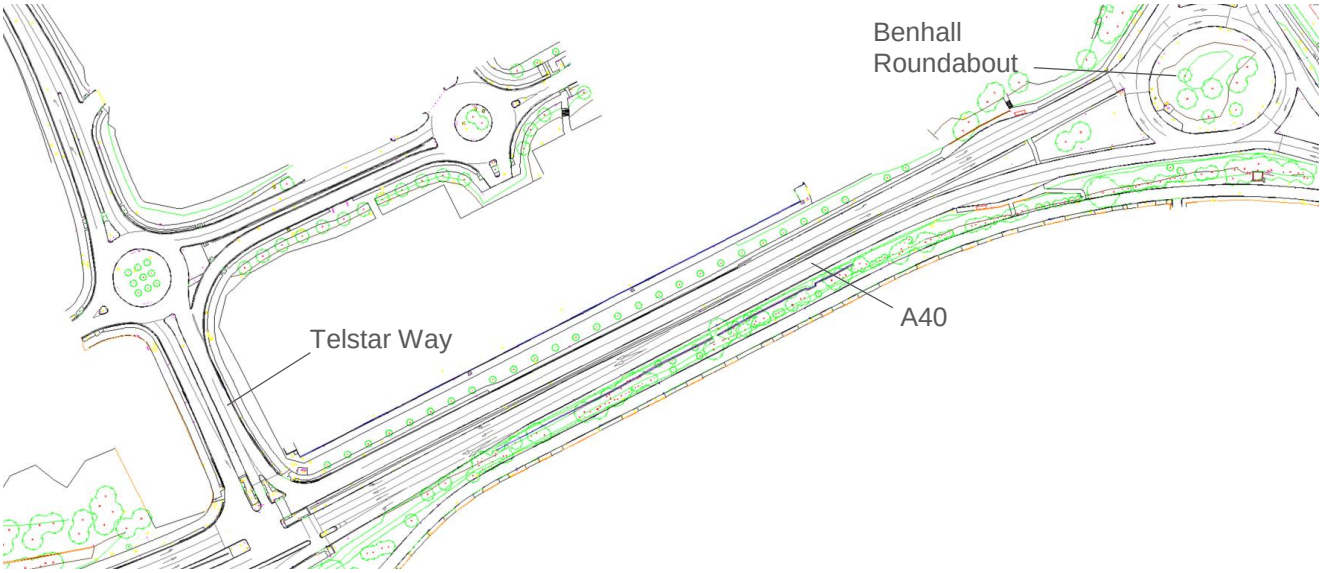


Figure 2-2 - Do Minimum Network Layout



The following three options have been tested to determine the optimal network design for the Phase 3 scheme. All options were specified to include:

- Four lanes on the A40 eastbound approach to the Telstar Way junction, with lane one as a dedicated left-turn lane;
- Three lanes on the Telstar Way southbound approach to the A40, with a dedicated left-turn lane and two right-turn lanes;
- Two new signalised pedestrian crossings, the Princess Elizabeth Way northbound exit from Benhall Roundabout, and on the A40 westbound exit from Benhall Roundabout;
- Widening of the Benhall Roundabout A40 eastbound exit to 3 lanes so that Phase 3 ties in smoothly with the existing network prior to Phase 4 improvements.
- Signal optimisation obtained from LinSig for the Arle Court Roundabout and Telstar Way / A40 junction, with visual checks on simulation performance at Benhall Roundabout.

2.1.1. Option 1

The option layout shown in Figure 2-3 includes the following network changes:

- Four lanes on the A40 eastbound approach to Benhall Roundabout, with the current bus layby removed and replaced with bus boarder arrangement and:
    - Lanes 1 and 2 left turn only for all vehicles, with lane 2 allowing buses to also go straight, and lanes 3 and 4 straight ahead only.
- Widening of the Benhall Roundabout northern circulatory to 3 lanes, with lane 1 for buses only.

2.1.2. Option 1a

The Phase 3 Option 1a network shown in Figure 2-4 is consistent with the Option 1 network, but with the inclusion of the bus layby on the A40 eastbound approach that was previously removed.

2.1.3. Option 2a

The option layout shown in Figure 2-5 includes the following network changes:

- Three lanes on the A40 eastbound approach to Benhall Roundabout, with the inclusion of the bus layby:
    - Lane 1 left only for vehicles, with buses allowed to go straight ahead, lanes 2 and 3 straight ahead only.
- Benhall Roundabout circulatory selectively widened on northern side to 3 lanes, with lane 1 of northern circulatory for buses only.

Figure 2-3 - Phase 3 Option 1, Benhall Roundabout

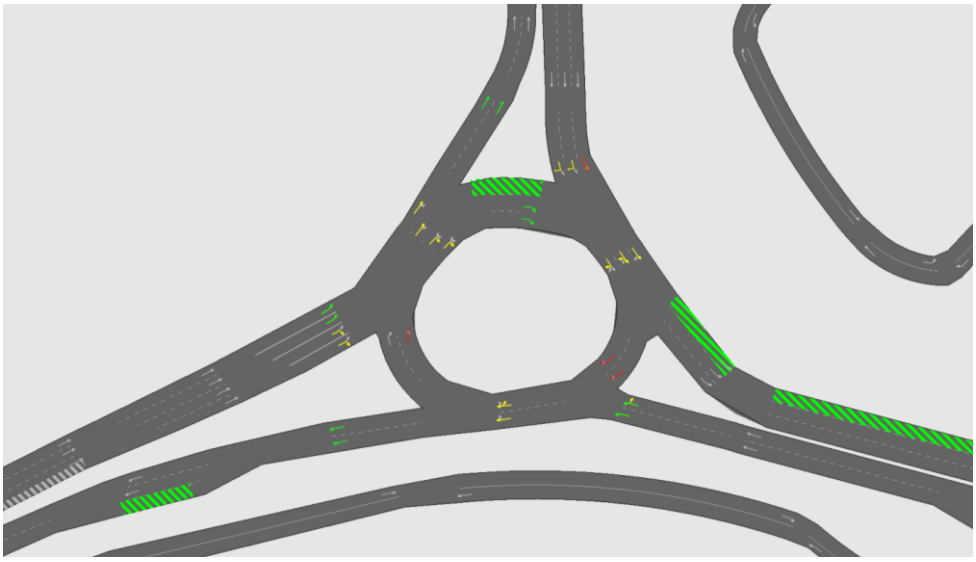


Figure 2-4 - Phase 3 Option 1a, Benhall Roundabout

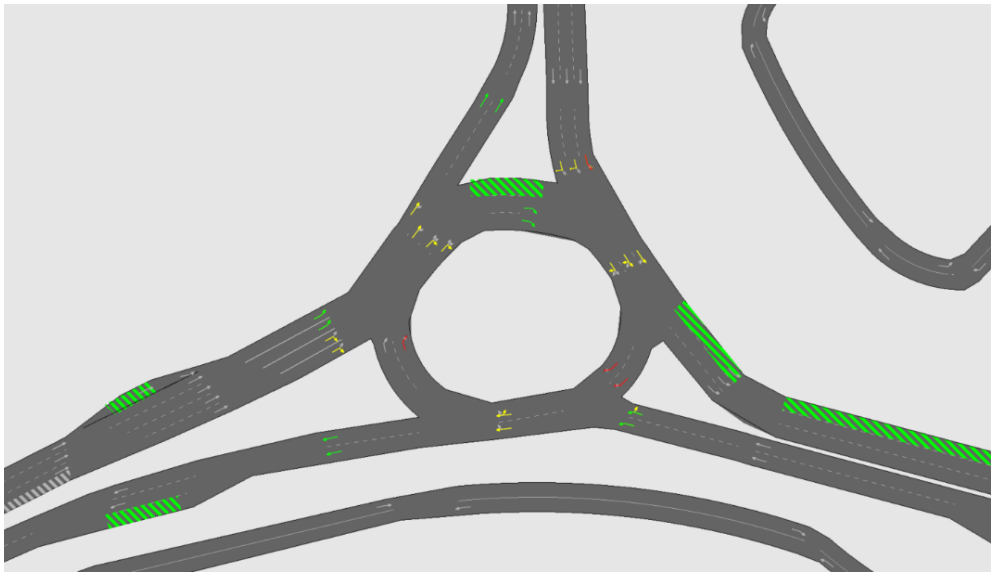
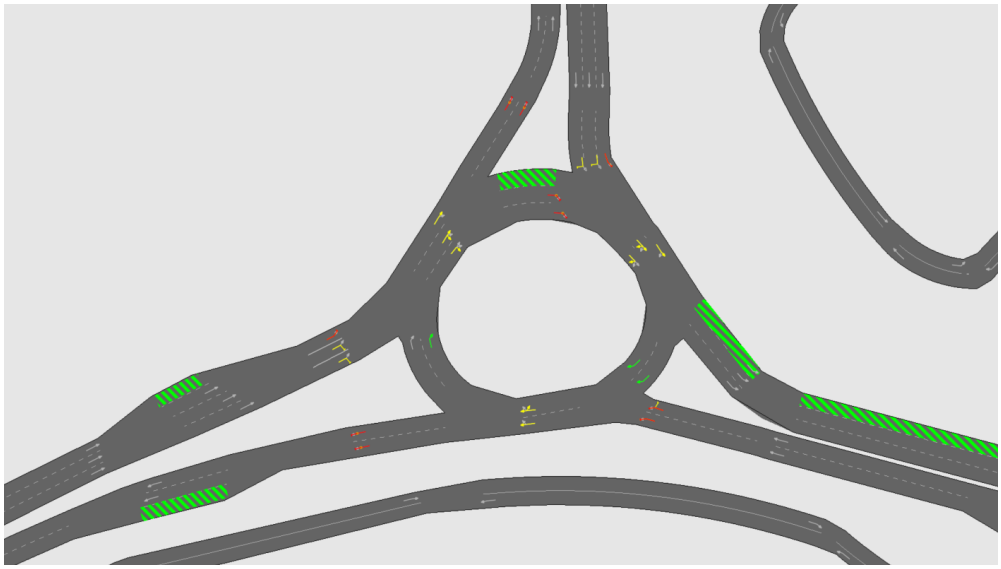


Figure 2-5 - Phase 3 Option 2a, Benhall Roundabout



2.2. Model Run Processing

As with Phases 1 and 2, the model runs were consistent with the modelling for economics outputs guidance from Systra. For the 2021 models, a total of 30 fixed-seed runs were carried out (valued from 1 to 30). The modelling results were then filtered based on a +/- 10% difference from the mean journey time across all runs, with those falling outside this criteria removed from further assessment. The filtered-out seeds from the Phase 3 analysis are shown in Table 2-1 below.

Table 2-1 – Phase 3 Filtered Seeds Outside 10% of the Mean Journey Time

Model	Option	AM Peak (08:00 – 09:00)		PM Peak (17:00 – 18:00)	
		Count	Seed Value	Count	Seed Value
Do Minimum		0	-	1	12
Do Something	Option 1	0	-	0	-
	Option 1a	0	-	1	4
	Option 2a	0	-	0	-

2.3. Option Assessment

As all Phase 3 options being tested affect both the vehicle and bus networks, it is important to capture the level of change for all vehicle classes across the different scenarios. Journey Time and Queue Routes were set up on key junctions and routes on the Phase 3 affected network to assess the impact of the modelled options on queuing and travel time. In addition, the Bus Delay output was used to assess the effect of network changes on overall bus journey times by route.

2.3.1. Journey Times

A journey time route assessment was carried out for three key routes on the modelled network for both the AM and PM single peak hours (08:00 – 09:00 and 17:00 – 18:00). These are:

- Route 1 – A40 mainline between the Arle Court Roundabout and the A40 / B4633 Gloucester Road (TGI Fridays) junction;
- Route 2 – A4013 Princess Elizabeth Way between the Benhall Roundabout and the A4019 / Kingsditch Lane Roundabout; and
- Route 3 – To and from GCHQ at Telstar Way to and from the Arle Court Roundabout and Benhall Roundabout.

Figure 2-6 - Journey Time Route 1

Figure 2-7 - Journey Time Route 2

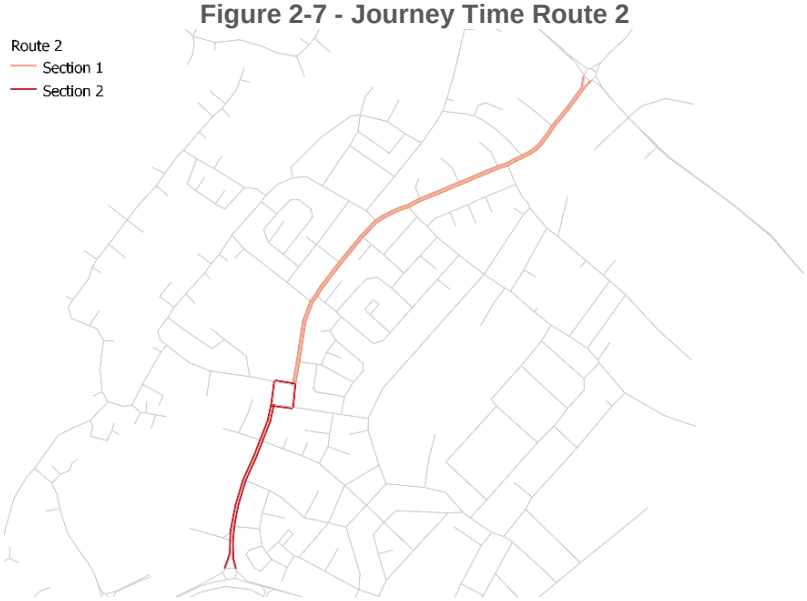
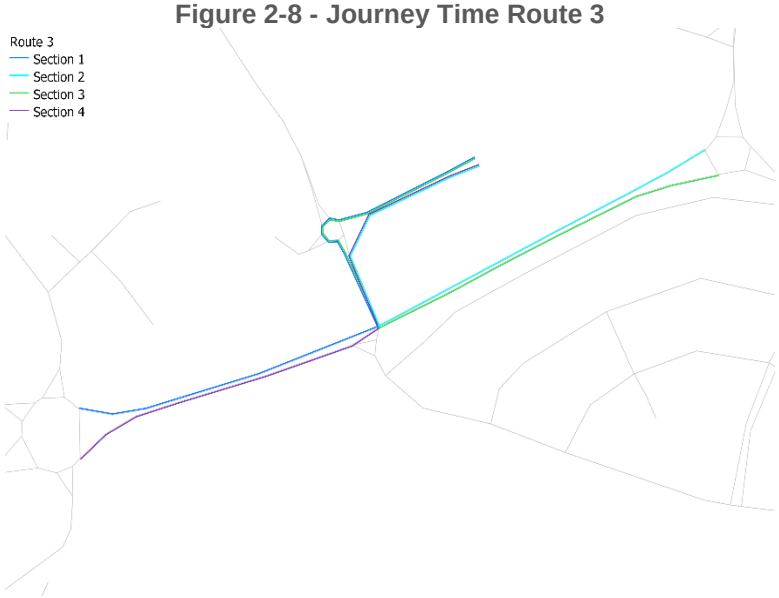


Figure 2-8 - Journey Time Route 3



2.3.1.1. Journey Time analysis of Route 1

Table 2-2 - Phase 3 Journey Time Comparison, Route 1 AM

Direction	Section	Description	Route 1 AM (08:00 – 09:00) Journey Time (s)			
			Do Minimum	Option 1	Option 1a	Option 2a
Eastbound	1	Arle Court to Telstar Way	39	30	30	30
	2	Telstar Way to Benhall	71	45	44	47
	3	Benhall to TGI Fridays	122	139	144	155
	Total		**232**	**214**	**218**	**233**
Westbound	3	TGI Fridays to Benhall	107	100	100	102
	2	Benhall to Telstar Way	68	59	59	59
	1	Telstar Way to Arle Court	59	60	59	59
	Total		**233**	**218**	**218**	**220**

Table 2-3 - Phase 3 Journey Time Comparison, Route 1 PM

Direction	Section	Description	Route 1 PM (17:00 – 18:00) Journey Time (s)			
			Do Minimum	Option 1	Option 1a	Option 2a
Eastbound	1	Arle Court to Telstar Way	34	30	30	30
	2	Telstar Way to Benhall	71	45	44	47
	3	Benhall to TGI Fridays	83	99	107	104
	Total		**188**	**175**	**181**	**182**
Westbound	3	TGI Fridays to Benhall	104	89	90	89
	2	Benhall to Telstar Way	57	56	56	56
	1	Telstar Way to Arle Court	50	49	50	48
	Total		**211**	**194**	**196**	**193**

Table 2-2 and Table 2-3 show that almost all options tested for Route 1 result in improvements to both the eastbound and westbound travel times for the AM and PM peaks compared to the Do Minimum scenario. Option 2a eastbound in the AM peak is the main exception to this, with the total journey time comparable to the Do Minimum. The most notable decreases in average time are shown to occur on sections 1 and 2, with travel times of up to 27 seconds less. Journey times on section 3 eastbound between Benhall Roundabout and TGI Fridays can be seen to increase over the Do Minimum for all options tested. This may be a result of improvements upstream leading to more vehicles reaching this section in less time, leading to more congestion and thus greater travel times. This is expected to be addressed by Phase 4 of the improvements scheme which consists of widening of the A40 to two lanes for mainline traffic and improving the TGI signalised junction, and is therefore not considered an issue.

Figure 2-9 - Phase 3 Bus Journey Time Comparison (s), Route 1 AM (08:00 – 09:00)

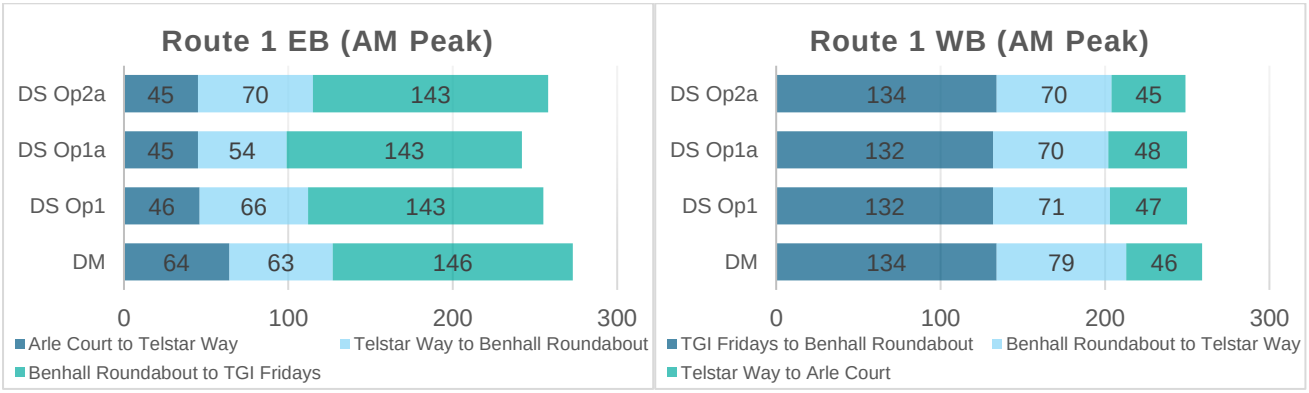


Figure 2-10 - Phase 3 Bus Journey Time Comparison (s), Route 1 PM (17:00 – 18:00)

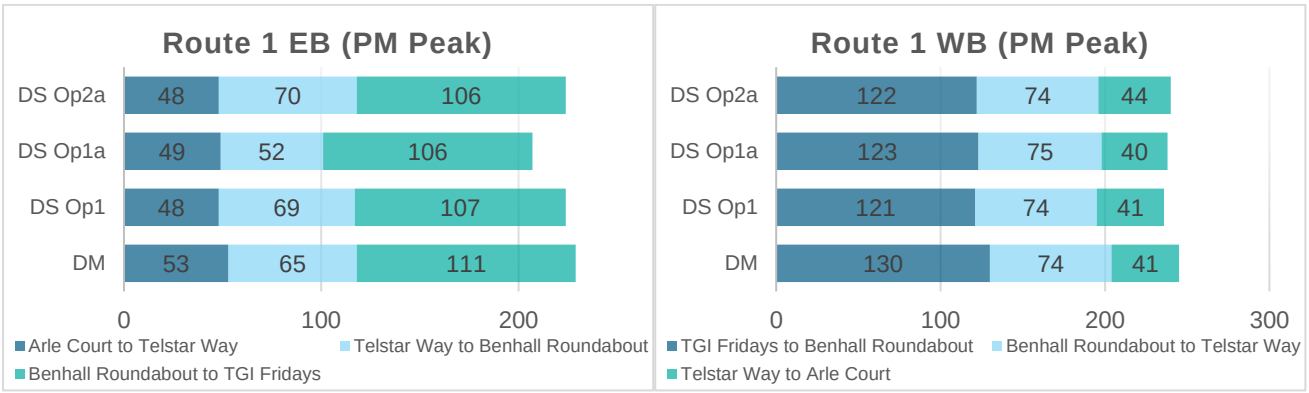


Figure 2-9 and Figure 2-10 show AM and PM Bus journey time results for Route 1, which show that all Do Something options display a positive improvement to bus travel times compared to the Do Minimum model. The most notable change is to the eastbound direction in the AM peak, with decreases of up to 28 seconds between Arle Court and Benhall Roundabout. Out of the three options tested, Option 1a is generally shown to perform the best, specifically for eastbound travel in the AM and PM peaks. Option 1 and 2a are also shown to improve bus travel times.

2.3.1.2. Route 2

Table 2-4 - Phase 3 Journey Time Comparison, Route 2 AM

Direction	Section	Description	Route 2 AM (08:00 – 09:00) Journey Time (s)			
			Do Minimum	Option 1	Option 1a	Option 2a
Northbound	2	Princess Elizabeth Way South	124	129	132	127
	1	Princess Elizabeth Way North	240	241	240	242
	Total		**365**	**370**	**372**	**369**
Southbound	1	Princess Elizabeth Way North	225	226	222	223
	2	Princess Elizabeth Way South	117	120	120	121
	Total		**342**	**346**	**342**	**344**

Table 2-5 - Phase 3 Journey Time Comparison, Route 2 PM

Direction	Section	Description	Route 2 PM (17:00 – 18:00) Journey Time (s)			
			Do Minimum	Option 1	Option 1a	Option 2a
Northbound	2	Princess Elizabeth Way South	143	145	145	145
	1	Princess Elizabeth Way North	212	211	217	207
	Total		**355**	**356**	**362**	**352**
Southbound	1	Princess Elizabeth Way North	179	177	176	177
	2	Princess Elizabeth Way South	129	132	133	134
	Total		**308**	**309**	**309**	**310**

The results for Route 2 as shown in Table 2-4 and Table 2-5 indicate little variation between the three options tested as well as from the Do Minimum scenario, with the northbound direction actually experiencing a slight increase of up to 7 seconds in travel time. This is likely a result of the new Pelican Crossing on Princess Elizabeth Way on the northbound exit of Benhall Roundabout contributing to additional delay on section 2. The minimal difference from the Do Minimum model shown by the results is likely due to the route existing on the peripheral of the Phase 3 improvements, therefore is unlikely to experience much effect from the scheme.

2.3.1.3. Route 3

Table 2-6 - Phase 3 Journey Time Comparison, Route 3 AM

Direction	Section	Description	Route 3 AM (08:00 – 09:00) Journey Time (s)			
			Do Minimum	Option 1	Option 1a	Option 2a
Eastbound	1	Arle Court to GCHQ	55	61	61	61
	2	GCHQ to Benhall	74	66	65	72
Westbound	3	Benhall to GCHQ	99	93	94	93
	4	GCHQ to Arle Court	102	107	106	106

Table 2-7 - Phase 3 Journey Time Comparison, Route 3 PM

Direction	Section	Description	Route 3 PM (17:00 – 18:00) Journey Time (s)			
			Do Minimum	Option 1	Option 1a	Option 2a
Eastbound	1	Arle Court to GCHQ	53	57	57	57
	2	GCHQ to Benhall	68	64	62	66
Westbound	3	Benhall to GCHQ	84	88	88	85
	4	GCHQ to Arle Court	109	93	93	92

In comparison to the Do Minimum model, Table 2-6 and Table 2-7 for Route 3 shows minimal changes to journey time for each of the Phase 3 options tested. Some sections are seen to experience minor increases in travel time, while others show a slight decrease. This may be reflective of the Phase 3 signal optimisation carried out at the Telstar Way / A40 junction which aimed to give more priority to the A40 movement. As with previous routes, all three options perform similarly well when compared to each other.

2.3.2. Bus Delay

The Paramics Discovery bus delay output represents the average overall journey time of buses by route and peak hour. The following key bus routes were assessed, with their respective route displayed in Figure 2-11 below:

- Route 511 – Arle Court to Cheltenham Park & Ride Service (OB);
- Route 511 – Cheltenham to Arle Court Park & Ride service (IB);
- Route 93 – Arle Court to Cheltenham Park & Ride Service (OB);
- Route 93 – Cheltenham to Arle Court Park & Ride Service (IB);
- Route 94 – Gloucester Market Parade to Cheltenham Promenade via Staverton Bridge (OB);
- Route 94 – Cheltenham Promenade to Gloucester Market Parade via Staverton Bridge (IB);
- Route 99 – Arle Court Park & Ride to Cheltenham via Cheltenham Hospital (OB); and
- Route 99 – Cheltenham to Arle Court Park & Ride via Cheltenham Hospital (IB).

Figure 2-11 - Phase 3 Bus Delay Routes

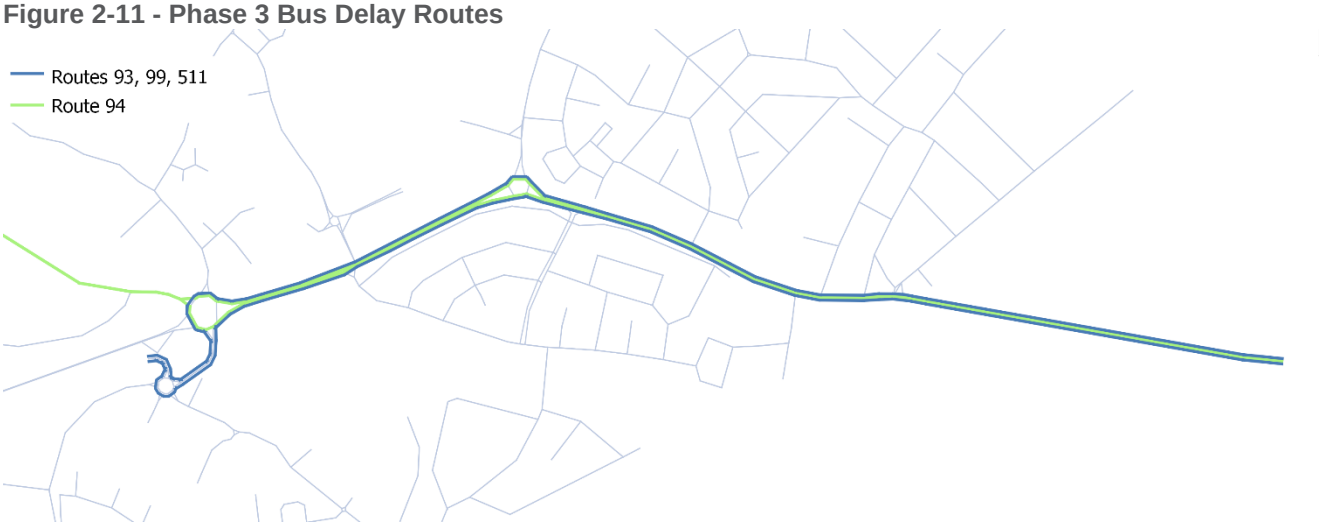


Figure 2-12 - Bus Route Journey Time Difference (s) from the Do Minimum (AM)

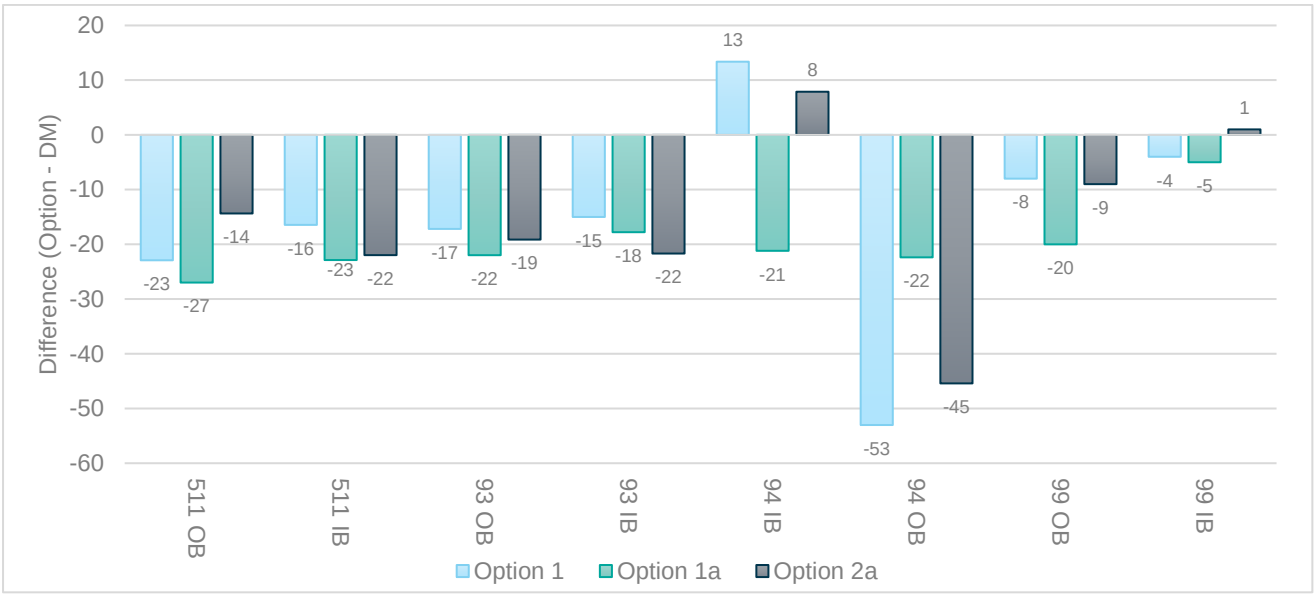
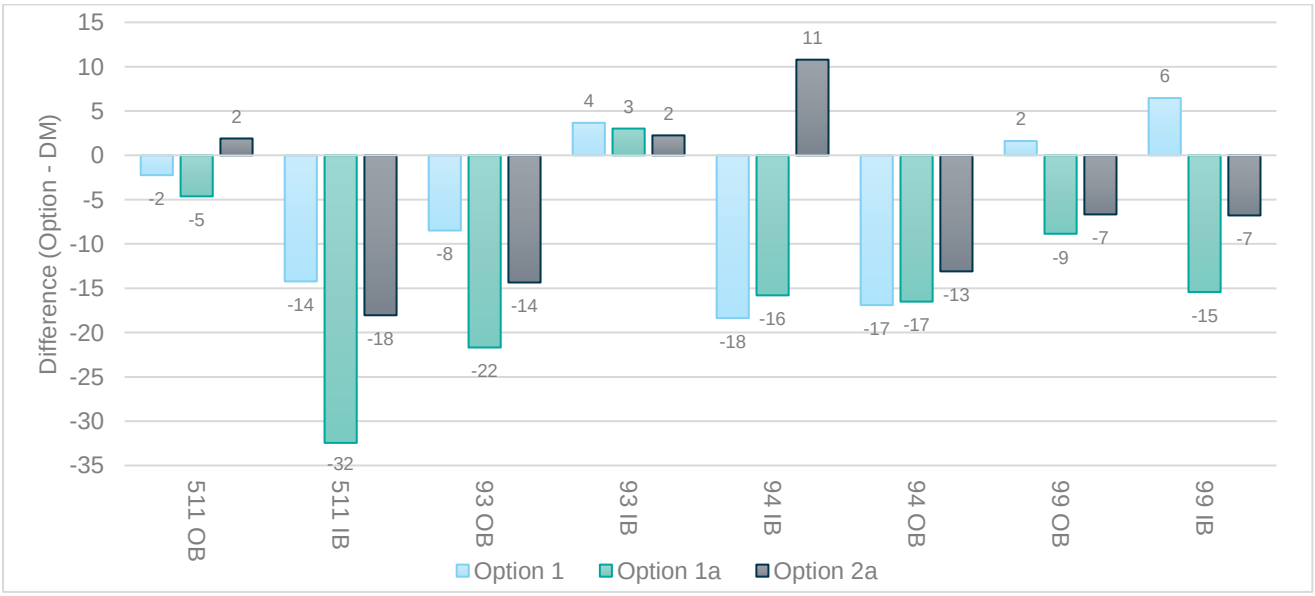


Figure 2-13 - Bus Route Journey Time Difference (s) from the Do Minimum (PM)



Based on the bus delay results as shown graphically in Figure 2-12 and Figure 2-13, Option 1a can be seen to perform the best out of the other options tested, with the greatest travel time savings for 6 out of 8 routes in both the AM and PM peak hours. This is understandable as this option consists of a 4-lane approach to Benhall Roundabout not present in Option 2a, as well as a dedicated bus layby on the A40 eastbound not included in Option 1. However, the results clearly show that all three of the options tested show significant improvements to overall bus journey times from the baseline Do Minimum scenario.

2.3.3. Queue Length

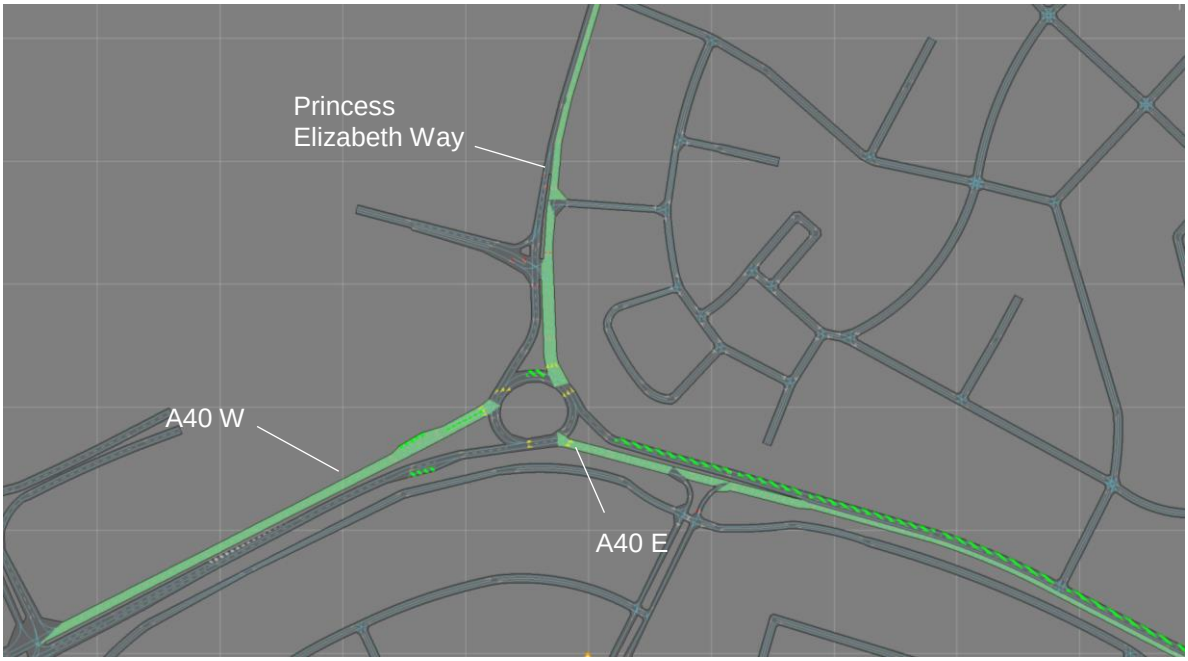
Queue routes on the following key junctions and roundabouts were set up to assess the potential Phase 3 improvements to queueing on the approaches:

- A40 / Telstar Way signalised junction - Figure 2-14; and
- Benhall Roundabout - Figure 2-15.

The average queue length is the weighted average queue for the entry arm assessed across all lanes and the maximum queue is the extent of queuing from the most congested individual lane of the approach.

Figure 2-14 - Queue Routes - Telstar Way

Figure 2-15 - Queue Routes - Benhall Roundabout



2.3.3.1. A40 / Telstar Way

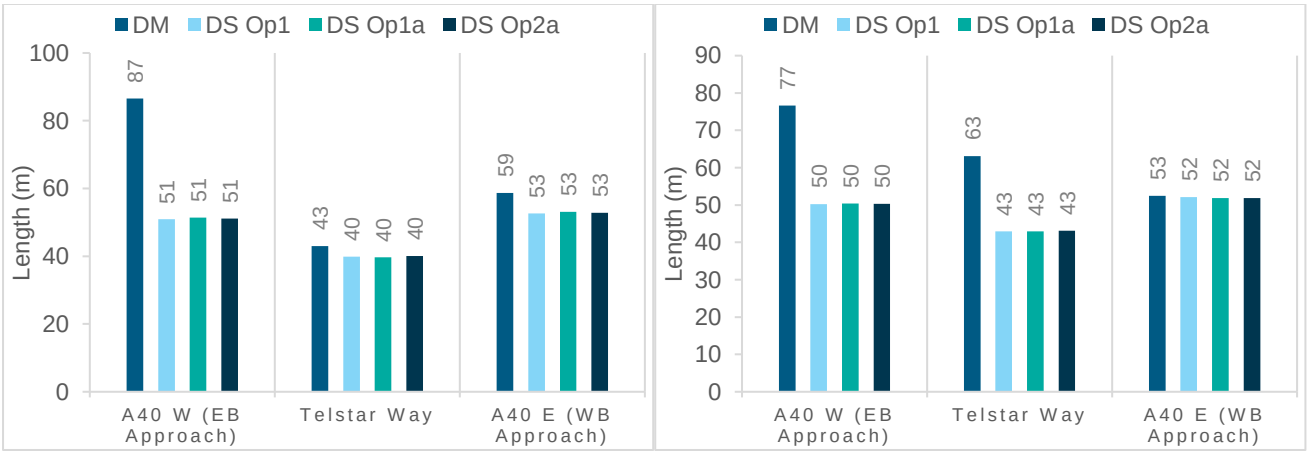
Table 2-8 - Phase 3 Queue Length Comparison (m), Telstar Way AM (08:00 - 09:00)

	Do Minimum		Option 1		Option 1a		Option 2a	
Arm	Average	Maximum	Average	Maximum	Average	Maximum	Average	Maximum
A40 W (EB Approach)	87	221	51	131	51	134	51	122
Telstar Way	43	97	40	74	40	74	40	75
A40 E (WB Approach)	59	162	53	129	53	131	53	128

Table 2-9 - Phase 3 Queue Length Comparison (m), Telstar Way PM (17:00 - 18:00)

	Do Minimum		Option 1		Option 1a		Option 2a	
Arm	Average	Maximum	Average	Maximum	Average	Maximum	Average	Maximum
A40 W (EB Approach)	77	171	50	102	50	103	50	107
Telstar Way	63	169	43	79	43	78	43	78
A40 E (WB Approach)	53	137	52	150	52	137	52	142

Figure 2-16 - Phase 3 Average Queue Length Comparison, Telstar Way (AM – left, PM – right)



The Telstar Way queue route results as presented in Table 2-8 and Table 2-9 and graphically in Figure 2-16 show that all approach arms to the junction experience similar levels of queueing across the three options tested, with all displaying improvements from the Do Minimum scenario. The approach with the overall lowest level of improvement is the A40 westbound approach, in which all options show only a minor decrease in average queue length of 6 seconds in the AM peak and 1 second in the PM peak. This may be due to a combination of signal timing optimisation carried out at this junction, and no changes applied to the westbound network as part of the Phase 3 improvements.

2.3.3.2. Benhall Roundabout

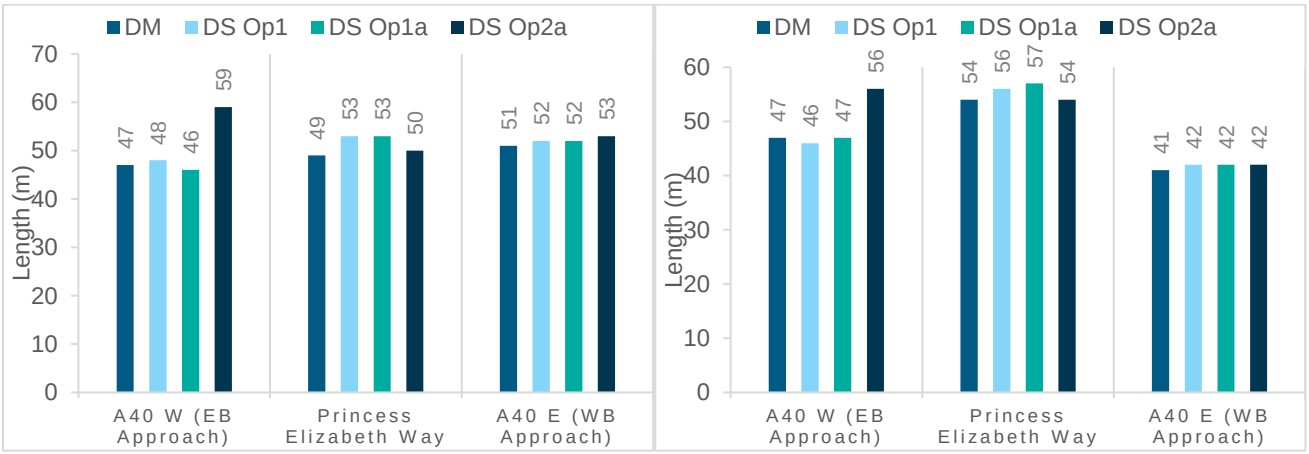
Table 2-10 - Phase 3 Queue Length Comparison (m), Benhall Roundabout AM (08:00 – 09:00)

	Do Minimum		Option 1		Option 1a		Option 2a	
Arm	Average	Maximum	Average	Maximum	Average	Maximum	Average	Maximum
A40 W (EB Approach)	47	147	48	127	46	106	59	168
Princess Elizabeth Way	49	186	53	197	53	197	50	194
A40 E (WB Approach)	51	167	52	170	52	166	53	165

Table 2-11 – Phase 3 Queue Length Comparison (m), Benhall Roundabout PM (17:00 – 18:00)

	Do Minimum		Option 1		Option 1a		Option 2a	
Arm	Average	Maximum	Average	Maximum	Average	Maximum	Average	Maximum
A40 W (EB Approach)	47	132	46	115	47	102	56	144
Princess Elizabeth Way	54	193	56	201	57	198	54	194
A40 E (WB Approach)	41	141	42	145	42	149	42	142

Figure 2-17 - Phase 3 Average Queue Length Comparison, Benhall Roundabout (AM – left, PM – right)



Queue route results in Table 2-10 and Table 2-11 at Benhall Roundabout for the AM and PM peaks and graphically in Figure 2-17 show little to no improvement in queue lengths on all approach arms at Benhall Roundabout. The results for Princess Elizabeth Way and the A40 westbound approaches are expected as these sections have not been changed as part of the Phase 3 improvements.

The A40 eastbound approach is central to the scheme, therefore it was expected to show significant improvements following an increase to the capacity of the approach for eastbound vehicles turning right towards Cheltenham. Following consultation with the software developers Systra, it was found these results reflect a limitation in the Paramics modelling software. In queue routes, Paramics assumes that each lane maps directly onto the same lane upstream, i.e. lane 1 on one link maps to lane 1 on the proceeding link. With this setup, where the A40 eastbound widens to 3 or 4 lanes adjacent to the bus layby, the lane numbers being reported are different for each option tested. This means that the queue route results are inconsistent and therefore cannot be compared. When each model is observed visually, there is a clear reduction in queue lengths from the Do Minimum, further supported by reported journey time results for Route 1 eastbound showing positive improvements.

2.4. Conclusions

It is clear from the results that all three of the options tested led to improvements to both journey time and queueing in comparison to the baseline (Do Minimum scenario). Overall, it was found that Option 1a, with both a four-lane approach to Benhall Roundabout and dedicated bus layby, resulted in slightly better modelled network performance when considering bus journey time improvements. Despite this however, Option 1 and 2a performed consistently well in comparison to the Do Minimum for both vehicle journey time and average queue lengths on key routes and junctions in the model. Therefore, it can be concluded that all three of the Phase 3 options tested would likely result in economic benefits. As Option 2a provides the lowest cost Phase 3 solution, shown to perform on a comparable level with the other higher cost solutions, it is recommended that this is the optimal scenario to implement.

3. Phase 4 Model Development

3.1. Introduction

This section details the process used to develop and analyse the two Paramics Discovery modelling options for Phase 4. In this, the Phase 3 Option 2a model was selected from the previous section to be taken forward, and is therefore included as an integral part of the Phase 4 assessment. To maximise scheme benefits, additional signal timing optimisation has been carried out at the A40 / B4633 Gloucester Road (TGI Fridays) Junction. The Phase 4 Do Minimum model scenario is consistent with the Do Minimum used in the Phase 3 analysis, with no further network changes applied except the optimisation of signal times at the TGI Friday junction.

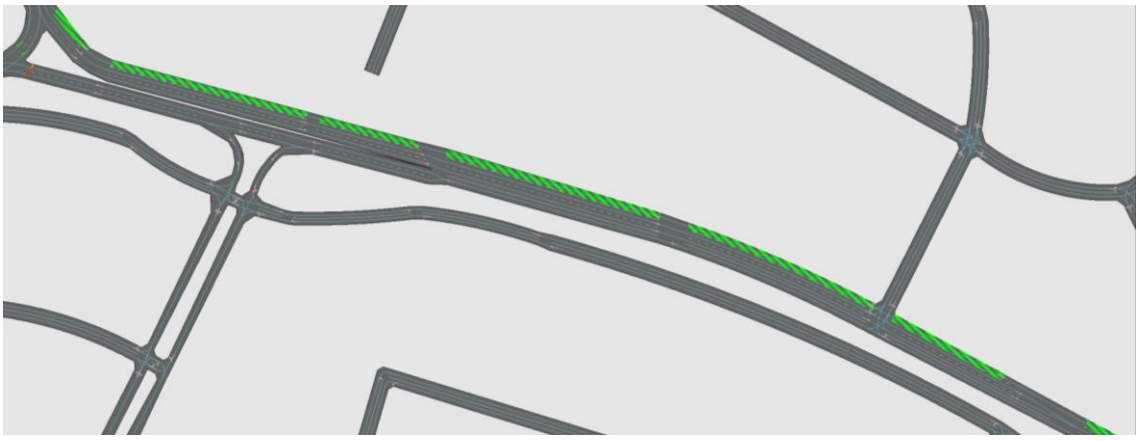
3.2. Phase 4 Options

The aim of the Phase 4 scheme is to reduce congestion on the A40 eastbound between Benhall Roundabout and the TGI Fridays junction. The existing network layout consists of a single lane for mainline eastbound traffic and a segregated bus lane between Benhall Roundabout and the A40 junction with Granley Road, where it joins regular traffic. To identify the optimal Phase 4 network design, the following two options were considered.

3.2.1. Option 1

Option 1 shown in Figure 3-1 below involved widening the existing general traffic provision from one to two lanes on the A40 eastbound exit from Benhall Roundabout, continuing to Oldfield Crescent where it merges back to a single lane, with the remaining section of the A40 eastbound continuing as existing. The current bus lane provision is maintained.

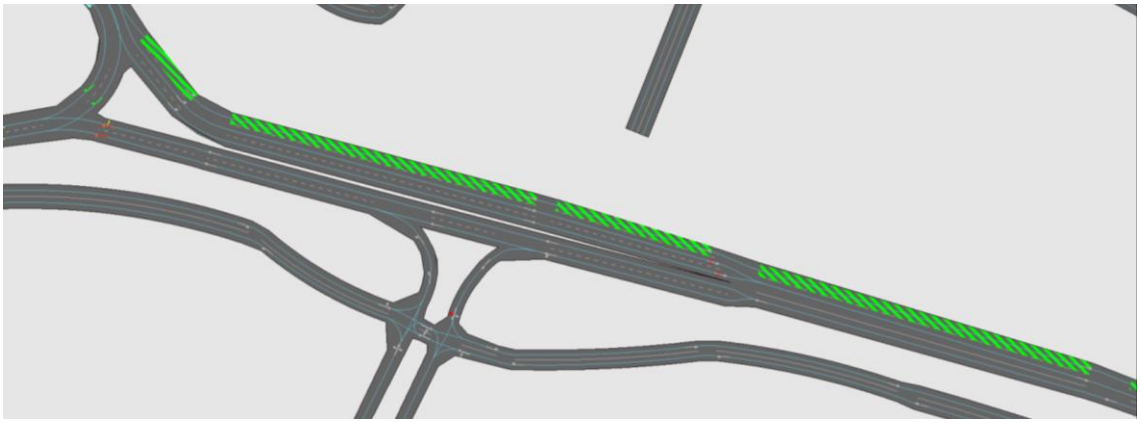
Figure 3-1 - Phase 4 Option 1 – A40 Long Merge Option



3.2.2. Option 2

Option 2 shown in Figure 3-2 below involved widening the existing general traffic lane provision from one to two lanes on the A40 eastbound exit from Benhall Roundabout, continuing to Benhall Gardens where it merges back to a single lane, with the remaining section of the A40 eastbound continuing as existing. The current bus lane provision is maintained.

Figure 3-2 - Phase 4 Option 2 – A40 Short Merge Option



3.3. Model Run Processing

As with Phases 3, the model runs were consistent with the modelling for economics outputs guidance from Systra, with a total of 30 fixed-seed runs carried out (valued from 1 to 30). The modelling results were also filtered based on the +/- 10% difference criteria from the mean journey time, with those outside this bracket removed from future analysis. The filtered seeds from the Phase 4 assessment are shown in Table 3-1 below.

Table 3-1 - Phase 4 Filtered Seeds Outside 10% of the Mean Journey Time

Model	Option	AM Peak (08:00 – 09:00)		PM Peak (17:00 – 18:00)	
		Count	Seed Value	Count	Seed Value
Do Minimum		0	-	1	17
Do Something	Option 1	0	-	0	-
	Option 2	0	-	0	-

3.4. Option Assessment

As for the Phase 3 analysis, the two Phase 4 modelling options were assessed using journey time and queue routes for both vehicles and buses.

3.4.1. Journey Times

Journey Time results were collected for the same 3 key routes in the model that were used in the Phase 3 assessment for both the AM and PM Peak hours (08:00 – 09:00 and 17:00 – 18:00 respectively).

3.4.1.1. Route 1

Table 3-2 - Phase 4 Journey Time Comparison, Route 1 AM

Direction	Section	Description	Route 1 AM (08:00 – 09:00) Journey Time (s)		
			Do Minimum	Option 1	Option 2
Eastbound	1	Arle Court to Telstar Way	38	30	30
	2	Telstar Way to Benhall	71	47	47
	3	Benhall to TGI Fridays	80	77	77
	Total		**189**	**154**	**154**
Westbound	1	TGI Fridays to Benhall	105	89	89
	2	Benhall to Telstar Way	67	59	59
	3	Telstar Way to Arle Court	59	61	61
	Total		**230**	**209**	**209**

Table 3-3 - Phase 4 Journey Time Comparison, Route 1 PM

Direction	Section	Description	Route 1 PM (17:00 – 18:00) Journey Time (s)		
			Do Minimum	Option 1	Option 2
Eastbound	1	Arle Court to Telstar Way	42	30	30
	2	Telstar Way to Benhall	85	47	47
	3	Benhall to TGI Fridays	114	89	87
	Total		**241**	**166**	**164**
Westbound	1	TGI Fridays to Benhall	123	81	83
	2	Benhall to Telstar Way	60	59	60
	3	Telstar Way to Arle Court	56	58	57
	Total		**239**	**198**	**198**

The journey time results for Route 1 (see Figure 2-6 for reference) given in Table 3-2 and Table 3-3 show that both Option 1 and Option 2 display significant reduction to travel times for both directions in the AM and PM peaks. The most significant journey time saving benefit is shown to occur on the A40 eastbound between Telstar Way and Benhall Roundabout in the PM peak, with a 38 second decrease for both options from the Do Minimum. This reflects the increased capacity east of Benhall Roundabout reducing exit constrain, leading to lower levels of blocking back to this section. It can be seen that Option 1 and Option 2 experience similar levels of benefit, with neither model standing out as the optimal solution. This suggests that the additional length of the A40 eastbound two-lane section in Option 1 may be unnecessary as no further benefit is shown to occur.

Figure 3-3 - Phase 4 Bus Journey Time Comparison (s), Route 1 AM (08:00 – 09:00)

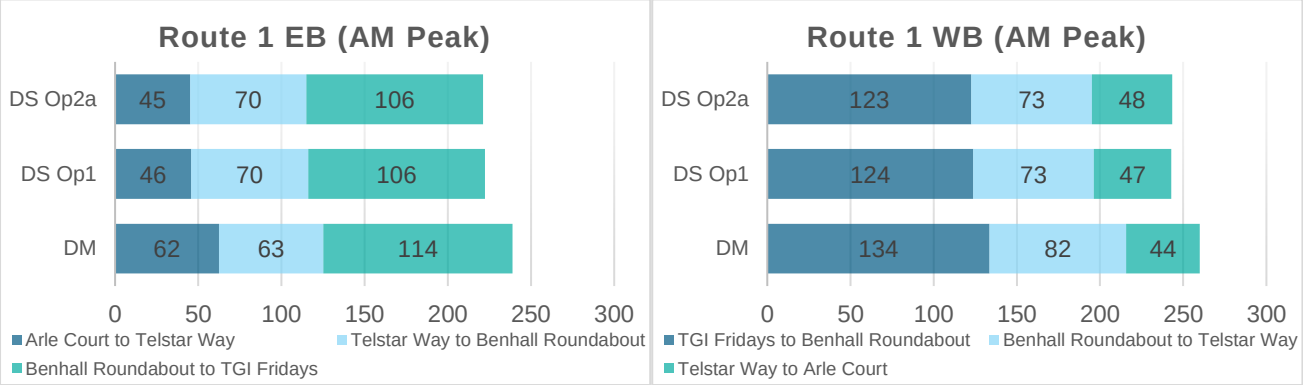
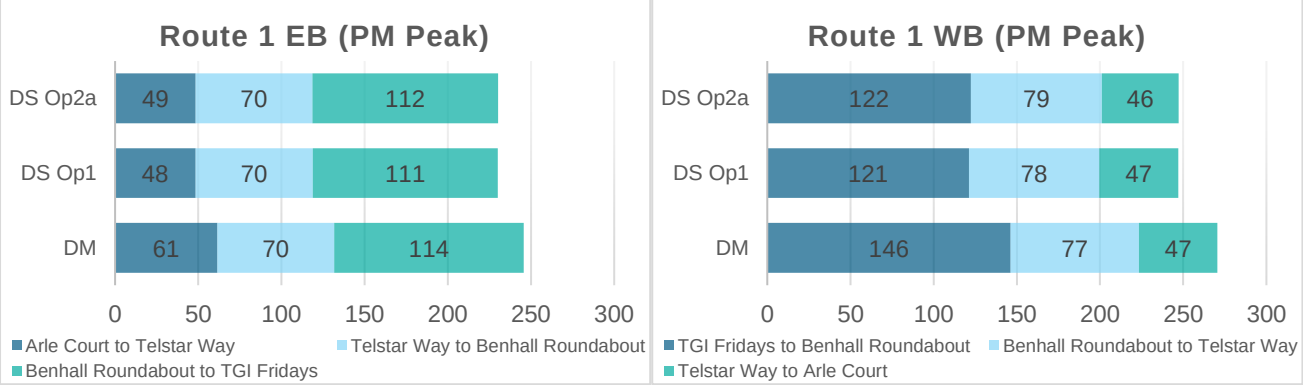


Figure 3-4 - Phase 4 Bus Journey Time Comparison (s), Route 1 PM (17:00 – 18:00)



In terms of the bus journey time comparison for Route 1 as shown in Figure 3-3 and Figure 3-4, it can be seen that both Option 1 and 2 result in faster bus travel times. As with the vehicle journey times, both options perform equally well. This result is expected as no changes have been made to the bus lanes between the two Phase 4 options. The largest time saving benefit between Arle Court and Telstar Way is shown to occur in the AM peak eastbound, with time improvements of up to 17 seconds. Despite no changes being made to the westbound network, benefits are also shown for this direction. This could be attributed to the signal timing optimisation carried out at Telstar Way, Benhall Roundabout and TGI Fridays.

3.4.1.2. Route 2

Table 3-4 - Phase 4 Journey Time Comparison, Route 2 AM

Direction	Section	Description	Route 2 AM (08:00 – 09:00) Journey Time (s)		
			Do Minimum	Option 1	Option 2
Northbound	2	Princess Elizabeth Way South	125	125	130
	1	Princess Elizabeth Way North	240	241	242
	Total		**365**	**366**	**372**

Direction	Section	Description	Route 2 AM (08:00 – 09:00) Journey Time (s)		
			Do Minimum	Option 1	Option 2
Southbound	1	Princess Elizabeth Way North	224	222	223
	2	Princess Elizabeth Way South	117	122	121
	Total		**342**	**344**	**345**

Table 3-5 - Phase 4 Journey Time Comparison, Route 2 PM

Direction	Section	Description	Route 2 PM (17:00 – 18:00) Journey Time (s)		
			Do Minimum	Option 1	Option 2
Northbound	2	Princess Elizabeth Way South	148	150	150
	1	Princess Elizabeth Way North	209	214	218
	Total		**356**	**364**	**367**
Southbound	1	Princess Elizabeth Way North	178	179	180
	2	Princess Elizabeth Way South	129	131	133
	Total		**307**	**310**	**313**

The journey time results for Route 2 (see Figure 2-7 for reference) are given in Table 3-4 and Table 3-5 which show limited levels of change from the Do Minimum for both peak hours and directions. This is expected as the route is located on the peripheral of the Phase 3 and 4 schemes, reflecting minimal changes to travel time.

3.4.2. Bus Delay

Similarly to the Phase 3 assessment, the bus delay output was used to analyse the potential Phase 4 benefits (see section 2.3.2 for further information).

Figure 3-5 - Bus Route Journey Time Difference (s) from the Do Minimum (AM)

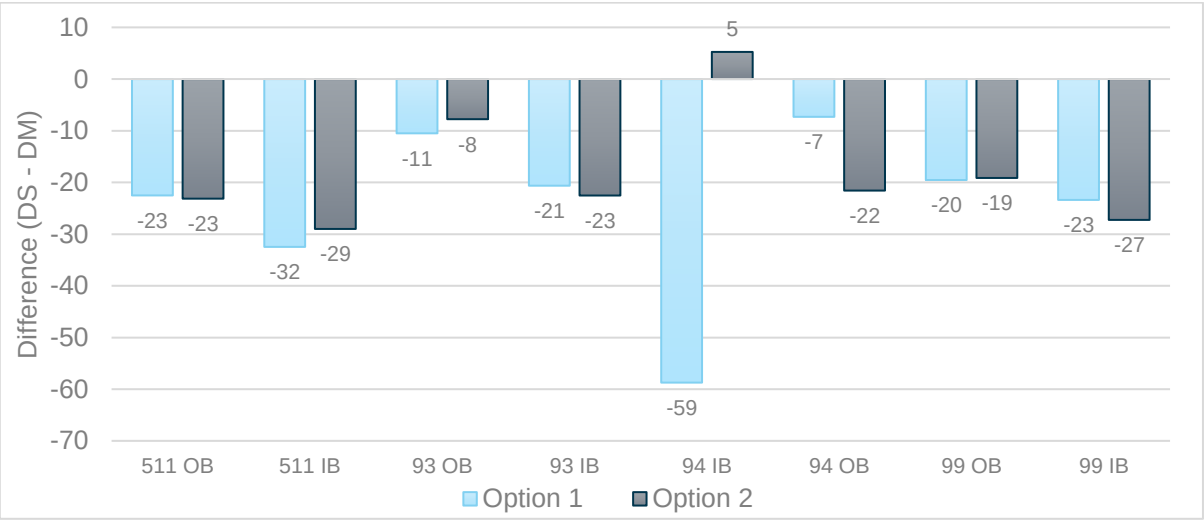
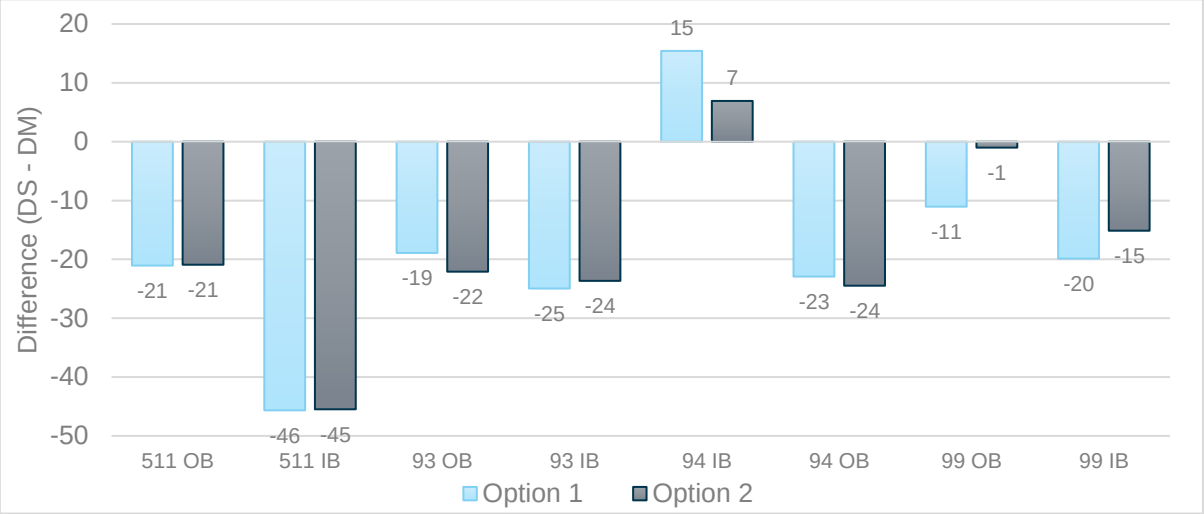


Figure 3-6 - Bus Route Journey Time Difference (s) from the Do Minimum (PM)



The bus delay results show that both Option 1 and Option 2 experience significantly faster bus route journey times than the Do Minimum, with 7 out of 8 routes in both the AM and PM showing improved times. This also shows a clear improvement in bus delay from the Phase 3 assessment. Both options can be seen to perform consistently well against each other which is understandable considering the nature of the Phase 4 improvements.

3.4.3. Queue Length

As with the Phase 3 assessment, queue routes were set up to analyse potential improvements to queueing at the following key junctions:

- A40 / Telstar Way signalised junction - Figure 2-14;
- Benhall Roundabout - Figure 2-15.
- A40 / B4633 Gloucester Road (TGI Fridays) signalised junction.

Figure 3-7 - Queue Routes - TGI Fridays

3.4.3.1. A40 / Telstar Way

Table 3-6 - Phase 4 Queue Length comparison (m), Telstar Way AM (08:00 – 09:00)

	Do Minimum		Option 1		Option 2	
Arm	Average	Maximum	Average	Maximum	Average	Maximum
Telstar Way	86	217	51	130	52	138
A40 E (WB Approach)	43	96	40	75	40	74
A40 W (EB Approach)	58	172	53	129	52	129

Table 3-7 - Phase 4 Queue Length comparison (m), Telstar Way PM (17:00 – 18:00)

	Do Minimum		Option 1		Option 2	
Arm	Average	Maximum	Average	Maximum	Average	Maximum
Telstar Way	87	203	50	106	50	103
A40 E (WB Approach)	64	174	43	79	43	78
A40 W (EB Approach)	56	168	55	175	56	175

Figure 3-8 - Phase 4 Average Queue Length Comparison, Telstar Way (AM – left, PM – right)

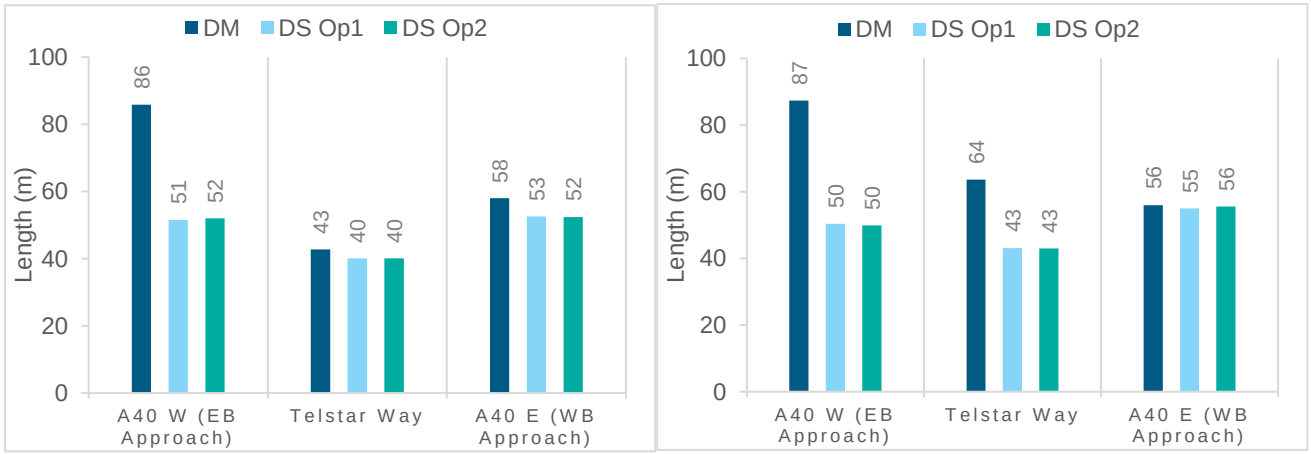


Table 3-6 and Table 3-7 give the average queue length results at Telstar Way junction (also shown graphically in Figure 3-8 which show an overall reduction in queueing for both options when compared to the Do Minimum. The exception to this is for the A40 westbound in the PM peak which shows no significant change in queue length. As proposed in the Phase 3 assessment, this may be due to the optimisation of signal timings carried out at Telstar Way and lack of westbound improvements. The greatest improvement is to the A40 eastbound approach, experiencing a decrease in queueing of 35 metres in the AM peak, and 37 metres in the PM peak period. In terms of overall performance, both Option 1 and Option 2 are shown to consistently perform well.

3.4.3.2. Benhall Roundabout

Table 3-8 - Phase 4 Queue Length comparison (m), Benhall Roundabout AM (08:00 – 09:00)

	Do Minimum		Option 1		Option 2	
Arm	Average	Maximum	Average	Maximum	Average	Maximum
A40 W (EB Approach)	47	139	59	166	59	166
Princess Elizabeth Way	50	191	51	196	49	190
A40 E (WB Approach)	51	166	54	170	54	166

Table 3-9 - Phase 4 Queue Length comparison (m), Benhall Roundabout PM (17:00 – 18:00)

	Do Minimum		Option 1		Option 2	
Arm	Average	Maximum	Average	Maximum	Average	Maximum
A40 W (EB Approach)	58	197	56	145	56	147
Princess Elizabeth Way	54	193	52	192	53	199
A40 E (WB Approach)	45	150	43	145	44	145

Figure 3-9 - Phase 4 Average Queue Length Comparison, Benhall Roundabout (AM – left, PM – right)

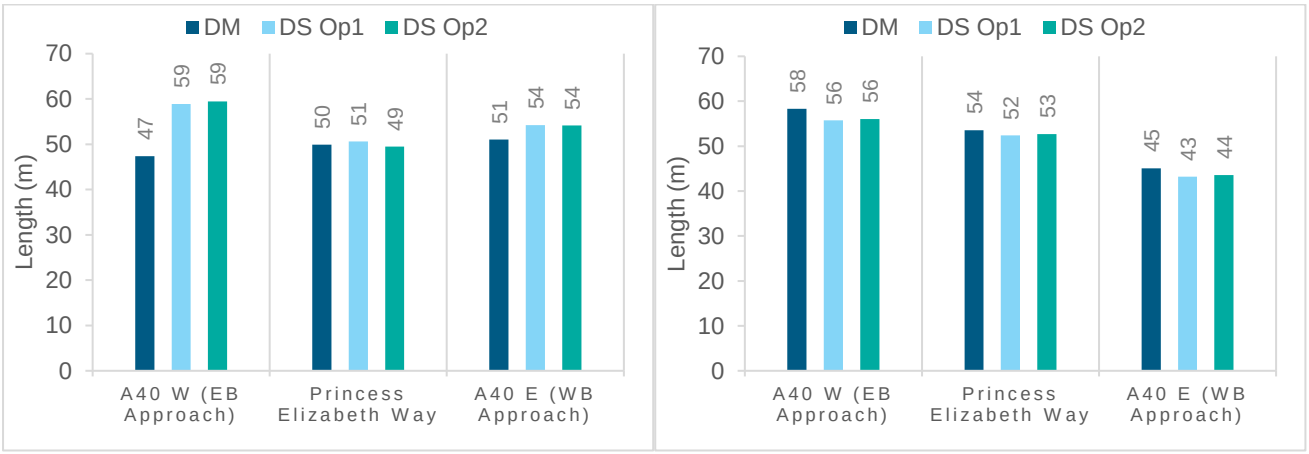


Table 3-8 and

Table 3-9 detail the queue routes at Benhall Roundabout which show varied results, with the eastbound approach experiencing lengthened queues in the AM and PM peak hours. This is consistent with the Phase 3 output, and may reflect the modelling limitation described in section 2.3.3.2 where the change in lanes on the A40 eastbound approach links makes the different modelling options incomparable to the Do Minimum.

3.4.3.3. TGI Fridays

Table 3-10 - Phase 4 Queue Length comparison (m), TGI Fridays AM (08:00 – 09:00)

	Do Minimum		Option 1		Option 2	
Arm	Average	Maximum	Average	Maximum	Average	Maximum
A40 W (EB Approach)	49	104	50	115	50	108
B4633 Gloucester Road	53	158	39	124	40	131
A40 E (WB Approach)	38	171	37	196	37	144

Table 3-11 - Phase 4 Queue Length comparison (m), TGI Fridays PM (17:00 – 18:00)

	Do Minimum		Option 1		Option 2	
Arm	Average	Maximum	Average	Maximum	Average	Maximum
A40 W (EB Approach)	50	139	49	142	49	125
B4633 Gloucester Road	72	188	40	125	41	119
A40 E (WB Approach)	33	78	33	74	33	73

Figure 3-10 - Phase 4 Average Queue Length Comparison, TGI Fridays

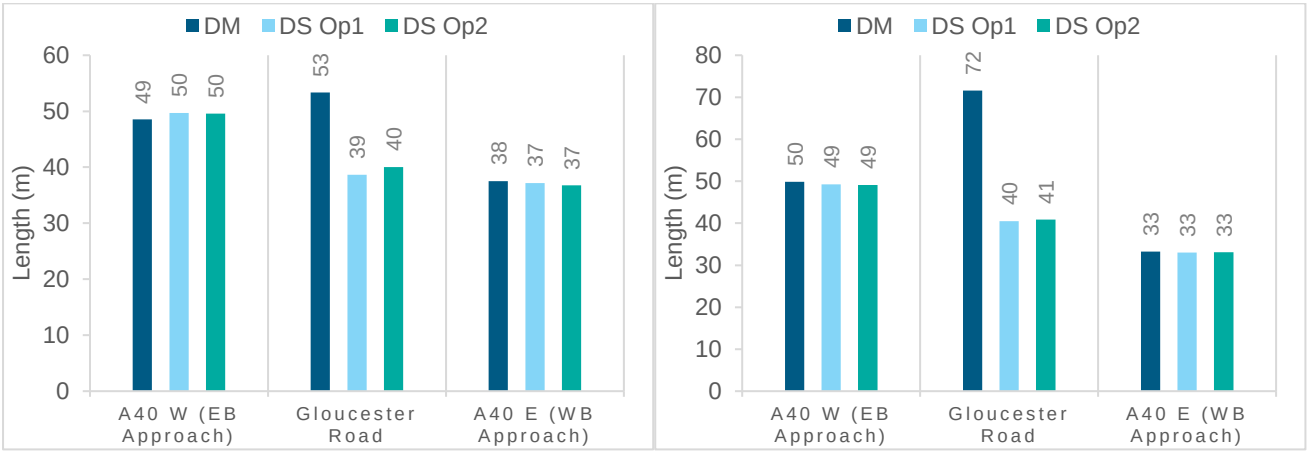


Table 3-10 and Table 3-11 and Figure 3-10 give the queue route results for the TGI Fridays junction show that both options experience significant levels of reduction in queueing when compared to the Do Minimum scenario. The most notable change is in the PM peak, with queue lengths decreasing by up to 32 metres for the Gloucester Road approach. This most likely reflects the optimisation of signals carried out in LinSig for the TGI Fridays junction resulting in a better performance for the Do Something models than the Do Minimum. As shown previously, both options display a similar level of benefit.

3.5. Conclusions

The Phase 4 results for journey time and queue lengths show that both Option 1 and 2 display positive improvements to average journey time and queue lengths on key routes and junctions on the modelled network from the Do Minimum model scenario. Based on these results, it can be seen that both modelling options experienced benefits to a similar degree, potentially suggesting the longer merge option on the A40 eastbound does not contribute to any further benefit from the proposed short merge option.