Active Travel Infrastructure: Horseshoe Bridge, Monaghan

Traffic Modelling Report

Monaghan County Council

February 2023

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1. Introduction

Monaghan County Council (the Client/MCC) as the Contracting Authority, appointed Atkins (the Consultant) to determine the potential traffic related impacts resulting from the introduction of active travel measures at Horseshoe Bridge, Mullaghmatt, Co. Monaghan.

1.1. Bridge Location

Horseshoe bridge is located on the southwest side of Monaghan town centre and carries Park Road over the Ulster canal in Monaghan Town. The bridge is in the townland of Mullaghmatt as summarised in the figure below.

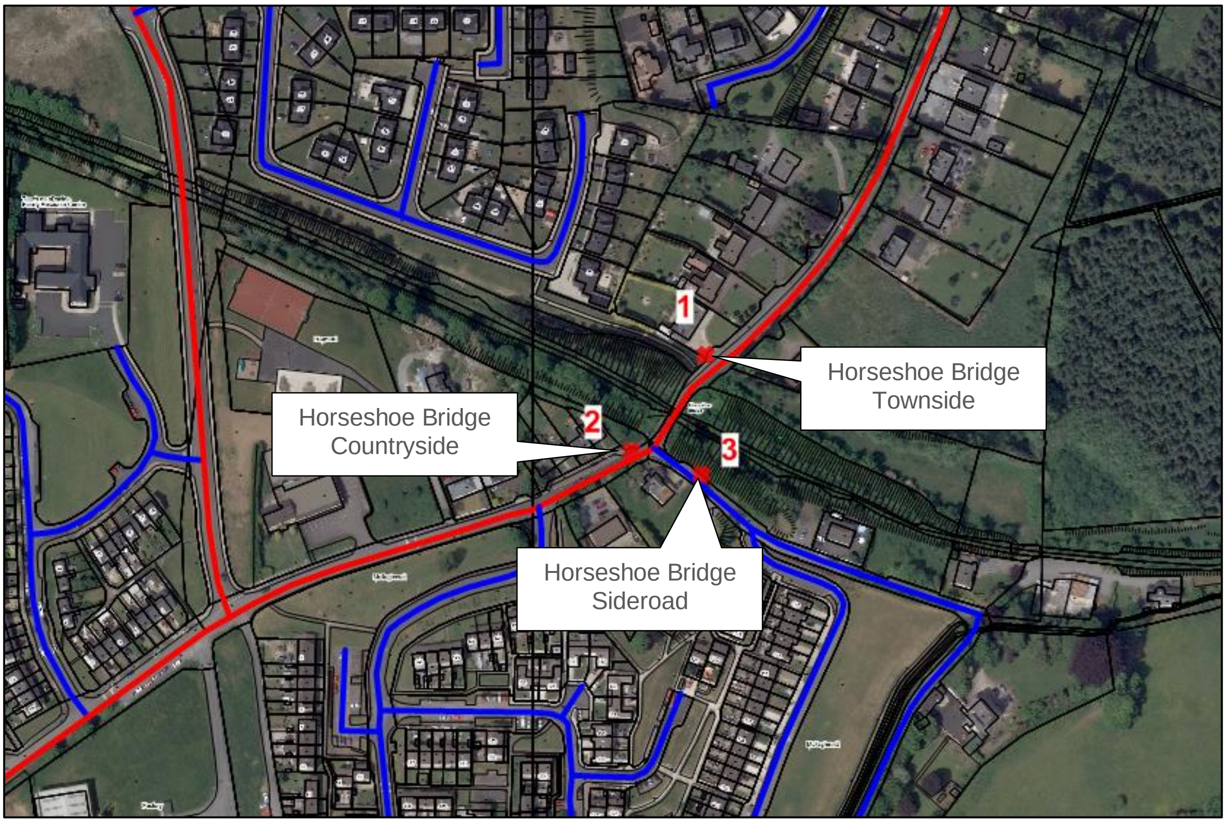
Figure 1-1 - Location of Horseshoe Bridge

2. Base Year Model Development

2.1. Receiving Environment

Traffic survey data for the bridge was collected by Monaghan County Council. The traffic Data included 7 day ATC data for the three locations identified in the figure below. The data was collected on dates between 10th June 2022 to 16th June 2022.

Figure 2-1 - Location of Horseshoe Bridge traffic counters

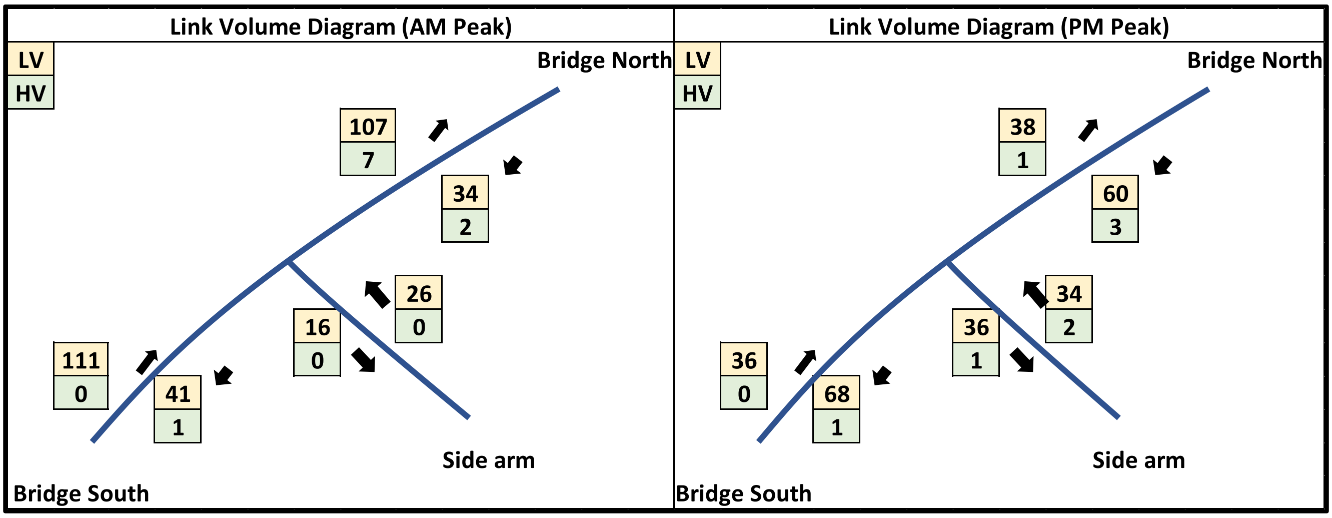


Based on the traffic data, the following peak hours were identified:

- **AM Peak:** 8 to 9 am
- **PM Peak:** 5 to 6 pm

For both the peak hours, the traffic data for all the three locations are summarised in the figure below:

Figure 2-2 - Link Volume Diagram: Horseshoe Bridge



In addition to ATC data, Monaghan County Council also provided the pedestrian and cycle volumes for two days (October 8, 2022 and October 22, 2022) at the study location. The table below summarised the maximum pedestrian and cyclist volumes over the two days.

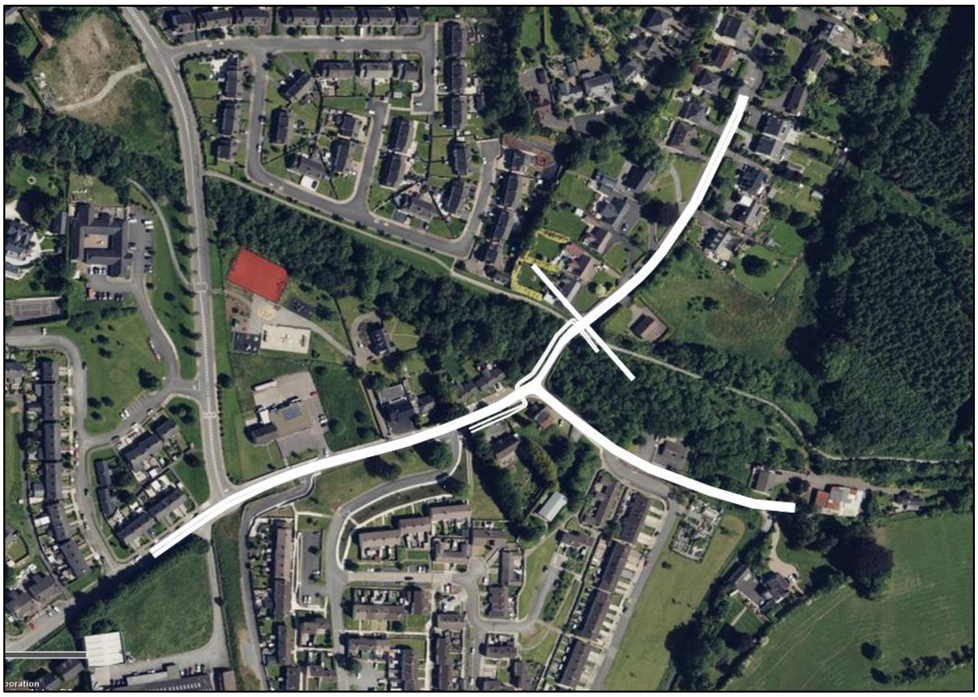
Table 2-1 - Base Year Pedestrian and Cycle Number

Time	Cyclist Number		Pedestrian Number	
	To Town	To Mullaghamat	To Town	To Mullaghamat
8.00am - 9.00am	1	0	91	27
9.00am - 10.00am	0	1	34	15
10.00am - 11.00am	0	0	22	5
11.00am - 12.00am	0	1	16	12
12.00pm - 1.00pm	0	0	12	16
1.00pm - 2.00pm	0	0	22	30
2.00pm - 3.00pm	0	0	24	50
3.00pm - 4.00pm	0	0	19	47
4.00pm - 5.00pm	0	1	15	41
5.00pm - 6.00pm	0	1	21	36
6.00pm - 7.00pm	0	0	12	6
7.00pm - 8.00pm	4	1	18	6
TOTALS	**5**	**5**	**306**	**291**

2.2. Model Development

To assess the potential traffic related impact, a microsimulation model was developed using VISSIM for the model cordon shown in white in the figure below. The extent of the model is shown in white. The model only included the priority junction of the side arm with the bridge. However, the arms of the bridge were extended far beyond, as shown in the figure below, in order to assess the extent of possible queue lengths for future year scenarios.

Figure 2-3 - VISSIM Model Extent



2.3. Model Calibration and Validation

The purpose of the model calibration and validation criteria is to compare parameters in the model to those observed on the ground and to check whether the comparison of these parameters meets the guidelines provided in the TII Document (PEPAG-02015) [1]. This will ensure that the model represents as close as possible the existing road network conditions.

The microsimulation model was calibrated for the base year scenario for the morning and evening peak hours.

The model was validated using the GEH statistic for the link volume as outlined below.

For validation, the model was run 5 times using varying random seeds for both the AM and PM peak. This allows for modelling of typical day to day variations in traffic flows and traffic patterns and more accurately models the real-world situation on site.

2.3.1. Link Volume Calibration

For Link Volume Calibration, the traffic volume recorded for both directions for the counters (Figure 2-1) as summarised in the Link Volume Diagram (Figure 2-2) was compared with the data collected from the model.

The modelled and observed volume for all counters were compared using the GEH statistic criteria as summarised in the table below.

The GEH static criteria is a form of chi-square statistic test which compares the modelled and observed traffic volume counts and is defined below:

$$GEH = \sqrt{\frac{2*(M-C)^2}{M+C}}$$

Where:

M = modelled count and C = observed count

The TII guidelines criteria for a valid traffic model is for 85% of turning movements to have a GEH value less than 5. The calibration results for the AM and PM Base Year scenarios are summarised in the table below.

Table 2-2 - Base Year Link Volume Calibration

Counters	Direction	AM Peak			PM Peak		
		Observed	Modelled	GEH	Observed	Modelled	GEH
Bridge North	Northeast Bound	114	124	**0.92**	39	39	**0.00**
	Southwest Bound	36	45	**1.41**	63	68	**0.62**
Bridge South	Northeast Bound	111	118	**0.65**	36	40	**0.65**
	Southeast Bound	42	43	**0.15**	69	71	**0.24**
Side Arm	Towards Bridge	26	28	**0.38**	36	41	**0.81**
	Away from Bridge	16	24	**1.79**	37	41	**0.64**

From the table above it is clear that for both the AM and the PM Peak Base Year models, the GEH criteria is met for all counters. Hence, the model was is considered to be calibrated given the available data.

3. Future Year Model

The future year model development consists of the following:

- Identification of future design years
- Identification of methodologies to estimate traffic for future design years
- Identification of scenarios for future design years.

3.1. Design Years

Future year modelling was carried out for all of the following design years:

- Opening Year (2024)
- Opening Year +5 (2029)
- Opening Year +15 (2039)

3.2. Background Traffic Growth (TII General Growth Factors)

3.2.1. Future Pedestrian/ Cyclist Volume

Future pedestrian volume was determined on the basis of the active travel target provided in the Monaghan County Walking and Cycling Strategy 2021-2026 [2]. The Local Authority has set these target to be achieved by 2031 and they are summarised below.

- 10% increase in recreational walking & cycling
- 20% increase in commuting by all Active Travel modes

Based on these targets, it was assumed that pedestrian and cycle volume will increase by 2% per year. As such, the growth rate for each design year is summarised below.

- **Opening Year (2024):** 1.0404
- **Opening Year +5 (2029):** 1.1487
- **Opening Year +15 (2039):** 1.4002

For the cyclists, in addition to the above growth, it was further assumed that private car users will shift to the cycle mode at the rate of 2% per year as these replace vehicle trips. Therefore, the total future cyclist number included the annual growth of the cyclists, and also include the new cyclist volume because of the modal shift.

Based on the above assumptions, the future pedestrian and cycle volume for each design year are summarised in the table below.

Table 3-1 – Future Pedestrian / Cyclist number for the Base Year

Peak	To Town	To Country	To Town	To Country	To Town	To Country	To Town	To Country
	Base year		Opening Year		Opening Year + 5		Opening Year + 15	
Cycle Numbers								
AM Peak (8 to 9 am)	1	0	6	2	18	6	40	15
PM Peak (5 to 6 pm)	0	1	2	5	6	11	14	24
Pedestrian Numbers								
AM Peak (8 to 9 am)	91	27	95	29	105	32	128	38
PM Peak (5 to 6 pm)	21	36	22	38	25	42	30	51

3.2.2. Future Motorists Volume

Growth factors were applied to all vehicular traffic volumes for each of the above design years using the link growth rates summarised in Table 6.2 of the TII Publication: Project Appraisal Guidelines for National Roads Unit 5.3 - Travel Demand Projections (PE-PAG-02017) [3].

The "Central Growth Factors" for the Monaghan County Area were utilised to estimate the background traffic growth. These growth factors for both LV and HV are summarised in the table below.

Table 3-2 - Link-Based Growth Rates for Monaghan County (excluding Metropolitan Area)

	LV	HV
2016-30	1.0115	1.0252
2030-40	1.0047	1.0112
2040-50	1.0041	1.0138

Based on the above growth factor, the percentage growths for all design years are summarised in the table below.

Table 3-3 – Growth Percentage

Design Year	LV Growth (%)	HV Growth (%)
Opening Year (2024)	2.3%	5.1%
Opening + 5 Year (2029)	8.3%	19.0%
Opening + 15 Year (2039)	14.3%	34.9%

It is planned that, in line with national and local policy, that the increase in the active travel pedestrian and cyclist mode share will result in the decrease of the car mode share. However, for robustness, no change in the mode share for the vehicles was assumed, to represent the most conservative scenario.

3.2.3. Ulster Canal Greenway Cycle Number

It is estimated that an average 100,000 people used the Ulster Canal Greenway last year. Since no data was available at Horseshoe Bridge, it was conservatively assumed that this entire number passed through this section of the greenway.

Assuming the linear usage over the year, the number of greenway users was determined as 274 per day (100,000 / 365). For the hourly distribution, it was assumed that it will follow the current pedestrian and cycle distribution as summarised in Table 2-1. Based on this, out of 274, 55 % will be using the greenway in the AM Peak (8 to 9 am) and 27% during the PM Peak (5 to 6 pm). Further, a 50-50 split for the north to south and south to north movements was assumed.

Based on these assumptions, the cycle number for both peak hours for the section of the Ulster Canal Greenway near Horseshoe Bridge are summarised in the table below. For the future year scenarios, a 2% growth in users per year was assumed as described in Section 3.2.1.

Table 3-4 – Ulster Canal Greenway Numbers for the Base Year

Peak	North to South	South to North	North to South	South to North	North to South	South to North	North to South	South to North
	Base Year		Opening Year		Opening Year + 5		Opening Year + 15	
AM Peak	28	28	29	29	32	32	39	39
PM Peak	14	14	15	15	16	16	19	19

3.3. Future Assessment Scenarios

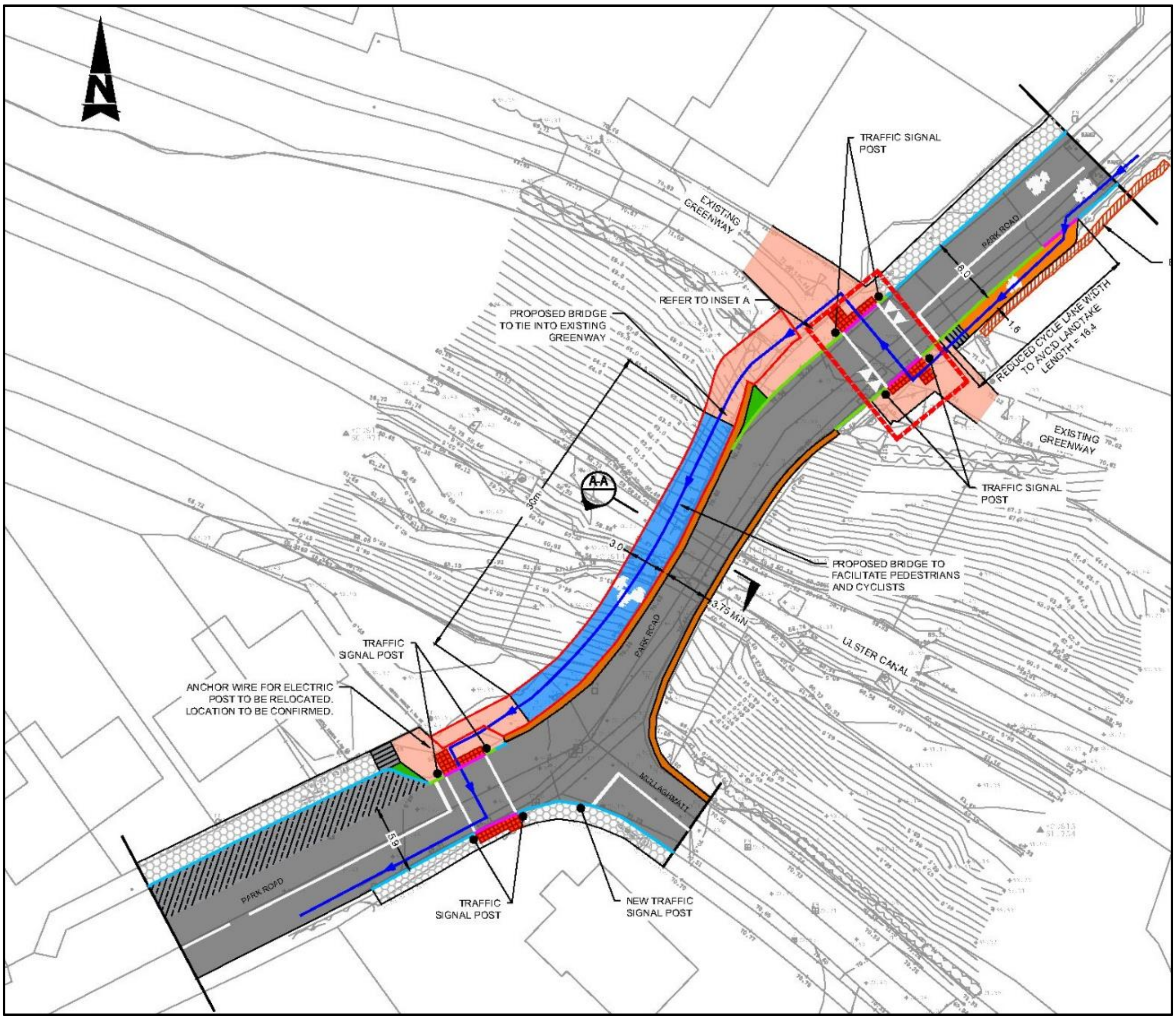
Following scenarios were modelled for each future design year and for both the AM and PM peak:

- Do Nothing
- Do Something

The Do Nothing Scenarios included the existing condition. In terms of the traffic numbers, it included background growth of traffic. These scenarios also included the cycle users along Ulster Canal Greenway. No active travel facilities currently exist for the pedestrian and cyclists; therefore, future pedestrian and cyclist volumes were not coded for the Do Nothing scenario.

For Do Something scenarios, the proposed active travel measures, as summarised in the figure below, were coded. In terms of the traffic volume, these scenarios included the background traffic growth, greenway users and the future pedestrian and cycle growth. The proposed active travel measures are summarised in the figure below. The active travel measures include the provision of a shared footpath and cycle path on the north side of the bridge together with provision of toucan crossing on the northern and southern approaches to the bridge. The northern toucan crossing also facilitates the safe crossing of the greenway users.

Figure 3-1 - Proposed Active Travel measures along Horseshoe Bridge



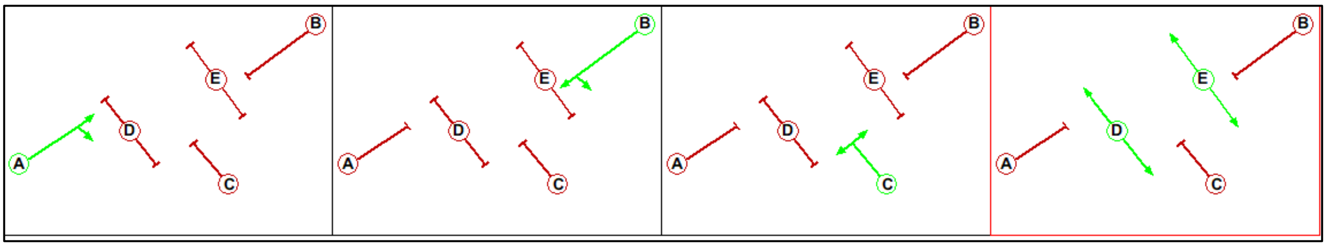
The following section summarises the methodology for coding the traffic signal at the Horseshoe Bridge.

3.3.1. Coding of Traffic Signal for the Bridge

For the Do Something scenarios, the traffic signal for the bridge was coded using Vehicle Actuated programming (VAP) in Vissim. The VAP programming included the junction's stages to only be run in each cycle when called on demand, thus optimising signal efficiency.

The general stage sequence for the bridge is shown below.

Figure 3-2 - Stage Sequence for Horseshoe Bridge



The methodology of the VAP coding is summarised below:

- 4 no. traffic stages were considered as shown in Figure 3-2 above.
- The default stage is the stage which was coded to remain green when no other stage was called on demand. In the AM Peak, the northeast bound traffic towards the town is higher than traffic on other arms. Therefore, Stage 1 was coded as the default stage. In the PM peak, the southwest traffic exiting the town was observed to be the highest. Therefore, Stage 2 was coded as the default stage in the PM peak.
- At the start of all the scenarios, the default stage was run first while demand on all other arms was continuously checked including the pedestrian/cycle stage. If no other stage is called by demand, the signals will continue to run the default stage.
- Once a stage is called by demand the signals will switch to the required stage following the required intergreen period. If all stages are called by demand, the cycle will operate in the sequence outlined above.
- The maximum cycle time for both AM and PM code was coded as 90 seconds in accordance to the DMURS.
- The intergreen for the stage was provided in accordance to the Traffic Advisory leaflet 1/06 by Department of Transport UK [4]. Based on the document, the intergreen between the stages were determined to be 8 seconds.
- Based on the Traffic Advisory Leaflet 5/05 by the Department of Transport UK [4], the green time for the pedestrian/cyclist stage was provided as 7 seconds with an amber phase equal to crossing width divided by 1.2 m/s (average walking speed of pedestrian) and a 2 seconds red phase before traffic regains priority. Based on that that, total intergreen time between pedestrian/cyclist stage and the vehicle stage was determined as 7 seconds (amber time = 5 seconds (6/1.2), and all red 2 seconds). The total pedestrian/cyclist crossing stage was, therefore, 16 seconds in length.

Although the pedestrian and cyclist stage (Stage 4) was coded as demand activated, this stage was observed to be called every cycle in the model due to the volume of active travel users. Therefore, this represents the most conservative possible scenario.

The results for all the scenarios are summarised in the following section.

4. Future Year Scenarios Results

The results for the future year scenarios are discussed in the following section. The data collected for each scenario include the following:

- Overall Network Performance
- Journey Time along the between the north-south direction of the bridge
- Junction Impact Assessment Results

The assessment was carried out for all the scenarios discussed in the earlier sections. For each scenario, similar to the Base Year model calibration, the model was run 5 times with varying random seeds. This allows for modelling of typical day to day variations in traffic flows and traffic patterns and more accurately models the real-world situation on site. The results were then collected for the average of all 5 runs and are summarised in the following section.

4.1. Overall Network Results

Results were collected for the entire network in VISSIM to assess the impact of the proposed development and infrastructure upgrade on the overall network. The overall network results include average delay, average speed and latent demand for the overall network.

a. The **average delay** per vehicle for each scenario was computed by dividing net delay by the total number of vehicles for each modelled peak period.

b. Net delay and total number of vehicles are determined as follow:

   i. Total delay includes total delay of all vehicles in the network or of those that have already exited it. Latent delay includes total waiting time of vehicles from input flows that were not used at their actual start time in the network. Latent delay and total delay for each hour were added to obtain the **net delay** across each modelled peak period for every scenario.

   ii. Total **number of vehicles** include Vehicles Arrived, Vehicles Active and Latent Demand for each modelled period. Vehicles Arrived are the total number of vehicles which have already reached their destination and have been removed from the network before the end of each peak period of simulation. Vehicle Active are the total number of vehicles still in the network at the end of each modelled peak period of the simulation. Latent demand includes the number of vehicles that could not enter the network until the end of the simulation for each modelled peak period.

c. Average Speed of each vehicle is calculated by simple formula Total distance/Total travel. Thereafter, the weightage average of the speed of all the vehicles within the network is determined to give the **average speed of all the vehicles over the entire network**. The weight is the respective travel time of the vehicles. This means that vehicles that have only a short travel time have less influence on the value of this result attribute than vehicles that have been in the Vissim network for a long time.

d. **Latent demand** signifies the congestion within the network. Higher latent demand means that congestion prevails at the end of the modelled period, due to which, it is likely that some vehicles are not able to enter the network from their designated zones within the model cordon.

The overall network results for all the scenarios for each design year are detailed in Appendix B and summarised in the table below.

Table 4-1 - Overall Network Performance Results Summary: All Scenarios

Parameters	AM Peak		PM Peak	
Base Year (2022)				
Average Delay	2 sec		2 sec	
Average Speed	32 km/hr		30 km/hr	
Latent Demand	0 veh		0 veh	

Parameters	AM Peak		PM Peak	
	Do Nothing	Do Something	Do Nothing	Do Something
Opening Year (2024)				
Average Delay	2 sec	20 sec	2 sec	18 sec
Average Speed	32 km/hr	25 km/hr	30 km/hr	24 km/hr
Latent Demand	0 veh	0 veh	0 veh	0 veh
Opening Year + 5 (2029)				
Average Delay	2 sec	20 sec	2 sec	19 sec
Average Speed	32 km/hr	25 km/hr	30 km/hr	24 km/hr
Latent Demand	0 veh	0 veh	0 veh	0 veh
Opening Year + 15 (2039)				
Average Delay	2 sec	20 sec	2 sec	20 sec
Average Speed	32 km/hr	25 km/hr	30 km/hr	23 km/hr
Latent Demand	0 veh	0 veh	0 veh	0 veh

From the above table, it can be observed that for both peak hours across all the design years, the average delay for the overall network was found to increase from 2 seconds for Do Nothing Scenario to 20 seconds for Do Something Scenario.

Across all the design years for both peak hours, the average speed for the entire network reduced from order of 30-32 km/hr for Do Nothing Scenario to 23-25 km/hr for Do Something Scenario.

The increase in the average delay and reduction in the average speed across the network is attributed to additional delay caused by the introduction of signals in the Do Something Scenarios. However, the delays of around 20 seconds for Do Something Scenario is small suggesting that overall, the network was found to be operating within the capacity for all the design years.

The latent demand across all the scenarios was observed to be zero, suggesting that no congestion was observed in the network.

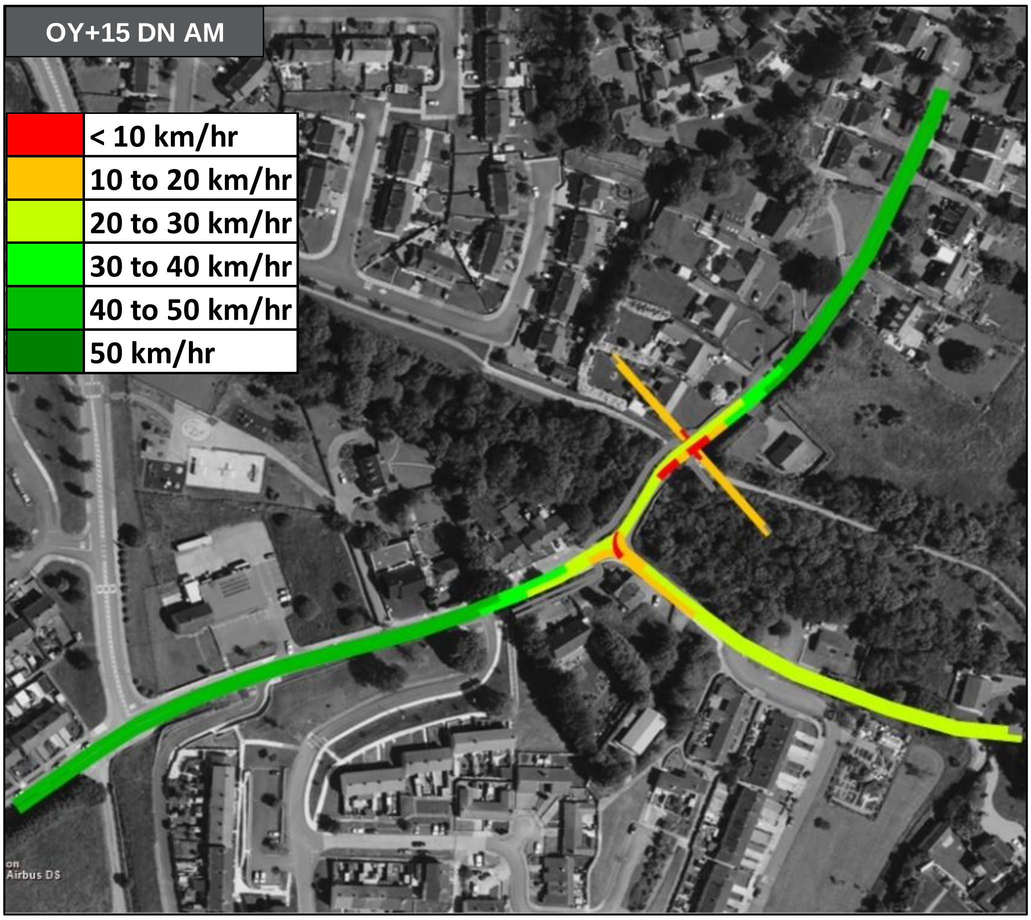
The average speed profile for all scenarios is included in the Figure 4-1 and Figure 4-2 below. The average speed profile helps to identify locations of potential congestion within the network.

The average speed profile figures below suggest that the network is generally free flowing across all the scenarios, with a small magnitude of congestion observed only for Do Something Scenarios near the signals. However, the this is very localised at the signals and does not extend to the wider network, and as such it can be said that the network was observed to be well within the capacity for all Do Something Scenarios. In the average speed profile, the pedestrian and cycle paths are red because the average speed of the pedestrian and cyclists were coded as 5 and 12 km/hr respectively.

Figure 4-1 - Average Speed Profile: AM Peak

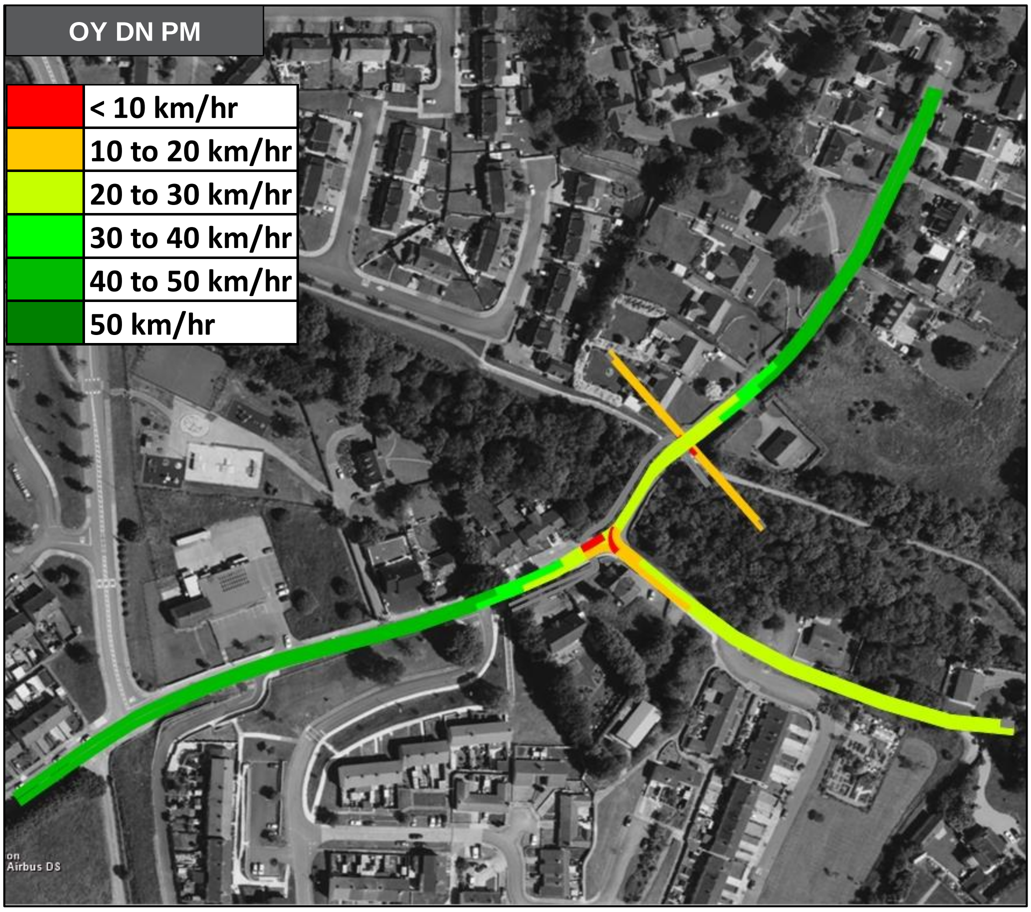

OY+5 DN AM
< 10 km/hr
10 to 20 km/hr
20 to 30 km/hr
30 to 40 km/hr
40 to 50 km/hr
50 km/hr
Airbus DS

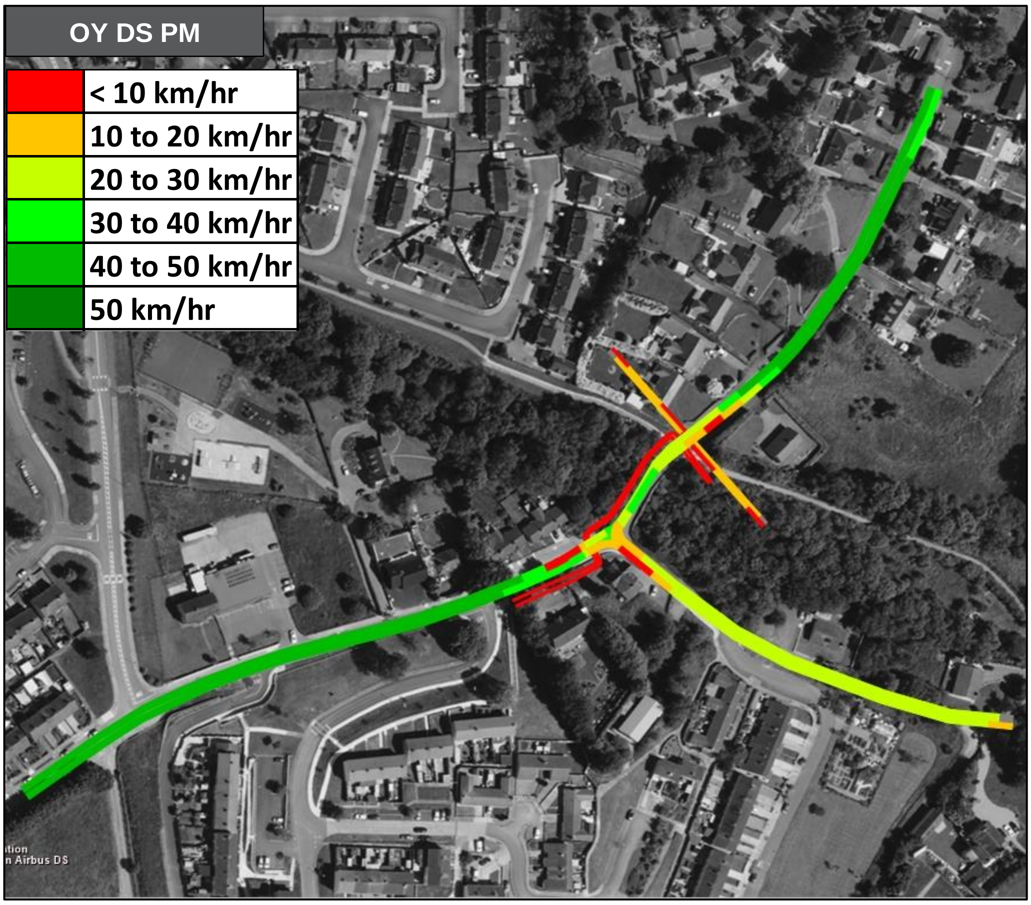

OY+5 DS AM
< 10 km/hr
10 to 20 km/hr
20 to 30 km/hr
30 to 40 km/hr
40 to 50 km/hr
50 km/hr
Airbus DS

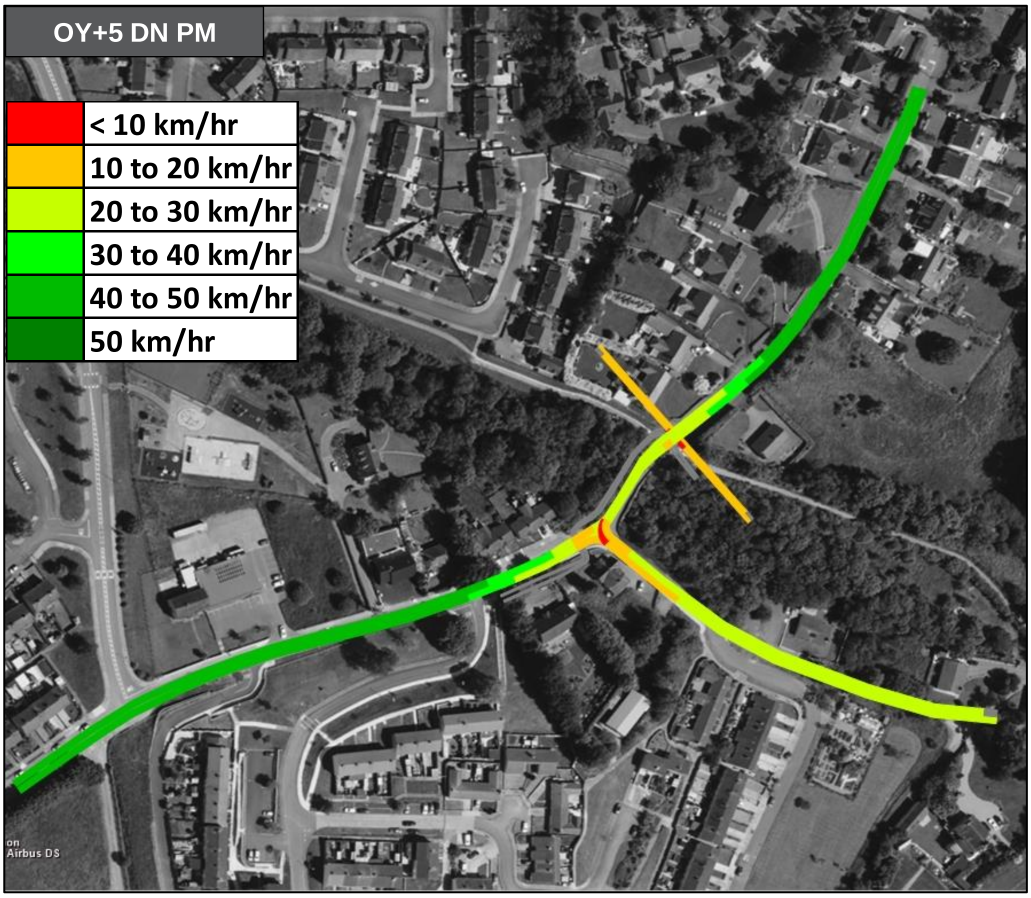

OY+15 DN AM
< 10 km/hr
10 to 20 km/hr
20 to 30 km/hr
30 to 40 km/hr
40 to 50 km/hr
50 km/hr


OY+15 DS AM
< 10 km/hr
10 to 20 km/hr
20 to 30 km/hr
30 to 40 km/hr
40 to 50 km/hr
50 km/hr

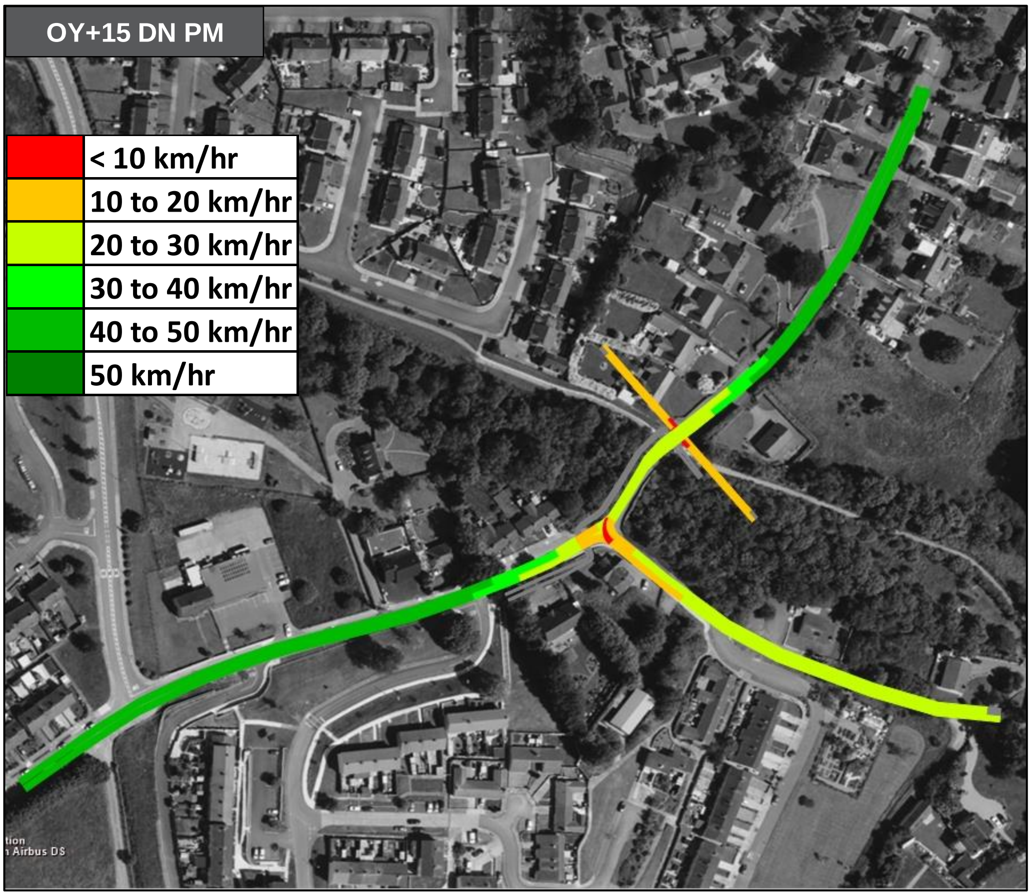
Figure 4-2 - Average Speed Profile: PM Peak

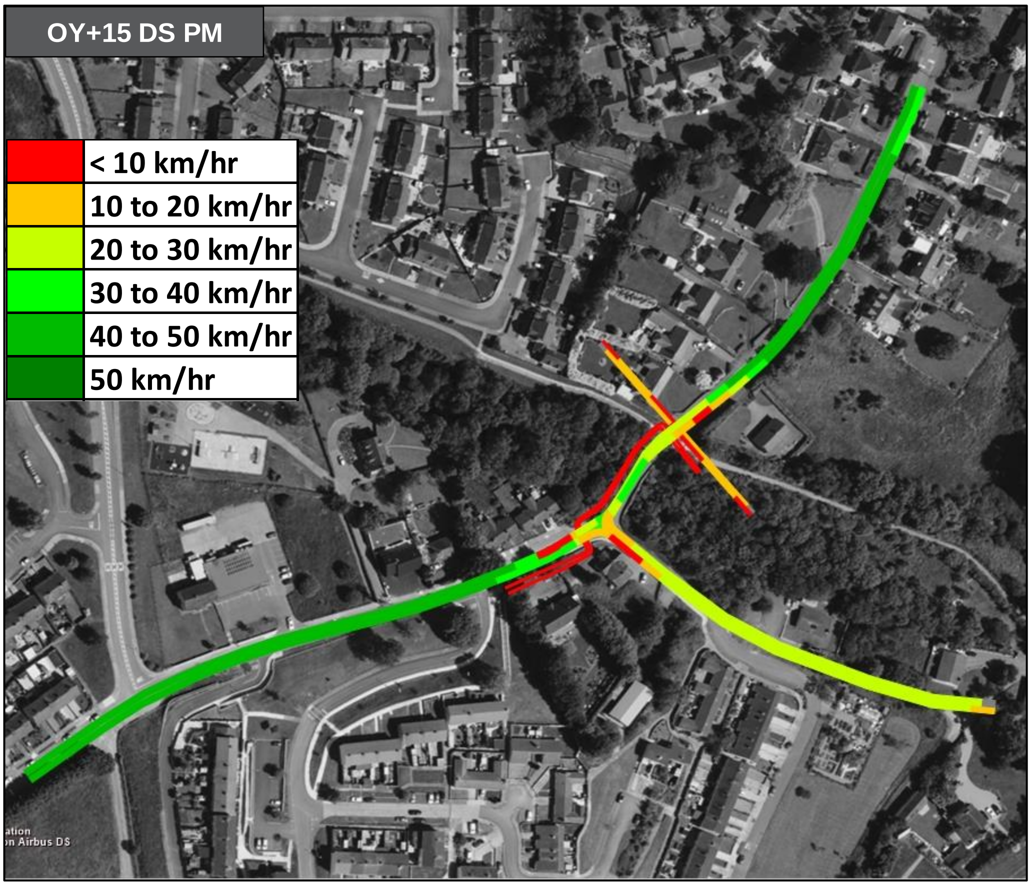





OY+5 DN PM
< 10 km/hr
10 to 20 km/hr
20 to 30 km/hr
30 to 40 km/hr
40 to 50 km/hr
50 km/hr
Airbus DS


OY+5 DS PM
< 10 km/hr
10 to 20 km/hr
20 to 30 km/hr
30 to 40 km/hr
40 to 50 km/hr
50 km/hr
n Airbus DS


OY+15 DN PM
< 10 km/hr
10 to 20 km/hr
20 to 30 km/hr
30 to 40 km/hr
40 to 50 km/hr
50 km/hr


OY+15 DS PM
< 10 km/hr
10 to 20 km/hr
20 to 30 km/hr
30 to 40 km/hr
40 to 50 km/hr
50 km/hr

4.2. Travel Time

The travel times for the northbound and southbound route along the bridge were collected for all the scenarios to determine the impact of the introduction of signals at the bridge in Do Something Scenarios. The travel times were collected between the extremities of the model cordon and summarised in the table below.

Table 4-2 – Travel Time Data

Parameters	AM Peak		PM Peak	
	Do Nothing	Do Something	Do Nothing	Do Something
Opening Year				
Bridge Northbound	47 sec	1 min 1 sec	51 sec	1 min 3 sec
Bridge Southbound	55 sec	1 min 3 sec	49 sec	58 sec
Opening Year + 5				
Bridge Northbound	47 sec	1 min 1 sec	50 sec	1 min 4 sec
Bridge Southbound	55 sec	1 min 3 sec	49 sec	59 sec
Opening Year + 15				
Bridge Northbound	48 sec	1 min 0 sec	50 sec	1 min 4 sec
Bridge Southbound	55 sec	1 min 4 sec	49 sec	1 min 2 sec

Across all the design years, for both the peak hours, when compared to Do Nothing Scenarios, the travel time for the Do Something Scenarios increased by the order of 8 to 14 seconds for both directions.

This suggests that for both peak hours, the impact of the introduction of the signals will have a small impact on the travel time along the bridge across all the design years.

4.3. Junction Impact Analysis

Junction Impact Assessment results include the average queue length and average delays for each arm of the Bridge.

a. **Average Queue Length:** VISSIM considers a vehicle to be queueing once its speed drops below 5 km/h and only leaves the queue once its speed returns to a value above 10 km/h. Vissim automatically generates queue counters in a node to detect queue lengths. Thereafter, Vissim calculates the average queue length detected by queue counters in a node and then calculates their mean.
b. **Average Delay:** To calculate the delay for a vehicle, Vissim calculates a theoretical travel time between a section of approach arm and exit arm, and then compares it with the actual travel time. The theoretical travel time is the travel time which could be achieved if there were no other vehicles and/or no signal controls or other reasons for stops.
c. Thereafter, the Vissim calculates the total delay of all the vehicles and divide it by total vehicles to give average delay for each movement at the junction.

The full results for the key junctions are included in Appendix C and a summary of the results is provided below.

Table 4-3 – Junction Impact Assessment Results: All Scenarios

Arms	AM Peak				PM Peak			
	Average Queue		Average delay		Average Queue		Average delay	
Base Year								
Bridge South	0 m		1 sec		0 m		2 sec	
Bridge North	0.1 m		7 sec		0 m		1 sec	
Side Arm	0 m		1 sec		0 m		3 sec	

Arms	AM Peak				PM Peak			
	Average Queue		Average delay		Average Queue		Average delay	
Opening Year								
	DN	DS	DN	DS	DN	DS	DN	DS
Bridge South	0 m	3.1 m	1 sec	18 sec	0 m	1.1 m	4 sec	21 sec
Bridge North	0 m	1.3 m	7 sec	20 sec	0 m	1.6 m	1 sec	17 sec
Side Arm	0 m	0.9 m	1 sec	22 sec	0 m	1.2 m	5 sec	17 sec
Opening Year+5								
	DN	DS	DN	DS	DN	DS	DN	DS
Bridge South	0 m	3.4 m	1 sec	18 sec	0 m	1.1 m	3 sec	21 sec
Bridge North	0 m	1.4 m	7 sec	20 sec	0 m	1.8 m	1 sec	17 sec
Side Arm	0 m	0.9 m	2 sec	20 sec	0 m	1.3 m	5 sec	18 sec
Opening Year+15								
	DN	DS	DN	DS	DN	DS	DN	DS
Bridge South	0 m	3.5 m	1 sec	20 sec	0 m	1.2 m	3 sec	21 sec
Bridge North	0.1 m	1.6 m	8 sec	21 sec	0 m	2.2 m	1 sec	19 sec
Side Arm	0 m	0.9 m	2 sec	20 sec	0 m	1.5 m	6 sec	20 sec

From the above table, it can be observed that for both peak hours across all the design years, in the Do Nothing Scenarios the average queue and delay were observed to be negligible for all arms.

Due to introduction of the signals in the Do Something Scenarios, the average queue increased to order of 1-3.5 meters for all the arms, which is less than 1 car length (5.75 m). No major delays were observed for all arms in Do Something Scenarios with average delays across all the design years for both the peak hours were observed to be in order of 17-21 seconds.

The average queue and delay parameters for Do Something Scenarios suggest that the junction was found to be operating within capacity for all the design years.

5. Summary

A microsimulation model was developed by Atkins to determine the traffic related impacts due to introduction of active travel measures at Horseshoe Bridge, Mullaghmatt, Co. Monaghan. The model included the bridge, Ulster Canal Greenway and the side arm near the bridge.

As per the guidelines provided in the TII Document PEPAG-02015, the baseline model was calibrated for GEH statistic criteria for the link volume. The results from the baseline model suggested that the model was fit for the future year analysis.

The following future years were assessed, Opening Year (2024), Opening Year + 5 (2029) and Opening Year + 15 (2039).

The traffic volume for the future design years were grown in accordance with the link growth rates provided in TII Document PE-PAG-02017.

The future pedestrian, cyclists and Ulster Canal Greenway user numbers were determined on the basis of the targets set out in the Monaghan City Council Walking and Strategy document.

For all the three design years, two scenarios were modelled, namely Do Nothing and Do Something. Do Nothing scenarios represent the baseline condition with the background traffic growth. The Do Something scenarios included the active travel measures for pedestrian, cyclists and Ulster Canal Greenway users.

The results for the future year scenarios included overall network results, journey time along the north-south direction of the bridge and the junction impact analysis result of the priority junction of the bridge and side arm.

The results for the overall network showed that the entire network was found to be operating well within capacity. The maximum delay for the overall network was found to be around 20 seconds. The latent demand was observed to be zero for all the scenarios.

The journey time results showed that for both the directions along the bridge, the travel time increased in order of 8-14 seconds and the impact due to introduction of signals were small for the Do Something Scenarios.

The junction impact results showed that the average queue for the Do Something Scenarios were under 1 car length (5.75 m) with a small average delay of around 20 seconds observed for the Do Something Scenarios for both peak hours.

The overall results showed that the bridge and the side arm will be operating well within capacity for the Do Something Scenarios and the introduction of the active travel measures will have a low impact.

Appendices

Appendix A. References

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Appendix B. Overall Network Results

	Avg Speed (LV)	Avg Speed (HV)	Total Delay (LV)	Total Delay (HV)	Vehicle Active (LV)	Vehicle Active (HV)	Vehicle Arrived (LV)	Vehicle Arrived (HV)	Latent Delay (sec)	Demand latent	Avg Speed	Net Delay (sec)	Total Vehicle	Avg Delay (sec)
OY DN AM	31.71	34.85	423.71	19.13	3	0	185	9	9.46	0.00	31.85	452.30	197	2.30
OY DN PM	29.62	27.94	311.93	13.40	3	0	148	5	6.00	0.00	29.57	331.33	156	2.12
OY DS AM	25.24	28.53	3711.83	165.80	4	0	185	9	11.46	0.00	25.39	3889.09	198	19.64
OY DS PM	23.93	24.17	2731.27	77.21	4	0	147	5	7.42	0.00	23.94	2815.90	156	18.05
OY+5 DN AM	31.60	35.21	469.21	14.17	4	0	197	10	9.92	0.00	31.77	493.29	211	2.34
OY+5 DN PM	29.65	28.55	313.72	10.87	3	0	157	5	5.26	0.00	29.62	329.85	165	2.00
OY+5 DS AM	25.42	26.33	3850.37	230.96	4	0	197	10	12.20	0.00	25.47	4093.53	211	20.00
OY+5 DS PM	23.71	23.03	2990.64	96.16	4	0	156	6	6.88	0.00	23.69	3093.68	166	18.64
OY+15 DN AM	31.61	34.21	510.74	24.64	4	0	207	12	11.76	0.00	31.75	547.15	223	2.45
OY+15 DN PM	29.58	29.50	356.95	7.48	3	0	165	6	6.22	0.00	29.58	370.64	174	2.13
OY+15 DS AM	25.32	27.80	4129.95	229.29	5	0	208	12	26.26	0.00	25.45	4385.50	225	20.00
OY+15 DS PM	23.13	24.23	3427.31	103.11	4	0	164	6	16.80	0.00	23.17	3547.23	174	20.39
Base AM	31.57	34.56	451.19	16.45	3	0	182	9	7.84	0.00	31.71	475.48	194	2.45
Base PM	29.74	28.73	263.05	9.92	3	0	145	5	5.70	0.00	29.71	278.67	153	1.82

Appendix C. Junction Impact Results

C.1. AM Peak

Arm	Movement	Average Queue		Maximum Queue		Average delay		Vehicles	
		DN	DS	DN	DS	DN	DS	DN	DS
Base Year									
Bridge South	To Side Arm	0 m		0 m		1 sec		14 veh	
	To Bridge North	0 m		0 m		0 sec		105 veh	
	Max/Average/Total	**0 m**		**0 m**		**1 sec**		**105 veh**	
Bridge North	To Side Arm	0.1 m		9.4 m		7 sec		10 veh	
	To Bridge South	0.1 m		9.4 m		7 sec		35 veh	
	Max/Average/Total	**0.1 m**		**9.4 m**		**7 sec**		**35 veh**	
Side Arm	To Bridge South	0 m		2 m		1 sec		8 veh	
	To Bridge North	0 m		2 m		1 sec		19 veh	
	Max/Average/Total	**0 m**		**2 m**		**1 sec**		**19 veh**	
Opening Year									
Bridge South	To Side Arm	0 m	3.1 m	0 m	35.7 m	1 sec	18 sec	14 veh	14 veh
	To Bridge North	0 m	3.1 m	0 m	35.7 m	0 sec	18 sec	107 veh	107 veh
	Max/Average/Total	**0 m**	**3.1 m**	**0 m**	**35.7 m**	**1 sec**	**18 sec**	**107 veh**	**107 veh**
Bridge North	To Side Arm	0 m	1.3 m	5.5 m	19.4 m	7 sec	19 sec	10 veh	10 veh
	To Bridge South	0 m	1.3 m	5.5 m	19.4 m	7 sec	20 sec	36 veh	36 veh
	Max/Average/Total	**0 m**	**1.3 m**	**5.5 m**	**19.4 m**	**7 sec**	**20 sec**	**36 veh**	**36 veh**
Side Arm	To Bridge South	0 m	0.9 m	0 m	14.4 m	0 sec	19 sec	8 veh	8 veh
	To Bridge North	0 m	0.9 m	0 m	14.4 m	1 sec	22 sec	19 veh	19 veh

Arm	Movement	Average Queue		Maximum Queue		Average delay		Vehicles	
		DN	DS	DN	DS	DN	DS	DN	DS
	Max/Average/Total	**0 m**	**0.9 m**	**0 m**	**14.4 m**	**1 sec**	**22 sec**	**19 veh**	**19 veh**
Opening Year+5									
Bridge South	To Side Arm	0 m	3.4 m	0 m	37.3 m	1 sec	17 sec	15 veh	15 veh
	To Bridge North	0 m	3.4 m	0 m	37.3 m	0 sec	18 sec	114 veh	113 veh
	Max/Average/Total	**0 m**	**3.4 m**	**0 m**	**37.3 m**	**1 sec**	**18 sec**	**114 veh**	**113 veh**
Bridge North	To Side Arm	0 m	1.4 m	8.7 m	20.2 m	7 sec	18 sec	11 veh	11 veh
	To Bridge South	0 m	1.4 m	8.7 m	20.2 m	7 sec	20 sec	38 veh	38 veh
	Max/Average/Total	**0 m**	**1.4 m**	**8.7 m**	**20.2 m**	**7 sec**	**20 sec**	**38 veh**	**38 veh**
Side Arm	To Bridge South	0 m	0.9 m	0 m	14.8 m	0 sec	18 sec	9 veh	9 veh
	To Bridge North	0 m	0.9 m	0 m	14.8 m	2 sec	20 sec	21 veh	21 veh
	Max/Average/Total	**0 m**	**0.9 m**	**0 m**	**14.8 m**	**2 sec**	**20 sec**	**21 veh**	**21 veh**
Opening Year+15									
Bridge South	To Side Arm	0 m	3.5 m	0 m	39.2 m	1 sec	20 sec	16 veh	16 veh
	To Bridge North	0 m	3.5 m	0 m	39.2 m	0 sec	18 sec	121 veh	121 veh
	Max/Average/Total	**0 m**	**3.5 m**	**0 m**	**39.2 m**	**1 sec**	**20 sec**	**121 veh**	**121 veh**
Bridge North	To Side Arm	0.1 m	1.6 m	10.2 m	20.2 m	8 sec	20 sec	11 veh	11 veh
	To Bridge South	0.1 m	1.6 m	10.2 m	20.2 m	7 sec	21 sec	41 veh	41 veh
	Max/Average/Total	**0.1 m**	**1.6 m**	**10.2 m**	**20.2 m**	**8 sec**	**21 sec**	**41 veh**	**41 veh**
Side Arm	To Bridge South	0 m	0.9 m	0 m	14.5 m	0 sec	18 sec	9 veh	9 veh
	To Bridge North	0 m	0.9 m	0 m	14.5 m	2 sec	20 sec	22 veh	22 veh
	Max/Average/Total	**0 m**	**0.9 m**	**0 m**	**14.5 m**	**2 sec**	**20 sec**	**22 veh**	**22 veh**

C.2. PM Peak

Arm	Movement	Average Queue		Maximum Queue		Average delay		Vehicles	
		DN	DS	DN	DS	DN	DS	DN	DS
Base Year									
Bridge South	To Side Arm	0 m		1.4 m		2 sec		19 veh	
	To Bridge North	0 m		1.4 m		2 sec		22 veh	
	Max/Average/Total	**0 m**		**1.4 m**		**2 sec**		**22 veh**	
Bridge North	To Side Arm	0 m		0 m		1 sec		22 veh	
	To Bridge South	0 m		0 m		1 sec		46 veh	
	Max/Average/Total	**0 m**		**0 m**		**1 sec**		**46 veh**	
Side Arm	To Bridge South	0 m		2.1 m		0 sec		25 veh	
	To Bridge North	0 m		2.1 m		3 sec		17 veh	
	Max/Average/Total	**0 m**		**2.1 m**		**3 sec**		**25 veh**	
Opening Year									
Bridge South	To Side Arm	0 m	1.1 m	1.4 m	18.1 m	2 sec	18 sec	19 veh	19 veh
	To Bridge North	0 m	1.1 m	1.4 m	18.1 m	4 sec	21 sec	23 veh	23 veh
	Max/Average/Total	**0 m**	**1.1 m**	**1.4 m**	**18.1 m**	**4 sec**	**21 sec**	**23 veh**	**23 veh**
Bridge North	To Side Arm	0 m	1.6 m	1.2 m	29.4 m	1 sec	17 sec	22 veh	23 veh
	To Bridge South	0 m	1.6 m	1.2 m	29.4 m	1 sec	15 sec	47 veh	47 veh
	Max/Average/Total	**0 m**	**1.6 m**	**1.2 m**	**29.4 m**	**1 sec**	**17 sec**	**47 veh**	**47 veh**
Side Arm	To Bridge South	0 m	1.2 m	9.2 m	20.4 m	1 sec	17 sec	26 veh	25 veh
	To Bridge North	0 m	1.2 m	9.2 m	20.4 m	5 sec	17 sec	17 veh	17 veh
	Max/Average/Total	**0 m**	**1.2 m**	**9.2 m**	**20.4 m**	**5 sec**	**17 sec**	**26 veh**	**25 veh**
Opening Year+5									
Bridge South	To Side Arm	0 m	1.1 m	0 m	17.9 m	1 sec	18 sec	19 veh	19 veh
	To Bridge North	0 m	1.1 m	0 m	17.9 m	3 sec	21 sec	24 veh	24 veh

Arm	Movement	Average Queue		Maximum Queue		Average delay		Vehicles	
		DN	DS	DN	DS	DN	DS	DN	DS
	Max/Average/Total	**0 m**	**1.1 m**	**0 m**	**17.9 m**	**3 sec**	**21 sec**	**24 veh**	**24 veh**
Bridge North	To Side Arm	0 m	1.8 m	1.2 m	29.3 m	1 sec	17 sec	25 veh	25 veh
	To Bridge South	0 m	1.8 m	1.2 m	29.3 m	1 sec	16 sec	50 veh	50 veh
	Max/Average/Total	**0 m**	**1.8 m**	**1.2 m**	**29.3 m**	**1 sec**	**17 sec**	**50 veh**	**50 veh**
Side Arm	To Bridge South	0 m	1.3 m	8 m	19.1 m	1 sec	18 sec	27 veh	26 veh
	To Bridge North	0 m	1.3 m	8 m	19.1 m	5 sec	18 sec	18 veh	18 veh
	Max/Average/Total	**0 m**	**1.3 m**	**8 m**	**19.1 m**	**5 sec**	**18 sec**	**27 veh**	**26 veh**
Opening Year+15									
Bridge South	To Side Arm	0 m	1.2 m	0 m	16.9 m	2 sec	19 sec	21 veh	21 veh
	To Bridge North	0 m	1.2 m	0 m	16.9 m	3 sec	21 sec	25 veh	25 veh
	Max/Average/Total	**0 m**	**1.2 m**	**0 m**	**16.9 m**	**3 sec**	**21 sec**	**25 veh**	**25 veh**
Bridge North	To Side Arm	0 m	2.2 m	0 m	29.6 m	1 sec	18 sec	25 veh	25 veh
	To Bridge South	0 m	2.2 m	0 m	29.6 m	1 sec	19 sec	53 veh	53 veh
	Max/Average/Total	**0 m**	**2.2 m**	**0 m**	**29.6 m**	**1 sec**	**19 sec**	**53 veh**	**53 veh**
Side Arm	To Bridge South	0 m	1.5 m	9.8 m	21.5 m	1 sec	20 sec	28 veh	27 veh
	To Bridge North	0 m	1.5 m	9.8 m	21.5 m	6 sec	20 sec	19 veh	19 veh
	Max/Average/Total	**0 m**	**1.5 m**	**9.8 m**	**21.5 m**	**6 sec**	**20 sec**	**28 veh**	**27 veh**

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