Solent Sub Regional Transport Model (SRTM)

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ROAD TRAFFIC MODEL

2019 MODEL CALIBRATION AND VALIDATION NOTE

SOLENT SUB REGIONAL TRANSPORT MODEL (SRTM)

ROAD TRAFFIC MODEL

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1. INTRODUCTION

1.1.1 SYSTRA was commissioned, as part of a wider team, to support Solent Transport with the development and application of a Sub-Regional Transport Model Suite (SRTM) for this nationally important area.

1.1.2 The model was originally developed with a 2010 base year and updated to a 2015 base year. A further update has now been undertaken to update the 2019 forecast model to the observed situation in 2019.

1.1.3 This Working Paper describes the calibration and validation of the 2019 Road Traffic Model (RTM) within the SRTM.

1.2 Report Structure

1.2.1 In addition to confirmation of methodologies, the purpose of this Working Paper is to demonstrate the quality of the base year (2019) assignment model in terms of how closely it reproduces a set of observations.

1.2.2 The chapters are as follows:

- Chapter 2: Matrix Calibration and Validation;
- Chapter 3: Network Calibration and Validation.
- Chapter 4: Summary of Standards Achived

2. MATRIX CALIBRATION AND VALIDATION

2.1 Introduction

2.1.1 This chapter describes:

- trip matrix estimation, including checks of significance of differences between prior and estimated trip matrices; and
- trip matrix validation, including checks of screenline flow against WebTAG guidelines.

2.2 Trip Matrix Estimation Process

The Purpose of Matrix Estimation

2.2.1 The primary purpose of matrix estimation is to refine estimates of trips not intercepted in surveys and which have therefore been synthesised. This is why counts on screenlines independent of the roadside interview cordons and screenlines are required. The refinements should be sufficiently small that they are not regarded as significant.

2.2.2 Matrix estimation only either increases or decreases non-zero cell values in the prior trip matrix. The technique cannot be used, therefore, to provide estimates of trips not intercepted in surveys or trips that have not been synthesised. Such situations are very rare however, as the Solent matrices are inherently "full" due to the manner in which they were constructed.

2.2.3 The screenlines used for matrix estimation are derived based on the principle of isolating major conurbations and activity centres, with particular emphasis on the two major, and distinct centres of Southampton and Portsmouth.

Applying Matrix Estimation

2.2.4 Matrix estimation has been applied in accordance with the guidance in section 8.3 of WebTAG unit M3.1.

2.2.5 Count constraints should generally be grouped and applied at the short screenline level; these are referred to later as 'mini-screenlines'. The use of counts at individual sites as constraints has been avoided where possible. The reason for this is that the mismatch between modelled flows and counts at any one location may be due to a number of reasons and not due solely to deficiencies in the trip matrices. In adjusting the prior matrices, matrix estimation may well compensate (undesirably) for other errors arising from the design of the zoning system, network structure, centroid connectors, network coding and route choice coefficients, which is why all these aspects should be checked before applying matrix estimation. Applying constraints at individual sites is likely to exacerbate the tendency of the matrix estimation procedure to compensate for deficiencies in other aspects of the model. In the SRTM the majority of counts are applied in mini-screenline groupings, however some individual site constraints are applied where the trip distibution is considered to be distinct to the particular link, and therefore grouping would not be appropriate, such as for motorway links.

2.2.6 The counts used as constraints in the matrix estimation are derived from two-week ATCs, and the vehicle type proportions for the four user classes (Car Business, Car Non Business, LGV and HGV) have been obtained from MCCs. Note because control counts are available at a three vehicle class level, the car user class needs to be divided between Car business and Car Non Business in order that matrix estimation could be applied at the Solent four user class assignment level. This is achieved by applying the Business/Non Business splits derived from the Pre Matrix Estimation assignment.

2.2.7 The Matrix Estimation process is constrained using the XAMAX = 2.5 to restrict individual cell value changes to a factor of 2.5 to prevent excessive distortion of the matrix.

Matrix Estimation Process

2.2.8 The matrix estimation process uses the SATURN program SATME2 in conjunction with the supplementary program SATPIJA. It is based on the theoretical procedure generally referred to as ME2 - Matrix Estimation from Maximum Entropy. SATME2 essentially tries to improve the fit between modelled and observed flows by selectively factoring individual cells of the input trip matrix. SATPIJA creates a file used by SATME2 which represents the proportion of trips between origin-destination pairs which uses the counted link (from SATURN Manual Section 13).

2.2.9 The PIJA proportions are dependant on the trip matrix and if the trip matrix is updated according to one set of PIJA factors when it is assigned it will be assigned to different paths and/or different path proportions from the original matrix and hence a new set of PIJA proportions will result. This feed-back effect requires an iterative looping procedure to find a trip matrix which is compatible with a set of PIJA factors such that those factors are themselves compatible with the trip matrix plus assignment. The procedure adopted within SATURN, follows algorithm whereby an assignment is used to derive the route choice/PIJA factors which are in turn used to estimate a revised trip matrix. Six such loops are undertaken for the SRTM which is consistent with common practice.

2.2.10 The inputs to the process are:

- highway networks, AM, IP and PM;
- highway prior matrices AM, IP, PM by user class; and
- SATME2 inputs – calibration counts divided into mini-screenlines.

Figure 1. SRTM Screenlines - Mainland

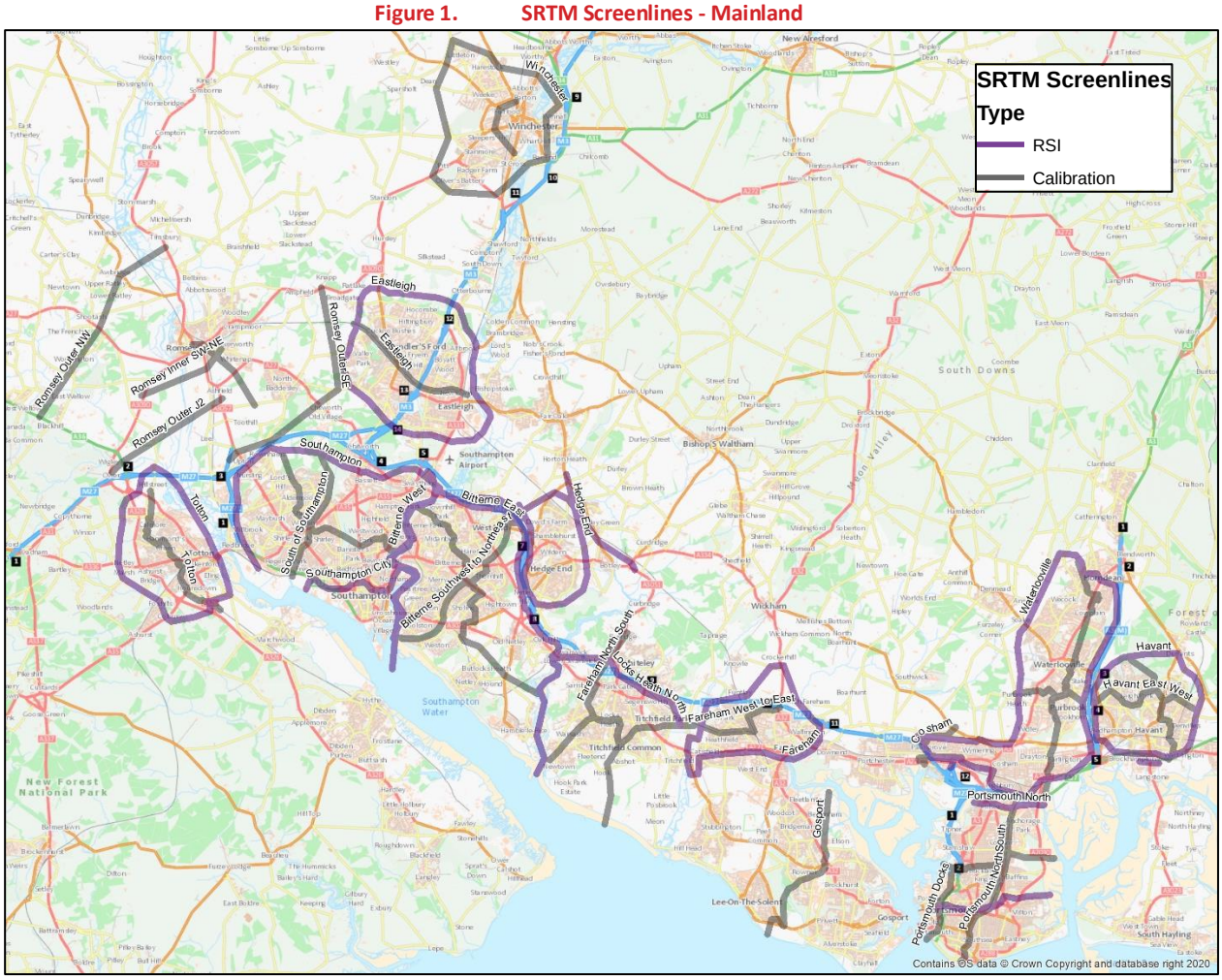
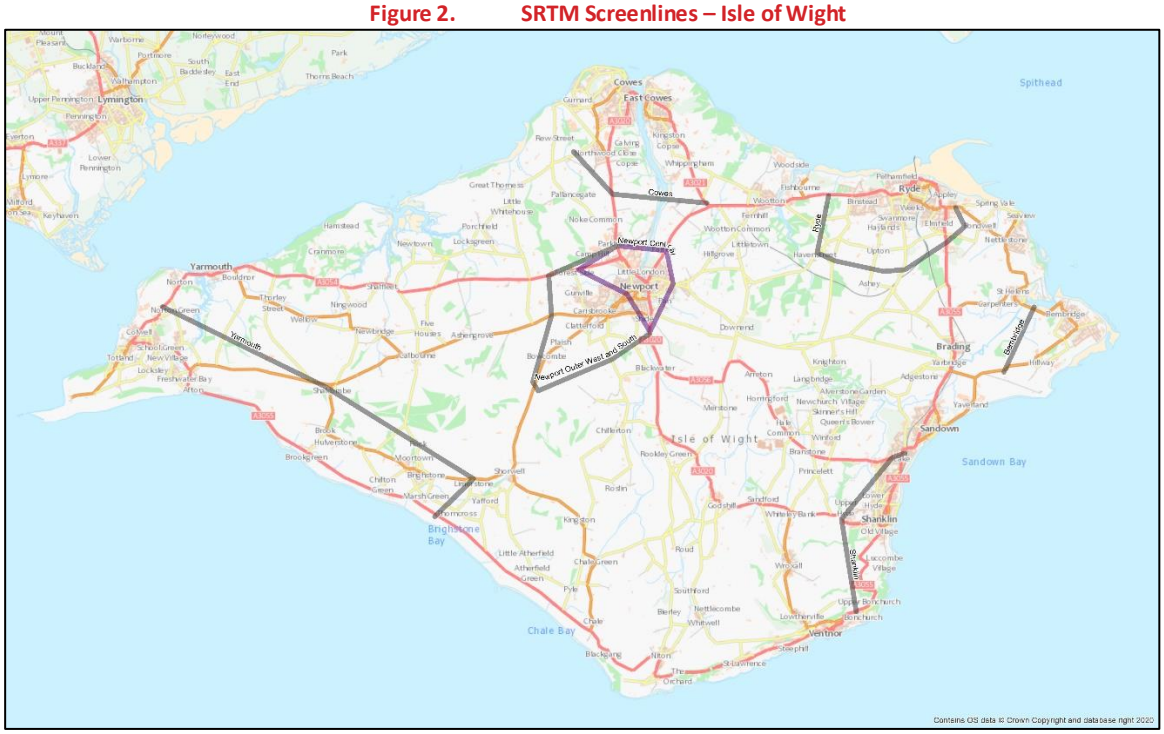


Figure 2. SRTM Screenlines – Isle of Wight



2.3 Trip Matrix Estimation Outcomes

2.3.1 This section describes the trip matrices before and after matrix estimation using the following analyses:

- matrix size by user class;
- statistical analysis of change in matrix cell values;
- statistical analysis of change in zonal trip ends;
- statistical analysis of change in trip length distributions;
- statistical analysis of change in sectoral trip ends;

Matrix size

2.3.2 Table 1 presents matrix sizes by user class before and after matrix estimation.

Table 1. Prior and Estimated Matrix Sizes

USER CLASS	1	2	3	4	TOTAL
	Car Business	Car Non Business	LGV	OGV	All Vehicles
AM peak hour					
Prior	19,130	176,628	21,653	11,674	229,084
Calibrated	19,770	180,559	22,463	11,794	234,587
% Diff	3.3%	2.2%	3.7%	1.0%	2.4%
Inter peak average hour					
Prior	15,372	131,849	16,975	8,797	172,993
Calibrated	15,496	135,366	17,567	8,931	177,361
% Diff	0.8%	2.7%	3.5%	1.5%	2.5%
PM peak hour					
Prior	15,161	189,249	19,131	7,361	230,901
Calibrated	15,297	194,705	20,166	7,707	237,875
% Diff	0.9%	2.9%	5.4%	4.7%	3.0%

2.3.3 The WebTAG criteria and acceptability guidelines for changes resulting from matrix estimation are shown in Table 2.

Table 2. Significance of Matrix Estimation Changes

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

Matrix zonal cell values

2.3.4 Figure 3, Figure 4 and Figure 5 shows scatter plots of the prior and post ME cell values for vehicles. All time periods show a reasonable correlation with slope values within the WebTAG criteria and intercept close to zero. Although the R^2 values fall slightly short of the criteria this is considered to be a satisfactory correlation overall for a general purpose model of this scale and complexity.

Figure 3. Scatter Plot of Prior and Post ME AM Peak Zonal Cell Values

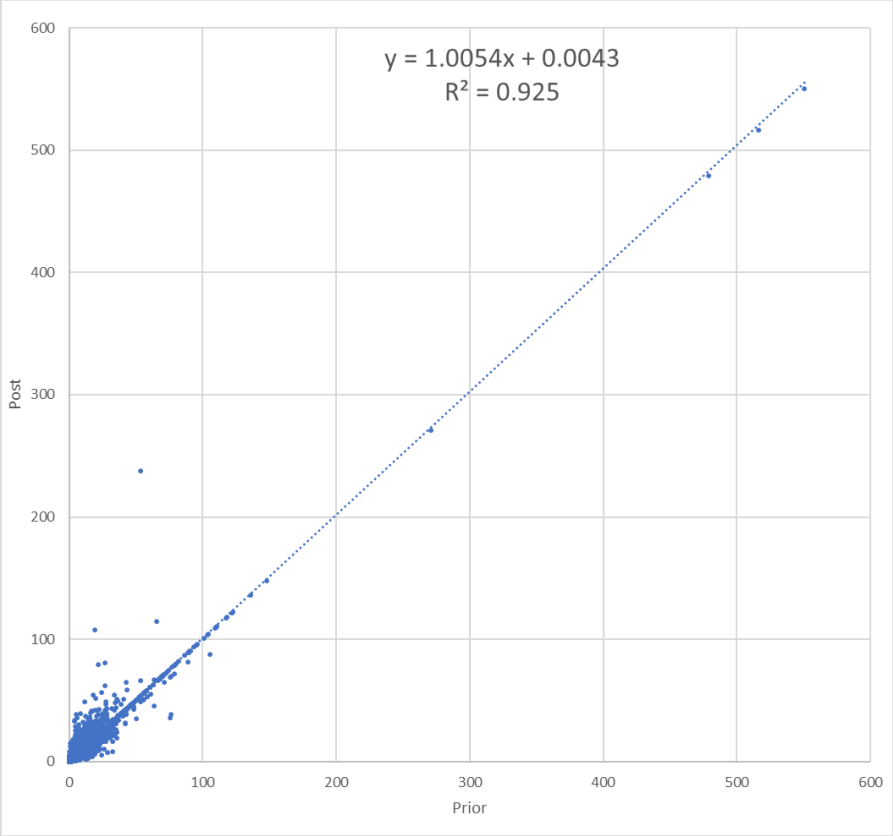


Figure 4. Scatter Plot of Prior and Post ME Inter-Peak Zonal Cell Values

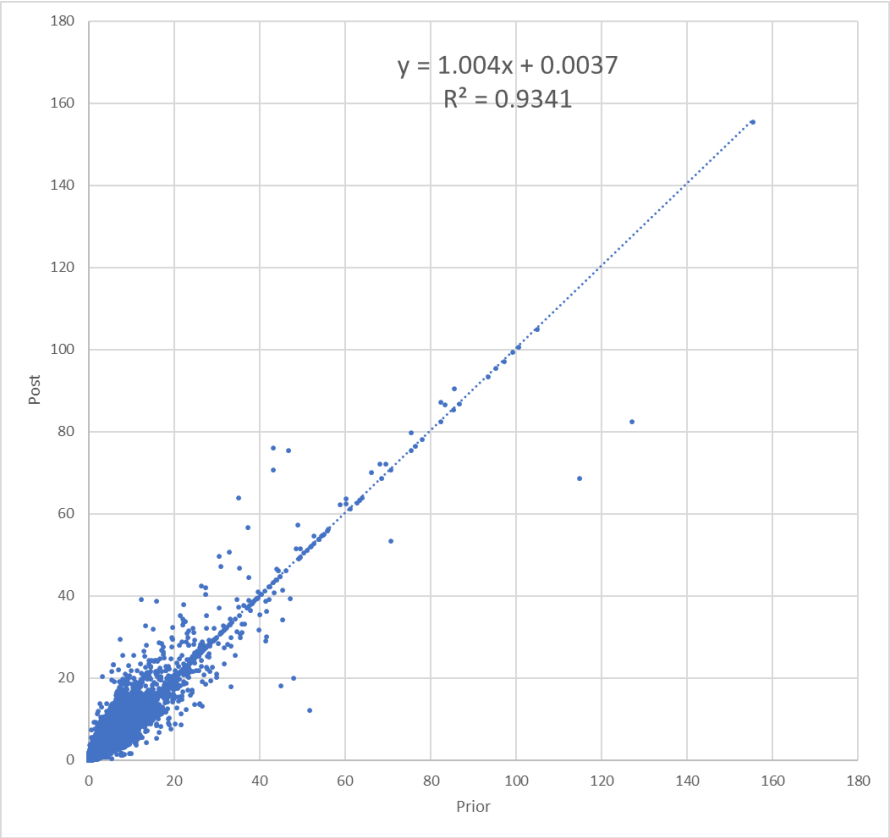
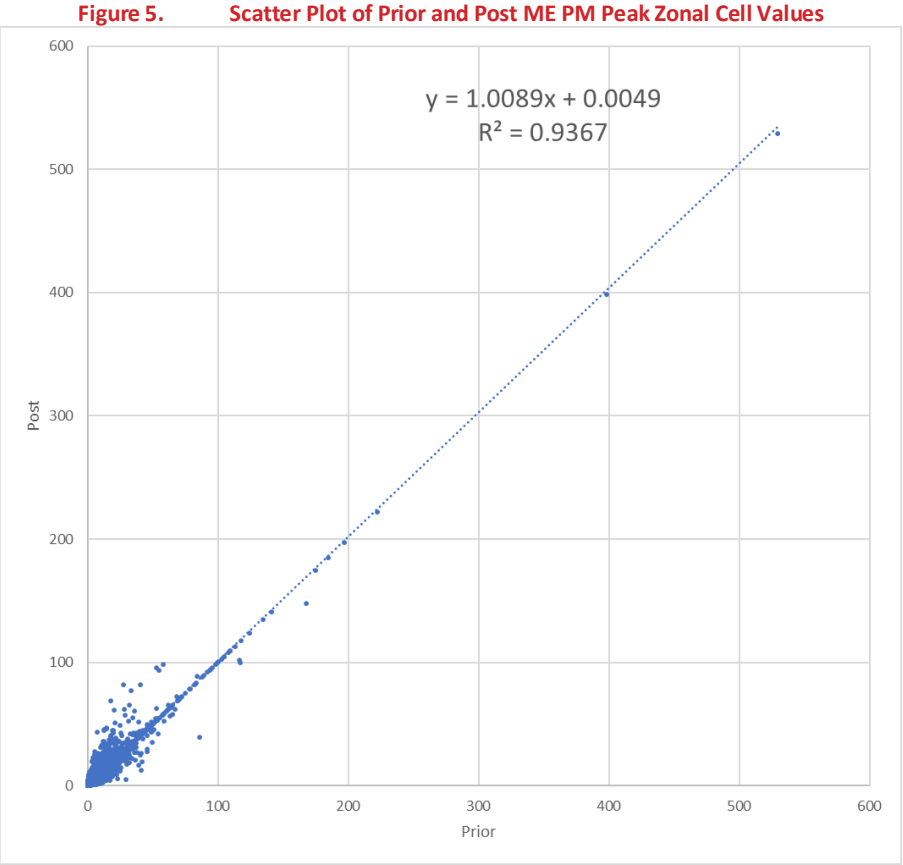


Figure 5. Scatter Plot of Prior and Post ME PM Peak Zonal Cell Values



Matrix zonal trip ends

2.3.5 Figure 6 to Figure 11 show scatter plots of the prior and post ME matrix trip end (origin and destination) totals for vehicles. All time periods show a reasonable correlation with slope values close to 1 and intercept close to zero. Although the slope and R^2 values sometimes fall short of the criteria this is considered to be a satisfactory correlation overall for a general purpose model of this scale and complexity.

Figure 6. Scatter Plot of Prior and Post ME AM Peak Origin Zonal Trip Ends

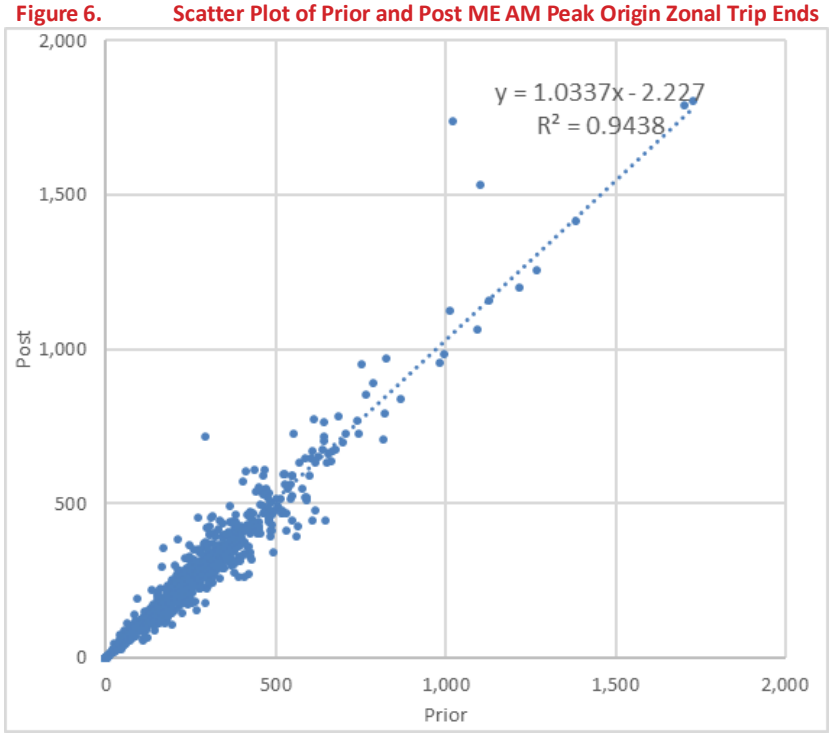


Figure 7. Scatter Plot of Prior and Post ME AM Peak Destination Zonal Trip Ends

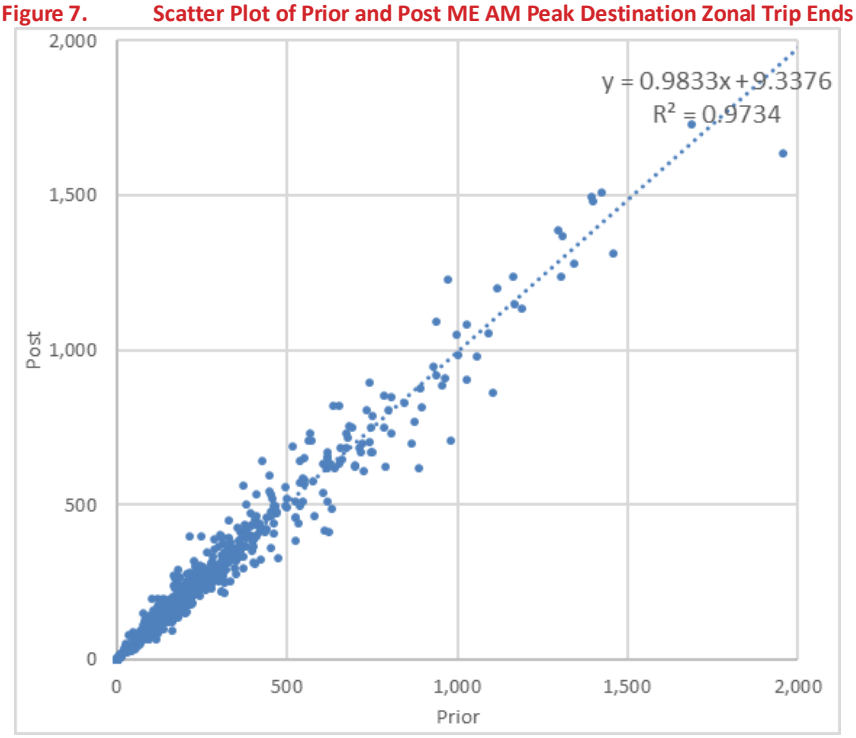


Figure 8. Scatter Plot of Prior and Post ME Inter Peak Origin Zonal Trip Ends

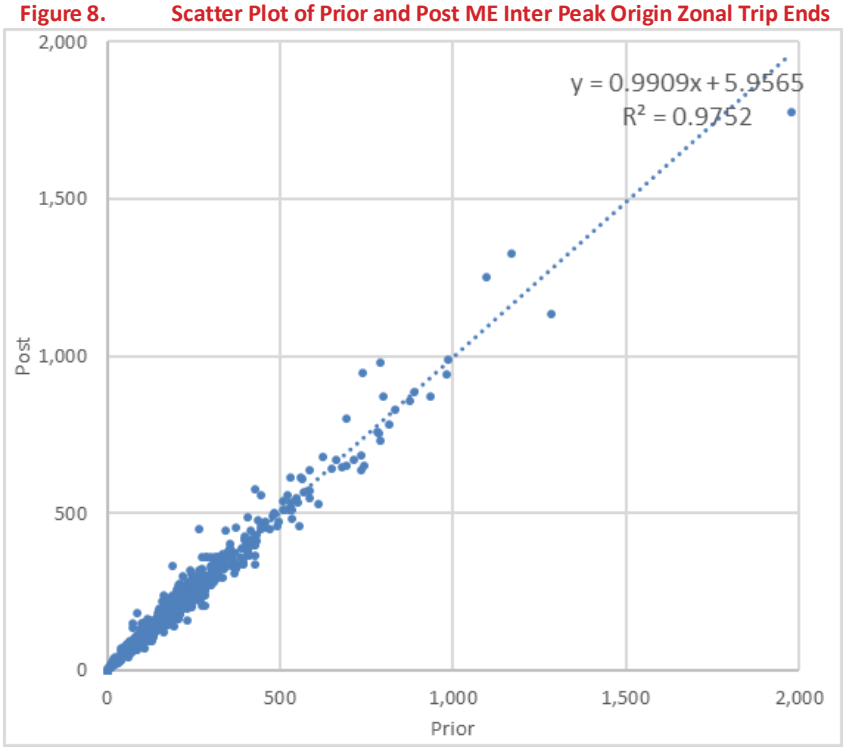


Figure 9. Scatter Plot of Prior and Post ME Inter Peak Destination Zonal Trip Ends

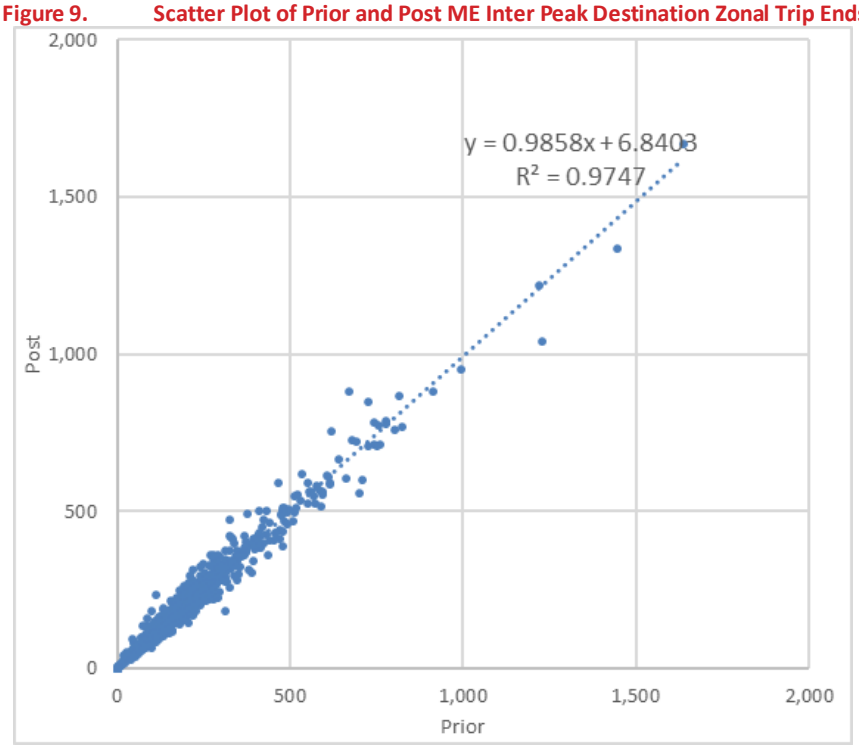


Figure 10. Scatter Plot of Prior and Post ME PM Peak Origin Zonal Trip Ends

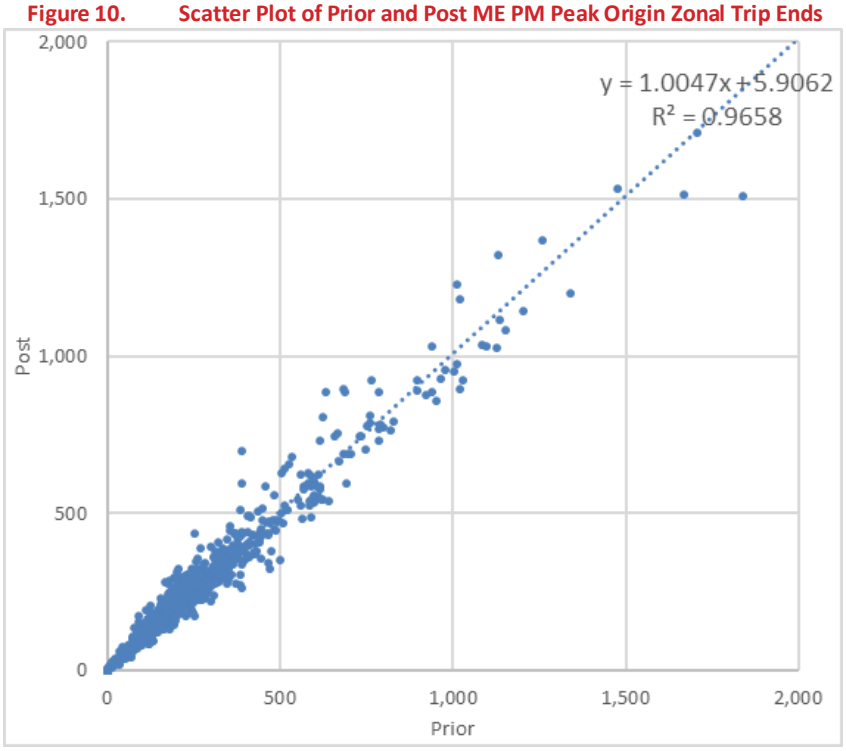
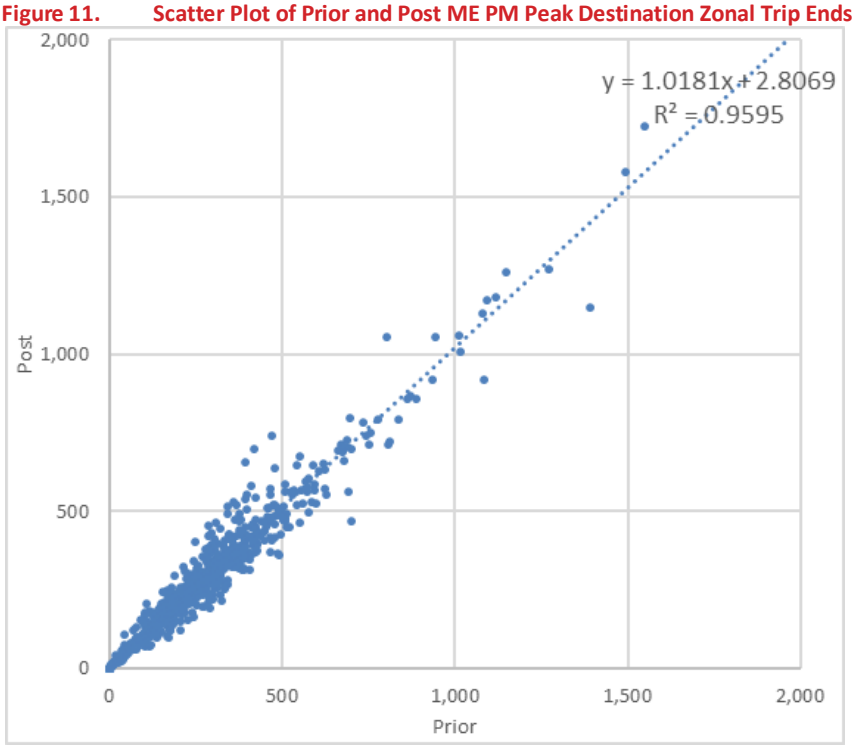


Figure 11. Scatter Plot of Prior and Post ME PM Peak Destination Zonal Trip Ends



Trip Length Distributions

2.3.6 Figure 12, Figure 13 and Figure 14 show trip length frequency distributions for all vehicles, showing the number of trips lying within each distance band pre and post matrix estimation, by period. Table 3 shows the mean trip length and standard deviations for the prior and post estimation matrices.

2.3.7 The shape of the curves in are in line with expectations for a model representing both urban and interurban trips, with short trips dominating the distribution, but a significant number of longer distance trips forming the tail of the distribution. The results show that the matrix estimation process has not significantly distorted the distribution in any of the AM, IP or PM periods.

2.3.8 Table 3 shows the mean trip length changes between -1.9% and -3.8%, with the average trip length decreasing slightly in all cases. The standard deviations are also within 5%.

Table 3. Mean Trip Length and Standard Deviation (SD) (km)

MODEL PERIOD	PRIOR MEAN	POST MEAN	%	PRIOR SD	POST SD	%
AM Peak Hour	22.3	21.8	-1.9%	38.6	38.3	-0.7%
IP Hour	19.4	18.9	-2.9%	37.8	37.0	-2.0%
PM Peak Hour	20.9	20.1	-3.8%	39.4	37.9	-3.8%

Figure 12. Trip Frequency Distribution Pre/Post ME AM Peak Hour, All Vehicles

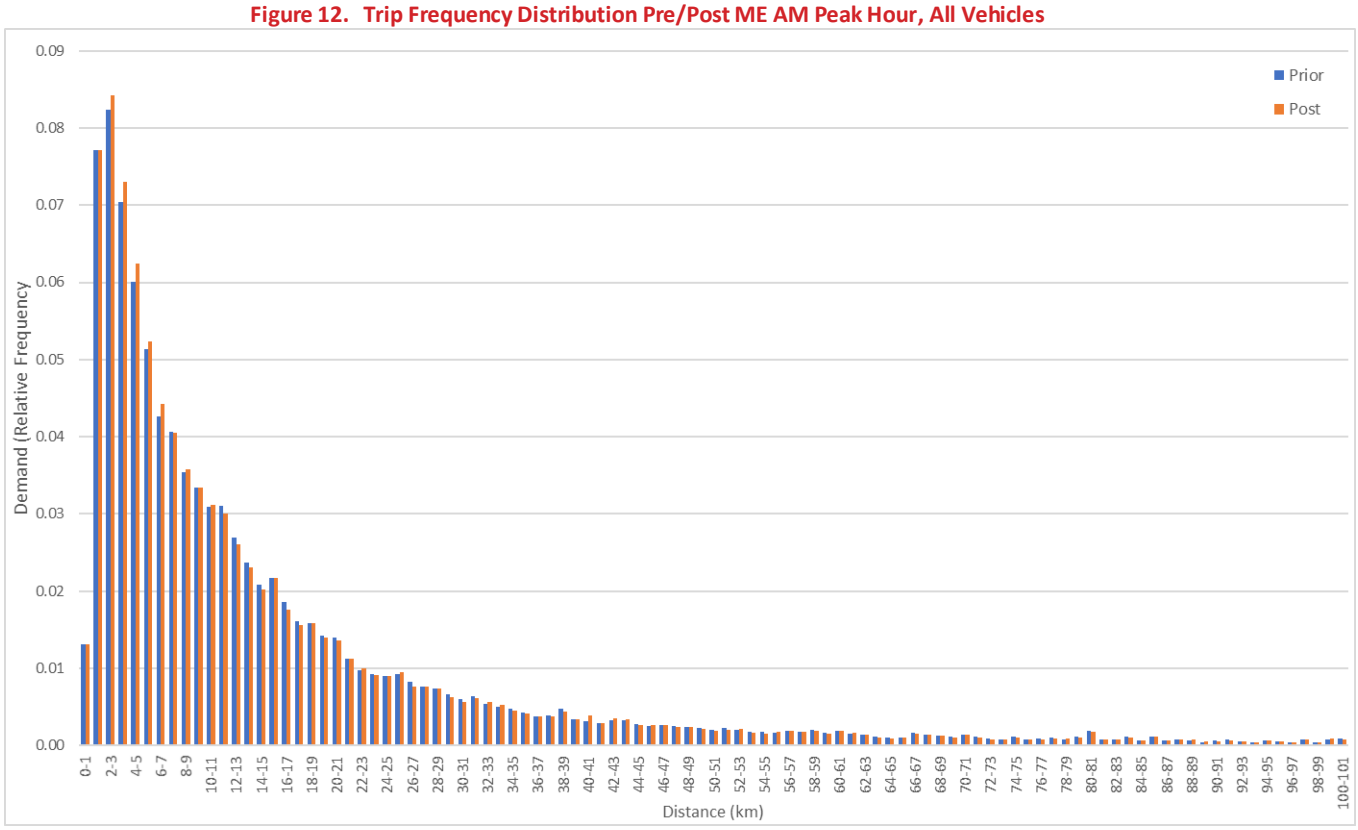


Figure 13. Trip Frequency Distribution Pre/Post ME Inter-Peak Hour, All Vehicles

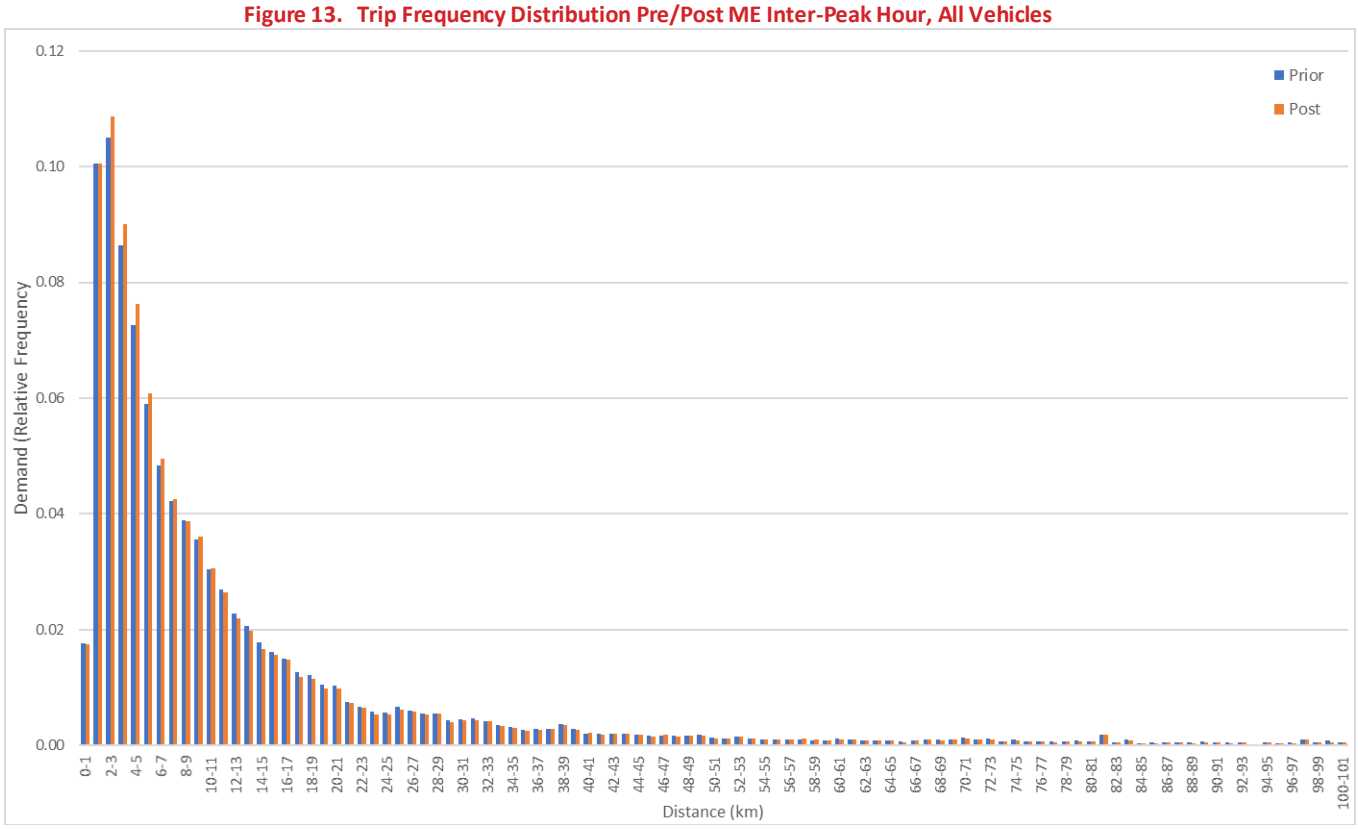
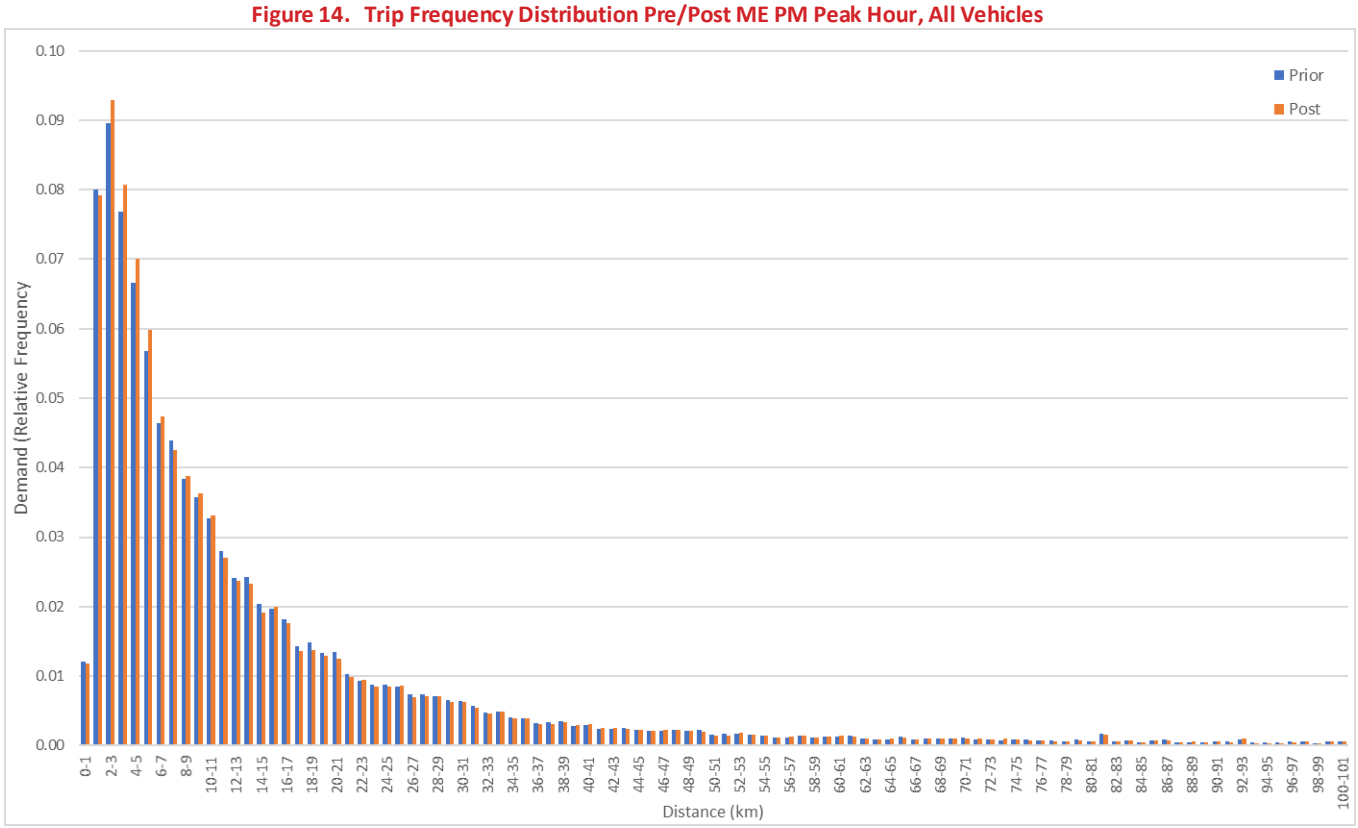


Figure 14. Trip Frequency Distribution Pre/Post ME PM Peak Hour, All Vehicles



Sector Changes

2.3.9 Table 4, Table 5 and Table 6 show the sector trip end changes resulting from matrix estimation. These show the majority of changes to be within or close to 5%.

Table 4. AM Peak Sector Trip Ends Changes (Vehicles)

AREA	ORIGIN	ORIGIN	%	DEST.	DEST.	%
New Forest, Totton, Romsey	17,588	18,646	6.0%	15,938	16,858	5.8%
Southampton	41,786	43,584	4.3%	42,770	44,884	4.9%
Eastleigh	14,097	13,823	-1.9%	12,719	12,686	-0.3%
LocksHeath, Fareham, Gosport	37,338	38,809	3.9%	36,234	38,459	6.1%
Portsmouth	21,355	20,951	-1.9%	21,627	21,577	-0.2%
WaterlooVille, Havant, East Hants	29,824	29,111	-2.4%	27,461	27,009	-1.6%
Isle of Wight	19,643	20,766	5.7%	19,626	20,756	5.8%
Winchester	11,410	11,652	2.1%	13,756	13,540	-1.6%
Marginal	18,698	19,093	2.1%	15,096	15,218	0.8%
External	17,346	18,152	4.6%	23,858	23,598	-1.1%
Total	**229,084**	**234,587**	**2.4%**	**229,084**	**234,587**	**2.4%**

Table 5. Inter-Peak Sector Trip Ends Changes (Vehicles)

AREA	ORIGIN	ORIGIN	%	DEST.	DEST.	%
New Forest, Totton, Romsey	11,870	12,324	3.8%	12,117	12,590	3.9%
Southampton	34,991	35,403	1.2%	35,236	35,998	2.2%
Eastleigh	10,673	11,299	5.9%	10,460	10,776	3.0%
LocksHeath, Fareham, Gosport	29,048	30,715	5.7%	29,132	30,330	4.1%
Portsmouth	18,079	17,940	-0.8%	17,624	17,783	0.9%
WaterlooVille, Havant, East Hants	21,862	21,811	-0.2%	22,892	22,550	-1.5%
Isle of Wight	17,993	18,857	4.8%	18,054	18,856	4.4%
Winchester	8,316	8,943	7.5%	8,490	8,799	3.6%
Marginal	5,849	5,867	0.3%	6,298	6,516	3.5%
External	14,312	14,201	-0.8%	12,691	13,162	3.7%
Total	**172,994**	**177,361**	**2.5%**	**172,994**	**177,361**	**2.5%**

Table 6. PM Peak Sector Trip Ends Changes (Vehicles)

AREA	ORIGIN	ORIGIN	%	DEST.	DEST.	%
New Forest, Totton, Romsey	15,257	16,083	5.4%	16,789	17,666	5.2%
Southampton	45,399	47,578	4.8%	46,944	48,142	2.6%
Eastleigh	13,395	14,148	5.6%	13,356	13,493	1.0%
LocksHeath, Fareham, Gosport	37,812	40,206	6.3%	37,708	40,894	8.5%
Portsmouth	22,426	22,443	0.1%	22,567	22,855	1.3%
WaterlooVille, Havant, East Hants	26,987	26,992	0.0%	29,686	29,472	-0.7%
Isle of Wight	20,832	21,422	2.8%	20,804	21,401	2.9%
Winchester	12,868	13,378	4.0%	10,844	10,760	-0.8%
Marginal	17,379	17,217	-0.9%	14,109	14,626	3.7%
External	18,547	18,409	-0.7%	18,095	18,567	2.6%
Total	**230,901**	**237,875**	**3.0%**	**230,901**	**237,875**	**3.0%**

2.4 Calibrated Trip Matrix Validation

2.4.1 The WebTAG criteria and acceptability guidelines for screenline flow are shown in Table 7.

Table 7. Screenline Flow Validation Criterion and Acceptability Guideline

CRITERIA	ACCEPTABILITY GUIDELINE
Differences between modelled flows and counts should be less than 5% of the counts	All or nearly all screenlines

2.4.2 Table 8 and Table 9 show the results of the cordon and screenline validation analysis for each of the modelled periods, for vehicles and cars respectively.

Table 8. Cordon and Screenline Flow Validation: Vehicles

Measure	Criteria	Acceptability Guideline	AM Peak	Inter Peak	PM Peak
Matrix Validation	**Differences between modelled flows and counts should be less than 5% of the counts**	**All or nearly all screenlines (WebTAG)**	**84%**	**84%**	**83%**
	Differences between modelled flows and counts should be within GEH=4 of the counts	*N/A*	*85%*	*88%*	*86%*
	*Differences between modelled flows and counts should be less than **10%** of the counts*	*N/A*	*91%*	*95%*	*88%*

Table 9. Cordon and Screenline Flow Validation: Cars

Measure	Criteria	Acceptability Guideline	AM Peak	Inter Peak	PM Peak
Matrix Validation	**Differences between modelled flows and counts should be less than 5% of the counts**	**All or nearly all screenlines (WebTAG)**	**79%**	**85%**	**85%**
	Differences between modelled flows and counts should be within GEH=4 of the counts	*N/A*	*90%*	*96%*	*96%*
	*Differences between modelled flows and counts should be less than **10%** of the counts*	*N/A*	*96%*	*93%*	*93%*

3. NETWORK CALIBRATION AND VALIDATION

3.1 Introduction

3.1.1 This chapter describes:

- link flow validation; and
- convergence and stability.

3.2 Link Flow Validation

3.2.1 The WebTAG criteria and acceptability guidelines for link flows are shown Table 10.

Table 10. Link Flow Validation Criteria and Acceptability Guidelines

CRITERIA	ACCEPTABILITY GUIDELINE
Individual flows within 15% of counts for flows from 700 to 2,700 veh/h	> 85% of cases
Individual flows within 100 veh/h of counts for flows less than 700 veh/h	> 85% of cases
Individual flows within 400 veh/h of counts for flows more than 2,700 veh/h	> 85% of cases
GEH < 5 for individual flows	> 85% of cases

3.2.2 Table 11 and Table 12 show the results of the network validation analysis for each of the modelled periods, for vehicles and cars respectively.

Table 11. Link Flow Validation: Vehicles

Measure	Criteria	Acceptability Guideline	AM Peak	Inter Peak	PM Peak
Link Flow Validation	**Individual flows within 15% of counts for flows from 700 to 2700 veh/h**	**>85% of cases (WebTAG)**	**71%**	**79%**	**69%**
	Individual flows within 100 veh/h of counts for flows less than 700 veh/h				
	Individual flows within 400 veh/h of counts for flows more than 2700 veh/h				
	GEH < 5 for individual flows	**> 85% of cases (WebTAG)**	**64%**	**71%**	**62%**
	*GEH < **10** for individual flows*	*N/A*	*86%*	*91%*	*84%*

Table 12. Link Flow Validation: Cars

Measure	Criteria	Acceptability Guideline	AM Peak	Inter Peak	PM Peak
Link Flow Validation	**Individual flows within 15% of counts for flows from 700 to 2700 veh/h**	**>85% of cases (WebTAG)**	**73%**	**83%**	**75%**
	Individual flows within 100 veh/h of counts for flows less than 700 veh/h				
	Individual flows within 400 veh/h of counts for flows more than 2700 veh/h				
	GEH < 5 for individual flows	**> 85% of cases (WebTAG)**	**65%**	**72%**	**63%**
	*GEH < **10** for individual flows*	*N/A*	*88%*	*92%*	*100%*

3.3 Convergence and Stability

3.3.1 The WebTAG criteria and acceptability guidelines for convergence are shown in Table 13.

Table 13. Summary of Convergence Measures and Base Model Acceptable Values

MEASURE OF CONVERGENCE	BASE MODEL ACCEPTABLE VALUES
Delta and %GAP	Less than 0.1% or at least stable with convergence fully documented and all other criteria met
Percentage of links with flow change (P)<1%	Four consecutive iterations greater than 98%
Percentage of links with cost change (P2)<1%	Four consecutive iterations greater than 98%

3.3.2 There are several important parameters in SATURN that are used to ensure convergence is acceptable. These are:

KONSTP "KONtrol of SToPping Criteria"

This defines the type of the conditions required for the assignment to end. The stopping criteria for assignment – simulation loops are based on either: ISTOP (KONSTP = 0); %GAP value (1); CPU time (2); RSTOP and/or CPU (3); %GAP and/or CPU (4); %GAP and RSTOP (5); %GAP or (6) %ISTOP. The assignment will also end when the number of assignment loops reaches MASL (see below).

WebTAG: N/A *SATURN Default: 5* *Solent Model: 5*

Therefore unless MASL is reached the assignment will only stop if %GAP and RSTOP criteria are reached.

MASL

This the maximum number of assignment/simulation loops.

WebTAG: N/A *SATURN Default: 15* *Solent Model: 150*

NISTOP

The number of successive loops which must satisfy the RSTOP criteria in the test for convergence of the assignment/simulation loops.

WebTAG: 4 *SATURN Default: 4* *Solent Model: 4*

STPGAP

WebTAG: 0.1% *SATURN Default: 1.0%* *Solent Model: 0.05%*

PCNEAR

Percentage change in flows judged to be "near" in successive assignments.

WebTAG: 1.0% *SATURN Default: 1.0%* *Solent Model: 1.0%*

RSTOP

Used in the test for convergence of the assignment/simulation loops. The loops stop automatically if RSTOP % of the link flows change by less than "PCNEAR" percent (default 5%) from one assignment to the next.

WebTAG: 98% *SATURN Default: 97.5%* *Solent Model: 98%*

3.3.3 Table 14 shows the performance of the model for the criteria. The stopping criteria set for the model are also shown; these exceed the guidelines and setting these ensured that the model iterations continued until all the set criteria were satisfactorily met.

Table 14. Convergence and Stability Model Results

MEASURE OF CONVERGENCE	SATURN PARAMETER	BASE MODEL ACCEPTABLE VALUES	STOPPING CRITERIA	AM PEAK	INTER-PEAK	PM PEAK
%GAP	**NISTOP STPGAP**	Less than **0.1%** or at least stable with convergence fully documented and all other criteria met	**<0.05%** (for base model)	0.033 0.032 0.032 0.032	0.013 0.0085 0.0098 0.0070	0.033 0.035 0.033 0.035
Percentage of links with flow change (P)<1% **(for final four iterations)**	**NISTOP PCNEAR RSTOP**	Four consecutive iterations greater than **98%**	Four consecutive iterations greater than **98%**	99.5 99.5 99.6 99.5	98.2 98.3 98.5 98.8	98.7 99.2 99.2 99.2
Percentage of links with cost change (P2)<1% **(for final four iterations)**	NONE	Four consecutive iterations greater than **98%**	Four consecutive iterations greater than **98%**	99.6 99.6 99.6 99.6	99.8 99.8 99.8 99.8	99.1 99.2 99.3 99.3

4. SUMMARY OF STANDARDS ACHIEVED

4.1.1 Table 15 presents an overall view of the performance of the model against WebTAG criteria. The screenline validation in particular shows good results for the overall Road Traffic Model. The link flow validation does not meet the WebTAG criteria, however these overall criteria mask a reasonable performance, which is close to the meeting the acceptability guidelines.

Table 15. Summary of Validation Statistics

Measure	Criteria	Acceptability Guideline	AM Peak	Inter Peak	PM Peak
Matrix Validation	**Differences between modelled flows and counts should be less than 5% of the counts**	**All or nearly all screenlines (WebTAG)**	**84%**	**84%**	**83%**
	Differences between modelled flows and counts should be within GEH=4 of the counts	*N/A*	*85%*	*88%*	*86%*
	*Differences between modelled flows and counts should be less than **10%** of the counts*	*N/A*	*91%*	*95%*	*88%*
Link Flow Validation	**Individual flows within 15% of counts for flows from 700 to 2700 veh/h**	**>85% of cases (WebTAG)**	**71%**	**79%**	**69%**
	Individual flows within 100 veh/h of counts for flows less than 700 veh/h				
	Individual flows within 400 veh/h of counts for flows more than 2700 veh/h				
	GEH < 5 for individual flows	**> 85% of cases (WebTAG)**	**64%**	**71%**	**62%**
	*GEH < **10** for individual flows*	*N/A*	*86%*	*91%*	*84%*

4.1.2 Table 15 demonstrates that the model performance is in general good, and that the screenline validation performs particularly well. This is critical, because the matrix validation screenlines are of particular importance, as discussed below:

- **Matrix Validation** – Highly important, as it ensures the demand in the model is correct for assessing interventions and future changes
- **Link Flow Validation** – Less significant at an individual link level, because routing can be volatile and vary from day to day

4.1.3 It should be noted also that Solent Transport view the matrix validation to be of more importance than the link flow validation, as the expected interventions to be tested

generally cover mode shift changes rather than major highway improvements affecting traffic routing.

4.2 Conclusion

4.2.1 The model has been constructed according to WebTAG recommendations, and validated against DMRB guidelines. The calibration process did not reveal any significant problems or shortcomings in the base year model. The quality of validation of the model is in general good, with the screenline validation performing particularly well. This is critical, as it ensures the demand in the model is correct for assessing multi-modal interventions and future changes.

4.2.2 It is often considered that the WebTAG thresholds of acceptability are more suited to smaller, less complex models, and as such it may be argued that a certain level of flexibility is acceptable given the scale and complexity of the SRTM.

4.2.3 The calibration and validation suggest that the model is fit for the purpose of representing the highway traffic patterns in the base year, as part of the SRTM.

4.2.4 The model encompasses a large geographic area at different levels of detail and is expected to be used to consider a range of strategic and specific interventions, e.g. representing the main highway movements, the impact of major highway and public transport interventions on those movements, and providing controlled and consistent inputs to local or more detailed models.

4.2.5 It is acknowledged that whilst fit for general purpose, depending on the nature and scope of the intervention being tested, additional local validation checks may be beneficial for model application for specific interventions at a local level.

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Birmingham – Newhall Street
5th Floor, Lancaster House, Newhall St,
Birmingham, B3 1NQ
T: +44 (0)121 233 7680 F: +44 (0)121 233 7681

Birmingham – Innovation Court
Innovation Court, 121 Edmund Street, Birmingham B3 2HJ
T: +44 (0)121 230 6010

Bristol
10 Victoria Street, Bristol, BS1 6BN
T: +44 (0)117 922 9040

Dublin
2nd Floor, Riverview House, 21-23 City Quay
Dublin 2,Ireland
T: +353 (0) 1 905 3961

Edinburgh – Thistle Street
Prospect House, 5 Thistle Street, Edinburgh EH2 1DF
United Kingdom
T: +44 (0)131 220 6966

Edinburgh – Manor Place
37 Manor Place, Edinburgh, EH3 7EB
Telephone +44 (0)131 225 7900 Fax: +44 (0)131 225 9229

Glasgow – St Vincent St
Seventh Floor, 124 St Vincent Street
Glasgow G2 5HF United Kingdom
T: +44 (0)141 225 4400

Glasgow – West George St
250 West George Street, Glasgow, G2 4QY
T: +44 (0)141 221 4030 F: +44 (0)800 066 4367

Leeds
100 Wellington Street, Leeds, LS1 1BA
T: +44 (0)113 397 9740 F: +44 (0)113 397 9741

Liverpool
Cotton Exchange, Bixteth Street, Liverpool, L3 9LQ
T: +44 (0)151 230 1930

London
3rd Floor, 5 Old Bailey, London EC4M 7BA United Kingdom
T: +44 (0)203 714 4400

Manchester – 16th Floor, City Tower
16th Floor, City Tower, Piccadilly Plaza
Manchester M1 4BT United Kingdom
T: +44 (0)161 831 5600

Newcastle
PO Box 438, Newcastle upon Tyne, NE3 9BT
United Kingdom
T: +44 (0)191 2136157

Perth
13 Rose Terrace, Perth PH1 5HA
T: +44 (0)1738 621 377 F: +44 (0)1738 632 887

Reading
Soane Point, 6-8 Market Place, Reading,
Berkshire, RG1 2EG
T: +44 (0)118 334 5510

Woking
Dukes Court, Duke Street
Woking, Surrey GU21 5BH United Kingdom
T: +44 (0)1483 728051 F: +44 (0)1483 755207

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