Smart Motorways Programme

M4 J3 - J12

Traffic Model Verification

Technical Note

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Revision P01

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Working on behalf of Highways England

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1. Overview

In bringing forward proposals to change parts of the M4 Junctions 3-12 SMP from Through Junction Running to No Through Junction Running, consideration has been given to the fact that the traffic information which informed the original DCO application and examination was based on a 2009 base year with a Present Year validation exercise undertaken using 2013 observed traffic data.

The transport assessments undertaken for the DCO application have been produced for a scheme opening year of 2022 and the design year of 2037. For each of the forecast years, a representative Do-Minimum (without the M4 SMP scheme) and a Do-Something (with the M4 SMP scheme) model run was undertaken. This provided an estimate of forecast flows, in each of the modelled time periods, along the scheme links and the wider strategic highway network.

The assumptions underpinning the traffic forecasts took account of demographic, economic and planning data (including permitted developments know at the time) forecasts valid at the time of traffic forecast model development (i.e. in 2013).

As such, given the passage of time since the DCO application, in both developing the proposals for NTJR for internal approval within Highways England (including initial environmental appraisal), and following this, in preparation for the Non-Material Change application, Highways England updated the forecast model using the Department for Transport's (DfT) most up to date version of TEMPRO 7.2 (National Tripend Model) and also undertook a model verification process with reference to observed WebTris data.

In this part of this Technical Note, the DCO application model updated for TEMPRO 7.2 is referred to as 'the existing model'.

This was undertaken to consider whether that model was still able to be used for the purpose of determining the impact of the change to No Through Junction Running, from a traffic perspective.

A number of model verification approaches were suggested and discussed with Highways England Transport Planning Group (TPG) in relation to verifying the continued use of the DCO model, of which two options were agreed as suitable model verification methodologies. To provide an evidence base to support its continuing use, the traffic model's performance, in terms of its forecasting accuracy, has been verified at link level following both of these methodologies.

The purpose of this part of this Traffic Technical Note is therefore to describe the methodologies adopted for the verification exercises and to report the results of the model verification process. This will demonstrate that the use of the DCO model is still appropriate for use for the purposes of the NMC application.

2. Verification Approach and Results

2.1 Model Forecasts

As part of all assessments undertaken to date, traffic model forecasts have been produced for the scheme opening year 2022 and for the design year 2037. For each of the forecast years, a representative Do-

Minimum (without the M4 SMP scheme) and a Do-Something (with the M4 SMP scheme) model runs were undertaken. These provided an estimate of forecast flows, in each of the modelled time periods, along the scheme links and the wider strategic highway network.

The assumptions underpinning the traffic forecasts took account of demographic, economic and planning data (including permitted developments known at the time) forecasts valid at the time of traffic forecast model development (i.e. in 2013).

For the FBC (Full Business Case) submission in 2016/2017 the forecast model was updated using the Department for Transport's (DfT) most up to date version of TEMPRO 7.2 (National Tripend Model, which accounts for all the changes with respect to demographic, economic, car ownership planning etc.,) this is still the most up to date full version.

2.2 Observed traffic data

Highways England maintains a database of continuously recorded traffic flow data for selected sections along the Strategic Road Network (SRN). This is published on its WebTRIS site and is available for download at an hourly and daily level across the years.

Observed data from 2020 onwards has been excluded from the model verification process due to the unexpected impact that the COVID-19 pandemic has had on travel patterns and travel demand.

Furthermore, due to the presence of roadworks and construction traffic on the M4 caused by the M4 SMP scheme construction, which began in July 2018, any observed traffic data from July 2018 onwards along this section of the M4 is also not considered representative of the typical traffic conditions (namely those without roadworks) that were represented by the traffic model forecasts.

It was therefore agreed that only the observed traffic data for the continuous 12 months prior to July 2018 would be used in the model verification process. The data was downloaded for the mainline sections of the M4 between Junction 3 and Junction 12 by direction and by hour, for each operational site.

Data was cleaned, analysed and averaged to represent an average 2018 hourly flow for the mainline sections of the M4 for early AM peak (AM1, 07:00-08:00), AM peak (AM2, 08:00-09:00), average interpeak (IP, average 10:00-16:00) and PM peak (17:00-18:00) consistent with the time periods represented within the traffic model.

2.3 Method 1

The first method is based on a comparison between existing model results for 2022 and the uplifted 2017-2018 observed data. The existing model results from Do-Minimum 2022 were used against observed 2018 WebTRIS data which was uplifted to 2022 using growth factors.

2.3.1 Observed data assumptions

As mentioned above, observed data was extracted from the Highways England WebTRIS portal for a 12-month period between July 2017 and June 2018 inclusive. It was decided to use the full 12 months data for the comparison purposes, as this would give a more robust indication of the M4 mainline flows between Junctions 3 and 12.

During the data cleaning process Public / bank holidays and school term holidays were excluded and more importantly outlier traffic data that would skew the final averages were removed. The traffic outliers were identified and discarded using the Standard Deviation approach.

If multiple WebTRIS sites were present in a single section of the motorway then data from all these sites were used to obtain the average traffic flow, this would reduce the impact of using traffic information from a single site that may have had some issues during certain time periods or hours or days.

The final set of cleaned 2018 observed data was uplifted to an appropriate 2022 level using the latest growth factors obtained from the Road Traffic Forecast (RTF 2018). The growth factor is estimated to be 5.5% (all traffic) for the motorways located in the South East for the four year period between 2018 and 2022.

2.3.2 Verification of the results

The uplifted 2022 data was compared against the existing model results from Do-Minimum 2022. This was done using an industry standard metric known as the GEH statistic, a formula used in traffic engineering, traffic forecasting, and traffic modelling to compare two sets of traffic volumes.

The GEH statistic incorporates both relative and absolute errors and is designed to provide a weighting in accordance to scale of traffic flow. GEH less than 5.0 is considered a good match, GEHs in the range of 5.0 to 10.0 are also considered to be a reasonable match (as advised by the Design Manual for Roads and Bridges, DMRB).

The GEH statistics presented in Table 1 confirm a good match between the observed data and the model forecasts. The comparisons are presented in Table 1 for each modelled peak period and separately by direction. The individual peaks are shown in Figure 1 to Figure 8.

Under method 1, close to 45% of the links have a GEH less than 5.0 across the individual peaks and during the AM peak it is about 65%. If we consider GEH less than 10.0 then about 83% of the links will fall within this category across all the modelled peaks, except during the PM peak, which is about 78%.

Table 1. M4 mainline traffic flow, Observed 2022 vs Modelled 2022

Section	Direction	Observed 2022 (Webtris 2017/2018 data uplifted to 2022)				Modelled 2022 (Existing Model)				Difference				GEH Statistic			
		AM1	AM2	IP	PM	AM1	AM2	IP	PM	AM1	AM2	IP	PM	AM1	AM2	IP	PM
J11 - J12	EB	5,725	4,979	3,668	4,940	5,911	5,754	4,056	5,692	3%	16%	11%	15%	2.4	10.6	6.2	10.3
	WB	4,516	4,490	3,700	5,385	4,875	4,751	3,767	5,381	8%	6%	2%	0%	5.2	3.8	1.1	0.1
J10 - J11	EB	5,385	4,833	3,654	4,933	6,064	6,084	4,376	5,840	13%	26%	20%	18%	9.0	16.9	11.4	12.4
	WB	4,776	4,578	3,443	5,127	5,149	5,144	4,072	5,716	8%	12%	18%	11%	5.3	8.1	10.3	8.0
J8/9 - J10	EB	5,496	5,060	3,772	5,104	5,875	5,336	4,090	5,216	7%	5%	8%	2%	5.0	3.8	5.1	1.6
	WB	5,403	4,900	3,855	5,366	5,018	4,822	4,180	5,899	-7%	-2%	8%	10%	5.3	1.1	5.1	7.1
J7 - J8/9	EB	5,526	5,485	3,994	5,298	5,869	5,958	4,317	5,156	6%	9%	8%	-3%	4.5	6.3	5.0	2.0
	WB	5,479	5,272	4,008	5,622	4,867	5,160	4,468	6,225	-11%	-2%	11%	11%	8.5	1.5	7.1	7.8
J6 - J7	EB	5,381	5,433	4,056	5,099	5,541	5,380	4,302	5,096	3%	-1%	6%	0%	2.2	0.7	3.8	0.0
	WB	5,234	4,855	4,077	5,212	5,006	5,140	4,484	5,800	-4%	6%	10%	11%	3.2	4.0	6.2	7.9
J5 - J6	EB	5,596	5,406	4,298	5,567	5,860	5,591	4,417	5,643	5%	3%	3%	1%	3.5	2.5	1.8	1.0
	WB	5,776	5,615	4,471	5,667	5,362	5,421	4,802	5,954	-7%	-3%	7%	5%	5.6	2.6	4.9	3.8
J4B - J5	EB	5,996	5,668	4,596	5,968	5,922	5,812	4,833	6,245	-1%	3%	5%	5%	1.0	1.9	3.5	3.5
	WB	6,202	5,605	4,670	5,761	6,006	5,811	5,154	6,508	-3%	4%	10%	13%	2.5	2.7	6.9	9.5
J4 - J4B	EB	5,730	5,871	4,673	5,680	6,358	6,378	5,165	6,616	11%	9%	11%	16%	8.1	6.5	7.0	11.9
	WB	7,054	6,160	5,079	5,822	6,126	6,091	5,099	6,433	-13%	-1%	0%	10%	11.4	0.9	0.3	7.8
J3 - J4	EB	4,271	3,890	3,563	4,397	5,105	5,211	4,688	5,816	20%	34%	32%	32%	12.2	19.6	17.5	19.9
	WB	5,956	5,551	4,603	5,010	5,469	5,665	4,596	5,237	-8%	2%	0%	5%	6.4	1.5	0.1	3.2

Note: AM1 Eastbound Peak 0700 to 0800, AM2 Westbound Peak 0800-0900, PM East and Westbound Peak 1700 to 1800

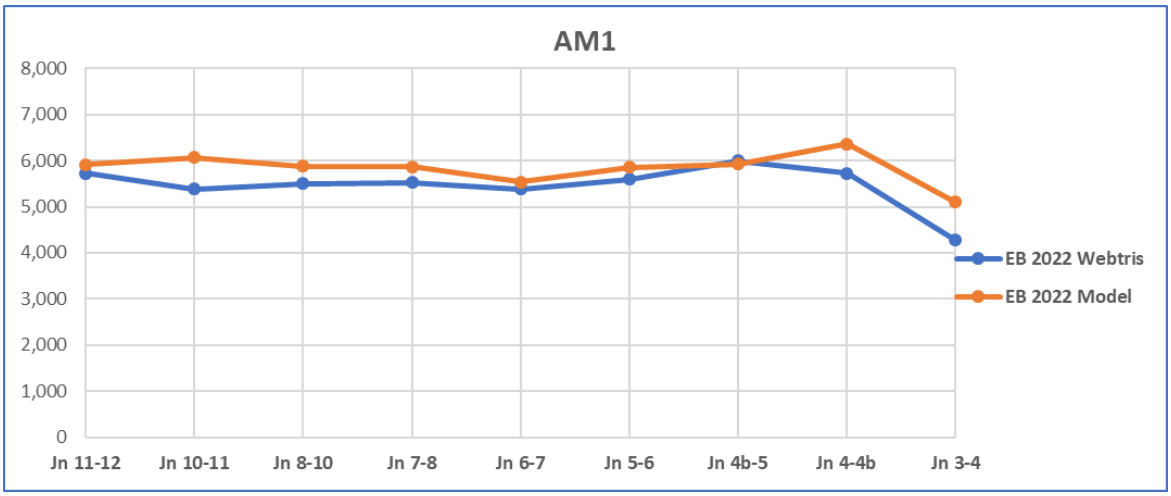

Figure 1. M4 mainline traffic flow (J12-J3) comparison: Model vs (uplifted) Observed data 2022; AM1 (07:00-08:00), Eastbound direction

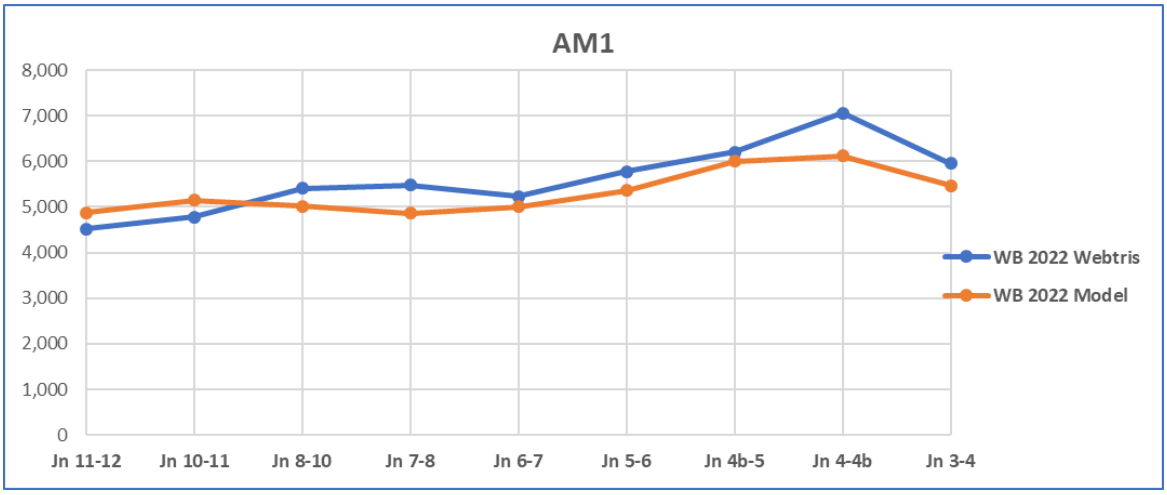

Figure 2. M4 mainline traffic flow (J12-J3) comparison: Model vs (uplifted) Observed data 2022; AM1 (07:00-08:00), Westbound direction

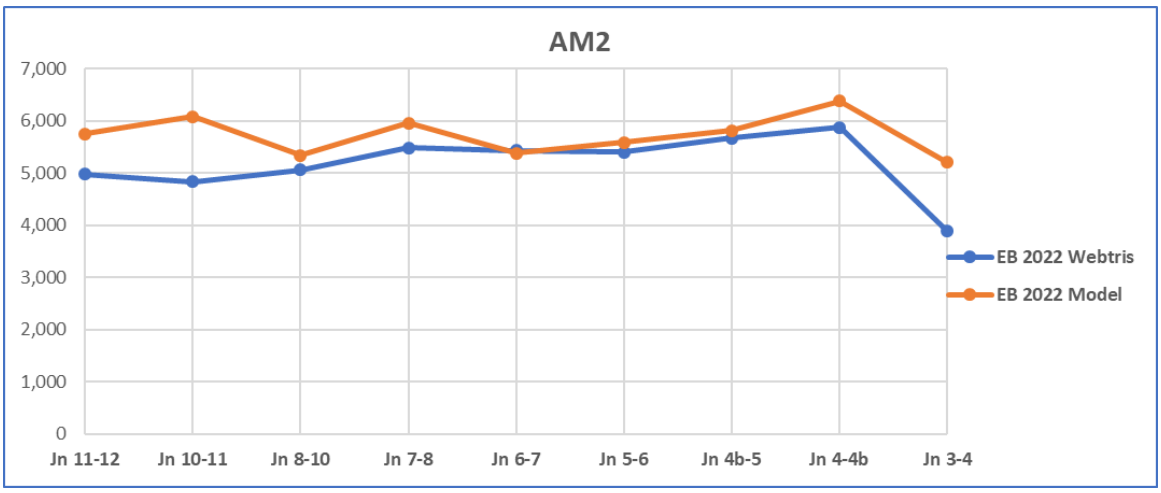

Figure 3. M4 mainline traffic flow (J12-J3) comparison: Model vs (uplifted) Observed data 2022; AM2 (08:00-09:00), Eastbound direction

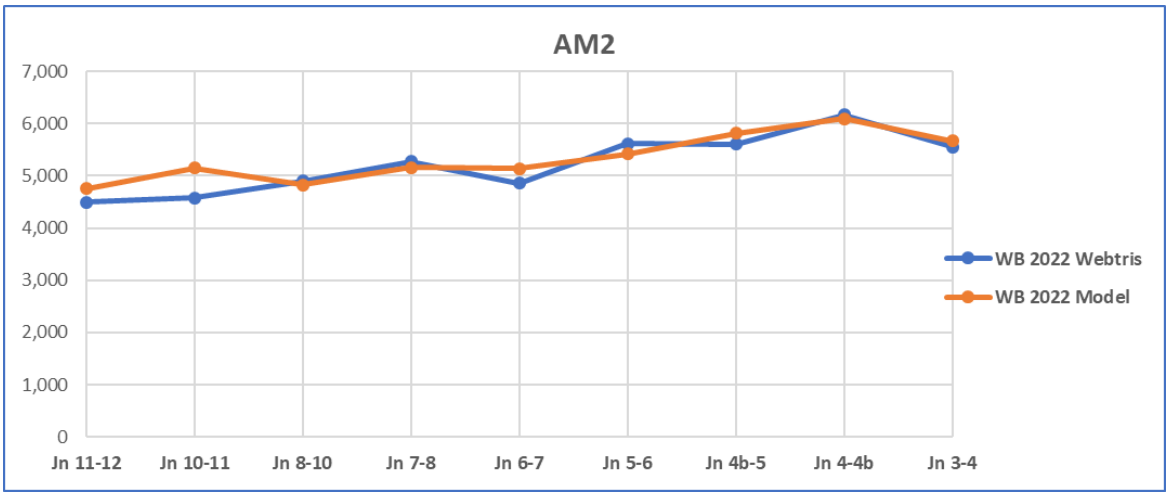

Figure 4. M4 mainline traffic flow (J12-J3) comparison: Model vs (uplifted) Observed data 2022; AM2 (08:00-09:00), Westbound direction

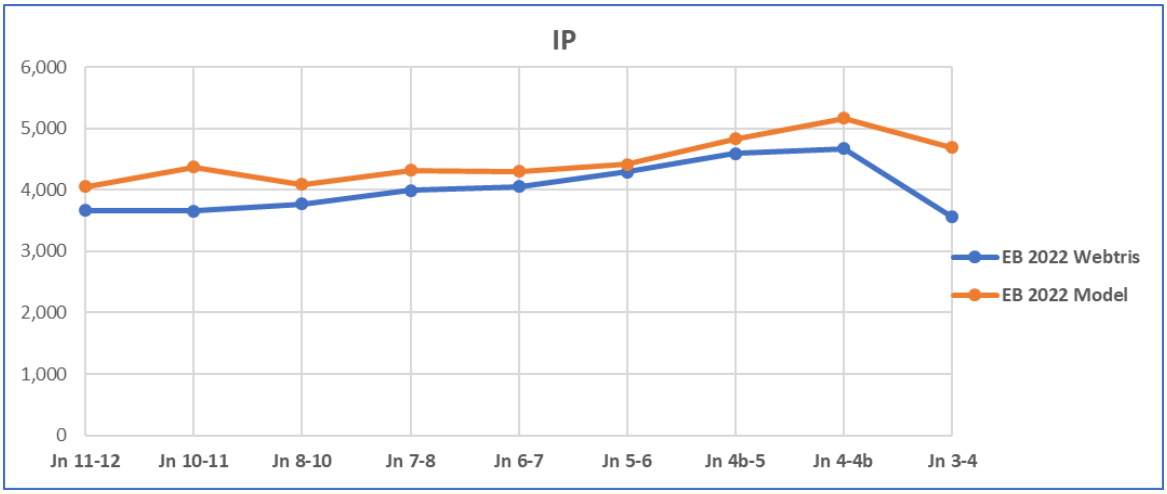

Figure 5. M4 mainline traffic flow (J12-J3) comparison: Model vs (uplifted) Observed data 2022; IP (average hour 10:00-16:00), Eastbound direction

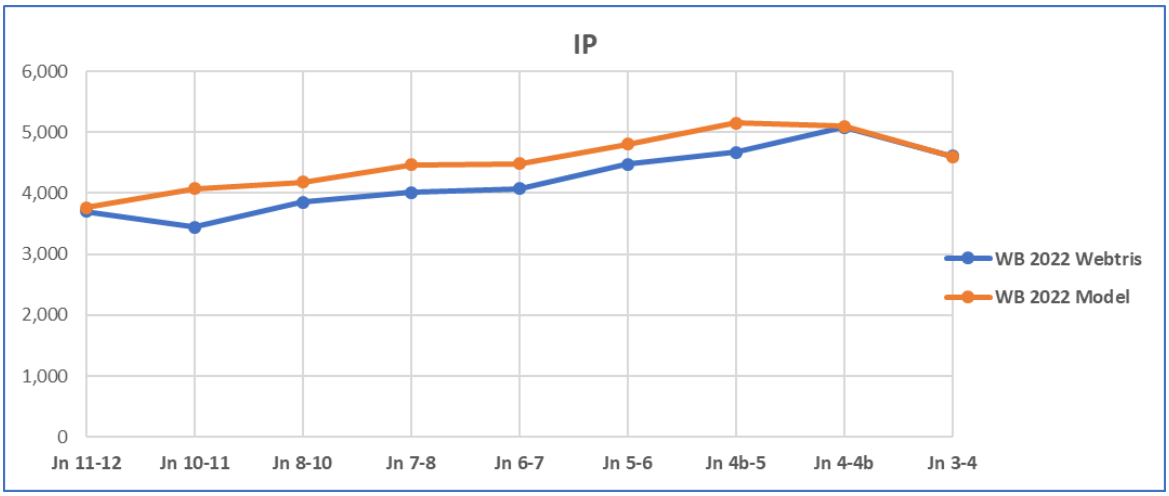

Figure 6. M4 mainline traffic flow (J12-J3) comparison: Model vs (uplifted) Observed data 2022; IP (average hour 10:00-16:00), Westbound direction

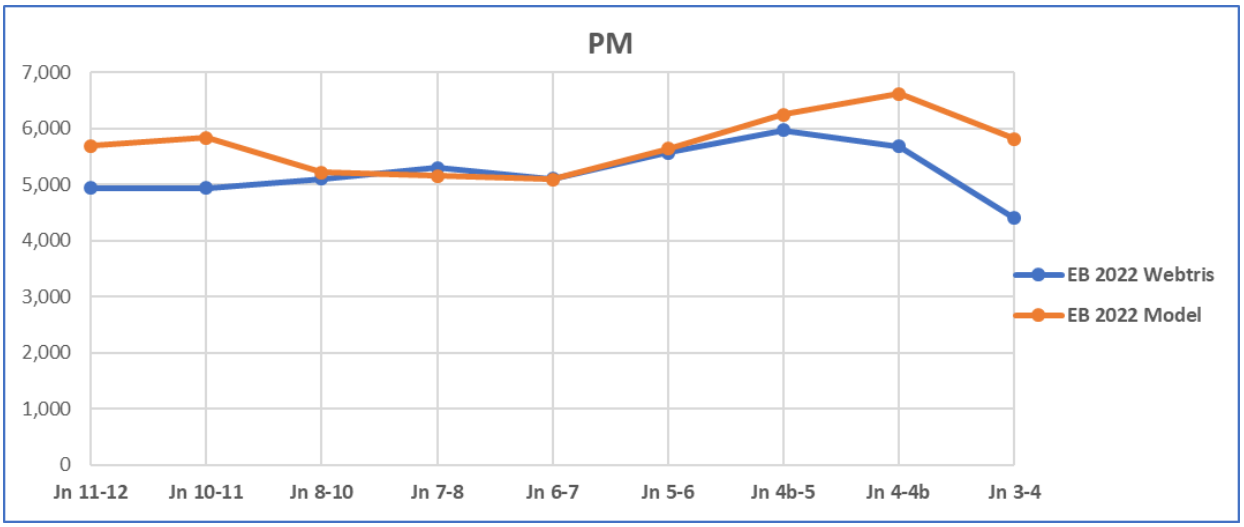

Figure 7. M4 mainline traffic flow (J12-J3) comparison: Model vs (uplifted) Observed data 2022; PM (17:00-18:00), Eastbound direction

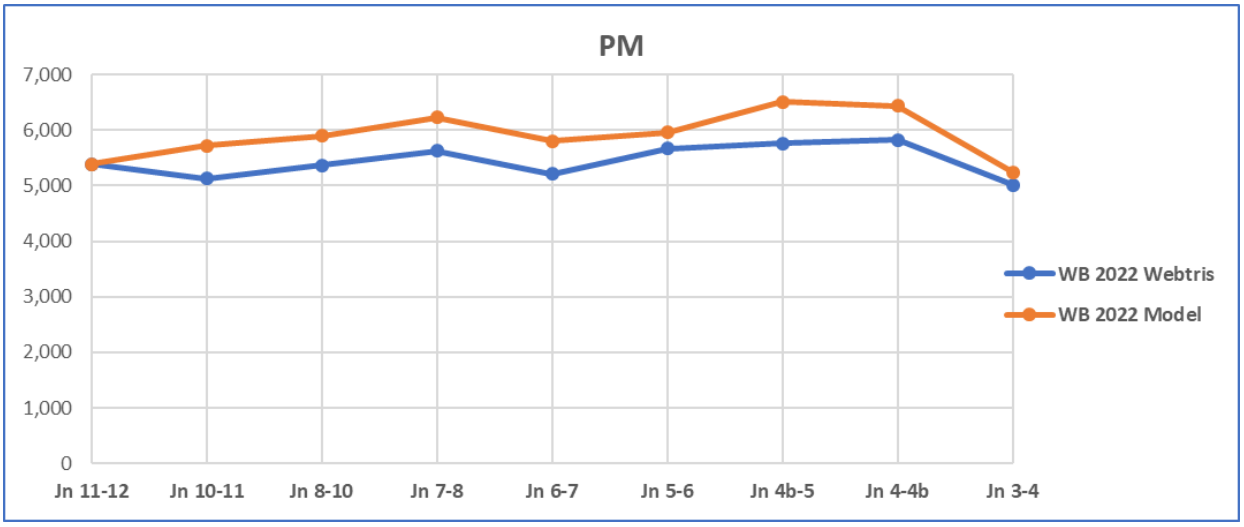

Figure 8. M4 mainline traffic flow (J12-J3) comparison: Model vs (uplifted) Observed data 2022; PM (17:00-18:00), Westbound direction

In the morning peak the eastbound flow (Reading to London) peak is between 0700 and 0800 hours and the westbound flow (London to Reading) peak is between 0800 and 0900. In the PM the Eastbound and Westbound peak is always 1700 to 1800 hours. As a result, two AM peaks and one PM peak were modelled.

Across all explicitly modelled peak time periods, the model shows relatively a good match to the observed data between J12 and J4b, with most of the differences falling within around 10%. There is generally a very close match to the observed data on the section between J8 and J4b.

There is however a larger discrepancy on the section between J10-J11, particularly in the eastbound direction, with the model overestimating flows by notably more than 10% in nearly all modelled time periods. It should be noted that reliable WebTRIS sites available for this section were limited. It is also understood that highway works were undertaken on/in the vicinity of this section of the M4 throughout much of 2017, with localised improvement works undertaken at J10 in Autumn 2017. These highway works are likely to have affected normal travel behaviours with drivers choosing other routes to avoid the disruption.

This is also a particularly complex section of the M4 surrounding Reading, used by both long-distance strategic traffic as well as more local traffic bypassing Reading. It is therefore possible that, any potential discrepancies in the assumed local planning data compared to the reality of the development completions and the local development's use of the strategic network, could have contributed to the differences seen along this section. It is however very reassuring that the adjacent sections (J11-J12 and J8-J10) away from the improvement works, the large urban centre and the potential impacts of the local traffic, have a much closer match to the observed data.

Notable differences are also observed along the eastbound sections of the M4 between J4b and J3, particularly east of Heathrow, where the traffic movements are also very complex and the model is reaching the edge of the detailed simulation area. The model overestimates traffic by over 1,000 vehicles in each of the AM2, IP and PM peak hours. However, the model shows a much closer match to the observed data with differences generally within 10% and often much lower along the Westbound section.

Comparing the model performance across the explicitly modelled time periods, the model data match the observed data best in the two AM hours and provides a very close match eastbound in the PM peak. In the interpeak, the model performs less well than in other modelled periods when compared to the observed data, however it provides a good match between J10 (Bracknell) - J4b (M25) which is the critical section in terms of the assessment of the M4 SMP scheme.

2.4 Method 2

An alternative method, Method 2, was also implemented, whereby the existing model results were used to derive a new Do-Minimum forecast for 2018, which was benchmarked against the observed 2018 WebTRIS data. The advantage of this method is that it maintained the integrity of the observed data, as there is no factoring of the observed data or the existing model.

2.4.1 2018 Forecast assumptions

The 2018 forecasts were undertaken using the same model set-up, parameters and methodology as used to produce the 2022 and 2037 forecasts at DCO stage. Only a Do-Minimum model forecast was undertaken for 2018 to enable a comparison against the observed traffic flows in 2018.

In line with the DCO forecast, the inputs into the 2018 forecast were:

- Planning data used in DCO forecast for 2022, assuming a linear build out rate between 2013 and 2022 to inform the 2018 development trip demands;
- TEMPRO growth from 2009-2018 for car, bus and rail trips; and
- Do-Minimum 2022 highway model network with economic parameters adjusted to reflect the 2018 generalised costs (Values of Time and Vehicle Operating Costs).

2.4.2 Verification of the results

The observed WebTRIS data for 12 months to July 2018 was compared against the 2018 Do-Minimum forecast flows created for this verification exercise. The comparisons are presented in Table 2 for each modelled peak period and separately by direction. The individual peaks are shown in Figure 9 to Figure 16.

Similar to Table 1, the GEH statistics presented in Table 2 also confirm a good match between the observed data and the model forecasts. The GEH statistic incorporates both relative and absolute errors and is designed to provide a weighting in accordance to scale of traffic flow. GEH less than 5.0 is considered a good match, GEHs in the range of 5.0 to 10.0 are also considered to be a reasonable match (as advised by the Design Manual for Roads and Bridges, DMRB). Under method 2, close to 45% of the links have a GEH less

than 5.0 across the individual peaks and during the AM peak it is about 50%. If we consider GEH less than 10.0 then about 83% of the links will fall within this category across all the modelled peaks, except during the PM peak, which is about 72%.

Table 2. M4 mainline traffic flow, Observed 2018 vs Modelled 2018

Section	Direction	Observed 2018 (Webtris 2017/2018 data)				Modelled 2018 (New 2018 Do-Minimum Assessment)				Difference				GEH Statistic			
		AM1	AM2	IP	PM	AM1	AM2	IP	PM	AM1	AM2	IP	PM	AM1	AM2	IP	PM
J11 - J12	EB	5,426	4,719	3,476	4,683	5,699	5,502	3,743	5,406	5%	17%	8%	15%	3.7	10.9	4.4	10.2
	WB	4,280	4,256	3,507	5,105	4,654	4,556	3,459	5,196	9%	7%	-1%	2%	5.6	4.5	0.8	1.3
J10 - J11	EB	5,105	4,581	3,464	4,676	6,065	5,857	3,985	5,565	19%	28%	15%	19%	12.8	17.7	8.5	12.4
	WB	4,527	4,339	3,264	4,860	4,964	4,874	3,735	5,539	10%	12%	14%	14%	6.3	7.9	8.0	9.4
J8/9 - J10	EB	5,209	4,797	3,575	4,838	5,732	5,053	3,820	5,031	10%	5%	7%	4%	7.1	3.7	4.0	2.7
	WB	5,122	4,645	3,654	5,086	4,878	4,652	3,855	5,673	-5%	0%	6%	12%	3.4	0.1	3.3	8.0
J7 - J8/9	EB	5,238	5,199	3,786	5,022	5,720	5,727	4,009	5,010	9%	10%	6%	0%	6.5	7.1	3.6	0.2
	WB	5,193	4,997	3,800	5,329	4,735	5,009	4,131	5,987	-9%	0%	9%	12%	6.5	0.2	5.3	8.7
J6 - J7	EB	5,100	5,150	3,844	4,834	5,428	5,180	4,096	4,924	6%	1%	7%	2%	4.5	0.4	4.0	1.3
	WB	4,961	4,602	3,865	4,940	4,888	5,004	4,197	5,565	-1%	9%	9%	13%	1.0	5.8	5.2	8.6
J5 - J6	EB	5,304	5,125	4,074	5,276	5,686	5,295	4,234	5,516	7%	3%	4%	5%	5.2	2.4	2.5	3.3
	WB	5,475	5,323	4,238	5,372	5,285	5,329	4,561	5,693	-3%	0%	8%	6%	2.6	0.1	4.9	4.3
J4B - J5	EB	5,684	5,373	4,357	5,657	5,745	5,534	4,635	6,065	1%	3%	6%	7%	0.8	2.2	4.2	5.3
	WB	5,878	5,313	4,427	5,461	5,980	5,766	4,913	6,190	2%	9%	11%	13%	1.3	6.1	7.1	9.5
J4 - J4B	EB	5,431	5,565	4,429	5,384	6,275	6,252	4,917	6,481	16%	12%	11%	20%	11.0	8.9	7.1	14.2
	WB	6,686	5,839	4,814	5,519	6,113	6,048	4,888	6,341	-9%	4%	2%	15%	7.2	2.7	1.1	10.7
J3 - J4	EB	4,048	3,687	3,377	4,168	5,036	5,074	4,536	5,800	24%	38%	34%	39%	14.7	21.0	18.4	23.1
	WB	5,646	5,262	4,364	4,749	5,485	5,637	4,488	5,209	-3%	7%	3%	10%	2.2	5.1	1.9	6.5

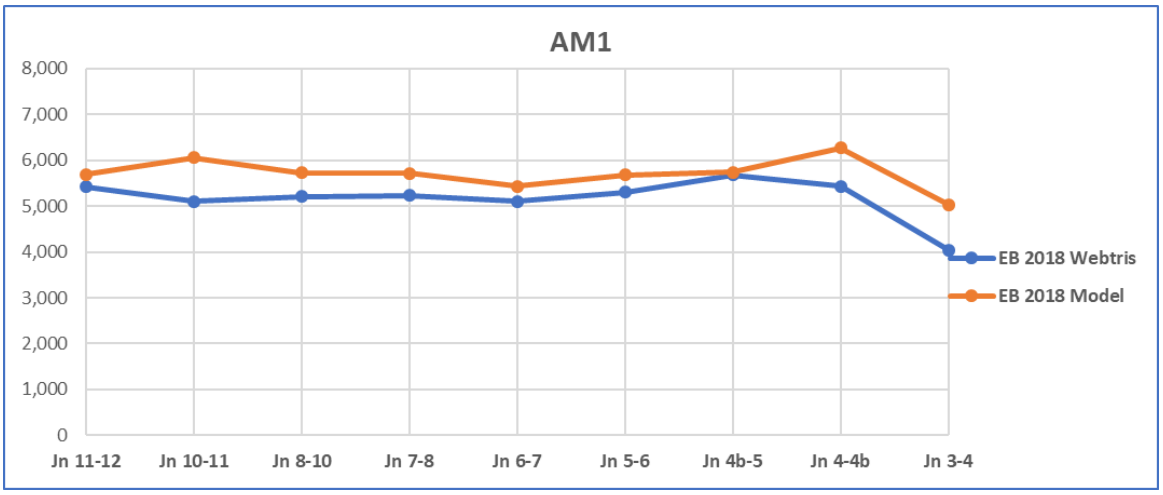

Figure 9. M4 mainline traffic flow (J12-J3) comparison: Model vs Observed data 2018; AM1 (07:00-08:00), Eastbound direction

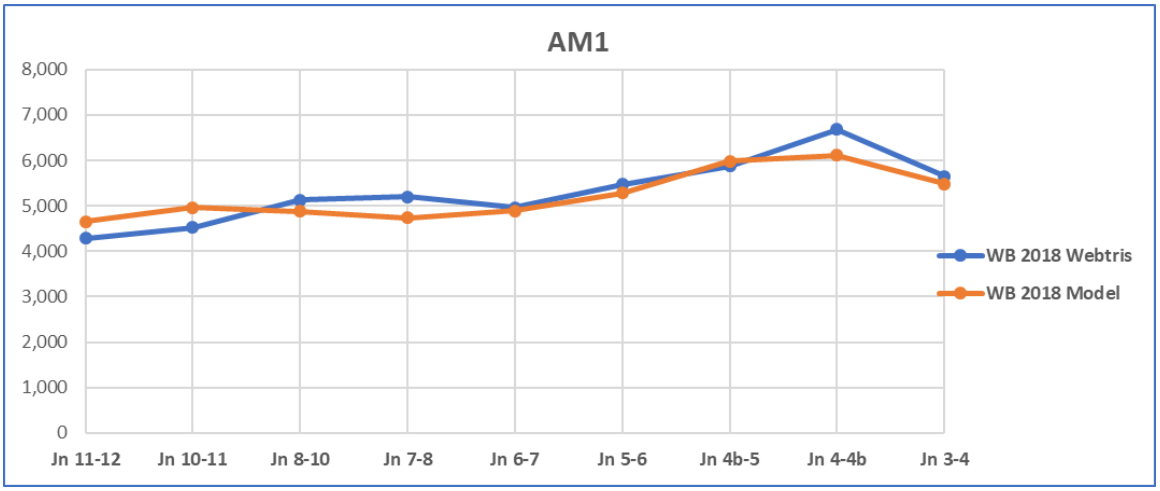

Figure 10. M4 mainline traffic flow (J12-J3) comparison: Model vs Observed data 2018; AM1 (07:00-08:00), Westbound direction

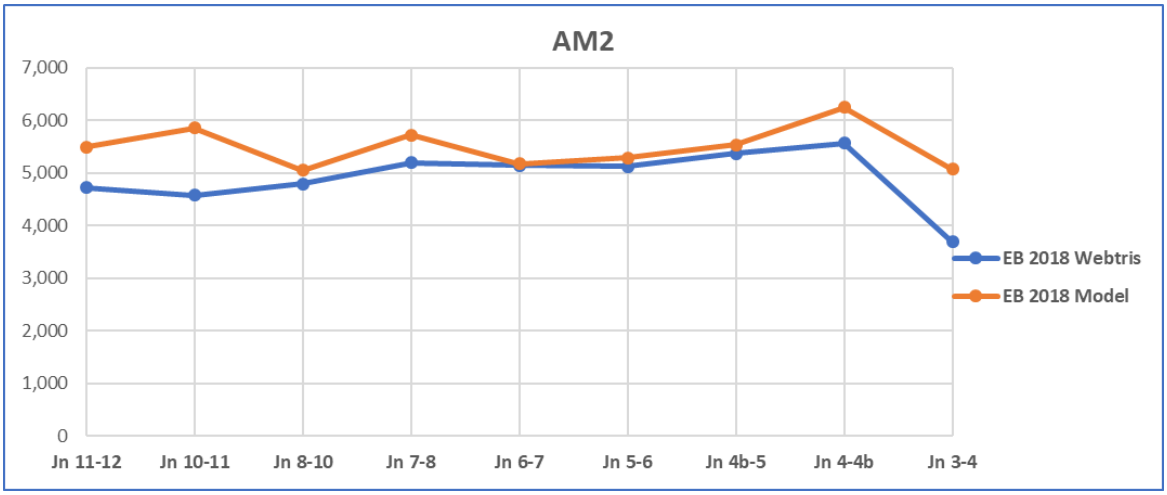

Figure 11. M4 mainline traffic flow (J12-J3) comparison: Model vs Observed data 2018; AM2 (08:00-09:00), Eastbound direction

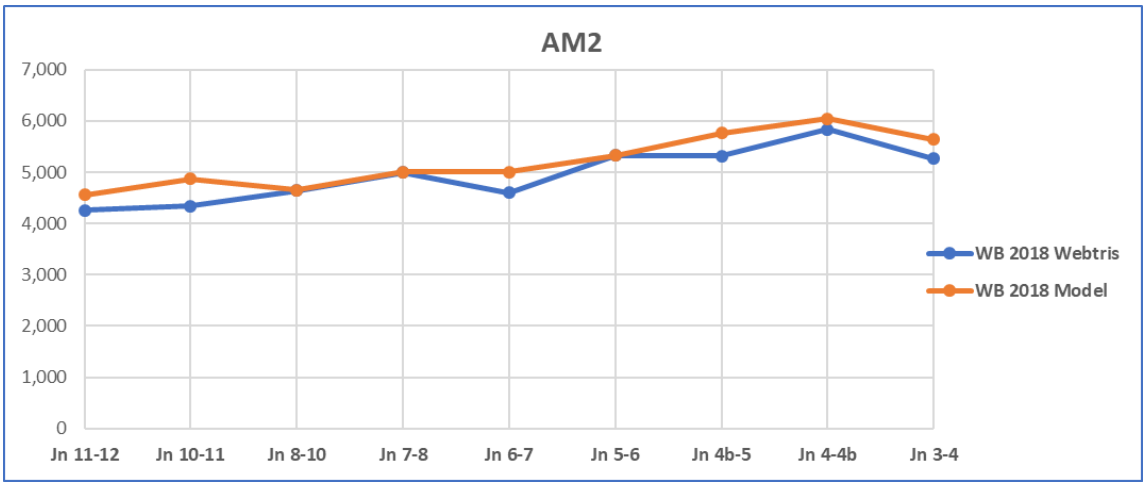

Figure 12. M4 mainline traffic flow (J12-J3) comparison: Model vs Observed data 2018; AM2 (08:00-09:00), Westbound direction

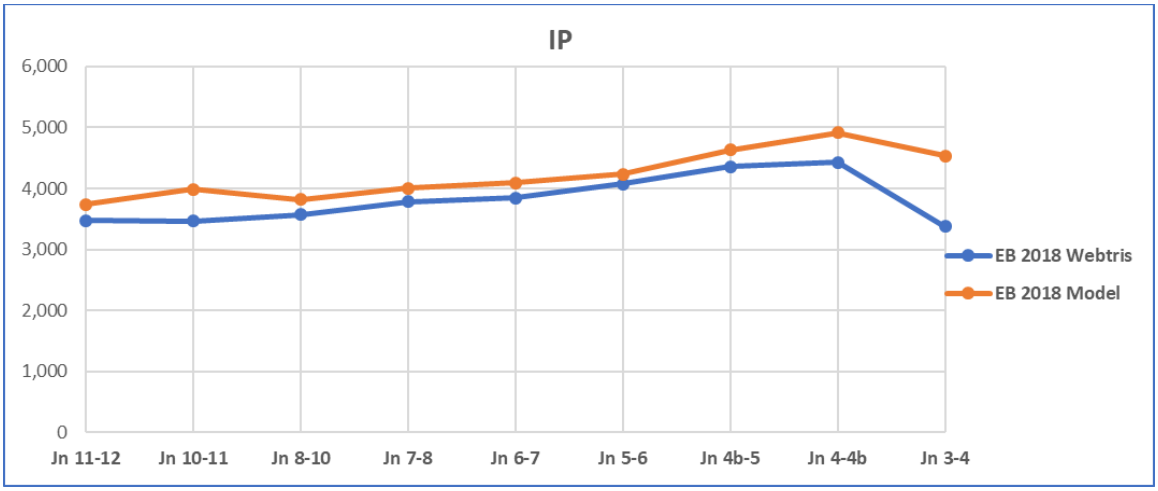

Figure 13. M4 mainline traffic flow (J12-J3) comparison: Model vs Observed data 2018; IP (average hour 10:00-16:00), Eastbound direction

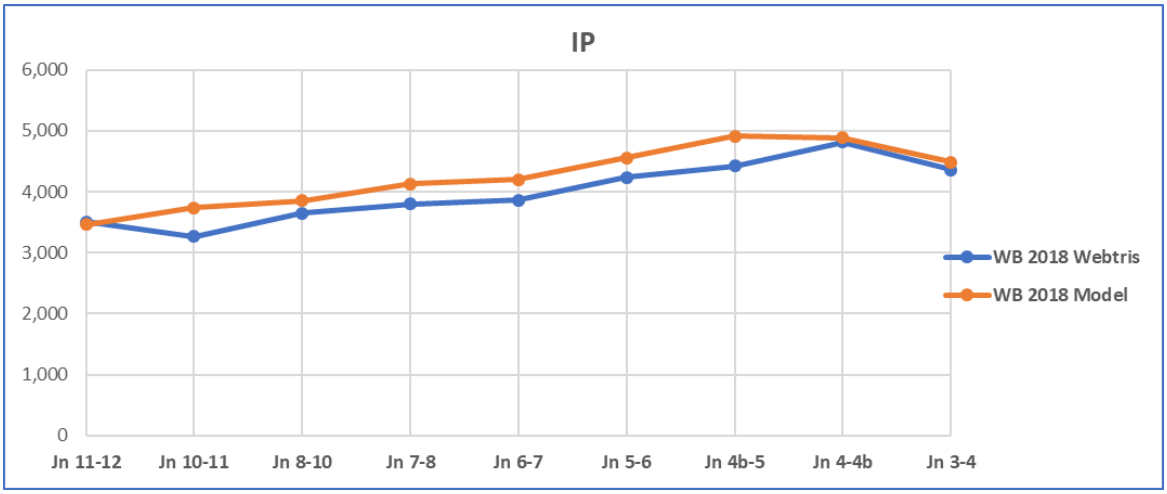

Figure 14. M4 mainline traffic flow (J12-J3) comparison: Model vs Observed data 2018; IP (average hour 10:00-16:00), Westbound direction

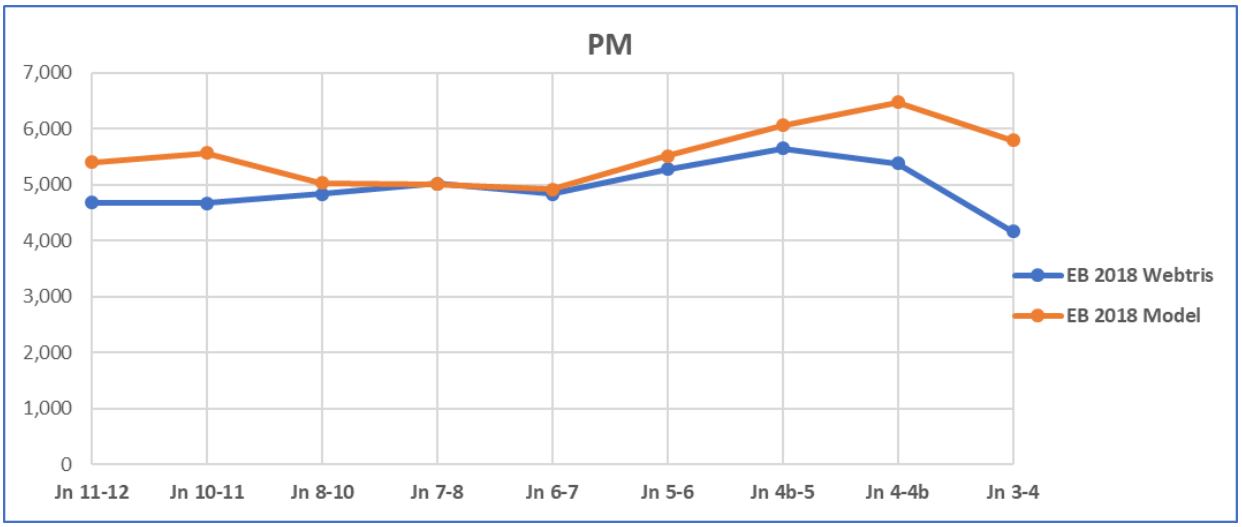

Figure 15. M4 mainline traffic flow (J12-J3) comparison: Model vs Observed data 2018; PM (17:00-18:00), Eastbound direction

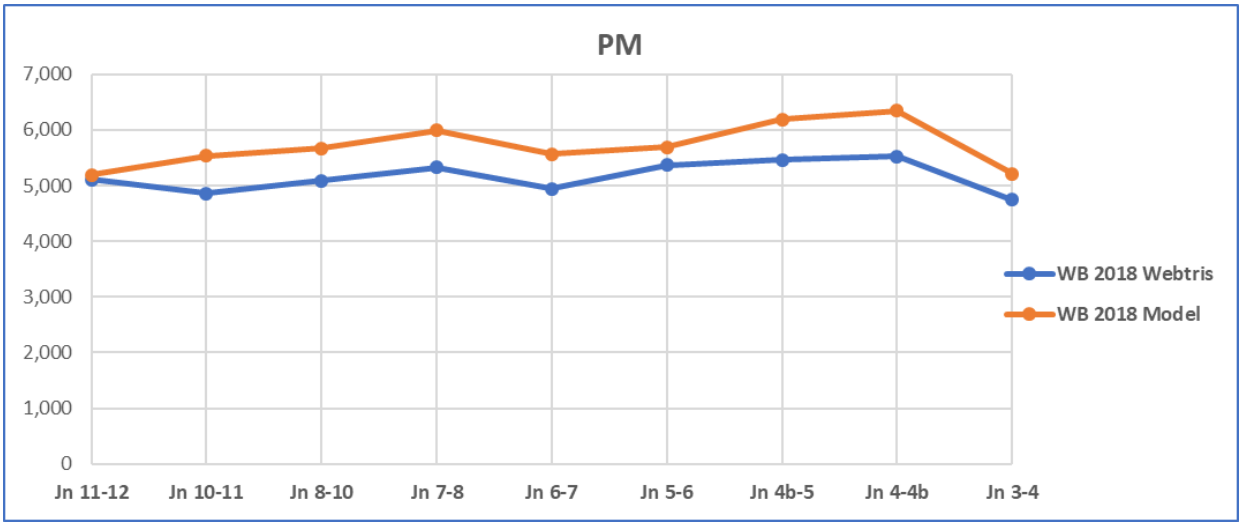

Figure 16. M4 mainline traffic flow (J12-J3) comparison: Model vs Observed data 2018; PM (17:00-18:00), Westbound direction

The findings of Method 2 are very similar to Method 1 and show relatively a good match across all the explicitly modelled time periods against the observed data, with most of the differences falling within around 10%. The GEH statics is also very similar to method 1 and reassuring.

2.5 Implications of verification exercises

The findings of both verification assessments (using Method 1 and Method 2) show that across all explicitly modelled peak time periods the model provides a good match with the observed WebTRIS data. While some discrepancies were observed on the sections between J10-11 and east of J4, the adjacent sections and more notably the section between J10 and J4b, which is the critical section in terms of the assessment of the M4 SMP scheme, were found to have a much closer match.

It can therefore be concluded that the model is robust and continues to be a valid and appropriate tool for continued use to assess the likely impacts of the M4 SMP scheme and specifically the variation to No-TJR layout.

3. Summary and Conclusions

This Technical Note has set out additional evidence in support of use of the existing M4 traffic model in relation to the Non-Material Change application. Two model verification approaches were suggested and agreed with Highways England to provide an analytical evidence base to support the model's continued use to assess the likely impacts of the No-TJR layout at selected junctions for the M4 SMP scheme.

Method 1 consisted of a comparison between existing model results for the Do-Minimum 2022 scenario and corresponding observed 2018 WebTRIS data uplifted to 2022 using RTF growth factors. Method 2 involved using the traffic model to derive a new Do-Minimum forecast for 2018 which was then benchmarked against the observed 2018 WebTRIS data. These two methods complement each other as one allows verification of existing results whilst the other has created a new scenario against which the performance of the model can be further verified.

In relation to the M4, the findings of both Method 1 and Method 2 showed that across all explicitly modelled peak time periods the model provides a good match with the observed WebTRIS data. Some differences were observed on the section between J10-11 (which could be an impact of localised roadworks near this location, which were not represented in any of the corresponding model forecasts) however the adjacent sections were found to have a much closer match. Further notable differences were observed on the sections of the M4 in the vicinity of the M25 where traffic movements are complicated (the impact of Heathrow airport) and the model is reaching the edge of the detailed simulation area. For J10-J4b however, which is the critical section in terms of the assessment of the M4 SMP scheme, the model shows a relatively good match to the observed data. It is therefore concluded that the model is suitable for continued use to assess the likely impacts of the No-TJR layout.