Adran yr Economi a'r Seilwaith
Department for Economy and Infrastructure

Llywodraeth Cymru
Welsh Government

The M4 Motorway (Junction 23 (East of Magor) to West of Junction 29 (Castleton) and Connecting Roads) and The M48 Motorway (Junction 23 (East of Magor) Connecting Road) Scheme 201-

The London to Fishguard Trunk Road (East of Magor to Castleton) Order 201-

The M4 Motorway (West of Magor to East of Castleton) and the A48(M) Motorway (West of Castleton to St Mellons)(Variation of Various Schemes) Scheme 201-

The M4 Motorway (Junction 23 (East of Magor) to West of Junction 29 (Castleton) and Connecting Roads) and the M48 Motorway (Junction 23 (East of Magor) Connecting Road) and The London to Fishguard Trunk Road (East of Magor to Castleton) (Side Roads) Order 201- ("the SRO")

The Welsh Ministers (The M4 Motorway (Junction 23 (East of Magor) to West of Junction 29 (Castleton) and Connecting Roads) and the M48 Motorway (Junction 23 (East of Magor) Connecting Road) and the London to Fishguard Trunk Road (East of Magor to Castleton)) Compulsory Purchase Order 201- ("the CPO")

The M4 Motorway (Junction 23 (East of Magor) to West of Junction 29 (Castleton) and Connecting Roads) and The M48 Motorway (Junction 23 (East of Magor) Connecting Road) (Supplementary) Scheme 201-

The Welsh Ministers (The M4 Motorway (Junction 23 (East of Magor) to West of Junction 29 (Castleton) and Connecting Roads) and The M48 Motorway (Junction 23 (East of Magor) Connecting Road) and The London to Fishguard Trunk Road (East of Magor to Castleton)) Supplementary Compulsory Purchase Order 201-

[The M4 Motorway (Junction 23 (East of Magor) to West of Junction 29 (Castleton) and Connecting Roads) and The M48 Motorway (Junction 23 (East of Magor) Connecting Road) (Supplementary) (No. 2) Scheme 201-

The Welsh Ministers (The M4 Motorway (Junction 23 (East of Magor) to West of Junction 29 (Castleton) and Connecting Roads) and The M48 Motorway (Junction 23 (East of Magor) Connecting Road) and The London to Fishguard Trunk Road (East of Magor to Castleton)) Supplementary (No 2) Compulsory Purchase Order 201-

The M4 Motorway (Junction 23 (East of Magor) to West of Junction 29 (Castleton) and Connecting Roads) and the M48 Motorway (Junction 23 (East of Magor) Connecting Road) and the London to Fishguard Trunk Road (East of Magor to Castleton) (Supplementary) (Side Roads) Order 201-

The Welsh Ministers (The M4 Motorway (Junction 23 (East of Magor) to West of Junction 29 (Castleton) and Connecting Roads) and the A48 Motorway (Junction 23 (East of Magor) Connecting Road) and the London to Fishguard Trunk Road (East of Magor to Castleton)) Supplementary (No. 3) Compulsory Purchase Order 201-

Revised Proof of Evidence

Bryan Whittaker, FCIHT

Welsh Government, Traffic

Document Reference: WG 1.2.1 Rev A

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1 Author

1.1 My name is Bryan Whittaker. When my original evidence was prepared, I was an Associate Director of Ove Arup and Partners Ltd (Arup), a multi-disciplinary consultancy, where I was responsible for Strategic Transport Modelling across the UK. Subsequently, I am now a Director of WSP Group, a multi-disciplinary consultancy where I have responsibility for Strategic Transport Modelling and Appraisal in the UK. However, it should be noted that my role on the M4 Corridor around Newport remains to be unchanged. I am a Fellow of the Chartered Institution of Highways and Transportation and have 36 years' experience in the field of transport modelling carrying out and leading transport modelling projects in both the public and private sectors.

1.2 I commenced employment with the Ministry of Transport in 1970, which subsequently became the Department for the Environment and then Department for Transport. I was later employed by the Highways Agency (now Highways England) between 1994 and 2008. In 2008, I joined Scott Wilson (subsequently becoming URS) in the position of Technical Director with responsibility for transport modelling associated with major project developments in the public sector until 2013 at which time I joined Ove Arup and Partners Ltd.

1.3 During my career with the Department of Transport and the Highways Agency, I was the Client Project Manager responsible for the development of a number of transport models for major road schemes at all stages of the Statutory Processes. I have been a member of a number of Department for Transport and Highways Agency's Working and Steering Groups, including the Deputy Prime Minister's 10 Year Plan Initiative and the Eddington Study that considered the role of transport in sustaining the UK's productivity and competitiveness. I was the Highways Agency Project Manager for the National Road Charging Feasibility Study and led the technical development of a number of the Multi-Modal Models and Land-Use Transport Interaction models.

1.4 During my employment at Scott Wilson/URS, I was the Project Director for the Highways Agency feasibility study into single tolled motorway lanes as part of a study to explore the benefits of tolled lanes. I was the Project Director for the development of the Department of Transport's Long Distance Model which was a model developed on a mode neutral basis that considered long distance travel by car, rail, air and coach. Whilst at Ove Arup and Partners Ltd, I was the technical lead and the chairman of a panel of independent international experts for the Provision of Market Research for Values of Travel Time Savings and Reliability undertaken for the Department of Transport which provided up to date values of in-vehicle travel time savings and the investigation of the factors which cause variation in the values.

1.5 I have led the ongoing development of the M4 Corridor around Newport (M4CaN) transport model over a two and a half year period and I have been supported by my team of transport modellers. They have worked to my instruction and I adopt their work as my own. The opinions that are expressed in my Proof of Evidence are my own.

1.6 The evidence which I have prepared and provide in this Proof of Evidence is true and I confirm that the opinions expressed are my true and professional opinions

2 Scope of Proof of Evidence

2.1 The Welsh Ministers' draft Supplementary Scheme Order (No. 2) dated March 2017 makes provision for the addition of the eastbound off-slip at Magor. The purpose of this Proof of Evidence WG 1.2.1 Rev A is to update the traffic issues, modelling and forecasting for the Scheme (as presented in the Proof of Evidence WG 1.2.1) to take account of the draft Supplementary Order. This evidence replaces WG 1.2.1 which is withdrawn. It describes the existing traffic conditions on the M4 around Newport, the modelling that has been undertaken to inform the Scheme's design and appraisal process and the forecast future conditions both with and without the Scheme.

2.2 In this Proof of Evidence, I particularise aspects of the modelling that has been undertaken and the assumptions used where they relate to topics raised by objectors in particular to:

a) the need for the Scheme in terms of traffic demand;
b) that the Scheme would lead to more traffic;
c) about the transport forecasting and its application;
d) that should the Severn Crossing tolls be abolished there would be more traffic demand; and
e) that demand management measures encourage reduced need to travel

2.3 My evidence is thus presented in the following structure:

1. Personal Statement
2. Scope of Evidence
3. Existing Conditions on the M4 Around Newport
4. M4CaN Transport Model
5. Model Calibration/Validation
6. Highway Model Validation
7. Public Transport Validation
8. M4CaN VISSIM Model
9. Future Year Forecasting
10. Model Forecasts

11. Model Journey Times
12. Alternative Public Transport Modelling Approach
13. M4CaN VISSIM Model Forecasts
14. Low and High Growth Forecasts
15. Accidents
16. Conclusions

3 Existing Conditions on the M4 Around Newport

3.1 Overview

3.1.1 As presented by Mr Matthew Jones (WG 1.1.1) in his evidence, the M4 around Newport forms part of the Trans European network and is critical to the Welsh economy transporting people and goods to homes, industry and employment. It provides access to ports and airports and serves the Welsh tourism industry. It is therefore a route of significant strategic importance.

However, the existing M4 between Magor and Castleton does not meet modern motorway design standards and carries a greater volume of traffic than it was originally designed for. The M4 between Junctions 28 and 24 was originally designed as the 'Newport Bypass' in the 1960s. Some sections have alignments (gradients and bends) that are below current motorway standards and in places there is no hard shoulder. In addition to this, there are frequent junctions, resulting in many weaving movements with vehicles accelerating, decelerating and changing lanes over relatively short distances.

Congestion, with frequent incidents, is a very common occurrence on the existing M4 between Junctions 23 and 29. Some sections of the motorway, particularly between the Brynglas Tunnels and Junction 29 (Castleton), are approaching peak hour capacity on a regular basis under current conditions. The restricted capacity of the Brynglas

Tunnels forms a regular bottleneck on the motorway at peak times, while traffic queuing to leave the motorway at Junctions 26 and 28 frequently extends onto the mainline, exacerbating the problems presented by the poor alignment of the motorway between these junctions.

3.2 M4 Traffic Volumes

3.2.1 The number of vehicles using the M4 has been obtained from the Motorway Incident Detection and Automatic Signalling (MIDAS) sensors, which are available for each section of the M4. The Annual Average Daily Traffic (AADT) flow is calculated by dividing the total number of vehicles detected across each MIDAS sensor in a year by 365. The average daily two-way flows on the M4 around Newport between 2011 and 2016 are summarised in the Table 3.1 below followed by Table 3.2 which shows the percentage increases in traffic flow 2011-2016:

Table 3.1 - Average daily two-way flows on the M4 around Newport between 2011 and 2016

MIDAS Traffic Count Location	2011	2012	2013	2014	2015	2016
	Both directions					
Magor - Coldra Jns. 23a-24	77,532	76,703	78,205	77,743	80,374	82,234
Coldra - Caerleon Jns. 24-25	92,766	92,412	94,104	97,030	99,638	101,255
Brynglas Tunnels Jns. 25-26	70,618	72,872	73,706	75,369	78,602	78,919
Malpas - High Cross Jns. 26-27	101,820	103,078	104,229	106,442	111,224	114,900
High Cross - Tredegar Park Jns. 27-28	99,367	101,237	102,454	105,333	109,229	111,569
Tredegar Park - Castleton Jns. 28-29	103,361	104,544	106,145	109,410	114,508	117,848

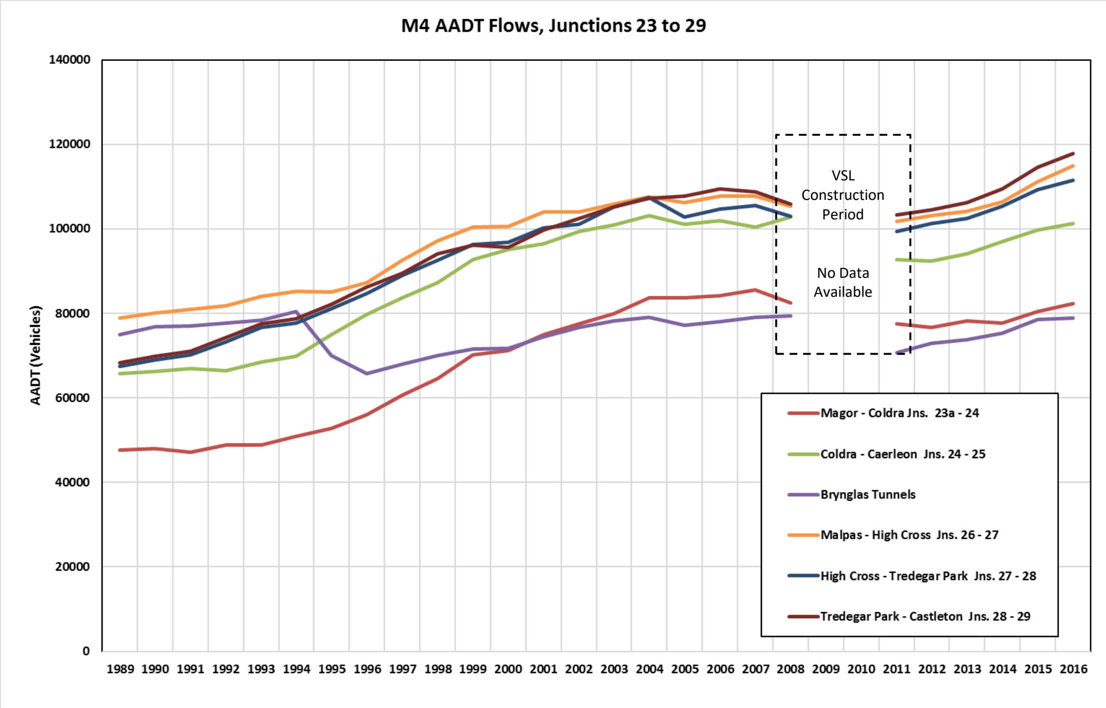
Table 3.2 – Percentage Increases in Traffic Flow 2011-2016

MIDAS Traffic Count Location	2011-12	2012-13	2013-14	2014-15	2015-16	2011-16
	Both directions					
Magor - Coldra Jns. 23a-24	-1.1%	2.0%	-0.6%	3.4%	2.3%	6.1%
Coldra - Caerleon Jns. 24-25	-0.4%	1.8%	3.1%	2.7%	1.6%	9.2%
Brynglas Tunnels Jns. 25-26	3.2%	1.1%	2.3%	4.3%	0.4%	11.8%
Malpas - High Cross Jns. 26-27	1.2%	1.1%	2.1%	4.5%	3.3%	12.8%
High Cross - Tredegar Park Jns. 27-28	1.9%	1.2%	2.8%	3.7%	2.1%	12.3%
Tredegar Park - Castleton Jns. 28-29	1.1%	1.5%	3.1%	4.7%	2.9%	14.0%

3.2.2 The section of the M4 between Junctions 29 and 28 carries the heaviest flow, with an average 117,848 vehicles per day in 2016. This is the most heavily trafficked section of road in Wales.

3.2.3 Figure 3.1 below shows how traffic volumes on the M4 around Newport have changed between 1989 and 2016. Major roadworks were in place on the M4 between Junctions 24 and Junction 28 from early 2009 to early 2011, which included resurfacing, barrier works and the installation of infrastructure to support the installation of the M4 Variable Speed Limit (VSL). In addition to a temporary 50mph speed limit over these sections for the durations of the work, the traffic management for the works consisted of a combination of narrow running lanes, overnight closures and frequent contraflow working over different sections. During this period, no flow data was available.

Figure 3.1 M4 AADT Flows, Junctions 23 to 29



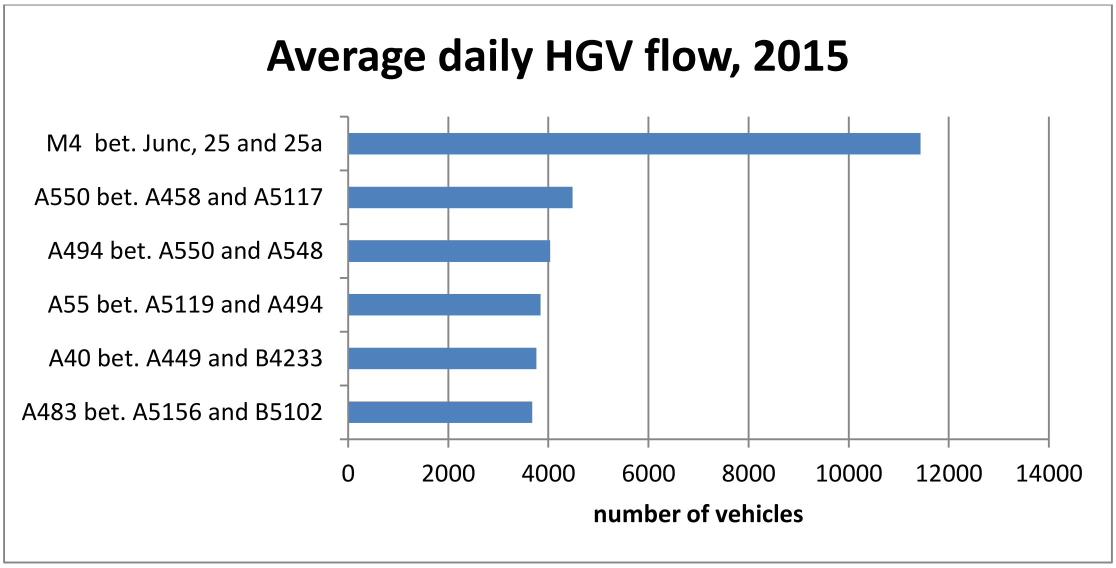
3.2.4 It can be seen that there was sustained growth between 1989 and 2007. The reduction in traffic through the Brynglas Tunnels in the mid-1990s was due to completion of the A4042 Malpas Road and Brynglas Tunnels relief scheme. The graph indicates a reduction in traffic volumes on almost all motorway sections around the time of the economic recession in 2008. By 2011 when the economy was in the period of recovery and at the same time, the Variable Speed Limit had been implemented, traffic levels were again beginning to grow and continued to do so up to 2016. At the eastern end of the M4, traffic levels reduced slightly after the opening of the Steelworks Access Road (A4810) in 2013 but have continued to grow since then.

3.2.5 In June 2011, the Variable Speed Limit (VSL) was introduced on the M4 between Junctions 24 and 28 to reduce congestion in busy periods by reducing the speed limit in order to smooth the traffic flow and prevent stop-start conditions. By slowing the traffic, the variable speed limits increase the capacity of the road, because slower vehicles travel closer together, making better use of the available road space and making journeys more reliable. By reducing the stop-start conditions and the need for lane changing over short distances which create weaving movements, variable speed limits also contribute to reducing accidents. When the M4 is operating in uncongested conditions, the variable speed limit is set to the national speed limit, except in the westbound direction through the Brynglas Tunnel which is set to 50mph.

3.2.6 The variable speed limits have been successful in improving safety and in smoothing the traffic flow at peak times, which is improving throughput, but at certain times due to the high travel demand, some congestion effects remain.

3.2.7 The M4 carries considerably more light and heavy goods vehicles than any other part of the road network in Wales. Figure 3.2 below shows the average daily number of heavy goods vehicles in 2015 on the busiest sections on the road network that are most used by freight traffic in Wales, on both the M4 and other Trunk Roads in Wales.

Figure 3.2 Average Daily HGV Flow, 2015



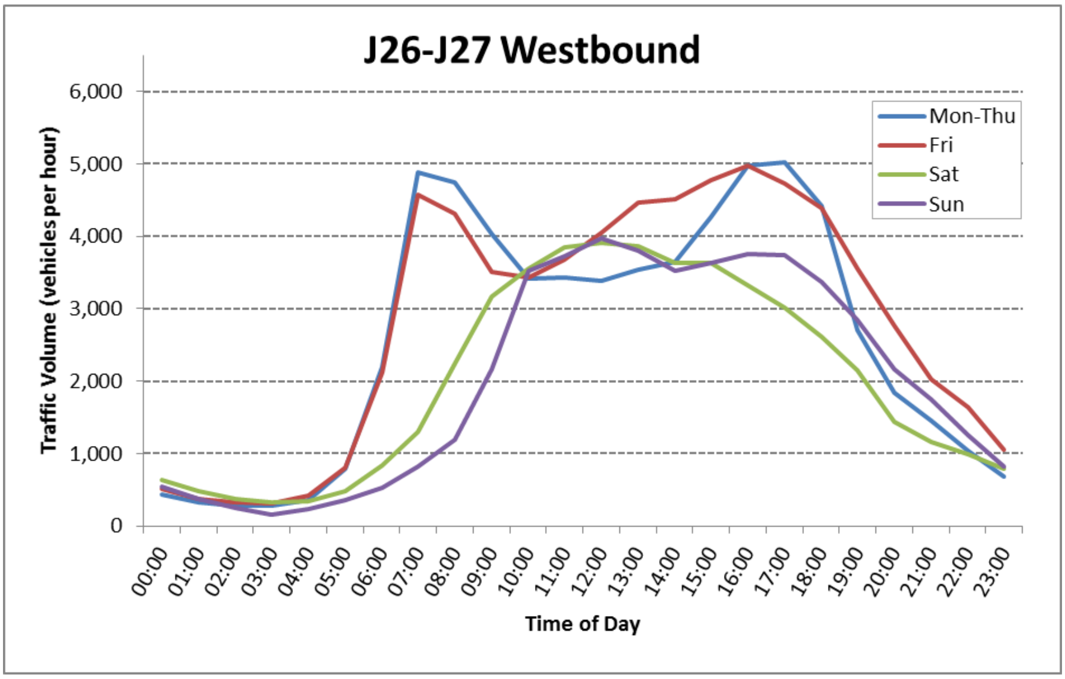
3.3 Traffic Flow and Speed Variation.

3.3.1 I will explain the operational conditions on the M4 around Newport and highlight the key issues, which will serve to address the objections received to the draft Orders that express concerns about traffic and the need for the proposed Scheme[1].

3.3.2 The flow of traffic along the M4 is not even throughout the day. Fig 3.3 -3.6 below show the average volume of traffic on the M4 in October 2015 between Junction 26 and Junction 27 and between Junction 28 and Junction 29 in both the westbound and eastbound directions.

3.3.3 The figures show distinctive peak periods in the morning and evening on weekdays. They also show that traffic volumes start to build up from mid-Friday mornings, resulting in a busier inter-peak. Traffic volumes at the weekend are lower during the morning and evening peaks than during weekdays. However, flows in the middle of the day are higher than during weekdays. On Sundays, the highest flow is the late morning/early afternoon in the eastbound direction and is almost as high as the Monday – Thursday weekday.

Figure 3.3 Traffic Volume by Time of Day, J26-27 Westbound



[1] OBJ0113, OBJ0134, OBJ0149, OBJ0153, OBJ0243, OBJ0247, OBJ248, OBJ259, OBJ0288, OBJ0307, OBJ0310, OBJ0102, OBJ0188, OBJ248, OBJ0287, OBJ0148, OBJ0074

Figure 3.4 Traffic Volume by Time of Day, J27-26 Eastbound

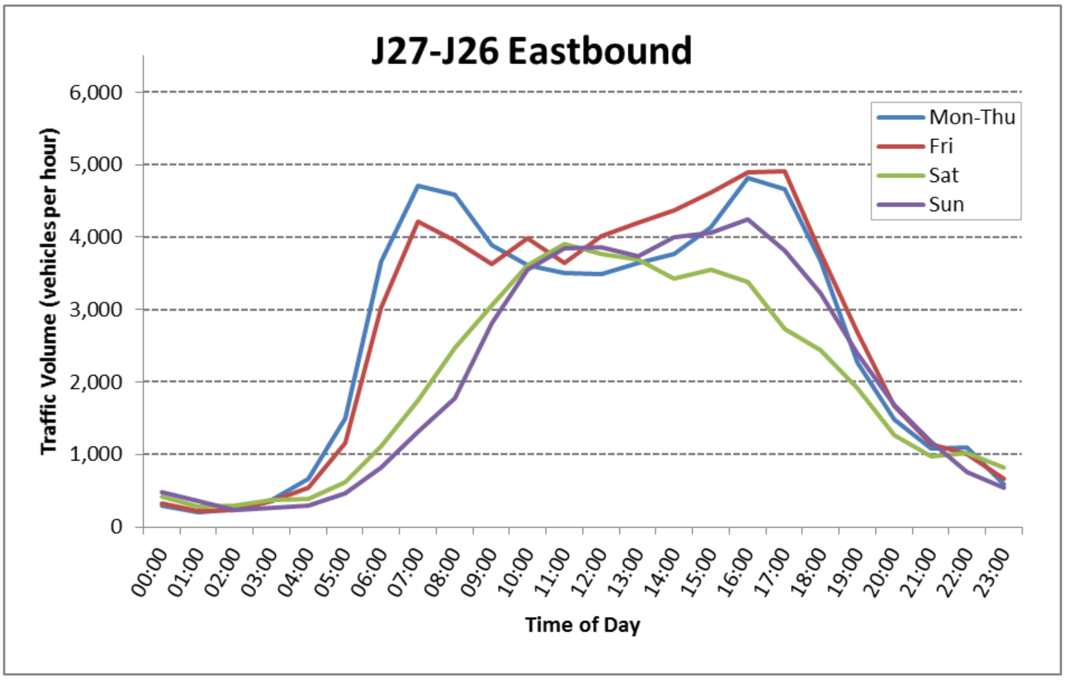


Figure 3.5 Traffic Volume by Time of Day. J28-29 Westbound

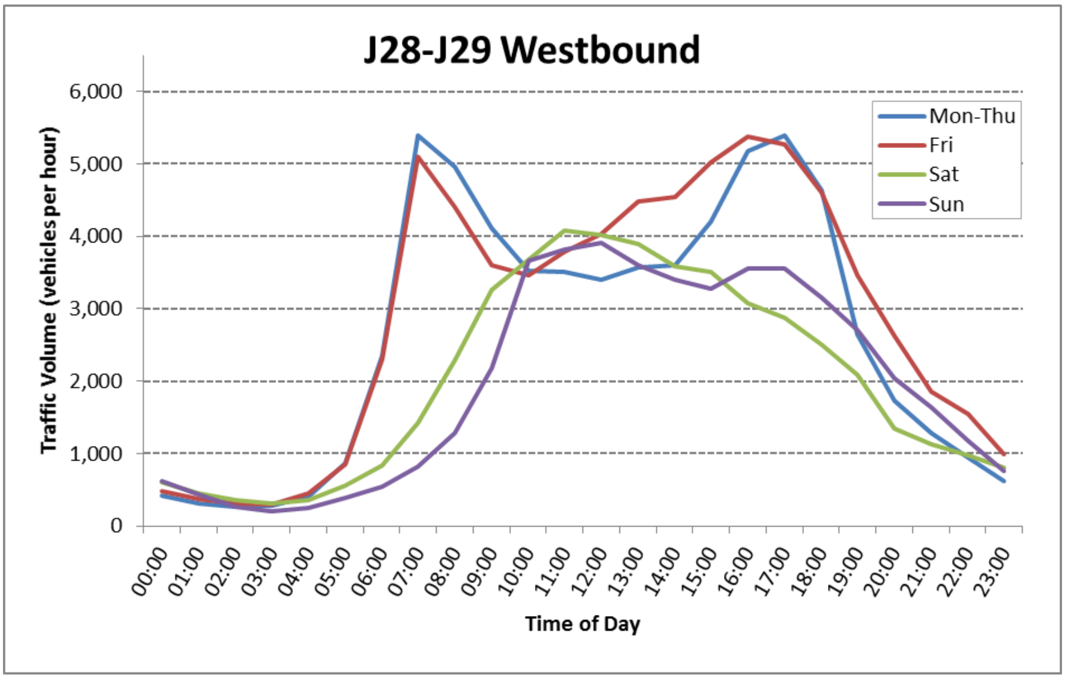
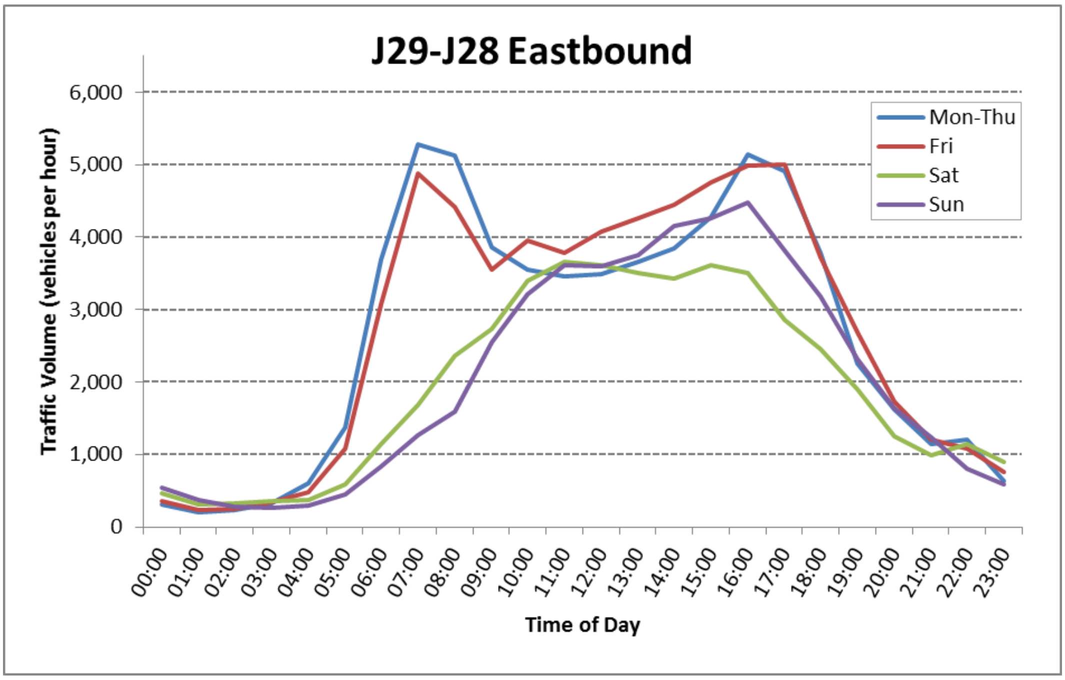


Figure 3.6 Traffic Volume by Time of Day, J29-28 Eastbound



3.3.4 The MIDAS loops in the surface of the M4 also record the speed of vehicles. The average speed for all vehicles using the M4 between Junction 26 and 27 on weekdays in 2015 is shown in Figures 3.7 and 3.8 below. It can be seen that that there is a decrease in average speeds during the peak periods as traffic volumes increase, where average evening peaks on a Friday fall well below 50mph. The effect is particularly noticeable in the eastbound direction travelling towards the Brynglas Tunnel where the motorway reduces to two lanes affecting the speed downstream of the capacity reduction. This serves to illustrate the non-linear relationship between traffic flow and speed, such that as traffic volumes increase, a disproportionate reduction in speed occurs.

3.3.5 The effect of increases in traffic volumes, especially when they approach or exceed available road capacity leads to congestion effects that affect the average speed of vehicles. Highways England have been undertaking research into congestion, primarily on motorways, over the last few years. The research indicates that once speeds drop below 50mph (80kph), stop-start conditions occur and speeds drop very quickly compared to free flow driving conditions that generally occur when travelling at speeds above 50mph.

Figure 3.7 Average Speed by Time of Day, J26-27 Westbound

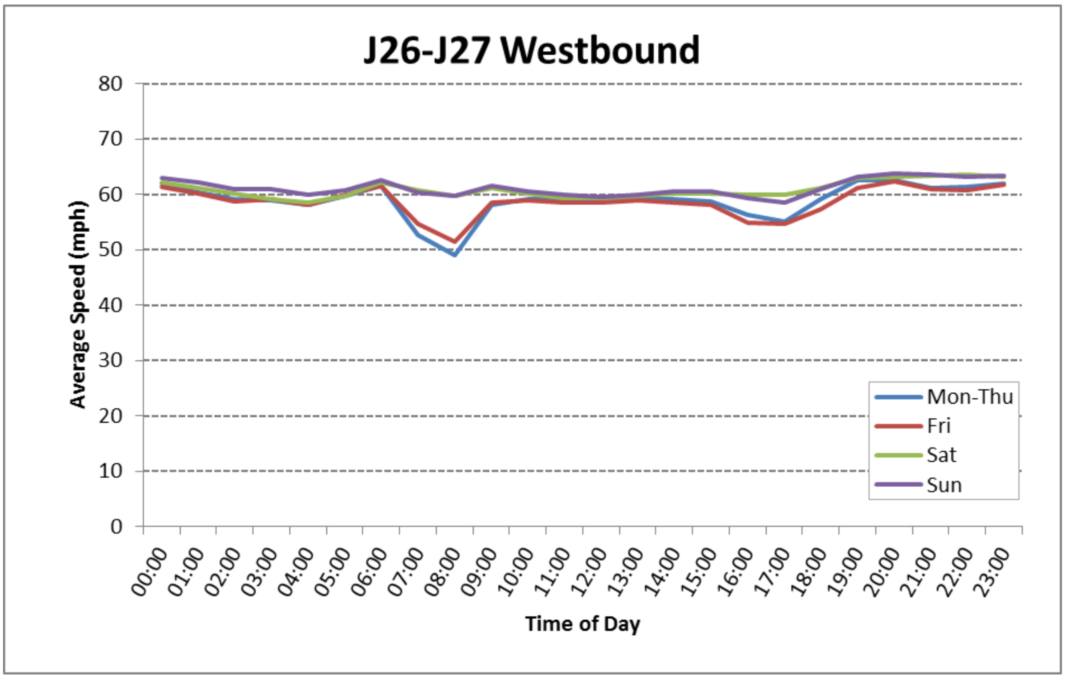
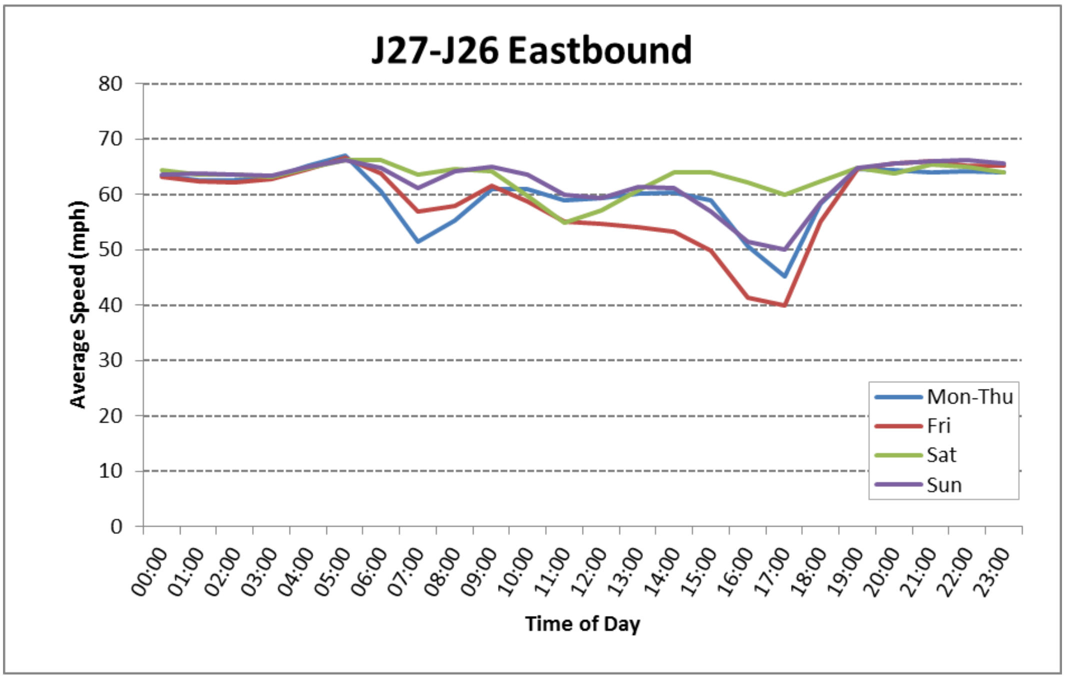


Figure 3.8 Average Speed by Time of Day, J27-26 Eastbound



3.3.6 The Welsh Government receive speed data from over 60,000 vehicles fitted with highly sensitive equipment provided by TrafficMaster in order to monitor speeds on the road network. TrafficMaster data provides a greater accuracy of actual speeds along the M4 than that derived from MIDAS data. MIDAS data is recorded at specific locations, mainly away from junctions, whilst TrafficMaster data tracks the time it takes a vehicle to travel along each section of the M4 and therefore shows the effect on average travel times on the main carriageway of traffic leaving and joining the motorway.

3.3.7 TrafficMaster data has been analysed for the M4, during September and October 2015, to provide the average speed for cars and light vehicles along the M4. These vehicles can potentially travel at 70mph under free flow conditions except in a westbound direction through Brynglas tunnels where there has been a permanent speed restriction following damage to lighting inside the tunnel as a result of a lorry fire in 2011. It is currently anticipated that the speed restriction will be removed in January 2018 following replacement of all the mechanical and electrical systems in the tunnels as well as the renewal of the carriageways, drainage and lining of the tunnels.

3.3.8 The ‘Heat’ chart shown in Table 3.3 below shows the average speed in miles per hour by 15 minute time periods for weekdays between 6am and 10pm in September and October 2015. The data is shown for cars and LGV’s for the M4 between Junctions 23 and 29 and for comparison purposes for the M4 between Junctions 35 and 37, which is a relatively uncongested section of three lane motorway. The travel times were converted into speed by dividing the length of each section of road by the travel time. The cells shown coloured in red in the heat chart indicate that the average speed for the 15 minute period was less than 50mph. For the M4 between Junctions 29 and 23A the speeds often fell well below 50mph. The slowest is between Junction 25 and 25A in the westbound direction where average speeds are below 30mph in the morning and evening peak periods.

Table 3.3 Average Speeds, miles per hour on the M4 around Newport

M4 AVERAGE SPEEDS ALONG EACH SECTION, SEPTEMBER-OCTOBER 2015 WEEKDAYS

EASTBOUND	06:00				07:00				08:00				09:00				10:00				11:00				12:00				13:00			
J23A_J23	71	68	65	63	62	62	64	66	67	68	68	67	67	68	68	67	67	65	66	67	66	67	66	67	66	67	68	68	67	67	68	68
J24_J23A	70	67	63	59	56	53	58	59	62	66	67	67	67	67	67	67	66	65	67	67	66	67	66	66	67	67	68	67	67	67	68	68
J25_J24	64	61	57	53	51	47	46	51	57	58	58	59	59	60	60	60	59	60	60	60	60	59	59	59	60	60	61	60	60	61	61	61
J25A_J25	64	62	60	57	55	55	54	50	55	54	56	59	59	60	60	61	60	60	60	60	60	59	59	60	60	61	61	60	60	61	61	61
J26_J25A	62	57	53	51	50	49	50	48	53	51	53	55	55	56	56	57	57	56	57	55	55	55	55	55	55	57	56	56	56	56	58	58
J27_J26	64	58	50	45	40	41	42	42	43	45	47	50	53	53	55	57	56	56	56	52	49	50	54	51	55	55	53	55	56	56	56	55
J28_J27	64	59	55	45	38	36	43	42	45	46	46	51	55	57	56	57	57	57	57	55	51	47	50	49	49	54	50	54	57	57	57	54
J29_J28	69	67	65	59	48	46	43	43	47	49	48	53	61	63	63	64	65	65	65	64	63	63	59	59	62	63	63	63	65	65	64	64
J36_J35	72	70	71	71	69	66	67	67	68	68	69	69	67	64	64	66	69	69	69	70	70	70	69	70	70	70	70	70	71	70	69	70
J37_J36	71	70	71	70	69	65	70	70	69	69	68	68	68	65	66	67	68	68	68	69	68	69	69	68	69	69	69	68	69	68	68	69

EASTBOUND	14:00				15:00				16:00				17:00				18:00				19:00				20:00				21:00			
J23A_J23	68	67	68	68	68	68	67	68	68	69	67	67	67	69	69	70	71	71	70	71	69	72	70	70	69	67	69	67	67	70	70	71
J24_J23A	68	67	68	68	69	68	67	69	68	68	67	67	68	70	69	70	69	69	71	69	70	72	70	71	70	68	68	70	66	70	69	72
J25_J24	57	52	58	59	55	57	52	55	58	60	59	58	59	60	60	62	62	63	63	64	64	64	60	63	62	61	60	62	61	65	64	67
J25A_J25	62	57	47	37	45	57	48	47	54	59	59	58	60	60	53	61	61	63	63	64	64	63	62	64	61	61	61	62	61	64	65	68
J26_J25A	57	54	42	44	50	47	39	55	53	53	53	53	54	55	54	56	56	59	59	61	62	62	60	61	57	56	58	57	56	62	61	65
J27_J26	56	56	53	47	49	51	44	43	45	41	40	38	38	40	40	42	47	52	58	60	61	62	61	52	46	51	49	49	53	54	55	66
J28_J27	56	55	55	56	45	42	45	45	43	41	41	41	41	39	39	42	46	52	59	59	63	62	63	46	39	42	48	44	51	51	47	64
J29_J28	66	64	64	63	60	53	50	48	43	43	47	47	45	43	42	48	52	61	66	67	70	69	67	50	45	51	48	46	51	53	62	69
J36_J35	70	70	67	70	71	71	70	71	71	71	73	73	73	72	70	74	72	73	70	72	71	72	70	71	70	72	72	70	74	70	68	71
J37_J36	69	69	69	70	70	70	70	69	68	71	71	71	71	72	70	72	72	70	68	73	70	71	69	70	70	72	73	72	71	69	66	71

WESTBOUND	06:00				07:00				08:00				09:00				10:00				11:00				12:00				13:00			
J23_J23A	66	67	66	67	69	66	68	69	68	69	69	67	63	62	53	66	68	67	68	69	68	69	68	66	68	68	68	66	67	68	66	64
J23A_J24	66	66	66	65	66	66	65	60	57	49	42	55	59	58	61	59	63	66	66	66	67	66	66	65	63	60	60	55	57	56	53	53
J24_J25	63	62	63	62	62	59	52	44	32	30	33	39	42	51	56	57	56	59	60	62	61	58	58	56	58	54	53	53	50	49	49	47
J25_J25A	55	55	56	54	53	48	41	35	30	27	29	32	34	45	49	50	49	52	52	53	51	50	48	48	48	49	47	49	47	47	44	44
J25A_J26	53	52	54	51	50	46	42	36	30	33	35	39	40	44	47	47	47	48	48	48	47	46	46	46	46	47	46	46	46	45	45	45
J26_J27	63	63	63	62	61	54	47	36	34	37	43	50	55	57	57	59	60	59	59	60	60	60	61	60	59	61	60	61	61	60	61	61
J27_J28	65	64	64	62	60	55	47	37	42	45	46	50	56	58	59	60	58	59	58	59	60	62	62	62	61	62	59	59	62	62	62	62
J28_J29	67	66	65	64	62	58	56	54	58	60	59	63	62	62	63	63	65	65	64	65	65	66	65	64	64	65	64	66	66	65	64	65
J35_J36	69	69	69	70	69	70	68	68	69	70	68	68	68	69	70	69	70	69	68	68	69	69	69	69	69	67	70	69	69	68	69	69
J36_J37	70	68	70	69	68	69	69	70	71	71	70	70	70	70	69	69	71	70	70	69	70	70	71	70	69	69	70	71	69	70	71	69

WESTBOUND	14:00				15:00				16:00				17:00				18:00				19:00				20:00				21:00			
J23_J23A	63	58	53	53	60	56	61	61	57	62	59	50	62	58	57	52	57	55	62	64	55	55	56	61	63	64	68	74	68	71	71	70
J23A_J24	50	47	48	48	45	44	42	47	44	46	44	45	43	41	41	43	42	51	49	54	62	56	53	55	62	64	59	63	61	66	68	69
J24_J25	46	43	39	37	38	37	39	40	39	35	30	26	25	23	23	25	29	29	31	38	46	52	52	53	56	59	57	59	58	62	65	64
J25_J25A	43	42	37	40	39	38	39	37	34	29	24	23	23	21	22	22	22	26	26	35	35	45	44	48	45	47	48	46	45	52	56	57
J25A_J26	44	43	42	43	43	43	42	41	39	36	34	33	34	33	34	34	35	37	38	42	42	46	46	49	47	49	50	48	46	49	52	53
J26_J27	61	60	60	59	60	60	58	58	58	56	56	55	53	52	53	56	57	58	59	60	61	62	63	63	64	63	65	64	61	61	64	64
J27_J28	62	61	62	61	62	62	61	61	61	60	60	60	59	59	59	59	61	62	63	63	64	62	64	65	64	65	66	65	62	63	65	65
J28_J29	65	64	66	66	65	66	65	65	64	64	64	63	61	61	61	58	62	62	64	66	66	66	67	68	68	68	68	68	67	66	69	68
J35_J36	70	68	69	70	70	70	70	68	70	69	69	68	70	70	70	68	70	71	70	71	70	70	69	69	70	69	70	69	72	71	69	68
J36_J37	71	70	70	71	70	71	71	70	70	71	70	68	71	70	71	71	71	72	71	71	71	70	69	69	70	71	70	71	69	73	70	70

3.4 Journey Time Variability.

3.4.1 Journey time variability is used as a measure to estimate how reliable individual road users' journey times are compared to the average. The inability to accurately predict journey times due to congestion can result in wasted time as individuals either arrive late for appointments or arrive early by allowing too much time for their journey. This in turn could then hinder economic growth as more time is spent travelling at the expense of other productive activities. The economic aspects of the Scheme are covered in more detail by Mr Stephen Bussell (WG 1.3.1).

3.4.2 The variability of journey times along the M4 around Newport can arise for a number of reasons, such as breakdown of flow due to heavy volumes of traffic, roadworks and incidents.

3.4.3 Figures 3.9 - 3.13 below show the average speeds of all vehicles taken from MIDAS for J24-25 westbound between 16.00 and 19.00 and Junction 27-28 eastbound between 16.00 and 18.00 for every Friday in 2015. The dotted horizontal line shows the average speed of all vehicles for all Fridays in the year. In the case of J24 to J25 westbound, throughout the three hour period, speeds dropped significantly below 50mph, and in a number of cases below 30mph for the greater majority of Fridays in 2015. Between 16.00 and 17.00, there were only 11 occasions in 2015 when average speeds were higher than 50mph and only 10 occasions between 17.00 and 18.00. Similarly, for J27-J28 eastbound between 16.00 and 18.00, average speeds were significantly below 50mph for the vast majority of Fridays and on a number of occasions they were below 30mph.

Figure 3.9 Average Speeds, miles per hour on the M4 around Newport

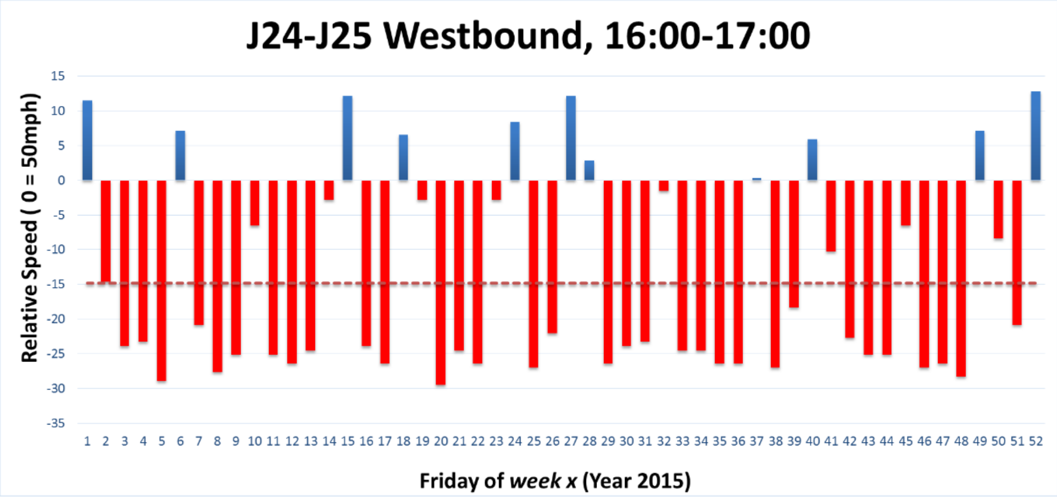


Figure 3.10 Friday Relative Speeds to 50mph, J24-25 Westbound between 17.00-18.00

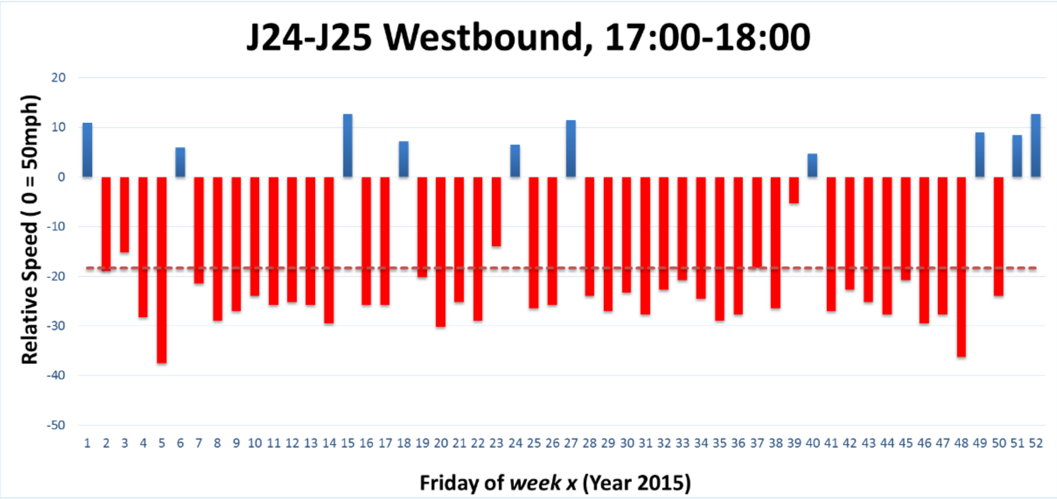


Figure 3.11 Friday Relative Speeds to 50mph, J24-25 Westbound between 18.00-19.00

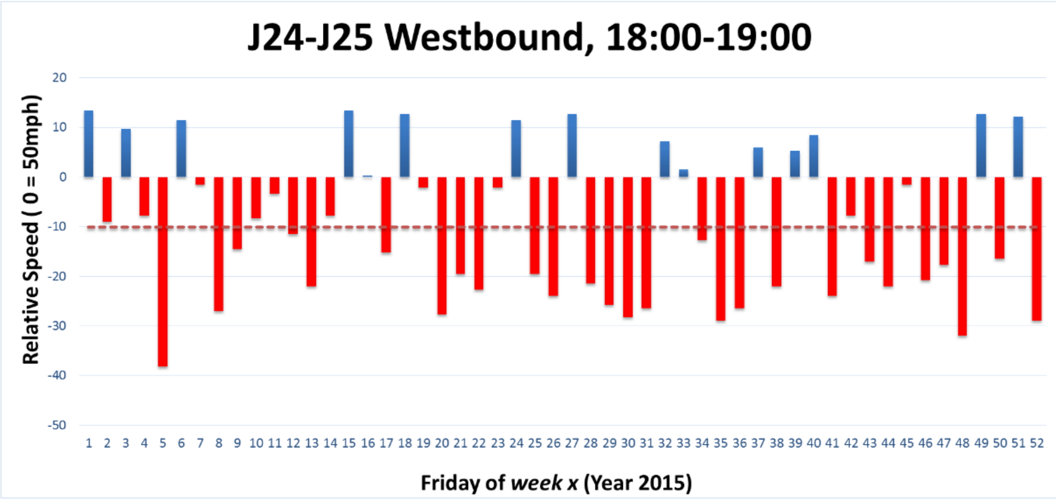


Figure 3.12 Friday Relative Speeds to 50mph, J27-28 Eastbound between 16.00-17.00

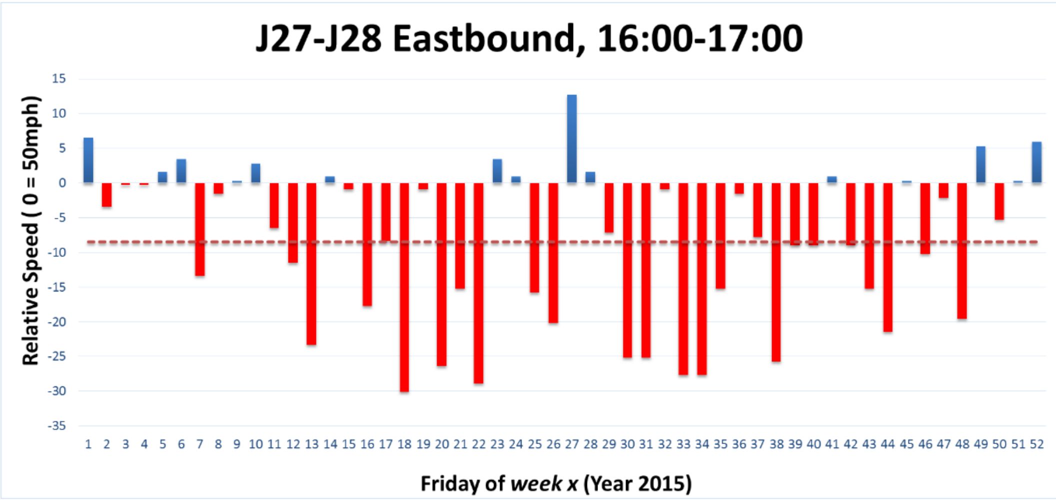
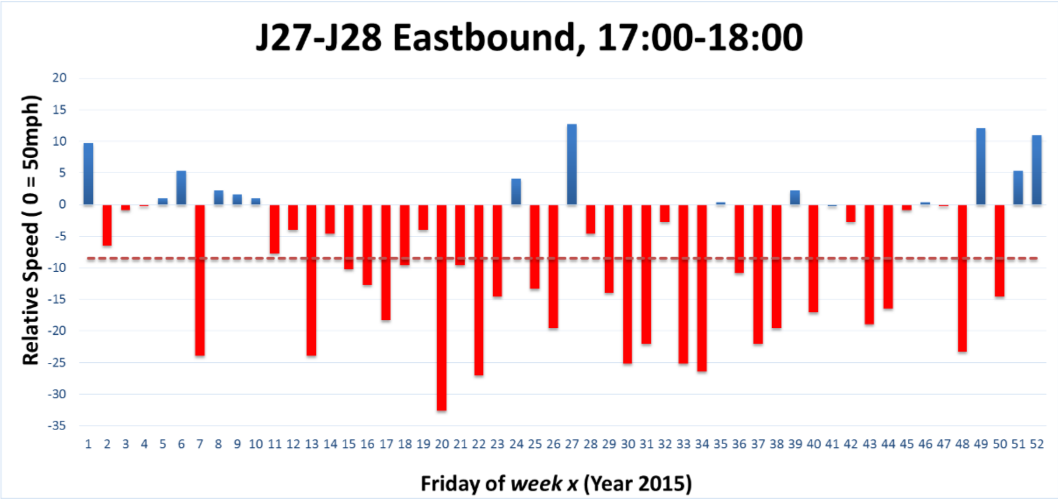


Figure 3.13 Friday Relative Speeds to 50mph, J27-28 Eastbound between 17.00-18.00



3.4.4 It can be concluded that the analysis demonstrates that speeds and therefore travel times frequently fall below the annual average on a number of Fridays throughout the year. Therefore, users who travel on the motorway will experience highly variable journey times even if they travel at the same time of the day each week.

3.5 Incidents and Congestion

3.5.1 Incident (an unplanned and unexpected event) data has been obtained from the Welsh Government's Traffic Wales Unit for the M4 corridor around Newport between Junction 23 and Junction 29. The data that was supplied was a record of notifications from their website regarding any disruption to travel. The data covers a one year period between January and December 2015. The data distinguishes two main categories of notifications, those related to incidents and congestion.

3.5.2 Traffic Wales have advised that there are set procedures in place for responding to incidents on the trunk road network. Their current incident process requires that they set a website alert if the effects of an incident are expected to last 20 minutes or more. Congestion alerts may also be set for typical rush hour congestion, or if there are high volumes of traffic being experienced without an incident necessarily having occurred. The procedures include the identification of pre-approved diversion routes, which are set depending on the location of an incident. In the event of a severe incident on the M4 between Junctions 24 and 28, a full closure of the M4 between those junctions would be implemented, with the A48 Newport Southern Distributor Road signed as a diversion route.

3.5.3 Analysis of the data shows that there were 82 specific incidents leading to disruption on the M4 motorway around Newport in 2015. This equates to one incident every four to five days. Further analysis of the data was undertaken to derive the number of occurrences of day to day congestion in which congestion that was a result of incidents was therefore excluded.

3.5.4 Day to day congestion is defined as the situation that occurs when queues (vehicles in a stationary position or slow moving with frequent stop-start) form on the motorway as a result of traffic volumes approaching or exceeding the capacity of the road network. In 2015, Traffic Wales recorded 1,053 occurrences of day to day congestion. In particular, the congestion alerts occurred mainly at the following sections

a) M4 Eastbound: J28 Tredegar Park to J26 Malpas (482): and
b) M4 Westbound: J24 Coldra to J26 Malpas (417)

3.5.5 Both of the above sections are either on the approach to or include Brynglas Tunnels and it can therefore be seen that the majority of occurrences of day to day congestion are related to the bottleneck formed by the Brynglas Tunnels.

3.6 Resilience

3.6.1 The ability to return back to normal operating conditions on the M4 following the impact of an incident or a prolonged period of congestion is severely restricted in the current network around Newport.

3.6.2 The traffic model described in Section 4 has been used to estimate the potential impacts on journey times from east of M4 J30 to the west of the Toll Plaza that may arise with an eastbound closure of the M4 between Junctions 28 and 24. The estimation of the possible impacts have been assessed based on the 2014 base year validated traffic levels occurring in the case of in the AM, Inter-Peak or PM Peak periods that is documented in Section 6.2 below.

3.6.3 The impacts of the closure are shown in Appendix A for both the wider model area and Newport area in both the AM Peak Period (Figures A.1 and A.2) and Inter-Peak Period (Figures A.3 and A.4). Figures A.1 and A.3 show the change in traffic flow on the highway network whilst Figures A.2 and A.4 show both the change in traffic flow on the highway network together with the change in average delay at key junctions. The figures show a significant diversion to the A465 (T) Heads of the Valleys road as an alternative route for longer-distance traffic. Some of the longer distance demand traffic seeks to avoid all of these delays by additionally rerouting to the A472 Newbridge to Pontypool road or the coast road (Lighthouse Road) between Cardiff and Newport.

3.6.4 The figures also indicate that the closure leads to queuing as demand exceeds available capacity on the eastbound off slip at Junction 28, queuing at Junction 24 resulting from the volumes of eastbound traffic wishing to re-join the M4, queuing eastbound at the traffic signals on the A48 Southern Distributor Road (SDR), and queuing eastbound on the A4810 Steelworks Access Road (SAR) approaching Junction 23A. Overall traffic levels on all east-west routes within Newport increase significantly as traffic tries to find alternative routes through the network between the two junctions.

3.6.5 The model assumes that all drivers have perfect information, and thus spread themselves optimally between the various alternative routes. With this optimal spread, eastbound through traffic that diverts via A48 SDR has a journey time in the order of 1 hour and 36 minutes longer than the normal journey along M4 in both the AM and PM and 36 minutes longer in the Inter-Peak. There are also knock-on delays to other traffic (particularly traffic queuing to turn right from or onto the A48 SDR across the greatly-increased eastbound flow).

3.6.6 Closure of Junction 28 – 24 in the eastbound direction causes total additional delay in vehicle hours in the AM peak hour, Inter-Peak and PM peak hour in the order of 19,200, 2,300 and 15,500 vehicle hours. The vehicle hours resulting from the closure were taken from the model to inform the economic cost of the closure, which is included in the evidence of Mr Stephen Bussell (WG 1.3.1).

3.7 Collisions

3.7.1 Information on collision data for the M4 around Newport has been obtained for the period between 2003 and 2015 inclusive. The dataset comprises collisions resulting in personal injuries and excludes damage-only collisions. The collision data has been broken down into the following three distinct time periods, which have been analysed separately in order to account for trends relating to pre and post variable speed limit (VSL), whilst also taking into account the major roadworks that preceded the VSL implementation as follows;

c) Pre VSL (January 2003 – August 2009)
d) VSL Roadworks (September 2009 – June 2011)
e) Post VSL (July 2011 – December 2015)

3.7.2 The M4 motorway has a number of two lane and three lane sections, and several grade separated sections via over or under passes. Some sections of the main carriageway have non-standard gradients, existing advisory speed limits and reduced visibility. Between Junction 23A and Junction 29, there was a total of 665 reported personal injury collisions on the M4 between January 2003 and December 2015, comprising 11 fatal, 43 Serious and 611 slight personal injury collisions. Of the 665 collisions 328 occurred in the eastbound direction, and 337 occurred in the westbound direction. The data was split into the three time periods identified in 3.6.1 relating to the implementation of VSL as shown in Table 3.4 below.

Table 3.4 - Collision Data, January 2003 – December 2015

Time Period	AM Peak	PM Peak	Inter Peak	Off Peak	Total
Pre VSL (Jan-03 to Aug-09)	103	129	128	72	432
VSL Roadworks (Sep-09 to Jun-11)	18	26	28	8	80
Post VSL (Jul-11 to Dec 2015)	29	49	41	34	153
Total	150	204	197	114	665

3.7.3 Using the estimates of AADT flows derived in Table 3.1, a comparison has been made between the observed collision rate (per million vehicle km) in the period Post VSL period and the average rates for motorway links and junctions as given in the WebTAG Databook, Department of Transport, November 2016.

3.7.4 The base WebTAG link collision rates provided in the Databook were adjusted using the 'change coefficients' provided, to reflect the predicted change in collision rates over time.

3.7.5 Observed collision rates are shown for the M4 corridor around Newport (Junction 23A to Junction 29) for the period Post VSL. These rates are shown in Table 3.5 below.

Table 3.5 - M4 Collision Rates

	Average Collision Rate (per million vehicle km)
	Post VSL (July 2011-December 2015)
J23A – J24	0.0375
J24 – J25	0.0625
J25 – J26	0.0408
J26 – J27	0.0735
J27 – J28	0.0550
J28 – J29	0.0436

3.7.6 In the period between July 2011 and December 2015, following the introduction of the Variable Speed Limit, the link only collision rate on every section was reduced compared to the pre-VSL period. The level of reduction, however, was particularly large on those sections where VSL has been implemented (Junction 24 to Junctions 28). The default WebTAG average link and junction collision rate for a motorway in the period 2011 to 2015 is 0.0561. There are two key sections either side of the tunnels where observed rates remain higher than the WebTAG average collision rate for a motorway and one key section where the observed accident rate is close to the WebTAG average collision rate.

4 M4CaN Transport Model

4.1 Overview

4.1.1 I will explain the transport model developed and applied as part of the assessment of the likely impacts of the proposed Scheme on transport conditions. In doing so, I will highlight the key issues, which will serve to address the objections received to the draft Orders that express concerns about traffic forecasting and the methods adopted[2], as well as concerns expressed that the Scheme would lead to more traffic[3].

4.1.2 The M4CaN Transport Model was developed to appraise the proposed M4 Scheme around Newport. In this respect, the M4CaN Transport Model is used to understand firstly, the impact of current traffic flows on the network around the M4 local to Newport, and secondly to provide evidence for the planning of changes to the transport network and to produce traffic forecasts that are used in the detailed economic, social and environmental appraisal of proposed interventions in the transport system. The model represents typical

[2] OBJ0125, OBJ0136
[3] OBJ0001, OBJ0052, OBJ0076, OBJ0151, OBJ0208, OBJ0264, OBJ0275, OBJ0283, OBJ0006, OBJ0023, OBJ0136, OBJ0150, OBJ204, OBJ0258, OBJ0310, OBJ0061, OBJ0275, OBJ0126, OBJ0338

operating conditions on the highway network in terms of average flows and speeds on a normal day of operation.

4.1.3 Transport models are a simplified representation of the movement of goods and people, designed to provide a quantitative and analytical framework that helps us to understand how the transport system works under current and future patterns of travel demand. Transport modellers start by creating as accurate a picture of the current functioning of the transport system as practicable and then use the resulting model to predict or forecast how the system will operate under different scenarios. In the case of the M4CaN, these future year forecasts are used in the design of the proposed Scheme, the economic assessment and the environmental appraisals.

4.1.4 The Department for Transport publishes guidance (known as 'WebTAG') on good practice for modelling and appraisal of highway schemes. The M4CaN model has been developed in accordance with this guidance and therefore forms a robust basis from which to forecast future year highway network conditions, both with and without the proposed Scheme and other changes to the transport system. The Local Model Validation Report (Reference: Document 2.3.9) sets out the methods and assumptions used in developing the base year transport model, whilst the Revised Forecasting Report (Document 2.4.13) sets out the development of the future year forecasts.

4.1.5 In principle, any change to journey times and costs of travel influences the level of demand for travel as a consequence. For instance, providing new capacity in the case of highway investment or service improvements to public transport could elicit a number of responses by travellers, which may include trip reassignment, re-distribution and modal shift. Such responses could result in additional trips and or additional vehicle mileage on the road network, which collectively is referred to as 'induced traffic'. Conversely, in a 'Do-Minimum' situation, i.e. in the absence of new capacity, the effects of forecast traffic growth and as a result of increasing traffic congestion could result in ‘trip suppression’ on the road network which could manifest itself as peak spreading, modal switching to public transport, and/or a reduction in the number, length or frequency of journeys, or even for the journey not to take place at all. These responses, as well as re-distribution, could lead to a reduced number of vehicle trips or mileage on the road network.

4.1.6 Whenever there is an induced response, individuals choosing to make a journey that they didn’t previously make before that results from lower time and monetary costs is a benefit to those individuals i.e. they could do what they did previously, but instead do something differently because they gain something from it. However, additional traffic may also impose external costs. The function of the transport model is to quantify all the gains and losses in a form that is suitable for the process of scheme appraisal.

4.1.7 Given the major change in the network resulting from the Scheme and the re-classification of the existing M4, the transport model has been developed in such a way that it can capture a range of behavioural responses to these changes. These responses include reassignment, the switching of trips between highways and public transport and changes in trip destination.

4.1.8 As stated in 4.1.1, the M4CaN model represents typical operating conditions on the highway network in terms of average flows and speeds on a normal day of operation. Traditionally, fuel consumption and, hence, vehicle emissions have been estimated by relating average vehicle speeds to the amount of fuel consumption per kilometre at that average speed. In many cases, this is the only practicable approach as data for a more complex evaluation is not available. However, in determining the methodology to use for a particular application, DMRB Volume 11 Section 3 Environment referring to HA 207/07 in Annex E states that on those projects which result in variations in driving patterns but do not greatly effect average speed, a more detailed emission model may be required.

4.1.9 Annex E referred to above, states that it may be necessary to use an ‘instantaneous’ emission model, in which emissions are related to vehicle operation on a second-by-second basis. The Annex provides examples of such models being MODEM and PHEM and that these types of models require vehicle operating information from a micro-simulation traffic model such as VISSIM or PARAMICS. Therefore, in addition to the M4CaN model, a VISSIM model has been developed for the purposes of carbon assessment. The carbon assessment is covered in the evidence of Mr Tim Chapman (WG 1.13.1) which is based on the PHEM results. In my evidence, I provide the details of the development of the VISSIM micro-simulation model in Section 8 of my evidence and is referred to as the M4CaN VISSIM model.

4.2 M4CaN Transport Model Study Area

4.2.1 The Transport Model Study Area consists of four distinct geographic areas which are shown in Appendix B Figure 3.1 comprising of:

a) An ‘Area of Detailed Modelling’ which is centred on Newport, extending from the Severn River Crossings to the eastern area of Cardiff.

b) The ‘Rest of the Fully Modelled Area’ which is bounded to the west by the A470 and the western edge of Cardiff, by the A465 and the A40 to the north, and by the River Wye to the east. All traffic in this area is represented, but at a lower level of detail.

c) The ‘Wider Area of Influence’ outside that of the ‘Rest of the Fully Modelled Area’. In this area, individual roads are modelled, but only the traffic to and from the fully modelled area is represented.

d) The 'External Area' comprising the rest of the UK outside of the Wider Area of Influence, where journey times are representative averages that do not relate to individual roads.

4.3 Data Collection

4.3.1 Prior to the development of the transport model development, an extensive data collection exercise was undertaken in spring and autumn 2014 including both collecting travel demand data in order to build trip matrices of the origin and destination of highway and public transport trips within the model area and obtaining details of the highway and public transport networks.

4.3.2 Roadside interview data, public transport passenger surveys and bus and rail ticket data together with anonymised mobile phone data were also collected to assist the building of the trip matrices. Traffic flow data and journey times along selected routes were collected specifically for the purpose of validating and calibrating the transport model.

4.3.3 Data on freight movements was extracted from the DfT's Base Year Freight Matrices (BYFM). These matrices represent all domestic freight moved within Great Britain by heavy goods vehicles (HGVs). Whilst no single data source covers all the component elements of these base year matrices, a modelling methodology was developed that enabled key information from various datasets to be extracted and merged in a consistent fashion so as to create the base matrices in a form that provides maximum detail and accuracy. The main outputs are matrices of zone-to-zone movements of freight in the base year of 2006.

4.4 M4CaN Transport Model Structure

4.4.1 Two broad mechanisms are used in the model (as is the general case in most transport modelling).

4.4.2 The first mechanism is the modelling of the transport network for highway and public transport conditions which affects the choice of routes that people undertake to get from their origin or start of trip to their destination or end of trip and how individuals choose routes to minimise the 'generalised cost' of travel (i.e. time and money costs).

4.4.3 The second mechanism is that of the modelling of the changes in demand for travel arising from the change in the travel choices of individuals as a result of changes in generalised cost from the changed transport network conditions.

4.5 M4CaN Transport Modelling Software

4.5.1 The M4CaN transport model's highway network component is a 'congested assignment' model using the SATURN software. This is used both in this country and overseas for the evaluation of all kinds of highway systems and proposals and is recognised as an industry standard traffic assignment model that satisfies the requirements for modelling highway networks as set out in WebTAG. The basic inputs to the SATURN model are the 'demand', in the form of a trip matrix of movements between transport 'zones', and the supply in the form of a data file representing the road network.

4.5.2 Following the network build procedure, the highway trip matrix is assigned to the network in order to determine the route choices made by drivers. The model assigns trips through the network between individual origins and destinations by calculating the 'generalised cost' of all reasonable routes, and allocating trips between the set of minimum cost routes, aiming to reach equilibrium where no driver can reduce their cost by travelling along a different route.

4.5.3 The public transport network and assignment model was developed using the specialist transport modelling software EMME. The public transport matrices which were assigned to the public transport networks were developed from the bus and rail counts and surveys. The public transport model has been used to derive the mode transfer from the M4 resulting from public transport upgrades for east-west movements that could in principle be served by the M4 or public transport. Hence, the public transport model has not been designed directly to forecast the public transport impacts, passenger volumes or benefits of other highway or public transport projects.

4.5.4 The demand modelling was undertaken using the DfT's DIADEM software. The demand matrices of trip movements together with matrices of the generalised cost of travel are produced by the highway and public transport models and feed into the demand model to enable forecasts to be made of the changes in both highway and public transport demand. The changes in forecast demands are then fed back into the highway and public transport model for a final assignment of the highway and public transport demands to their corresponding networks. This produces the forecast of traffic flows on each link and conditions on both transport networks.

4.6 Base Year Highway Model Development

4.6.1 The core area in the vicinity of the Scheme for use in the detailed simulation modelling is that defined as the 'Area of Detailed Modelling'. This is centred on Newport, extending from the Severn River Crossings to the eastern edge of Cardiff. It includes both Junction 29 and Junction 23, which form the western and eastern ends respectively of the new section of motorway. Within this core area are key roads of importance and corridors of interest, including:

a) The existing M4 and the route of the proposed Scheme
b) The existing M48 Motorway
c) Access routes to the existing M4 and M48 motorways from Cardiff, Newport, Chepstow and the hinterland north of Newport.
d) The corridors on the east and west banks of the Usk River that could connect Central Newport to the new section of motorway via intermediate junctions and;
e) East-West routes through Newport via Newport Bridge, George Street Bridge and the Southern Distributor Road (SDR)

4.6.2 Within this core area, all significant junctions are fully simulated, and links are coded where appropriate to give a representation of their speed and capacity. This level of detail represents the significance of the key links and junctions in route choice decisions through the study network. The core simulation area extends along key radial routes outside of the Area of Detailed Modelling to ensure that route choice for traffic entering this area is accurately represented.

4.6.3 Outside the Core Simulation Area is the Rest of the Fully Modelled Area, which is bounded to the west by the A470 and the western edge of Cardiff, by the A465 and the A40 to the north, and by the River Wye to the east. Whilst trips are fully represented, this area is modelled in less detail as buffer network only, with no simulation of junctions. All links in this area are allocated speed-flow curves sufficient to represent route choice alternatives.

4.6.4 Outside the Rest of the Fully Modelled Area is the Wider Area of Influence. The Wider Area of Influence is represented as a buffer network, in which fixed speeds are used on the links in this part of the network. It includes long distance movements that could be influenced by a new route for the M4 south of Newport. The Wider Area of Influence extends from Skewen (M4 J43) in the West, the A465 Heads of the Valleys Road and M50 in the North, and the M5 J8 to J18A in the east.

4.6.5 The External Area comprises the rest of the UK outside of the Wider Area of Influence, and does not have an explicit network representation. The external zones are connected to the network at the edge of the Wider Area of Influence by means of long distance centroid connectors, using fixed speeds.

4.6.6 Trip matrices were built for three time periods that are representative of the respective conditions across the model area:

a) AM Peak Hour – 08.00 to 09.00 (representing the AM peak period from 07.00 to 10.00)

b) Inter-Peak Hour – Average hour between 10.00 and 16.00 (representing the inter-peak between the AM and PM peak periods) and;
c) PM Peak Hour – 17.00 to 18.00 (representing the PM peak period from 16.00 to 19.00)

4.6.7 For the peak hour models, a pre-peak assignment was introduced as part of the calibration process. This enabled any resultant queuing that may have existed at the end of the pre-peak hour to be passed through into the peak hour assignment. This helps to improve both the route choice process within the assignment and the representation of journey times.

4.6.8 Different types of journeys have differing characteristics in terms of their distribution (origins to destinations) mode and travel times. For this reason, the base year trip matrices were split into five different ‘user classes’ namely:

a) Cars – Employers Business
b) Cars – Work (Commute)
c) Cars – Other Purposes
d) Light Goods Vehicles (LGV’s) and;
e) Heavy Goods Vehicles (HGV’s)

4.7 Development of Base Year Highway Matrices

4.7.1 In the development of the ‘prior’ trip matrices for the purpose of assignment and for input into the model calibration and validation processes, all trip movements in the Area of Detailed Modelling were derived from fully observed data, with movements outside this area being based on synthesised demand i.e. based on data that whilst being applicable for the purpose was not obtained by direct measurement.

4.7.2 Mobile phone network events were used as the prime source of developing the highway matrices for cars and LGVs. A mobile network is a communication network distributed over land areas called cells, each served by at least one fixed-location transceiver, known as a cell site or base station. This base station provides the cell with the network coverage which can be used for transmission of voice and data information. As mobile phones are used, they communicate their position with the mobile network for network operation, billing and regulatory purposes. This communication takes the form of single data points, called 'events'.

4.7.3 An 'event' can be summarised as any type of communication made between a unique device (mobile phone) and a 'cell'. All data provided by the Mobile Network Operator (MNO) is firstly anonymised before the data can be used for any purpose. This means that the device identification (ID) is replaced by a randomly generated key allocated to the device for the duration of the data collection period. This ensures that no privacy regulations are breached. Once the data has been anonymised then the process of building the base journey database is developed. As part of the data collection for the purpose of the M4CaN transport model; 2G, 3G and 4G mobile phone cells have been used.

4.7.4 Both 'Active' and 'Passive' events are identified in the data. Active events occur for instance when a mobile phone is used, e.g. to make or receive a call and Passive events are those which are identified by the frequent 'heartbeats' detected by the cells when the mobile phone is not active.

4.7.5 The mobile phone network events records were mapped to an aggregation or disaggregation of the transport model zone system, based on the location or locations of the mobile cell masts. The data was processed to identify trip ends, mode, time of day, home location and repeat patterns using a set of defined algorithms. Checks were made on the data through a comparison of trip ends with the DfT's National Trip End Model (NTEM), and a comparison of the distribution of trips (trip lengths) with TrafficMaster data was made at a sector to sector level, which showed a good match between origin and destination patterns in the two datasets. Data from the Road Side Interview (RSI) surveys was used to split motorised trips between from-home, to-home and non-home based, and also between work, other and employers' business trips. For home-based rail trips, data from the NTEM was used to estimate this split.

4.7.6 Whilst the mobile phone trip matrices provide full coverage of trips taking place in the Area of Detailed Modelling, this was not the case in other areas of the model. In the rest of the Fully Modelled Area, the mobile phone data only provided partial coverage of trip making. The infilling of trips within the Rest of the Fully Modelled Area was achieved through synthesising the travel demand using a standard gravity model approach. The synthetic output matrices were then merged with the mobile matrices produced for the Area of Detailed Modelling in order to produce the overall demand matrix. In this merging process, the mobile phone data took precedence over the synthesised data, so that trips in the synthesised demand matrices that were common to those derived from mobile phone were screened out. Thus the synthesised demand matrices represent only the fully unobserved movements in the final matrices.

4.7.7 Expanded Road Side Interview trip records at individual sites were checked and then combined into a single demand matrix. Within the process, any double counting of trips between RSI sites was eliminated. Following the creation of the individual mobile phone, RSI, synthetic and BYFM matrices, they were combined together to form the prior matrices used in the base model calibration and variable demand model realism testing. The method of combining the data aimed to utilise data in order of a hierarchy of data quality and robustness. For car and LGV trips the hierarchy (with the most robust data at the top) was as follows:

a) Mobile phone data;

b) Roadside Interview Data;

c) Synthetic data

4.7.8 For heavy goods vehicles, data was taken directly from BYFM in all areas, since none of the above data sources were able to provide information about goods vehicles with sufficient detail or accuracy.

4.8 Highway Assignment

4.8.1 The assignment process predicts the routes that drivers would choose taking into account the level of traffic demand and the road capacity. The assignment technique used in the updated M4CaN model is the Wardrop equilibrium assignment for multiple user classes. The principle of this assignment is that traffic arranges itself on the network such that the generalised cost of travel on all routes used between each origin and destination is equal to the minimum cost of travel and all unused routes have equal or greater cost. The need for rest stops on long journeys is not directly represented in the model. Trips that are observed to use a service area for instance are treated as being produced by or attracted to the relevant zones of the model, in the same way as any other production or attraction.

4.8.2 The generalised cost of travel is based on a combination of the time and distance of alternative routes. Generalised cost parameters are used in a SATURN model to represent travellers' value of time by pence per minute (PPM) and distance by pence per kilometre (PPK). Values of PPK and PPM can be set universally for the entire model or individually by user class. In the M4CaN model they were set individually by user class. Both PPM and PPK have been derived based on the economic parameters set out in the WebTAG Databook Version 1.6. Accordingly, the values of time applied in M4CaN are based on the 'new' values of time which were adopted into guidance in July 2016. Where a choice of route exists (as in nearly all cases) these values are used to determine which available route has a lower overall ‘cost’ to the traveller. Thus if the PPK value is high, routes chosen would tend to be those which minimise distance, conversely if the PPM is high, routes chosen would tend to be those that minimise the travel time.

4.8.3 Convergence (i.e. whether the system is “close enough” to equilibrium) of all transport models is required in order to ensure consistency and robust model results. Guidance on the degree of model convergence is given in WebTAG. The main measure of the convergence required of a traffic assignment is the Delta statistic, or %GAP. This is the difference between the costs along the chosen routes and those along the minimum cost routes, expressed as a percentage of the minimum costs. WebTAG recommends a guideline target for the %GAP value of 0.1% or less. In addition, WebTAG recommends that the proportion of links in which the changes in traffic volumes is less than 1% should be at least 98% for four consecutive iterations. The %GAP achieved was 0.045, 0.0026 and 0.022 in the AM, Inter-Peak and PM respectively, whilst the percentage of link flow changes over the final four iterations range from 98.0% to 99.0% in the AM Peak, 98.4% to 99.1% in the Inter-Peak and 98.3% to 98.9% in the PM Peak.

4.8.4 The M4CaN base year model assignments indicate that the model achieves a good level of convergence and that the results comply with the criteria set out in WebTAG.

4.9 Base Year Public Transport Model Development

4.9.1 The public transport model has been designed specifically to provide public transport inputs to the demand model. It has not been designed to forecast public transport impacts, passenger volumes or the benefits of other highway or public transport projects. The model provides the public transport demands and times/costs required to enable mode choice modelling within the demand forecasting for the M4 Scheme.

4.9.2 All rail services in the corridor Cardiff-Newport-Chepstow/Severn Tunnel including all through trips such as London to Swansea were included in the model. All bus journeys between Newport and Cardiff made on the X30 operated by Newport Bus and 30 services operated by both Newport Bus and Cardiff Bus were included in the model.

4.9.3 Service timetables were created from the 'May 2014 All Wales' MOIRA model provided by the Welsh Government, MOIRA being the rail industry's standard timetable and passenger demand model. To encompass all services that pass through the study area, the model includes all services to, from or through South and Mid Wales, plus all services via Swindon and Great Malvern.

4.9.4 The bus service network was created from the Traveline National Data Set service timetables and National Public Transport Access Nodes database service stop locations. The 30 and X30 service routes and stops in the study area were coded from this data.

4.9.5 Model zones were connected to service stops through centroid connectors. Centroid connector distances and times were set to represent average access journeys (from passenger surveys).

4.10 Development of Base Year Public Transport Matrices

4.10.1 To create the rail demand matrix, annual station to station matrices were extracted from MOIRA. Passenger counts obtained from First Great Western, Arriva Trains Wales and Cross Country were used to control the volume of trips on each train service. In addition, rail passenger surveys were undertaken on those train services provided by the above mentioned operators in October 2014, between 06.30 and 19.30 into and out of Cardiff Central and Newport Stations. The survey was conducted through face to face interviewing on the station platforms and on trains. The rail surveys provided the information required to separate the annual station matrices into the required user classes and provided information of car availability, journey purpose split and the mode of travel used for access/egress to and from the rail stations.

4.10.2 Electronic Ticket Machine (ETM) DATA from Cardiff Bus and Newport Bus was used to create bus demand matrices for the 30 and X30 services, representing journeys on these services between Cardiff and Newport. A survey of bus passengers was also carried out in October 2014 between 11.00 and 19.00 on both those services. The survey was conducted through face to face interviews. Whilst the surveys were undertaken in the inter-peak and PM peak periods, passengers were also asked about their outward journey earlier in the day to provide information on travel time and journey purpose patterns during the AM peak periods, together with car availability, journey purpose split and mode of travel for access/egress.

5 Model Calibration and Validation

5.1 Overview

5.1.1 This section summarises the work that was undertaken to verify that the transport model provides a sound and robust representation of the transport system in and around Newport.

5.2 Network Checks

5.2.1 Detailed network checks were undertaken on the modelled highway network to ensure that the junction layouts were in accord with what exists on the ground, and that modelled speed and capacity values are appropriate for the type of road. Following this process, the final base year SATURN networks were considered to accurately represent the physical layouts and operation of the highway network in the study area.

5.3 Matrix Estimation

5.3.1 Matrix estimation is a modelling technique that has become a standard feature in many traffic models. Essentially, the model is calibrated by adjusting the ‘prior’ trip matrices so as to fit the available traffic count data as closely as possible. The count data used for this purpose was a combination of video counts on weekdays (excluding Friday) and average Monday to Thursday flows from automatic traffic counters. The model can therefore be considered to represent Monday- Thursday traffic flow levels.

5.3.2 WebTAG suggests a set of benchmark criteria to be used to review the extent of changes due to matrix estimation. These are shown in Table 5.1 below.

Table 5.1 - Significance of Matrix Estimation Changes

Measure	**Benchmark Criteria**
Matrix zonal cell values	Slope within 0.98 and 1.02 Intercept near zero R2 in excess of 0.95
Matrix zonal trip ends	Slope within 0.99 and 1.01 Intercept near zero R2 in excess of 0.98
Trip length distributions	Means within 5% Standard deviations within 5%
Sector to sector level matrices	Differences within 5%

5.3.3 If the prior matrices are sound, the level of adjustment that is applied will be small. The performance of the model was reviewed against these criteria and any exceedances were examined and assessed for their importance particularly in relation to the area of influence of the Scheme to be assessed. In relation to the M4CaN model, this was considered to cover the M4 corridor contained within the core simulation area of the model. The analysis excluded all intra-zonal movements from the matrices (which are not affected through matrix estimation).

5.3.4 The changes brought about in the matrix estimation process were within the benchmark values provided in WebTAG which are shown in Table 5.2 below.

Table 5.2 Matrix Estimation Changes to Zonal Cell Values and Trip Ends

	AM Peak			Inter-peak			PM Peak		
	Cell Values	Rows	Cols	Cell Values	Rows	Cols	Cell Values	Rows	Cols
Slope	0.99	0.99	0.99	0.99	0.98	0.99	0.99	0.99	0.99
Intercept	0	0	0	0	0	0	0	0	0
R^2	0.99	0.98	0.98	0.99	0.95	0.97	0.99	0.98	0.99

5.3.5 It can be seen that the changes made during the matrix estimation process are within the benchmark values provided in WebTAG in almost all cases. The only exceedances of the WebTAG benchmarks occur in the Inter-Peak model, with row totals showing a R^2 of 0.95 and 0.97. Although these are outside the benchmark values in WebTAG, the values are not considered to be unreasonable given that the time period affected has lower number of trips and is less congested.

5.3.6 The changes in trip length distribution that result from matrix estimation is shown below in Table 5.3. The results show that the changes in trip length fall within the benchmarks suggested by WebTAG.

Table 5.3 Changes in Trip Length (km) due to Matrix Estimation

	Mean			Standard Deviation		
	Pre-ME2	Post-ME2	% Diff	Pre-ME2	Post-ME2	% Diff
AM Peak	19.2	19.2	0%	40.0	41.0	2%
Inter Peak	22.3	22.0	-1%	51.6	51.6	0%
PM Peak	19.7	19.9	1%	43.0	45.3	5%

5.3.7 The final check of the calibration process was to compare the modelled assignment flows with observed flows in terms of 'goodness of fit'. Traffic Flow comparisons of the observed and modelled flows following matrix estimation were undertaken for the morning peak, inter-peak and evening peak hours. The WebTAG flow comparison guidelines are shown below in Table 5.4. The results indicated that the link flows and screenline totals, other than in a very small number of instances meet the WebTAG guidance.

Table 5.4 Flow Comparison Guidelines

Criteria and Measures	**Acceptability Guideline**
Assigned Hourly Flows Compared with Observed Flows	
Individual flows within 15% for flows 700 – 2700 vph	> 85% of cases
Individual flows within 100 vph for flows <700 vph	> 85% of cases
Individual flows within 400 vph for flows >2700 vph	> 85% of cases
Total screenline/cordon flows (>5 links) to be within 5%	All (or nearly all) screenlines
GEH Statistic	
Individual flows: GEH < 5.0	> 85% of cases

5.3.8 The closeness of fit between observed and model data was measured using the GEH statistic that is a form of the Chi-squared statistic that incorporates both relative and absolute errors. GEH values can either be calculated for individual links or be calculated for groups of links, e.g. a screenline or a network-wide value. GEH is calculated using the formula:

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

where: M is the modelled flow, and C is the observed flow.

6 Highway Model Validation

6.1 Validation Process

6.1.1 Validation is the process of demonstrating the quality of the model by comparing the model output with observed data.

6.2 Traffic Flow Validation

6.2.1 The M4CaN model highway model validation was carried out on the mainline motorway links between Junction 23a and 29, together with a screenline of links crossing the Usk River in the Newport area, to provide a comparison between modelled and observed flows on the validation links in the AM, Inter-Peak and PM. These are shown in Appendix C in Tables C1, C2 and C.3.

6.2.2 The results show that, in the PM peak and inter-peak hours, the validation of flows on the motorway links between Junction 23a and Junction 29 passed both the flow and GEH WebTAG criteria in all cases. The AM peak hour has only one link that fails the GEH criteria, but this link passes the flow criteria. This shows that the model provides an accurate representation of existing traffic volumes on the M4 around Newport. The flows crossing the Usk River screenline pass the validation criteria, with only some individual counts failing the criteria during certain times of the day. Overall, the validation of the traffic flows on the mainline motorway and the Usk River screenline exceeded the WebTAG requirements, with over 85% of the modelled flows passing the flow/GEH criteria in all three time periods.

6.2.3 As well as checking the mainline motorway flows and the flows crossing the Usk River screenline as part of the validation process, a number of miscellaneous sites within Newport, which are on less critical links, were also checked. When these links were included in the model validation statistics, the AM and PM peak hour models still met the WebTAG GEH requirement and the inter-peak model reached

83%. This shows that the matrix validates well against independent counts.

6.3 Journey Time Validation

6.3.1 The purpose of journey time validation is to show that the model is correctly replicating journey times on critical routes. The WebTAG criterion for journey time comparisons is that the modelled journey times should be within 15% of the observed time (or one minute if higher) on at least 85% of routes surveyed.

6.3.2 Journey time surveys were carried out on 12 key routes through the Area of Detailed Modelling, together with a further eight strategic routes in the Rest of Modelled Areas. The results show that the validation of journey times in each of the modelled time periods meets the WebTAG guidance on all of the surveyed routes, indicating a robust representation of the network operation in the Area of Detailed Modelling. The journey time routes within the Area of Detailed Modelling and the journey time validation are shown in Appendix D in Figure D.1 and in Tables D.1, D.2 and D.3.

6.3.3 The M4CaN model 2014 base year assignments show that the sections of the existing M4 around Newport carrying the highest volume of traffic are those between Junctions 27 and Junction 29 with between 4,300 and 5,300 vehicles travelling in each direction during the peak hours and in excess of 100,000 vehicles per day on these sections. The lowest volume of traffic on the motorway is the two-lane section through Brynglas Tunnels (Junction 25A to Junction 26). At this location, there are around 2,600 to 3,300 vehicles travelling in each direction during the peak hours and around 68,000 daily two-way trips. The assignments show little tidality in traffic patterns, with the peak hour volumes being roughly equal in each direction along the M4 around Newport. The base year Peak Hour traffic flows and the base year AADT flows are shown in Appendix E in Figures E.1 and E.2.

7 Public Transport Model Validation

7.1 Rail Assignment Validation

7.1.1 The rail demand was assigned onto the network and validation was undertaken by comparing the modelled passenger flows against passenger count data. The Castleton section of the railway between Newport, Rogerstone and Cardiff Central Station was taken as the reference point for validation purposes.

7.1.2 The average hourly passenger volumes passing through the Castleton area were aggregated to calculate the volumes passing through key stations on the network in addition, namely Bristol Temple Meads, Bristol Parkway, Chepstow, Cwmbran and Ebbw Vale stations. This was undertaken for each of the modelled time periods.

7.1.3 The rail passenger volumes have not been reported in the Local Model Validation Report or in this Proof of Evidence due to the commercial sensitivity of the data. The validation results show that the total modelled flows closely match the passenger volume count data in all time periods and in both directions.

7.2 Bus Assignment

7.2.1 The Bus demand matrices were assigned onto the modelled bus network and validation was undertaken by comparing the modelled passenger flows against bus passenger counts. The reference point for validation of the bus assignment was also taken as Castleton, near the local authority boundary between Newport and Cardiff. The passenger counts were derived by calculating the cumulative bus occupancy at Castleton from the ETM data.

7.2.2 The bus passenger volumes have not been published in the Local Model Validation Report or in this Proof of Evidence due to commercial sensitivity of the data. The validation results show that the total modelled flows closely match the observed data in all time periods and both directions.

8 M4CaN VISSIM Model

8.1 Overview

8.1.1 The M4CaN VISSIM model is a traffic modelling technique that operates at the level of individual vehicles. The vehicles are categorised according to attributes such as operational characteristics or vehicle types.

8.1.2 VISSIM models comprise two main elements: a network representing the physical highway and demand matrices. The highway network is coded based on geometric data and the VISSIM software uses this information to ascertain capacity. This in turn determines levels of congestion once the traffic is loaded into the network. As for a strategic highway model such as the M4CaN Transport model, traffic flows and speeds can be output from the microsimulation model. Vehicles are modelled as a number of individual units and as such, vehicle operation and driver behaviours can be more accurately represented than in a strategic highway model.

8.1.3 The VISSIM model includes a baseline scenario representing existing conditions on the network which has been calibrated and validated using MIDAS speed and flow data together with a comparison against traffic counts and journey time surveys. Forecast year VISSIM models have been developed for a Do-Minimum scenario representing the future situation without the M4 Scheme and the Do-Something representing the future situation with the Scheme. It should be noted that the VISSIM model is based on the previous Published Orders Scheme and not the Supplementary Orders Scheme. The changes in traffic flow brought about by the introduction of the eastbound off-slip would not have a material effect in the VISSIM model, since the changes in traffic flow on an hourly basis are small.

8.2 VISSIM Model Area

8.2.1 The base model consists of the mainline M4 motorway from Junction 23 to 29. The model includes the roundabouts and signal controlled gyratories of Junctions 23a, 24, 25, 26, 27, and 28, and the B4245 junction south of Junction 23a. The model also includes the B4245 between Magor and Rogiet, as this link is connected to the proposed junction in the Do Something scenarios. Figure 8.1 shows the extent and zone structure of the Base and Do Minimum VISSIM model. Figure 8.2 shows the extent and zone structure of the Do Something model.

Figure 8.1 VISSIM Base and Do-Minimum model extent and zone structure

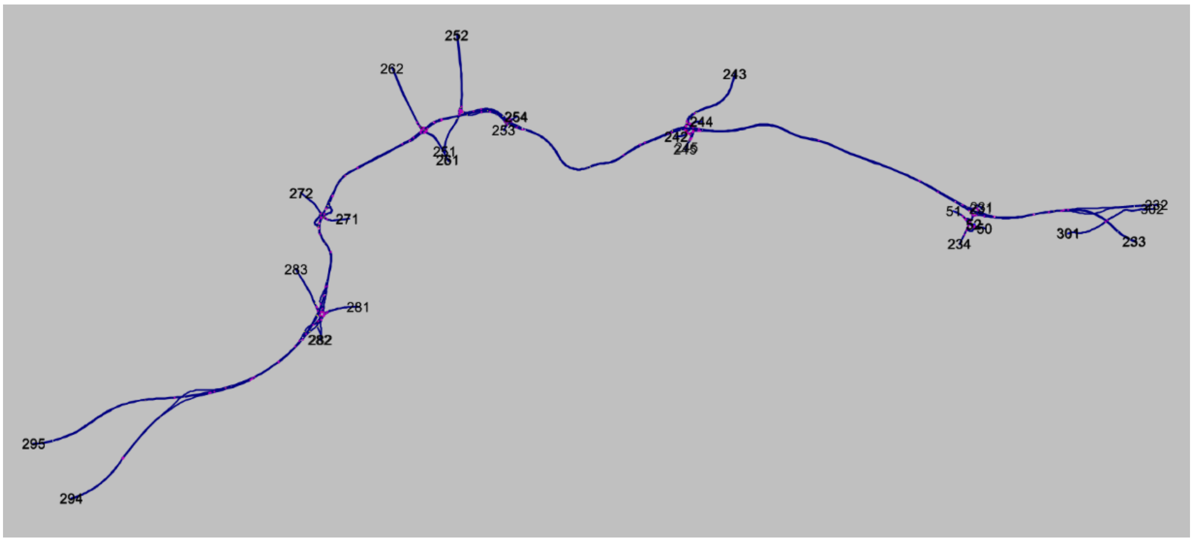
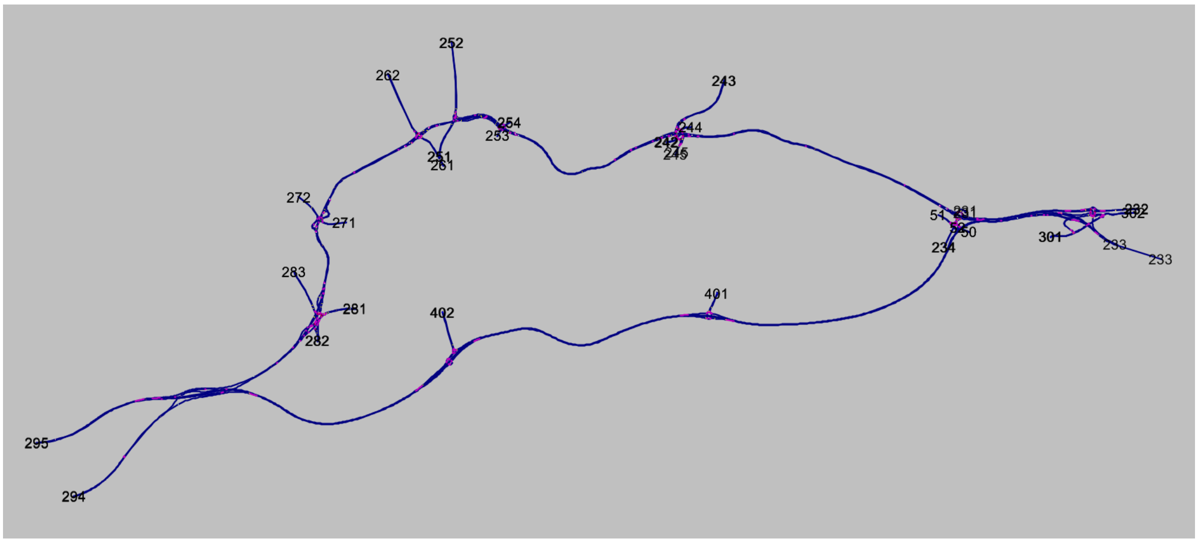


Figure 8.2 VISSIM Do – Something model extent and zone structure



8.3 Traffic Demand

8.3.1 Traffic demand matrices for the VISSIM model were developed by cordoning the wider M4 CaN SATURN assignment model, described in Section 4.8 above to match the extent of the VISSIM model, using the zone structure set out above in Figures 8.1 and 8.2.

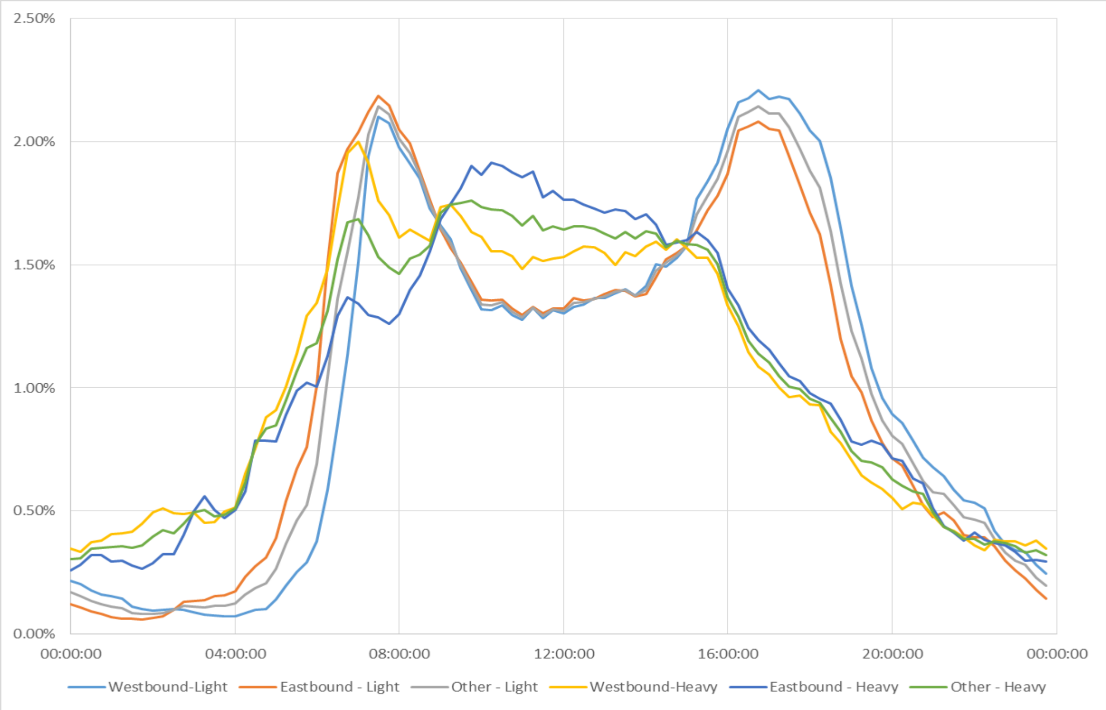
8.3.2 In order to extend the M4CaN modelled time periods described in 4.6 6 to represent the variation in flow over the whole 24 hour day, MIDAS data provided by Traffic Wales was used to derive appropriate factors. The MIDAS flow data was provided for mainline locations between Junction 23a and Junction 29 in 15 minute intervals for weekdays in May and June 2015.

8.3.3 The MIDAS data was used to generate daily profiles for both eastbound and westbound movements on the motorway, for both light and heavy vehicles. Origin-Destination pairs whose routes would not use the motorway, were profiled using an average of the eastbound and westbound profiles. These profiles were applied to the demand matrices extracted from the M4CaN model to in order to represent hours of the day not covered by the three modelled time periods. These profiles are illustrated in Figure 8.3 below with the vertical axis showing the proportion of daily traffic observed within the 15 minute interval.

8.3.4 Rather than model the whole 24 hour period using a single microsimulation model r, five time periods were run separately for each scenario:

a) Pre AM (midnight to 07:00) – based on the profiled M4CaN Inter-Peak flows
b) AM Peak (07:00 – 10:00) – based on the profiled M4CaN AM Peak flows
c) Inter-Peak (10:00 – 16:00) – based on the profiled M4CaN Inter-Peak flows
d) PM Peak (16:00 – 19:00) – based on the profiled M4CaN PM Peak flows
e) Post PM (19:00 to midnight) – based on the profiled M4CaN Inter-Peak flows

Figure 8.3 Weekday flow variation from MIDAS data



8.3.5 Each modelled time period included an additional 30 minute 'warm up' period to allow traffic to build up on the network, i.e. the AM peak model started at 06:30, but results were not extracted until 07:00.

8.3.6 The desired speed profiles for each section of the mainline in the original model were developed using minute-by-minute MIDAS data for the appropriate section of the M4, from the time period 20:00 to 21:00. These represent the range of traffic speeds that drivers along the corridor wish to travel at during uncongested conditions at each particular location along the existing motorway. The profiles were defined separately for light vehicles and heavy vehicles.

8.4 VISSIM Model Base Year Validation

8.4.1 For individual counts the DMRB advises that at least 85% of GEH values should be less than 5. Of the 288 hourly flow comparisons, 36 have a GEH of 5 or over, resulting in 87.5% having a GEH less than 5. This comparison is similar in the westbound and eastbound directions, with 86.8% and 88.2% meeting this criterion respectively.

9 Future Year Forecasting

9.1 Overview

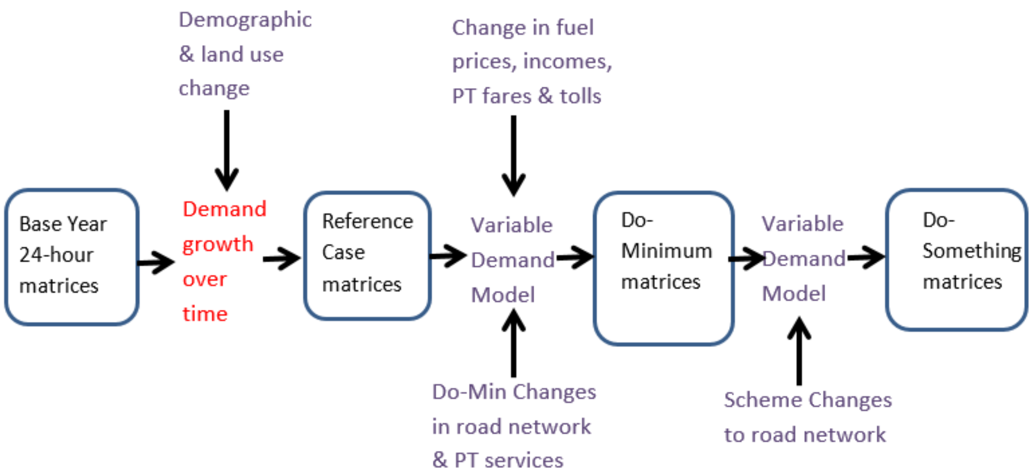
9.1.1 The projected economic and environmental impacts of the M4 Scheme are based on future year forecast runs of the traffic model. The traffic impact is the difference between two forecasts, the Do-Minimum (without-Scheme) and the Do-Something (with-Scheme). The 'Do-Minimum' consists of the future year traffic conditions in the absence of the proposed new section of motorway south of Newport, and the 'Do-Something' includes the proposed new section of motorway south of Newport together with reclassification and associated changes to the existing M4 north of Newport. These forecasts were generated for the projected Scheme opening year of 2022 and the design year of 2037.

9.1.2 Forecast results are presented for a most likely 'core forecast' future scenario. The core forecasts that are described in the Revised Traffic Forecasting Report were fully compliant with WebTAG guidance, and informed the Welsh Government decision to proceed to publication of draft orders for the Scheme.

9.1.3 Sensitivity tests were undertaken on alternative future scenarios, to check that the estimate of traffic impacts was robust to uncertainty about what the future will bring. Foremost among these were the low and high growth sensitivity tests that are documented in the Revised Traffic Forecasting Report.

9.2 Demand Forecasting Procedure.

9.2.1 The demand forecasting process is shown in simplified form below. The first step in the forecasting process is the development of the Reference Case forecast matrices which are a projection of what travel demand is likely to be in the future, if travel costs and travel times were to remain constant.



9.2.2 In the second step, the Variable Demand model is used to adjust these matrices to reflect responses to cost changes that would occur in the Do-Minimum and finally in the third step the Variable Demand model is used to adjust the Do-Minimum in response to the implementation of the Scheme.

9.3 Reference Case Demand

9.3.1 Demand growth over time for car drivers and passengers was derived from the National Trip End Model (NTEM) dataset through the TEMPRO software that presents the NTEM dataset. The NTEM has been developed by the DfT and provides a set of predictions for growth in travel demand at trip end level for a range of different modes. The NTEM datasets are long term forecasts – they represent the Department's estimate of the long term response to demographic and economic trends. The growth factors are not forecasts, they are factors based on predicted demographic changes and they do not take account changes in the generalised cost of travel changes or in the disutility that people attach to different elements of generalised cost.

9.3.2 WebTAG Unit M4 states that future year forecasts should be based on NTEM growth in demand, thereby allowing transport models to be developed on a fully consistent basis. On the 28th July 2016 a new version of TEMPRO and NTEM dataset (Version 7.0) was published and replaced Version 6.2 following a systematic of the key drivers of road demand which is summarised in the DfT's 'Understanding of the Drivers of Road Travel'. This report concluded that the factors that are customarily highlighted as being key drivers of road demand – incomes, costs and population – have been important drivers of recent trends in traffic, but there are other factors that need to be considered and reflected in the TEMPRO growth factors.

9.3.3 These other factors include such issues as the increasing concentrations of people living in urban areas, increased costs such as company car taxation and insurance, capacity constraints and technological developments which allow for homeworking and online shopping. Related to this, the number and nature of the journeys that people make, may all be playing a role in the observed changes in traffic levels. Some objectors to the draft Orders have suggested that demand management measures would reduce the need to travel, including working from home initiatives4. Whilst there is currently little evidence on the impact that certain issues, such as online shopping, may be having on travel decisions, it is known that most of the recent fall in per car mileage has arisen through a decline in the number of trips people are making.

9.3.4 The National Travel Survey (NTS) data has shown that the average number of trips has been falling and that there has been a general downward trend in trip rates. The two most common journey purposes (shopping and commuting), exhibit a statistically significant downward trend with reductions of 6% and 10% respectively between 2003 and 2010. The trends in this data are not uniform and vary according to purpose and segmentation (e.g. gender, area and household type). For example, the personal and employers' business purposes are stable while the holiday trip rate is increasing, and the trips that are reducing tend to be shorter trips.

[4] OBJ0008, OBJ0150, OBJ0162, OBJ0279, OBJ0310

9.3.5 The recent decline may also be partly due to economic conditions, and as these are forecast to improve in the future, the DfT are of the view that there is reason to believe the decline will not continue at its current rate in the long term and this view is reflected in the NTEM central growth forecast. The NTEM central growth scenario therefore is based on the latest trip rate data collected in the trip rate review assumes a declining trend in trip rates between its base year of 2011 and 2016 and then constant rates thereafter.

9.3.6 Following the release of NTEM7.0 an interim dataset for Wales (NTEMv7.1 Interim for Wales) was made available which incorporated revised assumptions on housing growth.

9.3.8 NTEM 7.1 Interim for Wales provides through TEMPRO 7.1, the trip end growth forecasts for use in the forecast Reference Case thus updating the Reference Case developed from TEMPRO 6.2 which formed the basis for forecasting as described in the March 2016 Forecasting Report.

9.3.9 NTEM growth factors for car trips in the forecast years were extracted from the TEMPRO Interim for Wales v7.1 database software for three journey purposes of employers' business, commuting and others in the AM peak, inter-peak and PM peak periods. For each user class, the relevant set of growth factors from NTEM was applied to the corresponding model zones in the base year 'prior' trip matrices.

9.3.10 NTEM does not produce growth factors for trips made by goods vehicles, and WebTAG advises that for modelling other vehicle types in highway models, growth factors from the National Transport Model (NTM) may be used. The most recent growth factors for goods from the NTM are available in the latest version of the Road Traffic Forecasts (RTF15). The NTM growth factors were adjusted by the NTEM ratio of growth in the study area to national growth, in order to reflect the differential change in economic activity in the study area compared to other parts of the country.

9.3.11 There is no explicit assumption in NTEM that particular developments do or do not go ahead. Planning data is provided at the local authority level and the households are distributed to the NTEM zones according to expected growth factors derived from historic trends. It is recognised in TAG Unit M4 – Forecasting and Uncertainty that with detailed development information, it is permissible to adjust the distribution of households or jobs at the model zone level. However, for modelling purposes, TEMPRO figures must be used as control totals over a larger area, usually the local authority or district level. This then implies that if jobs or households in a zone are adjusted, equal and opposite adjustments must be made in other zones to match the total from the NTEM dataset.

9.3.12 In accordance with the requirement set out in the paragraph above, trips generated by specific development sites in the Local Development Plans for Newport, Monmouthshire and Cardiff were taken into account and applied at the corresponding model zone level. Information regarding the detailed proposals and planning status of future developments were obtained from the Newport LDP which was adopted in January 2015, the Monmouthshire LDP which was adopted in February 2014 and the Cardiff LDP, which was adopted in January 2016.The specific developments were represented by a concentration of traffic growth in the model zones that correspond to their geographical locations. To offset this, growth factors applied across the remainder of the zones within each NTEM area were reduced so that the overall level of growth was constrained to the NTEM forecasts for the modelled area.

9.3.13 Specific developments outside Newport, Cardiff and Monmouthshire were deemed to be too far from the study area to have a direct impact on the Scheme and as such were not considered for explicit inclusion in the traffic forecasting. Traffic generated by these developments was considered to be captured in the NTEM growth for that particular region. The demand matrix was then updated to match the new trip ends using a Furnessing technique. This is a standard modelling process which makes the minimum change to the base year matrices necessary to make them consistent with the future year trip ends.

9.4 Future Year Highway Networks

9.4.1 The definition of the Do-Minimum network requires the identification of any highway schemes categorised as committed, near certain or most likely as defined in WebTAG Unit M4 Forecasting and Uncertainty within the study area that should be included in the traffic model. The Welsh Government, together with Newport, Cardiff and Monmouthshire Councils, were consulted to ascertain what transport schemes would be likely to be implemented within the timeframes of the M4CaN traffic forecasts. From the review, a list of highway improvements for inclusion in the M4CaM traffic model was identified.

9.4.2 These improvements consisted of:

a) the Scheme to improve the operation of Junction 28 roundabout at Tredegar Park as part of the M4 Corridor Enhancement Measures Programme (CEMP), comprising of an enlarged at-grade signalised gyratory, incorporating through links between the M4(west) and the A48;
b) conversion of the existing A467 Bassaleg roundabout into a signalised roundabout;
c) conversion of the A48 Pont Ebbw existing signalised ‘throughabout’ with a new link connecting the eastern and western arms of the A48 Southern Distributor Road;
d) A465 Heads of the Valleys Dualling (Abergavenny to Hirwaun)
e) construction of the Cardiff Eastern Bay Link Phase 1

9.4.3 All of these schemes were coded into the forecast Do-minimum network.

9.5 Future Year Public Transport Networks

9.5.1 South Wales Metro is a proposed major upgrade to regional public transport in the Cardiff Capital Region led by Transport for Wales on behalf of Welsh Government. This umbrella initiative is currently the subject of rapid development and whilst not yet established in a policy, the document 'Rolling out our Metro' issued by Welsh Government in autumn 2015 sets out the vision, and objectives for the project, as well as the scope and nature of likely component schemes.

9.5.2 The M4CaN model includes public transport upgrades in comparison to the existing situation

a) Great Western Route Modernisation includes the electrification of the Great Western Mainline from London Paddington to Cardiff by 2017. The electrification of the railway will reduce the journey time between London Paddington and Cardiff by 17 minutes.

b) Metro Phase 1) including new stations and Valley Lines Electrification

9.5.3 The future year public transport timetables were modified to reflect the increased service frequencies and improved journey times that could be achieved with electrification of the Great Western Mainline and electrification of the Valley Lines

9.5.4 Transport for Wales (on behalf of Welsh Government) and the Wales and Borders rail franchise bidders are currently undertaking further development on the possible services and modes that will form part of the South Wales Metro. It is recognised that these Metro proposals for Valley Lines Modernisation 'Metro Phase 2' to be delivered by 2023 may lead to changes in public transport provision which supersede the Valley Lines Electrification scheme currently assumed in the M4CaN model.

9.5.5 However, the details of these proposals are not yet known. The inclusion of the improved rail services on the Valley Lines in the model (in terms of journey time and service frequency improvements according to former electrification proposals) means that account has been taken of those aspects of Metro which are most relevant in consideration of their impact on the M4 proposals.

9.5.6 There are other potential future elements of the Metro proposals ‘Metro Phase 3’ to be delivered beyond 2023 but due to the lack of certainty or opening dates of these schemes, they have not been included in the M4CaN model. It is anticipated that ‘Phase 3’ will comprise of extensions/additions to and also wholly new routes connecting to the network.

9.5.7 Outside of the M4CaN model, an alternative approach has been developed to test the likely effect of traffic volumes on the M4. This approach considers the implementation of rail aspects of the Metro initiative.

9.5.8 New stations are proposed at Llanwern, St Mellons and Newport Road but the feasibility of delivering all of these stations in operational terms has yet to be fully determined. New station demand at St Mellons and Newport Road has not been accounted for in the alternative approach. At Llanwern demand related to the provision of a strategic 1,000 Park and Ride has been considered separately. This station could provide a Parkway style facility for journeys to Cardiff, Newport and Bristol.

9.6 Severn Crossing Tolls

9.6.1 I will explain the assumptions adopted about the continued collection of tolls over the River Severn Crossings, and how the M4 transport model takes the tolls into account as part of the assessment of the likely impacts of the proposed Scheme on transport conditions. In doing so, I will highlight the key issues, which will serve to address the objections received to the draft Orders that express concerns that should the Severn Crossing tolls be abolished there would be even more traffic5.

9.6.2 The traffic model network includes the two Severn River Crossings (the M48 Bridge and the M4 Second Severn Crossing), which link Wales and South West England. These bridges are currently both tolled in the westbound direction. The tolls are collected via toll booths, at Aust on the first Severn Bridge and approaching Magor for the Second Severn Crossing. The tolls are represented in the base year model by a monetary penalty (in 2014 prices) to represent the toll charge for each of the different vehicle types and a time penalty to represent the delay at the toll booths.

9.6.3 The Severn Bridges Act 1992 set out the basis for a concession agreement for the Severn Crossings and empowered the Secretary of State to level tolls. The Act established the conditions under which the concession would end, following which both crossings would revert to public ownership. Current expectations are that the concession agreement will come to an end either late in 2017 or early 2018 at which time ownership as well as the future maintenance burden, will transfer back to UK Government.

9.6.4 An announcement was made in the 2015 Budget that VAT would be removed from the toll charges when the bridges return to public ownership and that Category 2 vehicles would be reduced to the level charged for Category 1 vehicles. There was a further announcement in the 2016 Budget that the tolls would be halved. Therefore, for the M4CaN forecasting, a half toll representing the cumulative changes announced in both budgets is assumed in the future years. These toll charges are represented in the forecast model in 2014 prices and represent a change from the 'no toll' assumption that was assumed to be the case in the core scenario in the March 2016 Traffic Forecasting

[5] OBJ0206

Report. The updated approach to tolling assumes that the arrangements for toll collection will remain as they are now.

9.6.5 The M4CaN model is not able on its own to fully model the full effect of the impacts arising from a toll change as it does not include in sufficient detail the area to the east of the Crossings that would allow for the full induced demand effects that will result from a reduction in toll charges. However, since Draft Order Publication, a detailed study investigating the demand response of traffic crossing the Severn Bridges has been undertaken for the DfT that is referred to here as the ‘DfT Severn Toll Model’. That study was based on a more refined variable demand modelling approach (similar to that employed for the M4CaN model) which covered a wider geographic area and incorporated updated user delay assumptions representing the time lost at the toll booths. This time lost was derived from TrafficMaster observed journey time datasets. The M4CaN model takes the changes in demand resulting from changes in toll that are in turn derived from the ‘DfT Severn Toll Model’.

9.6.6 An automated process was developed to adopt the changes in demand contained within the DfT Severn Toll Model into the M4CaN traffic model demand matrix. In practice, the full effect of changes in toll levels on traffic demand will take a number of years to play out. The issue of the timing of demand responses is amplified by the fact that halving or removing the tolls results in a large change in generalised costs (as compared to highway improvement schemes). Therefore, there is good reason to believe that the traffic response to this change depends, to a greater degree than is usually the case, on long term behavioural responses such as those involving labour market or land use changes.

9.6.7 TAG Unit M2 characterises the fuel cost elasticity of -0.3 as broadly reflective of a 10 year demand response. At five years, an elasticity of -0.2 is suggested in WebTAG. By inference, two-thirds of the long term demand response is realised in the first 5 years after the change in travel cost. Whilst there is considerable uncertainty over the timing of the proposed changes to the Severn Tolls, any change will not come into force until the end of the current concession arrangements in late 2017 or early 2018. By the Scheme opening year of 2022, the change in toll level will only have been in place for a maximum of 4 or 5 years.

9.6.8 In view of this, it is considered appropriate to apply a 'ramp up' factor to the forecast traffic response to changes in the Severn Tolls in this year. Reflecting the evidence set out in WebTAG, a ramp up factor of 0.67 has been applied (such that the actual response is two thirds of the modelled response). By the design year of 2037, the change in toll prices is likely to have been in place for many years. Therefore, no such 'ramp up' factor has been applied to the design year.

10 Model Forecasts

10.1 Overview

10.1.1 This section presents the traffic forecasts for the Core Scenario resulting from design changes implemented in the draft Supplementary Scheme Order (No 2) dated March 2017. Central traffic forecasts have been produced for the three future years of 2022, 2037 and 2051. These future year forecasts cover the three modelled time periods of the AM Peak Hour, the average Inter-Peak Hour and the PM Peak Hour.

10.1.2 The draft Supplementary Orders Scheme incorporates a revised layout around Magor to that contained in the previous draft Orders Scheme which improves accessibility into Magor, Magor Services, the Wales 1 Business Park, Magor Brewery and the surrounding areas. This leads to a slight reduction in eastbound traffic volumes on the reclassified existing motorway and a corresponding increase in traffic on the proposed motorway. The increase in eastbound traffic is highest on the eastern section of the proposed motorway, where in addition to the above, some traffic which would have previously used the Glan Llyn Junction and travelled eastbound along the A4810 Steelworks Access Road will now be able to continue along the proposed motorway and exit onto the local road network using the eastbound off-slip at Magor instead.

10.1.3 The output matrices resulting from Variable Demand Modelling varies between the Base and the Do-Minimum and the Do-Minimum and Do-Something scenarios in respect of changes in the total number of trips, vehicle kilometres travelled and total network vehicle hours across the model wide area. The relative change in vehicles, kilometres and hours travelled between the key scenarios are stated in detail in Section 9.3 of the Revised Forecasting Report.

Table 10.1: Changes in Trips in the Core Scenario

Year	Scenario	AM Peak Hour	Inter-peak Hour	PM Peak Hour
2022	Base to Do Minimum	+5.7%	+7.2%	+5.6%
	Do Minimum to Do Something	+0.0%	+0.0%	+0.0%
2037	Base to Do Minimum	+20.4%	+23.3%	+19.8%
	Do Minimum to Do Something	+0.1%	+0.0%	+0.0%
2051	Base to Do Minimum	+29.3%	+32.3%	+29.0%
	Do Minimum to Do Something	+0.2%	-0.0%	+0.1%

Table 10.2: Changes in Vehicle-Kilometres in the Core Scenario

Year	Scenario	AM Peak Hour	Inter-peak Hour	PM Peak Hour
2022	Base to Do Minimum	+8.5%	+9.7%	+8.4%
	Do Minimum to Do Something	-0.1%	-0.3%	-0.2%
2037	Base to Do Minimum	+27.7%	+30.8%	+27.7%
	Do Minimum to Do Something	+0.3%	-0.3%	+0.0%
2051	Base to Do Minimum	+38.7%	+43.4%	+39.4%
	Do Minimum to Do Something	+0.9%	-0.3%	+0.5%

Table 10.3: Effects of VDM on Vehicle-Hours in the Core Scenario

Year	Scenario	AM Peak Hour	Inter-peak Hour	PM Peak Hour
2022	Base to Do Minimum	+11.7%	+12.4%	+11.2%
	Do Minimum to Do Something	-0.6%	-0.4%	-0.5%
2037	Base to Do Minimum	+41.8%	+36.5%	+39.7%
	Do Minimum to Do Something	-0.9%	-0.7%	-0.8%
2051	Base to Do Minimum	+66.4 %	+51.9%	+63.4%
	Do Minimum to Do Something	-0.2%	-1.1%	-0.4%

10.1.4 There is an increase in the number of trips between the base year and forecast Do-Minimum largely as a result of traffic growth, together with an increase arising from redistribution effects that result from the reduction in the toll charge across the Severn Crossings. Slightly counteracting this is a modal shift response from private to public transport as people respond to changes in highway network congestion. The difference in highway trips between the Do-Minimum and Do-Something in the forecast years captures the modal shift response that is to result directly from the introduction of the Scheme. As the Do-Something also includes the reclassification of the existing M4 this also impacts on modal shift.

10.1.5 The increase in vehicle-kilometres between the base year and forecast Do-Minimum in the forecast years is predicted to be slightly higher than the growth in the number of trips as a result of average trip lengths increasing slightly over time, partly as a result of the change in tolls. This response is also linked to the reducing cost of car travel in real terms as a result of factors such as increased fuel efficiency and also increases in average income levels. The difference in highway vehicle-kilometres between the Do Minimum and Do Something captures the overall distance savings that are predicted to result from the introduction of the Scheme. There are a number of trips experiencing shorter journeys on the motorway around Newport as a result of reassignment, however a significant number of trips experience an increase in vehicle-kilometres that occurs as a result of redistribution as travellers take advantage of the reduced levels of congestion in the Do Something scenario. In some time periods and years vehicle-kilometre savings are achieved despite the number of trips increasing slightly and trips lengthening in response to the Scheme.

10.1.6 The increase in vehicle-hours between the base year and forecast Do-Minimum in 2022 is predicted to be slightly higher than the growth in the number of vehicle kilometres. By 2037 and 2051 this difference is forecast to become significant. This illustrates the increasing level of traffic congestion predicted to result from general traffic growth. There is a slight decrease in vehicle-hours predicted between the Do-Minimum and Do-Something scenarios in all three forecast years. This is despite a small increase in the number of highway trips.

10.2 Forecast Traffic Flows

10.2.1 In the Do-Minimum scenario, the two-way AADT in 2037 through Brynglas Tunnels is 89,200, comprising of 52% two-way through traffic travelling between east of Junction 23 and west of Junction 29, 12% of two way traffic joining or leaving at Junctions 28, 27 and 26 travelling through the tunnels to the east of Junction 23A, 24% of two way traffic travelling from west of Junction 28 through the tunnels and joining or leaving at Junction 24 or Junction 23A, and 12% two-way traffic both joining and leaving between Junctions 23 and 29.

10.2.2 With the Supplementary Orders Scheme in place, the two-way AADT through the tunnels would reduce from 89,200 to 59,200 representing a 34% reduction. Elsewhere on the existing M4 the AADT flows reduce by between 32% to 61% in 2037, the smallest reduction being between Junctions 26 and Junction 27 (reducing from 130,100 to 89,000 AADT) and the largest reduction being between Junctions 25 and Junction 25a (reducing from 114,600 to 45,000).

10.2.3 On the remaining sections of M4 with Supplementary Orders Scheme in place, the two way-way AADT reduces between J23 and J23a by 57% (reducing from 107,100 to 46,300), between J23a and J24 by 55% (reducing from 105,100 to 47,200), between J24 and J25 by 42% (reducing from 124,800 to 73,000), between J27 and J28 by 35% (reducing from 129,000 to 84,900) and finally between J28 and J29 by 42% (reducing from 136,100 to 79,200).

10.2.4 There would also be a reduction in traffic on the local roads within Newport, including the A48. Through traffic travelling between east of Junction 23 and west of Junction 29, would use the proposed new section of motorway to the south of Newport, which is shorter and has a better alignment than the existing M4. In addition, some traffic accessing Newport would also use the proposed new section of motorway, utilising the intermediate junctions at Newport Docks and Glan Llyn.

10.2.5 Traffic from the Valley communities to the north of Newport and strategic traffic from the A449 corridor joining the existing M4 at Junction 24 would continue to use the existing M4 as this traffic would not have direct access onto the new section of motorway.

10.2.6 The two way AADT forecast in 2037 through the Brynglas Tunnels of 59,200 is made up of 3% two way through traffic travelling between east of J23 and west of Junction 29, 17% of two-way traffic joining or leaving at J28, 27 and 26 travelling through the tunnels to east of Junction 23A, 42% two-way travelling from west of J28 through the tunnels and joining or leaving at J24 or 23A and 37% two-way traffic both joining and leaving between Junctions 23 and 29.

10.2.7 The AADT forecast traffic flows on the Supplementary Orders Scheme across the Usk River are 56,700, 71,700 and 78,900 respectively in 2022, 2037 and 2051. In 2037, the forecast traffic flow of 71,700 comprises of 65% two-way through traffic travelling the whole length of proposed new section of motorway between Junctions 23 and 29, 14% two-way traffic joining or leaving at Docks Junction and using proposed new section of motorway to east of Junction 23, 14% two-way traffic joining or leaving at Glan Llyn Junction and using proposed new section of motorway and 7% two-way traffic travelling between Docks Junction and Glan Llyn Junction on proposed new section of motorway

10.3 Motorway Level of Service

10.3.1 The traffic flow forecasts provide an indication of the level of service on the motorway network around Newport, based on the ratio of flow to capacity (RFC) and the Congestion Reference Flow (CRF). The Design Manual for Roads and Bridges (DMRB) uses the concept of the CRF as a measure against which to judge acceptable performance for rural roads, whilst the performance of urban roads is assessed by comparing the peak hour flows with theoretical capacity (RFC), where a three-lane motorway has an estimated capacity of 5,600 vehicles per hour in each direction, reducing to 4,000 vehicles per hour on two-lane sections.

10.3.2 The proposed Scheme is classified and designed to rural motorway standards, however the existing M4 around Newport comprises both rural and urban sections of motorway passing through built-up areas with closely spaced junctions.

10.3.3 When the ratio of the AADT flow to CRF reaches 100%, it is estimated that congestion will occur in approximately half of the weekday peak periods, in the peak direction. However, some reliability problems with journey times may occur in advance of the ratio reaching 100%. In the assessment of journey time reliability for rural roads, Transport Analysis Guidance adopts a stress-based approach, which considers the change in ratio of flow to CRF between 75% and 125%. For the purpose of the assessment of level of service, 80% of CRF has been taken at the point at which journey time reliability becomes adversely affected and congestion begins to be experienced on the rural motorway sections.

10.3.4 On the urban motorway links, the level of service has been determined by analysis of the one-way capacity, or maximum throughput of the motorway links with the peak hour forecasts. It is generally accepted that once hourly flows reach about 80% of the theoretical capacity, operational problems can be expected and has reached a point at which journey time reliability becomes adversely affection and congestion begins to be experienced,

10.3.5 Congestion, with frequent incidents, is currently an everyday occurrence on the existing M4 between Brynglas Tunnels and Junction 29 and in particular westbound between Junctions 24 and 26 where traffic flows are approaching peak hour capacity. These capacity issues are illustrated by the CRF analysis. The restricted capacity of the tunnels forms a bottleneck on the motorway at peak times, while traffic queuing to leave the motorway at Junctions 26 and 28 frequently extends onto the mainline, thus exacerbating the problems presented by the poor alignment of the motorway between these junctions.

10.3.6 In the Do-minimum scenario, congestion would be expected to worsen as traffic volumes increase over time and ‘peak spreading’ is likely to occur resulting in the duration of peak periods getting longer. Higher traffic flows will also lead to unstable conditions where a higher number of incidents and accidents are likely to occur, which in turn may produce increasing stop-start conditions on the motorway on a more regular basis, leading to a further deterioration of journey time reliability.

10.3.7 In the Do-Something scenario, the proposed new section of motorway is forecast to operate within capacity. The reclassification of the existing motorway north of Newport with the proposed Scheme in place includes a reduction in the number of lanes from three to two lanes on some sections where three lanes are currently in place between Junction 23A and Junction 24, westbound between Junction 24 and Junction 25 and through Junction 28 where there is a lane drop/lane gain between slip roads. This reduction in capacity leads to some sections of the existing motorway corridor being flagged as likely to experience some traffic congestion even with the new motorway to the south of Newport. However, traffic conditions on the M4 would still be better in the Do-Something situation compared to the Do Minimum situation due to the relief provided by the new section of motorway.

10.3.8 In practical terms, the lower degree of saturation on the existing M4 together with the provision of a new motorway corridor operating within capacity would lead to smoother operation of the highway network around Newport. A lower frequency of incidents would also be expected and importantly, the provision of an alternative route for east-west traffic will further improve network resilience when incidents do occur.

11 Journey Times

11.1 Overview

11.1.1 The Scheme impacts on journey times throughout the network. Journey times have been derived from the M4CaN model and in particular focus on the change in journey time brought about by the draft Supplementary Orders Scheme:

a) travelling between Junction 30 of the M4 and the toll plaza at the Severn Crossing, not stopping at Magor Services
b) travelling between Junction 30 of the M4 and the toll plaza at the Severn Crossing, stopping at Magor and;
c) Journey Times to Newport Docks

11.1.2 It should be noted that the traffic model assumes 'typical' conditions without any incidents to disrupt traffic. In reality, as traffic volumes increase on the existing M4 without the proposed new section of motorway in place, conditions are likely to become more unstable leading to a higher frequency of incidents. Incidents on the existing M4 have been seen to result in stop-start conditions, sometimes even bringing traffic to a standstill. These impacts on journey time reliability are not taken into account by the traffic model.

11.2 Journey Times between Junction 30 and M4 Toll Plaza not stopping at Magor Services

11.2.1 The journey times along the existing M4 in the Do Something scenario in comparison to the Do-minimum are provided as an indicative benchmark only and are shown in Table 11.1 below. In practice, traffic travelling the full length of M4 between Junction 30 and the Second Severn Crossing would use the new motorway. Traffic travelling along the existing M4 when the new M4 is in place, would therefore only be travelling on part of the route between Junctions 23 and 29.

11.2.2 Journey times along the existing M4 would be affected by the following components of the Do Something as follows;

a) slight increase in distance due to the realignment of the existing M4 to accommodate the tie-in with the proposed new section of motorway. Eastbound traffic would need to negotiate a roundabout to access the M4 approach to the Second Severn Crossing, whilst westbound traffic would be free flow. In consequence, this is likely to result in a slight localised increase in journey times on these sections.

b) reclassification of the existing M4 includes a speed limit reduction and capacity reduction on some sections of the motorway which leads to a slight increase in journey time on those sections.

c) reduced volumes of traffic arising from the relief provided by the proposed new section of motorway reduces journey times on those sections not affected by reclassification.

Table 11.1: Journey Time between Junction 30 and M4 Toll Plaza for traffic not stopping at Magor Services (min:sec)

Direction	Time	Route	2022 Central Growth		2037 Central Growth		2051 Central Growth	
			Do Minimum	Do Somethin g	Do Minimum	Do Somethin g	Do Minimum	Do Somethin g
Eastbound	AM	Via existing M4	19:30	18:59	24:23	19:55	28:00	20:50
	IP	Via existing M4	17:30	17:54	19:34	18:26	22:10	18:49
	PM	Via existing M4	18:04	18:09	20:51	18:55	23:02	19:27
	AM	Via new motorway		15:03		16:03		16:35
	IP	Via new motorway		14:50		15:29		15:49
	PM	Via new motorway		14:53		15:34		15:51
Westbound	AM	Via existing M4	19:56	18:23	23:19	20:16	26:08	21:37
	IP	Via existing M4	17:12	17:08	18:08	17:44	18:53	18:11
	PM	Via existing M4	19:33	18:28	24:04	19:57	27:22	21:08
	AM	Via new motorway		15:35		16:38		17:29
	IP	Via new motorway		14:40		15:11		15:30
	PM	Via new motorway		15:32		16:38		17:27

***Note:** fastest journey time in each time period and scenario highlighted in green*

11.2.3 Journey times in 2022 along the existing M4 north of Newport decrease at peak times in both directions with the exception of eastbound in the PM peak which experiences an insignificant increase of 5 seconds. A slight increase in journey time also occurs during the Inter-Peak in the eastbound direction of 24 seconds which is followed by reductions in subsequent years as traffic growth occurs. By 2037, the journey time analysis shows that travel times along the existing M4 would decrease in both directions at all times of the day with the largest decreases eastbound in the AM and westbound in the PM by up to 4.5 minutes.

11.2.4 Through traffic using the proposed new section of motorway to travel east-west between Magor and Castleton would experience more significant journey time savings due to the shorter distance and reduced congestion levels. During the inter-peak, the time savings in comparison to the Do-Minimum would be expected to be around 2.5 to 3.5 mins minutes in 2022, increasing to between 3 and 4 minutes by 2037 and between 3 and 6 minutes in 2051. The latest saving in journey times being in the eastbound direction. During the peak hours, the journey time savings could be expected to between 3 - 4 minutes to 5 minutes in 2022, increasing to between 5.5 and 8 minutes in 2037 rising to between 7 and 11.5 minutes in 2051. Both eastbound and westbound directions in 2037 and 2051 experience a similar level of journey time saving.

11.3 Journey Times between Junction 30 and M4 Toll Plaza stopping at Magor Services

11.3.1 The existing Services at Magor is currently accessed indirectly from the M4 motorway at J23A where motorway users leave the mainline motorway via the junction slip roads and access via the grade separated J23A gyratory. Non-motorway traffic from the local surrounding area is also able to access the rest area via the A4810, which links into the J23A gyratory. The draft Supplementary Orders Scheme includes a new eastbound off-slip leaving the M4 west of Magor and joining the re-aligned Newport Road Roundabout. The addition of the eastbound will allow for improved accessibility to Magor Services and Junction 23a for users travelling eastbound on the new section of motorway. The proposed Newport Roundabout (junction of the A4810 Steelworks Access Road with B4245 Magor Road) layout has been amended to incorporate the eastbound slip road. It should be noted that the draft Supplementary Orders Scheme does not change the possible access routes for westbound traffic compared to the previous draft Orders Scheme.

11.3.2 Westbound traffic approaching from the M4 Second Severn Crossing would be able to access the Services at Magor via a free flow interchange link from the M4 to the reclassified M4 at J23 and then travel onwards to J23A. Eastbound traffic movements from the rest area joining the reclassified M4 at J23A would be provided with a 'throughabout' arrangement through the J23 gyratory instead of a free flow connection. Westbound traffic approaching from the M48 would be able to access the rest area via the J23 gyratory and the reclassified M4 to reach J23A. Eastbound traffic movements exiting the rest area at Magor would also pass through the J23 gyratory to get to the M48. None of the above journeys would require any notable distance in the opposite direction to the end destination. The difference in journey length between the existing situation and that with the Scheme would range from zero up to a maximum of 300m due to the need to pass through J23.

11.3.3. With the draft Supplementary Orders Scheme in place, eastbound traffic approaching from the West would have three route options available to access the Services as follows;

a) Via the existing M4;
b) Via the proposed new motorway and Junction 23 and
c) Via the proposed new motorway and eastbound off-slip at Magor.

11.3.4 Westbound traffic approaching from the east which wishes to access the Services is unaffected by the eastbound off-slip, the route options being unchanged from those in the previous draft Orders Scheme as follows;

a) Via existing M4;

b) Via proposed new motorway and Junction 23 and

c) Via proposed new motorway, Glan Llyn Junction and A4180.

Table 11.2: Journey Time between Junction 30 and M4 Toll Plaza for traffic stopping at Magor Services (min:sec)

Direction	Time	Route	2022 Central Growth		2037 Central Growth		2051 Central Growth	
			Do Minimum	Do Something	Do Minimum	Do Something	Do Minimum	Do Something
Eastbound	AM	Via existing M4	20:10	19:36	24:52	20:29	28:27	21:19
	IP		18:16	18:34	20:15	19:06	22:45	19:22
	PM		18:52	18:52	21:36	19:39	23:46	20:08
	AM	Via proposed new motorway and Junction 23		21:20		22:33		23:14
	IP			20:48		21:39		22:01
	PM			20:52		21:52		22:16
	AM	Via proposed new motorway, Glan Llyn Junction and A4810		N/A		N/A		N/A
	IP			N/A		N/A		N/A
	PM			N/A		N/A		N/A
	AM	Via proposed new motorway and Eastbound off-slip at Magor		18:20		19:30		20:10
	IP			17:50		18:41		19:07
	PM			17:44		18:38		19:01
Westbound	AM	Via existing M4	21:16	19:46	24:32	21:40	27:22	23:03
	IP		18:36	18:30	19:31	19:05	20:13	19:33
	PM		20:42	19:49	25:16	21:18	28:30	22:29
	AM	Via proposed new motorway and Junction 23		21:44		23:03		24:04
	IP			20:28		21:12		21:36
	PM			21:33		22:56		23:52
	AM	Via proposed new motorway, Glan Llyn Junction and A4810		20:35		21:45		22:43
	IP			19:37		20:07		20:26
	PM			20:37		21:45		22:42

Note: *fastest journey time in each time period and scenario highlighted in green*

11.3.5 In the Do Something scenario as stated above, the fastest route for traffic travelling between Junction 30 and M4 Toll Plaza in both eastbound and westbound directions that is not making a stop at Magor Services would be via the proposed new motorway as highlighted in green in Table 11.2.

11.3.6 When the same eastbound traffic wishes to stop at Magor Services, the fastest route would be via the proposed new motorway and east bound off slip at Magor providing journey time savings in the Inter-Peak of 1.5 mins in 2022 and 2037 and 3.5 mins in 2051 compared to the Do-Minimum. In the Peak Periods eastbound journey time savings are 2 mins in 2022, 5.5 mins in 2037 and 8.5 mins in 2051. In the PM the respective time savings compared to the Do-Minimum are 1 min, 3 mins and 4.5 minutes.

11.3.7 In the westbound direction, with the proposed scheme in place, the fastest route would be via the existing but reclassified M4 which would provide journey time savings of 1 mins, 4 mins and 6 mins in 2022, 2037 and 2051 compared to the Do-Minimum.

11.3.8 The alternative route via the proposed new motorway and Junction 23 would incur journey times of a similar order to those in the Do-Minimum but would incur slightly longer journey times than the reclassified M4 route in both Peak Hours in the order of 2 mins in 2022, 1.5 mins in 2037 and 1 min in 2051. The alternative route via the proposed new motorway, Glan Lynn Junction and A4810 would provide similar journey times to the reclassified existing M4, albeit slightly higher.

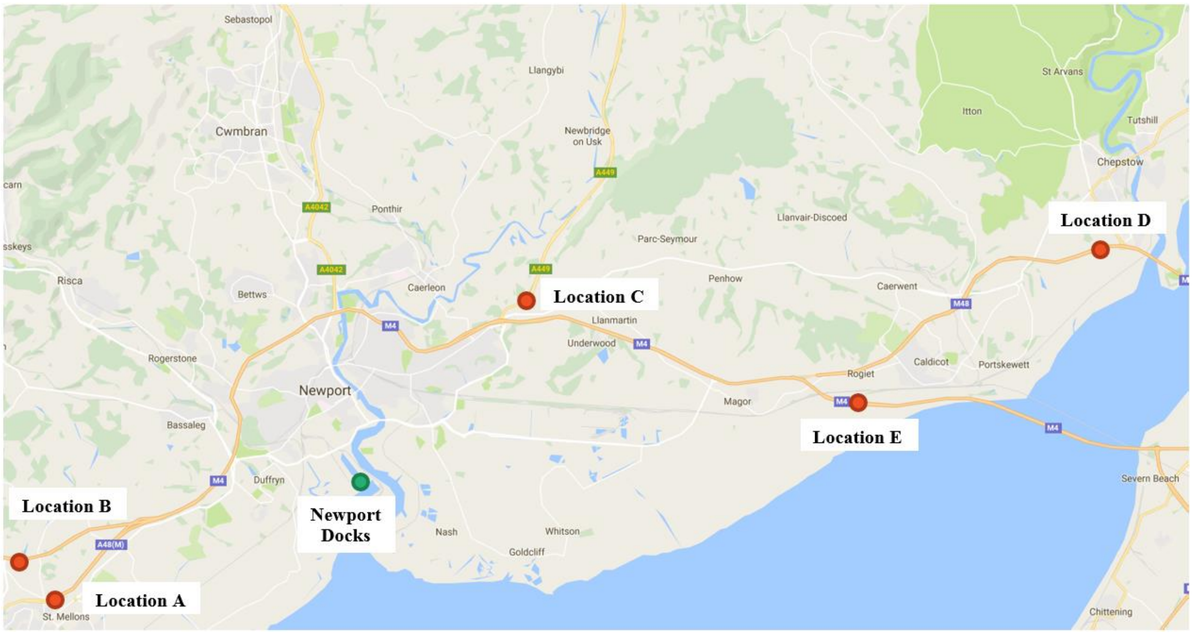
11.4 Journey Times to Newport Docks

11.4.1 The Scheme would affect journey times to and from Newport Docks. Journey times in the Do-Minimum (without the Scheme) and Do-Something (with the Scheme) have been compared for trips accessing Newport Docks that pass a set of locations on the strategic round network around Newport in 2022 and 2037 as follows;

a) Location A: A48(M) J29a – J29
b) Location B: M4 J30 – J29
c) Location C: A449 north of Coldra
d) Location D: M48 J23 – J2
e) Location E: M4 J23 – J22 (Second Severn Crossing Toll Plaza).

11.4.2 These locations are shown below in Figure 11.1 below.

Figure 11.1 Journey Time Passing Locations to Newport Docks



11.4.3 The journey times between the selected locations are shown in Tables 11.1 -11.5 below.

Table 11.1 Journey Time Passing Locations to Newport Docks

Direction	Route	Distance (km)	Time Period	Journey Time (Minutes: Seconds)			
				2022		2037	
				Without M4CaN	With M4CaN	Without M4CaN	With M4CaN
Eastbound (to Docks)	Via Existing M4 J28 and A48 Southern Distributor Road	10.0	AM Peak Hour	11:02	10:52	11:58	11:25
			Inter-Peak Hour	09:41	10:03	10:00	10:22
			PM Peak Hour	10:42	10:37	12:06	11:12
	Via New M4 and Docks Way Junction	11.9	AM Peak Hour	N/A	09:39	N/A	09:54
			Inter-Peak Hour	N/A	09:20	N/A	09:39
			PM Peak Hour	N/A	09:33	N/A	09:47
Westbound (from Docks)	Via Existing M4 J28 and A48 Southern Distributor Road	9.7	AM Peak Hour	09:32	09:27	10:19	09:35
			Inter-Peak Hour	08:54	09:11	09:10	09:26
			PM Peak Hour	10:11	09:44	11:59	09:55
	Via New M4 and Docks Way Junction	11.9	AM Peak Hour	N/A	09:46	N/A	09:55
			Inter-Peak Hour	N/A	09:30	N/A	09:47
			PM Peak Hour	N/A	10:14	N/A	10:27

Table 11.2 Journey Times to / from B: M4 West (M4 Junction 30)

Direction	Route	Distance (km)	Time Period	Journey Time (minutes: seconds)			
				2022		2037	
				Without M4CaN	With M4CaN	Without M4CaN	With M4CaN
Eastbound (to Docks)	Via Existing M4 J28 and A48 Southern Distributor Road	9.9	AM Peak Hour	10:47	10:35	11:58	11:23
			Inter-Peak Hour	09:33	09:53	09:52	10:11
			PM Peak Hour	10:29	10:24	12:02	11:07
	Via New M4 and Docks Way Junction	11.8	AM Peak Hour	N/A	09:17	N/A	09:46
			Inter-Peak Hour	N/A	09:08	N/A	09:25
			PM Peak Hour	N/A	09:14	N/A	09:36
Westbound (from Docks)	Via Existing M4 J28 and A48 Southern Distributor Road	9.9	AM Peak Hour	09:54	09:43	11:07	10:30
			Inter-Peak Hour	09:03	09:15	09:22	09:31
			PM Peak Hour	10:14	09:38	12:27	10:21
	Via New M4 and Docks Way Junction	12.1	AM Peak Hour	N/A	09:57	N/A	10:41
			Inter-Peak Hour	N/A	09:30	N/A	09:48
			PM Peak Hour	N/A	10:03	N/A	10:46

Table 11.3 Journey Times to / from C: A449 north of Coldra

Direction	Route	Distance (km)	Time Period	Journey Time (minutes: seconds)			
				2022		2037	
				Without M4CaN	With M4CaN	Without M4CaN	With M4CaN
Northbound (from Docks)	Via J24 and A48 Southern Distributor Road	9.2	AM Peak Hour	13:06	12:13	16:41	13:34
			Inter-Peak Hour	12:43	12:01	14:01	12:43
			PM Peak Hour	13:29	12:31	17:43	14:02
Southbound (to Docks)	Via J24 and A48 Southern Distributor Road	9.3	AM Peak Hour	14:34	14:05	22:28	18:40
			Inter-Peak Hour	12:00	12:07	13:01	12:59
			PM Peak Hour	12:06	12:16	15:38	14:50

Table 11.4 Journey Times to / from D: M48 J2

Direction	Route	Distance (km)	Time Period	Journey Time (minutes: seconds)			
				2022		2037	
				Without M4CaN	With M4CaN	Without M4CaN	With M4CaN
Eastbound (from Docks)	Via Existing M4 J24 and A48 Southern Distributor Road	27.8	AM Peak Hour	24:52	24:10	28:58	26:09
			Inter-Peak Hour	24:06	23:33	25:42	24:31
			PM Peak Hour	24:55	24:08	29:21	25:51
	Via New M4 and Docks Way Junction	26.8	AM Peak Hour	N/A	18:45	N/A	19:46
			Inter-Peak Hour	N/A	18:38	N/A	19:15
			PM Peak Hour	N/A	18:52	N/A	19:29
Westbound (to Docks)	Via Existing M4 J24 and A48 SDR	27.5	AM Peak Hour	23:14	24:07	25:55	25:16
			Inter-Peak Hour	22:11	23:27	23:04	24:21

Direction	Route	Distance (km)	Time Period	Journey Time (minutes: seconds)			
				2022		2037	
				Without M4CaN	With M4CaN	Without M4CaN	With M4CaN
			PM Peak Hour	23:00	23:51	25:36	25:11
	Via New M4 and Docks Way Junction	27.1	AM Peak Hour	N/A	19:48	N/A	20:25
			Inter-Peak Hour	N/A	19:11	N/A	19:42
			PM Peak Hour	N/A	19:31	N/A	20:27

Table 11.5 Journey Times to / from E: M4 East (Toll Plaza of Second Severn Crossing)

Direction	Route	Distance (km)	Time Period	Journey Time (minutes: seconds)			
				2022		2037	
				Without M4CaN	With M4CaN	Without M4CaN	With M4CaN
Eastbound (from Docks)	Via Existing M4 J24 and A48 Southern Distributor Road	19.4	AM Peak Hour	20:31	21:00	24:44	22:37
			Inter-Peak Hour	19:41	20:14	21:25	21:08
			PM Peak Hour	20:23	20:39	24:53	22:26
	Via New M4 and Docks Way Junction	18.4	AM Peak Hour	N/A	13:54	N/A	14:35
			Inter-Peak Hour	N/A	13:53	N/A	14:24
			PM Peak Hour	N/A	13:57	N/A	14:29
Westbound (to Docks)	Via Existing M4 J24 and A48 SDR	19.1	AM Peak Hour	18:34	18:12	21:18	19:19
			Inter-Peak Hour	17:28	17:48	18:24	18:34
			PM Peak Hour	18:07	18:26	20:46	19:27
	Via New M4 and Docks Way Junction	18.6	AM Peak Hour	N/A	14:10	N/A	14:42
			Inter-Peak Hour	N/A	13:45	N/A	14:08

Direction	Route	Distance (km)	Time Period	Journey Time (minutes: seconds)			
				2022		2037	
				Without M4CaN	With M4CaN	Without M4CaN	With M4CaN
			PM Peak Hour	N/A	14:11	N/A	14:48

12 Alternative Public Transport Modelling Approach

12.1 Overview

12.1.1 In order to test the potential impact of upgrades to public transport on demand for travel on the M4 and hence how these changes might affect the case for the M4 Corridor around Newport, a definition of the future public transport network is required. To test the maximum impact of public transport the scenario that has been modelled in the alternative approach which has been referred to in Section 9.5 7 comprises of the following:

Great Western Route Modernisation + Metro Phase 1 + Metro Phase 2 + Metro Phase 3

12.1.2 This scenario defines a potential future transport network which provides a further uplift in the level of public transport investment and services. This potential public transport network incorporates the Great Western Route Modernisation and Metro Phase 1 including new stations, but with Metro Phase 2 Valley Lines Modernisation superseding the Valley Lines Electrification offering a higher level of service provision in terms of journey frequency and times together with Metro Phase 3 comprising of improvements to the Welsh Marches Line in terms of additional services and improvements in journey times. Metro Phase 3 also incorporates proposed improvements in line speeds and the provision of new stations on the Great Western Main Line Relief Services to enable greater use to be made of these routes.

12.1.3 As stated earlier in 9.5.2 the M4CaN model includes the Valley Lines electrification scheme. However, in the alternative public transport modelling approach, the Valley Lines electrification has been revised to represent a potential Metro Phase 2 implementation of and improved level of service through combination of a light rail network to the north of Cardiff Central (the 'Core Valley Lines') with heavy rail services retained on the City Line, Vale of Glamorgan, Maesteg, Ebbw Vale and Penarth Lines as it offers a higher level of service provision. The service pattern represented in the model is illustrated in Figure 12.1. The service pattern of other regional heavy rail routes in the Cardiff Capital Region is represented in Figure 12.2 below. Each line in the figures represents an hourly service with blue lines representing light rail services and green lines representing heavy rail services.

12.1.4 These service patterns are as considered by Welsh Government in feasibility stage work but it is likely that the final solution delivered by the successful rail franchise bidder will differ.

Figure 12.1 - South Wales Metro Phase 2 – Assumed Core Valley Lines Service Pattern

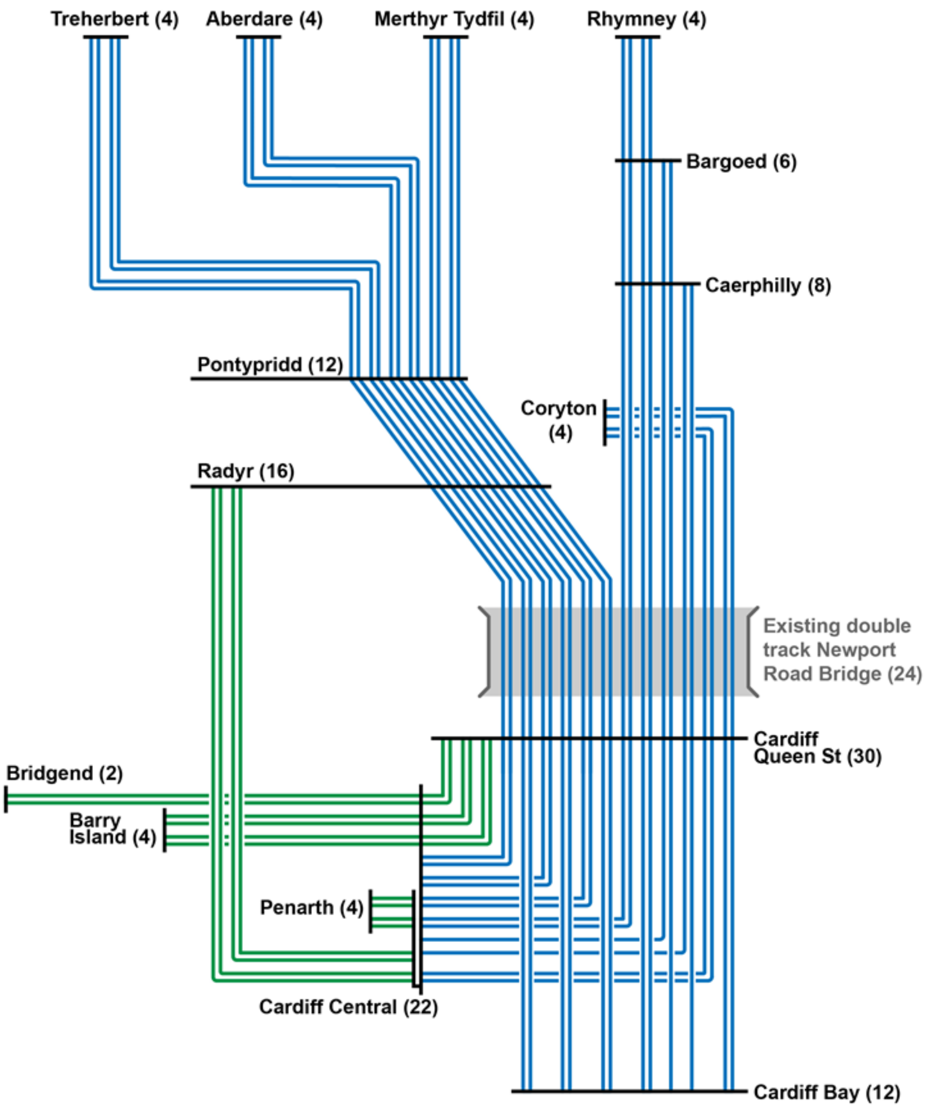
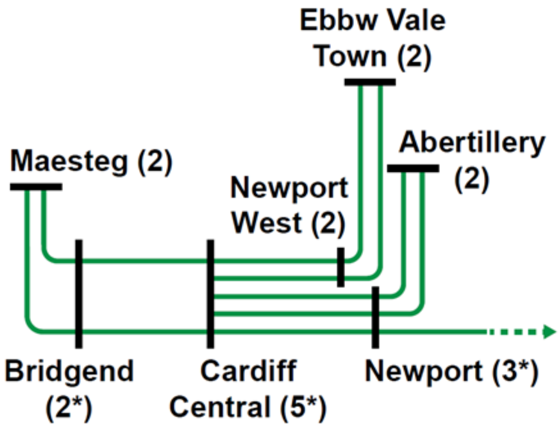


Figure 12.2 - South Wales Metro Phase 2 – Assumed Core Valley Lines Service Pattern



12.1.5 A number of Metro schemes, particularly in Phase 3, are remote from the M4 corridor and offer transport connections for which the M4 is not a valid alternative, these are therefore not included in the model. A set of agreed schemes has been defined for inclusion in the scenario through consultation with Transport for Wales and Welsh Government as described in the following sections. As a result of the modelling methodology used only the effects of rail and strategic Park and Ride schemes have been considered.

12.1.6 The Metro Phase 3 schemes which have been taken into the alternative modelling approach are the improvements to the Welsh Marches line in terms of additional services and journey times, but excluding any new stations and the Great Western Main Line Relief Lines Services. A number of existing train services, such as those to Ebbw Vale, already make use of the relief lines running parallel to the Great Western Mainline. However, proposed improvements to line speed and the provision of new stations will enable greater use to be made of these routes in the future.

12.2 Alternative Modelling Approach

12.2.1 Section 8 of the ‘Updated Public Transport Overview’ (WG 2.4.19) provides the approach used to test the likely effect on traffic volumes on the M4 as a result of implementing the set of measures set out in Section 12.1.2 above.

12.2.2 The approach used is based on the principles set out in the Passenger Demand Forecasting Handbook (PDFH) which is produced by the rail industry's Passenger Demand Forecasting Council. The relevant rail journey time elasticities (which represent how changes in service provision affect travel demand) quoted in PDFH are based on changes in Generalised Journey Time (GJT). GJT is a measure which combines rail journey time, intervals between trains and the need to interchange into a single value for the overall public transport journey.

12.2.3 The relevant formula taken from PDFH is:

$$\boldsymbol{I_j} = \left(\frac{\boldsymbol{GJT_{new}}}{\boldsymbol{GJT_{base}}}\right)^{\boldsymbol{g}}$$

Where:

I_j is the index for the change in volume due to journey time related factors;

g is the generalised journey time elasticity; and

GJT_{base} and GJT_{new} are the base and new generalised journey times.

12.2.4 Using this method a spreadsheet model was created to compare the GJT of the public transport provision assumed in the M4CaN base year to a scenario, in which South Wales Metro was delivered. The public transport demand matrix used in the M4CaN work does not capture all trips within South East Wales. In light of this 2014 station-to-station demand extracted from MOIRA for the South East Wales Transport Model has been used. MOIRA is a software package used by the rail industry to predict how changes in the timetable will affect passenger demand. This demand has been growthed to the 2037 forecast year used for the M4CaN using TEMPRO 7.1 Interim for Wales rail growth factors. The data represents all station-to-station demand within South East Wales, including any journeys which pass through or have only one trip end in the study area.

12.2.5 Using the calculated increase in rail patronage two methods have been used to indicate how changes in rail demand might affect traffic volumes on the M4 motorway around Newport. These differing methods have been used to create a range of potential impact which is considered to represent upper and low bounds of the likely impact.

12.2.6 **Method 1 –Upper Bound.** This method assumes that any increase in rail demand results from a switch from highway demand. By applying standard vehicle occupancy rates from WebTAG the demand is converted from person trips on rail to vehicle trips.

12.2.7 **Method 2 – Lower Bound**. The second option is based on WebTAG unit A5.4 (Marginal External Costs), which is typically used to calculate the diversion of demand from other travel modes in rail appraisals. The WebTAG guidance indicates that a 100km increase in rail travel could be expected to result in a 26km decrease in car drivers. Using this information, it has been assumed that 26% of additional rail trips are abstracted from current vehicle trips.

12.2.8 Using these methods, matrices of the reduction in highway demand were created and subsequently used to quantify the number of vehicles likely to be taken off the M4 motorway around Newport. This enables a percentage reduction in traffic on the M4 motorway to be calculated for the 2037 Do Minimum scenario representing the impact of South Wales Metro rail schemes. Tables 12.1 and 12.2 below set out the calculated increase in rail demand and corresponding percentage of M4 trips that would be extracted by South Wales Metro rail based measures between Junction 29 and Junction 28 of the M4.

Table 12.1 Upper bound effect of South Wales Metro Rail schemes on M4 J28-29 traffic flow

Time Period	Rail Demand Increase[7]	Two-way M4 Traffic Flows[9]	Vehicles per hour[6]	% M4 Trips Abstracted
AM Peak Hour	319	11,670	218	1.9%
Inter Peak Hour	139	8,663	87	1.0%
PM Peak Hour	297	11,793	194	1.6%

Table 12.2 Lower bound effect of South Wales Metro Rail schemes on M4 J28-29 traffic flow

Time Period	Rail Demand Increase[7]	Two-way M4 Traffic Flows[8]	Vehicles per hour[9]	% M4 Trips Abstracted
AM Peak Hour	319	11,670	83	0.7%
Inter Peak Hour	139	8,663	36	0.4%
PM Peak Hour	297	11,793	77	0.7%

12.2.9 The effect of the Llanwern Park and Ride has been considered separately as the effects of new stations cannot be accounted for using the PDFH approach outlined in 12.2.2. The Llanwern station and associated Park and Ride facility would be located such that it would be expected to attract trips currently using the M4.

12.2.10 In order to produce a simplified understanding of the maximum impact that a Llanwern Park and Ride could have on M4 traffic volumes a robust scenario has been used that considers the effect of the Park and Ride site reaching the 1,000 space capacity limit during the day i.e. use of the Park and Ride will have maximum abstraction from the M4 Junctions 23a to 28. In addition to passengers arriving by car it is also considered that the station would attract additional users arriving by bus and active travel modes particularly from the new developments surrounding the station.

12.2.11 The daily demand profile of Park and Ride has been taken from recent survey data collected for Welsh Government studies of rail Park and Ride sites and is formed from an amalgamation of observed demand at Newport, Abercynon and Bridgend stations. This approach has been used in recognition that each of these stations has similarities and differences from the proposal for Llanwern; the approach therefore creates a more general profile than would result from using a single site. Each arrival and departure from a Park and Ride site can be considered to represent a trip that has been removed from the highway network. As a result of vehicle occupancy the number of resulting rail trips would be expected to be proportionately greater

12.2.12 Figure 12.3 below illustrates the key destinations for Park and Ride journeys and also the most likely origins and access routes of Park and Ride users. For trips to the west (Newport/Cardiff/Swansea) a Park and Ride at Llanwern is most likely to be attractive to residents of Monmouthshire, eastern Newport and the Llanwern development itself. For trips to the east (Monmouthshire/Bristol and destinations towards London) a Park and Ride at Llanwern is most likely to be attractive to residents of eastern Cardiff, eastern Newport and the Llanwern development itself.

Figure 12.3 Key origins, destinations and routes of Llanwern Park and Ride users

12.2.13 As a result of the differing origins of Park and Ride users not all trips would have otherwise used the M4 around Newport – for instance trips from east Cardiff would be more likely to access the site via the A48 and the Steelworks Access Road and so not all Park and Ride users can be assumed to be abstracted from the M4. Conversely some Park and Ride users may use the M4 to access the station when their direct car trip to final destination would not have used the M4; for instance, journeys to/from Monmouthshire to Bristol using the Llanwern Park and Ride may now use a section of the M4 that they did not previously.

12.2.14 In light of such route considerations, and to develop upper and lower bounds, calculations have been made assuming that 80% and 60% of Park and Ride users would have otherwise used the M4 corridor around Newport.

12.2.15 Tables 12.3 and 12.4 set out the effect of calculated increase in rail demand and corresponding percentage of M4 trips that could be extracted by a 1,000 space Llanwern Park and Ride site between Junction 28 to Junction 29 of the M4.

Table 12.3 Upper bound effect of Llanwern Park and ride on M4 J28-29 traffic flow

Time Period	Park and Ride Arrivals/Departures	Two-way M4 Traffic Flows[9]	80% upper bound abstraction	% of M4 trips abstracted
AM Peak Hour	203	11,670	163	1.4%
Inter Peak Hour	130	8,663	104	1.2%
PM Peak Hour	339	11,793	271	2.3%

Table 12.4 Lower bound effect of Llanwern Park and ride on M4 J28-29 traffic flow

Time Period	Park and Ride Arrivals/Departures	Two-way M4 Traffic Flows[9]	60% lower bound abstraction	% of M4 trips abstracted
AM Peak Hour	203	11,670	122	1.0%
Inter Peak Hour	130	8,663	78	0.9%
PM Peak Hour	339	11,793	203	1.7%

12.2.16 Table 12.5 summaries the compound effect (summation of lower and upper bounds from Tables 12.1 to 12.4) of the Metro schemes that have been tested on forecast 2037 M4 traffic flow between Junction 28 and Junction 29 of the M4.

Table 12.5 Compound effects of public transport scenario on M4 traffic flows Junction 28-29

Time Period	Two-way M4 J28-29 traffic flow	M4 trips abstracted			
		Upper Bound		Lower Bound	
		Vehicles	Percentage	Vehicles	Percentage
AM Peak Hour	11,670	381	3.3%	205	1.7%
Inter Peak Hour	8,663	191	2.2%	114	1.3%
PM Peak Hour	11,793	465	3.9%	280	2.4%

12.2.17 In broad terms, around half of the percentage abstraction has been accounted for in the M4CaN traffic model. The balance is due to the combined impact of the higher level of service provision in Metro Phase 2, Metro Phase 3 and the Park and Ride facility at the new station at Llanwern. The overall mode transfer represents a significant increase in public transport patronage and it is recognised that the South Wales Metro will impact a wide range of movements in the region, many of which will be north-south rather than east-west orientated. Whilst achieving increased patronage and other benefits, the results indicate that the South Wales Metro would provide relatively minor reduction in motorway traffic volumes and therefore do not change the case for the Scheme.

12.2.18 A high level overview, based on first principles, has also been undertaken of the potential impact of a Newport Bus Rapid Transit. As part of a wider route network, it has been assumed that the Bus Rapid Transit service would have an east-west route between the Celtic Manor (in the vicinity of Junction 24) and Celtic Springs (in the vicinity of Junction 28) and that the service would incorporate measures to improve journey times such as dedicated bus lanes, off-board fare collection, high quality waiting facilities and high frequency services. In combination, these measures would be anticipated to create a service more attractive than existing urban bus services in Newport. The capacity given by one route operated by single decker buses with 6 services in each direction i.e. 12 services per hour is as follows. If it is assumed that there are 60 people in each bus (80% of full occupancy), then multiplying by 12 gives 720 individuals per hour. Many of these passengers would have previously used other bus services and it is therefore reasonable, to assume that only half might be wholly new bus passengers, therefore 360 new bus passengers per hour (east – west route)

12.2.19 If it is further assumed that these new passengers have all been abstracted from cars, then applying a car occupancy factor of 1.46 for the AM and 1.53 for the PM, the numbers of trips abstracted is 360/1.46 = 247 trips in the AM peak hour and 360/1.53 = 235 in the PM peak hour. These numbers are considered upper bound figures and assume that all new passengers would have otherwise made their trip using the M4.

12.2.20 The base figure of 360 new bus passengers per hour also forms the basis of the lower bound figures. The lower bound method is based on WebTAG (Marginal External Costs) which is typically used to calculate the diversion of demand from other travel modes in rail appraisal. WebTAG indicates that a 100km increase in rail travel could be expected to result in a 26km decrease in car drivers. Using this information, it has been assumed that 26% of additional trips are abstracted from current vehicle trips.

12.2.21 Therefore at the lower bound estimate that an extra 100km of extra rail will reduce car journeys by 26%, the amount abstracted would be 26% of 360 = 94. The 26% abstraction is based on rail journeys and there is no equivalent figure for bus, for bus it would be expected to be lower. Updating Table 12.5 above with the Newport Bus Rapid Transit abstraction, the PM lower bound figure becomes 77(Metro) + 303 (P&R) + 94 (Bus) = 374. The PM upper bound figure becomes 194 (Metro) + 271 (P&R) + 235 (Bus) = 700. In percentage terms without Newport Bus Rapid Transit, the abstraction from the M4 is a Lower Bound of 2.4% and an Upper Bound of 3.9% whilst with Newport Bus Rapid Transit, the abstraction becomes a Lower Bound of 3.2% and an Upper Bound of 5.9%.

12.2.22 In conclusion, the Newport Bus Rapid Transit adds less than P&R under both lower and upper bound assumptions in the PM and in the AM Peak lower bound but adds more than P&R under the AM peak upper bound. Bus Rapid Transit has more impact than the combination of other Metro measures in both upper and lower bounds in the AM and PM Peak hours. Whilst it can make a significant contribution, it does not in isolation constitute a step change in the capacity of public transport to solve congestion on the M4. It should also be noted that the Newport Bus Rapid Transit analysis contains a number of assumptions which are conservative i.e. generous as to the ability of Newport Bus Rapid Transit to remove trips from the M4.

13 M4CaN VISSIM Model Forecasts

13.1 Overview

13.1.1 In order to assess the impacts of the proposed M4 south of Newport, the future year scenario with the Scheme included has been compared to that without the Scheme, in the same way as set out above in the case of the M4CaN model. Two forecast years have been assessed:

a) 2022 – the proposed opening year for the proposed M4 motorway; and
b) 2037 – the design year, 15 years later.

13.2 Forecast Demand Matrices

13.2.1 The forecast traffic flows for the Do Minimum and Do Something scenarios were taken from the M4CaN model for the corresponding year, as set out in Section 9 above. The M4CaN Do-Minimum and Do-Something matrices was cordoned, and the cordoned matrices were expanded to 24 hour period matrices in the same way as the base year matrices development to be used in VISSIM.

13.3 Future Year Model Results

13.3.1 Models have been produced to consider the future operation of the M4 in 2022 and 2037, both with and without the proposed new motorway to the south of Newport. The traffic growth in the Do Minimum situations would result in heavy congestion on the existing M4.

13.3.2 The future year model results are summarised in Annex J. Table J1 shows the modelled hourly average speeds for the westbound locations for the different scenarios considered, and Table J2 shows the same for the eastbound locations. These tables also include the 2015 base model results for comparison. Table J3 shows the modelled average flows for the westbound locations for the different scenarios considered, and Table J4 shows the same for the east locations.

13.3.3 The additional capacity provided by the proposed new motorway to the south of Newport in the Do Something scenarios would provide relief to the existing and future congestion on the existing M4. This is illustrated by the generally higher speeds predicted during the peak hours when compared to the Base and Do Minimum models. The additional traffic demand in 2037 Do Something results in slightly lower speeds than the 2022 Do Something scenario, though these are still generally higher than the base year speeds.

14 Low and High Growth Forecasts

14.1 Overview

14.1.1 Low and High Growth scenarios for low and high growth assumptions were tested in addition to the Central Growth Core Scenario.

14.1.2 The low and high growth scenarios were developed from the central growth assignment matrices following the variable demand modelling process. This process follows the guidance contained in TAG Unit M4, in which a proportion of the base year matrix is subtracted from or added to the central growth matrix. This proportion changes in proportion to the square root of the number of years from the base. Table 14.1 shows the calculated proportion of the base matric added to or subtracted from the central growth matrices.

Table 14.1 Adjustment of Central Growth Matrices for Low and High Growth

	Low Growth	High Growth
2022	-7.07%	+7.07%
2037	-11.99%	+11.99%
2051	-15.00%	+15.00%

14.2 Effect of Low and High Growth Forecasts on Journey times

14.2.1 The motorway journey times in 2022 along the existing M4 north of Newport could increase slightly in the low growth scenario due to the realignment around Junction 23. This is especially the case in the eastbound direction due to the need to negotiate a roundabout for traffic to access the M4 approach to the Second Severn Crossing. By 2037 and 2051, the effects of the increased travel distance would be expected to be countered by further traffic growth and travel times along the existing M4 would be expected to reduce compared to the Do Minimum scenario.

14.2.2 Under high growth assumptions, travel times along the existing M4 would be expected to reduce in both directions in all time periods, with peak hour time savings of around 1 minute eastbound and 2 to 3 minutes westbound in 2022. The peak hour time savings could be expected to increase to over 7 minutes by 2037 and over 10 minutes in 2051.

14.2.3 During the inter-peak, the time savings by 2037 for through traffic using the proposed new section of motorway between Magor and Castleton would be expected, on average, to be around 3 minutes at low growth, and up to 7 minutes at high growth, whilst in 2051 the time savings would be in the order of 5 minutes at low growth and 9 minutes at high growth. During the 2037 peak hours, the journey time savings could be expected to be, around 6 minutes at low growth, increasing to 12 minutes at high growth.

15 Accidents

15.1 Overview

15.1.1 COBALT (**CO**st and **B**enefit to **A**ccidents – **L**ight **T**ouch) is a computer program developed by the DfT to undertake the analysis of the impact on accidents as part of the economic appraisal for a road scheme.

15.1.2 The program is used to assess the safety aspects of road schemes using detailed inputs of combined link and junctions that would be impacted by the Scheme. The assessment is based on a comparison of accidents by severity and associated costs in the Do-Minimum (without Scheme) and in the Do-Something (with Scheme), using details of link and junction characteristics, relevant accident rate and costs and forecast traffic volumes by link and junction. My evidence relates to the numbers of accidents in the M4CaN in the detailed modelled area, whilst Mr Bussell will refer to the costs of those accidents in his evidence (W.G 1.3.1).

15.2 Accident Assessment

15.2.1 For the purpose of the COBALT assessment, default accident rates taken from the WebTAG Databook, DfT, November 2016 have been applied across the detailed model area. However, an average observed accident rate between 2011 (the year in which variable speed limits were implemented) and 2015 for each section of the M4 has been applied. The accident rates are shown in Table 3.4 above.

15.2.2 For the purpose of the COBALT assessment, the observed rates on the existing M4 have been applied in both the Do Minimum and Do Something scenarios. This is despite the fact that in the Do Something scenario the existing M4 is reclassified as a trunk road or ‘A’ road, with various changes to its layout:

a) Removal of J25A and incorporation of west-facing slip roads at J25

b) Reduction to two lanes eastbound J25 to J24

c) Lane drop between slip roads at J28

d) Redesign of merge / diverge layouts at all junctions to current standards.

15.2.3 Reclassification of the M4 will allow changes to be made to be made to enable traffic management, safety and revised access arrangements to be made. Reclassification includes works to reopen the west facing slip roads of Junction 25, improving access to Caerleon and St Julian's areas, improving accessibility to northern Newport. As such there may therefore be some reduction in the existing M4 observed accident rate as a result of safety improvements arising from the resulting from the reclassification. In the Do-Something situation, the WebTAG default accident rate is used, as stated in 3.7.6 above. However, the new section of motorway would be designed to current standards of safety, with free flow conditions. This will address the traffic congestion problem, which in turn reduces the risks of accidents.

15.2.4 The accidents forecast impacts as output by COBALT in terms of number of accidents across the detailed model area are shown in Table 15.1 below.

Table 15.1 Accidents Saved with the Scheme

	Do Minimum	**Do Something**	**Accidents saved**
60 years (2022-2081)	17,960	17,659	301
Opening Year 2022	307	301	6
Design Year 2037	292	285	7
Horizon Year 2051	304	300	4

16 Conclusions

16.1 The M4 Corridor around Newport experienced sustained growth in traffic between 1989 and 2007, followed by a period of a slight decline through the period of economic recession. However, following the recession period traffic levels again started to increase and has continued to do so to the present day. It may be expected that further growth may be expected to occur on the M4 as the Welsh Economy grows.

16.2 Congestion, with frequent incidents, is a very common occurrence on the existing M4 between Junctions 23 and 29. Some sections of the motorway, particularly between the Brynglas Tunnels and Junction 29 (Castleton) and westbound between Junction 24 and the Tunnels, are approaching peak hour capacity on a regular basis under current conditions. The restricted capacity of the Brynglas Tunnels forms a regular bottleneck on the motorway at peak times, while traffic queuing to leave the motorway at Junctions 26 and 28 frequently extends onto the mainline, exacerbating the problems presented by the poor alignment of the motorway between these junctions.

16.3 There are a number of periods throughout the day when speeds on the M4 drop below 50mph and stop-start conditions start to occur resulting in further reductions in speed leading to the rapid onset of congestion.

16.4 In addition to day to day congestion, the M4 corridor has a high number of incidents (unexpected events) and the lack of network resilience means that the time before the M4 can return to normal operating condition following the incident can be significant. In the case of an incident which necessitates an eastbound closure of the motorway between Junctions 28 and Junction 24, the M4CaN model predicts wide spread consequences to the travelling public and significant delays to their journeys. An immediate effect is that the closure leads to queuing as demand exceeds capacity on the eastbound off slip at Junction 28, queuing at Junction 24 resulting from the volumes of eastbound traffic wishing to re-join the M4, queuing eastbound at the traffic signals on the A48 Southern Distributor Road, and queuing eastbound on the A4810 approaching Junction 23A. Furthermore, the impacts of the closure are such that as queuing quickly forms across the network there are significant diversions to the A465 Heads of the Valley for longer distance traffic. Some of the longer distance traffic seeks to avoid all these delays by additionally re-routeing to the A472 Newbridge to Pontypool road or the coast road (Lighthouse Road) between Cardiff and Newport.

16.5 Notwithstanding the introduction of Variable Speed Limits which had the effect of reducing the number of accidents on the M4, the 2015 accident rates on some of the sections of motorway still remain above the national average for motorways, due to the sub-standard nature of the M4. Some sections of the motorway have alignments (both vertically and horizontally) that are below current motorway standards and in certain places lacks a hard shoulder. There are frequent junctions, resulting in many weaving movements with vehicles accelerating, decelerating and changing lanes over relatively short distances.

16.6 In the future without the Scheme, congestion will become more prevalent and traffic growth and the impact of incidents will have significance consequences. Journey times will become longer causing increasing frustration to the travelling public and have a negative impact on the Welsh economy.

16.7 The M4CaN Transport Model has been developed to assess the impact of the proposed Scheme on transport conditions in the future. Transport Modelling provides quantified evidence-based estimates of the direct impacts of actions that affect the road network – the likely changes in traffic flows and speeds across the road network that feed into the economic, social and environmental appraisal of the Scheme. The Department for Transport publishes standardised methods of transport modelling and standardised growth rates, so that proposed transport investments across the UK are assessed on a consistent basis. The development of the M4CaN that has been presented in my evidence has been carried out in accordance with that WebTAG guidance and meets WebTAG criteria.

16.8 Providing new capacity in the case of the Scheme can elicit a number of responses by travellers, which includes those of trip reassignment, re-distribution and modal shift. Such responses can result in additional trips and or additional mileage on the road network, which collectively is referred to as ‘induced traffic’ The M4CaN model directly takes into account the effect of ‘induced traffic’.

16.9 WebTAG requires that future year forecasts are based on NTEM growth in demand. Future year forecasts have been based on NTEM 7.1 Interim for Wales released in December 2016 which assumes a decline in trip rates between its base year of 2011 and 2016 and constant trip rates thereafter. This reflects the data in NTS which shows that the average number of trips has been falling in recent years and that there has been a general downward trend in trip rates. The two most common trip purposes that have declined (shopping and commuting) probably reflect increased ‘online shopping’ and ‘working from home’. The growth forecasts used in the M4CaN model are delivered from NTEM 7.1 Interim for Wales which are latest available estimates of growth in particular to Wales

16.10 The future year forecasts derived from the M4CaN model are reflective of a ‘half toll’ based on 2015 and 2016 budget announcements. The M4CaN model takes the changes in demand resulting from changes in toll that are in turn derived from the ‘DfT

Severn Toll Model' and therefore reflect the latest Government views on future tolling.

16.11 In my evidence, I have provided details of the traffic flow forecasts in both the 'Do-Minimum' (without the Scheme) and the 'Do-Something (with the Scheme). In the 'Do-Minimum', the two-way AADT through the Brynglas Tunnels in 2037 is in the 89,200 comprising of 52% two-way through traffic travelling between east of Junction 23 and west of Junction 29. With the Scheme in place, the two-way AADT traffic flows through Brynglas Tunnels will reduce to 59,200 representing a 32% reduction. Between Junctions 28 and 29 which carries the highest AADT two-way flow of 136,000 in 2037 sees a reduction of 42% with the Scheme. In 2037 the AADT forecast traffic flow on the proposed Scheme across the River Usk is 71,700 ,700 comprising of 65% two-way through traffic travelling the whole length of the Scheme, 14% two-way traffic joining or leaving at Docks Way Junction and using the proposed Scheme to east of Junction 23, 14% two-way traffic joining or leaving at Glan Llyn/Magor Junctions and using proposed new section of motorway and 7% two-way traffic travelling between Docks Junction and Glan Llyn/Magor Junctions on proposed new section of motorway.

16.12 Through traffic using the proposed new section of motorway to travel east-west between Magor and Castleton would experience journey time savings due to the shorter distance and reduced congestion levels. During the inter-peak, compared to the Do-Minimum, the time savings would be expected, on average, to be around 2.5 minutes and 3,5 minutes in 2022, increasing to between 3 and 4 minutes by 2037. The higher time savings being in the eastbound direction. During the peak hours, the journey time savings could be expected to be, on average, between around 4 to 5 minutes in 2022, increasing to between 5.5 and 8 minutes in 2037 rising to 7 and 11.5 minutes in 2051.

16.13 The journey time savings for through traffic, as predicted by the traffic model, will be reduced for those trips making an intermediate stop at Magor Services. In the Do-Something scenario, the fastest route for traffic travelling between Junction 30 and the M4 Toll Plaza in both eastbound and westbound directions that is not making a stop at Magor Services would be via the proposed new motorway. When the same eastbound traffic wishes to stop at Magor Services, the fastest route would be via the proposed new motorway and eastbound off-slip at Magor providing journey time savings in the Inter-Peak of 1.5 minutes in 2022 and 2037 and 3.5 minutes in 2051 compared to the Do-Minimum. In the AM Peak Hours eastbound, journey time savings are 2.0 minutes in 2022, 5.5 minutes in 2037 and 8.5 minutes in 2051. In the PM the respective time savings compared to the Do-MINIMUM are 1 minute, 3 minutes and 4,5 minutes.

16.14 In the westbound direction, with the proposed scheme in place, the fastest route would be via the existing but reclassified M4 which would provide time savings of 1 minute, 4 minutes and 6 minutes in 2022, 2037 and 2051 compared to the Do-Minimum

16.15 The alternative route via the proposed new motorway and Junction 23 would incur journey times of a similar order to those in the Do Minimum but would incur slightly longer journey times than the reclassified M4 route in both Peak Hours in the order of 2 minutes in 2022, 1.5 minutes in 2037 and 1 minute in 2051. The alternative route via the proposed new motorway, Glyn Lynn Junction and A4810 would provide similar journey times to the reclassified existing M4, albeit slightly higher.

16.16 Journey time savings to and from Newport Docks passing a number of locations on the strategic road Network around Newport are provided with the Scheme. In particular journeys to the M48 J2 benefit from a journey time saving of 6 minutes in 2022 and 9 -10 minutes when travelling from Newport Docks to the M48 J2 via the Scheme and Docks Way Junction compared to travelling via the existing A48 Southern Distributor Road and M4 without the Scheme. Journeys to the M4 East (Toll Plaza of Second Severn Crossing) from Newport Docks benefit from a journey time saving of 6.5 minutes in 2022 and 10 minutes in 2037 travelling via the Scheme and Docks Way Junction when compared to travelling via the A48 Southern Distributor Road and M4.

16.17 An assessment of the potential impact of upgrades to public transport on the demand for travel on the M4 and how the impacts might affect the case for the Scheme has been undertaken. A scenario representing a major upgrade in public transport formed of Great Western Electrification and components of a South Wales Metro which represent an ambitious target both in terms of deliverability by 2037 (the M4CaN model design year) and required funding which significantly exceeds the Schemes currently committed in policy, was modelled to determine mode transfer from the M4. The predicted mode transfer whilst of a significant increase in public transport patronage, the results nonetheless indicated that the South Wales Metro would provide relatively minor reduction in motorway traffic volumes and therefore do not change the case for the Scheme. It is recognised that the South Wales Metro will however impact a wide range of movements in the region, many of which will be north-south rather than east-west trips which the M4 provides for.

16.18 An assessment of the safety aspects of the Scheme was undertaken comparing the number of accidents by severity in the Do-Minimum and Do-Something cases using details of link and junction characteristics, relevant accident rates and forecasts traffic volumes by link and junction. The assessment forecast a reduction in the number of accidents with the Scheme in place of around 300 during the 60 year appraisal period. I am, however of the view that reclassification of the M4 when the Scheme is in place would allow changes to be made to the current layout to enable traffic management, safety and revised access arrangements thus reducing the M4 observed accident rates used in the assessment. The new M4 would be designed to current standards of safety with free flow conditions, and I am equally of the opinion that the accident rate will be lower than the accident rate assumed by the default motorway accident rate used in the assessment. I am therefore of the view that the assessment will underestimate the saving in the number of accidents with the Scheme in place.