Appendix A

Aberdeen Western Peripheral Route

Aberdeen City Council

ASAM18: Junction Performance

A18.1A | C

08 March 2019

Aberdeen Western Peripheral Route

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A	13/08/2018	First Draft	Neil Rose	Mark Leishman	
B	08/02/2019	2nd Draft + Text Updates + Goval Test Data to address MA comments	Neil Rose	Mark Leishman	Rob Galbraith
C	08/03/2019	Final Issue	Neil Rose	Mark Leishman	Rob Galbraith

Contents

1. Introduction

1.1 Background

A number of Paramics models were developed as part of the Aberdeen Western Peripheral Route (AWPR) commission and were utilised in the assessment of the operational performance of the various junction designs where the proposed AWPR would link to the existing road network. The key junctions where the paramics models were used are:

- A90 North of Aberdeen at Blackdog;
- A947 North of Dyce at Goval;
- A96 at Craibstone;
- North Kingswells (Limited Access);
- A944 near Kingswells;
- A93 at Milltimber Brae;
- A90 Stonehaven;
- A90 Cleanhill;
- A90 South of Aberdeen at Charleston also connecting to the A956 Wellington Road;

The proposed Stonehaven Fastlink also provides a connection to the A90 north of Stonehaven at the existing B979 Netherley Road.

At each junction location a range of design layouts were assessed using the Paramics microsimulation software to determine their respective operational performance. The traffic demand input to the Paramics models was based on, or developed from, the Aberdeen Sub-Area Model (ASAM).

The scheme was promoted and consented based on the ASAM3B model developed in 2007 and tested against an opening year of 2012 and design year of 2027 (year of opening plus 15 years.)

Following the Public Local Inquiry in 2008 subsequent legal challenges thereafter resulted in delays to the overall procurement process which means that the scheme opening year is now 2018.

In March 2017 Aberdeen City Councillor Marie Boulton presented a Note of Motion to Aberdeen City Council which was subsequently agreed and stated:

“To instruct the Chief Executive to liaise formally with the AWPR/B-T funding partners to provide a report to the Communities Housing and Infrastructure Committee before the end of 2017 in respect of the capacities of the junctions associated with the AWPR/B-T within the Aberdeen City boundary. This information is essential in determining if there are sufficient capacities for existing traffic and for future development within the Aberdeen City boundary”.

Subsequently the AWPR/B-T Managing Agent requested that this report address all junctions on the AWPR. At the time of the Notice of Motion Systra, who had developed the ASAM3B model were engaged in updating the Aberdeen Sub Area Model. It was therefore agreed that outputs from the updated model, ASAM14+ Growth, would be provided when that work was complete, and that these outputs would form the basis of the junction capacity assessment.

The ASAM18 model takes account of local and regional committed land use developments and infrastructure and provides a forecast scenario of network conditions following the AWPR/B-T project being fully opened to use. It should be noted that the ASAM model assumes that travel patterns are stabilised based on road users being aware of their optimal route. In practice is likely to take several months for road users to reach this level of familiarity with the benefits provided by the new infrastructure, including local transfers of traffic onto existing roads where flows have reduced following transfer of traffic onto the AWPR/B-T roads.

In undertaking the detailed design of the AWPR/B-T project, Aberdeen Roads Limited has prepared Paramics models reflecting the final detailed design agreed in consultation with the relevant parties. Although these designs are similar in nature and to a large extent in detail to the designs that were described within the reports submitted to the Public Local Inquiry, there are some changes in detail. Where these changes have an effect on the performance of a junction they are described within the part of this report assessing the performance of that junction.

This reports details how the traffic demand levels have been extracted from ASAM18 and applied to the Paramics models prepared by Aberdeen Roads Limited, and presents the finding of the assessment of each of these junctions in respect of the updated traffic volumes.

2. Modelling Context

2.1 Overview

As noted above, the main modelling tool to be used for the appraisal of the AWPR was the Aberdeen Sub-Area Model (ASAM). Originally commissioned by Aberdeenshire Council, the ASAM model was to be used to inform the various AWPR project appraisals either requiring or being based on traffic related datasets.

ASAM itself has undergone a series of refinements and updates throughout the AWPR commission, and for the purposes of this report reference will be made to the ASAM3B and ASAM18 versions.

ASAM3B

ASAM 3B was prepared by updating the previous version of the model, which was originally developed in 2002 by MVA (now Systra), to provide a multi-modal strategic model covering the majority of the main road and public transport network within the North East of Scotland. Following a number of revisions, the model version ASAM3B was developed in 2007, and provided the outputs which informed junction appraisal on the AWPR project, as reported at the Public Local Inquiry held in 2008.

ASAM18

ASAM18 has been developed using the new ASAM14 model, which is calibrated to observed 2014 traffic and travel conditions. The 2018 forecast scenario (based on ASAM14) is aimed at reflecting the potential opening year demand of the full AWPR and A90 B-T scheme and also includes the impacts and benefits of recently delivered investment, such as the Diamond bridge over the Don.

The data / assumptions underpinning the 2018 Scenario include:

- Based on underlying 2014 traffic and travel conditions;
- Addition of estimates of recent new jobs and associated travel movements at major employment centres (i.e. at Dyce Drive and Prime Four only);
- Addition of some housing and population growth at Chapelton near Newtonhill;
- Around 5,000 additional population assumed within the North East between 2014 and end of 2017 – which are distributed pro-rata across the modelled area; and
- AWPR and A90 B-T schemes fully represented, including the signals settings from the latest AWPR intersection Paramics models.

The forecasts should provide a reasonable estimate of potential travel patterns, however, there are specific elements and uncertainties to bear in mind:

- The 2018 scenario conditions are not ‘calibrated’ (the model is calibrated to traffic counts observed within 2014 with growth then applied to provide 2018 estimate);
- The scale of impact of the energy sector downturn on jobs and subsequent travel patterns remains a relative unknown, and these forecasts are not aimed at representing these uncertainties. It is also uncertain exactly how and where recent employment levels have increased/decreased;
- The type of new development/employment and subsequent level of trip productions and attractions is uncertain, and in general the strategic model is traditionally likely to under-estimate trip making to/from new employment / residential sites (as overall trip making is constrained to a regional total);

- Traffic arrival time profiling may vary throughout the modelled area and potentially close to AWPR intersections;

- The ASAM14 model is being applied prior to the conclusions of the ASAM14 model audit;

- There is further uncertainty of any changes / increases in travel patterns over the last few and next few months until scheme opening; and

The new forecasts should cover the major movements, and also discount planned development which has not actually taken place (which would have been included in previous longer term forecasts).

3. Demand Development

3.1 ASAM18 Network Matrices

In order to update the existing Paramics demand models from using ASAM3B demands to using ASAM18 demands, it was important to identify the exact coverage of the Paramics model to allow cordoned demand matrices to be extracted from ASAM18 for application to the relevant Paramics models.

3.2 Cordon Matrices and Zone Equivalence

Cordon demand matrices were extracted from ASAM that covered the same areas represented by the Paramics model. The extracted demand consisted of two matrices for the AM and PM peak hours (0800-0900 and 1700-1800 respectively):

- Matrix 1: Cars \ Lights (Combined);
- Matrix 2: HGV's

Once the area had been cordoned, the cordoned ASAM18 network consisted of a series of specific links, zones and zone connectors that are located within the cordoned model area. Zone connectors are effectively new zones that are generated as part of the cordoning process and which are located where model links have been cut on the cordon boundary (i.e. external zones). They are used to identify traffic volumes travelling into and out of the cordon model area.

Once the cordon boundary was identified, a zone equivalence process was undertaken. This process aligns the demands attached to each of the ASAM18 zones to the equivalent zones in Paramics.

3.3 Expansion to Peak Period

There is a difference in the modelled time periods used by ASAM18 and by the Paramics models; ASAM18 considers only the AM and PM peak hours but the Paramics models cover longer lengths of time covering 3 hours during the peak period

In order to expand the ASAM18 matrices from peak hour to peak period, the existing profiles in the Paramics models have been utilised as they contain information on how traffic is released during the course of the modelled peak periods. Figure 3 below shows an example AM peak period profile (0700-1000).

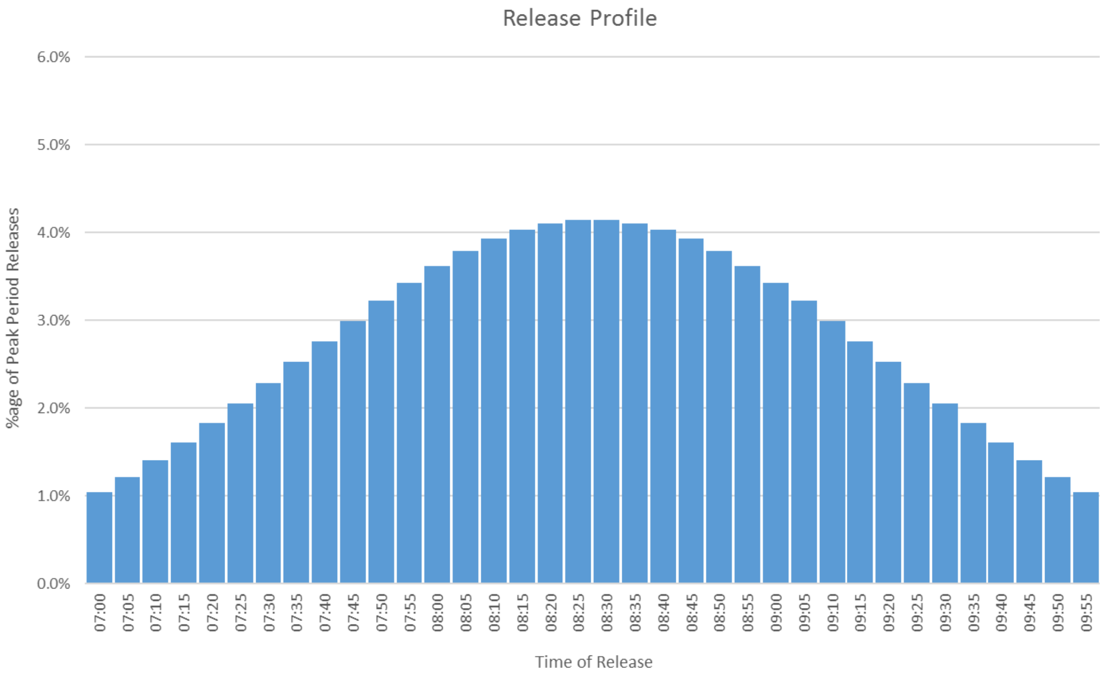


Figure 1 - Example Release Profile

Figure 1 shows the %age of traffic that is released from a particular zone over the course of the peak period (shown for every five-minute time slice within the peak period). This information can be used to expand the ASAM18 traffic from a peak hour to a peak period level.

For example, an ASAM18 cordoned matrix identifies that during the AM peak hour (0800-0900), 100 trips are released. The profile attached to the equivalent zone in the Paramics model shows that during the AM peak hour, 47.2% of trips are released during this time (see the red highlight on Figure 2).

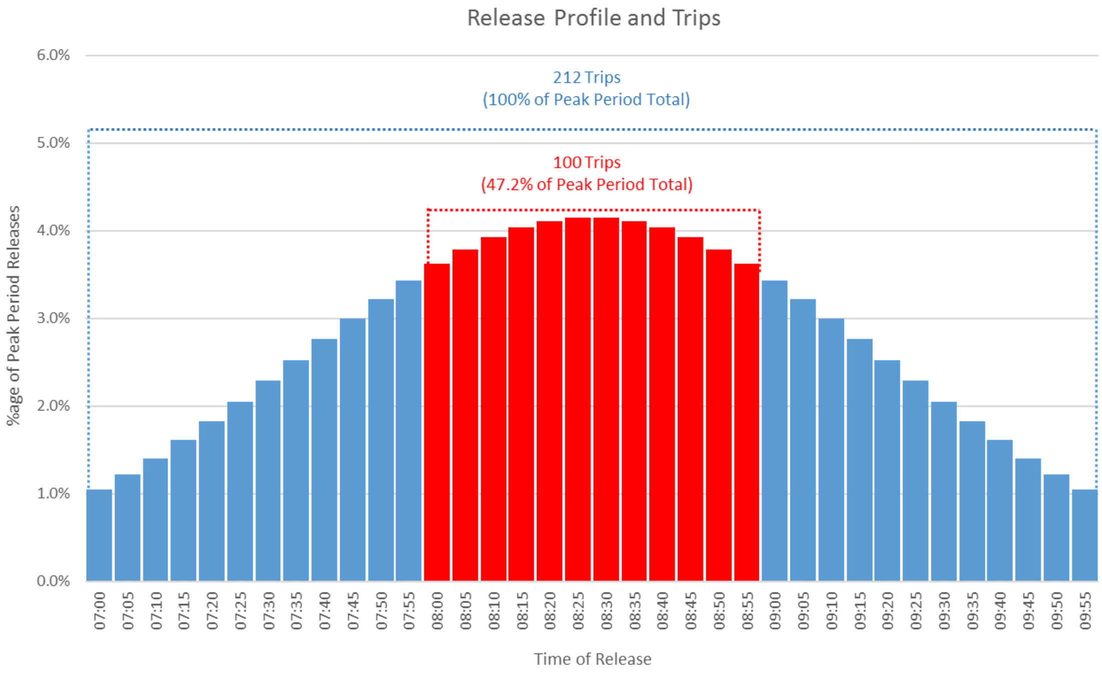


Figure 2 - Example Release Profile with peak hour highlighted

If 100 vehicles are to be loaded into the network during the peak hour, and this represents 47.2% of the peak period traffic, then the total volume of traffic expected over the peak period can be determined by factoring the peak hour totals using this information.

The factor to be used can be determined by dividing 100% by the proportion of traffic expected during the peak hour. In this particular example, the calculation is as follows:

Peak Period Trips = Peak Hour Trips * (100% / %age of releases in the peak hour)

Peak Period Trips = 100 * (100%/47.2%)

Peak Period Trips = 100 * 2.12

Peak Period Trips = 212

This methodology has been applied on a zone by zone basis for each peak and for each matrix (matrix 1 being cars\lights and matrix 2 being Heavies).

3.4 Comparison with ASAM18 Flows

Once the zone equivalence and demand expansion processes had been undertaken it was important to undertake a flow comparison between the ASAM18 and updated paramics models as it serves as a check that interface process between ASAM18 and the Paramics model has been completed correctly. It would be expected that, given the processes undertaken to develop the demands files for the Paramics models, peak hour flows would be reasonably consistent between the models albeit there will be some relatively small differences between the two modelling packages due to the difference in the modelled periods and the different way that junction delay is handled by each software package.

To check that the Paramics models showed a close correlation with ASAM18, a comparison was undertaken by comparing peak hour traffic flows at locations common to both models and calculating the absolute difference between the two. A relative comparison (i.e. percentage difference) was not undertaken as the Geoffrey E. Havers

(GEH) statistic is more useful as an indication of the acceptability of the difference in magnitudes between the ASAM18 and Paramics model flows.

Figure 3 below shows an example of how this comparison was carried out.

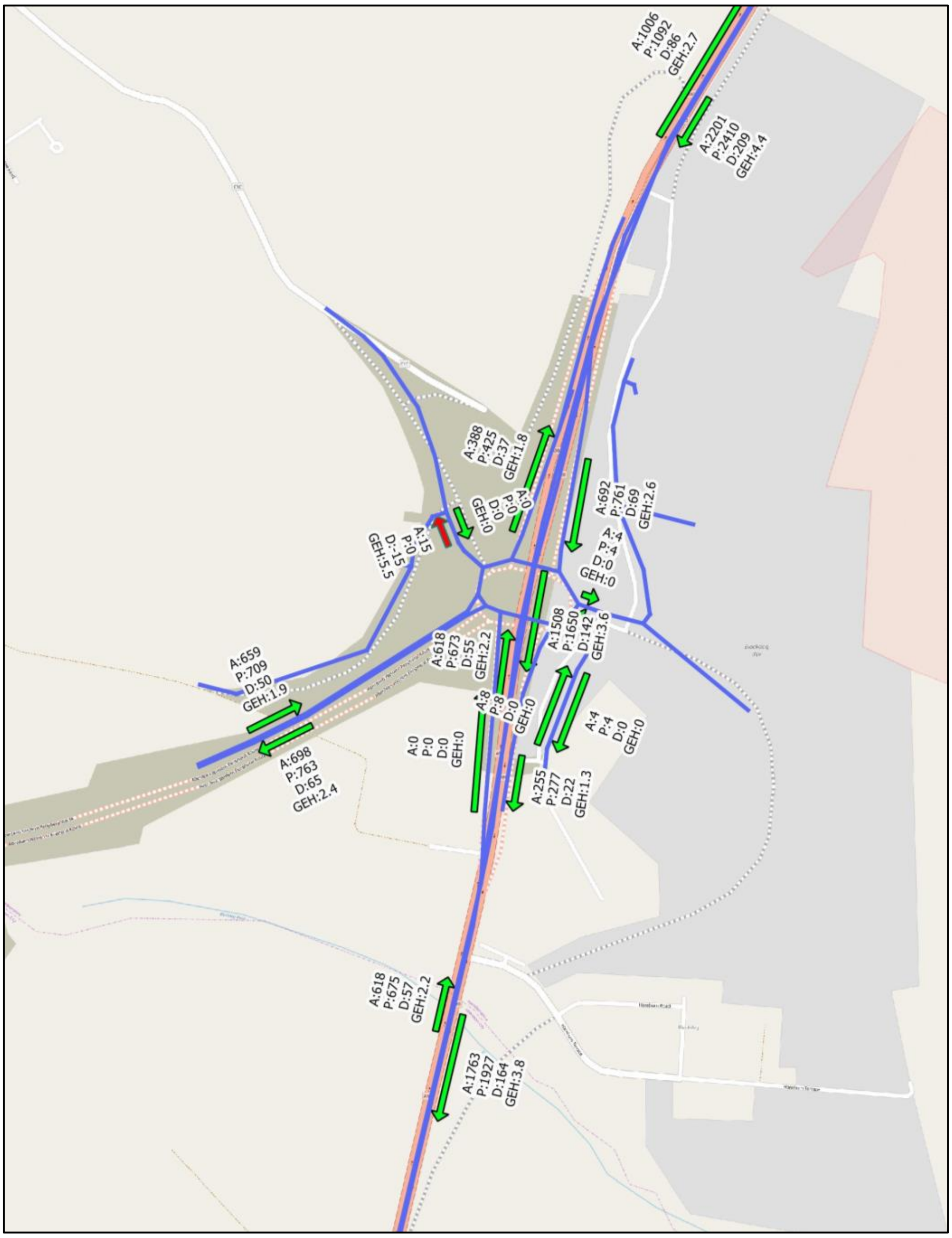


Figure 3 - Example Flow Comparison Diagram

Figure 3 shows several locations where traffic flows between the models have been compared (denoted by arrows parallel to the assessment link in question). The data attached to each location shows the ASAM18 peak hour flow (A), the Paramics peak hour flow (P), the absolute difference between A and P (D) and the GEH value calculated using the two modelled flow values (GEH).

The GEH statistic was used as it provides a useful comparison between the ASAM18 and paramics flows that considers the magnitude of the flows in calculating the difference between each and was considered a more useful statistic than a straight forward relative (i.e. percentage) difference. Where the GEH was less than 5, the paramics model was considered to be representative of the ASAM18 peak hour flows.

3.5 Comparison between ASAM18 and ASAM3B Flows

In overall terms traffic volumes associated with ASAM18 outputs are higher than the 2018 ASAM3B traffic volumes, with differences in travel patterns which vary across the Paramics models. These changes are understood to have arisen from differences in land use assumptions between the models, arising from changes in local and regional development plans and developments that have been consented which were not envisaged in previous local and regional development plans, together with some changes in modelling parameters. Increased traffic volumes will impact on the operation performance of the junctions by eroding reserve capacity, although to some extent this may be managed by adjustment of signal staging designs where traffic signals are present at junctions.

4. Stonehaven Junction Performance

4.1 Junction Description and Location

Figure 4 shows the location of Stonehaven junction at the southern end of the AWPR scheme and how it connects the A90 and the Fastlink (a new link proposed as part of the AWPR between Cleanhill and Stonehaven junctions).

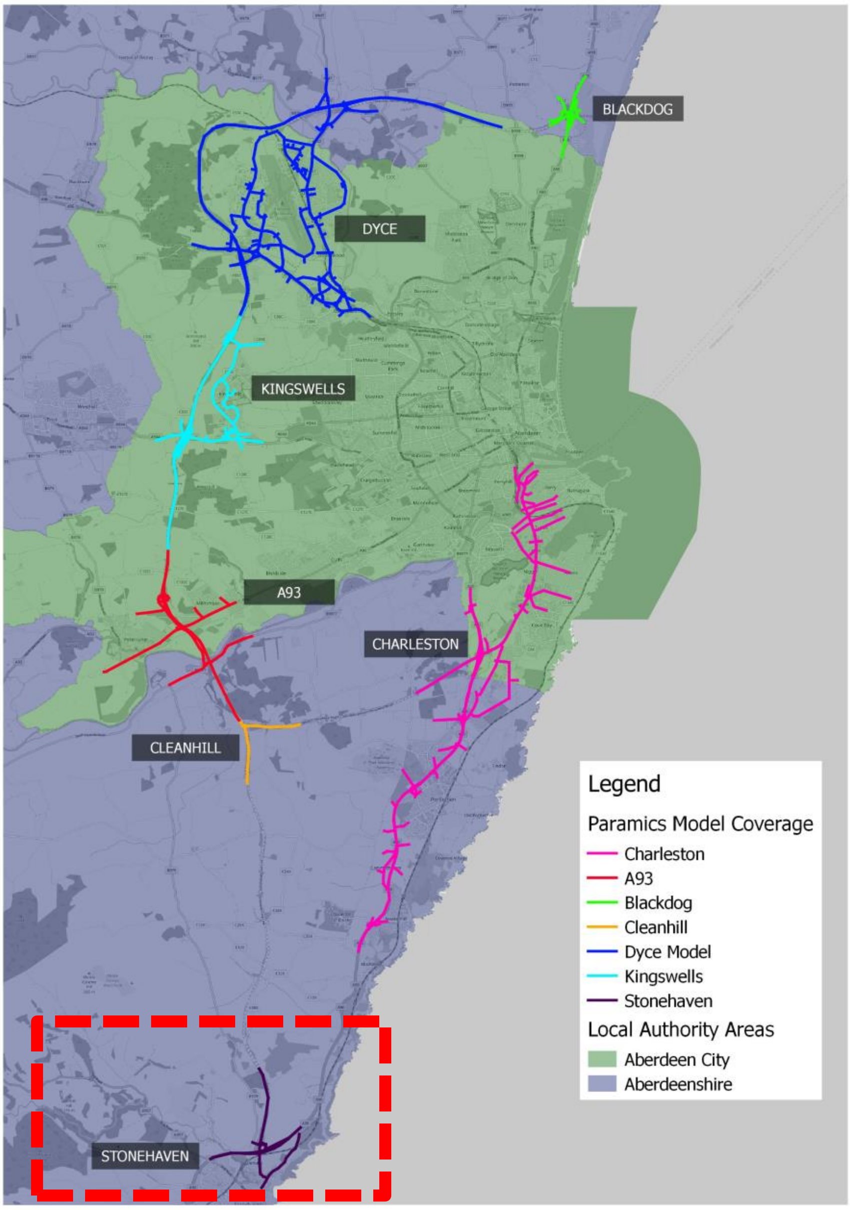


Figure 4 – Stonehaven Junction Location

Figure 5 shows the paramics model coverage and key locations within the model.

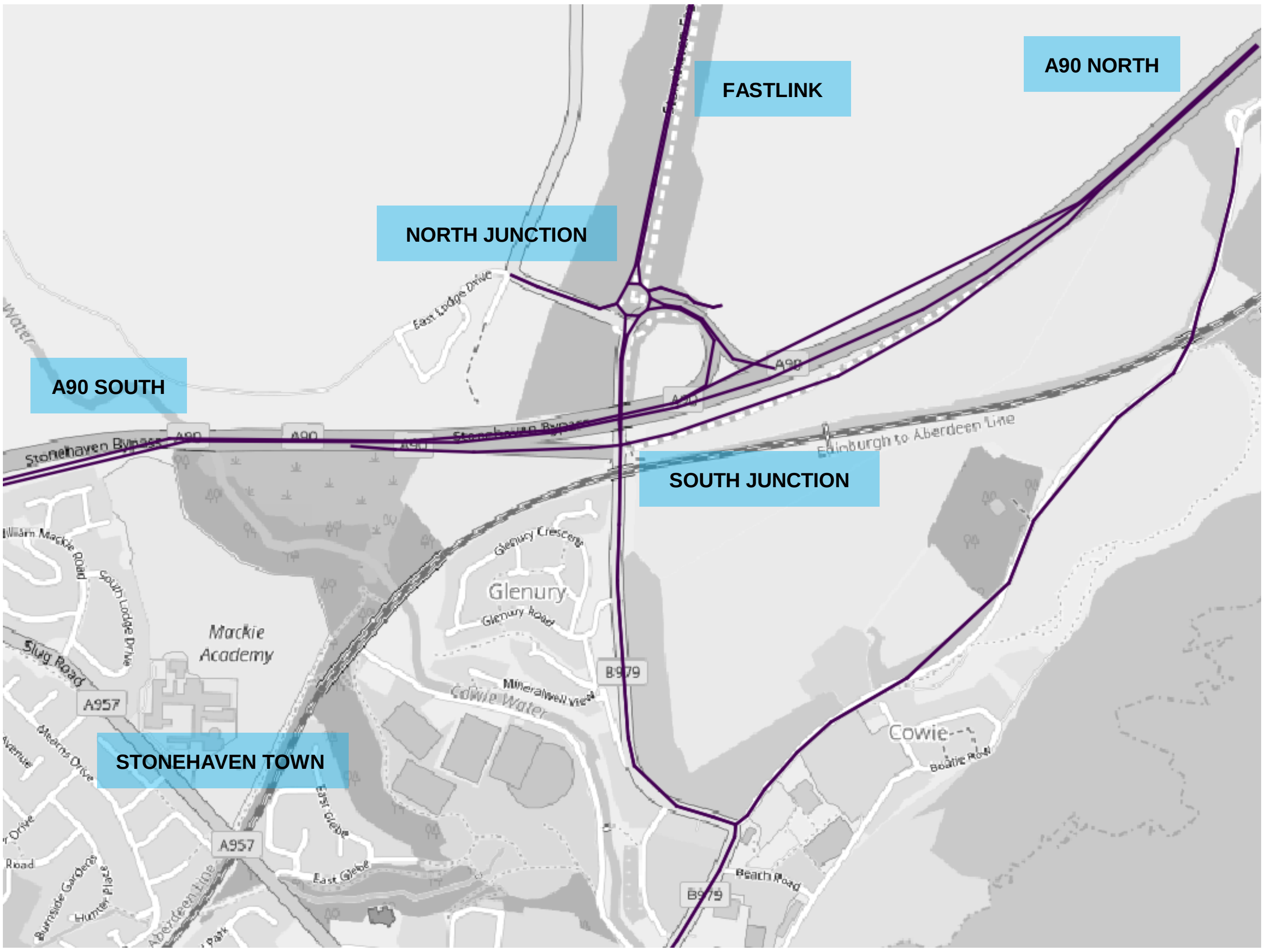


Figure 5 – Stonehaven Paramics Model and key locations

Stonehaven junction consists of a reconfiguration of the existing A90 junction at Stonehaven. The form includes a roundabout type junction with three lanes on the circulating carriageway (the North Junction) and a signalised crossroads (the South Junction) that serve to provide links to \ from Stonehaven, the A90 north, the A90 south, the Fastlink connection and local access roads.

The existing B979/A90 underbridge will be widened from two lanes (one lane in each direction) to three lanes (one northbound lane and two southbound lanes). The two southbound lanes are required on the approach to the signalised junction to accommodate the right turn demand accessing the A90 southbound merge.

The Fastlink has two lanes on the approach to the northern roundabout, with the B979 approach from the south widened to two lanes from the A90 underbridge north towards the roundabout.

The other main arms, the B979 approach from the west and A90 northbound diverge both have one lane on the approach to the junction.

4.2 Signal Information

The A90 southbound merge and diverge slip roads connect to the B979 via a signal controlled junction (the south junction). Initial signal timings were derived using the JCT Consultancy industry standard LINSIG Version 2 software, and input to the Paramics model for assessment. These initial timings were then further refined directly in Paramics throughout the assessment process where necessary.

Provision for pedestrians has also been incorporated at the signalised junction on the west side of the B979 across the A90 southbound merge slip road. Given the likely levels of pedestrian demand at this location, the pedestrian stage is activated randomly throughout the Paramics simulations, such that on balance it is activated five times in each modelled period. Figure 6 and Figure 7 illustrate the Paramics model signals timings used during the AM and PM peak periods respectively.

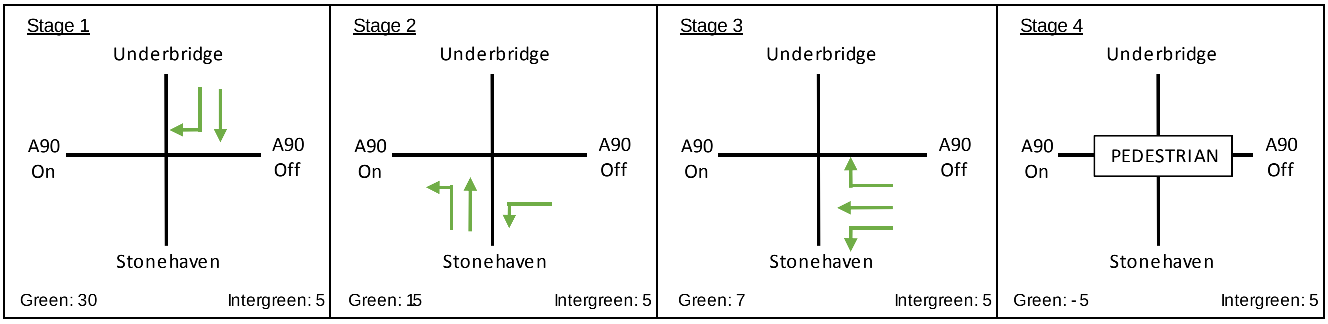


Figure 6 – AM Signal Timings

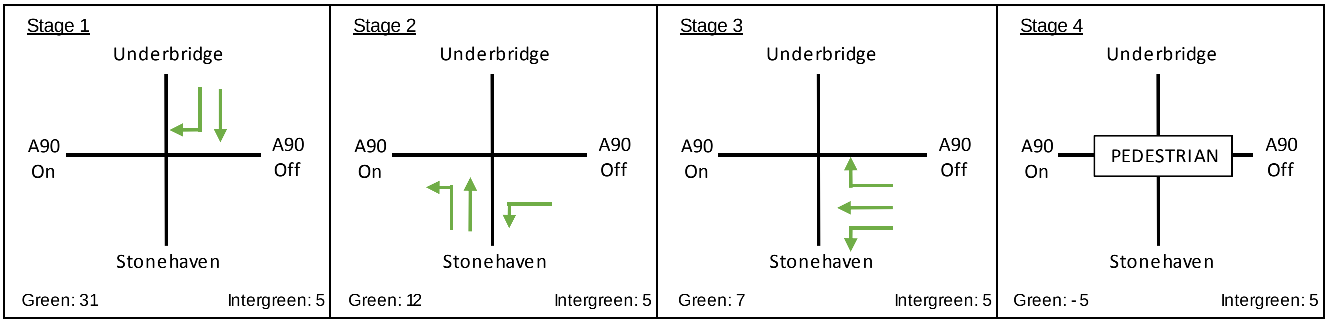


Figure 7 – PM Signal Timings

4.3 Key Junction Turning Movements

The turning counts for the three simulated hours in the AM and PM peak periods are shown in the Figures below.

As each Paramics model simulation run is different, the results are based on an average of ten model runs, as are all subsequent model statistics presented in this section. This ensures that the model results are representative of the junction operation and are not unduly influenced by a particularly free-flowing or particularly congested individual simulation run.

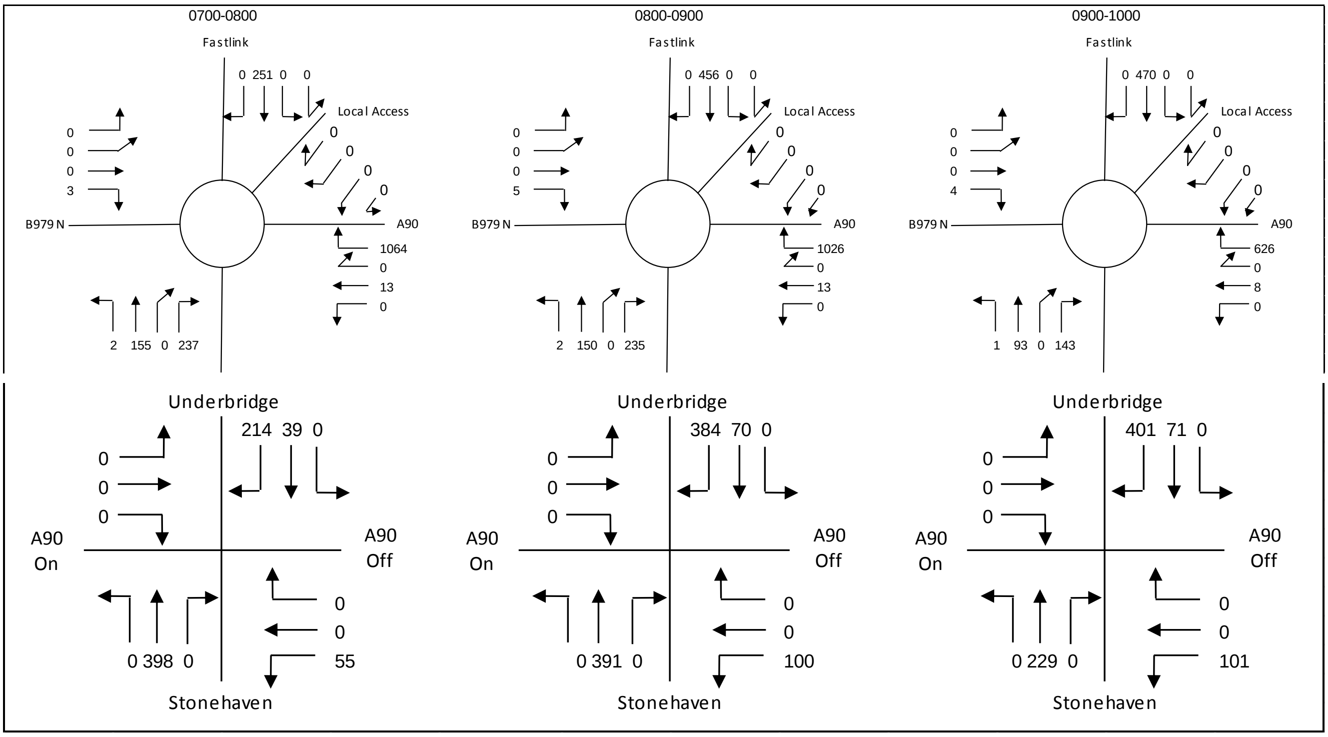


Figure 8 - AM Turning Movements

shows that the main movement during the AM peak is at the north junction where traffic is leaving the A90 and heading north onto the Fastlink. There is also a high volume movement where traffic is travelling from the Fastlink and travelling southbound toward the A90 south via the on slip at the south junction.

There is also a relatively low level of traffic travelling toward Stonehaven from both the Fastlink and from the A90 South.

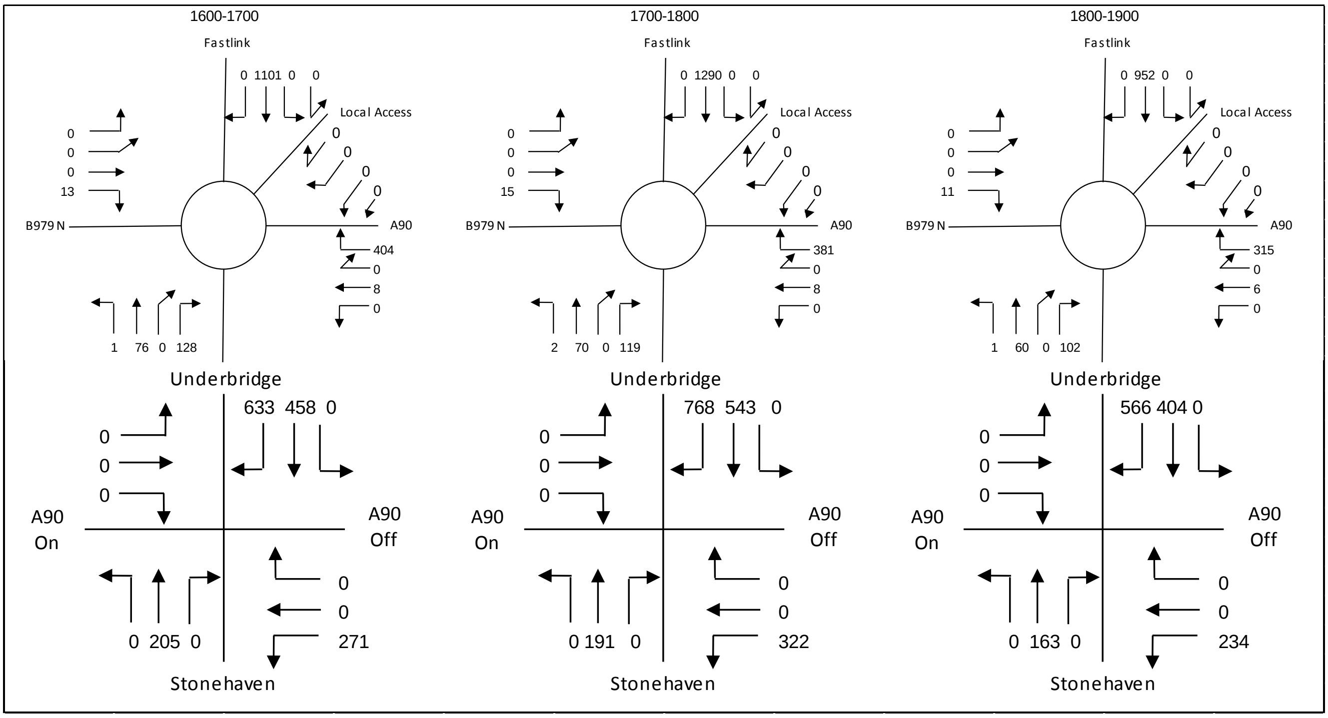


Figure 9 - PM Turning Movements

Figure 9 shows that in the PM peak, the highest volume movement is from the Fastlink toward either the A90 South (via the on slip at the south junction) or on to Stonehaven.

A relatively low volume of traffic is travels from the A90 to the Fastlink.

4.4 Vehicle Speeds

The average journey speed per vehicle, throughout the whole network, was assessed to illustrate the overall network performance throughout each simulation period. The average journey speed provides a good indication of the overall level of congestion on the network.

Figure 10 and Figure 11 show the average journey speed throughout the whole modelled network for the AM and PM modelled periods, respectively.

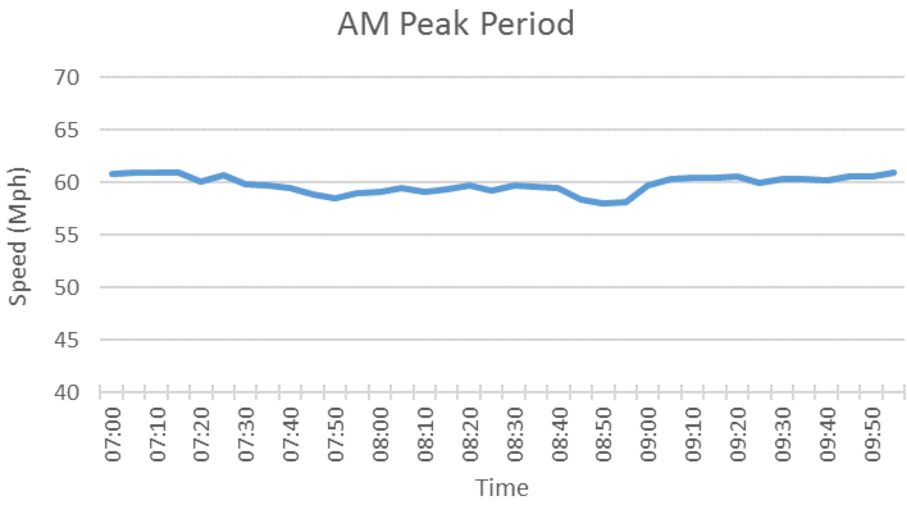


Figure 10 – AM Vehicle Speeds

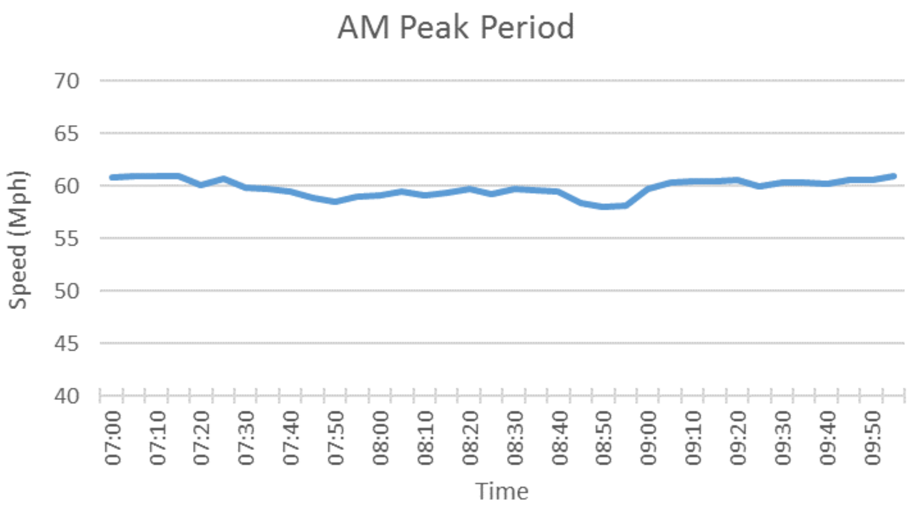


Figure 11 – PM Vehicle Speeds

The overall average journey speed is relatively high, approximately 60mph, as the Fastlink and the A90 both have 70mph speed limits and do not experience any capacity issues.

The figures show that there is not a significant variance in overall journey speed throughout the simulation periods. This indicates no real deterioration in the operational performance and can therefore accommodate the predicted levels of demand.

4.5 Queue Length Data

The detailed network results were derived by averaging the output results of 10 Paramics simulation runs for each modelled period. This reduces the risk of generating results from a particularly free-flowing or particularly congested simulation run that may result in an un-representative assessment of the operational performance. When analysed, the statistics from the 10 simulation runs are therefore much more representative of the operational performance of the preferred junction solution.

The statistics analysed as part of the detailed model results focussed on the extraction of queuing and journey time data for the Fastlink connection from each of the 10 simulation runs. Path and queue routes were constructed in Paramics to gather data on the modelled vehicles passing through the Stonehaven connection.

The queue routes were defined for each approach to the proposed Stonehaven connection modelled in the preferred option to extract queuing data for further analysis. Journey time data was extracted from the model by defining all paths through the proposed connection at Stonehaven.

Queuing Analysis

Note that in order to conduct the queuing analyses, the default Paramics Queue Recognition definitions have been applied to record and collect the queuing data during each model simulation run. The only adjustment made was to change the method of Multiple Queues reporting to the 'Propagate the last queue to end' option, such that all vehicles from the end of the last queue on the link to the end of the link are considered and reported as a single queue. For further details, reference should be made to the Paramics 2003 Reference Manual, Chapter 13, Page 13-6, Queue Recognition.

As a result, the absolute queue lengths reported in the analyses include gaps between vehicles, as the vehicle speed and the gap to the vehicle in front are both used to determine the thresholds below which a vehicle is considered to be in a queued state. Therefore, the queue lengths reported do not necessarily represent a continuous queue of vehicles, but serve to illustrate the maximum possible extent of the level of queuing on each approach.

Figure 12 shows the locations at which queues were recorded and used in the following analysis.

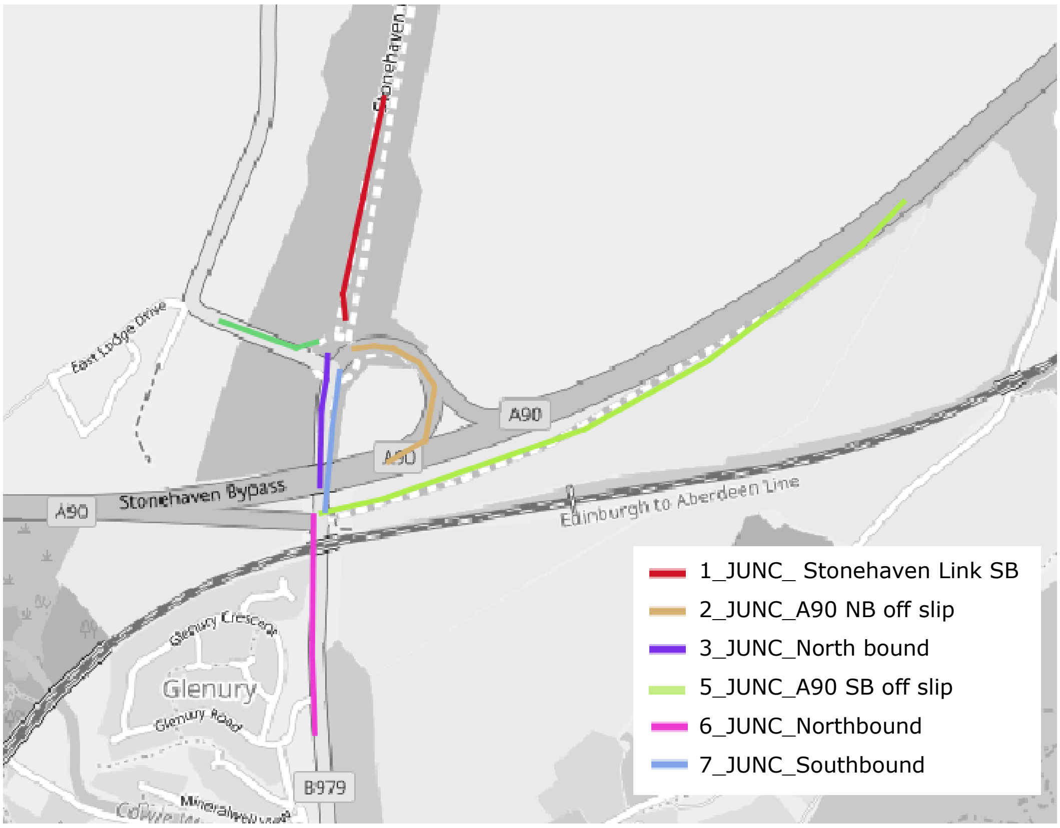


Figure 12 - Queue Routes

Table 1 and Table 2 show the maximum queue length and 95% confidence interval by lane, for each approach arm to the Stonehaven junction during the AM and PM peak periods. In the tables, the maximum queue lengths represent the average of the longest queues recorded during each of the 10 simulation runs, irrespective of the

5-minute time interval in which they occurred during each simulation. The 95% confidence levels indicate the upper and lower bounds of the range within which there can be 95% statistical confidence that the maximum queue recorded during any single simulation run will lie.

For example, in Table 1, the maximum queue length for lane 1 between 0700-0800 on the route “1_JUNC_Stonehaven Link SB Stonehaven Fastlink (averaged over 10 simulation runs) is 29 metres. The 95% confidence interval means that for 95 out of 100 random Paramics runs the maximum queue length will lie within the range from 26 to 32 metres.

		0700-0800			0800-0900			0900-1000		
Route	Lane	Max Q	95% CI		Max Q	95% CI		Max Q	95% CI	
"1_JUNC_Stonehaven Link SB"	1	29	26	32	47	45	48	56	54	58
"1_JUNC_Stonehaven Link SB"	2	56	55	58	85	83	87	71	70	72
"1_JUNC_Stonehaven Link SB"	3	48	47	49	48	47	49	48	47	48
"2_JUNC_A90 NB off slip"	1	128	124	132	141	136	145	86	83	89
"2_JUNC_A90 NB off slip"	2	44	43	44	44	43	44	44	43	44
"2_JUNC_A90 NB off slip"	3	-	-	-	-	-	-	-	-	-
"3_JUNC_North Bound"	1	35	33	37	40	38	42	26	23	28
"3_JUNC_North Bound"	2	82	79	84	91	89	94	82	79	84
"3_JUNC_North Bound"	3	-	-	-	-	-	-	-	-	-
"5_JUNC_A90 SB off slip"	1	49	48	51	59	58	60	55	54	57
"5_JUNC_A90 SB off slip"	2	-	-	-	-	-	-	-	-	-
"5_JUNC_A90 SB off slip"	3	-	-	-	-	-	-	-	-	-
"6_JUNC_North bound"	1	120	117	122	133	130	136	96	94	98
"6_JUNC_North bound"	2	-	-	-	-	-	-	-	-	-
"6_JUNC_North bound"	3	-	-	-	-	-	-	-	-	-
"7_JUNC_South bound"	1	35	33	37	49	48	50	50	47	53
"7_JUNC_South bound"	2	96	93	100	157	153	161	140	136	144
"7_JUNC_South bound"	3	-	-	-	-	-	-	-	-	-

Table 1 - AM Max Queue Lengths

To help illustrate the extent of the queuing, which does not necessarily occur simultaneously on all approaches, the schematic representation shown in Figure 13 has been produced. The figure is based on highest hourly mean maximum figures shown in Table 1 and shows the approximate extent of the maximum queue lengths.

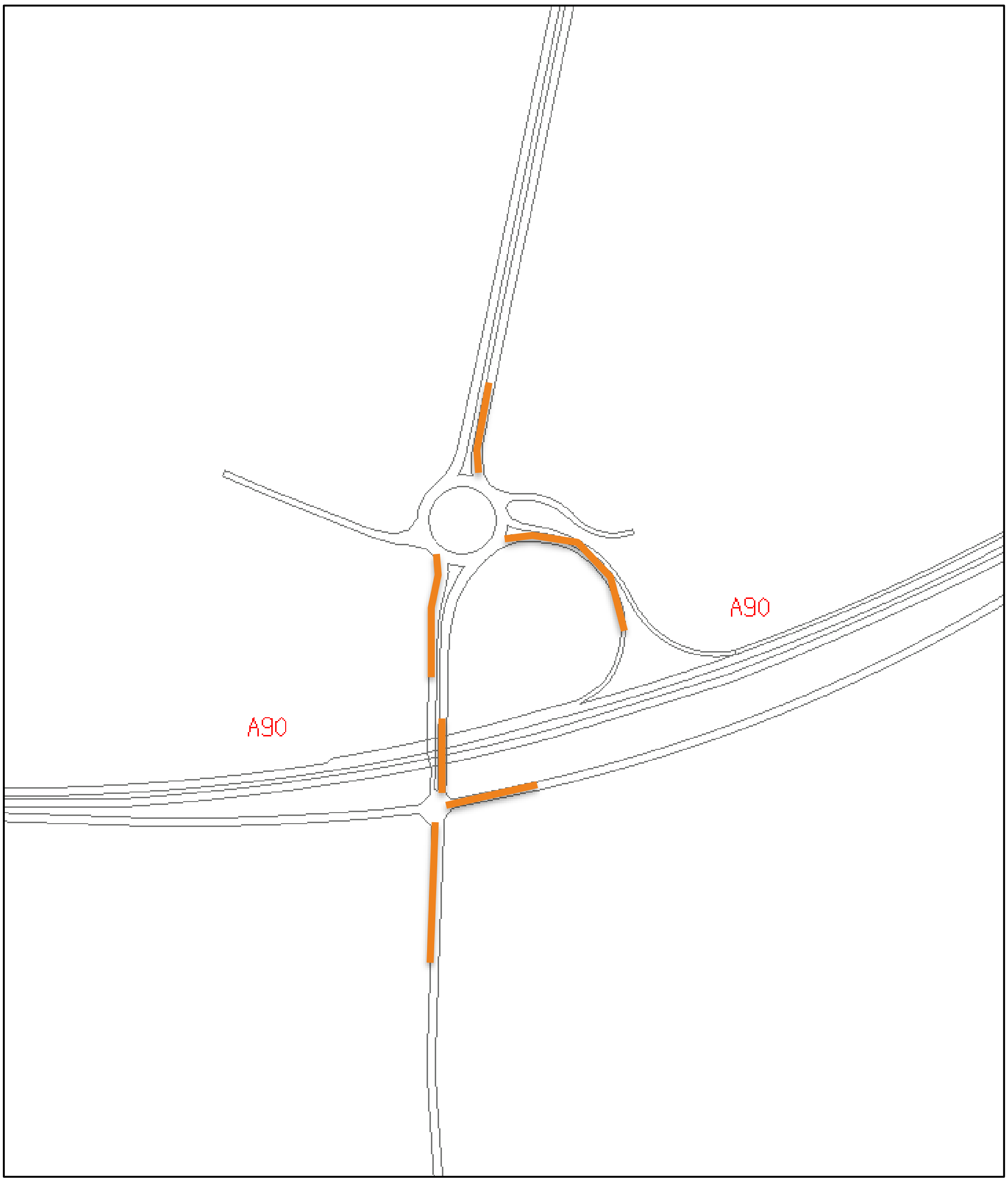


Figure 13 – AM Max Queue Length Diagram

Route	Lane	1600-1700			1700-1800			1800-1900		
		Max Q	95% CI		Max Q	95% CI		Max Q	95% CI	
"1_JUNC_Stonehaven Link SB"	1	57	55	58	85	83	87	49	48	51
"1_JUNC_Stonehaven Link SB"	2	107	105	110	98	96	100	77	75	79
"1_JUNC_Stonehaven Link SB"	3	48	48	49	48	47	48	44	44	45
"2_JUNC_A90 NB off slip"	1	79	76	81	73	71	76	72	70	74
"2_JUNC_A90 NB off slip"	2	44	43	44	44	44	45	44	43	44
"2_JUNC_A90 NB off slip"	3	-	-	-	-	-	-	-	-	-
"3_JUNC_North Bound"	1	38	35	41	-	-	-	29	-	-
"3_JUNC_North Bound"	2	59	57	62	50	48	52	23	-	-
"3_JUNC_North Bound"	3	-	-	-	-	-	-	-	-	-
"5_JUNC_A90 SB off slip"	1	49	48	51	59	58	60	55	54	57
"5_JUNC_A90 SB off slip"	2	-	-	-	-	-	-	-	-	-
"5_JUNC_A90 SB off slip"	3	-	-	-	-	-	-	-	-	-
"6_JUNC_North bound"	1	86	84	88	87	86	89	65	64	66
"6_JUNC_North bound"	2	-	-	-	-	-	-	-	-	-
"6_JUNC_North bound"	3	-	-	-	-	-	-	-	-	-
"7_JUNC_South bound"	1	115	109	122	151	147	156	130	123	137
"7_JUNC_South bound"	2	194	184	204	179	172	186	150	140	160
"7_JUNC_South bound"	3	-	-	-	-	-	-	-	-	-

Table 2 - PM Max Queue Lengths

Again, to help illustrate the extent of the queuing, which does not necessarily occur simultaneously on all approaches, the schematic representation shown in Figure 14 has been produced. The figure is based on highest hourly mean maximum figures shown in Table 2 and shows the approximate extent of the maximum queue lengths.

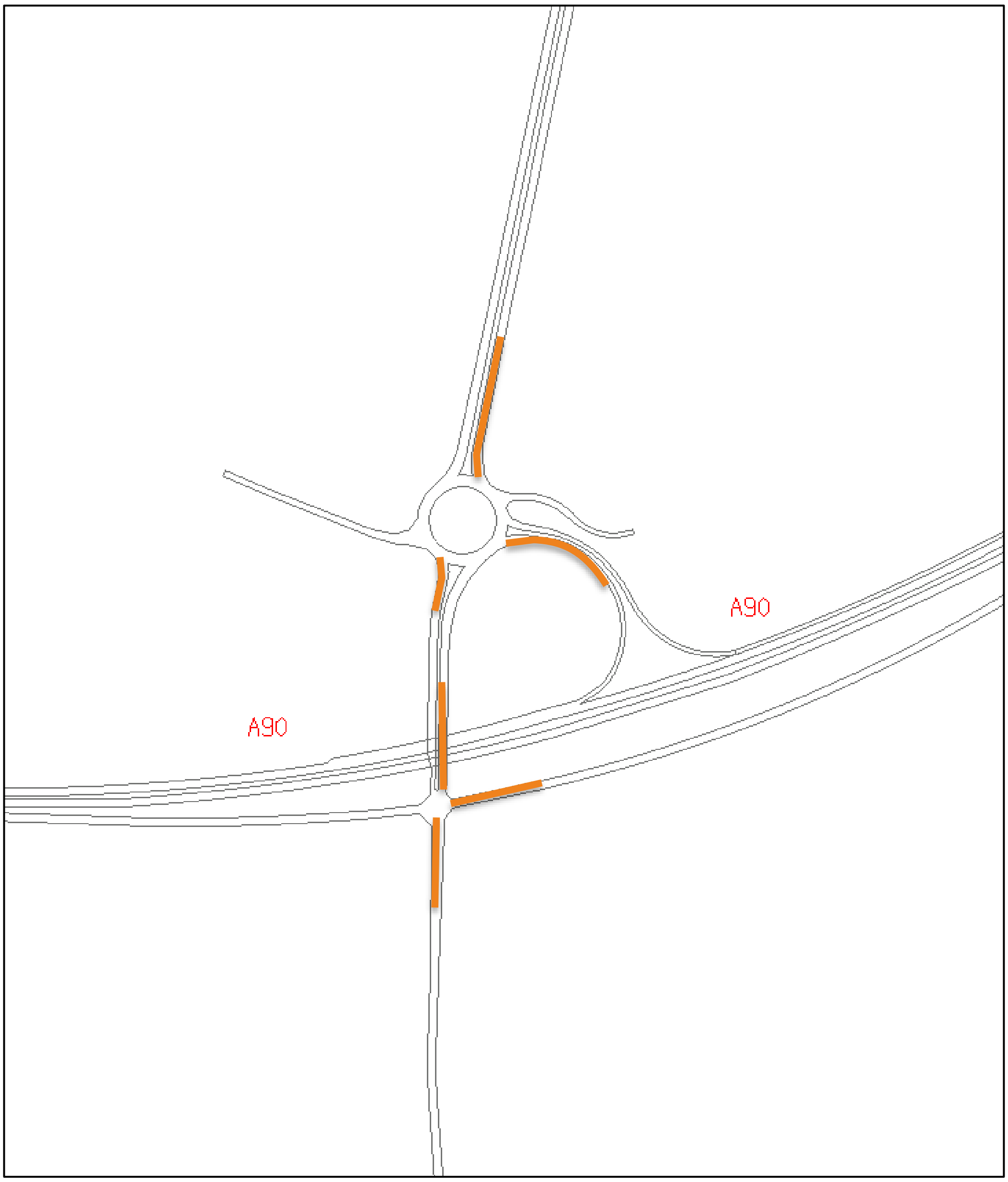


Figure 14 – PM Max Queue Length Diagram

Queue Length Distributions

To assess the significance of the maximum queue statistics extracted from the Paramics model simulations, and examine how the queues vary over time, the queue length distribution for each approach to the Stonehaven junction was analysed throughout the simulation period.

Figure 15 and Figure 16 show the average maximum queue length distribution, in metres, for each approach arm throughout the modelled AM and PM periods. It should be noted that the queue length distributions are extracted from the Paramics simulation runs for each 5 minute interval, and represent the average of the maximum queue recorded in each of the 10 simulations during each 5 minute interval.

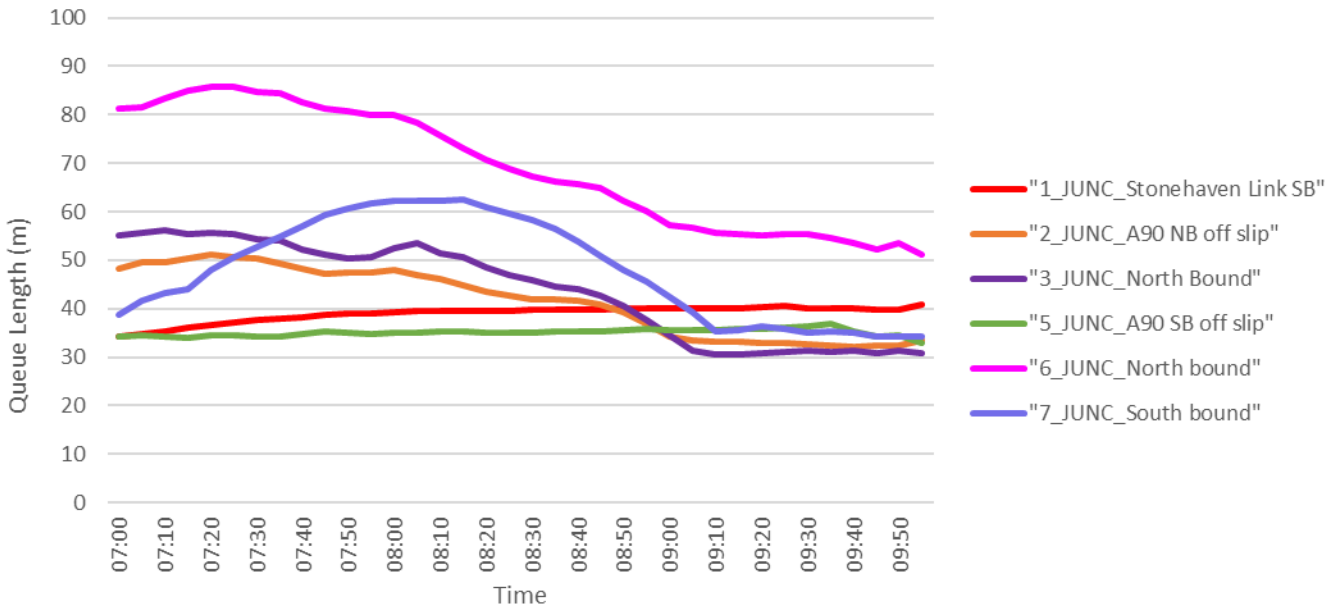


Figure 15 – AM Average Max Queue Length Distribution

During the AM peak, the route with the greatest variation is the “7_JUNC_Southbound” route (the southbound approach to the south junction). It shows that queuing starts relatively low at approximately 40 metres at the beginning of the peak before extending up to approximately 65 metres at around 08:00. Queuing decreases thereafter and from 09:00 onward, there is relatively low levels of queuing on this route.

The route “1_JUNC_Stonehaven Link SB” (the Fastlink SB approach to the north junction) shows a generally constant queue length throughout the modelled period. The length fluctuates between approximately 35-41m (6-7 vehicles in length).

The remaining queues show peaks early on in the modelled period at around 07:30 and generally reduce in length over the remainder of the modelled period.

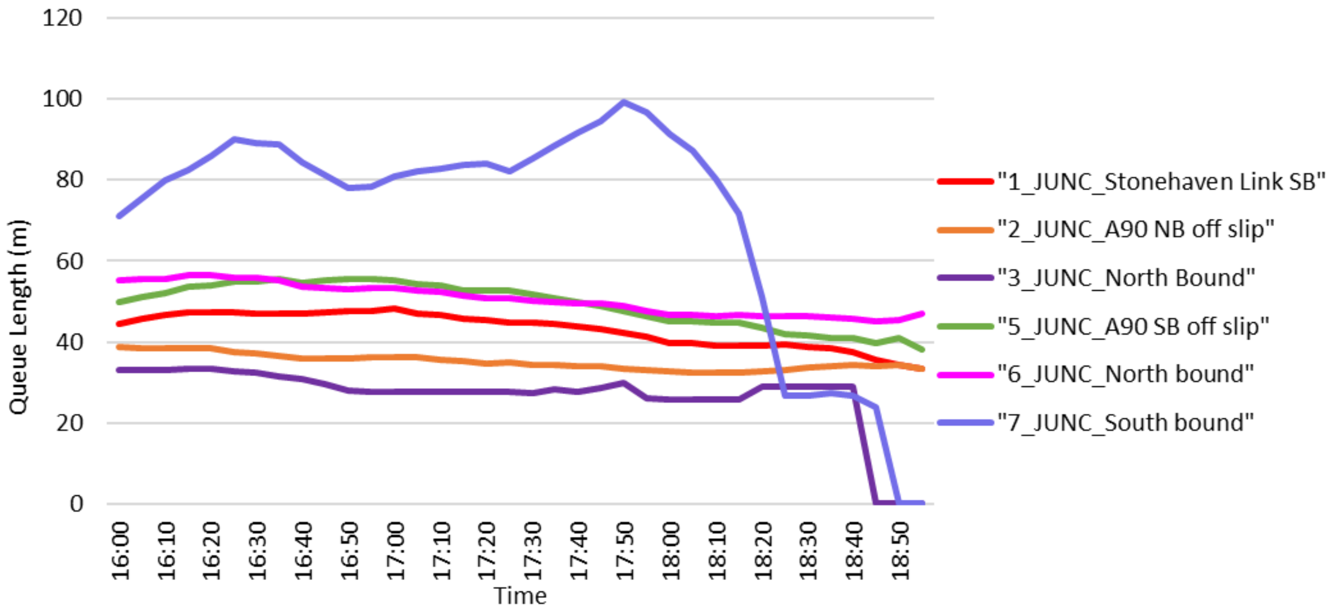


Figure 16 – PM Average Max Queue Length Distribution

During the PM peak, the route with the greatest variation is again the “7_JUNC_Southbound” route (the southbound approach to the south junction). It shows that queuing is generally consistent at around 70-90 metres between 16:00 and 17:20. Between 17:20 and 18:00, there is a distinct peak in length of 100 metres. After this point, queuing reduces quickly and eventually dissipates totally.

The remaining queue routes show queuing that is relatively consistent over the full duration of the modelled PM peak period; queues are typically between approximately 35-55 metres (5-9 vehicles) in length.

Queue lengths toward the end of the PM period reduce sharply for route “3_JUNC_North bound” and “7_JUNC_Southbound”; this occurs where the model shows that there is a period of short queues toward the end of the period followed by no queuing (and so a zero value for queue length is reported).

4.6 Journey Time Data

The average journey time for journeys from all approach arms of the Stonehaven junction are presented in this section. The journey time assessment provides a good indication of delay and congestion and serves to provide insight into overall level of performance.

The journey time graphs also highlight how the travel times change throughout the simulation period and highlight any differences between the AM and PM modelled periods for each route.

Figure 17 illustrates the journey time routes that were defined for the journey time analysis.

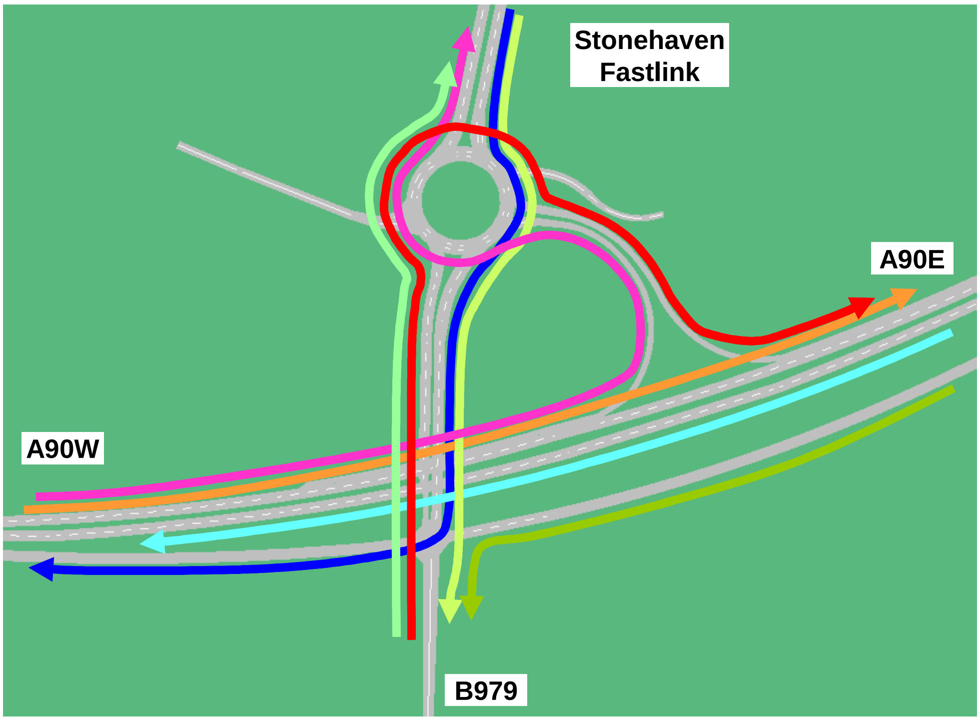


Figure 17 – Journey Time Routes

The average journey time distribution throughout the simulation period, for vehicles passing through the proposed Stonehaven junction is illustrated for each approach in Figure 18 and in Figure 19.

Note that certain journey time routes have been excluded from the analysis as there was not a significant number of vehicles (i.e. 20 vehicles or less) travelling along these routes throughout the simulation period.

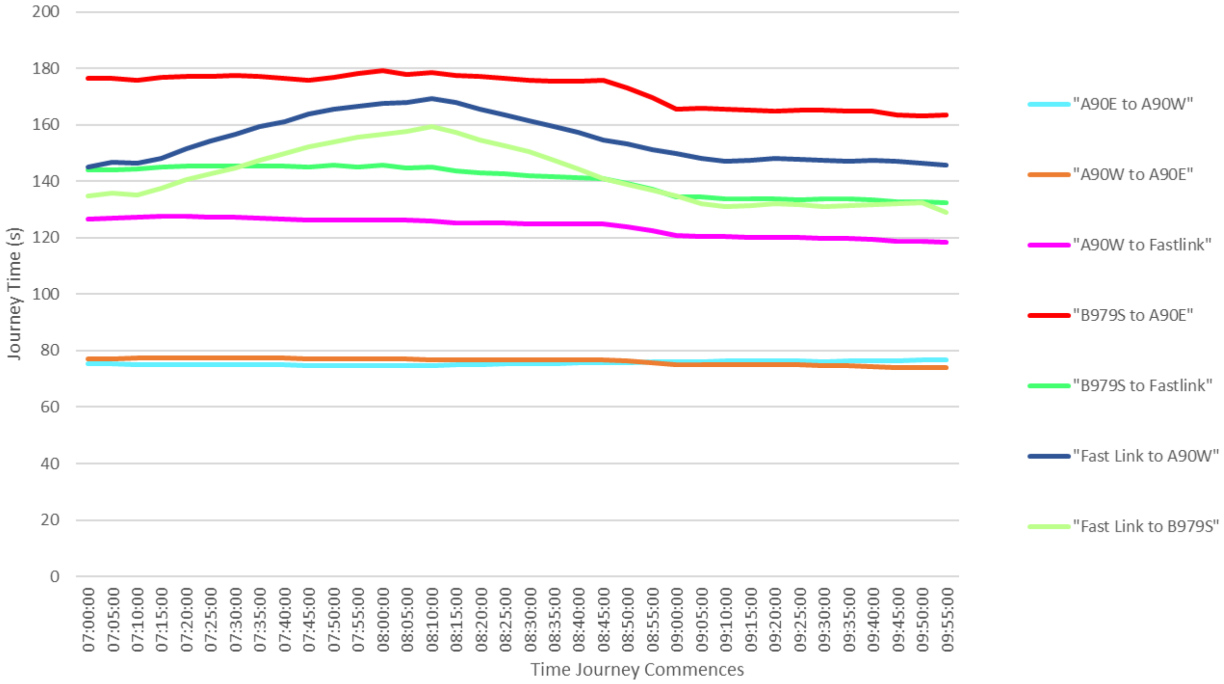


Figure 18 – AM Journey Time Data

During the AM peak period, journey times for trips travelling on the A90 east to west and west to east remain constant throughout the peak period. This is due to the fact that the A90 mainline is running under congestion free conditions with no points of delay along the route. The result is a stable and reliable journey time.

Trips from the B979 heading North show the greatest variability in journey times through the modelled period. This is a result of the fact that the higher, more dominant flows travelling through the north junction and toward the Fastlink (northbound) take priority over those vehicles trying to enter the roundabout form the B979 heading North. As a result, journey times fluctuate more for these routes when compared to other routes which have greater priority at the roundabout.

For trips travelling from all other origins, journey times are relatively constant throughout the modelled peak period. There are some marginally higher journey times in the period between 07:00 to 09:00 when traffic flows are at their highest. Some of the journey time accrued on these routes can be attributed to negotiating either the north or south junctions at Stonehaven junction.

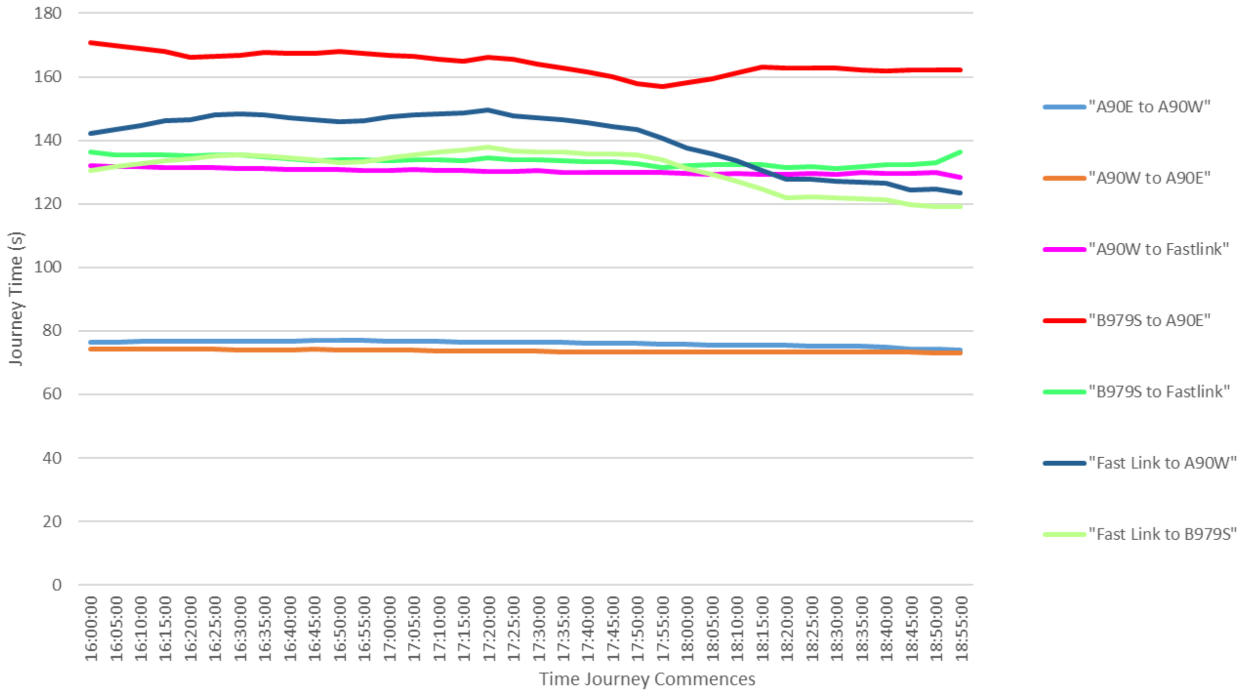


Figure 19 – PM Journey Time Data

During the PM peak period, journey times for trips travelling on the A90 east to west and west to east remain constant throughout the peak period. Again, this is due to the A90 mainline running under congestion free conditions with no points of delay along the route.

For trips travelling from all other origins, journey times are relatively constant throughout the modelled peak period. There are some marginally higher journey times in the period between 16:45 to 17:45 when traffic flows are at their highest. Some of the journey time accrued on these routes can be attributed to negotiating either the north or south junctions at Stonehaven junction.

5. Charleston Junction Performance

5.1 Junction Description and Location

Figure 20 shows the location of Charleston junction at the eastern end of the AWPR scheme and how it connects the A90 and the southern leg of the AWPR.

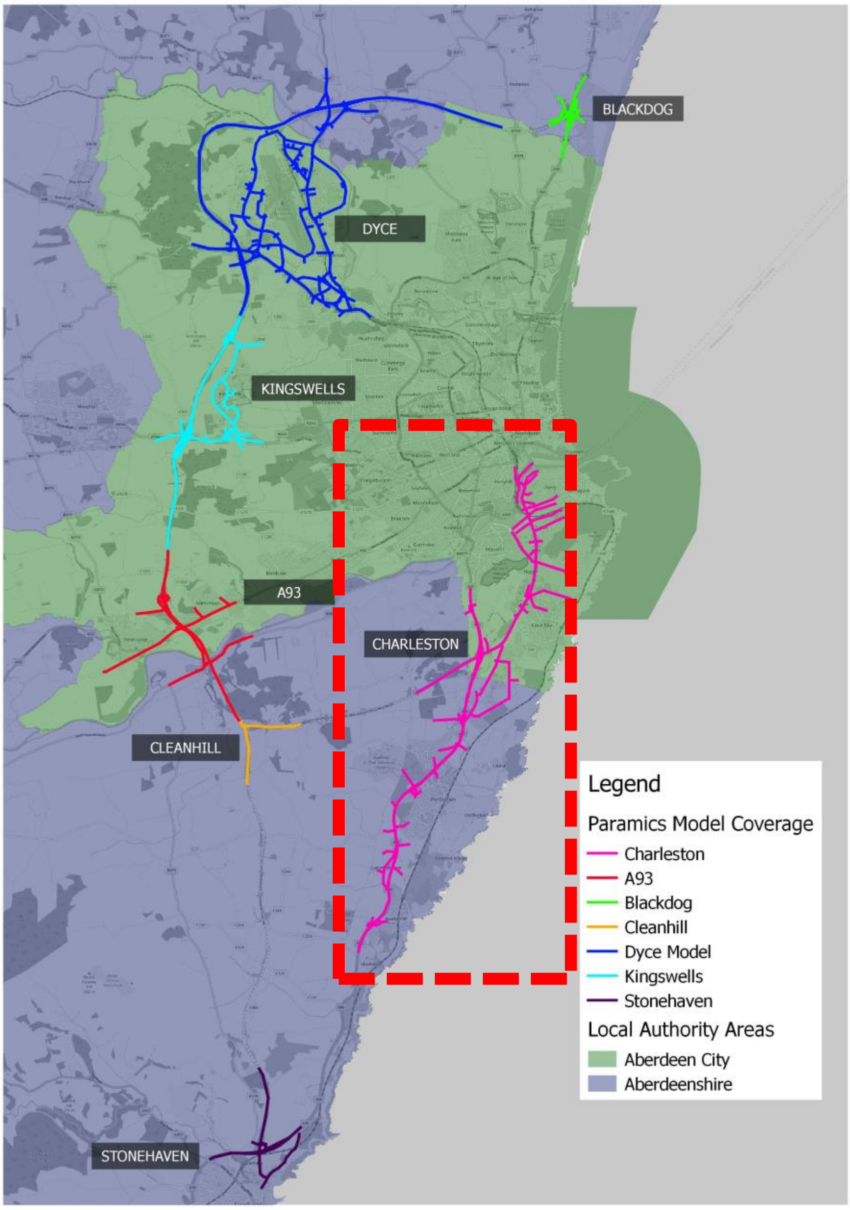


Figure 20 – Charleston Junction Location

Figure 21 shows the Paramics model coverage at key locations within the model.

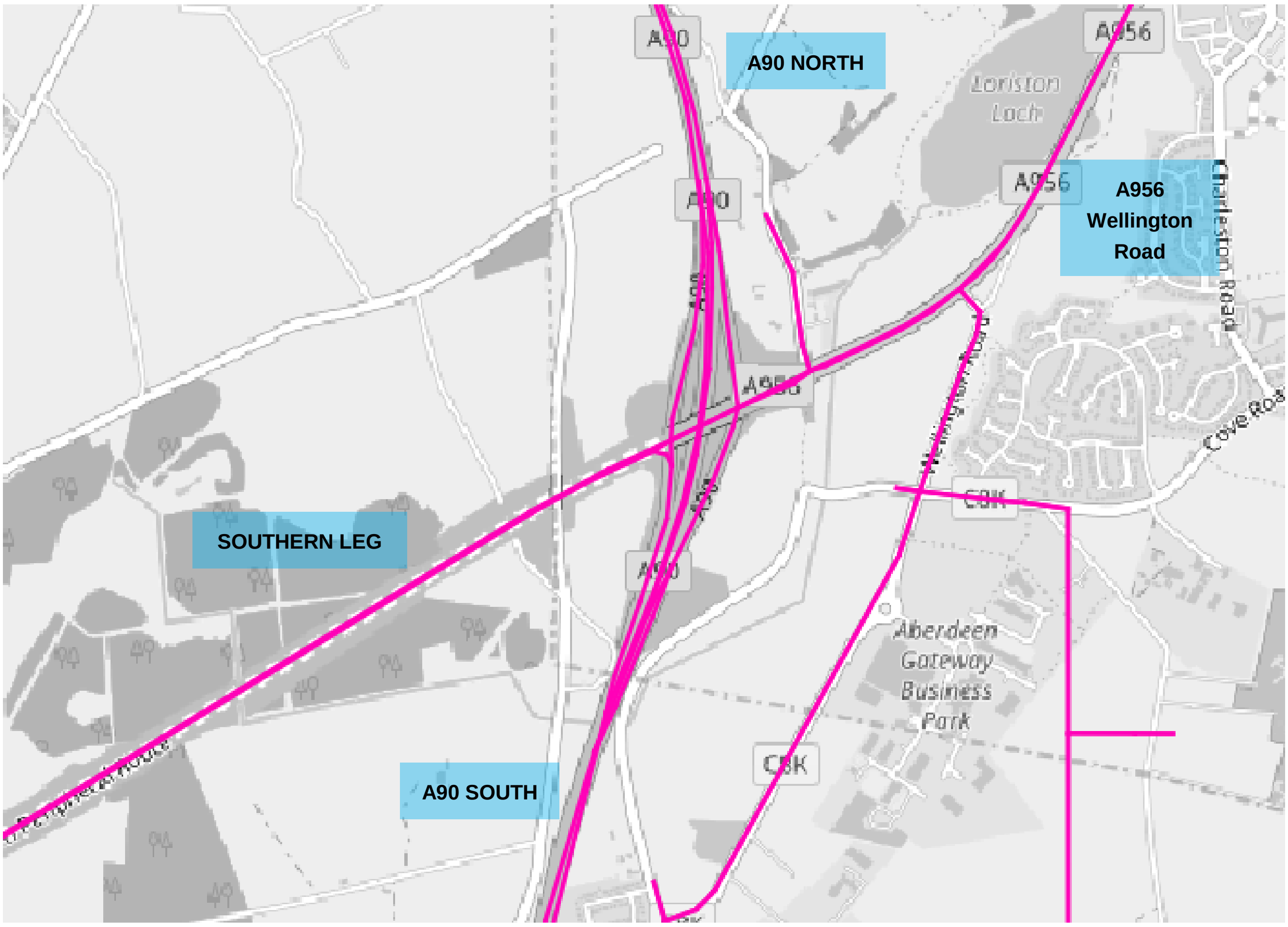


Figure 21 – Charleston Paramics Model and key locations

The preferred layout to connect the AWPR to the A90/A956 South of Aberdeen at Charleston has been identified as a single bridge, signalised priority-type junction arrangement.

The AWPR arm flares from two lanes to three lanes on the approach to the west set of signals. The nearside lane (lane 1) caters for the left turn and straight ahead movements, with lanes 2 and 3 catering for straight ahead movements only. Traffic in lane 3 would ultimately turn right at the east set of signals to access the A90 southbound merge.

Similarly, the A956 Wellington Road approach flares from two to three lanes at the entry to the east signalised junction. On the A956 approach lanes 1 and 2 cater for traffic turning left to access the A90 southbound merge, with lane 2 also catering for straight ahead movements. Lane 3 caters for traffic travelling straight ahead that can choose to turn right at the west junction to access the A90 northbound merge, or to continue straight ahead to access the AWPR.

The A90 southbound diverge flares from one lane to two lanes on the approach to the east junction. Traffic turning left onto the A956 Wellington Road is catered for in Lane 1, with Lane 2 catering for traffic turning right to access the AWPR.

On its approach to the west set of signals, the A90 northbound diverge flares from two to three lanes. In this case Lane 1 caters for left turning traffic accessing the AWPR, with the lane itself developed into a fully segregated left turn lane so removing this traffic movement from passing through the signalised junction. Lane 2 and Lane 3 both cater for right turning traffic travelling to the A956.

5.2 Signal Information

The nature of the preferred design option and the fact that the east and west signalised junctions are in close proximity meant they would require to operate in co-ordination to optimise the traffic progression.

It should be noted that the segregated left turn lane from the A90 northbound diverge to the AWPR is signalised as part of the west junction and operates to the same cycle time as the main junction operation.

Pedestrian crossing facilities have also been incorporated into the junction design and are located across the North side of the junction, crossing the A90 northbound merge and the A90 southbound diverge. The appropriate intergreen times were calculated based on swept path analyses to determine pedestrian/vehicle clearance times, with the pedestrian stage green times derived in accordance with DMRB Volume 8, Section 1, Part 1, TA 15/07.

Given the likely levels of pedestrian demand at this location, the pedestrian crossing facility across the A90 northbound merge is incorporated into the signal timings at the western junction and is assumed to be activated every two minutes.

The pedestrian crossing across the A90 southbound diverge is incorporated into the signal timings at the eastern junction and is therefore activated during every cycle when the southbound diverge signal stage is red (i.e. a “walk-with” configuration).

The simulation period for the Charleston model in the AM peak runs from 06:30 to 09:00, and in the PM peak runs from 16:00 to 18:30.

Figure 22 and **Figure 23** illustrate the Paramics model signals timings used in the AM and PM peak modelled periods.

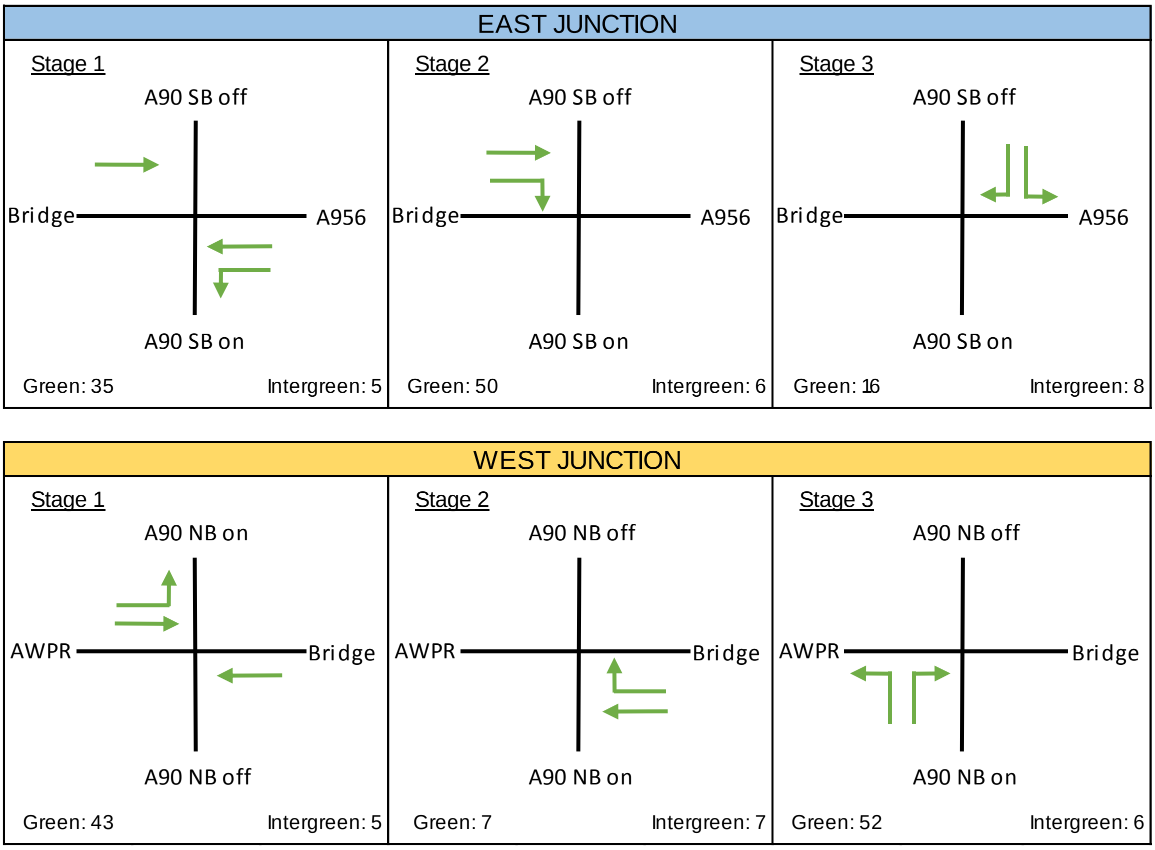


Figure 22 - AM Signal Timings

Figure 23 - PM Signal Timings

5.3 Key Junction Turning Movements

The turning flows for traffic passing through the Charleston junction were extracted from the AM peak Paramics models for the hours of 07:00 to 09:00, and are shown in Figure 24.

Figure 25 shows the PM peak turning flows extracted from `the Paramics models for the hours of 16:00 to 17:00, and 17:00 to 18:00 respectively.

As each Paramics model simulation run is different, the results are based on an average of ten model runs, as are all the further model statistics presented in this section. This ensures that the model results are representative of the junction operation and are not unduly influenced by a particularly free-flowing or particularly congested simulation run.

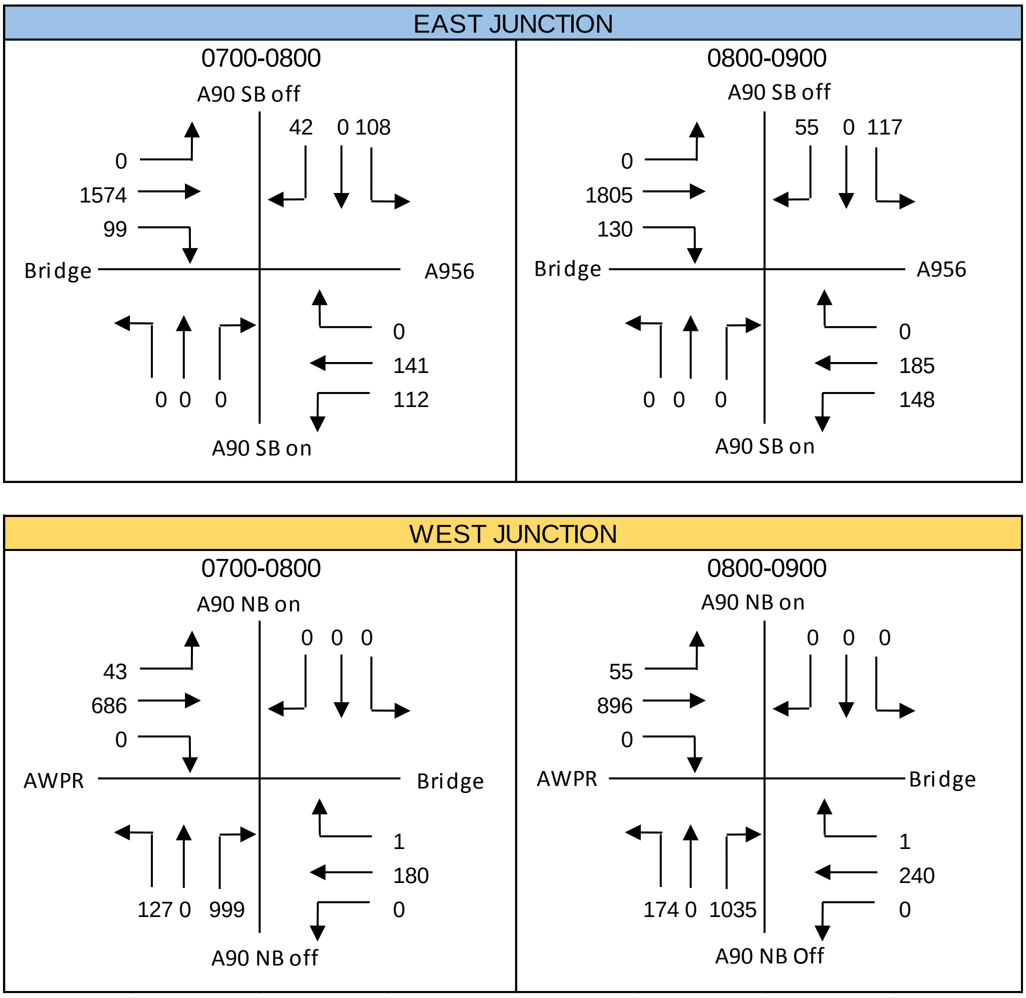


Figure 24 – AM Turning Movements

Figure 24 shows that the key flows in the AM peak are travelling from the A90 northbound diverge to the A956 Wellington Road, and from the AWPR to the A956. There are also significant levels of traffic travelling from the A956 to the A90 southbound merge and to the AWPR.

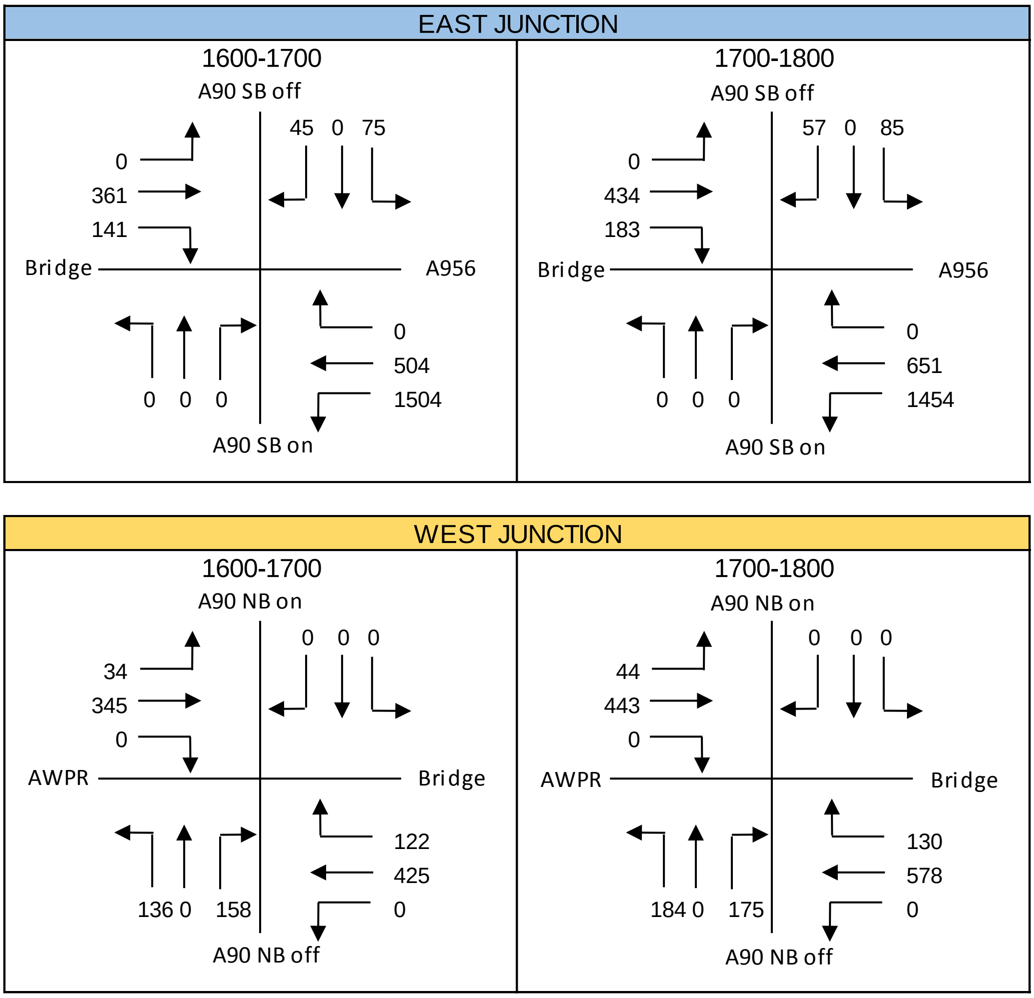


Figure 25 – PM Turning Movements

Figure 25 shows that the main movements during the PM peak period are travelling from A956 Wellington Road to the AWPR, and to the A90 southbound merge. There are also significant levels of demand wishing to travel from the AWPR to the A956 Wellington Road.

5.4 Vehicle Speeds

The average journey speed per vehicle, through the whole network, was derived to illustrate the overall network performance throughout the AM and PM modelled peak periods. A consistent downward trend in the average network speeds would indicate that the simulation experiences increasing levels of delay as the operational performance deteriorates over time.

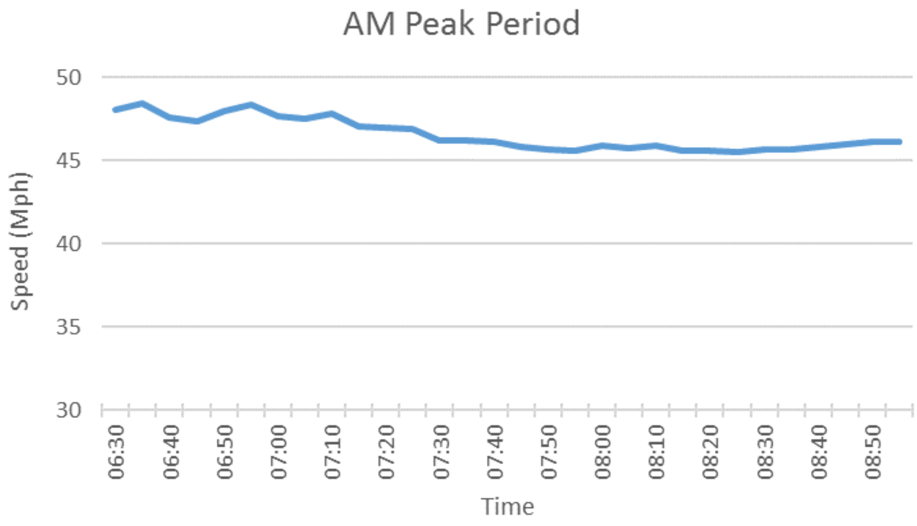


Figure 26 – AM Vehicle Speeds

Figure 26 shows that during the AM peak, speeds remain typically high throughout the modelled period despite a marginal downward trend. Average speeds are between 45 and 48 miles per hour throughout the peak which is indicative of a good level of performance throughout the network.

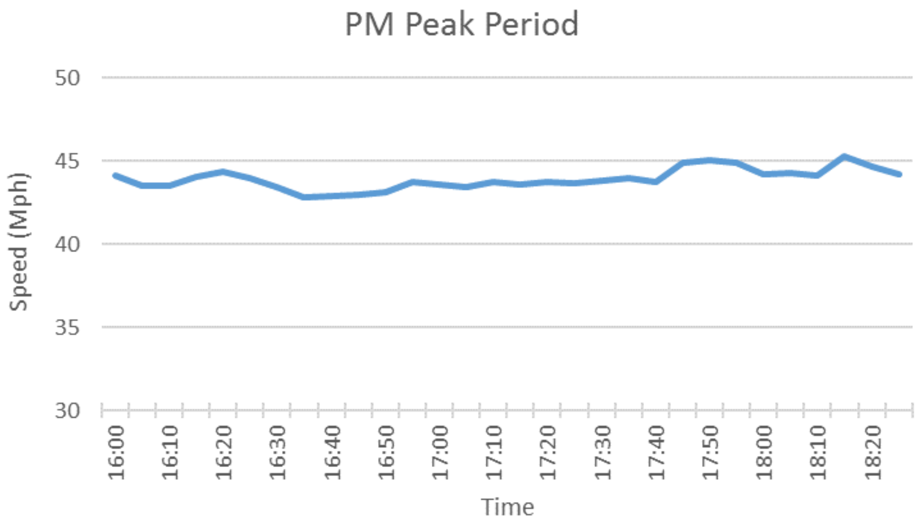


Figure 27 – PM Vehicle Speeds

Similar to the AM, the PM peak shows that, speeds remain typically high throughout the modelled period. Average speeds are between 43 and 45 miles per hour throughout the peak which is indicative of a good level of performance throughout the network (despite it being marginally poorer than the AM peak).

5.5 Queue Length Data

Queuing Analysis

Queuing data was collected from the model in a similar manner to the Stonehaven model. In the tables below, the maximum queue lengths represent the average of the longest queues recorded during each of the 10 simulation runs, irrespective of the 5 minute time interval in which they occurred during each simulation. The 95%

confidence levels indicate the upper and lower bounds of the range within which there can be 95% statistically confident that the maximum queue recorded during any single simulation run will be.

Figure 28 shows the locations at which queues were recorded and used in the following analysis.

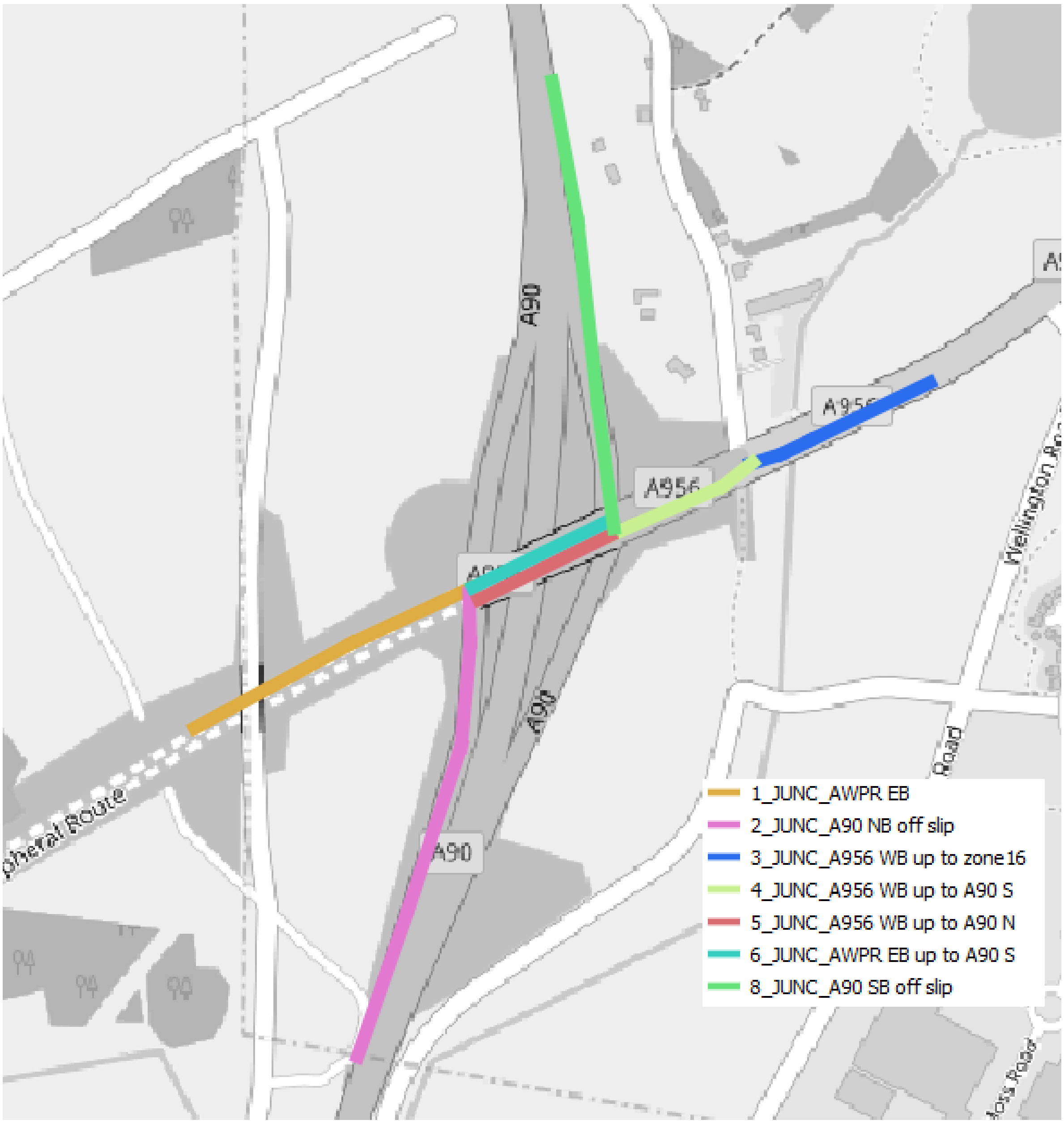


Figure 28 – Queue Routes

Route	Lane	0700-0800			0800-0900		
		Max Q	95% CI		Max Q	95% CI	
"1_JUNC_AWPR EB"	1	54	53	55	54	53	55
"1_JUNC_AWPR EB"	2	104	102	106	127	124	129
"1_JUNC_AWPR EB"	3	91	89	93	136	133	138
"2_JUNC_A90 NB off slip"	1	73	72	74	66	66	67
"2_JUNC_A90 NB off slip"	2	130	127	134	129	126	133
"2_JUNC_A90 NB off slip"	3	64	62	67	67	65	69
"3_JUNC_A956 WB up to zone1(	1	-	-	-	-	-	-
"3_JUNC_A956 WB up to zone1(	2	-	-	-	-	-	-
"3_JUNC_A956 WB up to zone1(	3	24	24	25	24	24	25
"4_JUNC_A956 WB up to A90 S"	1	57	55	58	64	62	65
"4_JUNC_A956 WB up to A90 S"	2	51	50	52	69	67	70
"4_JUNC_A956 WB up to A90 S"	3	50	49	51	63	61	64
"5_JUNC_A956 WB up to A90 N"	1	58	57	59	59	57	60
"5_JUNC_A956 WB up to A90 N"	2	71	70	73	61	59	62
"5_JUNC_A956 WB up to A90 N"	3	-	-	-	-	-	-
"6_JUNC_AWPR EB up to A90 S	1	69	67	70	64	62	65
"6_JUNC_AWPR EB up to A90 S	2	53	52	54	58	56	59
"6_JUNC_AWPR EB up to A90 S	3	49	48	51	47	45	48
"8_JUNC_A90 SB off slip"	1	82	81	83	84	82	85
"8_JUNC_A90 SB off slip"	2	69	68	70	67	66	68
"8_JUNC_A90 SB off slip"	3	-	-	-	-	-	-

Table 3 - AM Queue Length Data

Table 3 shows that during the AM peak that all approaches to the east and west junctions are all subject to a degree of queuing. It is evident from the table that the co-ordinated signal timings have effectively balanced the queuing on each approach and hence balanced the demand throughput.

The longest maximum queues occur on the A90 northbound diverge approach, with a queue length of up to 130 metres in lane 2 (equivalent to approximately 22 car lengths), and the AWPR eastbound approach, with a queue length of 136 metres in lane 3 (equivalent to approximately 23 car lengths).

Route	Lane	1600-1700 Max Q	95% CI		1700-1800 Max Q	95% CI	
"1_JUNC_AWPR EB"	1	47	46	48	51	51	52
"1_JUNC_AWPR EB"	2	91	89	92	84	82	86
"1_JUNC_AWPR EB"	3	77	75	78	92	90	94
"2_JUNC_A90 NB off slip"	1	63	62	65	63	62	64
"2_JUNC_A90 NB off slip"	2	53	52	54	54	53	55
"2_JUNC_A90 NB off slip"	3	-	-	-	-	-	-
"3_JUNC_A956 WB up to zone1(	1	52	42	61	43	35	51
"3_JUNC_A956 WB up to zone1(	2	57	55	58	40	39	41
"3_JUNC_A956 WB up to zone1(	3	-	-	-	-	-	-
"4_JUNC_A956 WB up to A90 S"	1	137	134	141	136	133	139
"4_JUNC_A956 WB up to A90 S"	2	162	158	166	160	157	162
"4_JUNC_A956 WB up to A90 S"	3	138	133	142	138	134	142
"5_JUNC_A956 WB up to A90 N"	1	71	69	72	88	87	90
"5_JUNC_A956 WB up to A90 N"	2	105	102	108	128	125	130
"5_JUNC_A956 WB up to A90 N"	3	74	73	76	85	83	87
"6_JUNC_AWPR EB up to A90 S	1	32	-	-	33	28	37
"6_JUNC_AWPR EB up to A90 S	2	-	-	-	-	-	-
"6_JUNC_AWPR EB up to A90 S	3	35	34	36	35	34	36
"8_JUNC_A90 SB off slip"	1	75	73	76	80	79	82
"8_JUNC_A90 SB off slip"	2	69	69	70	70	69	71
"8_JUNC_A90 SB off slip"	3	-	-	-	-	-	-

Table 4 - PM Queue Length Data

Similarly, Table 4 shows that in the PM peak all of the approaches again exhibit a degree of queuing at some point during the simulation run. In common with the AM modelled period, the co-ordinated signal timings balance the demand from each approach, and hence the level of queuing.

The longest maximum queue during the PM modelled period occurs on the A956 approach in lane 2 at 162 metres (equivalent to roughly 27 car lengths).

It should be noted that during both the AM and the PM peak, there is a short queue on the A956 westbound (route ID “3_JUNC_A956 WB up to zone 16”) as there are vehicles turning right to head toward the FedEx depot and Charlestown. Given that this junction is a priority arrangement, vehicles are required to queue for an appropriate gap in the eastbound traffic before manoeuvring.

To help illustrate the extent of the queuing, which does not necessarily occur simultaneously on all approaches, the schematic representation shown in Figure 29 and Figure 30 have been produced. The figures are based on highest hourly mean maximum figures shown in Table 3 and Table 4 and show the approximate extent of the maximum queue lengths in the AM and PM peak periods respectively.

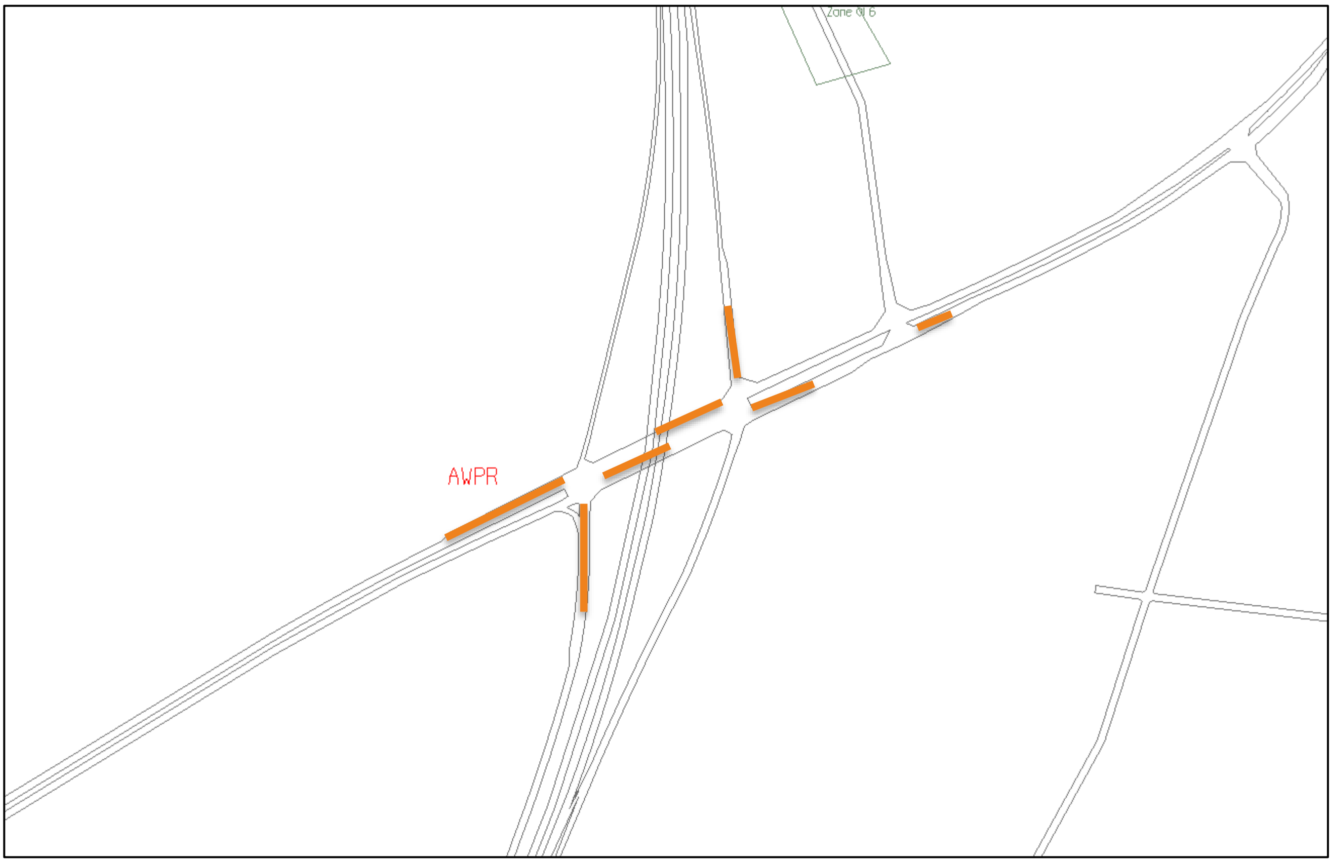


Figure 29 – AM Max Queue Lengths Illustrated

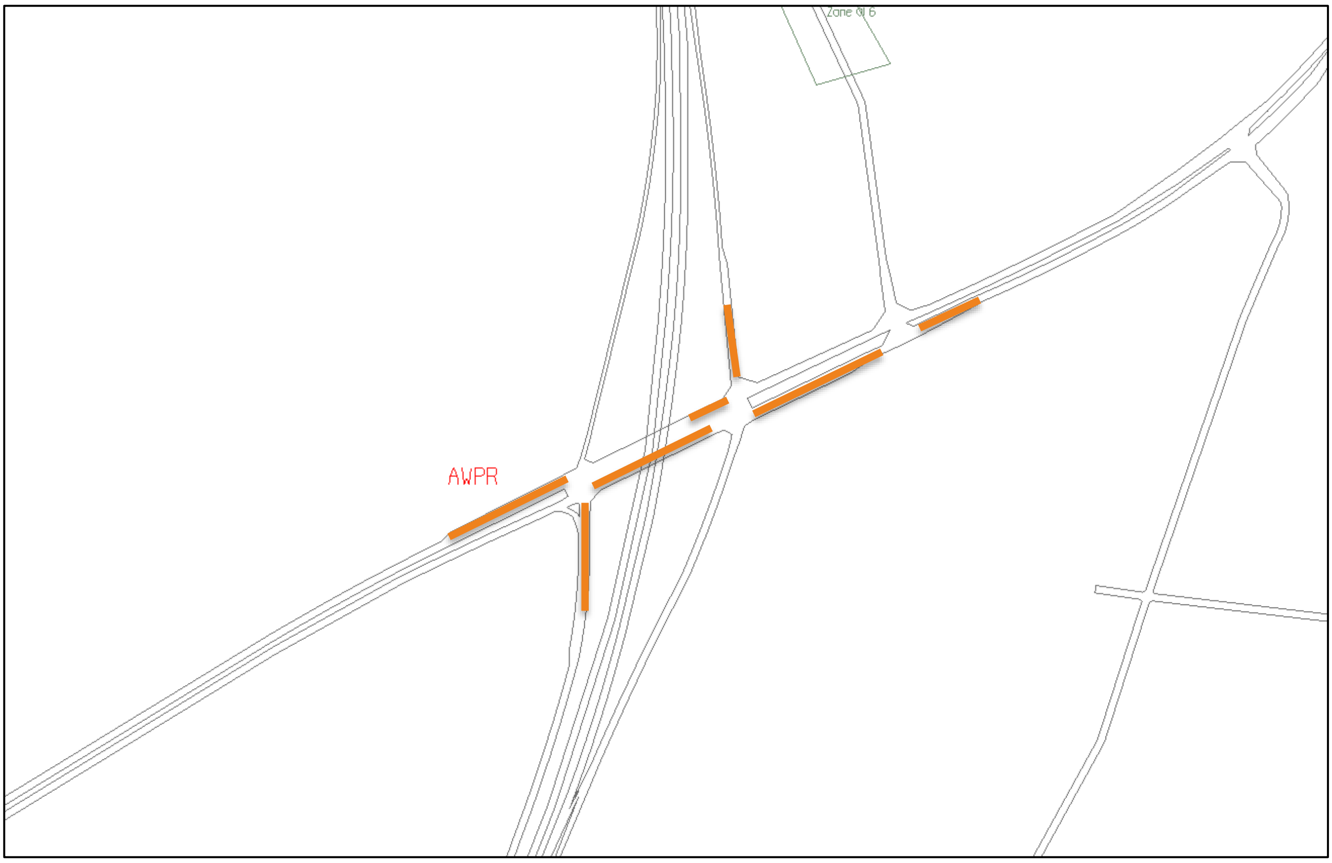


Figure 30 – PM Max Queue Lengths Illustrated

Queuing Length Distribution

To assess the significance of the maximum queue statistics extracted from the Paramics model simulations, and examine how the queues vary over time, the queue length distribution for each approach to the Charleston junction was analysed throughout the simulation period.

Figure 31 and Figure 32 show the average maximum queue length distribution, in metres, for each approach arm throughout the modelled AM and PM periods. It should be noted that the queue length distributions are extracted from the Paramics simulation runs for each 5-minute interval, and represent the average of the maximum queue recorded in each of the 10 simulations during each 5-minute interval. Therefore, the queue length values in Table 3 and Table 4 will not necessarily reflect the maximum queue values presented in Figure 31 and Figure 32, as the values in the tables may occur within any 5-minute increment during each of the 10 simulations.

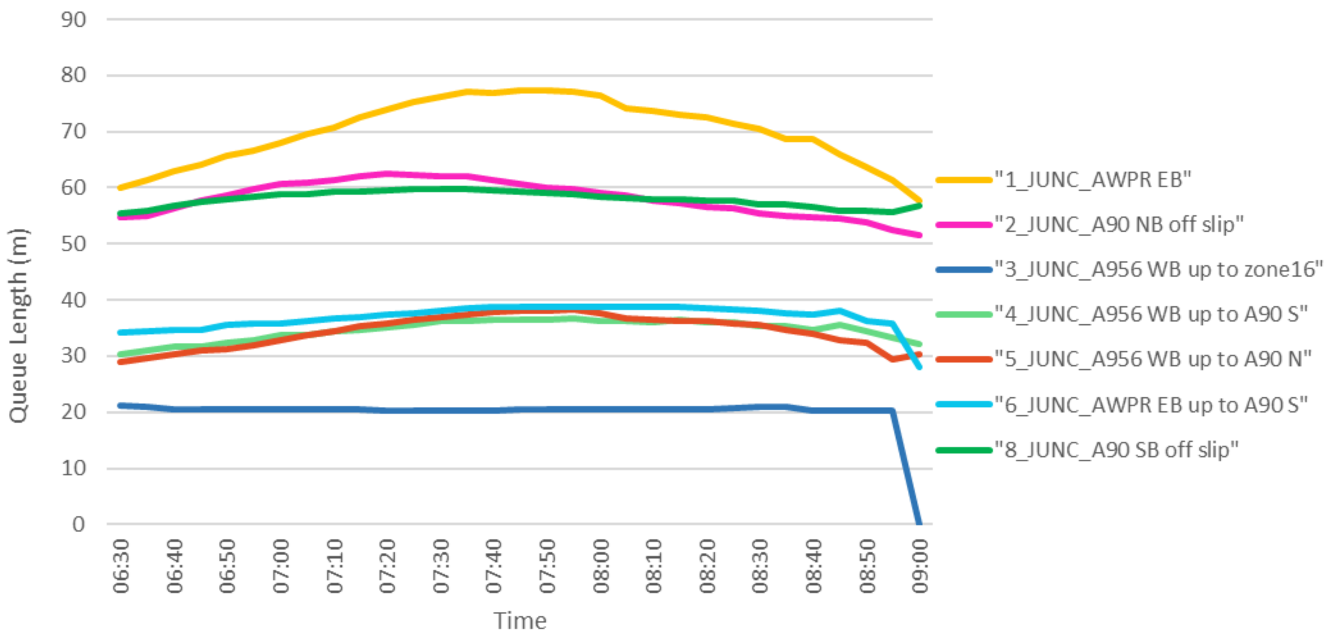


Figure 31 – AM Queue Length Distribution

During the AM peak, the route with the greatest variation is the "1_JUNC_AWPR EB" route (the AWPR EB approach to the junction). It shows that queuing starts relatively low at approximately 60 metres at the beginning of the peak before extending up to approximately 78 metres at around 07.30. From then onward, there is a reduction in the level of queuing on this route.

The remaining queues also show peaks in the modelled period at around 07:30 and generally reduce in length over the remainder of the modelled period.

Queue lengths toward the end of the AM period reduce sharply for route "3_JUNC_A956 WB up to zone16 toward the end of the AM period. ;

This queue is associated with traffic turning right from the A944 WB into Redmoss Road. The cause of the queuing at this location is the nature of the priority arrangement; vehicles turning right from the A944 WB and onto Redmoss Road are required to give way to the priority traffic stream (traffic travelling eastbound on the A944).

Throughout the modelled period, the queue length remains short at between 3-4 vehicles in length and is a function of the relatively few appropriate gaps in the A944 EB traffic that would allow the right turning traffic to undertake right turn safely.

Toward the end of the modelled period, the volume of traffic travelling on the A944 EB reduces as the peak passes and the number of gaps in the priority traffic stream increase in number and in length. This then affords more frequent and longer opportunities for vehicles turning right into Redmoss Road to undertake the right turn and so the queue drops sharply from 3-4 vehicles to 0.

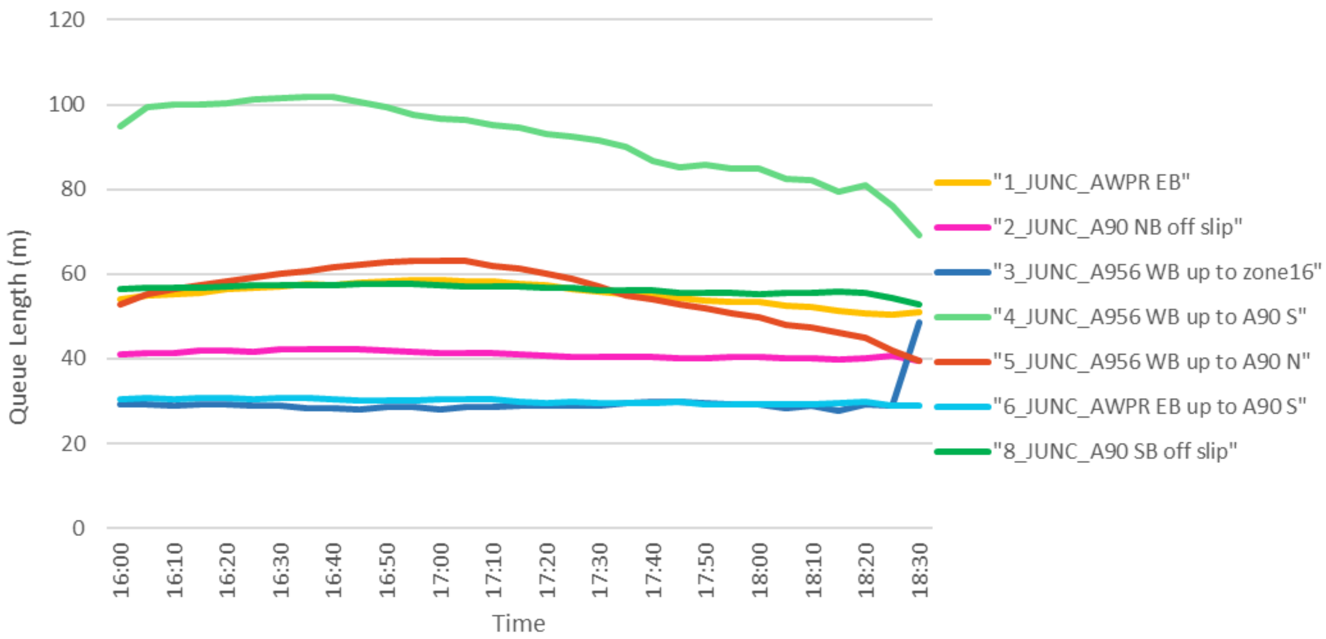


Figure 32 – PM Queue Length Distribution

During the PM peak, the route with the greatest variation is the route “4_JUNC_A956 WB up to A90” (the A956 WB approach to the east junction). It shows that queuing is generally around 90-100 metres between 16:00 and 17:20. After this point, queuing reduces gradually over the remainder of the peak period.

The route “5_JUNC_A956_WB up to A90 N” also shows some variation; at the beginning of the peak, queue lengths are approximately 55m which then extend up to 65m at the height of the peak before reducing to 40m in length at the end of the period.

The route “3_JUNC_A956 WB up to zone 16” shows a sharp increase in the queue length from 20m to 49m at the end of the PM peak.

During the final 10 minutes of the modelled period, there has been a single queue recorded that extends back from the signals at the AWPR eastern junction and through the Redmoss Road junction. This occurred during a single cycle of the signal timings causing a relatively longer queue to form for a very short time (some 25m longer than the queue lengths during the rest of the modelled period).

The remaining queue routes show queuing that is relatively consistent over the full duration of the modelled PM peak period.

5.6 Journey Time Data

Figure 33 illustrates the journey time routes that were defined for the journey time analysis.

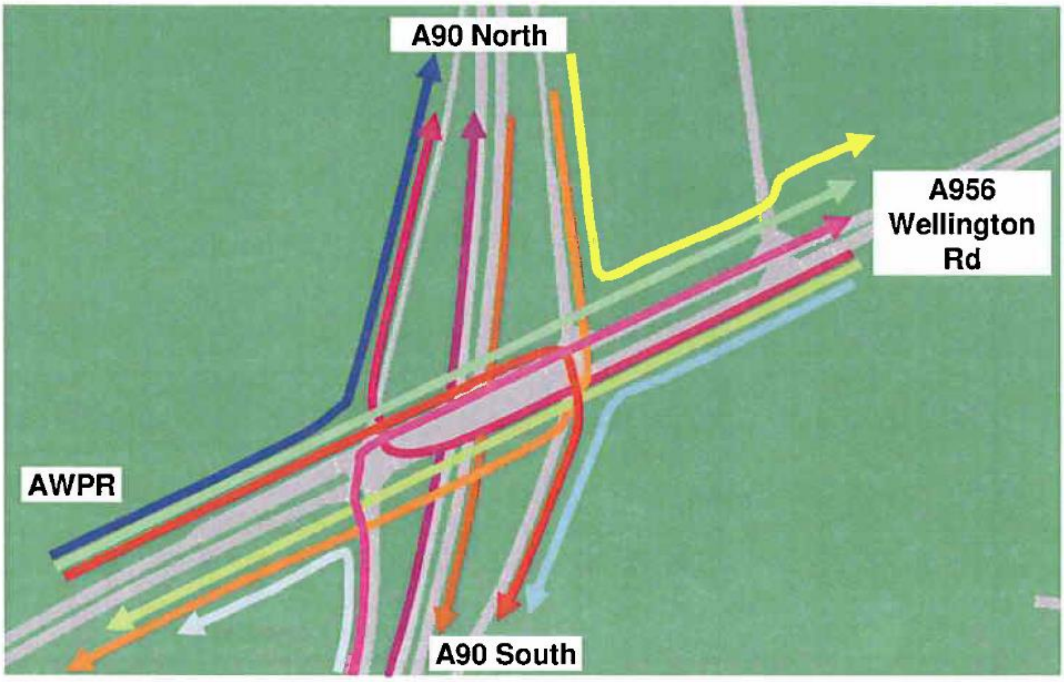


Figure 33 – Journey Time Routes

The journey time data was extracted from each Paramics simulation run by defining paths representing each available turning movement through the Charleston junction design. For the journey time analysis, the junction was treated as a whole such that the journey times are for movements travelling through both the individual west and east junctions where appropriate.

The following movements were therefore considered in the analysis:

- AWPR to A90 northbound merge
- AWPR to A956
- AWPR to A90 southbound merge
- A90 southbound diverge to A956
- A90 southbound diverge to AWPR
- A956 to A90 southbound merge
- A956 to AWPR
- A956 to A90 northbound merge
- A90 northbound diverge to AWPR
- A90 northbound diverge to A956

The results should clearly indicate whether significant congestion leads to a deterioration of the operational performance and therefore exhibits increasing journey times as the simulations progress. The analysis also compares the journey times between the modelled years, and serves to highlight where potential increases in traffic demand could result in increasing journey times as a result of increasing delays occurring.

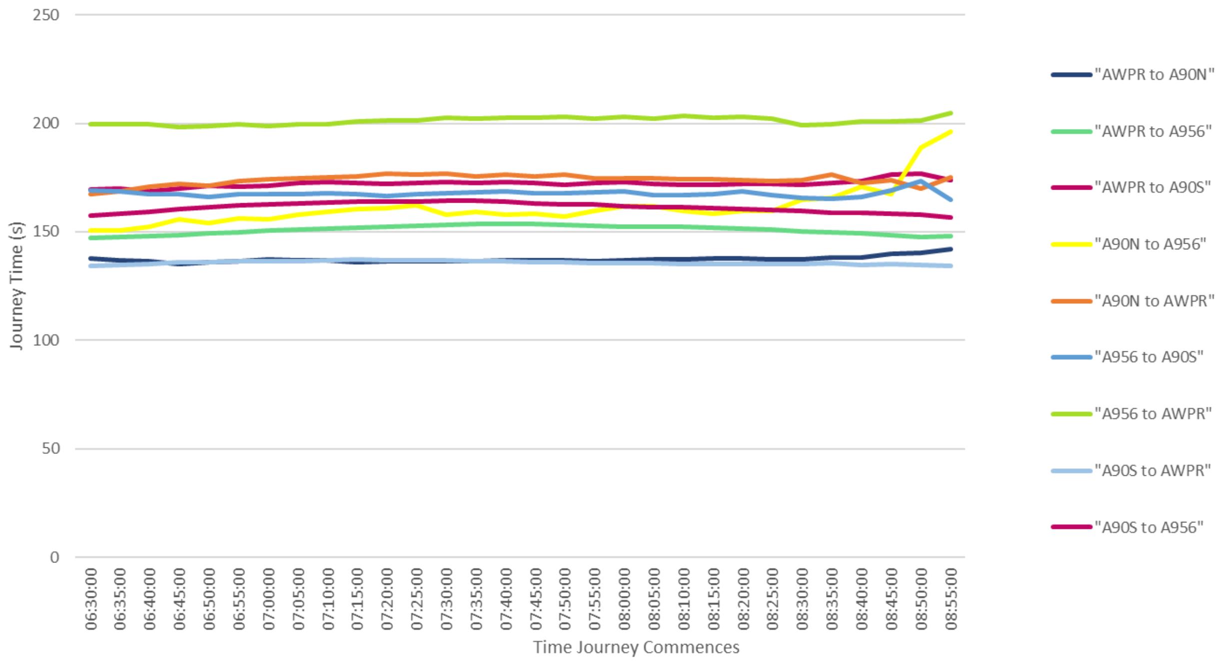


Figure 34 – AM Journey Time Data

During the AM peak, journey times vary between routes (from approximately 60 to 200 seconds) but considering each route individually shows that journey times for all but one route is consistent throughout the AM peak period.

The route A90N to A956 does show some variation in that it steadily increases from 150s at the beginning of the peak to approximately 160s at 08:25. Subsequently, journey time increase by 20-30 seconds by 09:00. This increase is a result of the average journey times recorded at end of period (when traffic volumes are lower) being informed by fewer trips. As a result, journey times show a greater level of variability.

With the exception of one route then, the results then show that there is no significant deterioration in operation over the course of the peak period. The A90N to A956 route shows some limited increase in JT however.

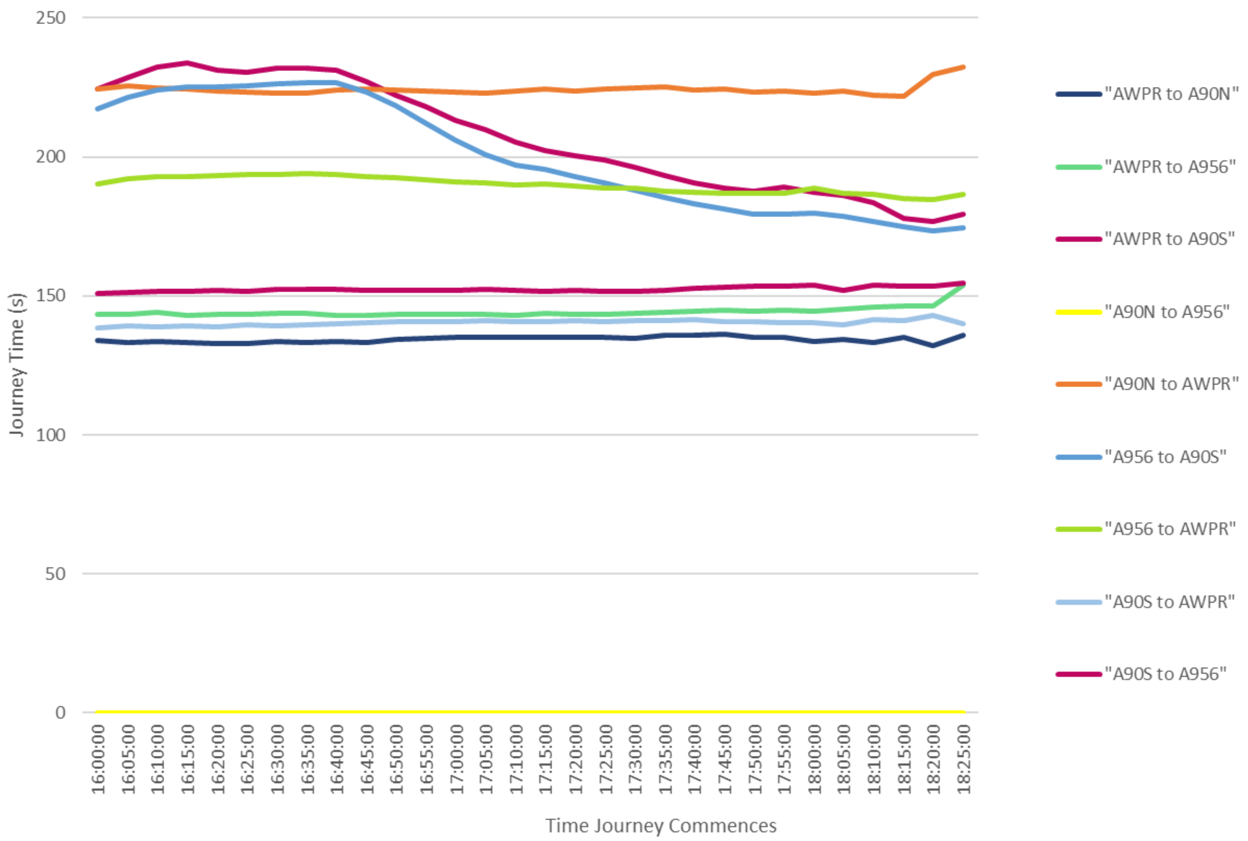


Figure 35 – PM Journey Time Data

During the PM peak, journey times for routes travelling toward the A90 South show a level of variation throughout the course of the peak period. Journey times are higher at the start of the PM peak (16:00-17:00) but reduce toward the end of the period (from 16:45 onward). The variation in journey times at the end of the period of between 3 and 11 seconds are a result of the lower volume of traffic arriving at signalised nodes at the end of the period. As average journey times at this point are informed by fewer trips there is a greater variability in the results.

Journey times for all other routes remain consistent throughout the duration of the PM peak period.

6. Cleanhill Junction Performance

6.1 Junction Description and Location

The proposed Cleanhill junction connects the AWPR to the Fastlink and has been identified as an at-grade roundabout with two lanes on the circulating carriageway.

Figure 36shows an overview of the wider Paramics model network developed for the preferred junction option, with Figure 37 showing the modelled network in more detail.

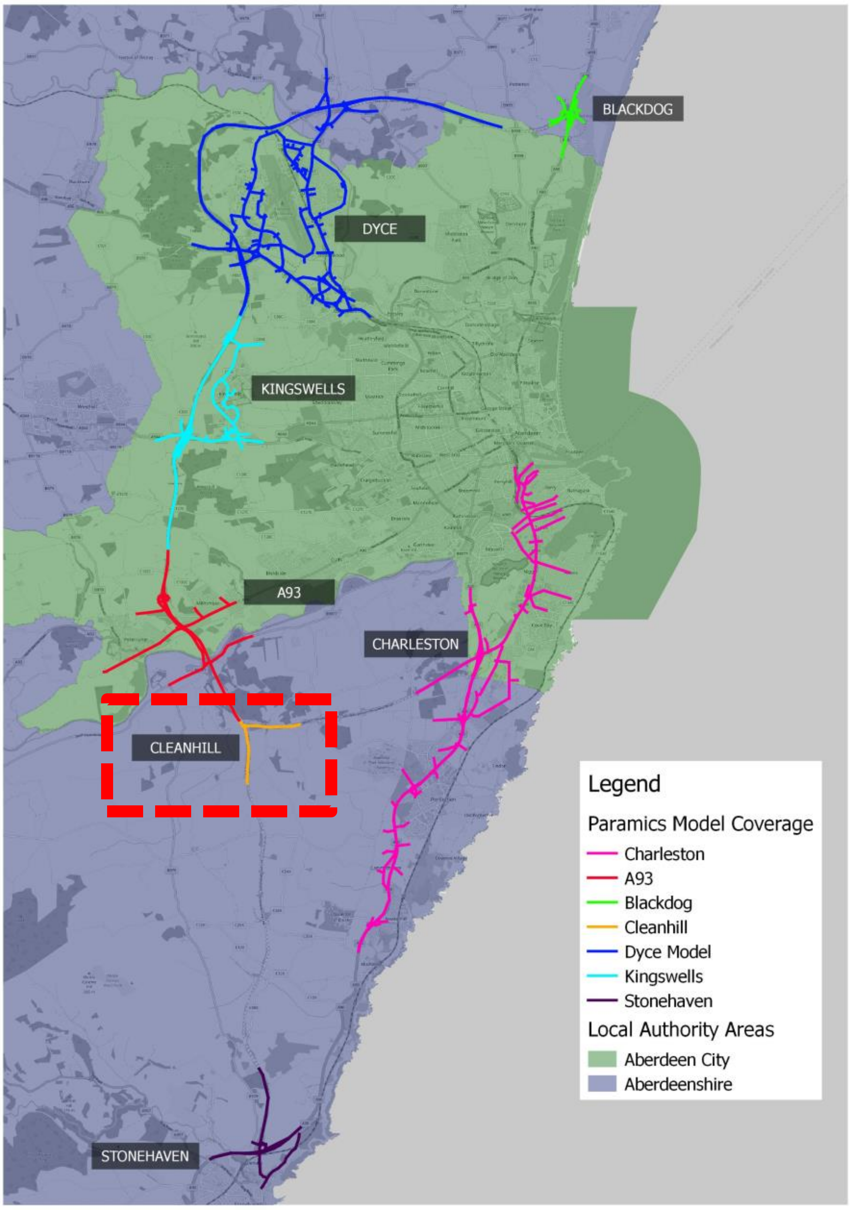


Figure 36 – Cleanhill Junction Location

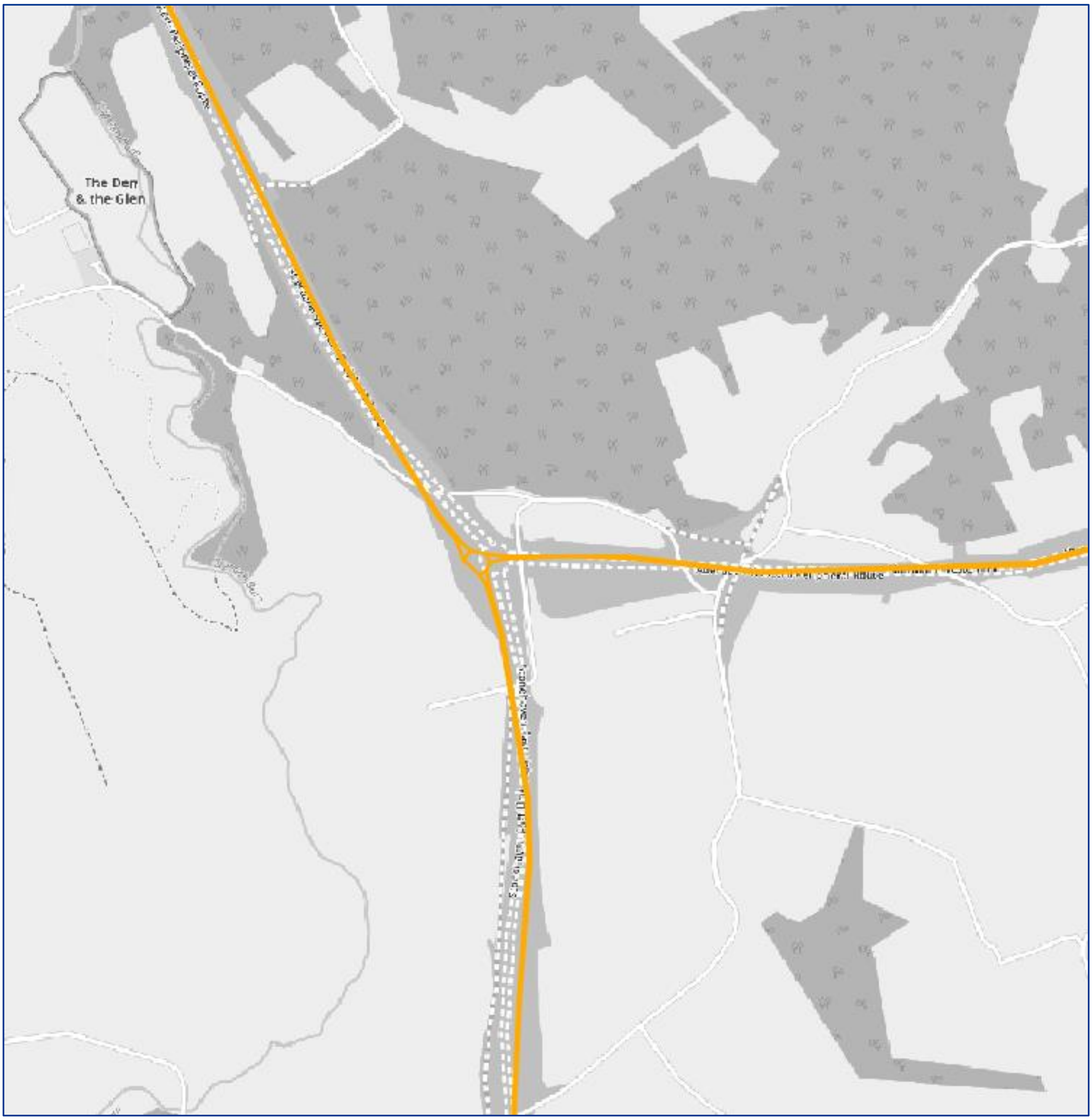


Figure 37 –Cleanhill Paramics Model and key locations

6.2 Key Junction Turning Movements

The turning flows for traffic passing through the Cleanhill junction were extracted from the AM and PM peak Paramics models, and are shown in Figure 38**Error! Reference source not found.** and **Figure 39**respectively.

As each Paramics model simulation run is different, the results are based on an average of ten model runs, as are all the model statistics presented in this section. This ensures that the model results are representative of the junction operation and are not unduly influenced by a particularly free-flowing or particularly congested simulation run.

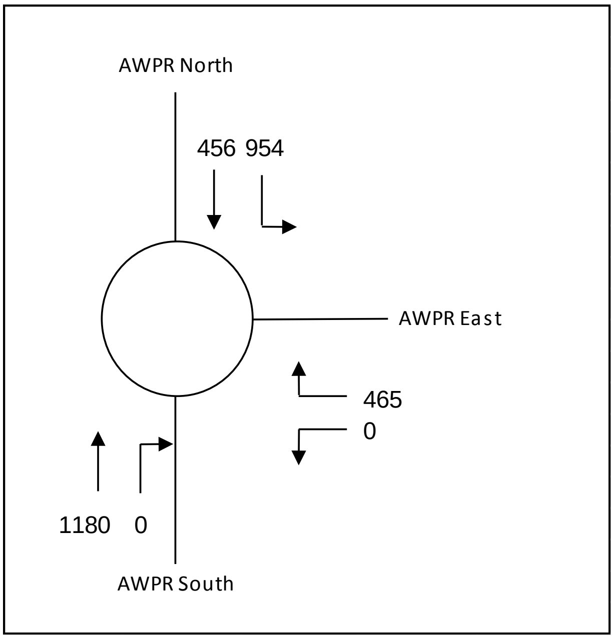


Figure 38 - AM Turning Movements

During the AM peak, the main movement is from the AWPR south to the AWPR north. There is also a major movement from the AWPR north to the AWPR east.

Relatively lower flow movements are from the AWPR east to the AWPR north and from the AWPR north to the AWPR south.

Overall, there is very little conflict between movements at the junction during the AM peak.

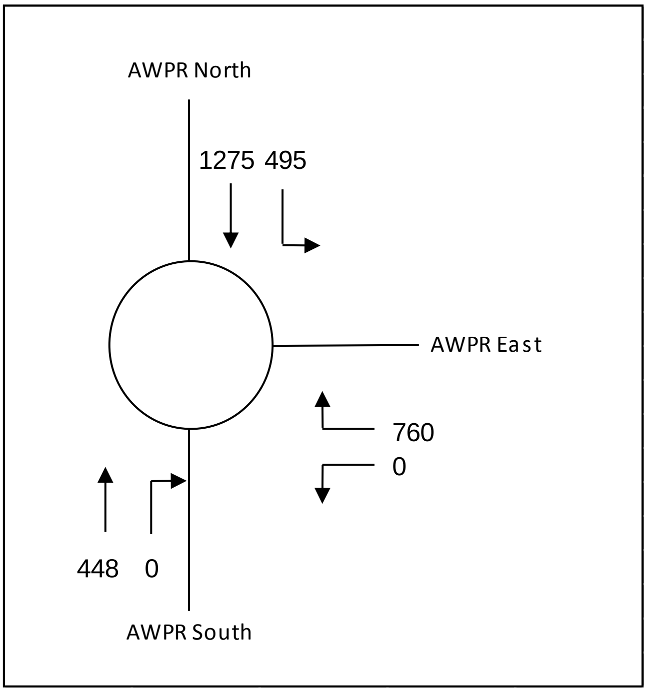


Figure 39 - PM Turning Movements

During the PM peak, the main movement is from the AWPR north to the AWPR south. There is also a major movement from the AWPR east to the AWPR north. This represents a conflict between these two traffic streams as the north to south movement will take priority over the east approach to the junction.

Relatively lower flow movements are from the AWPR north to the AWPR east and from the AWPR south to the AWPR north.

6.3 Vehicle Speeds

The average journey speed per vehicle, through the whole network, was derived to illustrate the overall network performance throughout the AM and PM modelled periods both in the year of opening. A consistent downward trend in the average network speeds would indicate that the simulation experiences increasing levels of delay as the operational performance deteriorates over time.

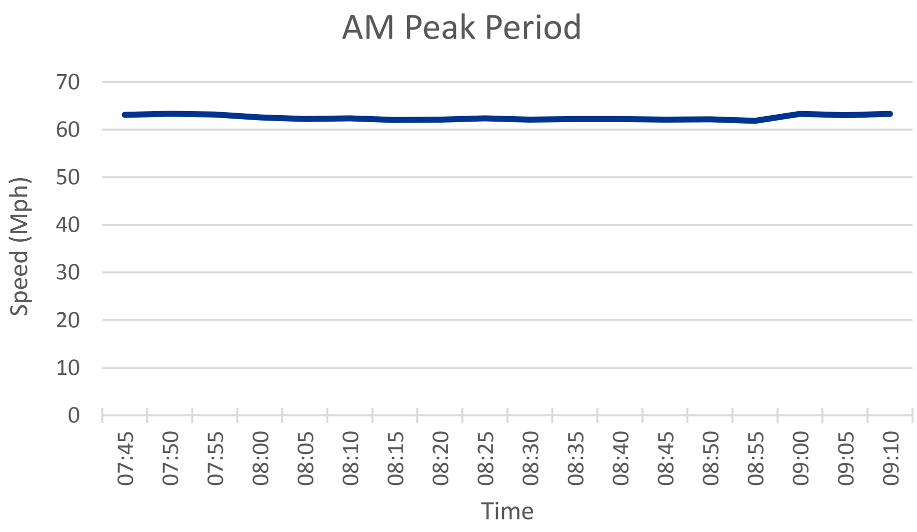


Figure 40 – AM Vehicle Speeds

Figure 40 shows that during the AM peak, the average journey speed remains relatively constant throughout the AM simulation at approximately 60-65mph. This indicates that the junction performs well during the AM peak.

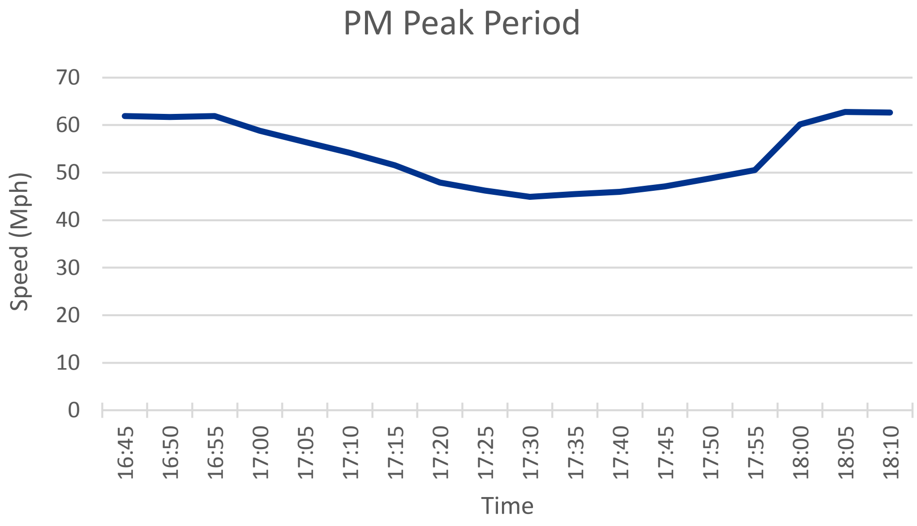


Figure 41 – PM Vehicle Speeds

Figure 41 shows that during the PM peak, there is a distinct drop in the average vehicle speeds from a high of approximately 60-65mph at 16:55 to a low of 45mph at 17:30. After this time, average modelled speed increases again returning to 60-65mph at 18:00.

The distinctly lower speeds at the height of the modelled period are suggestive of a relatively poorer level of performance when compared to the AM peak period but still acceptable.

6.4 Queue Length Data

Queuing Analysis

Note that in order to conduct the queuing analyses, the default Paramics Queue Recognition definitions have been applied to record and collect the queuing data during each model simulation run. The only adjustment made was to change the method of Multiple Queues reporting to the 'Propagate the last queue to end' option, such that all vehicles from the end of the last queue on the link to the end of the link are considered and reported as a single queue. For further details reference should be made to the Paramics 2003 Reference Manual, Chapter 13, Page 13-6, Queue Recognition.

As a result the absolute queue lengths reported in the analyses include gaps between vehicles, as the vehicle speed and the gap to the vehicle in front are both used to determine the thresholds below which a vehicle is considered to be in a queued state. Therefore the queue lengths reported do not necessarily represent a continuous queue of vehicles, but serve to illustrate the maximum possible extent of the level of queuing on each approach.

Figure 42 shows the queue routes over which there has been data collected. Table 5 and Table 6 show the maximum queue length and 95% confidence interval, by lane, for each approach arm to the Cleanhill junction for the AM and PM peaks respectively.

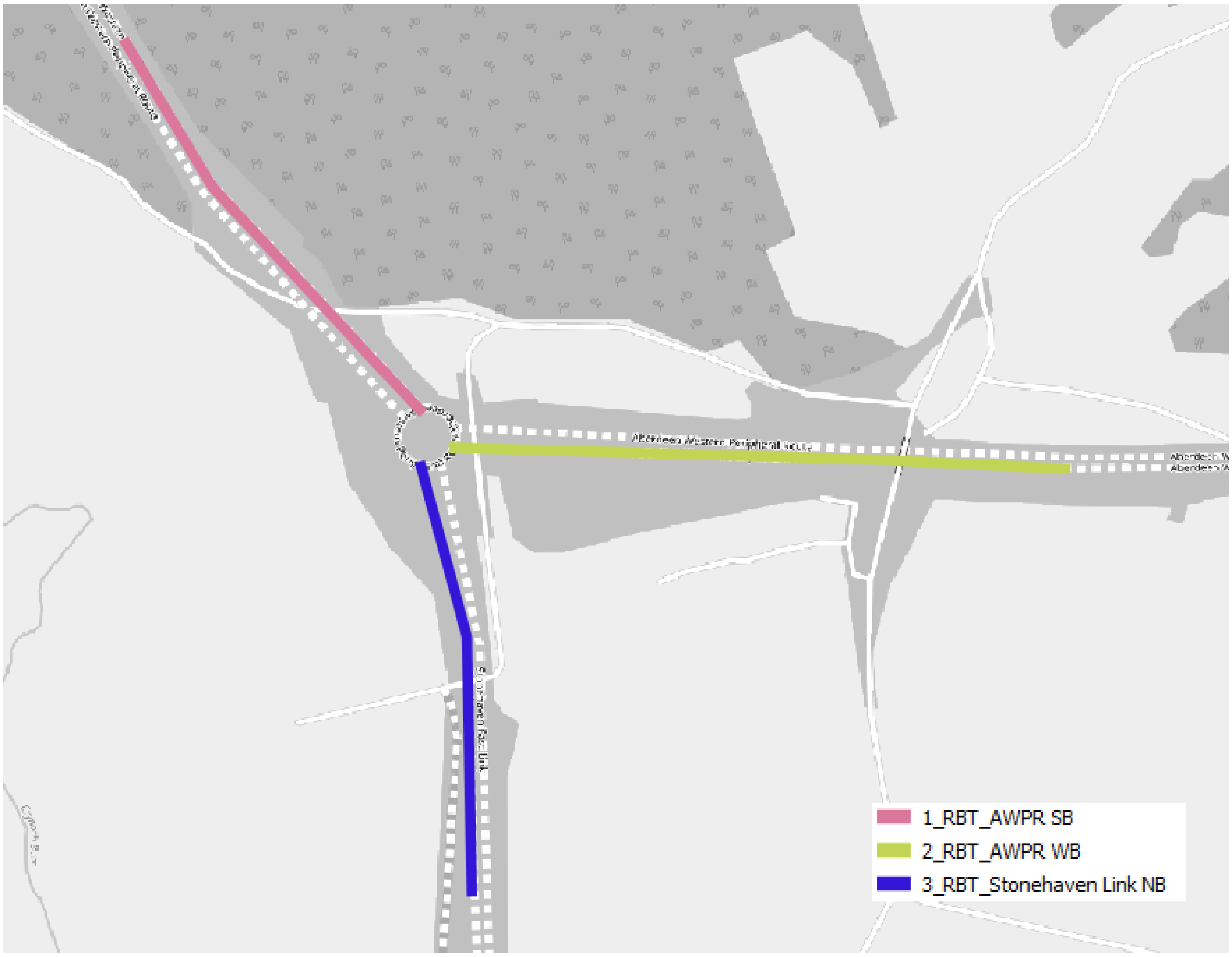


Figure 42 - Queue Routes

Route	Lane	0700-0800			0800-0900			0900-1000		
		Max Q	95% CI		Max Q	95% CI		Max Q	95% CI	
"1_RBT_AWPR SB"	1	27	21	34	33	31	35	-	-	-
"1_RBT_AWPR SB"	2	26	-	-	93	91	95	27	26	28
"1_RBT_AWPR SB"	3	-	-	-	-	-	-	-	-	-
"2_RBT_AWPR WB"	1	28	-	-	28	27	28	20	-	-
"2_RBT_AWPR WB"	2	-	-	-	24	23	25	-	-	-
"2_RBT_AWPR WB"	3	-	-	-	-	-	-	-	-	-
"3_RBT_Stonehaven Link NB"	1	23	22	23	49	48	50	29	27	31
"3_RBT_Stonehaven Link NB"	2	26	25	27	48	47	49	28	26	30
"3_RBT_Stonehaven Link NB"	3	-	-	-	-	-	-	-	-	-

Table 5 - AM Max Queue Lengths

Table 5shows that the AWPR SB experiences a degree of queuing with a maximum queue length of 93 metres (equivalent to approximately 16 car lengths) occurring in Lane 2. The other approaches exhibit insignificant levels of queuing with a maximum recorded queue length of 49 metres, equating to around 8 car lengths.

Route “1_RBT_AWPR_SB” shows a maximum queue length of up 93 metres during the AM peak where there is no conflicting flow; the queue develops as a result of the combination of the roundabouts geometry (the deflection angle) and the rate at which vehicles reach the stopline on the roundabout.

The radius of the turn means vehicles entering the roundabout must slow in order to safely negotiate the turn meaning the subsequent vehicles needs to slow to avoid a collision. This has the effect of forming a rolling queue on the approach to the junction.

To help illustrate the extent of the queuing, which does not necessarily occur simultaneously on all approaches, the schematic representation of the AM queue lengths has been shown in Figure 43.

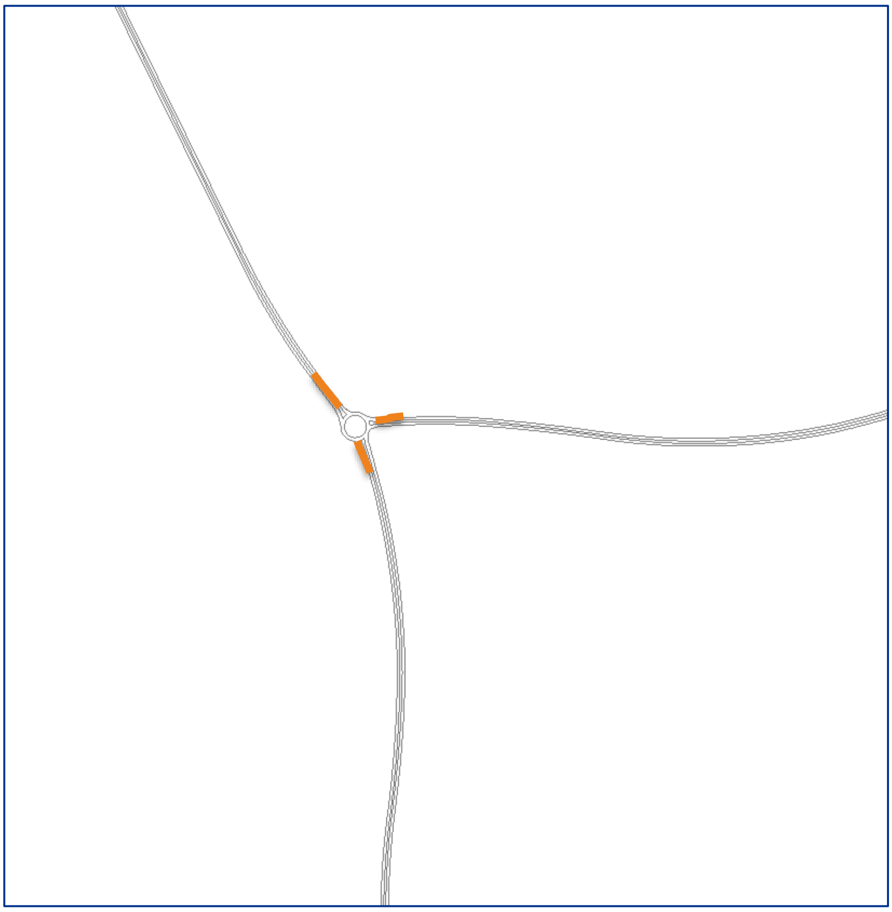


Figure 43 – AM Max Queue Length Diagram

		1600-1700			1700-1800			1800-1900		
Route	**Lane**	**Max Q**	**95% CI**		**Max Q**	**95% CI**		**Max Q**	**95% CI**	
"1_RBT_AWPR SB"	**1**	-	-	-	286	235	337	-	-	-
"1_RBT_AWPR SB"	**2**	92	85	99	548	515	581	111	99	123
"1_RBT_AWPR SB"	**3**	-	-	-	-	-	-	-	-	-
"2_RBT_AWPR WB"	**1**	35	33	37	62	61	63	37	35	39
"2_RBT_AWPR WB"	**2**	24	23	25	56	54	57	30	28	31
"2_RBT_AWPR WB"	**3**	-	-	-	-	-	-	-	-	-
"3_RBT_Stonehaven Link NB"	**1**	28	23	33	27	27	28	21	-	-
"3_RBT_Stonehaven Link NB"	**2**	21	-	-	26	25	27	21	-	-
"3_RBT_Stonehaven Link NB"	**3**	-	-	-	-	-	-	-	-	-

Table 6 - PM Max Queue Lengths

Table 6 shows that the AWPR SB experiences a high degree of queuing with a maximum queue length of 548 metres (equivalent to approximately 91 car lengths) occurring in Lane 2. The other approaches exhibit insignificant levels of queuing with a maximum recorded queue length of 62 metres, equating to around 10 car lengths.

Again, the route “1_RBT_AWPR_SB” shows a queue where there is no conflicting flow. As per the AM peak, the cause of the queue is a combination of the junction geometry and the rate at which vehicles approach the stop line.

To help illustrate the extent of the queuing, which does not necessarily occur simultaneously on all approaches, the schematic representation of the AM queue lengths has been shown in Figure 44.

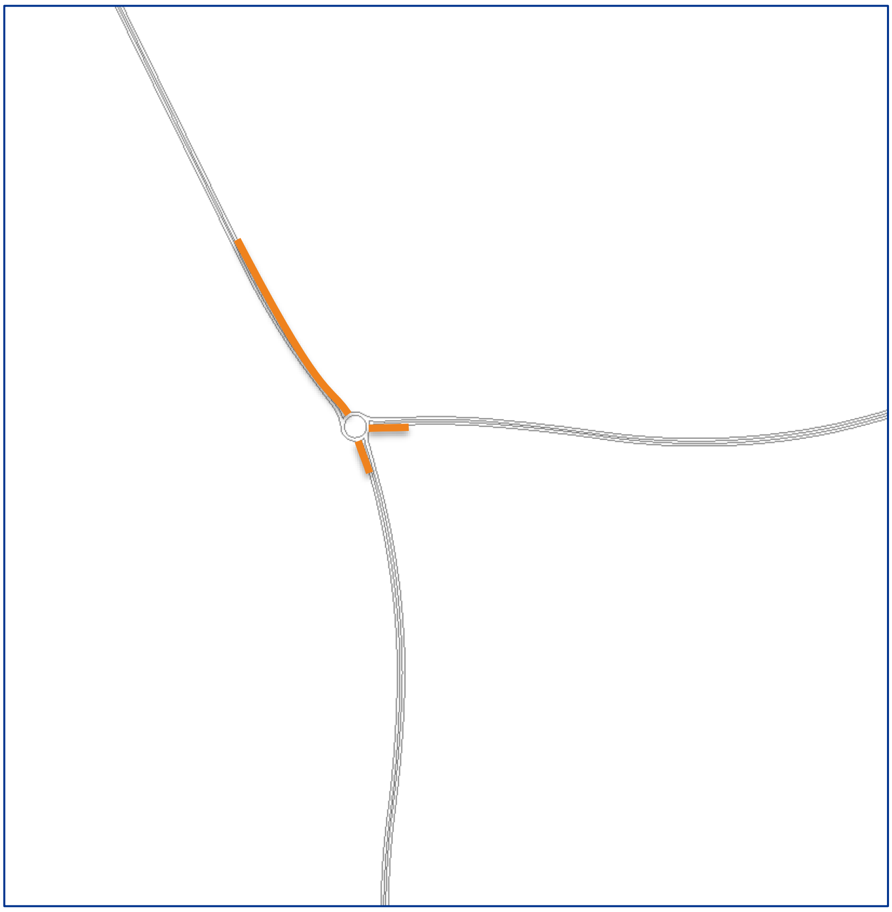


Figure 44 – PM Max Queue Length Diagram

Queue Length Distributions

To assess the significance of the maximum queue length statistics extracted from the Paramics model simulations, and examine how the queues vary over time, the queue length distribution for each main approach to the individual junctions that form the A90 design option was analysed throughout the simulation period.

Figure 45and Figure 46 show the maximum queue length distribution for each of the main approach arms over time for the AM and PM peaks respectively. It should be noted that as the average queue length distributions are extracted from the Paramics simulation runs at each 5-minute interval, the results may not necessarily reflect the maximum queue values presented in Table 5 and Table 6 as they may occur out with the 5 minute increments.

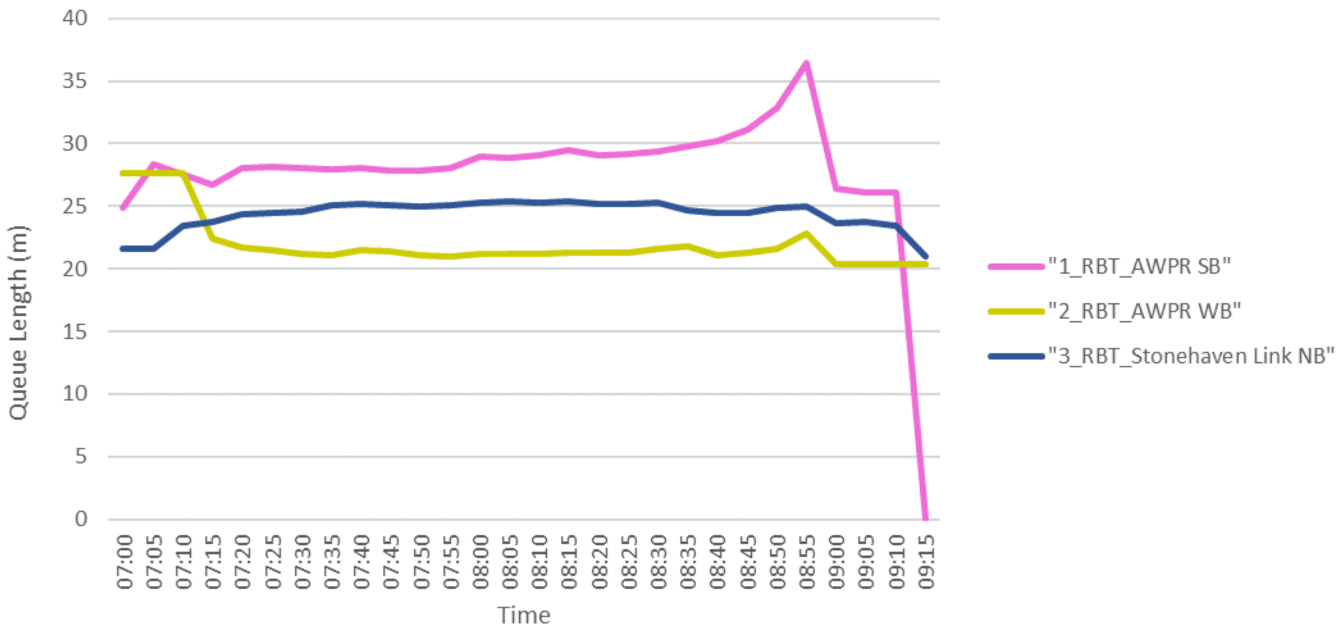


Figure 45 – AM Average Max Queue Length Distribution

Figure 45 shows that during the AM peak, queue lengths are consistently low throughout the modelled period. Maximum queue lengths extend to approximately 36m (6 vehicles) on the southbound approach to the junction at 08:55.

Queue lengths toward the end of the PM period reduce sharply for route “1_RBT_AWPR SB”for the last five minutes of the modelled period.

This is a function of both the peak volume of traffic approaching the junction from the north and on the circulating carriageway having passed. As a result, the amount of conflicting traffic at the give way onto the roundabout is greatly reduced; there are more gaps for traffic from the north to gap accept into and the queue length drops from between 4-5 vehicles to 0 for the final five-minute time slice.

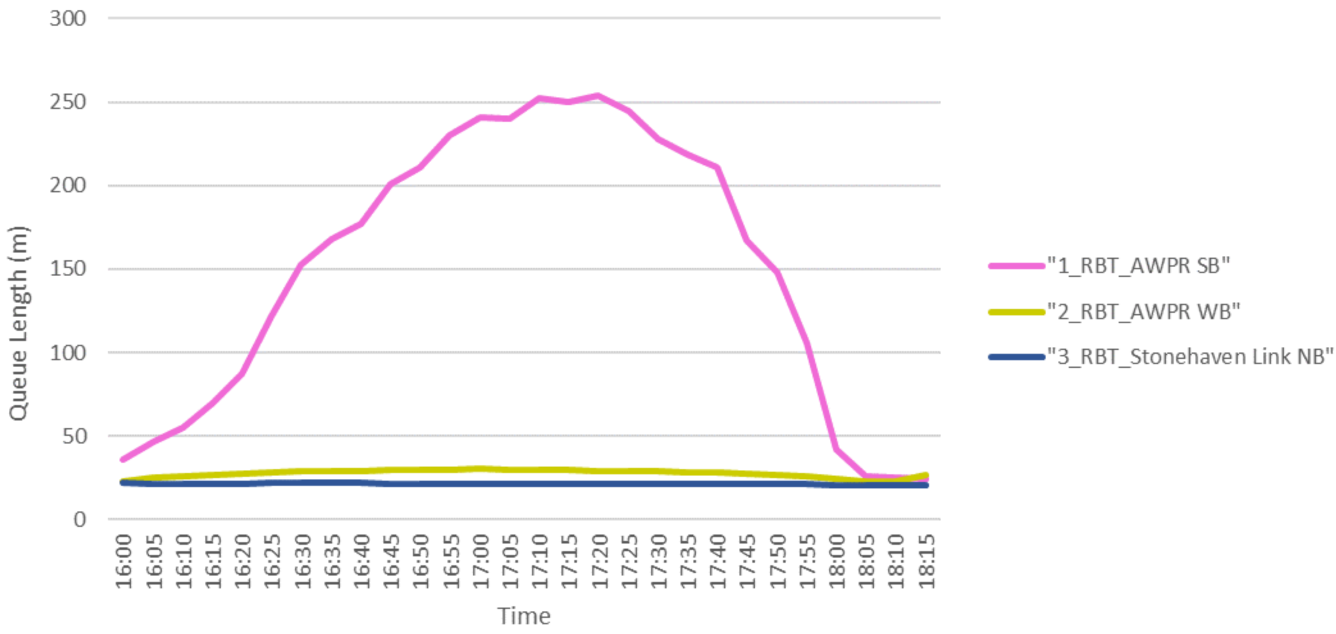


Figure 46 – PM Average Max Queue Length Distribution

During the PM peak, The southbound approach to the junction exhibits a distinct peak throughout the modelled period. Queue length increases steadily from the start of the modelled period to around 250m (42 vehicles) at 17:10. From this point onward, queue lengths begin to dissipate until toward the end of the modelled period at 18:00

For the remaining two approaches queue lengths are consistently low throughout the modelled period. Maximum queue lengths extend to approximately 30-40m (5-7 vehicles).

6.5 Journey Time Data

Figure 47 shows the routes over which journey times have been recorded. The journey time distributions are shown in Figure 48 and Figure 49 for the AM and PM peaks respectively.

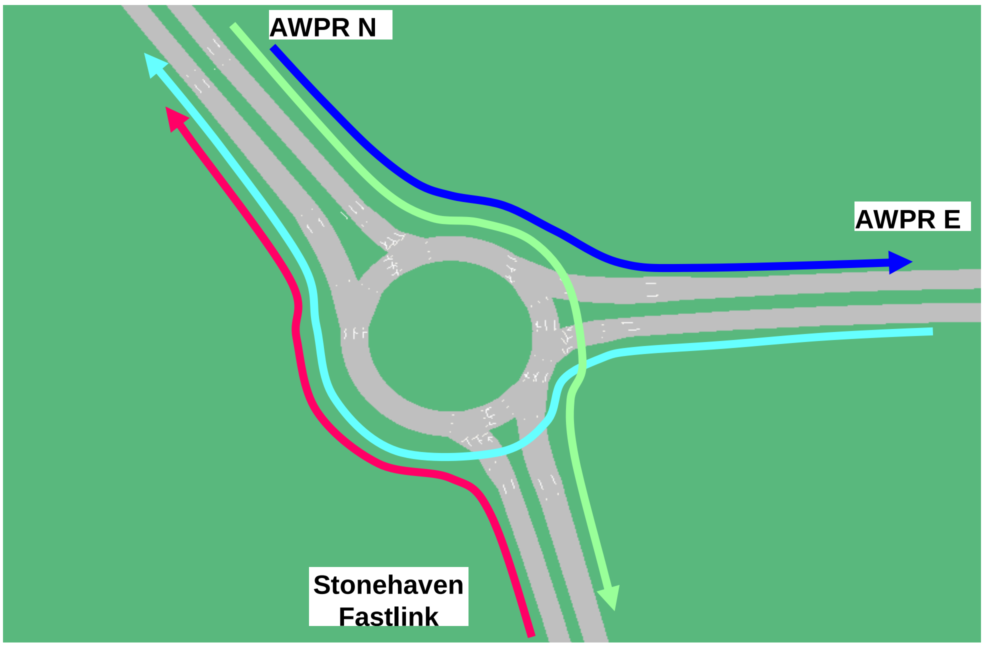


Figure 47 – Journey Time Routes

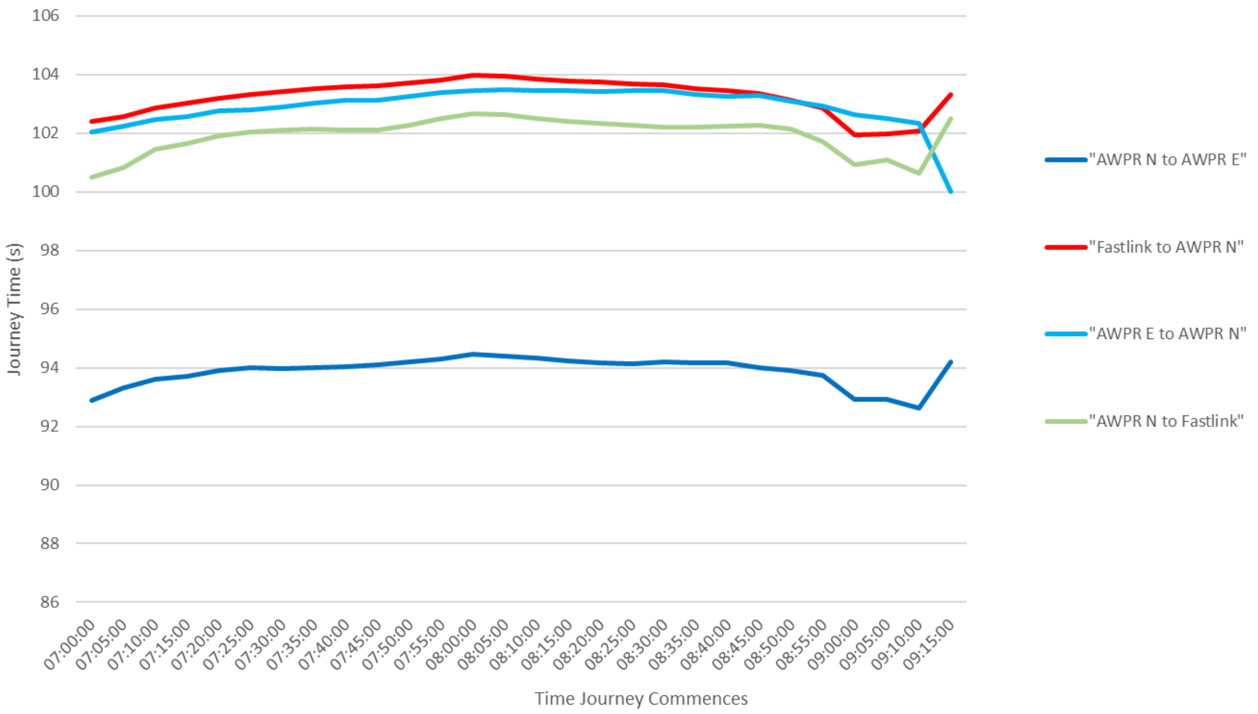


Figure 48 – AM Journey Time Data

Figure 48 shows that the journey times generally remain constant throughout the AM modelled period. There are no distinct peaks at any time.

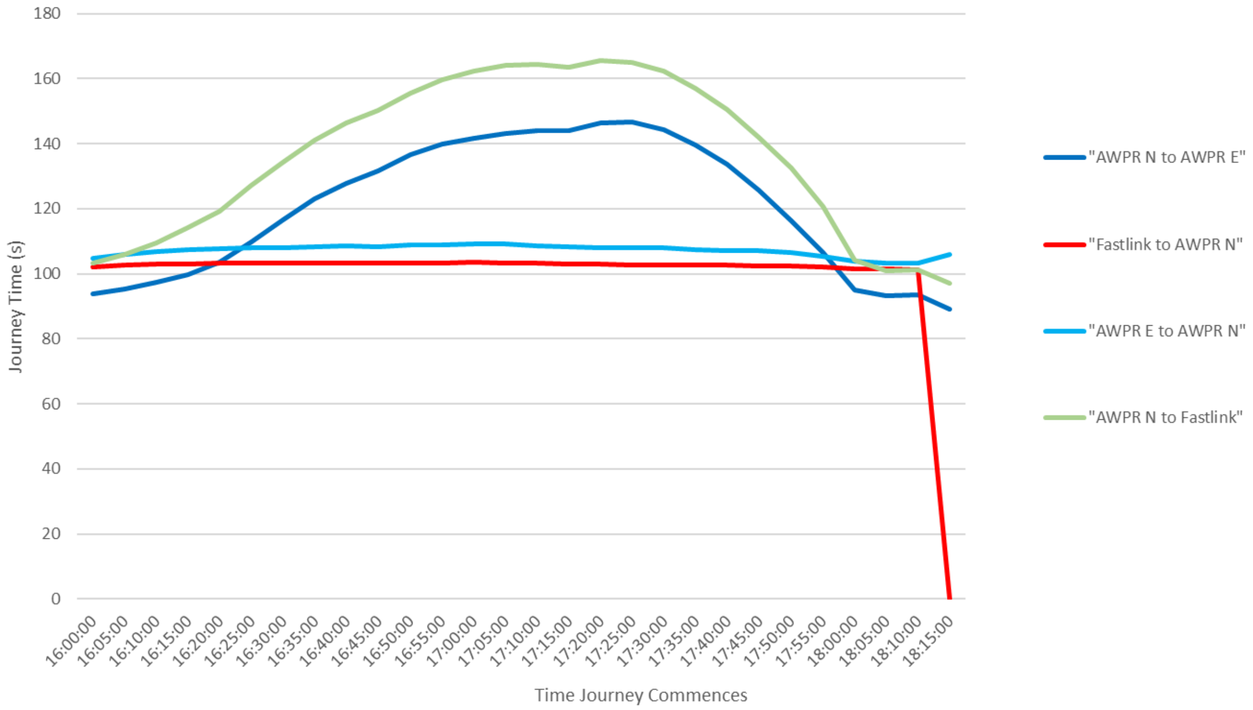


Figure 49 – PM Journey Time Data

During the PM peak, routes from the AWPR north show distinctly higher journey times when compare to both other routes in the PM peak and the same routes in the AM peak. This correlates with the longer queue length data shown previously for the southbound route associated with the geometric layout of the at-grade roundabout and the reduction in average model speeds during the PM peak period.

It should be noted that variations toward the end of the period are a result of the average journey times recorded being informed by fewer trips. As a result, journey times show a greater level of variability (or where there are no trips making a manoeuvre resulting in a ‘0’ value being reported; this is true of the “Fastlink to AWPR N” route for example).

Other routes during the PM peak show relatively low journey times of a similar magnitude to those in the AM peak.

7. A93 Milltimber Junction Performance

Figure 50 shows the location of the A93 Milltimber junction at the eastern end of the AWPR scheme and how it connects the A93 and the southern leg of the AWPR.

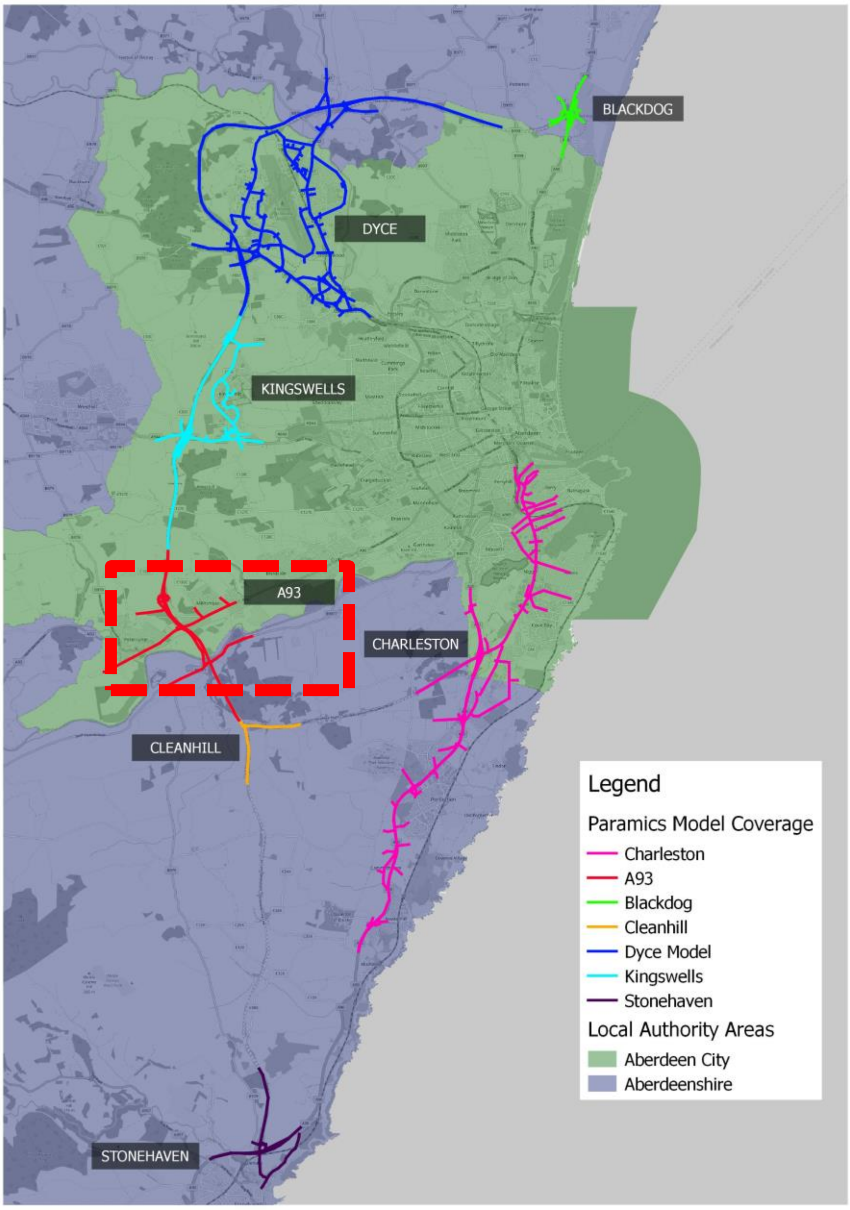


Figure 50 – Stonehaven Junction Location

The preferred design option to connect the AWPR to the A93, is a remote grade separated junction on the AWPR connecting to the existing A93 via a new link road. Figure 51 shows the overall extent of the proposed junction and its relationship with the existing local road network.

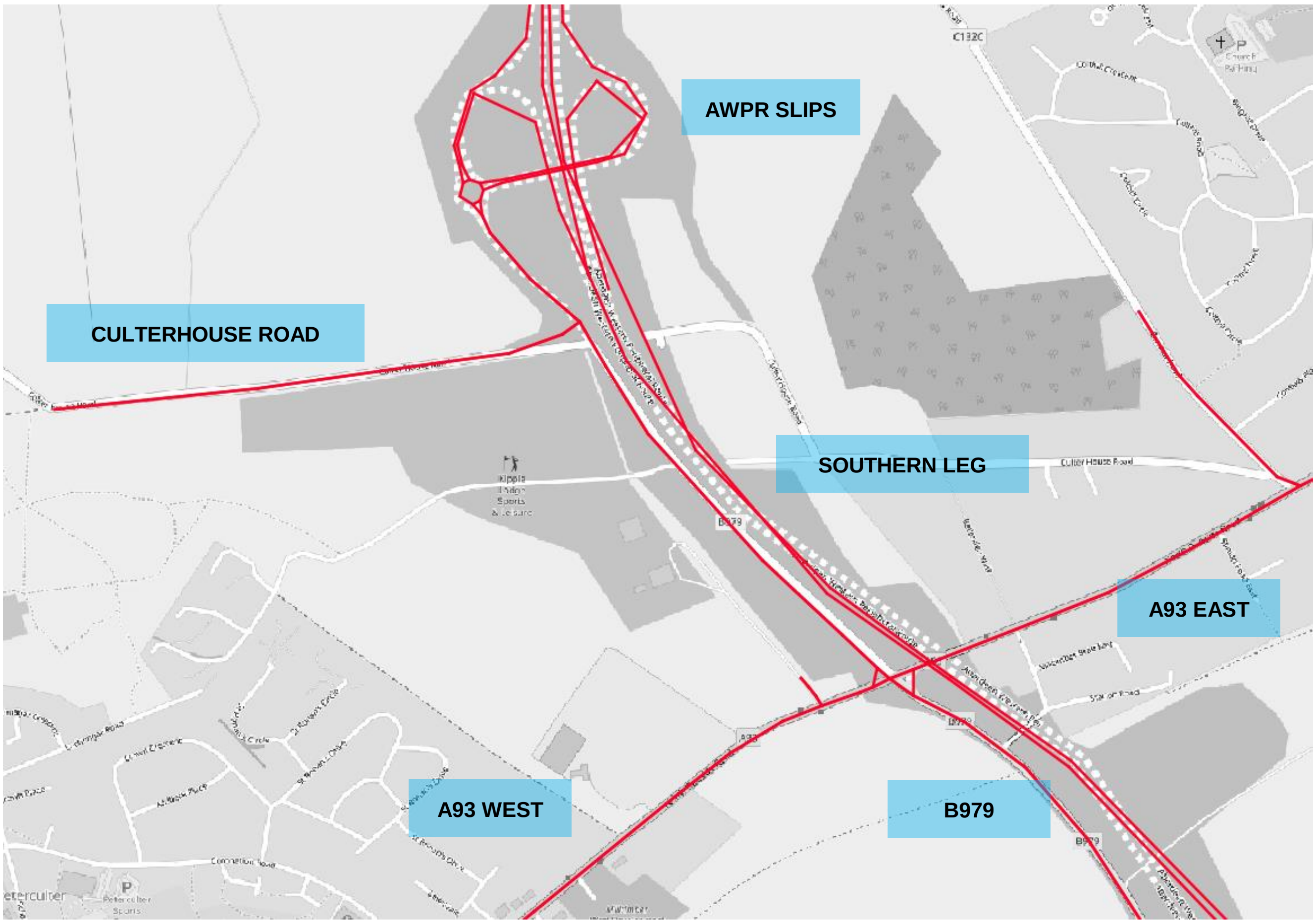


Figure 51 – A93 Milltimber Paramics Model and key locations

Due to the required junction form, the preferred option consists of a standard grade-separated looped layout with a connection back to an at-grade tie-in to the A93. The grade separated junction on the AWPR itself consists of loop merge/diverge slip roads arranged in a half-cloverleaf layout, and connected to a roundabout on the west side of the junction. A two-lane circulating carriageway is provided at the roundabout, with the approach arms flaring from one lane to two lanes at the roundabout entries. The new AWPR link road forms the southern approach to the roundabout, and provides the link to the second part of the junction.

The second part of the junction provides access to the existing road network, and connects the AWPR link road to the A93 and the B979 at the existing A93 North Deeside Road/B979 Milltimber Brae junctions.

As a result of the AWPR link road connecting into the existing junction from the north, the junction has become a four arm crossroads, and has been signalised to accommodate the increased traffic levels forecast. Both the A93 approaches include segregated left turn lanes, and all the approach arms provide for two lanes at the stoplines.

The design of this junction including lane arrangements and signal phasing was the subject of consultation by ARL with Aberdeen City Council, as Roads Authority, which indicated that it wished the resulting junction layout and signal phasing to be adopted. The consequence of adopting this approach is that the proposed junction layout limits the capacity of the junction compared to alternative lane arrangements and signal phasing's, whilst providing a perceived safer road layout. Aberdeen City Council, as Roads Authority, would be able to implement future modification of the lane arrangements and signal phasing at minor expense should it so wish.

7.1 Signal Information

Full pedestrian provision has been incorporated at this junction through the inclusion of pedestrian stages within the signalisation. Given the likely levels of pedestrian demand at this particular location, it has been assumed that activating the pedestrian stage in every second cycle, as a minimum, will be sufficient to cater for pedestrian movements. Signal timings are summarised in Figure 52 and Figure 53 for the AM and PM peaks respectively.

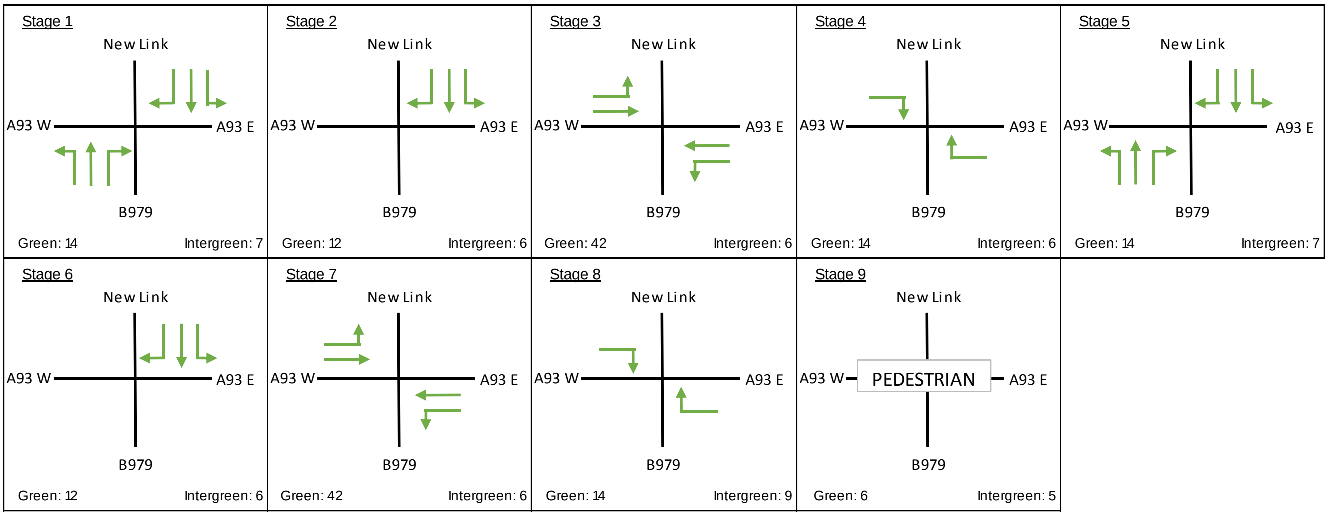


Figure 52 – AM Signal Timings

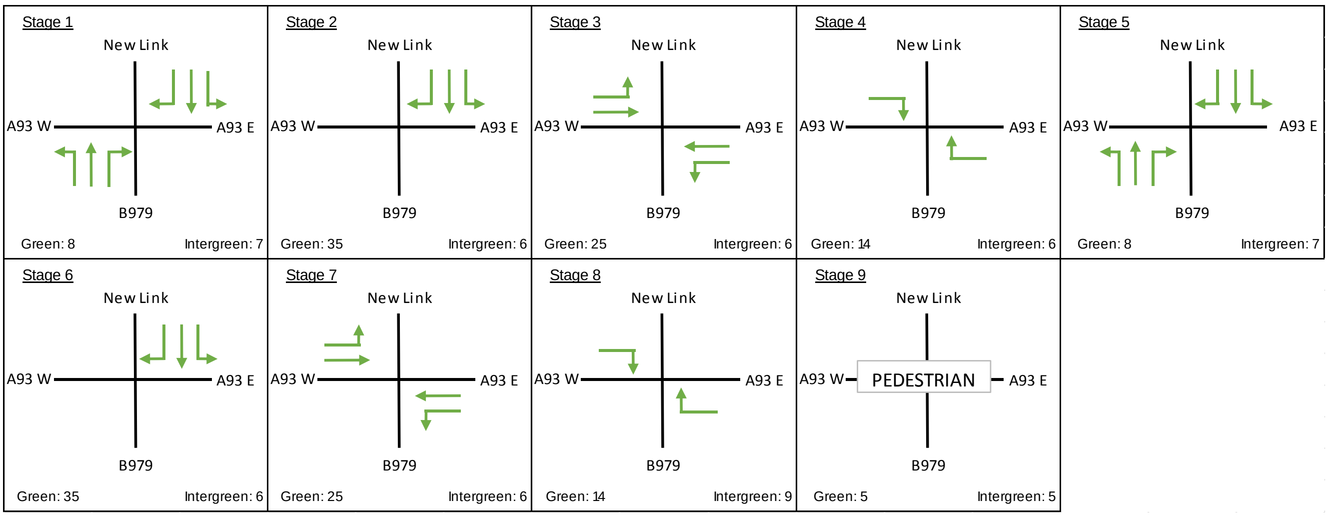


Figure 53 – PM Signal Timings

7.2 Key Junction Turning Movements

Figure 54 shows the turn counts for the parts forming the junction of the A93 design solution extracted from the A93 Paramics model in the AM peak hour (0730 – 0830), whilst Figure 55 shows the turning flows in the PM peak hour (1700 – 1800).

As each Paramics model simulation run is different, the results are based on an average of ten model runs, as are all the further model statistics presented in this section. This ensures that the model results are representative of the junction operation and are not unduly influenced by a particularly free-flowing or particularly congested simulation run.

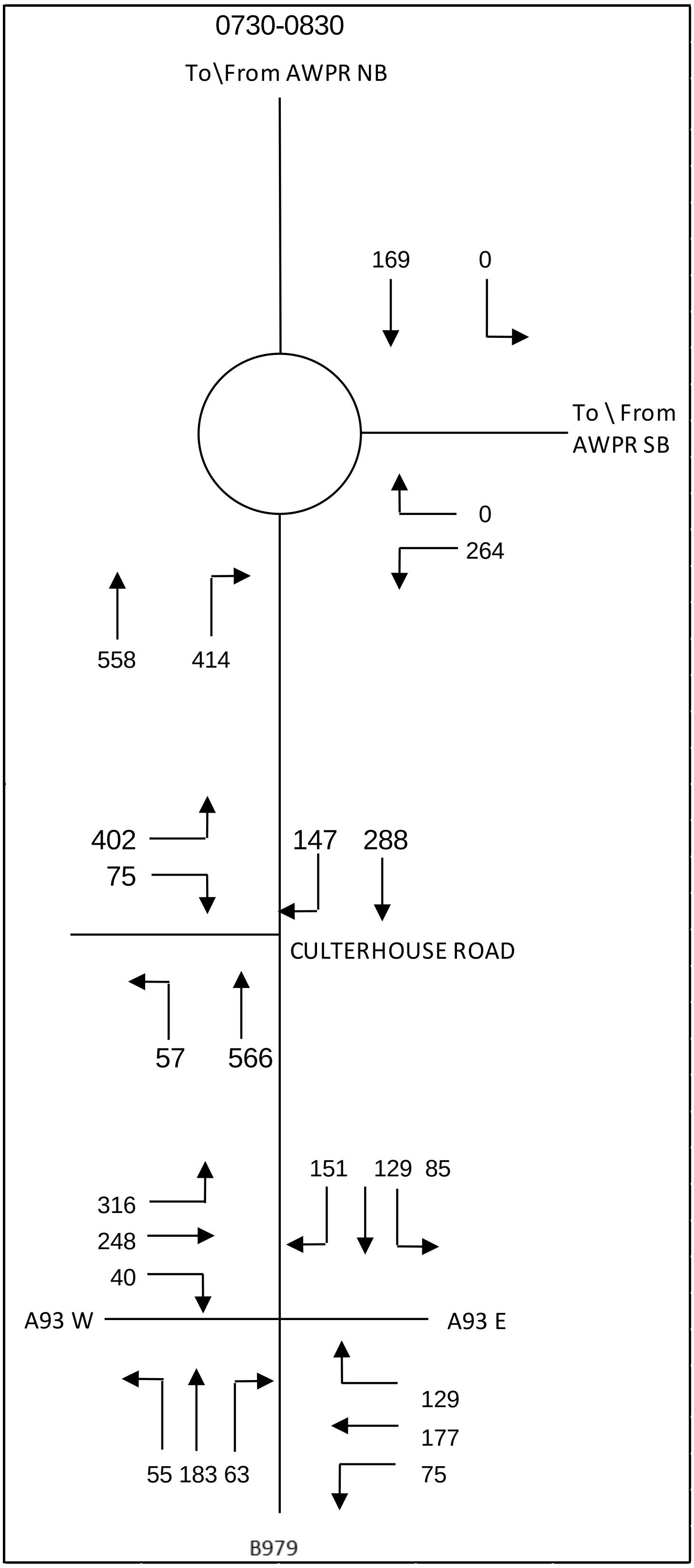


Figure 54 – AM Turning Movements – Signalised Crossroads

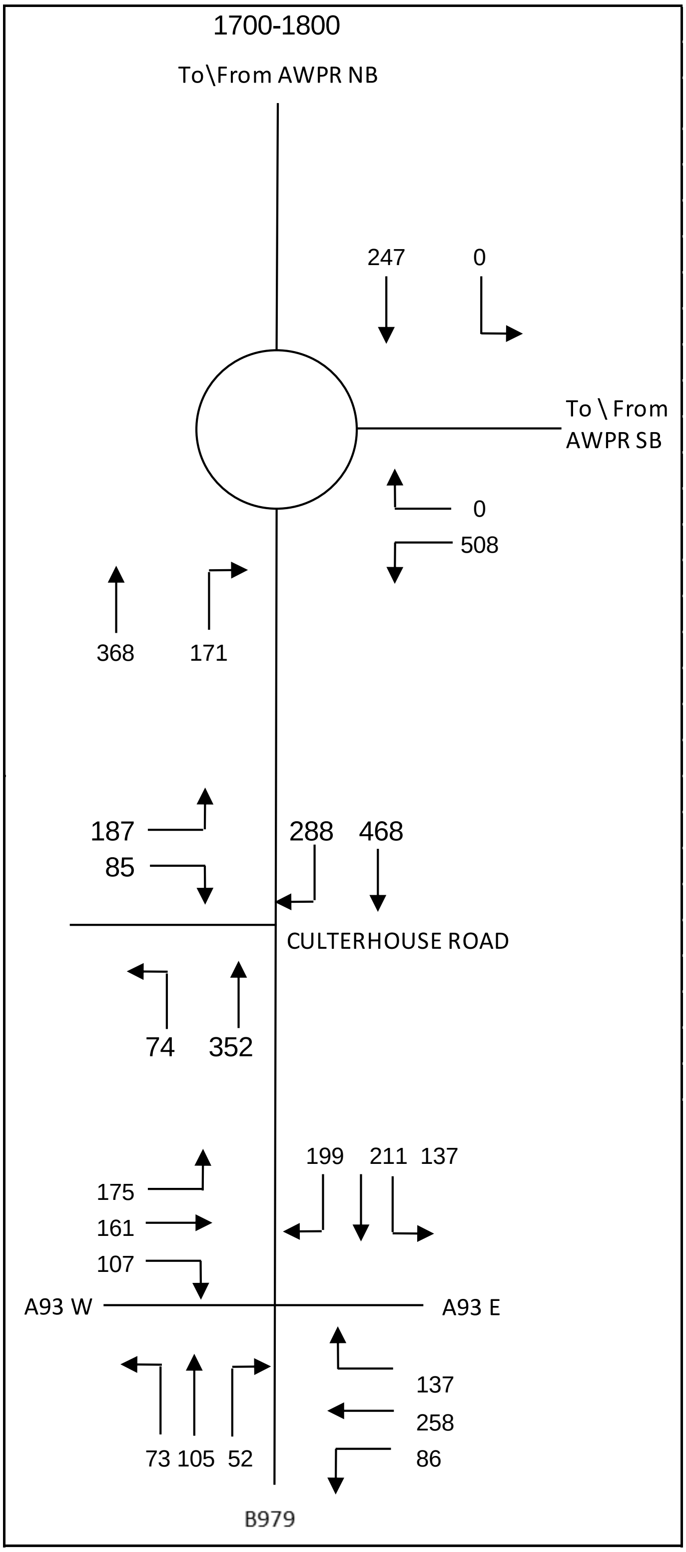


Figure 55 – PM Turning Movements – Signalised Crossroads

The dominant flow during the AM period at the signalised junction on the A93 is from the A93 West approach (travelling eastbound), with a high level of left turn traffic accessing the AWPR Link Road. The highest flow at the access roundabout connecting to the AWPR slip roads during the AM period is travelling from the Link Road to continue on the AWPR northbound.

During the PM period at the signalised A93 junction, the AWPR Link Road and the A93 West approaches have similar high levels of traffic. The dominant movement at the AWPR access roundabout is travelling from the AWPR southbound, and represents to a certain extent the reverse of the AM travel patterns.

7.3 Vehicle Speeds

The average journey speed per vehicle, through the whole network, was determined to provide an overview of the junction performance as it varies over time throughout the AM and PM model simulation periods in each forecast year. The change in the average speed throughout the modelled periods gives an indication of the overall levels of delay, which if increasing is likely to be as a result of increasing congestion and would be indicated by a consistent downward trend signifying a deterioration in operational performance. Figure 56 and Figure 57 show the average speeds in 5-minute increment throughout the modelled period for the AM and PM peak respectively.

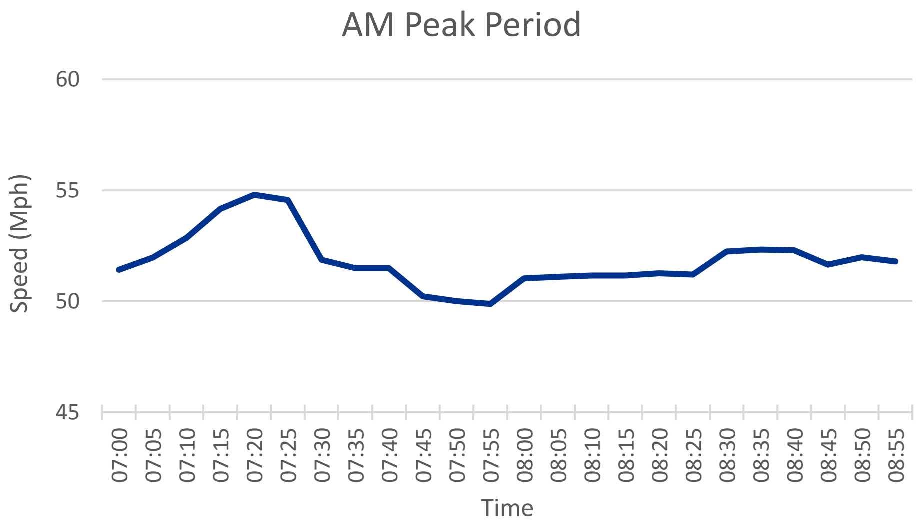


Figure 56 – AM Vehicle Speeds

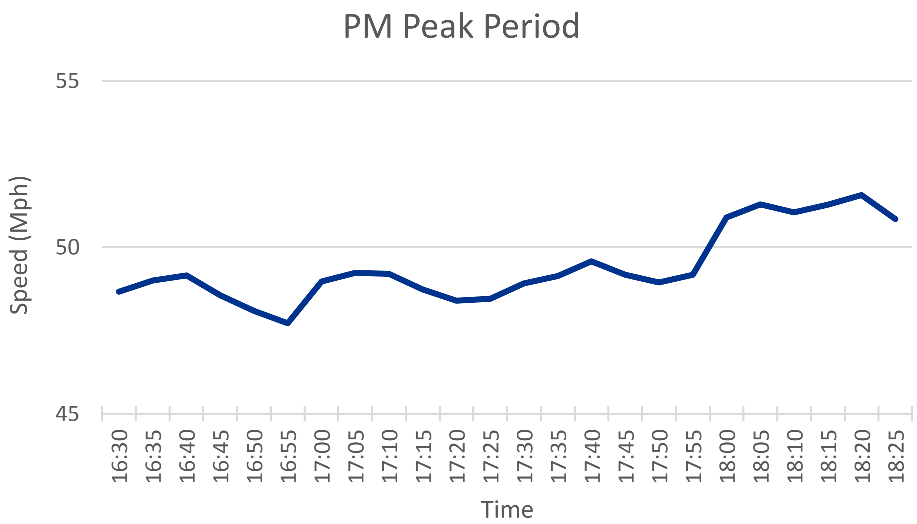


Figure 57 – PM Vehicle Speeds

During the AM period, there is a definite drop in the average network speeds around the 07:25 mark as traffic increases to a peak, and the level of delay increases. However, approximately 30 minutes later AM speeds begin to increase marginally again throughout the remaining simulation period as the level of delay decreases. This indicates that the junction does not reach an over-capacity situation despite being under pressure.

During the PM peak, vehicle speeds are low toward the start of the peak period and steadily increase through the peak. This indicates that the junction is under pressure toward the start of the modelled period but performance increases as demand is processed through the junction

7.4 Queue Length Data

The statistics analysed as part of the detailed model results focussed on the extraction of queuing data for the A93 signalised junction connecting the AWPR Link Road to the existing A93 and B979, from each of the 10 simulation runs. There was no significant queuing evident at the roundabout providing access to the AWPR slip roads, and therefore data collection at this junction was deemed unnecessary as the signalised junction exerts much greater control on the progression of traffic. Path and queue routes were therefore constructed in Paramics to gather data on the modelled vehicles passing through the A93 signalised junction.

The queue routes were defined for each approach to the proposed A93 junction modelled in the preferred option to extract queuing data for further analysis. Figure 58 shows the modelled queue routes where queue data was collected from the model.

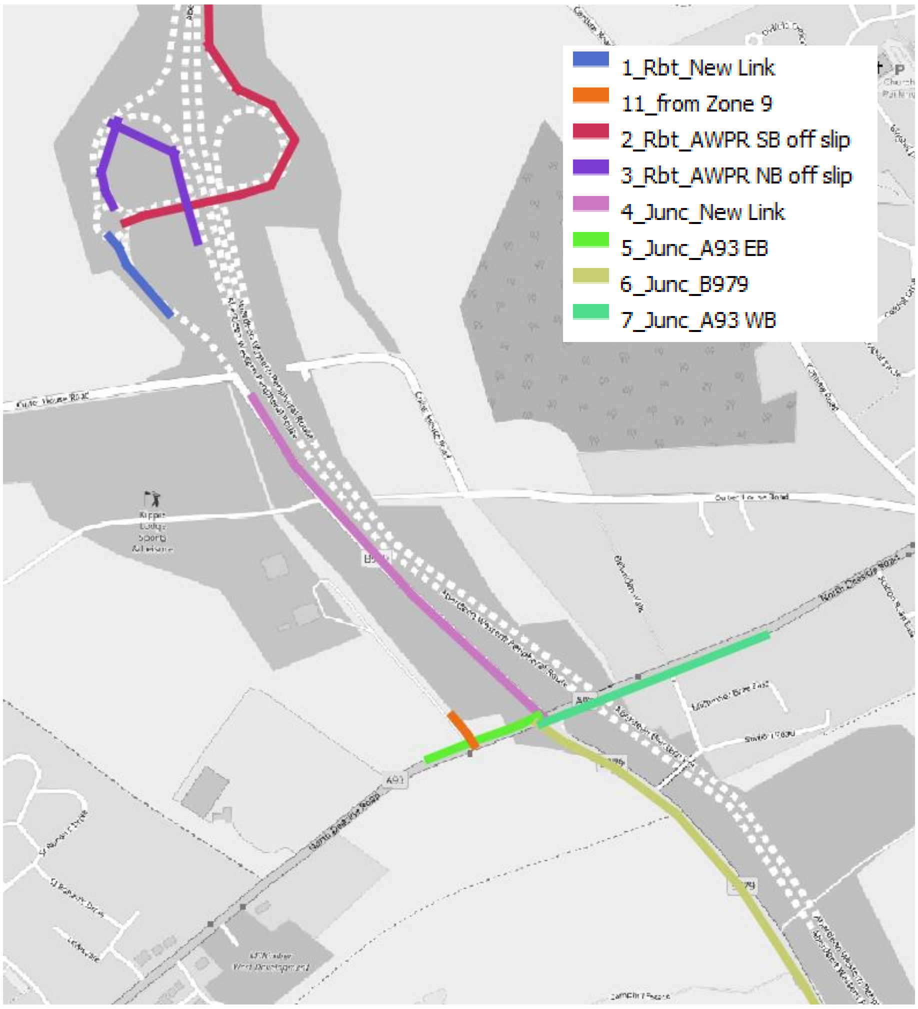


Figure 58 – Queue Routes

Route	Lane	0700-0800 Max Q	0700-0800 95% CI		0800-0900 Max Q	0800-0900 95% CI		0900-1000 Max Q	0900-1000 95% CI	
"1_Rbt_New Link"	1	39	37	42	43	42	45	32	-	-
"1_Rbt_New Link"	2	34	31	36	31	29	32	-	-	-
"1_Rbt_New Link"	3	-	-	-	-	-	-	-	-	-
"2_Rbt_AWPR SB off slip"	1	34	33	35	26	26	27	20	18	23
"2_Rbt_AWPR SB off slip"	2	-	-	-	-	-	-	-	-	-
"2_Rbt_AWPR SB off slip"	3	-	-	-	-	-	-	-	-	-
"3_Rbt_AWPR NB off slip"	1	23	16	29	-	-	-	-	-	-
"3_Rbt_AWPR NB off slip"	2	38	37	39	38	37	39	22	-	-
"3_Rbt_AWPR NB off slip"	3	-	-	-	-	-	-	-	-	-
"4_Junc_New Link"	1	64	62	67	67	64	69	35	31	40
"4_Junc_New Link"	2	70	68	73	84	81	86	38	36	41
"4_Junc_New Link"	3	-	-	-	-	-	-	-	-	-
"5_Junc_A93 EB"	1	128	125	132	109	105	112	34	32	36
"5_Junc_A93 EB"	2	58	56	60	60	59	62	34	29	39
"5_Junc_A93 EB"	3	18	-	-	-	-	-	-	-	-
"6_Junc_B979"	1	114	110	117	121	118	124	72	64	81
"6_Junc_B979"	2	45	44	46	61	60	62	34	32	35
"6_Junc_B979"	3	-	-	-	-	-	-	-	-	-
"7_Junc_A93 WB"	1	97	94	99	90	88	92	56	52	61
"7_Junc_A93 WB"	2	81	79	83	79	77	81	70	63	77
"7_Junc_A93 WB"	3	-	-	-	-	-	-	-	-	-
"11_from Zone 9"	1	23	22	25	24	22	25	-	-	-
"11_from Zone 9"	2	-	-	-	-	-	-	-	-	-
"11_from Zone 9"	3	-	-	-	-	-	-	-	-	-

Table 7 - AM Queue Length Data

Route	Lane	1600-1700 Max Q	1600-1700 95% CI		1700-1800 Max Q	1700-1800 95% CI		1800-1900 Max Q	1800-1900 95% CI	
"1_Rbt_New Link"	1	22	20	24	32	30	35	16	-	-
"1_Rbt_New Link"	2	23	-	-	20	-	-	23	21	25
"1_Rbt_New Link"	3	-	-	-	-	-	-	-	-	-
"2_Rbt_AWPR SB off slip"	1	45	43	47	68	66	70	63	61	65
"2_Rbt_AWPR SB off slip"	2	-	-	-	-	-	-	-	-	-
"2_Rbt_AWPR SB off slip"	3	-	-	-	-	-	-	-	-	-
"3_Rbt_AWPR NB off slip"	1	-	-	-	13	12	14	-	-	-
"3_Rbt_AWPR NB off slip"	2	31	29	33	32	30	33	31	30	32
"3_Rbt_AWPR NB off slip"	3	-	-	-	-	-	-	-	-	-
"4_Junc_New Link"	1	68	65	72	74	71	76	70	67	74
"4_Junc_New Link"	2	75	71	78	83	81	85	63	60	66
"4_Junc_New Link"	3	-	-	-	-	-	-	-	-	-
"5_Junc_A93 EB"	1	275	260	289	384	370	398	86	83	89
"5_Junc_A93 EB"	2	69	66	72	67	66	69	51	50	52
"5_Junc_A93 EB"	3	37	36	39	37	36	38	32	31	33
"6_Junc_B979"	1	120	114	126	382	365	398	372	354	390
"6_Junc_B979"	2	50	48	51	68	67	69	50	49	52
"6_Junc_B979"	3	-	-	-	-	-	-	-	-	-
"7_Junc_A93 WB"	1	189	183	195	132	128	136	113	109	117
"7_Junc_A93 WB"	2	78	75	80	87	86	89	68	66	70
"7_Junc_A93 WB"	3	-	-	-	-	-	-	-	-	-
"11_from Zone 9"	1	36	33	38	36	35	37	23	21	26
"11_from Zone 9"	2	-	-	-	-	-	-	-	-	-
"11_from Zone 9"	3	-	-	-	-	-	-	-	-	-

Table 8 - PM Queue Length Data

The results show that some degree of queuing builds up on all of the approach arms to the junction, during each peak period. In particular, Table 7 shows a maximum queue of 128 metres (equivalent to approximately 21 car lengths) experienced on Lane 1 of the A93 West approach. The B979 approach also shows some extensive queuing of up to 121m (approximately 20 car lengths). The remaining approaches all experience varying levels of queuing ranging from around 18 to 97 metres (approximately 3 to 16 car lengths).

During the PM peak period, there is some extensive queuing forming on the approaches to the A93 junction. Most notably, on the A93 eastbound approach, there is queuing of up to 384m (approximately 64 vehicles). This is a direct function of the signals operating to manage high volume conflicting movements during the PM peak. In particular, the A93 eastbound left turn (onto the new link road) is a relatively high volume movement that cannot be fully accommodated given the conflicting movements at the junction.

This is reflected in the queue lengths on the remaining approaches to the junction where there is queuing up to 382 (approximately 64 vehicles) and 189 metres (approximately 32 vehicles) on the B979 and A93 Westbound approaches respectively. The remaining approaches all experience varying levels of queuing ranging from around 13 to 87 metres (approximately 3 to 15 car lengths).

With this in mind, the junction is operating over capacity as the signals are unable to properly process all of the traffic expected during the PM peak.

To help illustrate the extent of the queuing, which does not necessarily occur simultaneously on all approaches, the schematic representations shown in Figure 59 and Figure 60 have been produced.

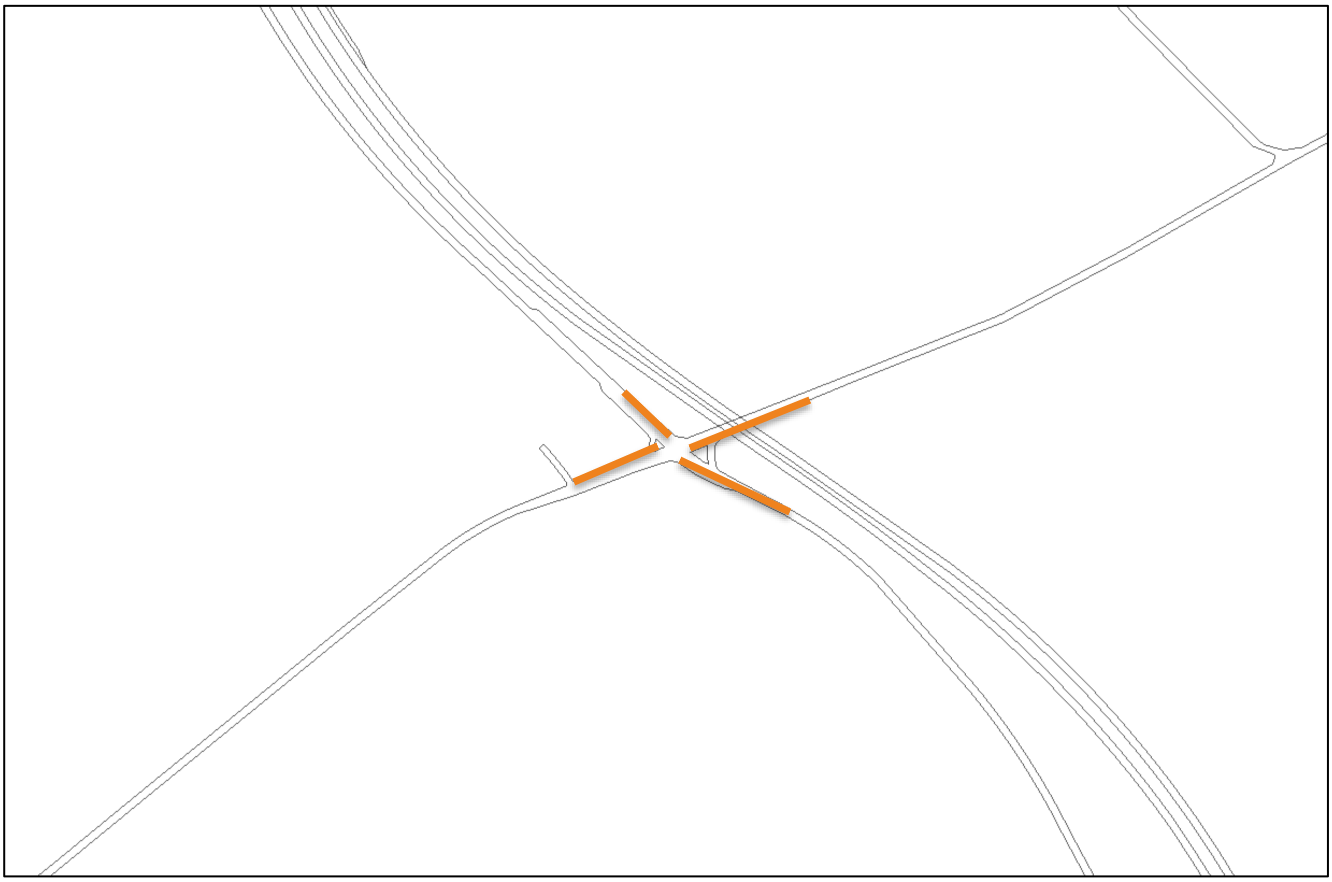


Figure 59 – AM Queue Lengths

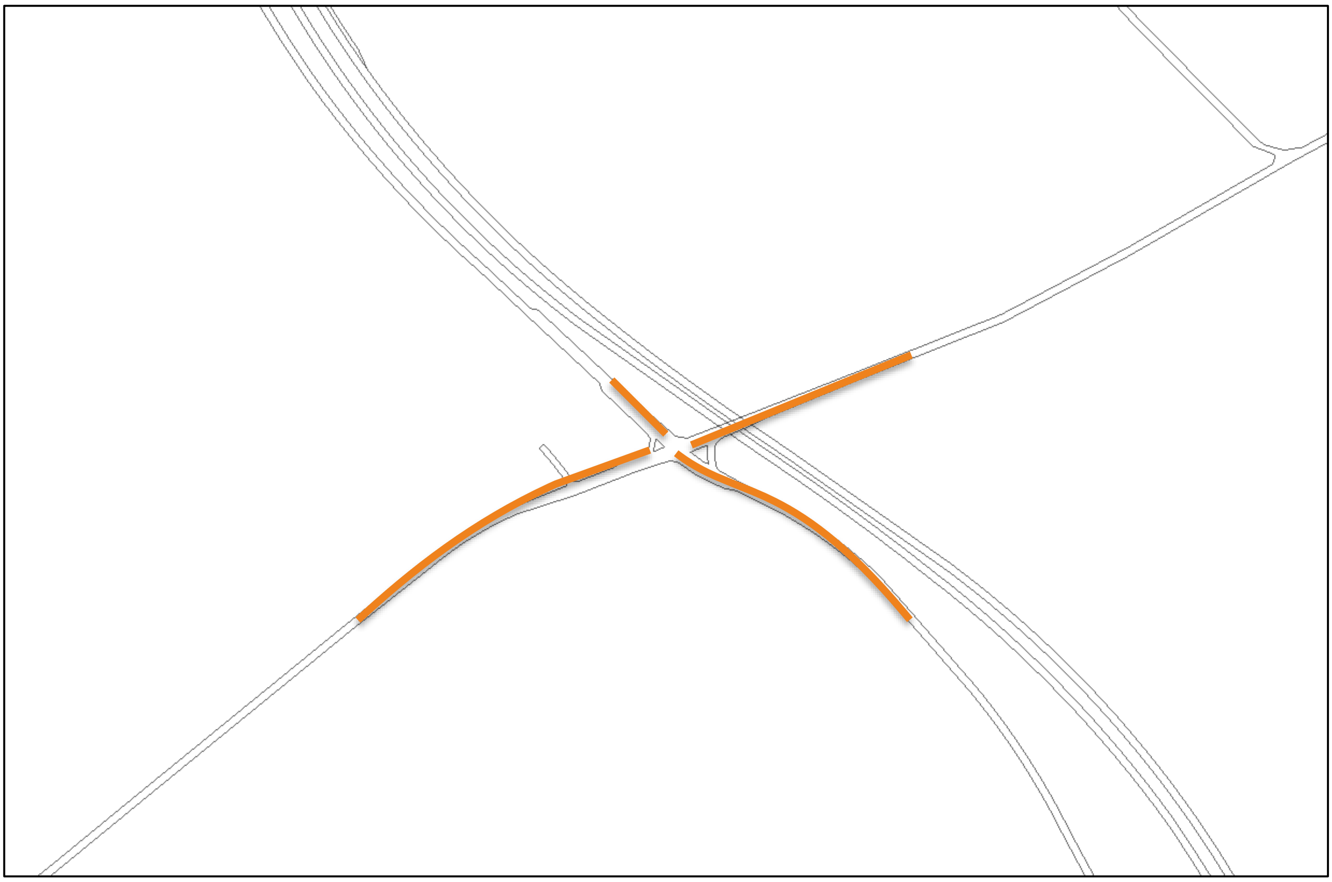


Figure 60 – PM Queue Lengths

Queuing Length Distribution

To assess the significance of the maximum queue statistics extracted from the Paramics model simulations, and examine how the queues vary over time, the queue length distribution for each approach to the Milltimber junction was analysed throughout the simulation period

Figure 61 and Figure 62 show the average maximum queue length distribution, in metres, for each approach arm throughout the modelled AM and PM periods. It should be noted that the queue length distributions are extracted from the Paramics simulation runs for each 5 minute interval, and represent the average of the maximum queue recorded in each of the 10 simulations during each 5 minute interval. Therefore, the queue length values in Figure 61 and Figure 62 will not necessarily reflect the maximum queue values presented in Table 7 and Table 8 as the values in the tables may occur within any 5-minute increment during each of the 10 simulations.

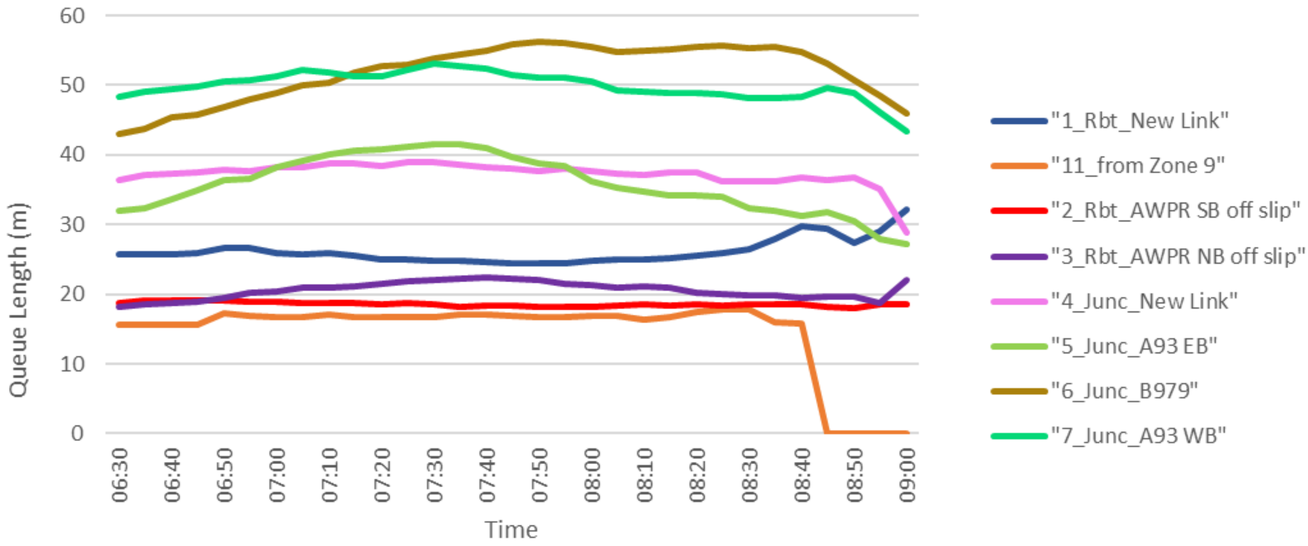


Figure 61 – AM Queue Length Distribution

During the AM peak, there is a general trend for queue lengths for routes that travel through the signalised junction to steadily increase between 07:00 and 08:00 as demand increases. The signals have a direct effect on queue length as the junction is operating at capacity.

Variations toward the end of the period are a result of the average journey times recorded being informed by fewer trips. As a result, journey times show a greater level of variability (or where there are no trips making a manoeuvre resulting in a '0' value being reported; this is true of the "11_from Zone 9" route for example).

The remaining queues show fairly consistent queue lengths throughout the modelled period.

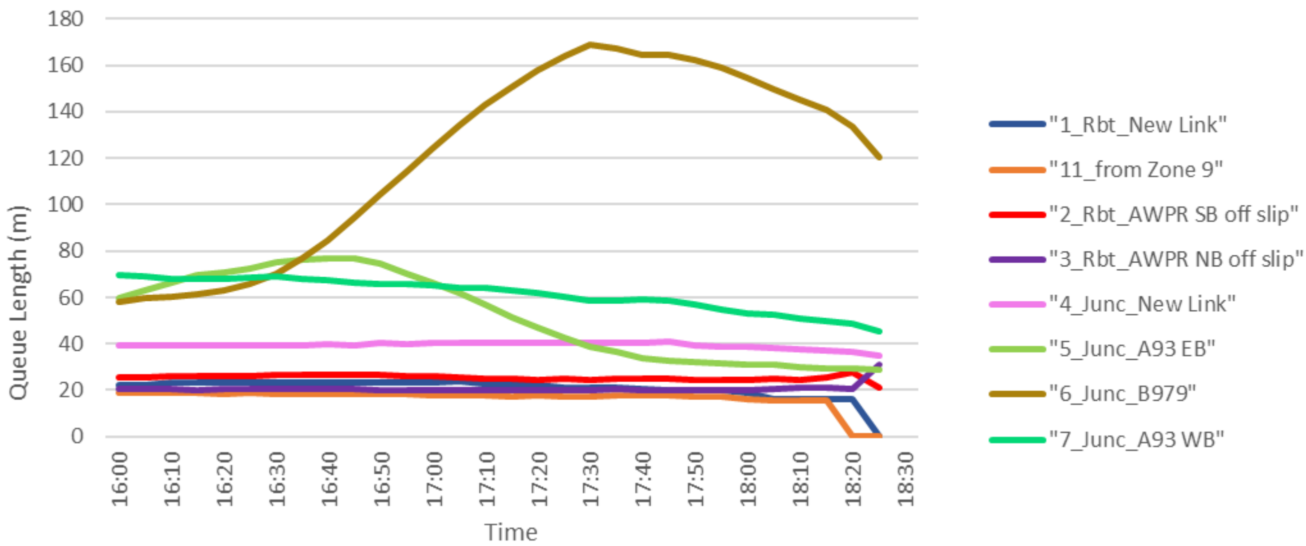


Figure 62 – PM Queue Length Distribution

During the PM peak, the B979 approach to the signalised junction shows a distinct increase in queue length between 16:30 and 17:30. As discussed previously, this is a function of the signalised junction operating under congested conditions during the PM peak.

Similarly, for the A93 EB, there is a shorter peak between 16:30 and 17:00 where queue lengths are higher (around 80m) before dropping in the latter half of the PM peak.

All other routes show a reasonably consistent queue length throughout the modelled period.

Variations toward the end of the period are a result of the average journey times recorded being informed by fewer trips.

7.5 Journey Time Data

In order to assess vehicle journey times, and their variation over time through the model, the journey time for each vehicle passing through the key junction movements on their identified routes through the model network was recorded. These individual journey times were analysed to determine the average journey time of all vehicles travelling each identified key route through the Paramics model in each five minute period. These results were in turn averaged across the ten model simulation runs to develop a representative picture of the variation over time.

Figure 63 illustrates the journey time routes that were defined for the journey time analysis.

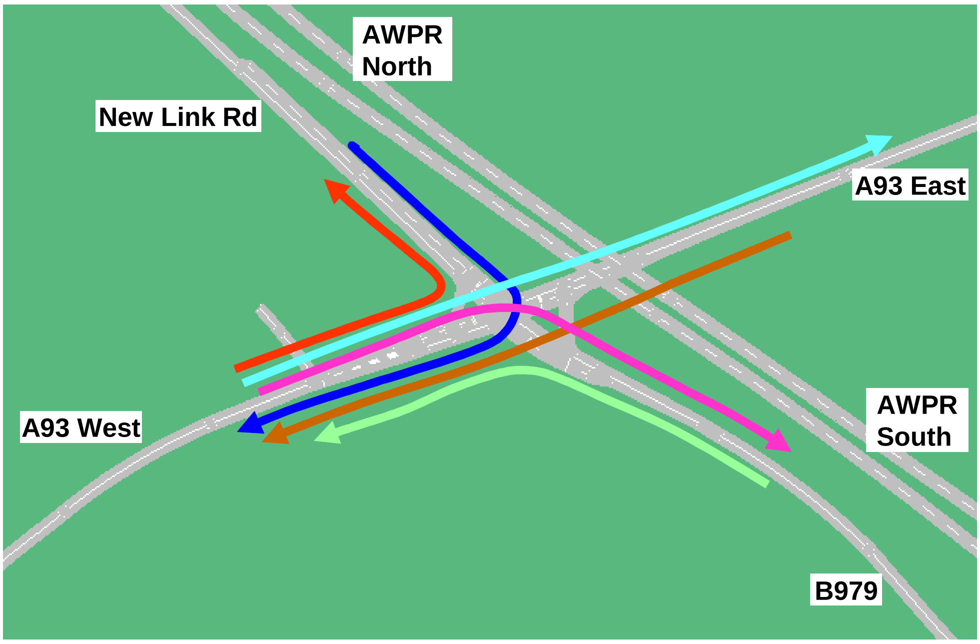


Figure 63 – Journey Time Routes

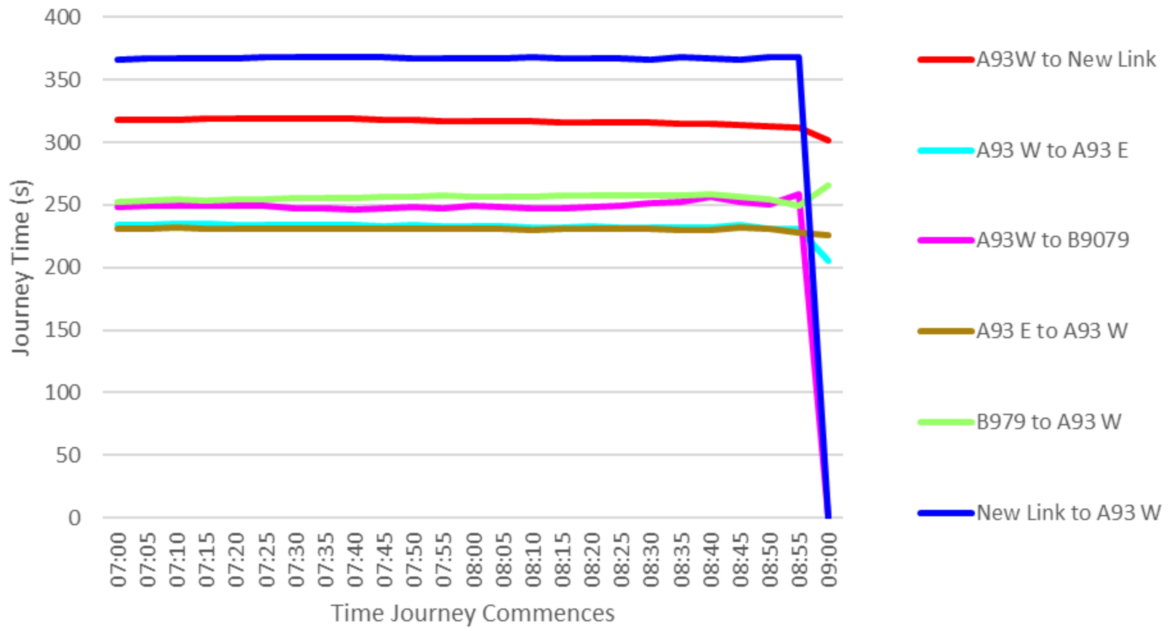


Figure 64 – AM Journey Time Data

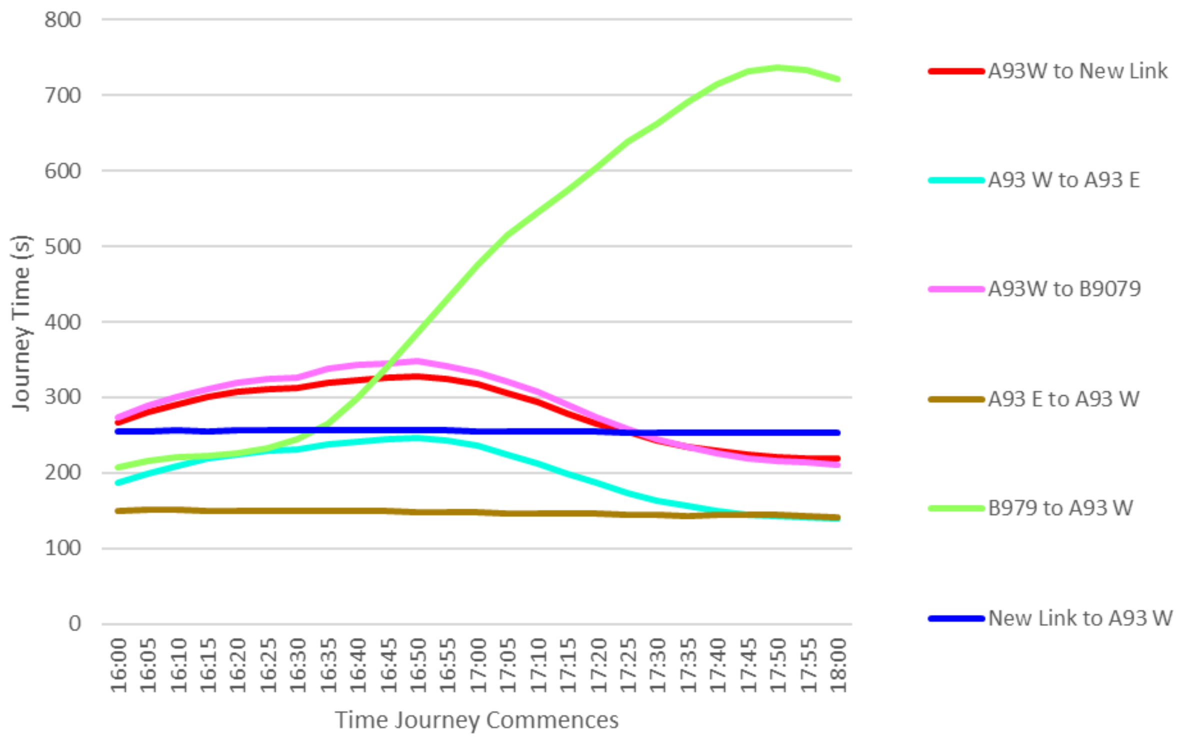


Figure 65 – PM Journey Time Data

From the figures it is clear that the journey time distributions have a very similar pattern to the queue length distributions.

During the AM peak, across all the key routes the journey times remain stable with little evidence of an increasing journey time trend throughout the simulation period and is consistent with the queue length distributions.

It should be noted that variations toward the end of the period are a result of the average journey times recorded being informed by fewer trips. As a result, journey times show a greater level of variability (or where there are no trips making a manoeuvre resulting in a '0' value being reported; this is true of the "New Link to A93W" route for example).

During the PM peak, the B979 approach to the signalised junction shows a distinct increase in journey time between 16:30 and 17:30. Again, this is a function of the signalised junction operating over capacity during the PM peak and being configured to better accommodate the heavier flows on the A93.

For the remaining routes, there is a shorter peak between 16:30 and 17:00 where queue lengths are higher (around 80m) before dropping in the latter half of the PM peak.

This provides further evidence that whilst vehicles do encounter a certain level of queuing (and therefore queuing and delay) as they progress through the signalised junction, outside the height of the peak hour, journey times remain relatively low and consistent.

The results of the detailed queuing and journey time analyses provide evidence that the junction design, and the signals developed for it, is operating over capacity during the PM peak period; queue lengths and journey times shows distinct peaks that are indicative of delay throughout the modelled period.

Aberdeen City Council, as Roads Authority, would be able to implement future modification of the lane arrangements and signal phasing at minor expense should it so wish.

8. Kingswells Junction Performance

8.1 Junction Description and Location

The preferred option to connect the proposed AWPR to the A944 has been identified as a large grade separated roundabout arrangement.

Figure 66 shows an overview of the wider Paramics model network developed for the preferred junction option, with

Figure 67 showing the grade separated roundabout layout in more detail.

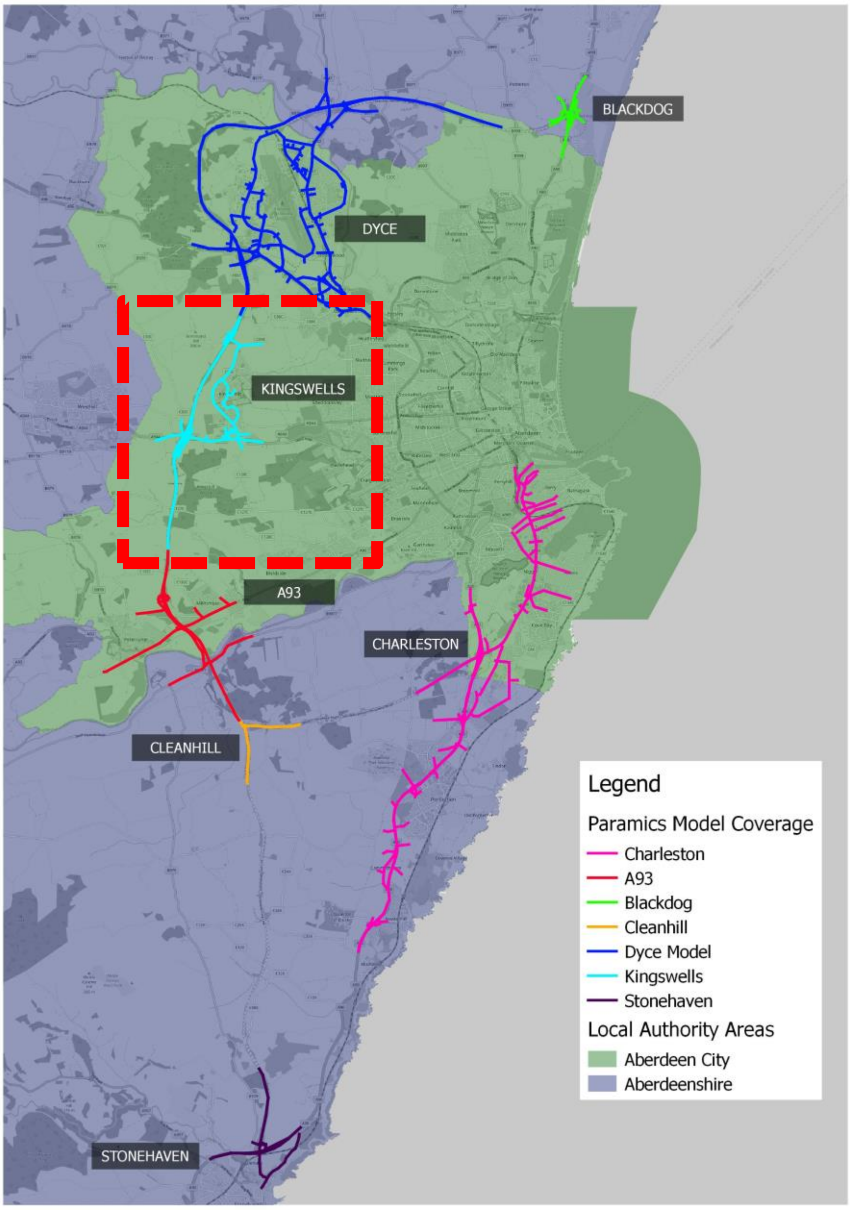


Figure 66 – Kingswells Junction Location

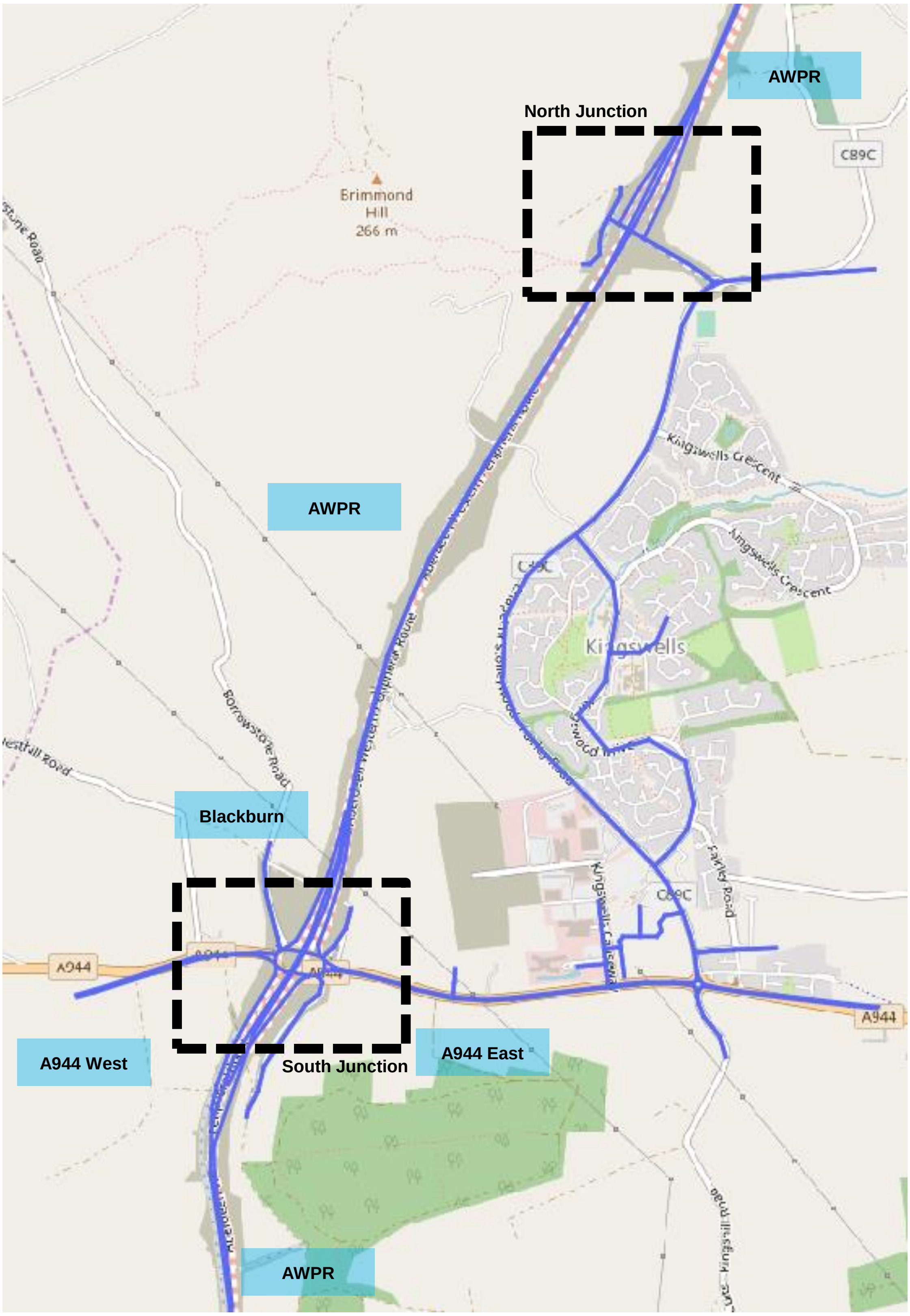


Figure 67 – Kingswells Paramics Model and key locations

The design layout comprises of full access merges and diverges to connect the proposed AWPR to the A944, and provides for two lanes on the circulating carriageway. The AWPR northbound and southbound diverges flare from one lane to two lanes on approach to the roundabout, with the A944 east and west approaches having two lanes at the roundabout entries. Due to the location of the junction the design also includes three local accesses connecting into the roundabout with one lane entries.

The preferred option also includes the provision of signalised pedestrian crossing facilities on the north side of the junction across the AWPR northbound merge and AWPR southbound diverge. As the traffic movements do not require signal control, the pedestrian crossings operate on a demand basis such that the crossings allow traffic to flow under a continuous green stage until the pedestrian stage is activated. Given the likely levels of pedestrian demand at this location, the pedestrian stage is activated randomly throughout the Paramics simulations, such that on balance it is activated five times in each modelled period.

At the North Kingswells junction access is provided to and from the AWPR North via a northbound merge and a southbound diverge. The merge and the diverge connect to the new underbridge link via priority junctions, and the junction is connected to the existing Kingswells Road via a small at-grade roundabout with 2 lanes on the circulating carriageway.

8.2 Key Junction Turning Movements

Figure 68 to Figure 71 show the turning flows for traffic passing through the north and south junctions for the AM peak and the PM peak.

As each Paramics model simulation run is different, the results are based on an average of ten model runs, as are all the further model statistics presented in this section. This ensures that the model results are representative of the junction operation and are not unduly influenced by a particularly free-flowing or particularly congested simulation run.

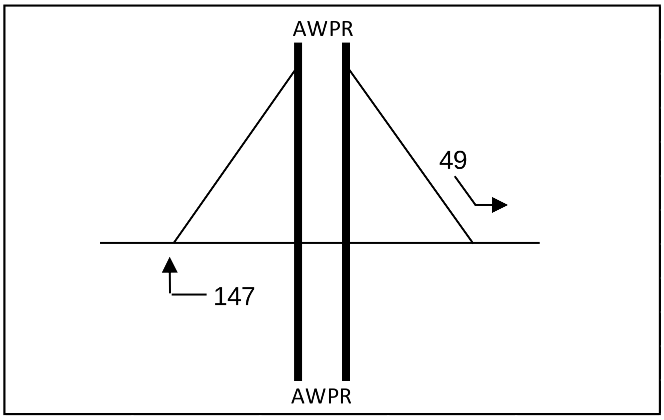


Figure 68 - AM Turning Movements – North Junction

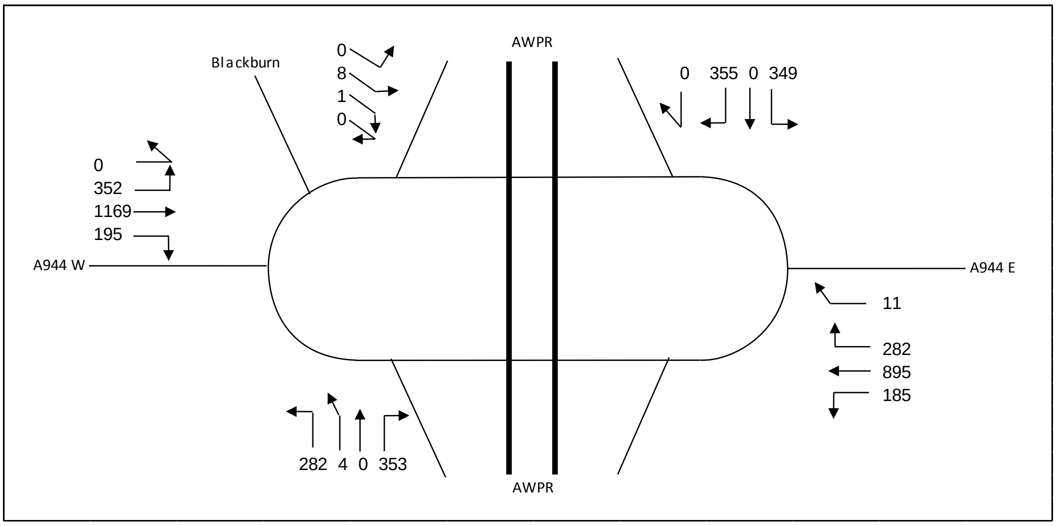


Figure 69 - AM Turning Movements – South Junction

Figure 68 shows that there is a relatively low flow at the north junction with the majority of movements taking place at the south junction.

Figure 69 shows that during the AM peak the main flows are travelling from the A944 West to the A944 East, and from the AWPR North (via the southbound diverge) to the A944 East and A944 west. There are also significant movements travelling from the AWPR South (via the northbound diverge) to the A944 East, and from the A944 East to both the AWPR North (via the northbound merge) and the A944 West.

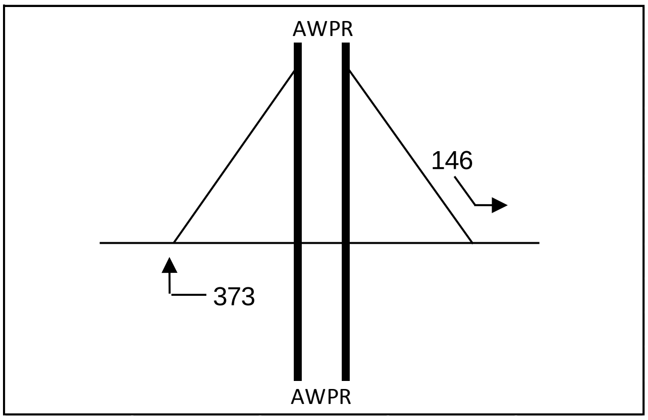


Figure 70 - PM Turning Movements – North Junction

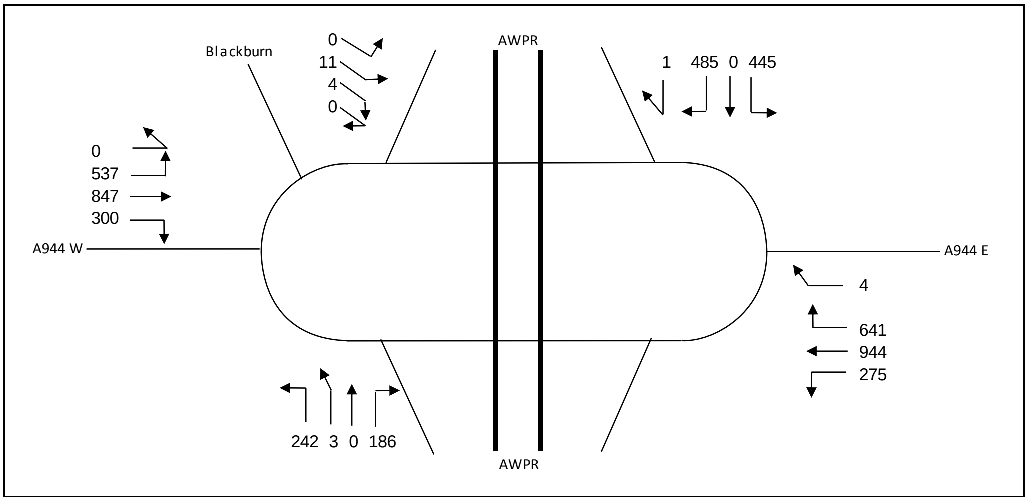


Figure 71 - PM Turning Movements – South Junction

During the PM peak period, the number of movements at the north junction are higher relative to the AM peak although still remain low comparative to the volume using the south junction.

Figure 71 shows that the main PM peak flows are travelling from the A944 East to the A944 West, and from the A944 West to the A944 East. There is also a high volume of traffic on the A944 East turning right to travel AWPR Northbound with 275 trips turning left to travel onto the AWPR Southbound.

From the A944 West, there is a high volume of traffic turning left to travel northbound on the AWPR. The model shows 300 trips turning right onto the AWPR Southbound.

There are also significant traffic movements travelling from the AWPR North to both the A944 East and the A944 West with a relatively low volume of traffic overall travelling from the AWPR south.

8.3 Vehicle Speeds

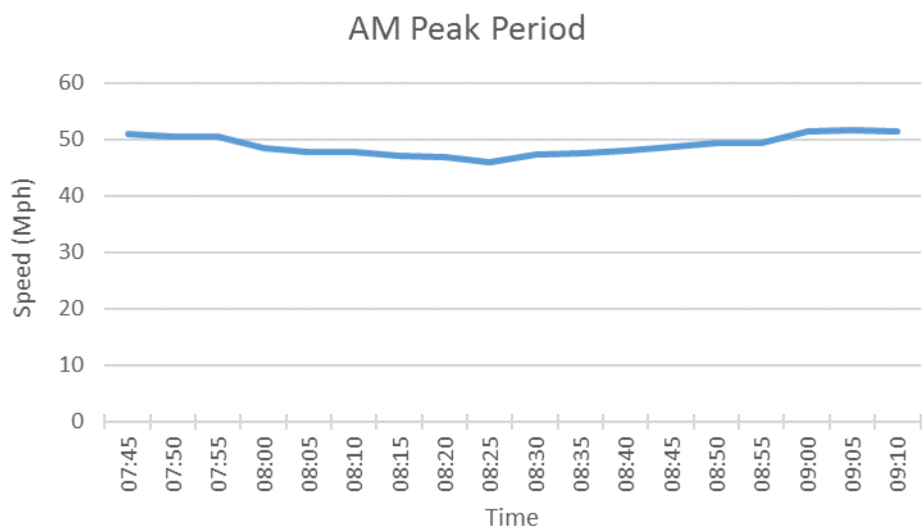


Figure 72 – AM Vehicle Speeds

Figure 72 shows that during the AM peak period the speeds show very little variation throughout the peak period; speeds remain consistently high around 48mph despite the average speed decreasing towards the middle of the simulation period.

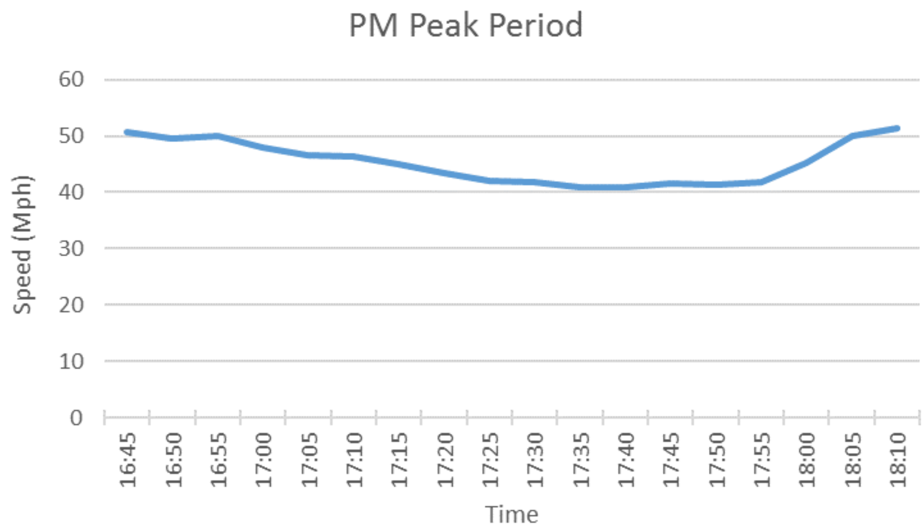


Figure 73 – PM Vehicle Speeds

Figure 73 shows the results for the PM peak. Outside the height of the peak, average speeds remain high (at around 50mph). For the period between 17:00 and 18:00, speeds are lower at around 40mph throughout the height of the peak.

The lack of any progressive deterioration in average speed in either the modelled AM or PM peak again provides a good indication that the design has sufficient operational performance to accommodate both the AM and the PM peak demand expected. However, during the PM peak, there is a distinct drop in the speed overall (of around 10mph) which can be attributed to some queuing that takes place on the A944 approaches to the AWPR junction.

8.4 Queue Length Data – South Kingswells Junction

Queuing Analysis

Figure 74 shows the routes over which the queue route data has been collected at the South Kingswells Junction.

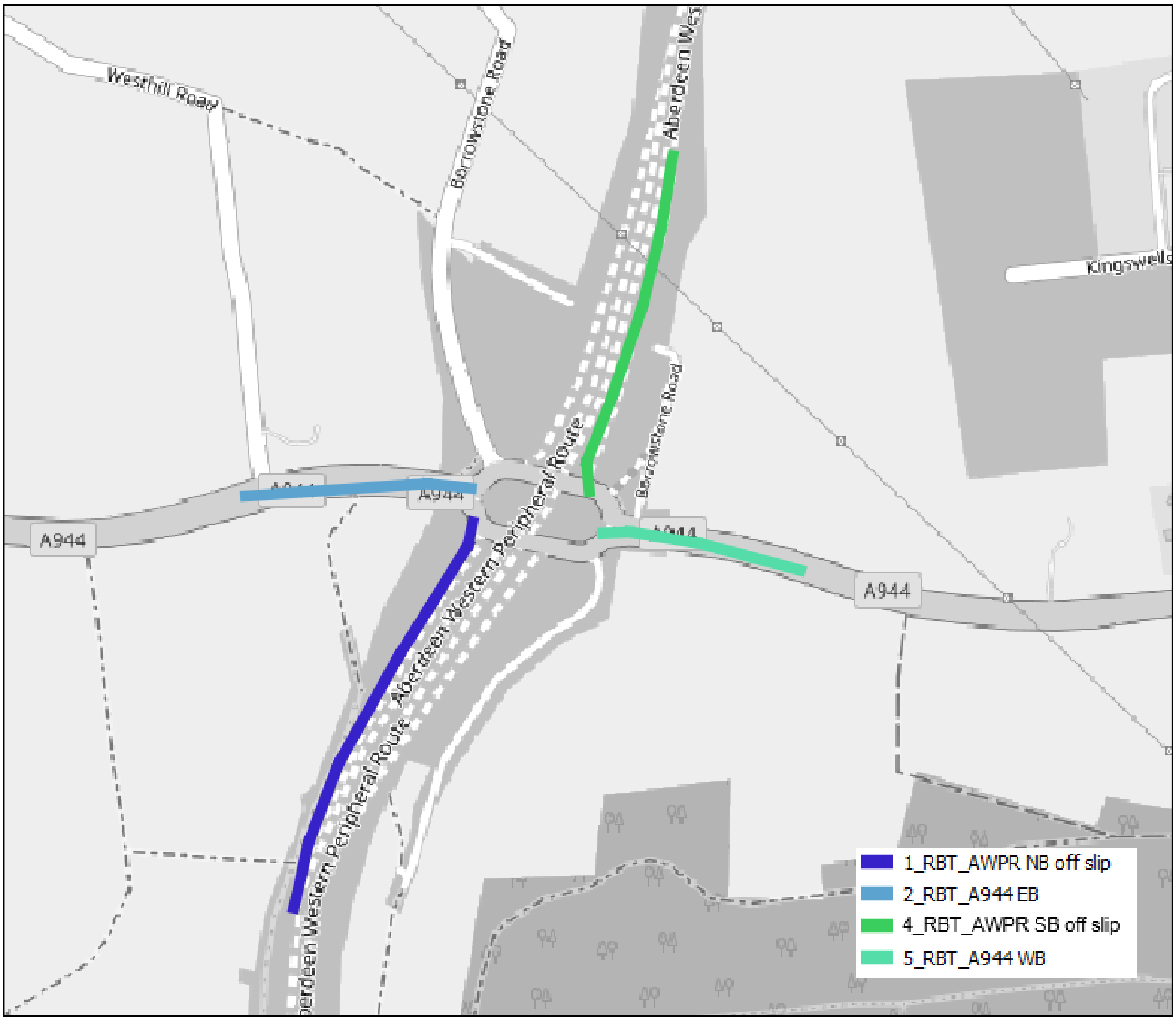


Figure 74 - Queue Routes at the South Kingswells Junction

Route	Lane	0700-0800			0800-0900			0900-1000		
		Max Q	95% CI		Max Q	95% CI		Max Q	95% CI	
"2_RBT_A944 EB"	1	86	83	89	188	183	194	80	75	85
"2_RBT_A944 EB"	2	64	61	68	183	177	188	75	70	79
"2_RBT_A944 EB"	3	-	-	-	-	-	-	-	-	-
"1_RBT_AWPR NB off slip"	1	33	31	36	51	50	52	32	31	34
"1_RBT_AWPR NB off slip"	2	42	40	44	68	66	70	52	50	55
"1_RBT_AWPR NB off slip"	3	-	-	-	-	-	-	-	-	-
"5_RBT_A944 WB"	1	38	36	41	259	251	268	40	37	42
"5_RBT_A944 WB"	2	42	39	44	239	230	247	64	60	68
"5_RBT_A944 WB"	3	-	-	-	-	-	-	-	-	-
"4_RBT_AWPR SB off slip"	1	50	47	53	81	79	83	42	39	45
"4_RBT_AWPR SB off slip"	2	25	24	26	46	45	47	23	22	24
"4_RBT_AWPR SB off slip"	3	-	-	-	-	-	-	-	-	-

Table 9 shows the queue length data collected during the AM peak for those routes shown in Figure 74.

Route	Lane	0700-0800			0800-0900			0900-1000		
		Max Q	95% CI		Max Q	95% CI		Max Q	95% CI	
"2_RBT_A944 EB"	**1**	86	83	89	188	183	194	80	75	85
"2_RBT_A944 EB"	**2**	64	61	68	183	177	188	75	70	79
"2_RBT_A944 EB"	**3**	-	-	-	-	-	-	-	-	-
"1_RBT_AWPR NB off slip"	**1**	33	31	36	51	50	52	32	31	34
"1_RBT_AWPR NB off slip"	**2**	42	40	44	68	66	70	52	50	55
"1_RBT_AWPR NB off slip"	**3**	-	-	-	-	-	-	-	-	-
"5_RBT_A944 WB"	**1**	38	36	41	259	251	268	40	37	42
"5_RBT_A944 WB"	**2**	42	39	44	239	230	247	64	60	68
"5_RBT_A944 WB"	**3**	-	-	-	-	-	-	-	-	-
"4_RBT_AWPR SB off slip"	**1**	50	47	53	81	79	83	42	39	45
"4_RBT_AWPR SB off slip"	**2**	25	24	26	46	45	47	23	22	24
"4_RBT_AWPR SB off slip"	**3**	-	-	-	-	-	-	-	-	-

Table 9 – South Kingswells AM Max Queue Lengths

During the AM modelled period, the A944 approaches experience a certain degree of queuing. The main queue occurs on the A944 Westbound approach with a maximum queue length of 259 metres (equivalent to approximately 43 car lengths). Additionally, the A944 Eastbound also shows a long queue length of up to 183 metres (31 car lengths) during the peak hour.

The other main approaches exhibit lower queuing levels with a maximum recorded queue length of 81 metres (approximately 14 car lengths) occurring on the AWPR NB off slip.

To help illustrate the extent of the queuing, which does not necessarily occur simultaneously on all approaches, the schematic representation shown in Figure 75 has been produced.

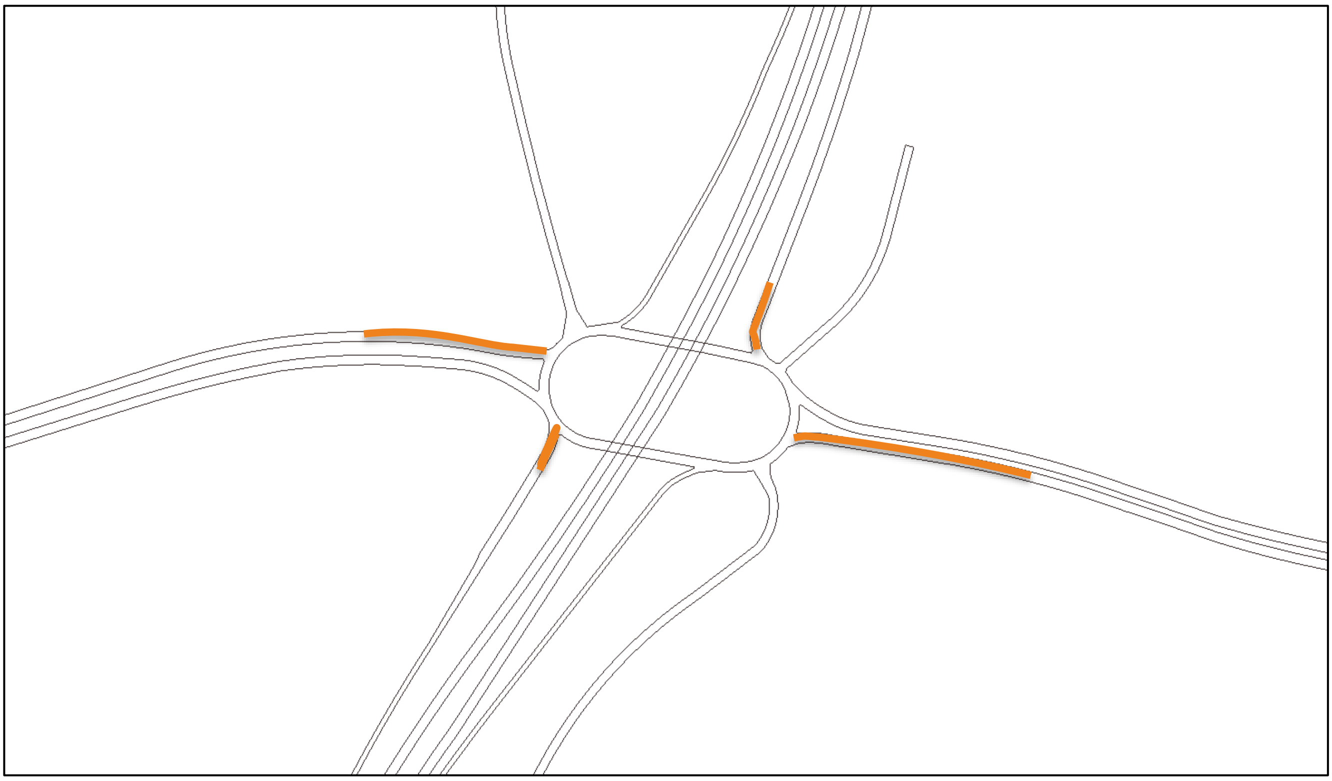


Figure 75 – South Kingswells AM Max Queue Length Diagram

Route	Lane	1600-1700			1700-1800			1800-1900		
		Max Q	95% CI		Max Q	95% CI		Max Q	95% CI	
"2_RBT_A944 EB"	1	73	68	77	323	304	342	317	272	362
"2_RBT_A944 EB"	2	65	60	69	318	301	335	317	273	361
"2_RBT_A944 EB"	3	-	-	-	-	-	-	-	-	-
"1_RBT_AWPR NB off slip"	1	24	19	29	29	27	30	29	21	36
"1_RBT_AWPR NB off slip"	2	43	41	45	72	70	73	56	53	58
"1_RBT_AWPR NB off slip"	3	-	-	-	-	-	-	-	-	-
"5_RBT_A944 WB"	1	90	85	95	279	266	292	276	252	301
"5_RBT_A944 WB"	2	129	122	136	282	273	291	277	250	303
"5_RBT_A944 WB"	3	-	-	-	-	-	-	-	-	-
"4_RBT_AWPR SB off slip"	1	72	68	76	121	118	124	97	93	102
"4_RBT_AWPR SB off slip"	2	46	41	50	68	66	69	43	41	45
"4_RBT_AWPR SB off slip"	3	-	-	-	-	-	-	-	-	-

Table 10 South Kingswells PM Max Queue Lengths

Route	Lane	1600-1700			1700-1800			1800-1900		
		Max Q	95% CI		Max Q	95% CI		Max Q	95% CI	
"2_RBT_A944 EB"	1	73	68	77	323	304	342	317	272	362
"2_RBT_A944 EB"	2	65	60	69	318	301	335	317	273	361
"2_RBT_A944 EB"	3	-	-	-	-	-	-	-	-	-
"1_RBT_AWPR NB off slip"	1	24	19	29	29	27	30	29	21	36
"1_RBT_AWPR NB off slip"	2	43	41	45	72	70	73	56	53	58
"1_RBT_AWPR NB off slip"	3	-	-	-	-	-	-	-	-	-
"5_RBT_A944 WB"	1	90	85	95	279	266	292	276	252	301
"5_RBT_A944 WB"	2	129	122	136	282	273	291	277	250	303
"5_RBT_A944 WB"	3	-	-	-	-	-	-	-	-	-
"4_RBT_AWPR SB off slip"	1	72	68	76	121	118	124	97	93	102
"4_RBT_AWPR SB off slip"	2	46	41	50	68	66	69	43	41	45
"4_RBT_AWPR SB off slip"	3	-	-	-	-	-	-	-	-	-

Table 10 shows that during the PM peak period the main approaches are subject to longer queuing levels to those extracted for the AM peak analysis.

In the PM peak, the A944 Eastbound approach shows the longest queue length of approximately 323m (approximately 54 car lengths).

The A944 Westbound approach experiences a recorded queue length of 282 metres (equivalent to approximately 47 car lengths).

The AWPR SB approach also exhibits higher levels of queuing with lengths of up to 121 metres long (approximately 20 car lengths). The AWPR NB shows a queue length very similar to the AM peak (72m or 12 car lengths).

Again, Figure 76 has been produced to illustrate the approximate length of queue lengths on the junction approaches during the PM peak and illustrate the data shown in Table 10.

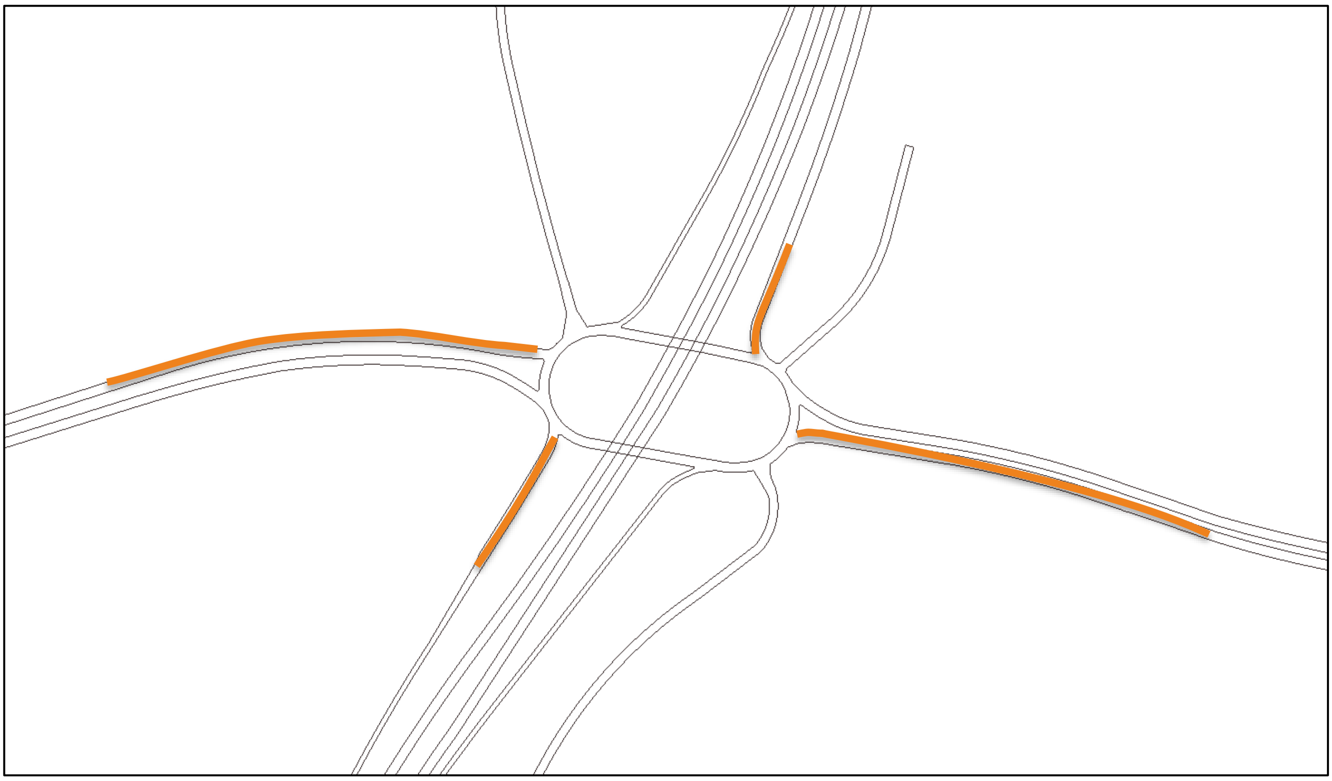


Figure 76 – South Kingswells PM Max Queue Length Diagram

Figure 77 shows the locations at which queues were recorded at the North Kingswells junction.

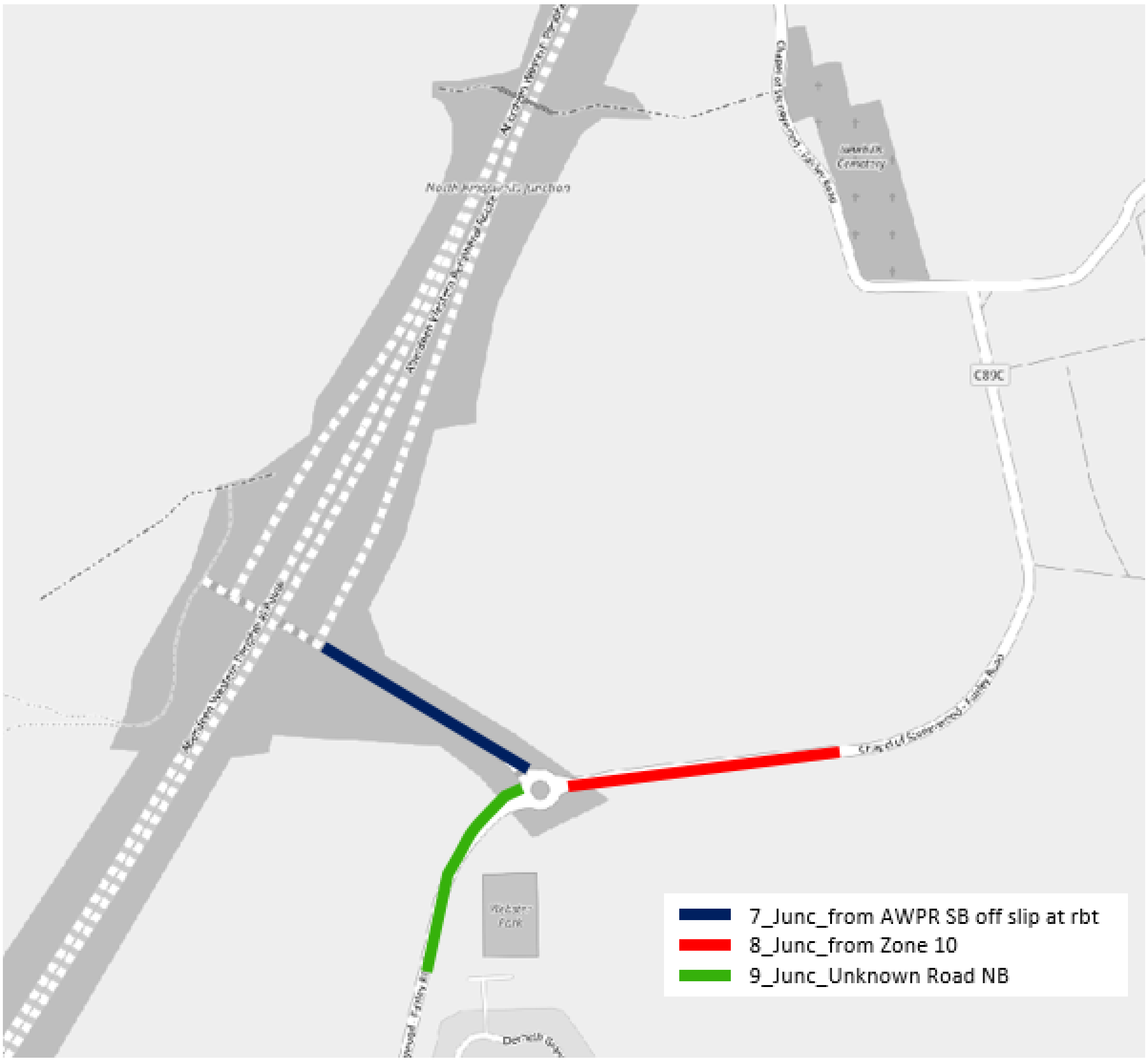


Figure 77 – Queue Routes at the North Kingswells Junction

Table 11 shows the queue length data collected during the AM peak for those routes shown in Figure 77.

		0700-0800			0800-0900			0900-1000		
Route	Lane	Max Q	95% CI		Max Q	95% CI		Max Q	95% CI	
"7_Junc_from AWPR SB off slip	1	-	-	-	19	-	-	-	-	-
"7_Junc_from AWPR SB off slip	2	-	-	-	-	-	-	-	-	-
"7_Junc_from AWPR SB off slip	3	-	-	-	-	-	-	-	-	-
"8_Junc_from Zone 10"	1	-	-	-	19	-	-	-	-	-
"8_Junc_from Zone 10"	2	-	-	-	-	-	-	-	-	-
"8_Junc_from Zone 10"	3	-	-	-	-	-	-	-	-	-
"9_Junc_Unknown Road NB"	1	-	-	-	-	-	-	-	-	-
"9_Junc_Unknown Road NB"	2	-	-	-	19	17	20	-	-	-
"9_Junc_Unknown Road NB"	3	-	-	-	-	-	-	-	-	-

Table 11 – North Kingswells AM Max Queue Lengths

Table 11 shows that there is minimal queuing at the North Kingswells junction during the AM peak. All three routes show a maximum queue length of up to 19m (approximately 3-4 car lengths).

For routes "7_Junc_from AWPR SB off slip at rbt" and "8_Junc_from Zone 10" there is only 1 queue recorded for each route and so no information on the confidence interval can be provided (this statistic requires a data population size of 2 or more).

The route "9_Junc_Unknown Road NB" shows a maximum queue length of up to 19m (approximately 3-4 car lengths). The confidence interval information here shows that the queued model length is typically between 17 and 20m.

Overall, during the AM peak, queue lengths are considered to be minimal.

Figure 78 has been produced to illustrate the approximate length of queues on the junction approaches during the AM peak and illustrate the data shown in Table 11.

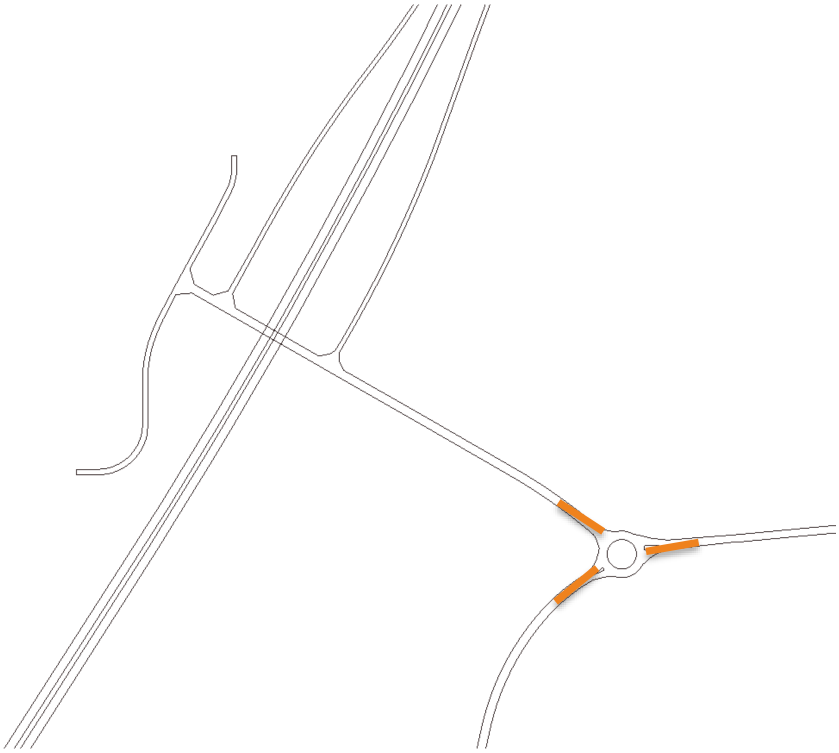


Figure 78 – North Kingswells AM Max Queue Length Diagram

Table 12 shows the queue length data collected during the PM peak for those routes shown in Figure 78.

Route	Lane	1600-1700			1700-1800			1800-1900		
		Max Q	95% CI		Max Q	95% CI		Max Q	95% CI	
"7_Junc_from AWPR SB off slip	1	-	-	-	19	19	19	19	-	-
"7_Junc_from AWPR SB off slip	2	-	-	-	-	-	-	-	-	-
"7_Junc_from AWPR SB off slip	3	-	-	-	-	-	-	-	-	-
"8_Junc_from Zone 10"	1	19	19	19	25	24	25	19	19	20
"8_Junc_from Zone 10"	2	21	20	21	31	30	33	20	18	22
"8_Junc_from Zone 10"	3	-	-	-	-	-	-	-	-	-
"9_Junc_Unknown Road NB"	1	20	-	-	23	23	24	-	-	-
"9_Junc_Unknown Road NB"	2	20	18	21	25	24	26	22	21	24
"9_Junc_Unknown Road NB"	3	-	-	-	-	-	-	-	-	-

Table 12 - North Kingswells PM Max Queue Lengths

The data shown in Table 12 shows that queue lengths on all routes on the approaches to the North Kingswells junction typically extend to between 19 and 31m (approximately 3- 6 vehicles).

For all routes, there are queues of limited length occurring and which extend up to 6 vehicles long. This is considered acceptable.

Figure 79 has been produced to illustrate the approximate length of queues on the junction approaches during the PM peak and illustrate the data shown in Table 12.

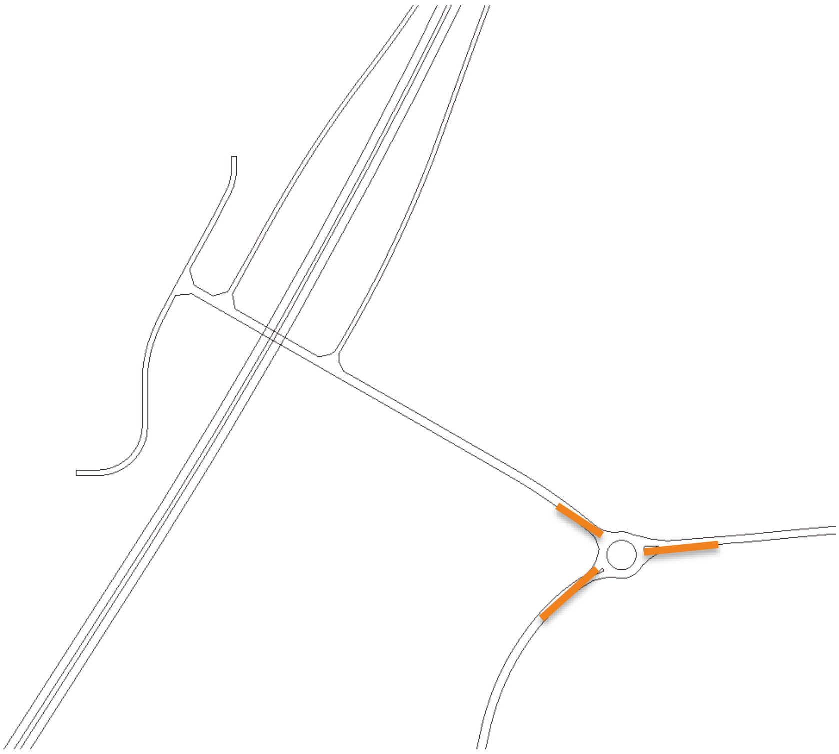


Figure 79 – North Kingswells PM Max Queue Length Diagram

Queue Length Distributions

To assess the significance of the maximum queue length statistics extracted from the Paramics model simulations, and examine how the queues vary over time, the queue length distributions for each main approach to the South Kingswells junction were analysed throughout the simulation period. The results of this analysis for the South Kingswells junction can be seen in Figure 80 and **Figure 81** for the AM and PM peaks respectively.

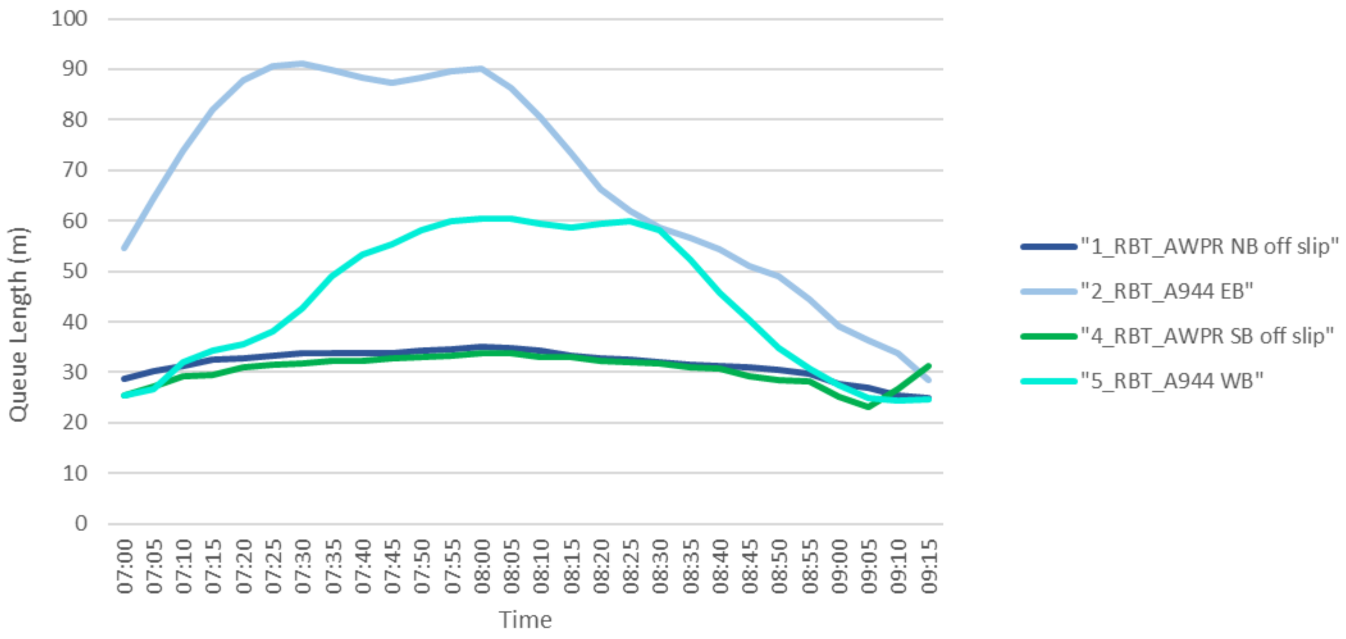


Figure 80 – AM Average Max Queue Length Distribution at the South Kingswells Junction

During the AM peak, the queueing on the AWPR approaches to the junction remains consistently low throughout the modelled period; queue lengths remain constant at around 30-35m throughout the full length of the modelled period.

The A944 eastbound approach to the junction shows a sharp increase in the queue length from 55m at 07:00 to 90m at approximately 7:20. From this time on, the queue length remains constant until 08:00 when queue lengths decrease steadily over the course of the following hour until they reach approximately 30m long at 09:10.

The A944 westbound approach shows that queue lengths peak at 60m for the duration between 07:50 and 08:30. Outside of these times, queue lengths are relatively short and remain between 30-60m in length (5-10 car lengths).

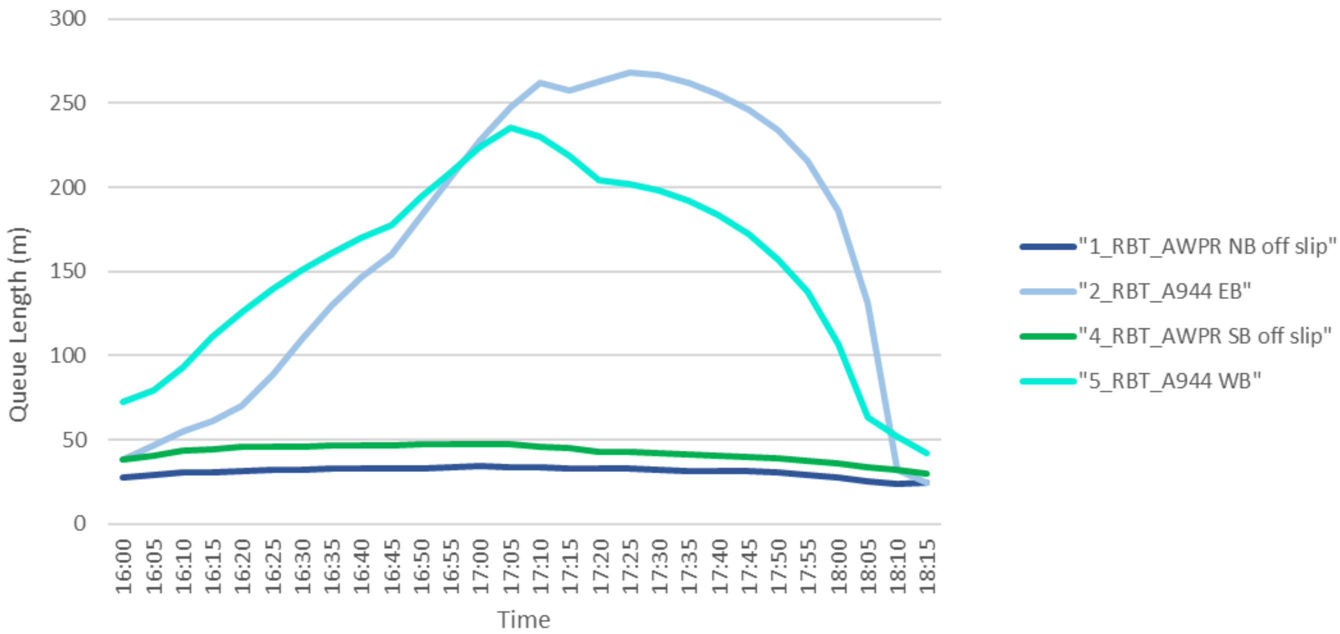


Figure 81 – PM Average Max Queue Length Distribution South Kingswells Junction

During the PM peak, the queueing on the AWPR approaches to the junction remains consistently low throughout the modelled period; queue lengths remain constant at around 30-40m and 40-50m throughout the full length of the modelled period.

The A944 eastbound and westbound approaches to the junction shows distinct increases in the queue length from 16:00 to a peak of approximately 250m on both approaches at 17:10. Queue lengths then remain high until 17:30 when they begin to show reductions in length up until 18:00.

The following graphs shown at Figure 82 and Figure 83 show queue length data for the North Kingswells junction during the AM and PM peaks respectively.

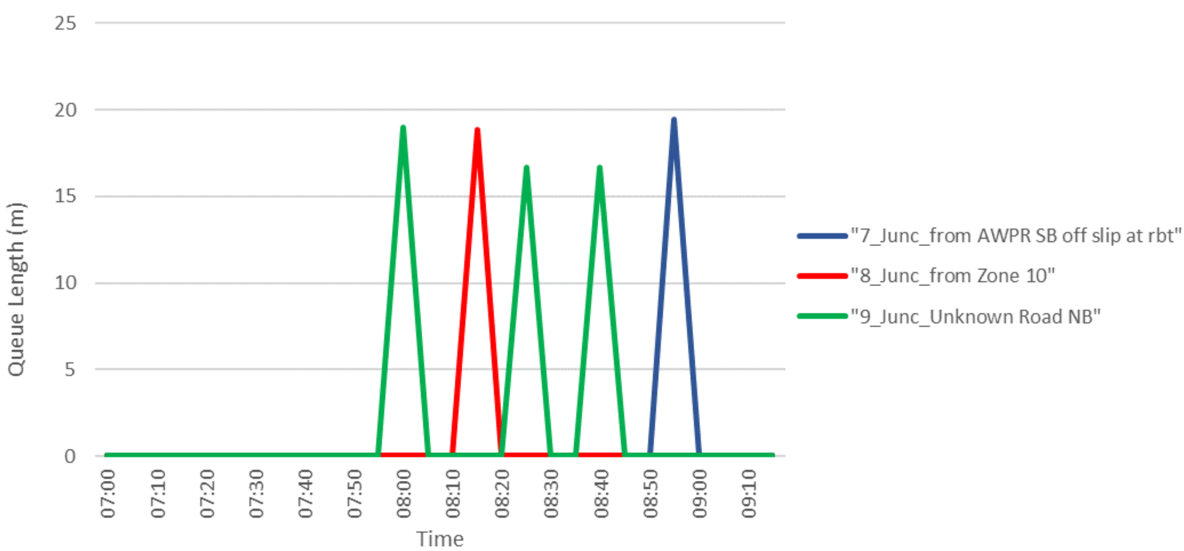


Figure 82 – AM Average Max Queue Length Distribution North Kingswells Junction

During the AM Peak, Figure 82 shows that queue lengths are very limited and occur only infrequently and for short periods of time.

This is considered to be an acceptable level of operation in terms of queue lengths.

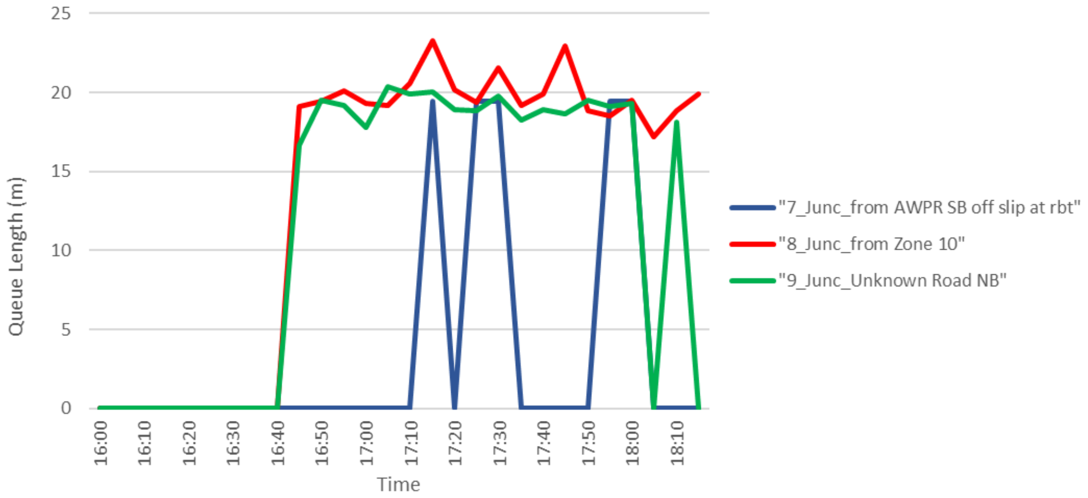


Figure 83 – AM Average Max Queue Length Distribution North Kingswells Junction

Figure 83 shows that queue lengths in the PM peak are very limited in length but are more persistent than the AM peak.

The route "7_Junc_from AWPR SB off slip at rbt" shows infrequent queues forming for short periods of time throughout the peak period; queues will extend up to approximately 20m.

For the routes "8_Junc_from Zone 10" and "9_Junc_Unknown Road NB”, queue lengths persist throughout the modelled period but remain short at 3-4 vehicles long.

Overall, the junction shows an acceptable level of performance throughout the modelled period in terms of queue lengths.

8.5 Journey Time Data

Figure 84 illustrates the journey time routes that were defined for the journey time analysis at the South Kingswells junction.

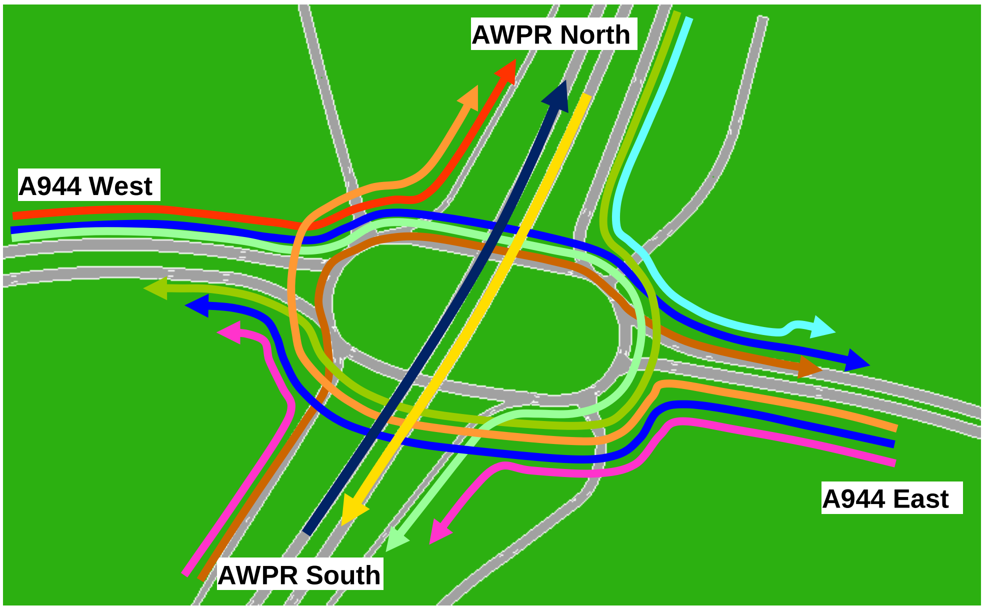


Figure 84 – Journey Time Routes at the South Kingswells Junction

The average journey time, as it varies over time throughout the simulation period, for each traffic movement passing through the A90 North junction is shown in **Figure 85** and Figure 86 for the AM and PM periods respectively.

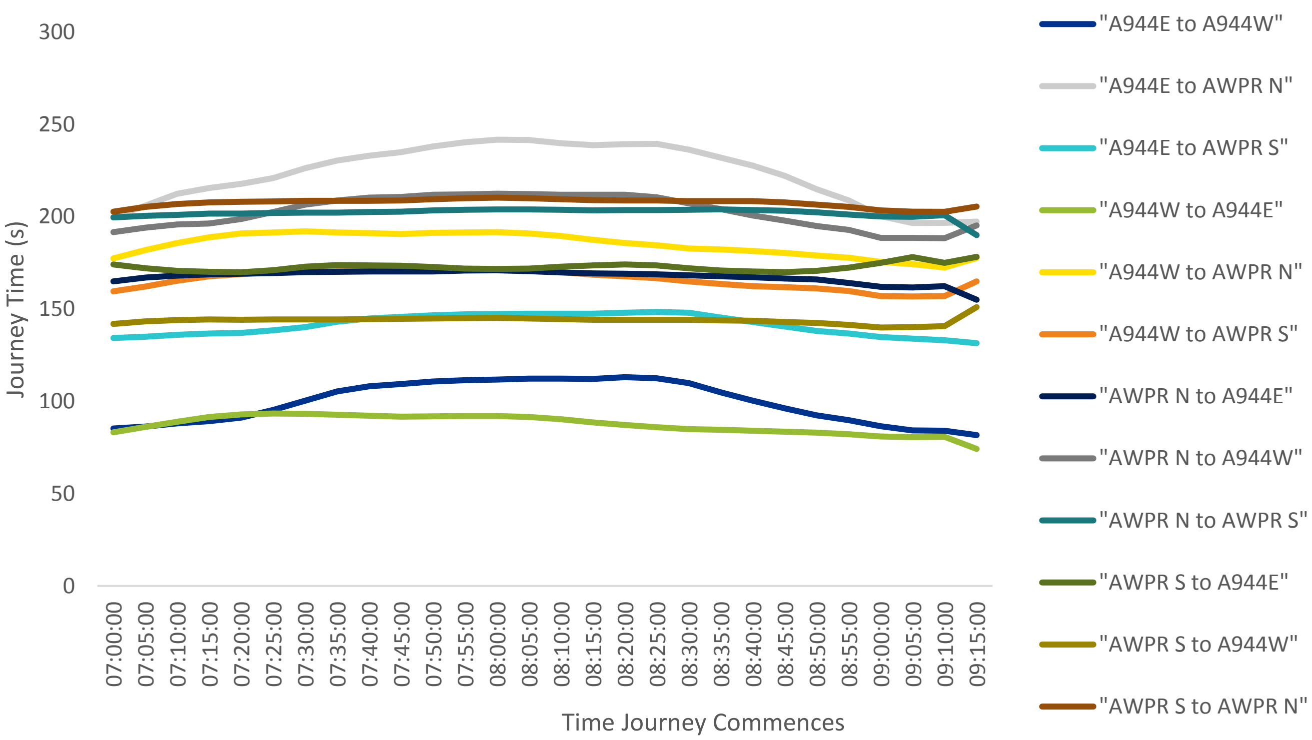


Figure 85 – AM Journey Time Data

During the AM peak, **Figure 85** shows that with the exception of the A944 east to the AWPR north route, journey times for all movements through the junction remain almost constant throughout the modelled period.

The increase in journey time for traffic travelling from the A944 east to the AWPR north is consistent with the average speed and queuing distribution analyses, and shows the journey times are highest between 07:10 and 08:20 before decreasing again to the end of the simulations.

For all other movements there is no significant increase in journey times through the junction over the course of the peak period, indicating no significant deterioration in the junction's operational performance during this time.

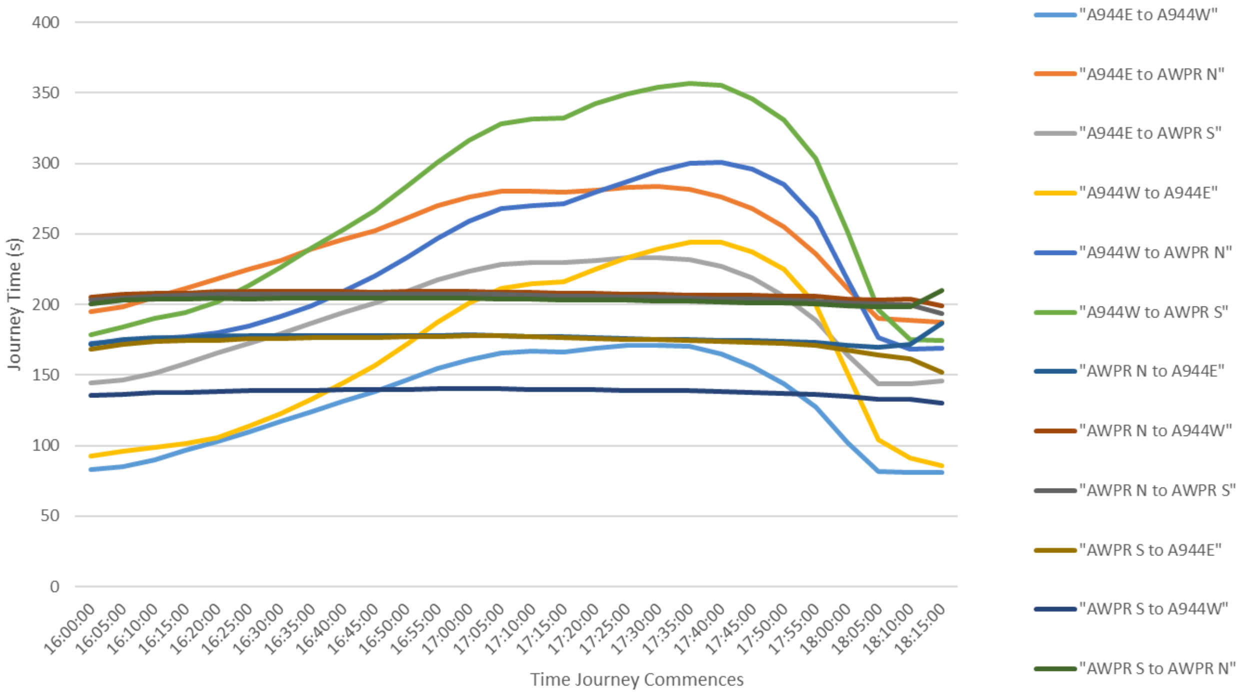


Figure 86 – PM Journey Time Data

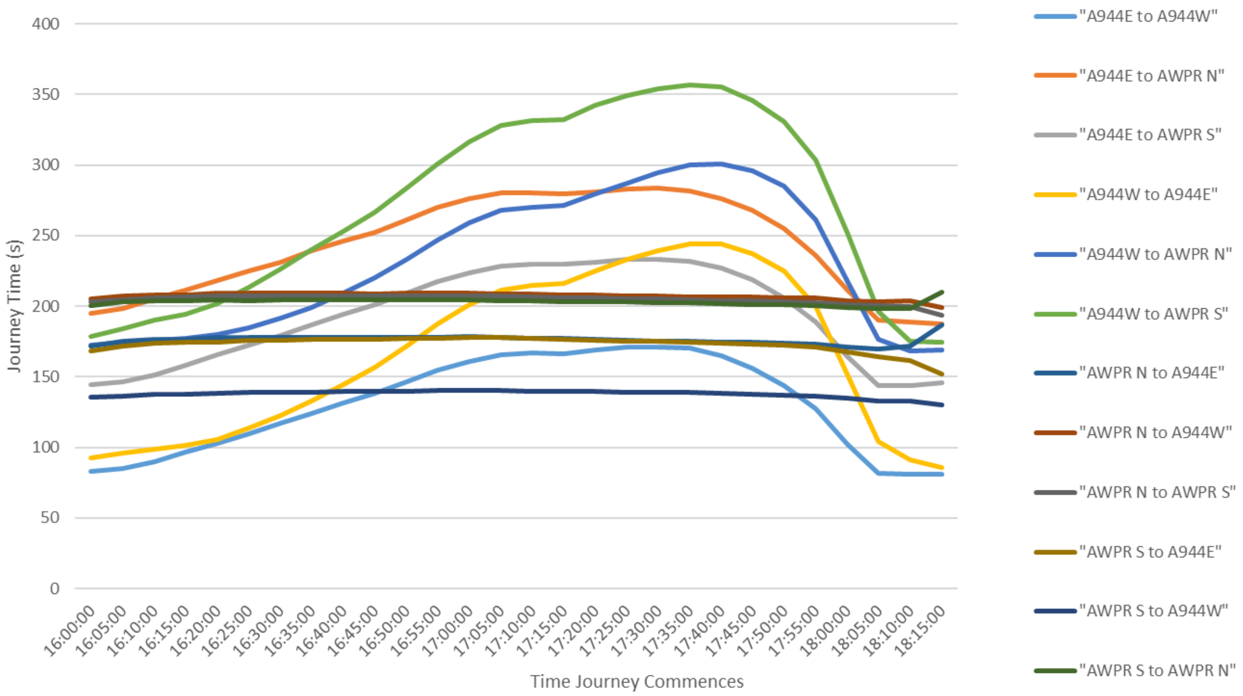


Figure 86 shows that during the PM peak period, journey times from both the A944 east and A944 west show that there are more significant increases in journey times throughout the simulation period. Journey times of up to 6 minutes are shown for the routes from the A944W approach arm and up to approximately 4 minutes for the A944E approach arm. Higher journey times are experienced on these arms as there is a high level of demand travelling between Aberdeen City and Westhill in both directions.

Again, these higher journey times are consistent with the average speed and queuing distribution analyses with the highest journey times on these approaches being experience during the period 16:30 to 18:10.

For the movements from the AWPR approaches, there is no significant increase in journey times through the junction over the course of the peak period, indicating no significant deterioration in the junction's operational performance for these routes during this time.

Journey times routes through the North Kingswells junction during the AM and PM peak periods are shown in Figure 87 with data for the AM and PM peaks show at Figure 88 and Figure 89 respectively.

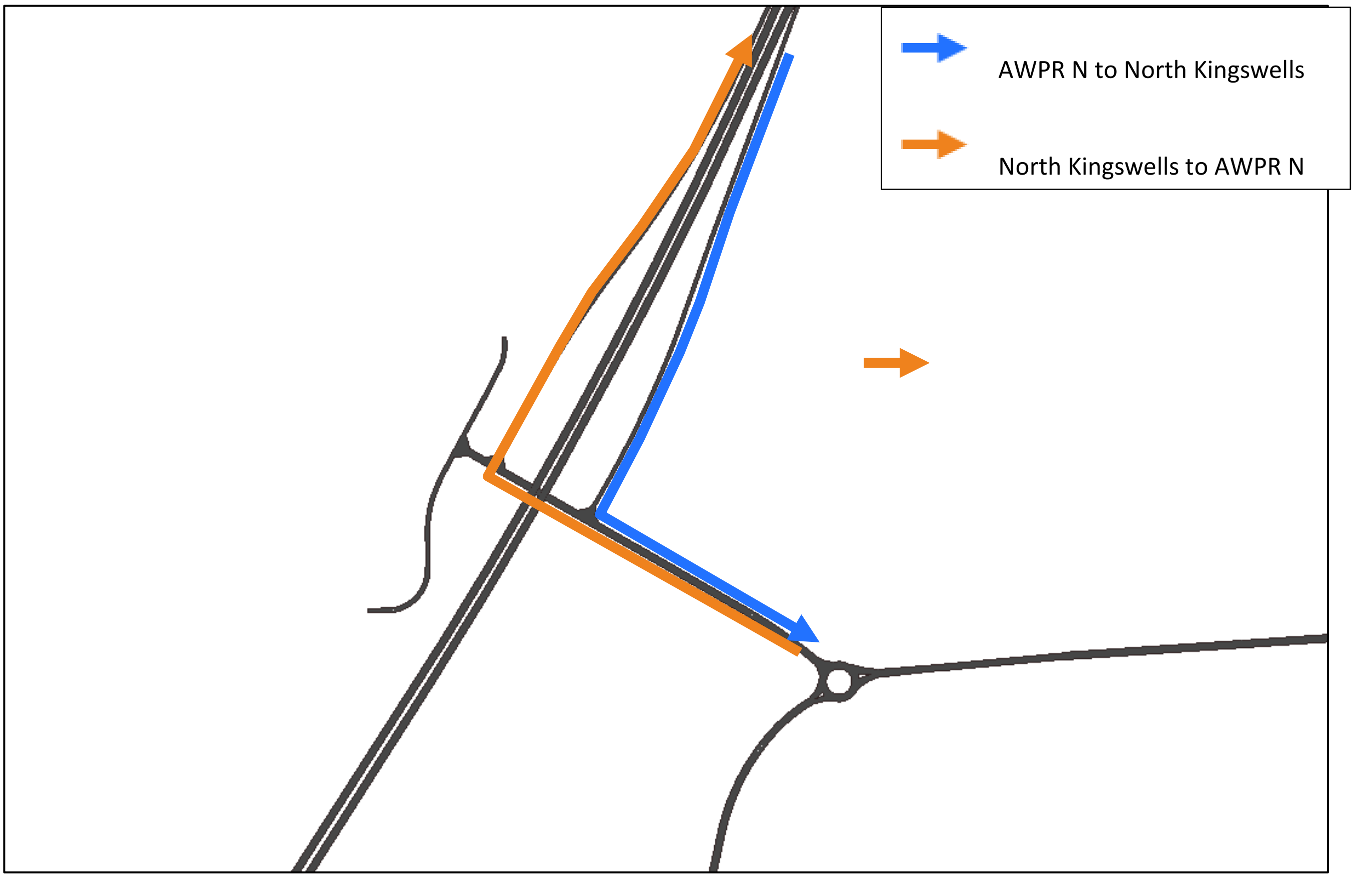


Figure 87 – Journey Time Routes at the North Kingswells Junction

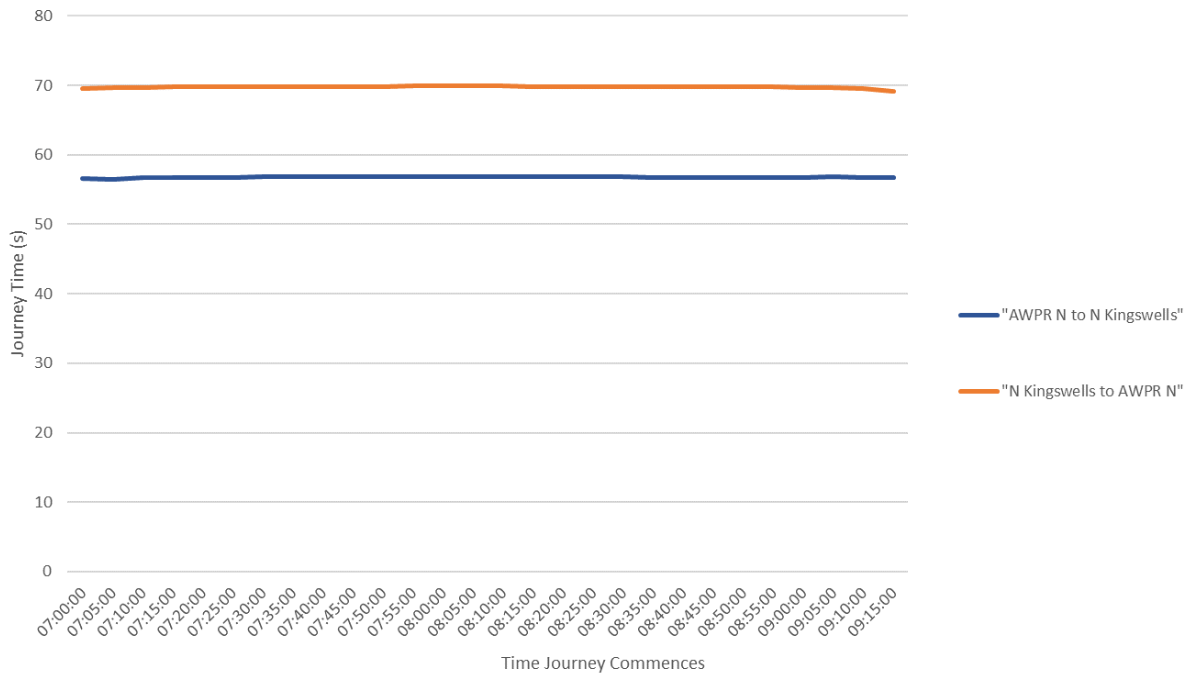


Figure 88 – AM Journey Times at the North Kingswells Junction

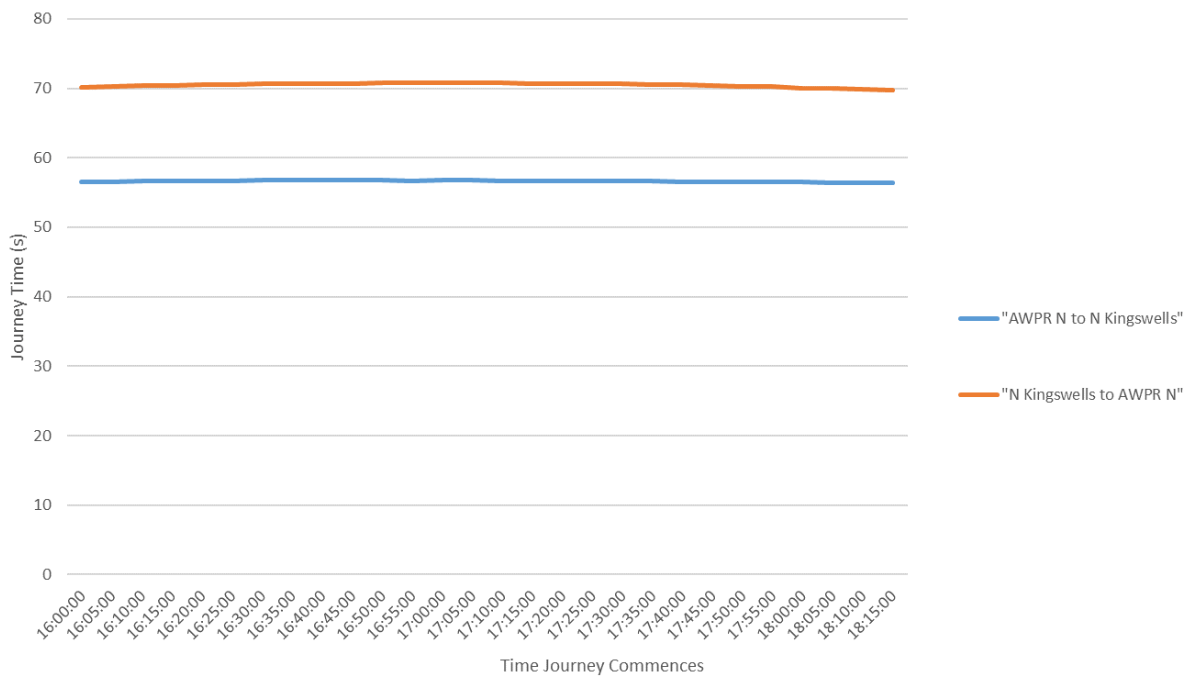


Figure 89 – AM Journey Times at the South Kingswells Junction

Figure 88 and Figure 89 show that journey times throughout both the AM and PM peaks are consistent throughout the modelled period with no points of delay occurring during this time.

9. Craibstone Junction Performance

9.1 Junction Description and Location

The preferred option to connect the proposed AWPR to the A96 has been identified as an arrangement with an at-grade roundabout on the A96, a grade-separated crossroad junction, a crossroad junction and a T-junction. Figure 90 shows an overview of the wider Paramics model network developed for the preferred junction option while Figure 91 shows the junctions and roundabout in more detail.

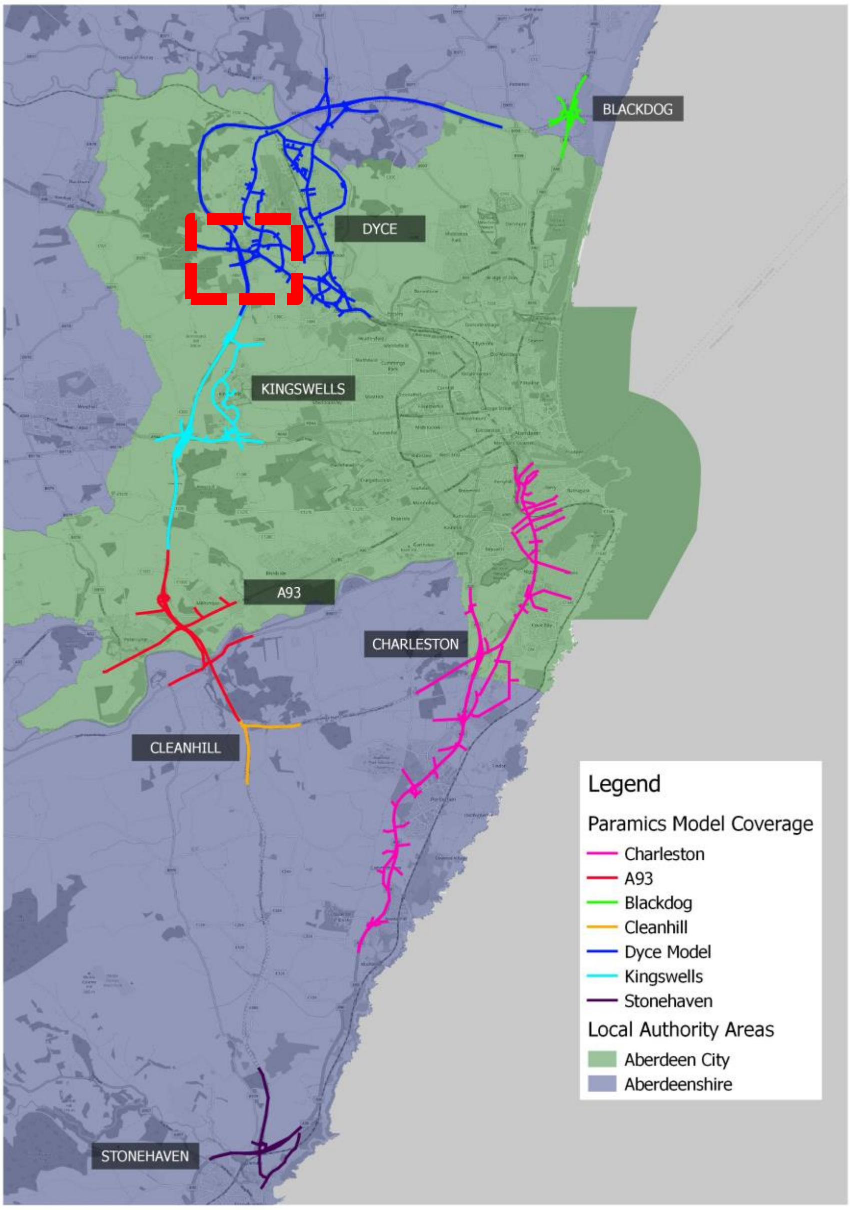


Figure 90 – Dyce Junction Location

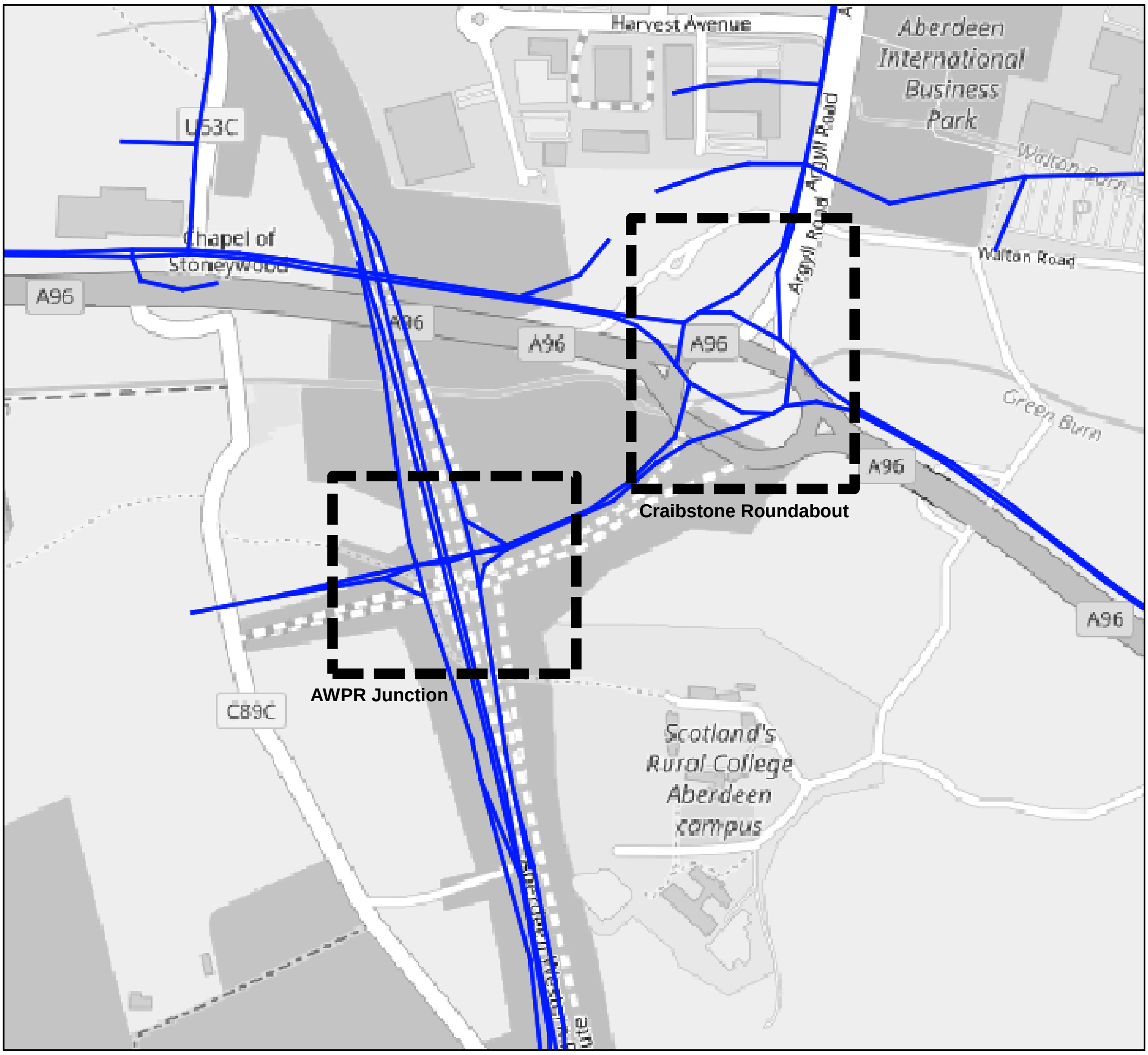


Figure 91 –Dyce Paramics Model and key locations

The design comprises a signalised priority-type layout for the grade separated AWPR junction, combined with a signalised at-grade roundabout on the A96. The two junctions are connected via a new link road which has provision for two lanes in each direction, flaring to three lanes at the respective junction entries.

The AWPR junction allows for full access to the AWPR North and South, with the AWPR merges and diverges connecting into signal controlled junctions. The AWPR northbound diverge has two lanes on approach to the west signal set, whilst the southbound diverge flares from one to two lanes on the approach to the east signals. The southbound diverge also includes the development of two segregated left turn lanes to cater for the demand travelling from the AWPR North (via the southbound diverge) to the A96 and beyond. The offside lane also continues to the signals stopline to cater for traffic travelling to the local access west of the junction.

At the east signals, two segregated left turn lanes are provided for traffic travelling from the new AWPR link road to access the AWPR southbound merge. Both the northbound and southbound merges have two lane exits from the respective east and west signalised junctions.

9.2 Signal Information

At the A96, the junction consists of an at-grade roundabout with full signalisation controlling both the entry flows and the flows on the circulating carriageway. The circulating carriageway provides for three traffic lanes, with the A96 East and West and the new link road approaches flaring from two lanes to three lanes at the entry stoplines. All exit arms from the roundabout are two lane exits.

Pedestrian crossing facilities have also been incorporated into both the AWPR and A96 junction designs and generally operate on a walk with basis under non-conflicting traffic stages. The appropriate intergreen times were calculated based on swept path analyses to determine pedestrian/vehicle clearance times, with the pedestrian stage green times derived in accordance with DMRB Volume 8, Section 1, Part 1, TA 15/07.

Figure 92 and Figure 93 illustrate the Paramics model signals timings derived for the Craibstone roundabout and AWPR junction both during the AM peak period.

Figure 94 and Figure 95 illustrate the Paramics model signals timings derived for the Craibstone roundabout and AWPR junction both during the PM peak period.

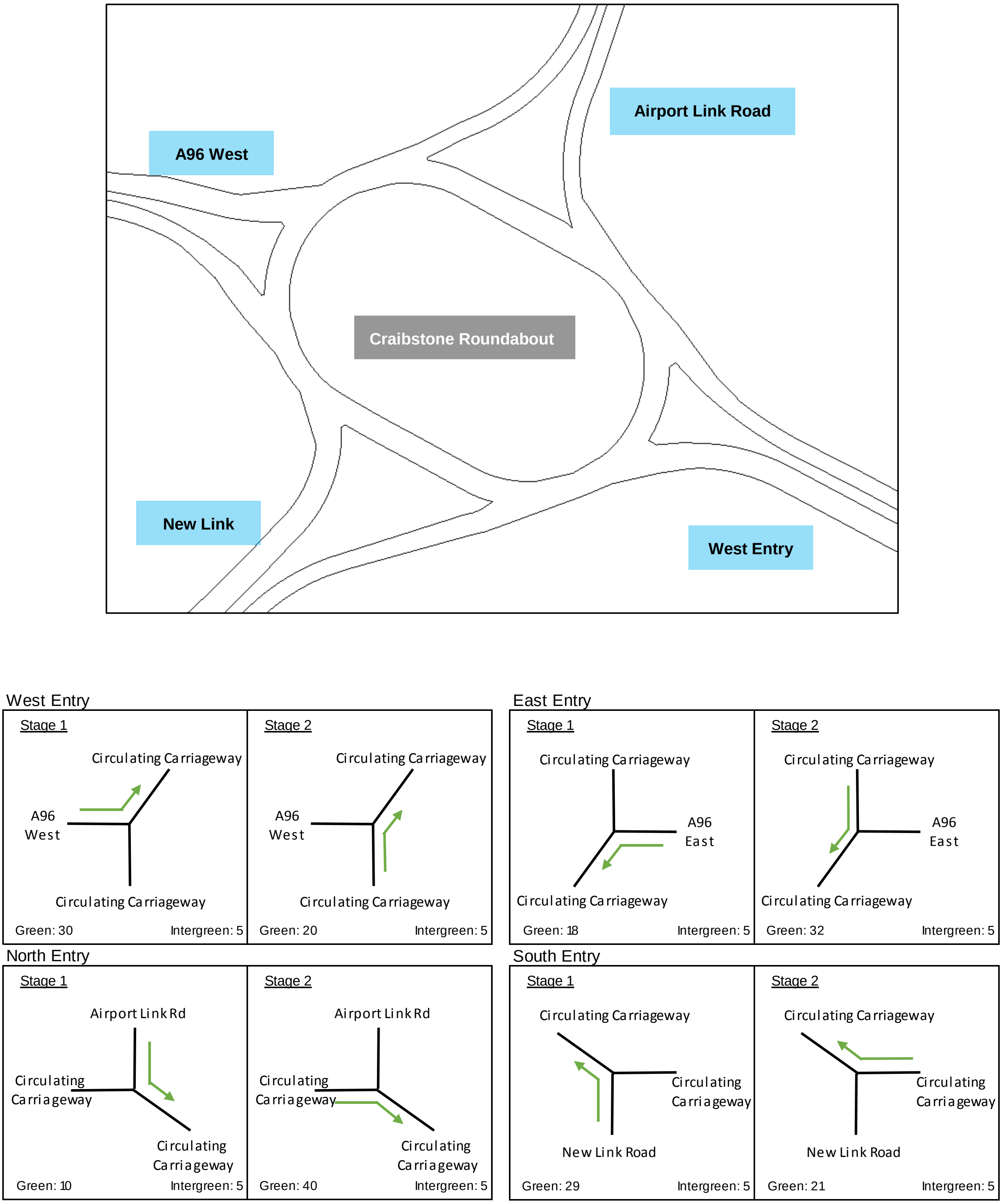
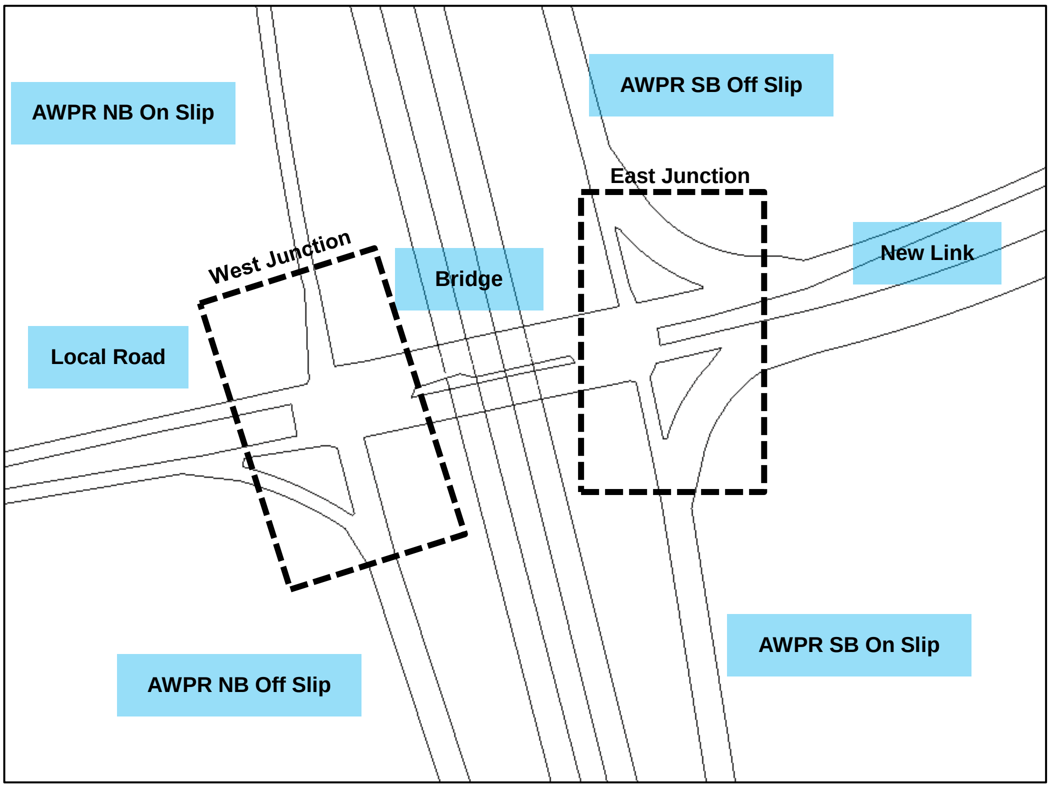
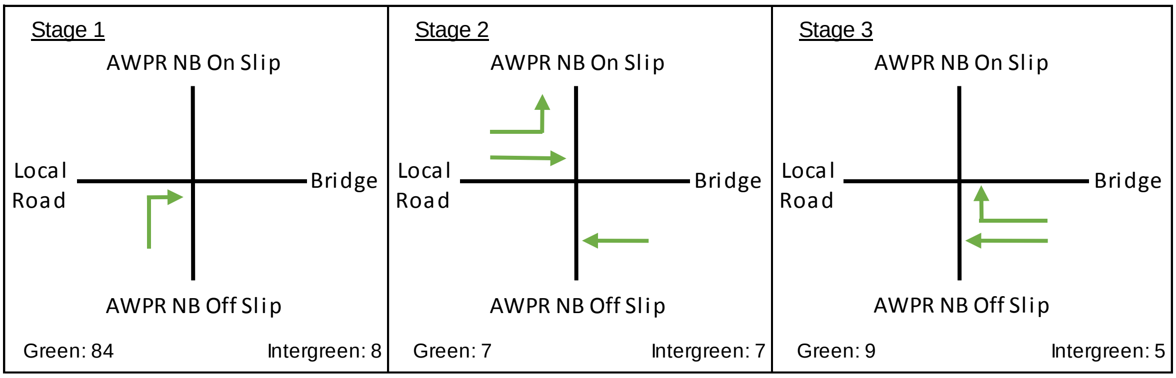


Figure 92 – AM Signal Timings – Craibstone Roundabout



West Junction



East Junction

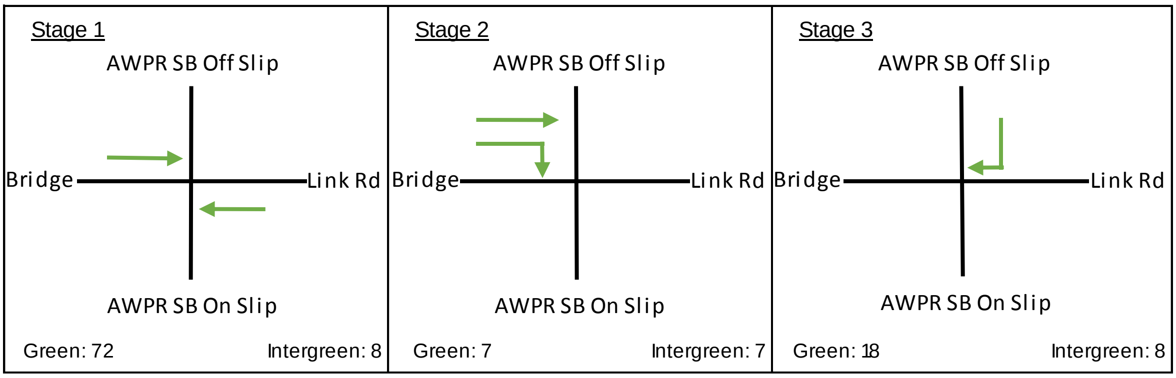
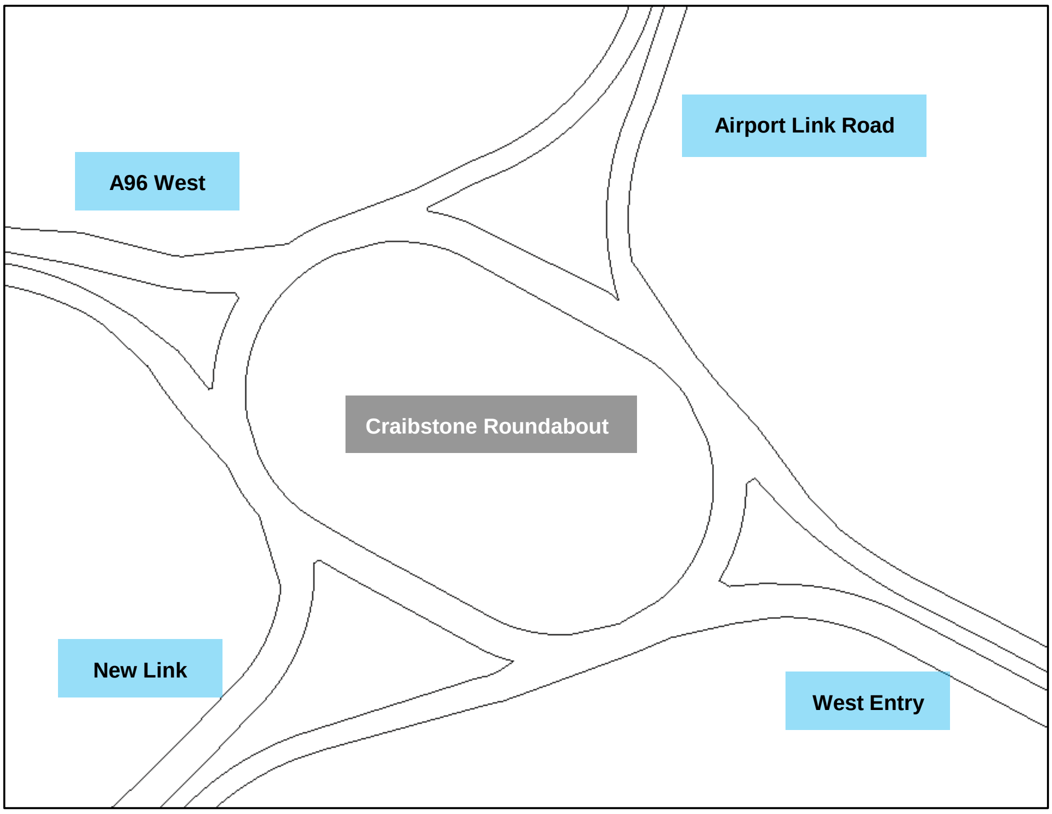


Figure 93 – AM Signal Timings – AWPR Junction



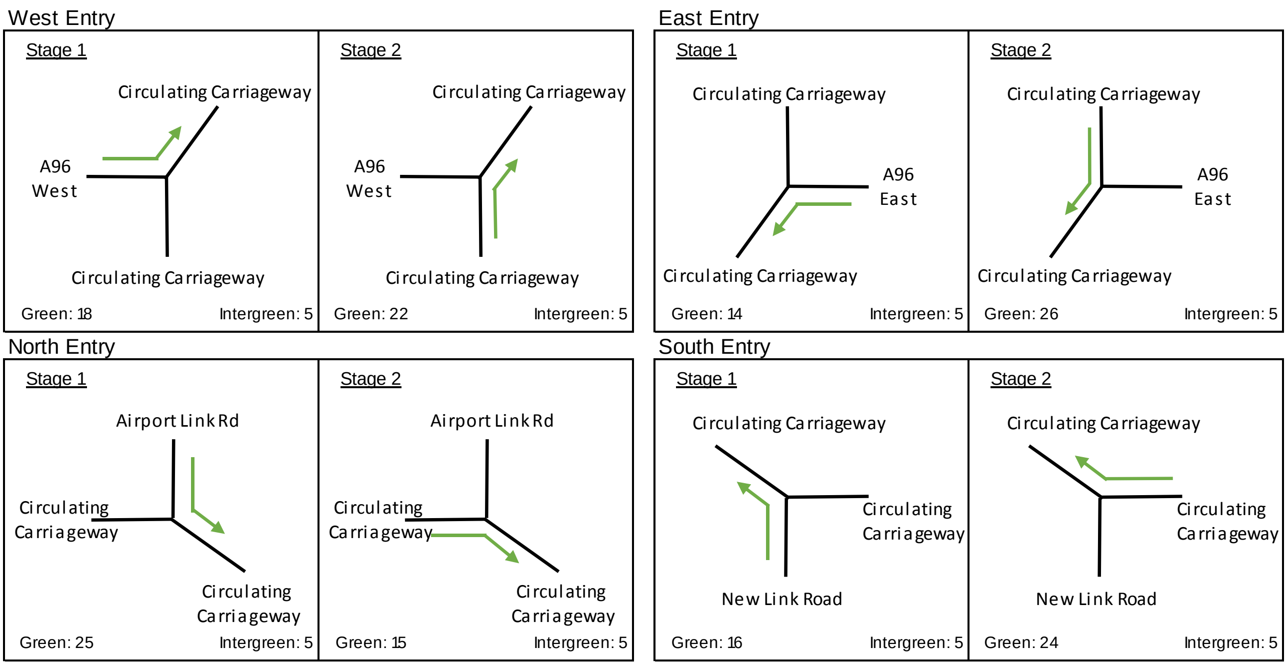
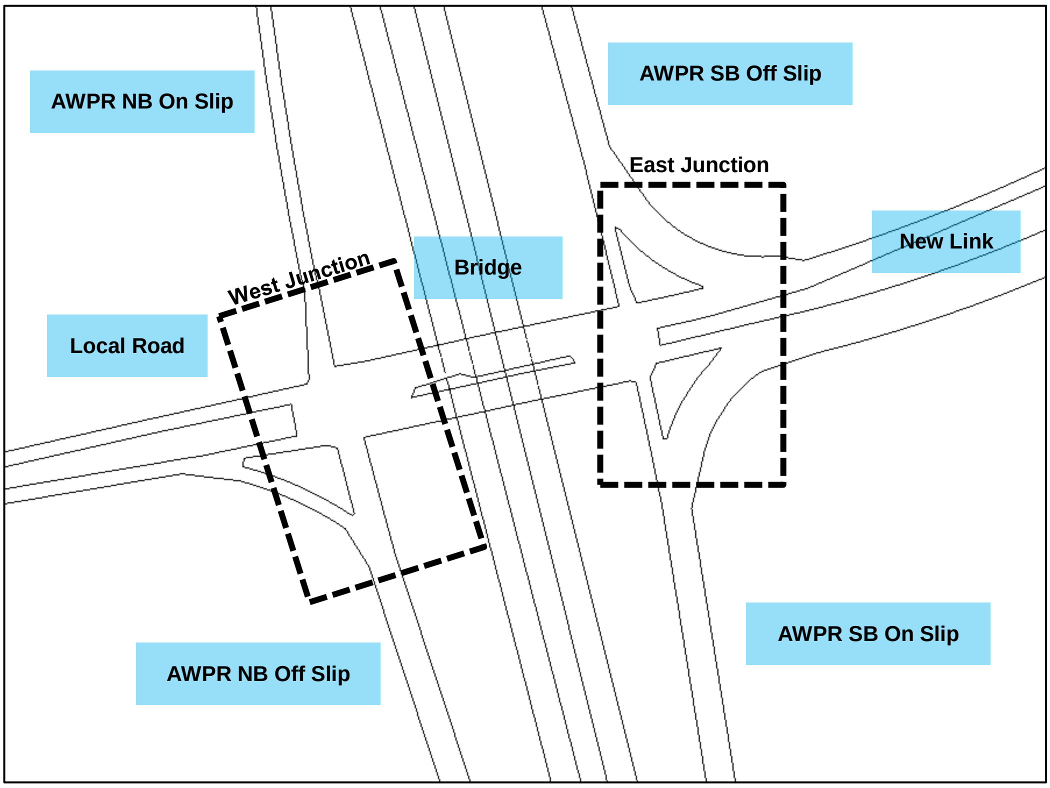


Figure 94 – PM Signal Timings – Craibstone Roundabout



West Junction

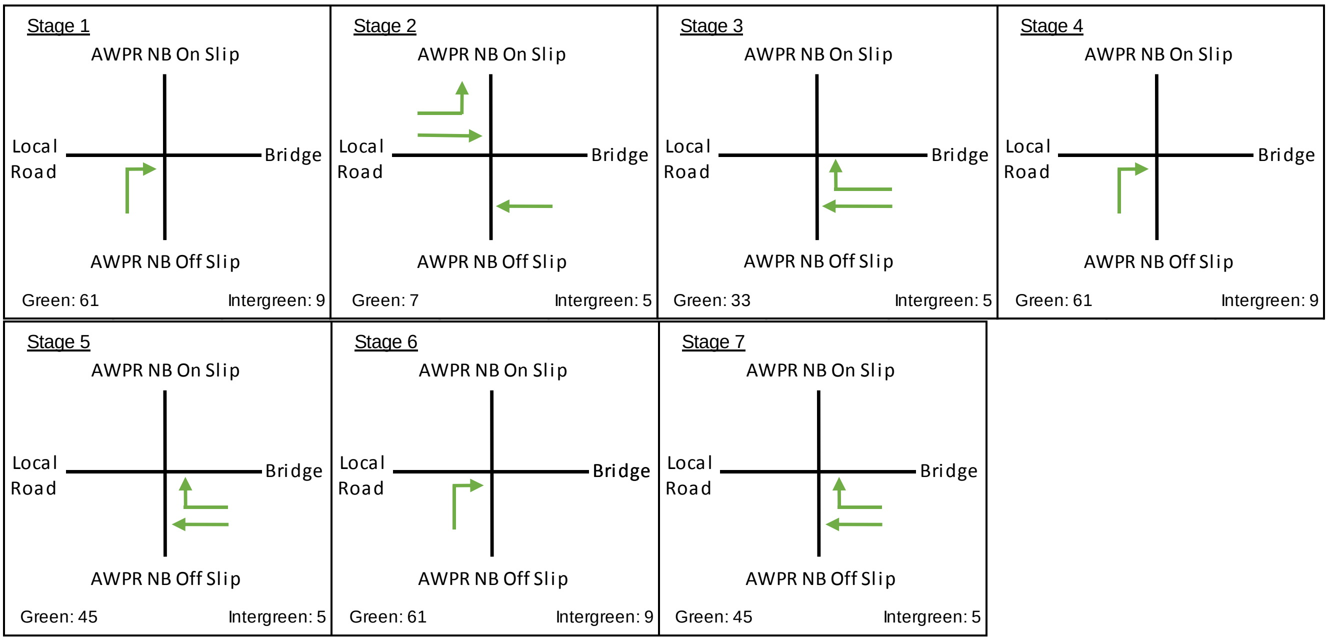


Figure 95 – PM Signal Timings – AWPR Junction

In the PM peak, the signal configuration in the model has been triple cycled:

- Stages 1,2 and 3 represent cycle one;
- Stage 4 and 5 represent cycle two;
- Stage 6 and 7 represent cycle three.

The reason for this is the very low flow from the ‘Local Road’ access at the west junction; during the PM peak it is expected that there will be 2 trips only and so to provide a stage every cycle for these trips is considered inefficient. With this in mind, stage 2 has been included to facilitate this movement but is called only once every 3 cycles.

East Junction

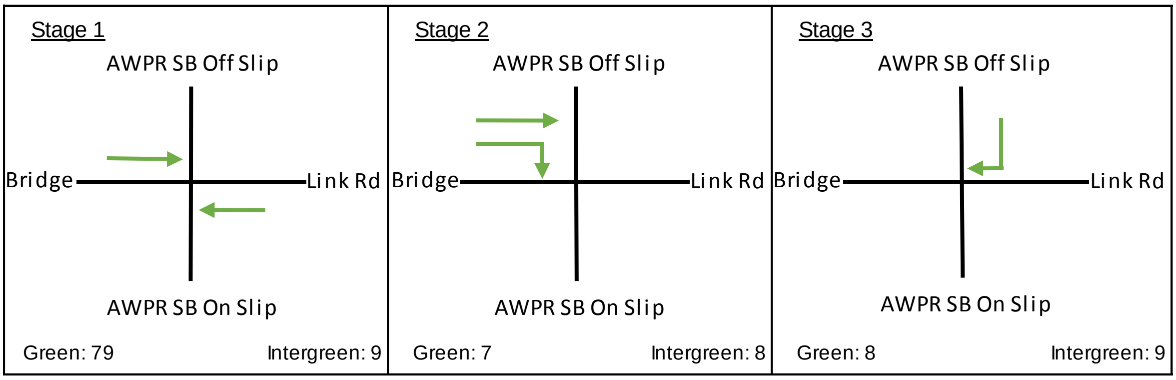


Figure 96 – PM Signal Timings – AWPR Junction

9.3 Key Junction Turning Movements

The modelled turning movements forecast to pass through the AWPR and A96 junctions have been extracted from the relevant Paramics models. Figure 97 shows the AM peak hour turning movements.

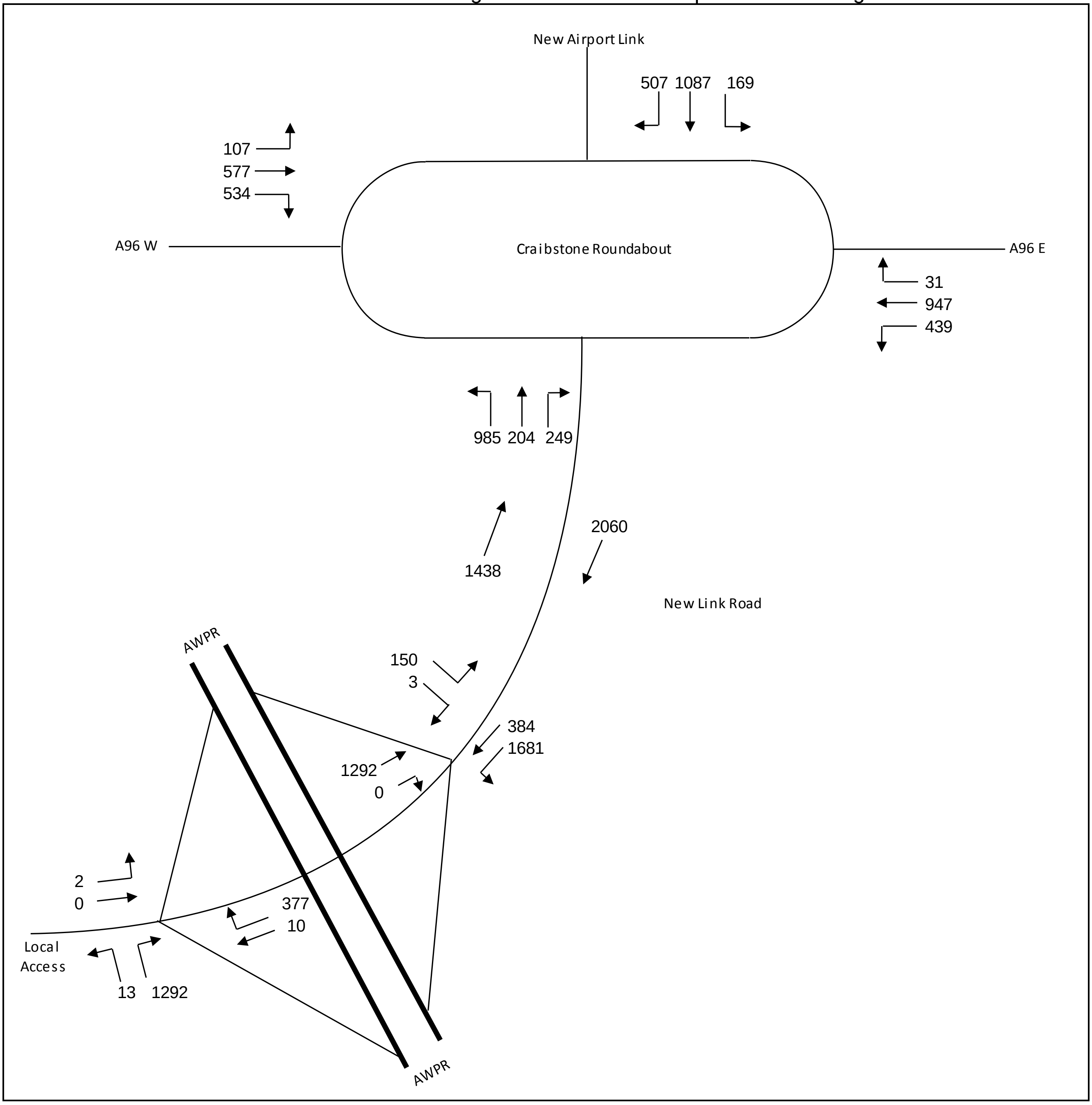


Figure 98 shows the PM peak turning movements occurring in each peak hour

As each Paramics model simulation run is different, the results are based on an average of ten model runs, as are all the further model statistics presented in this section. This ensures that the model results are representative of the junction operation and are not unduly influenced by a particularly free-flowing or particularly congested simulation run.

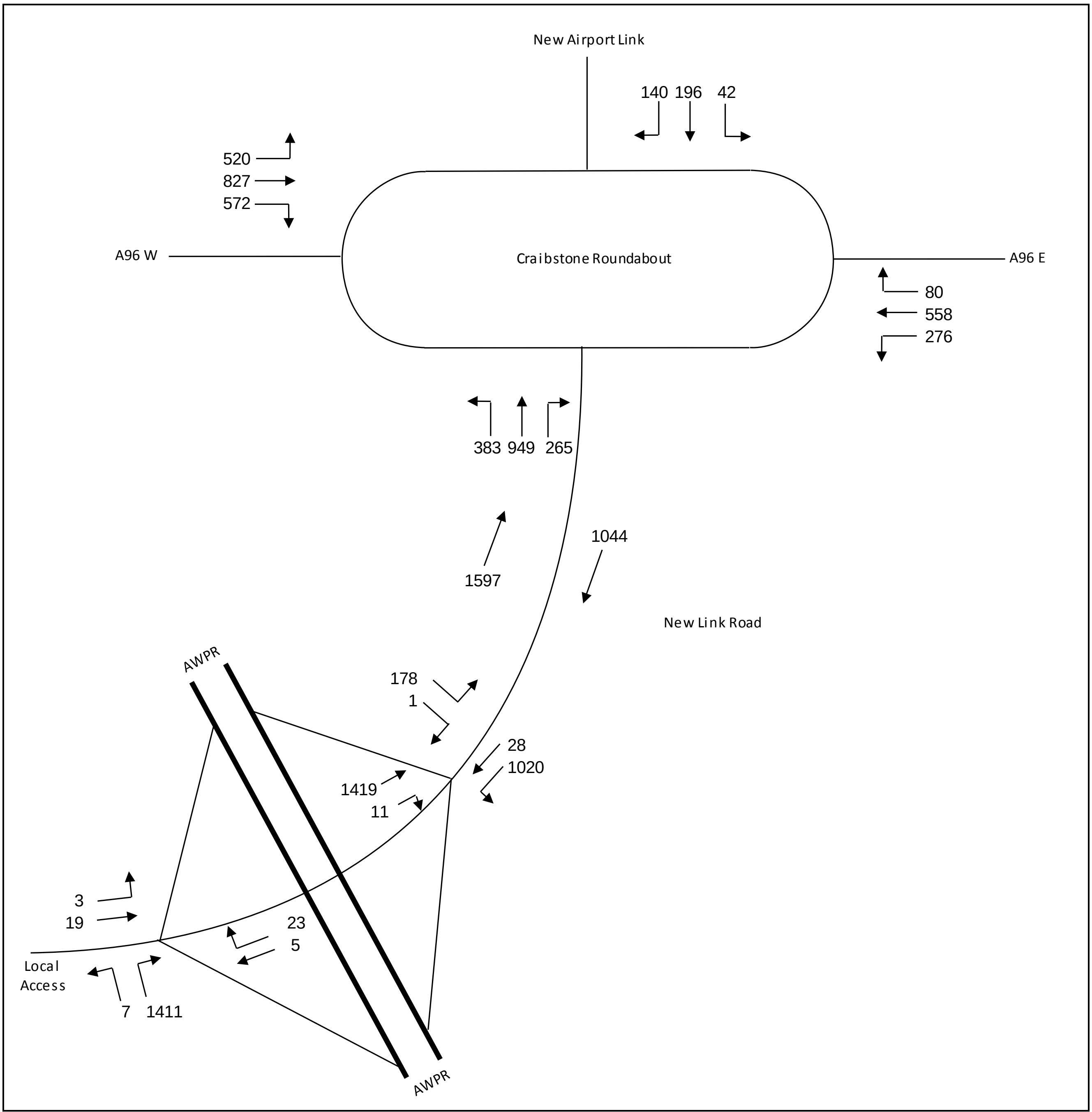


Figure 97 - AM Turning Movements

Figure 97 shows that during the AM peak the main traffic movements are travelling from the AWPR South (via the northbound diverge) passing through both junctions and toward the Airport area, that includes the new developments on the north side of the A96, Kirkhill Industrial Estate and the Airport itself. There are also significant levels of demand travelling straight through the A96 junction from the A96 West towards Aberdeen and the city's northern areas.

The figures also show significant flows accessing the AWPR South (via the southbound merge) the majority of which originates from the A96 West, the Airport development area and the A96 East. There is also a reasonably significant level of traffic travelling from the A96 West towards the Airport development area.

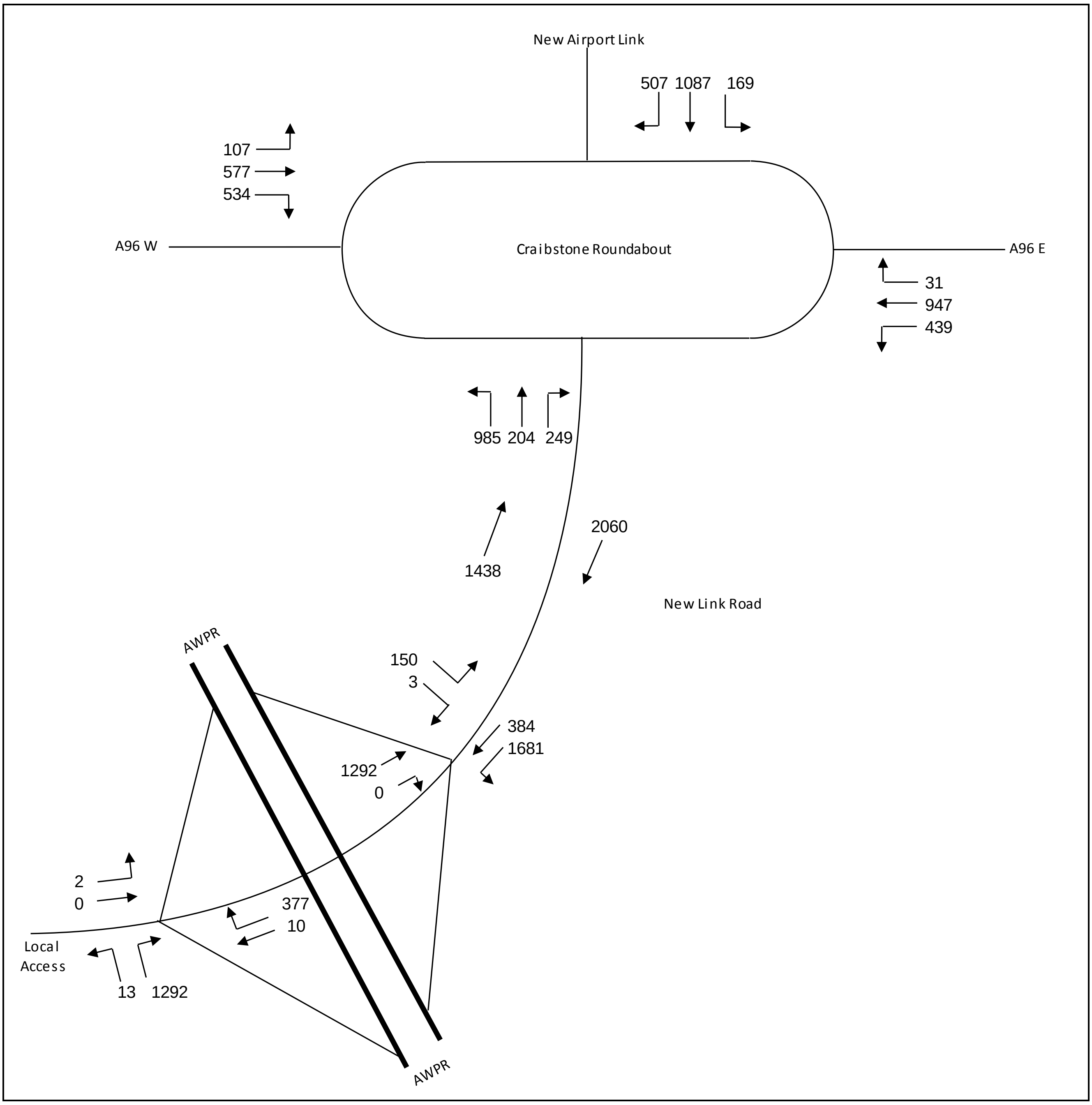


Figure 98 - PM Turning Movements

During the PM peak, the pattern of key movements passing through the junctions is generally the reverse of the AM peak pattern. The main PM peak flows are travelling from the Airport development area (the new developments north of the A96, Kirkhill Industrial Estate and the Airport itself) to the AWPR South via the southbound merge. Similarly, the figures show the high levels of westbound demand travelling straight through the A96 junction from the A96 East to the A96 West.

The figures also show there are significant levels of demand travelling from the AWPR South via the northbound diverge to the A96 West. There are also reasonably significant traffic flows travelling from the A96 East, the A96 West and the Airport development area to the AWPR North and South.

9.4 Vehicle Speeds

The average journey speed was derived for the AM and PM peak modelled periods in order to illustrate the overall network performance. A consistent downward trend in the average network speeds would indicate that the simulation experiences increasing levels of delay as the operational performance deteriorates over time.

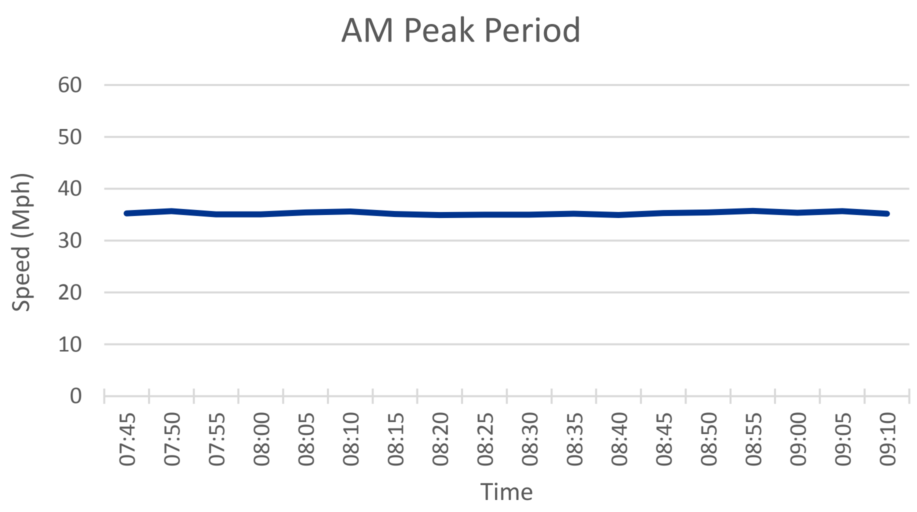


Figure 99 – AM Vehicle Speeds

Figure 99 shows the AM peak average speed analysis results throughout the duration of the modelled period. The figure shows that during the AM peak period the model shows consistent speeds (around 35mph) throughout the modelled period. The speed is relatively low but this is expected given the nature of the modelled network predominantly consists of roads with lower speed limits applied (30mph or 40mph).

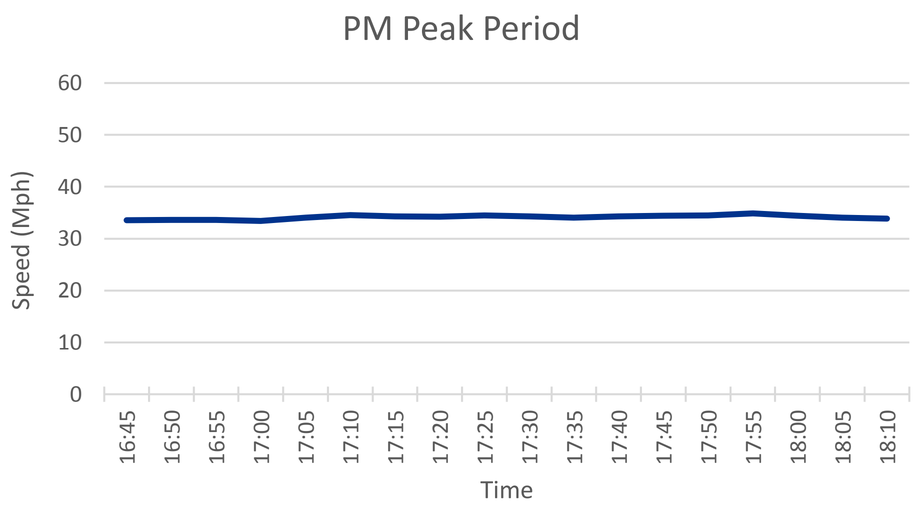


Figure 100 – PM Vehicle Speeds

Figure 100 shows results that for the PM peak, average speeds remain consistent throughout the modelled period (at around 35mph). Again, the speed is relatively low but this is again due to the modelled network predominantly consisting of roads with lower speed limits applied (30mph or 40mph).

9.5 Queue Length Data

Queuing Analysis

The default Paramics Queue Recognition definitions have been applied to record and collect the queuing data during each model simulation run. The only adjustment made was to change the method of Multiple Queues reporting to the 'Propagate the last queue to end' option, such that all vehicles from the end of the last queue on the link to the end of the link are considered and reported as a single queue.

As a result the absolute queue lengths reported in the analyses include gaps between vehicles, as the vehicle speed and the gap to the vehicle in front are both used to determine the thresholds below which a vehicle is considered to be in a queued state. Therefore the queue lengths reported do not necessarily represent a continuous queue of vehicles, but serve to illustrate the maximum possible extent of the level of queuing on each approach.

Figure 101 shows the routes over which the queue lengths were calculated.

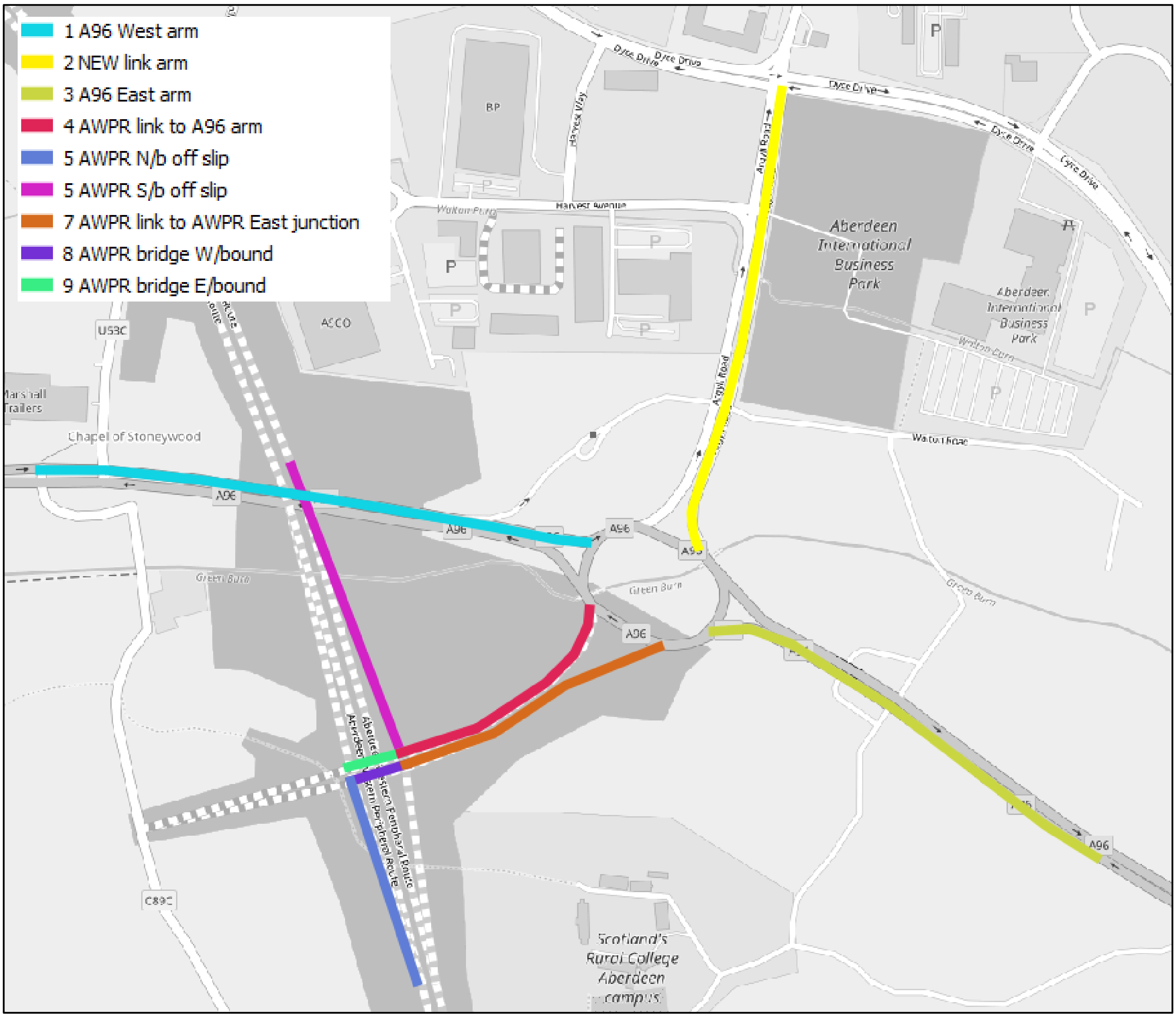


Figure 101 - Queue Routes

Route	Lane	0700-0800 Max Q	0700-0800 95% CI		0800-0900 Max Q	0800-0900 95% CI		0900-1000 Max Q	0900-1000 95% CI	
"1 A96 West arm"	1	74	72	76	75	73	77	73	71	74
"1 A96 West arm"	2	185	179	191	203	196	210	117	115	120
"1 A96 West arm"	3	220	213	227	215	208	221	132	129	135
"2 NEW link arm"	1	90	88	92	81	79	82	79	77	80
"2 NEW link arm"	2	85	83	87	82	81	84	70	69	72
"2 NEW link arm"	3	-	-	-	-	-	-	-	-	-
"3 A96 East arm"	1	120	117	123	149	146	152	94	92	96
"3 A96 East arm"	2	133	130	136	138	135	141	125	123	128
"3 A96 East arm"	3	130	127	133	166	163	169	100	98	102
"4 AWPR link to A96 arm"	1	66	65	67	88	86	90	83	81	85
"4 AWPR link to A96 arm"	2	74	72	75	185	182	188	97	94	99
"4 AWPR link to A96 arm"	3	105	103	108	166	161	171	137	134	141
"5 AWPR N/b off slip"	1	102	100	105	102	100	104	94	92	97
"5 AWPR N/b off slip"	2	240	236	245	238	233	243	83	81	86
"5 AWPR N/b off slip"	3	-	-	-	-	-	-	-	-	-
"6 AWPR S/b off slip"	1	80	79	82	76	75	77	67	66	69
"6 AWPR S/b off slip"	2	62	61	62	71	70	72	65	64	66
"6 AWPR S/b off slip"	3	-	-	-	-	-	-	-	-	-
"7 AWPR link to AWPR East jun	1	32	29	34	39	35	44	26	25	28
"7 AWPR link to AWPR East jun	2	30	-	-	31	17	44	-	-	-
"7 AWPR link to AWPR East jun	3	-	-	-	-	-	-	-	-	-
"8 AWPR bridge W/bound"	1	26	-	-	31	28	33	29	27	31
"8 AWPR bridge W/bound"	2	48	46	49	41	40	42	42	40	44
"8 AWPR bridge W/bound"	3	-	-	-	-	-	-	-	-	-
"9 AWPR bridge E/bound"	1	-	-	-	17	17	18	73	36	110
"9 AWPR bridge E/bound"	2	35	25	45	41	34	49	-	-	-
"9 AWPR bridge E/bound"	3	25	-	-	23	-	-	-	-	-

Table 13 - AM Max Queue Lengths

Table 13 shows the results of AM peak period queuing analysis. The tables show that in the AM peak the AWPR NB off slip exhibits the highest levels of queuing, with a recorded queue length of 240 metres (equating to around 40 car lengths).

The Craibstone junction also shows some longer queue lengths on its west, south and east approaches (220m, 185m and 166m respectively). These queues are a result of the high volume of traffic travelling on the A96 to\from Aberdeen City and travelling either via the A96 or the AWPR.

To help illustrate the extent of the queuing, which does not necessarily occur simultaneously on all approaches, the schematic representations shown in Figure 102 has been produced.

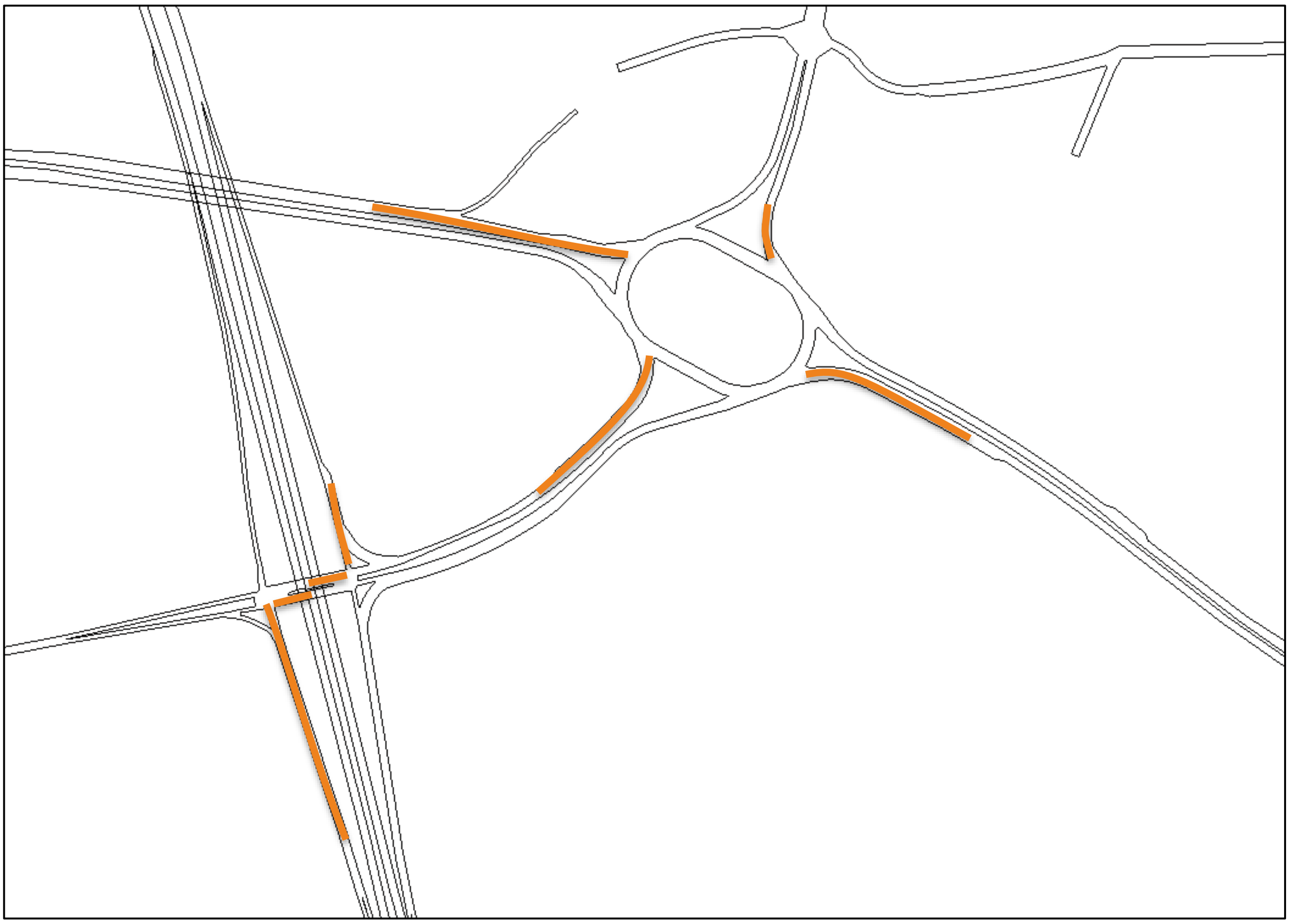


Figure 102 – AM Max Queue Length Diagram

Route	Lane	1600-1700			1700-1800			1800-1900		
		Max Q	95% CI		Max Q	95% CI		Max Q	95% CI	
"1 A96 West arm"	1	71	70	72	70	68	71	48	47	49
"1 A96 West arm"	2	167	163	172	116	113	119	102	100	104
"1 A96 West arm"	3	231	222	239	156	152	159	116	114	119
"2 NEW link arm"	1	145	141	149	221	216	225	142	138	146
"2 NEW link arm"	2	239	234	245	221	216	225	184	179	189
"2 NEW link arm"	3	-	-	-	-	-	-	-	-	-
"3 A96 East arm"	1	148	145	152	146	143	149	136	133	139
"3 A96 East arm"	2	200	196	205	149	147	152	139	136	142
"3 A96 East arm"	3	186	181	191	165	162	168	146	143	150
"4 AWPR link to A96 arm"	1	97	94	99	131	127	134	145	142	149
"4 AWPR link to A96 arm"	2	182	178	186	199	195	202	166	162	170
"4 AWPR link to A96 arm"	3	132	128	135	163	158	167	151	147	155
"5 AWPR N/b off slip"	1	120	118	123	138	135	140	111	108	113
"5 AWPR N/b off slip"	2	126	123	128	227	223	231	126	123	128
"5 AWPR N/b off slip"	3	-	-	-	-	-	-	-	-	-
"6 AWPR S/b off slip"	1	65	64	67	78	77	79	65	64	66
"6 AWPR S/b off slip"	2	66	65	67	65	64	66	57	56	58
"6 AWPR S/b off slip"	3	-	-	-	-	-	-	-	-	-
"7 AWPR link to AWPR East jun	1	145	140	151	185	181	190	178	173	184
"7 AWPR link to AWPR East jun	2	90	86	93	74	72	76	91	87	94
"7 AWPR link to AWPR East jun	3	13	-	-	91	87	96	101	96	107
"8 AWPR bridge W/bound"	1	30	-	-	-	-	-	-	-	-
"8 AWPR bridge W/bound"	2	78	76	80	97	95	99	95	93	98
"8 AWPR bridge W/bound"	3	-	-	-	-	-	-	-	-	-
"9 AWPR bridge E/bound"	1	37	35	38	54	52	56	32	31	32
"9 AWPR bridge E/bound"	2	37	35	38	74	71	77	30	29	31
"9 AWPR bridge E/bound"	3	-	-	-	-	-	-	-	-	-

Table 14 - PM Max Queue Lengths

Table 14 shows the results of PM peak period queuing analysis; it shows that the longest queue during the PM peak is on the new link arm (239m or approximately 40 vehicles). Similarly to the AM peak, some queuing does occur on the remaining three approaches to the Craibstone roundabout (west 231m, south 199m, east 200m) which is a result of the high volume of traffic using the A96 to travel between the AWPR, the Airport development area and the A96 to\from Aberdeen City.

Finally, there is also a queue of approximately 227m (approximately 38 vehicles) on the AWPR NB off slip.

Again, to help illustrate the extent of the queuing, which does not necessarily occur simultaneously on all approaches, the schematic representations shown in Figure 103 has been produced.

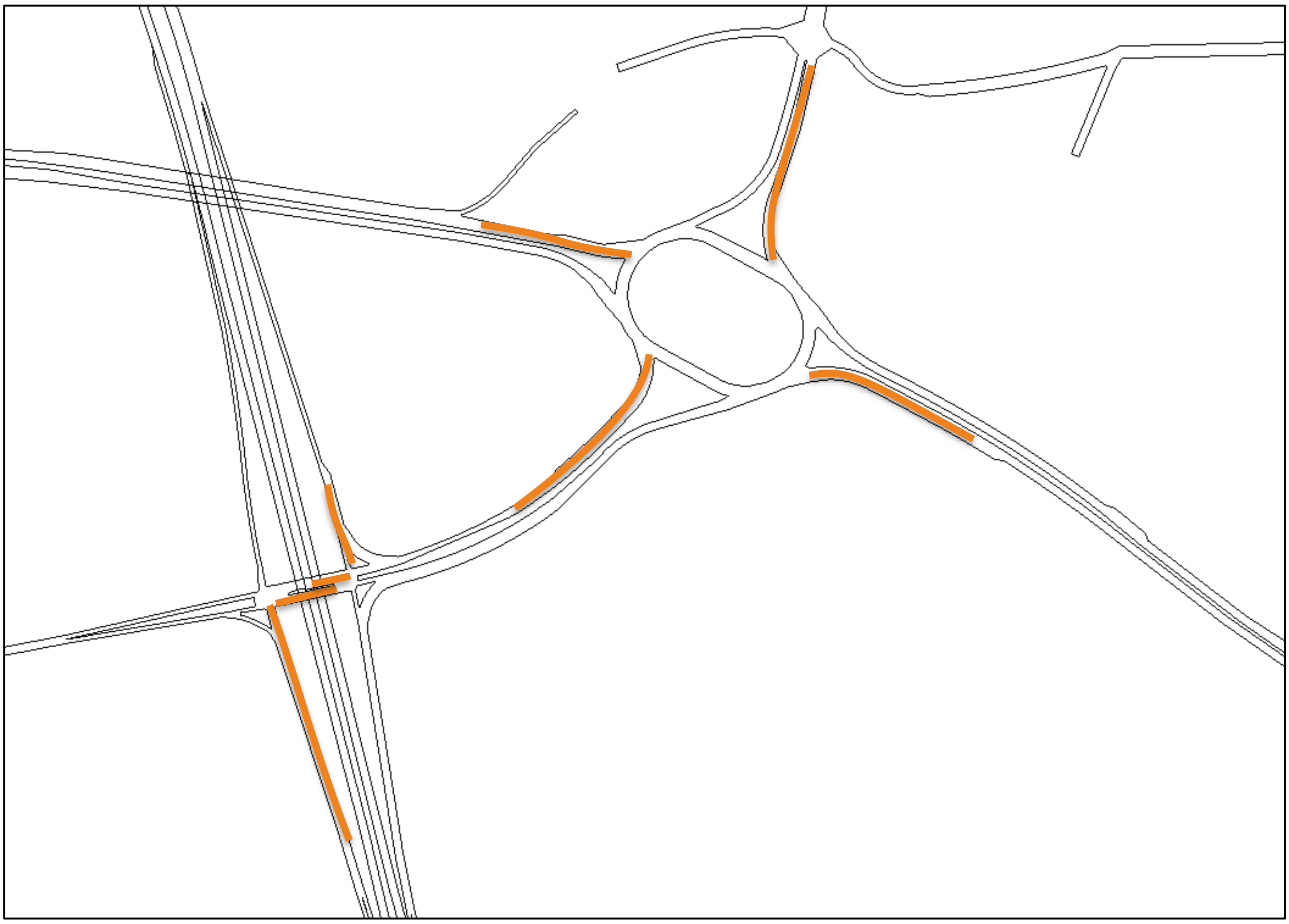


Figure 103 – PM Max Queue Length Diagram

Queue Length Distributions

Figure 104 and Figure 105 show the queue length distributions for the AM and PM peak periods respectively.

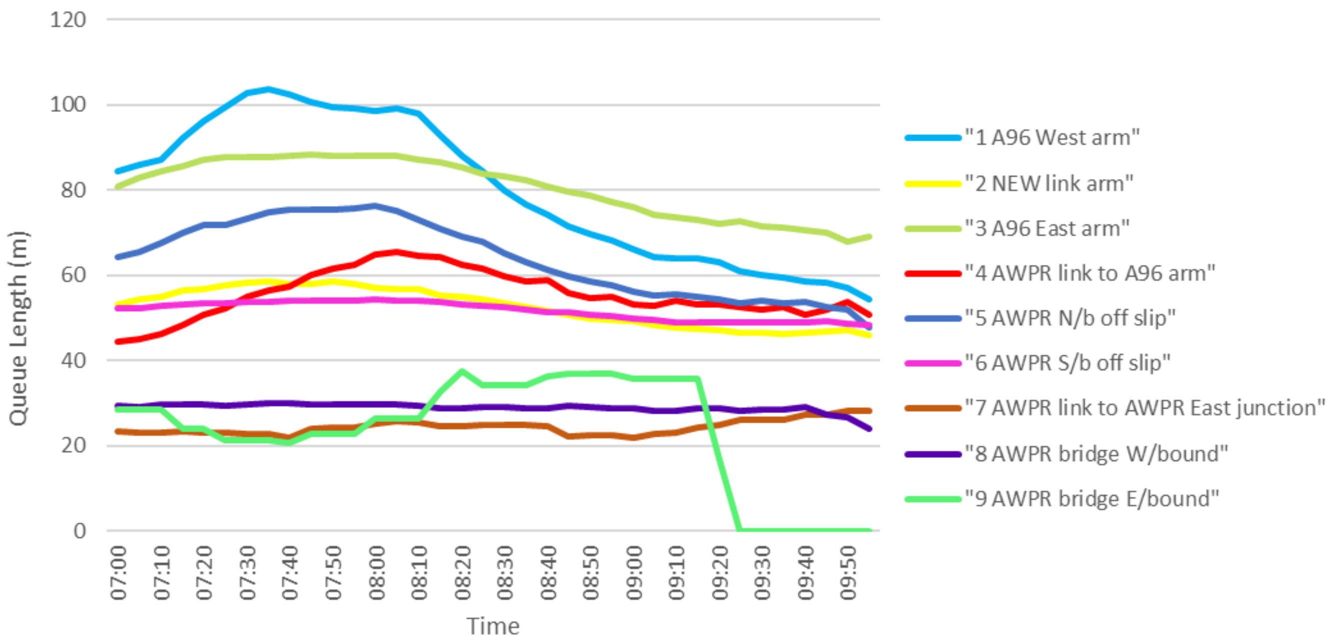


Figure 104 – AM Average Max Queue Length Distribution

During the AM peak, queueing occurs on the south (4 AWPR link to A96 arm), the east (3 A96 east arm) and the west (1 A96 West arm) approaches to the Craibstone roundabout. Over the course of the AM peak period, these routes show higher levels of variation as queues develop on the junctions approaches; queue lengths are longer during the period 07:20 to 08:20 but begin to reduce to shorter lengths after that time.

The queue on the AWPR NB off slip shows a similar queue length distribution with longer queue lengths occurring earlier in the period. The route “9 AWPR bridge E/bound” shows fluctuating queue lengths throughout the duration of the AM peak which is explained by the proximity of the signal sets located at the end of each of the AWPR off slips. By 09:20 these queues have gone.

All other routes show queue lengths that are consistently short (5-6 vehicles in length) for the duration of the AM peak period.

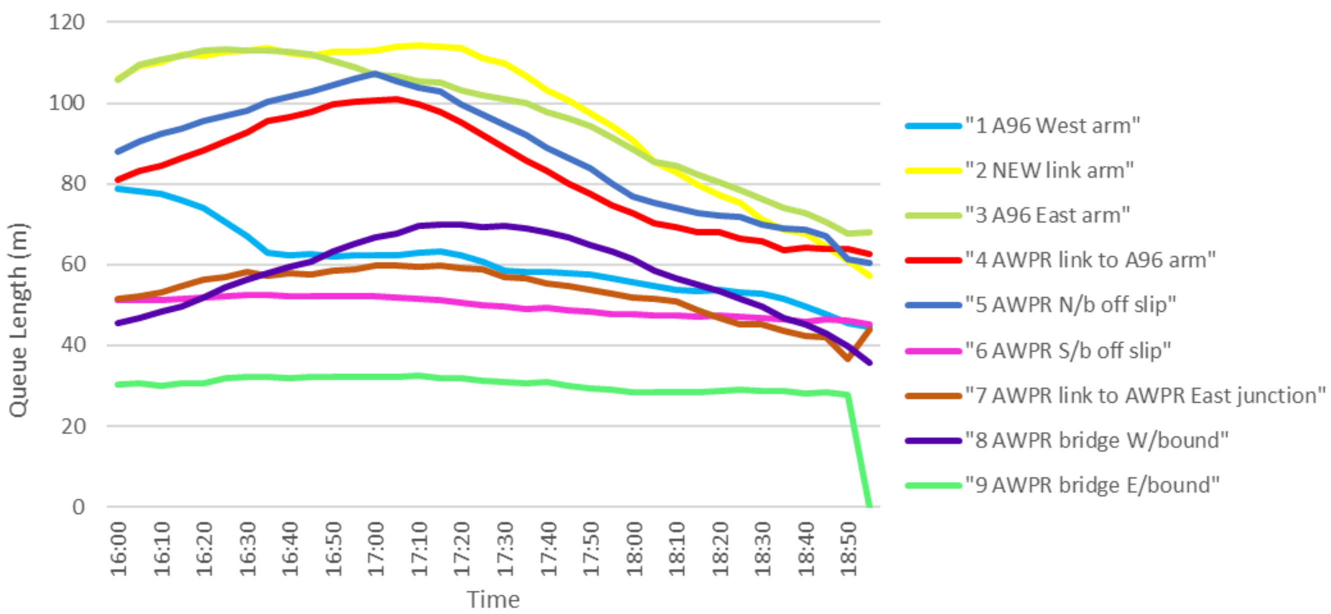


Figure 105 – PM Average Max Queue Length Distribution

During the PM peak, the north (2 NEW link) and the east (3 A96 east) arms show similar trends; queue lengths are typically longer between the period 16:10 to 17:30 with relatively shorter lengths outside of this peak hour.

For the south approach to Craibstone roundabout (4 AWPR link to A96 arm), the longest queues occur between 16:30 and 17:30 with queue lengths dropping steadily until 19:00. The AWPR NB off slip shows a similar trend but at a later time in the PM peak (17:00-17:30).

By the end of the peak period the queues on the “9 AWPR bridge E/bound” approach have gone.

All other routes show queue lengths that are consistently short (6-12 vehicles in length) for the duration of the PM peak period.

9.6 Journey Time Data

The following movements were considered in the journey time analysis:

- Route 1 A96 West to AWPR North
- Route 2 A96 West to new airport link
- Route 3 A96 West to A96 East
- Route 4 A96 West to AWPR South
- Route 5 New airport link to A96 East
- Route 6 New airport link to AWPR South
- Route 7 New airport link to A96 West
- Route 8 New airport link to AWPR North
- Route 9 A96 East to AWPR South

- Route 10 A96 East to A96 West
- Route 11 A96 East to AWPR North
- Route 12 A96 East to new airport link
- Route 13 AWPR South to A96 West
- Route 14 AWPR South to new airport link
- Route 15 AWPR South to A96 East
- Route 16 AWPR North to new airport link
- Route 17 AWPR North to A96 East
- Route 18 AWPR North to A96 West

Figure 106 illustrates the journey time routes that were defined for the journey time analysis.

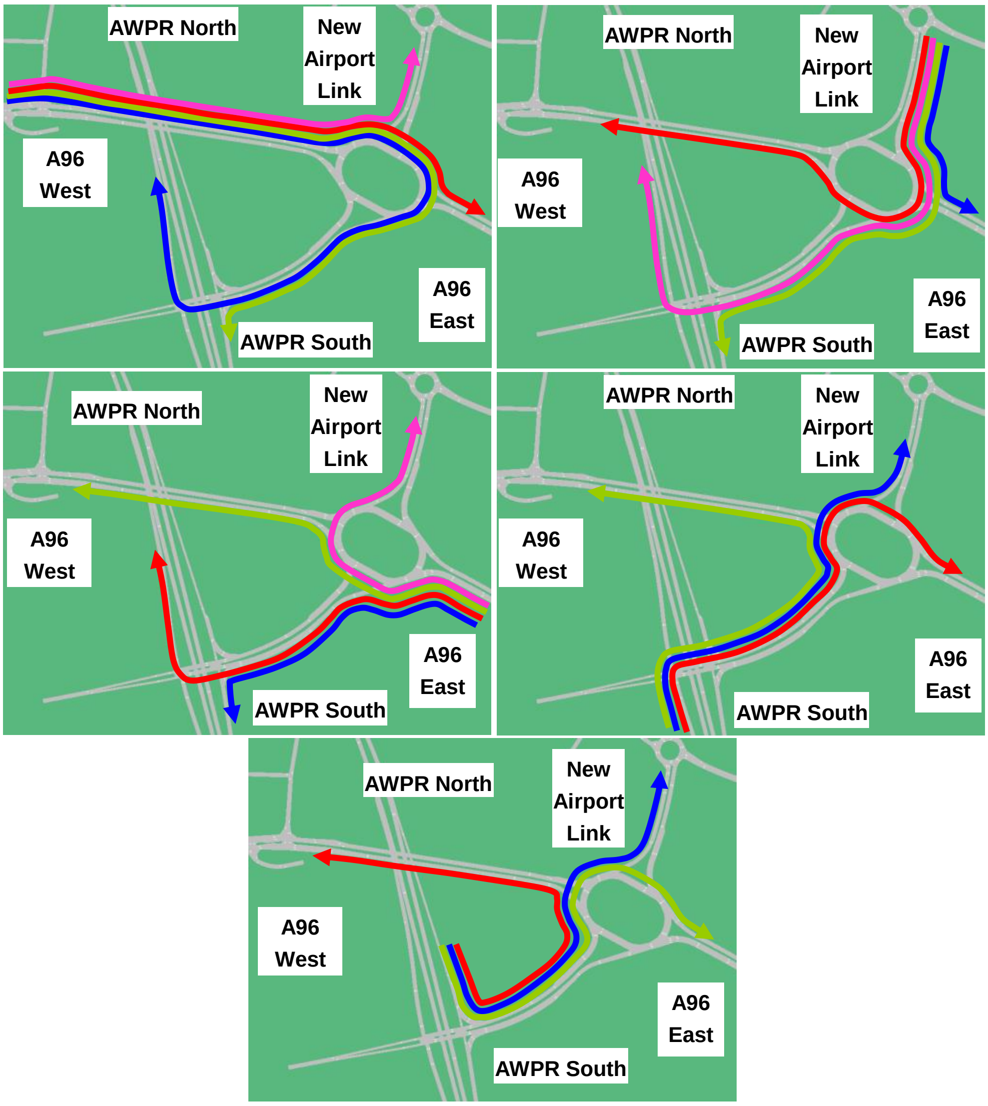


Figure 106 – Journey Time Routes

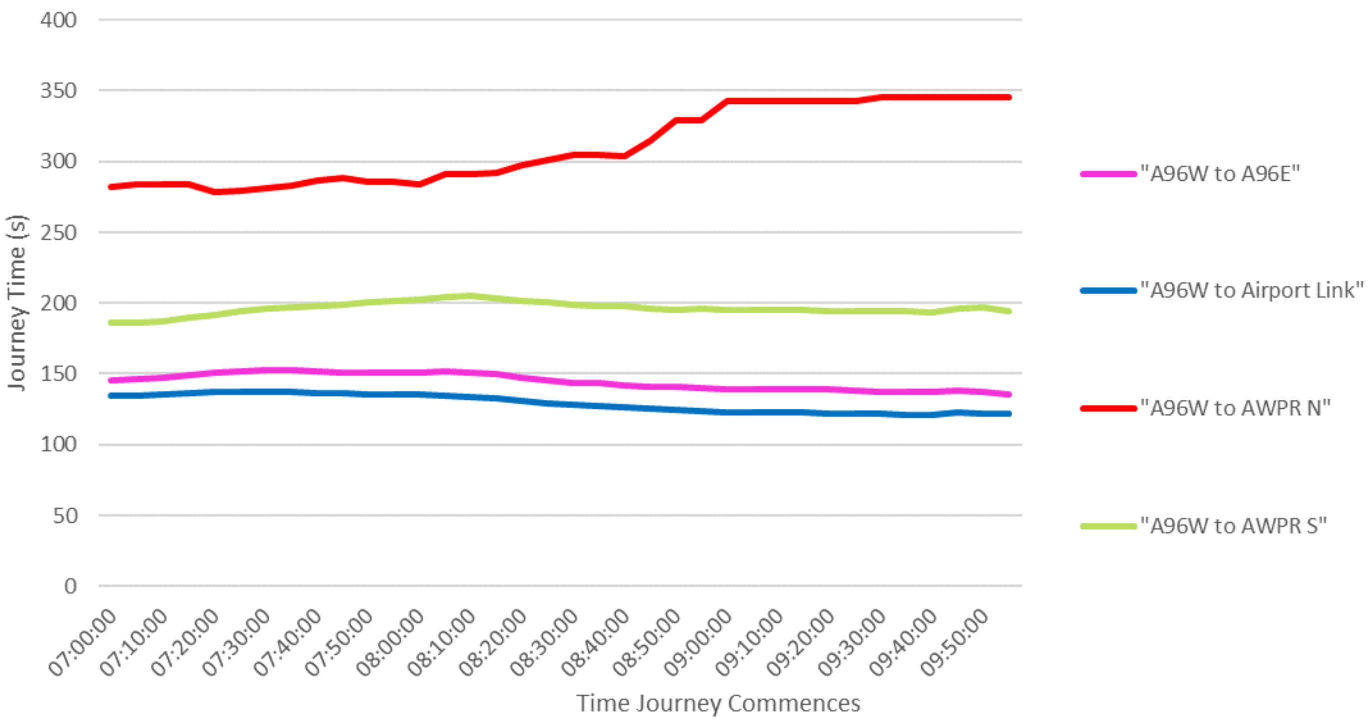


Figure 107 – AM Journey Time Data (Routes from the A96W)

Journey times for routes from the A96 West to the A96 East, AWPR N and to the Airport Link Road are consistent throughout the modelled period. Journey times to the AWPR north increase throughout the peak period by approximately 70 seconds however as a very low number of trips make that movement the journey times are considered acceptable.

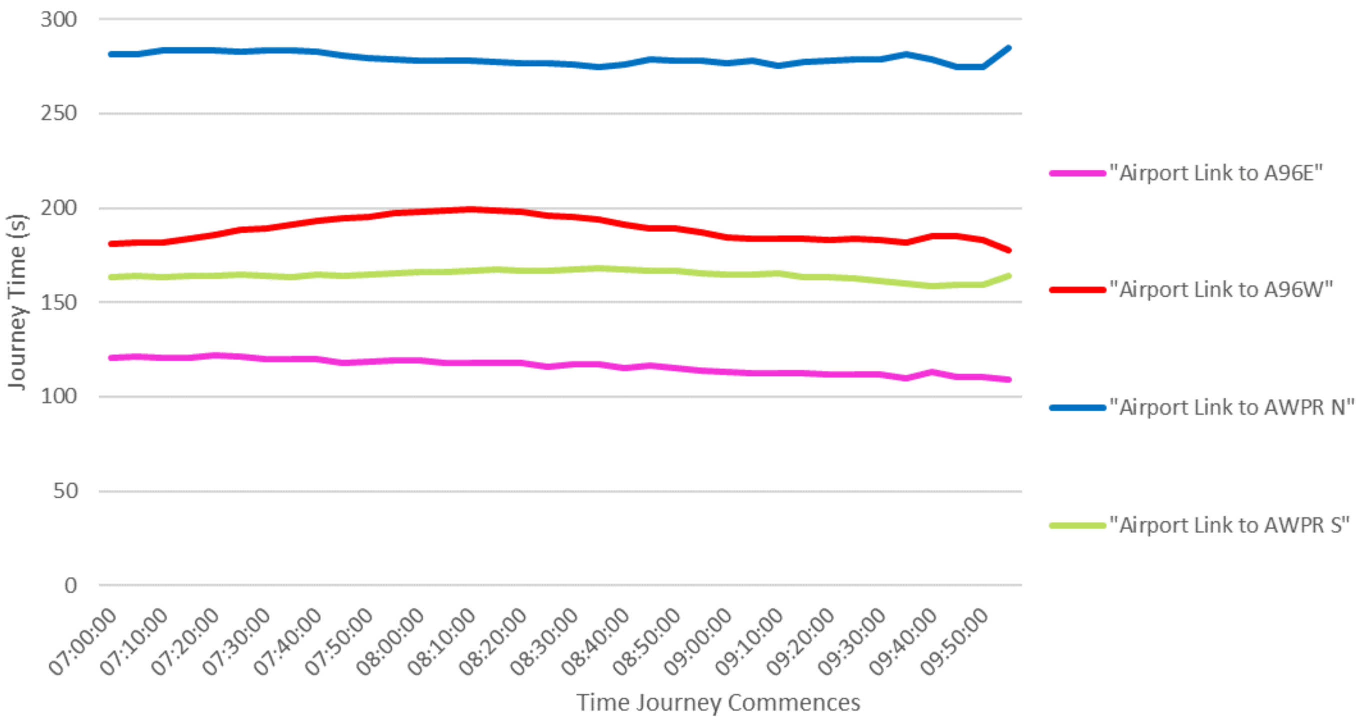


Figure 108 – AM Journey Time Data (Routes from the Airport Link Road)

For routes from the Airport Link to all other destinations, journey times are consistent throughout the modelled peak period. Journey times between the Airport Link Road and the A96 West does show a minor variation of approximately 20 seconds at most but generally remains consistent.

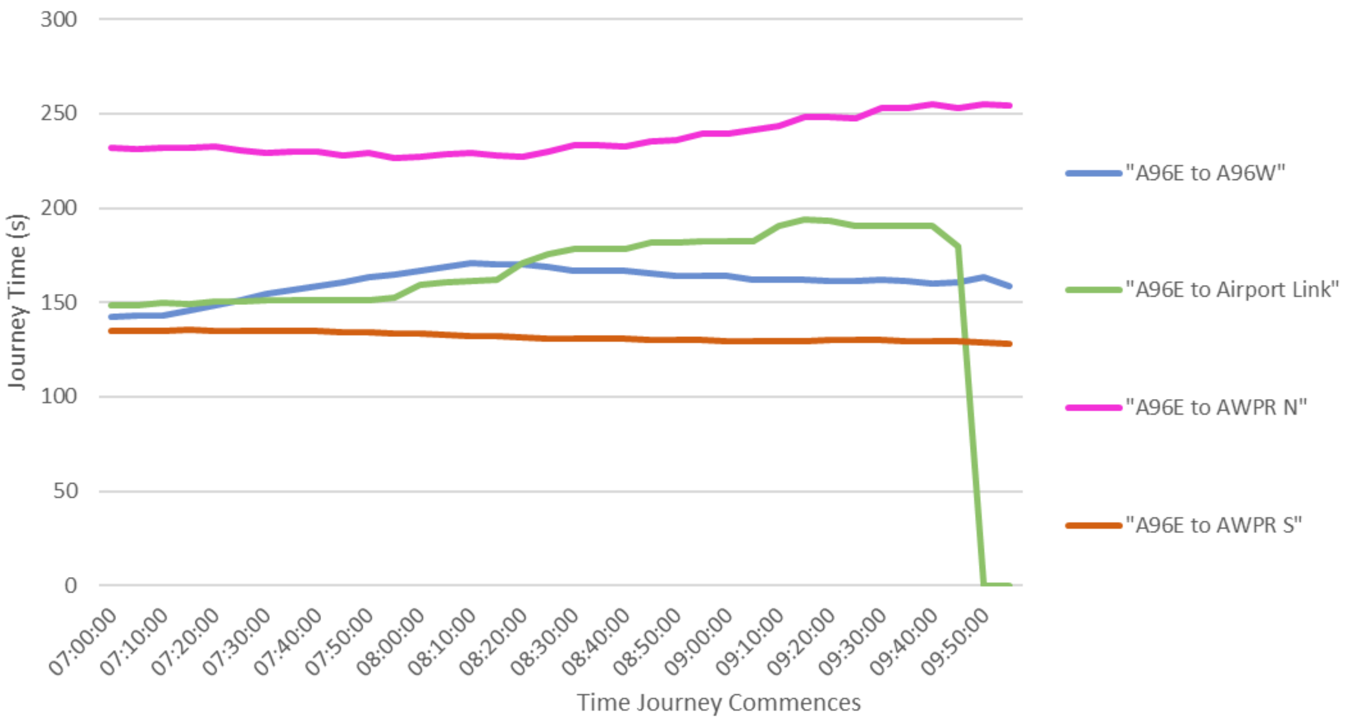


Figure 109 – AM Journey Time Data (Routes from the A96E)

It should be noted that variations toward the end of the period are a result of the average journey times recorded being informed by fewer trips. As a result, journey times show a greater level of variability (or where there are no trips making a manoeuvre resulting in a '0' value being reported; this is true of the "A96E to Airport Link" route for example). Trips heading to the A96W show an increase in journey times until approximately 08:10 after which journey times remain fairly consistent until the end of the peak period.

For journeys from the A96E, journey times to the Airport Link Road generally increase throughout the modelled period (by up to 40 seconds).

Journeys to the AWPR North and South are generally consistent until approximately 08:20. After this time, journey times to the AWPR north increase by approximately 20 seconds. Trips to the AWPR south are reasonably consistent through the peak period with limited variation of up to approximately 10 seconds at a maximum.

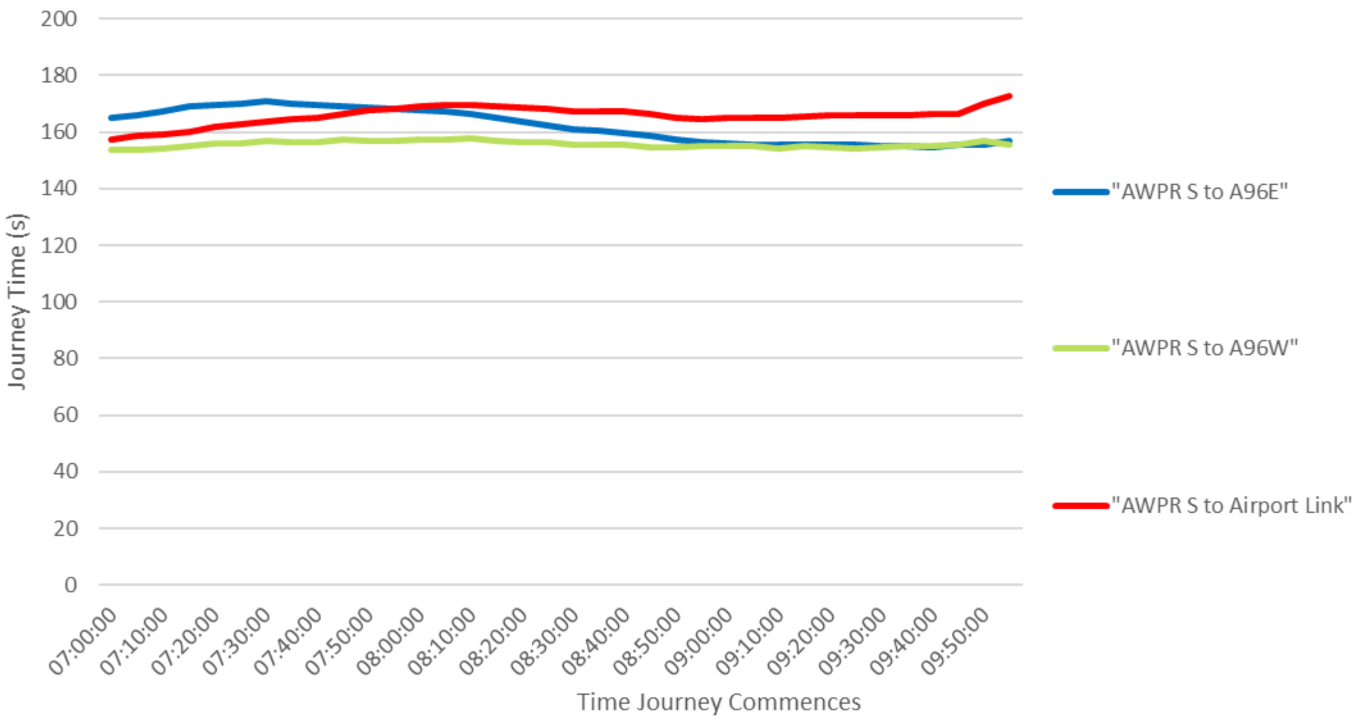


Figure 110 – AM Journey Time Data (Routes from the AWPR South)

For routes from the AWPR south to all other destinations, journey times are generally consistent throughout the modelled peak period.

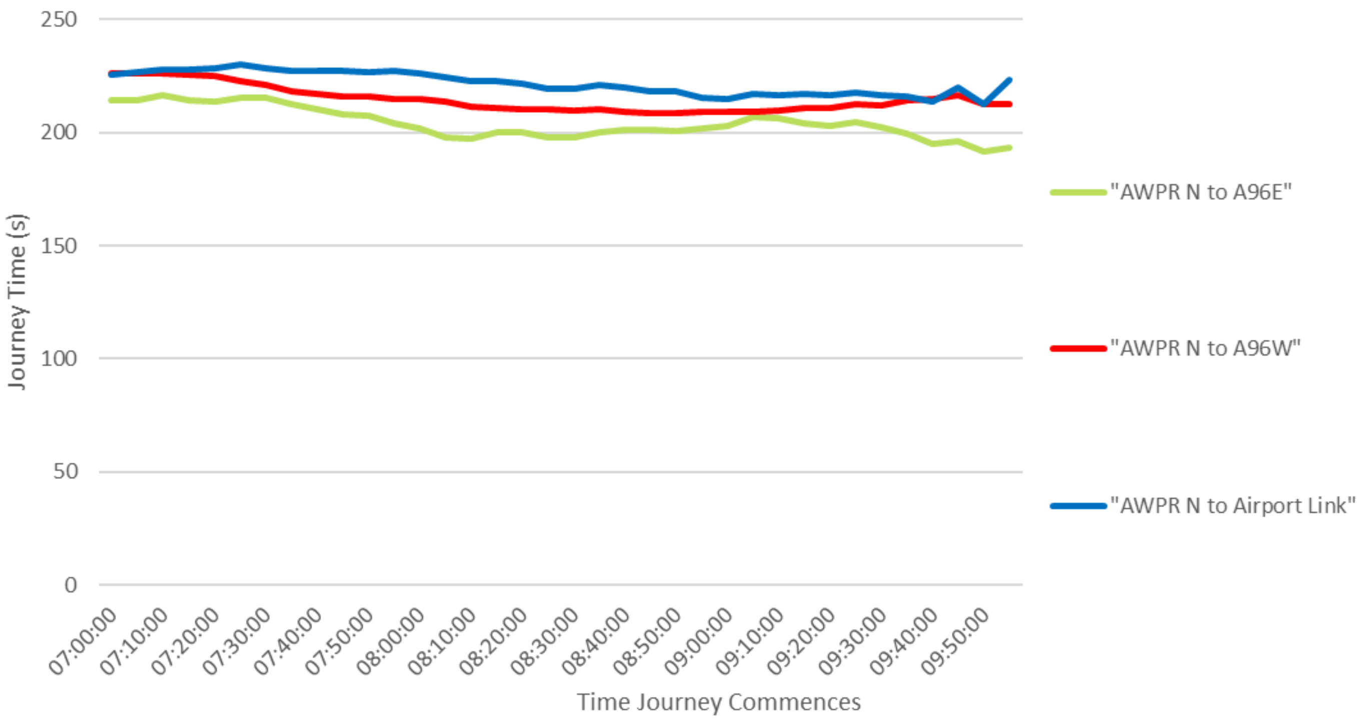


Figure 111 – AM Journey Time Data (Routes from the AWPR North)

For routes from the AWPR North to all other destinations, journey times are reasonably consistent throughout the modelled peak period showing a limited level of variation of up to approximately 10 seconds.

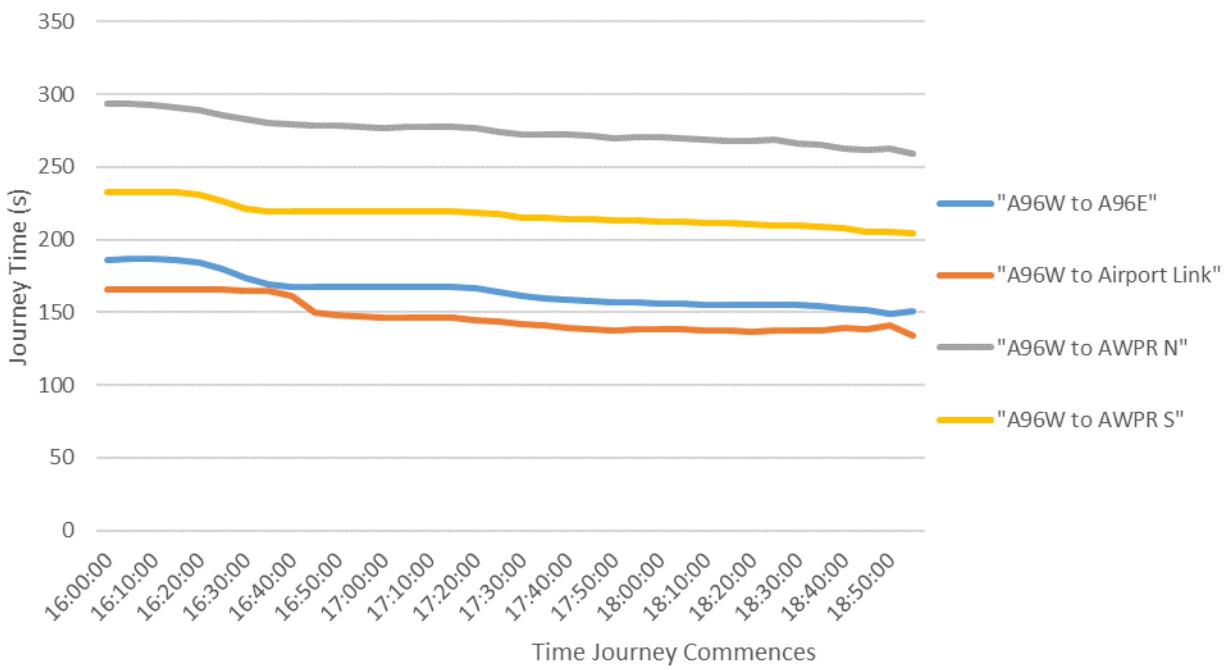


Figure 112 – PM Journey Time Data (Routes from the A96W)

For routes from the A96 West to all other destinations, journey times show a general trend for declining journey times; journey times at the end of the PM peak period are typically lower than at the start by approximately 20 to 50 seconds.

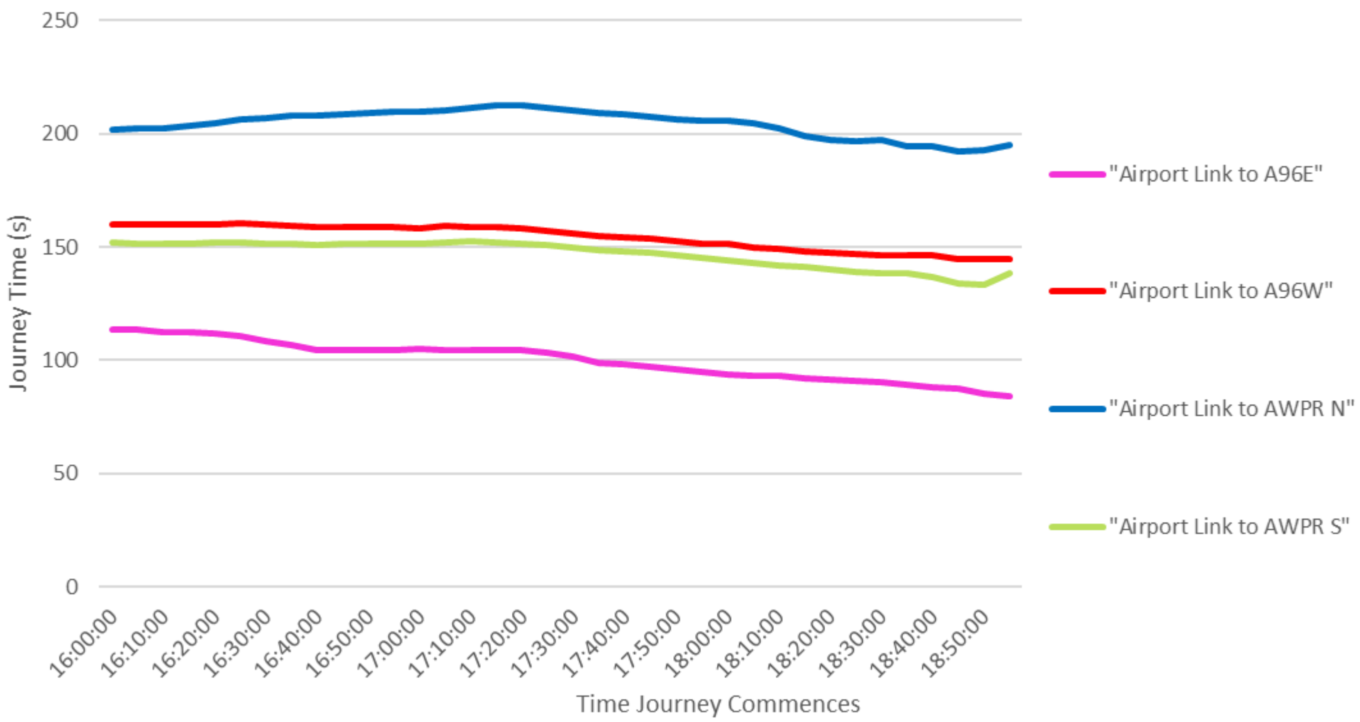


Figure 113 – PM Journey Time Data (Routes from the Airport Link Road)

The route from the Airport Link Road to the A96 East have journey times that show a general declining trend. Journey times at the end of the PM peak period are typically lower than at the start by approximately 10 to 20 seconds.

For all other routes, journey times are generally consistent throughout the modelled period.

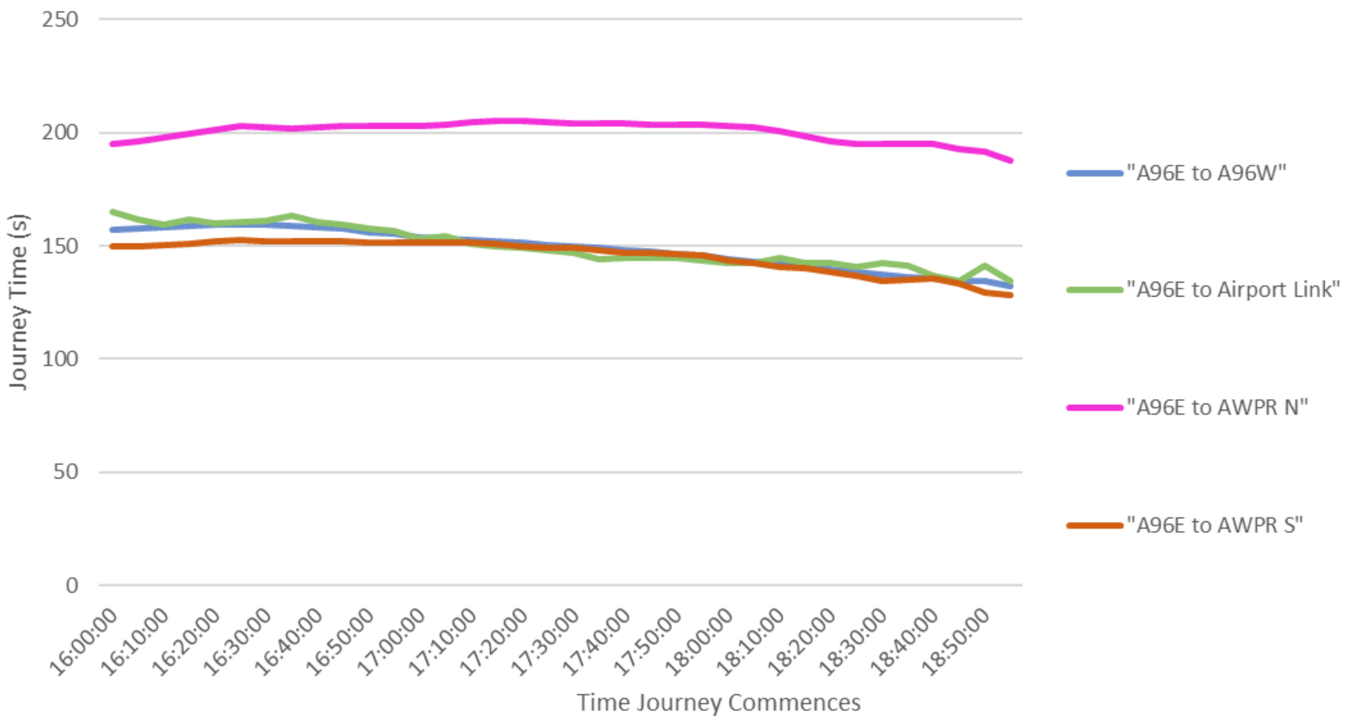


Figure 114 – PM Journey Time Data (Routes from the A96E)

Journey times from the A96 East to the AWPR N are consistent throughout the modelled period; journey times are typically approximately 200s +/-5s at any given time.

The routes from the A96 East to all other destinations have journey times that show a general declining trend; journey times at the end of the PM peak period are typically lower than at the start by approximately 10 to 20 seconds.

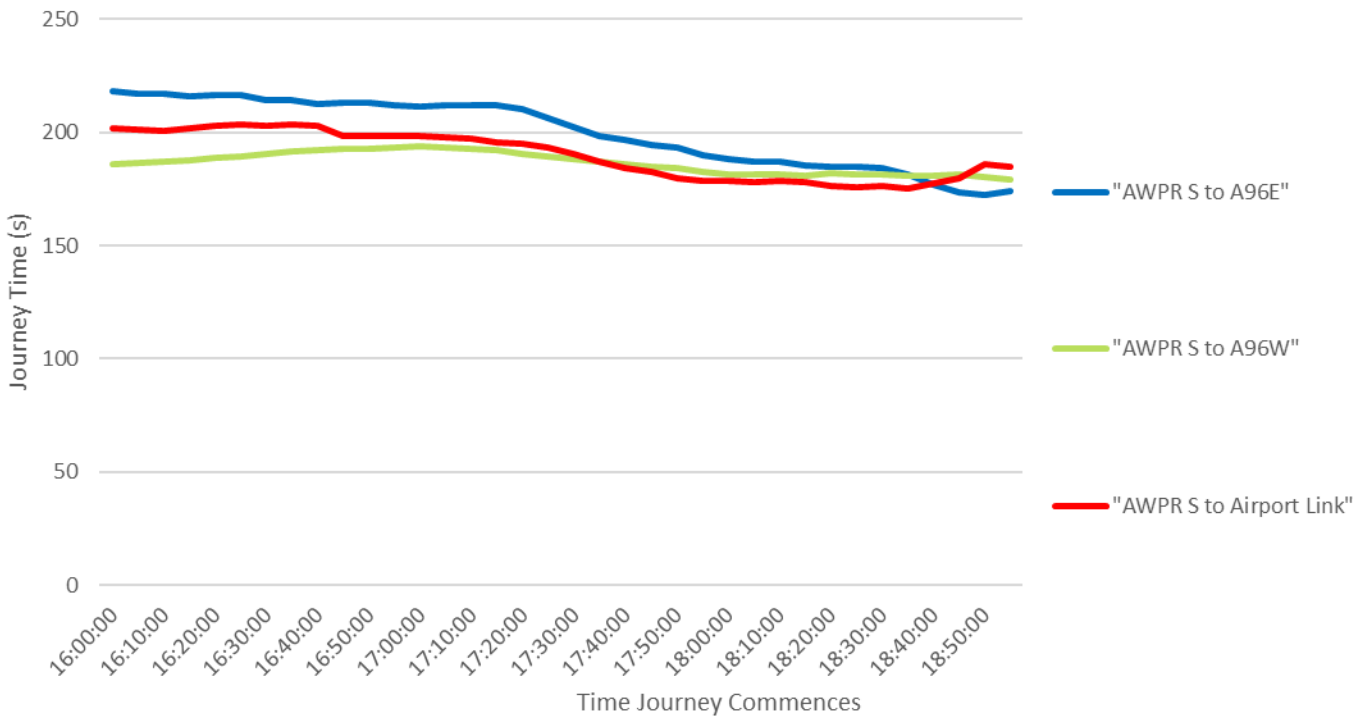


Figure 115 – PM Journey Time Data (Routes from the AWPR South)

With the exception of the AWPR South to North route (which is consistent throughout the PM peak period, journey times for routes from the AWPR North to all other destinations show a general trend for declining journey times; journey times at the end of the PM peak period are typically lower than at the start by approximately 10 to 40 seconds.

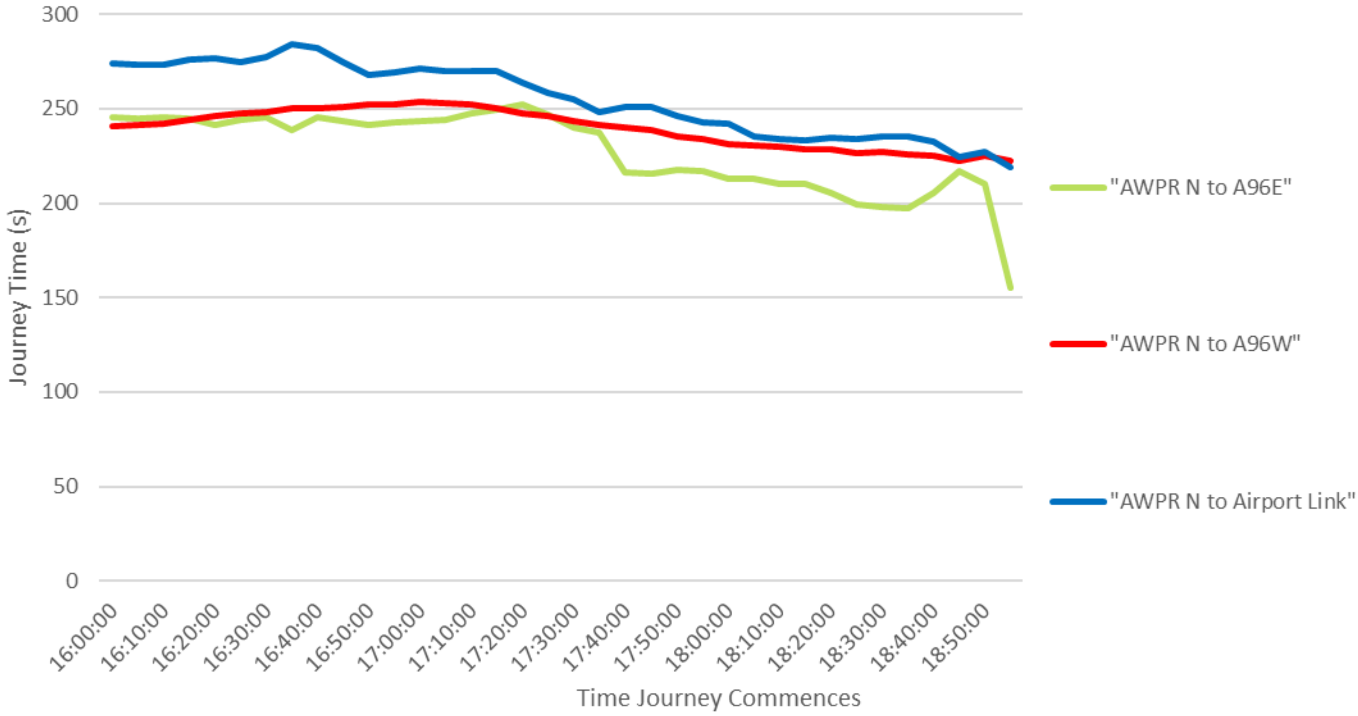


Figure 116 – PM Journey Time Data (Routes from the AWPR North)

With the exception of the AWPR North to South route (which is consistent throughout the PM peak period, journey times for routes from the AWPR South to all other destinations show a general trend for declining journey times; journey times at the end of the PM peak period are typically lower than at the start by approximately 20 to 60 seconds.

Again, variations toward the end of the period are a result of the average journey times recorded being informed by fewer trips.

10. Goval Junction Performance

10.1 Junction Description and Location

The Goval junction sits to the north of Dyce and the Airport area serving to provide a connection between the A947 north and the AWPR northern leg. **Figure 117** shows its general location and Figure 118 shows the specific layout of the junction.

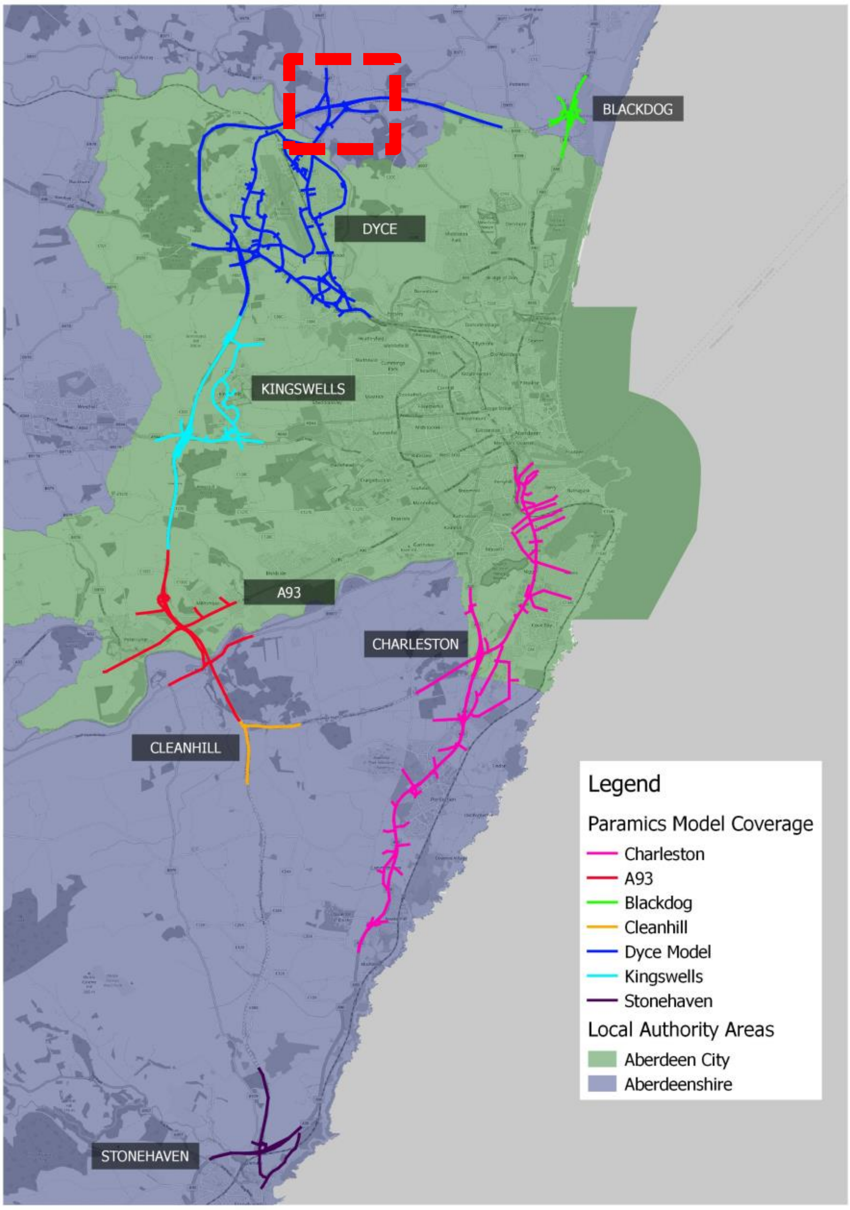


Figure 117 – Goval Junction Location

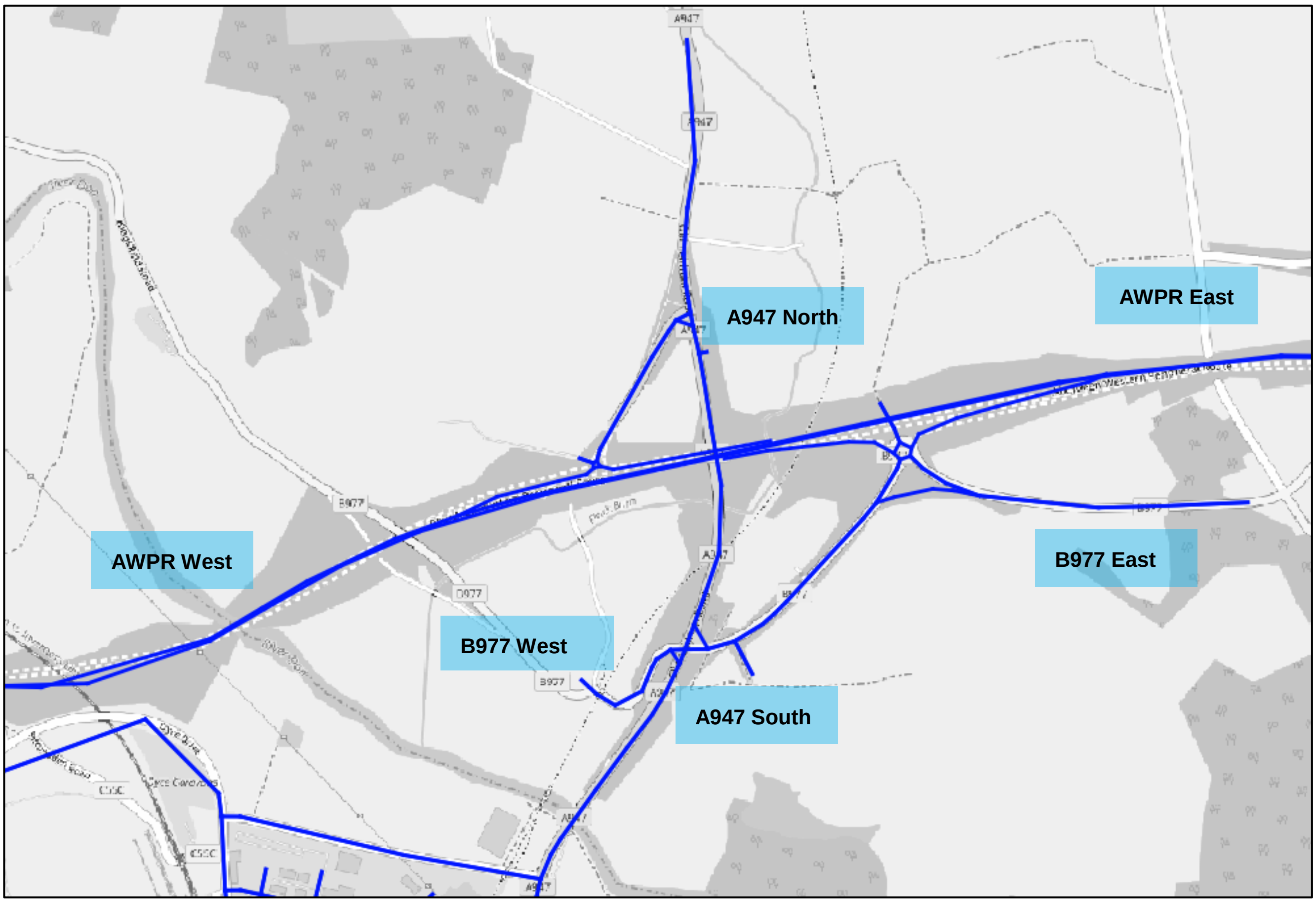


Figure 118 –Goval Paramics Model and key locations

The A947 is local road running approximately north to south and provides a key link between Dyce and Newmachar. Running east-west is the B977 which connects the A947 to the Danestone and Bridge of Don areas in Aberdeen city.

The northern leg of the AWPR at this location runs east-west and provides access between the Blackdog junction (to the east) and Craibstone junction (to the south). The AWPR junction allows full access to the AWPR east and west with the merges and diverges connecting into the A947.

Eastbound traffic leaving the AWPR can access the A947 via a new link road connecting the slips to the A947 north via a priority junction. Similarly, traffic travelling to the AWPR eastbound can access the eastbound on slip via the same priority junction and slip road.

At the A947 north junction, the eastbound approach is a single lane flaring to two over the last 150m. The north and south approaches to the junction both also flare from one lane to two; the north approach has two lanes over its final 60m and the south 120m.

Westbound traffic leaving the AWPR can do so by leaving via a new diverge and roundabout connecting the B977 to the AWPR. From here, destination in the wider network can be reached via the roundabout, the B977 and the A947. Traffic joining the AWPR to travel westbound at this location can do so via the A947 and B997/ B977.

The new roundabout at the AWPR westbound slips has four approaches all with a single lane.

The A947 south junction is signalised and has two left turn bypass lanes; the first connecting the north approach to the east egress and the second from the south approach to the west egress. Three out of the four approach arms flare from one lane to two:

- The north approach flares from one lane to two over the final 400m;
- The east approach flares from one lane to 2 over the final 200m; and
- The south approach flares from one lane to two over its final 130m.

The west approach has one lane only.

10.2 Signal Information

Figure 119 and Figure 120 illustrate the Paramics model signals timings used at the A947 \ B977 junction for the AM and PM peaks respectively.

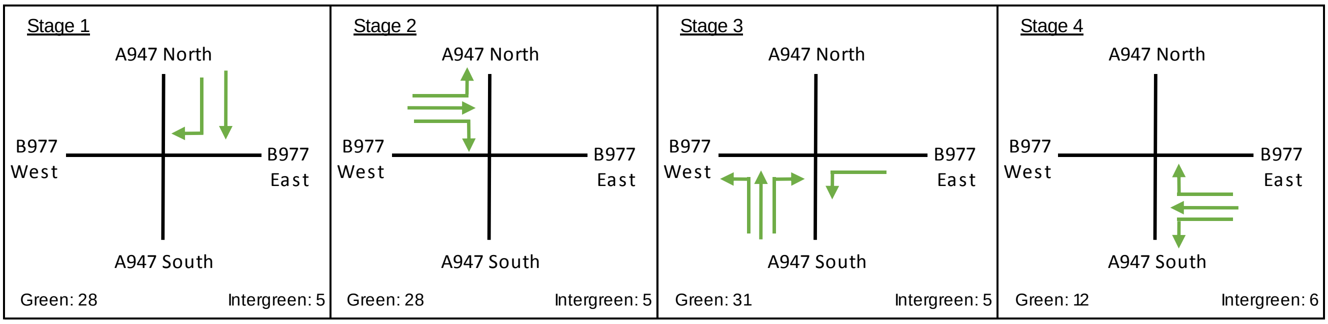


Figure 119 – AM Signal Timings – A947 Junction

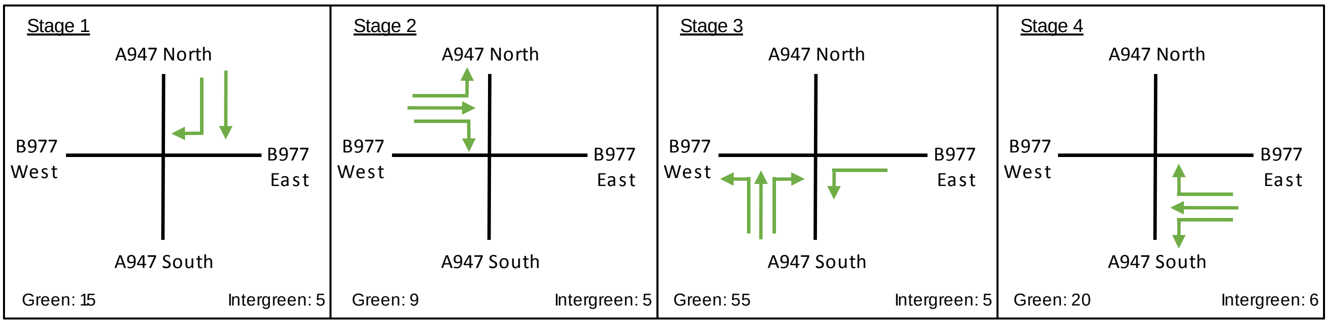


Figure 120 – PM Signal Timings – A947 Junction

10.3 Key Junction Turning Movements

The modelled turning movements forecast to pass through the AWPR and A947 \ B977 junctions have been extracted from the relevant Paramics models. Figure 121 and Figure 122 show the AM and PM peak turning movements occurring respectively.

As each Paramics model simulation run is different, the results are based on an average of ten model runs, as are all the further model statistics presented in this section. This ensures that the model results are representative of the junction operation and are not unduly influenced by a particularly free-flowing or particularly congested simulation run.

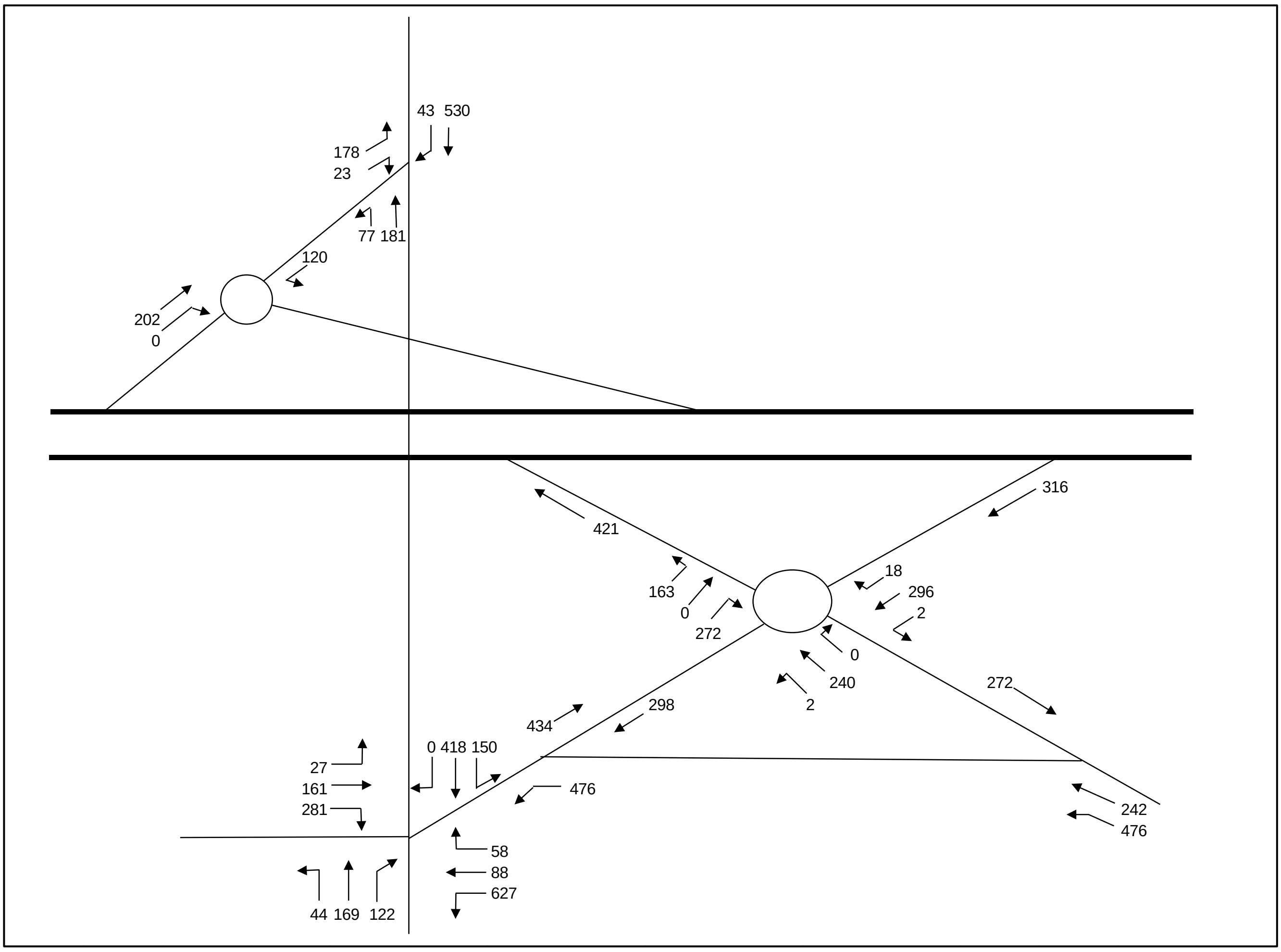


Figure 121 - AM Turning Movements

During the AM peak the traffic movements travelling from the AWPR West (202 vehicles) and AWPR East (316 vehicles) are relatively low compared to the movements approaching from the B977 East (718 vehicles in total) and from the A947 North (573 vehicles).

The figure also shows significant flows accessing the AWPR Westbound the majority of which originates from the A947 North, A947 South and the B977 West.

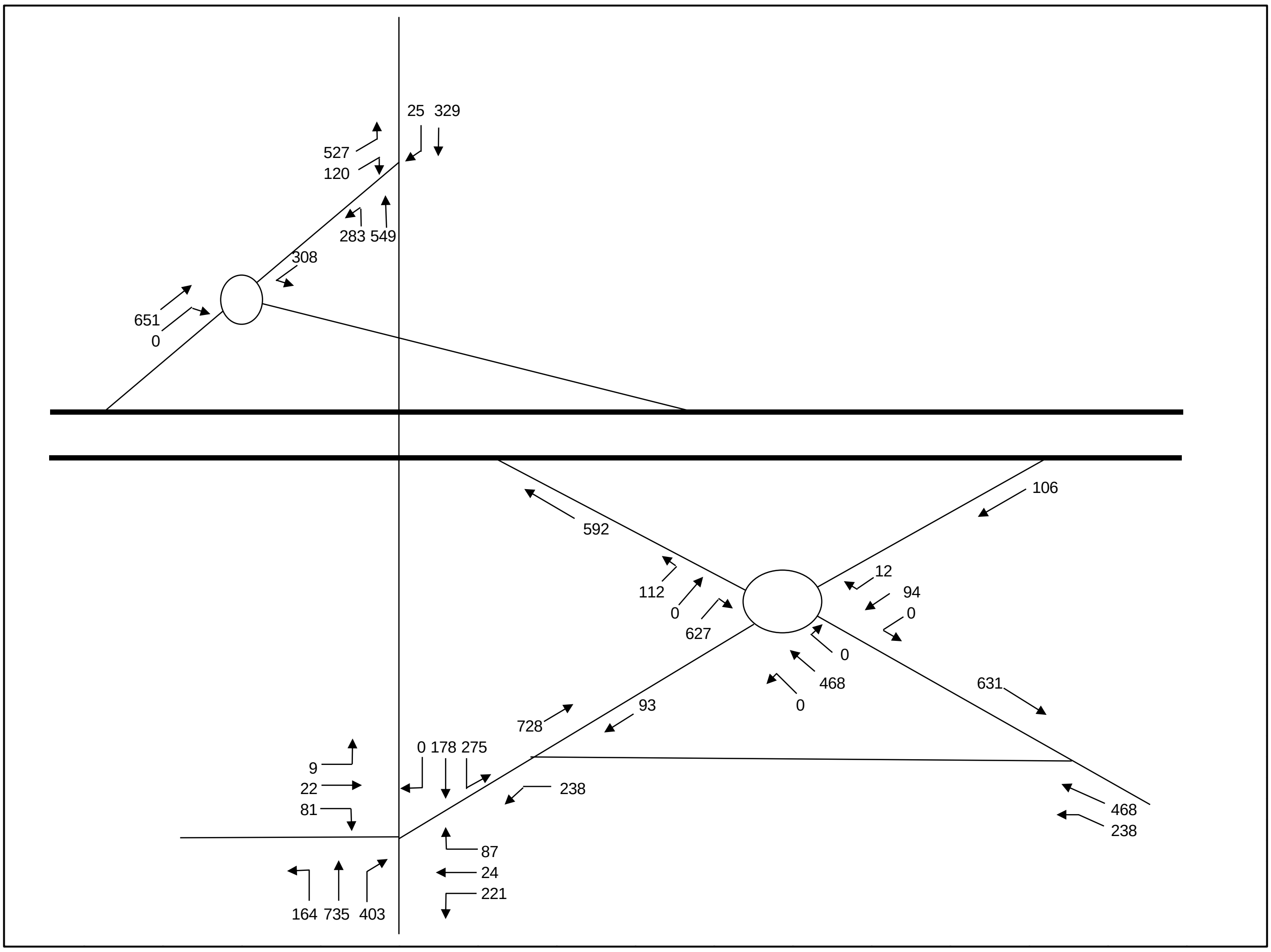


Figure 122 - PM Turning Movements

The PM peak traffic movements shows that the highest volumes of traffic are approaching the junction from the A947 South (1302 vehicles), the B977 East (706 vehicles) and from the AWPR west (651 vehicles).

Traffic approaching from the A947 South is destined either for the A947 North or the B977 east, trips from the B977 east are destined for the AWPR, the A947 south or the B977 west and trips from the AWPR west are heading for the A947 north.

All other movements through the junction are relatively low (c. 200 trips or fewer).

10.4 Vehicle Speeds

The average journey speed was derived for the AM and PM peak modelled periods in order to illustrate the overall network performance. A consistent downward trend in the average network speeds would indicate that the simulation experiences increasing levels of delay as the operational performance deteriorates over time.

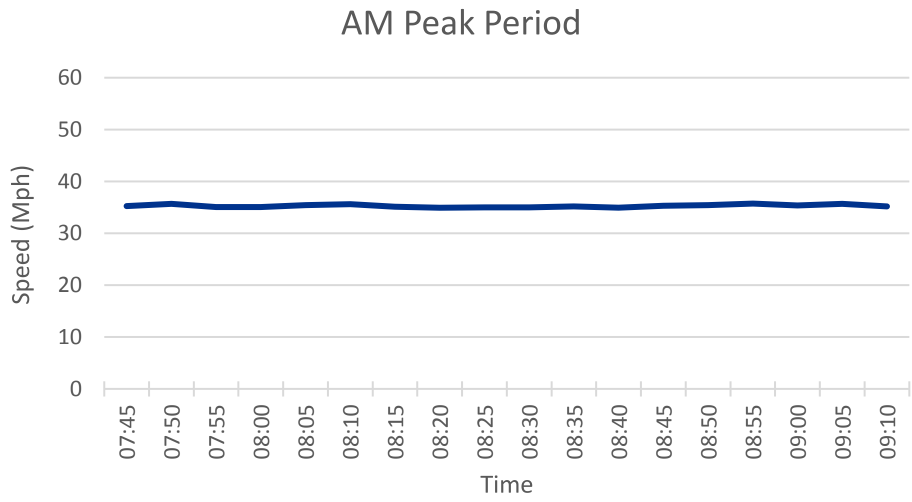


Figure 123 – AM Vehicle Speeds

Figure 123 shows the AM peak average speed analysis results throughout the duration of the modelled period. The figure shows that during the AM peak period the model shows consistent speeds (around 35mph) throughout the modelled period. The speed is relatively low but this is expected given the nature of the modelled network predominantly consists of roads with lower speed limits applied (30mph or 40mph).

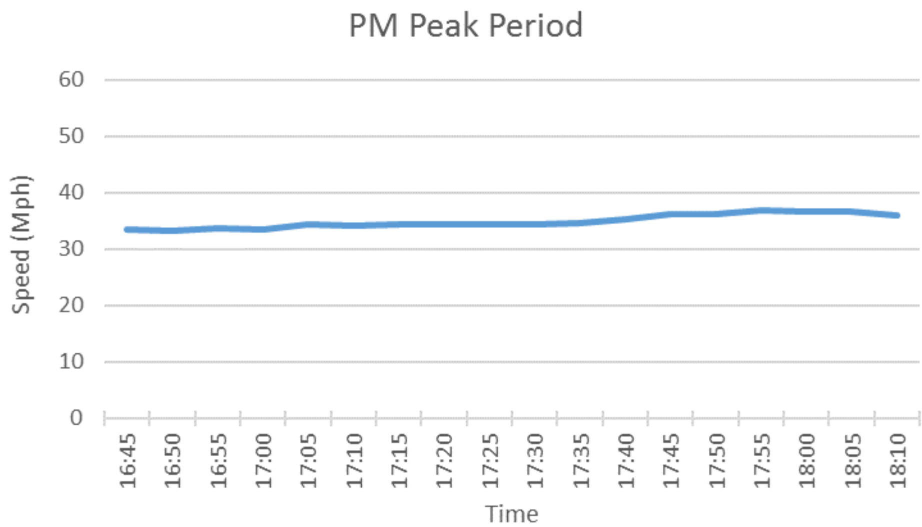


Figure 124 – PM Vehicle Speeds

Figure 124 shows results that for the PM peak, average speeds remain consistent throughout the modelled period (at around 35mph). Again, the speed is relatively low but this is again due to the modelled network predominantly consisting of roads with lower speed limits applied (30mph or 40mph).

10.5 Queue Length Data

Queuing Analysis

The default Paramics Queue Recognition definitions have been applied to record and collect the queuing data during each model simulation run. The only adjustment made was to change the method of Multiple Queues reporting to the 'Propagate the last queue to end' option, such that all vehicles from the end of the last queue on the link to the end of the link are considered and reported as a single queue.

As a result the absolute queue lengths reported in the analyses include gaps between vehicles, as the vehicle speed and the gap to the vehicle in front are both used to determine the thresholds below which a vehicle is considered to be in a queued state. Therefore the queue lengths reported do not necessarily represent a continuous queue of vehicles, but serve to illustrate the maximum possible extent of the level of queuing on each approach.

Figure 125 shows the routes over which the queue lengths were calculated.

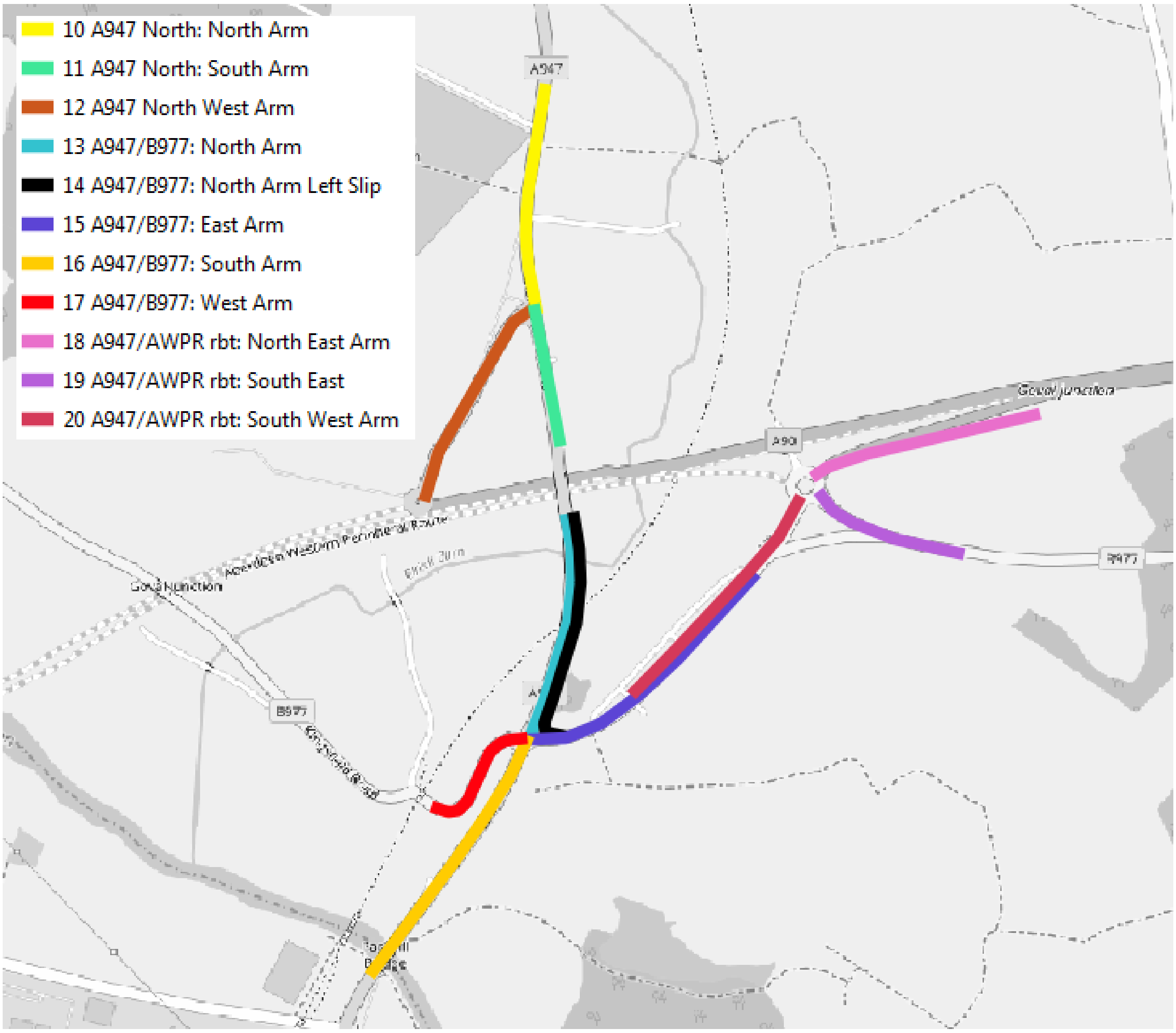


Figure 125 - Queue Routes

Route	Lane	0700-0800			0800-0900			0900-1000		
		Max Q	95% CI		Max Q	95% CI		Max Q	95% CI	
10 A947 North: North Arm	1	149	144	153	76	74	78	59	57	60
10 A947 North: North Arm	2	27	25	28	24	21	28	26	20	31
10 A947 North: North Arm	3	-	-	-	-	-	-	-	-	-
11 A947 North: South Arm	1	37	36	38	40	39	41	42	40	43
11 A947 North: South Arm	2	20	-	-	23	19	27	28	-	-
11 A947 North: South Arm	3	-	-	-	-	-	-	-	-	-
12 A947 North: West Arm	1	80	79	82	83	81	84	78	77	80
12 A947 North: West Arm	2	28	27	30	33	33	34	36	32	39
12 A947 North: West Arm	3	-	-	-	-	-	-	-	-	-
13 A947/B977: North Arm	1	165	160	169	110	108	112	68	67	70
13 A947/B977: North Arm	2	166	162	170	127	125	130	70	69	72
13 A947/B977: North Arm	3	-	-	-	-	-	-	-	-	-
14 A947/B977: North Arm Left Slip	1	44	43	46	34	32	35	28	26	30
14 A947/B977: North Arm Left Slip	2	-	-	-	-	-	-	-	-	-
14 A947/B977: North Arm Left Slip	3	-	-	-	-	-	-	-	-	-
15 A947/B977: East Arm	1	175	171	179	194	190	197	145	141	148
15 A947/B977: East Arm	2	82	80	84	94	92	96	68	67	69
15 A947/B977: East Arm	3	-	-	-	-	-	-	-	-	-
16 A947/B977: South Arm	1	94	92	97	91	88	93	102	99	104
16 A947/B977: South Arm	2	77	75	79	77	75	79	70	68	71
16 A947/B977: South Arm	3	-	-	-	-	-	-	-	-	-
17 A947/B977: West Arm	1	300	287	314	288	283	293	300	297	302
17 A947/B977: West Arm	2	49	48	49	49	48	50	49	48	50
17 A947/B977: West Arm	3	-	-	-	-	-	-	-	-	-
18 A947/AWPR rbt: North East Arm	1	-	-	-	-	-	-	-	-	-
18 A947/AWPR rbt: North East Arm	2	47	46	49	47	45	48	48	46	49
18 A947/AWPR rbt: North East Arm	3	-	-	-	-	-	-	-	-	-
19 A947/AWPR rbt: South East Arm	1	27	26	28	32	31	33	27	25	28
19 A947/AWPR rbt: South East Arm	2	-	-	-	-	-	-	-	-	-
19 A947/AWPR rbt: South East Arm	3	-	-	-	-	-	-	-	-	-
20 A947/AWPR rbt: South West Arm	1	102	98	105	98	95	101	62	60	65
20 A947/AWPR rbt: South West Arm	2	-	-	-	-	-	-	-	-	-
20 A947/AWPR rbt: South West Arm	3	-	-	-	-	-	-	-	-	-

Table 15 - AM Max Queue Lengths

Table 15 shows the results of AM peak period queuing analysis. The longest queues are shown on the A947\B977 West, East and North arms which exhibit a recorded queue length of 300 metres (equating to around 50 car lengths), 194 metres (equating to around 33 car lengths) and 166 metres (equating to around 28 car lengths) respectively.

The A947 North junctions north arm also shows some slightly longer queuing of up to 149m (approximately 25 car lengths) during the first hour of the modelled period.

All other queue lengths show lower values of 92m (16 car lengths) or less.

To help illustrate the extent of the queuing, which does not necessarily occur simultaneously on all approaches, the schematic representations shown in **Figure 126** has been produced.

Figure 126 – AM Max Queue Length Diagram

		1600-1700			1700-1800			1800-1900		
Route	**Lane**	**Max Q**	**95% CI**		**Max Q**	**95% CI**		**Max Q**	**95% CI**	
10 A947 North: North Arm	1	111	108	114	126	123	129	104	102	106
10 A947 North: North Arm	2	27	25	29	27	23	30	19	-	-
10 A947 North: North Arm	3	-	-	-	-	-	-	-	-	-
11 A947 North: South Arm	1	66	65	67	101	99	102	106	105	107
11 A947 North: South Arm	2	76	73	78	75	73	77	73	71	76
11 A947 North: South Arm	3	-	-	-	-	-	-	-	-	-
12 A947 North: West Arm	1	115	112	118	135	133	138	116	113	119
12 A947 North: West Arm	2	44	43	45	56	55	56	43	42	44
12 A947 North: West Arm	3	-	-	-	-	-	-	-	-	-
13 A947/B977: North Arm	1	66	64	67	69	67	71	59	58	60
13 A947/B977: North Arm	2	82	80	83	72	70	74	62	61	64
13 A947/B977: North Arm	3	-	-	-	-	-	-	-	-	-
14 A947/B977: North Arm Left Slip	1	94	92	97	88	85	90	62	61	64
14 A947/B977: North Arm Left Slip	2	-	-	-	-	-	-	-	-	-
14 A947/B977: North Arm Left Slip	3	-	-	-	-	-	-	-	-	-
15 A947/B977: East Arm	1	80	78	81	94	92	96	64	63	66
15 A947/B977: East Arm	2	78	77	80	84	82	85	63	62	64
15 A947/B977: East Arm	3	-	-	-	-	-	-	-	-	-
16 A947/B977: South Arm	1	284	274	293	311	304	319	220	214	227
16 A947/B977: South Arm	2	126	123	130	153	150	156	115	112	118
16 A947/B977: South Arm	3	-	-	-	-	-	-	-	-	-
17 A947/B977: West Arm	1	75	72	78	70	67	73	69	66	73
17 A947/B977: West Arm	2	48	48	49	49	48	49	48	47	49
17 A947/B977: West Arm	3	-	-	-	-	-	-	-	-	-
18 A947/AWPR rbt: North East Arm	1	-	-	-	-	-	-	-	-	-
18 A947/AWPR rbt: North East Arm	2	38	37	40	46	45	48	36	35	37
18 A947/AWPR rbt: North East Arm	3	-	-	-	-	-	-	-	-	-
19 A947/AWPR rbt: South East Arm	1	56	54	57	67	65	69	50	47	52
19 A947/AWPR rbt: South East Arm	2	-	-	-	-	-	-	-	-	-
19 A947/AWPR rbt: South East Arm	3	-	-	-	-	-	-	-	-	-
20 A947/AWPR rbt: South West Arm	1	516	486	546	515	490	541	160	154	166
20 A947/AWPR rbt: South West Arm	2	-	-	-	-	-	-	-	-	-
20 A947/AWPR rbt: South West Arm	3	-	-	-	-	-	-	-	-	-

Table 16 - PM Max Queue Lengths

During the PM peak, there is some significant queuing shown at the A947 \ B977 junction of up to 311m (52 car lengths). The cause of this queuing is not the configuration of the junction but the level of conflict at the A947\B977 junction connecting the AWPR westbound to the local road network.

Traffic approaching the junction from the B977 east and heading for the AWPR westbound (468 vehicles – movement denoted by the blue arrow in Figure 127) takes priority over the traffic approaching the junction from the A947\B977 junction (denoted by the red arrow in Figure127).

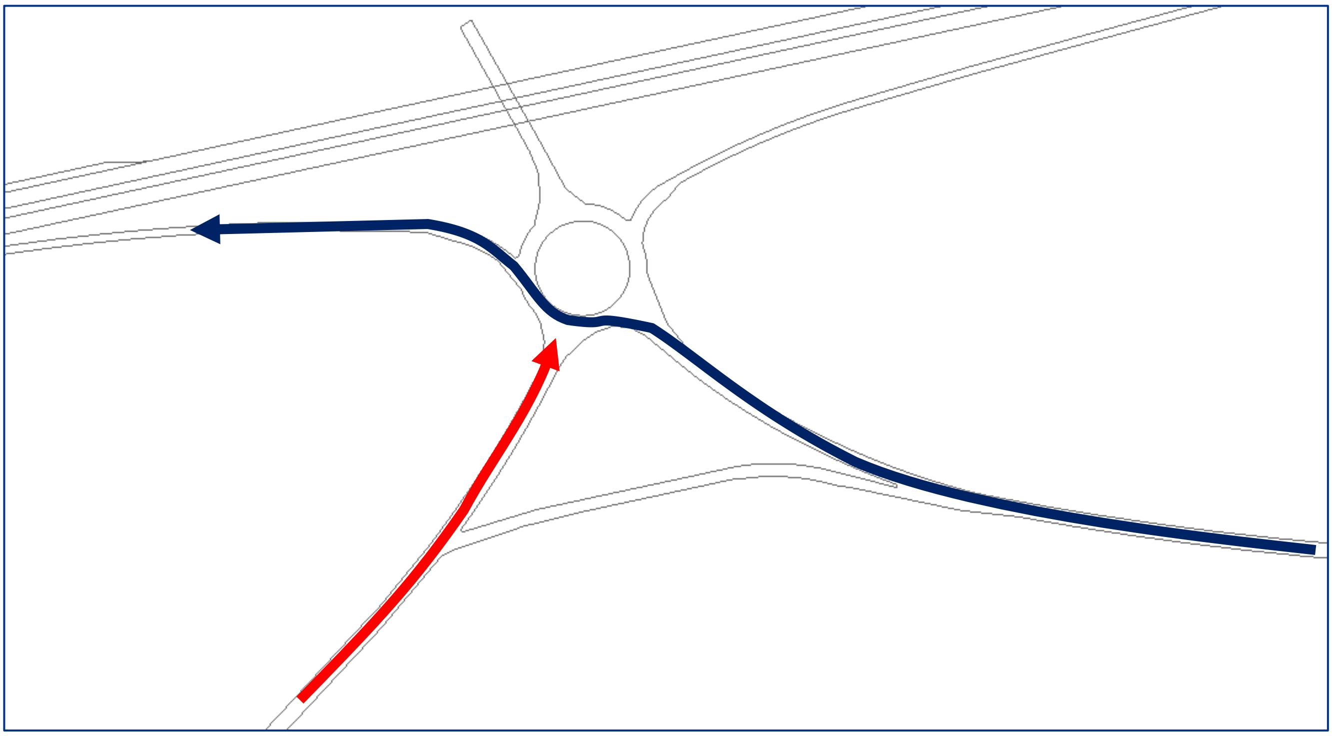


Figure 127 – PM Junction Conflict at the AWPR Goval (south) junction

As a result, eastbound queuing forms on link between the A947 south junction and the A947\B977 junction which then extends back along the B977.

The A947 South junctions south, north and west approaches show relatively short queue lengths of 311m (52 car lengths), 74m (12 car lengths) and 70m (12 car lengths) respectively.

To help illustrate the extent of the queuing, which does not necessarily occur simultaneously on all approaches, the schematic representations shown in Figure 129 has been produced.

Figure 128 – PM Max Queue Length Diagram

Queue Length Distributions

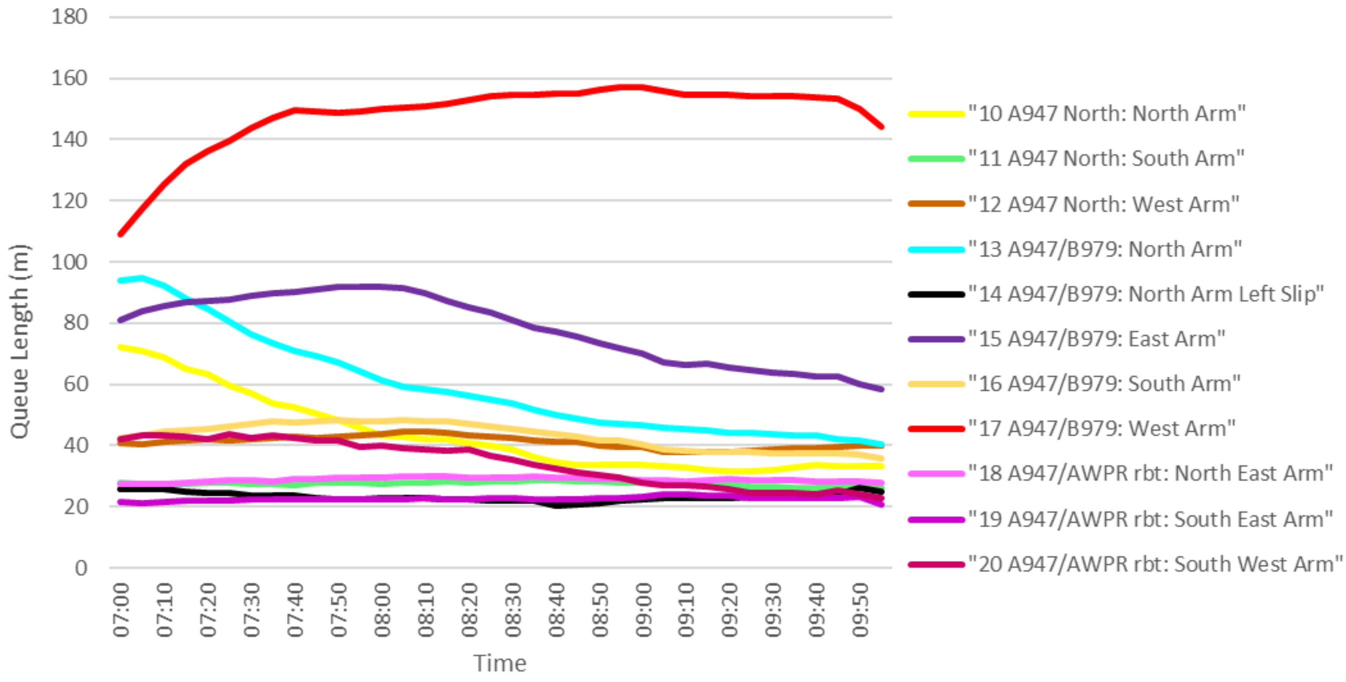


Figure 129 – AM Average Max Queue Length Distribution

During the AM peak, queueing occurs on the West, North and East approaches to the A947 \ B977 junction.

On the West approach, queues begin relatively short (around 110m) before extending up to c.155m at 09:00 where the queue length remains constant for the remainder of the peak period.

The North approach also starts relatively low at around 90m at the beginning of the peak. This then shows a trend for reduction as the period progresses and queue lengths drop to approximately 40m.

The A947 North junction north approach shows a similar trend to the south junctions North arm; queue lengths are high at the start of the period (around 70m) before dropping to 30m at the end of the peak

All other routes show queue lengths that are consistently short (less than 9 vehicles in length) for the duration of the AM peak period.

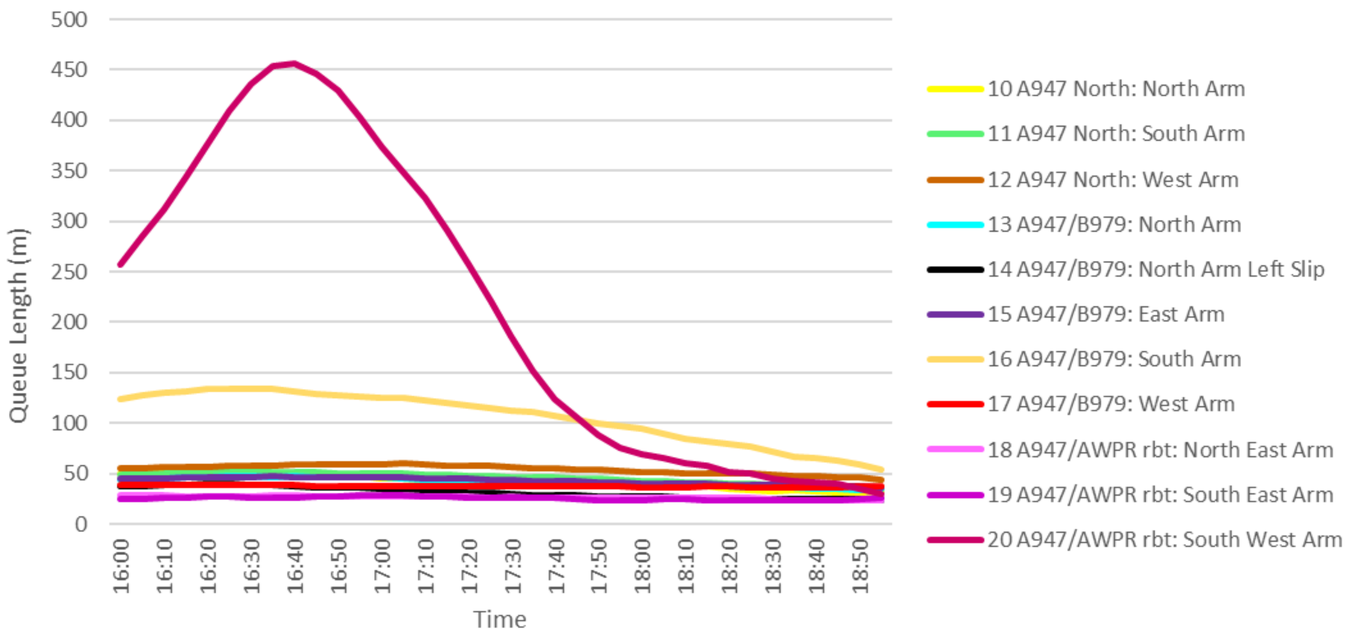


Figure 130 – PM Average Max Queue Length Distribution

The A947\AWPR roundabout route shows the longest queue length; queue lengths increase quickly from 16:10 and remain high at around 450m throughout the peak up until 16:40 when queues shorten rapidly toward the end of the period. This rapid accumulation and long length is a result of the issue shown at Figure 127.

Queue lengths on the A947 \ B977 are typically between 100 and 140 metres; this is caused by the signals at the A947 south junction where traffic must queue ahead of the signals. Throughout the modelled period, this is showing a general declining length.

The remaining queue lengths are typically short and extend up to 55m remaining constant throughout the modelled period.

10.6 Journey Time Data

Figure 131 – Journey Time Routes

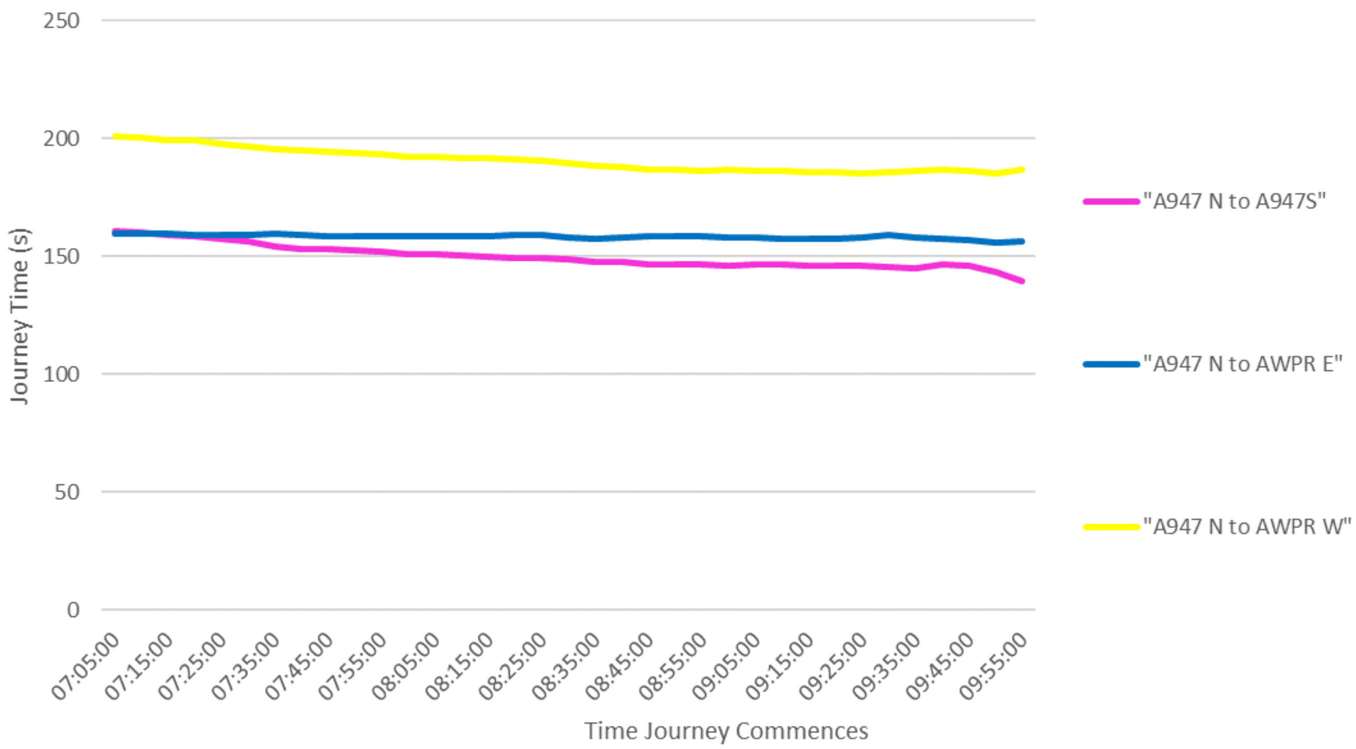


Figure 132 – AM Journey Time Data (Routes from A947 North)

For routes from the A947N to all other destinations, journey times are consistent throughout the modelled peak period. There is however a trend for a marginal reduction throughout the peak of around 10-20 seconds for routes to the AWPR West and the A947S.

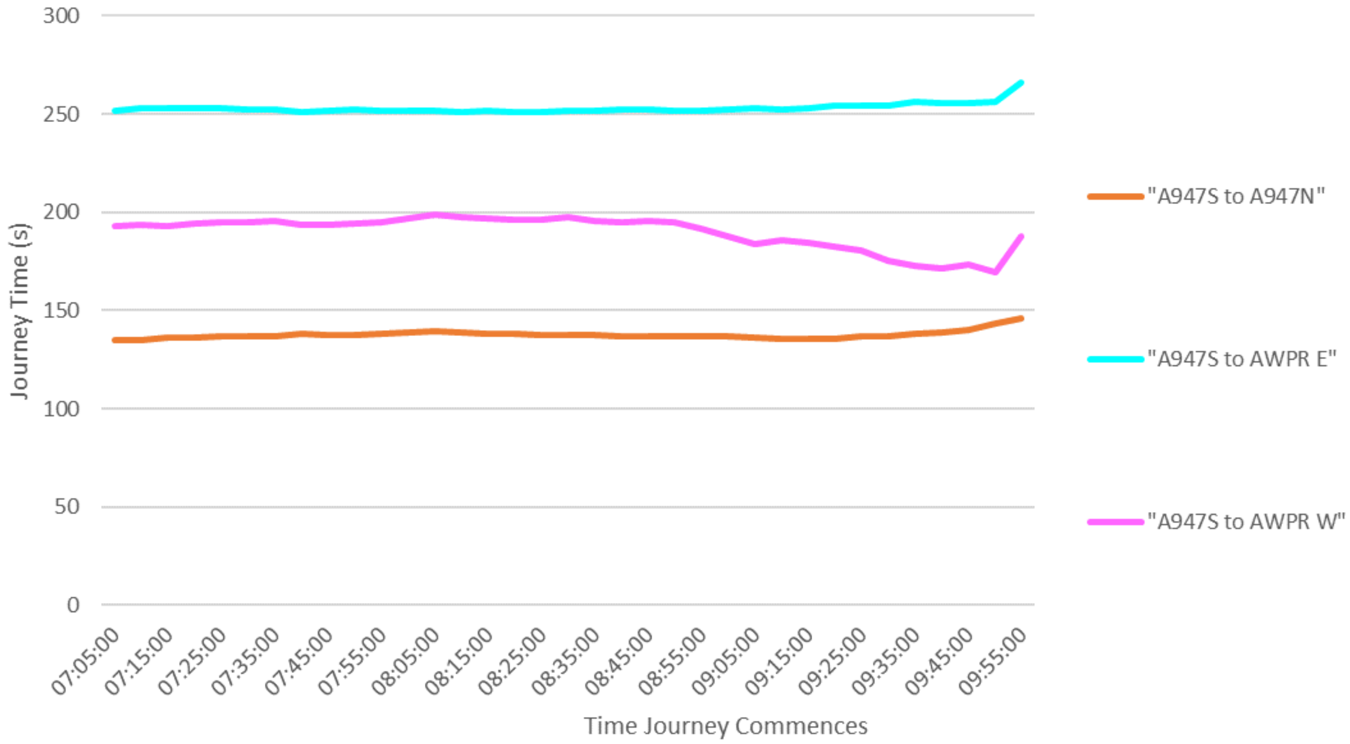


Figure 133 – AM Journey Time Data (Routes from A947 South)

For routes from the A947S to all other destinations, journey times are largely consistent throughout the modelled peak period. The route between the A947S and the AWPR W does show some minor fluctuation toward the end of the modelled period.

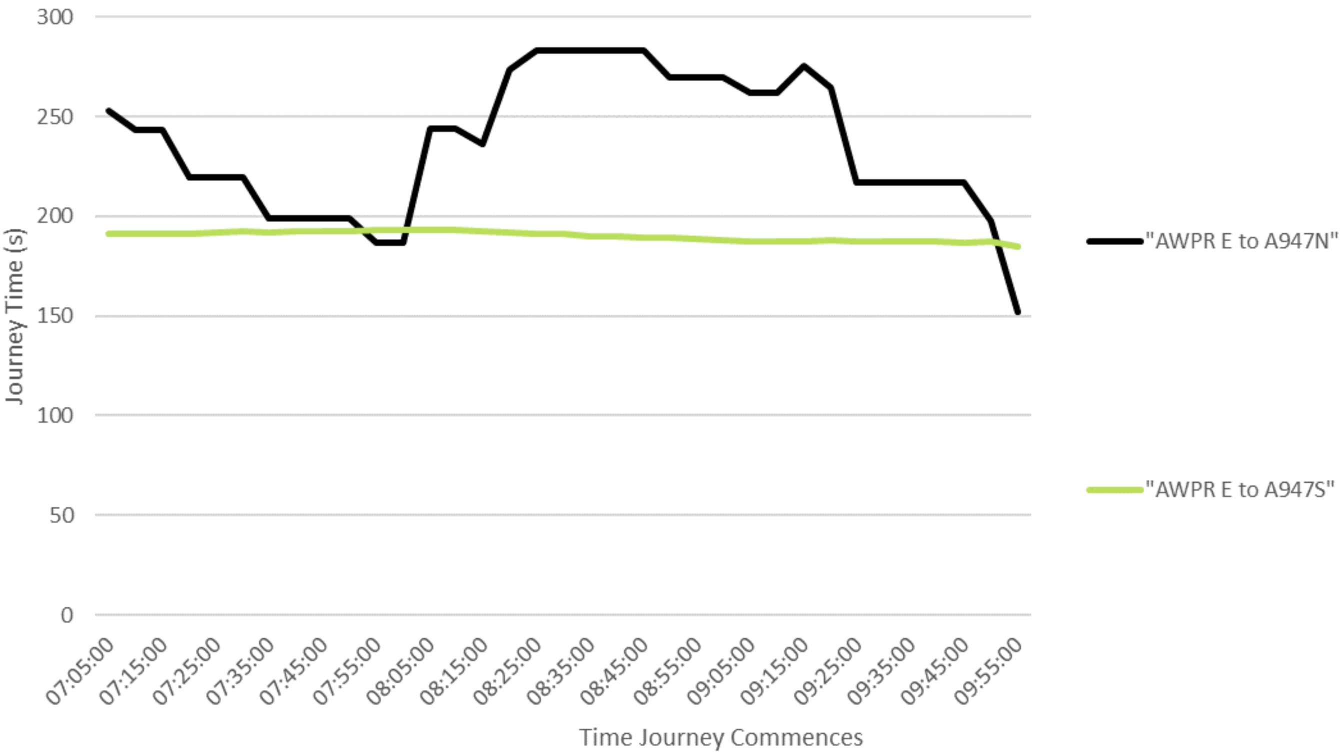


Figure 134 – AM Journey Time Data (Routes from the AWPR East)

The route between the AWPRE to the A947 shows a high degree of variation. This can be attributed to the roundabout at the end of the AWPR WB off slip and the signals at the A947\B977 junction; the requirement to give way at the roundabout and wait at the signals introduces some variation in journey times throughout the modelled period.

For the route from the AWPR E to the A947S, journey times are consistent throughout the modelled period.

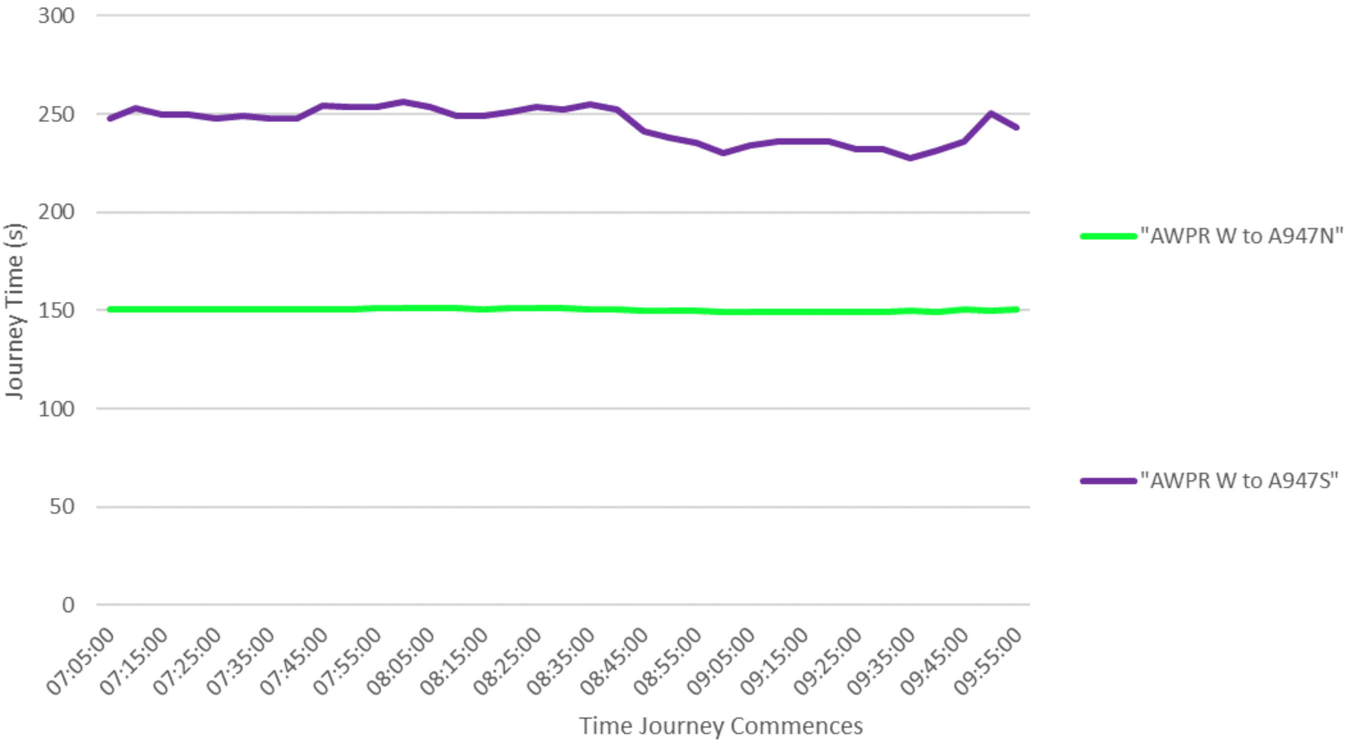


Figure 135 – AM Journey Time Data (Routes from the AWPR West)

For routes from the AWPR W to all other destinations, journey times are largely consistent throughout the modelled peak period. The route between the AWPR W and the A947N does show some minor fluctuation throughout the peak period. This can be attributed to the requirement to give way at the A947 North junction.

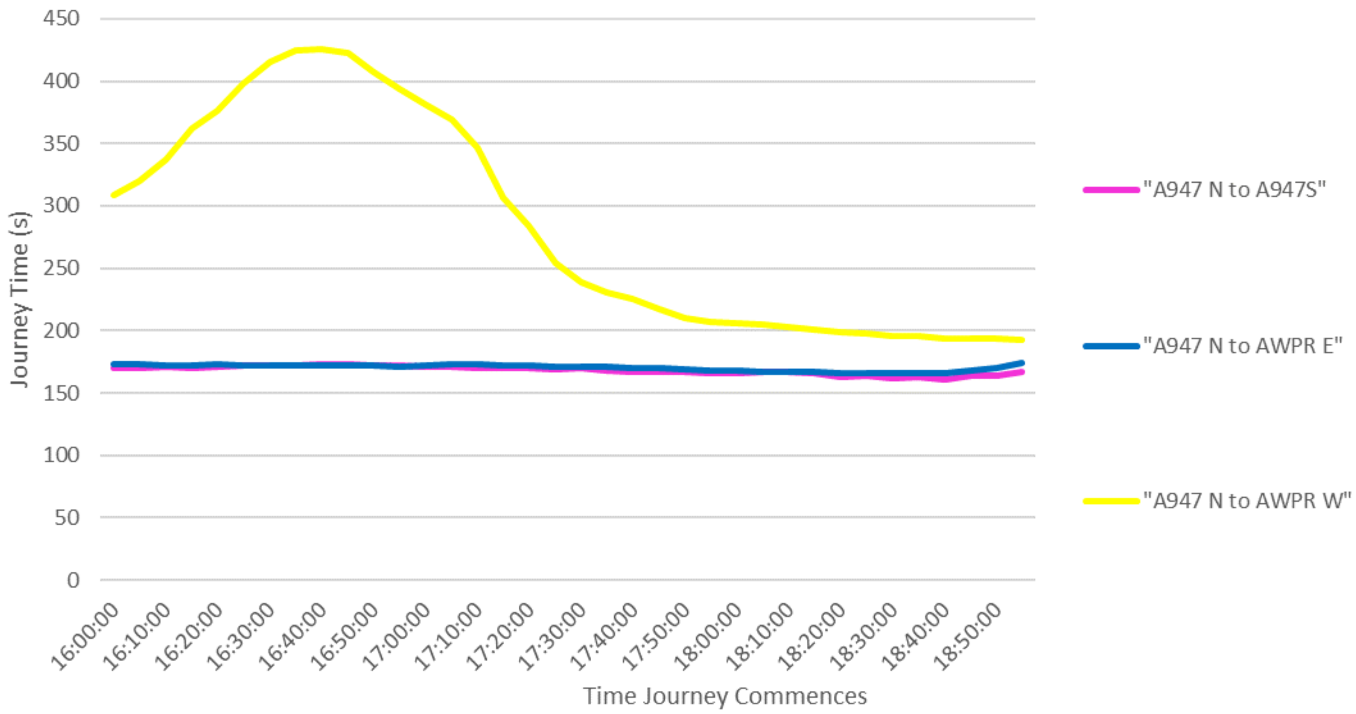


Figure 136 – PM Journey Time Data (Routes from A947 North)

There is a high journey time for trips travelling between the A947N and the AWPR W of around 450s. This long duration can be the issue described and shown at Figure 127; the conflict at the AWPR \ B977 roundabout is causing some queuing and higher journey times throughout the peak period.

Journey times for trips travelling between the A947N and the AWPR E\A947S show shorter journey times and remain consistent at around 175s seconds throughout the modelled peak.

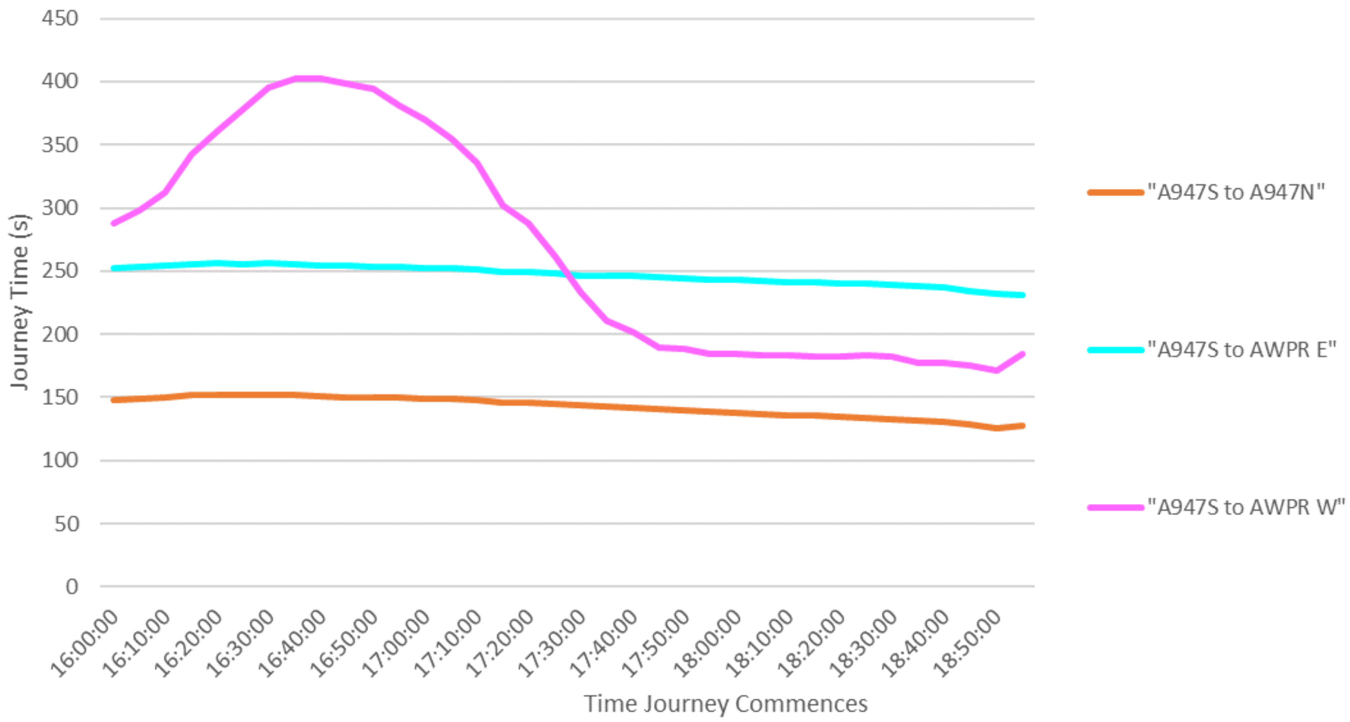


Figure 137 – PM Journey Time Data (Routes from A947 South)

There is again a high journey time for trips travelling between the A947S and the AWPR W of around 400s. This longer journey time can be attributed to the issue shown at Figure 127; the conflict at the AWPR \ B977 roundabout is causing some higher journey times throughout the peak period.

Journey times for trips travelling between the A947S and either the AWPR E and the A947N shows a shorter and more consistent journey times of up to around 250s and 150s respectively.

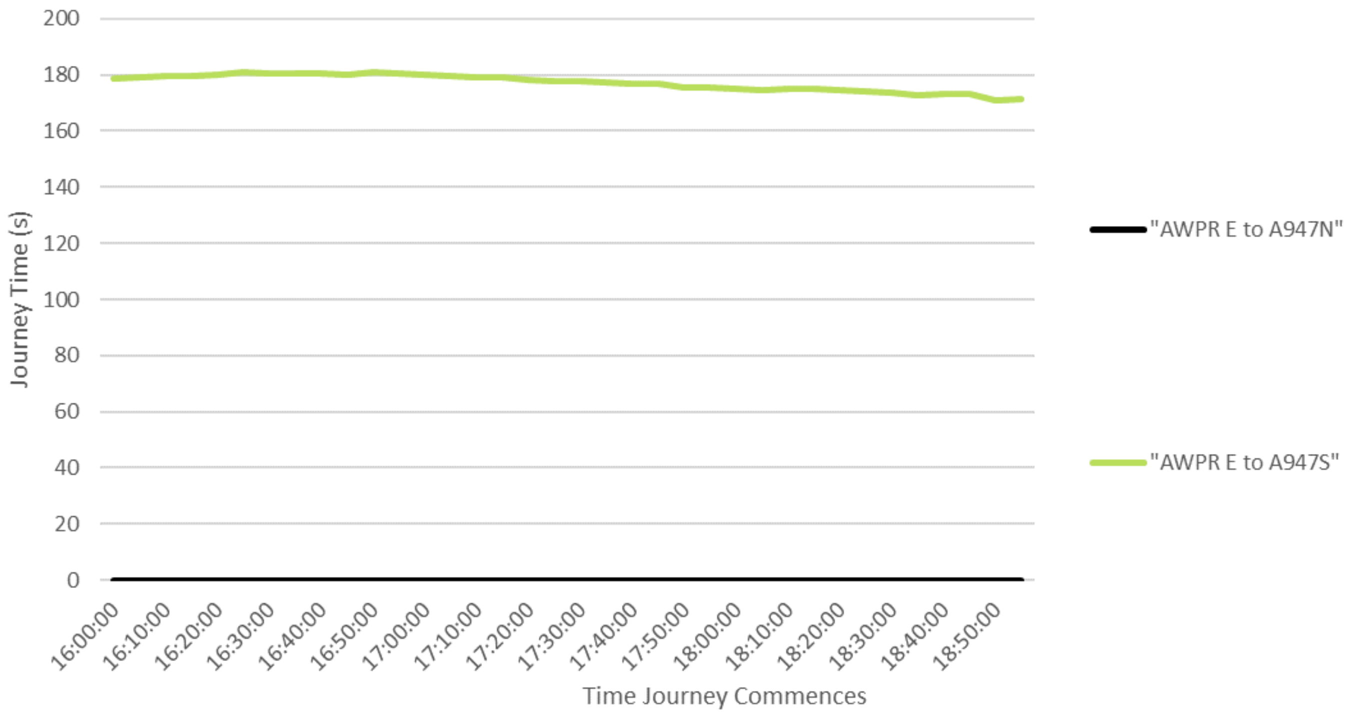


Figure 138 – PM Journey Time Data (Routes from the AWPR East)

Journey times between the AWPR E and the A947 N are consistent through the modelled period at 170-180s.

The journey time between the AWPR E and the A947S is at 0s as no trips have been recorded and so no journey time can be reported.

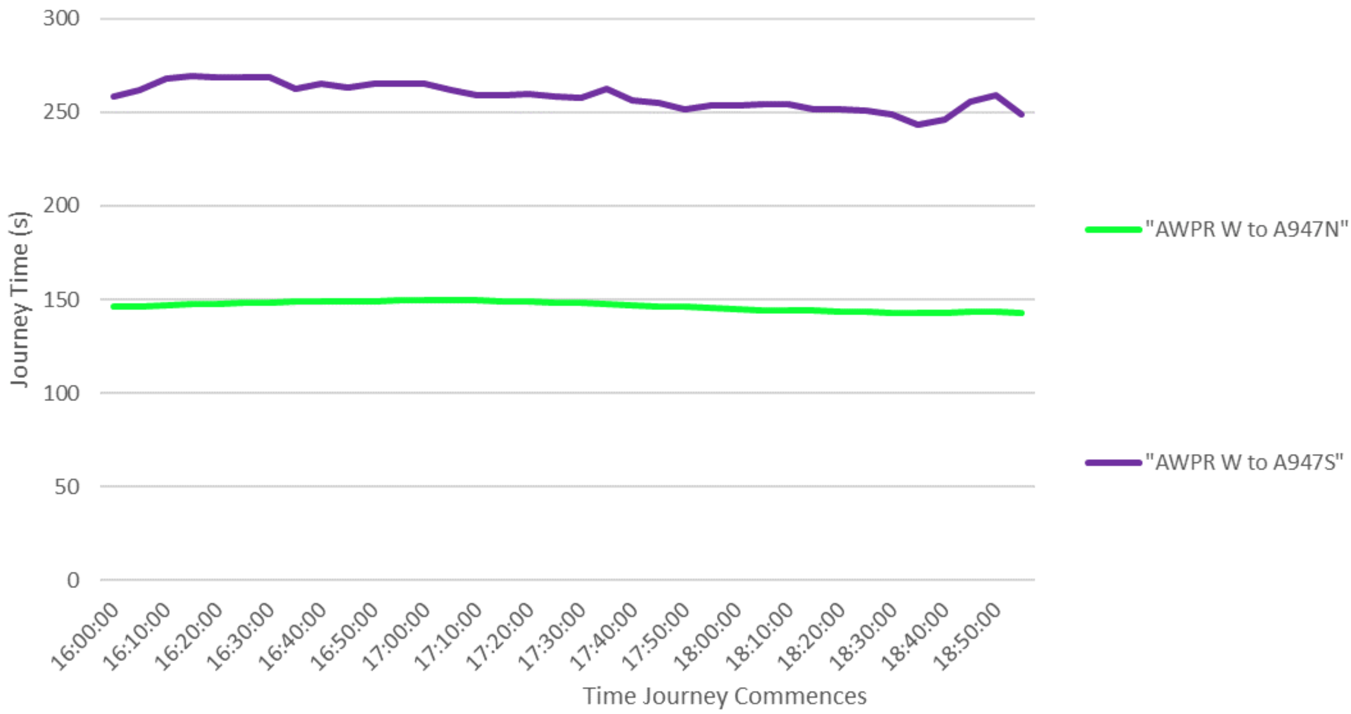


Figure 139 – PM Journey Time Data (Routes from the AWPR West)

Journey times for trips travelling between the AWPR W and the A947S show typically consistent journey times of up to 265s.

Journey times between the AWPR W and the A947 N are consistent through the modelled period at 150s.

11. Blackdog Junction Performance

11.1 Junction Description and Location

The Blackdog junction serves to connect the AWPR to the A90 North of Aberdeen via a large grade separated roundabout arrangement.

Figure 140 shows a wider view of the preferred junction option, with Figure 141 showing the grade separated roundabout layout in more detail.

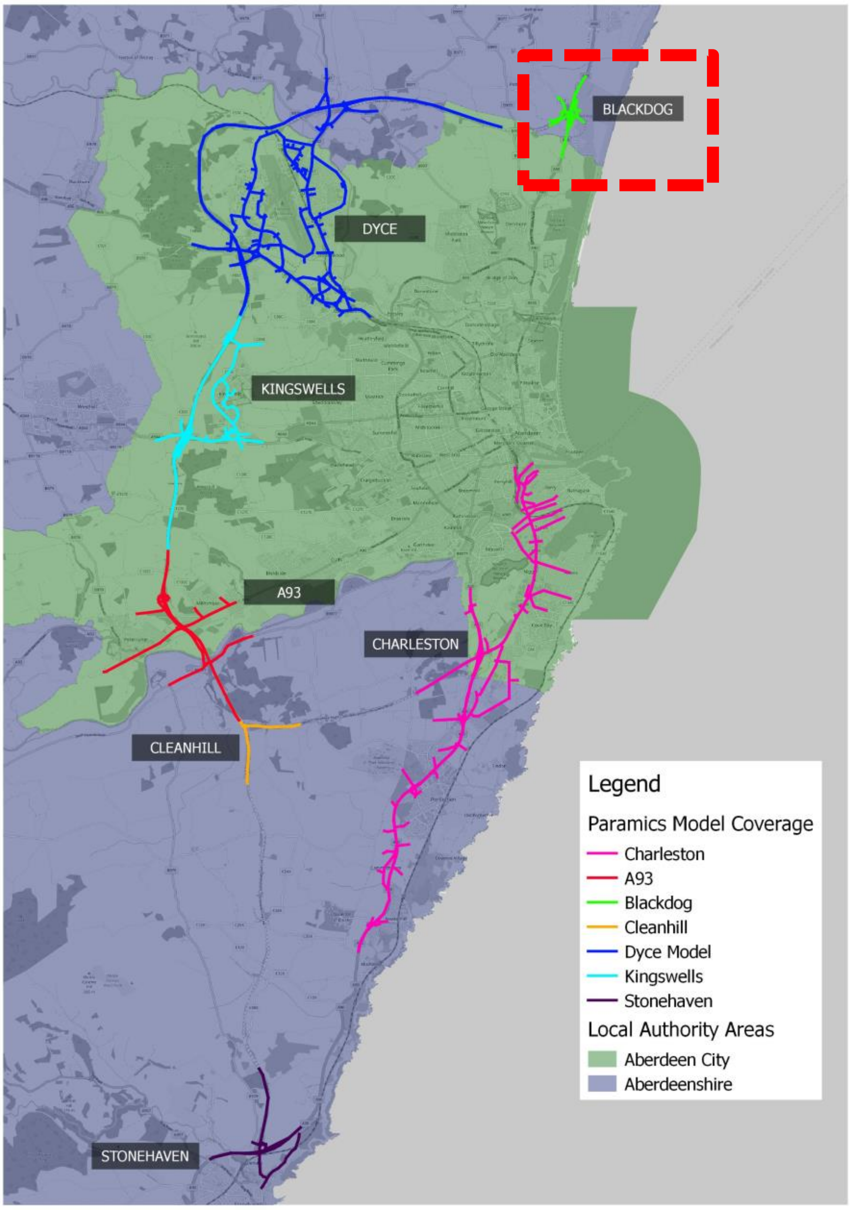


Figure 140 – Blackdog Junction Location

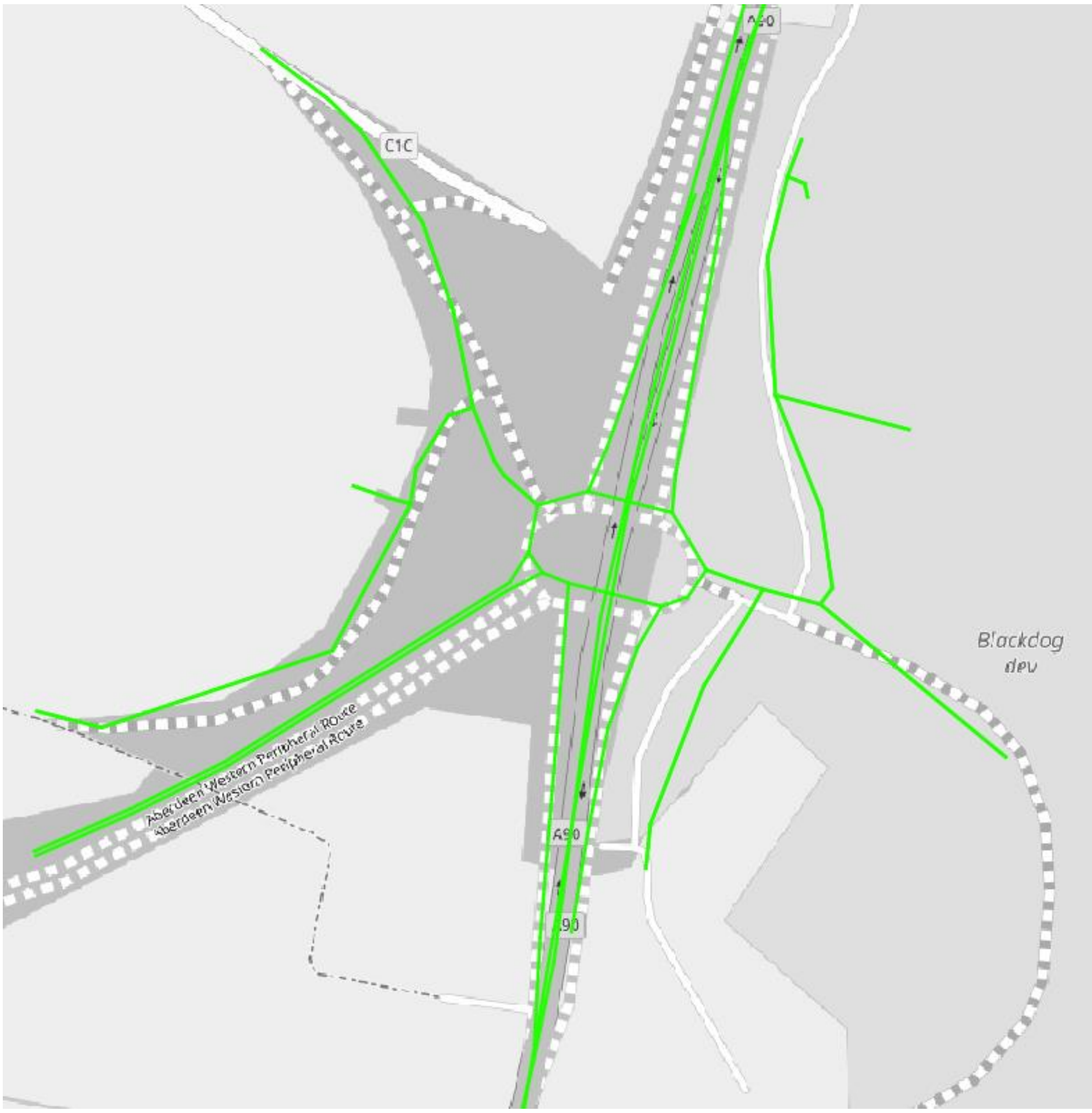


Figure 141 – Blackdog Paramics Model and key locations

The design layout comprises of full access merges and diverges to connect the proposed AWPR to the A90, and provides for two lanes on the circulating carriageway. The AWPR approach, and the A90 northbound and southbound diverge approaches have two lanes at their roundabout entries, with the A90 diverges both flaring from one lane to two lanes on approach to the junction. All exit arms from the roundabout are single lane exits, with the exception of the AWPR and the A90 northbound merge slip road that are two lane exits.

It also includes the provision of signalised pedestrian crossing facilities on the north side of the junction across the A90 northbound merge and A90 southbound diverge; and on the south side of the junction across the A90 northbound diverge and A90 southbound merge

11.2 Key Junction Turning Movements

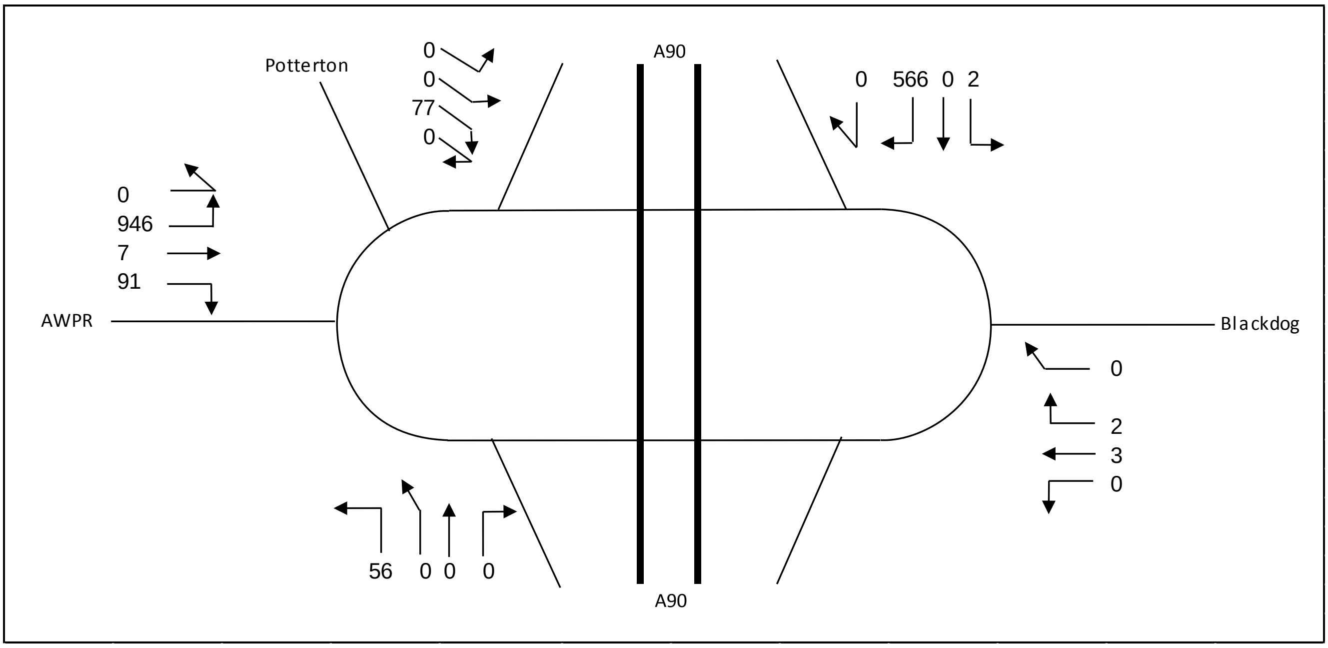


Figure 143 show the turning flows for traffic passing through the A90 North junction extracted from the Paramics models for the AM peak and the PM peak respectively.

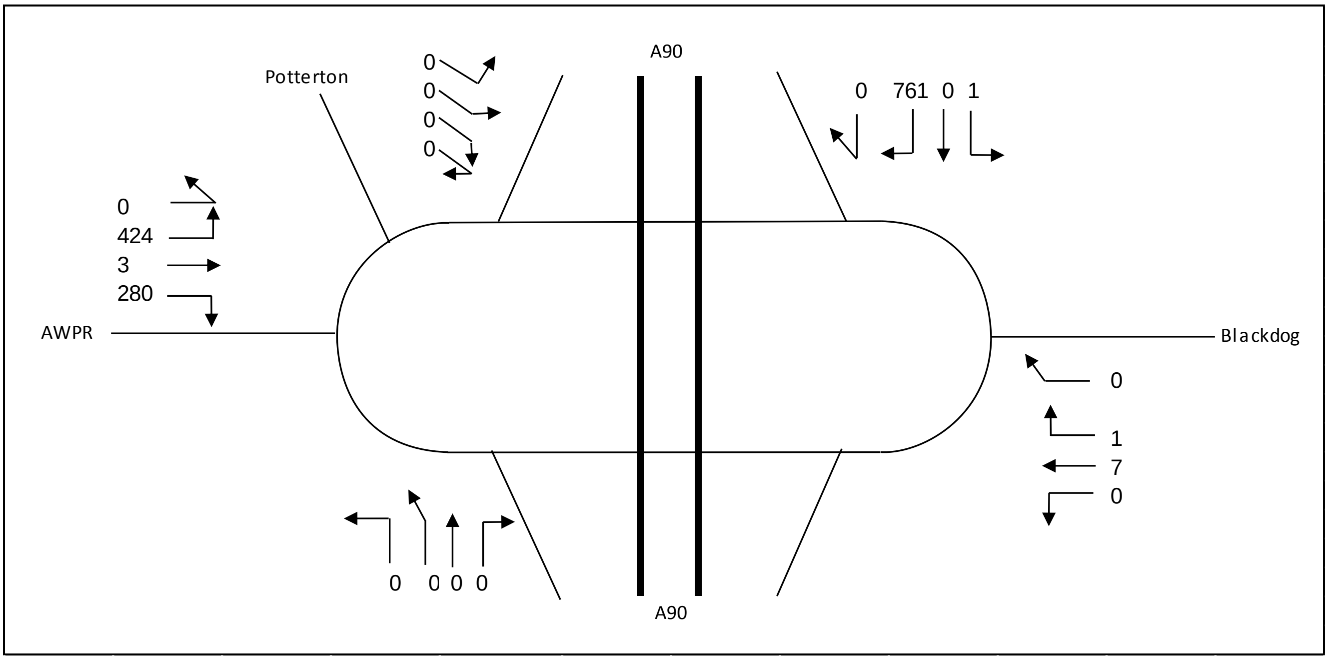


Figure 142 - AM Turning Movements

Figure 142 shows that during the AM Peak period the main flows are travelling from the A90 southbound diverge (i.e. from the A90 North) to the AWPR, and from the AWPR to the A90 northbound merge (i.e. to the A90 North). There are also less dominant traffic movements travelling from the AWPR to the A90 southbound merge (i.e. to the A90 South).

ASAM reports that there are no trips recorded on the NB off slip during the AM peak (which is reflected in the Paramics model). It is anticipated that trips on the de-trunked A90 NB off slip will be very low until the residential development is built out at Blackdog (generating new trips that will make use of the slip).

Until then, vehicles travelling on the de-trunked A90 NB from Aberdeen to Blackdog are anticipated to continue north on the A90. Very few vehicles are expected to turn off at this location and head for either Blackdog or Potterton (where there is currently very little development) or head west toward Dyce. Trips from Aberdeen heading toward the Dyce area are expected to travel primarily via either the A96 or the B977 rather than via the A90.

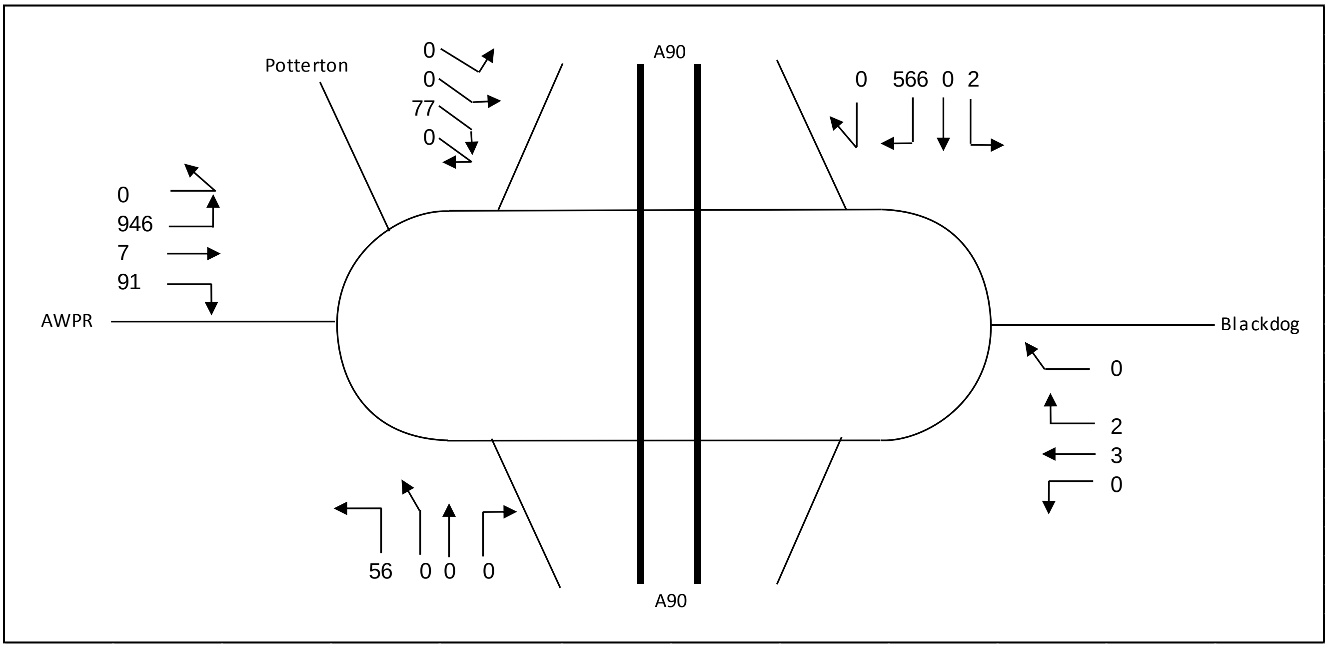


Figure 143 - PM Turning Movements

During the PM peak, the pattern of key movements passing through the junction is generally the reverse of the AM peak pattern. The dominant flows are travelling from the AWPR to the A90 northbound merge (i.e. to the A90 North), and from the A90 southbound diverge (i.e. from the A90 North) to the AWPR. There is also a lower volume of traffic flow travelling from the A90 northbound diverge (i.e. from the A90 South) to the AWPR evident in the PM peak.

11.3 Vehicle Speeds

The average journey speed per vehicle, through the complete model network, was obtained to illustrate the overall network performance throughout the AM and PM modelled periods. A consistent downward trend in the average network speeds would indicate that the simulation experiences increasing levels of delay as the operational performance deteriorates over time.

Figure 144 and Figure 145 show average speed data for the AM and PM peaks respectively.

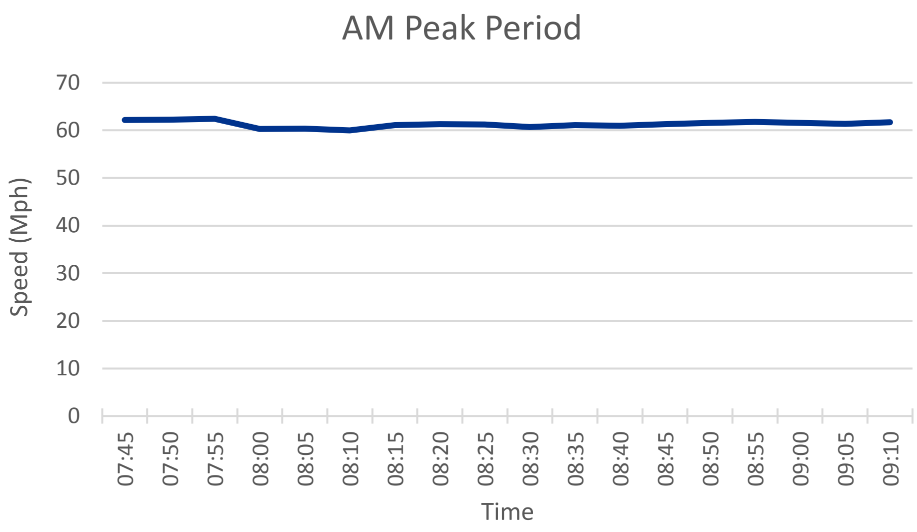


Figure 144 – AM Vehicle Speeds

During the AM peak, the average speed remains stable throughout the simulation period at approximate 60mph. This indicates that the design has sufficient overall operational performance to accommodate the AM peak demand expected.

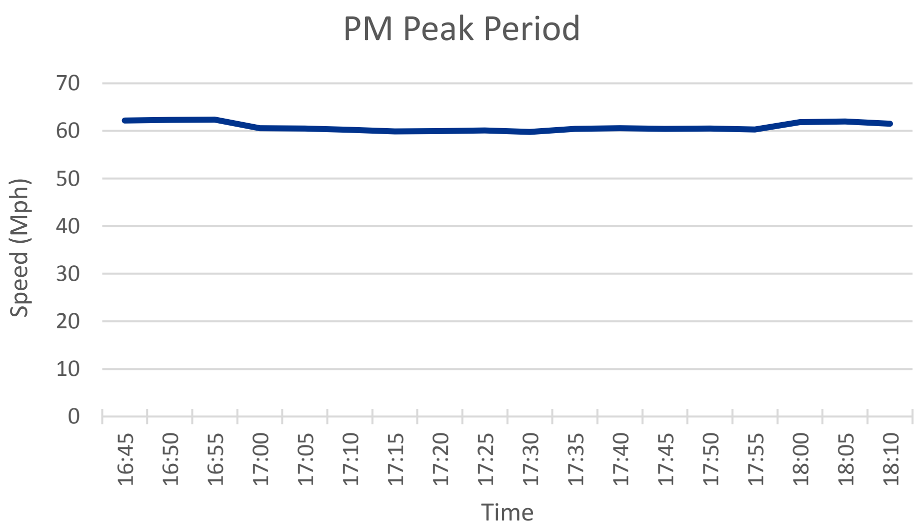


Figure 145 – PM Vehicle Speeds

Similarly to the AM peak, the PM peak data shows that the average speed remains stable throughout the simulation period at approximate 60mph. Again, this indicates that the design has sufficient overall operational performance to accommodate the AM peak demand expected.

11.4 Queue Length Data

Queuing Analysis

Note that in order to conduct the queuing analyses, the default Paramics Queue Recognition definitions have been applied to record and collect the queuing data during each model simulation run. The only adjustment made was to change the method of Multiple Queues reporting to the ‘Propagate the last queue to end’ option, such that all vehicles from the end of the last queue on the link to the end of the link are considered and reported as a single queue. For further details reference should be made to the Paramics 2003 Reference Manual, Chapter 13, Page 13-6, Queue Recognition.

As a result the absolute queue lengths reported in the analyses include gaps between vehicles, as the vehicle speed and the gap to the vehicle in front are both used to determine the thresholds below which a vehicle is considered to be in a queued state. Therefore the queue lengths reported do not necessarily represent a continuous queue of vehicles, but serve to illustrate the maximum possible extent of the level of queuing on each approach.

Figure 146 show the routes over which queue length data has been collected. Table 17 and Table 18 show queue length data for the AM and PM peaks respectively.

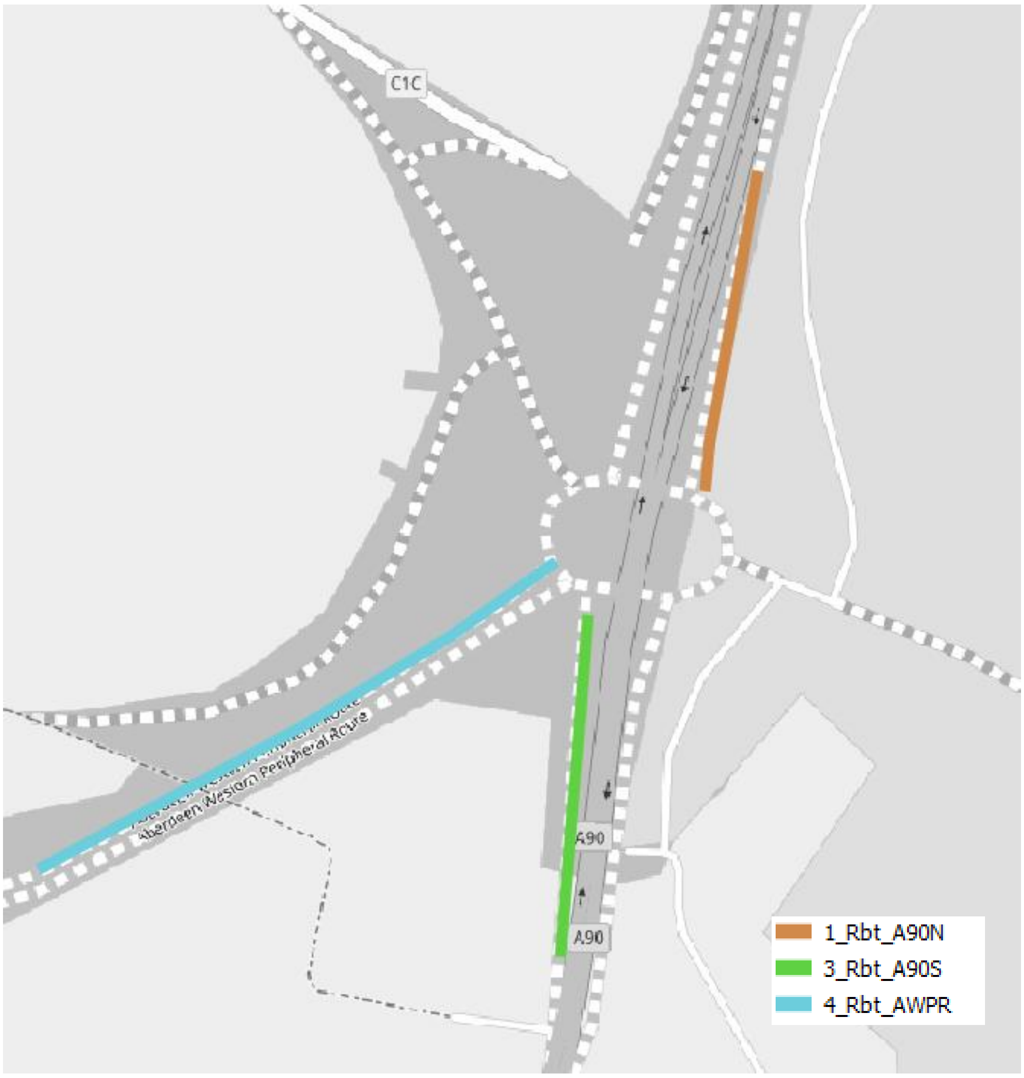


Figure 146 - Queue Routes

		0700-0800			0800-0900			0900-1000		
Route	Lane	Max Q	95% CI		Max Q	95% CI		Max Q	95% CI	
"1_Rbt_A90N"	1	52	50	55	69	67	71	33	31	34
"1_Rbt_A90N"	2	38	36	40	74	72	76	32	30	34
"1_Rbt_A90N"	3	-	-	-	-	-	-	-	-	-
"3_Rbt_A90S"	1	-	-	-	-	-	-	-	-	-
"3_Rbt_A90S"	2	-	-	-	-	-	-	-	-	-
"3_Rbt_A90S"	3	-	-	-	-	-	-	-	-	-
"4_Rbt_AWPR"	1	-	-	-	-	-	-	-	-	-
"4_Rbt_AWPR"	2	40	35	44	40	38	41	30	27	32
"4_Rbt_AWPR"	3	-	-	-	-	-	-	-	-	-

Table 17 - AM Max Queue Lengths

Table 17 shows that during the AM peak period, all the approaches to the A90 North junction experience a certain level of queuing. The main queue occurs on the A90 southbound diverge approach, with a queue length of 74 metres (equivalent to approximately 12 car lengths). The other approaches to the junction exhibit insignificant levels of queuing (if any) with a maximum recorded queue length of 40 metres, equating to around 7 car lengths.

To help illustrate the extent of the queuing during the AM peak, which does not necessarily occur simultaneously on all approaches, the schematic representations shown in Figure 147 has been produced.

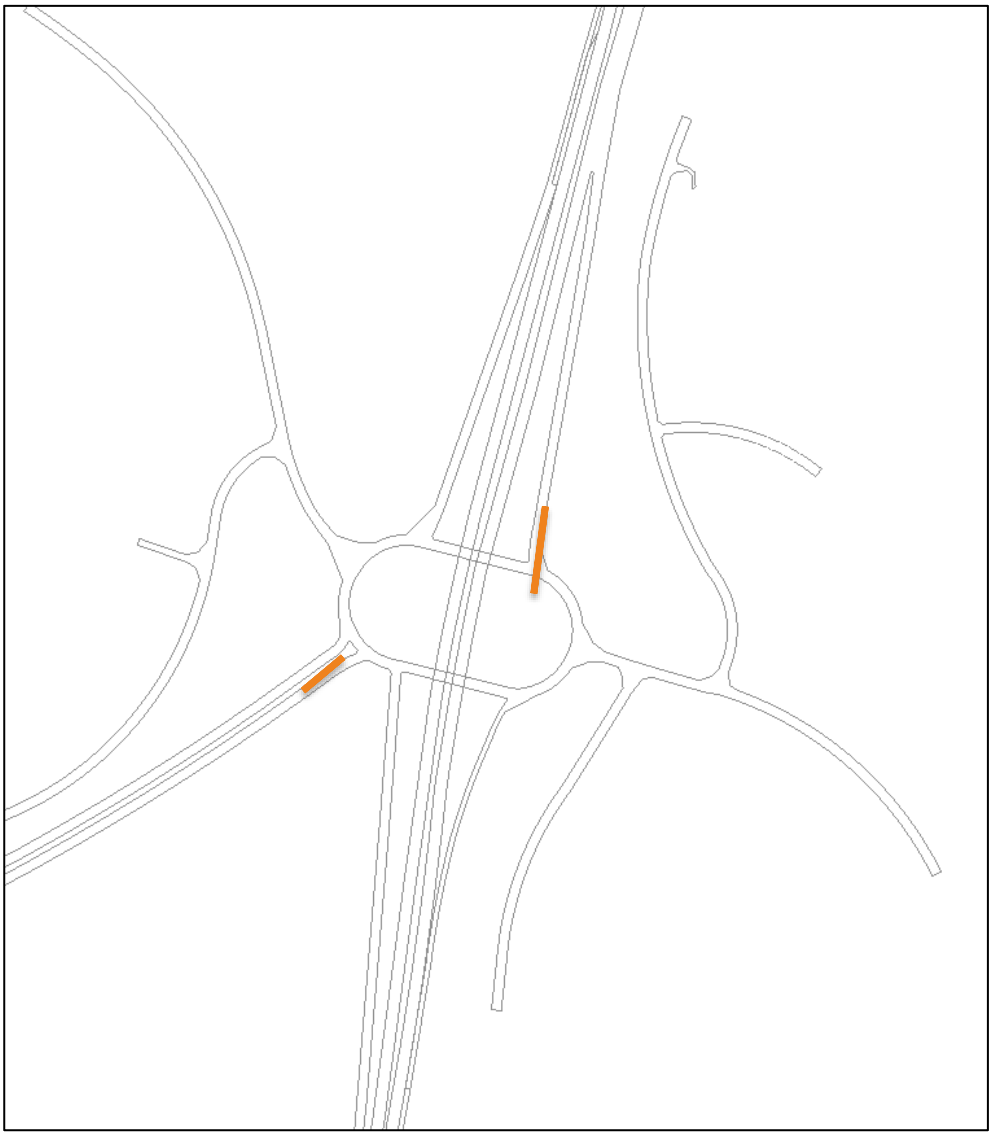


Figure 147 – AM Max Queue Length Diagram

Route	Lane	1600-1700 Max Q	1600-1700 95% CI		1700-1800 Max Q	1700-1800 95% CI		1800-1900 Max Q	1800-1900 95% CI	
"1_Rbt_A90N"	1	33	31	34	73	71	75	40	38	42
"1_Rbt_A90N"	2	34	32	36	37	36	38	33	31	35
"1_Rbt_A90N"	3	-	-	-	-	-	-	-	-	-
"3_Rbt_A90S"	1	-	-	-	34	29	39	-	-	-
"3_Rbt_A90S"	2	-	-	-	-	-	-	-	-	-
"3_Rbt_A90S"	3	-	-	-	-	-	-	-	-	-
"4_Rbt_AWPR"	1	27	-	-	30	28	32	-	-	-
"4_Rbt_AWPR"	2	39	33	45	40	38	41	29	26	31
"4_Rbt_AWPR"	3	-	-	-	-	-	-	-	-	-

Table 18 - PM Max Queue Lengths

During the PM peak, Table 18 shows that the approaches do not experience any significant levels of queuing. The maximum queue length that occurs is 73 metres (equivalent to approximately 12 car lengths). The other approaches to the junction exhibit insignificant levels of queuing with a maximum recorded queue length of 40 metres, equating to around 7 car lengths.

To help illustrate the extent of the queuing during the PM peak, which does not necessarily occur simultaneously on all approaches, the schematic representations shown in Figure 148 has been produced.

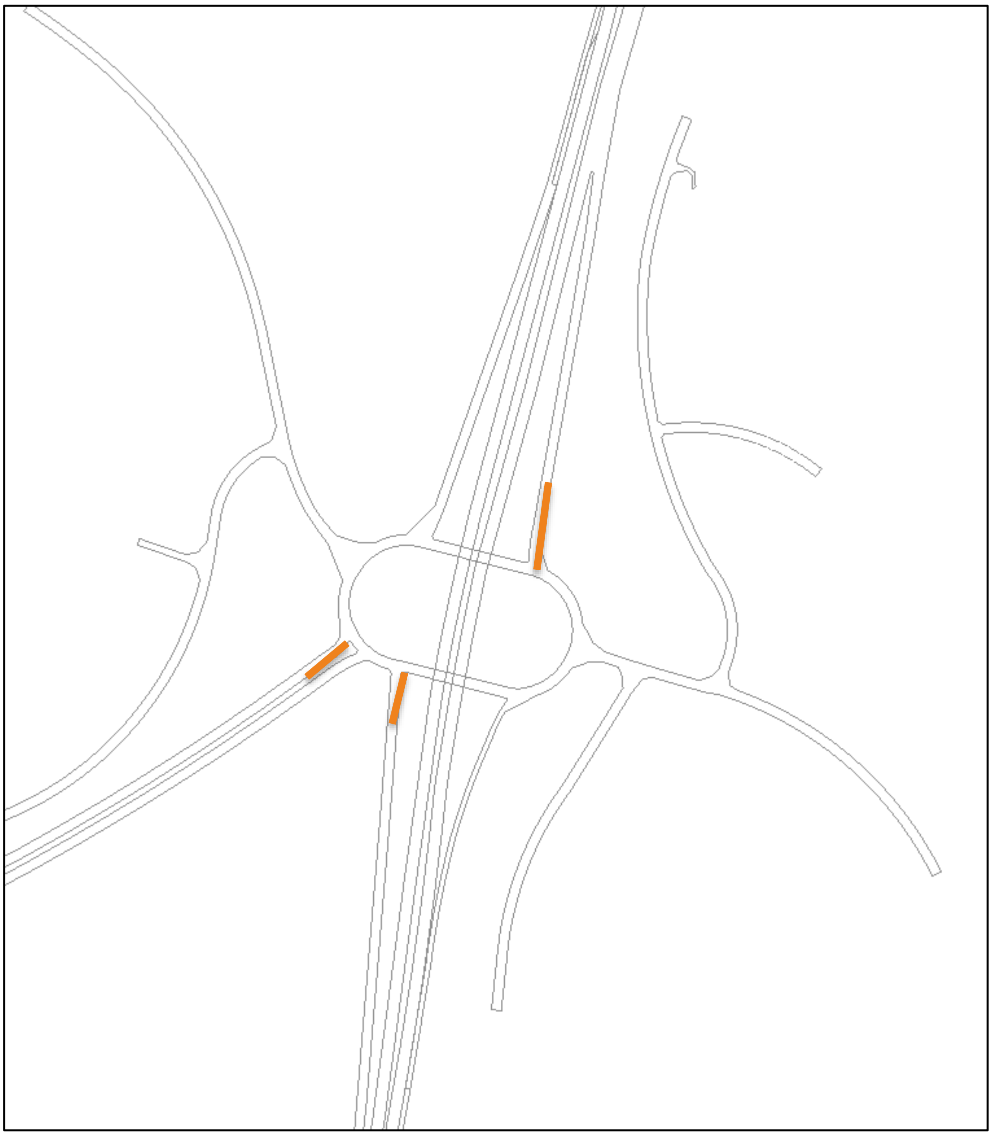


Figure 148 – PM Max Queue Length Diagram

Queue Length Distributions

To assess the significance of the maximum queue length statistics extracted from the Paramics model simulations, and examine how the queues vary over time, the queue length distribution for each main approach to the individual junctions that form the A90 design option was analysed throughout the simulation period.

Figure 148 and Figure 150 show the maximum queue length distribution for each of the main approach arms over time for the AM and PM peaks respectively. It should be noted that as the queue length distributions are extracted from the Paramics simulation runs at each 5-minute interval, the results may not necessarily reflect the maximum queue values presented in Table 17 and Table 18 as they may occur out with the 5 minute increments.

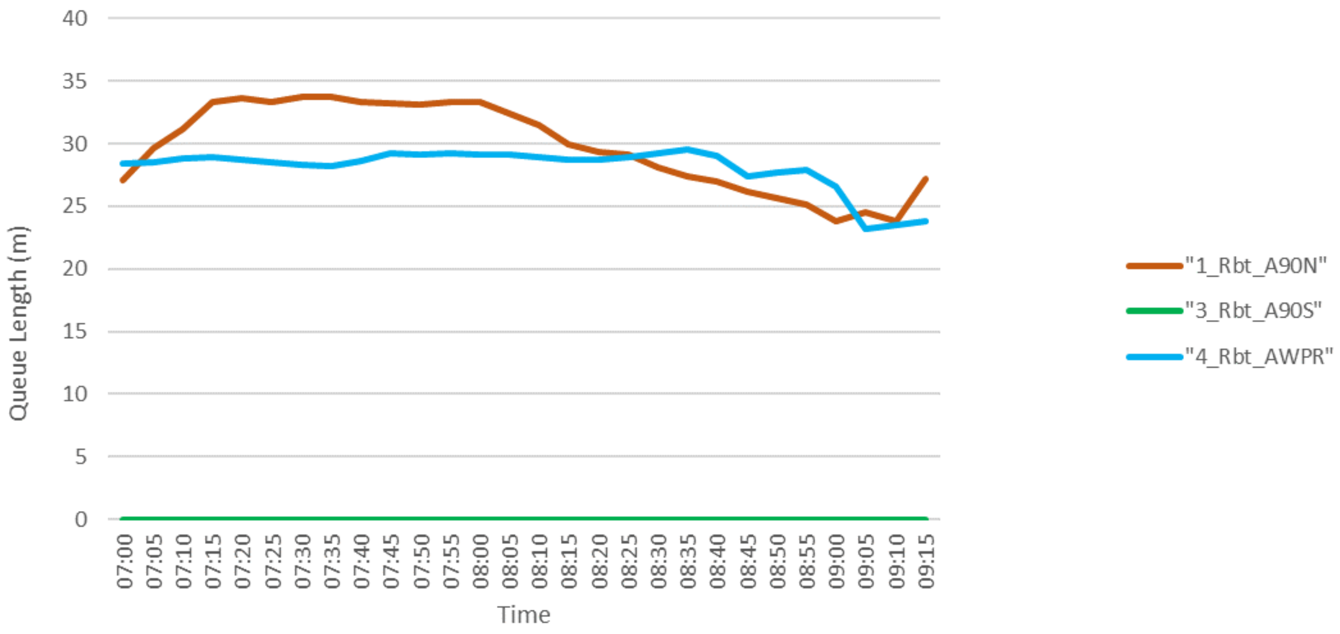


Figure 149 – AM Average Max Queue Length Distribution

During the AM peak, the A90 north and south approaches to the junction show some fairly limited queuing of around 30-35m (5-6 vehicles) throughout the modelled peak. There are no distinct peaks at any time.

The AWPR route shows no queuing at all in the AM peak.

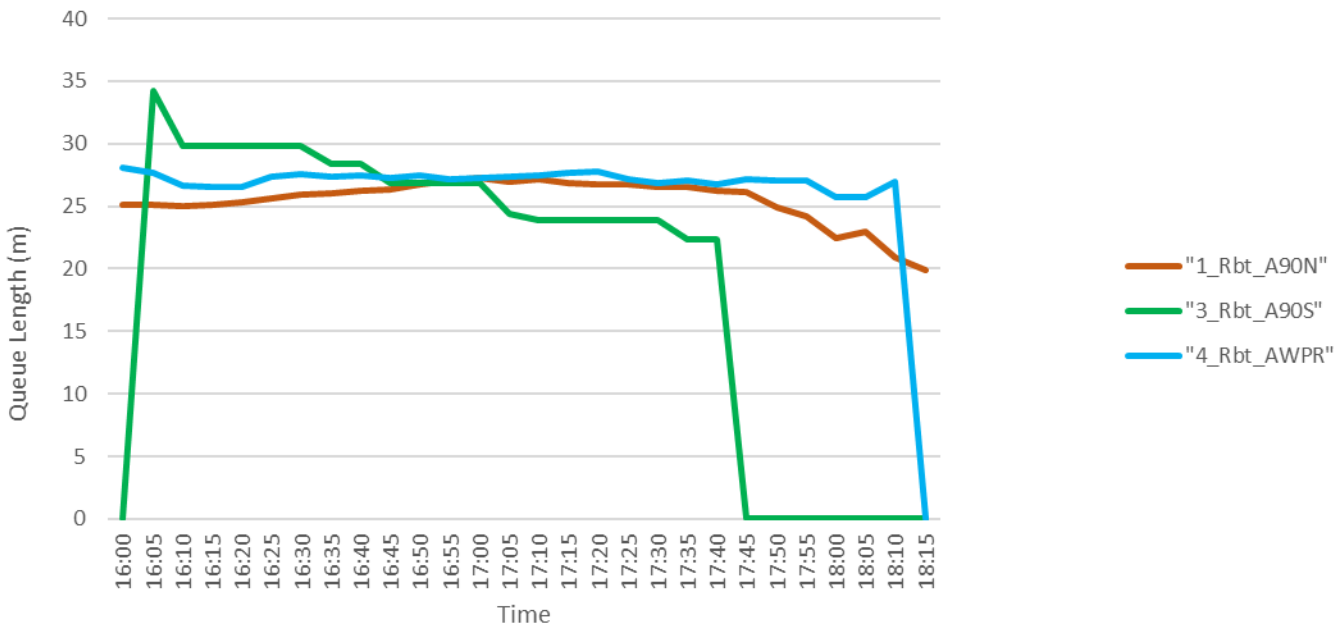


Figure 150 – PM Average Max Queue Length Distribution

During the PM peak, all approaches to the junction show some fairly limited queuing of around 25-30m (4-5 vehicles) throughout the modelled peak. There are no distinct peaks at any time.

It should be noted that variations toward the start and end of the period are a result of the average journey times recorded being informed by fewer trips (when queues are either not present or need time to build before they can be recorded). As a result, journey times show a greater level of variability (or where there are no trips making a manoeuvre resulting in a '0' value being reported; this is true of the "3 Rbt A90S" route for example).

11.5 Journey Time Data

In order to assess vehicle journey times, and their variation over time through the model, the journey time for each vehicle passing through the key junction movements on their identified routes through the model network was recorded.

These individual journey times were analysed to determine the average journey time of all vehicles travelling each identified key route through the Paramics model in each five minute period. These results were in turn averaged across the ten model simulation runs to develop a representative picture of the variation over time.

Figure 151 illustrates the journey time routes that were defined for the journey time analysis.

Figure 151 – Journey Time Routes

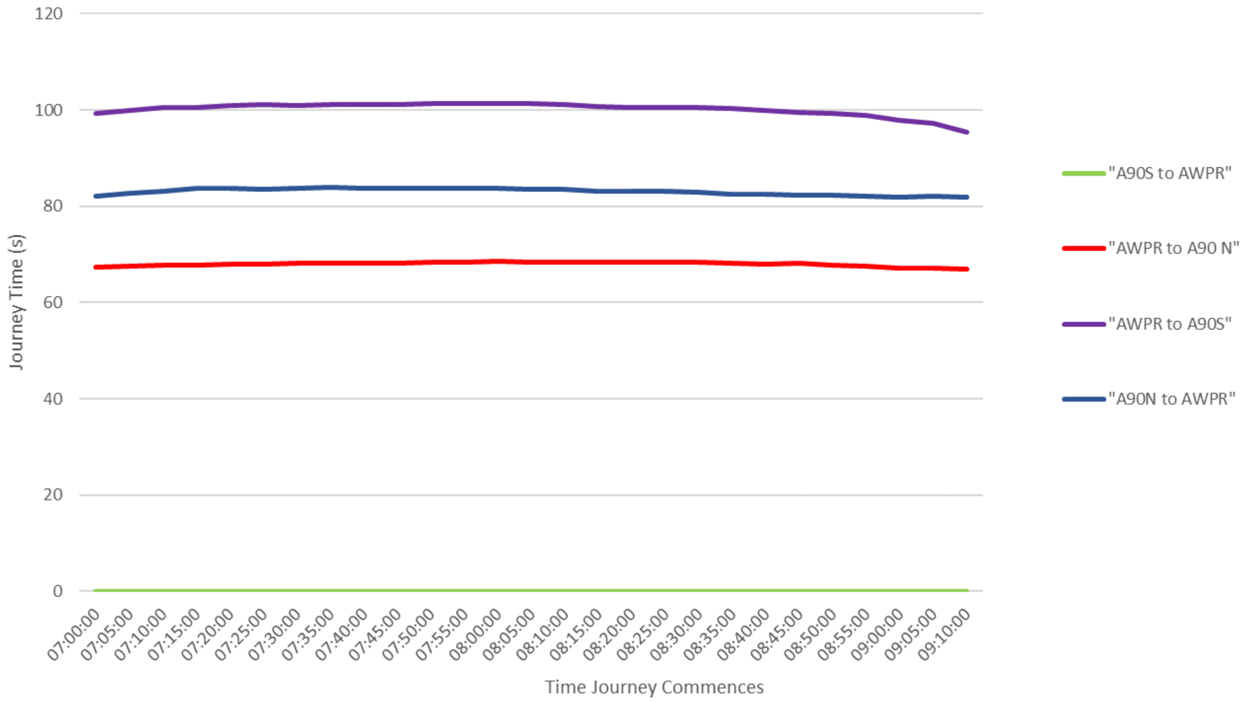


Figure 152 – AM Journey Time Data

During the AM peak, journey times for all movements through the junction remain almost constant throughout the modelled period indicating no significant deterioration in the junction's operational performance.

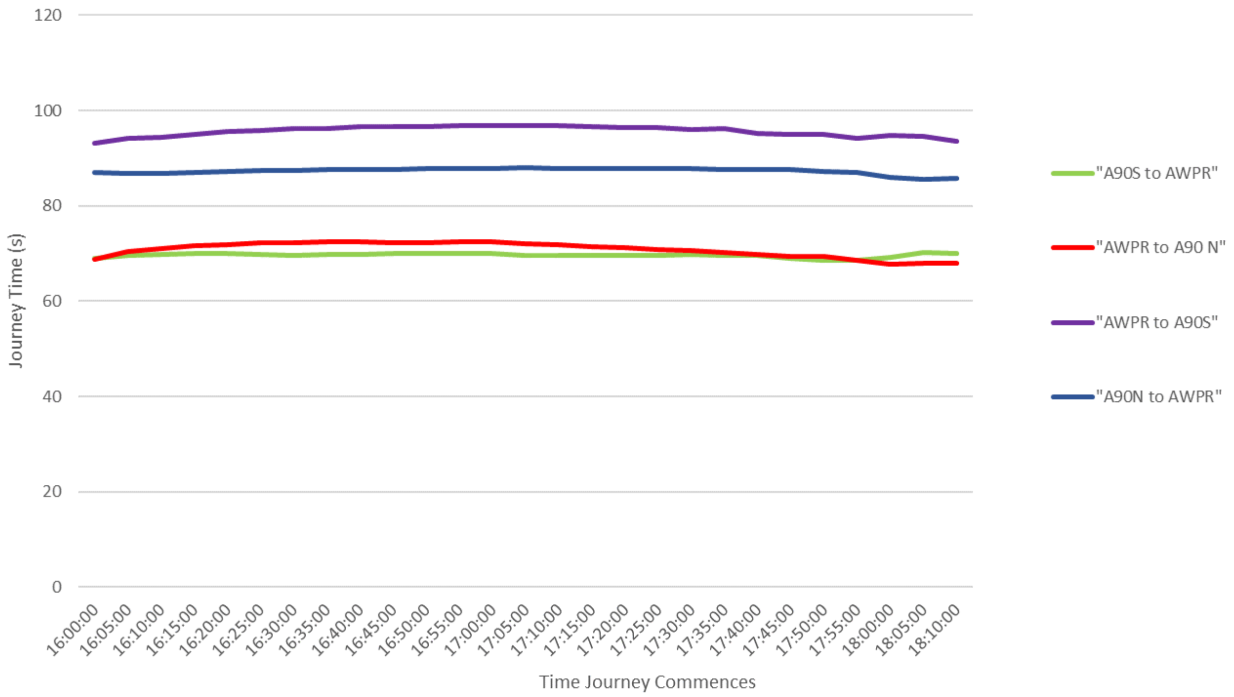


Figure 153 – PM Journey Time Data

Similarly to the AM peak, PM peak journey times for all movements through the junction remain almost constant throughout the modelled period. Again, this indicates no significant deterioration in the junction’s operational performance.

12. Model Performance Summary

12.1 Stonehaven Junction Performance Summary

Despite the junction at Stonehaven showing a degree of conflict between the traffic streams travelling through the junction during the AM and PM peaks, the Stonehaven junction exhibits high performance.

Vehicle speeds remain consistently high and journey times show little variation throughout the peak periods. There is some queueing through the junction in the southbound and northbound directions but maximum queues lengths extend up to between 10-15 vehicles. As the junction has enough stacking space to be able to accommodate queues of this length, they are not a concern in terms of operational performance.

12.2 Charleston Junction Performance Summary

As the Charleston junction is comprised of two signalised junctions in close proximity, the key to maintaining a good level of operational performance is ensuring that there is a high level of coordination between the two sets of signalised junctions.

Vehicle speeds remain consistently high and journey times show little variation throughout the peak periods. There is some queueing through the junction in the eastbound and westbound directions but maximum queues lengths extend up to between 10-15 vehicles. As the junction has enough stacking space to be able to accommodate queues of this length, they are not a concern in terms of operational performance.

12.3 Cleanhill Junction Performance Summary

During the AM peak period, the Cleanhill junction model shows a high level of performance; average speeds are consistently high throughout the modelled period, maximum queue lengths are very short and persist for only short periods of time and journey times are consistently low with little variation throughout the modelled period.

During the PM peak however, there are very long queues on the AWPR southbound approach to the junction; as there are no issues with conflicting traffic movements taking priority over the AWPR southbound traffic stream, the delay is a result of the volume of traffic travelling southbound in the peak hour (some 1770 vehicles) and the effect the geometric delay has in terms of slowing these vehicles down on the approach to the junction.

Where the radius on the southbound entry to the junction is tighter, vehicles need to slow in order to safely complete the manoeuvre. This effect combined with the heavy and persistent demand from the north results in some rolling queues forming on the southbound approach to the junction; as queues develop and persist throughout the PM peak period, average speeds show a decline and journey times increase.

12.4 A93 Milltimber Junction Performance Summary

It is anticipated that the A93 Milltimber junction is likely to see relatively low volumes of traffic using the junction in the opening year during the AM peak (compared to other junctions in the scheme) and there is also a relatively low level of conflict. As a result, queue lengths are relatively short (up to 121m), journey times are consistent throughout the modelled period and average speeds remain high.

During the PM peak however, traffic volumes are higher and there is a higher degree of conflict between traffic streams when compared to the AM peak. As a result, there are longer queues that develop on the approaches to the signalised junction on the A93. As a result, journey times through the A93 junction via the B979 are very high.

The new roundabout proposed as part of the new junction shows no operational issues during either modelled peak.

12.5 Kingswells Junction Performance Summary

During both the AM and the PM peak, there is a high volume of traffic travelling on the A944 toward the junction (in both the eastbound and westbound directions) which results in some conflict in movements between traffic streams at the junction.

The result is that journey times for traffic approaching the junction on the A944 can be higher (up to approximately 265 seconds) and queue lengths can be longer (up to 323 metres). However, the periods of time that the junction is showing a low level of performance is relatively short. In the AM peak, queue lengths are longest in the period 07:20 to 08:05 and journey times show some increases during this period.

In the PM peak, longer queue lengths and higher journey times generally occur for periods of 40-60 minutes with journey times of up to 6 minutes as a result of the heavy east-west and west-east movements on the A944.

Outside these peak times, the model shows that the junction operates comparatively well with short queue lengths and consistently low journey times.

12.6 Craibstone Junction Performance Summary

The results show that while the Dyce junction is showing some longer queue lengths, the junction is accommodating the high level of demand expected at the time of opening.

Vehicle speeds remain consistently high and journey times show some limited variation throughout the AM peak period; at the height of the peak, some journey times increase by a relatively small proportion with a corresponding increase in the queue length at the junction (particularly on the A96 approaches to Craibstone roundabout.

During the PM peak, the Craibstone roundabout shows some longer queuing on all four approaches; queue lengths do increase at the height of the peak but journey times for most routes through the junction show either little variation or some minor increases in journey times for key routes at the height of the peaks.

Overall however, the junction appears to be accommodating the demand expected despite some signs of relatively poor performance at the height of the peak hours.

12.7 Goval Junction Performance Summary

The results show that while the Goval junction is operating well in the AM peak, a particular issue relating to conflict at the B977 \ AWPR south junction is causing longer queues and high journey times at the A947 \ B977 link; traffic travelling through the roundabout for the AWPR WB take priority over the eastbound traffic and cause queueing along the B977 link road.

All other routes during both peaks show an acceptable level of performance able to accommodate the level of demand expected on the day of opening.

12.8 Blackdog Junction Performance Summary

During both the AM and the PM peak periods, the Blackdog junction model shows a high level of performance; queues are very short throughout the full modelled period, average speeds are consistently high and journey times are consistently low.

Overall, the design of the junction is able to accommodate the level of demand expected on the day of opening.

13. Observations of Junction Performance in Operation

Following opening of Phase 2B most of the junctions on the AWPR have been brought into operation in final form. The exceptions to this are North Kingswells Junction, where northbound merge access is not available, Craibstone Junction, where only the northbound diverge and the southbound merge slip roads are operating, and Goval Junction, where only the northbound merge and the southbound diverge slip roads are operating. Although travel patterns and traffic volumes will take some time to become established following opening to use of the whole project, it is possible to make some general observations of junction performance in operation to date.

13.1 Stonehaven Junction

Following opening of Phase 2B Stonehaven Junction was brought into operation in final form. To date the junction has performed well and it is considered that queuing and delays at this junction are not excessive.

13.2 Charleston Junction

Following opening of Phase 2B Charleston Junction was brought into operation in final form. To date the junction has performed well and it is considered that queuing and delays at this junction are not excessive.

13.3 Cleanhill Junction

Following opening of Phase 2B Cleanhill Junction was brought into operation in final form. To date the junction has performed well and it is considered that queuing or delays at this junction are not excessive. It has been noted that there has been an issue with driver perception of this junction and yellow transverse road markings have been installed on all approaches to improve driver awareness.

13.4 Milltimber Junction (Signed as Deeside Junction)

Following opening of Phase 2B Milltimber Junction was brought into operation in final form. To date the junction has performed well and it is considered that queuing or delays at this junction are not excessive.

13.5 South Kingswells Junction (Signed as Kingswells South Junction)

Following opening of Phase 2B South Kingswells Junction was brought into operation in final form. To date the junction has performed reasonably well, although instances of queuing and delay on the diverging slip roads have been observed during some peak periods. These are likely to be occurring as a consequence of the volume of traffic on the A944 not providing the expected frequency of sufficient gaps to allow traffic to enter the roundabout from the diverging slip roads. There have also been reports of some issues of driver perception of this junction in relation to the signalised crossing of the southbound diverge slip road. It is noted that Condition 23 of the Decision Notice approving the planning application by Aberdeen FC Community Trust & Aberdeen Football Club Plc for a new stadium at Kingsford includes reference to the potential for this junction to be made fully signalised in future.

13.6 North Kingswells Junction (Signed as Kingswells North Junction)

Following opening of Phase 2B North Kingswells Junction was brought into operation in partial form, involving use of the southbound diverge slip road only. To date the junction has performed well and it is considered that queuing or delays at this junction are not excessive, although the limited nature of its operation is noted.

13.7 Craibstone Junction

Following opening of Phase 1 the new at-grade roundabout on the A96 was brought into operation in partial form, involving use of the two A96 arms and the arm connecting the junction with the airport link road. Following opening of Phase 2B this roundabout was brought into operation in final form, although at that time Craibstone Junction was brought into operation in partial form, involving use of the northbound diverge and southbound merge slip roads only, with no traffic permitted to travel northbound beyond Craibstone Junction. In addition, the local road connecting to the C89C was not brought into operation. As the junction between the Aberdeen Western Peripheral Route and the link road connecting to the new at-grade roundabout is not yet operating as it will when fully operational, no observations have been made at this time on the performance of that part of the junction. However, to date the new at-grade roundabout on the A96 has performed well and it is considered that queuing or delays at this junction are not excessive.

13.8 Goval Junction (Signed as Parkhill Junction)

Following opening of Phase 2A Goval Junction was brought into operation in partial form, involving use of the northbound merge and southbound diverge slip roads only, with no traffic permitted to travel southbound beyond Parkhill Junction. The realigned A947 and B977 link roads which link these slip roads were in operation for some time before Phase 2A was opened to use. As this junction is not yet operating as it will when fully operational, no observations have been made at this time on the performance of the junction.

13.9 Blackdog Junction

Following opening of Phase 2A Blackdog Junction was brought into operation in final form. To date the junction has performed well and it is considered that queuing or delays at this junction are not excessive.