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HIGHWAYS AGENCY

Validation of Micro-simulation Models Technical Review

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An Executive Agency of the Department for Transport

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Validation of Micro-simulation Models: Validation of Micro-Simulation Model – Technical Report

Rev No	Comments	Date
1	Revisions from suppliers	6/2/07
2		
3		

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1 Introduction

Introduction

1.1 Introduction

The Highways Agency commissioned Faber Maunsell to undertake a study to provide advice on the design and validation of micro-simulation models appropriate to the Highways Agency's network. The study has four main aims:

- To provide a brief review of available micro-simulation software that is pertinent to the micro-simulation traffic modelling of schemes on the Highways Agency's network;
- To review the existing parameters in the main micro-simulation modelling software that are currently being used for assessing Highways Agency schemes, and to establish the default values and the effect of varying these defaults;
- To identify available data sources that can be used to provide information on the most important and influential parameters for the Highways Agency motorway network; and
- To draft guidance on the use of micro-simulation for HA scheme development.

The purpose of this report is two fold. The first is to provide the technical background for the development of guidance on the use of microsimulation modelling on the Highways Agency's network. The second is to provide the Highways Agency's Traffic Appraisal Modelling and Economics (TAME) team with a document which can be referred to when reviewing models submitted in support of development proposals or road schemes. Tests have been undertaken to assess the effect of changes to key parameters in each of the software packages and the findings are presented in this document. While there are some parameters which are found in each package eg Random Seeds, each package was effectively developed in a unique way and hence different parameters were identified by the suppliers as important to their particular software. Consequently, no direct comparisons have been made between the various packages. The Report simply comments on the testing of each package.

This report presents the findings of the technical reviews which were undertaken based on the feedback from the Software Review reported on in February 2006. For the purposes of this Technical Review the modelling work has focussed on the software which had been recently used for modelling schemes on the Highways Agency network. This included:

- AIMSUN NG Professional Edition 5.0.8
- S-Paramics 2005.1
- SISTM V6-0-005; and
- VISSIM Ver. 4.10-12

When considering the content of this document in relation to any modelling it must be remembered that the content herein relates to models developed with the software described above. Each of the suppliers continuously and regularly update their specific package and models delivered subsequent to the release of this report may have used a new release of the software. Checks must be made to ensure which version of the software has been used for the model development.

1.2 Network Descriptions

As indicated above the testing was carried out taking cognisance of the parameter feedback provided by the software suppliers. Changes to the parameters were then applied to networks which were selected as having characteristics typically displayed on the HA road network. The locations were as follows:

- M62 J26 – J27 - congested with weaving
- M60 J16 – J17 - gradients
- M60 J18 - signalised motorway junction

However, due to time restriction and the limitations of some software, eg SISTM does not model junctions, the tests and networks used varied in each software.

1.3 Layout of Report

The following Chapters report on the findings of the testing as follows;

- Chapter 2 – AIMSUN
- Chapter 3 – Paramics
- Chapter 4 – SISTM
- Chapter 5 - VISSIM

2 AIMSUN NG

AIMSUN NG – Summary of Findings

Outlined below are the findings from the model testing that was undertaken with AIMSUN software on a variety of networks which are described in detail in the main report. The version of the software that was used during the course of this work was AIMSUN NG Professional 5.0.8. Models of the following sections of motorway were used for testing purposes;

- M62 between Junctions 26 and 27 – congested network with merge, diverge and weaving;
- M60 J16-J17 – busy network with gradients; and
- J18 of the M60 – congested signalised junction.

These networks contain different conditions experienced on the Highways Agency's network, providing a wide ranging 'test bed' on which to investigate the sensitivity of the software.

The parameters tested were identified by the software developers as being important to the performance of the model

- **Random Seed Summary**

In uncongested conditions there was little variation in the journey time however, in congested conditions the variation in journey time exceeded the +/-5% that was suggested by the software suppliers. In the signalised junction the results varied depending on the movement – right turns, influenced by the signals, displayed more variation than other movements

- **Gradient Summary**

Changes in the gradient, positive or negative, had very limited impact on journey time along the network. This was despite the known impact of gradient on HGVs in particular. TSS who supply AIMSUN, has indicated that the present model considers gradients when the vehicle has to accelerate/decelerate. Vehicles in a non-congested network do not appreciate gradients because of movement at constant speed. Soon a more complex model dealing with loss of speed will be incorporated.

- **Demand Summary**

In uncongested conditions the increase in demand had a proportional impact on the journey time. The congested network was eventually unable to accommodate additional traffic and the journey times levelled off at a value which equated to the peak volume for the network. Where the traffic was affected by the signalised junction, once again the journey times of the right turning traffic was influenced most by the increased demand.

- **Observed Vehicles Summary**

Increasing the number of observed vehicles appeared to improve driver behaviour and consequently, either increased the flow of vehicles through the networks or had marginal effects on journey times.

- **Reaction Time Summary**

In congested conditions reducing the Reaction Time had a significant effect on journey time and throughput. This would suggest that this parameter must be used with caution especially in future year and 'Do-something' scenarios as the model may over estimate performance with reduced Reaction Time values.

- **Look Ahead Summary**

The variation to the 'look ahead' parameter had a negligible effect across all three networks with minimal variations in travel times and flows.

Conclusion

Whilst a number of key global parameters were tested for sensitivity the results obtained show that changes to the parameters had little effect on many of the network scenarios. In summary:

- In congested conditions changes to the Random Seed could result on changes to journey times greater than the expected +/-5%.
- Gradient changes had little or no impact on journey time.
- In uncongetsed conditions journey times increased with increasing demand. In congested conditions, where the model could not accommodate increased demand, journey times reached a peak.
- Increasing the Number of Observed vehicles reduced the journey time in congested conditions.
- Changing the Reaction Time had significant impact on the Journey Time in congested conditions. There was little impact in the other networks.
- Increasing the Look Ahead Distance slightly reduced journey times in congested conditions with little impact in the alternative networks.

The parameters clearly had a more significant impact on the congested M62 J26 to J27 network, and a far lesser impact on the signalised M60 J18 and free flowing / gradient model of the M60 J16 to J17.

AIMSUN NG

2.1 Introduction

For the purposes of this work the following three networks have been constructed and tested using AIMSUN NG professional 5.0.8. ;

- M62 between Junctions 26 and 27 – congested network with merge, diverge and weaving;
- M60 J16-J17 – relatively free flow with gradients and;
- M60 J18 – congested signalised junction.

These networks contain different conditions experienced on the Highways Agency's network, providing a wide ranging 'test bed' on which to investigate the sensitivity of the software.

Figures 2.1 to 2.3 present schematic network diagrams of the three aforementioned micro-simulation models constructed and tested, identifying origin and destination nodes used to input flows and routing decisions to the micro-simulation models.

The first network of the M62 between J26 and J27 models the eastbound mainline carriageway with associated ghost island merge and diverge links from J26 and J27 respectively. This network has been chosen to replicate a section of motorway network densely trafficked with a high degree of weaving movements.

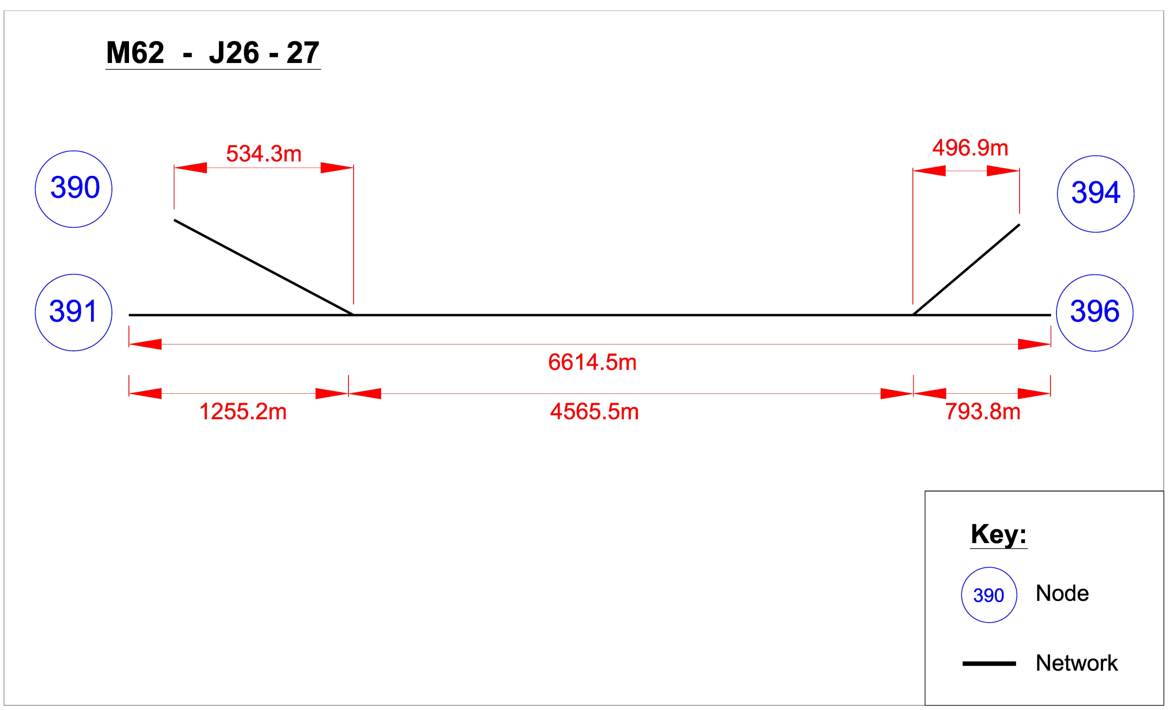

Figure 2.1 - M62 J26 to J27 Network Diagram

The second model of the M60 between J16 and J17 has been included to investigate the impact of varying link gradients on vehicle journey times by vehicle classification and link flows. Where link gradients are not assigned, this model replicates a free flowing network.

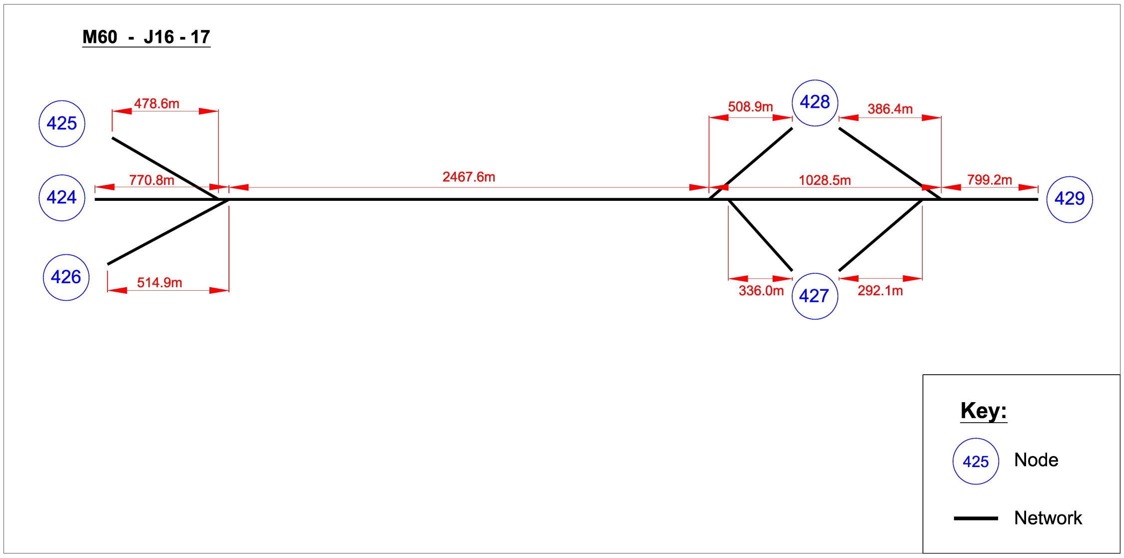

Figure 2.2 - M60 J16 to J17 Network Diagram

The third model, J18 of the M60, the intersection of the M60 and M62 motorways is a fully signalised intersection with left segregated slips on all approaches. This model investigates the characteristics of a signalised intersection / gyratory within the confines of a motorway network.

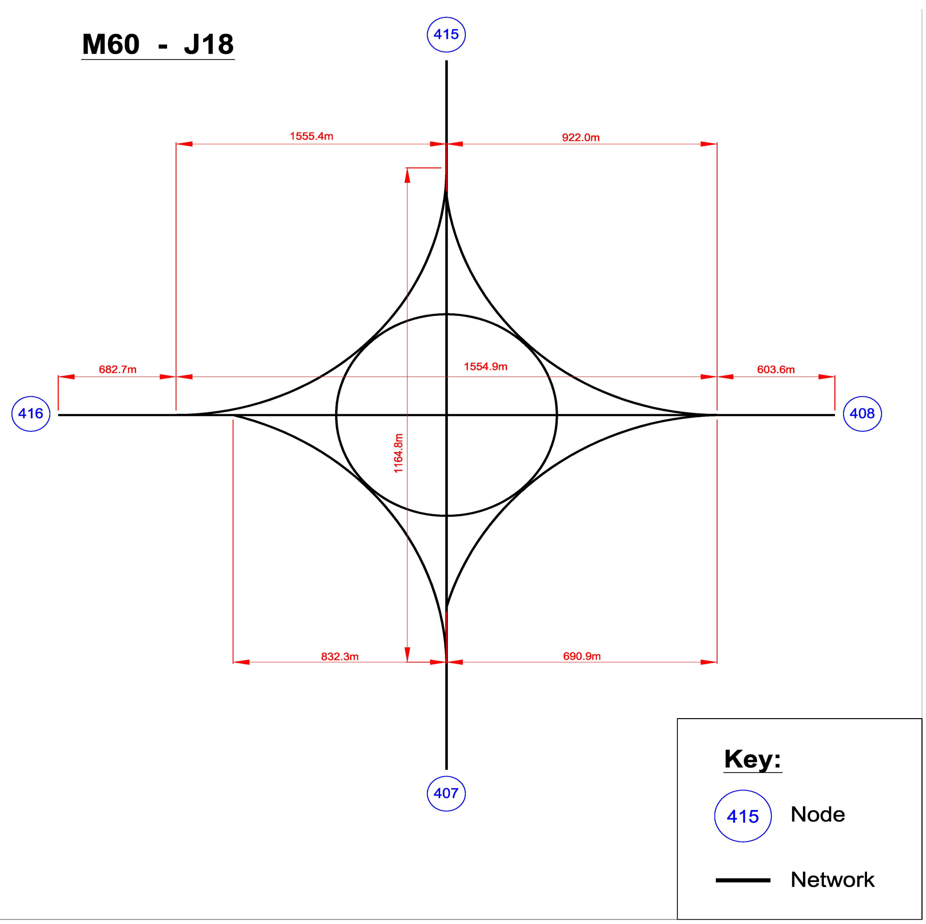

Figure 2.3 - M60 J18 Network Diagram

In addition to verification of the fitness for purpose of AIMSUN in modelling the basic network operation of UK strategic transportation networks, the sensitivity of AIMSUN simulation outputs to variations in the following parameters has been tested:

1. Random Seed Value;
2. Gradient;
3. Traffic Demand;
4. Number of Observed Vehicles;
5. Reaction Time; and
6. Look Ahead Distance.

2.2 Random Seed Value

The initial random seed for any new replication within a given evaluation in AIMSUN is assigned randomly. The range of permissible values is defined by the set of integers between 0 and 999,999,999. Ten different seed values have been randomly assigned and tested for each network with the results presented by average Journey Time in seconds against Random Seed Number for each OD pair within the coded networks.

Figure 2.4 shows the Random Seed test results on the congested M62 J26 to J27 network. It can be observed that there is a significant variation in travel times based upon the initial random seed number. The numerical outputs are given in Table 2.1 where the maximum variation is shown to be -14.34% to +7.64**%** per route, equating to a fluctuation in average journey times of 183 seconds. All the routes showed a fluctuation in journey times in excess of the ±5% as suggested could be expected by the software provider.

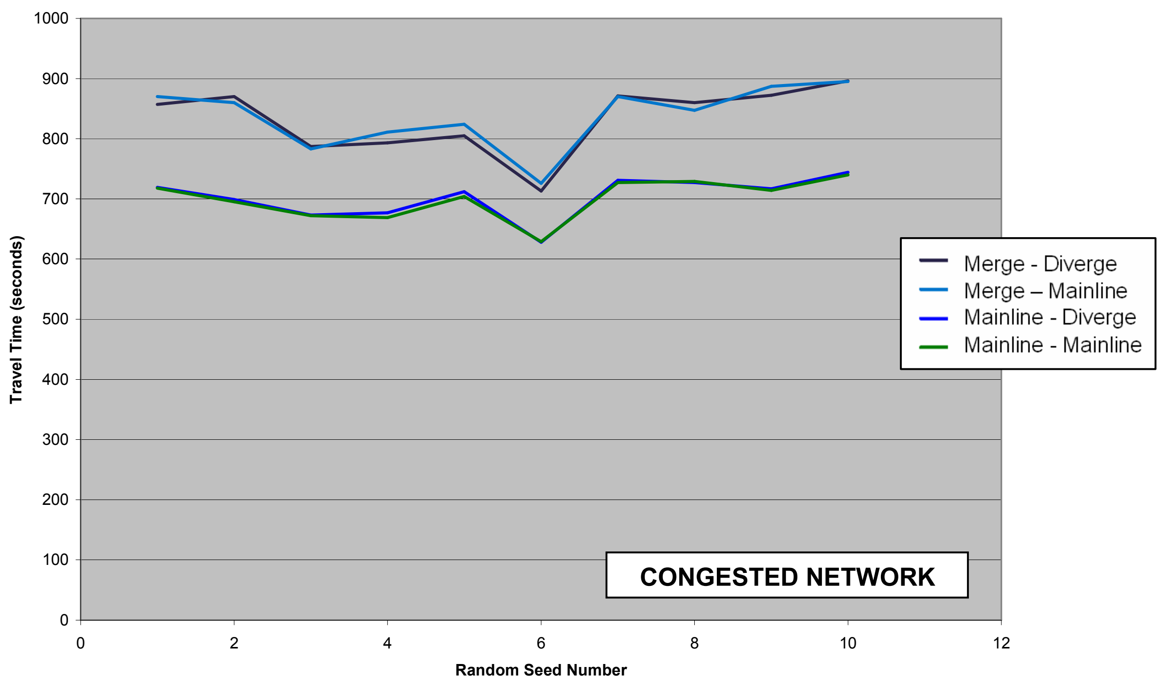

Figure 2.4 - M62 J26 to J27 - Random Seed Analysis

ttime	Random Seed Value									
Route	25032	5187	5069	24175	7155	26047	2860	13690	13842	25002
Mainline Mainline	718	695	672	669	704	629	727	729	714	740
Mainline Diverge	719	699	673	677	712	628	731	727	717	744
Merge Mainline	870	860	783	811	824	726	870	847	887	895
Merge Diverge	857	870	787	793	805	713	871	860	872	896

Deviation	Random Seed Value									
Route	25032	5187	5069	24175	7155	26047	2860	13690	13842	25002
Mainline Mainline	2.62%	-0.67%	-3.96%	-4.39%	0.61%	-10.10%	3.90%	4.19%	2.04%	5.76%
Mainline Diverge	2.32%	-0.53%	-4.23%	-3.66%	1.32%	-10.63%	4.03%	3.46%	2.04%	5.88%
Merge Mainline	3.91%	2.71%	-6.49%	-3.14%	-1.59%	-13.29%	3.91%	1.16%	5.94%	6.89%
Merge Diverge	2.96%	4.52%	-5.45%	-4.73%	-3.29%	-14.34%	4.64%	3.32%	4.76%	7.64%

Table 2.1 - M62 J26 to J27 - Random Seed Analysis

Figure 2.5 illustrates the Random Seed test results on the free flowing M18 J16 to J17 model without gradients applied to the network. It is clearly noticeable that the fluctuation in journey times associated with the variation in Random Seed is significantly less than that of the congested M62 model. Analysis shows that the maximum variation in journey time is -0.6% to +2.1%, equating to 2 seconds over a 1m 59s journey.

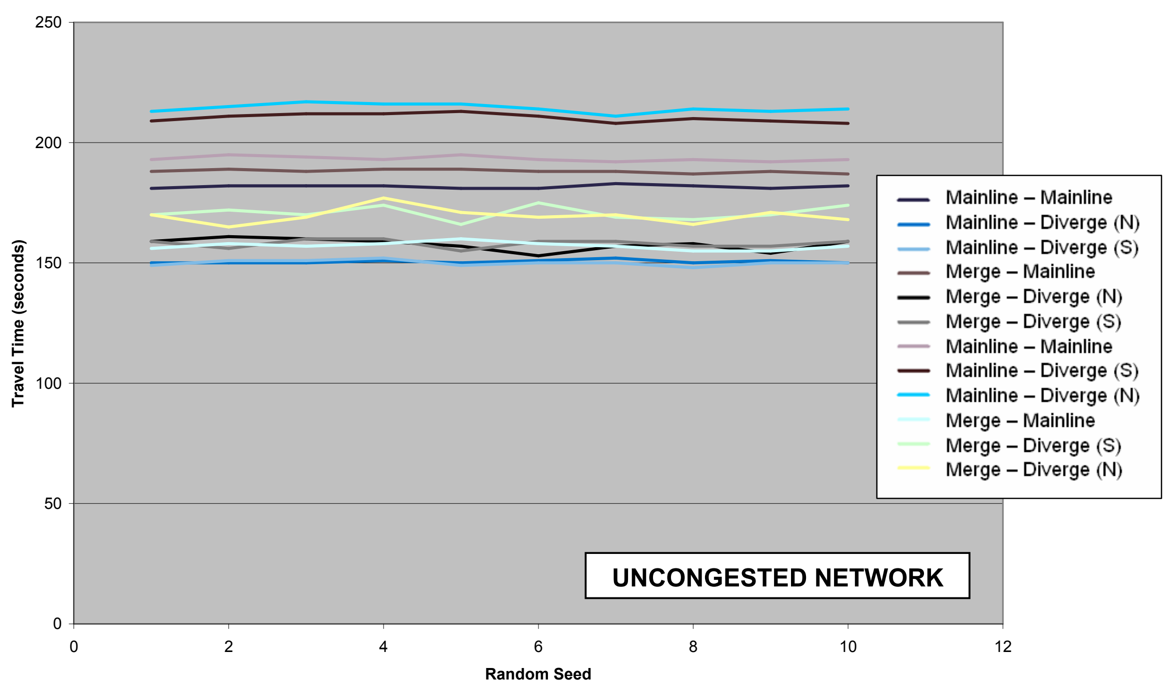

Figure 2.5 - M60 J16 to J17 - Random Seed Analysis

Ttime	Random Seed Value									
Route	**7540**	**8570**	**7327**	**28162**	**11648**	**15612**	**31191**	**1455**	**15541**	**25252**
Mainline Mainline	181	182	182	182	181	181	183	182	181	182
Mainline Diverge	150	150	150	151	150	151	152	150	151	150
Merge Mainline	188	189	188	189	189	188	188	187	188	187
Merge Diverge	159	161	160	159	157	153	157	158	154	159

Deviation	Random Seed Value									
Route	**7540**	**8570**	**7327**	**28162**	**11648**	**15612**	**31191**	**1455**	**15541**	**25252**
Mainline Mainline	-0.4%	0.2%	0.2%	0.2%	-0.4%	-0.4%	0.7%	0.2%	-0.4%	0.2%
Mainline Diverge	-0.3%	-0.3%	-0.3%	0.3%	-0.3%	0.3%	1.0%	-0.3%	0.3%	-0.3%
Merge Mainline	-0.1%	0.5%	-0.1%	0.5%	0.5%	-0.1%	-0.1%	-0.6%	-0.1%	-0.6%
Merge Diverge	0.8%	2.1%	1.5%	0.8%	-0.4%	-3.0%	-0.4%	0.2%	-2.3%	0.8%

Table 2.2 - M60 J16 to J17 - Random Seed Analysis

Figure 2.6 presents the Random Seed test results for the signalised motorway / motorway intersection with segregated left turn lanes on all approaches. The graph clearly shows that there is a significantly lesser impact of the Random Seed variable on some routes as opposed to others. The routes with the more significant variation in journey times from the mean are those with right turning movements, namely, those which are impacted upon by the signalised intersection. Maximum deviations are presented in Table 2.3 with a range of -6.98% to +10.41%.

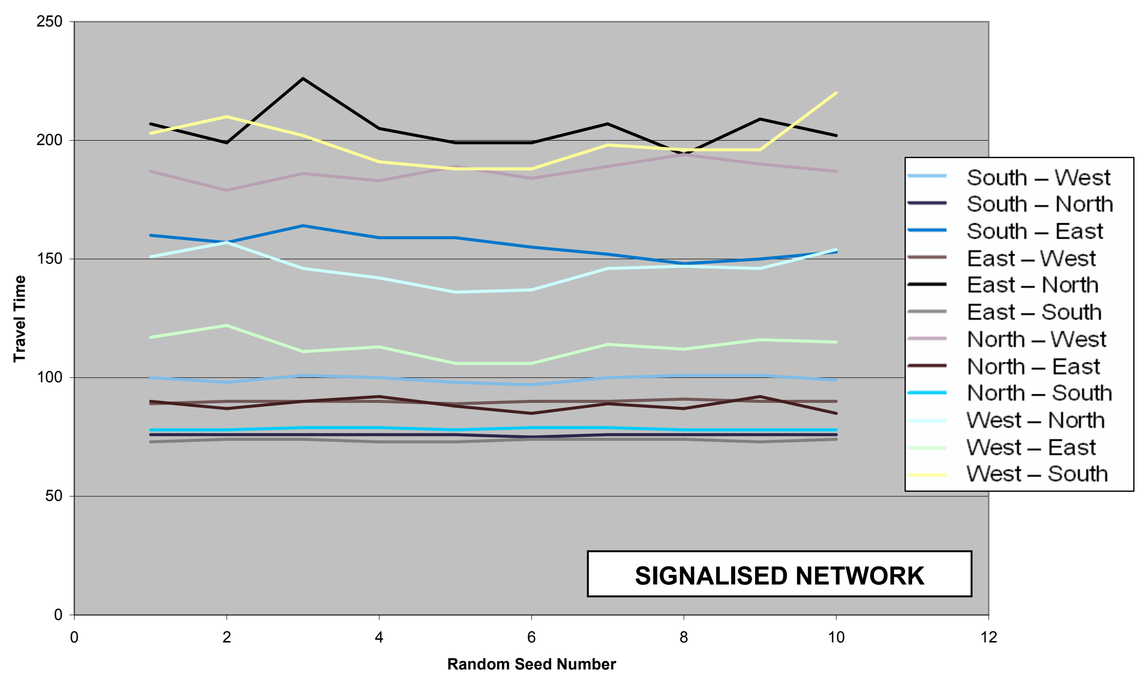

Figure 2.6 - M60 J18 - Random Seed Analysis

Ttime	Random Seed Value									
Route	**18996**	**31063**	**32759**	**1773**	**23740**	**10668**	**27764**	**10563**	**7565**	**20991**
West - North	151	157	146	142	136	137	146	147	146	154
West - East	117	122	111	113	106	106	114	112	116	115
West - South	203	210	202	191	188	188	198	196	196	220
North - East	90	87	90	92	88	85	89	87	92	85
North - South	78	78	79	79	78	79	79	78	78	78
North - West	187	179	186	183	189	184	189	194	190	187
East - South	73	74	74	73	73	74	74	74	73	74
East – West	89	90	90	90	89	90	90	91	90	90
East – North	207	199	226	205	199	199	207	194	209	202
South - West	100	98	101	100	98	97	100	101	101	99
South - North	76	76	76	76	76	75	76	76	76	76
South - East	160	157	164	159	159	155	152	148	150	153

Deviation	Random Seed Value									
Route	**18996**	**31063**	**32759**	**1773**	**23740**	**10668**	**27764**	**10563**	**7565**	**20991**
West - North	3.28%	7.39%	-0.14%	-2.87%	-6.98%	-6.29%	-0.14%	0.55%	-0.14%	5.34%
West - East	3.36%	7.77%	-1.94%	-0.18%	-6.36%	-6.36%	0.71%	-1.06%	2.47%	1.59%
West - South	1.91%	5.42%	1.41%	-4.12%	-5.62%	-5.62%	-0.60%	-1.61%	-1.61%	10.44%
North - East	1.69%	-1.69%	1.69%	3.95%	-0.56%	-3.95%	0.56%	-1.69%	3.95%	-3.95%
North - South	-0.51%	-0.51%	0.77%	0.77%	-0.51%	0.77%	0.77%	-0.51%	-0.51%	-0.51%
North - West	0.11%	-4.18%	-0.43%	-2.03%	1.18%	-1.50%	1.18%	3.85%	1.71%	0.11%
East - South	-0.82%	0.54%	0.54%	-0.82%	-0.82%	0.54%	0.54%	0.54%	-0.82%	0.54%
East – West	-1.00%	0.11%	0.11%	0.11%	-1.00%	0.11%	0.11%	1.22%	0.11%	0.11%
East – North	1.12%	-2.78%	10.41%	0.15%	-2.78%	-2.78%	1.12%	-5.23%	2.10%	-1.32%
South - West	0.50%	-1.51%	1.51%	0.50%	-1.51%	-2.51%	0.50%	1.51%	1.51%	-0.50%
South - North	0.13%	0.13%	0.13%	0.13%	0.13%	-1.19%	0.13%	0.13%	0.13%	0.13%
South - East	2.76%	0.83%	5.33%	2.12%	2.12%	-0.45%	-2.38%	-4.95%	-3.66%	-1.73%

Table 2.3 - M60 J18 - Random Seed Analysis

2.3 Random Seed Summary

The impact of changes to the Random Seed was very dependant on the traffic conditions on the network in question. In uncongested conditions there was little variation in the journey time however, in congested conditions the variation in journey time exceeded the +/-5% that was suggested by the software suppliers. In the signalised junction the results varied depending on the movement – right turns, influenced by the signals, displayed more variation than other movements.

2.4 Gradient

Link gradient or 'section slope' as defined in AIMSUN local section parameters, represented by altitude in metres, influences the vehicle parameters for acceleration and braking capabilities. A sloped section of approximately 1420m between M60 J16 and J17 was introduced ranging between -8 and 8 degrees, the **positive gradient for the eastbound link** and the **negative gradient for the westbound link**. Network construction was verified through 3 dimensional link assessment as initial models were found to contain steps in the links and connectors which vehicles were unable to negotiate.

The link gradients, incremented in integers between -8% and 8%, appear to have no significant effect on vehicle journey times within the study network. Positive gradients invoked a variation of up to 3.9**%** in journey time, however, these results were not proportional to the change in gradient. Similarly, the negative gradients varied about the mean by -5.3% to +1.3%, again with no distinct relationship between the gradient and the route travel time. Based upon Figure 2.7a, which displays the results for cars, it must be concluded that the impacts of introducing a gradient within a network has a negligible impact.

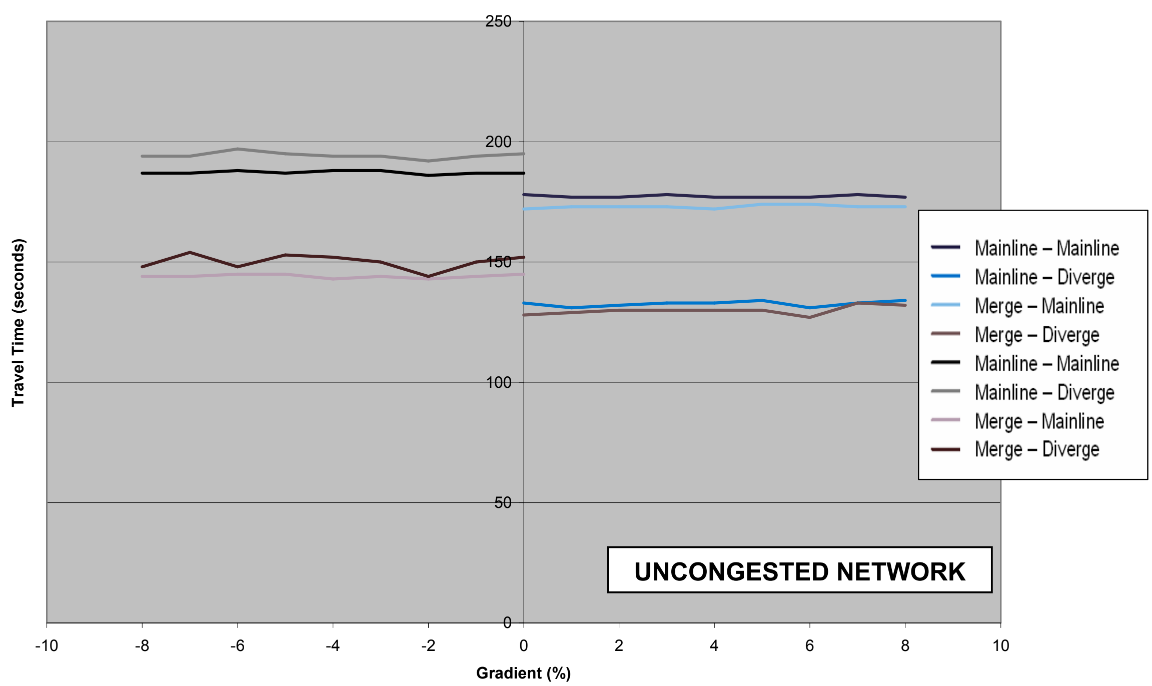

Figure 2.7a - M60 J16 to J17 – Link Gradient Analysis - Cars

ttime	Positive Gradient								
Route	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Mainline Mainline	172	170	170	172	171	171	171	172	171
Mainline Diverge	131	130	131	132	132	132	130	132	132
Merge Mainline	170	172	171	172	171	173	173	172	171
Merge Diverge	128	129	130	130	130	130	127	133	132

deviation	Positive Gradient								
Route	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Mainline Mainline	172	-1.2%	-1.2%	0.0%	-0.6%	-0.6%	-0.6%	0.0%	-0.6%
Mainline Diverge	131	-0.8%	0.0%	0.8%	0.8%	0.8%	-0.8%	0.8%	0.8%
Merge Mainline	170	1.2%	0.6%	1.2%	0.6%	1.8%	1.8%	1.2%	0.6%
Merge Diverge	128	0.8%	1.6%	1.6%	1.6%	1.6%	-0.8%	3.9%	3.1%

Table 2.4- M60 J16 to J17 – Positive Gradient Analysis - Cars

ttime	Negative Gradient								
Route	**-8**	**-7**	**-6**	**-5**	**-4**	**-3**	**-2**	**-1**	**0**
Mainline Mainline	180	180	181	180	180	181	179	180	179
Mainline Diverge	188	190	192	190	190	190	188	189	189
Merge Mainline	144	143	144	143	142	143	142	143	144
Merge Diverge	144	151	145	148	149	147	142	147	150

deviation	Negative Gradient								
Route	**-8**	**-7**	**-6**	**-5**	**-4**	**-3**	**-2**	**-1**	**0**
Mainline Mainline	0.6%	0.6%	1.1%	0.6%	0.6%	1.1%	0.0%	0.6%	179
Mainline Diverge	-0.5%	0.5%	1.6%	0.5%	0.5%	0.5%	-0.5%	0.0%	189
Merge Mainline	0.0%	-0.7%	0.0%	-0.7%	-1.4%	-0.7%	-1.4%	-0.7%	144
Merge Diverge	-4.0%	0.7%	-3.3%	-1.3%	-0.7%	-2.0%	-5.3%	-2.0%	150

Table 2.5- M60 J16 to J17 – Negative Gradient Analysis – Cars

Figure 2.7b below depicts the results for HGVs on the same network and it can be seen once again that the impact of gradient on journey time was negligible.

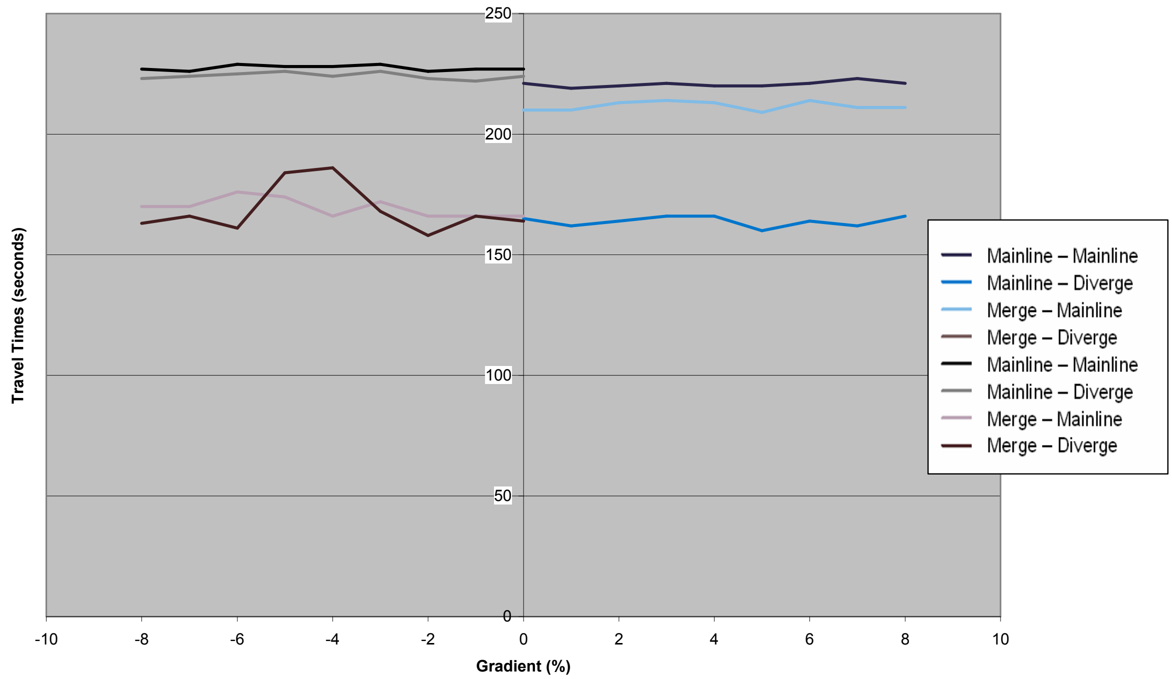

Figure 2.7b - M60 J16 to J17 – Link Gradient Analysis - HGVs

ttime	Positive Gradient								
Route	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Mainline Mainline	221	219	220	221	220	220	221	223	221
Mainline Diverge	165	162	164	166	166	160	164	162	166
Merge Mainline	210	210	213	214	213	209	214	211	211
Merge Diverge	No data available								

deviation	Positive Gradient								
Route	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Mainline Mainline	221	-0.9%	-0.5%	0.0%	-0.5%	-0.5%	0.0%	0.9%	0.0%
Mainline Diverge	165	-1.8%	-0.6%	0.6%	0.6%	-3.0%	-0.6%	-1.8%	0.6%
Merge Mainline	210	0.0%	1.4%	1.9%	1.4%	-0.5%	1.9%	0.5%	0.5%
Merge Diverge	No data available								

Table 2.4- M60 J16 to J17 – Positive Gradient Analysis - HGVs

ttime	Negative Gradient								
Route	**-8**	**-7**	**-6**	**-5**	**-4**	**-3**	**-2**	**-1**	**0**
Mainline Mainline	227	226	229	228	228	229	226	227	227
Mainline Diverge	223	224	225	226	224	226	223	222	224
Merge Mainline	170	170	176	174	166	172	166	166	166
Merge Diverge	163	166	161	184	186	168	158	166	164

deviation	Negative Gradient								
Route	**-8**	**-7**	**-6**	**-5**	**-4**	**-3**	**-2**	**-1**	**0**
Mainline Mainline	0.0%	-0.4%	0.9%	0.4%	0.4%	0.9%	-0.4%	0.0%	227
Mainline Diverge	-0.4%	0.0%	0.4%	0.9%	0.0%	0.9%	-0.4%	-0.9%	224
Merge Mainline	2.4%	2.4%	6.0%	4.8%	0.0%	3.6%	0.0%	0.0%	166
Merge Diverge	-0.6%	1.2%	-1.8%	12.2%	13.4%	2.4%	-3.7%	1.2%	164

Table 2.5- M60 J16 to J17 – Negative Gradient Analysis – HGVs

2.5 Gradient Summary

It can be seen from the graphs and tables that changes in the gradient, positive or negative, had very limited impact on journey time along the network. This is despite the known impact of gradient on HGVs in particular.

TSS, who supply AIMSUN, has indicated that: ‘the present model considers gradients when the vehicle has to accelerate/decelerate. Vehicles in a non-congested network do not appreciate gradients because of movement at constant speed. Soon a more complex model dealing with loss of speed will be incorporated.’

2.6 Demand

The demand matrices in the three models have been input into the networks at five user defined increments, namely, 100%, 105%, 110%, 120% and 150%. Applying growth rates to input matrices in order to evaluate future year scenarios is standard practice for scheme assessment and appraisal. The impact of increasing the demand on journey times and traffic throughput is given in Figures 2.8 to 2.11 and Tables 2.5 to 2.7.

Figure 2.8 shows the results for the already congested M62 J26 to J27 network. Whilst the graph shows that journey times did increase with the increased demand and associated congestion on the network, the traffic flow element of Table 2.5 reveals that the not of all the increased demand was released on the network as queuing already existed to the extents of the model during peak periods. It can be seen from Figure 2.8 that travel times increase up to 120% scaling of the demand matrix where it reaches a ceiling value due to the degree of congestion in the network.

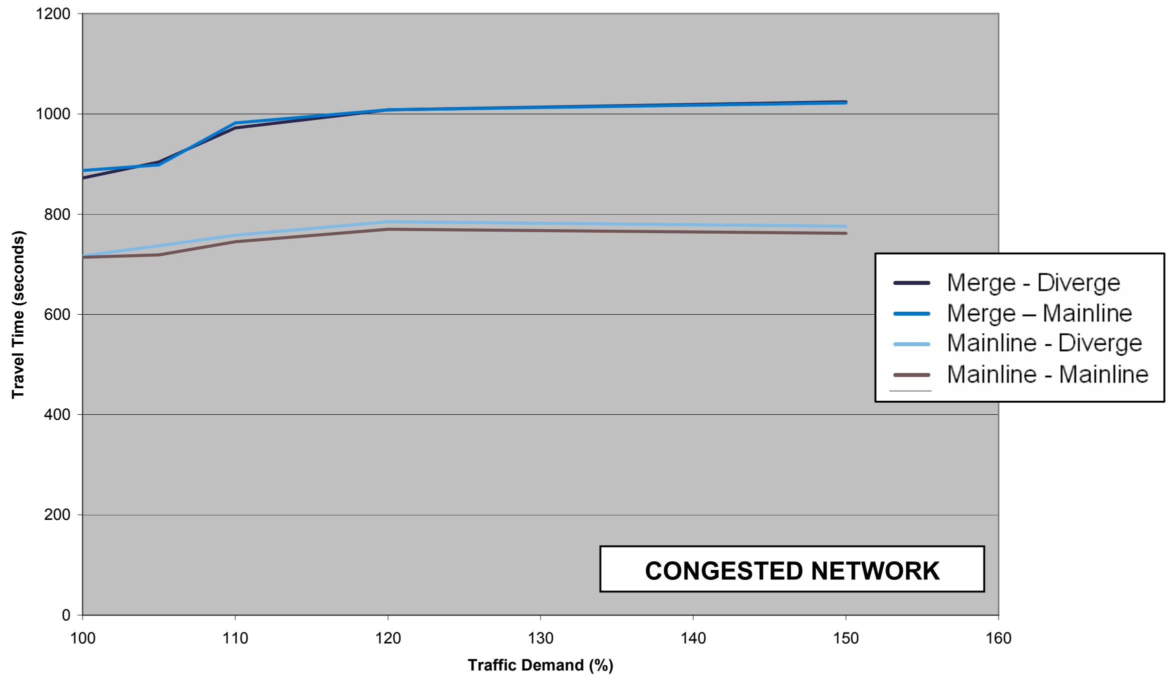

Figure 2.8 M62 J26 to J27 – Traffic Demand Analysis

ttime	Demand								
Route	100%	105%		110%		120%		150%	
	ttime (s)	ttime (s)	% dif	ttime (s)	% dif	ttime (s)	% dif	ttime (s)	% dif
Mainline Mainline	714	719	0.7%	745	4.3%	770	7.8%	762	6.7%
Mainline Diverge	717	737	2.8%	758	5.7%	785	9.5%	776	8.2%
Merge Mainline	887	898	1.2%	982	10.7%	1008	13.6%	1022	15.2%
Merge Diverge	872	904	3.7%	972	11.5%	1008	15.6%	1024	17.4%

nveh	Demand								
Route	100%	105%		110%		120%		150%	
	nveh	nveh	% dif	nveh	% dif	nveh	% dif	nveh	% dif
Mainline Mainline	1519	1546	1.8%	1565	3.0%	1504	-1.0%	1539	1.3%
Mainline Diverge	1621	1670	3.0%	1683	3.8%	1756	8.3%	1642	1.3%
Merge Mainline	495	545	10.1%	543	9.7%	501	1.2%	513	3.6%
Merge Diverge	927	866	-6.6%	834	-10.0%	811	-12.5%	874	-5.7%

Table 2.5 M62 J26 to J27 – Demand Analysis

Figure 2.9 presents the results from the M60 J16 to J17 model. Due to the network being uncongested the journey times increase proportionally with the demand input which correlates with the introduction of congestion and conflicts into the network. The corresponding number of vehicles making the trips as can be seen in Table 2.6 clearly shows that the flows incrementally increased throughout the scenario tests illustrating that the conflicts and increased demand were accommodated within the network.

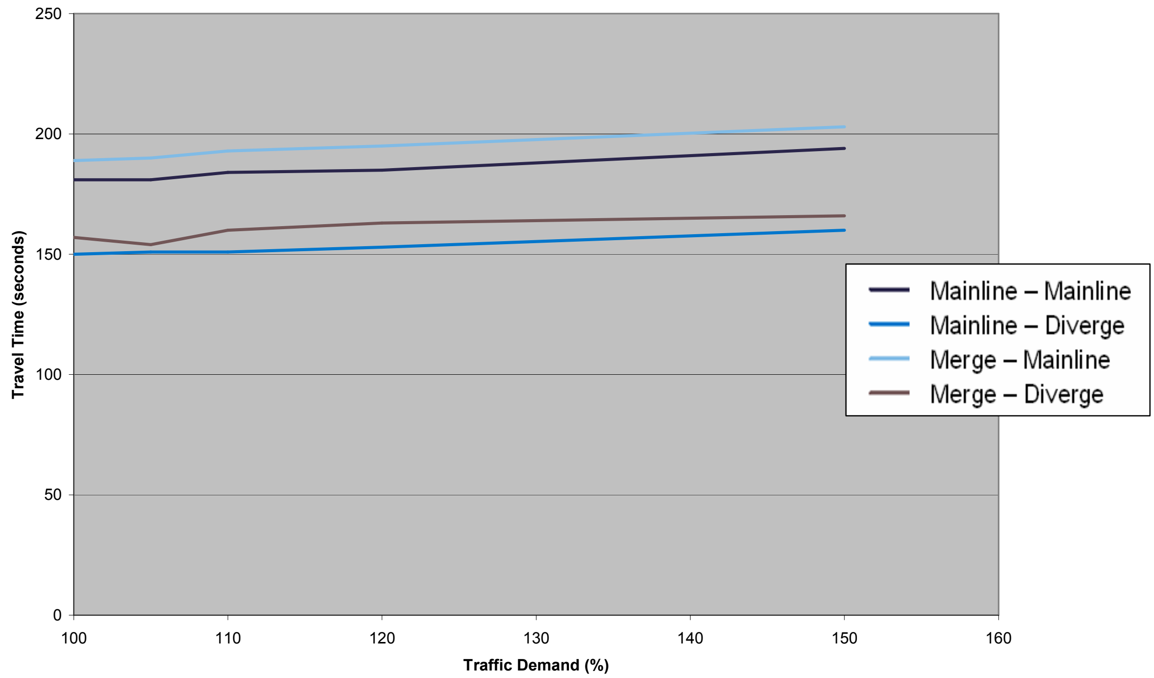

Figure 2.9 - M60 J16 to J17 – Traffic Demand Analysis

ttime	Demand								
Route	100%	105%		110%		120%		150%	
	ttime (s)	ttime (s)	% dif	ttime (s)	% dif	ttime (s)	% dif	ttime (s)	% dif
Mainline Mainline	181	181	0.0%	184	1.7%	185	2.2%	194	7.2%
Mainline Diverge	150	151	0.7%	151	0.7%	153	2.0%	160	6.7%
Merge Mainline	189	190	0.5%	193	2.1%	195	3.2%	203	7.4%
Merge Diverge	157	154	-1.9%	160	1.9%	163	3.8%	166	5.7%

nveh	Demand								
Route	100%	105%		110%		120%		150%	
	nveh	nveh	% dif	nveh	% dif	nveh	% dif	nveh	% dif
Mainline Mainline	4915	5293	7.7%	5577	13.5%	5982	21.7%	7603	54.7%
Mainline Diverge	420	506	20.5%	451	7.4%	552	31.4%	684	62.9%
Merge Mainline	501	534	6.6%	576	15.0%	600	19.8%	765	52.7%
Merge Diverge	28	20	-28.6%	30	7.1%	25	-10.7%	38	35.7%

Table 2.6 - M60 J16 to J17 – Demand Analysis

Figure 2.10 presents the results from the M60 Junction 18 model. The graph shows an increase in travel time with increased demand on the network which is in accordance with expectations. As with the random seed tests the degree of variation in journey times varies widely across the Origin / Destination pairs. Further investigation illustrates that all of the routes originating from node 407 are significantly increased as are the remaining right turning movements through the signalised intersection.

In this case, no ‘Yellow boxes’ were included in the model in order to reflect the on-site arrangements.

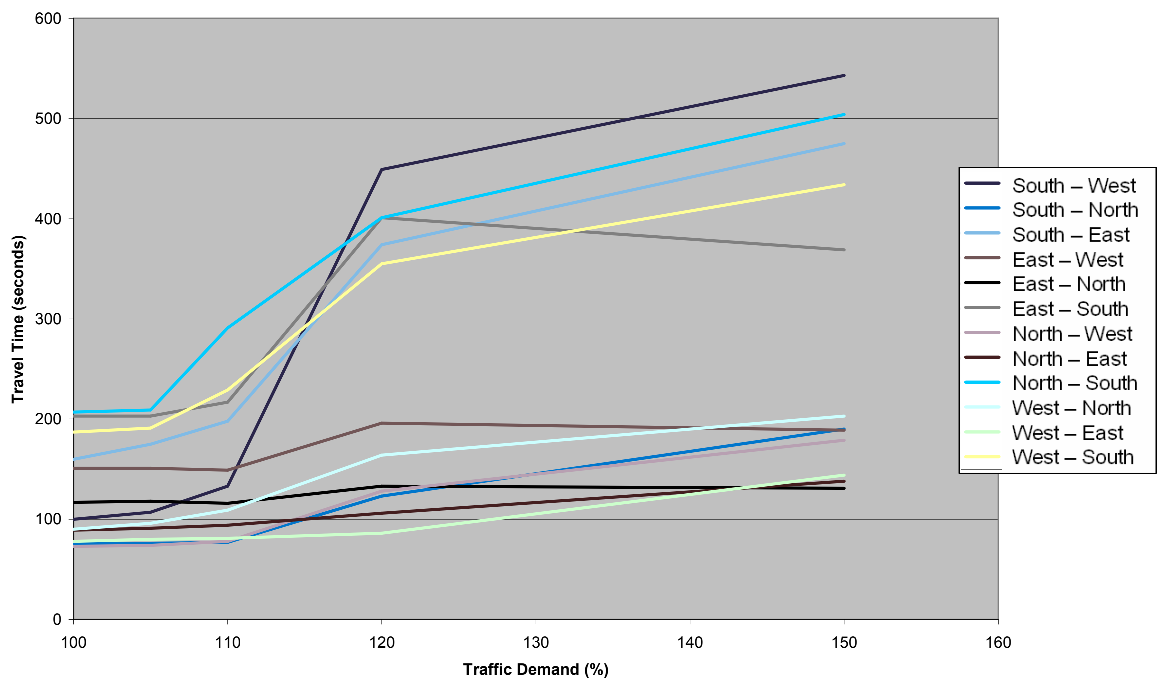

Figure 2.10 - M60 J18 – Traffic Demand Analysis

ttime	Demand								
Route	100%	105%		110%		120%		150%	
	ttime (s)	ttime (s)	% dif	ttime (s)	% dif	ttime (s)	% dif	ttime (s)	% dif
West - North	151	151	0.0%	149	-1.3%	196	29.8%	189	25.2%
West - East	117	118	0.9%	116	-0.9%	133	13.7%	131	12.0%
West - South	203	203	0.0%	217	6.9%	401	97.5%	369	81.8%
North - East	90	96	6.7%	109	21.1%	164	82.2%	203	125.6%
North - South	78	80	2.6%	81	3.8%	86	10.3%	144	84.6%
North - West	187	191	2.1%	229	22.5%	355	89.8%	434	132.1%
East - South	73	74	1.4%	78	6.8%	128	75.3%	179	145.2%
East - West	89	91	2.2%	94	5.6%	106	19.1%	138	55.1%
East - North	207	209	1.0%	291	40.6%	401	93.7%	504	143.5%
South - West	100	107	7.0%	133	33.0%	449	349.0%	543	443.0%
South - North	76	76	0.0%	77	1.3%	123	61.8%	190	150.0%
South - East	160	175	9.4%	198	23.8%	374	133.8%	475	196.9%

Table 2.7a - M60 J18 – Demand Analysis – Travel Time

Nveh	Demand								
Route	100%	105%		110%		120%		150%	
	nveh	nveh	% dif	nveh	% dif	nveh	% dif	nveh	% dif
West – North	1699	1732	1.9%	1909	12.4%	1697	-0.1%	1987	17.0%
West – East	5316	5462	2.7%	5851	10.1%	5071	-4.6%	4882	-8.2%
West – South	1830	1916	4.7%	1915	4.6%	1604	-12.3%	1543	-15.7%
North – East	1011	1069	5.7%	1123	11.1%	1220	20.7%	1258	24.4%
North – South	4783	5151	7.7%	5306	10.9%	5745	20.1%	6000	25.4%
North – West	1927	2009	4.3%	2103	9.1%	2199	14.1%	2228	15.6%
East – South	1666	1802	8.2%	1848	10.9%	1904	14.3%	1953	17.2%
East – West	5720	6106	6.7%	6458	12.9%	6561	14.7%	6848	19.7%
East – North	789	857	8.6%	899	13.9%	806	2.2%	840	6.5%
South – West	2261	2179	-3.6%	2462	8.9%	2556	13.0%	2452	8.4%
South – North	2486	2636	6.0%	2736	10.1%	3045	22.5%	2850	14.6%
South – East	1159	1245	7.4%	1188	2.5%	1214	4.7%	1211	4.5%

Table 2.7b - M60 J18 – Demand Analysis – Traffic flow

2.7 Demand Summary

As might be expected, in uncongested conditions the increase in demand had a proportional impact on the journey time. The congested network was eventually unable to accommodate additional traffic and the journey times levelled off at a value which equated to the peak volume for the network. Where the traffic was affected by the signalised junction, once again the journey times of the right turning traffic was influenced most by the increased demand.

2.8 Number of Observed Vehicles

The number of observed vehicles is a global parameter within AIMSUN that influences the behaviour of the car-following model based upon the impact of vehicles in adjacent lanes. The default value for the parameter is 4 vehicles. This test used values of 2, 3, 4, 5 and 10 to investigate the impact of this parameter on the simulations for the congested, uncongested and signalised motorway networks.

In theory, the more vehicles observed the smoother the traffic and merging situations should be within a model. If this hypothesis is correct, the greatest effect should therefore be noticed within the M62 Junctions 26 to 27 model as depicted in Figure 2.11. The trend of the graph suggests that the greater the number of observed vehicles parameter, the shorter the journey time for this, a congested network. This observed trend agrees with the hypothesis of the smoother traffic and merge and is validated by the results presented in Table 2.8 that shows that the reductions in journey times were not a result of a decrease in vehicle throughput.

The results for the M60 J16 to J17 and M60 J18 models show a negligible impact from the adjustment of this parameter as there is no significant scope to smooth the traffic within the scenarios.

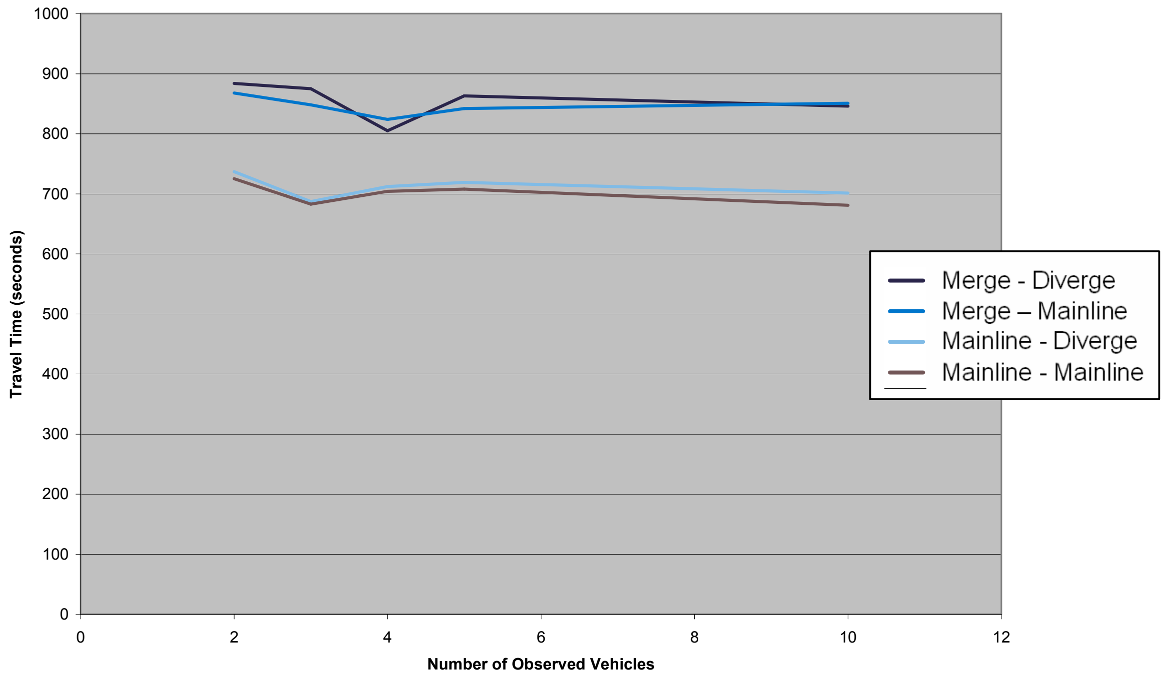

Figure 2.11 - M62 J26 to J27 – Observed Vehicles Analysis

ttime	Number of Observed Vehicles								
Route	2	3		4		5		10	
	ttime (s)	ttime (s)	% dif	ttime (s)	% dif	ttime (s)	% dif	ttime (s)	% dif
Mainline Mainline	725	683	-5.8%	704	-2.9%	708	-2.3%	681	-6.1%
Mainline Diverge	737	687	-6.8%	712	-3.4%	719	-2.4%	701	-4.9%
Merge Mainline	868	848	-2.3%	824	-5.1%	842	-3.0%	851	-2.0%
Merge Diverge	884	875	-1.0%	805	-8.9%	863	-2.4%	846	-4.3%

nveh	Number of Observed Vehicles								
Route	2	3		4		5		10	
	nveh	nveh	% dif	nveh	% dif	nveh	% dif	nveh	% dif
Mainline Mainline	1512	1493	-1.3%	1439	-4.8%	1415	-6.4%	1491	-1.4%
Mainline Diverage	1616	1678	3.8%	1629	0.8%	1631	0.9%	1578	-2.4%
Merge Mainline	485	519	7.0%	562	15.9%	504	3.9%	537	10.7%
Merge Diverge	906	871	-3.9%	922	1.8%	925	2.1%	904	-0.2%

Table 2.8 - M62 J26 to J27 – Observed Vehicles Analysis

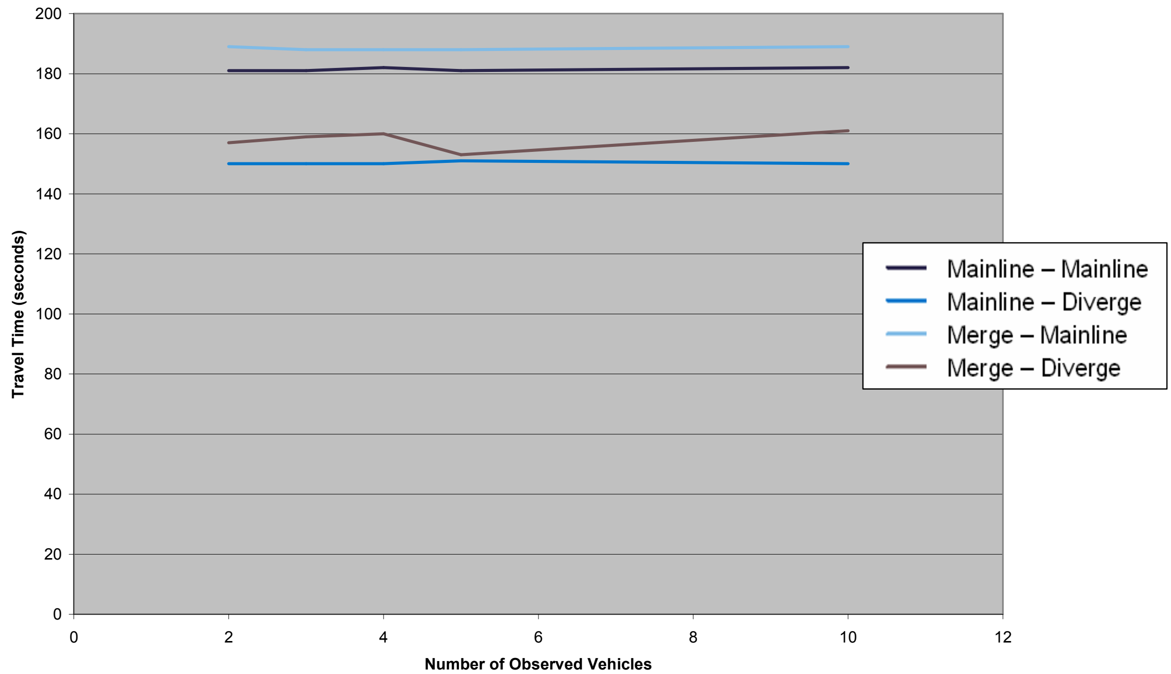

Figure 2.12 M60 J16 to J17 – Observed Vehicles Analysis

ttime	Number of Observed Vehicles								
Route	2	3		4		5		10	
	ttime (s)	ttime (s)	% dif	ttime (s)	% dif	ttime (s)	% dif	ttime (s)	% dif
Mainline Mainline	181	181	0.0%	182	0.6%	181	0.0%	182	0.6%
Mainline Diverge	150	150	0.0%	150	0.0%	151	0.7%	150	0.0%
Merge Mainline	189	188	-0.5%	188	-0.5%	188	-0.5%	189	0.0%
Merge Diverge	157	159	1.3%	160	1.9%	153	-2.5%	161	2.5%

nveh	Number of Observed Vehicles								
Route	2	3		4		5		10	
	nveh	nveh	% dif	nveh	% dif	nveh	% dif	nveh	% dif
Mainline Mainline	4915	5001	1.7%	4949	0.7%	4977	1.3%	5245	6.7%
Mainline Diverage	420	454	8.1%	469	11.7%	466	11.0%	503	19.8%
Merge Mainline	501	514	2.6%	563	12.4%	505	0.8%	514	2.6%
Merge Diverge	28	19	-32.1%	25	-10.7%	25	-10.7%	28	0.0%

Table 2.9 - M60 J16 to J17 – Observed Vehicles Analysis

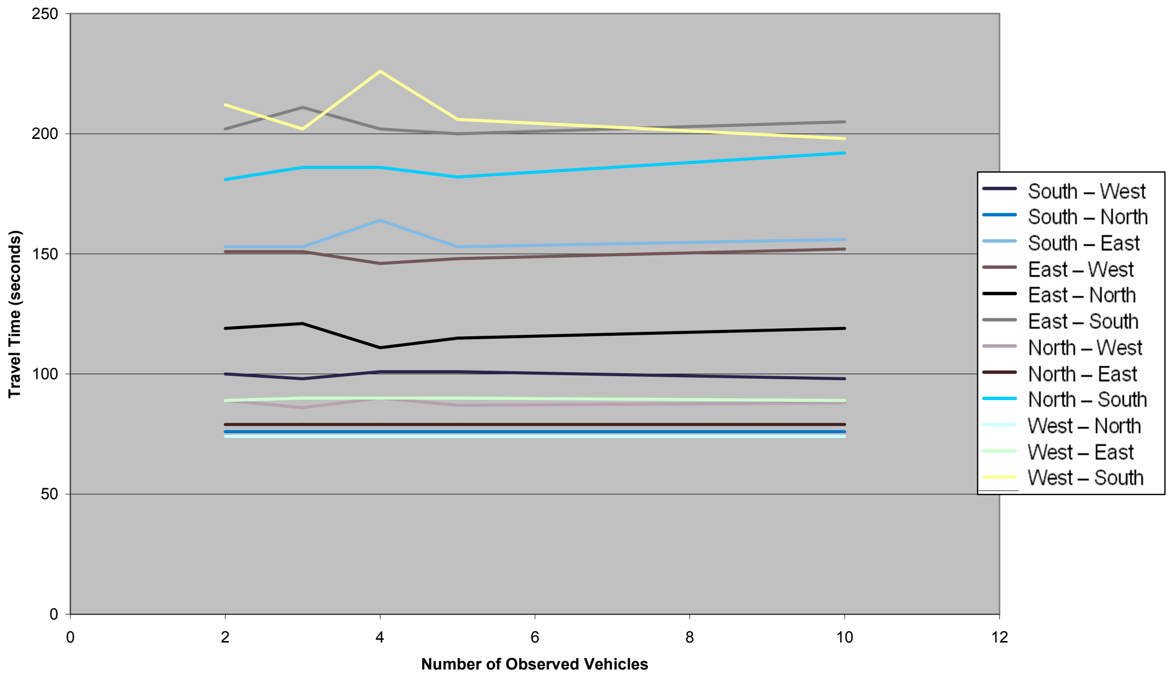

Figure 2.13 - M60 J18 – Observed Vehicle Analysis

ttime	Number of Observed Vehicles								
Route	2	3		4		5		10	
	ttime (s)	ttime (s)	% dif	ttime (s)	% dif	ttime (s)	% dif	ttime (s)	% dif
West - North	151	151	0.0%	146	-3.3%	148	-2.0%	152	0.7%
West - East	119	121	1.7%	111	-6.7%	115	-3.4%	119	0.0%
West - South	202	211	4.5%	202	0.0%	200	-1.0%	205	1.5%
North - East	89	86	-3.4%	90	1.1%	87	-2.2%	88	-1.1%
North - South	79	79	0.0%	79	0.0%	79	0.0%	79	0.0%
North - West	181	186	2.8%	186	2.8%	182	0.6%	192	6.1%
East - South	74	74	0.0%	74	0.0%	74	0.0%	74	0.0%
East - West	89	90	1.1%	90	1.1%	90	1.1%	89	0.0%
East - North	212	202	-4.7%	226	6.6%	206	-2.8%	198	-6.6%
South - West	100	98	-2.0%	101	1.0%	101	1.0%	98	-2.0%
South - North	76	76	0.0%	76	0.0%	76	0.0%	76	0.0%
South - East	153	153	0.0%	164	7.2%	153	0.0%	156	2.0%

Table 2.10 - M60 J18 – Observed Vehicle Analysis – Travel time

nveh	Number of Observed Vehicles								
Route	2	3		4		5		10	
	nveh	nveh	% dif	nveh	% dif	nveh	% dif	nveh	% dif
West - North	1681	1712	1.8%	1641	-2.4%	1740	3.5%	1730	2.9%
West - East	5243	5132	-2.1%	5232	-0.2%	5272	0.6%	5212	-0.6%
West - South	1892	1912	1.1%	1823	-3.6%	1842	-2.6%	1880	-0.6%
North - East	1029	990	-3.8%	1011	-1.7%	1082	5.2%	1061	3.1%
North - South	4793	4843	1.0%	4742	-1.1%	4771	-0.5%	4839	1.0%
North - West	1839	1906	3.6%	1918	4.3%	1867	1.5%	1995	8.5%
East - South	1666	1655	-0.7%	1687	1.3%	1699	2.0%	1738	4.3%
East - West	5717	5872	2.7%	5753	0.6%	5797	1.4%	5757	0.7%
East - North	789	804	1.9%	814	3.2%	814	3.2%	794	0.6%
South - West	2258	2210	-2.1%	2210	-2.1%	2212	-2.0%	2137	-5.4%
South - North	2486	2479	-0.3%	2524	1.5%	2534	1.9%	2521	1.4%
South - East	1159	1100	-5.1%	1184	2.2%	1167	0.7%	1194	3.0%

Table 2.10 - M60 J18 – Observed Vehicle Analysis – Traffic Flow

2.9 Observed Vehicles Summary

Increasing the number of observed vehicles appeared to improve driver behaviour and consequently, either increased the flow of vehicles through the networks or had marginal effects on journey times.

2.10 Reaction Time

The reaction time is again a global modelling parameter that influences driver behaviour and, through its very nature, section capacities. In theory the lower the reaction time the higher the section and on-ramp capacities as drivers react more quickly to a change in prevailing conditions. The default value for the reaction time is 0.75 seconds, this test ran the scenario simulations with reaction time values of between 0.65 and 0.85 in increments of 0.05.

Figure 2.14 illustrates the effect of varying the reaction time parameter on travel times through a congested network. It is apparent that there is a significant relationship between the travel time and reaction time parameters, with the increase in reaction time resulting in an increase in travel time approximately equal across all routes. Table 2.11 shows that a typical increase in reaction of 30% results in a journey time increase in excess of 100%. With this increased journey time there is an associated build up of queuing and congestion within the network resulting in a decrease in vehicle throughput, typically in the order of 25%.

As with for previous tests, the results for the M60 J16 to J17 and M60 Junction 18 models display negligible impact from the adjustment of this parameter with no network congestion.

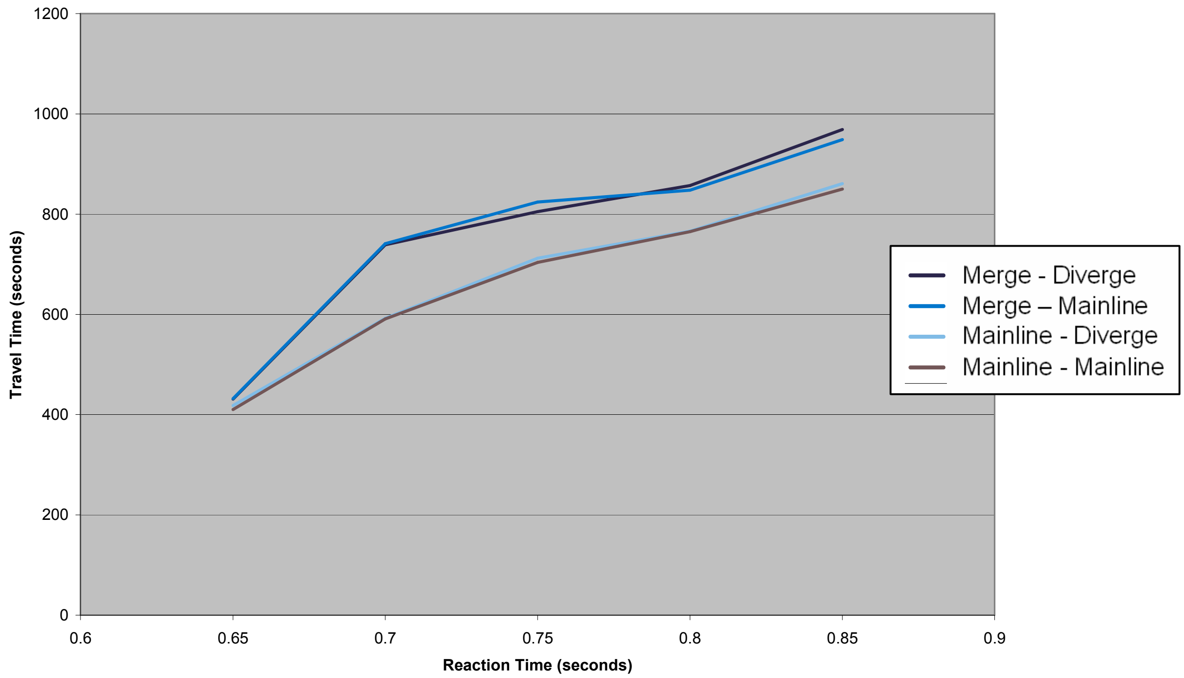

Figure 2.14 - M62 J26 to J27 – Reaction Time Analysis

ttime	Reaction Time (seconds)								
Route	0.75 (def)	0.65		0.70		0.80		0.85	
	ttime (s)	ttime (s)	% dif	ttime (s)	% dif	ttime (s)	% dif	ttime (s)	% dif
Mainline Mainline	704	410	-41.8%	591	-16.1%	765	8.7%	850	20.7%
Mainline Diverge	712	418	-41.3%	592	-16.9%	766	7.6%	861	20.9%
Merge Mainline	824	432	-47.6%	741	-10.1%	848	2.9%	949	15.2%
Merge Diverge	805	431	-46.5%	739	-8.2%	857	6.5%	969	20.4%

nveh	Reaction Time (seconds)								
Route	0.75 (def)	0.65		0.70		0.80		0.85	
	nveh	nveh	% dif	nveh	% dif	nveh	% dif	nveh	% dif
Mainline Mainline	1439	1612	12.0%	1573	9.3%	1432	-0.5%	1278	-11.2%
Mainline Diverge	1629	1789	9.8%	1756	7.8%	1563	-4.1%	1407	-13.6%
Merge Mainline	562	672	19.6%	562	0.0%	518	-7.8%	437	-22.2%
Merge Diverge	922	1183	28.3%	998	8.2%	873	-5.3%	809	-12.3%

Table 2.11 - M62 J26 to J27 – Reaction Time Analysis

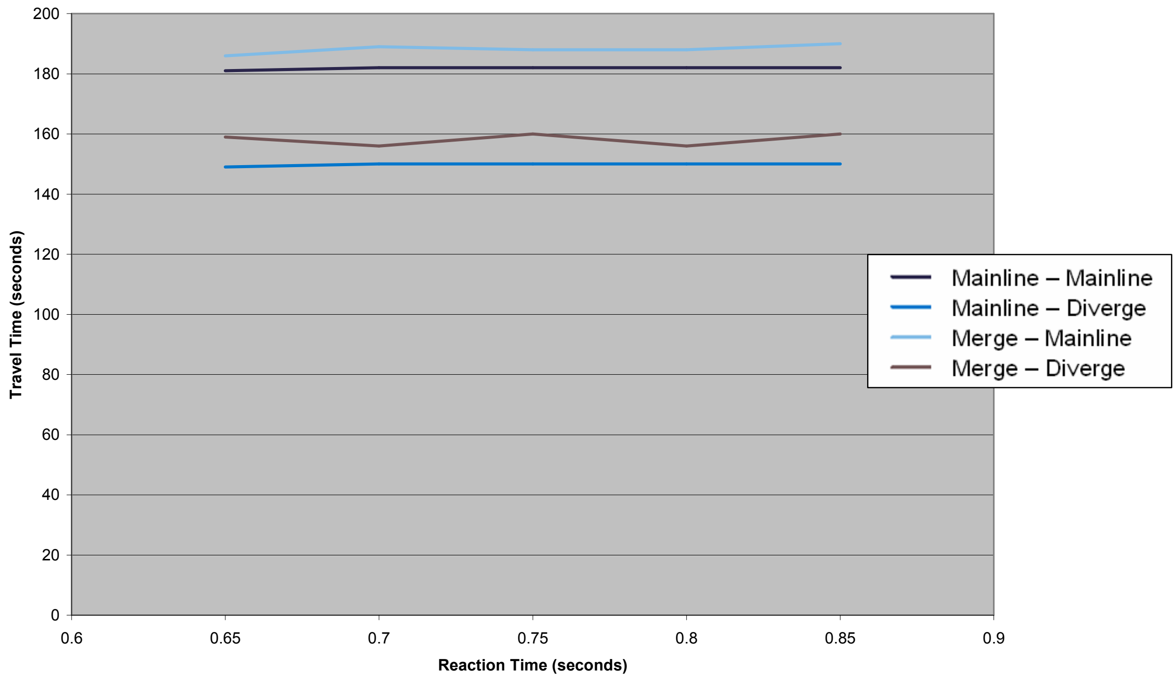

Figure 2.15 M60 J16 to J17 – Reaction Time Analysis

ttime	Reaction Time (seconds)								
Route	0.75 (def)	0.65		0.70		0.80		0.85	
	ttime (s)	ttime (s)	% dif	ttime (s)	% dif	ttime (s)	% dif	ttime (s)	% dif
Mainline Mainline	182	181	-0.5%	182	0.0%	182	0.0%	182	0.0%
Mainline Diverge	150	149	-0.7%	150	0.0%	150	0.0%	150	0.0%
Merge Mainline	188	186	-1.1%	189	0.5%	188	0.0%	190	1.1%
Merge Diverge	160	159	-0.6%	156	-2.5%	156	-2.5%	160	0.0%

nveh	Reaction Time (seconds)								
Route	0.75 (def)	0.65		0.70		0.80		0.85	
	nveh	nveh	% dif	nveh	% dif	nveh	% dif	nveh	% dif
Mainline Mainline	4949	4972	0.5%	5202	5.1%	5150	4.1%	5106	3.2%
Mainline Diverage	469	417	-11.1%	448	-4.5%	468	-0.2%	426	-9.2%
Merge Mainline	563	504	-10.5%	520	-7.6%	515	-8.5%	471	-16.3%
Merge Diverge	25	28	12.0%	24	-4.0%	25	0.0%	33	32.0%

Table 2.12 - M60 J16 to J17 – Reaction Time Analysis

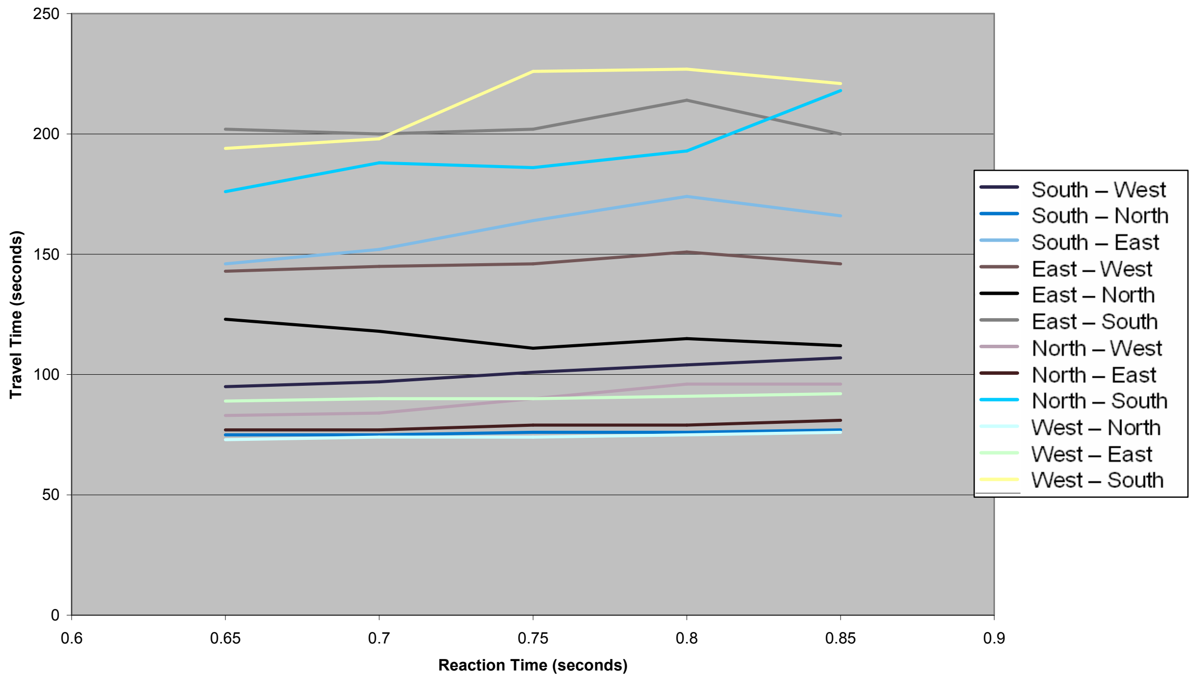

Figure 2.16 M60 J18 – Reaction Time Analysis

ttime	Reaction Time (seconds)								
Route	0.75 (def)	0.65		0.70		0.80		0.85	
	ttime (s)	ttime (s)	% dif	ttime (s)	% dif	ttime (s)	% dif	ttime (s)	% dif
West - North	146	143	-2.1%	145	-0.7%	151	3.4%	146	0.0%
West - East	111	123	10.8%	118	6.3%	115	3.6%	112	0.9%
West - South	202	202	0.0%	200	-1.0%	214	5.9%	200	-1.0%
North - East	90	83	-7.8%	84	-6.7%	96	6.7%	96	6.7%
North - South	79	77	-2.5%	77	-2.5%	79	0.0%	81	2.5%
North - West	186	176	-5.4%	188	1.1%	193	3.8%	218	17.2%
East - South	74	73	-1.4%	74	0.0%	75	1.4%	76	2.7%
East - West	90	89	-1.1%	90	0.0%	91	1.1%	92	2.2%
East - North	226	194	-14.2%	198	-12.4%	227	0.4%	221	-2.2%
South - West	101	95	-5.9%	97	-4.0%	104	3.0%	107	5.9%
South - North	76	75	-1.3%	75	-1.3%	76	0.0%	77	1.3%
South - East	164	146	-11.0%	152	-7.3%	174	6.1%	166	1.2%

Table 2.13a - M60 J18 – Reaction Time Analysis – Travel Time

nveh	Reaction Time (seconds)								
Route	0.75 (def)	0.65		0.70		0.80		0.85	
	nveh	nveh	% dif	nveh	% dif	nveh	% dif	nveh	% dif
West - North	1641	1650	0.5%	1640	-0.1%	1740	6.0%	1683	2.6%
West - East	5232	5287	1.1%	5065	-3.2%	5202	-0.6%	5321	1.7%
West - South	1823	1920	5.3%	1850	1.5%	1868	2.5%	1809	-0.8%
North - East	1011	1033	2.2%	1037	2.6%	1030	1.9%	1015	0.4%
North - South	4742	4694	-1.0%	4761	0.4%	4830	1.9%	4799	1.2%
North - West	1918	1909	-0.5%	1991	3.8%	1858	-3.1%	1947	1.5%
East - South	1687	1734	2.8%	1667	-1.2%	1705	1.1%	1759	4.3%
East - West	5753	5855	1.8%	5787	0.6%	5913	2.8%	5863	1.9%
East - North	814	865	6.3%	805	-1.1%	844	3.7%	811	-0.4%
South - West	2210	2230	0.9%	2204	-0.3%	2191	-0.9%	2106	-4.7%
South - North	2524	2551	1.1%	2443	-3.2%	2496	-1.1%	2523	0.0%
South - East	1184	1153	-2.6%	1119	-5.5%	1171	-1.1%	1118	-5.6%

Table 2.13b - M60 J18 – Reaction Time Analysis – Traffic Flow

2.11 Reaction Time Summary

In congested conditions reducing the Reaction Time had a significant effect on journey time and throughput. This would suggest that this parameter must be used with caution especially in future year and 'Do-something' scenarios as the model may over estimate performance with reduced Reaction Time values.

2.12 Look Ahead Distance

The Look Ahead distance is another global AIMSUN parameter that influences driver behaviour. In theory the greater the Look Ahead distance the smoother the traffic flow and merge behaviour. The Look Ahead distance was tested at 25, 50, 100, 150 and 200 metres.

In the congested network (M62 J26 – J27), increasing the Look Ahead distance appeared to improve conditions resulting in slightly reduced journey time although there was no change of note to the flow through network.

In the uncongested and signalised junction networks the changes to the Look Ahead distance did not produce any significant changes to the journey time or flow through the networks.

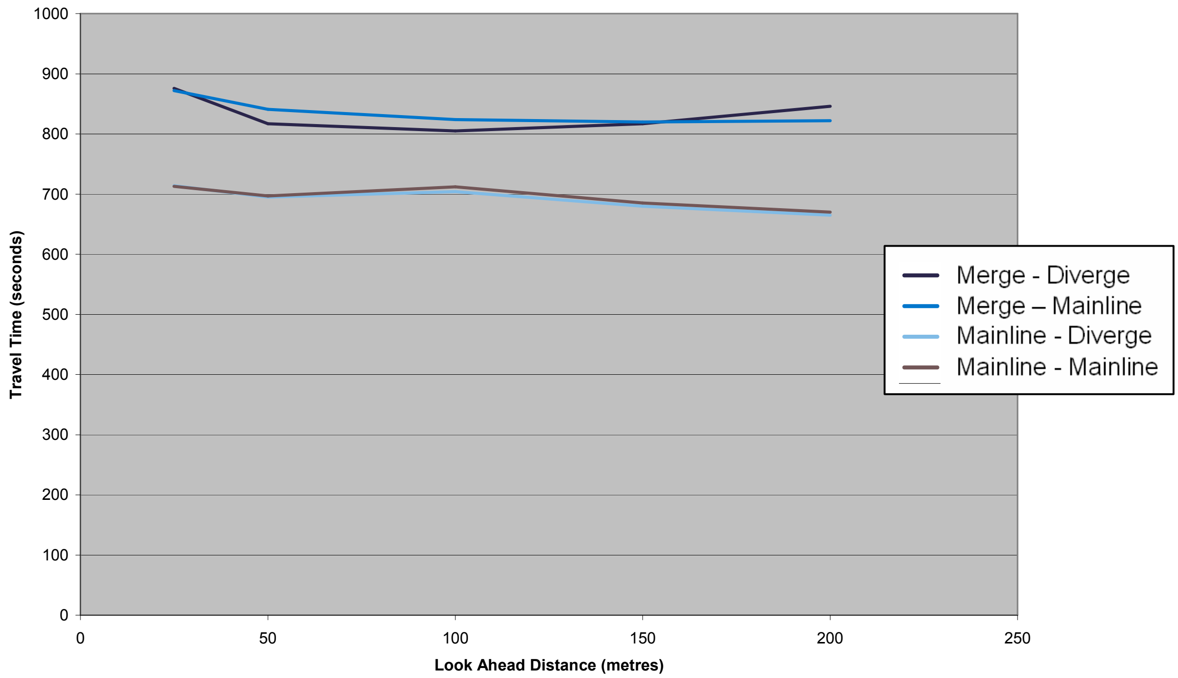

Figure 2.17 - M62 J26 to J27 – Look Ahead Distance Analysis

Ttime	Look Ahead Distance (metres)								
Route	25	50		100		150		200	
	ttime (s)	ttime (s)	% dif	ttime (s)	% dif	ttime (s)	% dif	ttime (s)	% dif
Mainline Mainline	714	695	-2.7%	704	-1.4%	680	-4.8%	665	-6.9%
Mainline Diverge	713	697	-2.2%	712	-0.1%	685	-3.9%	670	-6.0%
Merge Mainline	872	841	-3.6%	824	-5.5%	820	-6.0%	822	-5.7%
Merge Diverge	876	817	-6.7%	805	-8.1%	817	-6.7%	846	-3.4%

Nveh	Look Ahead Distance (metres)								
Route	25	50		100		150		200	
	nveh	nveh	% dif	nveh	% dif	nveh	% dif	nveh	% dif
Mainline Mainline	1540	1549	0.6%	1439	-6.6%	1522	-1.2%	1584	2.9%
Mainline Diverge	1667	1654	-0.8%	1629	-2.3%	1606	-3.7%	1548	-7.1%
Merge Mainline	518	527	1.7%	562	8.5%	537	3.7%	517	-0.2%
Merge Diverge	916	908	-0.9%	922	0.7%	888	-3.1%	919	0.3%

Table 2.14 - M62 J26 to J27 – Look Ahead Distance Analysis

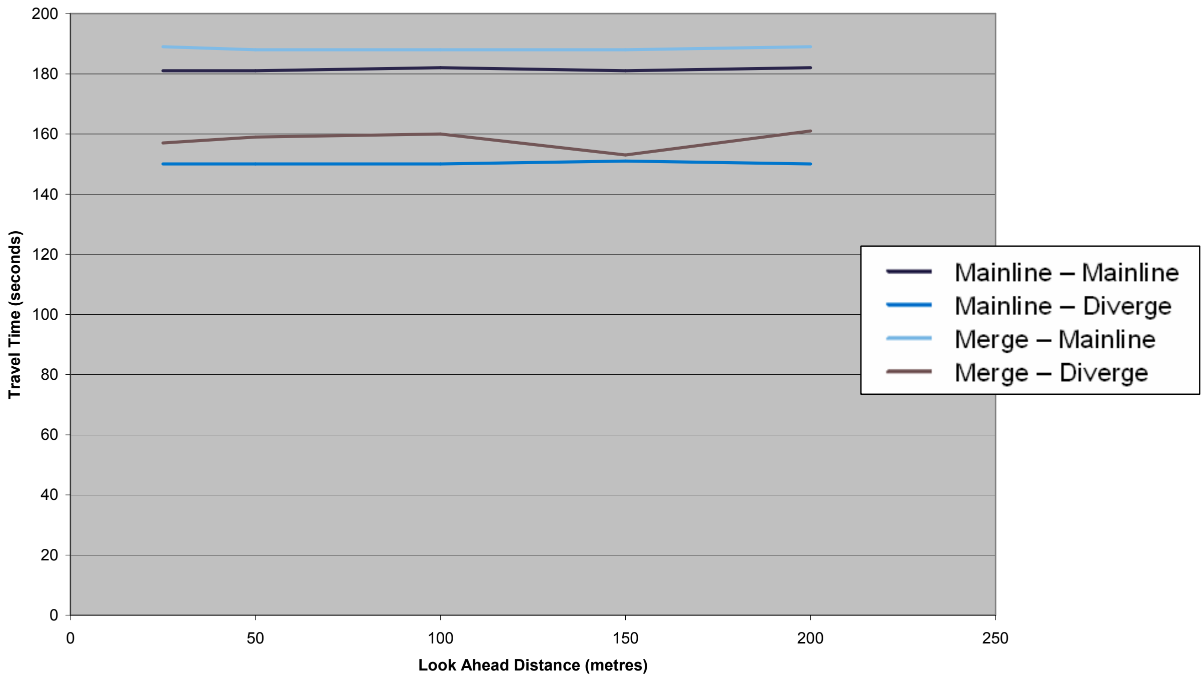

Figure 2.18 - M60 J16 to J17 – Look Ahead Distance Analysis

ttime	Look Ahead Distance (metres)								
Route	25	50		100		150		200	
	ttime (s)	ttime (s)	% dif	ttime (s)	% dif	ttime (s)	% dif	ttime (s)	% dif
Mainline Mainline	181	181	0.0%	182	0.6%	181	0.0%	182	0.6%
Mainline Diverge	150	150	0.0%	150	0.0%	151	0.7%	150	0.0%
Merge Mainline	189	188	-0.5%	188	-0.5%	188	-0.5%	189	0.0%
Merge Diverge	157	159	1.3%	160	1.9%	153	-2.5%	161	2.5%

nveh	Look Ahead Distance (metres)								
Route	25	50		100		150		200	
	nveh	nveh	% dif	nveh	% dif	nveh	% dif	nveh	% dif
Mainline Mainline	4915	5001	1.7%	4949	0.7%	4977	1.3%	5245	6.7%
Mainline Diverge	420	454	8.1%	469	11.7%	466	11.0%	503	19.8%
Merge Mainline	501	514	2.6%	563	12.4%	505	0.8%	514	2.6%
Merge Diverge	28	19	-32.1%	25	-10.7%	25	-10.7%	28	0.0%

Table 2.15 - M60 J16 to J17 – Look Ahead Distance Analysis

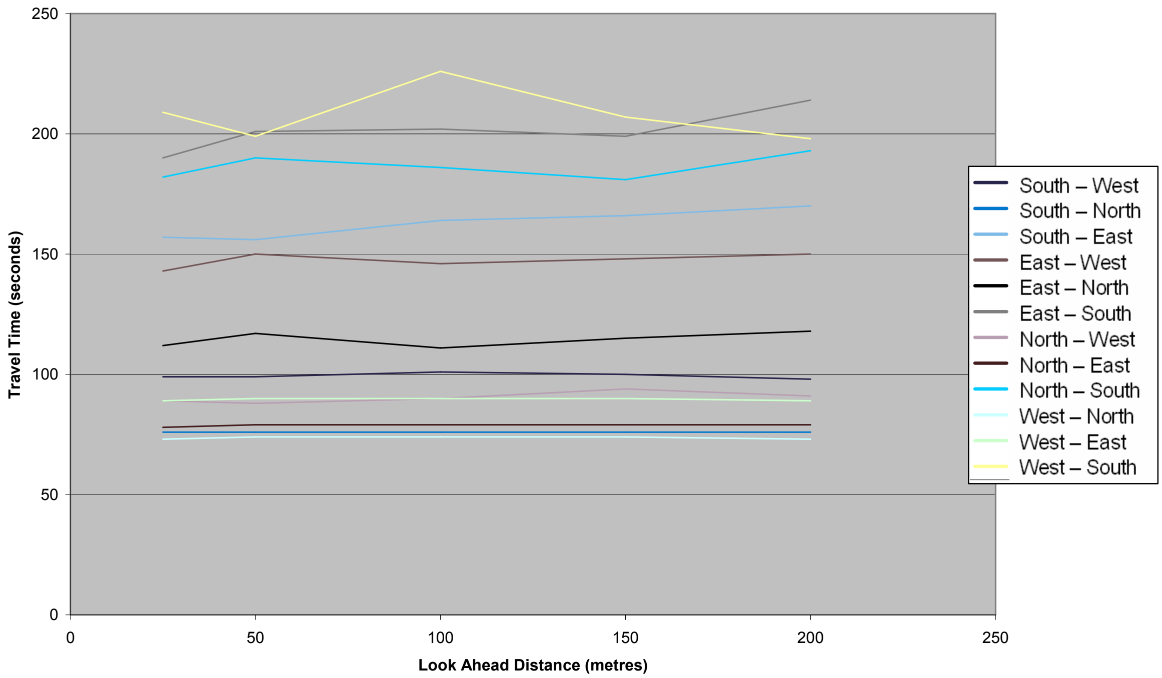

Figure 2.19 - M60 J18 – Look Ahead Distance Analysis

ttime	Look Ahead Distance (metres)								
Route	25	50		100		150		200	
	ttime (s)	ttime (s)	% dif	ttime (s)	% dif	ttime (s)	% dif	ttime (s)	% dif
West - North	143	150	4.9%	146	2.1%	148	3.5%	150	4.9%
West - East	112	117	4.5%	111	-0.9%	115	2.7%	118	5.4%
West - South	190	201	5.8%	202	6.3%	199	4.7%	214	12.6%
North - East	89	88	-1.1%	90	1.1%	94	5.6%	91	2.2%
North - South	78	79	1.3%	79	1.3%	79	1.3%	79	1.3%
North - West	182	190	4.4%	186	2.2%	181	-0.5%	193	6.0%
East - South	73	74	1.4%	74	1.4%	74	1.4%	73	0.0%
East - West	89	90	1.1%	90	1.1%	90	1.1%	89	0.0%
East - North	209	199	-4.8%	226	8.1%	207	-1.0%	198	-5.3%
South - West	99	99	0.0%	101	2.0%	100	1.0%	98	-1.0%
South - North	76	76	0.0%	76	0.0%	76	0.0%	76	0.0%
South - East	157	156	-0.6%	164	4.5%	166	5.7%	170	8.3%

Table 2.16a - M60 J18 – Look Ahead Distance Analysis – Travel Time

nveh	Look Ahead Distance (metres)								
Route	25	50		100		150		200	
	nveh	nveh	% dif	nveh	% dif	nveh	% dif	nveh	% dif
West - North	1640	1689	3.0%	1641	0.1%	1609	-1.9%	1697	3.5%
West - East	5137	5247	2.1%	5232	1.8%	5242	2.0%	5267	2.5%
West - South	1780	1810	1.7%	1823	2.4%	1838	3.3%	1864	4.7%
North - East	1004	1040	3.6%	1011	0.7%	1061	5.7%	1064	6.0%
North - South	4699	4908	4.4%	4742	0.9%	4897	4.2%	4796	2.1%
North - West	1841	1936	5.2%	1918	4.2%	1873	1.7%	1988	8.0%
East - South	1666	1655	-0.7%	1687	1.3%	1700	2.0%	1737	4.3%
East - West	5718	5876	2.8%	5753	0.6%	5797	1.4%	5758	0.7%
East - North	789	802	1.6%	814	3.2%	814	3.2%	795	0.8%
South - West	2270	2217	-2.3%	2210	-2.6%	2206	-2.8%	2140	-5.7%
South - North	2486	2479	-0.3%	2524	1.5%	2534	1.9%	2521	1.4%
South - East	1152	1102	-4.3%	1184	2.8%	1163	1.0%	1195	3.7%

Table 2.16b - M60 J18 – Look Ahead Distance Analysis – Traffic Flow

2.13 Look Ahead Summary

It can be clearly observed that the variation in look ahead parameter had a negligible effect across all three networks with minimal variations in travel times and flows.

2.14 Sensitivity Tests

Sensitivity tests were undertaken to ascertain any impacts of changing the seed value on parameter values. The parameter, Reaction Time, was selected as it previously had been shown to have an impact when changed. Each Reaction Time was replicated with 10 random seed numbers, the results can be seen in Table 2.17 and Graphs 2.20 through to 2.24.

ttime	Reaction Time (seconds) & Random Seed 1 (13842)								
Route	0.75 (def)	0.65		0.70		0.80		0.85	
	ttime (s)	ttime (s)	% dif	ttime (s)	% dif	ttime (s)	% dif	ttime (s)	% dif
Mainline Mainline	528	263	-50.2%	352	-33.3%	582	10.2%	760	43.9%
Mainline Diverge	528	265	-49.8%	354	-33.0%	583	10.4%	767	45.3%
Merge Mainline	551	265	-51.9%	361	-34.5%	600	8.9%	843	53.0%
Merge Diverge	554	265	-52.2%	362	-34.7%	619	11.7%	828	49.5%

Ttime	Reaction Time (seconds) & Random Seed 2 (5187)								
Route	0.75 (def)	0.65		0.70		0.80		0.85	
	ttime (s)	ttime (s)	% dif	ttime (s)	% dif	ttime (s)	% dif	ttime (s)	% dif
Mainline Mainline	556	262	-52.9%	327	-41.2%	631	13.5%	783	40.8%
Mainline Diverge	558	263	-52.9%	330	-40.9%	634	13.6%	787	41.0%
Merge Mainline	600	265	-55.8%	335	-44.2%	691	15.2%	852	42.0%
Merge Diverge	598	265	-55.7%	340	-43.1%	678	13.4%	854	42.8%

ttime	Reaction Time (seconds) & Random Seed 3 (7155)								
Route	0.75 (def)	0.65		0.70		0.80		0.85	
	ttime (s)	ttime (s)	% dif	ttime (s)	% dif	ttime (s)	% dif	ttime (s)	% dif
Mainline Mainline	562	260	-53.7%	346	-38.4%	671	19.4%	806	43.4%
Mainline Diverge	568	269	-52.6%	347	-38.9%	688	21.1%	719	26.6%
Merge Mainline	607	261	-57.0%	352	-42.0%	749	23.4%	867	42.8%
Merge Diverge	603	261	-56.7%	354	-41.3%	738	22.4%	862	43.0%

ttime	Reaction Time (seconds) & Random Seed 4 (5069)								
Route	0.75 (def)	0.65		0.70		0.80		0.85	
	ttime (s)	ttime (s)	% dif	ttime (s)	% dif	ttime (s)	% dif	ttime (s)	% dif
Mainline Mainline	494	264	-46.6%	392	-20.6%	645	30.6%	771	56.1%
Mainline Diverge	498	264	-47.0%	396	-20.5%	661	32.7%	784	57.4%
Merge Mainline	515	266	-48.3%	402	-21.9%	736	42.9%	867	68.3%
Merge Diverge	505	265	-47.5%	401	-20.6%	748	48.1%	862	70.7%

ttime	Reaction Time (seconds) & Random Seed 5 (24175)								
Route	0.75 (def)	0.65		0.70		0.80		0.85	
	ttime (s)	ttime (s)	% dif	ttime (s)	% dif	ttime (s)	% dif	ttime (s)	% dif
Mainline Mainline	562	268	-52.3%	398	-29.2%	648	15.3%	801	42.5%
Mainline Diverge	567	270	-52.4%	404	-28.7%	650	14.6%	806	42.2%
Merge Mainline	568	272	-52.1%	406	-28.5%	696	22.5%	886	56.0%
Merge Diverge	577	273	-52.7%	411	-28.8%	697	20.8%	881	52.7%

ttime	Reaction Time (seconds) & Random Seed 6 (2860)								
Route	0.75 (def)	0.65		0.70		0.80		0.85	
	ttime (s)	ttime (s)	% dif	ttime (s)	% dif	ttime (s)	% dif	ttime (s)	% dif
Mainline Mainline	519	259	-50.1%	359	-30.8%	663	27.7%	807	55.5%
Mainline Diverge	521	262	-49.7%	362	-30.5%	670	28.6%	820	57.4%
Merge Mainline	536	262	-51.1%	365	-31.9%	735	37.1%	871	62.5%
Merge Diverge	535	264	-50.7%	368	-31.2%	743	38.9%	871	62.8%

ttime	Reaction Time (seconds) & Random Seed 7 (13690)								
Route	0.75 (def)	0.65		0.70		0.80		0.85	
	ttime (s)	ttime (s)	% dif	ttime (s)	% dif	ttime (s)	% dif	ttime (s)	% dif
Mainline Mainline	552	261	-52.7%	373	-32.4%	651	17.9%	737	33.5%
Mainline Diverge	550	262	-52.4%	376	-31.6%	656	19.3%	744	35.3%
Merge Mainline	592	266	-55.1%	383	-35.3%	733	23.8%	838	41.6%
Merge Diverge	586	264	-54.9%	384	-34.5%	739	26.1%	848	44.7%

ttime	Reaction Time (seconds) & Random Seed 8 (25002)								
Route	0.75 (def)	0.65		0.70		0.80		0.85	
	ttime (s)	ttime (s)	% dif	ttime (s)	% dif	ttime (s)	% dif	ttime (s)	% dif
Mainline Mainline	582	273	-53.1%	364	-37.5%	615	5.7%	735	26.3%
Mainline Diverge	583	273	-53.2%	368	-36.9%	623	6.9%	741	27.1%
Merge Mainline	586	273	-53.4%	372	-36.5%	643	9.7%	840	43.3%
Merge Diverge	601	275	-54.2%	381	-36.6%	645	7.3%	847	40.9%

ttime	Reaction Time (seconds) & Random Seed 9 (26047)								
Route	0.75 (def)	0.65		0.70		0.80		0.85	
	ttime (s)	ttime (s)	% dif	ttime (s)	% dif	ttime (s)	% dif	ttime (s)	% dif
Mainline Mainline	472	267	-43.4%	310	-34.3%	680	44.1%	750	58.9%
Mainline Diverge	478	268	-43.9%	316	-33.9%	686	43.5%	753	57.5%
Merge Mainline	482	267	-44.6%	321	-33.4%	727	50.8%	799	65.8%
Merge Diverge	486	272	-44.0%	319	-34.4%	744	53.1%	798	64.2%

ttime	Reaction Time (seconds) & Random Seed 10 (25032)								
Route	0.75 (def)	0.65		0.70		0.80		0.85	
	ttime (s)	ttime (s)	% dif	ttime (s)	% dif	ttime (s)	% dif	ttime (s)	% dif
Mainline Mainline	487	261	-46.4%	267	-45.2%	658	35.1%	750	54.0%
Mainline Diverge	487	264	-45.8%	267	-45.2%	664	36.3%	757	55.4%
Merge Mainline	490	265	-45.9%	271	-44.7%	719	46.7%	854	74.3%
Merge Diverge	487	262	-46.2%	271	-44.4%	702	44.1%	850	74.5%

Table 2.17 - M62 Junctions 26 to 27 –Sensitivity Analysis

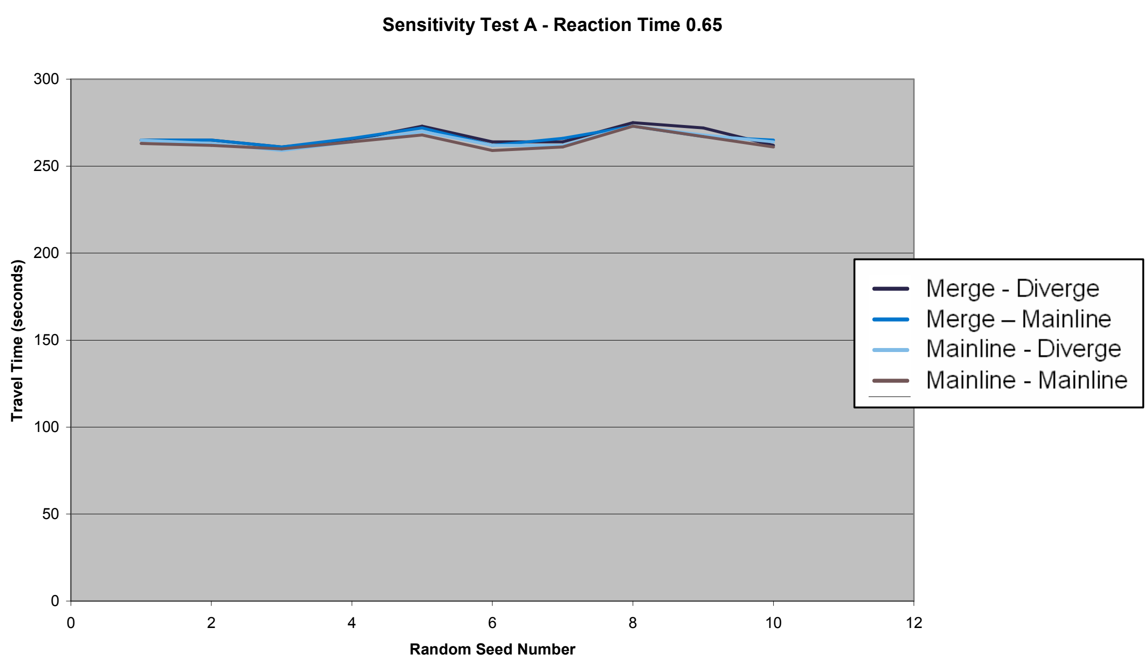

Figure 2.20 - M62 Junctions 26 to 27 - Sensitivity Analysis Reaction Time 0.65s

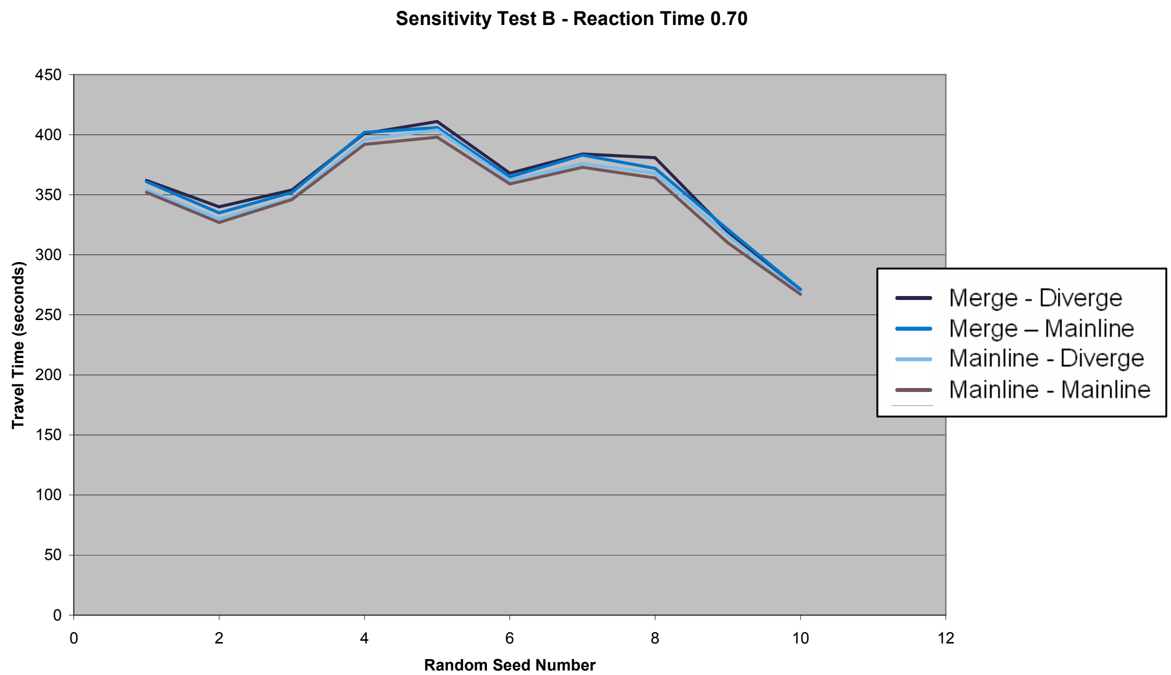

Figure 2.21 - M62 Junctions 26 to 27 - Sensitivity Analysis Reaction Time 0.70s

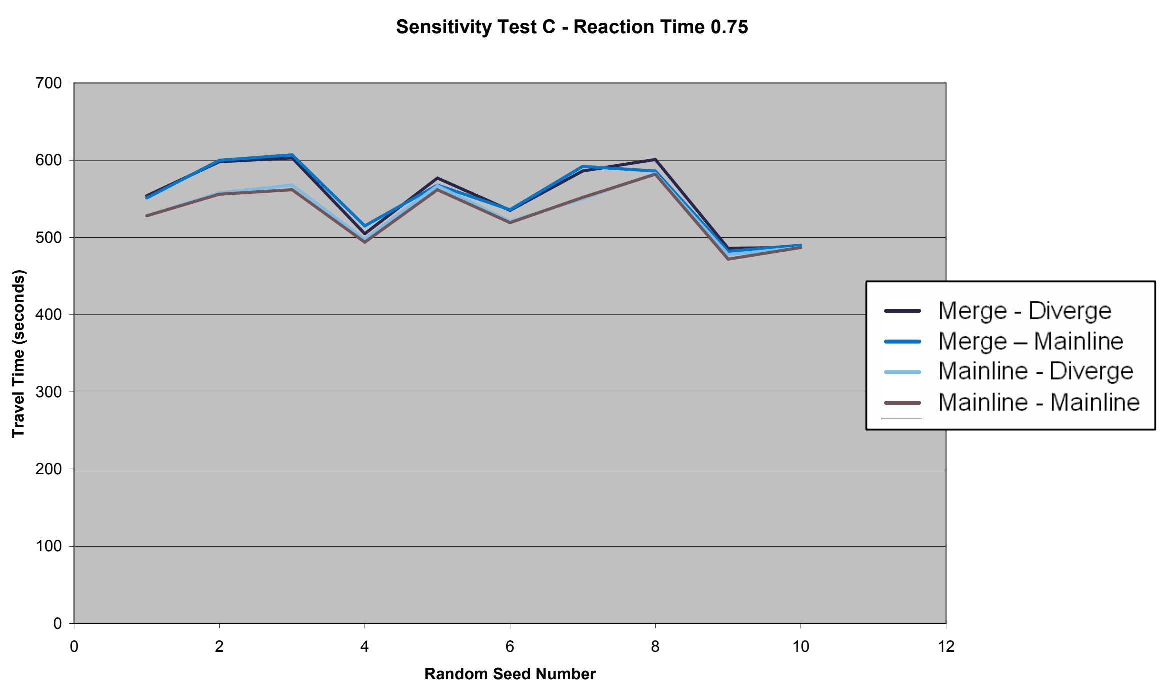

Figure 2.22 - M62 Junctions 26 to 27 - Sensitivity Analysis Reaction Time 0.75s

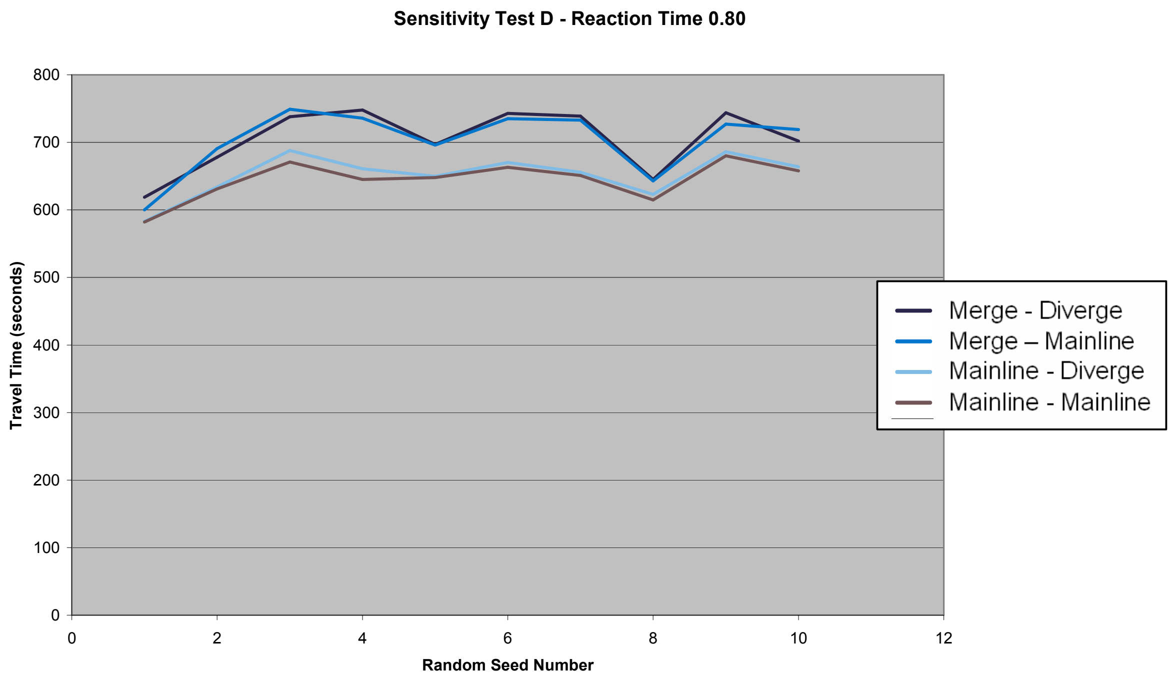

Figure 2.23 - M62 Junctions 26 to 27 - Sensitivity Analysis Reaction Time 0.80s

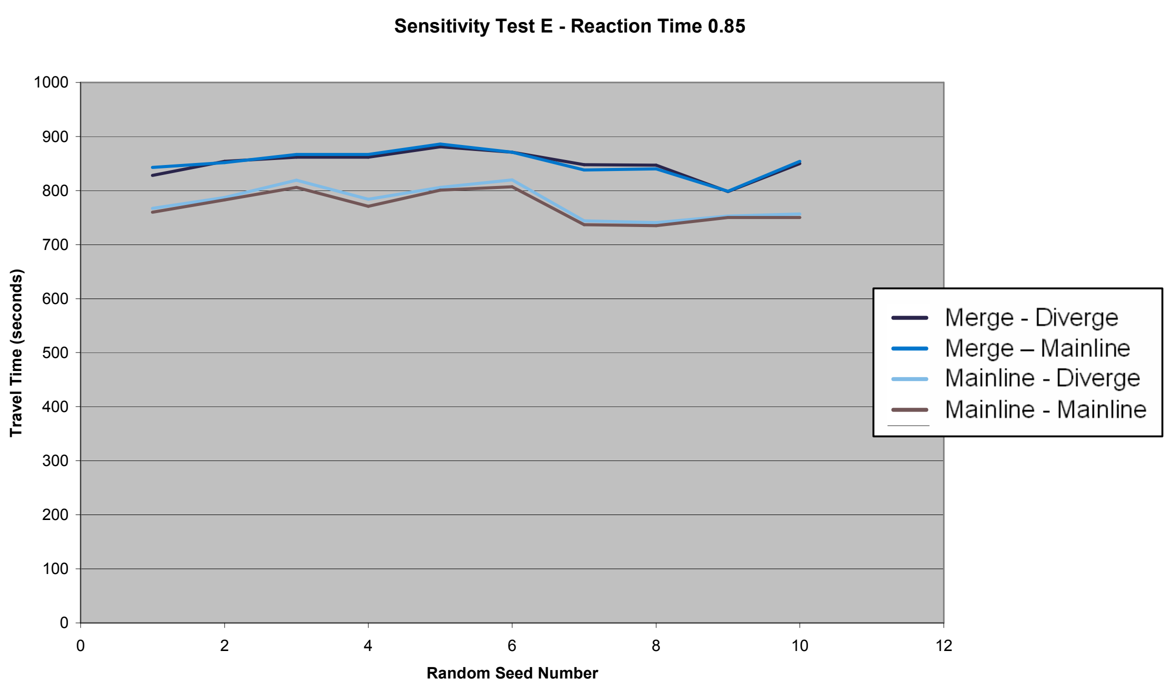

Figure 2.24 - M62 Junctions 26 to 27 - Sensitivity Analysis Reaction Time 0.85s

2.15 Conclusion

Whilst a number of key global parameters were tested for sensitivity the results obtained show that changes to the parameters had little effect on many of the network scenarios. In summary:

- In congested conditions changes to the Random Seed could result on changes to journey times greater than the expected +/-5%.
- Gradient changes had little or no impact on journey time.
- In uncongetsed conditions journey times increased with increasing demand. In congested conditions, where the model could not accommodate increased demand, journey times reached a peak.
- Increasing the Number of Observed vehicles reduced the journey time in congested conditions.
- Changing the Reaction Time had significant impact on the Journey Time in congested conditions. There was little impact in the other networks.
- Increasing the Look Ahead Distance slightly reduced journey times in congested conditions with little impact in the alternative networks.

The parameters clearly had a more significant impact on the congested M62 J26 to J27 network, and a far lesser impact on the signalised M60 J18 and free flowing / gradient model of the M60 J16 to J17.

3 Paramics

Paramics – Summary of Findings

Outlined below are the findings from the model testing that was undertaken with Paramics software on a variety of networks which are described in detail in the main report. The version of the software that was used during the course of this work was Paramics 2005.1. Models of the following sections of motorway were used for testing purposes;

- M62 between Junctions 26 and 27 – congested network with merge, diverge and weaving;
- M60 J16-J17 – relatively free flow with gradients and;
- M60 J18 – congested signalised junction.

These networks contain different conditions experienced on the Highways Agency's network, providing a wide ranging 'test bed' on which to investigate the sensitivity of the software.

The parameters tested were identified by the software developers as being important to the performance of the model.

- **Demand Rate Summary**

In the M62 J26-J27 network a 10% increase in the demand resulted in car journey times increasing by up to 50% while HGV journey times increased by up to 30%. However, in the M60 J18 network a 10% increase in demand increased journey times by up to 75% for certain movements.

- **Random Seed Summary**

In congested conditions the journey times varied by up to 9% for mainline traffic and 25% for slip traffic. Lane usage and speeds did not vary significantly.

Random seed has a greater impact on merge/diverge models than signal controlled junctions.

The random seed tests indicated that there are no effects on vehicle demands and relatively small impacts on vehicle throughput.

SIAS comment:

> *S-Paramics has two release algorithms. One is precise to within one whole vehicle of the demand requested in the OD matrix. The other converts the demand to a probability of a release in each second to be evaluated throughout the simulation and therefore will vary with the random seed. The models sent to SIAS used precise mode only and therefore this observation is correct: no variation should be seen. If investigation into the variation is required then more tests will be necessary*

- **Headway Summary**

For changes in the Headway from 1s to 3s, the M62 network journey times increased by up to 130%. However, on the M18 the journey time increased by almost 200% for certain movements.

The headway parameter affects journey times to a greater extent in signalised models; this is due to the reduced stop line capacity when vehicles are driving further apart. Consequently, this leads to increased journey times, especially when a movement is close to capacity.

At low speeds (<10mph), or the 'crawl speed' as referred to in Paramics, vehicle headway is controlled by the minimum Gap parameter which defaults to 1m. As speeds increase beyond this, the headway is also influenced by vehicle speed and increased vehicle headway is observed. The minimum gap of 1m may impact on throughput in congested networks.

- **Minimum Gap(m) Summary**

For the M62 network, journey times for slip traffic increased with the minimum gap length for merging traffic throughout the parameter range investigated. As minimum gap is reduced vehicles queue/crawl closer together. Under congested network conditions a small gap parameter allows the queued slip traffic to access the main line more easily. Increasing or decreasing minimum gap did not appear to significantly alter lane usage.

On the M60 network journey times increased throughout the parameter range except for the North to West movement, which is under capacity. The South to East Movement journey time increased greatly at gap greater than 2m. At this point the platoon of circulating vehicles is disrupted by queues that start to block back from signals.

- **Aggression Summary**

In the congested M62 network adoption of Distribution A improved journey times for merging traffic while Distribution B increased the journey time for all traffic. Using the Square Distribution also resulted in increased journey times. This is because distribution A contains more aggressive drivers who change lanes more often and accept smaller gaps, thus increasing capacity

However, in the less congested M60 model use of Distribution A and B had little effect on journey times. This is because vehicle behaviour parameters limited impact on behaviour at signals as lane choice and capacity are fixed by the network characteristics.

- **Awareness Summary**

In the congested M62 network adoption of Distribution A improved journey times for all traffic while Distribution B increased the journey time for merging traffic but reduced it for the mainline traffic. The Square Distribution increased the journey time for all traffic, especially slip movements. In general, more aware drivers will accept smaller gaps and changing Awareness had less impact than changing Aggression.

In the less congested M60 network changing Awareness had little effect due to limited impact of vehicle behaviour characteristics on model behaviour at signalised junctions.

- **Overtaking Desire Summary**

Within Paramics it should be noted that 'overtaking' and passing' are considered as separate events. 'Overtaking' would occur on single carriageway links and according to the manual, selecting overtaking on a link *'flags that overtaking on the link can use the other side of the road, i.e. against oncoming traffic'*. 'Passing' is the act of moving to an available adjacent lane to pass a slower moving vehicle ie the offside lane of a dual carriageway or motorway.

Consequently, while 'overtaking' was identified as an important vehicle behaviour factor by SIAS in the Questionnaire, for a motorway model this would be inappropriate. Also, given that networks are most often coded as separate one-way links, not possible to model.

- **Acceleration Profiles**

The acceleration profile for all vehicle types defaults as a flat profile, vehicle characteristics such as drag and inertia can be set to alter this distribution. We have modified these variables to create a linear acceleration profile. The effect of altering acceleration profiles on journey times in the M62 J26-7 network are summarised below:

  - Modified acceleration profile increased journey time for all vehicles.
  - The effect is more marked for slip trips.
  - Modified acceleration profile alters lane usage as reducing acceleration at high speed reduces ability of vehicles to overtake.

- **HGV Length**

The effect of increasing HGV length in the M62 J26-7 network was to increase journey times for all movements.

- **Gradients**

It should be noted that Paramics 2005.1 contains two deceleration models:

- Pre 2002.1 model
- New model.

The pre 2002.1 model is used as the default so as not to adversely affect previously calibrated models, but the new model more accurately describes the behaviour of OGV on inclines

- The results show that with the pre-2002.1 model a positive gradient does not significantly alter the speed distribution of OGV1 and OGV2
- Under a positive gradient the speed distribution is reduced significantly

However:

- The new deceleration model should be used as it more realistically represents vehicle behaviour.
- The effect of the new deceleration model at steep inclines (~2.5%) is to reduce maximum speed of HGVs significantly, down to 30mph in the M60 J16-J17 test model.
- The new deceleration model does not increase vehicle speeds above the vehicle maximum when travelling down hill.

- **Parameter Sensitivity to Seed Change**

- As expected, there is some variance in the results when the models are assigned using different seeds.
- There are no significant deviations from the trend reported from one seed when using alternative seed values
- For traffic entering form the main carriageway, the different seeds give the greatest variation in the journey times for the smallest or largest headways.
- The journey times of traffic entering from the slips varies more consistently across all of the different headways.

Paramics

3.1 Introduction

Outlined below are the findings from the model testing that was undertaken with Paramics software on a variety of networks which are described in detail in the main report. The version of the software that was used during the course of this work was S-Paramics 2005.1. Models of the following sections of motorway were used for testing purposes;

- M62 between Junctions 26 and 27 – congested network with merge, diverge and weaving;
- M60 J16-J17 – relatively free flow with gradients and;
- M60 J18 – congested signalised junction.

These networks contain different conditions experienced on the Highways Agency's network, providing a wide ranging 'test bed' on which to investigate the sensitivity of the software.

The parameters tested were identified by the software developers as being important to the performance of the model.

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M62 between Junctions 26 and 27

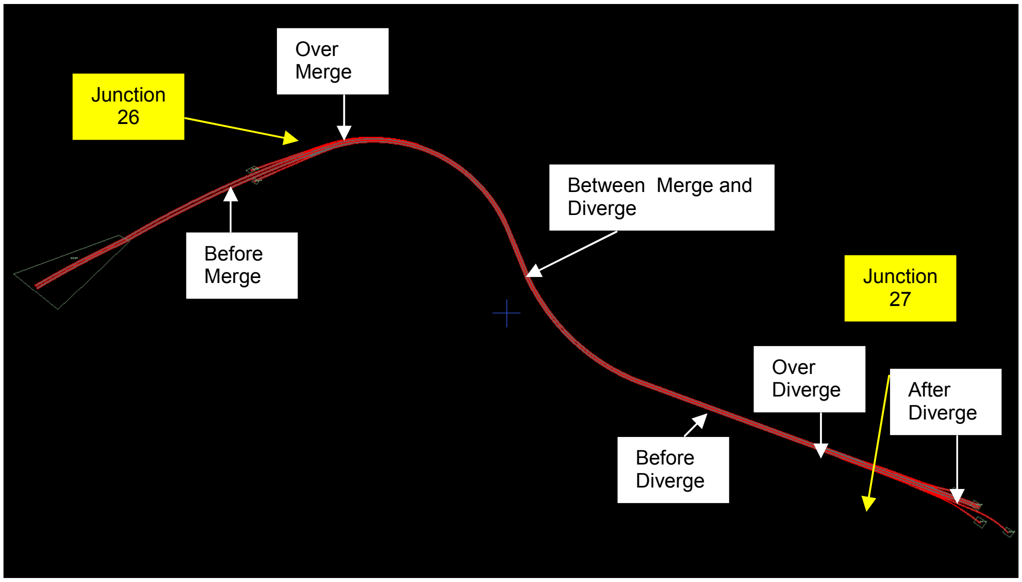
The motorway network in this area experiences dense traffic with a high incidence of lane changes due to heavy merging and diverging flows. This situation provides a robust platform on which to assess the relative impacts of varying the input parameters.

Test results for this network are given for the following four routes:

- Traffic remaining on the main carriageway of the motorway throughout the journey
- Traffic accessing the network through the main carriageway and leaving the motorway at the diverge
- Traffic entering the motorway at the merge and continuing on the mainline for the rest of the journey; and
- Traffic joining the motorway at the merge and leaving it at the diverge slip road

Flows and speeds by lane have been recorded at the following key points:

- Before merge
- Over merge
- Between merge and diverge
- Before diverge
- Across diverge
- After diverge



J18 of the M60

This test network is used to test the impact of parameter changes on the flow of traffic around a motorway roundabout. The network models the four exit roundabout at J18 of the M60. The following four routes through the network are available:

- North to West
- East to North
- South to East
- West to South

The first two movements exhibit low demand in the original set-up, whilst the latter two are characterised by fairly high demand.

M60 J16-J17

This test network is used to test the impact of gradients on HGV speeds.

Variables

The impact of varying the following parameters around their standard values has been investigated.

- Demand rate
- Random Seed
- Headway
- Gap
- Aggression
- Awareness
- Overtaking
- Acceleration profile
- HGV length

All variables have a default value when a blank model is opened; guidance and good practice dictates that some of these 'default' values should be changed to standard values.

The default and standard values for the parameters above are shown below in Table 3.1

Parameter	Default Value	Standard Value
Demand rate	100%	100%
Random Seed	0	-
Headway	1sec	1sec
Gap	2m	1m
Aggression	Normal distribution	Normal distribution
Awareness	Normal distribution	Normal distribution
Overtaking	Off	Off

Table 3.1 - Default Parameter Settings

Each variable has been changed independently and the flow, journey time and lane-use variation measured at key locations. The mean journey time from origin to destination has been evaluated by vehicle class.

3.2 Test 1 – Demand Rate

The purpose of this test is to investigate the impact of exceeding network capacity on modelled journey time and throughput. It is important to establish whether model behaviour at flow breakdown is realistic.

Parameter	Demand Rate	
Description	The demand rate scales the total demand for all vehicle types and periods.	
Possible Variation		
Test Variables	100%	- Default
	110%	
	120%	
	130%	
	140%	
	150%	

The effect of increasing the demand rate on journey times in the M62 J26-J27 network are given in Figures 3.1a/3.1b and Table 3.2. Tables 3.3 – 3.4 give an overview of flows and speeds by lane at key points.

Key Observations – M62 J26-J27

- This network is heavily congested in the base case (100% demand) exceeding this results in flow breakdown at the merge and diverge points. This breakdown results in queuing and shock waves which further disrupt behaviour.
- Increasing demand leads to a growth in car and HGV journey time; 10% growth in demand added approximately 20% to 50% to car journey times depending on the route taken through the network.
- HGV journey times increased between 20% and 35% in response to a 10% increase in demand.
- Movements originating on the mainline were more responsive to an increase in the level of demand.

Lane usage changes little with demand. The only discernable difference appears downstream from the diverge where utilisation of the left-most lane is higher at high levels of demand.

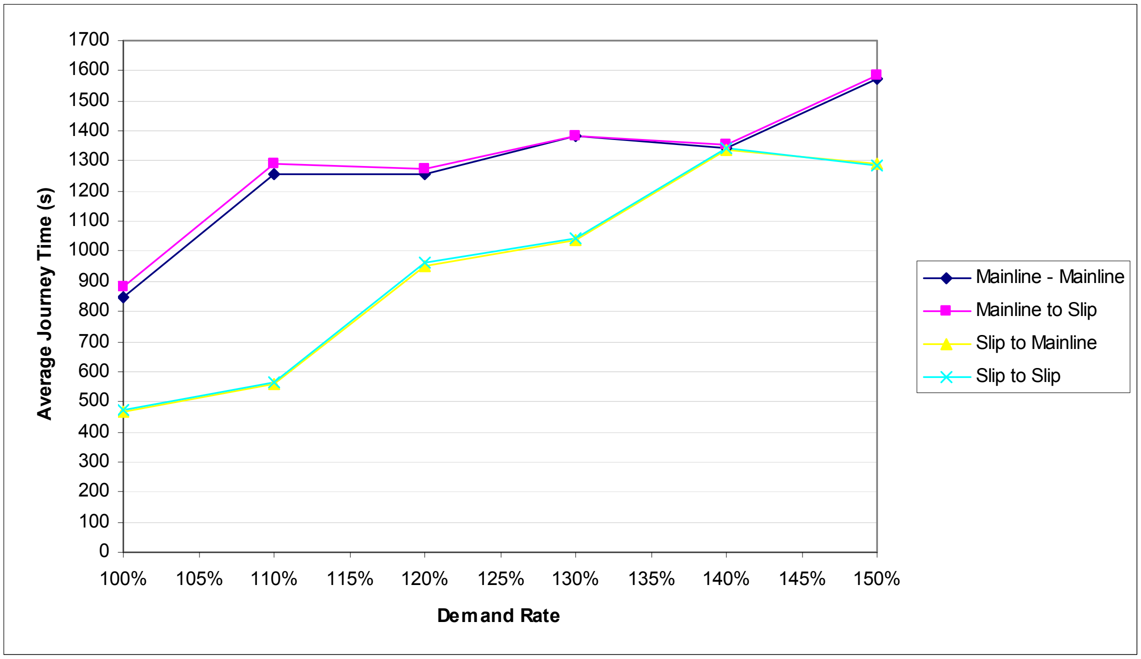


Figure 3.1a – M62 J26 - J27 Demand Rate Variation – lights

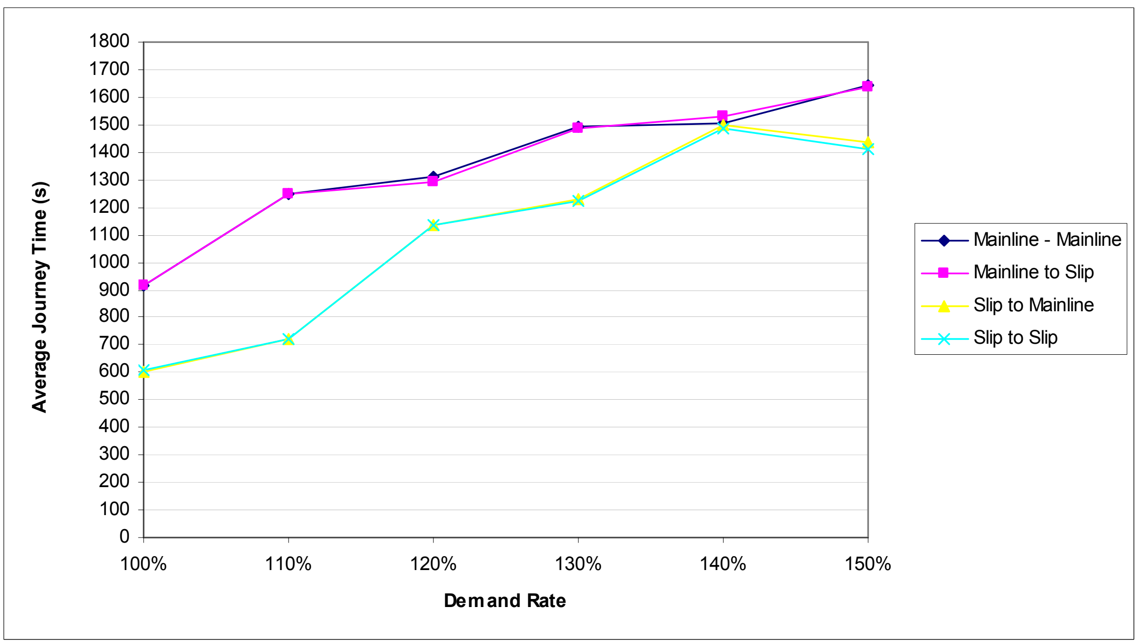


Figure 3.1b – M62 J26 – J27 Demand Rate Variation – HGVs

Zone Movement	Demand	Cars Mean Journey Time (s)	Cars % difference from the default journey time	HGV Mean Journey Time (s)	HGV % difference from the default journey time
Mainline - Mainline	100%	848	-	913	-
	110%	1255	48%	1245	36%
	120%	1258	48%	1312	44%
	130%	1384	63%	1490	63%
	140%	1345	59%	1506	65%
	150%	1573	85%	1643	80%
Mainline to Slip	100%	879	-	915	-
	110%	1292	47%	1248	36%
	120%	1276	45%	1295	41%
	130%	1383	57%	1485	62%
	140%	1356	54%	1533	68%
	150%	1583	80%	1637	79%
Slip to Mainline	100%	464	-	603	-
	110%	562	21%	724	20%
	120%	950	104%	1136	88%
	130%	1040	124%	1229	104%
	140%	1337	188%	1499	149%
	150%	1289	177%	1434	138%
Slip to Slip	100%	473	-	606	-
	110%	563	19%	724	19%
	120%	961	103%	1137	88%
	130%	1044	121%	1220	101%
	140%	1343	184%	1487	145%
	150%	1286	172%	1413	133%

Table 3.2 – M62 J26-J27: Journey time variation with different demand rate parameters

Location	Lane number	Lane key	Demand 100%	110%	120%	130%	140%	150%
Before Merge	1	Main Carriageway	42%	46%	45%	44%	45%	45%
	2	Main Carriageway	35%	36%	34%	32%	33%	33%
	3	Main Carriageway	23%	18%	21%	24%	23%	23%
Across Merge	1-2	Slip Road						
	3	Main Carriageway	28%	27%	26%	27%	27%	27%
	4	Main Carriageway	37%	40%	38%	34%	35%	35%
	5	Main Carriageway	36%	33%	36%	39%	38%	38%
Between Merge and Diverge	1	Main Carriageway	25%	25%	24%	24%	25%	25%
	2	Main Carriageway	29%	29%	30%	30%	31%	31%
	3	Main Carriageway	46%	45%	46%	46%	44%	44%
Before Diverge	1	Main Carriageway	30%	30%	29%	27%	39%	39%
	2	Main Carriageway	33%	33%	35%	35%	30%	30%
	3	Main Carriageway	37%	36%	36%	37%	31%	31%
Across Diverge	1-2	Slip Road						
	2	Main Carriageway	30%	29%	29%	28%	29%	29%
	3	Main Carriageway	41%	41%	41%	43%	42%	42%
	4	Main Carriageway	29%	30%	30%	29%	29%	29%
After Diverge	1	Main Carriageway	25%	25%	25%	25%	43%	43%
	2	Main Carriageway	45%	45%	45%	47%	23%	23%
	3	Main Carriageway	29%	29%	30%	28%	34%	34%

Table 3.3 - M62 J26-J27: Traffic flow variation for different demand rate

Location	Lane number	Lane key	Demand 100%	110%	120%	130%	140%	150%
Before Merge	1	Main Carriageway	31	27	26	23	23	23
	2	Main Carriageway	31	26	25	23	22	21
	3	Main Carriageway	39	29	30	32	34	34
		Average	**34**	**27**	**27**	**26**	**27**	**26**
Across Merge	1-2	Slip Road	48	39	31	36	31	27
	3	Main Carriageway	26	21	20	19	18	18
	4	Main Carriageway	26	22	21	20	19	21
	5	Main Carriageway	36	27	32	31	31	36
		Average	**27**	**22**	**21**	**21**	**20**	**20**
Between Merge and Diverge	1	Main Carriageway	21	21	20	21	21	23
	2	Main Carriageway	26	25	26	25	24	28
	3	Main Carriageway	55	55	54	53	53	57
		Average	**34**	**33**	**33**	**33**	**33**	**36**
Before Diverge	1	Main Carriageway	31	28	27	27	28	30
	2	Main Carriageway	42	39	40	39	40	42
	3	Main Carriageway	58	54	55	56	55	59
		Average	**43**	**40**	**40**	**40**	**41**	**44**
Across Diverge	1-2	Slip Road	60	60	60	61	59	60
	3	Main Carriageway	59	59	60	60	59	59
	4	Main Carriageway	77	77	77	77	76	77
	5	Main Carriageway	82	82	82	83	82	83
		Average	**56**	**56**	**56**	**56**	**55**	**56**
After Diverge	1	Main Carriageway	59	59	59	59	59	60
	2	Main Carriageway	76	77	77	77	59	59
	3	Main Carriageway	82	82	82	82	76	77
		Average	**73**	**73**	**73**	**73**	**65**	**65**

Table 3.4 - M62 J26-J27: Traffic speed (mph) for different demand rate

The effects of increasing the demand rate on journey times in the M60 J18 network are given in Figures 3.2a/3.2b and Table 3.5 while Table 3.6 gives an overview of flows by lane at key points.

Key Observations – M60 J18

- A 10% increase in demand increases journey times by approximately 10% to 75% depending on vehicle type and the route taken through the network.
- As the level of demand is increased further journey times increase as queues grow.
- Journey times increased by up to 330% of times produced by the standard set-up.
- Journey times on both non-congested routes as well as routes with fairly light flows are strongly affected by changes in the level of demand.
- No correlation has been detected between changes in the level of demand and lane usage.
- Table 3.5 shows that as demand increases throughput reduces and journey time increases this is due to a breakdown in circulating flow around the roundabout. As matrix demand increases the demand at the arm stop line increases and exceeds signal capacity. With resultant increases in queuing and journey time. Increased flow across the stop line increases the capacity at the circulating stop lines which results in blocking back around the junction reducing throughput and further increasing journey time.

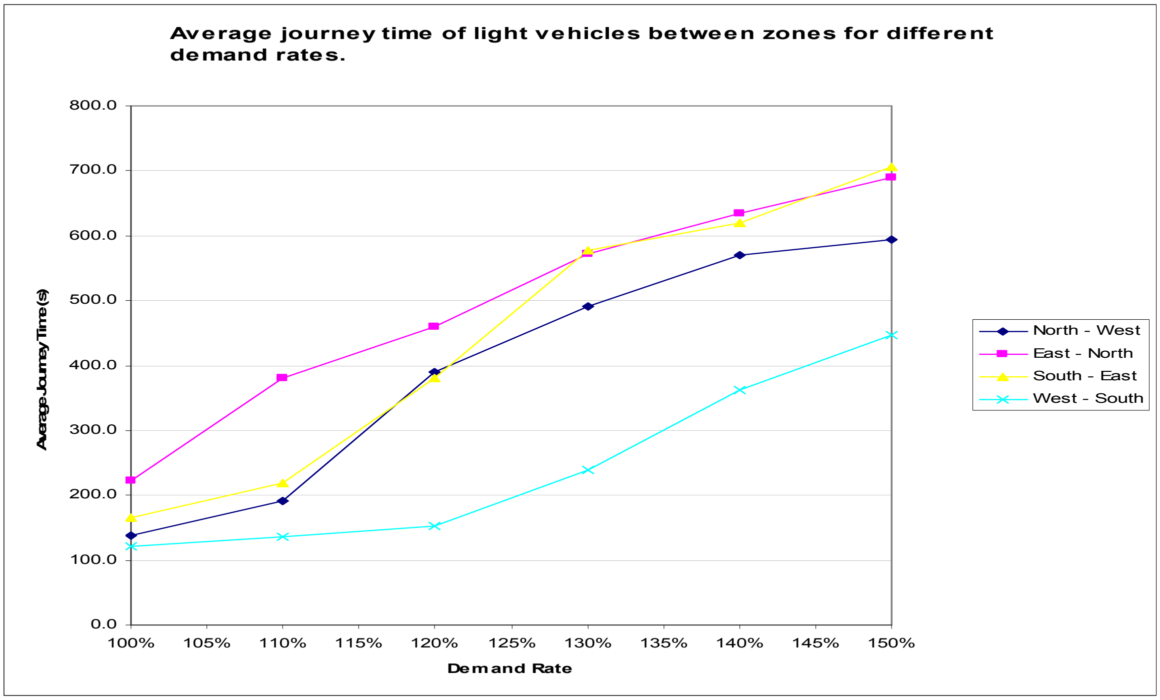


Figure 3.2a - M60 J18: Demand Rate Variation - lights

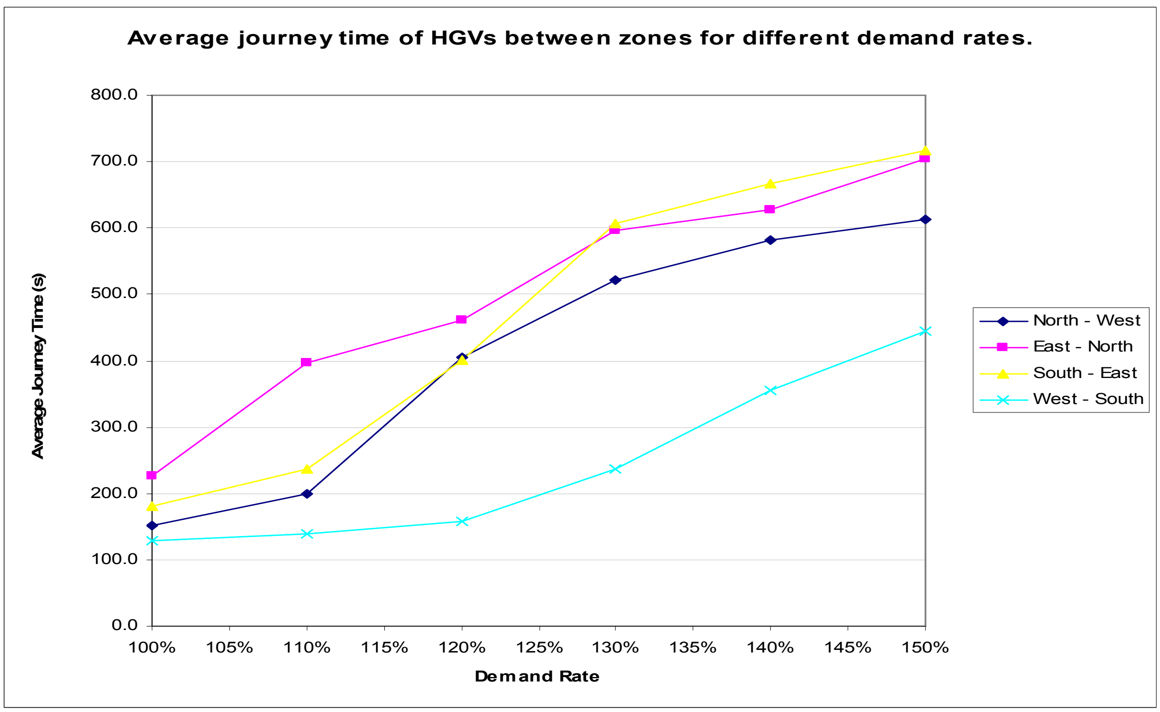


Figure 3.2b - M60 J18: Demand Rate Variation - HGVs

Zone Movement	Demand	Cars		HGV	
		Mean Journey Time (s)	% of the default journey time	Mean Journey Time (s)	% difference to default journey time
North - West	100%	138	-	151	-
	110%	192	39%	200	32%
	120%	389	182%	405	168%
	130%	491	256%	521	244%
	140%	570	313%	582	285%
	150%	594	330%	614	306%
East - North	100%	223	-	226	-
	110%	382	71%	398	76%
	120%	459	106%	461	104%
	130%	571	156%	596	164%
	140%	634	184%	628	178%
	150%	689	209%	705	212%
South - East	100%	165	-	181	-
	110%	218	32%	238	31%
	120%	381	131%	402	122%
	130%	578	250%	607	235%
	140%	621	276%	666	268%
	150%	707	328%	716	295%
West - South	100%	121	-	128	-
	110%	136	12%	138	8%
	120%	152	25%	157	23%
	130%	239	97%	237	85%
	140%	362	198%	355	178%
	150%	448	269%	445	248%

Table 3.5 - M60 J18: Journey time variation with different demand rate

			Demand					
Location	Lane number	Lane key	100%	110%	120%	130%	140%	150%
North	1	Main Carriageway	4%	3%	4%	4%	2%	6%
	2	Main Carriageway	96%	97%	96%	96%	98%	94%
East	1	Outer Slip Road	45%	44%	43%	42%	44%	44%
	2	Inner Slip Road	55%	56%	57%	58%	56%	56%
South	1	Main Carriageway	64%	54%	50%	48%	48%	48%
	2	Main Carriageway	36%	46%	50%	52%	52%	52%
West	1	Main Carriageway	18%	23%	26%	31%	29%	28%
	2	Main Carriageway	82%	77%	74%	69%	71%	72%

Table 3.6 - M60 J18: Lane Usage for different demand rates

3.3 Demand Rate Summary

In the M62 J26-J27 network a 10% increase in the demand resulted in car journey times increasing by up to 50% while HGV journey times increased by up to 30%. However, in the M60 J18 network a 10% increase in demand increased journey times by up to 75% for certain movements.

3.4 Test 2 – Random Seed

The purpose of this test is to investigate the sensitivity of changing the Random Seed on the model outputs. Random seeds are used in Paramics to alter the release pattern of vehicles and vary the allocation of driver behaviour characteristics to individual vehicles. The Random seed can be set specifically or set from the internal computer clock by entering the value 0. In this test 5 runs have been completed with random seed set to zero as this is standard practice when running multiple seed runs. The actual values derived from the clock are shown below.

Parameter	Random Seed
Description	Basis of random number generator which determines the release time of vehicles, the randomisation in route perturbation and the random assignment of attributes such as aggression and awareness to vehicles.
Possible Variation	Any integer 0 gives different seed each run from computer clock
Test Variables	1983
	1149516202
	1149516221
	1149516270
	1149516375

3.4.1 Results

The effects of changing the random seed on journey times in the M62 J26-J27 network are given in Figures 3.3a/3.3b and Table 3.7 below. Tables 3.8 and 3.9 give an overview of flows and speeds by lane at key points.

Key Observations – M62 J26-J27:

- Journey times for car and HGV movements from mainline vary by up to 9% between different seed runs.
- Journey times for car and HGV movements from slip vary by up to 25% between different seed runs. The greater impact on slip traffic implies that the variations in vehicle behaviour due to seed changes effect slip traffic to a greater extent than mainline traffic. This is to be expected as slip traffic uses vehicle behaviour characteristics to determine when to merge; variations in this will have a greater impact on journey time.
- Lane usage pattern and vehicle speeds across the whole route changed little under the different seeds tested.
- Vehicle throughput was unaffected by the changes in the random seed

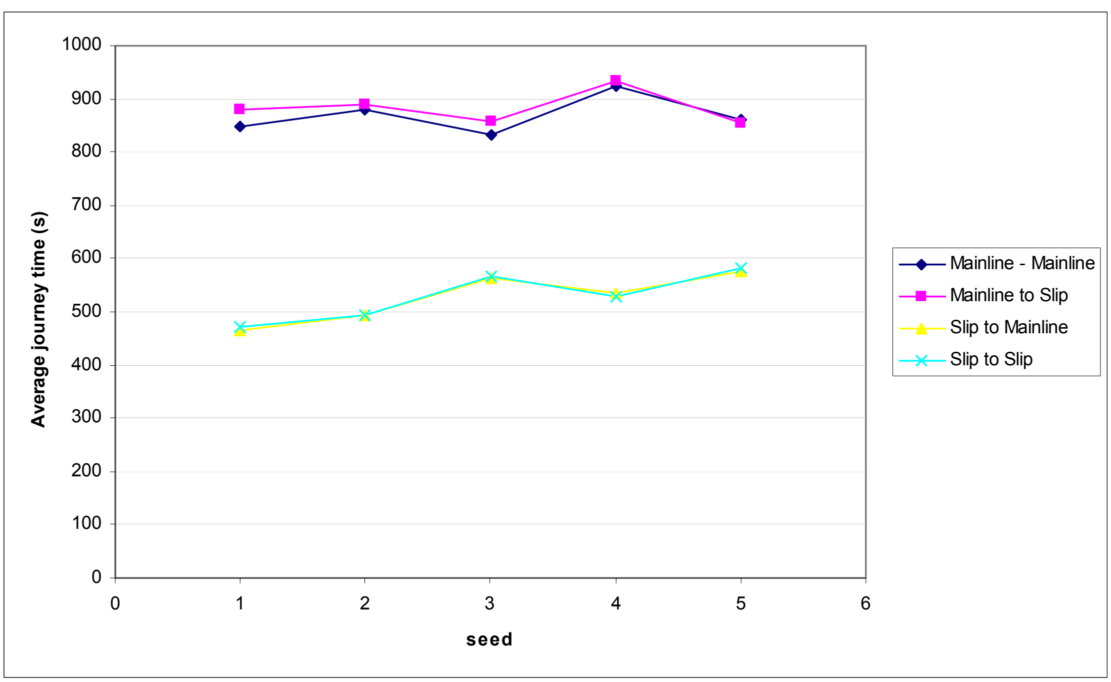


Figure 3.3a – M62 J26-J27: Journey time variation with different random seeds - Cars

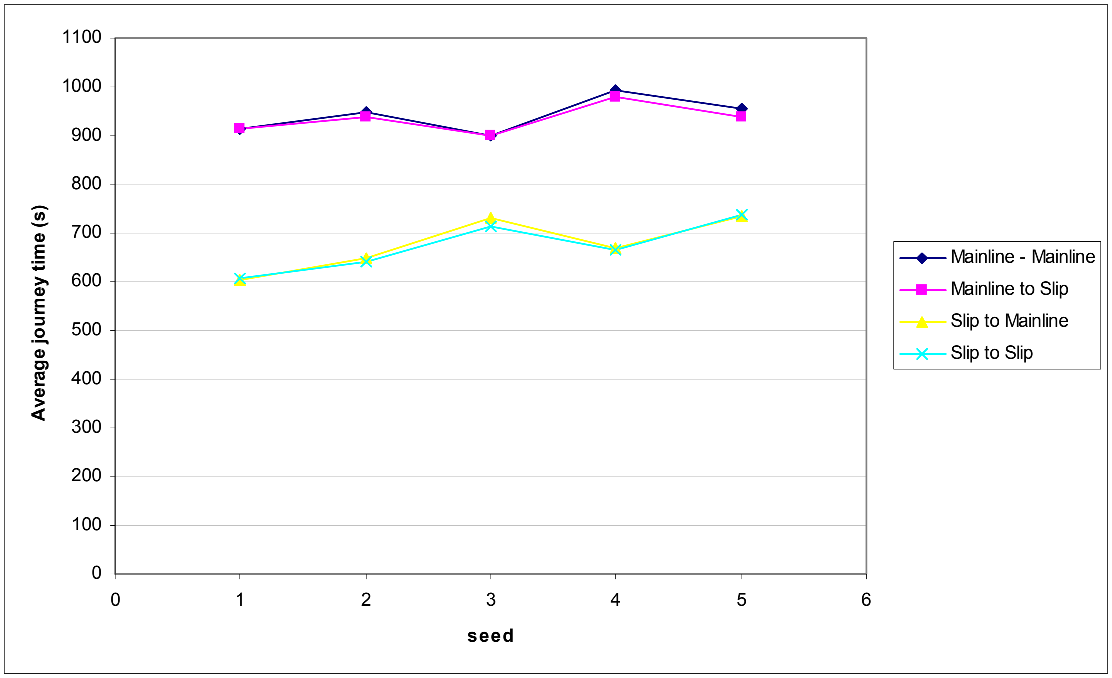


Figure 3.3b – M62 J26-J27: Journey time variation with different random seeds -HGVs

Zone Movement	random seed	Cars		HGV	
		Mean Journey Time	% difference from the default journey time	Mean Journey Time	% difference from the default journey time
Mainline - Mainline	1	848	-	913	-
	2	879	4%	949	4%
	3	832	-2%	899	-2%
	4	924	9%	992	9%
	5	860	1%	954	4.4%
Mainline to Slip	1	879	-	915	-
	2	890	1%	939	3%
	3	858	-2%	901	-2%
	4	933	6%	979	7%
	5	856	-3%	938	3%
Slip to Mainline	1	464	-	603	-
	2	492	6%	648	7%
	3	564	21%	731	21%
	4	535	15%	670	11%
	5	576	24%	735	21.8%
Slip to Slip	1	473	-	606	-
	2	493	4%	642	6%
	3	567	20%	713	18%
	4	529	12%	667	10%
	5	582	23%	738	22%

Table 3.7 – M62 J26-J27: Journey time variation with different random seeds

			Random Seed				
Location	**Lane**	**Lane key**	**1**	**2**	**3**	**4**	**5**
Before Merge	1	Main Carriageway	42%	42%	40%	42%	42%
	2	Main Carriageway	35%	37%	38%	36%	37%
	3	Main Carriageway	23%	22%	22%	22%	21%
Across Merge	1-2	Slip Road					
	3	Main Carriageway	28%	26%	28%	25%	24%
	4	Main Carriageway	37%	37%	34%	37%	37%
	5	Main Carriageway	36%	37%	38%	37%	39%
Between Merge and Diverge	1	Main Carriageway	25%	24%	25%	25%	25%
	2	Main Carriageway	29%	30%	29%	30%	29%
	3	Main Carriageway	46%	46%	46%	45%	46%
Before Diverge	1	Main Carriageway	41%	42%	39%	40%	39%
	2	Main Carriageway	28%	28%	29%	29%	29%
	3	Main Carriageway	31%	30%	32%	31%	32%
Across Diverge	1-2	Slip Road					
	2	Main Carriageway	30%	30%	30%	31%	29%
	3	Main Carriageway	41%	41%	42%	42%	41%
	4	Main Carriageway	29%	29%	28%	27%	30%
After Diverge	1	Main Carriageway	25%	26%	26%	27%	43%
	2	Main Carriageway	45%	45%	46%	46%	24%
	3	Main Carriageway	29%	29%	28%	28%	33%

Table 3.8 - M62 J26-J27: Summary of traffic flow for different values of the random seed

			Random Seed				
Location	**Lane**	**Lane key**	**1**	**2**	**3**	**4**	**5**
Before Merge	1	Main Carriageway	31	33	34	31	33
	2	Main Carriageway	31	35	36	33	34
	3	Main Carriageway	39	45	45	39	43
		Average	**34**	**37**	**38**	**35**	**37**
Across Merge	1-2	Slip Road	48	49	42	54	43
	3	Main Carriageway	26	26	29	25	26
	4	Main Carriageway	26	26	28	24	26
	5	Main Carriageway	36	37	41	36	35
		Average	**34**	**34**	**35**	**35**	**33**
Between Merge and Diverge	1	Main Carriageway	21	21	21	20	22
	2	Main Carriageway	26	24	26	25	26
	3	Main Carriageway	55	55	57	55	55
		Average	**34**	**33**	**35**	**33**	**34**
Before Diverge	1	Main Carriageway	31	31	30	28	30
	2	Main Carriageway	42	43	43	41	40
	3	Main Carriageway	58	59	60	57	55
		Average	**43**	**44**	**44**	**42**	**42**
Across Diverge	1-2	Slip Road	60	61	61	62	60
	3	Main Carriageway	59	59	59	60	60
	4	Main Carriageway	77	77	77	77	77
	5	Main Carriageway	82	82	83	83	82
		Average	**70**	**70**	**70**	**70**	**70**
After Diverge	1	Main Carriageway	59	59	58	59	60
	2	Main Carriageway	76	77	77	77	60
	3	Main Carriageway	82	82	82	82	77
		Average	**73**	**73**	**72**	**73**	**66**

Table 3.9 – M62 J26-J27: Summary of traffic speed (mph) for different random seed

The effect of changing the random seeds on journey times in the M60 J18 network are given in Figures 3.4a/3.4b and Table 3.10 while Table 3.11 gives an overview of flows by lane at key points.

Key Observations – M60 J18:

- More stable to changes in seed value than merge/diverge model due to signal controlled nature of the junction. The seed affects driver behaviour which has a greater impact on models where there are long stretches and lane choice, in this model lane use is heavily controlled through the roundabout and there is limited opportunity for vehicle behaviour to impact on stop line capacity.
- Journey times varied by no more than 7% for different values of the random seed.
- Lane usage is little affected by changes in the random seed parameter.
- Vehicle throughput was unaffected by the changes in the random seed.

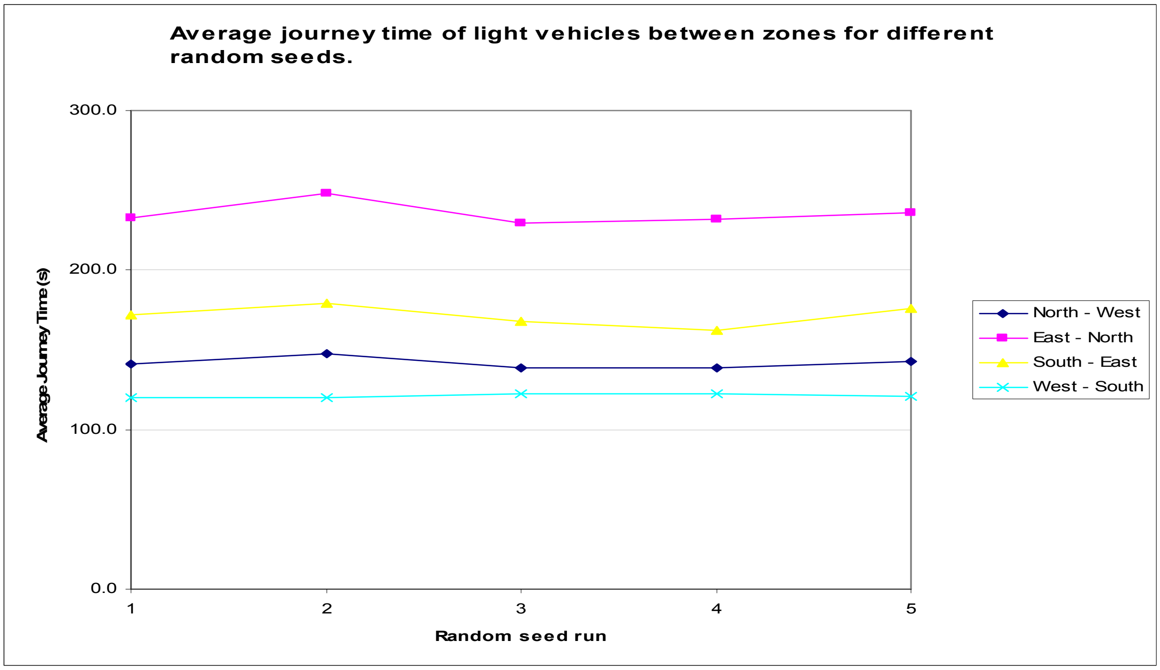


Figure 3.4a - M60 J18: Journey time variation with different random seeds - Cars

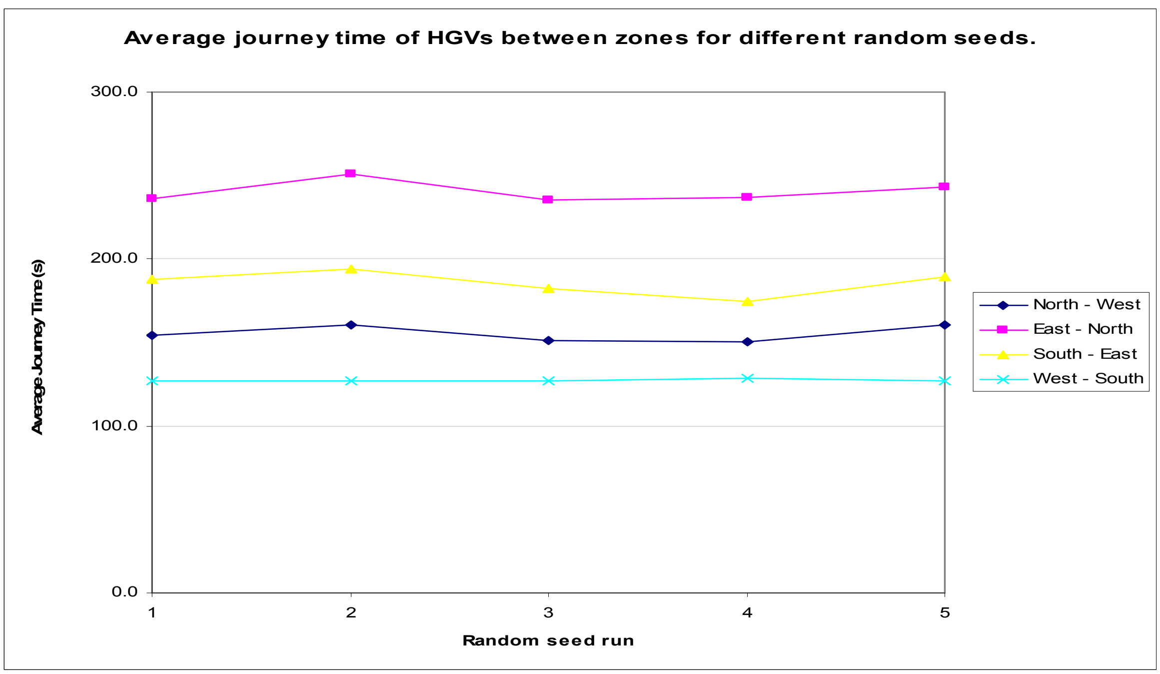


Figure 3.4b - M60 J18: Journey time variation with different random seeds - HGVs

Zone Movement	Random seed	Cars		HGV	
		Mean Journey Time (s)	% of the default journey time	Mean Journey Time (s)	% difference to default journey time
North - West	1	141	-	154	-
	2	148	5%	161	4%
	3	139	-1%	151	-2%
	4	139	-1%	151	-2%
	5	143	2%	161	4%
East - North	1	233	-	236	-
	2	248	6%	251	6%
	3	230	-1%	236	0%
	4	232	0%	237	0%
	5	236	1%	243	3%
South - East	1	172	-	187	-
	2	179	4%	194	3%
	3	168	-3%	182	-3%
	4	163	-6%	175	-7%
	5	176	2%	189	1%
West - South	1	120	-	127	-
	2	120	0%	127	0%
	3	122	2%	127	0%
	4	122	2%	129	2%
	5	121	1%	127	1%

Table 3.10 - M60 J18: Journey time variation with different random seeds

Location	Lane number	Lane key	Random seed run number				
			1	2	3	4	5
North	1	Main Carriageway	7%	2%	2%	5%	4%
	2	Main Carriageway	93%	98%	98%	95%	96%
East	1	Outer Slip Road	43%	42%	43%	43%	43%
	2	Inner Slip Road	57%	58%	57%	57%	57%
South	1	Main Carriageway	64%	64%	63%	64%	65%
	2	Main Carriageway	36%	36%	37%	36%	35%
West	1	Main Carriageway	17%	18%	18%	18%	18%
	2	Main Carriageway	83%	82%	82%	82%	82%

Table 3.11 - M60 J18: Summary of traffic flows for different values of the random seed

3.5 Random Seed Summary

In congested conditions the journey times varied by up to 9% for mainline traffic and 25% for slip traffic. Lane usage and speeds did not vary significantly.

Random seed has a greater impact on merge/diverge models than signal controlled junctions.

The random seed tests indicated that there are no effects on vehicle demands and relatively small impacts on vehicle throughput.

SIAS Comment:

S-Paramics has two release algorithms. One is precise to within one whole vehicle of the demand requested in the OD matrix. The other converts the demand to a probability of a release in each second to be evaluated throughout the simulation and therefore will vary with the random seed. The models sent to SIAS used precise mode only and therefore this observation is correct: no variation should be seen. If investigation into the variation is required then more tests will be necessary.

3.6 Test 3 – Headway

The purpose of this test was to investigate the impact of varying headway on the journey time and throughput.

Parameter	Headway
Description	Time in seconds between moving vehicles modified by individual levels of awareness and aggression and proximity to junctions
Test Variables	0.8
	0.9
	1.0s - Default
	1.5s
	2.0s
	2.5s
	3.0s

In Paramics the Headway combines with Minimum Gap to define vehicle separation in the model. When vehicles are travelling below the crawl speed their distance from the vehicle in front is determined by the minimum gap parameter such that, at speeds less than 10mph (eg congested conditions that may be expected on the HA network) the min Gap threshold takes priority and vehicles will tend to keep around 1m apart. As speed increases to >10mph then the Headway distance will take speed in to account and there will be an increase in the following distances which will vary. The crawl speed (default 10mph) is defined in the configuration text file but is not editable through the graphics user interface. The values of headway and minimum gap for individual vehicles are modified depending upon aggression and awareness levels.

Figure 3.5 below shows, in simplistic terms, how the minimum gap and headway interact via the crawl speed to give vehicle separation at different speeds. SIAS has provided a fuller explanation of vehicle behaviour as speeds increase beyond the 'crawl' speed. The graph assumes the default headway of 1 second.

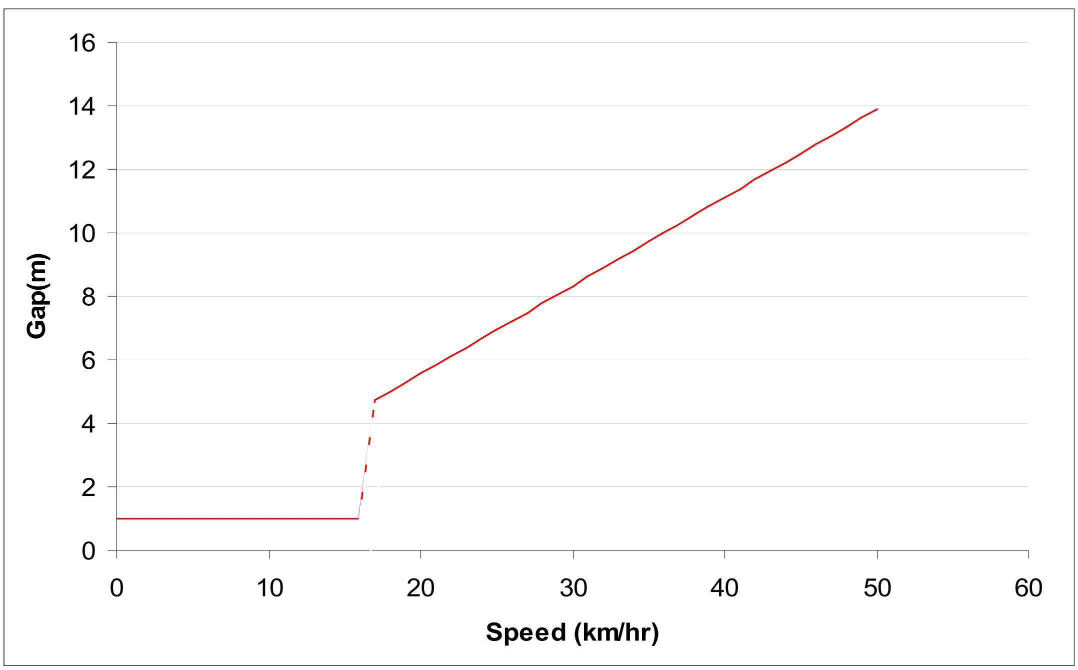


Figure 3.5 – Desired Headway at Differing Speeds

The graph suggests that a discontinuity exists in the headway model as the vehicle speeds move from 'crawling' (<10mph(16kph)) to 'moving' (> 10mph(16kph)). Should this be the case, this default profile has implications for model performance in very congested conditions and will have an effect on model throughput per lane when traffic speeds are less than 10mph. It is considered that the relationship shown may be theoretically incorrect and consequently may result in anomalous results in congested conditions.

However, SIAS has provided the following information to assure the user that the software will operate satisfactorily:

'*As a vehicle moves from a distance-based headway to a time-based headway careful matching of parameters is required, and the variation of headway with aggression and awareness implies this match will not be perfect. If the gap based headway is being applied then this must be because the vehicle is following another and therefore its acceleration will be constrained. This behaviour will override any discontinuous jumps in headway or speed as the vehicle moves from distance based to time based headway*.'

Fig 3.5 suggests an event which cannot happen within a simulation. It implies that a vehicle is both constrained in its speed by headway to the vehicle ahead while simultaneously being unconstrained in its ability to instantaneously accelerate to change the headway. It does not take into account the delays in speed setting inherent in the model due to driver reaction and vehicle dynamics. The paper produced by Duncan et al 1996 describes how the acceleration changes according to the history of the vehicle's speed, the speed of the vehicle ahead, and the headway to it. The headway / velocity-difference phase space illustrated by Fig 3.5a denotes how acceleration is affected by the hysteresis within the system. The magnitude of the arrow shows the size of the acceleration and the direction of the arrow shows which part of the phase space we expect to move to.

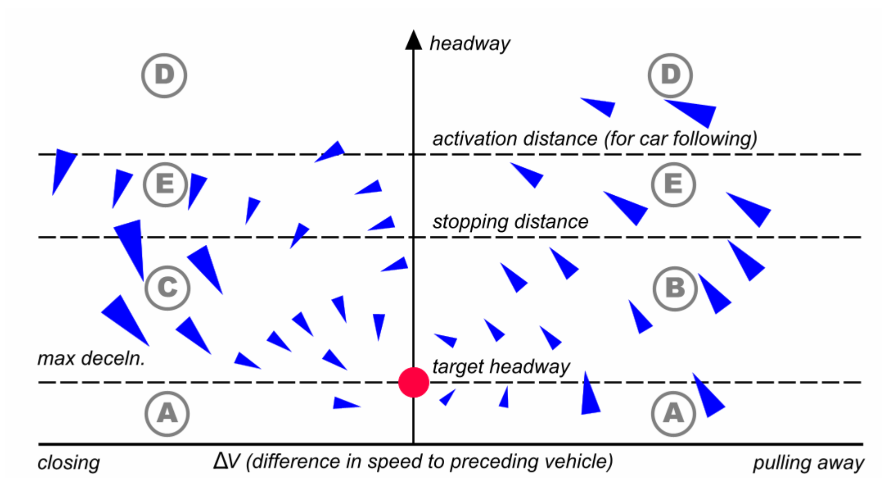
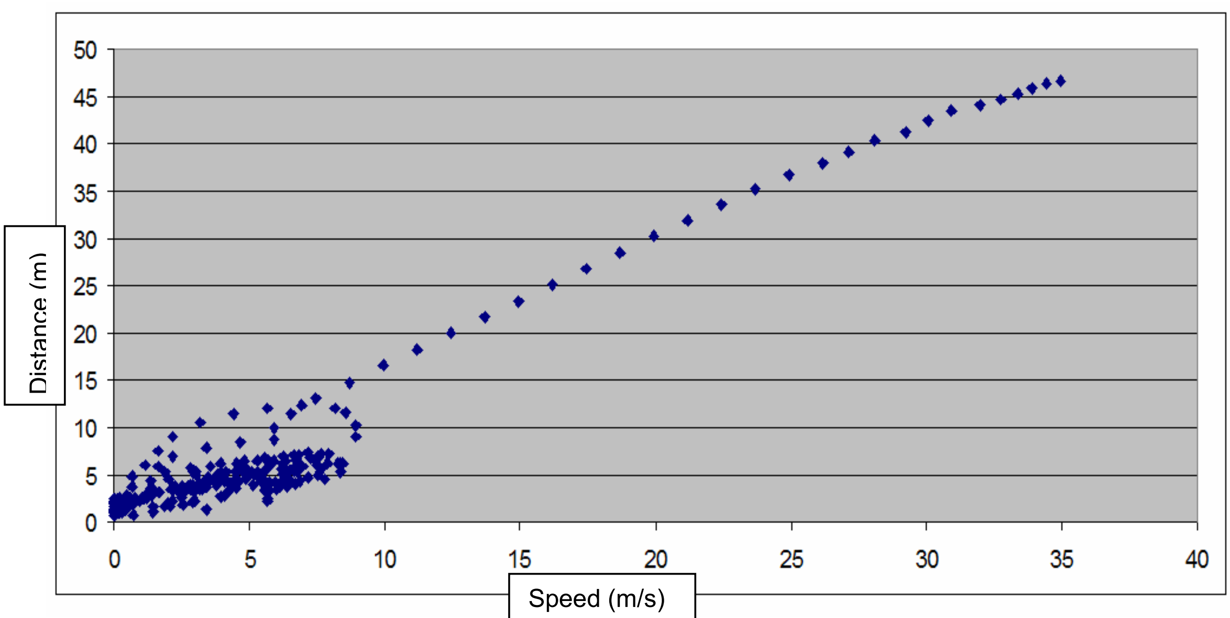


Figure 3.5a

In support of this, the following graph was produced by SIAS from Headway data collected from a test network



This graph was produced by sampling the speed and headway of a vehicle for every time step it was queued and subsequently as it accelerated away from the head of the queue. The times where the *queue is moving and headways increase can be identified. Also the more complex relationship between speed and headway is shown. Fig 3.5 suggests that there is a single simple relationship between speed and headway and that gaps between 1m and 5m cannot be achieved. This plot demonstrates that this is not the case.*

3.6.1 Results

The effect of increasing headway on journey times in the M62 J26-J27 network are given in Figure 3.6a/3.6b and Table 3.12 below. Tables 3.13 and 3.14 give an overview of flows and speeds by lane at key points.

Key Observations – M62 J26-J27:

- The default value of 1.0 second minimised journey times for slip traffic.
- Headways less than 1.0 second further reduce journey time for mainline movements and increases journey time for slip movements. This is a result of mainline vehicles travelling closer together and limiting the opportunity for slip traffic to access the mainline.
- Increasing headway from 1 to 2 seconds increased journey time for mainline traffic.
- Journey time for traffic originating on the slip road peaked at a headway value of 1.5 seconds and fell slightly at higher headways
- This may be attributed to mainline vehicles leaving larger gaps when modelled with larger headway, which allows slip traffic to enter the main flow more easily as their gap acceptance is unchanged.
- Larger headway spreads vehicles travelling above the crawl speed (10mph) out along the mainline and may reduce capacity. This can be seen in reduced flow values as headway increases.

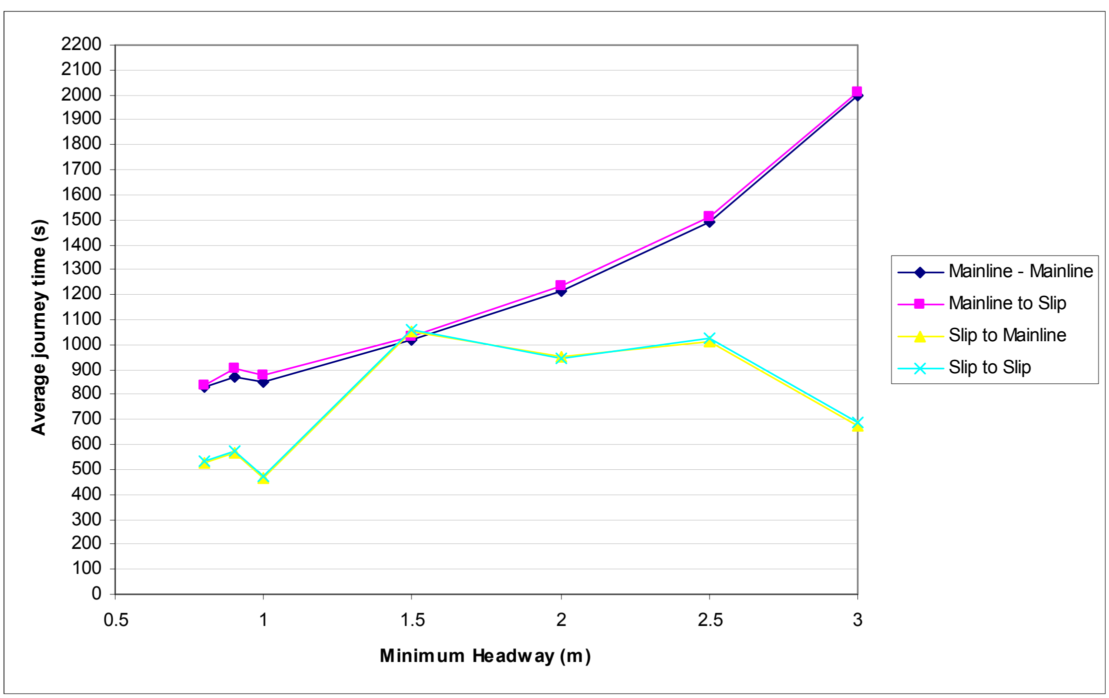


Figure 3.6a – M62 J26-J27: Journey time variation with different headway parameters - Cars

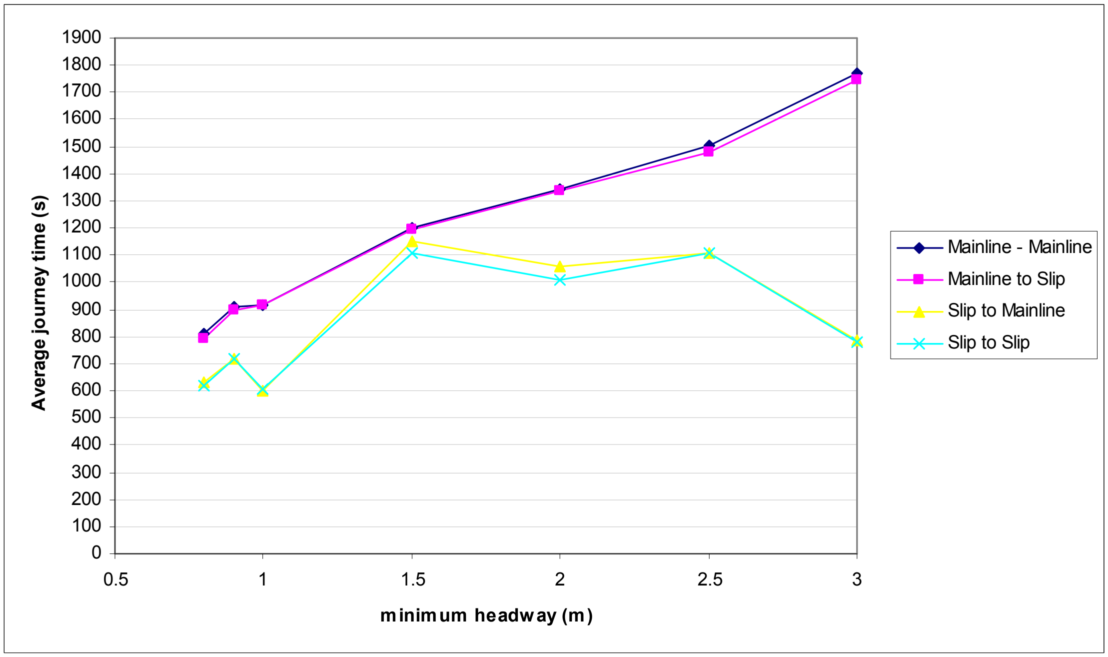


Figure 3.6b – M62 J26-J27: Journey time variation with different headway parameters - HGVs

Zone Movement	Headway (m)	Cars: Mean Journey Time	Cars: % difference from the default journey time	HGV: Mean Journey Time	HGV: % difference to default journey time
Mainline - Mainline	0.8	828	-2%	809	-11%
	0.9	871	3%	910	0%
	1.0	848	-	913	-
	1.5	1018	20%	1203	32%
	2.0	1213	43%	1342	47%
	2.5	1493	76%	1504	65%
	3.0	1996	135%	1773	94%
Mainline to Slip	0.8	835	-5%	793	-13%
	0.9	903	3%	900	-2%
	1.0	879	-	915	-
	1.5	1030	17%	1192	30%
	2.0	1235	40%	1336	46%
	2.5	1513	72%	1482	62%
	3.0	2010	129%	1742	90%
Slip to Mainline	0.8	529	14%	632	5%
	0.9	569	22%	720	19%
	1.0	464	-	603	-
	1.5	1054	127%	1152	91%
	2.0	952	105%	1060	76%
	2.5	1015	118%	1110	84%
	3.0	678	46%	787	31%
Slip to Slip-	0.8	531	12%	619	2%
	0.9	573	21%	716	18%
	1.0	473	-	606	-
	1.5	1056	123%	1105	82%
	2.0	947	100%	1007	66%
	2.5	1025	117%	1105	82%
	3.0	688	45%	781	29%

Table 3.12 - M62 J26-J27: Journey time variation with different headway parameters

			Headway						
Location	**Lane number**	**Lane key**	**0.8**	**0.9**	**1.0**	**1.5**	**2.0**	**2.5**	**3.0**
Before Merge	1	Main Carriageway	42%	41%	42%	40%	40%	44%	50%
	2	Main Carriageway	35%	35%	35%	33%	32%	33%	32%
	3	Main Carriageway	22%	24%	23%	27%	28%	23%	18%
Across Merge	1-2	Slip Road							
	3	Main Carriageway	28%	25%	28%	24%	26%	28%	31%
	4	Main Carriageway	36%	37%	37%	31%	27%	33%	31%
	5	Main Carriageway	36%	38%	36%	45%	46%	39%	38%
Between Merge and Diverge	1	Main Carriageway	27%	24%	25%	24%	25%	26%	26%
	2	Main Carriageway	32%	29%	29%	29%	31%	30%	31%
	3	Main Carriageway	41%	47%	46%	47%	44%	44%	43%
Before Diverge	1	Main Carriageway	38%	37%	41%	46%	48%	50%	50%
	2	Main Carriageway	32%	31%	28%	26%	25%	23%	24%
	3	Main Carriageway	31%	32%	31%	28%	27%	27%	26%
Across Diverge	1-2	Slip Road							
	3	Main Carriageway	32%	30%	30%	30%	31%	32%	32%
	4	Main Carriageway	43%	42%	41%	38%	36%	34%	34%
	5	Main Carriageway	25%	28%	29%	32%	32%	34%	34%
After Diverge	1	Main Carriageway	27%	26%	25%	26%	26%	27%	45%
	2	Main Carriageway	47%	46%	45%	41%	40%	38%	27%
	3	Main Carriageway	26%	28%	29%	33%	34%	35%	28%

Table 3.13 – M62 J26-J27: Summary of traffic flow for different values of Headway

			Headway						
Location	**Lane number**	**Lane key**	**0.8**	**0.9**	**1.0**	**1.5**	**2.0**	**2.5**	**3.0**
Before Merge	1	Main Carriageway	34	33	31	25	20	17	14
	2	Main Carriageway	34	36	31	24	16	14	10
	3	Main Carriageway	47	51	39	35	23	16	13
		Average	**38**	**40**	**34**	**28**	**20**	**16**	**13**
Across Merge	1	Slip Road	47	46	48	30	25	20	20
	3	Main Carriageway	29	26	26	20	19	18	15
	4	Main Carriageway	29	27	26	17	14	13	11
	5	Main Carriageway	43	40	36	28	20	17	13
		Average	**37**	**35**	**34**	**24**	**19**	**17**	**15**
Between Merge and Diverge	1	Main Carriageway	29	21	21	16	18	15	15
	2	Main Carriageway	36	25	26	20	21	19	19
	3	Main Carriageway	63	52	55	43	34	33	29
		Average	**43**	**33**	**34**	**26**	**24**	**22**	**21**
Before Diverge	1	Main Carriageway	34	31	31	29	32	32	34
	2	Main Carriageway	46	43	42	40	45	45	46
	3	Main Carriageway	62	59	58	56	60	63	65
		Average	**48**	**45**	**43**	**42**	**46**	**47**	**48**
Across Diverge	1	Slip Road	62	+	60	59	57	57	58
	2	Main Carriageway	59	59	59	59	59	58	58
	3	Main Carriageway	77	77	77	77	77	78	78
	4	Main Carriageway	83	83	82	82	82	81	82
		Average	**70**	**70**	**70**	**70**	**69**	**69**	**69**
After Diverge	1	Main Carriageway	58	59	59	59	57	58	58
	2	Main Carriageway	76	77	76	77	77	76	58
	3	Main Carriageway	83	82	82	82	81	81	78
		Average	**73**	**72**	**73**	**73**	**72**	**72**	**65**

Table 3.14 - Summary of traffic speed (mph) for different values of Headway

The effects of increasing the headway on journey times in the M60 J18 network are given in Figure 3.7a/3.7b and Table 3.15. Table 3.16 gives an overview of flows by lane at key points.

Key Observations M60 J18:

- The default value of 1 second minimised journey times on all routes.
- For the range of values tested (1.0 -3.0 seconds) journey times varied by up to nearly 200%.
- Increasing headway increased journey time as flow across stop lines is reduced when vehicles drive further apart.
- Headway has a greater impact in this model than in the merge/diverge model as headway changes separation of vehicles and therefore significantly affects the capacity of the signals. At high headways fewer vehicles can get across the stop line as they drive further apart. This results in greater queuing and increased journey time, especially on movements that are nearer capacity in the base situation.

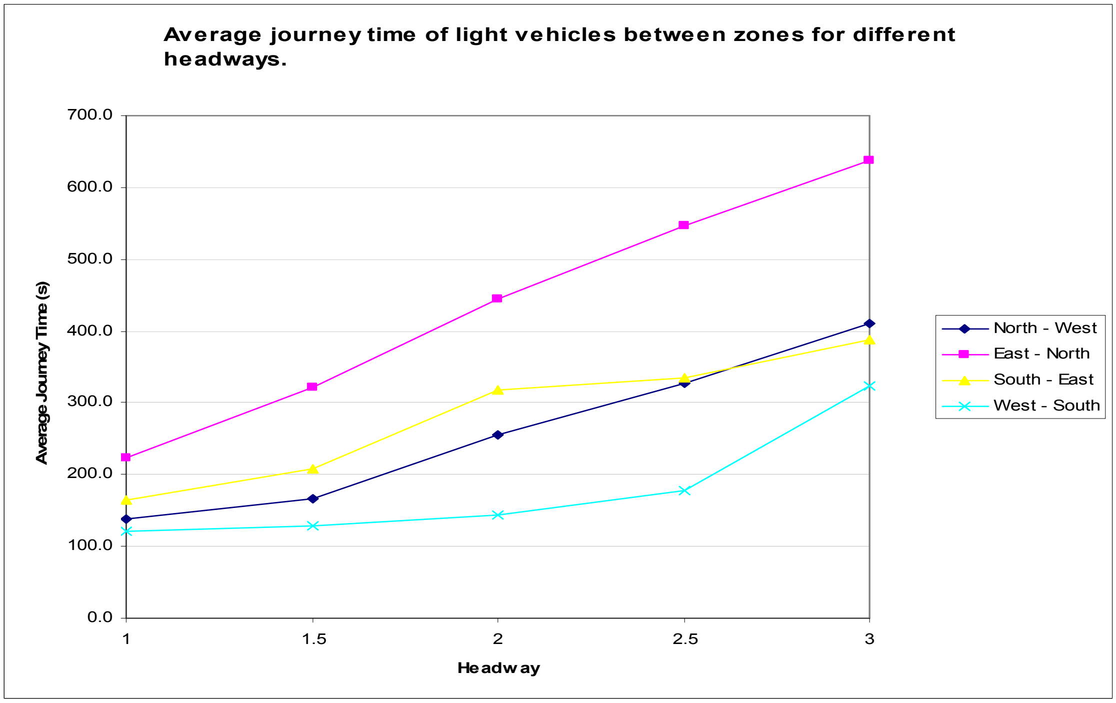


Figure 3.7a - M60 J18: Journey time variation with different headway parameters - Cars

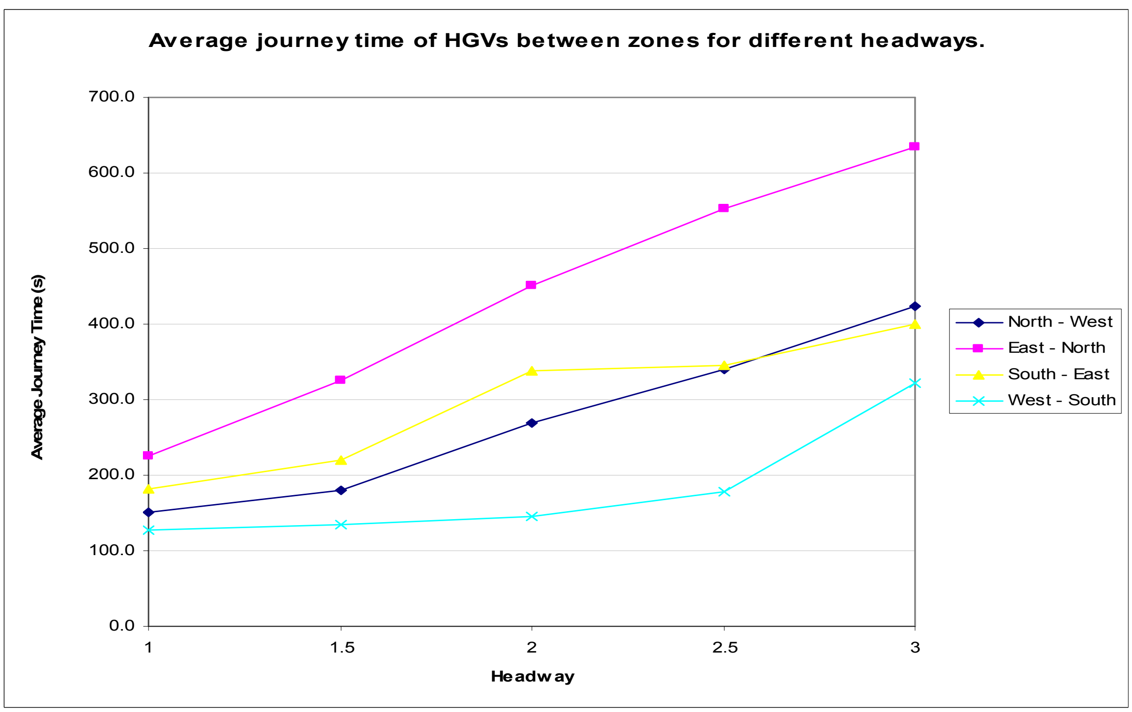


Figure 3.7b - M60 J18: Journey time variation with different headway parameters - HGVs

Zone Movement	Headway	Cars		HGV	
		Mean Journey Time (s)	% of the default journey time	Mean Journey Time (s)	% difference to default journey time
North - West	1	138	-	151	-
	1.5	166	20%	180	19%
	2	256	86%	268	77%
	2.5	328	138%	339	124%
	3	411	198%	424	180%
East - North	1	223	-	226	-
	1.5	321	44%	325	44%
	2	444	99%	450	99%
	2.5	547	145%	553	145%
	3	638	186%	635	181%
South - East	1	165	-	181	-
	1.5	208	26%	220	21%
	2	318	93%	339	87%
	2.5	335	103%	345	90%
	3	387	134%	399	120%
West - South	1	121	-	128	-
	1.5	129	6%	134	5%
	2	143	18%	146	14%
	2.5	177	46%	178	39%
	3	324	167%	322	152%

Table 3.15 - M60 J18 Journey time variation for different values of the headway parameter

			Headway (s)				
Location	**Lane number**	**Lane key**	**1.0**	**1.5**	**2.0**	**2.5**	**3.0**
North	1	Main Carriageway	3%	5%	4%	4%	5%
	2	Main Carriageway	97%	95%	96%	96%	95%
East	1	Outer Slip Road	46%	45%	45%	45%	45%
	2	Inner Slip Road	54%	55%	55%	55%	55%
South	1	Main Carriageway	58%	47%	64%	48%	48%
	32	Main Carriageway	42%	53%	36%	52%	52%
West	1	Main Carriageway	19%	25%	18%	27%	28%
	2	Main Carriageway	81%	75%	82%	73%	72%

Table 3.16 - M60 J18 Traffic flow variation for different values of the headway parameter

3.7 Headway Summary

For changes in the Headway from 1s to 3s, the M62 network journey times increased by up to 130%. However, on the M18 the journey time increased by almost 200% for certain movements.

The headway parameter affects journey times to a greater extent in signalised models; this is due to the reduced stop line capacity when vehicles are driving further apart. Consequently, this leads to increased journey times, especially when a movement is close to capacity.

At low speeds (<10mph), or the ‘crawl speed’ as referred to in Paramics, vehicle headway is controlled by the minimum Gap parameter which defaults to 1m. As speeds increase beyond this, the headway is also influenced by vehicle speed and increased vehicle headway is observed. The minimum gap of 1m may impact on throughput in congested networks.

3.8 Test 4 – Minimum Gap

The purpose of this test was to investigate the impact of changing the minimum gap parameter on model outputs. The minimum gap parameter determines the separation of vehicles when below a crawl speed, i.e. when they are in a stationary or slow moving queue. The minimum gap parameter for individual vehicles is modified by the aggression and awareness of that vehicle. The relationship with headway is discussed on the preceding chapter.

Parameter	**Minimum Gap**
Description	Gap left between vehicles when below the crawl speed (default 10mph)
Test Variables	1.0m - Standard Value
	1.5m
	2.0m - Default
	2.5m
	3.0m

The effects of increasing the minimum gap on journey times in the M62 J26-J27 network are given in Figures 3.8a/3.8b and Table 3.17 below. Tables 3.18 and 3.19 give an overview of flows and speeds by lane at key points.

Key Observations – M62 J26-J27:

- The lower bound of the parameter range investigated (1m) minimised journey times for slip traffic
- For trips originating on the merge slip road, journey times increased with the minimum gap length throughout the parameter range investigated. This is because as gap increases the queuing slip traffic becomes more spread out, reducing capacity of the slip,
- For trips originating on the mainline, journey times peaked at a parameter value of 1.5m. For parameter value larger than 1.5 journey times remained approximately constant.
- As minimum gap is increased under congested network conditions slip capacity is reduced this reduces impact on mainline traffic and reduces journey time for mainline traffic.
- Increasing or decreasing minimum gap did not appear to significantly alter lane usage.
- Changing the minimum gap had no effect on flow throughput

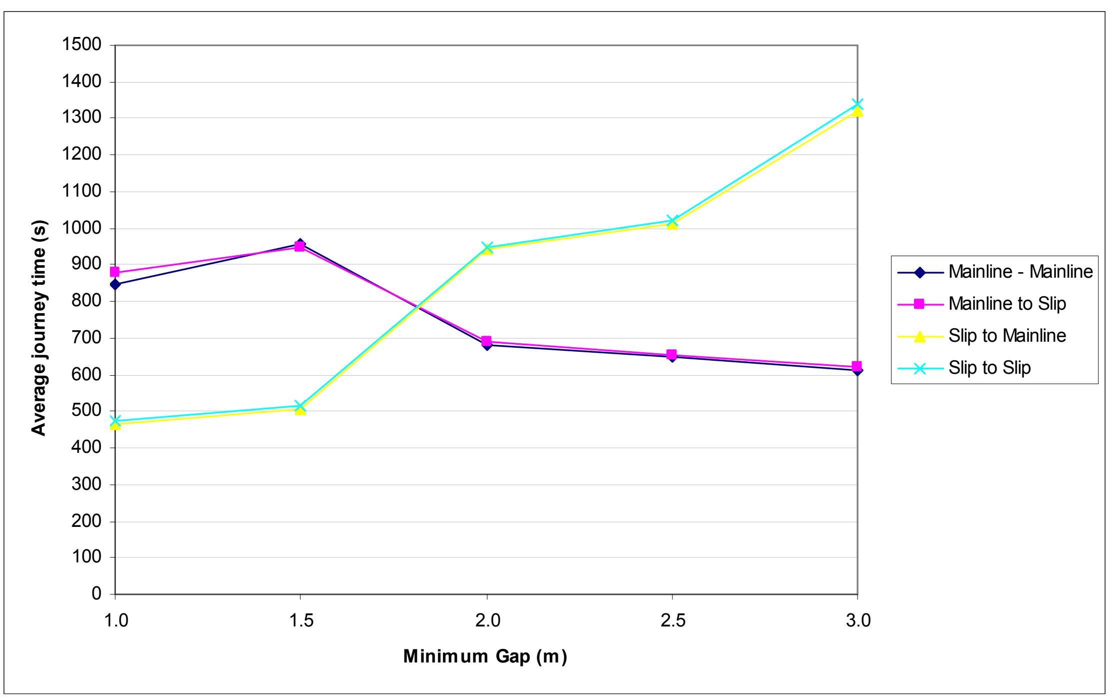


Figure 3.8a – M62 J26-J27: Journey time variation with different minimum gap - Cars

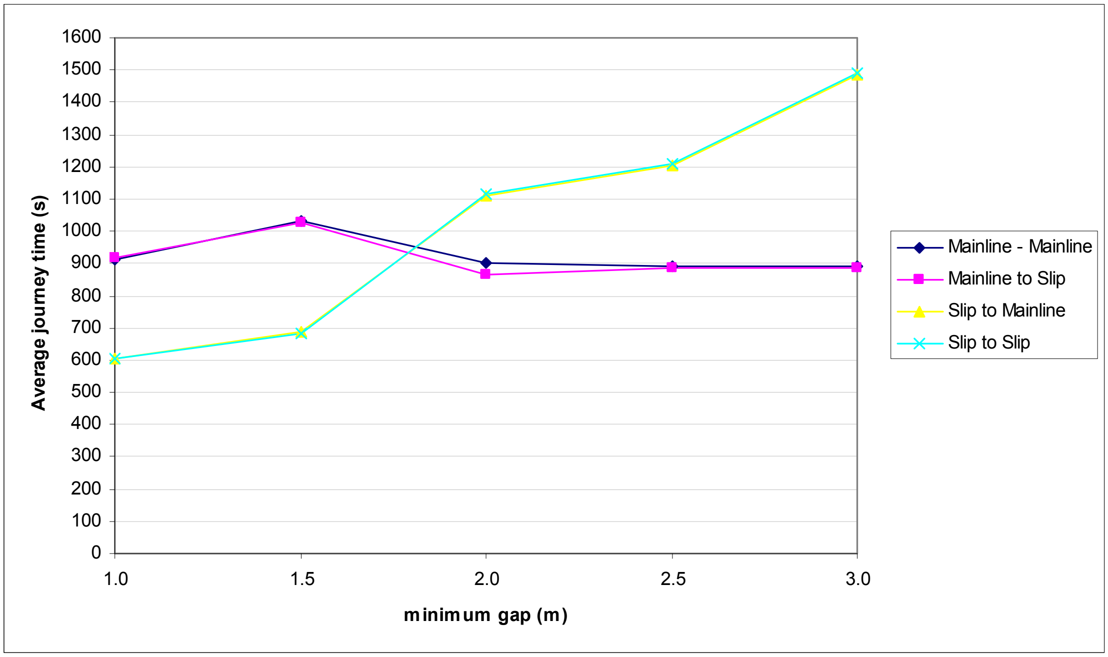


Figure 3.8b – M62 J26-J27: Journey time variation with different minimum gap - HGVs

Zone Movement	Gap (m)	Cars		HGV	
		Mean Journey Time	% difference from the default journey time	Mean Journey Time	% difference to default journey time
Mainline - Mainline	1.0	848	-	913	-
	1.5	957	13%	1032	13%
	2.0	679	-20%	900	-1%
	2.5	649	-24%	892	-2%
	3.0	611	-28%	892	-2%
Mainline to Slip	1.0	879	-	915	-
	1.5	946	8%	1025	12%
	2.0	692	-21%	865	-5%
	2.5	655	-26%	884	-3%
	3.0	622	-29%	887	-3%
Slip to Mainline	1.0	464	-	603	-
	1.5	505	9%	686	14%
	2.0	944	103%	1112	84%
	2.5	1010	118%	1203	99%
	3.0	1321	184%	1486	146%
Slip to Slip	1.0	473	-	606	-
	1.5	513	9%	682	12%
	2.0	948	100%	1118	84%
	2.5	1022	116%	1209	99%
	3.0	1338	183%	1493	146%

Table 3.17 – M62 J26-J27: Journey time variation with different minimum gap parameter

Location	Lane number	Lane key	1.0	1.5	2.0	2.5	3.0
Before Merge	1	Main Carriageway	42%	41%	38%	36%	35%
	2	Main Carriageway	35%	38%	35%	35%	34%
	3	Main Carriageway	23%	21%	27%	29%	31%
Across Merge	1-2	Slip Road	28%	29%	21%	19%	16%
	3	Main Carriageway	20%	19%	21%	21%	23%
	4	Main Carriageway	26%	29%	26%	26%	26%
	5	Main Carriageway	26%	23%	33%	34%	36%
Between Merge and Diverge	1	Main Carriageway	25%	25%	23%	23%	22%
	2	Main Carriageway	29%	29%	28%	27%	27%
	3	Main Carriageway	46%	46%	49%	50%	50%
Before Diverge	1	Main Carriageway	41%	39%	40%	39%	40%
	2	Main Carriageway	28%	29%	28%	30%	28%
	3	Main Carriageway	31%	32%	32%	31%	32%
Across Diverge	1-2	Slip Road	34%	35%	34%	33%	34%
	2	Main Carriageway	20%	19%	19%	19%	20%
	3	Main Carriageway	27%	28%	28%	28%	28%
	4	Main Carriageway	19%	19%	20%	20%	19%
After Diverge	1	Main Carriageway	25%	25%	24%	25%	42%
	2	Main Carriageway	45%	46%	46%	44%	24%
	3	Main Carriageway	29%	29%	29%	31%	34%

Table 3.18 – M62 J26-J27 Traffic flow for different values of the minimum gap parameter

Location	Lane number	Lane key	1.0	1.5	2.0	2.5	3.0
Before Merge	1	Main Carriageway	31	31	34	34	34
	2	Main Carriageway	31	32	35	36	36
	3	Main Carriageway	39	39	46	48	49
		Average	**34**	**34**	**38**	**39**	**40**
Across Merge	1-2	Slip Road	48	46	35	28	26
	3	Main Carriageway	26	27	25	25	27
	4	Main Carriageway	26	26	23	25	26
	5	Main Carriageway	36	35	36	38	40
		Average	**27**	**27**	**24**	**23**	**24**
Between Merge and Diverge	1	Main Carriageway	21	21	17	17	18
	2	Main Carriageway	26	25	22	21	21
	3	Main Carriageway	55	56	52	52	50
		Average	**34**	**34**	**30**	**30**	**30**
Before Diverge	1	Main Carriageway	31	29	30	30	30
	2	Main Carriageway	42	42	40	42	40
	3	Main Carriageway	58	60	55	57	55
		Average	**43**	**44**	**42**	**43**	**42**
Across Diverge	1-2	Slip Road	60	61	60	61	61
	3	Main Carriageway	59	59	59	59	59
	4	Main Carriageway	77	77	77	77	77
	5	Main Carriageway	82	83	83	83	83
		Average	**56**	**56**	**56**	**56**	**56**
After Diverge	1	Main Carriageway	59	59	58	59	62
	2	Main Carriageway	77	77	77	77	60
	3	Main Carriageway	83	83	83	83	78
		Average	**73**	**73**	**73**	**73**	**66**

Table 3.19 – M62 J26-J27: traffic speed (mph) for different values of minimum gap

The effect of increasing the minimum gap on journey times in the M60 J18 network are given in Figures 3.9a/3.9b and Table 3.20 while Table 3.21 gives an overview of flows by lane at key points.

Key observations – M60 J18:

- The lower bound of the parameter range investigated (1m) minimised journey times on all routes.
- Journey times increased throughout the parameter range except for the North to West movement, which is under capacity.
- The South to East Movement journey time increased greatly at gap greater than 2m. At this point the platoon of circulating vehicles is disrupted by queues that start to block back from signals.

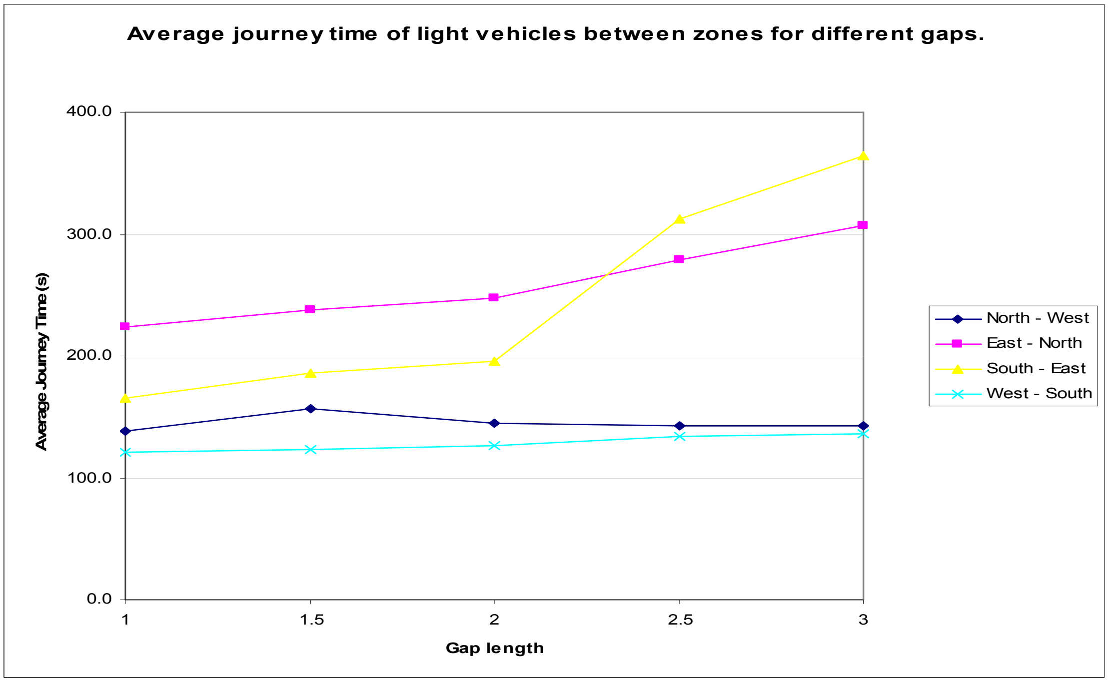


Figure 3.9a - M60 J18: Journey time variation with different the minimum gap - Cars

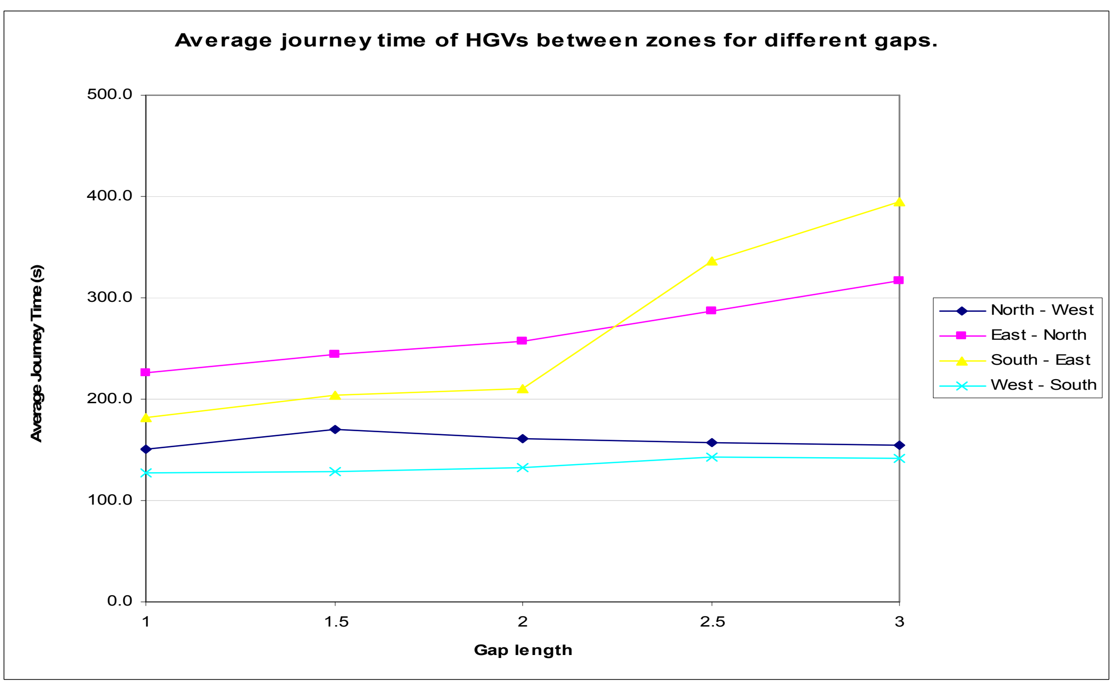


Figure 3.9b - M60 J18: Journey time variation with different the minimum gap - HGVs

Zone Movement	Gap	Cars		HGV	
		Mean Journey Time (s)	% of the default journey time	Mean Journey Time (s)	% difference to default journey time
North - West	1	138	-	151	-
	1.5	157	14%	170	13%
	2	145	5%	160	6%
	2.5	143	3%	157	4%
	3	143	4%	155	2%
East - North	1	223	-	226	-
	1.5	238	7%	244	8%
	2	248	11%	257	13%
	2.5	279	25%	287	27%
	3	307	37%	317	40%
South - East	1	165	-	181	-
	1.5	186	12%	204	13%
	2	196	18%	211	16%
	2.5	313	89%	336	85%
	3	364	120%	395	118%
West - South	1	121	-	128	-
	1.5	123	2%	128	0%
	2	126	4%	132	3%
	2.5	134	10%	142	11%
	3	136	12%	142	11%

Table 3.20 - M60 J18 Journey time variation with different minimum gap

Location	Lane number	Lane key	Gap				
			1.0	1.5	2.0	2.5	3.0
North	1	Main Carriageway	4%	6%	5%	4%	2%
	2	Main Carriageway	96%	94%	95%	96%	98%
East	1	Outer Slip Road	45%	45%	45%	45%	47%
	2	Inner Slip Road	55%	55%	55%	55%	53%
South	1	Main Carriageway	64%	61%	58%	51%	50%
	2	Main Carriageway	36%	39%	42%	49%	50%
West	1	Main Carriageway	18%	19%	19%	20%	21%
	2	Main Carriageway	82%	81%	81%	80%	79%

Table 3.21 - M60 J18 Traffic flow variation for different values of the minimum gap

3.9 Minimum Gap(m) Summary

For the M62 network, journey times for slip traffic increased with the minimum gap length for merging traffic throughout the parameter range investigated. As minimum gap is reduced vehicles queue/crawl closer together. Under congested network conditions a small gap parameter allows the queued slip traffic to access the main line more easily. Increasing or decreasing minimum gap did not appear to significantly alter lane usage.

On the M60 network journey times increased throughout the parameter range except for the North to West movement, which is under capacity. The South to East Movement journey time increased greatly at gap greater than 2m. At this point the platoon of circulating vehicles is disrupted by queues that start to block back from signals.

3.10 Test 5 – Aggression

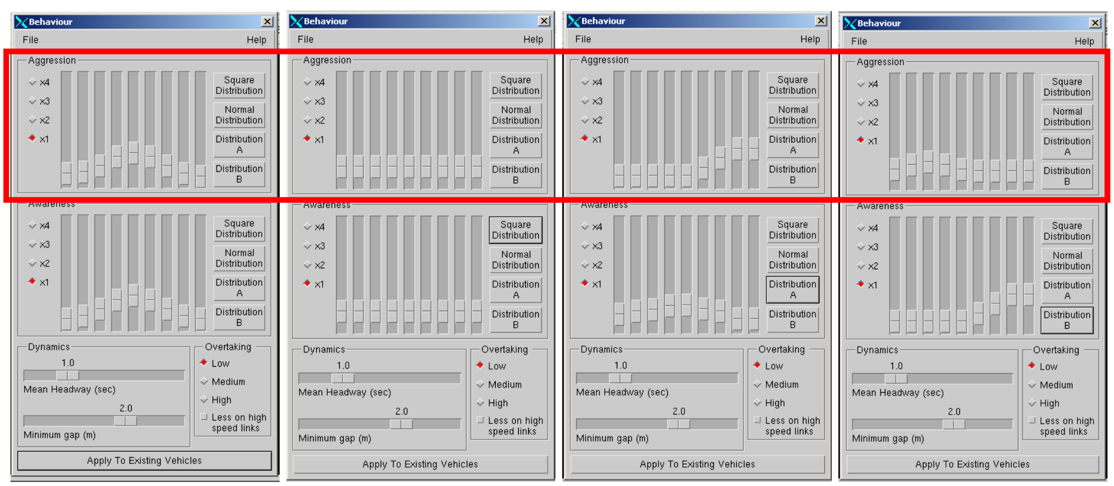
The purpose of this test was to investigate the impact on model output of altering the Aggression distributions.

Parameter	Aggression
Description	Behaviour characteristic that influence drivers gap acceptance, car following, and lane changing characteristics
Possible Variation	The scale of the distribution can be changed (x1,x2,x3,x4) This does not affect the results only the scale of the graph displayed. The shape of the distribution can be changed (normal, square, Distribution A, Distribution B) User defined distribution can be specified using sliders
Test Variables	normal distribution - Default
	distribution A
	distribution B
	square distribution

3.10.1 Distributions

There are four pre-defined distributions available:

- Normal Distribution – default distribution
- Square Distribution – more high and low aggression vehicles, less mid aggression vehicles
- Distribution A – more higher aggression vehicles
- Distribution B – more lower aggression vehicles



Normal Distribution | Square Distribution | Distribution A | Distribution B

Above are the Aggression distributions available within Paramics.

The predefined distributions can be further modified by moving the sliders to create a unique distribution.

The (x1, x2, x3, x4) scale does not vary the Aggressiveness of the vehicles. Testing the impacts and close study of the distribution has shown that these buttons only alter the display of the distribution and do not affect the modelled behaviour.

3.10.2 Results

The effects of increasing the aggression distribution on journey times in the M62 J26-J27 network are given in Figures 3.10a/3.10b and Table 3.22 below. Tables 3.23 and 3.24 give an overview of flows and speeds by lane at key points.

All tests have been compared against the default normal distribution results.

Key Observations – M62 J26-J27:

- Distribution A, which contains more high aggression drivers, resulted in reduced car journey times for merging traffic and slowed cars originating on the mainline when compared to the default normal distribution.
- Distribution B, which contains more low aggression drivers, resulted in increased car journey times for all movement compared to the default normal distribution.
- The effect on car journey time of altering the aggression distribution appears to be more marked for slip movements.
- The response of HGV's to changes in the aggressiveness distribution is similar. The only divergence from the behaviour outlined above is given by a reduction of journey times on all routes when distribution A is applied.
- This behaviour can be explained by considering vehicle behaviour characteristics. More aggressive drivers will take a smaller gap when joining the mainline and are less willing to lane change to allow joiners onto the mainline. This explains the increased journey times when there are less aggressive drivers in the distribution.
- The impact is greater for slip movements as vehicle behaviour changes impact more heavily on vehicles on slip roads, these vehicles are using vehicle behaviour parameters to decide when to merge and are more sensitive to variations in aggression.
- The aggression distribution alters lane usage as it impacts on the level of overtaking

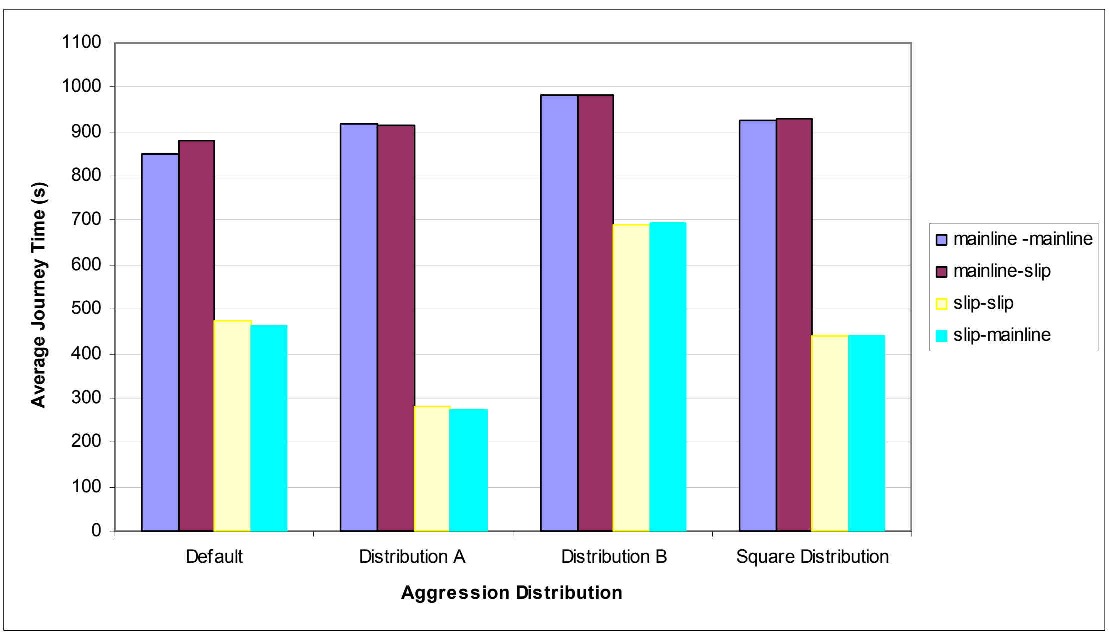


Figure 3.10a – M62 J26-J27: Journey time variation with different aggression distribution - Cars

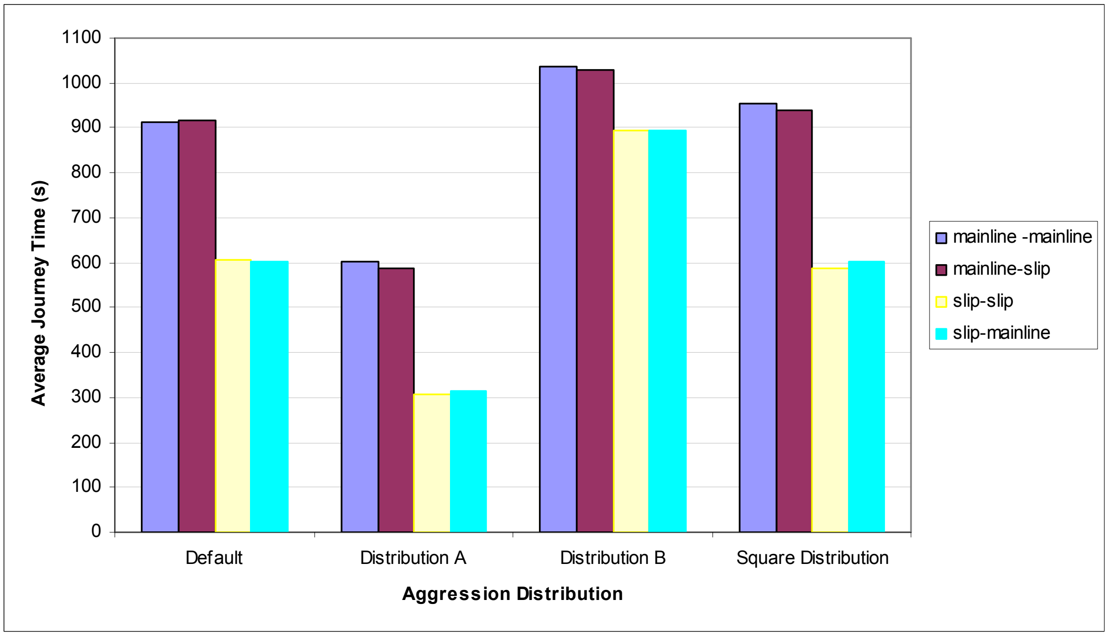


Figure 3.10b – M62 J26-J27: Journey time variation with different aggression distribution – HGVs

Zone Movement	Aggression	Cars		HGV	
		Mean Journey Time	% difference from the default journey time	Mean Journey Time	% difference from the default journey time
Mainline -Mainline	Default	848	-	913	-
	Distribution A	916	8%	601	-34%
	Distribution B	982	16%	1036	13%
	Square Distribution	926	9%	955	5%
Mainline-Slip	Default	879	-	915	-
	Distribution A	914	4%	587	-36%
	Distribution B	984	12%	1028	12%
	Square Distribution	928	6%	939	3%
Slip-Mainline	Default	464	-	603	-
	Distribution A	274	-41%	314	-48%
	Distribution B	693	49%	896	48%
	Square Distribution	438	-6%	604	0%
Slip-Slip	Default	473	-	606	-
	Distribution A	279	-41%	305	-50%
	Distribution B	690	46%	896	48%
	Square Distribution	441	-7%	587	-3%

Table 3.22 – M62 J26-J27: Journey time variation with different aggression distributions

Location	Lane	Lane key	Aggression Distribution: Normal Distribution	Distribution A	Distribution B	Square Distribution
Before Merge	1	Main Carriageway	42%	34%	40%	41%
	2	Main Carriageway	35%	40%	35%	35%
	3	Main Carriageway	23%	26%	25%	24%
Across Merge	1-2	Slip Road				
	3	Main Carriageway	28%	22%	24%	28%
	4	Main Carriageway	37%	45%	34%	36%
	5	Main Carriageway	36%	33%	41%	36%
Between Merge and Diverge	1	Main Carriageway	25%	21%	22%	24%
	2	Main Carriageway	29%	40%	28%	30%
	3	Main Carriageway	46%	40%	50%	46%
Before Diverge	1	Main Carriageway	41%	27%	41%	39%
	2	Main Carriageway	28%	37%	25%	28%
	3	Main Carriageway	31%	36%	33%	34%
Across Diverge	1-2	Slip Road				
	3	Main Carriageway	30%	37%	29%	31%
	4	Main Carriageway	41%	21%	37%	35%
	5	Main Carriageway	29%	41%	34%	34%
After Diverge	1	Main Carriageway	25%	44%	45%	44%
	2	Main Carriageway	45%	36%	24%	26%
	3	Main Carriageway	29%	20%	31%	30%

Table 3.23 – M62 J26-J27: Summary of traffic flow for different aggression distributions

Location	Lane	Lane key	Normal Distribution	Distribution A	Distribution B	Square Distribution
Before Merge	1	Main Carriageway	31	35	29	30
	2	Main Carriageway	31	36	29	30
	3	Main Carriageway	39	40	37	40
		Average	**34**	**37**	**32**	**33**
Across Merge	1-2	Slip Road	48	74	41	53
	3	Main Carriageway	26	30	25	28
	4	Main Carriageway	26	28	22	25
	5	Main Carriageway	36	32	26	33
		Average	**34**	**41**	**29**	**35**
Between Merge and Diverge	1	Main Carriageway	21	50	18	21
	2	Main Carriageway	26	60	21	25
	3	Main Carriageway	55	79	49	52
		Average	**34**	**63**	**29**	**33**
Before Diverge	1	Main Carriageway	31	42	28	29
	2	Main Carriageway	42	62	40	40
	3	Main Carriageway	58	75	56	57
		Average	**43**	**60**	**41**	**42**
Across Diverge	1-2	Slip Road	60	64	54	57
	3	Main Carriageway	59	62	56	56
	4	Main Carriageway	77	79	73	73
	5	Main Carriageway	82	90	81	83
		Average	**56**	**59**	**53**	**54**
After Diverge	1	Main Carriageway	59	64	54	57
	2	Main Carriageway	76	62	56	56
	3	Main Carriageway	82	79	73	73
		Average	**73**	**69**	**61**	**62**

Table 3.24 – M62 J26-J27: Summary of traffic speed (mph) for different aggression distribution

The effects of altering the aggression distribution on journey times in the M60 J18 network are given in Figures 3.11a/3.11b and Table 3.25 below. Table 3.26 gives an overview of flows by lane at key points.

Key Observations – M60 J18:

- The highest change in journey times was caused by Distribution A, which contains a high number of high aggression drivers.
- When Distribution B is applied journey times increased by up to 30% compared with the standard distribution.
- Changing the aggression distribution had no discernable impact on lane usage. This is as expected as lane usage is defined by the network.

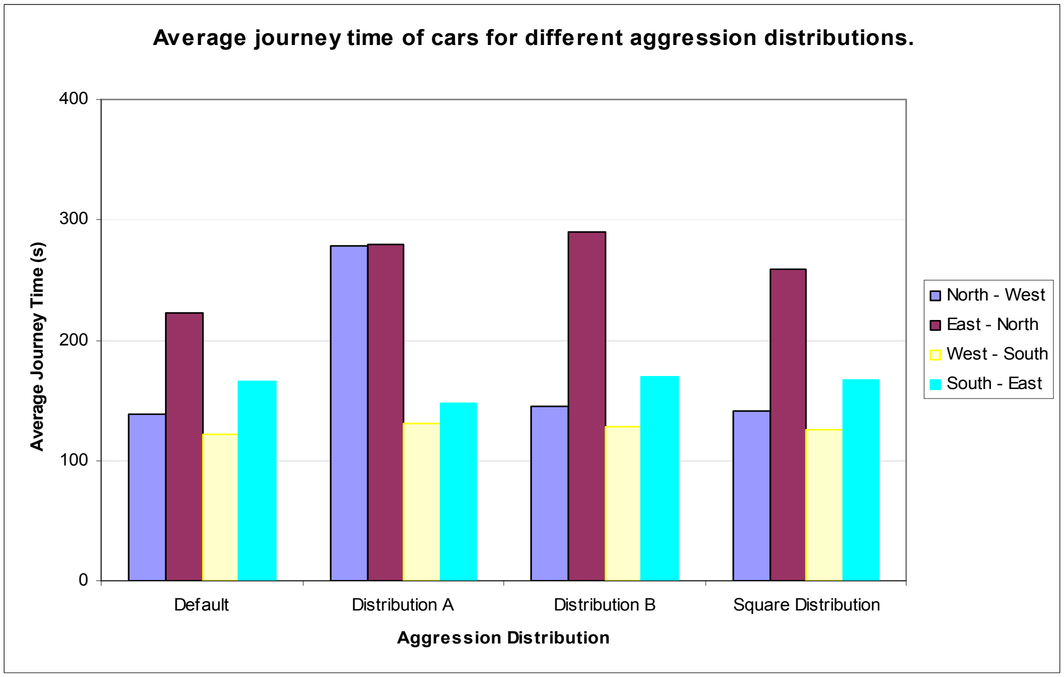


Figure 3.11a - M60 J18: Journey time variation with different aggression distributions - Cars

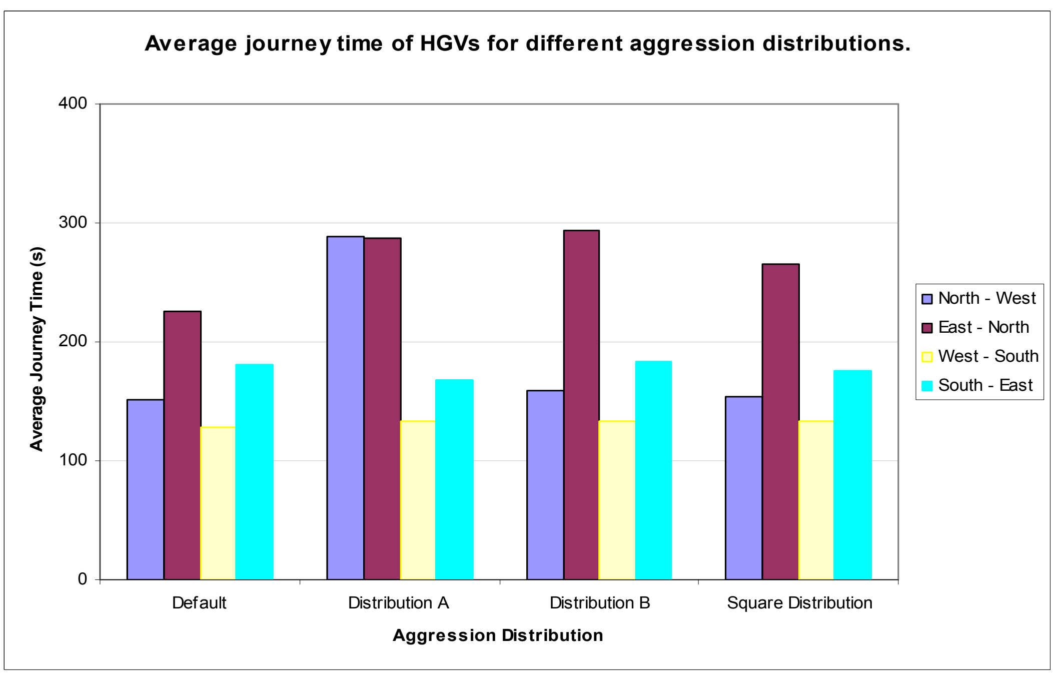


Figure 3.11b - M60 J18: Journey time variation with different aggression distributions - HGVs

Zone Movement	Aggression	Cars: Mean Journey Time	Cars: % of the default journey time	HGV: Mean Journey Time	HGV: % difference to average journey time
North - West	Default	138	-	151	-
	Distribution A	278	101.5%	288	90.6%
	Distribution B	146	5.5%	159	5.1%
	Square Distribution	141	1.8%	153	1.4%
East - North	Default	223	-	226	-
	Distribution A	279	25.2%	288	27.1%
	Distribution B	290	30.1%	294	30.0%
	Square Distribution	259	15.9%	265	17.2%
South - East	Default	165	-	181	-
	Distribution A	148	-10.7%	168	-7.6%
	Distribution B	170	2.7%	183	1.2%
	Square Distribution	167	1.0%	176	-2.9%
West - South	Default	121	-	128	-
	Distribution A	131	7.9%	133	4.3%
	Distribution B	129	6.0%	134	4.6%
	Square Distribution	125	3.1%	133	4.1%

Table 3.25 - M60 J18: Journey time variation with different aggression distributions

			Aggression Distribution			
Location	**Lane**	**Lane key**	**Normal Distribution**	**Distribution A**	**Distribution B**	**Square Distribution**
North	1	Main Carriageway	4%	9%	2%	3%
	2	Main Carriageway	96%	91%	98%	97%
East	1	Outer Slip Road	45%	48%	40%	41%
	2	Inner Slip Road	55%	52%	60%	59%
South	1	Main Carriageway	64%	69%	64%	65%
	2	Main Carriageway	36%	31%	36%	35%
West	1	Main Carriageway	18%	18%	17%	18%
	2	Main Carriageway	82%	82%	83%	82%

Table 3.26 - M60 J18: Summary of traffic flows for different aggression distributions

3.11 Aggression Summary

In the congested M62 network adoption of Distribution A improved journey times for merging traffic while Distribution B increased the journey time for all traffic. Using the Square Distribution also resulted in increased journey times. This is because distribution A contains more aggressive drivers who change lanes more often and accept smaller gaps, thus increasing capacity

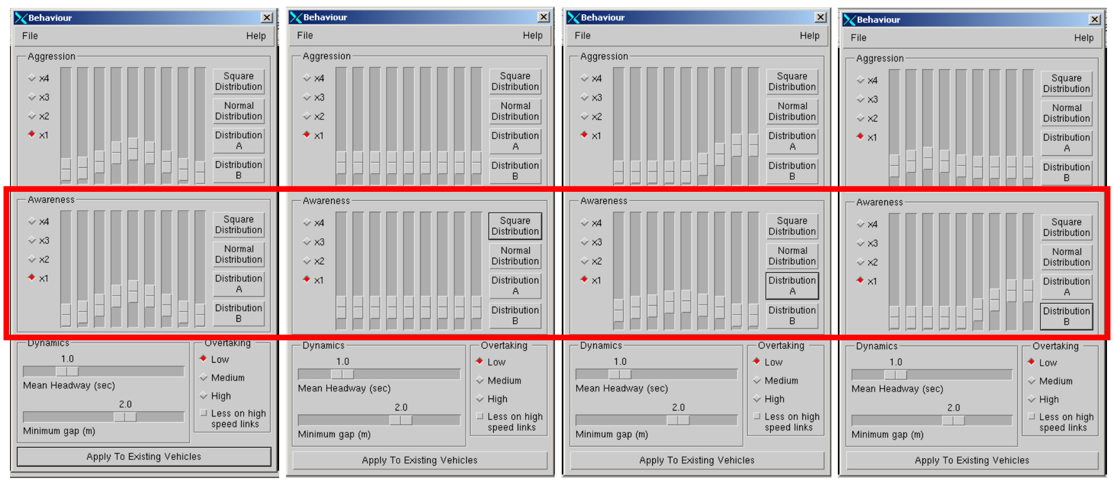
However, in the less congested M60 model use of Distribution A and B had little effect on journey times. This is because vehicle behaviour parameters limited impact on behaviour at signals as lane choice and capacity are fixed by the network characteristics.

3.12 Test 6 – Awareness

The purpose of this test is to investigate the impact on model output of altering the Aggression distributions.

Parameter	**Awareness**
Description	Behaviour characteristic that influence drivers gap acceptance, car following, and lane changing characteristics
Possible Variation	The scale of the distribution can be changed (x1,x2,x3,x4) This does not affect the modelled results. The shape of the distribution can be changed (normal, square, Distribution A, Distribution B) User defined distribution can be specified using sliders
Test Variables	normal distribution - Default
	distribution A
	distribution B
	square distribution

3.12.1 Distributions



Normal Distribution	Square Distribution	Distribution A	Distribution B

Above are the Awareness distributions available within Paramics.

There are four pre-defined distributions available:

- Normal Distribution – default distribution
- Square Distribution – more high and low awareness vehicles, less mid awareness vehicles
- Distribution A – more lower awareness vehicles
- Distribution B – more higher awareness vehicles

The predefined distributions can be further modified by moving the sliders to create a unique distribution.

The (x1, x2, x3, x4) scale does not vary the awareness of the vehicles. Testing the impacts and close study of the distribution has shown that these buttons only alter the display of the distribution and do not affect the modelled behaviour.

3.12.2 Results

The effect of altering the awareness distributions on journey times in the M62 J26-J27 network are given in Figures 3.12a/3.12b and Table 3.27 below. Tables 3.28 and 3.29 give an overview of flows and speeds by lane at key points.

Key Observations M62 J26-J27:

- Distribution A only sums to 98, therefore the default distribution will not assign. 1 was added to the two most-aware slider bars to allow assignment.
- Distribution B, which contains more high awareness drivers, resulted in a drop in journey times for routes with origin on the mainline. Traffic on merging routes takes slightly longer to pass through the network.
- Distribution A, which contains more low awareness drivers, resulted in increased journey times for all movement compared to the normal distribution default.
- The Square Distribution, which contains more very high and low awareness drivers produced larger journey times on slip movements (+20%), and marginally longer for mainline movements.
- This is expected because more aware drivers will take a smaller gap when joining the mainline and are less willing to lane change to allow joiners onto the mainline. This may explain the increased journey times when there are less aware drivers in the distribution such as Distribution A and reduced journey times when there are more aware drivers such as Distribution B.
- The effects of varying awareness distribution are less than those of varying aggression distribution in this model.
- The effects of varying awareness impact more heavily on mainline traffic journey time than slip lane traffic.

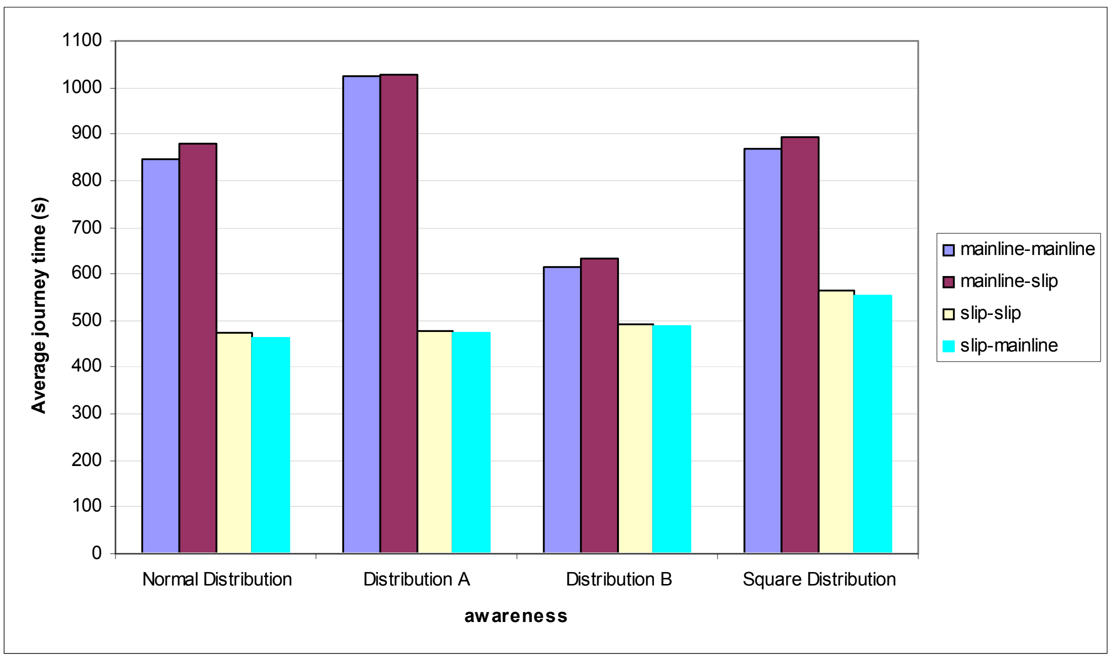


Figure 3.12a – M62 J26-J27: Journey time variation with different awareness distributions - Cars

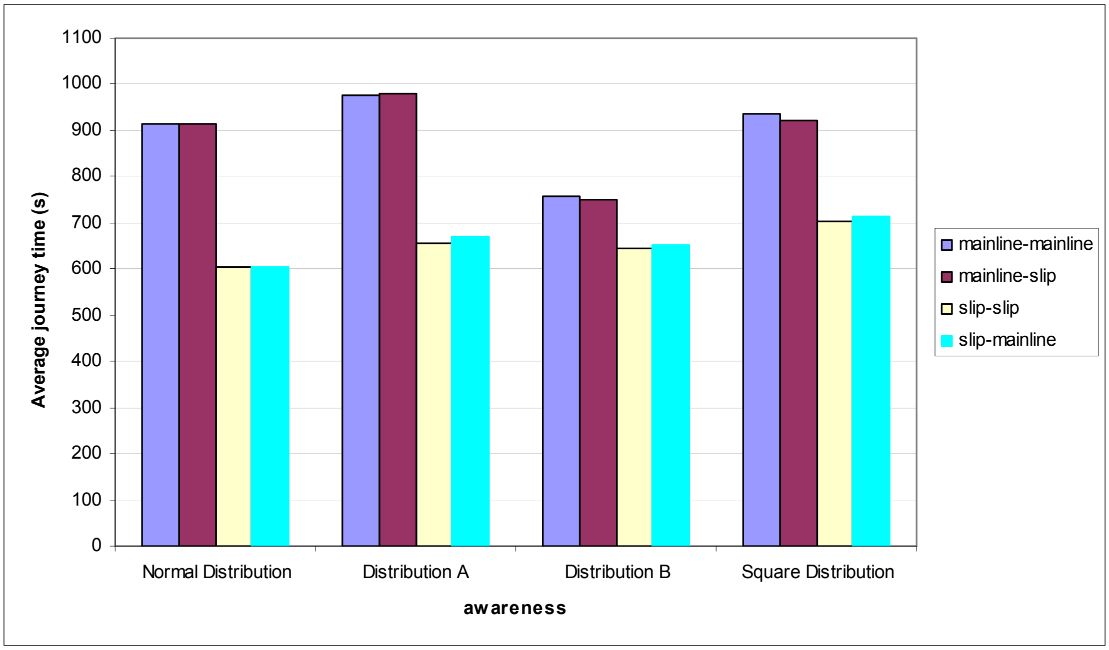


Figure 3.12b – M62 J26-J27: Journey time variation with different awareness distributions - HGVs

Zone Movement	Awareness	Cars: Mean Journey Time	Cars: % difference from the default journey time.	HGV: Mean Journey Time	HGV: % difference from the default journey time.
mainline-mainline	Normal Distribution	848	-	913	-
	Distribution A	1024	21%	977	7%
	Distribution B	616	-27%	756	-17%
	Square Distribution	869	2%	936	3%
mainline-slip	Normal Distribution	879	-	915	-
	Distribution A	1029	17%	981	7%
	Distribution B	633	-28%	751	-18%
	Square Distribution	895	2%	923	1%
slip-mainline	Normal Distribution	464	-	603	-
	Distribution A	476	2%	671	11%
	Distribution B	488	5%	651	8%
	Square Distribution	553	19%	712	18%
slip-slip	Normal Distribution	473	-	606	-
	Distribution A	479	1%	655	8%
	Distribution B	492	4%	645	6%
	Square Distribution	563	19%	702	16%

Table 3.27 – M62 J26-J27: Journey time variation with different awareness distributions

Location	Lane	Lane key	Awareness Distribution: Normal Distribution	Distribution A	Distribution B	Square Distribution
Before Merge	1	Main Carriageway	42%	42%	39%	41%
	2	Main Carriageway	35%	37%	36%	37%
	3	Main Carriageway	23%	22%	25%	22%
Across Merge	1-2	Slip Road				
	3	Main Carriageway	28%	25%	26%	28%
	4	Main Carriageway	37%	36%	34%	36%
	5	Main Carriageway	36%	39%	41%	36%
Between Merge and Diverge	1	Main Carriageway	25%	25%	23%	24%
	2	Main Carriageway	29%	29%	28%	30%
	3	Main Carriageway	46%	46%	49%	46%
Before Diverge	1	Main Carriageway	41%	38%	43%	36%
	2	Main Carriageway	28%	29%	26%	31%
	3	Main Carriageway	31%	33%	31%	32%
Across Diverge	1-2	Slip Road				
	3	Main Carriageway	30%	29%	31%	30%
	4	Main Carriageway	41%	41%	38%	41%
	5	Main Carriageway	29%	30%	32%	29%
After Diverge	1	Main Carriageway	25%	43%	43%	43%
	2	Main Carriageway	45%	24%	26%	24%
	3	Main Carriageway	29%	33%	32%	33%

Table 3.28 – M62 J26-J27: Summary of traffic flow for different awareness distributions

Location	Lane	Lane key	Normal Distribution	Distribution A	Distribution B	Square Distribution
Before Merge	1	Main Carriageway	31	31	39	33
	2	Main Carriageway	31	32	41	35
	3	Main Carriageway	39	37	53	45
		Average	**34**	**33**	**44**	**38**
Across Merge	1-2	Slip Road	48	57	51	43
	3	Main Carriageway	26	25	32	28
	4	Main Carriageway	26	25	28	25
	5	Main Carriageway	36	28	38	39
		Average	**34**	**34**	**37**	**34**
Between Merge and Diverge	1	Main Carriageway	21	21	20	20
	2	Main Carriageway	26	26	24	24
	3	Main Carriageway	55	57	55	55
		Average	**34**	**35**	**33**	**33**
Before Diverge	1	Main Carriageway	31	28	33	29
	2	Main Carriageway	42	38	43	40
	3	Main Carriageway	58	56	56	57
		Average	**43**	**41**	**44**	**42**
Across Diverge	1-2	Slip Road	60	60	61	60
	3	Main Carriageway	59	58	61	59
	4	Main Carriageway	77	77	78	77
	5	Main Carriageway	82	83	83	83
		Average	**56**	**56**	**57**	**56**
After Diverge	1	Main Carriageway	59	60	61	60
	2	Main Carriageway	76	58	61	59
	3	Main Carriageway	82	77	78	77
		Average	**73**	**65**	**67**	**65**

Table 3.29 – M62 J26-J27: Summary of traffic speed for different awareness distributions

The effects of altering the awareness distribution on journey times in the M60 J18 network are given in Figure 3.13a/3.13b and Table 3.30 below. Table 3.31 gives an overview of flows by lane at key points.

Key Observations M60 J18:

- Changing the awareness distribution had a less marked impact on journey times than changing the aggression distribution.
- The only sizeable deviation from the standard distribution occurred on the East – North movement where journey times increased by 18.9% for cars and 20% for HGV's.
- Adjusting the awareness distribution had no impact on lane usage.
- Adjusting the awareness distribution has limited impact on throughput due to stability in the model caused by signalised nature of junction.

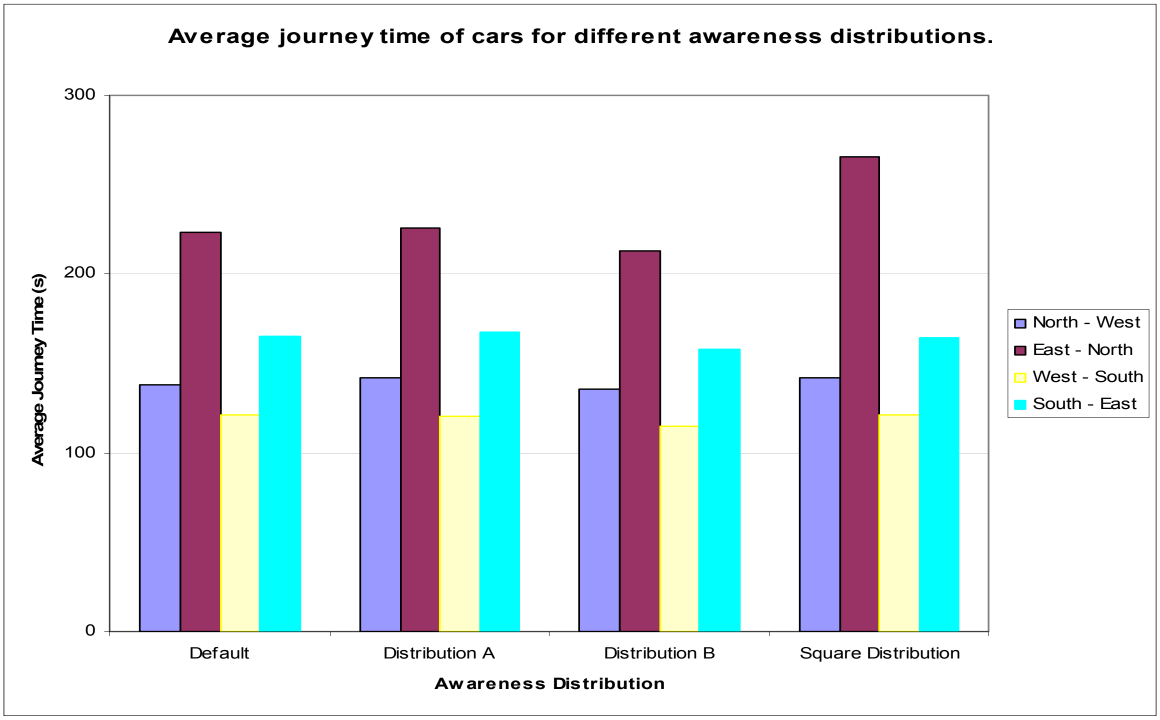


Figure 3.13a - M60 J18: Journey time variation with different awareness distributions - Cars

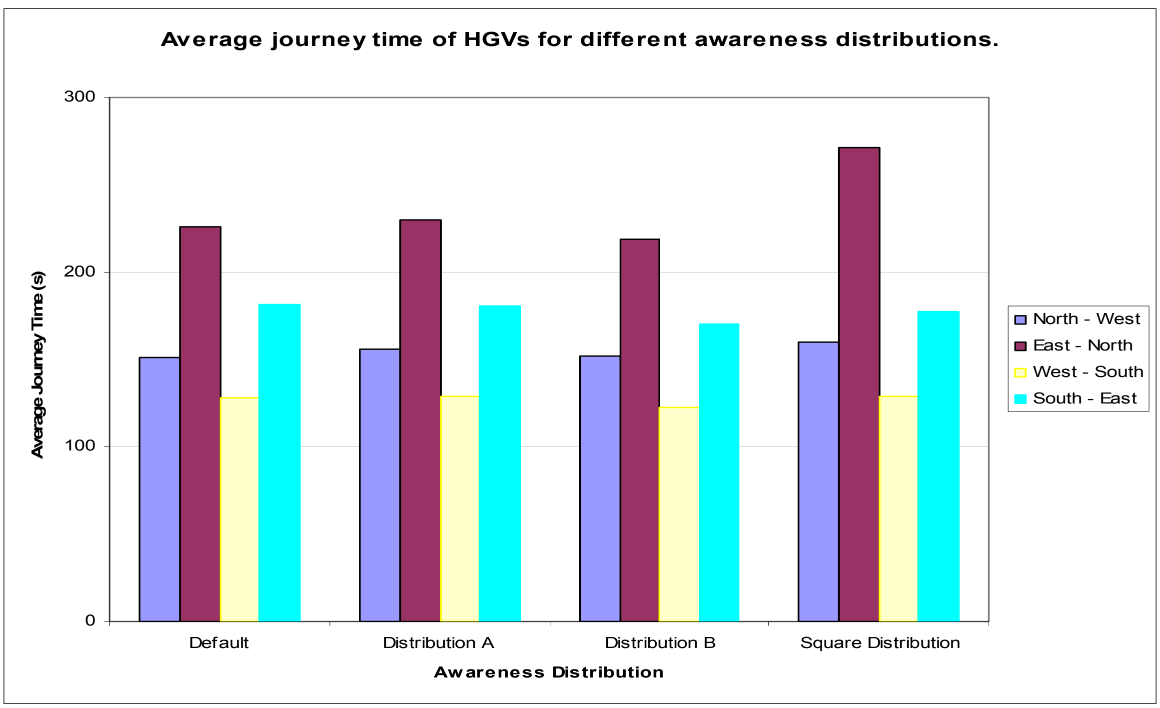


Figure 3.13b - M60 J18: Journey time variation with different awareness distributions - HGVs

Zone Movement	Awareness	Cars		HGV	
		Mean Journey Time	% of the default journey time	Mean Journey Time	% difference to average journey time
North - West	Default	138	-	151	-
	Distribution A	142	3%	156	3%
	Distribution B	136	-2%	152	0%
	Square Distribution	142	3%	160	6%
East - North	Default	223	-	226	-
	Distribution A	225	1%	230	2%
	Distribution B	213	-5%	219	-3%
	Square Distribution	265	19%	271	20%
South - East	Default	165	-	181	-
	Distribution A	167	1%	180	0%
	Distribution B	158	-5%	170	-6%
	Square Distribution	165	0%	178	-2%
West - South	Default	121	-	128	-
	Distribution A	121	0%	129	1%
	Distribution B	115	-5%	123	-4%
	Square Distribution	122	0%	129	1%

Table 3.30 - M60 J18: Journey time variation with different awareness distributions

			Awareness Distribution			
Location	Lane	Lane key	Normal Distribution	Distribution A	Distribution B	Square Distribution
North	1	Main Carriageway	4%	5%	4%	2%
	2	Main Carriageway	96%	95%	96%	98%
East	1	Outer Slip Road	45%	44%	43%	43%
	2	Inner Slip Road	55%	56%	57%	57%
South	1	Main Carriageway	64%	64%	71%	66%
	2	Main Carriageway	36%	36%	29%	34%
West	1	Main Carriageway	18%	18%	16%	20%
	2	Main Carriageway	82%	82%	84%	80%

Table 3.31 - M60 J18: Summary of traffic flows for different awareness distributions

3.13 Awareness Summary

In the congested M62 network adoption of Distribution A improved journey times for all traffic while Distribution B increased the journey time for merging traffic but reduced it for the mainline traffic. The Square Distribution increased the journey time for all traffic, especially slip movements. In general, more aware drivers will accept smaller gaps and changing Awareness had less impact than changing Aggression.

In the less congested M60 network changing Awareness had little effect due to limited impact of vehicle behaviour characteristics on model behaviour at signalised junctions.

3.14 Test 7 – Overtaking Desire

Within Paramics it should be noted that 'overtaking' and passing' are considered as separate events. 'Overtaking' would occur on single carriageway links and according to the manual, selecting overtaking on a link *'flags that overtaking on the link can use the other side of the road, i.e. against oncoming traffic'*. 'Passing' is the act of moving to an available adjacent lane to pass a slower moving vehicle ie the offside lane of a dual carriageway or motorway.

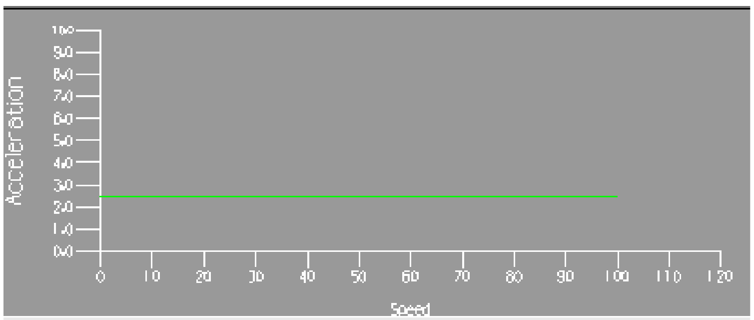
Consequently, while 'overtaking' was identified as an important vehicle behaviour factor by SIAS in the Questionnaire, for a motorway model this would be inappropriate. Also, given that networks are most often coded as separate one-way links, not possible to model.

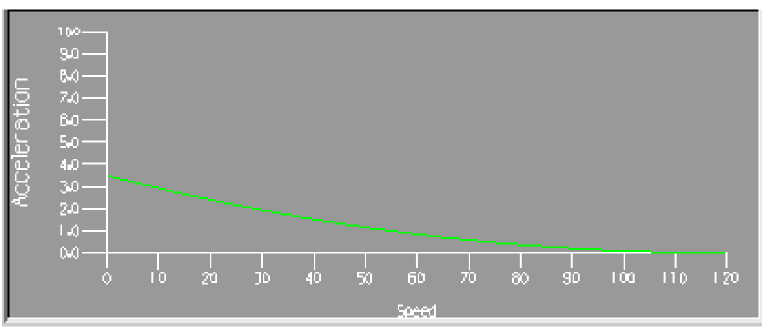
3.15 Test 8 – Acceleration profile

The purpose of this test is to investigate the impact of altering the acceleration profile on model output

Parameter	Acceleration Profile	
Description	Plot of maximum acceleration at different speeds is set by vehicle type	
Test Variables	Normal acceleration	- Default flat profile
	Modified acceleration	- reducing acceleration at higher speeds

The acceleration profile for all vehicle types defaults as a flat profile, vehicle characteristics such as drag and inertia can be set to alter this distribution. We have modified these variables to create a linear acceleration profile. These are shown below.





3.15.1 *Results*

The effect of altering acceleration profiles on journey times in the M62 J26-J27 network are given in Figures 3.14a/3.14b and Table 3.35 below. Tables 3.36 and 3.37 give an overview of flows and speeds by lane at key points.

Key Observations – M62 J26-J27:

- Modified acceleration profile increased journey time for all vehicles.
- The effect is more marked for slip trips.
- Modified acceleration profile alters lane usage as reducing acceleration at high speed reduces ability of vehicles to overtake.

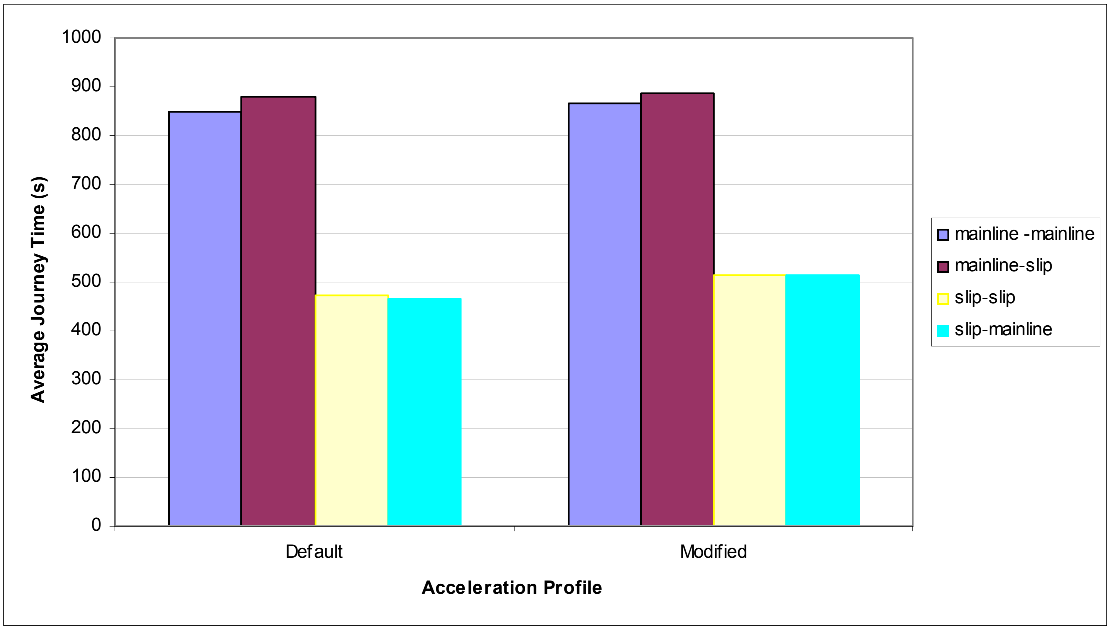


Figure 3.14a – M62J26-J27: Journey time variation with different acceleration profiles – Cars

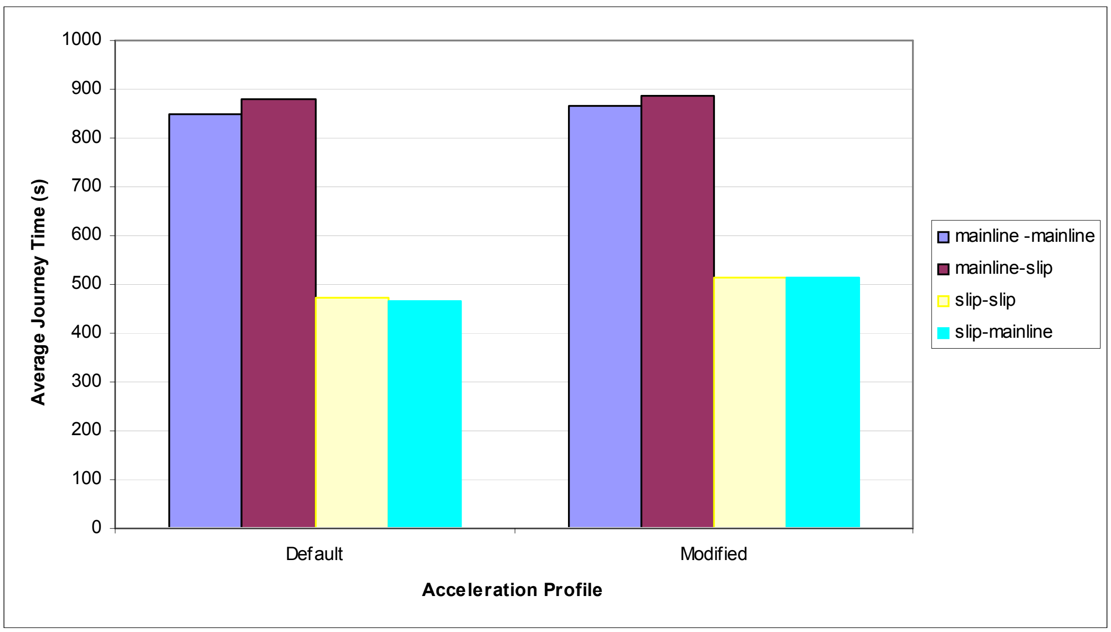


Figure 3.14b – M62J26-J27: Journey time variation with different acceleration profiles - HGVs

Zone Movement	Acceleration Profile	Cars		HGV	
		Mean Journey Time	% difference from the default journey time	Mean Journey Time	% difference from the default journey time
mainline-mainline	Default	848	-	913	-
	Modified	864	2%	942	3%
Mainline-slip	Default	879	-	915	-
	Modified	887	1%	945	3%
slip-mainline	Default	464	-	603	-
	Modified	512	10%	675	12%
slip-slip	Default	473	-	606	-
	Modified	513	8%	666	10%

Table 3.35 – M62J26-J27: Journey time variation with different acceleration profile

Location	Lane	Lane key	Acceleration Profile Default	Modified
Before Merge	1	Main Carriageway	42%	41%
	2	Main Carriageway	35%	35%
	3	Main Carriageway	23%	24%
Across Merge	1-2	Slip Road		
	3	Main Carriageway	28%	30%
	4	Main Carriageway	37%	36%
Between Merge and Diverge	1	Main Carriageway	25%	26%
	2	Main Carriageway	29%	30%
	3	Main Carriageway	46%	44%
Before Diverge	1	Main Carriageway	41%	38%
	2	Main Carriageway	28%	31%
	3	Main Carriageway	31%	32%
Across Diverge	1-2	Slip Road		
	3	Main Carriageway	30%	27%
	4	Main Carriageway	41%	35%
	5	Main Carriageway	29%	37%
After Diverge	1	Main Carriageway	25%	45%
	2	Main Carriageway	45%	24%
	3	Main Carriageway	29%	31%

Table 3.36 – M62J26-J27: Summary of traffic flow for different acceleration profiles

Location	Lane	Lane key	Default acceleration profile	Modified acceleration profile
Before Merge	1	Main Carriageway	31	41
	2	Main Carriageway	31	42
	3	Main Carriageway	39	44
		Average	**34**	**42**
Across Merge	1-2	Slip Road	48	57
	3	Main Carriageway	26	29
	4	Main Carriageway	26	28
	5	Main Carriageway	36	38
		Average	**34**	**38**
Between Merge and Diverge	1	Main Carriageway	21	22
	2	Main Carriageway	26	26
	3	Main Carriageway	55	54
		Average	**34**	**34**
Before Diverge	1	Main Carriageway	31	27
	2	Main Carriageway	42	37
	3	Main Carriageway	58	51
		Average	**43**	**39**
Across Diverge	1-2	Slip Road	60	66
	3	Main Carriageway	59	63
	4	Main Carriageway	77	75
	5	Main Carriageway	82	82
		Average	**56**	**57**
After Diverge	1	Main Carriageway	59	66
	2	Main Carriageway	76	63
	3	Main Carriageway	82	75
		Average	**73**	**68**

Table 3.37 – M62J26-J27: Summary of traffic speed for different acceleration profiles.

3.16 Test 9 – HGV Length

Parameter	**HGV length**	
Description	Length of vehicle is set by vehicle type	
Test Variables	11m	- Default HGV length
	15m	- Standard HGV length

3.16.1 Results

The effect of altering HGV length on journey times in the M62 J26-J27 network are given in Figure 3.15a/3.15b and Table 3.38 below. Tables 3.39 and 3.40 give an overview of flows and speeds by lane at key points.

Key Observations

- Increasing HGV length increased car and HGV journey times for all movements

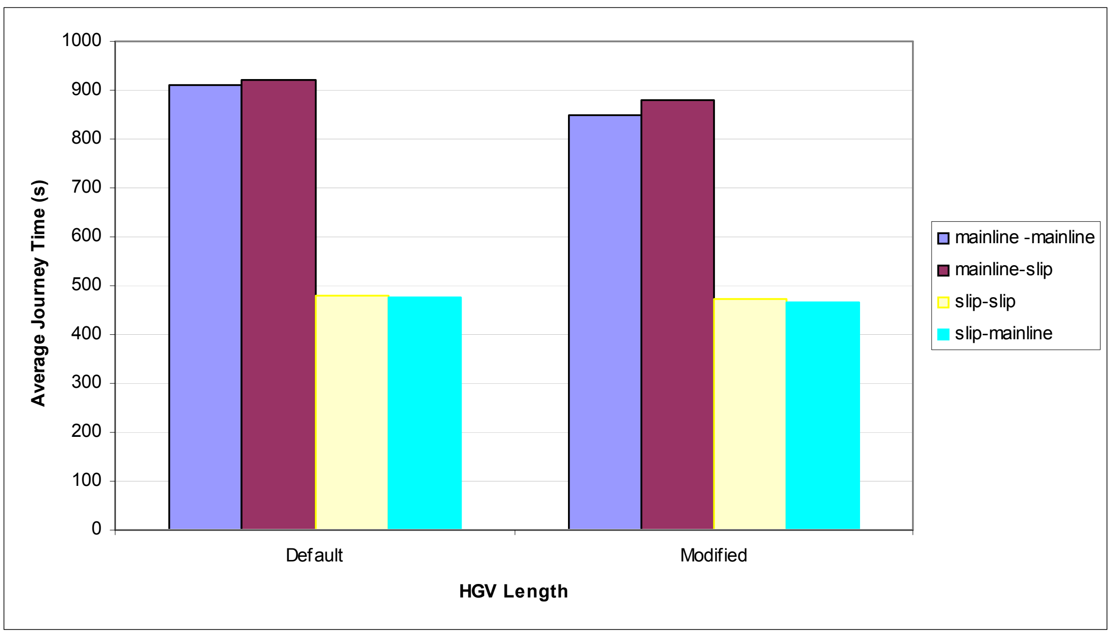


Figure 3.15a – M62J26-J27: Journey time variation with different HGV lengths - Cars

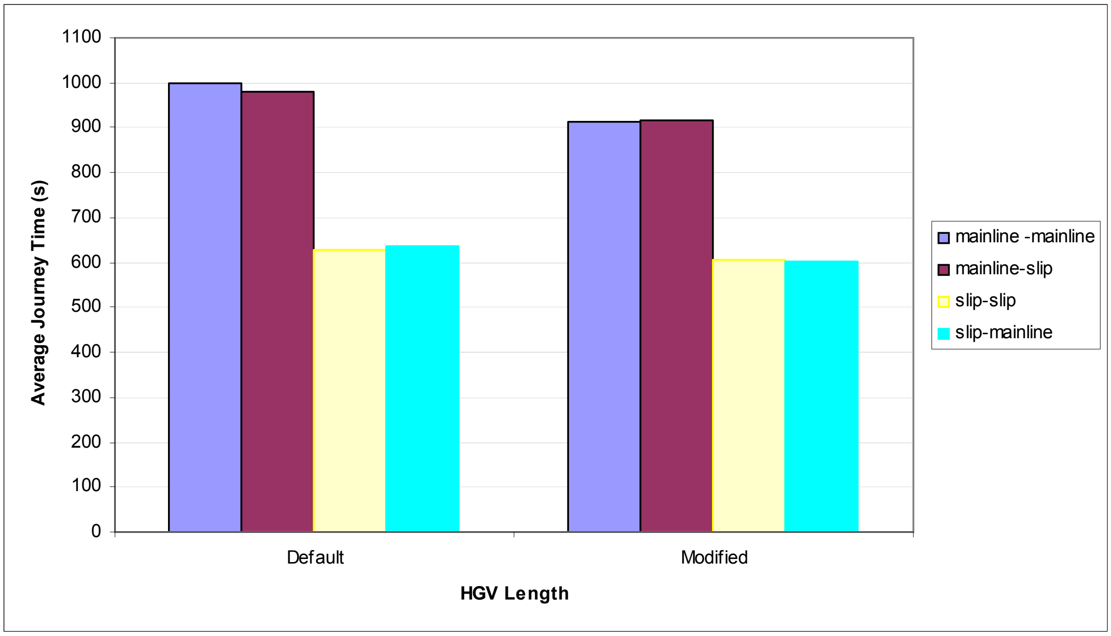


Figure 3.15b – M62J26-J27: Journey time variation with different HGV lengths - HGVs

Zone Movement	Aggression	Cars		HGV	
		Mean Journey Time	% difference from the default journey time	Mean Journey Time	% difference from the default journey time
mainline -mainline	Default	910	-	998	-
	Modified	848	-7%	913	-8%
mainline-slip	Default	922	-	981	-
	Modified	879	-5%	915	-7%
slip-mainline	Default	475	-	636	-
	Modified	464	-2%	603	-5%
slip-slip	Default	479	-	630	-
	Modified	473	-1%	606	-4%

Table 3.38 – M62J26-J27: Journey time variation with different HGV length

Location	Lane	Lane key	HGV Length Default	HGV Length Modified
Before Merge	1	Main Carriageway	42%	42%
	2	Main Carriageway	35%	35%
	3	Main Carriageway	22%	23%
Across Merge	1-2	Slip Road		
	3	Main Carriageway	27%	28%
	4	Main Carriageway	35%	37%
	5	Main Carriageway	38%	36%
Between Merge and Diverge	1	Main Carriageway	25%	25%
	2	Main Carriageway	29%	29%
	3	Main Carriageway	47%	46%
Before Diverge	1	Main Carriageway	40%	41%
	2	Main Carriageway	28%	28%
	3	Main Carriageway	32%	31%
Across Diverge	1-2	Slip Road		
	3	Main Carriageway	29%	30%
	4	Main Carriageway	43%	41%
	5	Main Carriageway	29%	29%
After Diverge	1	Main Carriageway	26%	42%
	2	Main Carriageway	46%	25%
	3	Main Carriageway	28%	34%

Table 3.39 – M62J26-J27: Summary of traffic flow for different HGV lengths

Location	Lane	Lane key	Normal length (12.15m)	Modified length (16.15m)
Before Merge	1	Main Carriageway	31	31
	2	Main Carriageway	31	31
	3	Main Carriageway	38	39
		Average	**33**	**34**
Across Merge	1-2	Slip Road	60	48
	3	Main Carriageway	25	26
	4	Main Carriageway	24	26
	5	Main Carriageway	33	36
		Average	**36**	**34**
Between Merge and Diverge	1	Main Carriageway	21	21
	2	Main Carriageway	25	26
	3	Main Carriageway	53	55
		Average	**33**	**34**
Before Diverge	1	Main Carriageway	30	31
	2	Main Carriageway	42	42
	3	Main Carriageway	58	58
		Average	**43**	**43**
Across Diverge	1-2	Slip Road	61	60
	3	Main Carriageway	59	59
	4	Main Carriageway	77	77
	5	Main Carriageway	83	82
	5		0	0
		Average	**56**	**56**
After Diverge	1	Main Carriageway	58	60
	2	Main Carriageway	77	59
	3	Main Carriageway	82	77
		Average	**72**	**65**

Table 3.40 – M62J26-J27: Summary of traffic speed for different HGV lengths.

3.17 Gradients in Paramics

Paramics determines the speed of an individual vehicle by combining physical and behavioural characteristics of the vehicle with the specification of the network to derive a desired speed.

Every vehicle has a “target” speed for the link that it is travelling on determined by the geometry and assigned values of the link, the physical capabilities of the vehicle and the values of Aggression and Awareness – which are randomly assigned from a configurable distribution. Therefore a speed distribution as such, is not input but is derived from physical and psychological conditions.

The distribution of aggressiveness and awareness applied to the vehicles will result in a distribution of desired speeds in the network.

When a section of network has a gradient the incline data adds into the derived desired speed distribution calculation to modify the resultant speeds for OGV1 and OGV2 only.

Paramics 2005.1 contains two deceleration models:

- Pre 2002.1 model
- New model.

The pre 2002.1 model is used as the default so as not to adversely affect previously calibrated models, but the new model more accurately describes the behaviour of OGV on inclines. The following description from the manual describes the process.

> *In the new deceleration model the behaviour of heavy vehicles is more accurately simulated by defining two curves: for maximum sustainable speed and deceleration shift against percentage incline. The maximum sustainable speed simply states the greatest speed that a vehicle of this type can maintain on a given gradient. The deceleration shift, again with respect to the gradient, supplies a value which is subtracted from the overall acceleration this vehicle type is expected to achieve on an incline.*

Figures 3.16a/3.16b below show the maximum sustainable speed (mS(i)) and deceleration shift (Ds(i)) as a function of percentage incline (i) for HGVs under the default pre 2002.1 and new models.

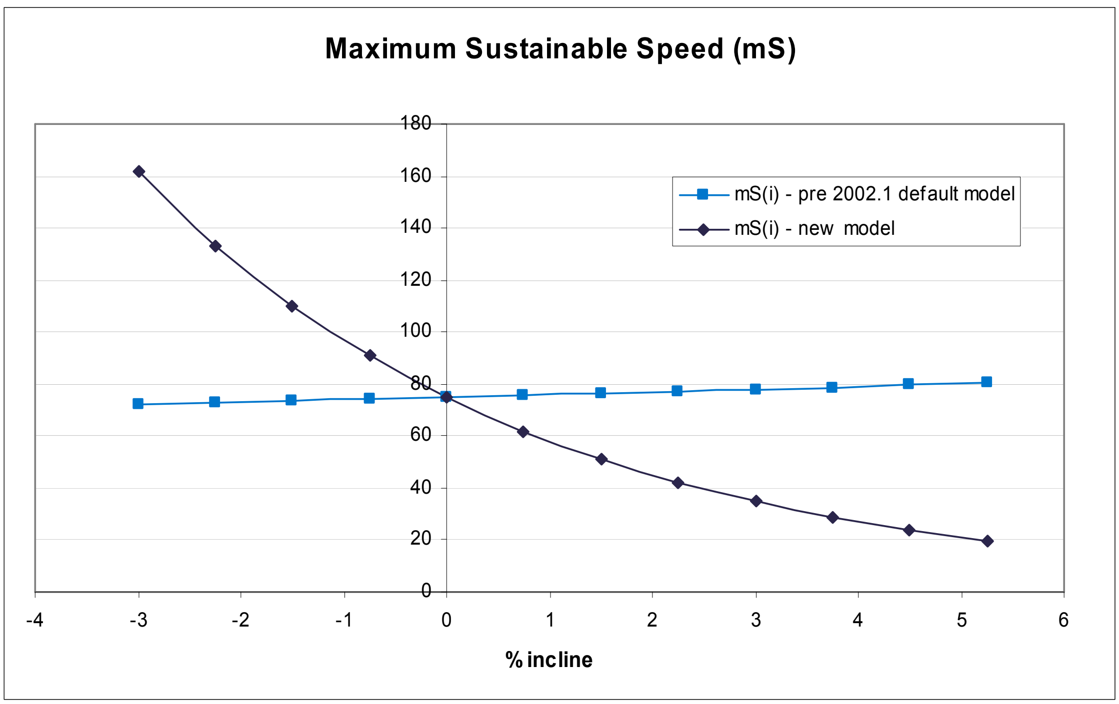


Figure 3.16a

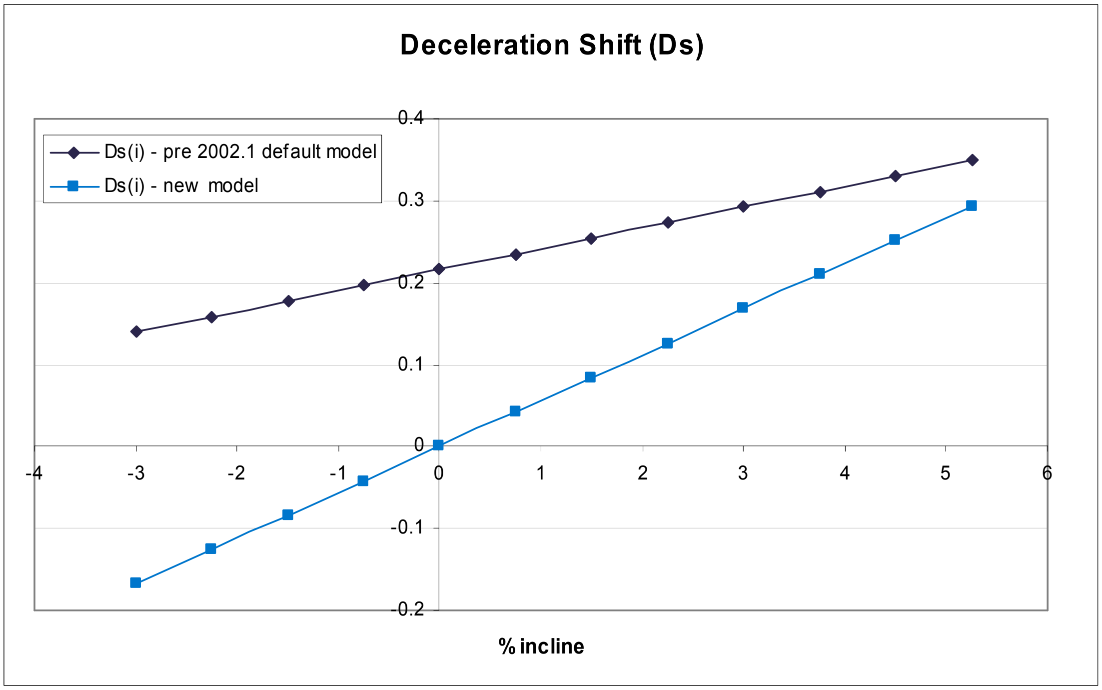


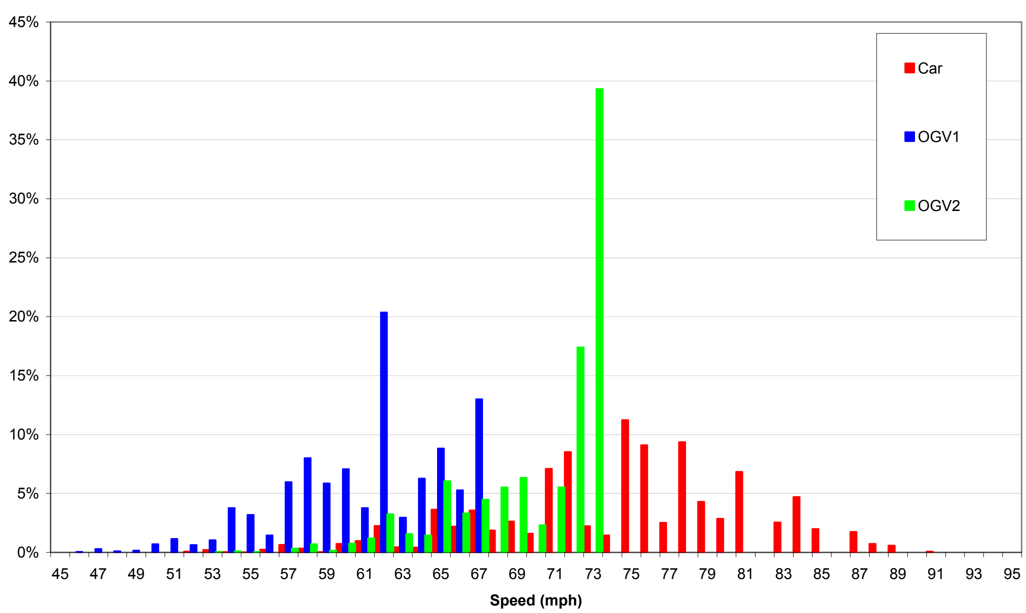
Figure 3.16b

The maximum sustainable speed is factored from the maximum speed of the vehicle type at zero gradient; in the plots above this is 75mph, the default value for HGV.

3.17.1 Speed Distribution

The default derived speed distribution for a non-gradient model has been assessed by creating a test model. A 2.5km straight flat 3 lane section of motorway has been coded with a 70mph speed limit. Vehicles were released along the network at 1 minute intervals to ensure that vehicles speed was determined only by its individual behaviour parameters and physical characteristics rather than interaction with other vehicles. The average speed along the section for each vehicle was determined and used to generate a distribution of desired speeds.

The distribution of desire speed for default vehicle types are shown in Figure 3.17



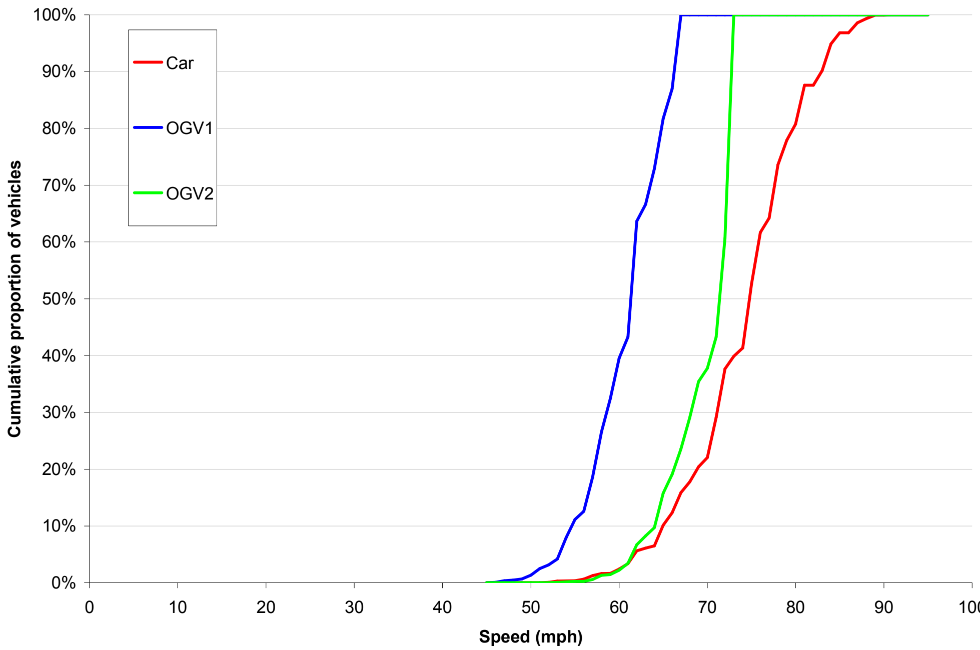


Figure 3.17 - Speed Distribution for default Vehicle Types

Figure 3.17 shows that the way the speed distribution appears to be applied is a distribution about a mean with values exceeding the maximum speed capped to the maximum speed, this accounts for the peaks at 67mph for OGV1 and 73 mph for OGV2.

It should be noted that standard guidance is to *'check that the top speed of HGV vehicle types is appropriate for the modelled area'*. If the default top speeds are retained 60% of OGV1 and 98% of OGV2 would be travelling at greater than 60mph.

This model was then run with varying gradients to investigate the effects on speed distribution of OGV vehicle types, the tests conducted are outlined below:

Parameter	Gradient	
Test Variables		
	-2%	New Deceleration Model
	-1.5%	New Deceleration Model
	-1%	New Deceleration Model
	0%	New Deceleration Model
	1%	New Deceleration Model
	1.5%	New Deceleration Model
	2%	New Deceleration Model

Figures 3.18a / 3.18b show the distribution of OGV1 speed distributions under positive and negative gradients respectively. Figures 3.19a / 3.19b show the distribution of OGV2 speed distributions under positive and negative gradients respectively.

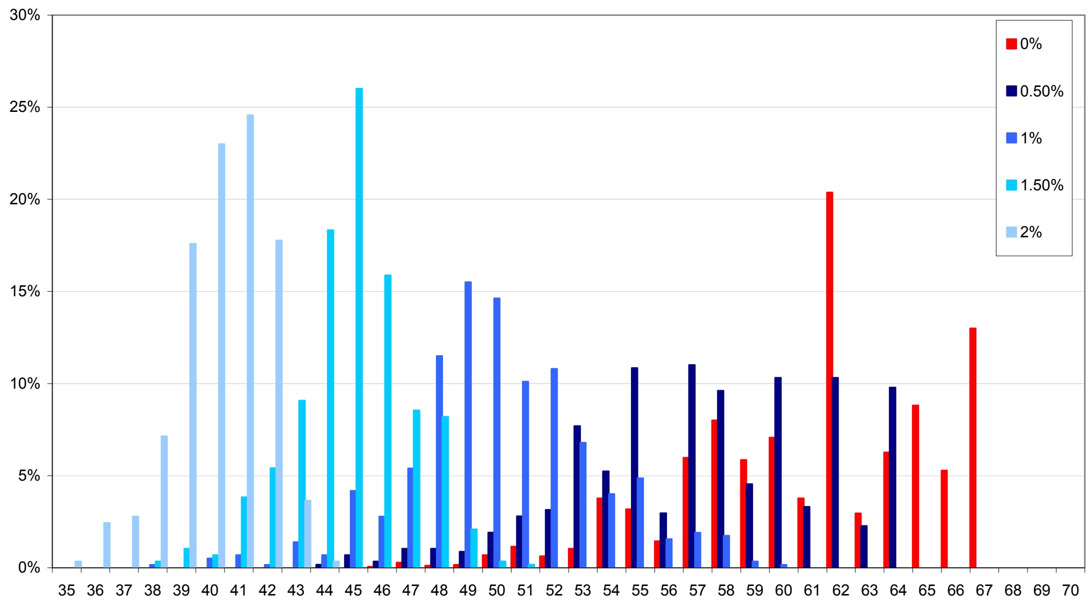


Figure 3.18a – Speed Distribution for Positive Gradients (OGV1)

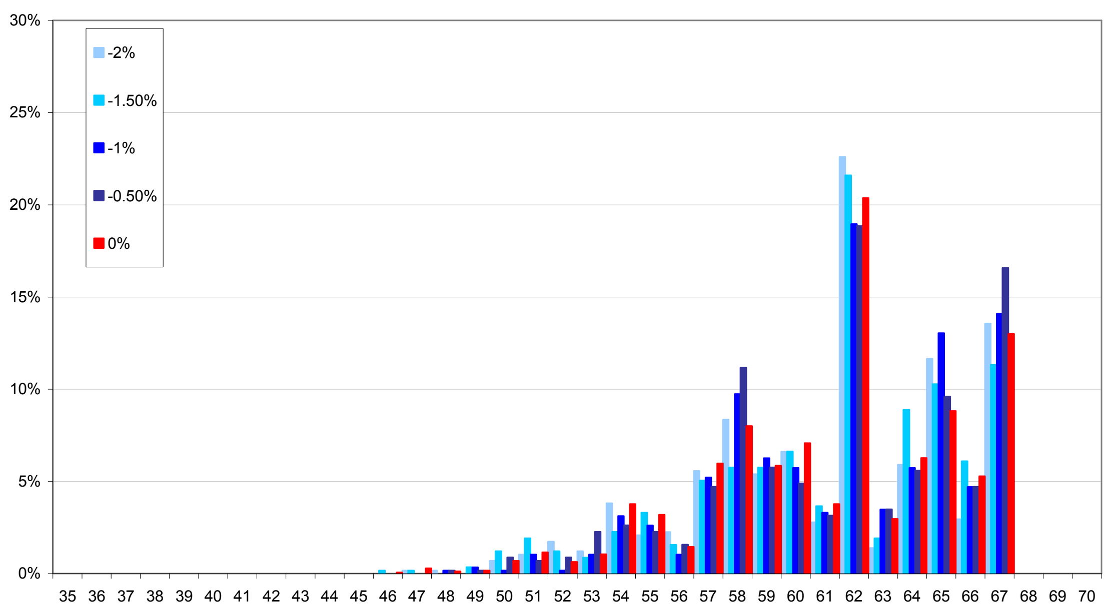


Figure 3.18b – Speed Distribution for Negative Gradients (OGV1)

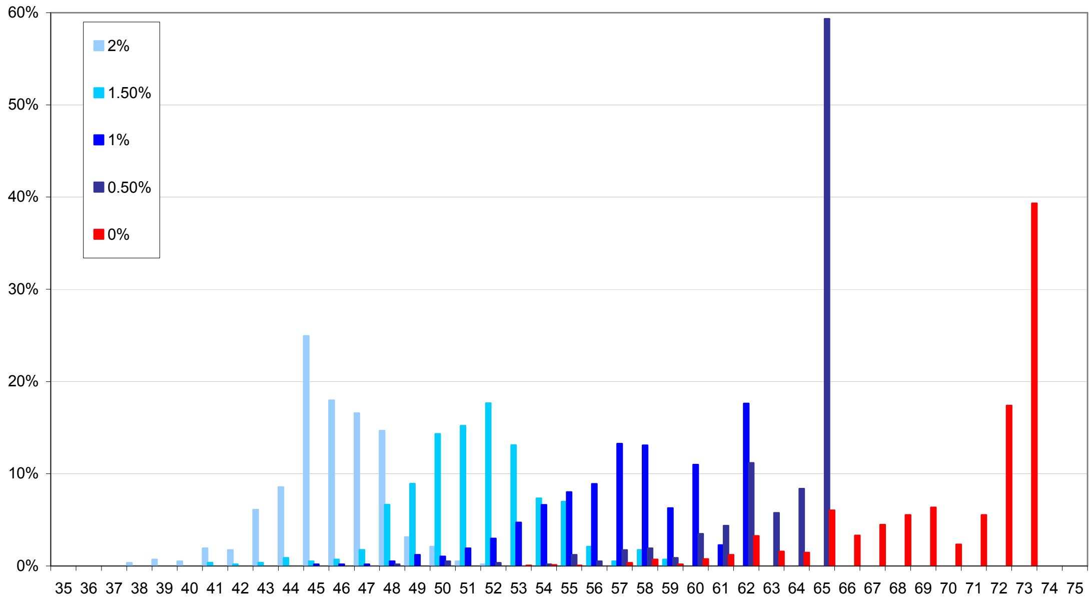


Figure 3.19a - Speed Distribution for Positive Gradients (OGV2)

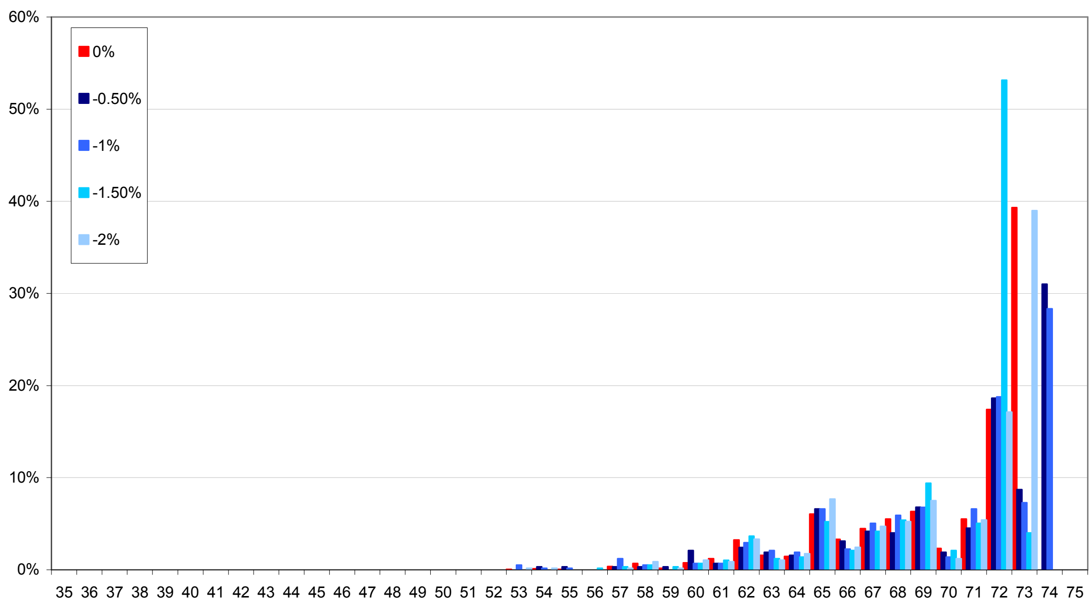


Figure 3.19b - Speed Distribution for Negative Gradients (OGV2)

Key Observations

- The figures above show that a positive gradient does not significantly alter the speed distribution of OGV1 and OGV2
- Under a positive gradient the speed distribution is reduced significantly

3.17.2 Real Networks

A base Paramics model has been developed covering a section of the M60 between J16 and J17. The motorway network in this area has been chosen in order to test a stretch of road characterised by changing gradient. This situation provides a robust platform on which to assess the relative impacts on vehicle behaviour of varying the gradient model in a ‘real life’ situation.

The two Paramics OGV deceleration models have been assigned and the speed of HGV vehicles at key locations along the route measured. The maximum HGV speed has been reduced from the default to the standard value of 56kmph. We have released vehicles individually along the network to remove interaction between vehicles from the results. The results are shown in Figures 3.20a / 3.20b along with a schematic of the gradient profile of the road section.

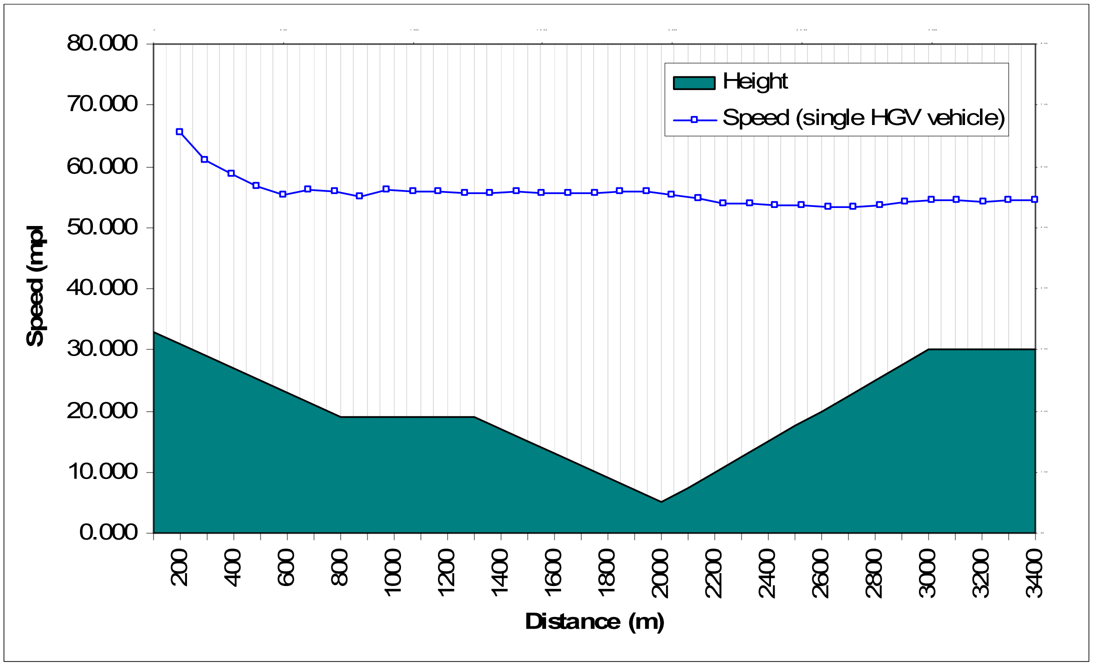


Figure 3.20a - Default pre 2002.1 Deceleration Model

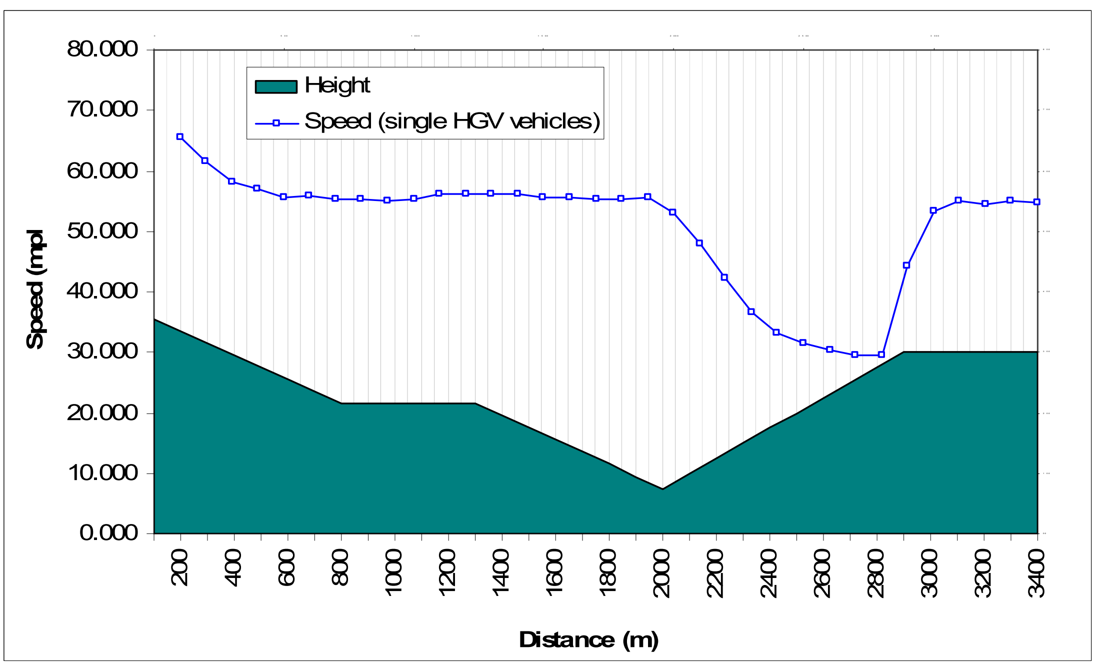


Figure 3.20b - New Deceleration Model

Key Observations

- The new deceleration model should be used as it more realistically represents vehicle behaviour.

- The effect of the new deceleration model at steep inclines (~2.5%) is to reduce maximum speed of HGVs significantly, down to 30mph in the M60 J16-J17 test model.
- The new deceleration model does not increase vehicle speeds above the vehicle maximum when travelling down hill.

3.18 Parameter Sensitivity to Seed Change

Standard practise is to complete multiple runs of models at different seed values and take an average value of flow or journey time. The number of seed runs needed should be assessed so that the average is statistically reliable. A sensitivity test into the impact of varying seed value on the model response to changing headway has been run to assess whether the patterns in response to parameters varied under different seed values.

A congested network is most appropriate for investigation into the variation with different seed values of the impact of using different headways on journey times.

The model of the section of motorway between J26 and J27 on the M62 was chosen as it is often congested because a large proportion of the traffic joins the motorway at J26 and/or leaves the motorway at J27. This normally requires the vehicles to change lanes (or 'weave' across the motorway), and a large number of vehicles behaving in such a manner will inevitably slow the flow of traffic.

The effect of different headways for a fixed seed has already been evaluated. Below are the results of repeating these tests with 5 different seed values, within each test the seed values were kept constant.

There are four movements between the two junctions, each of which will be examined below.

3.18.1 Movement - Mainline-Mainline

Table 3.41 shows the mean journey time for the mainline to mainline movement with different headway values and different seed values.

Figures 3.21 to 3.24 show the variation in trend for car and HGV journey time vs. headway with the different seed values.

Headway (s)	Seed	Cars		HGV	
		Mean Journey Time	% difference from the default journey time	Mean Journey Time	% difference from the default journey time
1	1983	848	-	913	-
	1149516202	879	-	949	-
	1149516221	832	-	899	-
	1149516270	924	-	992	-
	1149516375	848	-	913	-
1.5	1983	1018	20%	1203	32%
	1149516202	917	8%	1111	22%
	1149516221	1025	21%	1149	26%
	1149516270	880	4%	1036	14%
	1149516375	847	0%	1042	14%
2	1983	1213	43%	1342	47%
	1149516202	1164	37%	1310	43%
	1149516221	1124	32%	1237	35%
	1149516270	1097	29%	1247	37%
	1149516375	1182	39%	1306	43%
2.5	1983	1493	76%	1504	65%
	1149516202	1406	66%	1483	62%
	1149516221	1413	67%	1439	58%
	1149516270	1482	75%	1572	72%
	1149516375	1684	99%	1591	74%
3	1983	1996	135%	1773	94%
	1149516202	1953	130%	1739	90%
	1149516221	1895	123%	1664	82%
	1149516270	1996	116%	1773	79%
	1149516375	1909	125%	1754	92%

Table 3.41 – Mainline to mainline mean journey time and flow data for different headways using five different seeds

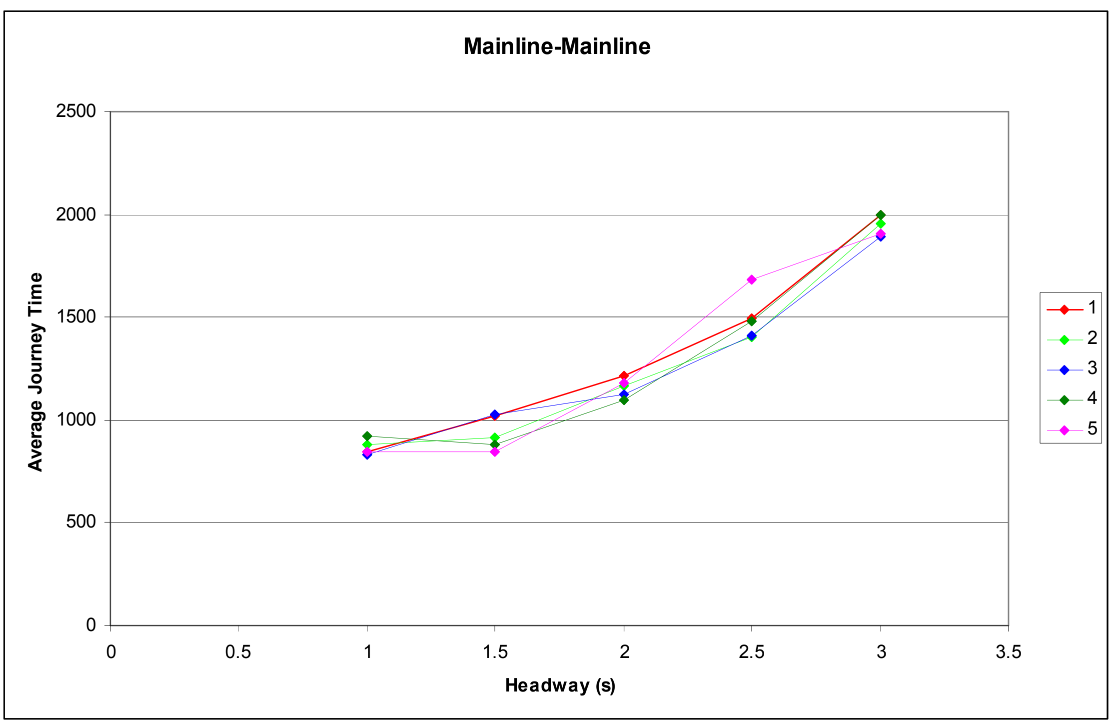


Figure 3.21 – Mean journey times of cars for different headways, using six different seeds.

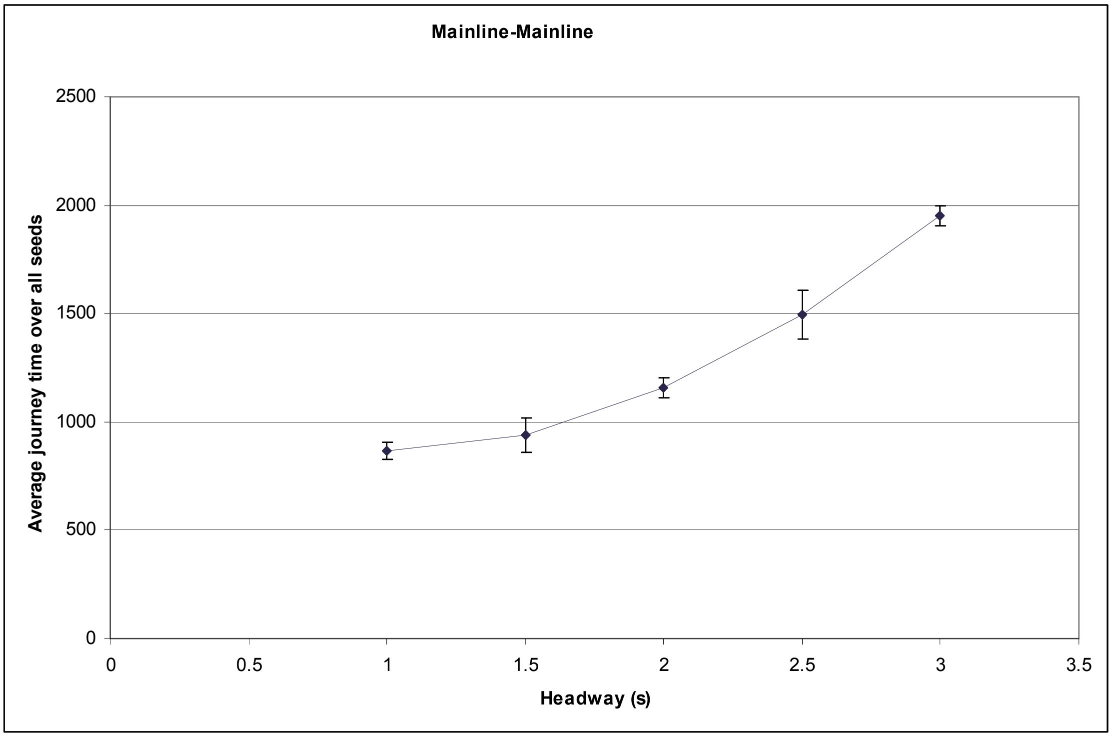


Figure 3.22 – Mean journey times of cars, averaged over the six seeds for each headway setting, with the corresponding standard deviations.

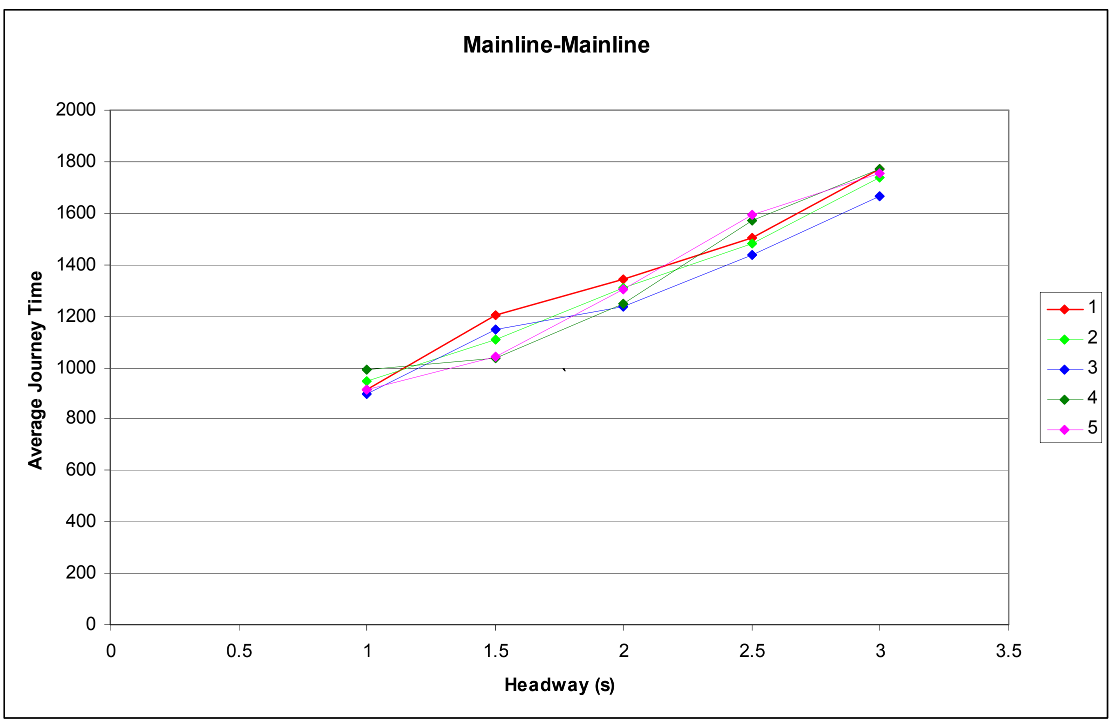


Figure 3.23 – Mean journey times of HGVs for different headways, using six different seeds

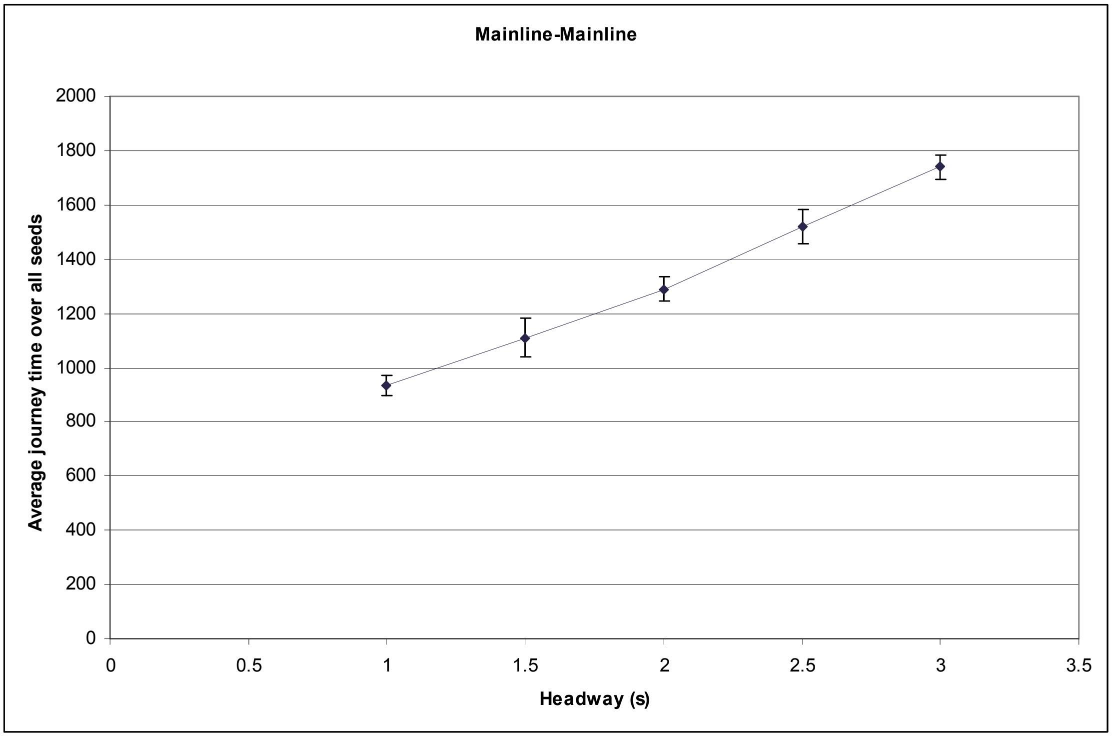


Figure 3.24 – Mean journey times of HGVs, averaged over the six seeds for each headway setting, with the corresponding standards deviations

3.18.2 Movement - Mainline-Slip

Table 3.42 shows the mean journey time for the mainline to slip movement with different headway values and different seed values.

Figures 3.25 to 3.28 show the variation in trend for car and HGV journey time vs. headway with the different seed values.

Headway (s)	Seed	Cars		HGV	
		Mean Journey Time	% difference from the default journey time	Mean Journey Time	% difference from the default journey time
1	1983	879	-	915	-
	1149516202	890	-	939	-
	1149516221	858	-	901	-
	1149516270	933	-	979	-
	1149516375	879	-	915	-
1.5	1983	1030	17%	1192	30%
	1149516202	931	5%	1087	16%
	1149516221	1033	21%	1146	27%
	1149516270	902	-3%	1022	4%
	1149516375	859	-2%	1031	13%
2	1983	1235	40%	1336	46%
	1149516202	1167	31%	1293	38%
	1149516221	1122	31%	1235	37%
	1149516270	1104	18%	1239	27%
	1149516375	1168	33%	1290	41%
2.5	1983	1513	72%	1482	62%
	1149516202	1406	58%	1480	58%
	1149516221	1407	64%	1418	57%
	1149516270	1510	62%	1591	62%
	1149516375	1680	91%	1596	74%
3	1983	2010	129%	1742	90%
	1149516202	2006	125%	1768	88%
	1149516221	1908	123%	1713	90%
	1149516270	2010	116%	1742	78%
	1149516375	1930	119%	1768	93%

Table3.42 – Mean journey time and flow data for different headways using six different seeds

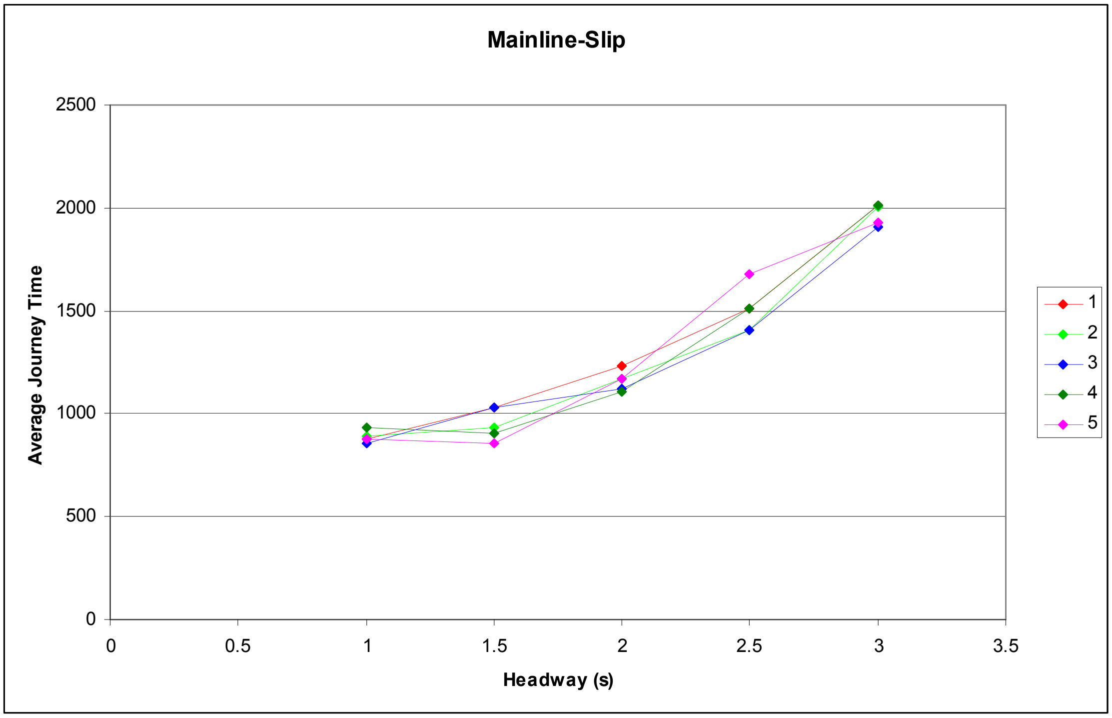


Figure 3.25 – Mean journey times of cars for different headways, using six different seeds.

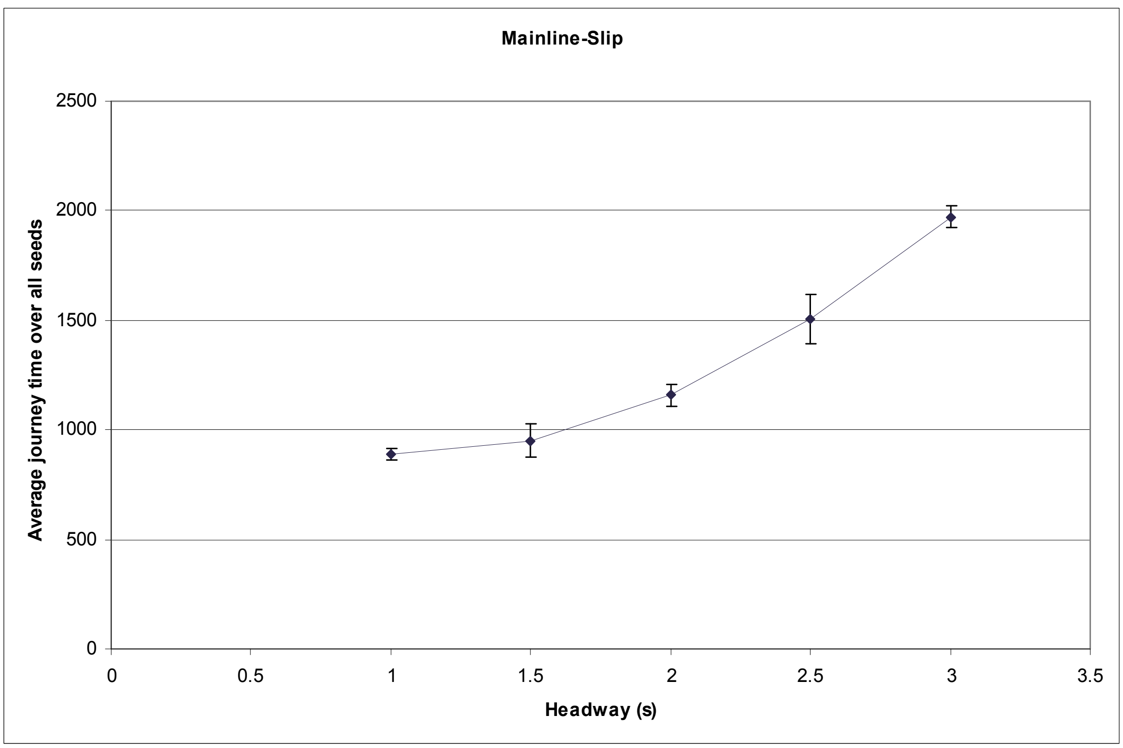


Figure 3.26 – Mean journey times of cars, averaged over the six seeds for each headway setting, with the corresponding standard deviations.

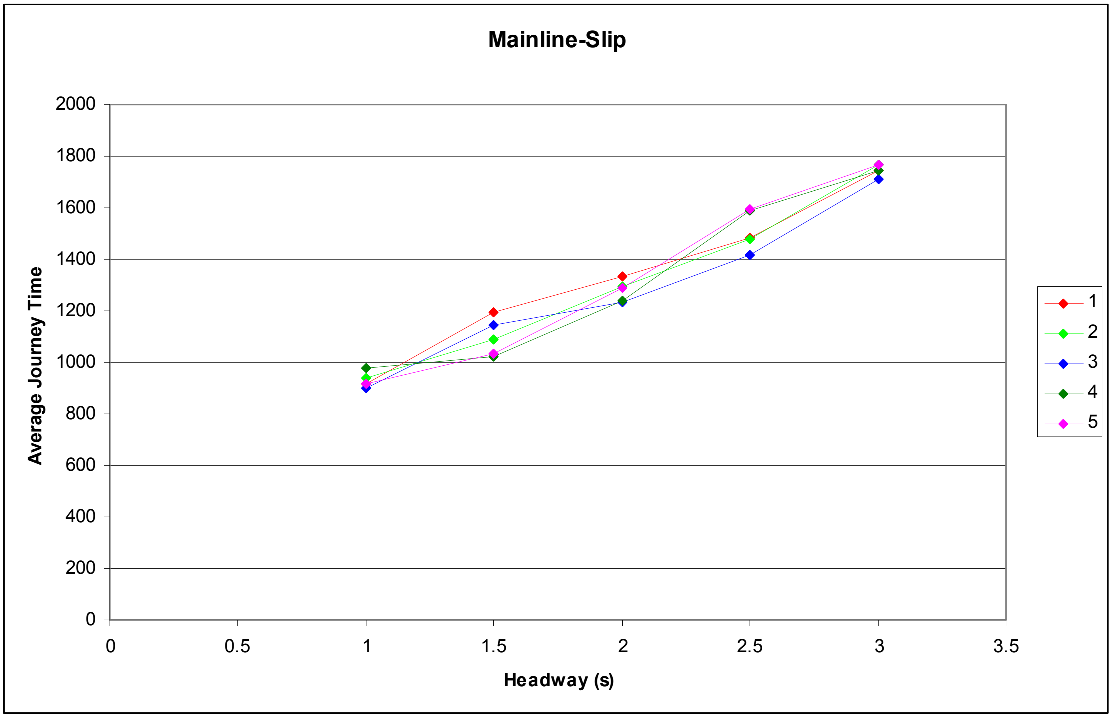


Figure 3.27 – Mean journey times of HGVs for different headways, using six different seeds.

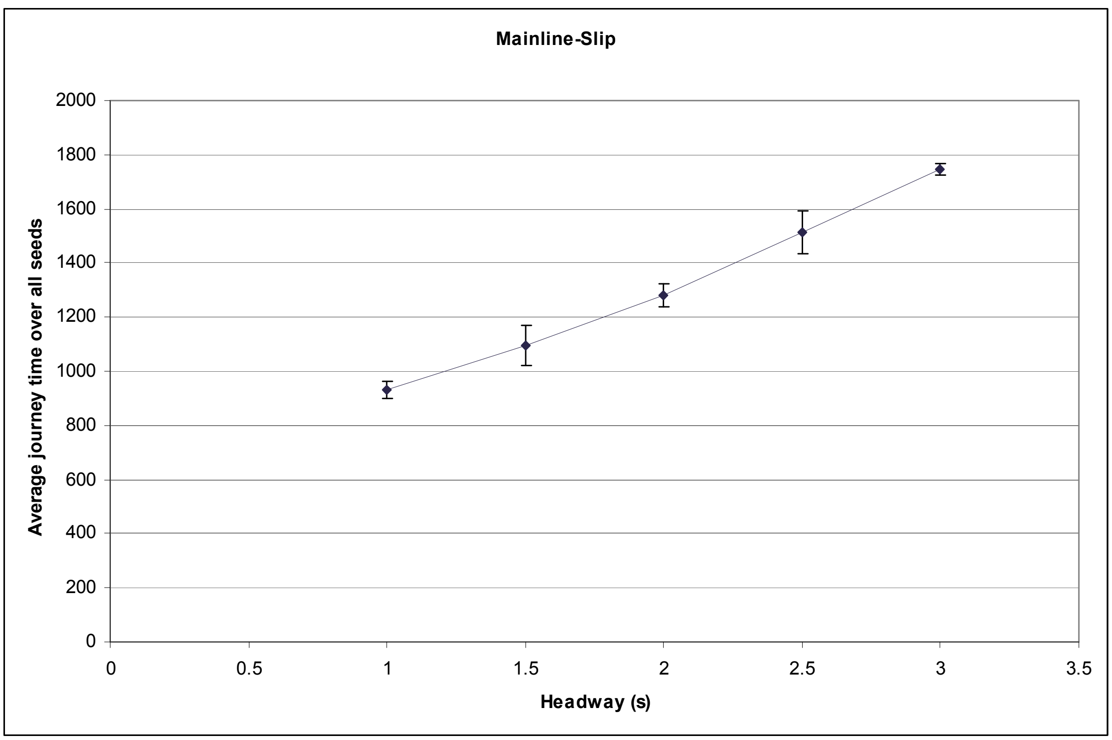


Figure 3.28 – Mean journey times of HGVs, averaged over the six seeds for each headway setting, with the corresponding standards deviations.

3.18.3 Movement - Slip-Mainline

Table 3.43 shows the mean journey time for the slip to mainline movement with different headway values and different seed values.

Figures 3.29 to 3.32 show the variation in trend for car and HGV journey time vs. headway with the different seed values.

Headway (s)	Seed	Cars		HGV	
		Mean Journey Time	% difference from the default journey time	Mean Journey Time	% difference from the default journey time
1	1983	464	-	603	-
	1149516202	492	-	648	-
	1149516221	564	-	731	-
	1149516270	535	-	670	-
	1149516375	464	-	603	-
1.5	1983	1054	127%	1152	91%
	1149516202	1238	151%	1277	97%
	1149516221	1027	82%	1159	58%
	1149516270	1200	125%	1322	97%
	1149516375	1320	184%	1376	128%
2	1983	952	105%	1060	76%
	1149516202	1167	137%	1251	93%
	1149516221	1223	117%	1337	83%
	1149516270	1235	131%	1220	82%
	1149516375	1264	172%	1387	130%
2.5	1983	1015	118%	1110	84%
	1149516202	1114	126%	1210	87%
	1149516221	1009	79%	1137	55%
	1149516270	973	82%	1065	59%
	1149516375	767	65%	872	44%
3	1983	678	46%	787	31%
	1149516202	635	29%	739	14%
	1149516221	754	34%	850	16%
	1149516270	678	27%	787	18%
	1149516375	738	59%	828	37%

Table 3.43 – Mean journey time and flow data for different headways using six different seeds.

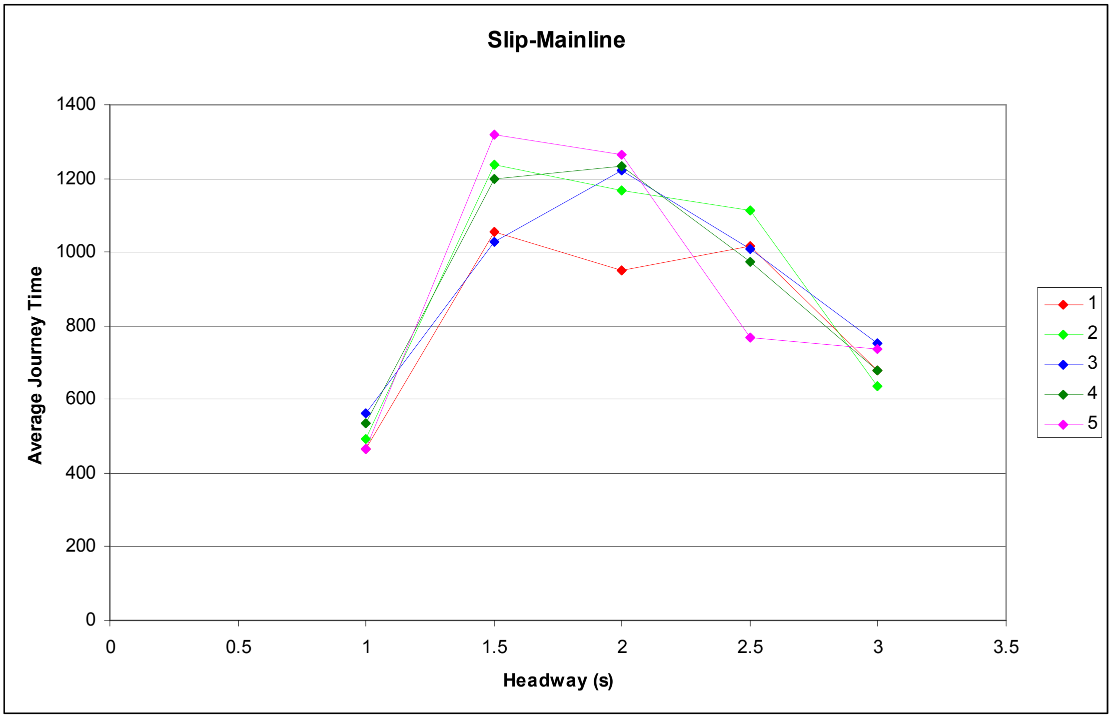


Figure 3.29 – Mean journey times of cars for different headways, using six different seeds.

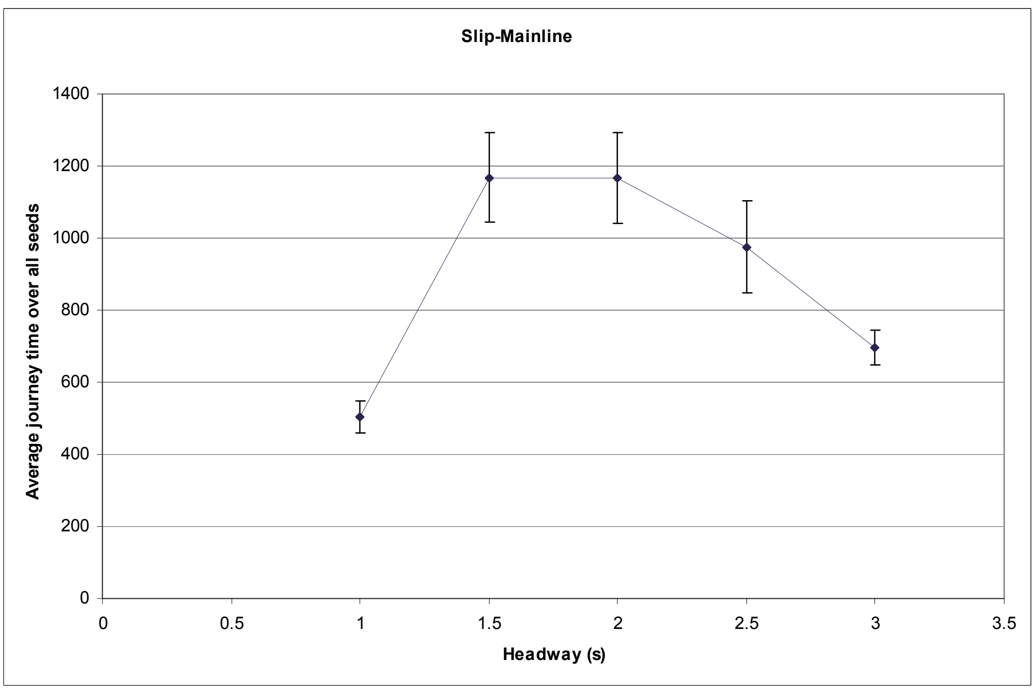


Figure 3.30 – Mean journey times of cars, averaged over the six seeds for each headway setting, with the corresponding standard deviations.

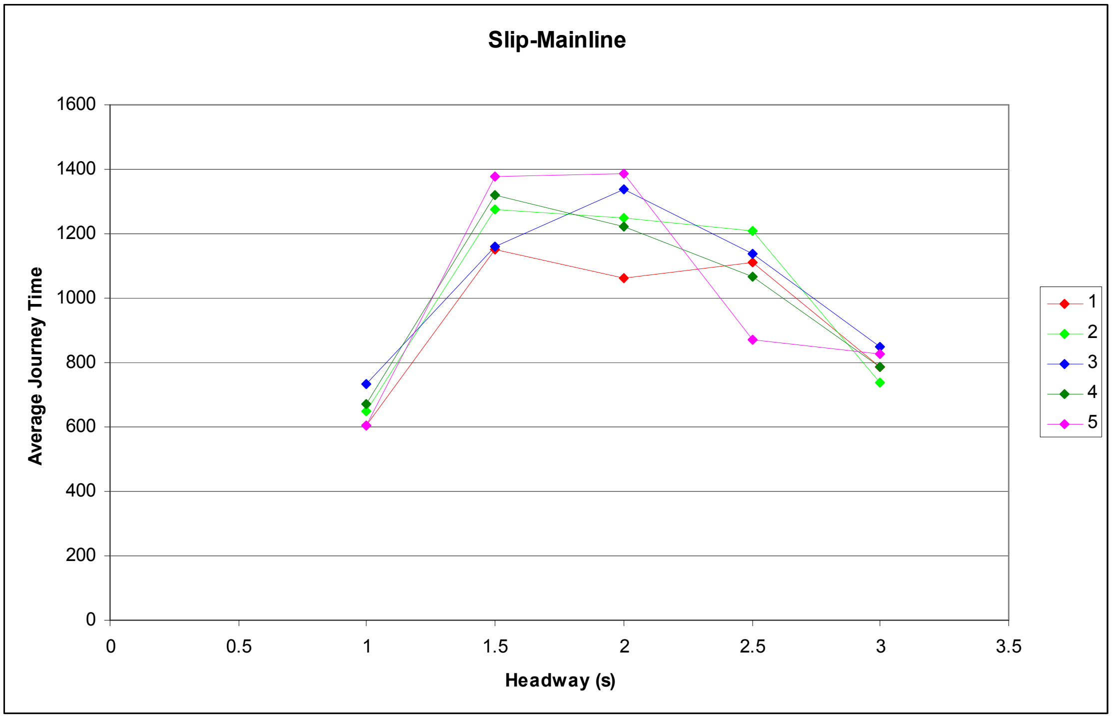


Figure 3.31 – Mean journey times of HGVs for different headways, using six different seeds.

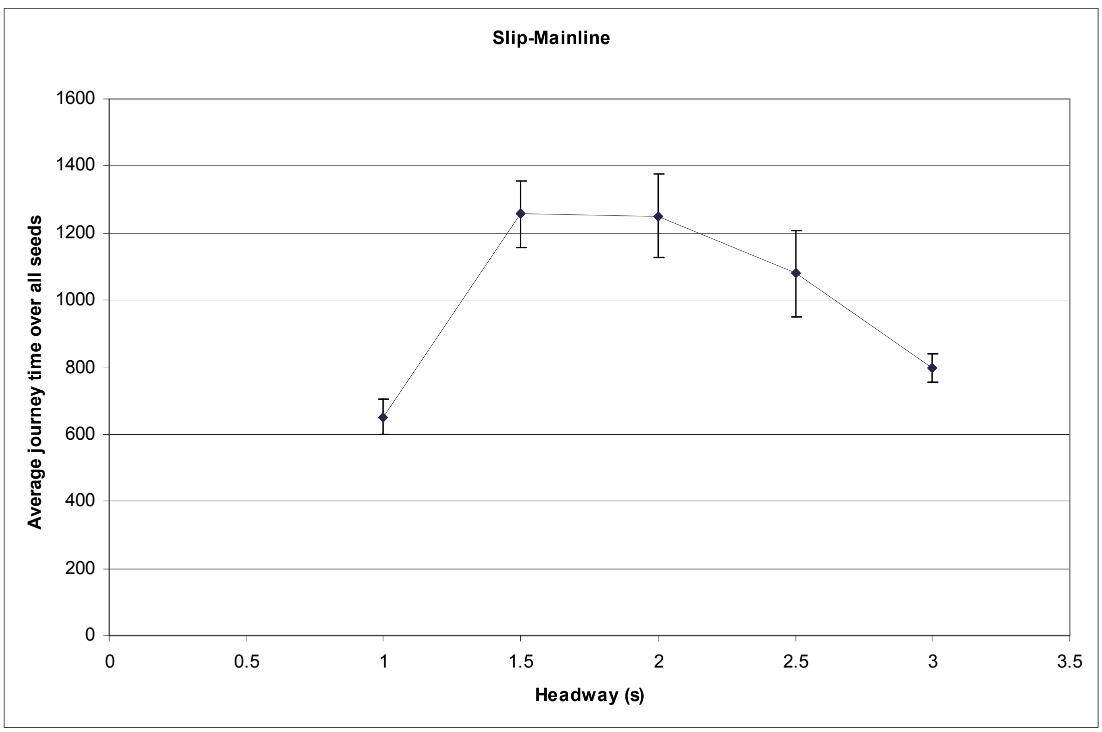


Figure 3.32 – Mean journey times of HGVs, averaged over the six seeds for each headway setting, with the corresponding standards deviations

3.18.4 Movement - Slip-Slip

Table 3.44 shows the mean journey time for the slip to slip movement with different headway values and different seed values.

Figures 3.33 to 3.36 show the variation in trend for car and HGV journey time vs. headway with the different seed values.

Headway (s)	Seed	Cars		HGV	
		Mean Journey Time	% difference from the default journey time	Mean Journey Time	% difference from the default journey time
1	1983	473	-	606	-
	1149516202	493	-	642	-
	1149516221	567	-	713	-
	1149516270	529	-	667	-
	1149516375	473	-	606	-
1.5	1983	1056	123%	1105	82%
	1149516202	1221	148%	1299	102%
	1149516221	1035	83%	1111	56%
	1149516270	1198	126%	1308	96%
	1149516375	1289	173%	1347	122%
2	1983	947	100%	1007	66%
	1149516202	1172	138%	1211	89%
	1149516221	1201	112%	1329	86%
	1149516270	1207	128%	1261	89%
	1149516375	1281	171%	1330	119%
2.5	1983	1025	117%	1105	82%
	1149516202	1125	128%	1187	85%
	1149516221	1005	77%	1110	56%
	1149516270	980	85%	1050	58%
	1149516375	768	63%	874	44%
3	1983	688	45%	781	29%
	1149516202	640	30%	730	14%
	1149516221	766	35%	853	20%
	1149516270	688	30%	781	17%
	1149516375	746	58%	834	38%

Table 3.44 – Mean journey time and flow data for different headways using five different seeds.

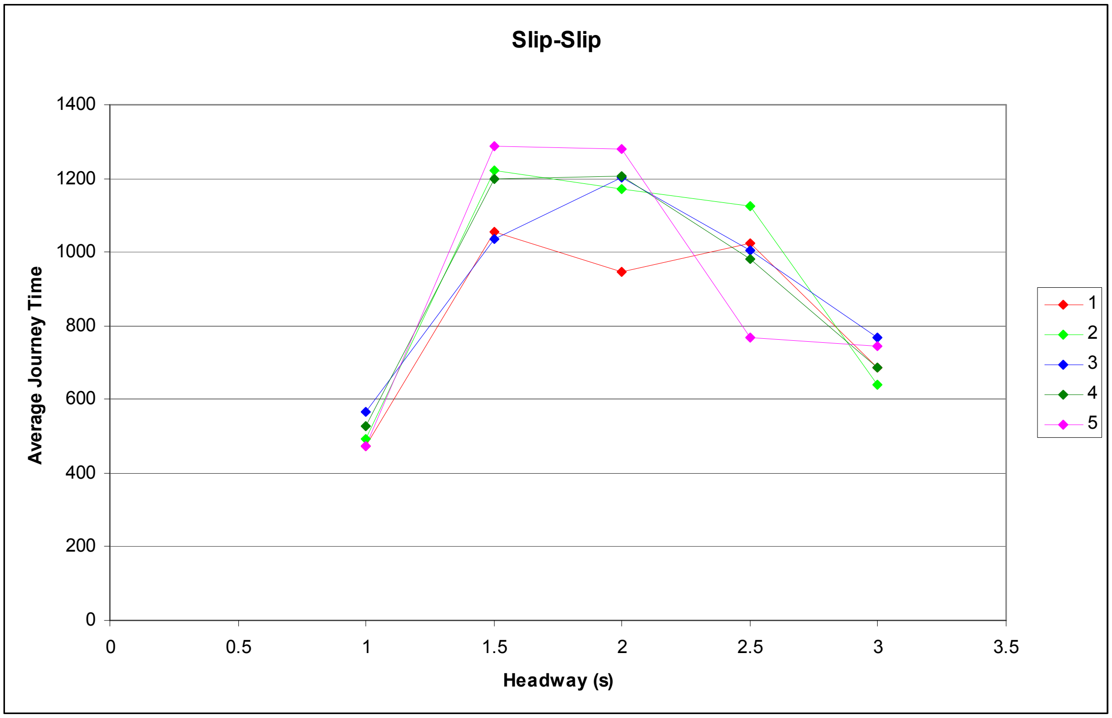


Figure 3.33 – Mean journey times of cars for different headways, using six different seeds.

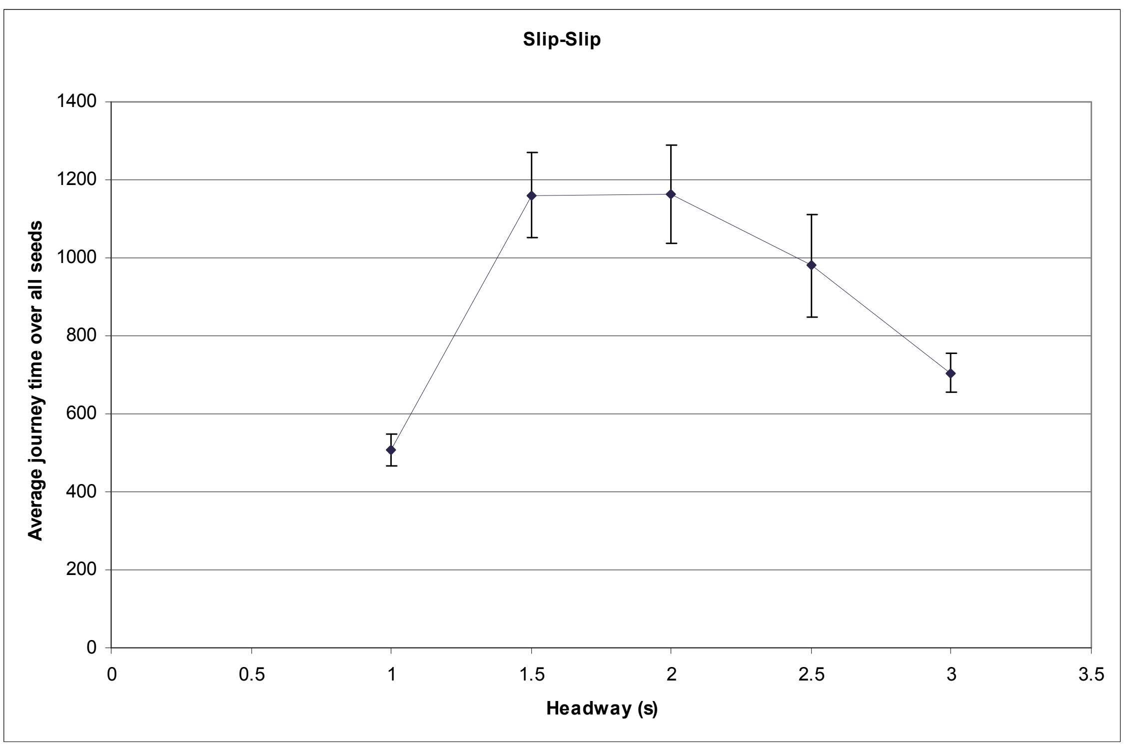


Figure 3.34 – Mean journey times of cars, averaged over the six seeds for each headway setting, with the corresponding standard deviations.

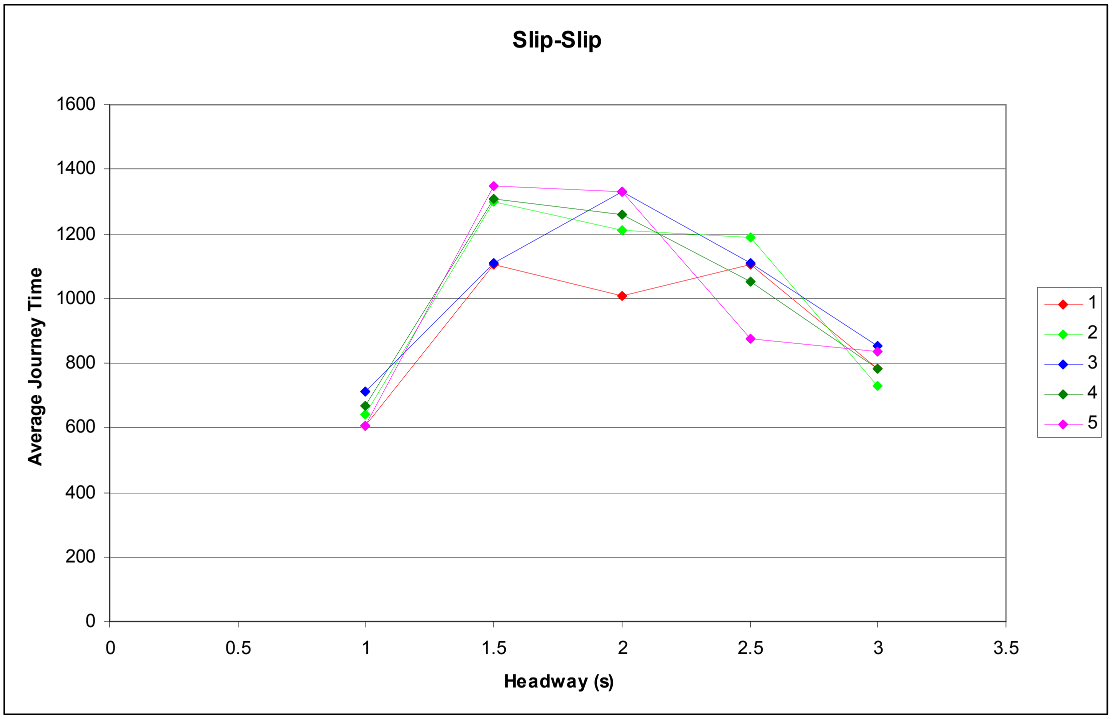


Figure 3.35 – Mean journey times of HGVs for different headways, using six different seeds.

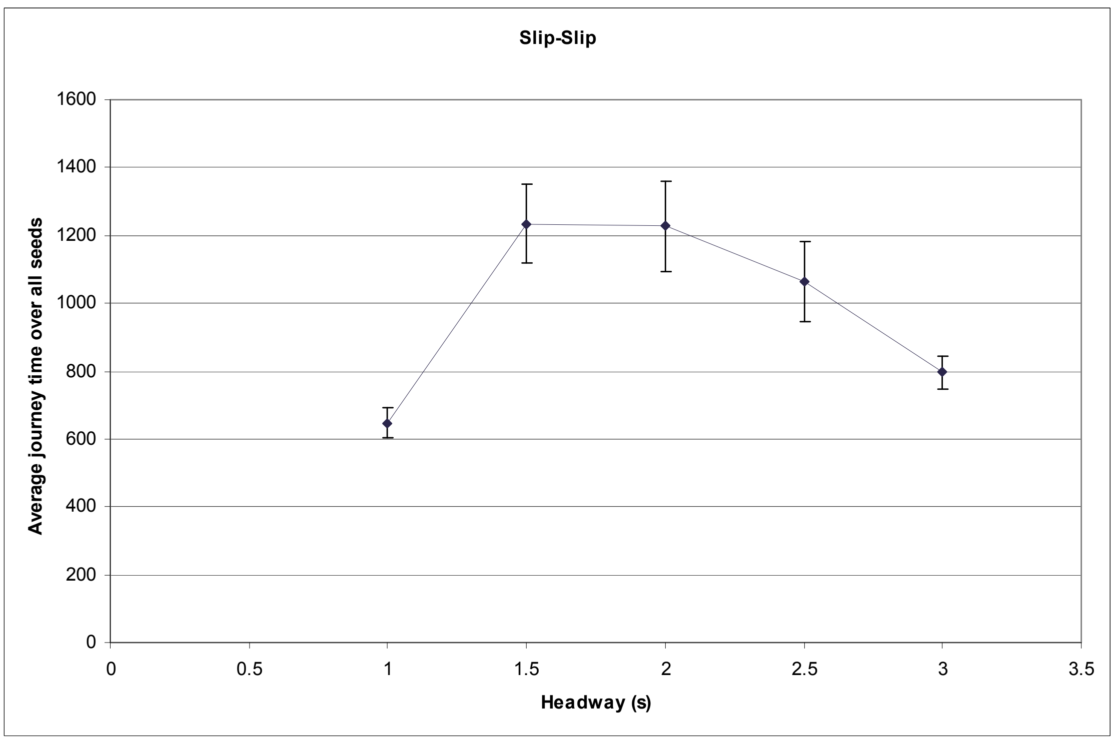


Figure 3.36 – Mean journey times of HGVs, averaged over the six seeds for each headway setting, with the corresponding standard deviations.

3.18.5 Commentary

- As expected, there is some variance in the results when the models are assigned using different seeds.
- There are no significant deviations from the trend reported from one seed when using alternative seed values

- For traffic entering form the main carriageway, the different seeds give the greatest variation in the journey times for the smallest or largest headways.
- The journey times of traffic entering from the slips varies more consistently across all of the different headways.

4 SISTM

SISTM – Summary of Findings

Outlined below are the findings from the model testing that was undertaken with SISTM 6-0-005 As SISTM does not model junctions but only models motorway main line carriageways with merge and diverge situations only two networks were tested;

- M62 between Junctions 26 and 27 – congested network with merge, diverge and weaving;
- M60 J16-J17 – relatively free flow with gradients and;

The parameters tested were identified by the software developers as being important to the performance of the model.

- **Demand Summary**

A considerable increase in journey times is observed in both networks as the demand is increased to capacity and beyond. In the M62 network, where there is extensive interaction between vehicles the increase is gradual. A higher demand here merely results in a further reduction in speeds in the merge and diverge areas, which were already characterised by dense, slow-moving traffic at the original level of demand (approximately 80% of capacity).

Results for the M60 network show little change as the demand is increased to 80% of capacity. There is little interaction between vehicles in this network and so drivers experience less disruption to speeds than at a similar density in the M62 network. The onset of congestion effects is delayed until demand is increased to full capacity. Platoons of slow moving traffic appear in the merge and diverge areas as demand is increased by 50%. This explains the sharp increase in journey times at this level of demand.

- **Random Seed Summary**

In a congested network, changes to the Random Seed varied the journey time results by more than the variation of +/-5%. However, in uncongested conditions the variation was around +/-1%.

In both models the traffic flows were unaffected by the change in random seed and as such the observed changes in journey times are a direct result of how the random seed is used in varying driver behavioural characteristics.

The clear conclusion to be drawn from the random seed tests is that if stable results are required from the use of SISTM, particularly if they are to be used for appraisal, then several different random seeds need to be run. The number of random seeds required to be run is not fixed and will need to be calculated separately for each model application so that a required degree of confidence in the average results can be achieved. This is clearly shown by the differences observed between the M62 and M60 networks where over the random seed tests the standard deviation of the average journey times are 2.7% and 0.3% of the average times respectively.

- **Epoch Length Summary**

Changing the epoch length (i.e. changing the lower bound of the length of the time gap between drivers updating their decisions) had a less predictable effect on simulation output from the M62 J26-J27 network. Drivers on the mainline take longer to speed up after giving way to merging vehicles or vehicles changing lanes. As a result journey times for the Mainline to Mainline and the Mainline to Diverge routes displayed a positive correlation with epoch length. Journey times for the other two routes increased as the epoch length increased from 8/16 to 12/16, however, the trend did not continue when the parameter value was set to 16/16. Inspection of the traffic flow figures shows that when the epoch length exceeds 10/16 the volume of traffic arriving at the destination specified falls below demand.

Another byproduct of a longer epoch length for this network is an increase in the number of collisions as shown in the Table below. TRL advise that collisions are “the result of a lane change in which the lane changing vehicle is in both lanes for two time increments, but the acceleration is calculated for the new lane.” The problem is currently under investigation.

Epoch length	Number of Collisions (M62 J26-J27)	Number of Collisions (M60 J16-J17)
8/16	1	0
10/16	314	0
12/16	1124	0
16/16	4995	13

M60 J16-J17 - Number of collisions for different epoch lengths

In view of the major changes arising in congested conditions when the Epoch length is changed it is concluded that altering the Epoch length from the calibrated default values is not recommended

- **Signposting Summary**

Journey times increased in both networks as lane changing scores increased and diverge signposts were moved further upstream along the carriageway. At higher scores vehicles make their lane choice earlier. In uncongested conditions this leads to higher flows in the nearside lane. The opposite is true of congested networks where the migration of additional traffic into the nearside lane results in near flow breakdown.

The basic techniques available in SISTM of being able to set different signposting points and the probability of a driver responding to each separate ‘signpost’ are in principle the correct approach. The ability too reflect observed behaviour in this way is a strength of SISTM. Unfortunately there is a significant flaw in the diverging model. Disruption to speeds is minimised at low lane changing scores. This is because any vehicles left in the wrong lane at the diverge point are allowed to “jump” straight across the carriageway with minimum disruption to other traffic. In order to ensure simulation results are meaningful it is therefore important to choose a parameter set that ensures the correct lane is chosen in good time.

As a result of this it is absolutely essential that when developing a SISTM model that it is carefully viewed, and analysed, under differing demand scenarios to ensure that all vehicles complete their diverging movement before reaching the ‘diverge point’ where they are then allowed to cross lanes with no impacts on other vehicles. Without very detailed investigation of the SISTM model this can be a fatal flaw in the model operation.

- **Gradient Summary**

HGV journey times increased with gradient on all routes and the rate of growth for each percent of gradient increases for larger slopes.

- **Reaction Time Summary**

Journey times changes for the M60 J16-J17 network suggest that the impact of varying the parameter is limited in uncongested conditions. In a congested situation merging traffic was more strongly affected by an increase in the maximum reaction time. This is considered to be due to a reduction in merging drivers’ ability to react to gaps in traffic on the main carriageway leading to a build up of queues on the slip road. The problem is further aggravated by fewer drivers on the main carriageway seizing the opportunity to change lanes to the right in order to make space for joining traffic. An increase in the maximum reaction time is accompanied by a sharp drop in lane changes when traffic is dense. Gaps are larger in lighter traffic, diluting the effects of longer reaction times. The strong impact of changes in the reaction time on resulting journey times for merging traffic suggests that it is not advisable to allow a change in the parameter value of more than 10%.

The critical factor with regard to reaction time is that it is intrinsically linked to the Epoch length and as such the selection of an appropriate range for the reaction time value is really dictated by the correct combination of Epoch length and reaction time. The table below shows some examples of Epoch length and reaction times that are considered acceptable. This is based on not allowinf the outturn reaction time in seconds to fall outside the range of 0.8 – 1.0 seconds with a central value of 0.91 seconds.

- **Reaction to Brake Lights Summary (P5)**

SISTM allows the user to influence car following behaviour in the model by adjusting the drivers' reaction to seeing brake lights ahead (P5). This is defined in terms of the braking rate adopted on seeing brake lights on the vehicle ahead. Congestion at the merge was exacerbated by congestion of the nearside lane resulting from excessive braking in reaction to higher lane changing frequency in the area near the diverge. Under congested conditions this leads to queues on the merge slip road as merging traffic is unable to join the main carriageway. In the M62 J26-J27 network the situation was made worse by the merge geometry. A backlog of traffic over-reacting to the downstream merge point presented an obstacle to traffic emerging from the upstream merge point.

A further increase in the parameter beyond -40 km/h/s had no impact on the networks tested.

Test results suggest that the braking rate adopted in reaction to seeing brake lights ahead should not be allowed to vary beyond a narrow bracket around the default value of -5.0 km/h/s unless absolutely necessary. If the parameter is allowed to vary significantly a test should be run with the default value in order to ensure that the resulting simulation results are not unreasonable.

- **Drivers Perceivable Acceleration Summary (P8)**

The drivers' perceivable acceleration (P8) influences drivers' reactions to situations, which require them to change speed. When the acceleration or deceleration necessary in order to adjust a vehicle's speed to the desired value is less than P8 the driver retains his original speed. The adverse effect of increasing P8 on journey times is more pronounced in dense traffic where vehicle interactions abound. In this case, the reduced sensitivity of drivers' response to deviations from their desired speed as P8 is increased, results in queues forming in the nearside lane. In particular, in areas near a merge, or diverge slip road, where drivers are required to slow down in order to give way to merging vehicles or vehicles that change lanes in order to diverge. Increasing congestion in the nearside lane as P8 is increased above 10.0 km/h/s led to an increase in the number of lane changes in the networks tested as drivers moved to a faster lane in order to avoid queues. Speed in the offside and offside-1 is adversely affected at high values for P8 as the speed of slower vehicles dropped to a lower value before drivers develop the desire to choose a slower lane.

When the parameter is increased above 30 km/h/s the program breaks down.

- **Random Seed Value and Reaction to Brake Lights ahead – Summary**

Varying the random seed value at any one value for P5, results in oscillation of the simulation results around the mean for the P5 value. However, the magnitude of this oscillation is small in comparison with the impact of changing the value of P5.

SISTM

4.1 Introduction

For the purposes of this work SISTM V6-0-005 was used and, while a number of different networks were identified earlier, as SISTM does not model junctions but only models motorway main line carriageways with merge and diverge situations only two networks were tested;

- the M62 between J26 and J27; and
- the M60 between J16 and J17.

The M62 model has dense traffic with a high incidence of lane changing while the M60 was chosen in order to test a stretch of road characterised by changing gradient. Figure 4.1 and Figure 4.2 present schematic sketches of the two networks. A comparison of the different levels of demand applied in the tests reported below with the theoretical capacities of the two roads is given in Table 4.1 and Table 4.2.

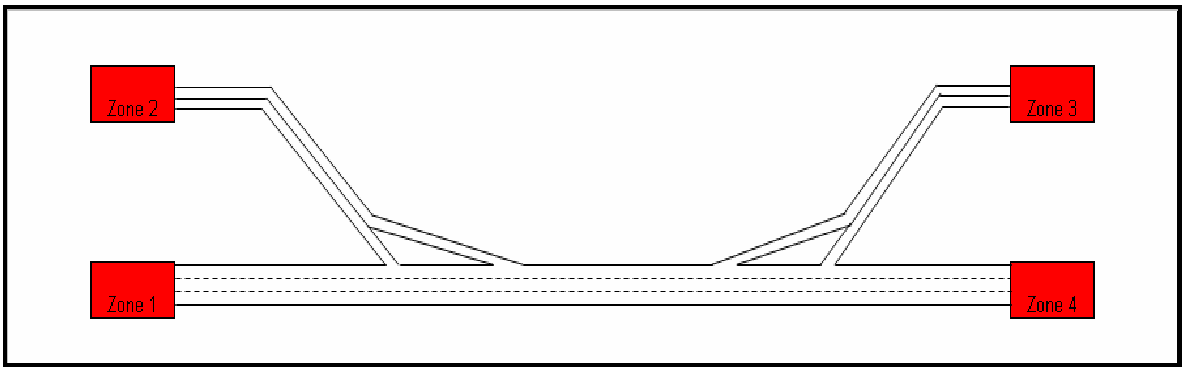


Figure 4.1: M62 J26-J27 - Network diagram

		Demand as percentage of capacity		
	Demand	Upstream of Merge	Between Merge and Diverge	Downstream of Merge
Basic	5696	82%	82%	82%
Basic + 10%	6267	90%	90%	90%
Basic + 20%	6835	98%	98%	98%
Basic + 50%	8544	123%	123%	123%
Capacity		6969	6972	6974

Table 4.1 - M62 J26-J27 - Comparison of demand input with theoretical road capacity

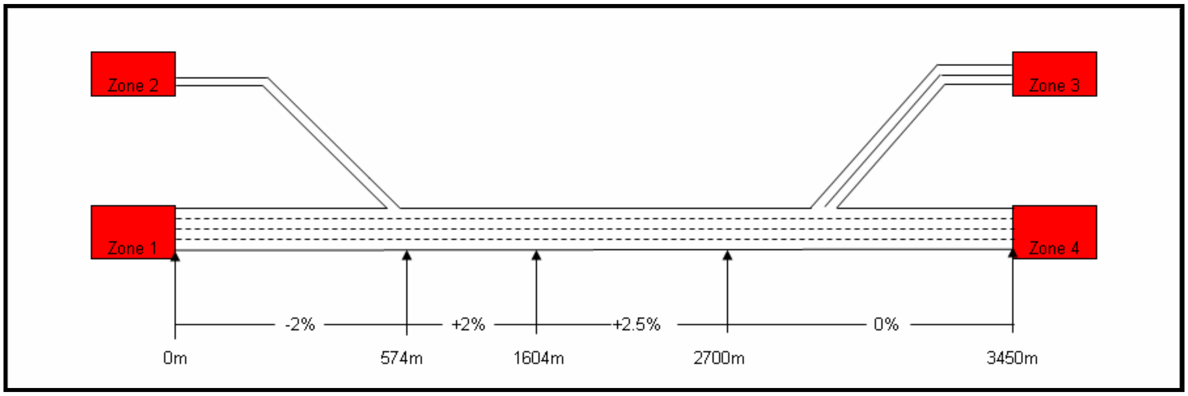


Figure 4.2: M60 J16-J17 - Network diagram

		Demand as percentage of capacity		
	Demand	**Upstream of Merge**	**Between Merge and Diverge**	**Downstream of Merge**
Basic	4801	69%	69%	69%
Basic + 10%	5282	76%	76%	76%
Basic + 20%	5761	83%	83%	83%
Basic + 50%	7204	103%	103%	103%
Capacity		**6978**	**6980**	**6978**

Table 4.2 - M60 J16-J17 - Comparison of demand input with theoretical road capacity

4.2 Desired speed profile

SISTM provides the following types of distribution for defining the desired speed profile:

1. Normal distribution,
2. Poisson distribution,
3. Uniform distribution,
4. Triangular distribution; and
5. Empirical distribution.

The user also has the option of defining an arbitrary desired speed distribution by entering data points. The default is given by a normal distribution with mean 109.46 kph and a standard deviation of 9.11 kph. A plot of the probability mass function for this distribution is given in Figure **4.3** from which it can be seen that, for the default speed distribution, around 40% of the vehicles will have a desired speed in excess of the national speed limit. Although less than 5% are in excess of 80mph.

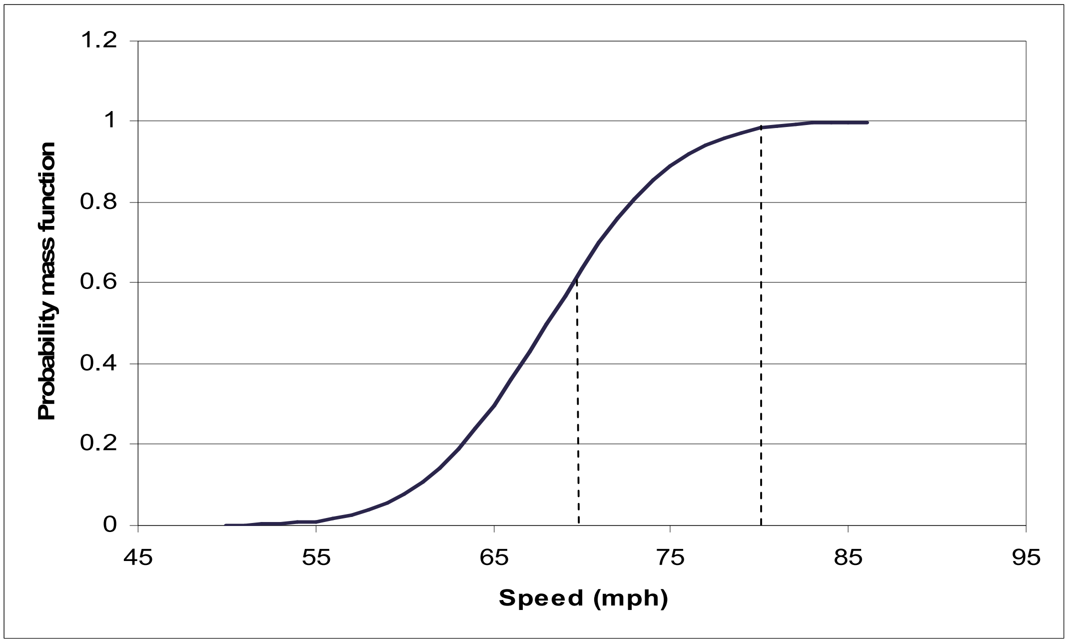


Figure 4.3 - Probability mass function for the SISTM default speed distribution

The responsiveness of SISTM simulation output to changes in the following input and parameters has been tested:

1. Increase in Demand
2. Random seed value
3. Epoch length
4. Merge signposts:
    - Distance from merge
    - Lane changing scores
5. Gradient
6. Maximum reaction time (P11)
7. Drivers' reaction to seeing brake lights ahead (P5)
8. Drivers' perceivable acceleration (P8)

4.3 Test 1: Increase in the level of demand:

The impact of increasing the demand on journey times in the two test networks is given in Figure 4.4, for the M62, and Figure 4.5, for the M60, below. Journey times are given for the four route options through the network, i.e.

- Traffic remaining on the main carriageway of the motorway throughout the journey,
- Traffic accessing the network through the main carriageway and leaving the motorway at the diverge,
- Traffic entering the motorway at the merge and continuing on the mainline for the rest of the journey; and
- Traffic joining the motorway at the merge and leaving it at the diverge slip road.

As can be seen in Figure 4.4, for the M62 J26-J27 model there is a marked increase in journey times on all four routes when a 10% growth in demand is applied. However, the rate of change tails off as a further 10% is added to the demand. Journey times for trips originating from the merge slip road are far more responsive to changes in the level of demand. Journey time figures for both networks expose a much higher sensitivity to changes in demand for routes passing through the merge slip road than for the other two routes. Journey times through the M60 network show little response as the demand is increased by 20%. This corresponds to an increase to approximately 80% of capacity. When demand is increased further to approximately 103% of network capacity, journey times leap up as the high levels of flow through the network result in slow moving traffic in the merge and diverge areas.

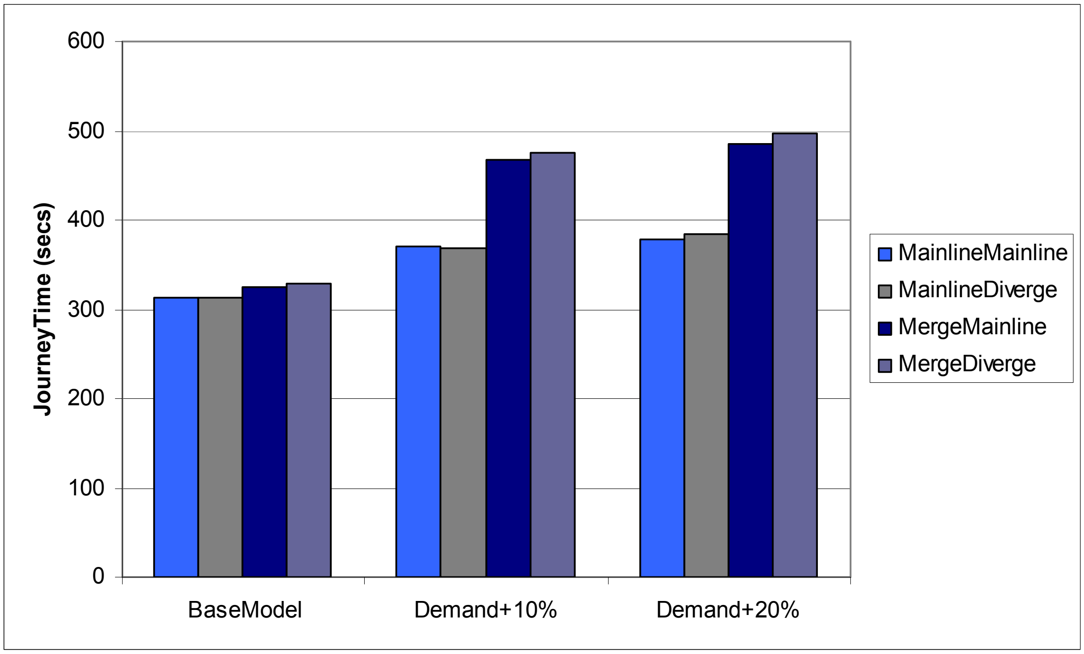


Figure 4.4 - M62 J26-J27 - Effect of increasing traffic volume on journey times

Route	Demand+10%	Demand+20%
Mainline Mainline	18.3%	20.9%
Mainline Diverge	17.8%	22.3%
Merge Mainline	43.5%	49.2%
Merge Diverge	44.5%	51.1%

Table 4.3 - M62 J26 – J27 - Percentage increase in journey times due to changes in demand

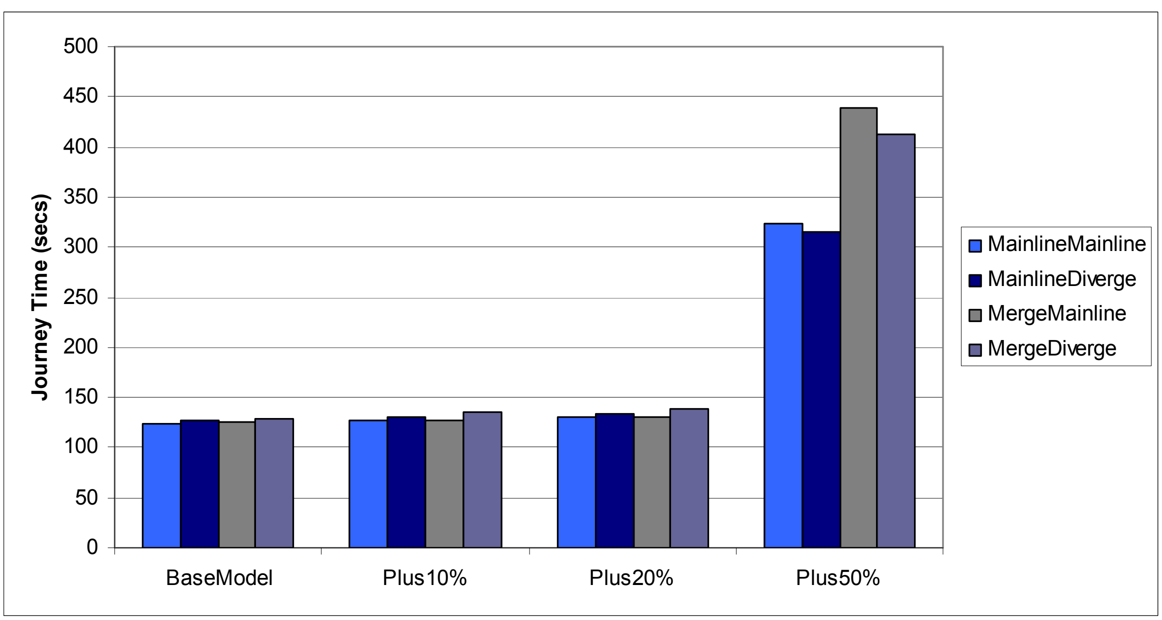


Figure 4.5 - M60 J16-J17 - Effect of increasing traffic volume on journey times

Route	Plus10%	Plus20%	Plus50%
Mainline Mainline	2.6%	4.9%	160.1%
Mainline Diverge	2.5%	4.7%	147.8%
Merge Mainline	1.9%	4.3%	250.1%
Mainline Diverge	2.5%	4.7%	147.8%
Merge Diverge	3.9%	7.4%	218.6%

Table 4.4 - M60 J16-J17 - Journey time variation due to changes in demand

In both cases the proportional effect of increased demand profiles is greater on the merging traffic once the overall demand on the main line exceeds 80% of the assumed network capacity. This implies that in saturated conditions SISTM results in higher delays for merging traffic compared to main line traffic. This raises some concerns as observation indicates that the main line traffic cooperates by allowing slip road traffic to enter in congested conditions which leads to greater delays and queues on the main line.

4.4 Demand Summary

A considerable increase in journey times is observed in both networks as the demand is increased to capacity and beyond. In the M62 network, where there is extensive interaction between vehicles the increase is gradual. A higher demand here merely results in a further reduction in speeds in the merge and diverge areas, which were already characterised by dense, slow-moving traffic at the original level of demand (approximately 80% of capacity).

Results for the M60 network show little change as the demand is increased to 80% of capacity. There is little interaction between vehicles in this network and so drivers experience less disruption to speeds than at a similar density in the M62 network. The onset of congestion effects is delayed until demand is increased to full capacity. Platoons of slow moving traffic appear in the merge and diverge areas as demand is increased by 50%. This explains the sharp increase in journey times at this level of demand.

4.5 Test 2: Response to changes in the initial random seed value

The initial random seed value defaults to 1999. The range of permissible values for the parameter is defined by the set of integers between 0 and 2,500,000. Ten different seed values were tested for each network. It can be seen from Table 4.5 that the impact of changing the random seed was higher on the M62 model which is characterised by congestion and a high incidence of weaving. Here, two initial seed values, namely 10 and 750, result in journey time changes in excess of 5% from the default model. However, as Table 4.6 displays, changing the initial value for the random seed has very little impact on journey times through the M60 network. Journey times for this section vary from the mean by no more than 1%. The throughput remained the same on all routes.

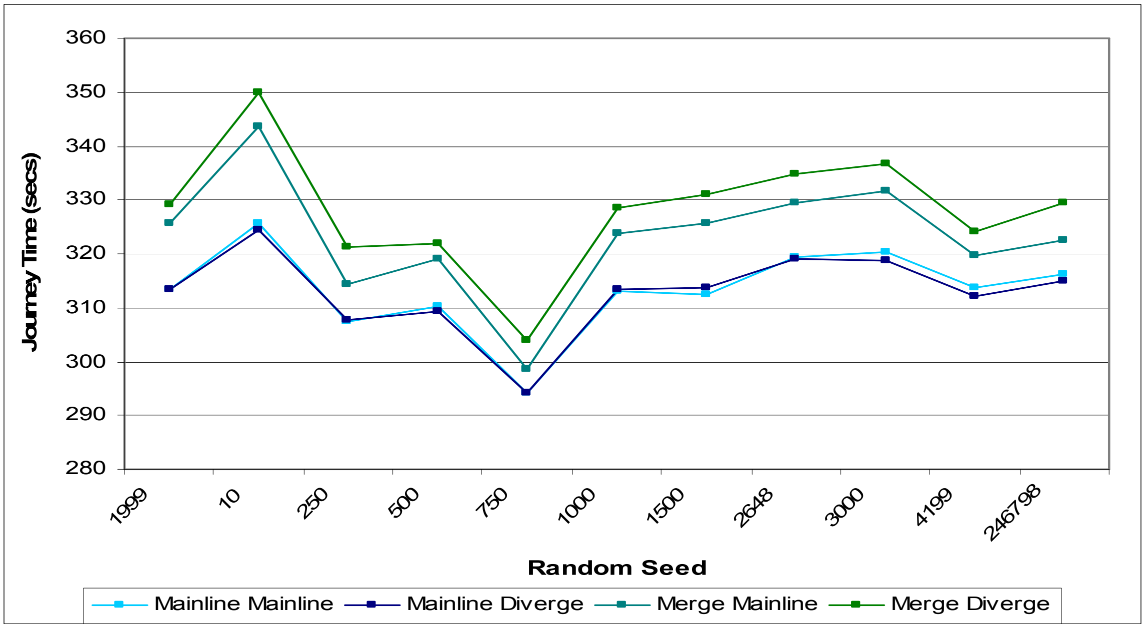


Figure 4.6a - M62 J26-J27- Impact of changes in the random seed on journey times

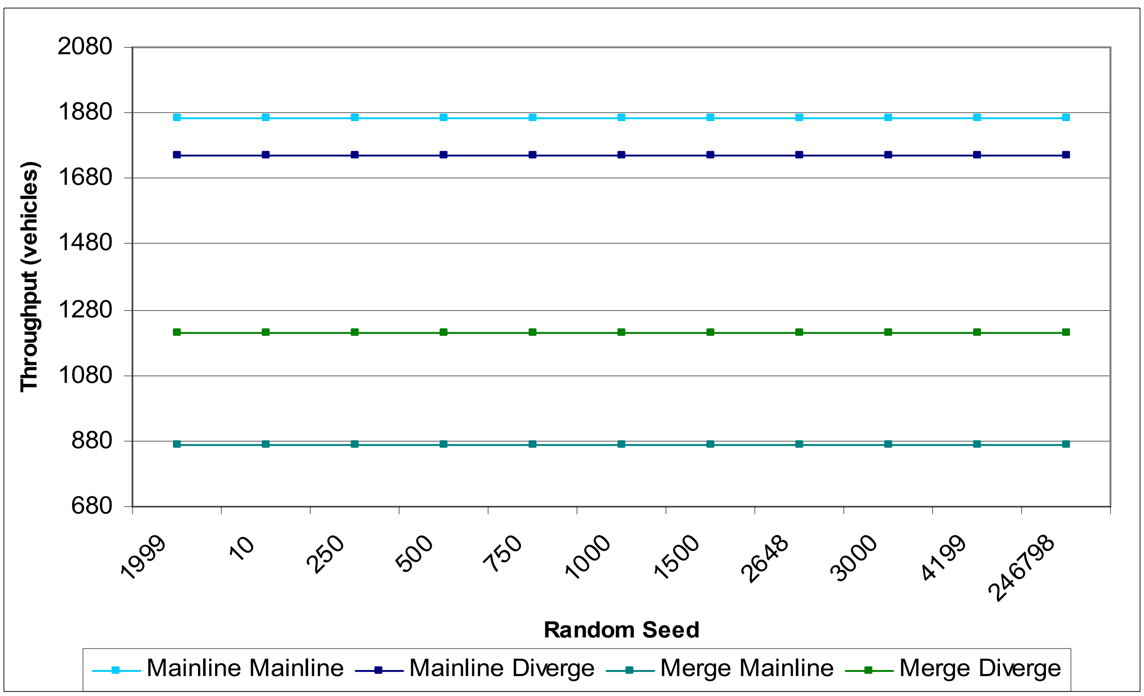


Figure 4.6b - M62 J26-J27 - Impact of changes in the random seed on throughput

	Random Seed Value									
Route	10	250	500	750	1000	1500	2648	3000	4199	246798
Mainline Mainline	3.9%	-1.9%	-0.9%	-6.1%	-0.1%	-0.3%	2.0%	2.3%	0.1%	1.0%
Mainline Diverge	3.8%	-1.7%	-1.2%	-6.0%	0.2%	0.3%	2.0%	1.9%	-0.2%	0.7%
Merge Mainline	6.4%	-2.7%	-1.3%	-7.5%	0.2%	0.8%	2.0%	2.7%	-1.0%	-0.2%
Merge Diverge	6.6%	-2.1%	-2.0%	-7.4%	0.1%	0.8%	2.0%	2.6%	-1.3%	0.3%

Table 4.5 - M62 J26-27 - Percentage deviation of journey times from average journey times

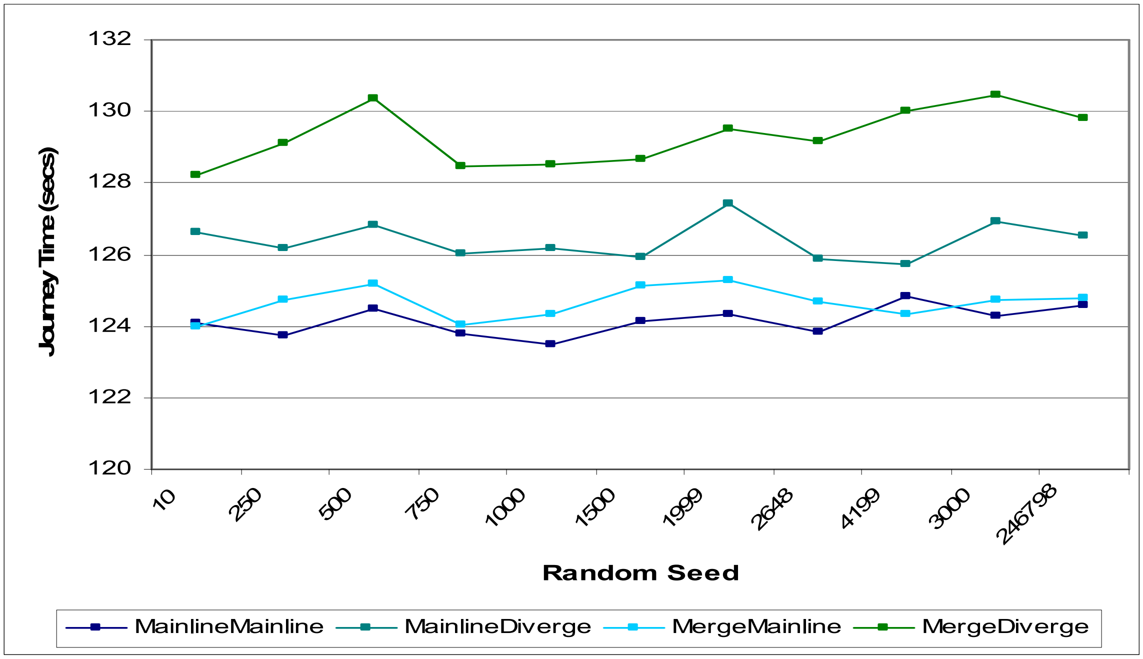


Figure 4.7a - M60 J16-J17 - Impact of changes in the random seed on journey times

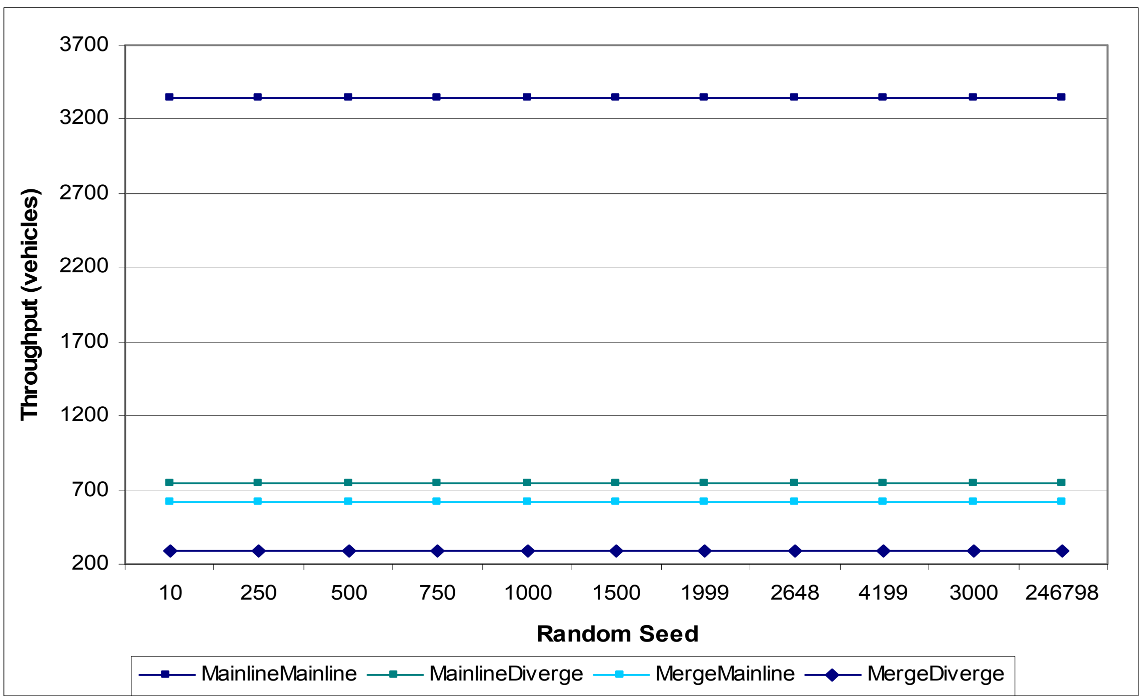


Figure 4.7b - M60 J16-J17 - Impact of changes in the random seed on throughput

	Random Seed Value									
Route	10	250	500	750	1000	1500	2648	4199	3000	246798
Mainline Mainline	0.0%	-0.3%	0.3%	-0.3%	-0.5%	0.0%	-0.3%	0.6%	0.1%	0.3%
Mainline Diverge	0.2%	-0.2%	0.3%	-0.3%	-0.2%	-0.4%	-0.4%	-0.5%	0.4%	0.1%
Merge Mainline	-0.5%	0.1%	0.4%	-0.5%	-0.3%	0.4%	0.0%	-0.3%	0.0%	0.1%
Merge Diverge	-0.8%	-0.1%	0.8%	-0.6%	-0.6%	-0.5%	-0.1%	0.5%	0.9%	0.4%

Table 4.6 - M60 J16-J17 Percentage deviation of journey times from mean journey time (secs)

4.6 Random Seed Summary

In a congested network, changes to the Random Seed varied the journey time results by more than the variation of +/-5%. However, in uncongested conditions the variation was around +/-1%.

In both models the traffic flows were unaffected by the change in random seed and as such the observed changes in journey times are a direct result of how the random seed is used in varying driver behavioural characteristics.

The clear conclusion to be drawn from the random seed tests is that if stable results are required from the use of SISTM, particularly if they are to be used for appraisal, then several different random seeds need to be run. The number of random seeds required to be run is not fixed and will need to be calculated separately for each model application so that a required degree of confidence in the average results can be achieved. This is clearly shown by the differences observed between the M62 and M60 networks where over the random seed tests the standard deviation of the average journey times are 2.7% and 0.3% of the average times respectively.

Acceptable levels of accuracy are to be recommended in the final micro-simulation guidelines.

4.7 Test 3: Adjusting the Epoch Length

SISTM takes input for the simulation time increment, i.e. the Epoch length, in multiples of 1/16th of a second. The following set defines the values permitted for the parameter (8/16, 10/16, 12/16, 16/16). The calibrated default is 10/16. Results for the M62 J26-J27 network are summarised in Table 4.7 – 4.11. A plot of the journey time changes resulting from different values for the epoch length parameter is given in Figure 4.8. .

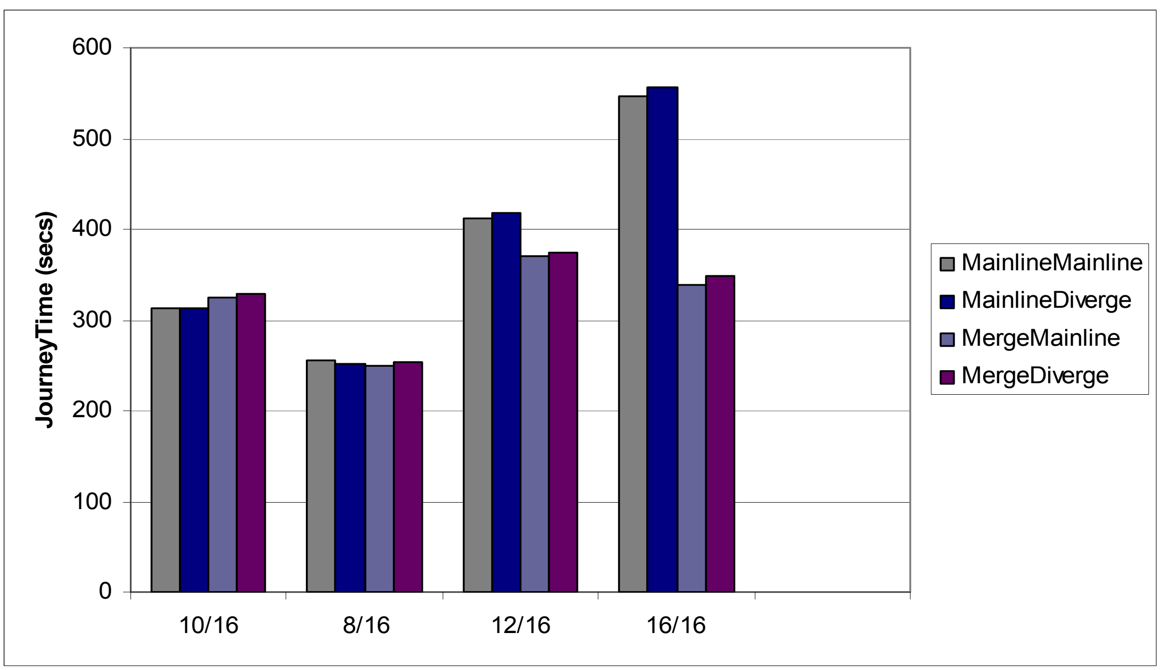


Figure 4.8: M62 J26-J27 - Journey times for different values of the epoch length

	Epoch length		
Route	**8/16**	**12/16**	**16/16**
Mainline Mainline	-18.7%	31.2%	74.5%
Mainline Diverge	-19.8%	33.3%	77.6%
Merge Mainline	-23.1%	13.7%	3.8%
Merge Diverge	-23.2%	13.9%	6.0%

Table 4.7 - M62 J26-J27 - Journey time change as compared with default epoch length

The figures above show extremely sensitive responses to changes in the Epoch length. On the mainline the journey times more than double for a change from 0.5 seconds to 1.0 seconds.

	Epoch length			
Route	**8/16**	**10/16**	**12/16**	**16/16**
Mainline Mainline	1863	1863	1628	1214
Mainline Diverge	1751	1751	1554	1111
Merge Mainline	869	869	869	869
Merge Diverge	1210	1210	1209	1210
Total Flow	5693	5693	5261	4404

Table 4.8 - M62 J26-J27 - Summary of traffic flow for different values of the epoch length

The effect on traffic volume of changes in the Epoch length, shown in Table 4.8, is interesting as the mainline flow prior to the merge point significantly reduces with increasing Epoch length whereas the merge flow remains unaffected.

				Epoch Length			
Location	**Chainage**	**Lane Number**	**Lane Key**	**8/16**	**10/16**	**12/16**	**16/16**
Upstream of Merge	100m	1		0	0	0	0
	100m	2		0	0	0	0
	100m	3	Main Carriageway	1265	1254	418	474
	100m	4	Main Carriageway	1499	1476	1083	852
	100m	5	Main Carriageway	858	895	1566	864
		Main Carriageway Total		**3622**	**3625**	**3067**	**2190**
Across Merge	400m	1	Merge Slip Road Right Lane	1156	1184	1178	1126
	400m	2	Merge Slip Road Left Lane	925	898	905	957
	400m	3	Main Carriageway	716	629	240	298
	400m	4	Main Carriageway	1895	1492	919	909
	400m	5	Main Carriageway	1009	1487	1893	982
		Main Carriageway Total		**3620**	**3608**	**3052**	**2189**
Between Merge and Diverge	3000m	1		0	0	0	0
	3000m	2		0	0	0	0
	3000m	3	Main Carriageway	1850	1425	1201	934
	3000m	4	Main Carriageway	2107	1936	1829	1612
	3000m	5	Main Carriageway	1732	2217	2109	1712
		Main Carriageway Total		**5689**	**5578**	**5139**	**4258**
Across Diverge	5900m	1	Diverge Slip Road Left Lane	2016	1778	1689	1488
	5900m	2	Diverge Slip Road Right Lane	942	1124	1019	769
	5900m	3	Main Carriageway	777	665	533	372
	5900m	4	Main Carriageway	1200	1145	1070	923
	5900m	5	Main Carriageway	747	862	817	730
		Main Carriageway Total		**2724**	**2672**	**2420**	**2025**
Downstream of Diverge	6400m	1		0	0	0	0
	6400m	2		0	0	0	0
	6400m	3	Main Carriageway	883	739	586	387
	6400m	4	Main Carriageway	1205	1192	1127	967
	6400m	5	Main Carriageway	637	740	716	664
		Main Carriageway Total		**2725**	**2671**	**2429**	**2018**

Table 4.9 - M62 J26-J27 - Summary of hourly flows at key points

Increasing the Epoch length significantly affects the throughput of traffic by lane as it approaches the merge point in congested conditions.

				Epoch Length			
Location	**Chainage**	**Lane Number**	**Lane Key**	**8/16**	**10/16**	**12/16**	**16/16**
Upstream of Merge	100m	1		0	0	0	0
	100m	2		0	0	0	0
	100m	3	Main Carriageway	93	91	13	13
	100m	4	Main Carriageway	102	100	28	16
	100m	5	Main Carriageway	115	113	44	22
Across Merge	400m	1	Merge Slip Road Right Lane	84	85	83	78
	400m	2	Merge Slip Road Left Lane	88	86	85	80
	400m	3	Main Carriageway	91	67	8	10
	400m	4	Main Carriageway	99	72	19	17
	400m	5	Main Carriageway	116	93	36	24
Between Merge and Diverge	3000m	1		0	0	0	0
	3000m	2		0	0	0	0
	3000m	3	Main Carriageway	87	85	85	90
	3000m	4	Main Carriageway	98	93	93	98
	3000m	5	Main Carriageway	111	106	105	107
Across Diverge	5900m	1	Diverge Slip Road Left Lane	91	85	90	92
	5900m	2	Diverge Slip Road Right Lane	101	98	102	104
	5900m	3	Main Carriageway	91	87	91	94
	5900m	4	Main Carriageway	105	103	105	108
	5900m	5	Main Carriageway	114	113	113	115
Downstream of Diverge	6400m	1		0	0	0	0
	6400m	2		0	0	0	0
	6400m	3	Main Carriageway	95	93	95	96
	6400m	4	Main Carriageway	106	105	106	108
	6400m	5	Main Carriageway	115	114	114	115

Table 4.10 - M62 J26-J27 - Average Speed (km/h) at key points

The increased Epoch length created breakdown in flows and speeds on the approach to and across the merge for the mainline traffic. Merging traffic was unaffected as was all traffic once past the merge point.

Time		**Epoch length**			
From	**To**	**8/16**	**10/16 (default)**	**12/16**	**16/16**
08:00:00	09:00:00	20148	18008	15190	12266

Table 4.11 - M62 J26-J27 - Impact of epoch length on the number of lane changes

As simulation time increases drivers see less opportunities to change lane. This probably explains the impacts on the pre-merge traffic.

M62 J26-7 Changing the Epoch Length: Key Observations

- Reduction in total flows with epoch length at all key points but all related to main line flows from before the merge point.
- Large values for the epoch length result in flow breakdown at merge.
- Decline in number of lane changes with growing epoch length.

In congested conditions the results indicate extensive sensitivity to the Epoch length. Consequently, there would need to be a strong evidence base for making any change to the calibrated default. It is, therefore, recommended that in SISTM that the default Epoch length be used.

Similar summaries relating to results for M60 J16-J17 are given in Table 4.12 – 4.16. For the M60 network journey times increase as a result of growing epoch length. The volume of traffic passing through the network remains unchanged. However, changing the value for the epoch length does have an impact on lane usage. Flow figures at key points are given in Table 4.13. As the epoch length is increased a higher proportion of traffic uses the outside lane. However, total flow figures across the main carriageway remain unchanged

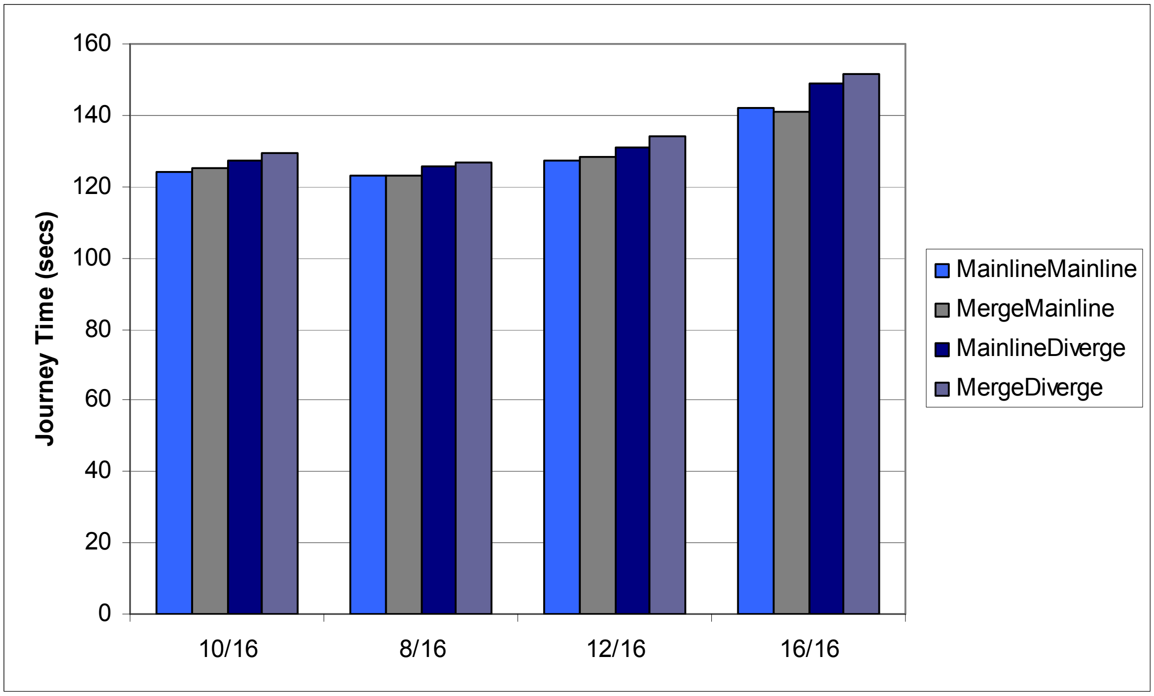


Figure 4.9: M60 J16-J17 - Journey times for different values of the epoch length

	Epoch length			
Route		**8/16**	**12/16**	**16/16**
Mainline Mainline		-1.2%	2.2%	14.2%
Mainline Diverge		-1.3%	2.6%	16.7%
Merge Mainline		-1.7%	2.6%	12.7%
Merge Diverge		-2.3%	3.4%	16.8%

Table 4.12 - M60 J16-J17 - Journey time variation from default for different epoch lengths

	Epoch length			
Route	**8/16**	**10/16**	**12/16**	**16/16**
Mainline Mainline	3348	3348	3348	3348
Mainline Diverge	747	747	747	747
Merge Mainline	615	615	615	614
Merge Diverge	291	291	291	291
Total Flow	5001	5001	5001	5000

Table 4.13 - M60 J16-J17 - Summary of traffic flows for different values of the epoch length

In the uncongested M60 model changing the Epoch length has no affect on the traffic flow throughput, Table 4.13, and relatively small effects on journey times, until a 1.0 sec Epoch length is used.

It is, therefore, clear that until congested conditions are encountered the Epoch length has small effects. However, as capacity is reached the effect of changing the Epoch length is highly significant and fundamentally influences model output.

				Epoch Length			
Location	**Chainage**	**Lane Number**	**Lane Key**	**8/16**	**10/16**	**12/16**	**16/16**
Across Merge	200m	1	Merge Slip Road Right Lane	0	0	0	0
	200m	2	Merge Slip Road Left Lane	913	913	913	913
	200m	3	Main Carriageway	655	648	659	601
	200m	4	Main Carriageway	1582	1567	1526	1365
	200m	5	Main Carriageway	1202	1172	1160	1096
	200m	6	Main Carriageway	447	500	543	834
			Main Carriageway Total	**3886**	**3887**	**3888**	**3896**
Between Merge and Diverge	1000m	1		0	0	0	0
	1000m	2		0	0	0	0
	1000m	3	Main Carriageway	1391	1277	1143	997
	1000m	4	Main Carriageway	1585	1578	1521	1232
	1000m	5	Main Carriageway	1281	1323	1349	1334
	1000m	6	Main Carriageway	554	635	797	1264
			Main Carriageway Total	**4811**	**4813**	**4810**	**4827**
Across Diverge	3300m	1	Diverge Slip Road Left Lane	837	834	819	832
	3300m	2	Diverge Slip Road Right Lane	110	113	127	126
	3300m	3	Main Carriageway	1084	955	855	782
	3300m	4	Main Carriageway	1120	1086	1028	947
	3300m	5	Main Carriageway	1088	1108	1101	1092
	3300m	6	Main Carriageway	601	742	910	1116
			Main Carriageway Total	**3893**	**3891**	**3894**	**3937**

Table 4.14 - M60 J16-J17 Summary of hourly flows at key points

				Epoch Length			
Location	**Chainage**	**Lane Number**	**Lane Key**	**8/16**	**10/16**	**12/16**	**16/16**
Across Merge	200m	1	Merge Slip Road Right Lane	0	0	0	0
	200m	2	Merge Slip Road Left Lane	81	78	78	75
	200m	3	Main Carriageway	95	94	93	84
	200m	4	Main Carriageway	101	99	98	88
	200m	5	Main Carriageway	113	113	112	101
	200m	6	Main Carriageway	122	121	120	109
Between Merge and Diverge	1000m	1		0	0	0	0
	1000m	2		0	0	0	0
	1000m	3	Main Carriageway	94	93	92	89
	1000m	4	Main Carriageway	101	99	98	95
	1000m	5	Main Carriageway	113	112	111	105
	1000m	6	Main Carriageway	121	120	118	112
Across Diverge	3300m	1	Diverge Slip Road Left Lane	103	103	102	102
	3300m	2	Diverge Slip Road Right Lane	92	94	99	94
	3300m	3	Main Carriageway	91	88	88	86
	3300m	4	Main Carriageway	103	101	99	97
	3300m	5	Main Carriageway	112	111	108	106
	3300m	6	Main Carriageway	120	118	115	112

Table 4.15 - M60 J16-J17 - Summary of speeds (km/h) at key points

Time		**Epoch length**			
From	**To**	**8/16**	**10/16**	**12/16**	**16/16**
08:00:00	09:00:00	10243	9004	10319	13345

Table 4.16 - M60 J16-J17 - Impact of epoch length on the number of lane changes

M60 J16-J17 Changing the Epoch Length: Key Observations

- No change in total flows with epoch length
- Higher usage of offside lane as traffic moves across from the nearside lane for higher values of the epoch length
- Higher number of lane changes for epoch length 16/16
- As epoch length grows speeds drop in some lanes despite a decline of the traffic volume

4.8 Epoch Length Summary

Changing the epoch length (i.e. changing the lower bound of the length of the time gap between drivers updating their decisions) had a less predictable effect on simulation output from the M62 J26-J27 network. Drivers on the mainline take longer to speed up after giving way to merging vehicles or vehicles changing lanes. As a result journey times for the Mainline to Mainline and the Mainline to Diverge routes displayed a positive correlation with epoch length. Journey times for the other two routes increased as the epoch length increased from 8/16 to 12/16, however, the trend did not continue when the parameter value was set to 16/16. Inspection of the traffic flow figures shows that when the epoch length exceeds 10/16 the volume of traffic arriving at the destination specified falls below demand.

Another byproduct of a longer epoch length for this network is an increase in the number of collisions as shown in Table 4.17. TRL advise that collisions are "the result of a lane change in which the lane changing vehicle is in both lanes for two time increments, but the acceleration is calculated for the new lane." The problem is currently under investigation.

Epoch length	Number of Collisions (M62 J26-J27)	Number of Collisions (M60 J16-J17)
8/16	1	0
10/16	314	0
12/16	1124	0
16/16	4995	13

Table 4.17 - M60 J16-J17 - Number of collisions for different epoch lengths

In view of the major changes arising in congested conditions when the Epoch length is changed it is concluded that altering the Epoch length from the calibrated default values is not recommended.

4.9 Test 4: Impact of Diverge Signposts

SISTM has a facility for defining "diverge signposts" in order to model the impact of a nearby diverge on the lane changing behaviour of drivers on the section of the main carriageway prior to the slip road. A diverge signpost is defined by its location and the associated lane changing score. Both parameters have been tested with respect to their impact on simulation output. No default set-up is given in the User Guide, however an example included in the documentation suggests the settings given in Table 4.18. These settings have been used as a starting point for the tests documented below, and will be referred to as "standard set-up".

Distance from merge sliproad	**Score**
-200m	120
-400m	80
-600m	50
-800m	20

Table 4.18 - Diverge signpost settings from "SISTM: Creating a small model - A Step by Step Guide"

The 'score' is a weighting factor that determines the probability of a driver moving over to the desired lane for diverging. The higher the score the greater the probability of moving into the diverge lane at that point.

The impact of changing signpost settings was reduced in the M62 J26 – J27 as the existing congestion in the model dampened any additional effects. The results are presented below. However, in the uncongested conditions displayed in the M60 J16 - J17 network the impact of changing the signpost parameters is more pronounced for diverging vehicles.

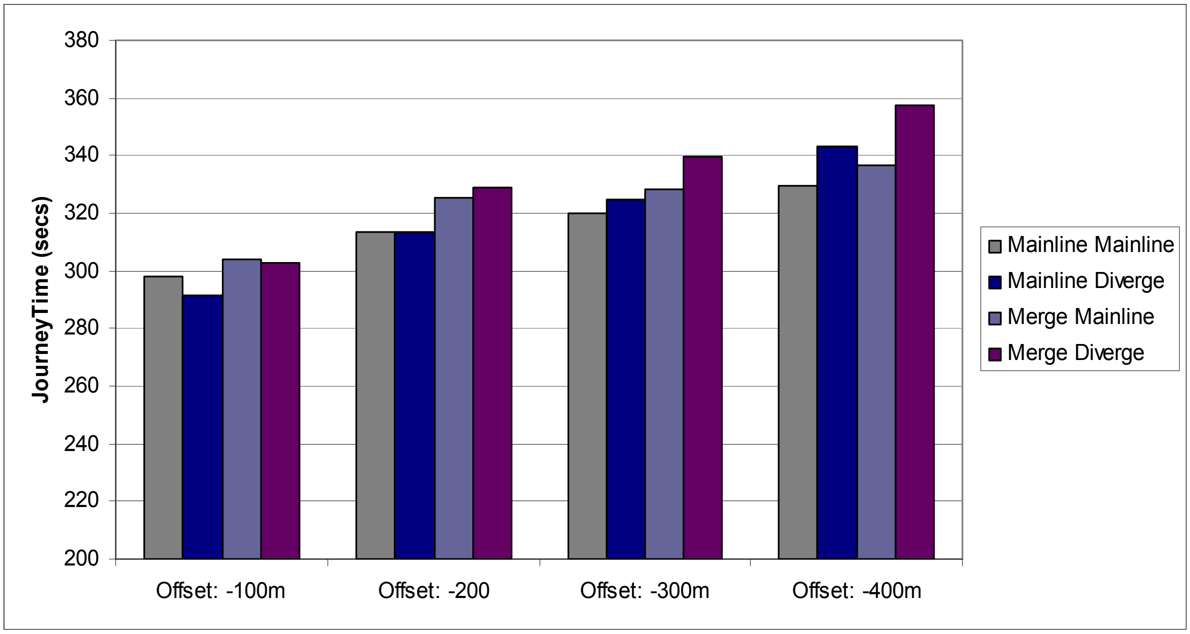


Figure 4.10: - M62 J26-J27 - Impact of changing diverge signpost positioning

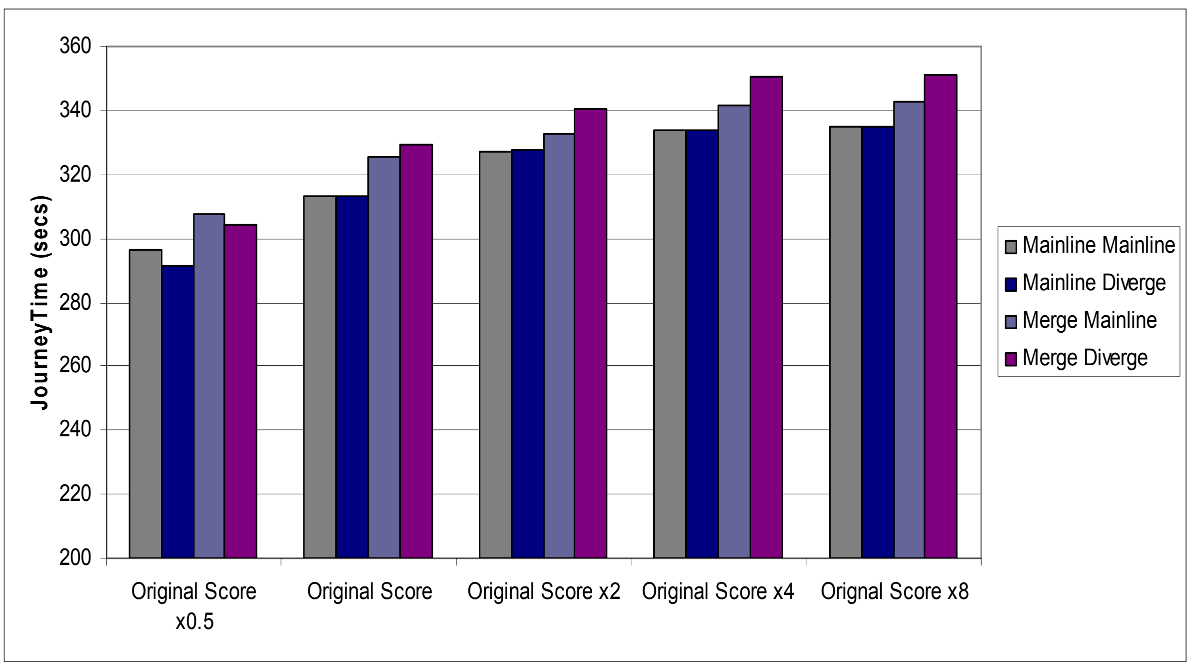


Figure 4.11 - M62 J26-J27 - Impact of changing diverge signpost scores

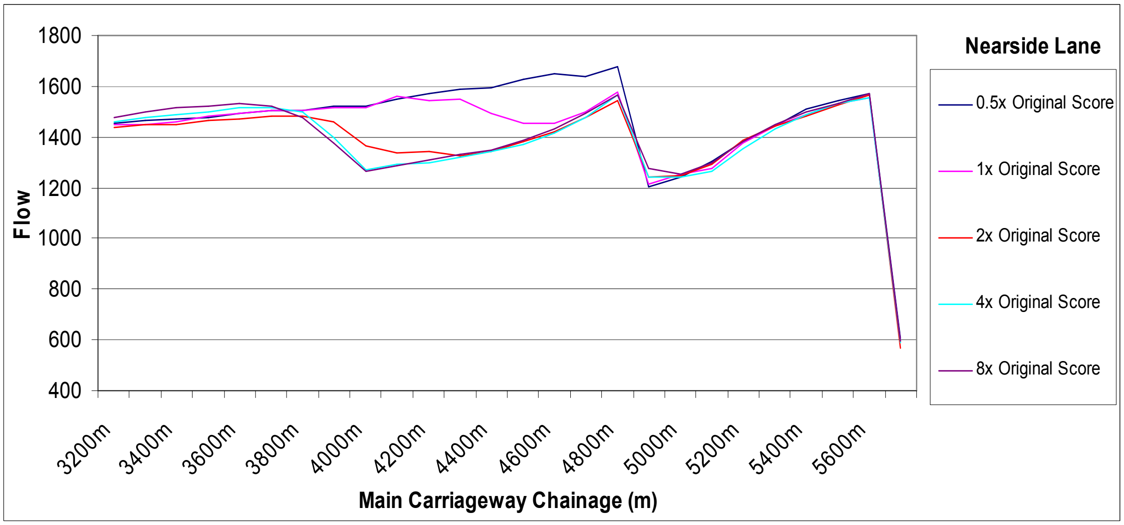


Figure 4.12 - M62 J26-J27 – Flow changes due to diverge signpost scores - nearside lane

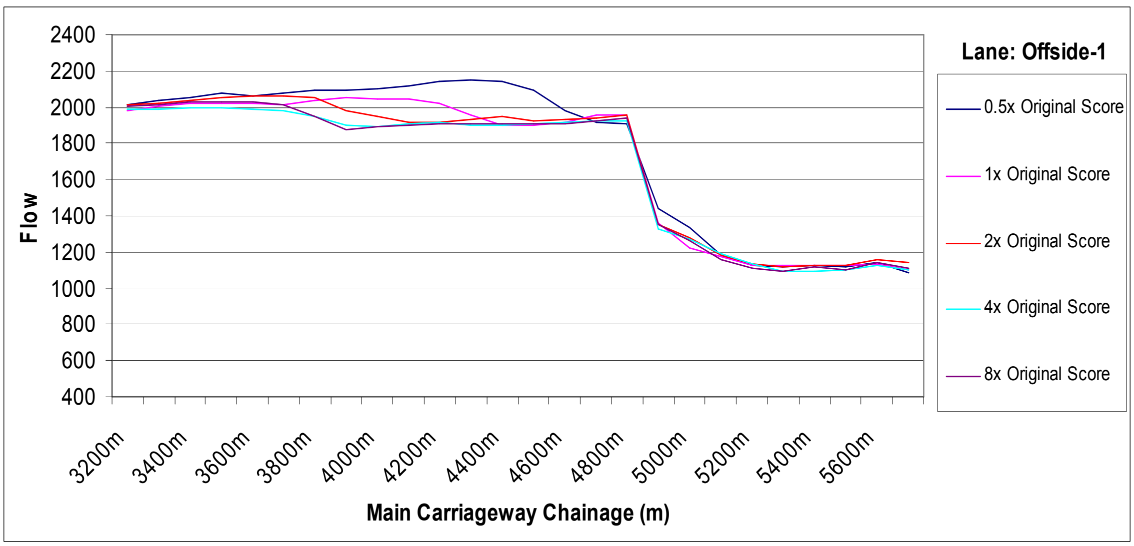


Figure 4.13 - M62 J26-J27 - Flow changes due to diverge signpost scores - offside lane 1

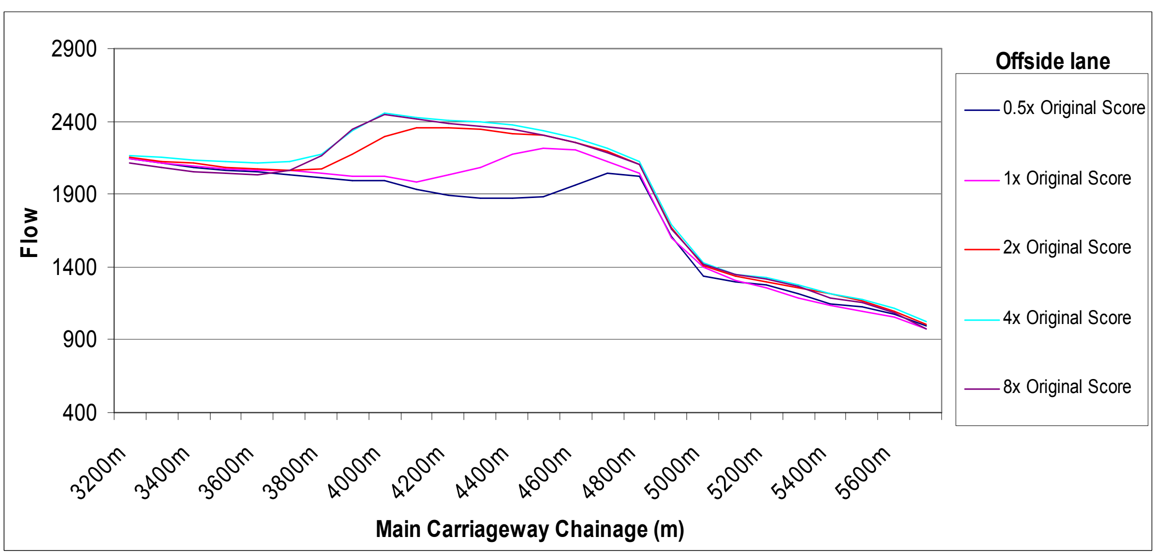


Figure 4.14 - M62 J26-J27 - Flow changes due to diverge signpost scores - offside lane

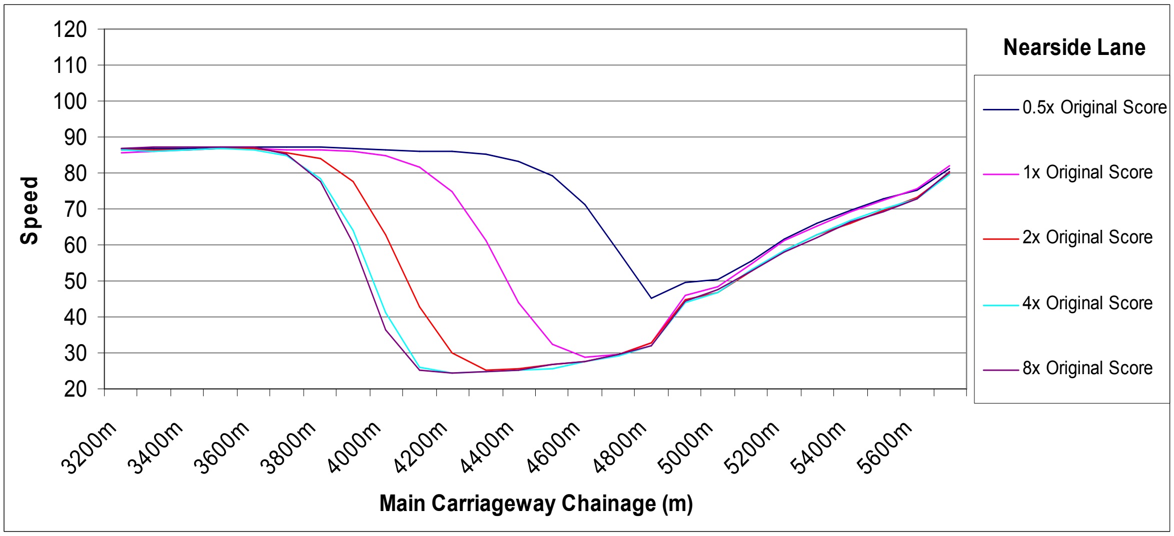


Figure 4.15 - M62 J26-J27 – Speed variation due to diverge signpost scores -nearside lane

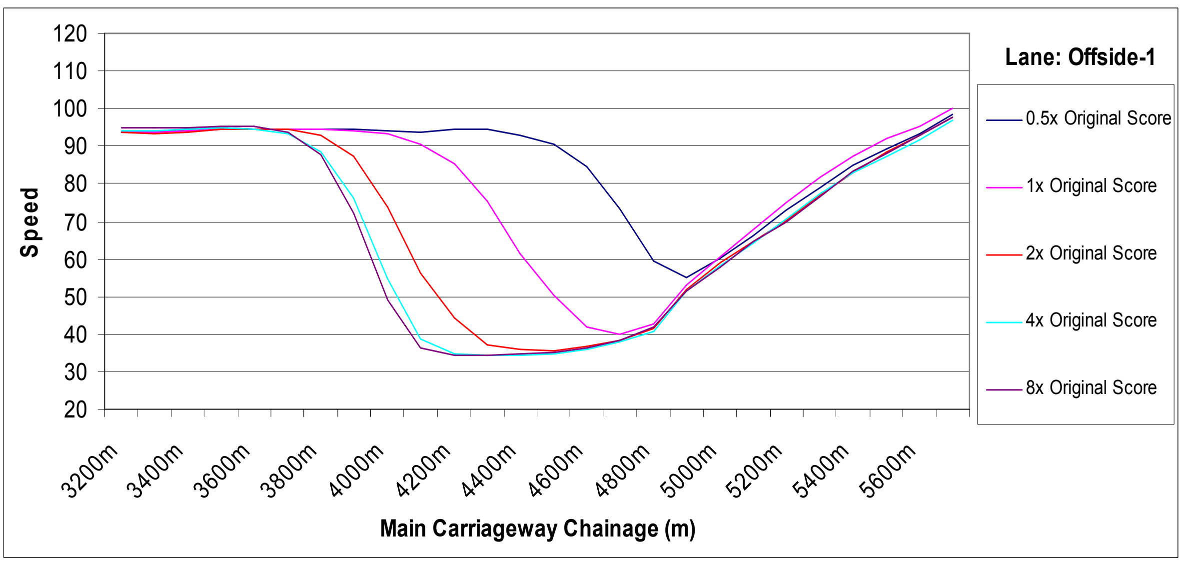


Figure 4.16 - M62 J26-J27 - Speed variation due to diverge signpost scores - offside-1 lane

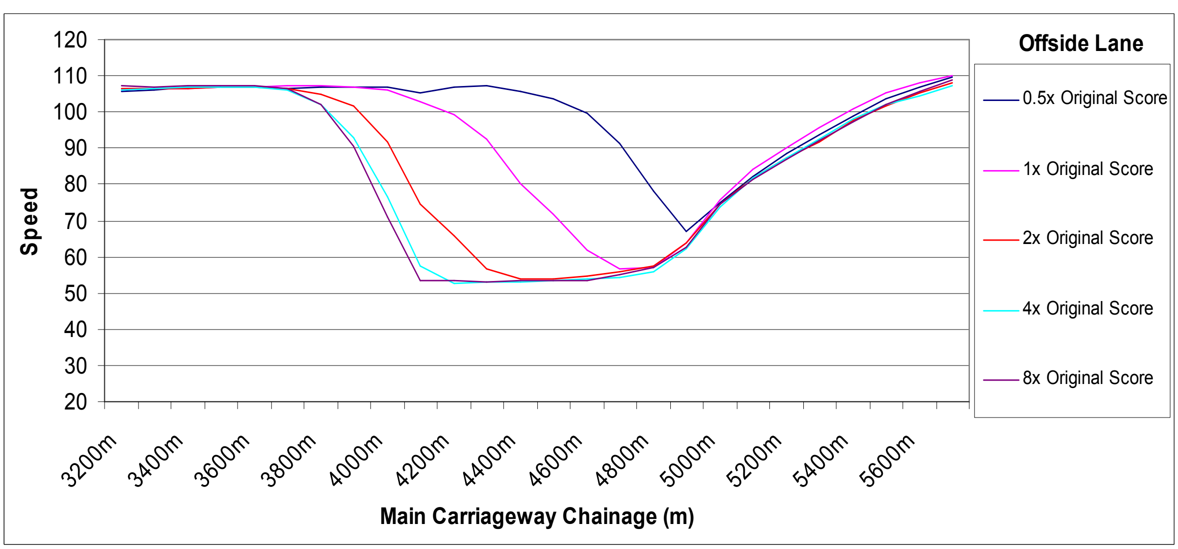


Figure 4.17 - M62 J26-J27 - Speed variation due to diverge signpost scores - offside lane

	Diverge signpost set-up			
	Original Score	**Original Score**	**Original Score**	**Original Score**
Route	**Offset: -100m**	**Offset: -200**	**Offset: -300m**	**Offset: -400m**
Mainline Mainline	-4.9%	0.0%	2.2%	5.2%
Mainline Diverge	-6.9%	0.0%	3.6%	9.5%
Merge Mainline	-6.7%	0.0%	0.8%	3.5%
Merge Diverge	-7.9%	0.0%	3.3%	8.6%

Table 4.19 - M62 J26-J27 – Journey Time variation due to diverge signpost positions

	Diverge signpost set-up				
	Original Score x0.5	**Original Score**	**Original Score x2**	**Original Score x4**	**Original Scores x8**
Route	**Offset: -200m**	**Offset: -200m**	**Offset: -200m**	**Offset: -200m**	**Offset: -200m**
Mainline Mainline	-5.4%	0.0%	4.5%	6.6%	6.8%
Mainline Diverge	-7.0%	0.0%	4.5%	6.5%	6.8%
Merge Mainline	-5.6%	0.0%	2.2%	4.9%	5.2%
Merge Diverge	-7.5%	0.0%	3.4%	6.4%	6.7%

Table 4.20 - M62 J26-J27 - Journey Time variation due to diverge signpost scores

<u>M62 J26-J27 Changing Diverge Signpost Scores and Positioning: Key Observations</u>

- Journey times increase as signposts are positioned further upstream from the diverge and as scores are increased.
- At higher scores drivers choose the nearside lane earlier creating congestion in the nearside and offside-1 lanes.
- As a result of lane changes speeds drop in all lanes on the section of road upstream of the diverge.
- Speeds decrease most in the nearside lane.
- At higher score values the decrease in speeds is more significant and speeds drop on a longer stretch of road.

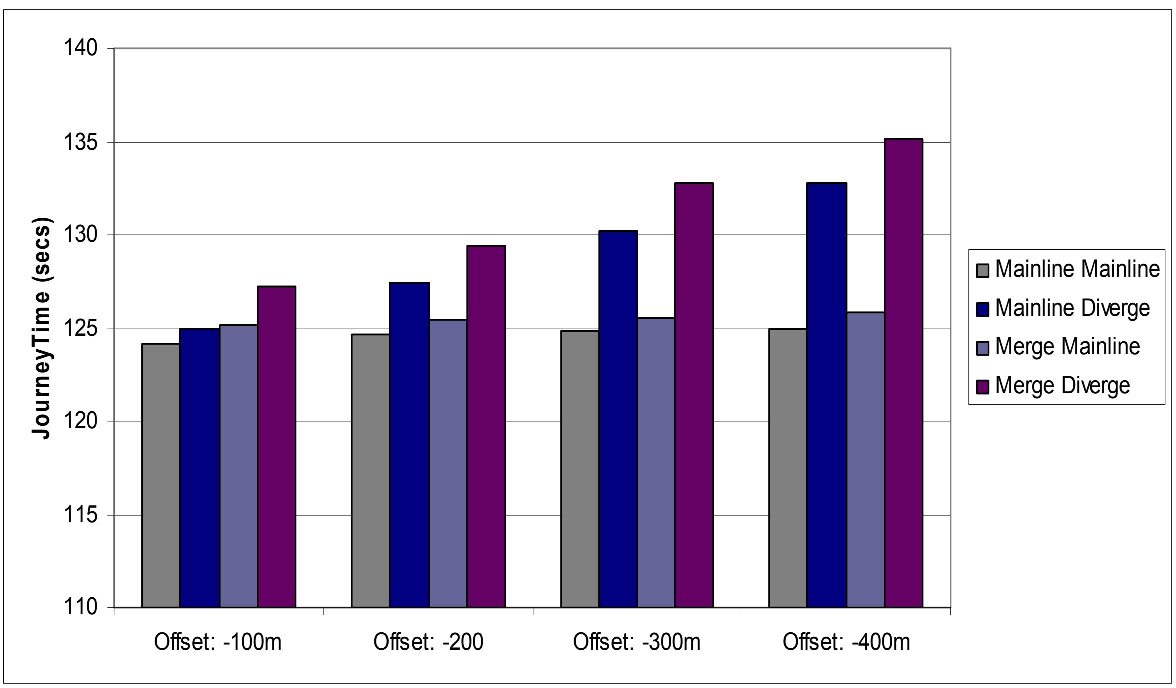


Figure 4.18 - M60 J16-J17 - Impact of changing diverge signpost positioning

	Merge signpost set-up			
	Original Score	**Original Score**	**Original Score**	**Original Score**
Route	**Offset: -100m**	**Offset: -200**	**Offset: -300m**	**Offset: -400m**
Mainline Mainline	-0.4%	0.0%	0.2%	0.2%
Mainline Diverge	-1.9%	0.0%	2.2%	4.2%
Merge Mainline	-0.3%	0.0%	0.0%	0.3%
Merge Diverge	-1.7%	0.0%	2.6%	4.4%

Table 4.21 - M60 J16-J17 – Journey time variation due to diverge signpost distance

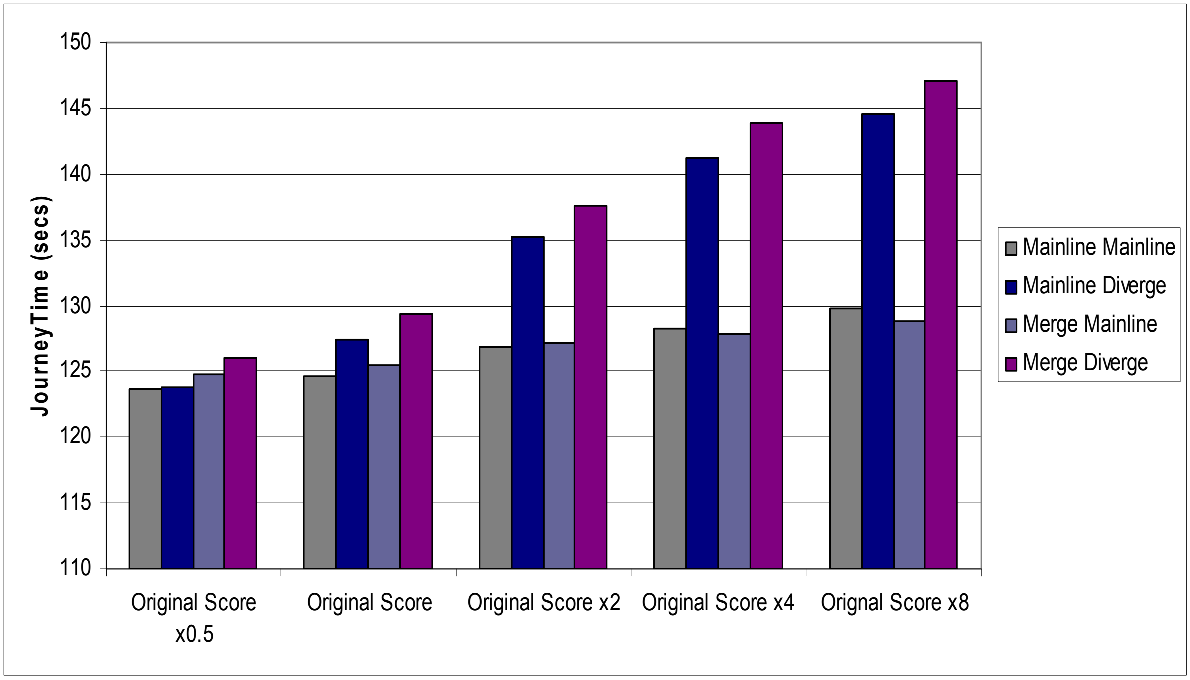


Figure 4.19 - M60 J16-J17 - Impact of changing diverge signpost scores – Journey Time

	Diverge signpost set-up				
	Original Score x0.5	**Original Score**	**Original Score x2**	**Original Score x4**	**Original Score x8**
Route	**Offset: -200m**	**Offset: -200m**	**Offset: -200m**	**Offset: -200m**	**Offset: -200m**
Mainline Mainline	-0.8%	0.0%	1.8%	3.0%	4.1%
Mainline Diverge	-2.9%	0.0%	6.1%	10.8%	13.4%
Merge Mainline	-0.5%	0.0%	1.3%	1.9%	2.6%
Merge Diverge	-2.6%	0.0%	6.3%	11.1%	13.6%

Table 4.22: M60 J16-J17 - Journey time variation due to changing diverge signpost scores

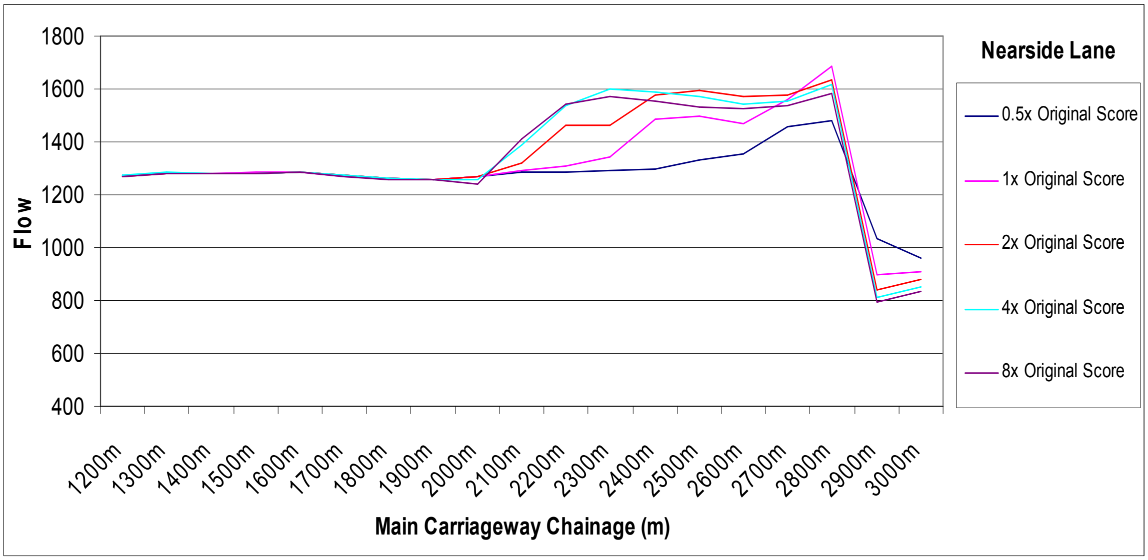


Figure 4.20 - M60 J16-J17 – Flow changes due to diverge signpost scores - nearside lane

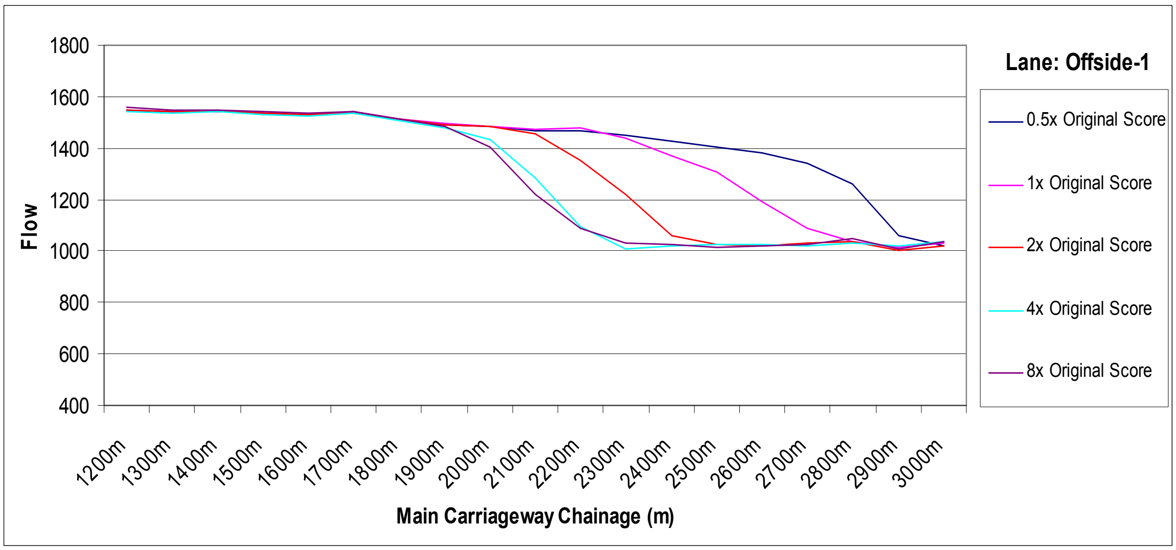


Figure 4.21: M60 J16-J17 – Flow variation due to diverge signpost score - offside-1 lane

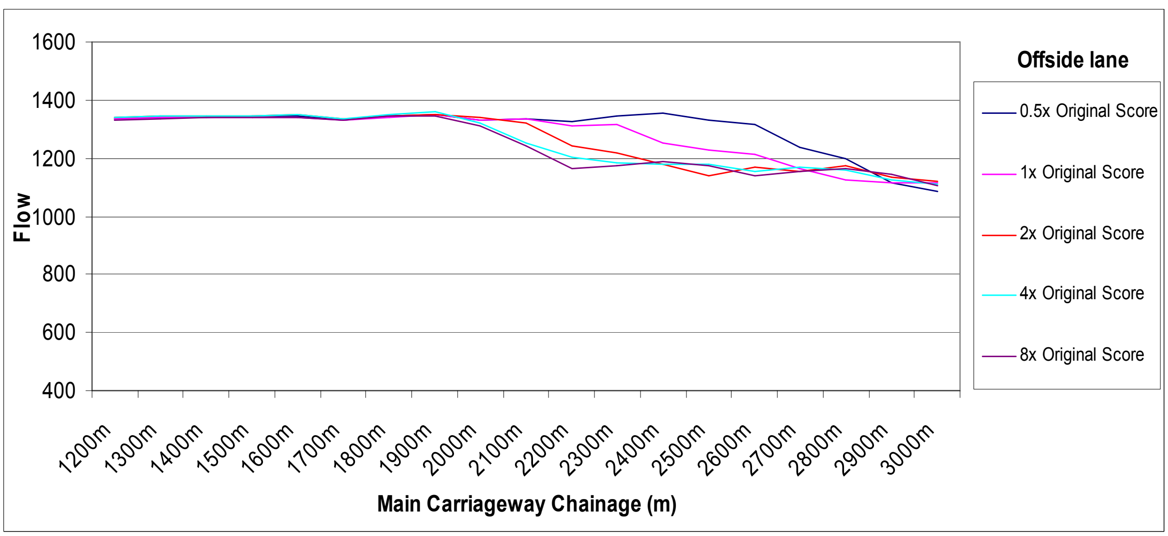


Figure 4.22: M60 J16-J17 - Flow variation due to diverge signpost score - offside-lane

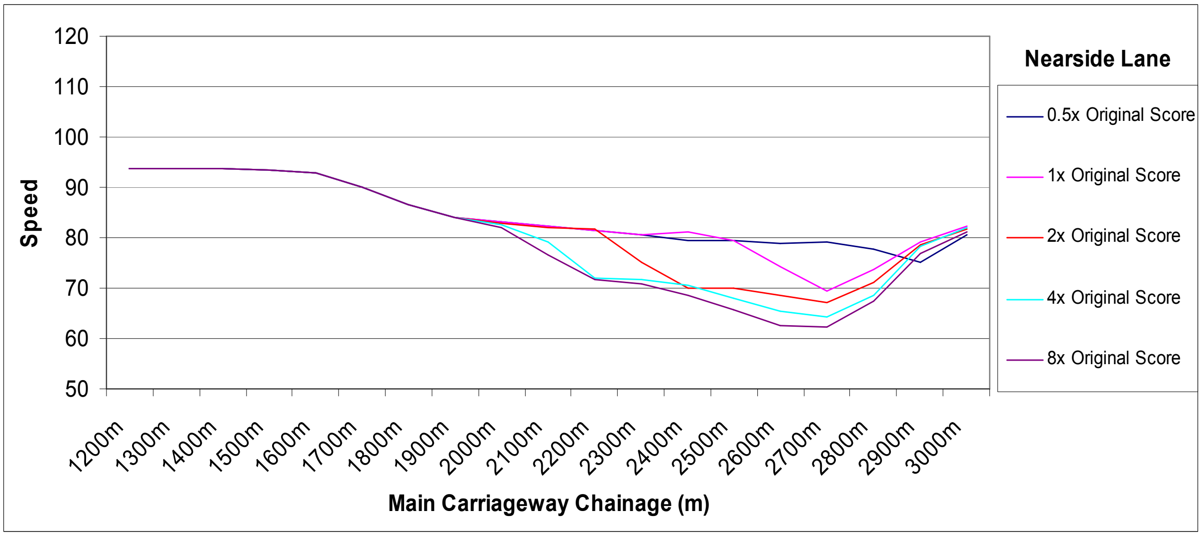


Figure 4.23 - M60 J16-J!7 – Speed changes due to diverge signpost scores - nearside lane

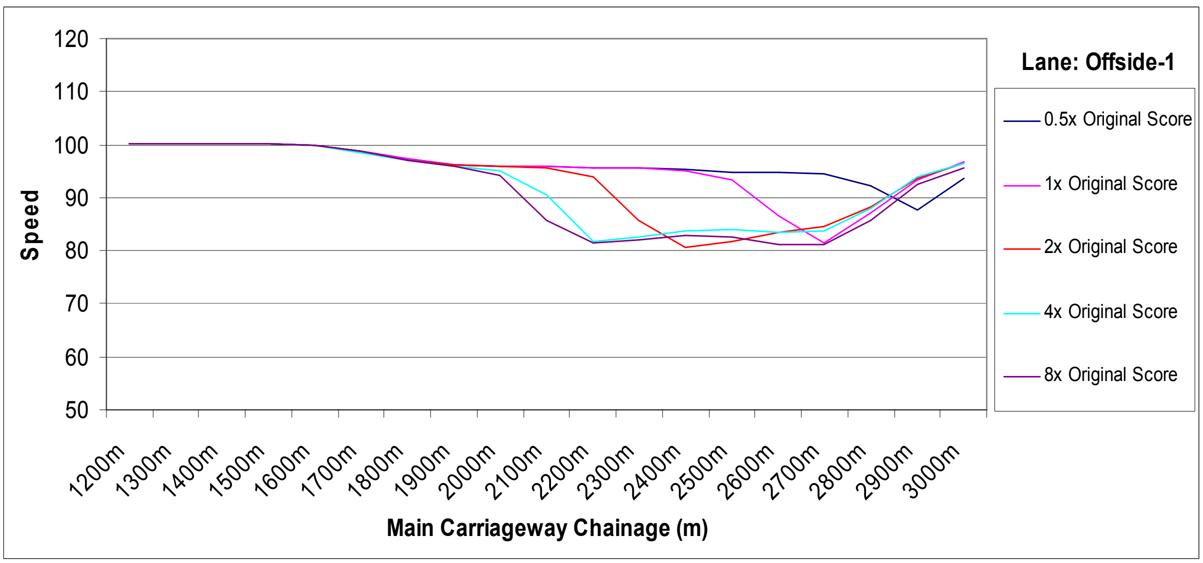


Figure 4.24 - M60 J16-J17 - Speed changes due to diverge signpost scores – Offside-Lane 1

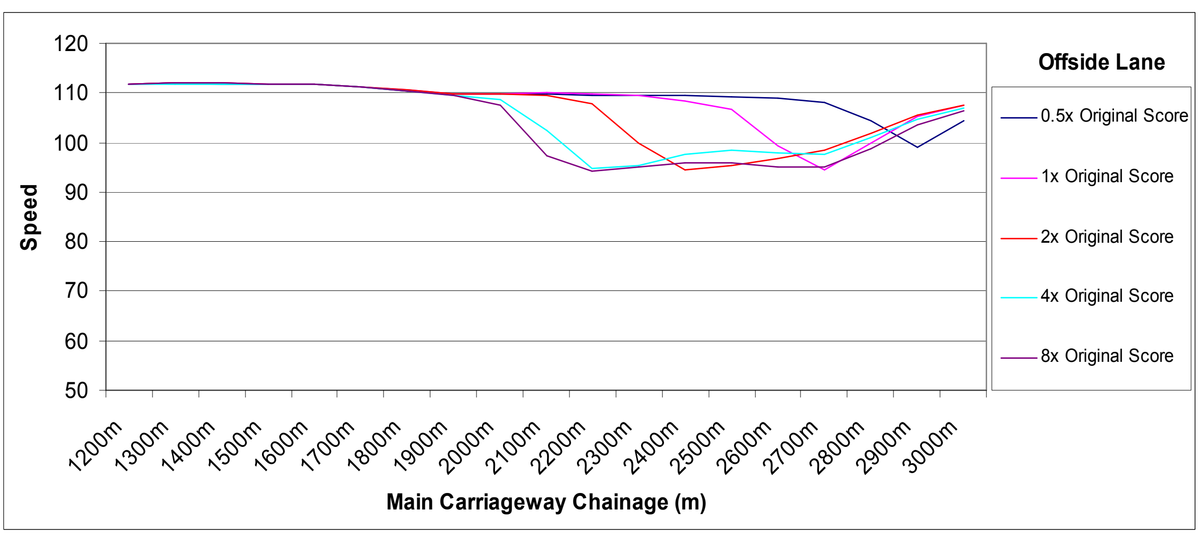


Figure 4.25 - M60 J16-J17 - Speed changes due to diverge signpost scores – Offside-Lane

M60 J16-J17 Changing Diverge Signpost Scores and Positioning: Key Observations

- Journey times increase when signposts are positioned further upstream from the diverge and as lane changing scores increase.
- Journey times are more strongly affected for diverging vehicles.
- At higher scores drivers choose the nearside lane earlier, i.e. higher flows in the nearside lane.
- As a result of lane changes speeds drop in all lanes on the section of road upstream of the diverge.
- Speeds decrease most in the nearside lane.
- At higher score values the decrease in speeds is more significant and speeds drop on a longer stretch of road.

4.10 Signposting Summary

Journey times increased in both networks as lane changing scores increased and diverge signposts were moved further upstream along the carriageway. At higher scores vehicles make their lane choice earlier. In uncongested conditions this leads to higher flows in the nearside lane. The opposite is true of congested networks where the migration of additional traffic into the nearside lane results in near flow breakdown.

The basic techniques available in SISTM of being able to set different signposting points and the probability of a driver responding to each separate ‘signpost’ are in principle the correct approach. The ability too reflect observed behaviour in this way is a strength of SISTM. Unfortunately there is a significant flaw in the diverging model. Disruption to speeds is minimised at low lane changing scores. This is because any vehicles left in the wrong lane at the diverge point are allowed to “jump” straight across the carriageway with minimum disruption to other traffic. In order to ensure simulation results are meaningful it is therefore important to choose a parameter set that ensures the correct lane is chosen in good time.

As a result of this it is absolutely essential that when developing a SISTM model that it is carefully viewed, and analysed, under differing demand scenarios to ensure that all vehicles complete their diverging movement before reaching the ‘diverge point’ where they are then allowed to cross lanes with no impacts on other vehicles. Without very detailed investigation of the SISTM model this can be a fatal flaw in the model operation.

4.11 Test 5: Response to Changing the Gradient

SISTM defines the responsiveness of vehicles to gradient in terms of the rate of speed loss for each percent of gradient. This facility is available for both light and heavy vehicles. However, the parameter defaults to zero for light vehicles, whilst the default value for heavy vehicles is set to 0.50. The range available for the parameter is 0 to 99kph. The impact of changing the gradient at default settings for the parameter was tested. Matrices releasing one HGV per minute for each origin – destination pair have been assigned to the model for the purposes of this test. This was to remove the effects of vehicle interaction where possible. The demand for the one-hour interval from 08:00 to 09:00 is summarised in Table 4.23. The gradient was increased from 1.5% to 7.5% in 1% steps. The impact of changing the gradient on journey times is summarised in Table 4.24, Table4.25 and Figure 4..

		Destination Zone	
		3	**4**
Origin Zone	**1**	60	60
	2	60	60

Table 4.23: Demand for the gradient tests (HGVs per hour)

	Gradient (%)						
Route	**1.5**	**2.5**	**3.5**	**4.5**	**5.5**	**6.5**	**7.5**
Mainline Mainline	2.6%	5.1%	8.2%	11.7%	15.3%	19.5%	24.4%
Mainline Diverge	2.7%	5.4%	8.5%	11.8%	15.1%	20.0%	25.0%
Merge Mainline	2.4%	4.9%	7.7%	11.1%	14.3%	18.6%	23.1%
Merge Diverge	2.9%	5.3%	8.3%	11.9%	15.1%	19.4%	24.3%

Table 4.24: Journey time variation due to Gradient changes

	Gradient (%)					
Route	**2.5**	**3.5**	**4.5**	**5.5**	**6.5**	**7.5**
Mainline Mainline	2.5%	3.1%	3.5%	3.6%	4.2%	4.9%
Mainline Diverge	2.7%	3.1%	3.3%	3.4%	4.9%	5.0%
Merge Mainline	2.5%	2.8%	3.4%	3.3%	4.2%	4.5%
Merge Diverge	2.5%	3.0%	3.6%	3.2%	4.2%	4.9%

Table 4.25 - Percentage growth due to last percent growth in gradient

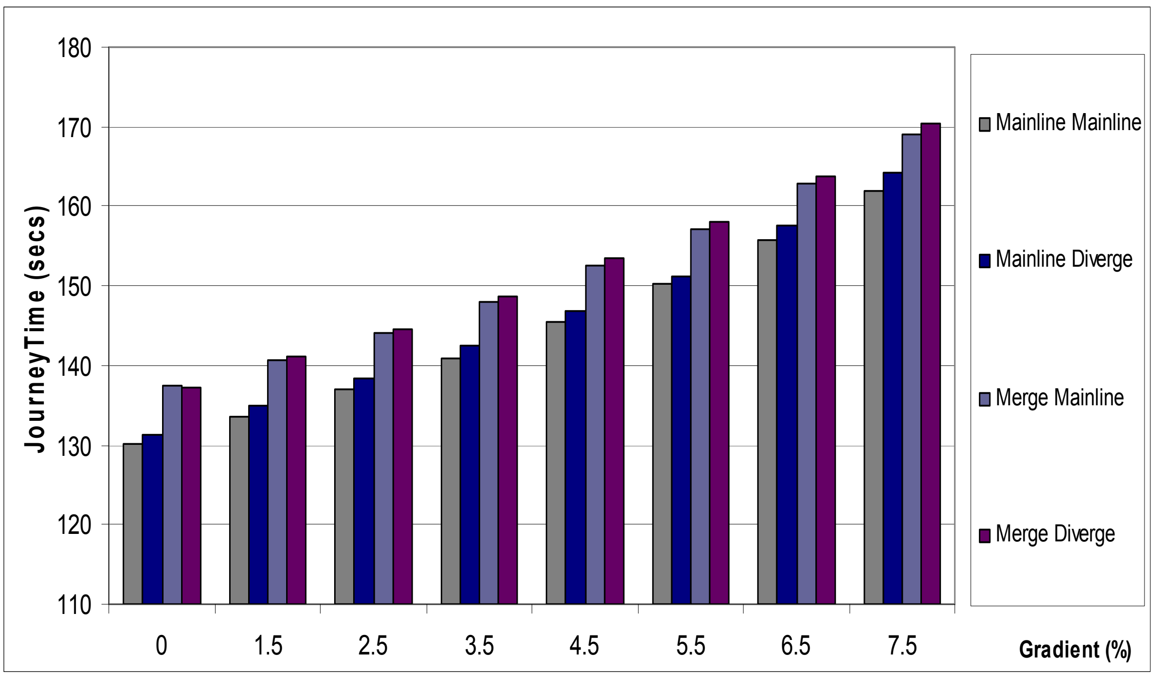


Figure 4.26 - M60 J16-J17 - Impact of changing the gradient on journey times

4.12 Gradient Summary

HGV journey times increased with gradient on all routes and Table 4.25 shows that the rate of growth for each percent of gradient increases for larger slopes.

4.13 Test 6: Changing the Maximum Reaction Time

A driver's maximum reaction time is expressed in SISTM in terms of epochs, i.e. the unit of the simulation time increment. The range available for the parameter varies from 1.0 epoch to 1.99 epochs and the parameter defaults to a value of 1.45 epochs. At a default epoch length of ten sixteenths of a second this is equivalent to a reaction time of approximately 0.91 seconds. Increasing the maximum reaction time beyond 1.2 epochs has very significant effects on journey times in congested conditions.

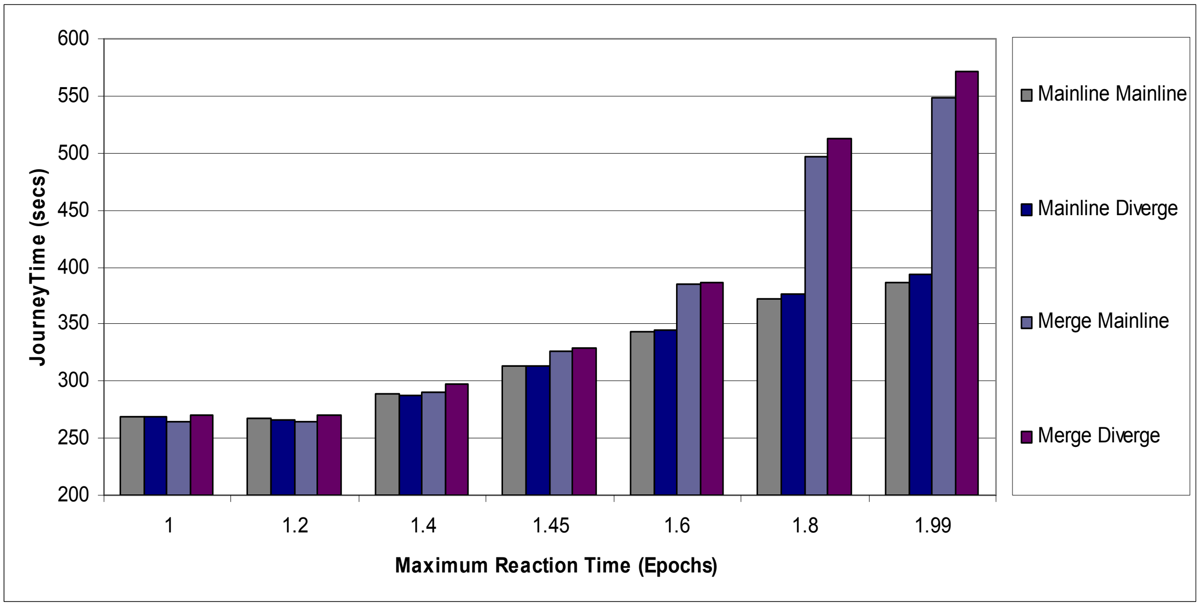


Figure 4.27: M62 J26-J27 - Impact of changing the maximum reaction time on journey times

	Maximum Reaction Time (P11) in epochs						
Route	**1**	**1.2**	**1.4**	**1.45 (default)**	**1.6**	**1.8**	**1.99**
Mainline Mainline	-14.1%	-14.5%	-7.6%	0.0%	9.4%	18.9%	23.3%
Mainline Diverge	-14.0%	-14.9%	-8.1%	0.0%	9.9%	20.1%	25.5%
Merge Mainline	-18.8%	-18.6%	-10.7%	0.0%	18.3%	52.7%	68.5%
Merge Diverge	-18.0%	-17.7%	-9.7%	0.0%	17.3%	55.9%	73.4%

Table 4.26 - M62 J26-J27 – Journey Time variation due to change in maximum reaction time

Time		**Maximum Reaction Time (epochs)**						
From	**To**	**1**	**1.2**	**1.4**	**1.45 (default)**	**1.6**	**1.8**	**1.99**
08:00:00	09:00:00	23954	18281	17796	18008	16883	15211	14077

Table 4.27 - M62 J26-J27 - Number of lane changes due to changing the maximum reaction

<u>M62 J26-J27 Impact of Changing the Maximum Reaction Time (P11) – Key Points:</u>

- Journey times increase significantly with increasing reaction times.
- Routes passing through the merge slip road are most strongly affected with journey times at a maximum reaction time of 2.0 epochs almost twice as long as at 1.0 epochs.
- Queues are building up on the merge slip road as drivers react too slowly to take advantage of gaps.
- High impact on lane changing behaviour: As the maximum reaction time is increased from 1.0 to 2.0 epochs the number of lane changes drops by over 40%.

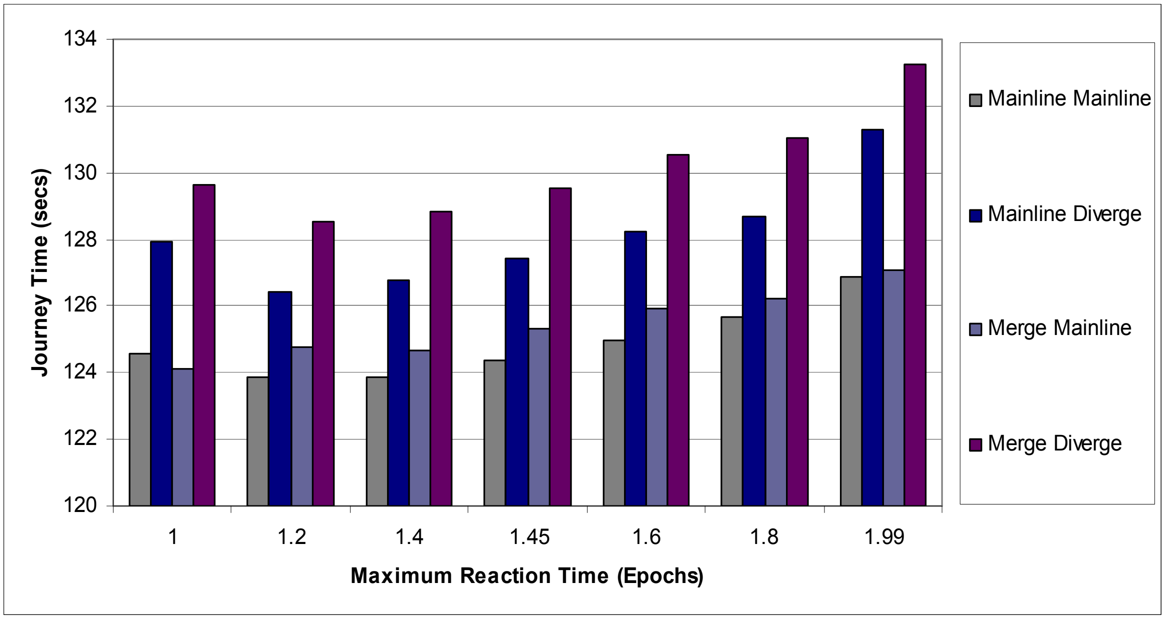


Figure 4.28 - M60 J16-J17 - Impact of changing the maximum reaction time on journey times

	Maximum reaction time (P11) in epochs						
Route	**1**	**1.2**	**1.4**	**1.45 (default)**	**1.6**	**1.8**	**1.99**
Mainline Mainline	0.2%	-0.4%	-0.4%	0.0%	0.5%	1.0%	2.0%
Mainline Diverge	0.4%	-0.8%	-0.5%	0.0%	0.7%	1.0%	3.1%
Merge Mainline	-0.9%	-0.4%	-0.5%	0.0%	0.5%	0.7%	1.4%
Merge Diverge	0.1%	-0.8%	-0.5%	0.0%	0.8%	1.2%	2.9%

Table 4.29: M60 J16-J17 - Journey Time variation due to change in maximum reaction time

Time		**Maximum Reaction Time (P11) in epochs**						
From	**To**	**1**	**1.2**	**1.4**	**1.45 (default)**	**1.6**	**1.8**	**1.99**
08:00:00	09:00:00	11618	9424	8969	9004	9130	9031	9735

Table 4.30 - M60 J16-J17 - Number of lane changes due to changing the maximum reaction

M60 - J16-J17 Impact of Changing the Maximum Reaction Time (P11) – Key Points:

- Journey times increase with increasing reaction time
- Variation of journey times with maximum reaction time remains below 5% for all routes

4.14 Reaction Time Summary

Journey times changes for the M60 J16-J17 network suggest that the impact of varying the parameter is limited in uncongested conditions. In a congested situation merging traffic was more strongly affected by an increase in the maximum reaction time. This is considered to be due to a reduction in merging drivers' ability to react to gaps in traffic on the main carriageway leading to a build up of queues on the slip road. The problem is further aggravated by fewer drivers on the main carriageway seizing the opportunity to change lanes to the right in order to make space for joining traffic. An increase in the maximum reaction time is accompanied by a sharp drop in lane changes when traffic is dense. Gaps are larger in lighter traffic, diluting the effects of longer reaction times. The strong impact of changes in the reaction time on resulting journey times for merging traffic suggests that it is not advisable to allow a change in the parameter value of more than 10%.

The critical factor with regard to reaction time is that it is intrinsically linked to the Epoch length and as such the selection of an appropriate range for the reaction time value is really dictated by the correct combination of Epoch length and reaction time. The table below shows some examples of Epoch length and reaction times that are considered acceptable. This is based on not allowinf the outturn reaction time in seconds to fall outside the range of 0.8 – 1.0 seconds with a central value of 0.91 seconds.

Epoch Length	Maximum Reaction Time (Y * Epoch length)						
	1.0	1.2	1.4	1.45	1.6	1.8	1.99
8/16	0.50	0.60	0.70	0.73	0.80	0.90	1.0
10/16	0.63	0.75	0.88	0.91	1.00	1.13	1.24
12/16	0.75	0.90	1.05	1.09	1.20	1.35	1.49
16/16	1.00	1.20	1.40	1.45	1.60	1.8	1.99

Note : Figures in table are in seconds, and figures highlighted in yellow are acceptable combinations

4.15 Test 7: Changing Drivers' Reaction to Seeing Brake Lights Ahead (P5)

SISTM allows the user to influence car following behaviour in the model by adjusting the drivers' reaction to seeing brake lights ahead (P5). This is defined in terms of the braking rate adopted on seeing brake lights on the vehicle ahead. The parameter range available is 0 to -99 km/h/s with a default value of -5.00. Changing P5 through the range available has a significant impact on journey times through both congested and relatively non-congested networks. Journey times increased as P5 is increased to -40.0 km/h/s. This is mainly caused by drivers' excessive reaction to vehicles seizing the gap in front of them, either when changing lanes or when joining the motorway at the merge. Excessive braking causes such disturbances to be diffused further upstream the carriageway.

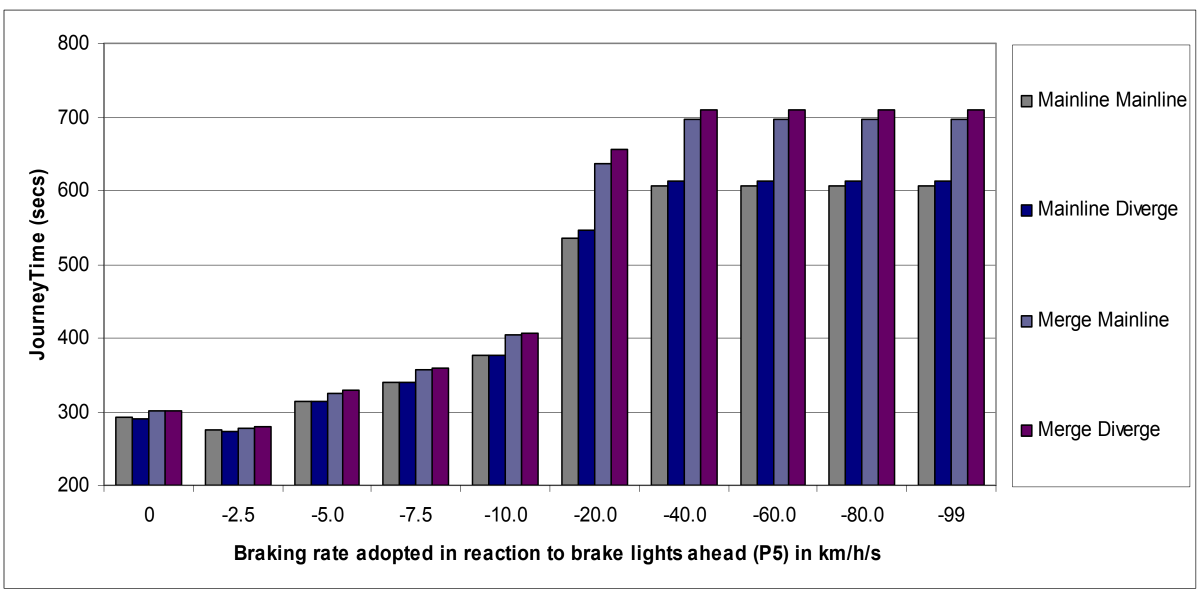


Figure 4.29 - M62 J26-J27 - Impact reaction to brake lights ahead (P5) on journey times

	Braking Rate Adopted in Reaction to Brake Lights Ahead (P5) in km/h/s									
Route	**0**	**-2.5**	**-5.0**	**-7.5**	**-10.0**	**-20.0**	**-40.0**	**-60.0**	**-80.0**	**-99.0**
Mainline Mainline	-6.5%	-12.0%	0.0%	8.3%	20.4%	70.7%	93.6%	93.6%	93.6%	93.6%
Mainline Diverge	-7.5%	-13.2%	0.0%	8.2%	20.3%	74.5%	95.4%	95.4%	95.4%	95.4%
Merge Mainline	-7.9%	-14.5%	0.0%	9.4%	24.0%	95.3%	113.7%	113.7%	113.7%	113.7%
Merge Diverge	-8.2%	-14.7%	0.0%	9.2%	23.2%	99.1%	115.7%	115.7%	115.7%	115.7%

Table 4.31 - M62 J26-J27 - Impact of P5 on journey times - Comparison with default set-up

M62 – J26-J27 Impact of Changing Drivers' Reaction to Seeing Brake Lights Ahead (P5) – Key Points:

- Steady growth of journey times on all routes as P5 is increased to -40km/h/s.
- Further increases in P5 have no impact on journey times.
- Merging traffic is more strongly affected due to:
    1. Queues from the diverge dissipating further upstream.
    2. A backlog of vehicles from the downstream merge point causing congestion in the outside lane near the upstream merge point.

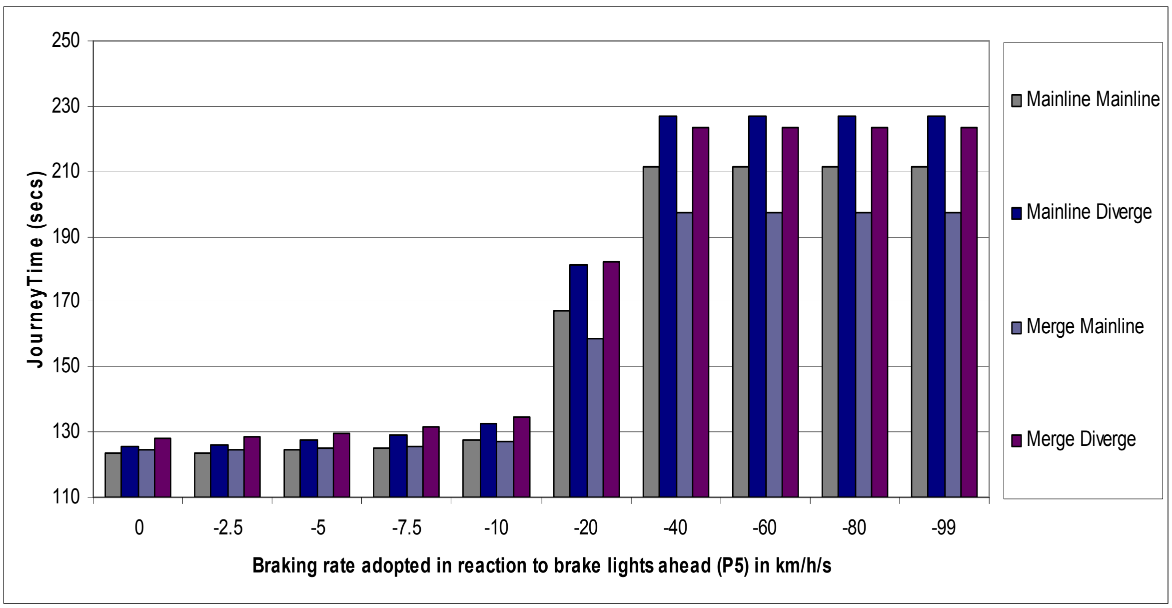


Figure 4.30 - M60 J16-J17 - Impact of reaction to brake lights ahead (P5) on journey times

	Braking Rate Adopted in Reaction to Brake Lights Ahead (P5) in km/h/s									
Route	**0.0**	**-2.5**	**-5.0**	**-7.5**	**-10.0**	**-20.0**	**-40.0**	**-60.0**	**-80.0**	**-99.0**
Mainline Mainline	-0.8%	-0.7%	0.0%	0.7%	2.4%	34.6%	70.0%	70.0%	70.0%	70.0%
Mainline Diverge	-1.3%	-1.1%	0.0%	1.4%	4.2%	42.2%	78.0%	78.0%	78.0%	78.0%
Merge Mainline	-0.5%	-0.5%	0.0%	0.2%	1.6%	26.8%	57.4%	57.4%	57.4%	57.4%
Merge Diverge	-1.1%	-0.8%	0.0%	1.5%	3.9%	40.6%	72.4%	72.4%	72.4%	72.4%

Table 4.32 - M60 J16-J17 - Impact P5 on journey times - Comparison with default set-up

M60 - J16-J17 Impact of Changing Drivers' Reaction to Seeing Brake Lights Ahead (P5) – Key Points:

- Below -10km/h/s journey time growth with increasing P5 is slow but consistent.
- Increasing P5 beyond -10km/h/s up to -40km/h/s produces a significant change in journey times.
- Further increase has no effect.

4.16 Reaction to Brake Lights Summary

Congestion at the merge was exacerbated by congestion of the nearside lane resulting from excessive braking in reaction to higher lane changing frequency in the area near the diverge. Under congested conditions this leads to queues on the merge slip road as merging traffic is unable to join the main carriageway. In the M62 J26-J27 network the situation was made worse by the merge geometry. A backlog of traffic over-reacting to the downstream merge point presented an obstacle to traffic emerging from the upstream merge point.

A further increase in the parameter beyond -40 km/h/s had no impact on the networks tested.

Test results suggest that the braking rate adopted in reaction to seeing brake lights ahead should not be allowed to vary beyond a narrow bracket around the default value of -5.0 km/h/s unless absolutely necessary. If the parameter is allowed to vary significantly a test should be run with the default value in order to ensure that the resulting simulation results are not unreasonable.

4.17 Test 8: Changing Drivers' Perceivable Acceleration (P8)

The drivers' perceivable acceleration (P8) influences drivers' reactions to situations, which require them to change speed. When the acceleration or deceleration necessary in order to adjust a vehicle's speed to the desired value is less than P8 the driver retains his original speed. The range available is 0 – 99 km/h/s although the parameter defaults to 5 km/h/s.

P8 is crucial in controlling the "smoothness" of traffic flow. Increasing P8 from 0 to 10 km/h/s leads to a slight decrease in journey times as drivers are less likely to react to small local speed variations, thus minimising disruption caused by vehicles changing lanes or joining the motorway as well as natural variations in the desired speed profile. At higher parameter values drivers change lanes later when they approach slow vehicles resulting in the formation of clusters of slow moving vehicles.

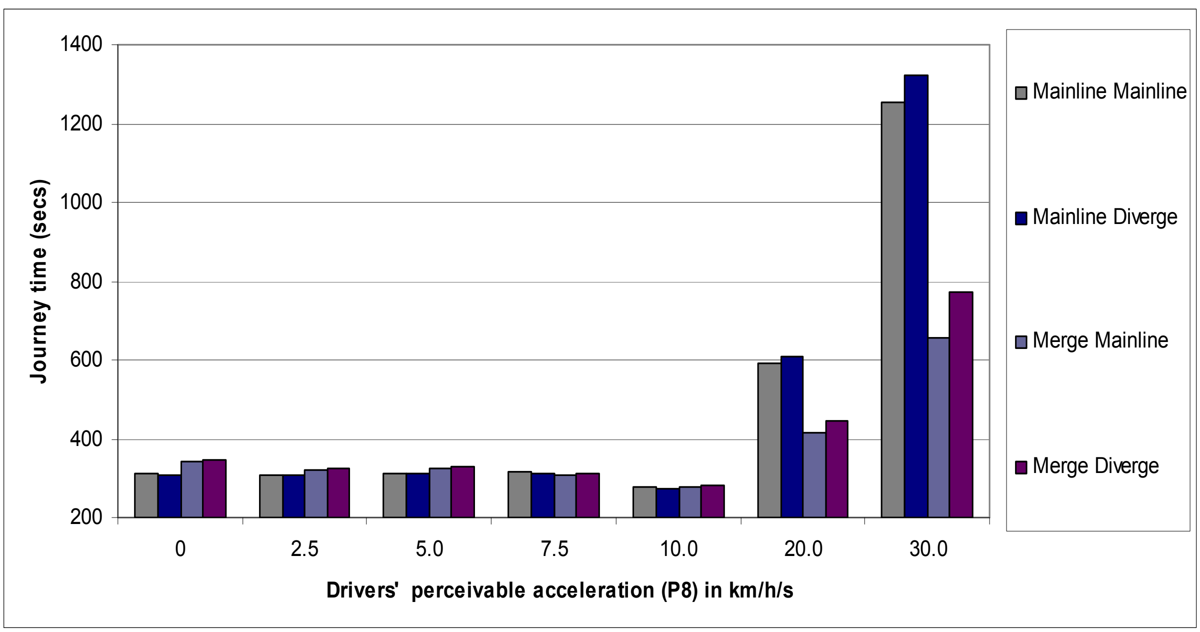


Figure 4.31 - M62 J26-J27 – Journey Time variation due to change in perceivable acceleration (P8)

	Driver's perceivable acceleration (P8) in km/h/s						
Route	**0**	**2.5**	**5.0**	**7.5**	**10.0**	**20.0**	**30.0**
Mainline Mainline	-0.5%	-1.5%	0.0%	0.4%	-11.8%	88.7%	299.9%
Mainline Diverge	-2.1%	-2.1%	0.0%	0.1%	-12.5%	93.6%	321.6%
Merge Mainline	5.1%	-1.0%	0.0%	-5.4%	-15.1%	28.1%	101.6%
Merge Diverge	5.5%	-1.0%	0.0%	-5.9%	-14.9%	35.8%	135.0%

Table 4.33: M62 J26-J27 - Impact of P8 on journey times - Comparison with default set-up

Time		Driver's perceivable acceleration (P8) in km/h/s						
From	**To**	**0**	**2.5**	**5.0**	**7.5**	**10.0**	**20.0**	**30.0**
08:00:00	09:00:00	17562	17865	18008	17481	17127	27378	23010

Table 4.34: M62 J26-J27 - Impact of changing P8 on the number of lane changes

M62 J26-J27 Impact of Changing the Drivers' Perceivable Acceleration (P8) – Key Points

- Increasing P8 from 0 to10.0 km/h/s results in a slight decline in journey times for merging traffic, the number of lane changes fluctuates.
- As P8 is changed from 10.0 to 30.0 km/h/s journey times increase, however results at P8 = 30 km/h/s may not be reliable as SISTM shows signs of break down at this parameter value.
- The lane changing frequency leaps from approximately 17,000 lane changes to a figure in excess of 27,000 as P8 is increased from 10.0 to 20.0 km/h/s.
- Merging traffic is most affected by slowing journey times in a high parameter value regime as congestion mounts in the nearside lane and larger difference between the actual and desired speeds are necessary in order to stimulate vehicles to change lanes.

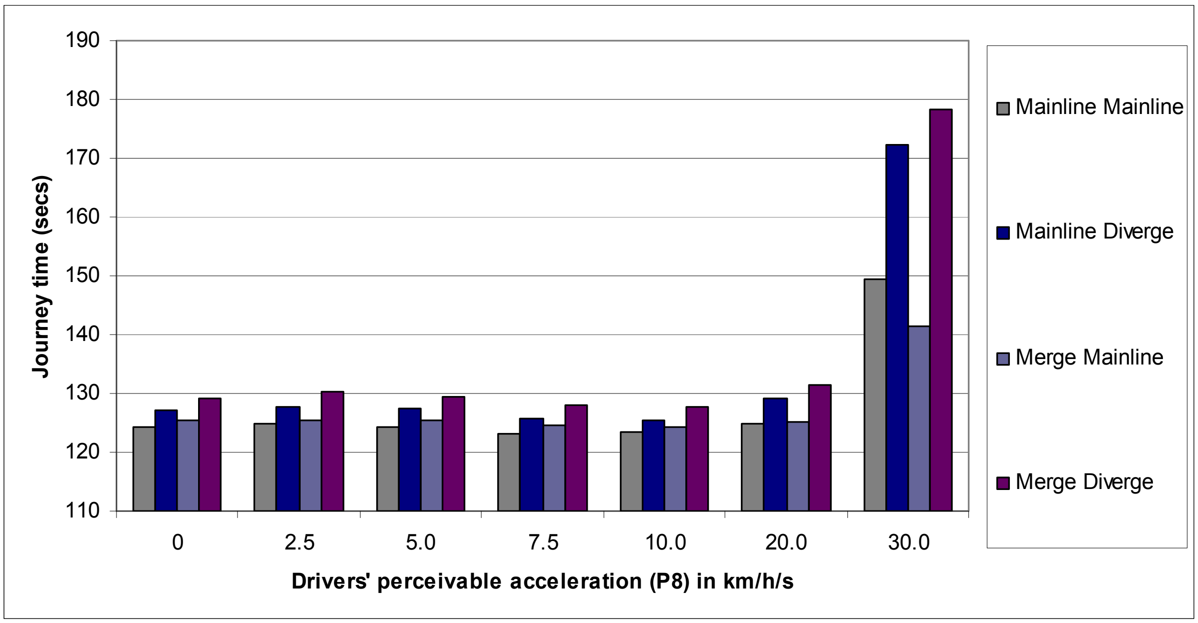


Figure 32 - M60 J16-J17 - Impact of changing drivers' perceivable acceleration (P8) on journey times

	Driver's perceivable acceleration (P8) in km/h/s						
Route	**0**	**2.5**	**5.0**	**7.5**	**10.0**	**20.0**	**30.0**
Mainline Mainline	-0.1%	0.3%	0.0%	-0.9%	-0.8%	0.4%	20.1%
Mainline Diverge	-0.3%	0.2%	0.0%	-1.4%	-1.5%	1.3%	35.2%
Merge Mainline	0.0%	0.1%	0.0%	-0.5%	-0.7%	-0.1%	12.8%
Merge Diverge	-0.3%	0.5%	0.0%	-1.1%	-1.4%	1.4%	37.5%

Table 35 - M60 J16-J17 - Impact of P8 on journey times - Comparison with default set-up

Time		**Driver's perceivable acceleration (P8) in km/h/s**						
From	**To**	**0**	**2.5**	**5.0**	**7.5**	**10.0**	**20.0**	**30.0**
08:00:00	09:00:00	8711	9086	9004	8195	8138	10226	15862

Table 4.36 - M60 J16-J17 - Impact of changing P8 on the number of lane changes

4.18 Drivers Perceivable Acceleration M60 J16 – J17 Summary

- Increasing P8 from 0 to 10.0 km/h/s leads to a slight decline in journey times for merging traffic, the number of lane changes fluctuates.
- When P8 is changed to 30.0 km/h/s journey times increase, however, results may not be reliable as SISTM shows signs of break down at this parameter value.
- The lane changing frequency approximately doubles as P8 is increased from 10.0 to 30.0.

- Merging traffic is less affected by increases in the journey time as the simple geometry of the merge together with a low traffic density minimise disruption.

4.19 Drivers Perceivable Acceleration Summary

The adverse effect of increasing P8 on journey times is more pronounced in dense traffic where vehicle interactions abound. In this case, the reduced sensitivity of drivers' response to deviations from their desired speed as P8 is increased, results in queues forming in the nearside lane. In particular, in areas near a merge, or diverge slip road, where drivers are required to slow down in order to give way to merging vehicles or vehicles that change lanes in order to diverge. Increasing congestion in the nearside lane as P8 is increased above 10.0 km/h/s led to an increase in the number of lane changes in the networks tested as drivers moved to a faster lane in order to avoid queues. Speed in the offside and offside-1 is adversely affected at high values for P8 as the speed of slower vehicles dropped to a lower value before drivers develop the desire to choose a slower lane.

When the parameter is increased above 30 km/h/s the program breaks down.

4.20 Test 9: Testing the Sensitivity of Journey Times to Changes in the Initial Random Seed for Different Values of the Reaction to Seeing Brake Lights Ahead (P5)

The sensitivity of simulation results for different values of P5 to variations in the initial random seed has been tested. A network modelling the stretch of the M62 between J26 and J27 has been chosen. Demand across the network is near saturation and there is a high incidence of weaving. This choice has been made in order to maximise the effects of changes in the initial random seed value on journey times. Journey times are plotted for the different routes through the network in Figure 4.33 to Figure 4.36. Figures 4.37 to 4.40 give plots of the mean and standard deviations for the journey time distributions for different values of P5.

Percentage changes in journey time when compared with the average are detailed in Tables 4.37 to 4.40. Averages have been evaluated based on the series of eleven random seeds tested for each value of P5. Cells marked red indicate where the deviation of journey times from the mean exceeds 5%.

The impact of changing the random seed value was significantly smaller in magnitude than the impact of changes in the reaction to brake lights ahead (P5). However, varying the random seed value does have a sizeable impact on journey times with a deviation from the mean as high as 11% recorded for some values of P5. Variations are noticeably larger for smaller values of P5, as an increased incidence of very slow moving queues when P5 is large masks some of the effects of variations in the distribution of driver characteristics.

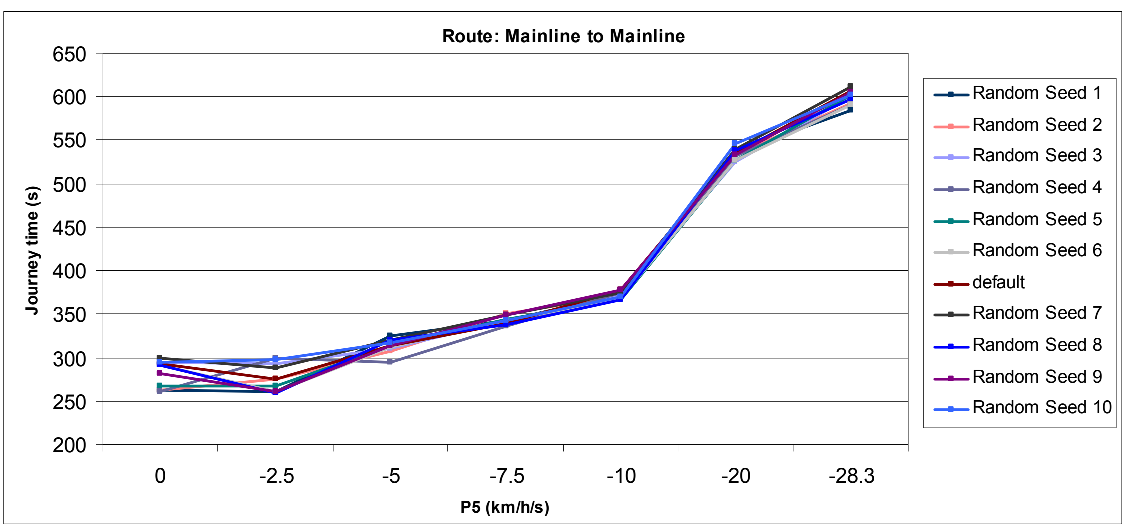


Figure 4.33 - Variation of journey times with random seed for different values of P5 -

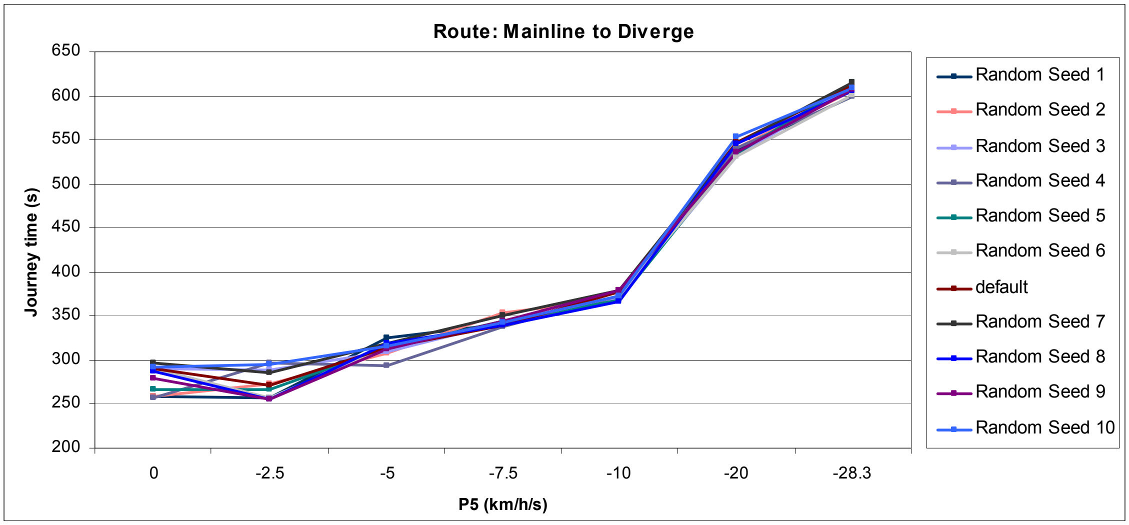


Figure 4.34 - Variation of journey times with random seed for different values of P5

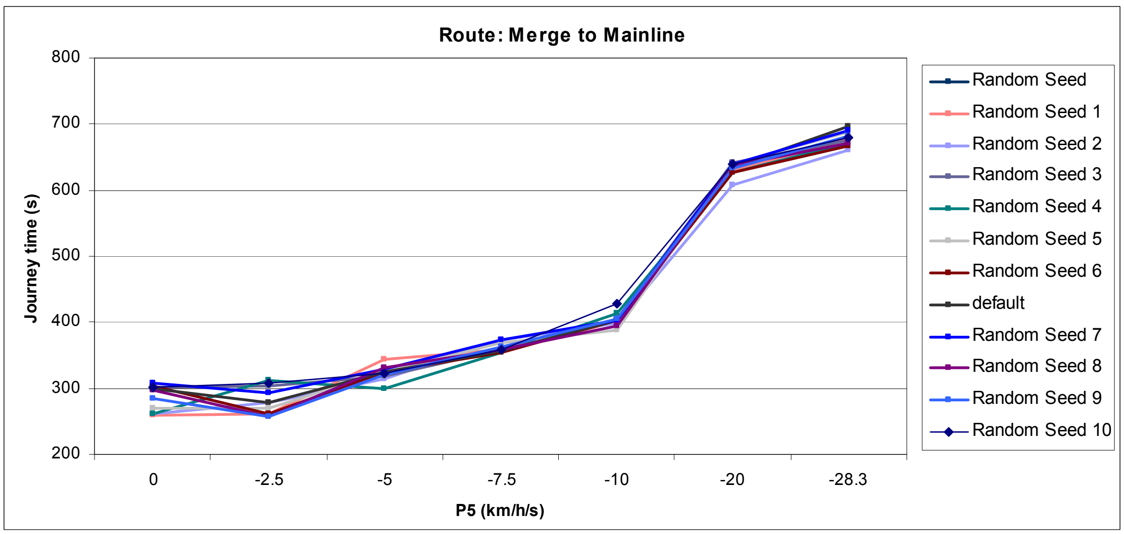


Figure 4.35 - Variation of journey times with random seed for different values of P5

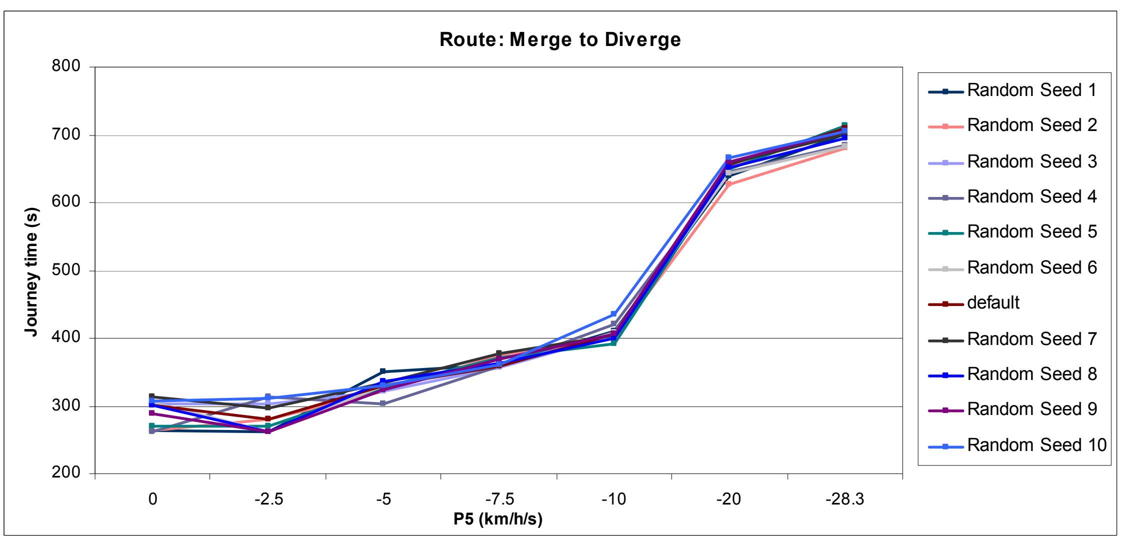


Figure 4.36 - Variation of journey times with random seed for different values of P5

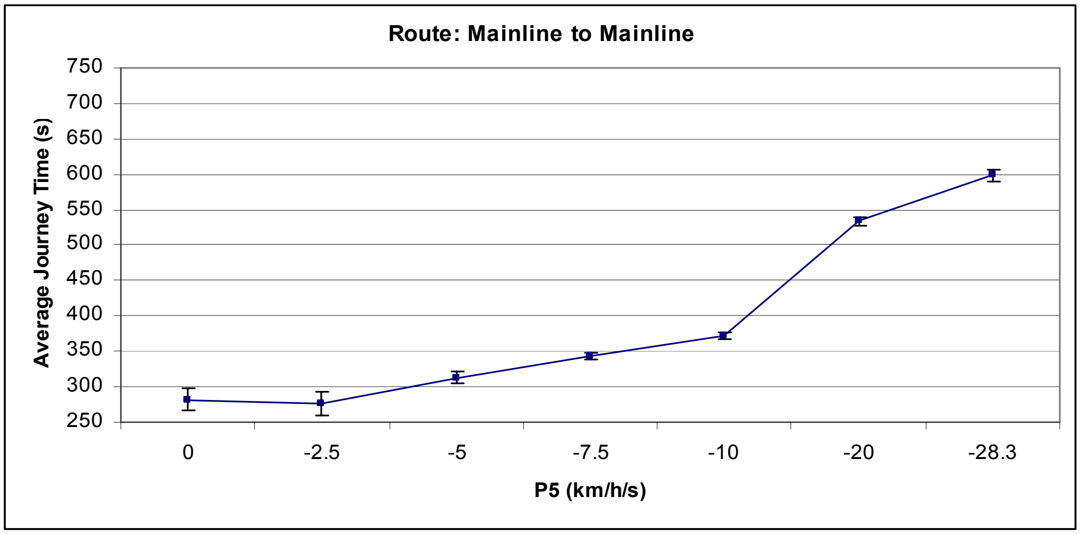


Figure 4.37 - Mean and standard deviation of journey time distribution for different values of P5

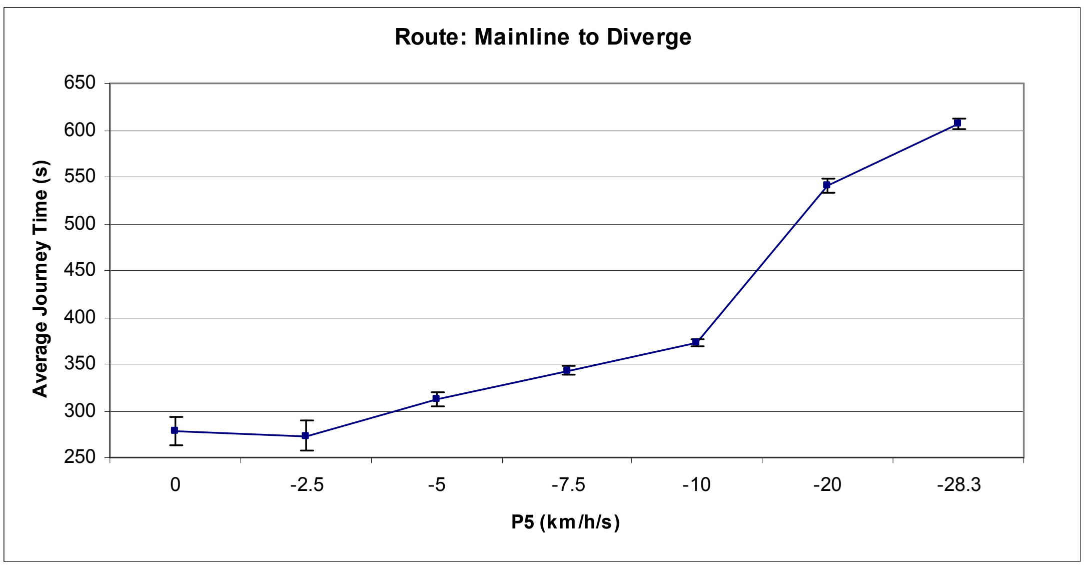


Figure 4.38 - Mean and standard deviation of journey time distribution for different values of P5

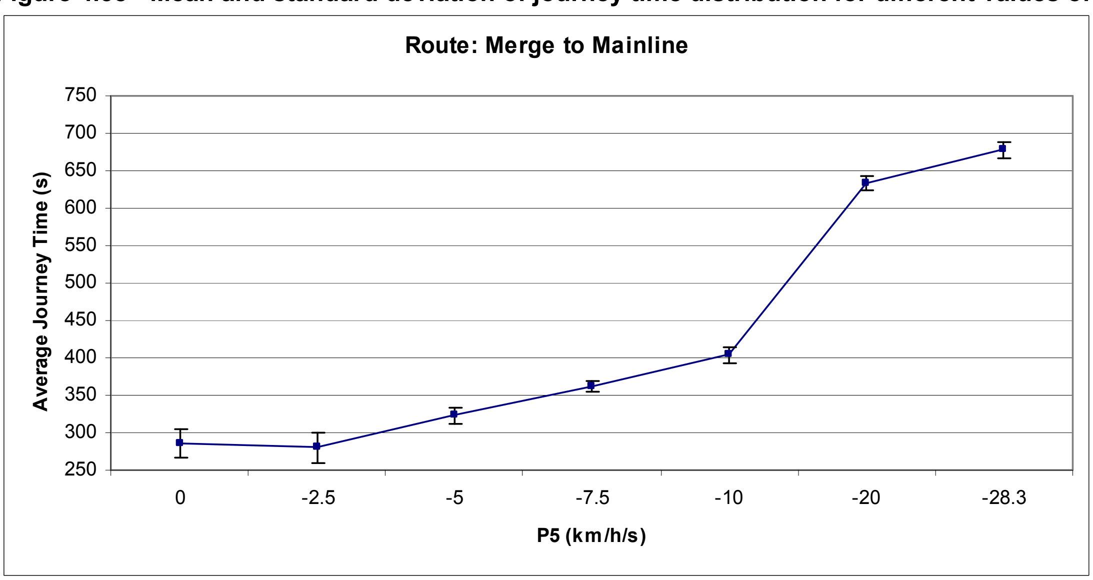


Figure 4.39 - Mean and standard deviation of journey time distributions for different values of P5

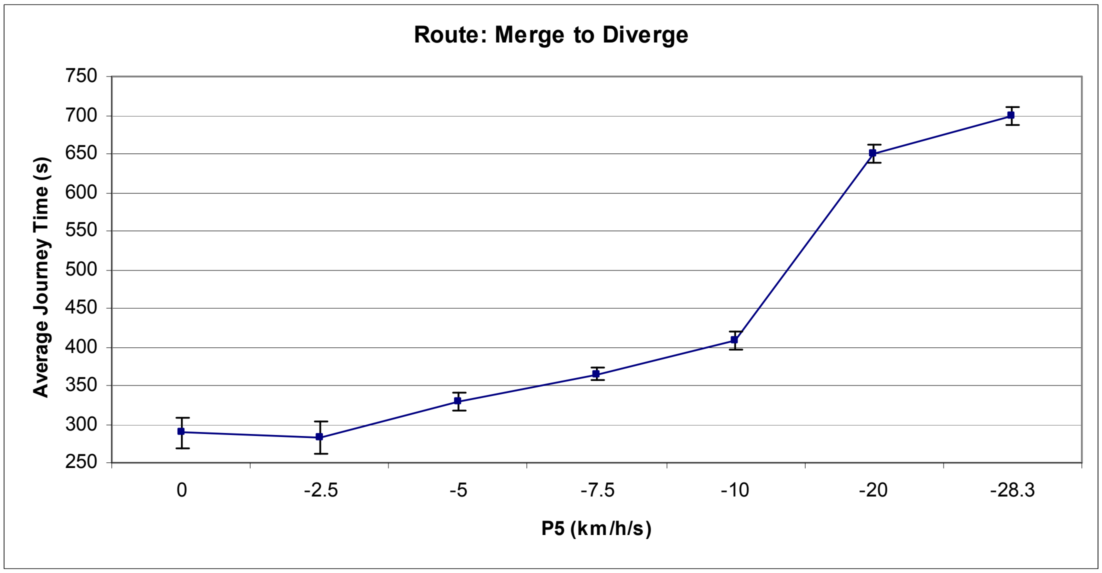


Figure 4.40 - Mean and standard deviation of journey time distribution for different values of P5

	Drivers reaction to seeing brake lights ahead (km/h/s)						
Random Seed	**0**	**-2.5**	**-5**	**-7.5**	**-10**	**-20**	**-28.3**
Random Seed 1	-6.9%	-5.4%	3.9%	-0.1%	0.3%	0.5%	-2.3%
Random Seed 2	-6.8%	-0.3%	-1.9%	2.3%	-0.1%	-0.2%	-1.1%
Random Seed 3	4.6%	6.0%	-0.9%	-0.4%	-0.2%	-1.6%	0.4%
Random Seed 4	-7.2%	8.5%	-6.1%	-1.9%	0.6%	-0.5%	-1.2%
Random Seed 5	-5.1%	-3.1%	-0.1%	0.1%	-1.5%	-1.2%	0.7%
Random Seed 6	3.6%	-5.7%	-0.3%	-0.2%	-1.0%	-1.4%	-1.2%
Default	4.1%	-0.3%	0.0%	-1.2%	1.4%	0.2%	1.4%
Random Seed 7	6.2%	4.1%	2.0%	1.5%	0.6%	1.1%	2.1%
Random Seed 8	3.3%	-6.1%	2.3%	-1.6%	-1.3%	0.8%	-0.3%
Random Seed 9	-0.1%	-5.7%	0.1%	1.5%	1.7%	-0.1%	1.1%
Random Seed 10	4.5%	7.9%	1.0%	0.0%	-0.4%	2.3%	0.5%

Table 4.37 - Percentage change in journey times as compared with average – Route: Mainline to Mainline

	Drivers reaction to seeing brake lights ahead (km/h/s)						
Random Seed	0	-2.5	-5	-7.5	-10	-20	-28.3
Random Seed 1	-7.4%	-5.7%	3.8%	-0.6%	-0.4%	-0.2%	-1.4%
Random Seed 2	-6.9%	0.1%	-1.7%	2.9%	-0.7%	0.1%	-0.3%
Random Seed 3	4.5%	6.0%	-1.2%	-0.4%	-0.3%	-1.6%	0.8%
Random Seed 4	-8.0%	8.7%	-6.0%	-1.5%	-0.1%	0.1%	-1.3%
Random Seed 5	-4.5%	-2.7%	0.2%	0.1%	-1.2%	-1.1%	1.2%
Random Seed 6	4.0%	-5.9%	0.3%	-0.3%	-0.2%	-1.8%	-1.1%
Default	4.1%	-0.4%	0.2%	-1.2%	1.2%	1.2%	0.8%
Random Seed 7	6.4%	4.6%	2.0%	2.0%	1.6%	0.8%	1.2%
Random Seed 8	3.2%	-6.2%	1.9%	-1.1%	-1.5%	0.8%	-0.3%
Random Seed 9	0.0%	-6.4%	-0.2%	0.3%	1.8%	-0.7%	0.0%
Random Seed 10	4.7%	7.8%	0.7%	-0.3%	0.0%	2.5%	0.3%

Table 4.38 - Percentage change in journey times as compared with average - Route: Mainline to Diverge

	Drivers reaction to seeing brake lights ahead (km/h/s)						
Random Seed	0	-2.5	-5	-7.5	-10	-20	-28.3
Random Seed 1	-9.1%	-7.1%	6.4%	-0.9%	-0.6%	-0.6%	-0.1%
Random Seed 2	-8.4%	-0.8%	-2.7%	3.1%	-1.2%	-3.8%	-2.5%
Random Seed 3	5.2%	8.1%	-1.3%	-1.1%	0.3%	1.5%	-0.4%
Random Seed 4	-8.9%	11.2%	-7.5%	-2.1%	2.4%	-0.8%	-1.0%
Random Seed 5	-5.9%	-3.3%	0.2%	2.0%	-4.0%	1.2%	1.4%
Random Seed 6	6.3%	-7.0%	0.8%	-1.9%	-0.4%	-0.9%	-1.7%
Default	4.9%	-0.5%	0.8%	-1.4%	-0.1%	0.6%	2.7%
Random Seed 7	7.5%	5.0%	2.0%	3.2%	-0.3%	1.2%	1.7%
Random Seed 8	3.8%	-7.8%	2.7%	-0.5%	-2.2%	0.6%	-1.0%
Random Seed 9	-0.8%	-7.9%	-1.0%	0.5%	0.0%	0.0%	0.6%
Random Seed 10	5.4%	10.3%	-0.2%	-1.1%	6.2%	1.1%	0.3%

Table 4.39 - Percentage change in journey times as compared with average - Route: Merge to Mainline

	Drivers reaction to seeing brake lights ahead (km/h/s)						
Random Seed	0	-2.5	-5	-7.5	-10	-20	-28.3
Random Seed 1	-8.9%	-7.0%	6.6%	-1.0%	0.7%	-1.8%	0.4%
Random Seed 2	-8.6%	-1.0%	-2.1%	3.1%	-2.1%	-3.7%	-2.5%
Random Seed 3	5.1%	7.1%	-2.0%	-2.5%	-0.7%	1.3%	0.8%
Random Seed 4	-9.4%	11.3%	-7.4%	-1.4%	3.2%	-0.7%	-2.1%
Random Seed 5	-6.2%	-4.0%	0.1%	1.7%	-3.9%	-0.1%	2.1%
Random Seed 6	5.9%	-7.2%	0.8%	-1.9%	-0.1%	-1.1%	-2.2%
Default	4.5%	-0.6%	0.3%	-1.5%	-0.6%	0.8%	1.6%
Random Seed 7	8.2%	5.5%	2.0%	3.6%	-0.8%	1.2%	0.5%
Random Seed 8	3.9%	-7.3%	2.6%	-0.3%	-1.7%	0.2%	-0.5%
Random Seed 9	-0.3%	-7.4%	-1.3%	1.3%	-0.4%	1.5%	0.9%
Random Seed 10	6.0%	10.6%	0.3%	-1.1%	6.5%	2.4%	1.1%

Table 4.40 - Percentage change in journey times as compared with average - Route: Merge to Diverge

<u>M62 – J26-J27 Sensitivity of Results for Different Values of the Reaction to Seeing Brake Lights Ahead (P5) to Changes in the Initial Random Seed Value – Key Points:</u>

- Changes due to different random seed values are small in comparison with variations due to changes in P5.
- Changes in the initial random seed result in journey time variations of up to 11% when compared with average journey times.
- Journey times on merging routes are more responsive to changes in the random seed value.
- Simulation set-ups with small values of P5 are more responsive to changes in the random seed value.
- The default setting of P5 = -5.0 km/h/s results in a maximum deviation of 7.5% when compared with average journey times on the network tested.

4.21 Random Seed Value and Reaction to Brake Lights ahead – Summary

Varying the random seed value at any one value for P5, results in oscillation of the simulation results around the mean for the P5 value. However, the magnitude of this oscillation is small in comparison with the impact of changing the value of P5.

5 VISSIM

VISSIM – Summary of Findings

Outlined below are the findings from the model testing that was undertaken with VISSIM software on a variety of networks which are described in detail in the main report. The version of the software that was used during the course of this work was VISSIM V4.10-12. Models of the following sections of motorway were used for testing purposes;

- M62 between Junctions 26 and 27 – congested network with merge, diverge and weaving;
- M60 J16-J17 – relatively free flow with gradients and;
- M60 J18 – congested signalised junction.

These networks contain different conditions experienced on the Highways Agency's network, providing a wide ranging 'test bed' on which to investigate the sensitivity of the software.

The parameters tested were identified by the software developers as being important to the performance of the model.

- **Number of Observed Vehicles Summary**

  - The results suggest that in uncongested conditions the main effects occur at the lower end of the range tested.
  - In controlled situations eg traffic signals, there is little impact in changing the parameter.
  - Journey time results often indicated erratic changes when altering the observed vehicle parameter. This is probably due to the traffic volumes and complex merging behaviour which takes place in many of the models.
  - Results suggest a general trend towards increased journey time with respect to number of observed vehicles in congested networks. However, as the parameter is increased the ability for merging traffic flows to penetrate the main flow is enhanced.
  - Vehicle counts remained relatively constant with only marginal variation.
  - Overall it seems that the effect of varying the number of observed vehicles parameter is amplified by the level of congestion i.e. vehicle interaction.

The results suggest that a value of 1 should not be used and that the default value (2) provides reasonable results in each situation. While at the higher end the results appear to stabilise however, this should be taken in the context of the number of vehicles passing through the merge areas. It may be the case that at the higher end of the range vehicles are extremely cautious and this results in increased queuing prior to the merge areas.

It should be noted, however, that for technical reasons (some fixed network elements are considered as 'vehicles' internally by the software) there will be cases where the No. of Observed Vehicles on a particular link is increased in order to improve vehicle behaviour at junctions.

- **Seed Value Summary**

  - The results have shown that changing the Random Seed can produce major variations in journey times for specific movements through congested junctions although, taking account of the global figure, the variation was around +/-6% of the mean although maximum vehicle count variation did not exceed 4%;
  - In congested networks the Random Seed values can produce rogue results which are out of sync with the general pattern of output values generated by other seed values.

The Table below summarises the variation that occurred in journey times and traffic throughput over the ten random seed runs in each model. The variations are expressed as the standard deviation as a percentage of the average journey time or flow.

Model	Standard Deviation as % of Average	
	Journey Time	Flow Throughput
M62 J26 – J27	2.1	1.4
M60 J16 – J17	9.7	0.4
M60 J18	3.6	0.3

Summary of Random Seed Variation

In all cases the model throughput is relatively stable. However, there can be significant variation in journey times depending on the extent of congestion in the network and the physical nature of the network.

- **Gradient Model Summary**

  - The salient point of note is that increasing the gradient can make significant increases to travel time for HGVs, which in turn reduces the vehicle count.
  - Care should be taken to ensure that the power and weight distributions for HGVs will not result in low powered heavy HGVs.
  - A gradient of 6 can significantly reduce vehicle speeds impacting upon journey times and consequently vehicle counts.

- **Parameter CC1 Model Results Summary**

  - In general increasing CC1 has the effect of increasing the journey time and reducing the number of vehicles able to complete their route.

As the capacity of the motorway is heavily dictated by the value of CC1 selected there would need to be a strong case for adopting values of CC1 that differed more than +/-10% from the default value of 0.9 seconds.

- **Parameter CC2 Model Summary**

  - Vehicle counts all drop with the increase in CC2.
  - Similarly to CC1, the additional distance being created between vehicles increases the queue length.
  - When viewing the error file, it indicates that as CC2 increases there is also a gradual increase in unreleased vehicles.
  - As stated in the PTV VISSIM manual, CC2 values outwith the default value of 4 can cause unstable vehicle activity especially under free flow situations.
  - The congested model indicates journey times are greater when using the default value of 4.
  - Looking at all graphs involved there seems to be a pattern occurring where CC2 values at the higher end of the range presents results which can become very unstable.

- **Parameter CC3 Model Summary**

  - Vehicle counts all drop as CC3 increases
  - The reduction in traffic is a result of traffic flows breaking down due to quick deceleration due to average distances between vehicles reducing
  - Reducing CC3 causes journey times to increase
  - As stated previously the break down in traffic flow has had a detrimental effect on the journey times which have increased.

- **Lane change Variation – Journey times**

The results suggest that in this particular network, for maximum flow and minimum journey times, the Lane Change distance should be around 200m – 500m. However, these results were not representative of the observed conditions as shown from the Base data points in the graphs.

This emphasises the need for the modeller to be aware of the existing traffic conditions and ensure that the model fairly presents the observed data.

VISSIM

5.1 Introduction

Outlined below are the findings from the model testing that was undertaken with VISSIM software on a variety of networks which are described in detail in the main report. The version of the software that was used during the course of this work was VISSIM 4.10-12. Models of the following sections of motorway were used for testing purposes;

- M62 between Junctions 26 and 27 – congested network with merge, diverge and weaving;
- M60 J16-J17 – relatively free flow with gradients and;
- M60 J18 – congested signalised junction.

These networks contain different conditions experienced on the Highways Agency's network, providing a wide ranging 'test bed' on which to investigate the sensitivity of the software.

The parameters tested were identified by the software developers as being important to the performance of the model and are as follows:

- CC1 – headway time which is the time (in seconds) that a driver wishes to keep from the vehicle in front. The higher this value the more cautious the driver. Default = 0.9s
- CC2 – car following variation (in metres) which may be added to the desired safety distance before a vehicle intentionally moves closer to the vehicle in front. Default = 4m
- CC3 – time (in seconds) accepted before reaching the safety distance for vehicle to begin to decelerate; Default = -8s

as well as

- Random Seed Value – influences vehicle release profiles and characteristics which have a range of values eg acceleration, speed.
- Road Gradient; and
- Number of Observed Vehicles - .

In order to appropriately appraise and assess the sensitivity of the VISSIM micro simulation model to the highlighted parameters, previously calibrated networks (reflecting different conditions and exhibiting many of the characteristics experienced on a motorway) were run and results taken. The key focal point of the study was to evaluate the effect of varying the parameters on the model outputs, ultimately providing information on the use of VISSIM for HA personnel.

Note that despite the original networks varying link type default values for the different parameters, e.g. CC1 they were all standardised and changed to the analysed value e.g. 3 to create a homogenous network.

5.2 Model Background

The traffic flow model of VISSIM is a discrete, stochastic, time step based microscopic model, with driver-vehicle-units as single entities. VISSIM contains a psycho-physical car following model for longitudinal movements with the Wiedemann 99 algorithm being applied for motorway traffic.

The model considers parameter thresholds such as driver reaction time, risk, safety requirements together with headway and relative speed in relation to the vehicle in front defining perception limits. When the thresholds are exceeded, this results in a changed state for the driver and transition in his/her behaviour. Therefore, as car following and lane change models directly affect the vehicle interaction changing the parameters should cause differences in simulation results.

The following section provides background and explanations orientated around the models analysed, together with the car following parameters investigated.

5.3 Parameters Investigated

It should be noted that for most of these parameters, while absolute values are inserted by the User, the values given in the driver behaviour definition are multiplied with random values for the individual drivers (normal distributed). Also, the CC-parameters describe the position of action thresholds, i.e. the driver reacts when he crosses the threshold in the dv-dx-plane. This means, the value is not taken exactly but also depends on the dynamic driving situation.

5.3.1 Number of Observed Vehicles

The number of 'observed vehicles' affects how well vehicles in the network can predict other vehicle movements and react accordingly. Hence, increasing the number of observed vehicles "should" give each driver greater knowledge of the traffic ahead.

Therefore, it could be hypothesised that as the number of observed vehicles increases, the more cautious the driver becomes and consequently journey time would correspondingly increase. Furthermore, the effect of increasing the number of observed vehicles would probably be amplified on a congested network.

PTV advise that, as a basic modelling technique, this value should be increased for links where there are several network elements within a short distance.

5.3.2 Seed Value

The seed value parameter initialises the random number generator. The software uses the Random Seed on a variety of parameters where ranges apply eg Speed distribution, acceleration / deceleration. Adopting a different random seed will change the profile of the traffic arriving (stochastic variation of input flow arrival times) and therefore results are expected to change. However, in order to minimise the traffic input variation when multiple runs with different Seeds are used, the option – Generate the exact number of vehicles – should be used.

However, where simulation runs with identical input files and random seeds are used, VISSIM will generate identical results.

5.3.3 Gradient

The links and connectors have a gradient parameter that can be altered and as such an increase in slope of a road should slow vehicles especially HGV's. The result being that journey times were expected to increase.

5.3.4 CC1 Headway

CC1 indicates the time distance a driver wishes to keep from the vehicle in front. It is one of the parameters included in the calculation which makes up the 'Safe Distance' that vehicles adopt when following another vehicle.

Safe Distance = CC0 + CC1*v

CC0 = Standstill distance between vehicles (default 1.5m)
V = Speed (m/s)

5.3.5 CC2 Following Variation (Metres)

CC2 is the distance in which a vehicle will add to the safety distance before he/she intentionally moves closer to the vehicle in front.

Note: PTV recommends a default value of 4 metres which results in a stable following process.

Therefore, as CC2 increases it would be presumed that it would have the direct impact of increasing journey time as headways between vehicles increase reducing the density of vehicles along a network, especially on a congested route. It should be noted that the software manipulates this value to produce an acceptable range for each vehicle.

5.3.6 CC3 Threshold for entering 'Following'

CC3 defines how many seconds before reaching the safety distance the driver starts decelerating.

Hence, it could be expected that as the CC3 parameter is increased then the journey time would increase, as vehicles take longer to slow towards the safe distance threshold. However, PTV advise that flow becomes unstable at low values of CC3.

5.3.7 Seed Variation

Following on from the tests to assess the impact of changing parameter values a further test was undertaken to assess the impact of changes to the Random Seed as well as the change in a parameter. For the purposes of this test the change in Random Seed was applied to changes in the CC2 parameter using the M1 J42 network model.

5.3.8 Lane Change Distance

Finally, the performance of a network was assessed based on changes to the Lane Change distance which is associated with Connectors, with particular reference to the operation of a diverge. In this case the M62 J26-J27 network was used.

5.4 Models Investigated

Outlined below are descriptions of the networks which have been modelled together with the parameter values which were used in order to develop the 'Base' validated models. It can be seen from the Tables that in some cases, where different link types were used, different values were used for the same parameter. For the purposes of the tests the parameter in question was altered from the 'Base' value to the test value resulting in all Link Types having the same value for each parameter. The values from the 'Base' are provided for comparison purposes.

5.4.1 M62 J26-J27 Weaving Section Model

The first model to be examined was the M62 J26-J27 weaving section model. This section of the motorway network regularly experiences congestion problems due to the volume of traffic and the weaving between the junctions.

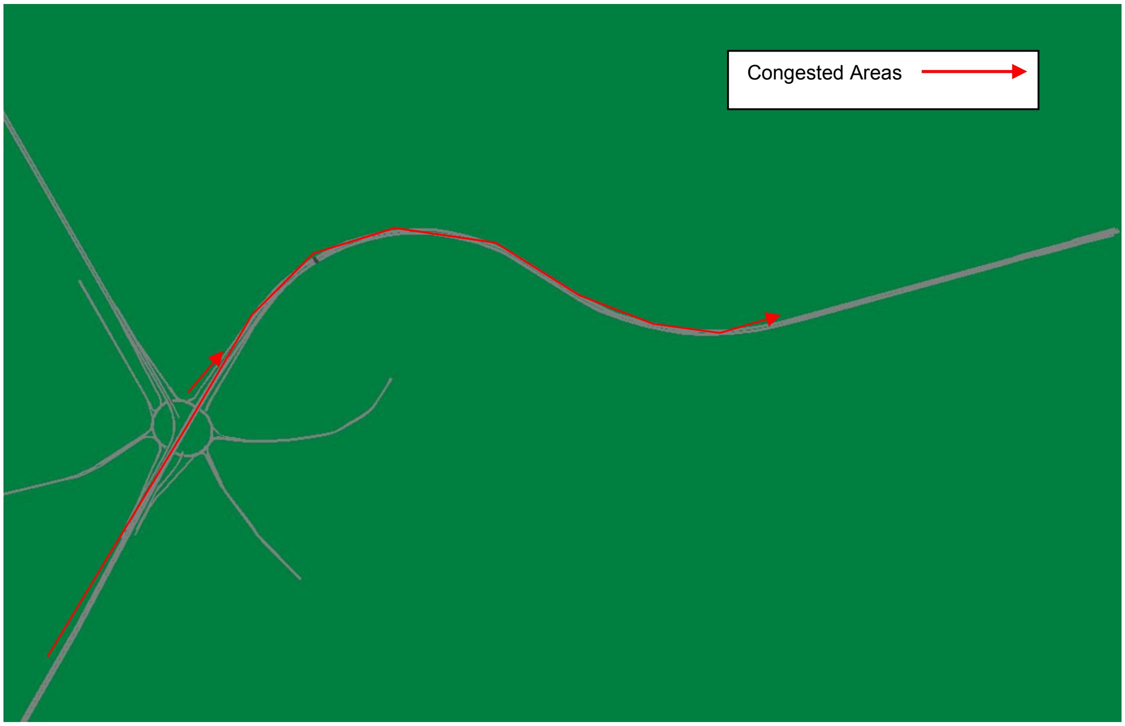


Figure 5.1 - M62 J26-J27 Weaving Section VISSIM Model

The model was appraised in the morning peak whereby merging and diverging was evident. Journey times were taken on all movements.

Link Type	Parameter			
	No. of Obs Veh	CC1	CC2	CC3
Left Side Rule (Motorised)	2	0.9	4	-8
Freeway (Free Lane Sect)	2	0.9	3	-8

Table 5.1- M62 J26-J27 Weaving Section Base Model Parameters

5.4.2 M60 J16-J17 Motorway With Gradients

The second model analysed was the M60 J16-J17 Motorway with gradients, located to the north of Manchester (see Table 5.2 for default parameter values). Junction 16 consists of an eastbound on slip and a westbound off slip and, Junction 17 is grade separated. The network operated in free flow.

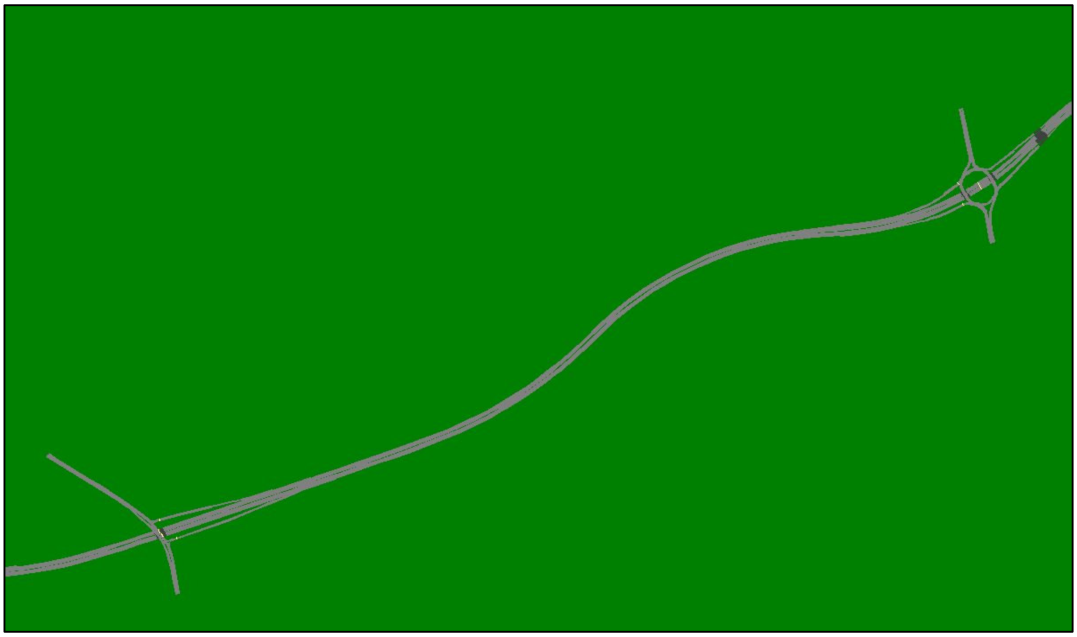


Figure 5.2 - M60 J16-J17 VISSIM Model

The model was examined in the morning peak in both directions with journey times taken for all movements.

Link Type	Parameter			
	No. of Obs Veh	CC1	CC2	CC3
Urban(Motorised)	2	0.9	4	-8
Freeway (Left Side Rule)	3	0.7	4	-12

Table 5.2 - M60 J16-J17 Motorway with Gradients Base Model Values.

5.4.3 M60 J18 Signalised Motorway Intersection

Thirdly, a model of the M60 J18 Signalised Motorway Intersection located to the north of Manchester (see Table 5.3 for default values) was examined. The model consists of a grade separated junction with signalised roundabout which functioned in free flow with occasional disruptions to the traffic.

Figure 5.3 - M60 J18 Signalised Motorway Intersection VISSIM Model

The model was analysed in the morning peak whereby merging and diverging was taking place. Journey times were taken on all movements.

Link Type	Parameter			
	No. of Obs Veh	CC1	CC2	CC3
Left Side Rule	3	1.1	4	-12
Freeway (Left Side Rule)	3	0.7	4	-12
Freeway (Forced Merge)	3	1.3	4	-12
Freeway (Free Lane Sect)	2	1	4	-12
Motorway Merge/Diverge	6	0.85	4	-12

Table 5.3 - M60 J18 Signalised Motorway Intersection Base Model Values

5.5 Driver Behaviour - Number of Observed Vehicles

In order to understand the effect this parameter has on the driver behaviour, a range of test values were used:-

- Value range - 1, 2, 3, 4, 5, 6, 7, 8, 9, 10

The VISSIM default for this parameter is 2 which is considered by PTV to be suitable for most conditions. In case of dense infrastructure, 3 or even 4 may be used to solve problems caused by vehicles that do not react on the infrastructure properly. In general the modeller should only need to increase the number of observed vehicles if driver parameter sets that allow overtaking of vehicles on the same lane, e.g. with bicycles or very wide lanes, are used.

Clearly, the range of values used (1 – 10) for this parameter exceeds the expected values (2 – 4) however this extended range should provide a full picture of the impact of this parameter on the network performance.

It should be noted that an increase in the number of observed vehicles will result in a reduction in the applied acceleration of vehicles and hence, potentially reduce the overtaking opportunities. This will in turn produce increased journey times.

5.5.1 *Model Results M62 J26-J27 Weaving Section*

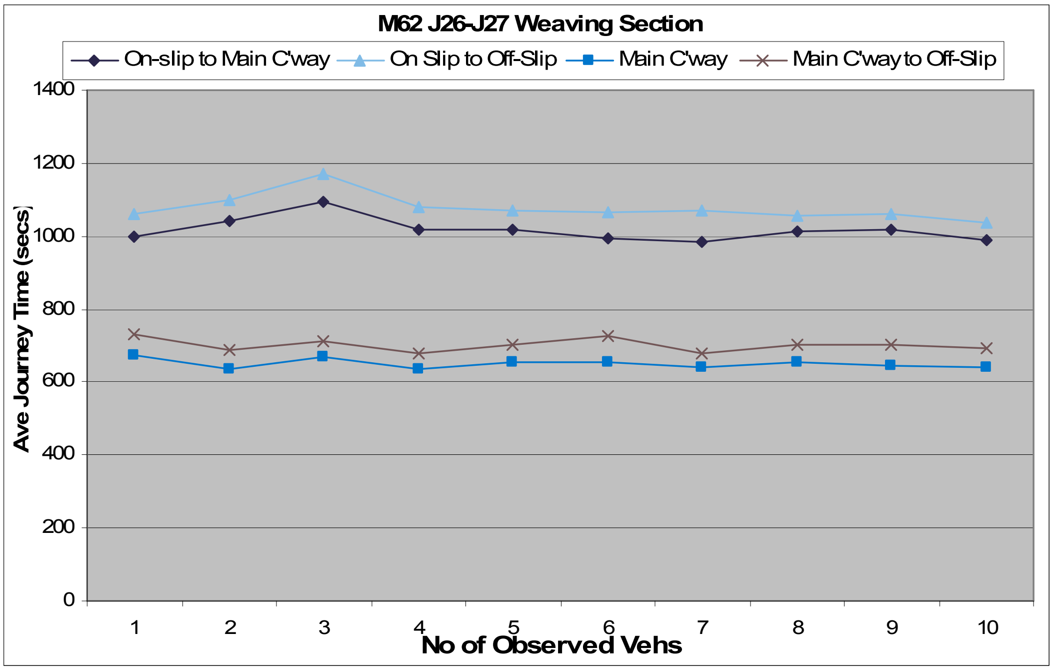


Figure 5.4 - M62 J26-J27 Weaving Section Model Global Journey Time Results

The graph and results in Table 5.4 show that for this particular network the largest variation in the results (+6.5%) occurred at around a parameter value of 3 for the traffic merging in to the mainline from the slip road. Many of the results are relatively similar, even for values at the higher end of the range where the change from the default was -5.7%.

Travel Time	Obs. Vehs									
Movement	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
On-slip to Main C'way	1000.1	1039.5	1094.9	1018.6	1018.2	993.2	983.1	1010.8	1020.0	989.5
On Slip to Off-Slip	1060.5	1101.1	1172.7	1079.8	1072.5	1065.3	1068.2	1056.9	1061.7	1038.1
Main C'way	672.0	637.5	669.2	633.7	653.4	653.4	639.7	653.7	644.0	641.3
Main C'way to Off-Slip	730.0	689.5	713.4	677.7	704.0	724.7	678.5	703.1	702.2	694.5

Travel Time	Obs. Vehs									
Movement	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
On-slip to Main C'way	-3.8%	Default	5.3%	-2.0%	-2.0%	-4.5%	-5.4%	-2.8%	-1.9%	-4.8%
On Slip to Off-Slip	-3.7%		6.5%	-1.9%	-2.6%	-3.3%	-3.0%	-4.0%	-3.6%	-5.7%
Main C'way	5.4%		5.0%	-0.6%	2.5%	2.5%	0.3%	2.5%	1.0%	0.6%
Main C'way to Off-Slip	5.9%		3.5%	-1.7%	2.1%	5.1%	-1.6%	2.0%	1.8%	0.7%

Table 5.4 – M62 J26-J27 Change in Journey Time by Movement

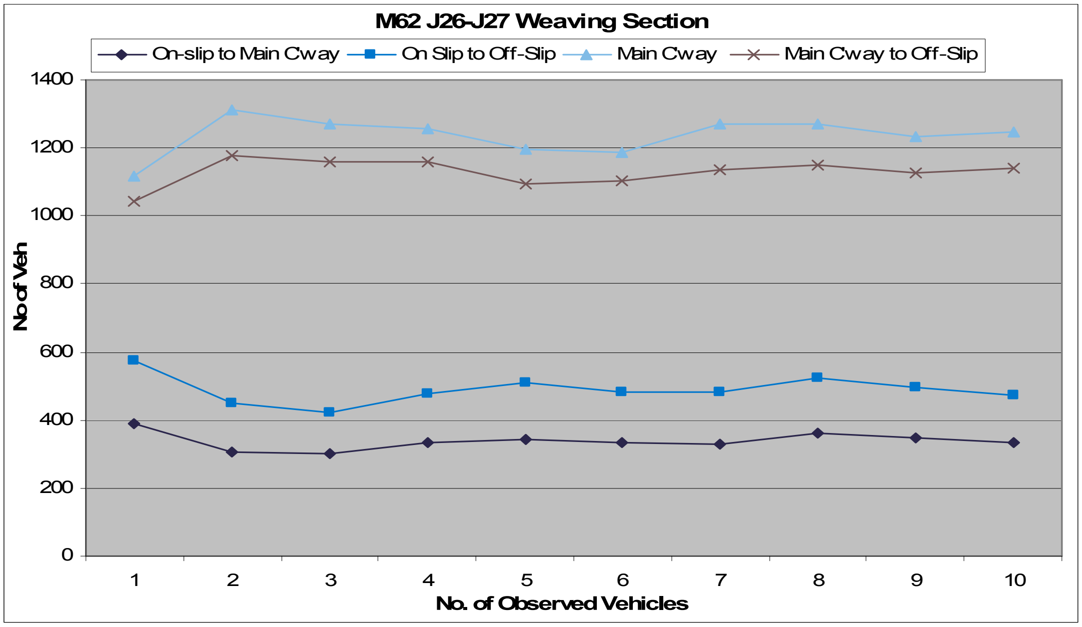


Figure 5.5 - M62 J26-J27 Weaving Section Model Global Vehicle Count Data

No. of Vehicles	Obs. Vehs									
Movement	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
On-slip to Main C'way	389	305	302	334	345	335	327	360	350	335
On Slip to Off-Slip	573	450	424	478	510	482	480	525	496	472
Main C'way	1117	1312	1271	1255	1195	1185	1271	1269	1234	1246
Main C'way to Off-Slip	1044	1179	1159	1161	1095	1104	1136	1148	1127	1140

No. of Vehicles	Obs. Vehs									
Movement	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
On-slip to Main C'way	27.5%	Default	-1.0%	9.5%	13.1%	9.8%	7.2%	18.0%	14.8%	9.8%
On Slip to Off-Slip	27.3%		-5.8%	6.2%	13.3%	7.1%	6.7%	16.7%	10.2%	4.9%
Main C'way	-14.9%		-3.1%	-4.3%	-8.9%	-9.7%	-3.1%	-3.3%	-5.9%	-5.0%
Main C'way to Off-Slip	-11.5%		-1.7%	-1.5%	-7.1%	-6.4%	-3.6%	-2.6%	-4.4%	-3.3%

Table 5.5 – M62 J26-J27 Change in Vehicle Flow by Movement

From the results displayed in Figure 5.5 and Table 5.5 the most notable changes in the results occur between values of 2 to 4 where it can be seen that the flow on the mainline reduces while the merging traffic flow increases. The trend would appear to be that as the value increased the merging flow from the slip road increases.

Merging interaction on motorway slips is a complex phenomenon as the behaviour of entering and main line traffic changes significantly as the relative flows on the slip road and mainline increase. This may be further compounded where and whether there is a down stream queue on the mainline. Slip road traffic generally forces its way into the main line with the implied consent of mainline traffic as it either moves over a lane or reduces speed to enable traffic to safely enter the main traffic streams.

When running the weaving section model, and considering data on a macro level, it appears that when the number of observed vehicles is set at low values, it may impact on the ability of the merging traffic to enter the main traffic stream. Consequently, this results in delays/unreleased vehicles on the merging link and improved journey times for the main stream traffic flows. However, at higher values, it dis-benefits both traffic streams such that changes in the mainstream traffic characteristics allow the merging traffic a relatively free passage in. Consequently, there will be less delay and unreleased vehicles from the merging link but an increased delay to the main stream traffic.

5.5.2 Model Results M60 J16-J17 Motorway With Gradients

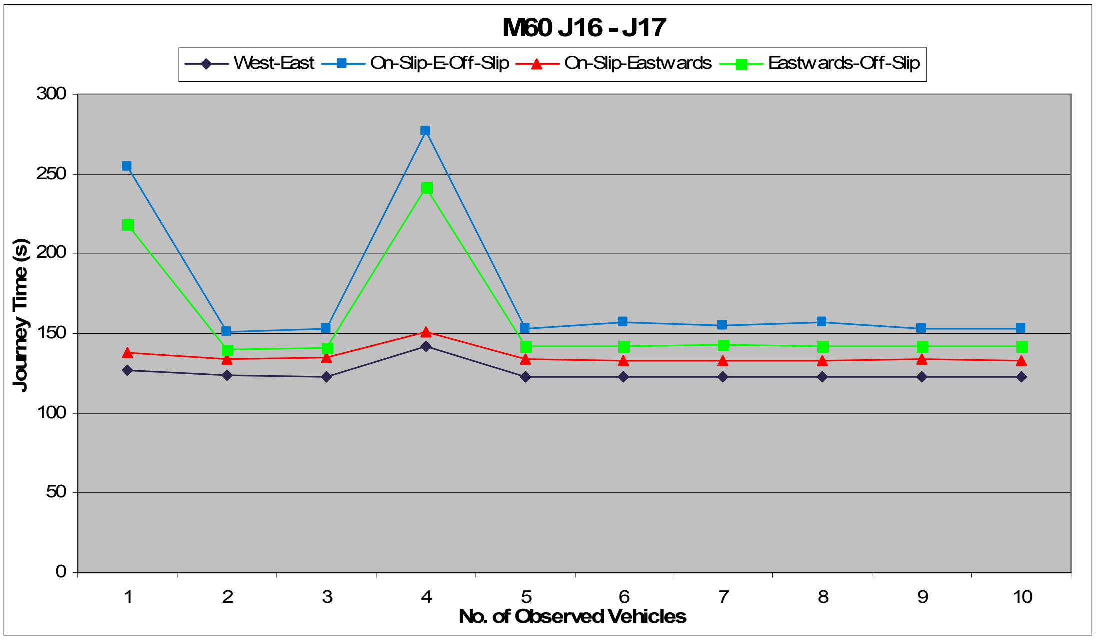


Figure 5.6 - M60 J16-J17 Motorway with Gradients Journey Time Results

Travel Time	**Obs. Vehs**									
Movement	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
West-East	127.1	123.6	123.3	141.5	123.1	123.0	123.1	123.0	123.1	123.0
On-Slip-E-Off-Slip	254.4	150.7	153.2	276.7	153.0	156.6	155.4	156.6	153.2	153.5
On-Slip-Eastwards	137.9	133.9	134.8	150.6	133.7	133.3	132.9	133.3	133.4	133.3
Eastwards-Off-Slip	218.2	140.0	141.3	241.2	142.0	142.2	142.9	142.2	142.2	142.3

Travel Time	**Obs. Vehs**									
Movement	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
West-East	2.8%	Default	-0.3%	14.4%	-0.4%	-0.5%	-0.4%	-0.5%	-0.4%	-0.5%
On-Slip-E-Off-Slip	68.8%		1.6%	83.6%	1.5%	3.9%	3.1%	3.9%	1.6%	1.8%
On-Slip-Eastwards	3.0%		0.7%	12.5%	-0.1%	-0.4%	-0.7%	-0.4%	-0.3%	-0.4%
Eastwards-Off-Slip	55.9%		0.9%	72.3%	1.5%	1.6%	2.1%	1.6%	1.6%	1.7%

Table 5.6 - M60 J16-J17 Change in Journey Time Results

From examination of Figure 5.6 it is apparent that there are 2 distinct outliers at values of 1 and 4. Excluding these results the journey time show relatively little variation although there is a slight trend towards reduced journey times. The isolated peak at a value of 4 may in part be due to the complex driver movements taking place with merging/diverging at four locations within the model together with the effects of the gradient.

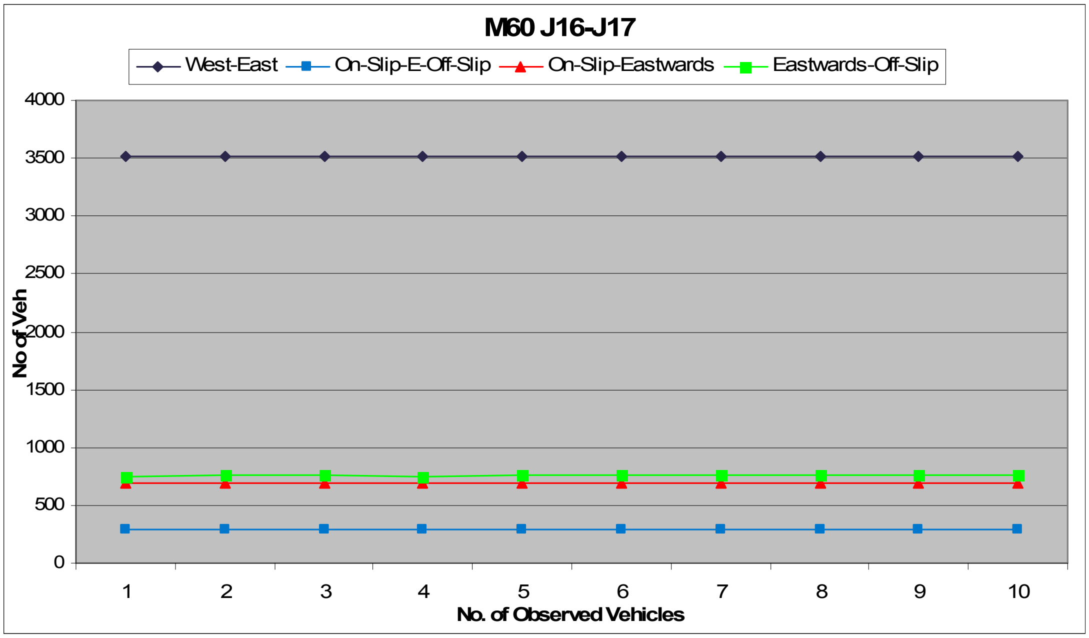


Figure 5.7 - M60 J16-J17 Change in Vehicle Flow by Movement

No. of Vehicles	**Obs. Vehs**									
Movement	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
West-East	3511	3513	3514	3514	3514	3514	3514	3514	3514	3514
On-Slip-E-Off-Slip	291	294	293	287	294	293	294	293	294	294
On-Slip-Eastwards	693	693	693	693	693	693	693	693	693	693
Eastwards-Off-Slip	748	758	758	751	758	760	758	760	759	758

No. of Vehicles	**Obs. Vehs**									
Movement	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
West-East	-0.1%	Default	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
On-Slip-E-Off-Slip	-1.0%		-0.3%	-2.4%	0.0%	-0.3%	0.0%	-0.3%	0.0%	0.0%
On-Slip-Eastwards	0.0%		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Eastwards-Off-Slip	-1.3%		0.0%	-0.9%	0.0%	0.3%	0.0%	0.3%	0.1%	0.0%

Table 5.7 - M60 J16-J17 Change in Journey Time Results

With reference to Figure 5.7 it can be seen that the number of vehicles modelled has changed very little through the increasing range of values.

5.5.3 Model Results M60 J18 Signalised Motorway Intersection

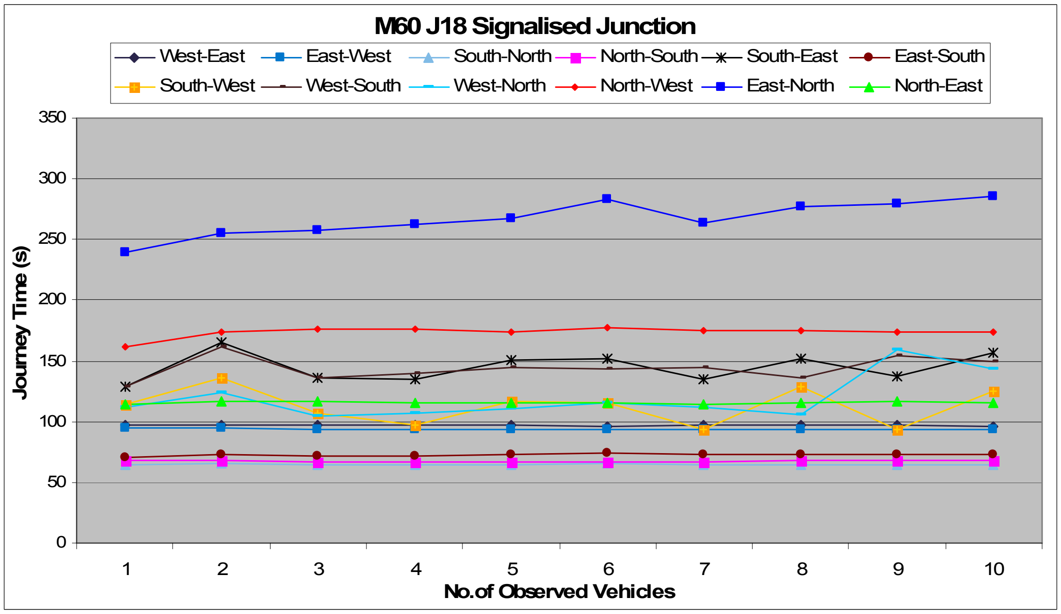


Figure 5.8 - M60 J18 Signalised Motorway Intersection Journey Time Results

Travel Time	**Obs. Vehs**									
Movement	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
West-East	97.2	97.7	96.7	96.7	96.9	96.4	96.9	96.8	97.2	96.6
East-West	94.4	94.4	94.1	94.0	94.1	94.0	94.1	94.0	94.2	94.0
South-North	65.0	65.2	64.9	64.8	64.8	65.0	64.8	64.9	64.8	65.0
North-South	67.5	67.5	66.8	67.2	67.2	67.3	67.3	67.6	67.7	67.7
South-East	128.6	165.4	136.5	135.1	150.3	152.3	135.1	151.5	136.8	156.7
East-South	71.0	73.4	71.7	71.8	72.6	73.8	72.3	73.1	72.5	72.6
South-West	114.6	136.4	106.6	96.9	117.0	115.5	93.0	128.4	94.2	125.6
West-South	129.3	161.5	136.6	139.2	145.2	143.0	145.1	136.4	153.8	149.9
West-North	111.2	123.9	105.1	106.6	110.0	115.2	111.6	105.2	159.7	143.5
North-West	162.0	173.7	176.0	175.8	174.2	177.3	175.1	175.1	173.3	174.0
East-North	239.3	255.5	257.2	262.6	266.8	282.8	263.3	276.7	279.9	286.1
North-East	114.1	117.2	116.3	115.4	115.1	115.6	114.5	115.4	116.3	115.2

Travel Time	**Obs. Vehs**									
Movement	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
West-East	-0.4%	**Default**	-1.0%	-1.0%	-0.8%	-1.3%	-0.8%	-0.9%	-0.5%	-1.1%
East-West	0.0%		-0.3%	-0.4%	-0.3%	-0.4%	-0.3%	-0.4%	-0.2%	-0.4%
South-North	-0.3%		-0.4%	-0.6%	-0.6%	-0.2%	-0.6%	-0.4%	-0.6%	-0.3%
North-South	-0.1%		-1.1%	-0.6%	-0.5%	-0.3%	-0.3%	0.0%	0.3%	0.2%
South-East	-22.2%		-17.5%	-18.3%	-9.1%	-7.9%	-18.3%	-8.4%	-17.3%	-5.2%
East-South	-3.2%		-2.4%	-2.2%	-1.1%	0.6%	-1.5%	-0.5%	-1.3%	-1.1%
South-West	-15.9%		-21.8%	-28.9%	-14.2%	-15.3%	-31.8%	-5.8%	-30.9%	-7.9%
West-South	-19.9%		-15.4%	-13.8%	-10.1%	-11.4%	-10.1%	-15.6%	-4.8%	-7.2%
West-North	-10.2%		-15.2%	-13.9%	-11.2%	-7.0%	-9.9%	-15.1%	29.0%	15.9%
North-West	-6.7%		1.3%	1.2%	0.3%	2.1%	0.8%	0.8%	-0.2%	0.2%
East-North	-6.3%		0.7%	2.8%	4.4%	10.7%	3.1%	8.3%	9.5%	12.0%
North-East	-2.7%		-0.7%	-1.5%	-1.8%	-1.4%	-2.3%	-1.5%	-0.7%	-1.7%

Table 5.8 – M60 J18 Change in Journey Time

From examination of Figure 5.8 the most notable changes in journey time occur on the movements from the south and west – the most congested of the four approaches. Again the use of a value of 1 and greater than 7 produces results which are considered unstable. The traffic signal control in this particular network helps to control the operation of the network and hence stabilise results.

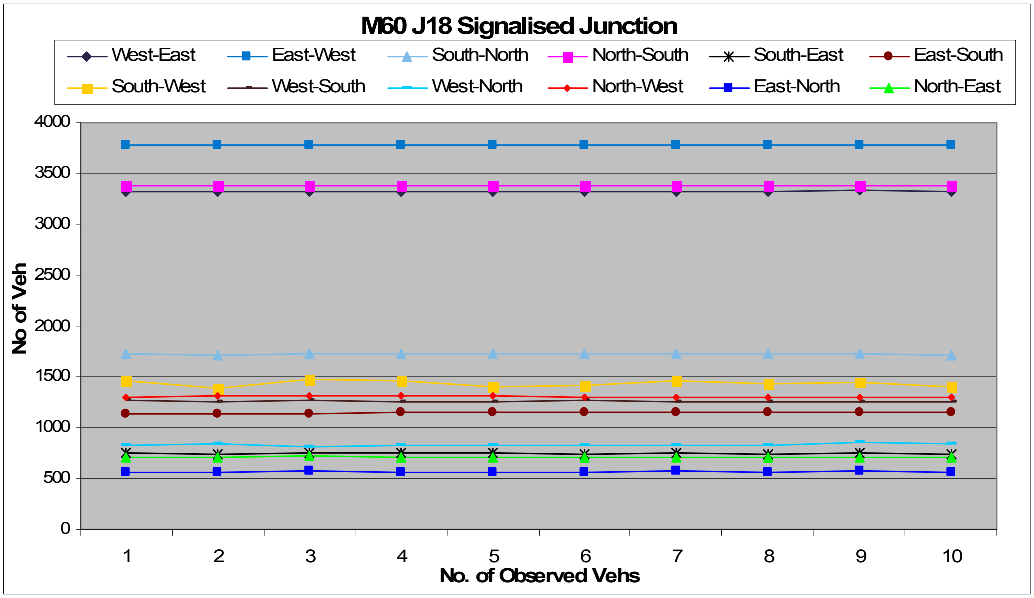


Figure 5.9 - M60 J18 Signalised Motorway Intersection Vehicle Count Data

No. of Vehs	**Obs. Vehs**									
Movement	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
West-East	3323	3322	3328	3320	3321	3324	3319	3323	3331	3321
East-West	3779	3782	3780	3785	3784	3779	3784	3782	3781	3783
South-North	1725	1709	1729	1729	1729	1720	1729	1729	1728	1711
North-South	3382	3382	3383	3377	3377	3377	3377	3377	3377	3377
South-East	758	735	760	760	750	734	759	743	758	734
East-South	1139	1141	1140	1148	1148	1148	1147	1148	1148	1148
South-West	1464	1389	1469	1464	1407	1418	1464	1425	1452	1395
West-South	1263	1261	1264	1258	1258	1265	1260	1253	1255	1258
West-North	829	840	812	825	829	827	828	821	854	836
North-West	1299	1311	1313	1309	1310	1304	1302	1300	1295	1295
East-North	562	565	569	565	564	567	569	564	569	568
North-East	712	712	716	713	714	715	715	713	709	711

No. of Vehs	**Obs. Vehs**									
Movement	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
West-East	0.0%	**Default**	0.2%	-0.1%	0.0%	0.1%	-0.1%	0.0%	0.3%	0.0%
East-West	-0.1%		-0.1%	0.1%	0.1%	-0.1%	0.1%	0.0%	0.0%	0.0%
South-North	0.9%		1.2%	1.2%	1.2%	0.6%	1.2%	1.2%	1.1%	0.1%
North-South	0.0%		0.0%	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%	-0.1%
South-East	3.1%		3.4%	3.4%	2.0%	-0.1%	3.3%	1.1%	3.1%	-0.1%
East-South	-0.2%		-0.1%	0.6%	0.6%	0.6%	0.5%	0.6%	0.6%	0.6%
South-West	5.4%		5.8%	5.4%	1.3%	2.1%	5.4%	2.6%	4.5%	0.4%
West-South	0.2%		0.2%	-0.2%	-0.2%	0.3%	-0.1%	-0.6%	-0.5%	-0.2%
West-North	-1.3%		-3.3%	-1.8%	-1.3%	-1.5%	-1.4%	-2.3%	1.7%	-0.5%
North-West	-0.9%		0.2%	-0.2%	-0.1%	-0.5%	-0.7%	-0.8%	-1.2%	-1.2%
East-North	-0.5%		0.7%	0.0%	-0.2%	0.4%	0.7%	-0.2%	0.7%	0.5%
North-East	0.0%		0.6%	0.1%	0.3%	0.4%	0.4%	0.1%	-0.4%	-0.1%

Table 5.9 – M60 J18 Change in Traffic Flow

With reference to Figure 5.9 it is apparent that the vehicle counts remain relatively constant with a very small range in the total flow.

5.6 Number of Observed Vehicles Summary

- In controlled situations eg traffic signals, there is little impact in changing the parameter.
- Journey time results often indicated erratic changes when altering the observed vehicle parameter. This is probably due to the traffic volumes and complex merging behaviour which takes place in many of the models.
- Results suggest a general trend towards increased journey time with respect to number of observed vehicles in congested networks. However, as the parameter is increased the ability for merging traffic flows to penetrate the main flow is enhanced.
- Vehicle counts remained relatively constant with only marginal variation.
- Overall it seems that the effect of varying the number of observed vehicles parameter is amplified by the level of congestion i.e. vehicle interaction.

The results suggest that a value of 1 should not be used and that the default value (2) provides reasonable results in each situation. While at the higher end the results appear to stabilise however, this should be taken in the context of the number of vehicles passing through the merge areas. It may be the case that at the higher end of the range vehicles are extremely cautious and this results in increased queuing prior to the merge areas.

It should be noted, however, that for technical reasons (some fixed network elements are considered as ‘vehicles’ internally by the software) there will be cases where the No. of Observed Vehicles on a particular link is increased in order to improve vehicle behaviour at junctions.

5.7 Seed Value

In this section the parameter investigated is that of seed value. The values used were 52, 47, 42, 37, 32, 27, 22, 17, 12, 7 and 2. The ‘default’ is set at 42.

5.7.1 Model Results M62 J26-J27 Weaving Section

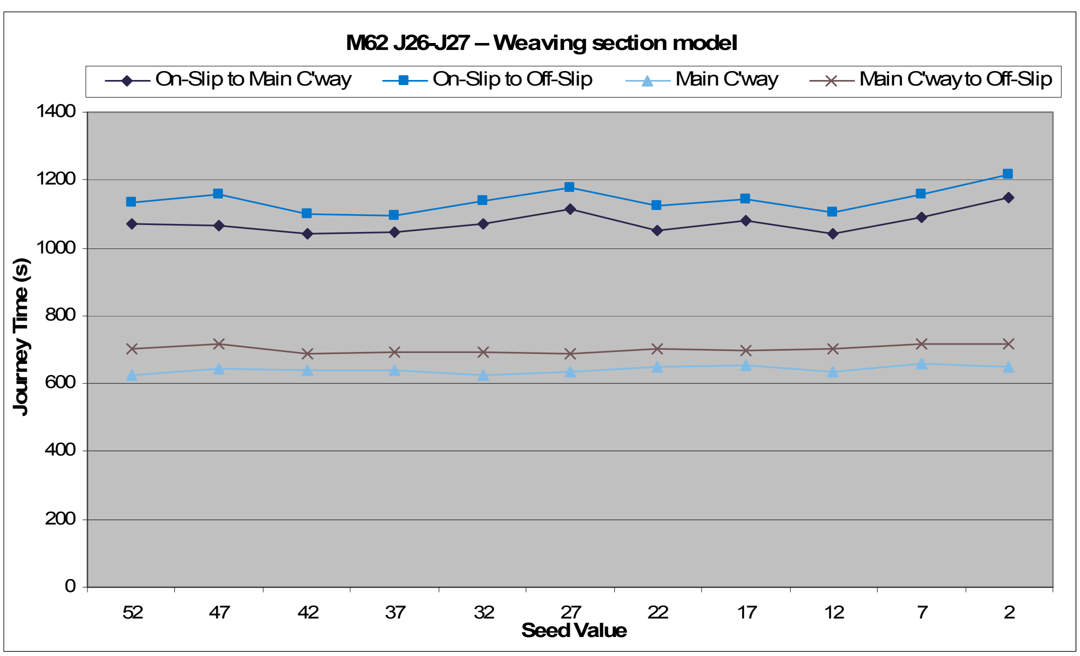


Figure 5.10 - M62 J26-J27 Weaving Section Model Journey Time Results

Travel Time	Random Seed Value										
Movement	**52**	**47**	**42**	**37**	**32**	**27**	**22**	**17**	**12**	**7**	**2**
On-Slip to Main C'way	1072.0	1065.2	1039.5	1046.2	1072.1	1112.1	1053.0	1082.1	1042.7	1087.7	1148.0
On-Slip to Off-Slip	1132.5	1155.5	1101.1	1092.9	1138.0	1176.2	1124.9	1142.5	1105.0	1157.0	1214.9
Main C'way	626.9	643.9	637.5	641.0	626.8	632.6	649.5	655.9	636.9	658.0	649.5
Main C'way to Off-Slip	701.9	715.4	689.5	691.8	692.4	689.7	702.0	698.5	701.6	715.5	717.4

Travel Time	Random Seed Value										
Movement	**52**	**47**	**42**	**37**	**32**	**27**	**22**	**17**	**12**	**7**	**2**
On-Slip to Main C'way	3.1%	2.5%	Default	0.6%	3.1%	7.0%	1.3%	4.1%	0.3%	4.6%	10.4%
On-Slip to Off-Slip	2.9%	4.9%		-0.7%	3.4%	6.8%	2.2%	3.8%	0.4%	5.1%	10.3%
Main C'way	-1.7%	1.0%		0.5%	-1.7%	-0.8%	1.9%	2.9%	-0.1%	3.2%	1.9%
Main C'way to Off-Slip	1.8%	3.8%		0.3%	0.4%	0.0%	1.8%	1.3%	1.8%	3.8%	4.0%

Table 5.10 – M62 J26 – J27 Change in Journey Time

From analysis of Figure 5.10 and Table 5.10 it is clear that that the largest changes in the journey times occurred for the merging traffic (10.4%) while there was little impact on the mainline traffic. This may be due to the change in arrival profiles for the merging traffic.

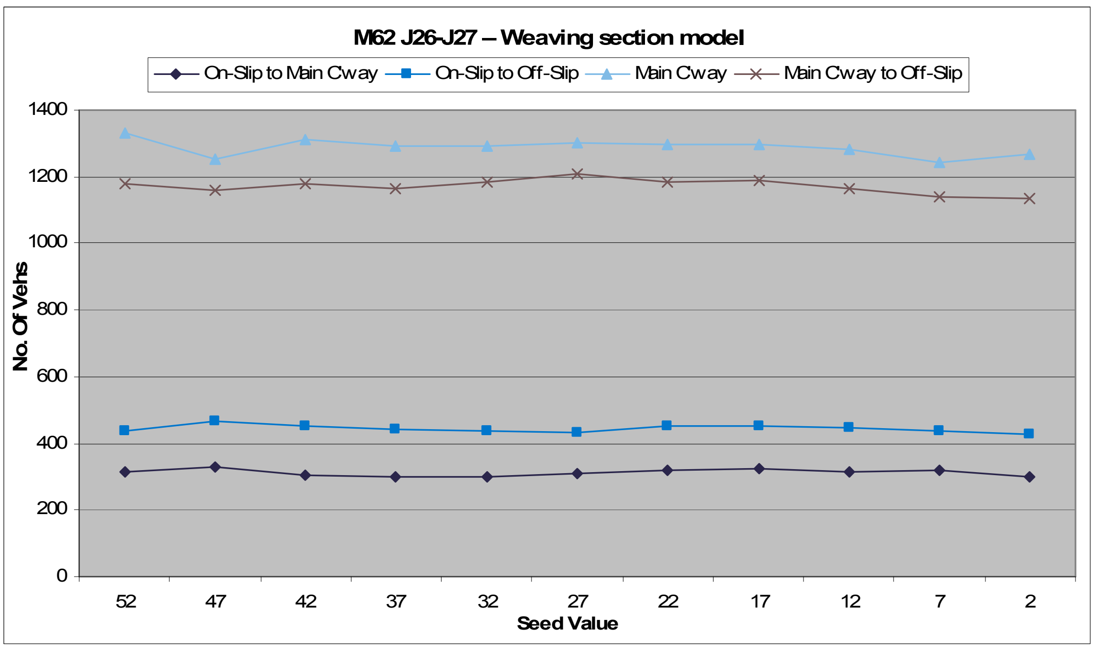


Figure 5.11 - M62 J26-J27 Weaving Section Model Vehicle Count Data

No. of Vehicles	Random Seed Value										
Movement	**52**	**47**	**42**	**37**	**32**	**27**	**22**	**17**	**12**	**7**	**2**
On-Slip to Main C'way	312	329	305	298	300	310	321	323	313	319	299
On-Slip to Off-Slip	438	466	450	440	438	431	452	452	446	439	428
Main C'way	1329	1253	1312	1293	1291	1304	1297	1299	1281	1245	1269
Main C'way to Off-Slip	1177	1157	1179	1165	1182	1209	1185	1191	1166	1140	1137

No. of Vehicles	Random Seed Value										
Movement	**52**	**47**	**42**	**37**	**32**	**27**	**22**	**17**	**12**	**7**	**2**
On-Slip to Main C'way	2.3%	7.9%	Default	-2.3%	-1.6%	1.6%	5.2%	5.9%	2.6%	4.6%	-2.0%
On-Slip to Off-Slip	-2.7%	3.6%		-2.2%	-2.7%	-4.2%	0.4%	0.4%	-0.9%	-2.4%	-4.9%
Main C'way	1.3%	-4.5%		-1.4%	-1.6%	-0.6%	-1.1%	-1.0%	-2.4%	-5.1%	-3.3%
Main C'way to Off-Slip	-0.2%	-1.9%		-1.2%	0.3%	2.5%	0.5%	1.0%	-1.1%	-3.3%	-3.6%

Table 5.11 – M62 J26-J27 Change in Traffic Flow

Figure 5.11 shows that the largest change in traffic flow (7.9% - 24 vehs) occurred on the slip road approach. Overall, the variation over the range of Seed values was only 4% suggesting very stable results despite the changes.

5.7.2 Model Results M60 J16-J17 Motorway With Gradients

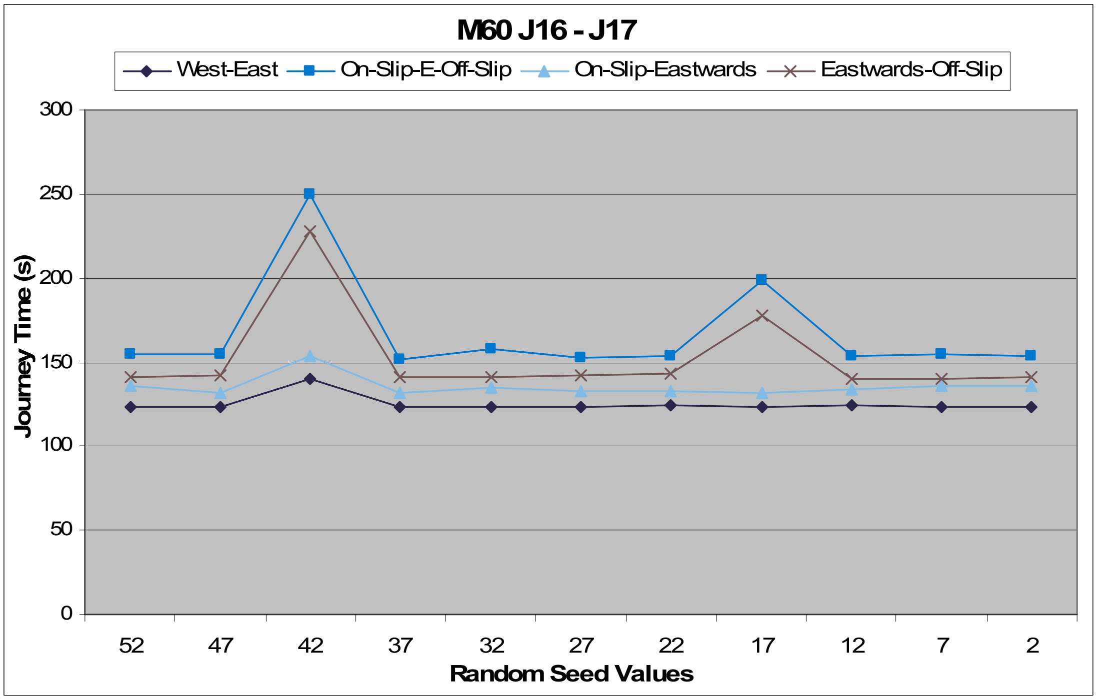


Figure 5.12 - M60 J16-J17 Motorway with Gradients Journey Time Results

With reference to Figure 5.12 there are 2 distinct peaks at Seed values of 42 and 17. This may be as a result of the variation in the release of vehicles, and HGVs in particular, on a network in which gradients impact on the behaviour/speed of the vehicles.

Travel Time	**Random Seed Value**										
Movement	**52**	**47**	**42**	**37**	**32**	**27**	**22**	**17**	**12**	**7**	**2**
West-East	123.5	123.3	140.0	123.2	123.7	123.3	123.9	123.4	124.1	123.3	123.5
On-Slip-E-Off-Slip	154.3	154.3	250.2	151.5	157.6	152.9	154.1	199.0	153.3	154.2	154.2
On-Slip-Eastwards	135.6	131.7	153.6	132.2	135.3	132.6	133.0	131.4	134.0	136.1	135.6
Eastwards-Off-Slip	140.8	141.9	227.6	141.2	141.5	142.3	142.7	177.2	140.2	140.3	140.9

Travel Time	**Random Seed Value**										
Movement	**52**	**47**	**42**	**37**	**32**	**27**	**22**	**17**	**12**	**7**	**2**
West-East	-11.8%	-12.0%	Default	-12.0%	-11.7%	-11.9%	-11.5%	-11.9%	-11.4%	-12.0%	-11.8%
On-Slip-E-Off-Slip	-38.3%	-38.3%		-39.5%	-37.0%	-38.9%	-38.4%	-20.5%	-38.7%	-38.4%	-38.4%
On-Slip-Eastwards	-11.7%	-14.2%		-13.9%	-11.9%	-13.6%	-13.4%	-14.4%	-12.8%	-11.4%	-11.7%
Eastwards-Off-Slip	-38.2%	-37.7%		-37.9%	-37.8%	-37.5%	-37.3%	-22.1%	-38.4%	-38.3%	-38.1%

Table 5.12 – M60 J16 – J17 Change in Journey Time

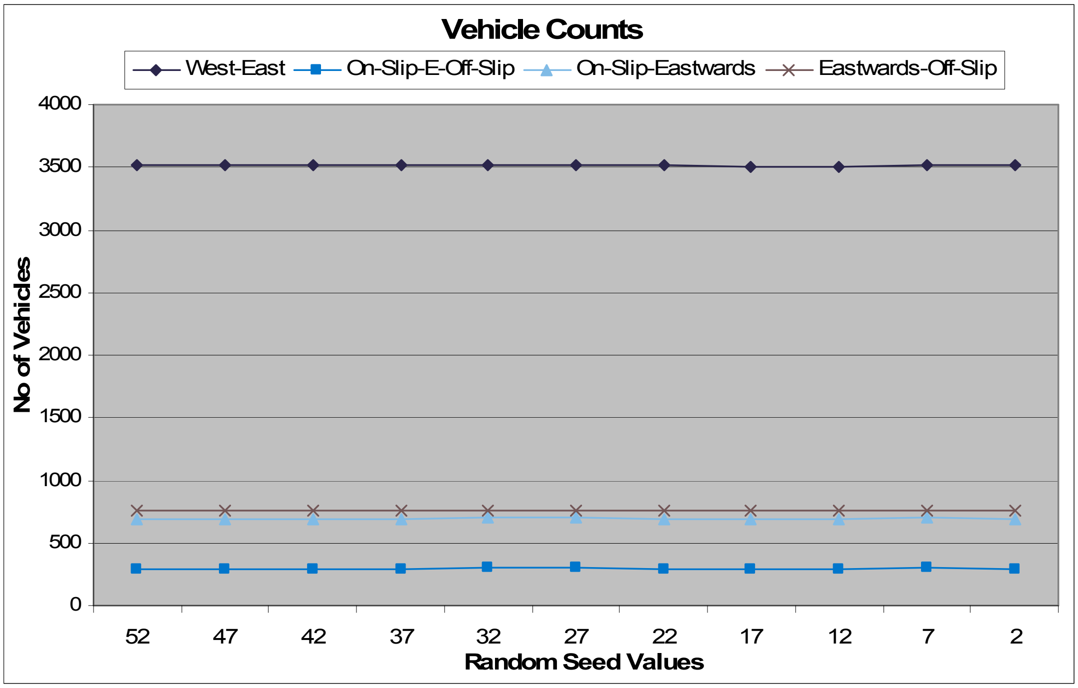


Figure 5.13 - M60 J16-J17 Motorway with Gradients Vehicle Count Data

However, Figure 5.13 illustrates once again that the change in Seed value had minimal impact on the total flow through the network although there were increased variation in journey times.

No. of Vehicles	Random Seed Value										
Movement	**52**	**47**	**42**	**37**	**32**	**27**	**22**	**17**	**12**	**7**	**2**
West-East	3514	3514	3514	3522	3521	3521	3520	3508	3504	3512	3516
On-Slip-E-Off-Slip	293	294	293	294	301	298	294	287	295	298	296
On-Slip-Eastwards	692	690	693	690	702	697	696	693	696	700	694
Eastwards-Off-Slip	763	758	757	756	756	757	756	753	756	753	756

No. of Vehicles	Random Seed Value										
Movement	**52**	**47**	**42**	**37**	**32**	**27**	**22**	**17**	**12**	**7**	**2**
West-East	0.0%	0.0%	Default	0.2%	0.2%	0.2%	0.2%	-0.2%	-0.3%	-0.1%	0.1%
On-Slip-E-Off-Slip	0.0%	0.3%		0.3%	2.7%	1.7%	0.3%	-2.0%	0.7%	1.7%	1.0%
On-Slip-Eastwards	-0.1%	-0.4%		-0.4%	1.3%	0.6%	0.4%	0.0%	0.4%	1.0%	0.1%
Eastwards-Off-Slip	0.8%	0.1%		-0.1%	-0.1%	0.0%	-0.1%	-0.5%	-0.1%	-0.5%	-0.1%

Table 5.13 – M60 J16 – J17 Change in Vehicle Count

5.7.3 Model Results M60 J18 Signalised Motorway Intersection

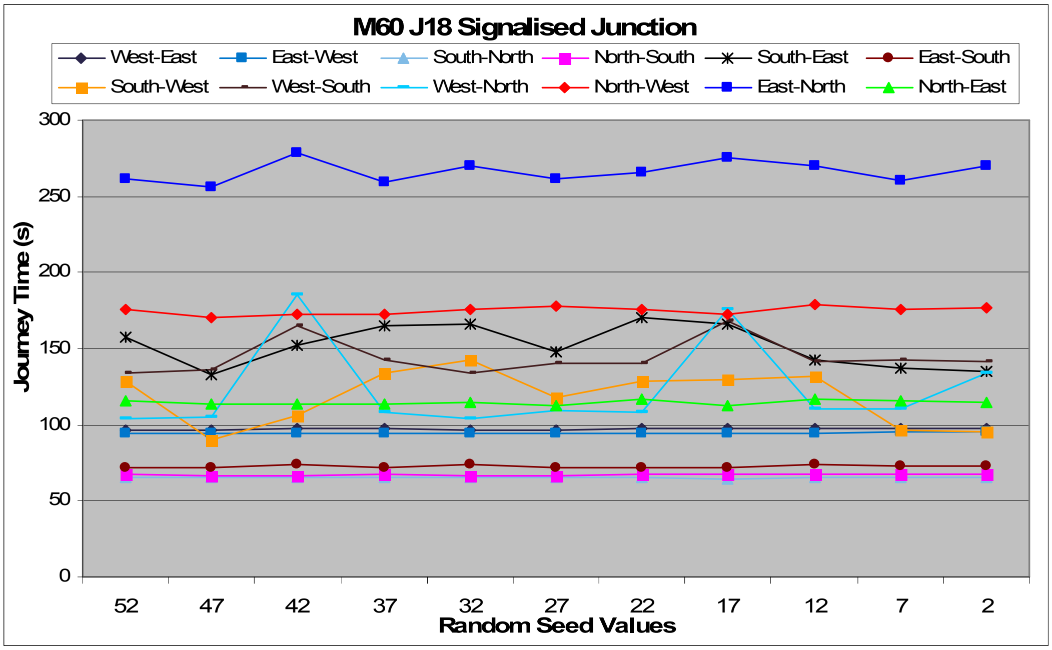


Figure 5.14 - M60 J18 Signalised Motorway Intersection Journey Time Results

Travel Time	Random Seed Value										
Movement	**52**	**47**	**42**	**37**	**32**	**27**	**22**	**17**	**12**	**7**	**2**
West-East	95.9	96.3	97.7	97.2	96.2	96.9	97.8	97.9	97.4	97.4	97.2
East-West	94.1	94.5	94.3	94.7	94.8	94.4	94.4	94.2	94.7	95.0	94.9
South-North	65.1	64.9	65.7	65.0	65.8	65.3	65.5	64.8	65.2	65.2	65.1
North-South	67.4	66.9	66.8	67.2	66.8	66.6	67.6	67.4	67.6	67.3	67.1
South-East	157.1	133.0	151.9	165.4	166.5	147.4	170.4	166.3	142.2	137.4	134.7
East-South	71.7	71.8	73.9	72.0	73.9	71.6	72.3	71.9	74.0	72.4	72.5
South-West	128.3	90.0	106.3	134.2	142.1	118.0	128.3	129.2	131.7	96.2	95.6
West-South	134.3	136.0	165.3	142.6	133.6	140.6	140.4	168.3	141.0	142.1	140.9
West-North	103.9	105.2	185.4	108.5	103.8	109.1	107.8	175.8	110.3	110.4	133.4
North-West	175.9	170.2	172.2	172.2	175.3	177.5	175.5	173.0	178.5	175.7	176.3
East-North	261.8	256.5	278.9	258.9	269.8	261.3	265.4	275.8	270.1	260.4	269.9
North-East	115.7	113.3	113.8	114.1	114.2	112.6	116.7	112.4	116.6	115.9	114.2

Travel Time	Random Seed Value										
Movement	**52**	**47**	**42**	**37**	**32**	**27**	**22**	**17**	**12**	**7**	**2**
West-East	-1.8%	-1.4%	**Default**	-0.4%	-1.5%	-0.8%	0.1%	0.2%	-0.3%	-0.3%	-0.5%
East-West	-0.2%	0.2%		0.4%	0.5%	0.1%	0.1%	-0.2%	0.4%	0.7%	0.7%
South-North	-0.9%	-1.2%		-1.2%	0.0%	-0.7%	-0.4%	-1.4%	-0.8%	-0.9%	-1.0%
North-South	0.9%	0.1%		0.6%	-0.1%	-0.3%	1.1%	0.9%	1.2%	0.7%	0.4%
South-East	3.4%	-12.4%		8.9%	9.6%	-2.9%	12.2%	9.5%	-6.4%	-9.5%	-11.3%
East-South	-3.0%	-2.9%		-2.6%	0.0%	-3.1%	-2.2%	-2.6%	0.1%	-2.0%	-1.8%
South-West	20.7%	-15.3%		26.3%	33.6%	11.0%	20.7%	21.5%	23.9%	-9.5%	-10.1%
West-South	-18.7%	-17.7%		-13.8%	-19.2%	-14.9%	-15.1%	1.8%	-14.7%	-14.0%	-14.8%
West-North	-43.9%	-43.3%		-41.5%	-44.0%	-41.1%	-41.9%	-5.2%	-40.5%	-40.5%	-28.0%
North-West	2.2%	-1.2%		0.0%	1.8%	3.1%	1.9%	0.4%	3.6%	2.0%	2.4%
East-North	-6.1%	-8.0%		-7.2%	-3.3%	-6.3%	-4.8%	-1.1%	-3.2%	-6.6%	-3.2%
North-East	1.6%	-0.5%		0.2%	0.3%	-1.1%	2.5%	-1.3%	2.4%	1.8%	0.3%

Table 5.14 – M60 J18 Change in Journey Time

Figure 5.14 shows that for this network changing the Random Seed produced some variations in journey time which were relatively high (over 20%)l. The major changes occurred on movements which were required to negotiate the traffic signals suggesting that the change in seed altered the arrival profiles and hence journey times. The movements which did not negotiate the signals showed little change in their journey times.

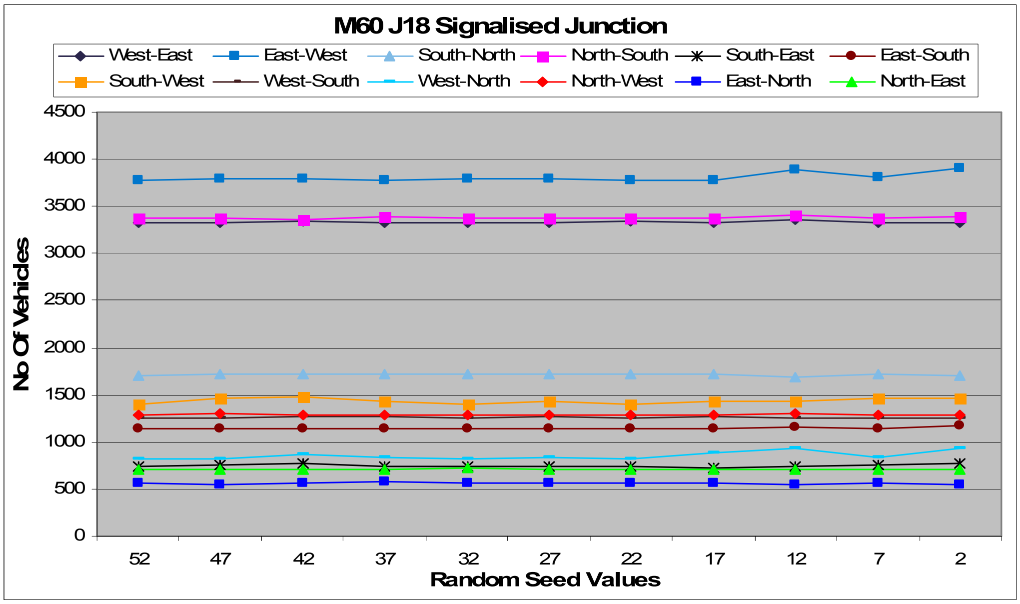


Figure 5.15 - M60 J18 Signalised Motorway Intersection Vehicle Count Data

No. of Vehs	Random Seed Value										
Movement	**52**	**47**	**42**	**37**	**32**	**27**	**22**	**17**	**12**	**7**	**2**
West-East	3328	3319	3337	3332	3333	3329	3337	3331	3365	3327	3327
East-West	3779	3794	3797	3783	3787	3785	3783	3782	3892	3809	3903
South-North	1711	1719	1725	1724	1725	1722	1721	1723	1693	1725	1701
North-South	3373	3373	3366	3390	3378	3376	3382	3372	3405	3383	3397
South-East	733	762	765	743	732	741	737	719	743	762	768
East-South	1140	1140	1140	1143	1140	1143	1141	1143	1160	1141	1169
South-West	1395	1462	1473	1428	1400	1430	1392	1428	1424	1456	1464
West-South	1254	1256	1262	1265	1258	1266	1260	1263	1248	1259	1247
West-North	820	817	875	834	820	828	822	878	933	828	935
North-West	1289	1298	1293	1293	1292	1279	1292	1293	1297	1282	1291
East-North	570	554	561	573	570	556	559	568	546	567	544
North-East	711	710	712	712	716	709	710	714	705	711	702

No. of Vehs	Random Seed Value										
Movement	**52**	**47**	**42**	**37**	**32**	**27**	**22**	**17**	**12**	**7**	**2**
West-East	-0.3%	-0.5%		-0.1%	-0.1%	-0.2%	0.0%	-0.2%	0.8%	-0.3%	-0.3%
East-West	-0.5%	-0.1%		-0.4%	-0.3%	-0.3%	-0.4%	-0.4%	2.5%	0.3%	2.8%
South-North	-0.8%	-0.3%		-0.1%	0.0%	-0.2%	-0.2%	-0.1%	-1.9%	0.0%	-1.4%
North-South	0.2%	0.2%		0.7%	0.4%	0.3%	0.5%	0.2%	1.2%	0.5%	0.9%
South-East	-4.2%	-0.4%		-2.9%	-4.3%	-3.1%	-3.7%	-6.0%	-2.9%	-0.4%	0.4%
East-South	0.0%	0.0%	**'Default'**	0.3%	0.0%	0.3%	0.1%	0.3%	1.8%	0.1%	2.5%
South-West	-5.3%	-0.7%		-3.1%	-5.0%	-2.9%	-5.5%	-3.1%	-3.3%	-1.2%	-0.6%
West-South	-0.6%	-0.5%		0.2%	-0.3%	0.3%	-0.2%	0.1%	-1.1%	-0.2%	-1.2%
West-North	-6.3%	-6.6%		-4.7%	-6.3%	-5.4%	-6.1%	0.3%	6.6%	-5.4%	6.9%
North-West	-0.3%	0.4%		0.0%	-0.1%	-1.1%	-0.1%	0.0%	0.3%	-0.9%	-0.2%
East-North	1.6%	-1.2%		2.1%	1.6%	-0.9%	-0.4%	1.2%	-2.7%	1.1%	-3.0%
North-East	-0.1%	-0.3%		0.0%	0.6%	-0.4%	-0.3%	0.3%	-1.0%	-0.1%	-1.4%

Table 5.15 – M60 J18 Change in Traffic Flow

In general, the traffic flow through the network were not affected by the change in Seed although movements such as west to north did display changes of around +/-6%.

5.8 Seed Value Summary

- The results have shown that changing the Random Seed can produce major variations in journey times for specific movements through congested junctions although, taking account of the global figure, the variation was around +/-6% of the mean although maximum vehicle count variation did not exceed 4%;
- In congested networks the Random Seed values can produce rogue results which are out of sync with the general pattern of output values generated by other seed values.

Table 5.16 below summarises the variation that occurred in journey times and traffic throughput over the ten random seed runs in each model. The variations are expressed as the standard deviation as a percentage of the average journey time or flow.

Model	Standard Deviation as % of Average	
	Journey Time	Flow Throughput
M62 J26 – J27	2.1	1.4
M60 J16 – J17	9.7	0.4
M60 J18	3.6	0.3

Table 5.16 – Summary of Random Seed Variation

In all cases the model throughput is relatively stable. However, there can be significant variation in journey times depending on the extent of congestion in the network and the physical nature of the network.

5.9 Gradients

The following section investigates the impact that changing gradients has on the M60 J16-J17 motorway with gradients model. For the purpose of the testing the gradient for the mainline was adjusted as follows:

-6%, -4%, -2%, 0, 2%, 4% and 6%.

In addition, it should be noted that the testing was undertaken to isolate the effects of the gradient on the different vehicle types by assigning an HGV matrix in network and a car matrix in another. Furthermore, as the default power (150kw – 600kw) and weight (2.5T – 40T) distributions in VISSIM led to some low powered heavy vehicles which brought the traffic flow to a standstill when the gradients increased, revised distributions were adopted as follows:

- Power 250kw – 400kw (1kw = 1.34hp)
- Weight 30T – 40T

5.9.1 Model Results M60 J16-J17 Motorway With Gradients

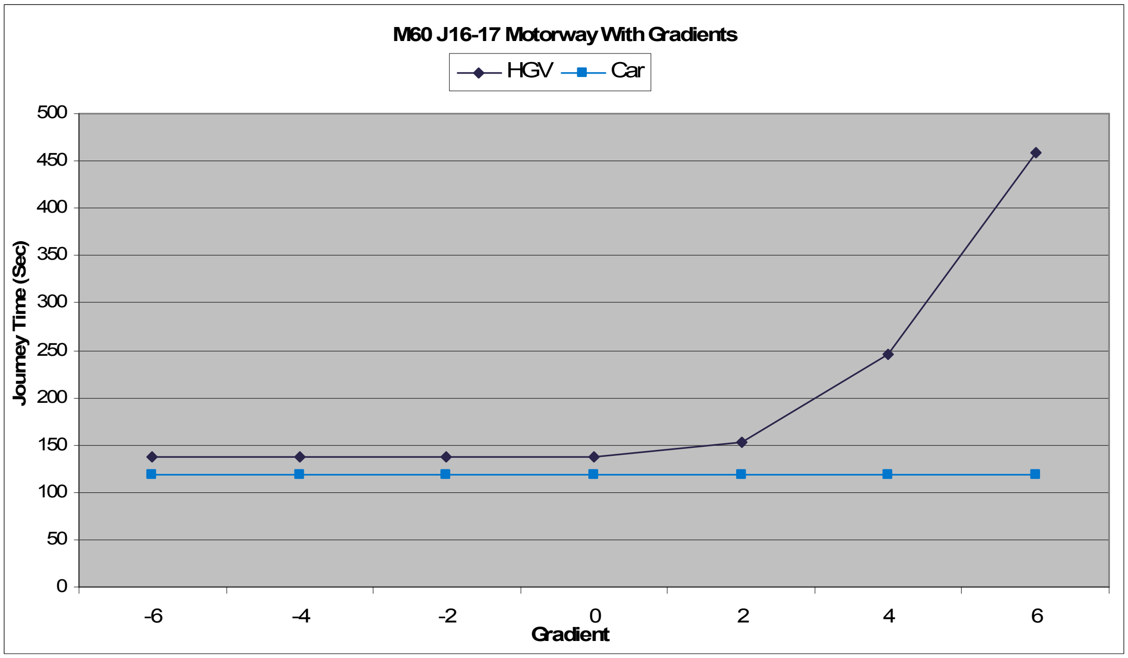


Figure 5 16 - M60 J16-J17 Motorway with Gradients Journey Time Results

With reference to Figure 5.16, it is clear that as gradients become positive, HGV journey time increases, particularly once positive gradients are incorporated in to the network. The effect on cars, when modelled in isolation, is minimal however their speeds will be affected by HGVs when modelled in combination.

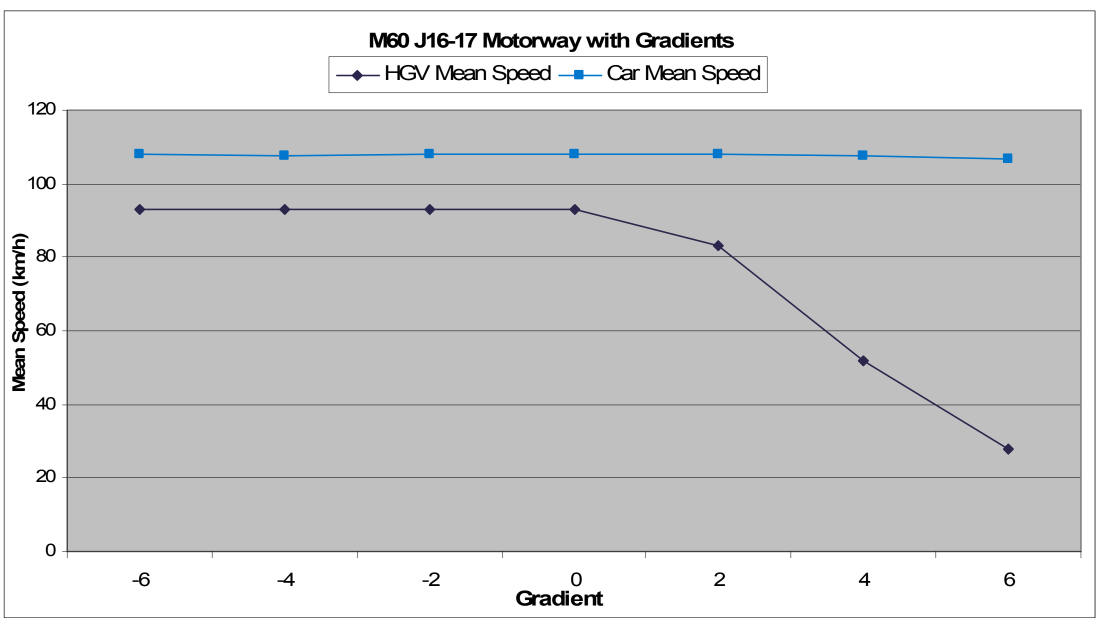


Figure 5.17 - M60 J16-J17 Motorway with Gradients Speeds

In line with the increase in HGV journey times presented in Figure 5.17, the average speed of HGVs reduces significantly as the gradient increases.

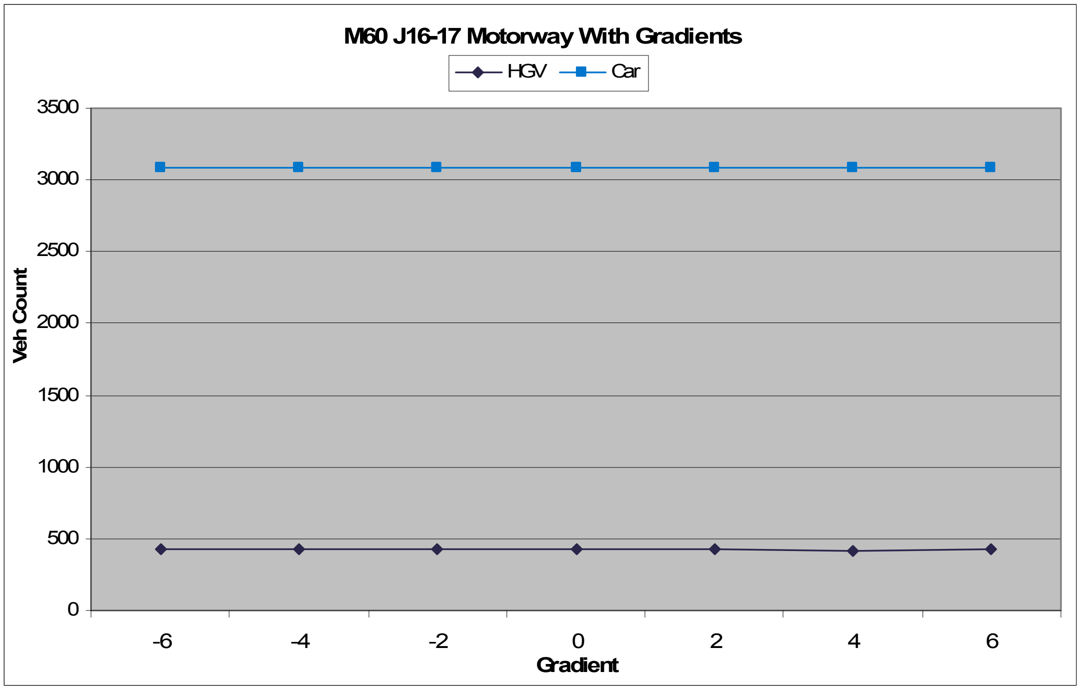


Figure 5.18 - M60 J16-J17 Motorway with Gradients Vehicle Count Data

From Figure 5.18 it can be seen that there was little change in the number of vehicles counted over the network did not vary despite the reduction in speed observed earlier. With regard to the HGV traffic, this can be attributed to the fact that fewer vehicles complete their journey in the 'build-up' period and remain on the network longer. They are then included in the count for the modelled hour. The flow for cars remained constant as the gradient does not appear to impact on car performance.

5.10 Gradient Model Summary

- The salient point of note is that increasing the gradient can make significant increases to travel time for HGVs, which in turn reduces the vehicle count.
- Care should be taken to ensure that the power and weight distributions for HGVs will not result in low powered heavy HGVs.
- A gradient of 6 can significantly reduce vehicle speeds impacting upon journey times and consequently vehicle counts.

5.11 CC1

The following section presents the data gathered for altering the time headway parameter CC1 (default = 0.9s) on the analysed models. For the purposes of the testing a 'base' value of 1 was used and the tables compare the results with those for this 'base' rather than the default. The change from 0.9s to 1.0s is not considered to change the conclusions.

5.11.1 Model Results M62 J26-J27 Weaving Section

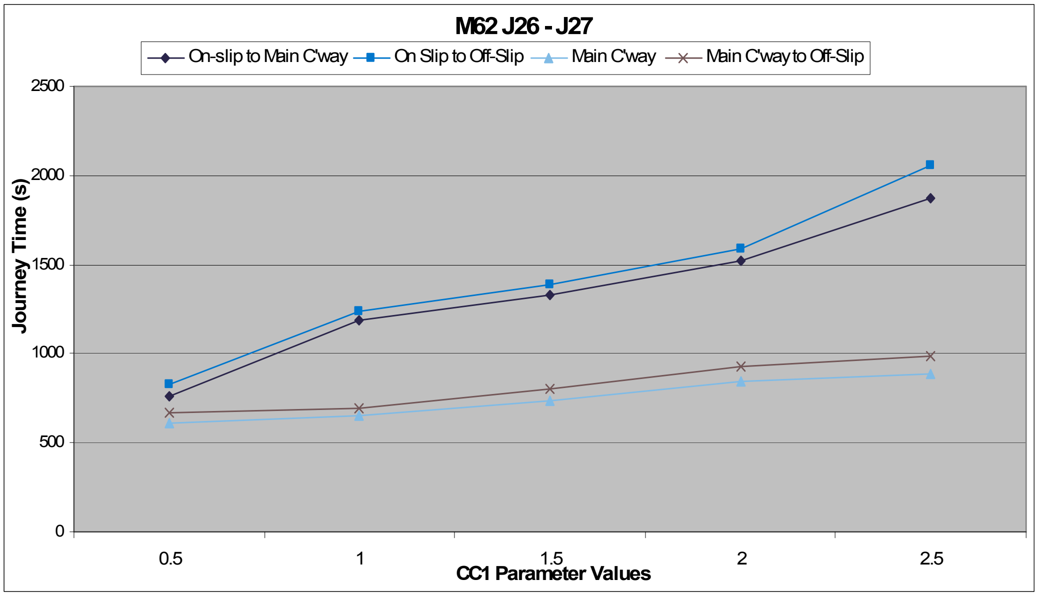


Figure 5.19 - M62 J26-J27 Weaving Section Model Journey Time Results

In this case, it can be seen from Figure 5.19 and Table 5.17 that there is a clear correlation between increasing the CC1 value and increased journey times. Through investigation of the Error files it seems that a significant number of vehicles are either unable to access the network or make lane changes and thus removed from the network when headway is increased incurring additional delays and affecting the results.

Travel Time	**CC1 Parameter**				
Movement	**0.5**	**1**	**1.5**	**2**	**2.5**
On-slip to Main C'way	759.9	1185.4	1330.2	1522.5	1871.4
On Slip to Off-Slip	829.9	1241.0	1390.0	1585.9	2053.7
Main C'way	610.0	649.3	736.5	842.3	884.9
Main C'way to Off-Slip	666.5	696.6	802.1	924.2	988.3

Travel Time	**CC1 Parameter**				
Movement	**0.5**	**1**	**1.5**	**2**	**2.5**
On-slip to Main C'way	-35.9%	1185.4	12.2%	28.4%	57.9%
On Slip to Off-Slip	-33.1%	1241.0	12.0%	27.8%	65.5%
Main C'way	-6.1%	649.3	13.4%	29.7%	36.3%
Main C'way to Off-Slip	-4.3%	696.6	15.1%	32.7%	41.9%

Table 5.17 – M62 J26-J27 Change in Travel Time

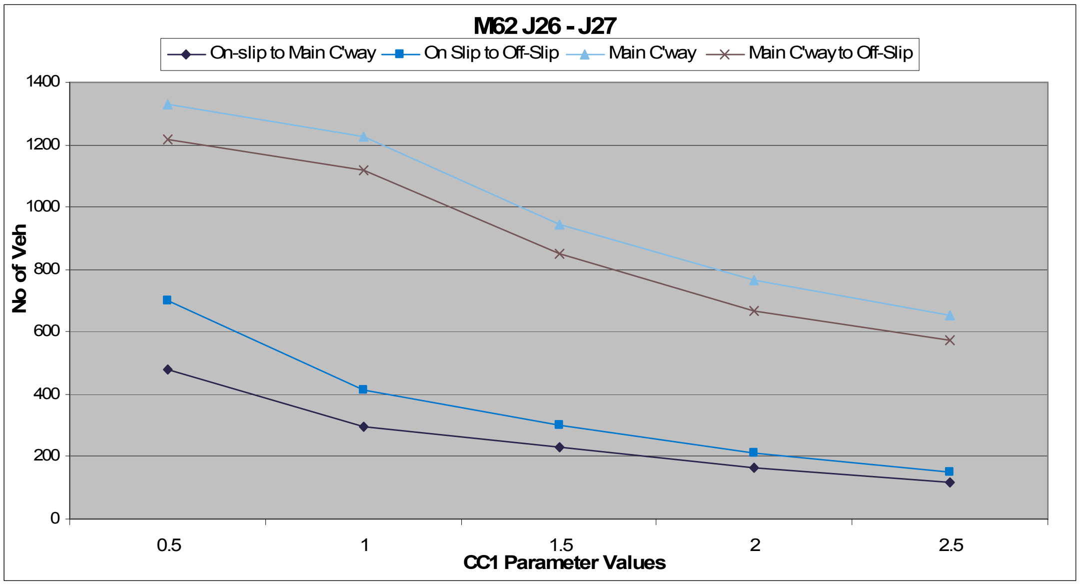


Figure 5.20- M62 J26-J27 Weaving Section Model Vehicle Count Data

Figure 5.20 above shows that, in line with the increased journey times presented in Figure 5.21 below, the vehicle counts decrease with increasing headway values.

No. of Vehs	CC1 Parameter				
Movement	**0.5**	**1**	**1.5**	**2**	**2.5**
On-slip to Main C'way	479	294	231	166	116
On Slip to Off-Slip	700	414	303	211	151
Main C'way	1329	1225	942	765	654
Main C'way to Off-Slip	1219	1118	850	669	571

No. of Vehs	CC1 Parameter				
Movement	**0.5**	**1**	**1.5**	**2**	**2.5**
On-slip to Main C'way	62.9%	294	-21.4%	-43.5%	-60.5%
On Slip to Off-Slip	69.1%	414	-26.8%	-49.0%	-63.5%
Main C'way	8.5%	1225	-23.1%	-37.6%	-46.6%
Main C'way to Off-Slip	9.0%	1118	-24.0%	-40.2%	-48.9%

Table 5.18 – M62 J26-J27 Change in Traffic Flow

5.11.2 Model Results M60 J16-J17 Motorway With Gradients

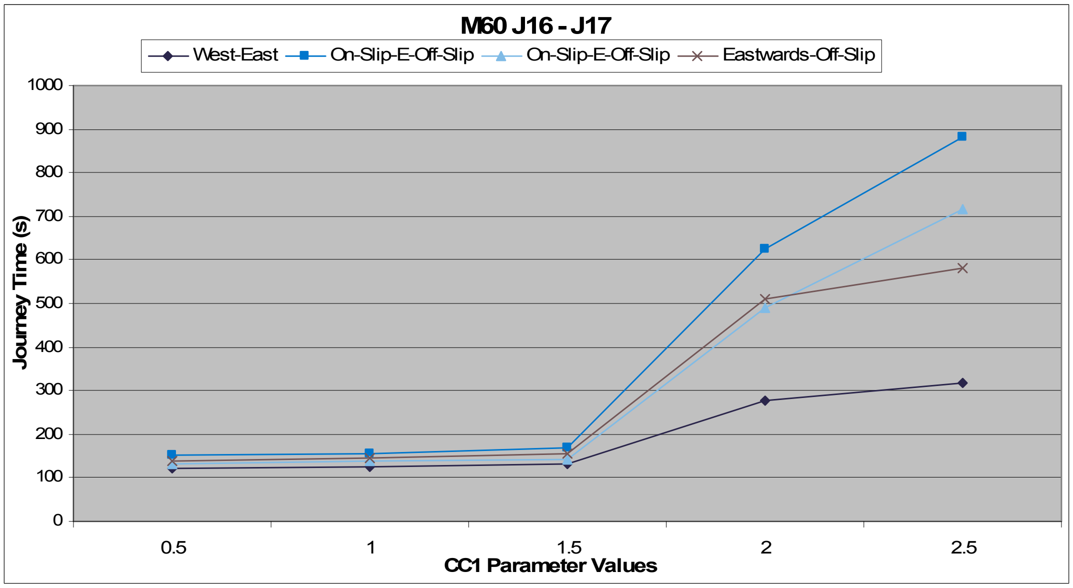


Figure 5.21 - M60 J16-J17 Motorway with Gradients Journey Time Results

Travel Time	**CC1 Parameter**				
Movement	**0.5**	**1**	**1.5**	**2**	**2.5**
West-East	122.3	125.9	130.8	276.4	317.7
On-Slip-E-Off-Slip	151.6	154.9	169.2	626.6	882.8
On-Slip-Eastwards	132.9	137.1	143.4	488.2	717.7
Eastwards-Off-Slip	139.0	143.9	155.8	508.8	582.7

Travel Time	**CC1 Parameter**				
Movement	**0.5**	**1**	**1.5**	**2**	**2.5**
West-East	-2.9%	125.9	3.9%	119.5%	152.3%
On-Slip-E-Off-Slip	-2.1%	154.9	9.2%	304.6%	470.0%
On-Slip-Eastwards	-3.0%	137.1	4.6%	256.1%	423.5%
Eastwards-Off-Slip	-3.4%	143.9	8.3%	253.7%	305.1%

Table 5.19 – M60 J16-J17 Change in Travel Time

With regard to the results displayed in Figure 5.21 and Table 5.19 it can be seen that at the lower end of the range tested there was little change in the resultant journey times. However, as the parameter value increased above 1.5 there were significant increases in the journey time over the network. This increase in Journey time was reflected in the traffic flow reductions presented in Figure 5.22 below.

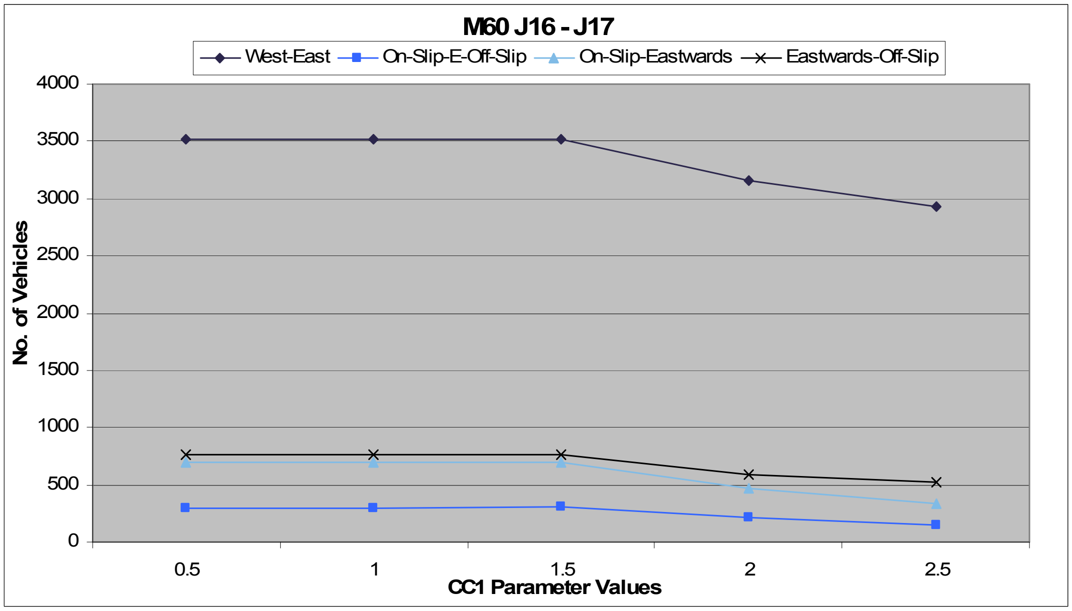


Figure 5.22 - M60 J16-J17 Motorway with Gradients Vehicle Count Data

No. of Vehs	**CC1 Parameter**				
Movement	**0.5**	**1**	**1.5**	**2**	**2.5**
West-East	3515	3515	3522	3157	2929
On-Slip-E-Off-Slip	295	296	302	213	146
On-Slip-Eastwards	693	696	700	462	337
Eastwards-Off-Slip	759	758	761	593	516

No. of Vehs	**CC1 Parameter**				
Movement	**0.5**	**1**	**1.5**	**2**	**2.5**
West-East	0.0%	3515	0.2%	-10.2%	-16.7%
On-Slip-E-Off-Slip	-0.3%	296	2.0%	-28.0%	-50.7%
On-Slip-Eastwards	-0.4%	696	0.6%	-33.6%	-51.6%
Eastwards-Off-Slip	0.1%	758	0.4%	-21.8%	-31.9%

Table 5.20 – M60 J16 - J17 Change in Traffic Flow

5.11.3 Model Results M60 J18 Signalised Motorway Intersection

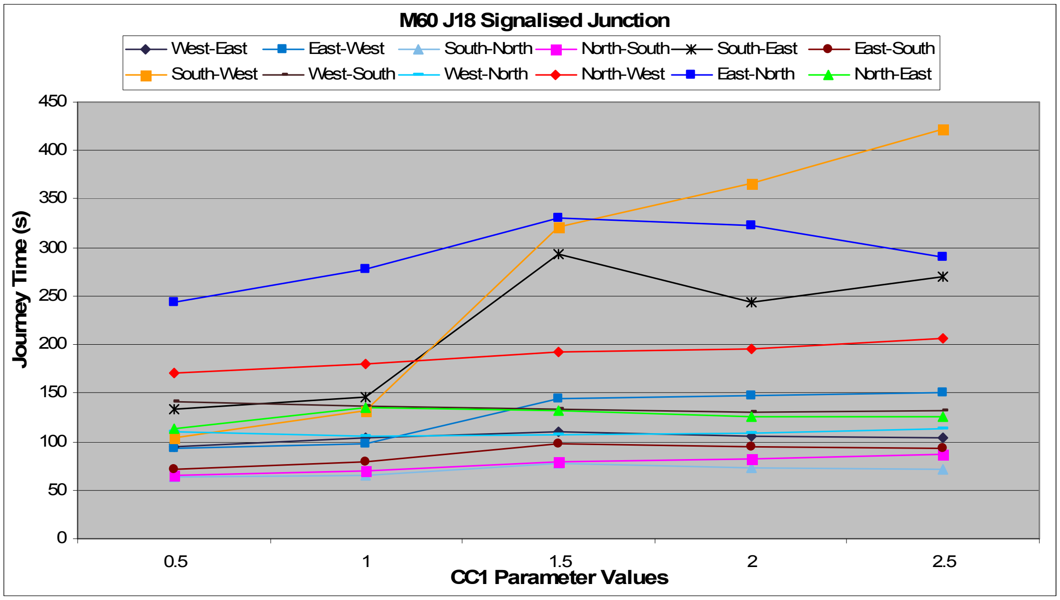


Figure 5.23 - M60 J18 Signalised Motorway Intersection Journey Time Results

Again Figure 5.23 illustrates that as CC1 increases in value, journey time also tends to increase with more impact being seen on movements which are heavily trafficked..

Travel Time			**CC1 Parameter**		
Movement	**0.5**	**1**	**1.5**	**2**	**2.5**
West-East	95.3	104.7	110.2	105.2	103.4
East-West	93.2	97.4	143.8	146.7	150.3
South-North	64.3	65.3	78.2	72.8	71.5
North-South	65.8	70.5	79.4	81.9	87.4
South-East	133.7	145.6	293.4	244.1	269.9
East-South	70.7	79.4	97.6	94.6	93.5
South-West	103.7	131.2	321.0	365.7	422.8
West-South	141.8	135.9	133.1	131.0	131.9
West-North	109.4	104.9	107.6	109.2	112.9
North-West	170.9	179.7	191.7	195.3	206.0
East-North	243.7	277.6	330.7	322.1	290.2
North-East	112.7	134.3	131.8	125.4	125.8

Travel Time			**CC1 Parameter**		
Movement	**0.5**	**1**	**1.5**	**2**	**2.5**
West-East	-9.0%	104.7	5.2%	0.4%	-1.3%
East-West	-4.3%	97.4	47.6%	50.6%	54.3%
South-North	-1.5%	65.3	19.7%	11.4%	9.5%
North-South	-6.6%	70.5	12.6%	16.2%	24.0%
South-East	-8.2%	145.6	101.6%	67.7%	85.4%
East-South	-11.0%	79.4	22.9%	19.1%	17.7%
South-West	-21.0%	131.2	144.6%	178.7%	222.2%
West-South	4.3%	135.9	-2.1%	-3.6%	-2.9%
West-North	4.4%	104.9	2.6%	4.2%	7.7%
North-West	-4.9%	179.7	6.7%	8.7%	14.6%
East-North	-12.2%	277.6	19.1%	16.0%	4.5%
North-East	-16.1%	134.3	-1.8%	-6.6%	-6.3%

Table 5.21 – M60 J18 Change in Travel Time

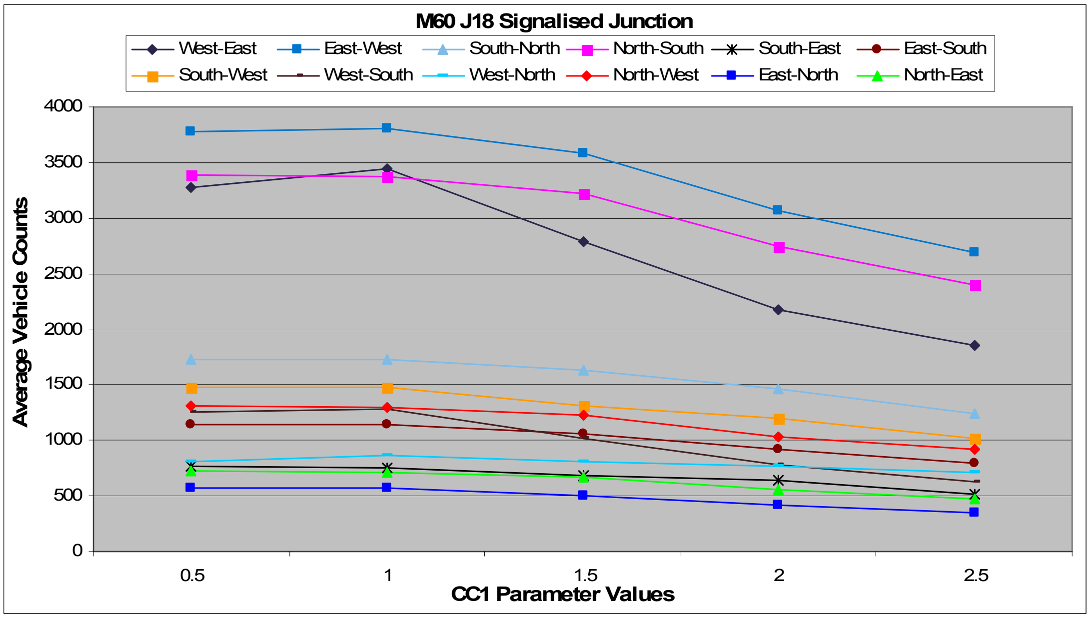


Figure 5.24 - M60 J18 Signalised Motorway Intersection Vehicle Count Data

As with the previous examples Figure 5.24 demonstrates that increasing the CC1 parameter has a significant impact upon vehicle counts.

No. of Vehs	CC1 Parameter				
Movement	**0.5**	**1**	**1.5**	**2**	**2.5**
West-East	3276	3448	2792	2181	1850
East-West	3779	3800	3586	3073	2683
South-North	1729	1733	1634	1468	1242
North-South	3383	3377	3225	2747	2396
South-East	761	759	689	639	521
East-South	1140	1149	1065	918	790
South-West	1483	1481	1316	1194	1021
West-South	1252	1278	1021	782	627
West-North	806	863	806	764	707
North-West	1304	1301	1226	1033	921
East-North	570	567	495	413	343
North-East	718	711	669	557	472

No. of Vehs	CC1 Parameter				
Movement	**0.5**	**1**	**1.5**	**2**	**2.5**
West-East	-5.0%	3448	-19.0%	-36.7%	-46.3%
East-West	-0.6%	3800	-5.6%	-19.1%	-29.4%
South-North	-0.2%	1733	-5.7%	-15.3%	-28.3%
North-South	0.2%	3377	-4.5%	-18.7%	-29.0%
South-East	0.3%	759	-9.2%	-15.8%	-31.4%
East-South	-0.8%	1149	-7.3%	-20.1%	-31.2%
South-West	0.1%	1481	-11.1%	-19.4%	-31.1%
West-South	-2.0%	1278	-20.1%	-38.8%	-50.9%
West-North	-6.6%	863	-6.6%	-11.5%	-18.1%
North-West	0.2%	1301	-5.8%	-20.6%	-29.2%
East-North	0.5%	567	-12.7%	-27.2%	-39.5%
North-East	1.0%	711	-5.9%	-21.7%	-33.6%

Table 5.22 – M60 J18 Change in Traffic Flow

5.12 CC1 Model Results Summary

- In general increasing CC1 has the effect of increasing the journey time and reducing the number of vehicles able to complete their route.

As the capacity of the motorway is heavily dictated by the value of CC1 selected there would need to be a strong case for adopting values of CC1 that differed more than +/-10% from the default value of 0.9 seconds.

5.13 CC2

In this section the parameter investigated is the CC2 value (default=4), the Following Variation. In order to understand the affect this parameter has on the driver behaviour, a range of test values were used

Value range - 2, 3, 4, 5, 6, 7, 8, 9 and 10.

As indicated the default value is 4m which is considered by PTV to be the optimum value for stable results. The testing has taken the value to an extreme of 10m. This is not expected to be seen as part of any model but was used to observe the effects of a wide range of values for the parameter.

5.13.1 Model Results M62 J26-J27 Weaving Section

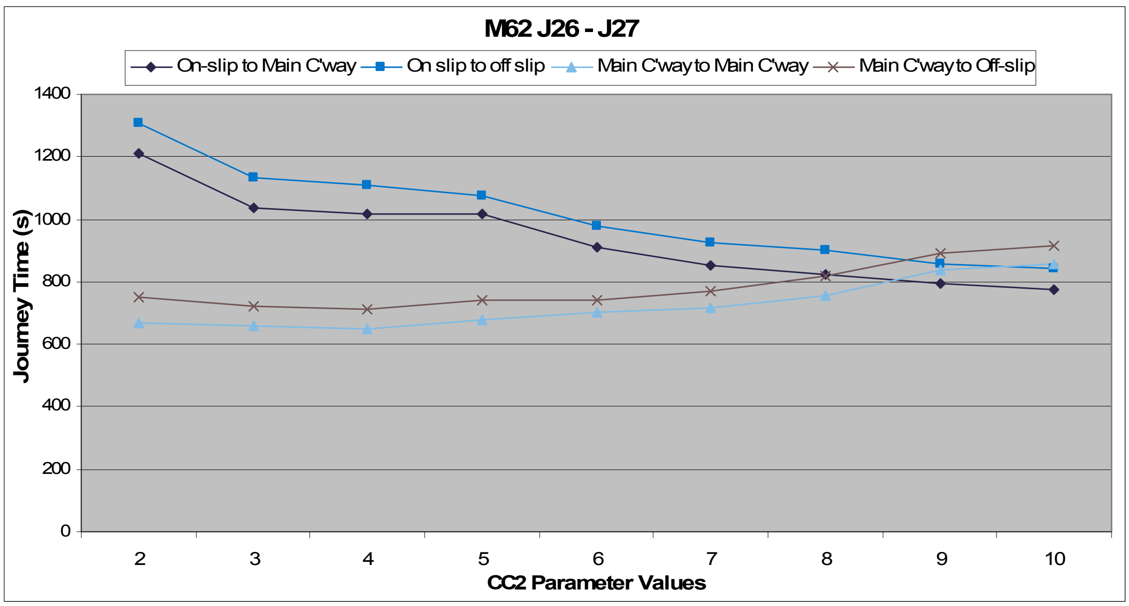


Figure 5.25 - M62 J26-J27 Weaving Section Model Journey Time Results

Travel Time	CC2 Parameter Values								
Movement	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
On-slip to Main C'way	1213.1	1038.7	1016.2	1015.1	910.2	854.7	825.3	792.6	776.3
On slip to off slip	1308.3	1134.3	1107	1077	980.7	926.6	902.4	858.4	843.8
Main C'way to Main C'way	669.6	659.7	651.2	680.1	702.3	719.2	756.2	838.6	857.7
Main C'way to Off-slip	751.3	722	713.3	741.8	740.4	767.9	819.7	892.2	916.2

Travel Time	CC2 Parameter Values								
Movement	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
On-slip to Main C'way	19.4%	2.2%	Default	-0.1%	-10.4%	-15.9%	-18.8%	-22.0%	-23.6%
On slip to off slip	18.2%	2.5%		-2.7%	-11.4%	-16.3%	-18.5%	-22.5%	-23.8%
Main C'way to Main C'way	2.8%	1.3%		4.4%	7.8%	10.4%	16.1%	28.8%	31.7%
Main C'way to Off-slip	5.3%	1.2%		4.0%	3.8%	7.7%	14.9%	25.1%	28.4%

Table 5.23 – M62 J26 – J27 Change in Journey Time

This model represents a different network configuration with only a merge and diverge occurring on the mainline carriageway. However, the different traffic streams displayed different characteristics with the traffic merging from the slip road showing reduced journey times while the that for the mainline traffic increased. This again will be a result of increased gaps in the mainline traffic making it easier for the sliproad traffic to access the mainline.

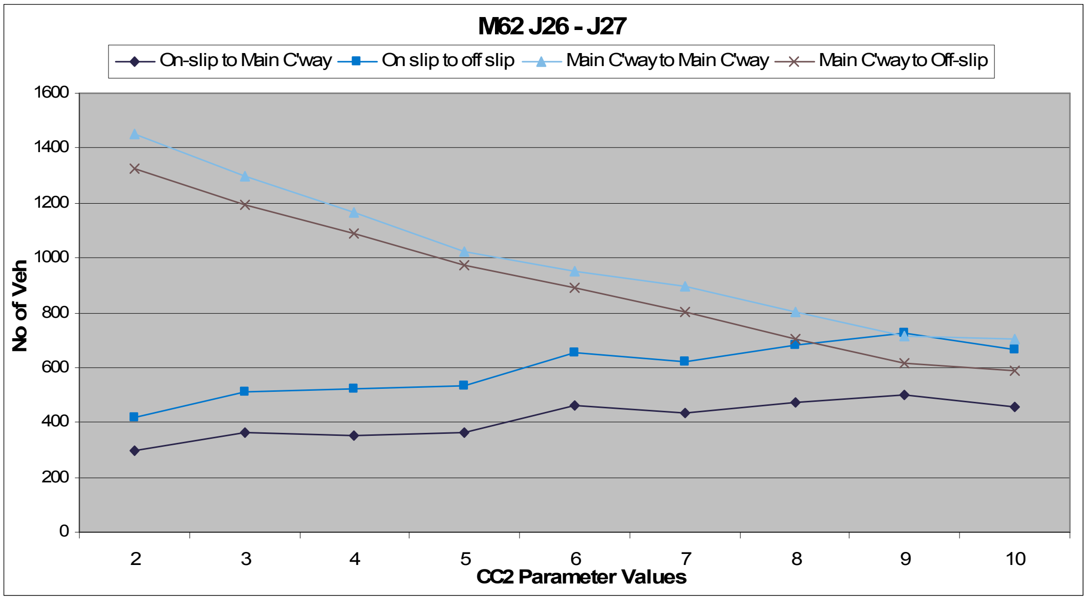


Figure 5.26 - M62 J26-J27 Weaving Section Model Vehicle Count Data

No. of Vehs.	CC2 Parameter Values								
Movement	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
On-slip to Main C'way	298	364	353	361	463	437	473	498	458
On slip to off slip	420	514	520	534	656	620	683	724	668
Main C'way to Main C'way	1451	1296	1168	1025	951	898	802	713	705
Main C'way to Off-slip	1323	1195	1089	975	888	804	705	617	590

No. of Vehs.	CC2 Parameter Values								
Movement	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
On-slip to Main C'way	-15.6%	3.1%	Default	2.3%	31.2%	23.8%	34.0%	41.1%	29.7%
On slip to off slip	-19.2%	-1.2%		2.7%	26.2%	19.2%	31.3%	39.2%	28.5%
Main C'way to Main C'way	24.2%	11.0%		-12.2%	-18.6%	-23.1%	-31.3%	-39.0%	-39.6%
Main C'way to Off-slip	21.5%	9.7%		-10.5%	-18.5%	-26.2%	-35.3%	-43.3%	-45.8%

Table 5.24 – M62 J26 – J27 Change in Traffic Flow

The vehicle count graph gives a similar result to that in the previous example in that as the parameter value increases the number of vehicles passing through the model decreases.

Figures 5.25 and 5.26 represent what a user of VISSIM would expect when running a micro simulation model. That is, when running a model it will behave in a way that, when the vehicle count on a network increases, the journey time will decrease as well. However, this will only occur until the network becomes saturated with vehicles and the journey time will increase dramatically as the model 'breaks'.

This 'break' in the model can be seen at the end of each graph although this may only be due to the global effect of the change in CC2 values.

5.13.2 Model Results M60 J16-J17 Motorway With Gradients

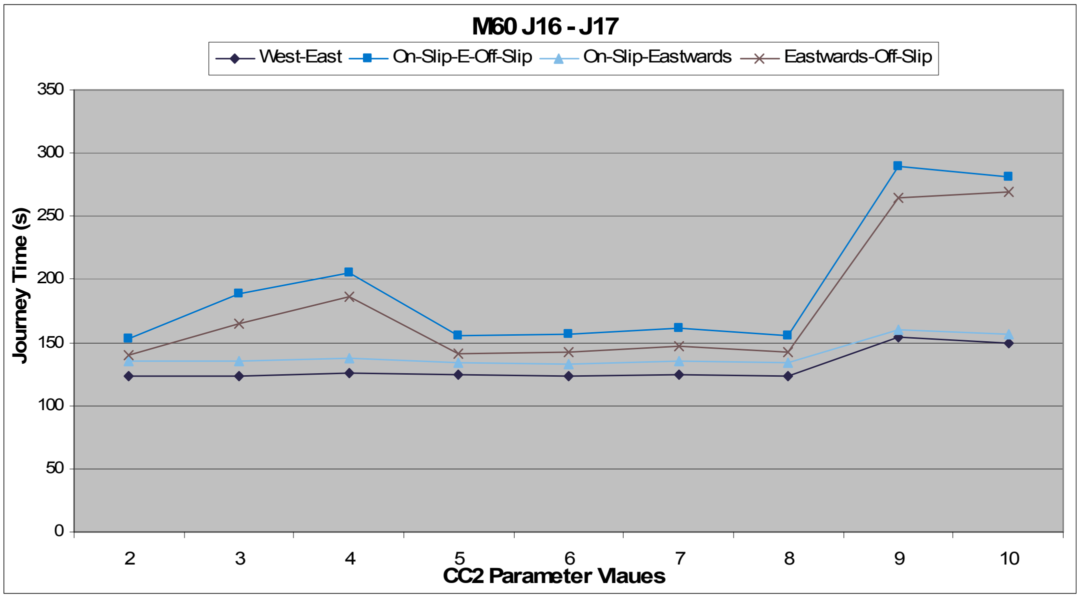


Figure 5.27- M60 J16-J17 Motorway with Gradients Journey Time Results

Travel Time	CC2 Parameter Values								
Movement	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
West-East	123.5	123.6	126.3	124.1	123.0	124.1	123.1	153.8	150.0
On-Slip-E-Off-Slip	153.5	188.5	204.8	155.7	156.6	161.2	155.7	289.8	281.3
On-Slip-Eastwards	135.0	135.6	137.9	133.6	133.3	135.0	133.7	160.2	156.2
Eastwards-Off-Slip	140.0	165.0	186.7	141.2	142.2	146.7	142.9	264.4	269.5

Travel Time	CC2 Parameter Values								
Movement	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
West-East	-2.3%	-2.2%	Default	-1.8%	-2.6%	-1.8%	-2.6%	21.7%	18.8%
On-Slip-E-Off-Slip	-25.0%	-8.0%		-24.0%	-23.5%	-21.3%	-24.0%	41.5%	37.4%
On-Slip-Eastwards	-2.1%	-1.6%		-3.1%	-3.3%	-2.0%	-3.0%	16.2%	13.3%
Eastwards-Off-Slip	-25.0%	-11.6%		-24.3%	-23.8%	-21.4%	-23.5%	41.6%	44.4%

Table 5.25 – M60 J16 – J17 Change in Journey Time

The variation in results displayed in Figure 5.27 suggest that for this particular network, M60 J16 – J17 - Motorway with Gradients, the impact of the gradient and the increase in the CC2 value combine to make any definitive conclusion difficult. However, there is still an upward trend in the journey times as the parameter value increases.

An interesting feature of Figure 5.27 is the shape of the graph where there is a slight levelling off of journey times between 5 and 8 before a return to the higher values seen at CC2 values of 3and 4.

When using a smaller value of CC2, main stream traffic has minimum safe distance between vehicles which in turn restricts merging traffic from the on slip. However as the CC2 value increases, the safe distance/following variation between vehicles increases and merging vehicles fit in easier to enter the mainstream traffic flow.

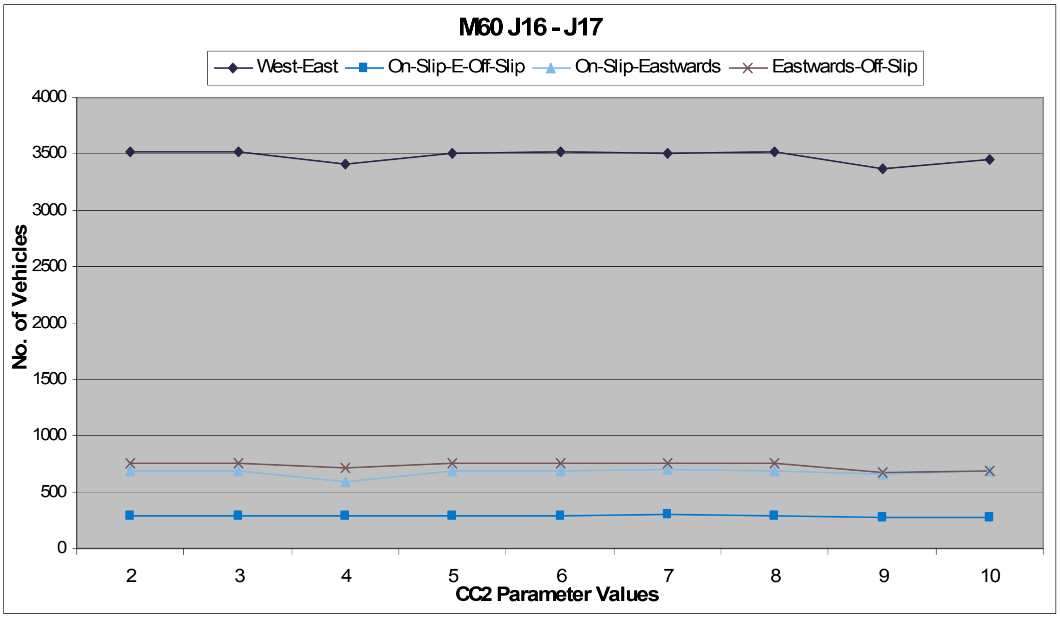


Figure 5.28 - M60 J16-J17 Motorway with Gradients Vehicle Count Data

No. of Vehs.	**CC2 Parameter Values**								
Movement	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
West-East	3517	3517	3414	3509	3514	3511	3514	3374	3451
On-Slip-E-Off-Slip	293	293	285	294	293	299	293	281	276
On-Slip-Eastwards	694	693	586	693	693	697	693	666	684
Eastwards-Off-Slip	757	757	718	759	760	759	759	677	683

No. of Vehs.	**CC2 Parameter Values**								
Movement	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
West-East	3.0%	3.0%	Default	2.8%	2.9%	2.8%	2.9%	-1.2%	1.1%
On-Slip-E-Off-Slip	2.8%	2.8%		3.2%	2.8%	4.9%	2.8%	-1.4%	-3.2%
On-Slip-Eastwards	18.4%	18.3%		18.3%	18.3%	18.9%	18.3%	13.7%	16.7%
Eastwards-Off-Slip	5.4%	5.4%		5.7%	5.8%	5.7%	5.7%	-5.7%	-4.9%

Table 5.26 – M60 J16 – J17 Change in Traffic Flow

Figure 5.28 shows that while there is a downward trend in the traffic flow in this network, particularly at the higher end of the range, there tends to be distinct variations from the default value which was at the lower end of the vehicle count range. While this particular model is free flowing and there are no real obstacles for vehicles to overcome there is a gradient which could change the vehicle count on the main carriageway from west to east. This causes HGV's and other large vehicles to slow and create a shockwave effect through the traffic, speeding up on the down slopes and slowing on the Gradients.

5.13.3 Model Results M60 J18 Signalised Motorway Intersection

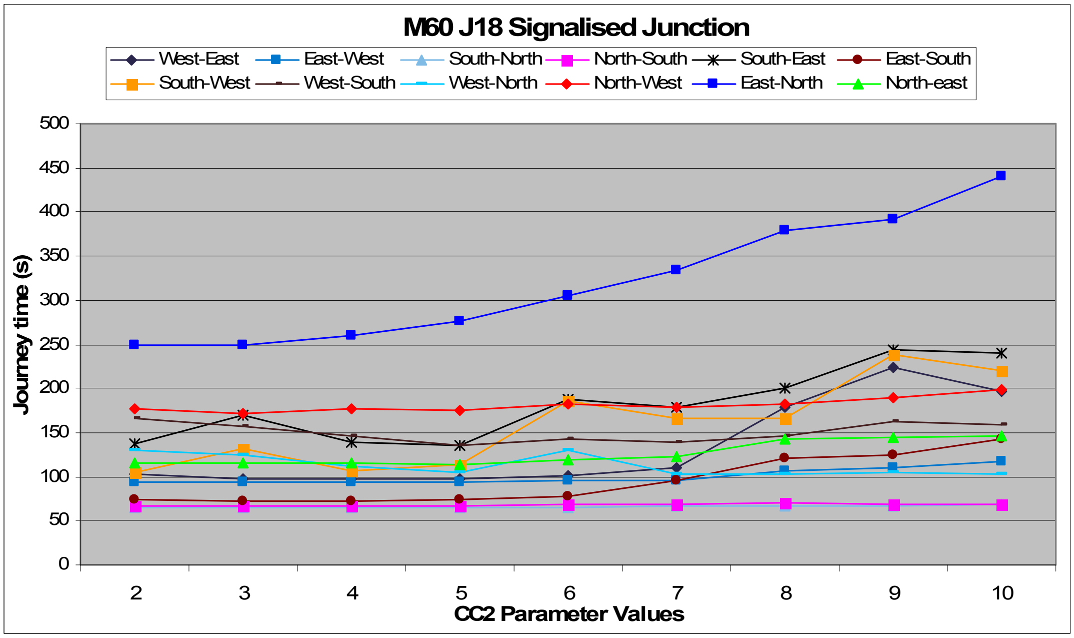


Figure 5.29 - M60 J18 Signalised Motorway Intersection Journey Time Results

Travel Time	**CC2 Parameter Values**								
Movement	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
West-East	102.0	97.7	97.1	97.2	101.6	109.7	178.3	224.1	195.9
East-West	94.4	94.6	94.2	94.6	94.8	95.8	106.5	110.2	117.3
South-North	65.0	65.1	64.8	65.0	65.8	66.6	66.0	67.4	68.1
North-South	66.6	67.2	66.8	67.5	68.5	68.9	69.5	69.2	68.6
South-East	137.4	169.1	138.7	135.8	187.7	179.1	199.8	243.4	239.5
East-South	73.2	71.9	72.1	73.6	76.8	96.5	120.2	124.1	143.3
South-West	104.6	132.1	106.2	113.1	185.8	165.2	166.7	238.1	220.3
West-South	166.9	157.9	146.5	135.5	142.0	139.9	146.4	162.8	159.3
West-North	130.2	124.6	112.8	105.5	129.1	102.6	102.3	105.0	102.6
North-West	177.0	170.8	177.1	174.9	182.2	178.1	183.1	189.5	198.4
East-North	248.7	249.2	259.2	276.7	304.3	334.4	378.2	391.7	440.8
North-east	114.7	114.7	115.7	114.5	119.2	122.9	142.6	144.4	146.4

Travel Time	**CC2 Parameter Values**								
Movement	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
West-East	5.1%	0.6%	**Default**	0.1%	4.7%	13.0%	83.6%	130.8%	101.8%
East-West	0.2%	0.3%		0.4%	0.6%	1.7%	13.0%	16.9%	24.5%
South-North	0.3%	0.4%		0.3%	1.6%	2.7%	1.9%	3.9%	5.1%
North-South	-0.3%	0.6%		1.1%	2.5%	3.2%	4.1%	3.6%	2.8%
South-East	-0.9%	21.9%		-2.1%	35.4%	29.2%	44.1%	75.6%	72.7%
East-South	1.6%	-0.3%		2.2%	6.6%	33.9%	66.7%	72.2%	98.8%
South-West	-1.6%	24.4%		6.4%	74.9%	55.5%	57.0%	124.1%	107.4%
West-South	13.9%	7.8%		-7.5%	-3.1%	-4.5%	-0.1%	11.1%	8.7%
West-North	15.4%	10.5%		-6.5%	14.5%	-9.1%	-9.3%	-6.9%	-9.0%
North-West	-0.1%	-3.5%		-1.2%	2.9%	0.6%	3.4%	7.0%	12.0%
East-North	-4.1%	-3.9%		6.7%	17.4%	29.0%	45.9%	51.1%	70.0%
North-east	-0.9%	-0.8%		-1.0%	3.0%	6.2%	23.2%	24.8%	26.6%

Table 5.27 – M60 J18 Change in Journey Time

The Signalised Motorway Interchange shows, in a more definite manor, similar results to the previous network. The journey time results are more stable at the lower end of the range but increase rapidly from values of 6 upward.

In general, the movements which negotiated more traffic signals tended to experience more delays eg east to north, south to east. This is considered to be due to the impact of the increasing space between the vehicles as the parameter increased together with the signals at the Intersection which control the flow of traffic. In the previous model there was no use of traffic signals so the entry and merging of vehicles was purely down to driver behaviour and reactions. However with the signalised motorway interchange the traffic signals provide a controlled flow of traffic in to the junction. The steady increase in journey time with increasing CC2 value confirms the findings from the previous tests.

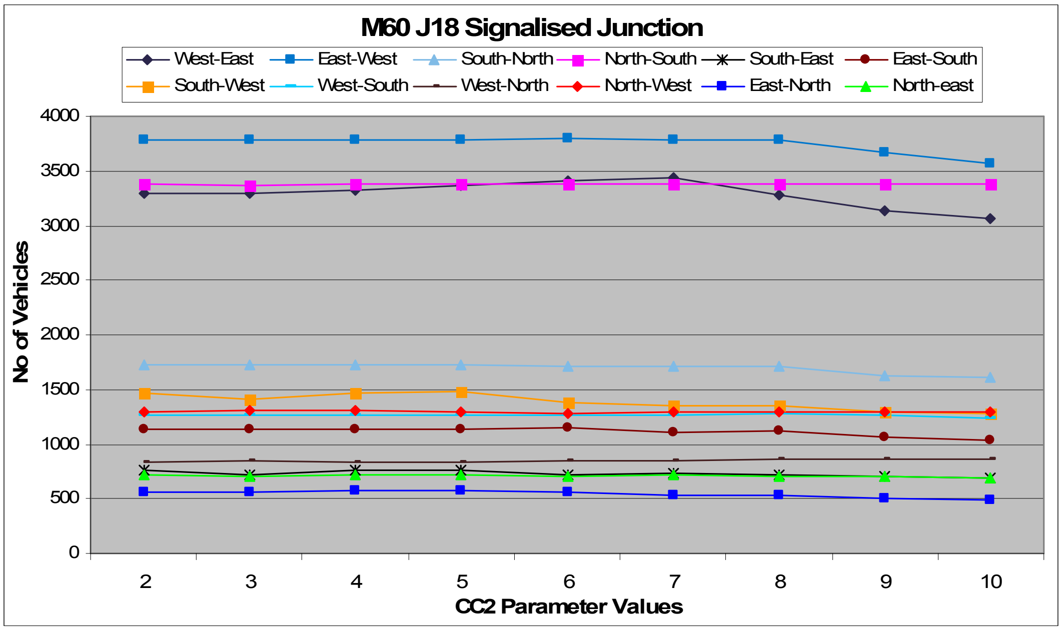


Figure 5.30 - M60 J18 Signalised Motorway Intersection Vehicle Count Data

The results displayed in Figure 5.30 confirm the earlier findings in that the flow through the model has decreased as the parameter value increased. Once again, the reduction becomes more pronounced at the higher end of the range. If these values are not included in the graph then there would be a steady vehicle throughout the change in CC2.

No. of Vehs.	**CC2 Parameter Values**								
Movement	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
West-East	3292	3291	3318	3372	3408	3436	3279	3138	3071
East-West	3783	3790	3781	3782	3799	3782	3789	3676	3568
South-North	1726	1729	1729	1732	1717	1707	1715	1624	1611
North-South	3375	3374	3383	3382	3383	3379	3381	3381	3383
South-East	758	723	759	759	723	728	723	702	697
East-South	1140	1140	1141	1140	1147	1111	1127	1063	1032
South-West	1467	1407	1465	1485	1388	1350	1359	1299	1284
West-South	1260	1263	1264	1261	1263	1264	1276	1267	1239
West-North	834	843	838	836	848	844	860	867	859
North-West	1297	1303	1310	1301	1283	1297	1294	1296	1291
East-North	562	556	570	572	563	527	527	505	490
North-east	714	712	718	716	708	716	700	710	696

No. of Vehs.	CC2 Parameter Values								
Movement	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
West-East	-0.8%	-0.8%	Default	1.6%	2.7%	3.6%	-1.2%	-5.4%	-7.4%
East-West	0.1%	0.2%		0.0%	0.5%	0.0%	0.2%	-2.8%	-5.6%
South-North	-0.2%	0.0%		0.2%	-0.7%	-1.3%	-0.8%	-6.1%	-6.8%
North-South	-0.2%	-0.3%		0.0%	0.0%	-0.1%	-0.1%	-0.1%	0.0%
South-East	-0.1%	-4.7%		0.0%	-4.7%	-4.1%	-4.7%	-7.5%	-8.2%
East-South	-0.1%	-0.1%		-0.1%	0.5%	-2.6%	-1.2%	-6.8%	-9.6%
South-West	0.1%	-4.0%		1.4%	-5.3%	-7.8%	-7.2%	-11.3%	-12.4%
West-South	-0.3%	-0.1%		-0.2%	-0.1%	0.0%	0.9%	0.2%	-2.0%
West-North	-0.5%	0.6%		-0.2%	1.2%	0.7%	2.6%	3.5%	2.5%
North-West	-1.0%	-0.5%		-0.7%	-2.1%	-1.0%	-1.2%	-1.1%	-1.5%
East-North	-1.4%	-2.5%		0.4%	-1.2%	-7.5%	-7.5%	-11.4%	-14.0%
North-east	-0.6%	-0.8%		-0.3%	-1.4%	-0.3%	-2.5%	-1.1%	-3.1%

Table 5.28 – M60 J18 Change in Traffic Flow

5.14 CC2 Model Summary

- Vehicle counts all drop with the increase in CC2.
- Similarly to CC1, the additional distance being created between vehicles increases the queue length.
- When viewing the error file, it indicates that as CC2 increases there is also a gradual increase in unreleased vehicles.
- As stated in the PTV VISSIM manual, CC2 values outwith the default value of 4 can cause unstable vehicle activity especially under free flow situations.
- The congested model indicates journey times are greater when using the default value of 4.
- Looking at all graphs involved there seems to be a pattern occurring where CC2 values at the higher end of the range presents results which can become very unstable.

5.15 CC3

In this section the parameter investigated is the CC3 value which impacts on the behaviour of vehicles as they decelerate towards vehicles ahead. The default for motorway type links is -8secs.

5.15.1 Model Results M62 J26-J27 Weaving Section

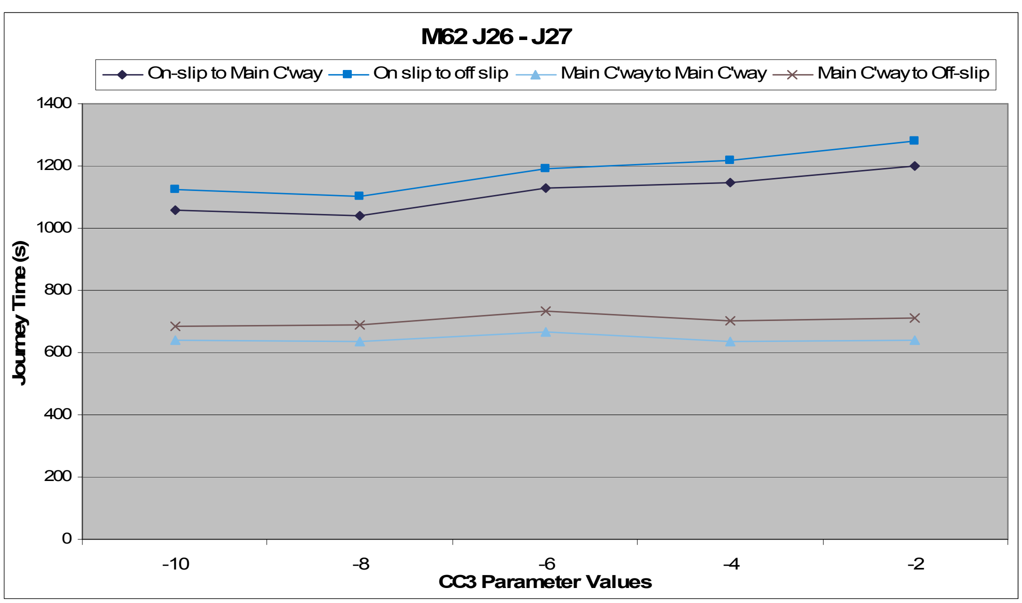


Figure 5.31 - M62 J26-J27 Weaving Section Model Journey Time Results

Travel Time	**CC3 Parameter Values**				
Movement	**-10**	**-8**	**-6**	**-4**	**-2**
On-slip to Main C'way	1056.7	1039.5	1130.7	1144.5	1199
On slip to off slip	1122.8	1101.1	1193.2	1219.7	1278.2
Main C'way to Main C'way	641.4	637.5	666.4	636.4	639.4
Main C'way to Off-slip	686	689.5	732.4	702.8	711

Travel Time	**CC3 Parameter Values**				
Movement	**-10**	**-8**	**-6**	**-4**	**-2**
On-slip to Main C'way	1.7%	Default	8.8%	10.1%	15.3%
On slip to off slip	2.0%		8.4%	10.8%	16.1%
Main C'way to Main C'way	0.6%		4.5%	-0.2%	0.3%
Main C'way to Off-slip	-0.5%		6.2%	1.9%	3.1%

Table 5.29 – M62 J26-J27 Change in Journey Time

This weaving section model shows a different result to the congested motorway interchange even though this is also a congested network. The problem with this is the weaving nature of the vehicles on the on slip merge with the mainline vehicles. Using a large value of CC3 in the model makes the vehicles break earlier and in turn create safer movement through the network for all vehicles. As the CC3 value decreases this safety reduces, drivers become more erratic and hence increase their travel times.

Looking at the line of best fit gives a good indication at the behaviour of the vehicles through journey time.

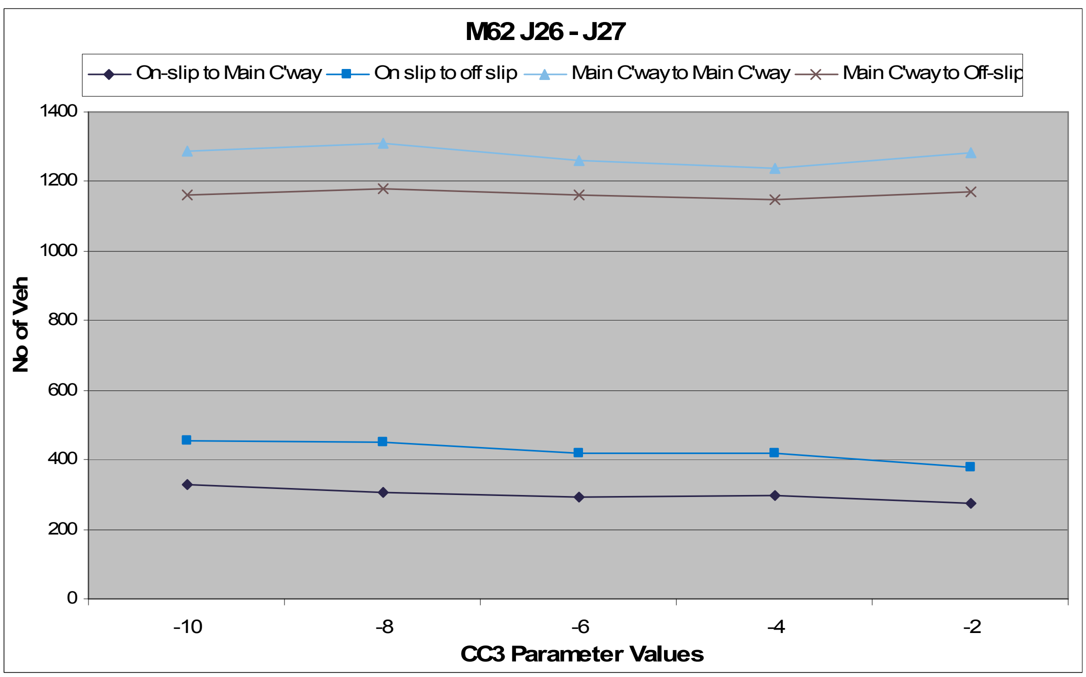


Figure 5.32 - M62 J26-J27 Weaving Section Model Vehicle Count Data

No. of Vehs.	**CC3 Parameter Values**				
Movement	**-10**	**-8**	**-6**	**-4**	**-2**
On-slip to Main C'way	328	305	293	296	274
On slip to off slip	455	450	420	419	377
Main C'way to Main C'way	1287	1312	1262	1240	1282
Main C'way to Off-slip	1162	1179	1162	1148	1172

No. of Vehs.	CC3 Parameter Values				
Movement	**-10**	**-8**	**-6**	**-4**	**-2**
On-slip to Main C'way	7.5%	Default	-3.9%	-3.0%	-10.2%
On slip to off slip	1.1%		-6.7%	-6.9%	-16.2%
Main C'way to Main C'way	-1.9%		-3.8%	-5.5%	-2.3%
Main C'way to Off-slip	-1.4%		-1.4%	-2.6%	-0.6%

Table 5.30 – M62 J26-J27 Change in Traffic Flow

While Figure 5.32 indicates that the reduction of CC3 had little impact on the mainline flow while reducing the flow from the slip road to the mainline. This compares well with the journey time findings which should increased journey time for the slip road traffic with little variation for the mainline.

5.15.2 Model Results M60 J16-J17 Motorway With Gradients

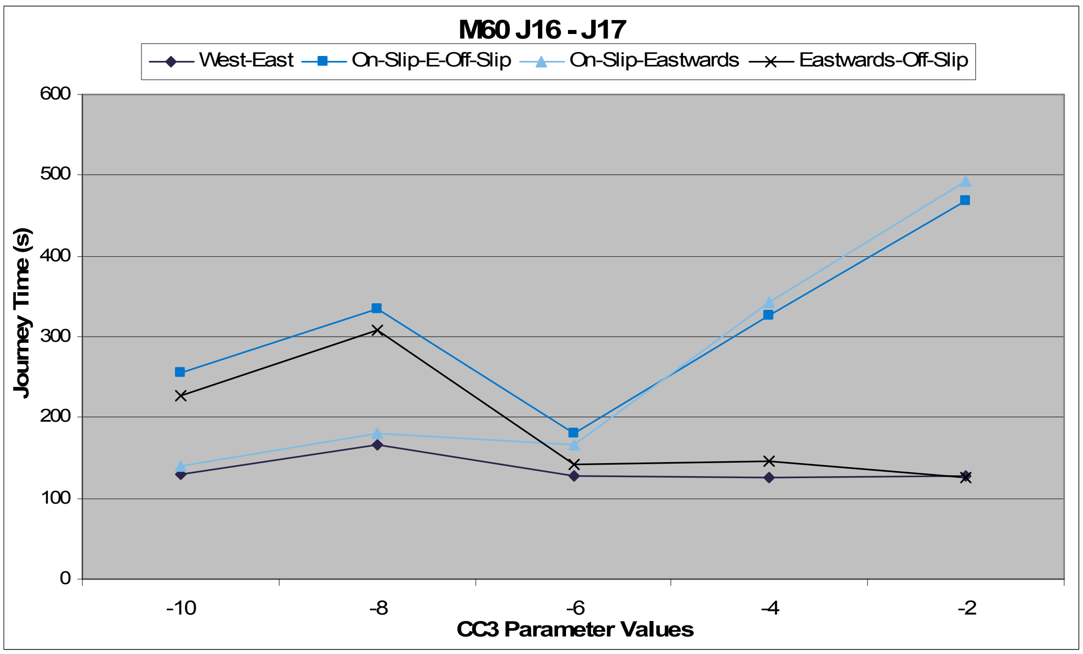


Figure 5.33 - M60 J16-J17 Motorway with Gradients Journey Time Results

Travel Time	CC3 Parameter Values				
Movement	**-10**	**-8**	**-6**	**-4**	**-2**
West-East	129.5	167.2	127.2	126.5	127.3
On-Slip-E-Off-Slip	254.9	334.9	180.9	325.4	467.9
On-Slip-Eastwards	140.3	179.5	166.6	343.2	493.1
Eastwards-Off-Slip	227.3	308.6	141.5	145.6	125.2

Travel Time	CC3 Parameter Values				
Movement	**-10**	**-8**	**-6**	**-4**	**-2**
West-East	-22.6%	Default	-23.9%	-24.3%	-23.8%
On-Slip-E-Off-Slip	-23.9%		-46.0%	-2.8%	39.7%
On-Slip-Eastwards	-21.9%		-7.2%	91.2%	174.7%
Eastwards-Off-Slip	-26.4%		-54.2%	-52.8%	-59.4%

Table 5.31 – M60 J16-J17 Change in Journey Time

Figure 5.33 shows the behaviour of different CC3 values in the gradient model. It shows that as the parameter increased in value (towards -2) the journey time increased for the traffic entering from the slip road while the mainline traffic flow journey time tended to reduce. At the lower end (-10,-8) the higher journey times were experienced by traffic heading toward the off-slip.

The mix of results from this model suggest that the impact of the gradient together with the change in the parameter value make it less clear how the change in the parameter has affected the operation of the network.

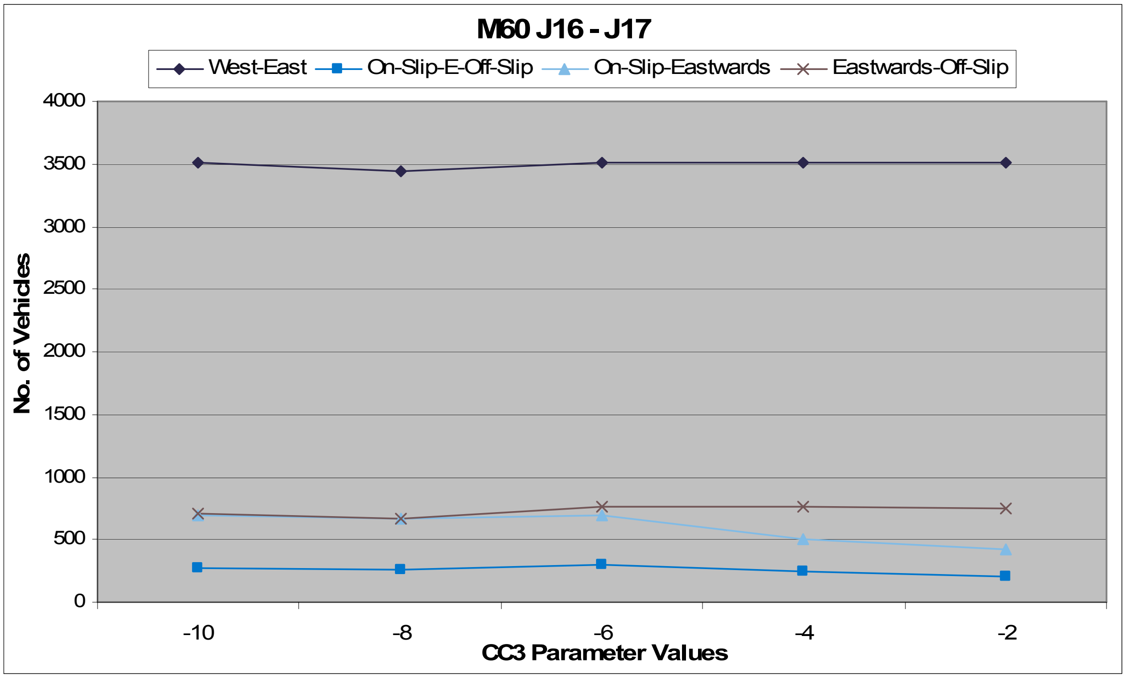


Figure 5.34 - M60 J16-J17 Motorway with Gradients Vehicle Count Data

No. of Vehs.	CC3 Parameter Values				
Movement	**-10**	**-8**	**-6**	**-4**	**-2**
West-East	3510	3442	3514	3513	3508
On-Slip-E-Off-Slip	274	254	296	242	209
On-Slip-Eastwards	694	673	694	507	424
Eastwards-Off-Slip	710	661	757	759	755

No. of Vehs.	CC3 Parameter Values				
Movement	**-10**	**-8**	**-6**	**-4**	**-2**
West-East	2.0%	Default	2.1%	2.1%	1.9%
On-Slip-E-Off-Slip	7.9%		16.5%	-4.7%	-17.7%
On-Slip-Eastwards	3.1%		3.1%	-24.7%	-37.0%
Eastwards-Off-Slip	7.4%		14.5%	14.8%	14.2%

Table 5.32 – M60 J16-J17 Change in Traffic Flow

Figure 5.34 and Table 5.32 show that as the parameter increased the number of vehicles running on the mainline showed little change while the numbers entering from the slip road decreased significantly in the time period allocated. This relates to Figure 5.33 in that as the journey time rises the number of vehicles counted falls. It is noticeable that the variation in the free flow models is much greater than in the congested networks. This is because there is much more scope for change in the free flow models ie. if the vehicles are nose to tail in a model then there isn't much area for change whereas in a model where vehicles are flowing freely and not being held up by any other vehicles there is area for change within the model.

It can be concluded from the motorway with gradients model that CC3 values should always be larger ie. -10 rather than -2 when running a free flow model.

5.15.3 Model Results M60 J18 Signalised Motorway Intersection

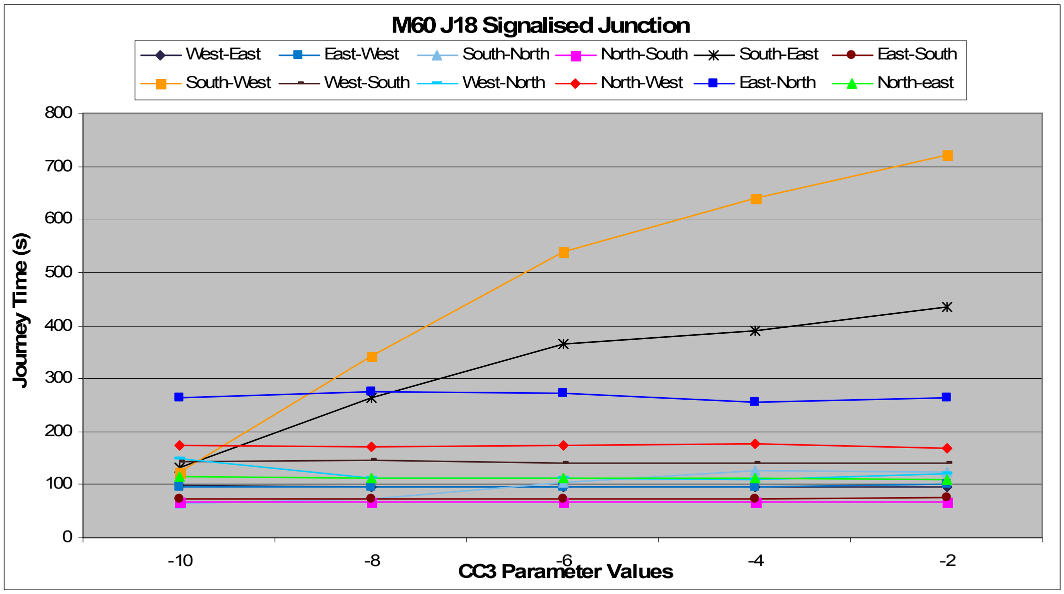


Figure 5.35 - M60 J18 Signalised Motorway Intersection Journey Time Results

Travel Time	**CC3 Parameter Values**				
Movement	**-10**	**-8**	**-6**	**-4**	**-2**
West-East	96.9	96.1	96.2	95.9	96.1
East-West	95.3	95.6	96.3	96.8	99.9
South-North	64.9	73.3	104.0	125.3	122.9
North-South	67.2	67.5	66.8	67.0	67.5
South-East	132.8	263.3	365.8	389.2	435.9
East-South	71.7	74.0	72.6	73.3	75.0
South-West	123.7	342.8	539.9	639.7	720.7
West-South	143.7	144.6	141.5	140.2	141.4
West-North	149.9	113.1	112.0	110.2	121.4
North-West	173.6	172.0	172.7	176.8	168.9
East-North	263.1	273.8	272.9	256.8	262.6
North-east	116.2	112.2	112.7	111.9	109.2

Travel Time	**CC3 Parameter Values**				
Movement	**-10**	**-8**	**-6**	**-4**	**-2**
West-East	0.8%	Default	0.0%	-0.3%	-0.1%
East-West	-0.4%		0.7%	1.3%	4.4%
South-North	-11.5%		41.8%	70.9%	67.7%
North-South	-0.4%		-1.1%	-0.8%	0.0%
South-East	-49.6%		38.9%	47.8%	65.6%
East-South	-3.0%		-1.9%	-0.9%	1.4%
South-West	-63.9%		57.5%	86.6%	110.2%
West-South	-0.6%		-2.1%	-3.0%	-2.2%
West-North	32.6%		-0.9%	-2.5%	7.3%
North-West	0.9%		0.4%	2.8%	-1.8%
East-North	-3.9%		-0.3%	-6.2%	-4.1%
North-east	3.5%		0.4%	-0.3%	-2.7%

Table 5.33 – M60 J18 Change in Journey Time

The majority of the movements tended to reduce or showed little change as the CC3 parameter was varied. However, the movements from the heavily trafficked south approach were seen to increase significantly. This result is in line with that reported in the previous section of this report, CC2. However, the increase in journey time with CC3 may be attributed to the fact that vehicles are reacting to each other at a later time leading to increased vehicle interaction and the resultant shockwaves causing delays.

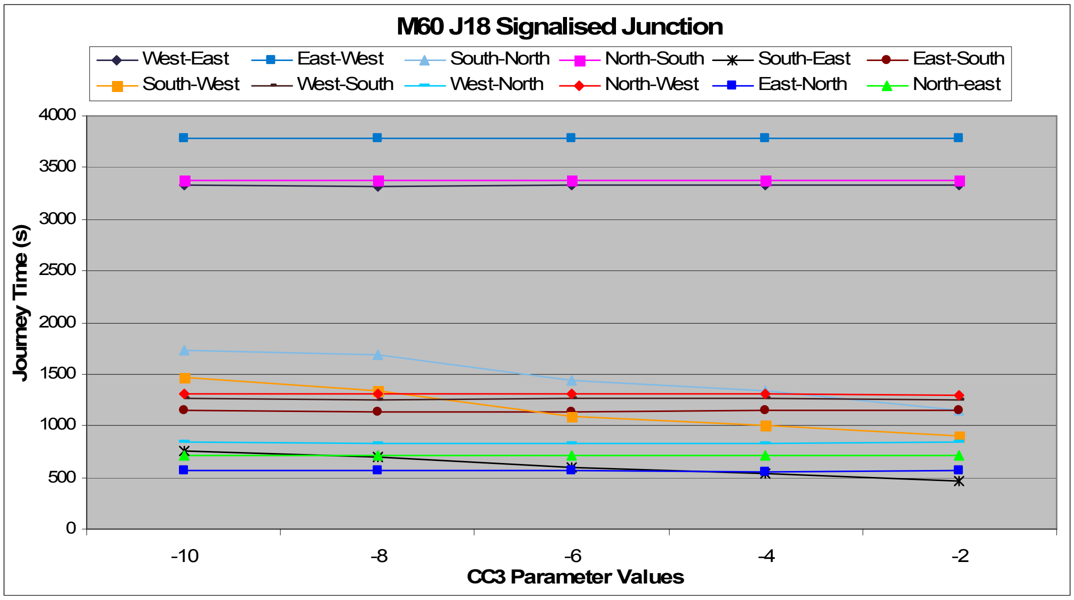


Figure 5.36 - M60 J18 Signalised Motorway Intersection Vehicle Count Data

No. of Vehs.	**CC3 Parameter Values**				
Movement	**-10**	**-8**	**-6**	**-4**	**-2**
West-East	3333	3315	3330	3334	3325
East-West	3777	3784	3785	3777	3786
South-North	1726	1685	1445	1341	1150
North-South	3379	3380	3374	3380	3372
South-East	757	701	598	539	465
East-South	1142	1137	1140	1144	1142
South-West	1469	1335	1089	998	898
West-South	1267	1251	1264	1263	1255
West-North	843	822	828	836	843
North-West	1303	1306	1316	1304	1301
East-North	566	570	566	555	563
North-east	711	711	717	711	714

No. of Vehs.	**CC3 Parameter Values**				
Movement	**-10**	**-8**	**-6**	**-4**	**-2**
West-East	0.5%	Default	0.5%	0.6%	0.3%
East-West	-0.2%		0.0%	-0.2%	0.1%
South-North	2.4%		-14.2%	-20.4%	-31.8%
North-South	0.0%		-0.2%	0.0%	-0.2%
South-East	8.0%		-14.7%	-23.1%	-33.7%
East-South	0.4%		0.3%	0.6%	0.4%
South-West	10.0%		-18.4%	-25.2%	-32.7%
West-South	1.3%		1.0%	1.0%	0.3%
West-North	2.6%		0.7%	1.7%	2.6%
North-West	-0.2%		0.8%	-0.2%	-0.4%
East-North	-0.7%		-0.7%	-2.6%	-1.2%
North-east	0.0%		0.8%	0.0%	0.4%

Table 5.34 – M60 J16-J17 Change in Traffic Flow

In line with the increased journey times for vehicles from the south through the network, there was a reduction in the number of vehicles completing the movements. While the other movements displayed little change in traffic flows.

5.16 CC3 Model Summary

- Vehicle counts all drop as CC3 increases
- The reduction in traffic is a result of traffic flows breaking down due to quick deceleration due to average distances between vehicles reducing
- Reducing CC3 causes journey times to increase
- As stated previously the break down in traffic flow has had a detrimental effect on the journey times which have increased.

5.17 Seed Variation

As with the other software, a final test was undertaken to assess the impact of using various Random Seed values with different values of a particular parameter. In the case of VISSIM the chosen parameter was CC2 – the variation in the following distance. For the purposes of this test a separate network was used. This network (M1 J42), although not reported on in this document, has a number of the 'typical' network characteristics and had previously been modelled extensively in VISSIM on behalf of the HA. Consequently, it was considered, due to the understanding of this network, that this would be suitable to assess the impact of variations resulting from changes to both parameters and the Random Seed.

Figure 5.37 below displays the results from the analysis, using the M1 J42 network, that was undertaken. While the results show large variation in the global journey times at the lower CC2 values it should be noted that PTV has indicated that results are expected to be unstable for CC2 values less that 4. In general the profile produced by the change in Random Seed from the results is very similar. More detail is provided in Tables 5.35 and 5.36.

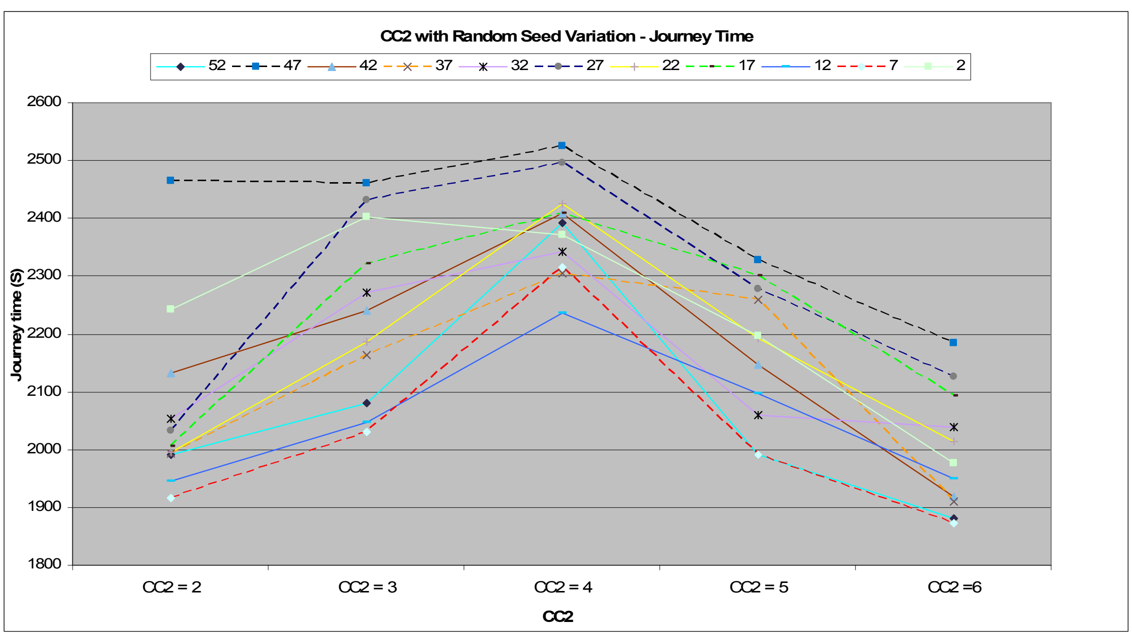


Figure 5.37 – CC2 Change with Various Random Seeds – Journey Times.

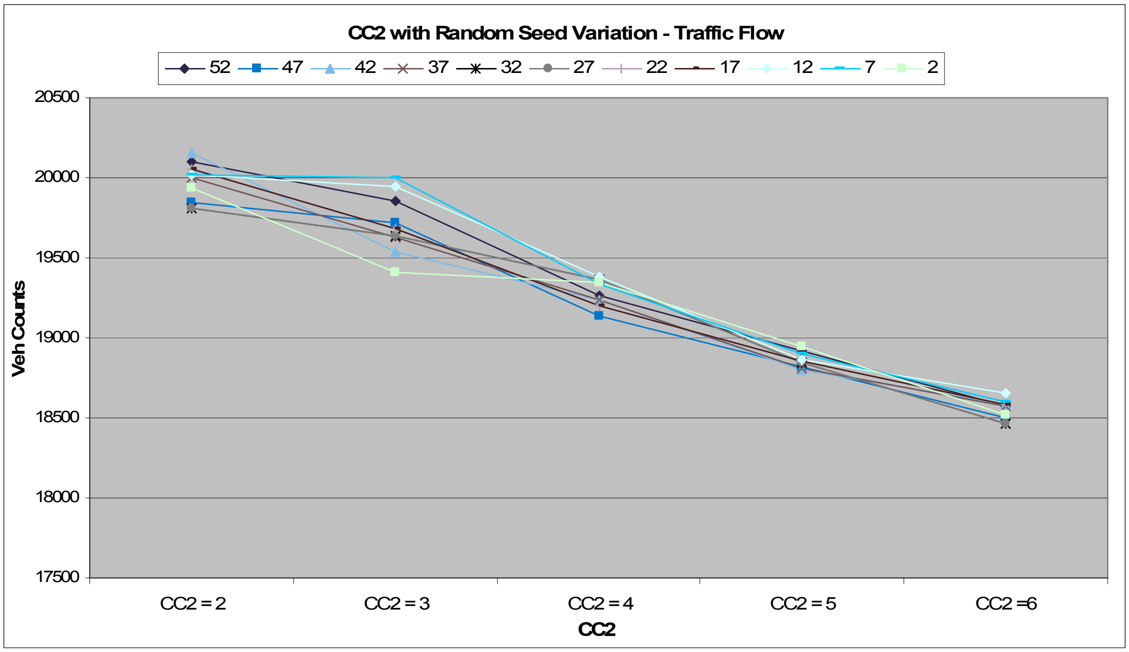


Figure 5.38 – CC2 Change with Various Random Seeds - Traffic flow

Table 5.38 provides the numerical data relating to journey times from the modelling. As indicated earlier the range of results for values of CC2 less than 4 is very high (+19% to -9% from the average) while at 4 and above the variation is from +9% to -6% with the default value of 4 giving the least variation.

Seed	CC2 = 2	CC2 = 3	CC2 = 4	CC2 = 5	CC2 =6
52	1991.20	2080.53	2391.68	1991.98	1880.50
47	2465.58	2460.80	2524.80	2328.60	2184.48
42	2132.88	2241.15	2409.10	2146.25	1917.95
37	1992.35	2163.58	2304.08	2260.03	1909.68
32	2052.68	2272.35	2341.63	2059.60	2038.43
27	2032.98	2430.70	2495.78	2278.48	2126.08
22	1996.33	2185.75	2425.18	2192.78	2014.30
17	2005.03	2321.18	2408.18	2300.65	2092.10
12	1946.05	2047.45	2237.40	2096.98	1949.48
7	1917.03	2029.95	2316.25	1990.53	1872.08
2	2242.20	2401.98	2370.85	2196.33	1976.78
Average	2070.39	2239.58	2384.08	2167.47	1996.53
Low	-7%	-9%	-6%	-8%	-6%
High	19%	10%	6%	7%	9%

Table 5.35 – Journey Time variation with Random Seed changes

In Table 5.36 it can be seen that the change of Random Seed for each parameter value had very little effect on the number of vehicles modelled.

Seed	Total Veh Count	Total Veh Count	Total Veh Count	Total Veh Count	Total Veh Count
52	20104	19856	19262	18919	18571
47	19841	19719	19135	18822	18502
42	20151	19535	19235	18800	18585
37	20000	19630	19238	18805	18569
32	19807	19637	19366	18848	18463
27	19786	19401	19264	18843	18443
22	20054	19683	19202	18855	18586
17	20257	19563	19239	18773	18424
12	20020	19947	19379	18862	18655
7	20016	20003	19335	18904	18597
2	19932	19411	19348	18948	18522
average	19997	19671	19273	18853	18538
Low	-1%	-1%	-1%	0%	-1%
High	1%	2%	1%	1%	1%

Table 5.36 – Vehicle Flow variation with Random Seed changes

It is readily seen that the variability caused by the random seeds is less than that which occurs as a result of varying the parameter value.

5.18 Lane Change Distances

One element of the network building data input which must be input with some care is the Lane Change Distance (and associated Emergency Stop distance). The Lane Change distance informs the vehicles in the model when they should begin to change lanes, if required, in order to be in the right position to change direction to complete their journey i.e. diverge off a motorway. The associated Emergency Stop distance is the distance from the junction/diverge at which vehicles will finally stop on the mainline and wait for an opportunity to change lanes. The 'default' distances associated with these are:

- Lane change 200m
- Emergency Stop 5m

In the example shown in Figure 5.39 below vehicles that wish to continue their route on the slip road are advised to begin to change lanes 1500m in advance of the slip with an emergency stop distance of 50m. This means that the vehicles have 1450m prior to the diverge to move to the nearside.

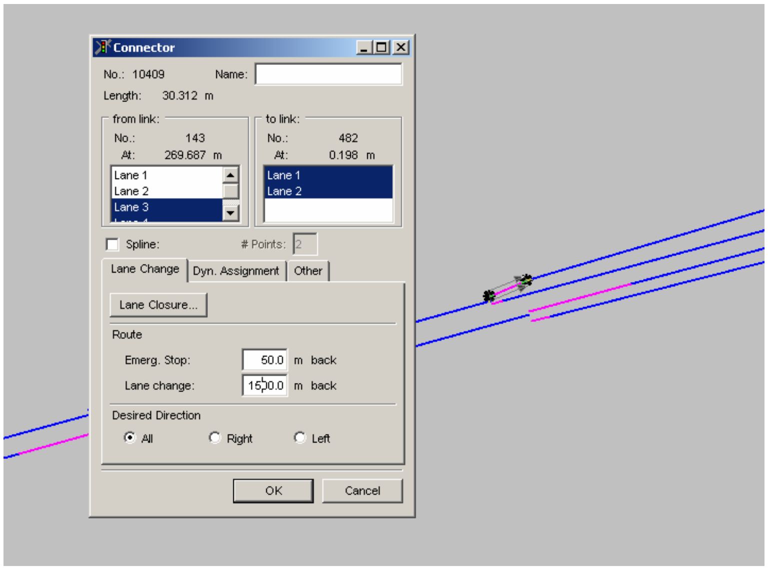


Figure 5.39 – Example of Lane Change Values

It should be noted that increasing the lane change distance will result in vehicles moving to the required lane well in advance of the junction and can lead to queuing which is not representative of the observed situation.

In order to show the effect of changes to the Lane Change, the values associated with the diverge to J27 on the M62 J26-J27 model were adjusted. In the original Base model for this network the values used were those shown in Fig. 5.39 above: Lane change =1500m and Emergency Stop = 50m. For the purposes of this test the following Lane Change values were used;

1. 50m
2. 100m
3. 200m
4. 500m
5. 1000m

In each case the default Emergency Stop distance of 5m was used.

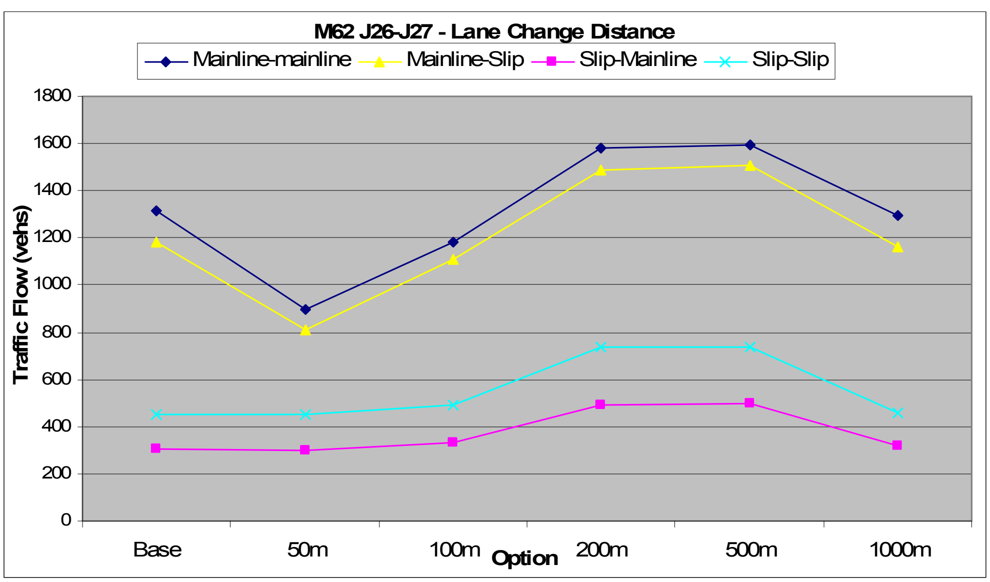


Figure 5.40 – Lane Change Variation – Traffic Flow

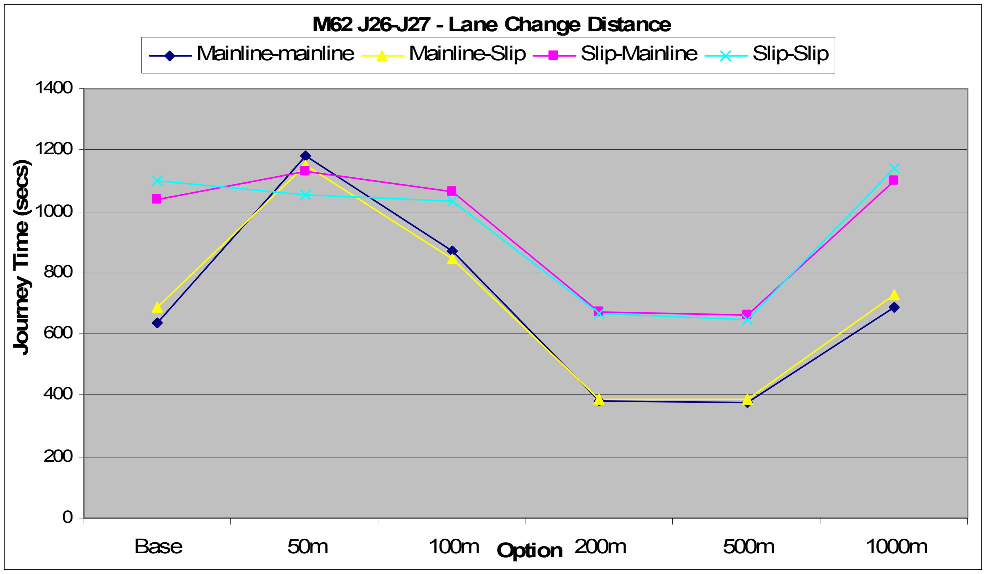


Figure 5.41 – Lane change Variation – Journey times

The results suggest that in this particular network, for maximum flow and minimum journey times, the Lane Change distance should be around 200m – 500m. However, these results were not representative of the observed conditions as shown from the Base data points in the graphs.

This emphasises the need for the modeller to be aware of the existing traffic conditions and ensure that the model fairly presents the observed data.

Appendix A

Appendix B