

LATIS Lot 4 Transport Model Audit Services TMfS12 Audit Report

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LATIS Lot 4 Transport Model Audit Services

TMfS12 Audit Report

Rev No	Comments	Checked by	Approved by	Date
1	Updated in response to Client comments	RC		02/06/14

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Reference LOT4.002

Date Created April 2014

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1 Introduction

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1 Introduction

1.1 Purpose of Report

AECOM, as framework consultant for Lot 4 of the LATIS commission, were commissioned by Transport Scotland (TS) to undertake an audit of the model development work associated with developing the Transport Model for Scotland 12 (TMfS12). TMfS12 is an updated version of TMfS, the national transport model for Scotland, calibrated and validated using available data for 2012, which is intended for a range of future uses.

The audit has involved a review of the TMfS12 base model networks for the roads and public transport (PT) models and a review of the documentation produced by the model developers, SIAS, for the roads, PT and demand models.

This task has not involved the audit of the associated land use model, TELMoS. This will be commissioned by TS separately.

1.2 Audit Guidance

It should be borne in mind when reading this document that we assume that all users of TMfS have sufficient technical knowledge of the transport modelling concepts and software packages pertinent to the application of TMfS. Where insufficient detail is available from the supporting model development documentation, or this Audit Report, it is further assumed that users will refer to the model development documentation and LATIS support team for the necessary advice. Contact details and the Terms of Use can be found on the LATIS website.

Prospective model users of the LATIS service must complete a LATIS User Request Form to be submitted to TS prior to the use of data, the application of any of the modelling components or the use of model outputs. This has mutual benefits for both the model developers and potential users. Prospective users of TMfS should bear this process in mind when embarking on any study using TMfS or its inputs and outputs.

The audit process documented in this report has considered the development, calibration and validation of the TMfS12 base model only. At the time of writing we have not reviewed the associated development work, inputs to or outputs from any future Reference Case, Do-Minimum or Variance Case situation. Furthermore, while the audit seeks to undertake a thorough review of the base model development this has been balanced against the practicality of undertaking the audit within an appropriate timeframe and making best use of the resources invested by TS in this process. The audit offers a thorough review of the base model, but the detail of which is necessarily limited by this practicality. By implication, topics not outlined or referenced in this Audit Report should be considered as not having been subject to the audit process.

The Services Brief A4205341 issued to SIAS contained the scope of services for the "...update [of] the existing national Transport Model for Scotland (TMfS) from a 2007 base to a 2012 base." Part of the services specified by the Brief concerned the preparation of a scoping report for approval by Transport Scotland, which would establish the requirements and features of the model.

AECOM were supplied with "LATIS Lot 1 Scoping Note Version 2 – Development of TMfS12" (SIAS, January 2013) for consideration. This makes clear that "...the main focus of development for TMfS12 should relate to improvements required for the applications on the Perth-Inverness and Aberdeen-Inverness corridors only at this stage." Further, the model "...will effectively be a refreshed version of TMfS07 that reflects the 2012 network, includes some refinements to the zoning system for the assignment models and makes use of the available 2012 data for the calibration/validation process." Finally, it is important to note that the model development "...will be documented in the model development, calibration and validation reports in a similar form to those produced for TMfS07."

It is assumed that any hands-on user of the model will undertake a thorough, study specific review of TMfS in their intended study area to establish its localised strengths and weaknesses and overall fitness for purpose prior to application. This review process should also continue throughout the model application to ensure that amendments are included as appropriate and to verify the robustness of any assumptions made, the model inputs and its outputs in forecast mode. If in any doubt over this matter users should seek advice and clarification through the LATIS service. This will enable any issues to be resolved and if required, rectified for any future model releases.

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1.3 Acknowledgments

AECOM wish to acknowledge the assistance and cooperation of Transport Scotland and SIAS in supplying the necessary information during the course of this audit.

1.4 Background

As discussed above, TMfS12 generally takes the same structure as that of TMfS07. The model, therefore, has been constructed using the Cube Voyager software. The model was calibrated and validated using version 6.0.2. Model users should ensure that they have this version of the software installed prior to use.

The audit drew on a number of pieces of information including:

- LATIS Lot 1 – Services Brief – Development of TMfS, Transport Scotland;
- LATIS Lot 1 Scoping Note Version 2 – Development of TMfS12, SIAS, January 2013
- TMfS07 Model Development Audit Report, SIAS, October 2009;
- Draft Version of the TMfS12 Road Model Development Report (RMDR), SIAS, August 2013;
- Draft Version of the TMfS12 Public Transport Development Report (PTMDR), SIAS, October 2013;
- Draft Version of the TMfS12 Update of Demand Model (2012UDM), Peter Davidson Consultancy, September 2013
- Model zone system in GIS format, June 2013;
- Model network in CUBE format, June 2013;
- Traffic flow data;
- Roadside interview data;
- Journey time data;
- Public transport boarding and alighting data;
- Generalised cost parameter spreadsheet;
- Fares updating spreadsheet;
- Analysis, calibration and validation spreadsheets.

As discussed at the Transport Model Audit Services inception meeting (13th February 2013), there is no generic all encompassing fitness for purpose requirement for the TMfS12, rather the suitability of the model must be judged for each application. Nevertheless, the model should be expected to be suitable for a wide range of national scale policy and scheme interventions.

The following guidance is considered relevant to the audit:

- WebTAG 3.5.6;
- WebTAG 3.10;
- WebTAG 3.11.2;
- WebTAG 3.15; and
- WebTAG 3.19, and residual aspects of DMRB/TAM that relate to trip matrices.

We note that it was agreed between SIAS and TS that the documentation of the model would be to a similar level to that of TMfS07. However, we have referred to guidance for the recommended levels of documentation, and, where they differ from that provided have highlighted the difference. This is as an aid to the specification of any future update to TMfS.

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1.5 Structure of Report

This report contains a further six chapters, the contents of which are summarised below:

- Chapter Two audits the processing of data for the model development;
- Chapter Three reviews the updating of the Roads assignment model;
- Chapter Four presents an analysis of the calibration and validation of the Roads assignment model;
- Chapter Five reviews the updating of the PT assignment model
- Chapter Six audits the calibration and validation of the PT assignment model; and
- Chapter Seven reviews the updating of the Demand model.

Summary and conclusions are presented at the end of each chapter.

2 Data collection, collation and assimilation

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2 Data collection, collation and assimilation

2.1 Introduction

The use of statistically robust and up-to-date data is fundamental to the development of reliable and fit-for-purpose transport models. An assessment of data adequacy, and the methods to address shortcomings, lies at the heart of the balance between risk and timely delivery of model results.

The following key pieces of data have been used by SIAS to inform the development of TMfS12:

- traffic flow data;
- roadside interview data; and
- journey time route data.

These datasets are considered in turn in the following sections with the scope of the audit checks clearly stated at the beginning of each section.

2.2 Traffic Flow Data

2.2.1 Introduction

SIAS have used data from the Scottish Roads Traffic Database (SRTDb) to create a database of traffic flows on links across the country for use in model building, in particular calibration and validation. The aim of this process was to produce a comprehensive database of cleaned and processed hourly traffic counts representing “average” conditions for all sites across the country.

Details of processes used and the complete suite of spreadsheets used for the cleaning and processing of data have been provided. The scope of the audit has been to conduct a review of the general process followed and checks carried out, alongside an in-depth check of the application of this process for a sample of sites within the supplied spreadsheets.

2.2.2 General Assumptions

The following general assumptions have been adopted by SIAS:

- a year of data from September 2011 to August 2012 has been used. This is because full data for 2012 was not available at the time the data processing was undertaken. Given the time constraints of the model development, this is acceptable;
- data in SRTDb is in the form of vehicle counts. For use in TMfS12 a PCU factor of 1.9 is used to convert HGVs to PCUs. It is understood that this is consistent with previous versions of the model and, as such, has not been updated for some years. This factor should be reviewed for future versions of the model; and
- data is processed to provide outputs in terms of the following vehicle classes: Cars, LGVs and Heavies.

2.2.3 Cleaning and Processing Steps

The cleaning and processing steps undertaken by SIAS are as follows:

2.2.3.1 Starting point

- the initial outputs from SRTDb are generally in the form of separate CSV files for each site/direction in the database.

2.2.3.2 Initial processing

- input files are split as required as some SRTDb output files include data for two directions;
- standardisation of files – depending on the age/setup of each site, flow data can be collected in different vehicle classifications with some sites more disaggregate than others;
- removal of weekends, bank holidays, other special one-off days and Mondays/Fridays, leaving only typical Tuesdays to Thursdays; and
- around 2628 sites were passed through the process with 2509 sites eventually being passed on to the model building stage following the processing and cleaning checks.

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2.2.3.3 Data Cleaning

1 – Removal of day outliers

- for each site, each separate month was analysed with days where flow falls >1 standard deviation (SD) outside the average daily total flow for the month rejected; and
- it is understood that sites with a high proportion of rejected days at this stage were identified and it is assumed that these sites were removed;

2 – Removal of month outliers

- calculation of a “filtered” daily average total flow including only relevant months of “good” data;
- relevant neutral months considered to be Sept, Oct, Nov 2011 and Feb, Mar, May 2012;
- months with daily average totals >1SD outside the average rejected.

3 – Further data quality checks

- combination of sites where two sites are in the same place (e.g. individual lane counts on some motorway links);
- check of directional averages for lengths of route and removal of counts on route >200% different from the average count for the route;
- tidality by route/direction – check of ratio of AM/PM flows by route and direction with inconsistencies identified and corrected where possible. This often highlighted incorrect assignment of counts to links due to incorrect coordinates;
- check of adjacent counts where upstream and downstream counts differed by >100%; and
- check of motorway ramp locations and counts.

4 - Final Processing

- Conversion of HGV vehicular flows to PCUs using the PCU conversion factor. Where a site was not classified, this stage also calculated a 24 hour HGV proportion from all classified sites within that local authority area to apply to the unclassified sites.

2.2.3.4 Audit Comments

- Initial processing
 - the initial cleaning and processing of the data is carried out using sensible assumptions, removing appropriate days from consideration to limit the calculations to typical Tuesday-Thursday conditions.
- Data cleaning
 - a key assumption is the rejection of days where flows fall outside 1SD of the average flow for that month. This is a relatively stringent criterion but is considered a suitable basis for the cleaning of data in such a large overall dataset;
 - the choice of neutral months appears to be reasonable although some analysis of wider data might be useful to ensure that the months are truly representative of “typical” conditions. DMRB volume 12 Section1 Part 1 lists the standard neutral months as April, May, June, September and October. Given the lack of data for late 2012 it is acceptable to make use of late 2011 data;
 - the rejection of full month data falling outside 1SD of the average for all months is, again, a relatively stringent criterion and is appropriate for this case;
 - the final data quality checks are considered to be reasonable although, by their nature, it is difficult to fully confirm that they have been carried out satisfactorily. Some commentary on this subject would be beneficial to fully understand the quality of the final data;
 - it would be beneficial to see some summary statistics (e.g. in the form of a Technical Note) to understand the numbers of days/months etc. rejected at each checking stage to gain a better understanding of the checks carried out and the quality of data carried forward to the final dataset; and
 - the final stage of PCU conversion is generally reasonable. There is some risk attached to the use of 24 hour data to create proxy HGV proportions for each local authority area as there is often a considerable difference in HGV proportions across the day.

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2.2.3.5 Application of Process

Checks of the application of each stage of the process have been carried out to verify that the assumptions considered above have been applied correctly. Table 1 summarises these checks.

Table 1: Summary of Count Processing Checks

Site	Direction	Initial Processing		Removal of Day and Month Outliers				Further Data Quality Checks	Final Conversion to PCUs.
		"Out" sheet correct	Copied into "Processed" workbook correctly	"Processed" workbook without errors *	Copied into "Totals"	Months rejected correctly	Combined correctly (if necessary)	Included in "periodic flows" correctly	Included in "periodic PCU" correctly **
104326	North	Y	Y	Y	Y	Y	N/A	Y	Y
104326	South	Y	Y	Y	Y	Y	N/A	Y	Y
103094	North	Y	September 2011 missing. Possible cause is that one Tues-Thurs is missing Also May 2012.	Y	Y	Y	N/A	Y	Y
103094	South	Y	Same missing months as North site.	Y	Y	Y	N/A	Y	Y
107840	North	Y	Y	Y	Y	Y	N/A	Y	Y
107840	South	Y	Y	Y	Y	Y	N/A	Y	Y
104481	North	Y	Y - only months with a large number of missing days (seemingly > 3 incomplete Tue-Thur days) excluded.	Y	Y	Y	N/A	Y	Y
104481	South	Y	Y - as above	Y	Y	Y	N/A	Y	Y

* excluding small error previously identified with partial days. Checked using random checks on cell references

** not including small differences due to rounding

It can be seen that the process has been applied correctly in all tested cases subject to the following identified issues:

- an issue has been identified during the section of the process where day outliers are removed. This occurs in hours surrounding a site "outage" and is illustrated below where the reading for 2pm on the 2012-01-11 is clearly incorrect, yet it has been confirmed with the model builder that this data is not directly rejected at that stage but is included in calculations for the "all data" average and variance stats for the hour for that month, and then is checked against the bounds of acceptability and kept or rejected accordingly. It is likely that the average and variance stats would be affected by this outage and the record rejected at the next stage so the impact of this processing error is not considered to be significant; and

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- an error was found where the Further Data Quality Checks made at the end of the process were not properly transferred to the spreadsheet conducting the final conversion to PCUs, affecting some HGV flows passed to the model build. This was queried with SIAS who produced corrected analysis showing that the impact of the error at this stage on the output HGV flows is no more than 8%, furthermore, that the impact on count sites actually used in the model build is negligible. The impact of this error is not significant.

Date (yyyy-n)	Exclude day?	Hourly Total															
		12:00 AM	1:00 AM	2:00 AM	3:00 AM	4:00 AM	5:00 AM	6:00 AM	7:00 AM	8:00 AM	9:00 AM	10:00 AM	11:00 AM	12:00 PM	1:00 PM	2:00 PM	
2012-01-03	FALSE	36	31	18	19	25	30	63	97	126	74	103	220	261	305	323	
2012-01-04	FALSE	40	30	31	17	34	53	123	210	250	280	289	381	383	385	400	
2012-01-05	FALSE	41	30	23	27	46	77	122	230	295	264	267	334	403	362	335	
2012-01-10	FALSE	26	33	29	22	40	96	195	399	421	358	277	270	254	270	278	
2012-01-11	FALSE	36	29	26	21	45	86	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	1	
2012-01-12	FALSE	36	29	24	25	45	81	191	421	432	371	304	253	286	269	300	
2012-01-17	FALSE	33	31	32	30	38	86	186	391	492	384	304	283	276	280	233	
2012-01-18	FALSE	33	35	26	30	43	72	187	400	468	341	333	298	283	297	327	
2012-01-19	FALSE	33	33	29	23	51	100	191	371	428	361	287	247	271	281	284	
2012-01-24	FALSE	37	31	32	20	40	82	206	409	465	361	301	280	313	300	312	
2012-01-25	FALSE	38	25	23	22	47	82	201	368	450	367	299	268	280	284	325	
2012-01-26	FALSE	40	29	22	32	54	88	179	401	428	355	288	275	295	294	330	
2012-01-31	FALSE	30	30	25	23	49	93	205	433	455	381	281	292	282	273	265	

2.2.4 Summary and Recommendations

The model builder has applied a predominantly automated processing and data cleaning process to a large count dataset. Some issues have been found with the process as follows:

- it would be beneficial to produce a report/technical note on the processing to understand the nature of non-automated data cleaning tasks to further understand the checks carried out and the quality of data retained;
- a small number of processing issues have been found which give rise to some concern about the data processing. However, the auditors checks suggest that the impact of these errors on the counts passed to the model build are not significant; and
- in some cases, HGV counts may need to be treated with caution due to the use of 24 hour data to generate proxy factors for HGVs.

2.3 Roadside Interview Data

2.3.1 Introduction

SIAS have used RSI data to inform the updating of the trip matrix. The audit covers the processes used to check and clean this data. 33 sites were considered with a processing spreadsheet containing 26 sites provided by SIAS.

2.3.2 General Survey Characteristics

2.3.2.1 Survey Years

The RSI data was collected between 2004 and 2012 as shown in Table 2. WebTAG Unit 3.19 Paragraph 8.1.1. suggests that data more than six years old should not be used for model development. This affects one site, 19, Dumfries Site 1 Galloway Street, eastbound, Direction E.

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Table 2: RSI Survey Years

Year	Number of Sites
2004	1
2005	0
2006	0
2007	9
2008	0
2009	3
2010	7
2011	0
2012	6

Table 3: Pre 2008 RSI Sites

Site Number	Year	Description
8	2007	A93, around 1 mile south of Blairgowrie just to the north of Meikleour Forest
9	2007	A94, north of Scone Airport at the Rait junction
19	2004	Dumfries Site 1 Galloway Street, eastbound, Direction E
27	2007	Forth Road Bridge A90 Direction N
28	2007	A90, North of Forfar
29	2007	A90, South of Forfar
30	2007	A90, North of Swallow Roundabout
31	2007	A85 Swallow
32	2007	A92
33	2007	Tay Bridge

2.3.2.2 Survey Types

All sites have been surveyed by direct on-site driver interviews with the exception of those sites shown in Table 4. The use of postcard surveys tends to lead to poor HGV samples as these drivers tend to ignore the postcards. This should be recognised when considering results.

Table 4: RSI Survey Types

Site Number	Survey Type	Description
1	Mix postcard and survey	Barnchurch Road - Smithton - Tue 16th Mar 2010.xls
2	Postcard	B9006 Culloden Road Westhill (40mph with 30mph TTRO) Wednesday 25th November 2009
6	Postcard	A862 at Bunchrew Campsite (National Speed Limit with 30MPH TTRO) Wednesday 25th November 2009
7	Postcard	A96 West Side of Nairn (Outside Westerlea Hotel) Wednesday 25th November 2009
19	Postcard	Dumfries Site 1 Galloway Street, eastbound, Direction E
27	Postcard	Forth Road Bridge A90 Direction N
33	Postcard	Tay Bridge

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2.3.2.3 Sample Rates

Sample rates have been provided but without supporting analysis. Table 5, Table 6 and Table 7 summarise sample rates for all RSI sites for cars, LGVs and HGVs, comparing actual achieved rates with the rates required to achieve a +/-10% confidence interval at 95% confidence (based on guidance contained in DMRB Volume 12, Section 1, Appendix D13). Surveys where this requirement is satisfied are highlighted. It can be seen that the sample of cars is satisfied for the majority of sites.

RSI sample rates for Goods vehicles are often somewhat lower than those for cars. In the auditor's experience, this is a particular issue at postcard sites where goods vehicle drivers appear to be somewhat less inclined to return postcards than car drivers. The sample rates for the sites in question are consistent with this experience, with very few sites meeting the same level of sample rate for good vehicles as for cars. It is suggested that the emerging alternative methods of sampling trip patterns and purposes be considered for future iterations of the model.

Table 5: Car RSI Sample Analysis

		Counts			Proportion			Requirement			Met?		
		AM	IP	PM	AM	IP	PM	AM	IP	PM	AM	IP	PM
1	SB	1223	1489	718	20.3%	21.7%	25.6%	7.3%	6.1%	11.8%	YES	YES	YES
2	WB	472	1464	1236	92.2%	26.4%	15.0%	16.9%	6.2%	7.2%	YES	YES	YES
3	SB	1373	2123	1277	10.4%	14.5%	14.6%	6.5%	4.3%	7.0%	YES	YES	YES
4	SB	320	681	314	48.4%	36.1%	31.2%	23.1%	12.4%	23.5%	YES	YES	YES
5	NB	168	367	198	72.0%	75.7%	79.8%	36.5%	20.8%	32.8%	YES	YES	YES
6	EB	771	672	313	36.8%	20.2%	39.3%	11.1%	12.5%	23.5%	YES	YES	YES
7	WB	995	2191	1395	32.9%	19.4%	12.8%	8.8%	4.2%	6.4%	YES	YES	YES
8	SB	574	738	370	63.4%	74.5%	71.6%	14.4%	11.5%	20.7%	YES	YES	YES
9	SB	389	507	353	75.8%	69.2%	53.3%	19.8%	16.0%	21.4%	YES	YES	YES
10	SB	924	2857	1546	16.2%	7.5%	5.7%	9.4%	3.3%	5.9%	YES	YES	NO
11	NB	328	1611	761	24.4%	12.0%	11.0%	22.7%	5.6%	11.2%	YES	YES	NO
12	SB	776	2295	1206	18.4%	10.7%	6.6%	11.0%	4.0%	7.4%	YES	YES	NO
13	SB	431	1008	551	5.3%	5.8%	5.4%	18.3%	8.7%	14.9%	NO	NO	NO
14	SB	273	580	299	23.8%	18.3%	14.7%	26.1%	14.2%	24.4%	NO	YES	NO
15	SB	184	519	287	23.9%	9.6%	10.8%	34.4%	15.6%	25.1%	NO	NO	NO
16	NB	101	512	236	67.3%	28.7%	21.6%	49.0%	15.8%	29.0%	YES	YES	NO
17	NB	299	1166	666	24.7%	16.3%	14.3%	24.4%	7.6%	12.6%	YES	YES	YES
18	WB	142	564	267	47.9%	31.4%	16.9%	40.5%	14.6%	26.5%	YES	YES	NO
28	SB	1257	2424	1707	18.3%	16.5%	14.1%	7.1%	3.8%	5.3%	YES	YES	YES
29	SB	2273	3293	2150	18.2%	16.9%	17.4%	4.1%	2.8%	4.3%	YES	YES	YES
30	EB	1962	3262	2244	14.4%	15.4%	15.9%	4.7%	2.9%	4.1%	YES	YES	YES
31	SB	2133	2744	1611	19.8%	24.4%	25.4%	4.3%	3.4%	5.6%	YES	YES	YES
32	EB	1595	4142	3294	20.9%	15.1%	14.3%	5.7%	2.3%	2.8%	YES	YES	YES
33	SB	1547	3434	3383	20.5%	15.1%	23.0%	5.8%	2.7%	2.8%	YES	YES	YES

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Table 6: LGV RSI Sample Analysis

		Counts			Proportion			Requirement			Met?		
		AM	IP	PM	AM	IP	PM	AM	IP	PM	AM	IP	PM
1	SB	167	141	75	10.2%	10.6%	5.3%	36.7%	40.7%	56.5%	NO	NO	NO
2	WB	80	173	104	21.3%	9.8%	3.8%	54.9%	35.8%	48.3%	NO	NO	NO
3	SB	253	438	270	13.4%	14.8%	18.1%	27.6%	18.0%	26.3%	NO	NO	NO
4	SB	37	131	132	48.6%	26.0%	18.9%	72.7%	42.5%	42.3%	NO	NO	NO
5	NB	35	40	20	62.9%	67.5%	75.0%	73.9%	71.1%	83.5%	NO	NO	NO
6	EB	121	152	59	13.2%	18.4%	33.9%	44.5%	38.9%	62.3%	NO	NO	NO
7	WB	275	413	145	8.4%	11.9%	9.7%	26.0%	18.9%	40.0%	NO	NO	NO
8	SB	68	124	98	41.2%	55.6%	28.6%	58.9%	43.8%	49.8%	NO	YES	NO
9	SB	53	109	76	73.6%	39.4%	35.5%	64.9%	47.1%	56.2%	YES	NO	NO
10	SB	NA	NA	NA									
11	NB	48	262	160	54.2%	9.5%	4.4%	67.1%	26.9%	37.7%	NO	NO	NO
12	SB	NA	NA	NA									
13	SB	103	162	98	2.9%	1.2%	4.1%	48.5%	37.4%	49.8%	NO	NO	NO
14	SB	70	86	43	55.7%	18.6%	20.9%	58.2%	53.0%	69.6%	NO	NO	NO
15	SB	46	91	58	13.0%	6.6%	1.7%	68.1%	51.6%	62.8%	NO	NO	NO
16	NB	30	75	40	70.0%	30.7%	7.5%	76.8%	56.5%	71.1%	NO	NO	NO
17	NB	104	157	53	17.3%	7.0%	18.9%	48.3%	38.1%	64.9%	NO	NO	NO
18	WB	45	80	40	53.3%	18.8%	5.0%	68.6%	54.9%	71.1%	NO	NO	NO
28	SB	193	527	336	20.7%	17.8%	12.8%	33.3%	15.4%	22.3%	NO	YES	NO
29	SB	352	758	410	17.0%	14.6%	11.7%	21.5%	11.3%	19.0%	NO	YES	NO
30	EB	520	718	364	11.3%	12.7%	14.6%	15.6%	11.8%	20.9%	NO	YES	NO
31	SB	287	352	126	19.5%	18.2%	18.3%	25.1%	21.5%	43.4%	NO	NO	NO
32	EB	239	434	192	6.7%	6.7%	6.8%	28.8%	18.2%	33.5%	NO	NO	NO
33	SB	338	540	331	7.7%	7.2%	12.1%	22.2%	15.1%	22.5%	NO	NO	NO

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Table 7: HGV RSI Sample Analysis

		Counts			Proportion			Requirement			Met?		
		AM	IP	PM	AM	IP	PM	AM	IP	PM	AM	IP	PM
1	SB	54	82	27	3.7%	3.7%	7.4%	64.4%	54.2%	78.7%	NO	NO	NO
2	WB	25	45	27	8.0%	8.9%	3.7%	80.0%	68.6%	78.7%	NO	NO	NO
3	SB	130	313	128	13.8%	14.1%	10.2%	42.7%	23.5%	43.1%	NO	NO	NO
4	SB	44	121	69	25.0%	9.1%	5.8%	69.1%	44.5%	58.5%	NO	NO	NO
5	NB	30	38	18	26.7%	52.6%	27.8%	76.8%	72.2%	85.0%	NO	NO	NO
6	EB	28	62	25	17.9%	21.0%	20.0%	78.1%	61.2%	80.0%	NO	NO	NO
7	WB	144	240	82	11.1%	10.8%	12.2%	40.2%	28.7%	54.2%	NO	NO	NO
8	SB	58	121	25	37.9%	26.4%	32.0%	62.8%	44.5%	80.0%	NO	NO	NO
9	SB	48	122	58	60.4%	41.0%	48.3%	67.1%	44.2%	62.8%	NO	NO	NO
10	SB	NA	NA	NA									
11	NB	78	387	150	23.1%	6.5%	4.0%	55.5%	19.9%	39.2%	NO	NO	NO
12	SB	NA	NA	NA									
13	SB	65	169	82	27.7%	11.8%	12.2%	60.0%	36.4%	54.2%	NO	NO	NO
14	SB	25	42	25	4.0%	0.0%	0.0%	80.0%	70.1%	80.0%	NO	NO	NO
15	SB	52	132	61	17.3%	10.6%	0.0%	65.3%	42.3%	61.5%	NO	NO	NO
16	NB	20	40	23	50.0%	7.5%	0.0%	83.5%	71.1%	81.4%	NO	NO	NO
17	NB	79	110	58	1.3%	0.9%	1.7%	55.2%	46.8%	62.8%	NO	NO	NO
18	WB	19	69	26	100.0%	11.6%	7.7%	84.2%	58.5%	79.3%	YES	NO	NO
28	SB	279	964	343	14.0%	8.6%	10.8%	25.7%	9.1%	21.9%	NO	NO	NO
29	SB	438	1049	353	4.1%	7.3%	7.9%	18.0%	8.4%	21.4%	NO	NO	NO
30	EB	625	1020	317	11.4%	12.2%	14.2%	13.3%	8.6%	23.3%	NO	YES	NO
31	SB	150	277	83	15.3%	17.0%	16.9%	39.2%	25.8%	53.9%	NO	NO	NO
32	EB	157	351	76	1.3%	0.9%	0.0%	38.1%	21.5%	56.2%	NO	NO	NO
33	SB	220	414	123	5.5%	2.9%	3.3%	30.5%	18.9%	44.0%	NO	NO	NO

2.3.3 Initial Data Cleaning

Our understanding of the initial data cleaning stages is as follows:

- postcodes for each record mapped to TMfS zones. Geographically illogical movements checked and removed where necessary;
- pulled into consistent format with coding of journey purposes harmonised to a consistent format;
- records with missing origin or destination removed.

At this stage no checks were made of reported journey purpose being correct (e.g. high number of work – home trips in AM peak period). It would have been beneficial to carry out these checks to understand certain characteristics of the data.

2.3.4 Survey Processing

The spreadsheet used for the processing of RSI records has been checked and is discussed below.

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2.3.4.1 Derivation of Journey Purposes

Following the harmonisation of survey journey purposes, a process was applied to convert all potential pairs of origin-destination purposes to one of five user classes as follows:

- 1: Car in work;
- 2: Car non work commute;
- 3: Car non work other;
- 4: LGV; and
- 5: HGV.

An issue has been identified with this journey purpose mapping concerning the allocation of “Car in work” trips. SIAS’ assumption has been to map only workplace-workplace trips to “Car in work”. Analysis of the processed RSIs has shown that the proportion of these business trips is, therefore, somewhat lower than might be expected when compared with typical values from National Travel Survey data – around 2.5% of all trips. This will have the impact of unduly biasing trips in affected areas such that the proportion of trips in “business” time is too low affecting routing in the model and subsequent economic analysis.

2.3.4.2 Derivation of “reverse” time of journey

The RSI surveys only survey vehicles travelling in one direction. Therefore, a set of assumptions were developed to assign a time of journey to return or “reverse” journeys in the opposite direction. The assumptions adopted by SIAS are shown in Table 8.

Table 8: Reverse Journeys Assumptions

User Class	Description	Reverse Trip Time	
1	Car in work	Home to work, AM	Add 9 hours
		Home to work, IP and PM	Add 3 hours
		Work to Home, AM and IP	Subtract 3 hours
		Work to Home, PM	Subtract 9 hours
		Otherwise	Same
2	Car non work, commute	AM, PM	Add/subtract 9 hours
		IP	Same
3	Car non work, other	Same	
4	LGV	Same	
5	HGV	Same	

Identified comments and issues with this process are as follows:

- the “non work commute” rule is reasonable for AM and PM peaks – it is sensible to assume that the commuter is heading to/from a typical 8 hour work day plus an allowance for journey time;
- in the IP period the situation is less satisfactory – someone travelling from home to their normal workplace at 3pm, for example, would be considered to be making their return journey before 4pm. Since we can determine whether someone is travelling to or from home, it would be possible to adopt a more sophisticated approach to apply an offset to this in a similar manner to AM and PM – “to home” journeys will have had a “from home” journey a few hours earlier, and vice versa; and
- further sophistication could be applied to the “reverse” journey’s process to better reflect the most likely patterns of reverse trips for a given outward trip. For example, the Scottish Household Survey Travel Diary could be interrogated to create a probability distribution of reverse journey times rather than adopting the standard assumptions stated above.

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2.3.4.3 Check of Spreadsheet Procedures

A check of spreadsheet calculations and procedures involved in the data processing has been carried out. The following issues have been identified:

- no explanation is provided for why some records in the spreadsheet have been marked as rejected records – spot checks suggest that these have been rejected as part of the earlier checks due to being geographically illogical movements but this should be clarified;
- the processing of site numbers 8, 9, 29, 30, 31, 32 and 33 maps an origin of “meeting/other workplace” with a destination of “normal workplace” or “meeting/other workplace” to “Car non work other”. The auditor considers that it would be more appropriate to map these as “Car in Work”;
- an error in the calculation of expansion factors is identified as the calculation appears to include rejected records for reverse trips. This will have the impact of under-expanding interviews with a greater impact on those sites where there is a larger proportion of rejected records.

2.3.5 Summary and Recommendations

The model builder has used a part automated process to clean and process RSI records for use in the model build. The following issues are identified, all of which are considered to have a potential impact on the quality of the model in the areas where new surveys have been incorporated into the matrix.

- 10 sites surveyed in 2007 or earlier are used. The location of these sites should be recognised when considering the quality and use of the model;
- 7 sites were surveyed using part or all postcards. Again, the location of these sites should be recognised when considering the quality and use of the model;
- Sample rates have been analysed and show that, in common with many RSI surveys, rates are generally lower for LGVs and HGVs than for cars. It is suggested that the emerging alternative methods of sampling trip patterns and purposes be considered for future iterations of the model;
- No logic checks of reported journey purpose appear to have been made although records have reportedly been checked for geographically illogical movements;
- An issue has been identified with the mapping of survey records to the journey purposes used in TMfS12 resulting in business trips being understated; and
- Additional sophistication might be applied to the timing applied to reverse trips to better reflect potential reverse trip timing.

2.4 Journey Time Route Data

2.4.1 Introduction

Journey time data used for the validation of the model has been taken from the INRIX database. The audit covers the processes used to extract data from INRIX and the assumptions and processes used to clean the data.

Data for the same journey time routes as those used in TMfS07 has been extracted for use. It is unclear what range of dates the survey data covers. The model developers and TS are unable precisely define the data dates but it is thought to cover the period 2008-11.

2.4.2 Data Extraction and Processing

The data was processed as follows:

- Trace the relevant paths in TMfS12 to get the model nodes along the route and derive the unique link identity code from the “ITN” representation of the road network (known as the TOID) for each TMfS12 link;
- Use mapinfo to associate INRIX data for each TOID with the journey time route TOIDs above; and
- Export as csv for analysis in MS Excel.

This is a simple process and whilst it was not possible to audit this part of the work, the risk of significant errors is minimal. Notwithstanding, a key issue faced by SIAS was the fact that the ITN networks were not consistent between TMfS12 and the INRIX data. This means that there are some gaps in the data which required filling within MS Excel. This is considered below.

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2.4.3 Data Cleaning

The assumption used for the filling of gaps in the data was to use the speed from the link immediately preceding the link with missing data on the route. If there were several links with missing data this was carried through all affected links. This approach is considered reasonable.

The process used to apply this patching has been checked with no issues found.

Table 9 summarises the patching process in terms of the proportion of each length of route which uses patched data. This shows that only 6 one-way routes see greater than 20% of route length patched with most routes less than 10%. An analysis of the model network also shows that, in many cases, the missing links are isolated shaping nodes or links through junctions so the risk of patching significantly understating or overstating time on a route would be relatively small.

Routes 7, 11 and 29 (Helmsdale-Thurso, Crianlarich-Oban and Stirling-Glasgow) have the longest sections of patched data and the reduced confidence we would therefore have in the journey times for these and other routes should be recognised when considering the calibration and validation of the model.

It should also be noted that INRIX data is presented in terms of a two-way averages (with the exception of motorways and dual carriageways where directional averages are given). This should be borne in mind when considering the results of sections made up of single carriageway roads.

Table 9: Journey Time Patching Analysis

Proportion of Route Length Patched	Number of Routes
0.05	37
0.1	40
0.15	20
0.2	4
0.25	0
0.3	1
0.35	1

2.4.4 Summary and Conclusion

INRIX data has been used to derive journey time data for use in the calibration and validation process. The process and any issues are summarised as follows:

- The mismatch between various ITN layers means that there are some gaps in routes that required “patching”;
- This involved using the speed from the link immediately preceding the link with the missing data to derive a time for that link;
- No issues were found with the application of this process; and
- Analysis of the data showed that most routes are not significantly affected by patched data. Routes 7, 11 and 29 are the most significantly affected and the level of patched data on all routes should be recognised when considering the calibration and validation of the model.

2.5 Summary and Recommendations

Table 10 reproduces the issues identified as part of the data audit categorised as follows:

- Model or reporting deficient – action to rectify required;
- Advice to model users; and
- Advice to TS on future model development.

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Table 10: Summary and recommendations - data collection, collation and assimilation

Subject	Details
Advice to model users	
Traffic flow data	A small number of processing issues have been found which give rise to some concern about the data processing. However, the auditors checks suggest that the impact of these errors on the counts passed to the model build are not significant.
Traffic flow data	In some cases, HGV counts may need to be treated with caution due to the use of 24 hour data to generate proxy factors for HGVs.
Traffic flow data	It would be beneficial to produce a report/technical note on the processing to understand the nature of non-automated data cleaning tasks to further understand the checks carried out and the quality of data retained.
Roadside interview data	10 sites surveyed in 2007 or earlier are used. The location of these sites should be recognised when considering the quality and use of the model.
Roadside interview data	Sample rates have been analysed and show that, in common with many RSI surveys, rates are generally low for LGVs and HGVs. It is accepted that this represents the best quality of data that could potentially be achieved. 7 sites have also been identified as having particularly low car sample rates.
Roadside interview data	No logic checks of reported journey purpose appear to have been made although records have reportedly been checked for geographically illogical movements.
Roadside interview data	An issue has been identified with the processing of the RSIs added in the development of TMfS12 in the mapping of survey records to the journey purposes. This results in business trips being understated.
Journey time route data	The mismatch between various ITN layers means that there are some gaps in routes that required "patching". This involved using the speed from the link immediately preceding the link with the missing data to derive a time for that link. No issues were found with the application of this process
Journey time route data	Analysis of the data showed that most routes are not significantly affected by patched data. Routes 7, 11 and 29 are the most significantly affected and the level of patched data on all routes should be recognised when considering the calibration and validation of the model.
Advice to TS on future model development	
Traffic flow data	The continued use of the historic HGV PCU factor of 1.9 should be reviewed for future model updates
Roadside interview data	Additional sophistication might be applied to the timing applied to reverse trips to better reflect potential reverse trip timing
Roadside interview data	An issue has been identified with the processing of the RSIs added in the development of TMfS12 in the mapping of survey records to the journey purposes. This results in business trips being understated. A modified definition should be adopted in future to correct for this issue, and future data collection should include modified survey forms to allow the separate identification of 'normal' and 'other' workplace.

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Roadside interview data	Emerging alternative methods of sampling trip patterns and purposes should be considered for future iterations of the model.
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3 Roads Model Development

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3 Roads Model Development

3.1 Introduction

As noted in Chapter 1, it is understood that changes to the road network and zone system have been limited and focused on the A9 and A96 corridors, with the exception of inserting recently built infrastructure.

We have undertaken a document review (which includes developing understanding of the rationale behind any changes) and sampled checking.

Any issues highlighted in the audit of TMfS07 outside of these corridors are assumed to be still valid and should be borne in mind, along with any issues identified here, for future model development and use. Briefly, the main identified issues that are considered still to apply are:

- the changing role of the National model compared to versions prior to TMfS07 and the requirement to consider the development and application of regional models (see TMfS07 Audit Report Para 2.3.7);
- the requirement for users of the model (and associated sub-area/regional models) to seek advice from the model developers/TS regarding the details of the planning assumptions included in the future year forecasts in the localities relevant to their particular application (see TMfS07 Audit Report Para 2.3.15); and
- the importance for each user of undertaking a review of the model and any sub-area or regional models in the areas of specific interest to their intended applications prior to using the model(s) (see TMfS07 Audit Report Para 2.3.25).

As an aid to the reader, the auditor's specific comments on the development of TMfS07 are summarised at the beginning of the relevant section.

3.2 Model Zoning

3.2.1 Introduction

The discussion of the changes to the model zone system affects all elements of the model - Highway, PT and Demand. The content of this section is equally relevant to all these elements.

SIAS and TS agreed that the TMfS12 zoning system be structured as follows:

- consistent with TMfS07 for TELMoS;
- consistent with TMfS07 for the TMfS12 Demand Model; and
- refined in the Aberdeen-Inverness and Perth-Inverness corridors for the TMfS12 roads and PT assignment models.

The TMfS07 audit comments are summarised as follows:

- rationale for adopting consistency between data zones and model zones is considered sensible;
- reduction in number of zones from prior versions is consistent with the objective of creating a coarser, more strategic national model;
- ratio of data zones to model zones is consistent across the model area – generally between 7-10 data zones per model zone;
- general principle of splitting data zones to more than one model zone in some places is considered good general working practice; and
- approach to zoning of airports is considered appropriate.

The scope of this section of the audit is limited to the changes made in the Aberdeen-Inverness and Perth-Inverness corridors in the assignment models only, together with the interface between this revised zone system and the TMfS07 zone system used for the remaining elements of the model.

3.2.2 Zone System Updates

The TMfS07 zone system incorporates 720 zones with the revised TMfS12 zone system expanded slightly to incorporate 734 assignment model zones. The zoning of the demand model is unchanged with an interface between the two zone systems used. As noted above, the updates to the zone system have been carried out with a focus on the Aberdeen-Inverness (A96) and Perth-Inverness (A9) corridors.

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The revised zone system contains:

- 722 internal zones (i.e., within Scotland);
- four airport zones (Aberdeen, Edinburgh, Glasgow and Prestwick); and
- eight external zones covering England and Wales.

It is understood that compatibility was retained between the zone systems such that the changes involved the splitting of TMfS07 zones rather than the redrawing of zone boundaries.

Considering the specific changes made to the zones system: a preliminary feasibility assessment of improvements to the A9 and A96 had been undertaken by Jacobs around December 2012. Accordingly Jacobs provided advice to SIAS and reviewed the detailed work undertaken in disaggregating the zone system of TMfS12 in these corridors. The conclusion of this review is set out in Table 11 which contains the detailed comments made by Jacobs and the SIAS' responses to these comments. The responses from SIAS together with GIS layers comparing the TMfS07 and expanded zone system have been analysed and the auditor can confirm that the Jacobs comments have been taken into account. The only exception to this is comment 1 where the SIAS response is accepted.

Table 11: Rezoning Detail

	Comment from Jacobs	SIAS Response
1	"Ardersier, Croy and Inverness Airport (zone 694) – it may be desirable to split this zone given planning aspirations for significant development at Tornagrain and the potential testing of a new rail station and Park and Ride facilities at Dalcross. However, it is not clear what the most appropriate boundary definition to split this zone would be."	Zone 694 has been disaggregated into 3 zones, 694 Inverness Airport, 715 Ardesier and 716 Croy. Due to the demand model being unchanged the addition of specific development will not be reflected in the zone disaggregation, the potential to test a new rail station and park and ride will be better reflected with the refined zoning system.
2	"Nairn (zone 698) – it may be desirable to split this zone into an 'urban' zone representing the town of Nairn itself and a 'rural' zone representing the less densely populated areas to the south: an area which is likely to lie to the south of any bypass option and for which public transport alternatives are perhaps a less viable option. The most appropriate location for the zone centroid connector for the 'rural' zone would possibly be Cawdor or Aulderm."	Zone 698 has been disaggregated into 2 zones 698 Nairn and 717 Blairmore. Zone 698 represents the 'urban' Nairn zone which has the road and rail accessibility and zone 717 represents the rural areas which joins the road network on the B9101.
3	"Forres (zone 635) – as for Nairn it may be desirable to split this zone into an 'urban' zone representing the town of Forres itself (which has greater access to public transport) and a rural zone representing the less densely populated areas to the west and south. Splitting this zone is perhaps less important than for Nairn, but may help improve the validation of demand on the rail network (which appears to underestimate demand into Inverness in the morning and outbound in the evening) and improve what appears to be relatively poor flow validation on the A96 between Nairn and Forres."	Zone 635 has been disaggregated into 2 zones 635 Forres and 718 Damaway. Zone 635 represents the 'urban' Forres zone which has the road and rail accessibility and zone 718 represents the rural areas which joins the road network on the A940.

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	Comment from Jacobs	SIAS Response
4	Fochabers and Mosstodloch (zone 642) – this zone is relatively large in relation to the length of any A96 upgrade and therefore it may be desirable to split this zone along the line of the River Spey. A zone to the west would therefore represent Lhanbryde and Mosstodloch, with a zone to the east representing Fochabers.	Zone 642 has been disaggregated into 2 zones 642 Lhanbryde And Mosstodloch and 719 Fochabers. Zone 642 and 718 represent the areas as specified above and the connectivity on the A96 has been refined.
5	Keith (zone 643) – as for Nairn and Forres, it may be desirable to split this zone to distinguish between the urban area (which would be bypassed and is likely to be better served by public transport) from the more rural area to the southwest.	Zone 643 has been disaggregated into 2 zones 643 Keith and 720 Auchlunkart. Zone 643 represents the 'urban' Keith zone which has the road and rail accessibility and zone 720 represents the rural areas which joins the road network on the A95.
6	Inverness South (zone 684) – since much of the recent residential development in the Inverness area has occurred close to the B8082 Sir Walter Scott Drive, it may be desirable to split this zone into the existing 'urban' areas along the B8082 (Hilton, Milton and Lochardil Wards) and the more recent and future development areas to the south. This may assist in the testing of any future A9 / A96 connection options (as well as future land use modelling).	Zone 684 has been disaggregated into 2 zones 684 Inverness South and 721 Essich. Whilst the zone disaggregation will not fully account for additional development specific to any zone it does reflect some refinement to the zone system and the loading points on the network. Zone 721 loads onto the B8082 on the boundary of Inverness.
7	Aviemore (zone 700) – it may be desirable to split this zone into two, with the northern part of this zone representing Aviemore and the southern part of the zone representing Kincaig, as traffic to / from Kincaig may access the A9 at either the B9152 junction south of Aviemore or the Kingussie junction. This split may assist with junction strategy options.	Zone 700 has been disaggregated into 2 zones 700 Aviemore and 722 Kincaig. This refines the zone loading points as discussed above and also refines the rail accessibility.
8	Aberfeldy (zone 526) – this zone represents a very large geographical area. Consequently, it may be desirable to split the southeast section of this zone representing Aberfeldy and the other settlements along the A827, which would access the A9 at Ballinluig, from the more rural areas to the north (Tummel Bridge, Kinloch Rannoch and Calvine), which would likely access the A9 further north at Calvine.	Zone 526 has been disaggregated into 2 zones 526 Aberfeldy and 723 Tummel. Zone 526 represents the trips from Aberfeldy which loads onto the A827 which could access the A9 at Ballinluig. Zone 723 loads onto the A9 at the north junction to Pitlochry and the rail link to Rannock station has been retained so it is consistent with the TMfS07 zone system.
9	Pitlochry (zone 529) – it may be desirable to split this zone into two areas representing Pitlochry (an area better served by public transport) and Ballinluig (which lies to the south of an existing dual carriageway section and is much less well served by public transport compared to Pitlochry).	Zone 529 has been disaggregated into 2 zones 529 Pitlochry and 724 Ballinluig. This disaggregation retains the rail accessibility to Pitlochry and takes account of the rural nature of zone 724 which accesses the road network on the A827.
10	Methven (zone 532) – it may be desirable to split this zone	Zone 532 has been disaggregated into 2 zones 532

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	Comment from Jacobs	SIAS Response
	into a northern portion representing traffic that would join the A9 at Luncarty and a southern section representing traffic that would access the A9 via the A85 onto the existing Perth western bypass.	Luncarty and 725 Methven. Zone 532 loads onto the B8063 which accesses the A9 at Luncarty and zone 725 accesses the network via the A85.
11	Fort Augustus, Invermoriston, Drumnadrochit and Cannich (zone 674) – this zone represents a very large geographical area and it may be necessary to split this zone to improve the representation of traffic on the A82, as the preliminary assessment of the A9 upgrade has indicated significant potential for route switching between the A82 and the A9, possibly because journey times along the A82 are not represented accurately enough in the base model (potentially due to the zone size).	Zone 674 has been disaggregated into 2 zones 674 Drumnadrochit and 726 Fort Augustus. The zones have been refined to take account of the above and now represent a reasonable geographical size.
12	We agree with the disaggregation of zone 682 into three separate zones for Kingussie, Newtonmore and Dalwhinnie”	Zone 682 has been disaggregated into 3 zones; 682 Newtonmore, 713 Dalwhinnie and 714 Kingussie. Zone 682 represents the built up area of Newtonmore and zone 714 represents the built up area of Kingussie whereas zone 682 represents Dalwhinnie and the remainder of the TMfS07 zone. All three zones have individual connections to both the local road network and rail station which is consistent with the TMfS07 connectivity however it has been refined for TMfS12.

As auditor, we were satisfied by the scope and competence of this review process and did not therefore seek independently to replicate this. We limited our review to compliance with best practice set out in WebTAG 3.19, taking into consideration the objectives of TMfS, and areas where the work undertaken could have been improved. In this regard we noted the following issues:

- guidance recommends a review of tripends / zone to ensure that loading onto the network is not unduly 'lumpy' and while this is of particular importance when modelling junctions in urban networks, there would be benefits applying such practice to regional / national models. Subsequent discussion between the auditor and SIAS has confirmed that the trip ends were not a driver for the disaggregation of each zone; and
- homogeneity of land use assists interpretation of forecasting assumptions for future disaggregation of trips. While accepting that the linkage with TELMoS provides some assurance in this regard there would have been benefits in reviewing the choice of zone boundaries on this basis.

No further issues were identified on the A96 corridor.

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On the A9 corridor the following issues are highlighted:

- zone size - the zones around the A9 generally cover large geographic areas but only have a low density of trip generators such as population and employment. Each of these zones has only one centroid connector. Despite relatively low levels of demand, the likely consequence of this will be difficulty in achieving a close match in the variations of traffic flow along the A9. In some cases, the zones represent dispersed populations which may actually load in very different places. For strategic trips, this is probably acceptable. However, it can make a difference to low flow situations on the A9. One example of this issue is described below;
- zone 531 is called Blair Atholl and the one centroid connector loads at the village by the A9. However, the A93 passes through the eastern side of the zone. The Glen Shee ski area is on the A93 close to the boundary between zones 531 and 579. In reality, these trips will not be using the A9 and should be loaded at a different point. The only way that this could be improved would be to subdivide these zones.

Through the A82 corridor, zoning faces similar issues to the A9 due to the sparse population and large geographical area covered. Generally, the zoning system used appears fit for purpose with the following comments, which should be borne in mind for future development of the model:

- Zone 458 should be divided into two on a north-south axis to cover the distinct population centres of Killin and Lochearnhead in the east and Crianlarich and Tyndrum in the west.
- Zone 656 covers two distinct loading points onto the A82; the A83 in the south and the A85 in the north. This zone should be split such that trips can be split across these two roads appropriately.

3.2.3 Disaggregation and TELMoS/Demand Model to Supply Model Interface

SIAS state that the disaggregation of the zones is applied at a trip end level with factors derived from the 2001 census table KS01, usual resident population. These factors have been applied to the household field in the zones specification and also to the trip disaggregation for the road and public transport assignment. The output assignment skims and costs have been aggregated back up to the 720 zone system using a procedure which weights the costs by the number of trips in that particular zone.

The data used are older than desired, nevertheless this approach is considered acceptable. Therefore, there are uncertainties in trip ends which may have implication for model use. This should be borne in mind and due care exercised in model application.

It is noted that 2011 census information at the required level of disaggregation is not yet available. Once it becomes available its use should be considered for further updates to the model.

3.2.4 Summary

In summary, the TMfS07 zone system has been retained in TMfS12, with disaggregation in the A96 and A9 corridors. The approach taken was for Jacobs, drawing on their recent experience of applying TMfS07, to advise where access to the A96/A9 may be represented in too aggregate a way for operational appraisal. The model builder considered these and established a finer zone system along these routes.

In addition to the zone system providing a basis to represent access to the network in sufficient precision, best practice is for the land use patterns to be reasonably homogeneous and for the trip ends to be reasonably similar in total in each zone. The work undertaken drew upon TMfS07 consideration of these additional issues and no explicit consideration was given.

The approach taken is considered generally satisfactory. However, whilst undertaking this review, the auditor noted that in the A9 corridor the zone size and connectivity results in some flows along the A9 being inadequately represented and potential users of the model should be aware of this finding.

Capabilities on project:
Transportation

3.3 Network Development

3.3.1 Introduction

Given the relatively limited scope of the update of the model from TMfS07 to TMfS12, network enhancements have been limited to the incorporation of an agreed set of schemes completed since 2007 together with enhancements to network coverage in the A9 and A96 corridors. This audit has covered these enhancements only.

The TMfS07 audit comments are summarised as follows:

- in terms of the road network, the geographical coverage of the model is appropriate;
- the link attributes attached to each model link are considered appropriate "in general terms";
- road link types used are consistent with those outlined in "Scottish Transport Statistics Note 24" (August 2005) to enable correspondence of output statistics with observations. Generic capacities used are considered reasonable and representative for each link type. A detailed check "generally showed that capacity coding across the network was acceptable"; and
- an approach to reflect localised delays at rural junctions was deemed acceptable with a warning the methodology would not, however, be recommended for regional or sub-area modelling".

The scope of the audit is therefore limited to an investigation of the added schemes and network connectivity in the A9 and A96 corridors.

3.3.2 Background to Network Detail and Extents

The coded network is based on the TMfS07 network and has been reviewed against the OS Meridian Dataset, local knowledge and Google Maps. This provides a geographically accurate network suitable for noise, air quality analysis and traffic modelling.

All motorways and A-roads in Scotland are included along with strategically important B-roads in the Central Belt, Scottish Borders and Aberdeenshire. Other minor roads are included as required where appropriate. No changes have been made in the skeleton network for England and Wales.

Each link has a number of attributes assigned to it in the network database. A number of these are used for the identification of links by area and type and are useful for both the more detailed coding of the model and the analysis of results.

No changes have been made to link types and capacities compared with TMfS07 so no check of the coded capacities has been made apart from new links added to the network associated with road schemes or other identified enhancements.

3.3.3 Network Enhancements

The following schemes have been identified and agreed with TS for inclusion in TMfS12:

- M74 Completion;
- M80 Upgrade;
- A68 Dalkeith Northern Bypass;
- M9 Spur;
- A82 Strathleven;
- Upper Forth Crossing;
- Pollock Silverburn;
- Glasgow East End Regeneration Route Phase 1 & 2;
- M8 Heartlands;
- A96 Fochabers Bypass;
- A830 Arisaig to Loch nan Uamh;
- Airdrie Bathgate Rail Link;
- Stirling Alloa Rail Link;
- Edinburgh Trams Phase 1a; and
- Laurencekirk station.

Capabilities on project:
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The coding for these schemes has been checked with the following issues arising:

- M80 Stepps to Haggs – the upgrade to motorway standard of the section between Mollinsburn to Haggs appears to have been overlooked with the link type for this section remaining type 3 (Trunk A-road non built up) and, for example, the rearrangement of the “Old Inns” junction not being included.

Several other network enhancements were identified as part of a network review undertaken by SIAS:

- Correction of over 250 identified instances where short connecting links between one-way dual carriageway links and over-bridges were incorrectly connected (>250 updates);
- Coding issues identified as part of the TMfS07 audit (38 updates);
- A9 corridor review showed that routing through many junctions was not correct so 158 banned turns were identified and corrected in the network coding;
- 13 adjustments made on parallel corridors to the A9 and A96;
- Jacobs identified a number of coding enhancements to the A9 and A96 corridors which were applied to the network;
- TS suggested some enhancements to the coding of B9007 between the A938 and A940 (to be removed) and an alteration to the A826 between the A822 and Aberfeldy to make it less attractive; and
- coding alterations were made between the Forth Road Bridge and Dundee to better reflect RSI observations.

The auditor considers these alterations to be appropriate and is satisfied that an appropriate level of network checking has taken place in the development of TMfS12. However, users of the model should be aware of the possibility that some network coding errors will still remain and verification of the network in the area of interest should be carried out before application of the model to specific schemes or studies.

3.3.4 A96 and A9 Corridors

Given that immediate applications of TMfS12 were identified in the brief as improvements to the A9 and A96 we have specifically reviewed actions taken in this regard. Table 11, above, includes some comments and responses regarding the connectivity of zones in these corridors.

Further issues identified as part of the A9 dualling fitness for purpose review are discussed below.

It is important to include in the network all links where there might be a material change in traffic flow as a result of the upgrade. Clearly, the most important road in the study area is the A9. This is modelled in adequate detail. The next important roads are feeder roads and alternative routes. The inclusion of these roads should allow a correct assessment of the transfer of trips resulting from the upgrade. The major long-distance alternative roads including the A82, A93 and A939 are included in the model. Hence, it is possible that long-distance transfers can be modelled accurately. The situation with respect to local alternatives is less satisfactory. A number of local alternatives to the A9 are not included. In some situations, the routes taken on these roads may alter as a result of the dualling of the A9. The improvements should encourage trips to use the A9 in preference to the alternatives. This can only be taken into account if these alternative roads are included in the model. One example of this issue is described below.

Trips from Tummel (zone 723) load just north of Pitlochry. The roads in this area are not included in the model. However, there are alternative roads which may be used which allow trips from this area to join the A9 near Calvine. Trips from zone 723 to Inverness will be included in the count just to the north of Pitlochry but may not pass through this point in reality. This can only be improved by adding more of the secondary road network. At present, nearly all of the interzonal trips between adjacent zones will be modelled as using the A9 as the local alternatives are not modelled. In this case, it is important to ensure that the network and matrix detail are consistent.

3.3.5 Summary

SIAS' approach to network development has been to concentrate upon enhancements limited to the incorporation of an agreed list of schemes and changes to zone connectivity consistent with the zone system enhancements within the A9 and A96 corridors. The audit has covered these issues only.

Capabilities on project:
Transportation

The following issues have been identified:

- scheme coding – issues were found with the scheme coding of the M80 Stepps to Haggs scheme;
- A9 banned turns – project specific detail suitable for consideration of model application to the A9 OBC work would be required; and
- A9 shorter distance trips/local network – it is noted that TMfS12 is of national scale and, as such, would not be expected to model local movements in great detail. However, it should be acknowledged that, in places, the local road network provides an alternative to the A9 for local trips/accessibility. Local impacts should be reviewed, and full use of more detailed models of the area would be expected.

3.4 Demand Matrix Development

3.4.1 Introduction

This section considers the development of the demand matrix. The methodology for the development of this matrix has been to use the TMfS07 prior matrix (i.e. the matrix developed from observations used as the input to matrix estimation) as a starting point and enhance this matrix with further data sources and repeat the matrix estimation process with up-to-date traffic count data.

The TMfS07 Audit Report (paragraph 4.7.8) carried the recommendation that:

“... future model development reports include additional detail relating to the processing, cleaning, logic checking and factoring of all data sources used in matrix development, including summary statistics where appropriate. This will enable conclusions to be drawn regarding the quality of data and the robustness of the processing undertaken.”

Specific comments were as follows:

- improved documentation of the use of Census TTW data, particularly with respect to factors used to convert to time periods and other adjustment factors;
- consideration of use of HGV RSI data on the Forth Road Bridge and in the Dumfries area;
- consider how to increase the proportion of observed data in the final matrix;
- improved documentation including documenting the process in a single report and supplementing the information through the inclusion of summary statistics showing the proportion of the matrix made up of observed and synthesised data; and
- checking and reporting of small values in the matrix.

The scope of this audit is, therefore, as follows:

- data sources for matrix enhancements;
- application of methodology; and
- application of previous audit comments.

Note that the Roads Model Development Report (RMDR) considers the matrix estimation process in a different section to the matrix development. The audit of this section of the process is therefore covered in Section 4 of this report.

Capabilities on project:
Transportation

3.4.2 Data Sources

A number of RSI surveys were made available and were used to “patch” the TMfS07 prior matrix. The location of these surveys was primarily in the A9 corridor although surveys in other areas of Scotland were available. The data were reviewed and SIAS identified 24 surveys to inform the matrix enhancement. It is understood that some surveys were rejected due to inadequate quality of data. No detailed analysis of the surveys used has been provided as part of the TMfS12 documentation. However, as identified in Section 2 of this report a misinterpretation of business purpose was identified that significantly understates the proportion of business trips extracted from the new survey data.

3.4.3 Methodology

3.4.3.1 Zone Disaggregation

The revised zone system in TMfS12 meant the TMfS07 prior matrix needed to be disaggregated. There are a number of ways that this can be achieved. In this case population levels were used. Alternative approaches exist, such as the use of employment numbers rather than population for certain journey purposes but the auditor considers that the use of population levels an acceptable basis for the disaggregation of the relatively large zones containing a broad mix of land uses as found in a strategic model such as TMfS12.

3.4.3.2 Prior Matrix Development

The following steps were used to “refresh” the prior matrix:

- processing of the RSIs to generate an RSI matrix;
- assignment of this matrix to the network;
- “sense check” of routeing with changes made to network where errors identified;
- extraction of traffic passing through RSI site locations from the TMfS07 prior matrix; and
- incorporation of the RSI matrix into the TMfS07 matrix to form a revised prior matrix.

Outside the inclusion of the new RSI data, it is understood that no changes were made to the TMfS07 prior matrix.

Notwithstanding any issues with the processing of the RSI interview records themselves, as discussed in Section 2, our comments on this process are as follows:

- the level of detail in the reporting of the building of the prior matrix is not sufficient to make any further judgments on the quality of the prior matrix or the processes used to create it;
- the use of RSI sites in Dumfries and the Forth Road Bridge has not been carried out. In the case of Dumfries it is understood from the model builder that the data was not of sufficient quality and robustness to be used. The other comments relating to the provenance of the TMfS07 prior matrix are still valid and, to the auditors understanding, are not addressed as part of this update.

The following minor issues should also be noted. The impact of these issues on the final matrix is considered to be minor and the approach used acceptable given the time constraints of the model build:

- whilst it is accepted that traffic growth has been low in intervening years, the justification for making no changes to the TMfS07 prior matrix outside the inclusion of the new RSI data should be set out;
- no account of sample rate and data confidence has been taken. Where a movement is seen at multiple sites, techniques exist that would provide a more robust assessment of true movements than a simple averaging of values. For example, at a site with a higher sample rate, we would have more confidence in observations at this site and, therefore, it should be given a higher weighting in any averaging that takes place; and
- a similar issue applies to the removal of movements from the TMfS07 prior matrix and the re-incorporation of the RSI matrix. The TMfS07 prior matrix makes use of both observed (in the form of Census TTW and RSI data (HGV's only)) and synthesised data. The relative levels of confidence we would have in the updated RSI surveys and the initial prior matrix should be taken into account in the combining of the two matrices.

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3.4.4 Previous Audit Comments

As noted above, the TMfS07 audit carried a number of recommendations pertaining to the development and reporting of the demand matrix. The auditors comments on those aspects not addressed above are covered below.

The previous audit recommendation that “... *future model development reports include additional detail relating to the processing, cleaning, logic checking and factoring of all data sources used in matrix development, including summary statistics where appropriate. This will enable conclusions to be drawn regarding the quality of data and the robustness of the processing undertaken*” has not been addressed within the reporting for TMfS12. Limited information on the data and processes used has been supplied within the report although correspondence with SIAS has allowed some understanding which is covered as appropriate within this report.

The comments on the use of Census TTW data, summary statistics and small values within the matrix are not addressed although it is accepted that Census TTW data has not been a part of the matrix update for TMfS12.

The proportion of observed data within the matrix has been increased through the use of additional RSI sites as discussed above.

3.4.5 Summary

In summary, the model builder's approach to the enhancement of the matrix is to incorporate further RSI surveys into the TMfS07 prior matrix and then re-estimate the matrix using up-to-date traffic flow data. The audit scope has been limited to consideration of the new data sources and the process followed to achieve this. The following issues have been identified:

- data sources – 24 RSI surveys were identified for use in the matrix update but no information has been provided on data quality;
- zonal disaggregation – due to the changes in the zone system it was required to disaggregate the TMfS07 prior matrix to the TMfS12 zone system. This has been done by using factors based on population which is a suitable methodology;
- incorporation of new RSIs into the prior matrix – a data coding/processing issue concerning the proportion of business trips has been identified. This is a significant issue and has implications for the quality of the final matrix. In addition, no account of sample rate and data confidence in the new surveys or the TMfS07 prior matrix has been taken when combining the two;
- the decision to retain the TMfS07 prior matrix without making further changes to areas not covered by the new RSI surveys used should be justified;
- previous audit comments to make use of RSIs in Dumfries and the Forth Road Bridge area have not been taken into account. Neither have other previous auditor comments been explicitly addressed; and
- whilst nothing in the reported information gives rise to major concerns, the level of reporting does not make it possible to come to a definitive view on whether the prior matrix is suitable for use. The reporting requirements for updates to the model should be formed with reference to WebTAG M3.1 Appendix F, and the concerns raised in both this audit and that of TMfS07.

3.5 Assignment Model Development

3.5.1 Introduction

This section considers the development of the road assignment model. The model is assigned in an identical manner to TMfS07 for which the audit identified no significant issues. The scope of this audit is therefore limited to a simple verification that the TMfS07 methodology is still appropriate for TMfS12.

3.5.2 General Assignment Procedure

The CUBE Voyager HIGHWAY module is used. An implementation of the Time versus Cost methodology is used which allows a continuous distribution of the value of time to be used for converting monetary items in the generalised cost formulation into equivalent time units.

The assignment procedure uses a standard implementation of the Method of Successive Averages (MSA), in common with previous versions of TMfS.

Capabilities on project:
Transportation

Generalised costs have been calculated in accordance with WebTAG Unit 3.5.6 (October 2012). These calculations have been reviewed. A small number of alterations (primarily to input assumptions) were identified as part of this review and these have been carried out to the auditor's satisfaction. The generalised costs are considered suitable for use in TMfS12.

The following CUBE parameters have been used in running the model:

NOITR = 10;

TOLERANCE = 0.0001;

NSUCC = 3.

The assignment method is unchanged from that of TMfS07, when the audit considered it appropriate. We would recommend that the method is reviewed in any update to the model against best practice and emerging guidance.

3.5.3 Flow Delay Relationships

No changes to flow-delay relationships have been made compared with TMfS07 where the auditor commented that the relationships appeared to have been defined appropriately. No further investigation of these has been carried out as part of this audit.

3.5.4 Treatment of Heavy Goods Vehicles

In common with TMfS07, a Heavy Goods Vehicle speed cap, equivalent to the HGV speed limit for the relevant road type is used. The TMfS07 audit concluded that this would provide an improved representation of HGV speeds and costs output from the roads model.

This conclusion is supported in principle here, although it is suggested that the observed HGV speeds on each link or link type should be used as the speed cap. This analysis and improvement should be reviewed for future versions of the model and refined if suitable data exist.

3.5.5 Summary

TMfS12 sees very few changes made to the assignment model compared with TMfS07. The only comment of significance is as follows:

- In future model updates, an analysis of actual HGV speeds on various link types may be beneficial to define a more appropriate HGV speed cap.

3.6 Summary and Recommendations

SIAS has undertaken an agreed programme of changes to the road network, zone system, matrix and assignment model, generally limited and focused on the A9 and A96 corridors, with the exception of inserting recently built infrastructure. The audit has comprised of a review of the changes made and documentation. The general activities undertaken in the building of the roads model are as follows:

- The TMfS07 zone system has been retained in TMfS12, with disaggregation in the A96 and A9 corridors. The approach taken was for Jacobs, drawing on their recent experience of applying TMfS07, to advise where access to the A96/A9 may be represented in too aggregate a way for operational appraisal. The model builder considered these and established a finer zone system along these routes.
- The approach to network development has been to generally take a relatively light touch with enhancements limited to the incorporation of an agreed list of schemes and changes to zone connectivity consistent with the zone system enhancements within the A9 and A96 corridors. The audit has covered these issues only.
- The approach to the enhancement of the matrix is to incorporate further RSI surveys into the TMfS07 prior matrix and then re-estimate the matrix using up-to-date traffic flow data. The audit scope has been limited to consideration of the new data sources and the process followed to achieve this.

Capabilities on project:
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Table 12 reproduces the issues identified as part of the audit of the road network, zone system, matrix and assignment model are categorised as follows:

- Advice to model users; and
- Advice to TS on future model development.

Table 12: Summary and recommendations – roads model

Subject	Details
Advice to model users	
Zoning	The approach taken is considered generally satisfactory. However, whilst undertaking this review, the auditor noted that in the A9 corridor the zone size and connectivity results in some flows along the A9 being inadequately represented.
Network development	A9 banned turns – project specific detail suitable for consideration of model application to the A9 OBC work would be required.
	A9 shorter distance trips/local network – it is noted that TMfS12 is of national scale and, as such, would not be expected to model local movements in great detail. However, it should be acknowledged that, in places, the local road network provides an alternative to the A9 for local trips/accessibility and the level of detail in the A9 corridor remains a concern for the A9 OBC work.
Advice to TS on future model development	
Network development	Scheme coding – issues were found with the scheme coding of the M80 Stepps to Haggs scheme.
Matrix development	Previous audit comments to make use of RSIs in Dumfries and the Forth Road Bridge area have not been taken into account. Neither have other previous auditor comments been explicitly addressed.
Zoning	In addition to the zone system providing a basis to represent access to the network in sufficient precision, best practice is for land use patterns to be reasonably homogeneous and for the trip ends to be reasonably similar in total for each zone. Whilst the auditor would suggest that this should form an aspiration for a large strategic model, the latter is probably easier to achieve than the former.
Matrix development	The reporting requirements for updates to the model should be formed with reference to WebTAG M3.1 Appendix F, and the concerns raised in both this audit and that of TMfS07.
Assignment Model development	An analysis of actual HGV speeds on various link types may be beneficial to define a more appropriate HGV speed cap.

4 Road Model Calibration and Validation

Capabilities on project:
Transportation

4 Roads Model Calibration and Validation

4.1 Introduction

This section considers the data, procedures, and results of the roads model calibration and validation. The prior matrix, observed traffic counts, and initial modelled travel paths throughout the network are all used as inputs to the matrix estimation process with the results then compared against other data to verify the quality of fit of the model.

The following information was used for this part of the audit:

- the TMfS12 Road Model Development Report (RMDR);
- relevant spreadsheets; and
- details of screenline, journey time comparison routes and other observed data.

As noted in Section 1.2, TS instructed the model developer that the model development “..will be documented in the model development, calibration and validation reports in a similar form to those produced for TMfS07”.

The audit covers the following:

- data sources;
- specification of screenlines;
- matrix estimation methodology;
- quality of model calibration; and
- quality of model validation.

4.2 Calibration Procedures

4.2.1 Introduction

The RMDR states that 137 counts (143 in the interpeak period) were initially used in the formation of screenlines. Once a reasonable level of fit was obtained, further individual counts were used in order to improve the quality of calibration across the model. The AM, interpeak and PM models were all calibrated separately.

The use of further individual counts, and justification for how and why they were introduced to the matrix estimation procedure was not included in the RMDR.

Observed and modelled values are in terms of Passenger Car Units (PCUs). It is noted that there is a mis-match between observed and modelled values in that modelled values contain bus “pre-load” information. This is expected to have a small impact on modelled-observed comparison. Ideally the comparisons would be consistent but it is agreed that, for a strategic model, this mis-match will not significantly alter model conclusions. Nevertheless, this should be rectified for future model calibration work.

4.2.2 Data Sources

The main exogenous data input to the calibration process is traffic count data. The collection and processing of this data is covered in Section 2. This data has been formed into a number of screenlines. These have been reviewed based on information supplied by SIAS in July 2013.

Basic screenline details are as follows:

- calibration – 274 separate count sites (one-way) grouped into 35 screenlines with a further 80 sites used individually. Three “screenlines” actually incorporate one count site only.
- validation – 250 separate counts sites.

The processing of the count data was covered in Section 2 of this report and showed that adjustments were made to represent a neutral month in 2012. The standardised processing means that the quality of count data was consistent across the dataset.

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Table 13, Table 14 and Table 15 provide more information on the screenlines. This information has been produced by the auditor to better understand the nature of screenlines across the model. Table 13 shows the area in which each screenline is located and the number of counts that make up each. Table 14 shows the number of screenlines in each area. Table 15 shows how many screenlines include a particular number of counts.

Analysis of Table 14, together with screenline maps contained in Appendix H of the RMDR, shows that the number of screenlines is low in the Southwest and Tayside areas. The Highlands is also generally less well covered. The central belt, including Edinburgh and Glasgow is better covered. Table 15 shows the distribution of the numbers of count sites that make up each screenline. This shows that 18 of the 35 screenlines use three count sites or less.

Table 13 Screenline Detail

Screenline	Area Description	Number of Counts
1	Aberdeen Area	5
2	Aberdeen Area	4
3	Aberdeen Area	1
8	Edinburgh Area	5
9	Edinburgh Area	9
10	Edinburgh Area	4
11	Edinburgh Area	2
12	Forth Area	6
13	Forth Area	5
14	Edinburgh Area	5
15	Glasgow Area	7
17	Glasgow Area	8
20	Glasgow Area	7
21	Glasgow Area	2
22	Glasgow Area	6
25	Forth Area	3
27	Tayside Area	3
28	Tayside Area	2
29	South East Area	5
30	South East Area	1
31	South East Area	3
32	Highlands Pt 2	2
33	Glasgow East Area	2
34	Glasgow East Area	1
35	South East Area	3
36	Highlands Pt 2	2
37	Highlands Pt 2	2
38	Highlands Pt 1	2

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Screenline	Area Description	Number of Counts
39	Highlands Pt 1	3
40	Forth Area	5
41	Edinburgh Area	3
42	South West Area	7
43	South West Area	4
44	South East Area	6
50	Highlands Pt 1	2

Table 14 Screenline Detail - Screenlines by Area

Area Description	Number of Screenlines
Aberdeen Area	3
Edinburgh Area	6
Forth Area	4
Glasgow Area	5
Glasgow East Area	2
Highlands Pt 1	3
Highlands Pt 2	3
South East Area	5
South West Area	2
Tayside Area	2

Table 15 Screenline Detail - Screenlines by Number of Counts

Number of Count Sites	Number of Screenlines
1	3
2	9
3	6
4	3
5	6
6	3
7	3
8	1
9	1

Capabilities on project:
Transportation

The following observations are made:

- with the exception of Elgin, the A96 corridor between Inverness and Aberdeen mainly comprises of single sites. The use of single sites in calibration/matrix estimation carries the risk of introducing short distance trips into the matrix to satisfy matrix estimation count constraints, and distorting the matrix due to local network coding/routeing or count data errors;
- the A9 corridor, between Perth and Inverness, is better covered than the A96, with screenlines to the south of Inverness, between Kingussie and Aviemore and to the north of Perth. Some single sites bolster this coverage with, once more, the risk that the use of these as an estimation constraint could introduce short distance trips to the network;
- an alternative north-south route to the A9, the A82, is covered by a screenline to the south of Loch Ness and a small number of individual count sites. This level of coverage is insufficient to properly understand route choice changes between these two corridors;
- coverage to the north-west of Scotland is extremely limited with the exception of screenlines in the Inverness area;
- coverage in the Dumfries region is limited; and
- screenline coverage through the central belt is considered appropriate for a model of this scale and scope but comments on individual screenlines below should be taken into account.

Regarding specific areas and screenlines, the following observations are made:

- Inverness
 - Screenline 38 covers two links which serve different movements.
- Elgin
 - Screenline 37 is missing a minor road and covers a spread of different movements.
- Aberdeen
 - Screenline 1 missing A947 (Aberdeen – Dyce) and includes a spread of different movements.
- Tayside
 - Dundee is not adequately covered.
- Perth
 - Screenline 27 – covers inconsistent movements (A9 to north and south, A85 to west).
- A9 corridor
 - covered by 3 single counts only (north of Perth which is in direct conflict with screenline 27, north of Blair Atholl and south of Kingussie).
- A96 corridor
 - covered by 7 single counts in addition to screenlines to the east of Inverness (Barn Church Road), Nairn, between Nairn and Forres (conflict with screenlines 36 and 37 near Elgin), Fochabers, Keith, Huntly, south of Inverurie.
- Fife area
 - Screenline 13 to the NW of Dunfermline is too long covering a spread of inconsistent movements.
 - Screenline 12 covers the Forth crossings between the Forth Bridge and Stirling covering too large a range of geographic movements.

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- Edinburgh
 - Screenline 31 to the SE of the city is missing the B6355.
 - Screenline 9 covers too large a geographic area and does not include the A6094 at its eastern end.
 - Screenline 41 to the west of Livingston is missing a pair of local roads (A705 and B7015) but would capture strategic movements on the A72 and M8 satisfactorily.
- South-East Scotland
 - Screenline 44 is extremely lengthy and covers movements across a number of different corridors between Scotland and England. Several links do not include counts (including the A7) and the line is ill-defined in the Coldstream area.
- Dumfries
 - Coverage is limited with only the northern Dumfries cordon (screenline 29) and some isolated single sites.
- Ayrshire
 - Screenline 42 (Ayr) – Dundonald Road (B730) is not included.
 - Screenline 43 (Kilmarnock) – missing minor roads to the NE.
- Glasgow
 - Screenline 17 (east Glasgow) definition is uncertain. Some roads are not included (e.g. A74, A89, A80) and the definition of this screenline to include further single count sites in the vicinity should be considered.
 - Screenline 22 covers all crossings of the River Clyde from Erskine Bridge to the centre of Glasgow. The Erskine Bridge caters for a different pattern of movements compared to the city centre crossings so its inclusion in this screenline is inappropriate.

A number of deficiencies have been identified in the make-up and location of screenlines across the model. These carry the risk that the model does not properly reflect real world traffic movements adequately. It is appreciated that, in some places, observed data is either unavailable or not of sufficient quality for use in the calibration exercise. Nevertheless, the comments in the above section should be borne in mind, both when assessing the suitability of the model for specific application and for future model updates. It is, however, understood from TS that a data collection exercise will be undertaken in Spring 2014 which will alleviate some of these issues.

4.2.3 Matrix Estimation

Matrix estimation has been carried out using the ANALYST element of CUBE Voyager. The process appears to be identical to that used in the development of TMfS07. The general process is illustrated in Figure 5.1 of the RMDR and, in principle, is considered to be suitable. It is understood that the TMfS07 prior matrix, augmented by new RSI counts as documented in the previous section, is appropriately used as the starting point for matrix estimation.

The main inputs to the process with their associated confidences are stated as:

- traffic counts (100-500%);
- trip end data (30% internal, 20% external); and
- prior matrix traffic pattern (80%).

It is considered appropriate to attach greater confidence to count data but it is slightly surprising to see a considerably lower confidence attached to trips relative to the prior matrix. At this stage it should be noted that the RMDR does not make it clear whether the matrix estimation process has estimated data using the defined screenlines or estimated at individual count level with the results reported at screenline level. This should be clarified.

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The source of traffic count data is discussed in Section 2. Trip end data comes from the row/column totals in the prior matrix along with the prior matrix travel pattern information. Travel paths are updated at each iteration from the most recent run of the estimated matrix through the assignment model.

It is not clear from the RMDR if matrix estimation has been carried out at individual vehicle class or all vehicle level. Based on the presentation of results later in the report it seems likely that all vehicle level has been used. Given the model assigns cars, LGVs and HGVs separately this means that there is a risk that the mix of vehicles in the network is not properly and consistently reflected. Given that the count data is available at individual vehicle class level it would be expected that the estimation would also be carried out at this level.

4.3 Calibration Results

4.3.1 Introduction

This section considers the results of the calibration process. The quality of calibration of the model has generally been assessed by reference to the criteria contained in DMRB volume 12. WebTAG Unit 3.19 supersedes the DMRB standards and, whilst the respective guidance notes are identical in most criteria, this should be noted.

The RMDR argues that the DMRB guidance has been written with smaller road models built for specific scheme appraisal with more consistent data collection meaning that the guidance is too stringent for such a model. The calibration and validation process therefore “makes efforts to balance a goodness of fit between all observed data sources and the resultant base model assignment”. This comment is acknowledged.

4.3.2 Calibration checks

The calibration checks made are as follows:

- demand matrix comparisons – the pre and post-estimation matrices are aggregated into a nine region sector system and the pre and post-estimation values and differences are reported at total PCU level;
- trip length distribution analysis – visual analysis of the change in trip length distribution pre and post-estimation;
- comparison of strategic screenline flows at total PCU level;
- comparison of individual count site flows at total PCU level; and
- modelled/observed count correlation analysis at total PCU level.

These are valid comparisons but, as noted above, it would be beneficial for the analysis to be carried out across each vehicle class separately as required by WebTAG 3.19.

In addition, matrix estimation monitoring checks not already included, as contained in Section 8.3 of WebTAG 3.19, should be presented to allow an understanding of the scale of impact matrix estimation has had on the prior trip matrix. This refers specifically to analysis of the changes in matrix zonal cell values and matrix zonal trip ends between the prior and post matrix estimation matrices.

With the above issues in mind, the following comments on the quality of calibration make an attempt to interpret the results in the context of the WebTAG 3.19 guidance.

4.3.3 Demand Matrix Comparisons

Appendix E of the RMDR contains sectorised matrix totals before and after matrix estimation for all time periods at total PCU level. A nine sector system is used for analysis. The WebTAG 3.19 benchmark criterion for this analysis is that differences should be within 5% and all exceedences of these criteria should be examined and assessed for their importance for the accuracy of the matrices in the Fully Modelled Area or the area of influence of the scheme to be assessed. This should be carried out and reported ensuring that the sector system used is defined such that there would be confidence that the source data for the prior matrix is observed to a comparable level of accuracy to that used in the test.

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As an example, from an initial check of the AM results, it can be seen that 54 of the 81 sector to sector movements see changes in excess of 5%. The interpeak and PM comparisons show that 57 and 43 of the sector to sector pairs respectively see changes of more than 5%.

To gain a greater understanding of the levels and significance of changes to the matrix, a more detailed analysis of this data undertaken by the auditor considers absolute changes for those sector to sector movements changing in excess of 5%. This reveals that, in the AM peak period, 3 sector-sector pairs have changes greater than 100 PCUs/10%. In the interpeak period 9 sector-sector pairs are identified, with none in the PM peak period. This shows that, whilst the benchmark criterion is often not met, relatively few sector-sector pairs see gross levels of change, particularly in the peak periods.

Appendix F of the RMDR contains a comparison of aggregate modelled and observed flows in each sector before and after matrix estimation. This comparison is not part of the WebTAG 3.19 criteria but carries some value as a high level check of the impacts of matrix estimation. The comparisons show that matrix estimation generally improves the overall fit at sector level although differences remain outside 5% in some sectors.

4.3.4 Trip Length Distribution Analysis

Appendix G of the RMDR provides a comparison of the pre and post matrix estimation trip length distributions. These are carried out at total PCU level for each separate time period.

It can be seen from a visual inspection of the graphs that there appears to be little significant change in the trip length distributions. Ideally, comparisons of the mean and standard deviations of trip lengths before and after matrix estimation, reported against the WebTAG 3.19 criteria (within 5%) should be presented, although it is accepted that the likelihood of significance changes to these metrics, based on the graphs, is low.

4.3.5 Further Matrix Estimation Monitoring

The RMDR contains no analysis or reporting of comparisons of matrix zonal cell values and trip ends. These should be calculated and the slope, intercept and R^2 values reported as per WebTAG 3.19 Section 8.3.

4.3.6 Strategic Screenline Flow Comparisons

The flows across strategic screenlines have been compared and reported in Appendix H of the RMDR. These have been assessed against DMRB criteria (differences <5% or GEH <4). WebTAG 3.19 drops the GEH<4 criterion. This means that for lower values (less than around 6000) the WebTAG criterion (i.e. differences <5% only) is more stringent than the DMRB guidance used in the RMDR.

This means that the general screenline fit comparisons presented in Table 5.1 are reflective of WebTAG 3.19 guidance with Table 5.2, covering the fit against the GEH criterion, not relevant.

Again, Table 5.1 should be expanded to show results at the individual vehicle class level to allow a full understanding of the quality of calibration of the model.

Notwithstanding, Table 5.1 provides a general understanding of the quality of calibration and suggests that the proportion of screenlines meeting the WebTAG 3.19 criterion is between 39% and 60% dependant on time period. This sharply increases when the number of screenline differences less than 10% is considered with values of at least 79% seen. This demonstrates some appreciable differences between modelled and observed traffic patterns. While this may well be acceptable when applying the model for assessing regional or national strategy, its primary purpose, it does emphasise the need for care in considering the suitability of the model for testing individual schemes.

4.3.7 Individual Count Site Flow Comparisons

Comparisons of observed and modelled flows at individual site level have been assessed against DMRB criteria. WebTAG 3.19 has not updated these criteria which allow either a direct flow comparison (generally within 15% except for flows <700 or greater than 2700 where modelled flows should be within 100 and 400 vph respectively) or a GEH comparison (<5).

These comparisons are also contained in Appendix H of the RMDR.

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Tables 5.3 – 5.6 provide the relevant comparisons at GEH level. Table 5.3 shows that the fit at individual count level is not good, with 62% - 75% of count sites within a GEH of 5. Close to 85% are within a GEH of 7. The results in this table should be updated to reflect the direct flow related criteria also. For high and low flows <700 and >2700 this may improve the presented results.

It is appropriate and consistent with WebTAG guidance to report the model performance against these standard criteria. We would observe that these criteria were developed in the context of scheme models of relatively small geographic scale and large scale models such as TMfS are not usually observed to meet these criteria. Nevertheless the reproduction of flows demonstrated here is relatively poor even in this context. This is not to mean that the model update is unsatisfactory, but that care is needed in reviewing the adequacy of the model for particular applications, especially those related to more localised schemes.

Tables 5.4 – 5.6 provide a comparison disaggregated by road type. This is a worthwhile comparison and shows that the calibration of the model is generally better on trunk roads than non-trunk or minor roads as might be expected in a strategic model of this size.

4.3.8 Modelled Flow/Observed Count Correlation Analysis

A correlation analysis of modelled and observed flows is included in Appendix I of the RMDR. This is not included in the WebTAG guidelines but provides a useful general view of the performance of the model. It shows that the modelled flows are underestimated in the AM and PM peak periods (by around 7-8%) but very slightly overestimated (<0.3%) in the interpeak period.

It is the auditor's view that the AM and PM peak underestimates are of significance and the reasons for this should be analysed and reported.

4.3.9 Summary and Recommendations

The audit has covered the data, processes and results of the model calibration process. The following issues have been identified:

- DMRB guidance criteria are used rather than WebTAG unit 3.19 which supersedes DMRB;
- modelled flows contain bus "pre-load" flows creating a mis-match with observed values;
- issues have been found with the definition of screenlines which carry the risk that the model does not properly reflect real world traffic movements adequately;
- it appears that matrix estimation and reporting has been carried out at an all-vehicle level only rather than at separate vehicle class level as required by WebTAG 3.19;
- some key elements of WebTAG 3.19 are omitted, namely network and assignment calibration reporting;
- matrix estimation - some monitoring checks have been carried out but it is recommended that comparisons, as per WebTAG 3.19 are carried out. The reporting that is present in the RMDR shows that the sector-sector changes require further analysis/justification and more detailed statistics concerning cell value changes and trip length distribution changes should be provided;
- screenline comparisons – this analysis suggests that the model fits to observed counts relatively poorly. Further, more detailed analysis, to better understand the quality of the calibration across the country is recommended;
- individual count comparisons – some improvements to the reporting of the fit of the model against individual count observations should be made to better understand the quality of the model. The stated results show that the model fit against observed counts at individual counts is relatively poor; and
- count correlation analysis – this analysis suggests that there may be a systematic underestimation of flows in the model in the AM and PM peak periods. This should be analysed and explained.

It is noted that the timescales under which the model development was required to proceed led to the agreement of a "light touch" approach to model development and reporting between the model developers and TS. Nevertheless, the overall conclusion is that some deficiencies have been identified in the inputs, processes and reporting of the calibration process which cast some doubt over model quality and its ability to reflect traffic flows and compositions adequately. With the initial comment in mind, it is suggested that the identified deficiencies in reporting are addressed in future updates to the model, with identified issues highlighted as matters for model users to be aware of.

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4.4 Validation

4.4.1 Introduction

This section considers the results of the validation. Again, DMRB criteria have generally been used along with several other checks considered relevant to the model development. The audit covers an analysis of the processes and reported validation results.

4.4.2 Validation checks

The validation checks made were as follows:

- link count comparisons in terms of total PCUs;
- total traffic flows;
- heavy goods vehicles;
- comparison on key road bridges;
- journey time data; and
- comparisons at RSI sites – journey length and trip distribution.

These comparisons are considered appropriate, although, as with the calibration checks, comparisons should be made at individual vehicle class level as per WebTAG 3.19. Some validation of route choice (as per Section 7 of WebTAG 3.19) should also be presented.

The following comments on the quality of validation make an attempt to interpret the results in the context of the WebTAG 3.19 guidance.

4.4.3 Link Count Validation

Link count validation has been carried out against the DMRB standards for individual link counts which have remained unchanged in WebTAG 3.19 (generally within 15% except for flows <700 or greater than 2700 where modelled flows should be within 100 and 400 vph respectively) or a GEH comparison (<5). Table 6.1 of the RMDR provides a summary of the validation results and Appendix J provides more detail.

WebTAG Unit 3.19 recommends that screenlines are also used in validation. Whilst it is noted that traffic data is sparse in places the potential for forming validation screenlines should be investigated if it has not been already.

Table 6.1 shows that 250 counts sites are included in the validation process with the proportion of links with a GEH value of <5 ranging from 54% - 60%. If a value of <7 is used then this proportion increases to 68% - 74%. This is below the WebTAG 3.19 guideline. In common with the analysis of the model calibration, this is not to mean that the model update is unsatisfactory, but that care is needed in reviewing the adequacy of the model for particular applications, especially those related to more localised schemes.

Table 6.1 should be presented in terms of individual vehicle classes (i.e. Cars and All vehicles) although it is noted that HGVs are considered separately in Section 6.4 of the RMDR. It is also noted that care should be taken with the analysis of individual count sites where data are not reliable with counts presented in groups/mini screenlines where this is the case. In addition, it is recommended that the results in this table are updated to reflect the direct flow related criteria also. For high and low flows <700 and >2700 this may improve the presented results.

Appendix J provides locations and results of validation counts across the country. The sites appear to be suitably distributed across the modelled area with coverage on the majority of key roads across Scotland with enhanced coverage around the main urban areas of Edinburgh, Glasgow and Inverness. However, coverage around Aberdeen and Dundee is less comprehensive. Further count comparison should be made in these areas to better understand the quality of validation.

Summary results for the various areas of the country should also be presented to allow a better understanding of the quality of validation in different areas of the country.

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4.4.4 Heavy Goods Vehicle Validation

HGV flows at 89 locations have been compared against the same criteria as total flows. It is correctly noted that the criteria are not normally appropriate for HGVs but the comparison is, nevertheless, considered to be useful. Table 6.2 shows that the proportion of counts with a GEH <5 is 46% - 57%. If GEH <7 is used this rises to 58% - 69%.

Appendix K of the RMDR provides more detailed HGV statistics. As noted above, summary results for different areas of the country should be provided.

4.4.5 Comparison on Key Bridges

A comparison of modelled and observed flows (PCUs) on a selection of Scotland's key bridges has been included. These are:

- A9 Kessock Bridge;
- A92 Tay Bridge;
- M90 Friarton Bridge;
- A876 Kincardine Bridge;
- A90 Forth Road Bridge;
- M8 Kingston Bridge; and
- A898 Erskine Bridge.

This is considered a worthwhile comparison although, once again, value would be added if it were presented in terms of individual vehicle classes. Nevertheless, the results in Table 6.3 – 6.5 show that the model exhibits a good fit across bridges with only three movements in the AM peak and three movements in the PM peak failing to meet the WebTAG flow validation criteria.

4.4.6 Journey Time Comparisons

The DMRB criteria, retained in WebTAG 3.19 have been used for the comparison of journey time data. This requires modelled and observed journey times to be within 15% or one minute of one another for 85% of routes assessed.

Table 6.6 of the RMDR shows that 75% - 80% of routes meet the criterion across the time periods.

Appendix L provides detail on a route-by-route basis which allows a good understanding of the quality of the model validation across various areas of the country.

Additional analysis is included in Table 6.7 which shows that there is a tendency for the model to represent journey times quicker than those observed. It is possible that this is related to the understatement of flows across the model. This should be investigated in more detail.

4.4.7 RSI Comparisons

Appendices not provided so detailed analysis will be added later.

4.4.8 Summary and Recommendations

The audit has considered the validation processes and results. The following issues have been identified:

- the potential for forming validation screenlines rather than individual counts should be investigated;
- the results of the model validation should be presented at vehicle class level;
- reporting of route choice validation, as per Section 7 of WebTAG Unit 3.19 should be included;
- count site coverage in Aberdeen and Dundee areas is insufficient;
- analysis of the results by area (e.g. using the sector system previously defined) should be carried out; and
- journey times show a tendency to be too fast. It is possible that this is related to the general understatement of flow in the calibration and this should be investigated.

Similar to the count calibration, issues have been found in the reporting and results of the model validation that give rise to doubt over model quality and its ability to reflect traffic flows, compositions and journey times adequately.

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4.5 Summary and Recommendations

The key findings of the audit of the calibration and validation of the roads model are summarised in Table 16, categorised as follows:

- Model or reporting deficient – action to rectify required;
- Advice to TS on future model development; and
- Advice to model users.

Table 16: Summary and recommendations – roads model calibration and validation

Subject	Details
Model or reporting deficient – action to rectify required	
Model calibration	Modelled flows contain bus “pre-load” flows creating a mismatch with observed values.
Model calibration	Count correlation analysis – this analysis suggests that there may be a systematic underestimation of flows in the model in the AM and PM peak periods. This should be analysed and explained.
Advice to model users	
Model calibration	Issues have been found with the definition of screenlines which carry the risk that the model does not properly reflect real world traffic movements adequately.
Model validation	Count site coverage in Aberdeen and Dundee areas is insufficient.
Model calibration	Journey times show a tendency to be too fast. It is possible that this is related to the general understatement of flow in the calibration and this` should be investigated.
Advice to TS on future model development	
Model calibration	DMRB guidance criteria are used rather than WebTAG unit 3.19 which supersedes DMRB.
Model calibration	It appears that matrix estimation and reporting has been carried out at an all-vehicle level only rather than at separate vehicle class level as required by WebTAG 3.19.
Model calibration	Some key elements of WebTAG 3.19 are omitted, namely network and assignment calibration reporting.
Model calibration	Matrix estimation - some monitoring checks have been carried out but it is recommended that comparisons, as per WebTAG 3.19 are carried out. The reporting that is present in the RMDR shows that the sector-sector changes require further analysis/justification and more detailed statistics concerning cell value changes and trip length distribution changes should be provided.
Model calibration	Screenline comparisons – this analysis suggests that the model fits to observed counts relatively poorly. Further, more detailed analysis, to better understand the quality of the calibration across the country is recommended.
Model calibration	Individual count comparisons – some improvements to the reporting of the fit of the model against individual count observations should be made to better understand the quality of the model. The stated results show that the model fit against observed counts at individual counts is relatively poor.
Model validation	The results of the model validation should be presented at vehicle class level.
Model validation	The potential for forming validation screenlines rather than individual counts should be investigated.
Model validation	Reporting of route choice validation, as per Section 7 of WebTAG Unit 3.19 should be included.

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Model validation	Analysis of the results by area (e.g. using the sector system previously defined) should be carried out.
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General comments are that, similar to the count calibration, deficiencies have been found in the reporting and results of the model validation that give rise to doubt over model quality and its ability to reflect traffic flows, compositions and journey times adequately.

A theme common to the calibration and validation is the relatively poor fit against observed counts at individual sites. It is noted that strategic national models of the scale and scope of TMfS12 often show relatively poor results against this criteria and, therefore, that this deficiency may not mean that the model update is unsatisfactory, but that care is needed in reviewing the adequacy of the model for particular applications, especially those related to more localised schemes.

Most recommendations with regard to future model development would be addressed by following the guidance for processes and reporting contained in WebTAG 3.19.

5 Public Transport Model Development

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5 Public Transport Model Development

5.1 Background

The TMfS12 National PT Model was developed in Cube Voyager and forms the PT assignment module of the overall TMfS12 model system. This section of the report presents the initial findings from the audit of the PT model

The update to the overall TMfS model concentrates on the roads model and the resultant necessary adjustments to the demand model. The PT model update therefore “...focused on the inclusion of infrastructure changes between 2007 and 2012 and consistency with TMfS07 rather than more widespread enhancements”. The update of the TMfS07 PT model to TMfS12 therefore concentrates on PT service coding refinement, leaving the demand matrices unchanged. SIAS confirmed with the developers of TMfS07, Systra that version 2.1 was the appropriate starting point for model development.

Given the programme requirements and the lack of new OD and count data for rail and bus, AECOM considers this a practical approach.

Given the focus of the model update on the Road model, the audit of the TMfS12 PT model has been confined to a document review. This chapter relates to the audit of the PT model development, and follows the *National Public Transport Model Development Report – Draft* (SIAS, 18 October 2013) structure, commenting on each Chapter relating to the development of the model in turn.

As an aid to the reader, the auditor’s specific comments on the development of TMfS07 are summarised in each relevant section.

5.2 Chapter 2: Model Dimensions

5.2.1 Time Periods

The TMfS12 PT model was developed to represent a 2012 base year with the following time periods:

- AM Peak hour 0800-0900, within an 0700-1000 peak period;
- Inter Peak hour 1/6 of 1000-1600 inter peak period; and
- PM Peak hour 1700-1800, within a 1600-1900 peak period.

Factors to transform period matrices into (inter) peak hour matrices were derived from the National Rail Travel Survey and TMfS07 bus occupancy counts. The two sources resulted in factors that were sufficiently similar to allow the use of a single factor across the combined public transport mode for each time period. The lack of more up to date information has led SIAS to use the previous TMfS07 factors unchanged:

- AM Peak hour 0.45;
- Inter Peak hour 0.167 (by definition); and
- PM Peak hour 0.44.

The TMfS07 audit concluded that the peak hour factors were “...derived from an appropriate dataset and are acceptable...”. As the factors are unchanged from the previous model, AECOM have performed no additional checks on their derivation. Given the lack of more up to date data, we consider the continued use of the factors to be reasonable.

5.2.2 User Classes

The user classes represented within the model are unchanged from TMfS07:

- In work (IW);
- To/from work (TW); and
- Non work (NW).

PT demand matrices are prepared for each user class, and assigned separately. These user classes are identical to those used by STAG and WebTAG, and were accepted without additional comment by the TMfS07 audit. AECOM consider the user class disaggregation to be appropriate.

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5.2.3 Modes

Six separate modes are used by the PT model:

- Urban Bus;
- Inter-urban Bus;
- Rail;
- Underground;
- Ferry; and
- Tram.

The base year PT model does not contain any tram services: it is included to facilitate coding of forecast models, which should include the Edinburgh Tram scheme. AECOM is content with this approach.

5.3 Chapter 3: Public Transport Network

5.3.1 Public Transport Network

The TMfS12 National Model continues the use of a single software platform (Cube Voyager) for the Road, PT and Demand models. Similarly, the PT and Road assignment models use a single modelled network. The TMfS07 network was developed using a Geographic Information System (GIS) and is based on the Ordnance Survey (OS) Integrated Transport Network (ITN) layer. This provides a geo-rectified network, of particular use in secondary analysis, such as environmental assessments.

As discussed in Section 3, the update of the TMfS07 network for TMfS12 involved the identification of infrastructure improvements implemented between 2007 and 2012 for inclusion in the TMfS12 model.

The network includes links representing the strategic road network, heavy rail, underground, ferry routes, walk connections between PT stops, and between PT stops and the road network, and zone connectors. AECOM are content with the general description of the network outlined in the Report. A more detailed review of the network update is contained in Section 3.

5.3.2 Public Transport Lines Data

The details of each PT service are contained within the PT Lines File. For each service the following data are required:

- Mode;
- Operating company;
- Route type (circular/linear);
- Service type (express/stopping);
- Headway (for the three modelled periods);
- Fare (reference to fares tables for each time period);
- Long and short text descriptions; and
- List of nodes comprising the route.

As with TMfS07, the Urban and Inter Urban bus lines have been coded to stop at every node on the network, with the exception of nodes used solely for the purpose of providing a more accurate network shape. Rail services stop only at the appropriate stations.

The update of the TMfS07 lines was undertaken in the following manner:

- Services that stop within the A9 and A96 corridors were identified; For buses, the lines file was reviewed, updated, and infilled where additions were required; and
- For rail, the lines file was derived from first principles for the A9/A96 services.

Given the model development focus and programme, AECOM concur that this selective update of the lines coding, along with scheme specific updates such as the Airdrie – Bathgate rail link, was appropriate.

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Ferry and underground services were, therefore, left unmodified. The following TMfS07 audit issues are therefore still valid:

- With respect to the inclusion of Ferry services, these cover the majority of services between the Scottish mainland and the larger/most populated islands, however, it should be noted that not all ferry services are represented. Examples of ferry services not represented in the TMfS07 National PT Model include:
 - Port Askaig-Feolin linking Jura and Islay as both islands are modelled as a single, combined zone with ferry services only represented to/from Islay
 - Services to Eigg, Muck, Rhum and Canna
 - Intra-island ferries within the Orkney and Shetland archipelagos.
- In the context of a national, strategic model, such as TMfS07, then the omission of these ferry services is unlikely to represent a significant issue in the vast majority of model applications and can be considered acceptable. The TMfS07 National Model has appropriate, but limited, ferry service representation commensurate with its intended application. The TTAA does note that for specific policy or scheme assessments where services currently not represented are relevant and/or where sensitivity to travel cost by ferry is high, then it may be necessary to update and refine the ferry representation within the TMfS07 National Model or to develop a more detailed local model for the specific circumstances being considered.

Similarly, the Urban bus mode, which is defined as operating entirely within the urban areas of Aberdeen, Dundee, Edinburgh or Glasgow, was not updated from TMfS07, and therefore consists of amalgamations of individual services into corridors, with average frequencies representative of all services on the corridor. The TMfS07 audit recommended that:

- Users of the model should, however, note this relatively simple approach to urban bus coding when using or interpreting outputs from the TMfS07 National Model. It should also be noted that this approach to urban bus representation may require reconsideration in the development of any sub-area or regional models which operate within the overall TMfS07 hierarchy.

The Inter Urban bus services will sometimes have a modified route due to a lack of sufficient detail in the Road model network. The TMfS07 audit noted that:

- generally content with this approach to inter-urban bus coding, however, potential users should take note of this simplification in the coding of inter-urban buses.

AECOM agree with these conclusions.

5.4 Chapter 4: Matrix Development

As described above, the TMfS07 PT matrices were used, unmodified, for the TMfS12 model. The following data sources were used in the development of the TMfS07 matrices:

- National Rail Travel Survey (NRTS);
- TMfS07 Inter-Urban Bus Passenger Surveys;
- 2001 Census Journey to Work Data; and
- synthesised demand based on planning data.

The TMfS07 audit comments therefore remain applicable and are summarised as follows:

- future model development reports should include additional detail relating to the processing, cleaning, logic checking and factoring of all data sources used in matrix development, including summary statistics where appropriate;
- any users wishing to test PT measures or policies using TMfS07(12) should familiarise themselves with the contents of the Model Development Note 2 relating to the Inter-Urban Bus Surveys;
- based on a review of the documentation and additional data supplied, the TTAA is satisfied that the described process for creating the demand matrices appears logical and appropriate;
- ...the predominance of very small values in the matrix would merit some formal additional checking procedures being adopted during the matrix development process to ensure that such values only occur in locations where it is appropriate and/or unavoidable. In particular, it would be anticipated that the observed elements of the matrix should contain a lower number of very small cell values compared with the synthesised elements. The TTAA recommends that such checks are instigated and reported during the next upgrade of TMfS07.

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As previously commented, given the programme requirements and the lack of new OD and count data for rail and bus, AECOM considers the lack of a matrix update to be a practical approach. However, we would recommend that any future update of TMfS include the creation of new public transport matrices, discarding aged data sources where appropriate, and addressing the TMfS07 audit recommendations. Such an update should also include a review of the time period to period hour factors.

5.5 Chapter 5: Assignment Model Development

5.5.1 Introduction

The PT assignment model comprises the network, a PT lines file and a matrix of hourly travel demand, all described above. The assignment process comprises path building and loading, crowding, and bus speed factors.

5.5.2 Path Building and Loading

Model assignment is split into route enumeration, where the set of discrete routes over which demand will be split is chosen, and route evaluation, where the demand is split across the chosen routes.

As noted in the TMfS07 audit report, and the TMfS12 model development report, route enumeration does not take fares or crowding into account when deciding on the set of discrete routes to include. However, SIAS note that "...a mode specific run-time factor, exclusively used in route enumeration, is used to make a proxy of the impact of fare on generalised costs." This is unchanged from TMfS07, and as such, the previous audit conclusions are still relevant:

- the reader is referred to the Cube Voyager software help documentation for further detail on the route enumeration and route evaluation process;
- it is significant to note that the Route Enumeration does not explicitly take cognisance of either crowding or fares. While it is understood that this is a current limitation of the CUBE Voyager software, this could potentially have implications in terms of erroneously including or excluding potential PT routes/modes in the assignment. This is most likely to be an issue affecting sub-mode assignment between competing bus and rail services where such factors may be important considerations. All users of the TMfS07 National PT Model should note this when interpreting the model's outputs or considering its potential application.

5.5.3 Crowding

The treatment of crowding is unchanged for TMfS12:

- crowding is applied to the AM and PM peak rail services only;
- the Passenger Demand Forecasting Handbook (PDFH) "Non London Commuting Rail Crowding" table is used to define crowding factors;
- 'crush capacity' is defined as 40% above seated capacity;
- vehicle and passenger arrival profiles are assumed to be level throughout the modelled time periods, leaving no allowance for varying demand on services within the peak hours; and
- the crowding model runs iteratively, with the number of iterations set to five.

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The treatment of crowding in PDFH changed after version 4.1, from a load factor approach to one that uses load factors only up to 100% of seats being taken, but then changes to standing passengers per m² of standing space beyond that. The rationale behind this change is that different rolling stock can have radically different levels of crowding at the same load factor. Due to this change we recommend that any update to the TMfS12 PT model include a review of the rolling stock in use in Scotland, in order to derive individual, or, where sufficiently similar, average crowding curves. The crush capacity values should similarly be reviewed.

The TMfS07 audit recommendations are listed below:

- While this may be appropriate to ensure satisfactory convergence of the base model, users may need to review and adjust the number of iterations for particular option or policy tests being undertaken;
- In the PT assignment procedure, where the PT sub-mode split is undertaken at the assignment stage, on corridors with high PT modal competition this could have implications for both the base year sub-mode split and more particularly, when applying the model in forecast mode. While these are unlikely to be significant issues for the majority of applications of the TMfS07 National Model, users should note these when interpreting the model outputs or considering its application. In some cases it may be prudent to examine the outputs in sufficient detail to ensure that the resultant loadings on services conform with expectations.

5.5.4 Bus Speed Factors

Modelled bus journey times in TMfS12 are based on the assigned speeds from the Roads model, adjusted by a factor defined by link class. These factors are uniform across the time periods, and are unchanged from TMfS07, when they were adjusted in calibration to their current values:

- Motorway 0.95 ;
- Rural single 0.85 ;
- Rural dual 0.95;
- Urban single 0.50;
- Urban dual 0.75; and
- Bus lanes 0.80.

AECOM are satisfied that these factors are consistent, though we will comment in Section 6.3 on the comparison of the resulting bus journey times with timetabled data.

5.5.5 Assignment Model Parameters

The TMfS12 PT assignment model parameters are unchanged from TMfS07, with the exception of the Values of Time (VoT), which have been updated to 2012 values.

The TMfS07 audit recommendations therefore remain applicable and were as follows:

- The other assignment parameters were also defined during the calibration process by examining the assigned sub-mode split between bus and rail and these are based on standard ranges used in previous studies. In principle, this is a reasonable approach to adopt for TMfS07. The TTAA does, however, note that the assignment factors and parameters are applied globally and in some cases this may require to be refined and reviewed for a future upgrade of TMfS07.

AECOM received the spreadsheet "TMfS.12_V3.0_WEBTAG_gencost_params.xls", and reviewed and confirmed the derivation of the VoTs are consistent with WebTAG 3.5.6 (October 2012).

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5.5.6 Wait Curves

The TMfS07 wait curve has been retained for TMfS12. This calculates the wait time in perceived time (meaning that no additional wait time factor is required), and is derived from PDFH, with a maximum wait of 60 minutes. It applies to all time periods. The TMfS07 audit recommended that:

- It would be appropriate to consider differentiating the wait curves by peak and Inter-peak in a future upgrade of the model.

We concur that this would be desirable for a future update to the model.

5.5.7 Fares Model

Fares were modelled in TMfS07 through the use of an initial boarding fare plus a set of distances and fares that derive points on a curve with the exception of flat fares for various operators and services where appropriate. The distance based element of the fare was derived through linear regression of distance against fare of “standard return” fares for various bus and rail operators. The TMfS07 auditor was satisfied with the approach adopted in general with a caveat that the impact of travel cards and other discounted fares was not reflected (although it was accepted that this was unlikely to be an issue for most applications).

The approach to modelling fares in TMfS12 was left generally unchanged from TMfS07, with the TMfS12 fare structure simply uplifted based on the ratio of the 2007 and 2012 values of a sample of fares. Due to the timescales it was not possible to use raw data.

We reviewed the spreadsheet “PT fares analysis for TMfS12_audit.xls” used to calculate the uplift factors, and identified minor issues which were corrected. AECOM are therefore content that the adopted methodology has been applied correctly. Given the focus of the model development and the required programme, we are satisfied with the methodology chosen. However, in any future update of TMfS12 we would recommend that the fare curves are re-examined, and recalculated from raw data. This should include an examination of the effect of travel cards and concessionary travel on the actual price paid, and examine whether it is possible and desirable to disaggregate the representation of fares in order to represent geographic variations.

5.6 Summary and Recommendations

The audit has considered the development of the PT assignment model. The identified issues are summarised in Table 17, all of which are categorised under the heading “Advice to TS on future model development”.

Table 17: Summary and recommendations – public transport model development

Subject	Details
Advice to TS on future model development	
General	The accepted selective nature of the update has meant that most TMfS07 audit recommendations are still valid, and should be addressed in any update to the model.
General	Any future update of TMfS should include the creation of new public transport matrices, discarding aged data sources where appropriate, and addressing the TMfS07 audit recommendations. Such an update should also include a review of the time period to period hour factors.
General	Any update to the TMfS12 PT model should include a review of the rolling stock in use in Scotland, in order to derive individual, or, where sufficiently similar, average crowding curves. The crush capacity values should similarly be reviewed.
General	Any future update of TMfS12 should include a re-examination of the fare curves, and a recalculation from raw data. This should include an examination of the effect of travel cards and concessionary travel on the actual price paid, and examine whether it is possible and desirable to disaggregate the representation of fares in order to represent geographic variations

6 Public Transport Model Calibration and Validation

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6 Public Transport Model Calibration and Validation

6.1 Introduction

This chapter relates to the audit of the PT model calibration and validation, and follows the *National Public Transport Model Development Report – Draft* (SIAS, March 2014), commenting on each Chapter relating to the calibration and validation of the model in turn.

Given the agreed focus of the model development described in Section 5.1, that is, no update to the demand matrices, and an update to the PT lines representation based on schemes implemented since 2007, and a review of the lines in the A9 and A96 corridors, the approach taken to PT calibration was to:

- demonstrate consistency between the TMfS07 and TMfS12 assigned PT volumes and passenger loading/unloading; and
- confirm that any significant differences were in locations where the lines coding has changed.

The model development report therefore continues with sections that compare TMfS12 with those from TMfS07, to demonstrate that model differences are explained by changes to the representation of PT services, and then moves on to present the validation of the model against 2007 observed counts in an identical manner to that of the TMfS07 calibration and validation report, so that a direct comparison of the goodness of fit can be drawn.

6.2 Chapter 6: Model Comparison with TMfS07

This section concludes that the differences are concentrated where either infrastructure has been introduced and/or timetables have been amended. We concur with this observation.

SIAS note that local rail boarding/alighting demonstrate some variability at individual station level within the Glasgow conurbation and further investigation as part of any further model update is recommended. The auditor backs up this recommendation.

6.3 Chapter 7: Model Validation

During the reporting of the PT model, it became apparent that there was a considerable deterioration in fit of PT flows and boardings/alightings against observed values in TMfS12 compared with the equivalent comparisons in TMfS07. This issue has been investigated with Systra and it was found that the version 2.1 of the model used as the starting point for TMfS12 development differed from the version used to generate the comparisons in the TMfS07 reporting. This version 2.1 of the model was found to contain some double counting of trips within the Park and Ride procedure, which led to an previously unreported deterioration in the model validation.

Given the generally limited difference between version 2.1 of the TMfS07, reported in the above section, and TMfS12, it appears that version 2.1 of TMfS07 is not well validated and this deficiency has fed through to TMfS12. As an example, Table 18 presents a comparison of the validation statistics presented for TMfS07 and TMfS12 for the Cordon Screenlines where it can be seen that there is a general reduction in validation quality for rail trips in the AM and PM peak periods particularly. It can be surmised that this discrepancy largely results from the differences between the reported version of TMfS07 and version 2.1 of the same model rather than any issues with the limited development work undertaken in the preparation of TMfS12.

Table 18: Comparison of TMfS07 and TMfS12 Cordon Screenlines Compliance

Mode	AM		IP		PM	
	TMfS07	TMfS12	TMfS07	TMfS12	TMfS07	TMfS12
Bus within 15%	64%	57%	50%	57%	71%	43%
Bus within 25%	79%	64%	79%	71%	79%	79%
Rail within 15%	50%	14%	50%	21%	64%	14%
Rail within 25%	64%	21%	71%	71%	86%	36%
Multi within 15%	79%	50%	71%	71%	79%	50%
Multi within 25%	93%	71%	93%	93%	100%	79%

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SIAS recommend that this issue is resolved in future versions of TMfS. The auditor concurs with this assessment and recommends that this be addressed in any update to TMfS12, whatever the focus of the model development. The overall model validation can now be described as poor, with considerable uncertainty regarding the linkage between the developed prior matrices and the resulting PT matrices. Addressing the issue would ideally be through a matrix update as recommended in section 5.4. In light of these concerns we would recommend that extreme caution be exercised prior to proceeding with any application where PT is sensitive. In line with every application of TMfS, it is essential that a review of the robustness of the PT validation is undertaken. However, we would recommend that until these issues are addressed the default position for an application for use for a PT sensitive project would be to refuse.

A brief summary of the other elements of the validation follows:

- Validation at individual sites (within 25%) – 44%, 60% and 49% for the AM, interpeak and PM peak respectively with a reduced fit for sites in excess of 150 passengers.
- Boarding and alighting comparisons – 58% - 75% of sites within a GEH value of 5. Peak periods generally see lower levels of validation than the interpeak.
- Bus journey times – 50% to 55% of routes to within 15% of timetabled journey times with this proportion increasing to around 75% within 25% of timetabled journey times.

This further illustrates the poor level of validation of the PT model, adding further weight to the recommendations above.

6.4 Conclusions

We find that SIAS have applied the agreed methodology satisfactorily. However, the uncertainty regarding the changes between the PT matrices of TMfS07 v1.0 and v2.1, and the resulting drop in flow validation, is of great concern, and should be addressed as a matter of priority in any update to TMfS12. This is summarised in Table 19.

Table 19: Summary and recommendations – public transport model calibration and validation

Subject	Details
Advice to model users	
General	In light of the concerns raised above we would recommend that extreme caution be exercised prior to proceeding with any application where PT is sensitive. In line with every application of TMfS, it is essential that a review of the robustness of the PT validation is undertaken. However, we would recommend that until these issues are addressed the default position for an application for use for a PT sensitive project would be to refuse.
Advice to TS on future model development	
General	The use of V2.1 of TMfS07 as a basis for development of TMfS12 has led to a poor level of validation, with considerable uncertainty regarding the linkage between the developed prior matrices and the resulting PT matrices.

7 Demand Model Development

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7 Demand Model

7.1 Introduction

This section considers the development and calibration/validation of the demand model. This is described in the report "2012 Update of the Demand Model" (for the remainder of this chapter referred to as 2012UDM). This report was initially completed in Autumn 2013 and, subsequently re-issued in response to the draft version of this audit report in March 2014. Additionally, TS requested that the 2012UDM report be redrafted for its final form using an alternative structure, although it is understood that this contains identical information. The audit comprises a review of the revised version of the initial 2012UDM and NOT the restructured final version of the document.

7.2 Scope of Demand Model Update

SIAS state that the aim of the update is to:

- update the base year of the trip end model to 2012 and to accept TELMOS land use changes from 2012 as a base instead of 2007.
- test the sensitivity of the model parameters to ensure they are within the recommended realism ranges.
- establish the incremental adjustment matrices to be used in predicting demand for the forecast years.

The defined scope of the update stated at the outset in the document "Scoping Note Version 2 – Development of TMfS12" (January 2013), is lacking in detail but is stated as "modifications to the demand model to reflect the 2012 updates". This is generally consistent with the stated aims in the 2012UDM report and is considered to be a proportionate approach which is consistent with the requirements of WebTAG.

The audit takes a similarly light touch, covering those issues associated with the update to TMfS12.

7.3 Findings of TMfS07 Audit

Given the relatively light touch taken to the development of the TMfS12 demand model, compared with the TMfS07 starting point, it would be relevant and useful to understand the findings of the audit of the TMfS07 demand model. This is not covered in the 2012UDM so, in order to inform this Audit Report, the key findings of the previous audit are stated below:

- suitable choice structure incorporated;
- appropriate forecast inputs and data sources;
- appropriate zoning system;
- appropriate demand segmentation in terms of journey purposes, household types, user classes, time period specifications etc.;
- approach to modelling parking suitable for this type of model but users should be aware of the limited application of parking charges which should be noted for specific applications of the model. It is also noted that the functionality to reflect significant changes in car parking supply is not incorporated;
- appropriate inputs and data sources used in the demand model development;
- appropriate development of base matrices;
- recommendation that future demand model development documentation includes a detailed summary of the process followed and analysis undertaken in determining the demand model structure;
- data shows plausible patterns and appears a sound basis for developing the demand model;
- appropriate method (contraction mapping) used to develop Alternative Specific Constants (ASCs);
- mode and destination choice model parameters appear reasonable and intuitive. General similarity with previous TMfS versions;
- appropriate method used for deriving mode specific constants;
- appropriate method used for reflecting park and ride in the National Model. However, future documentation of the park and ride model would benefit from some more detail regarding the park and ride data being included such as locations, data collected, sample sizes etc;
- the level of calibration achieved for park and ride sites is acceptable for a National Model. However, for specific applications of the model, it may be necessary to examine in more detail and/or refine the park and ride site calibration at those locations that exhibit poorer calibrations;

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- demand model operates for “from home” trips in AM and IP only. Factoring processes used for the derivation of other movements which are considered appropriate and consistent with previous versions of TMfS;
- peak spreading effects are not included within the model and, as such, would need to be accounted for in relevant regional or sub-area models as appropriate;
- trip frequency, macro time of day choice and high occupancy vehicle choice are modelled in separate sub models. These are appropriate with the warning that the high occupancy vehicle choice model should only be used where a specific high occupancy vehicle measure needs testing;
- appropriate realism tests are carried out. These generally output sensible results although for some journey purposes show sensitivities outside the expected range (employers business – higher than expected sensitivity to fuel prices, home-based employers business – lower than expected PT fare sensitivity, AM home base other – higher than expected fare sensitivity);
- trip end model suitably specified and applied;
- based year trips ends suitable with a warning that users should examine base year trip ends and rates in the area of interest prior to applying the model;
- overall model operation is suitable although users should note the default number of iterations for the inner and outer loops and the fixing of PT costs after a single external demand model loop. The defaults may need changing in specific circumstances;
- an appropriate method of incremental forecasting is used; and
- the model is considered fit for purpose overall but the auditor recommends that the appropriate sensitivity tests are undertaken as required to establish the robustness of the model for use in scheme appraisals.

7.4 Key Model Dimensions

The 2012UDM covers the key model dimensions which are identical to TMfS07. The TMfS07 audit concluded that there were no issues with the structure and dimensions of the model and that conclusion is maintained here. Our additional comments with reference the TMfS12 are as follows:

- the 2012UDM should note the use of an interface to cover the transfer of data between the demand and assignment model (the latter of which uses a revised expanded zone system); and
- the sourcing of PM demand. This is derived from factors derived from the interpeak. This was considered an appropriate approach in TMfS07 and it is acknowledged that this is consistent with previous versions of TMfS. The auditor’s view is that this is not consistent with current best practice. We recommend that for any further update of TMfS, this approach is either justified or brought into line with best practice.

7.5 Review of Model Operation

Section 2 of the 2012UDM covers the model builder’s review of the demand model. This is generally considered to be a useful and helpful section of the report.

It should be noted that this section does not fully define the model. However, it is stated in paragraph 1.1 of the 2012UDM that the report should be read in conjunction with the TMfS07 Demand Model Development Report, where a detailed description of the model is included in Section 2 and Appendix A.

The auditor’s comments on this section are as follows:

- model structure – active modes are not considered as part of the demand mode. Therefore, the decision to turn off the time period/trip frequency response by default should be reviewed, as operating the model in this manner could be expected to understate the response for non-commuting and non-business purposes in particular. This is a recommendation from WebTAG guidance and accepted by the model developer
- destination choice model – it is understood from the model developer that calibration constants (K factors) have been used in the model. This is a legacy of the TMfS07 model build and these factors have not been reviewed or updated for the 2012 update;
- high occupancy vehicle choice model – it is understood that this element of the model is not used. The facility to switch on this element of the model remains, in which case it should be confirmed that there is no differentiation in costs between drivers and passengers (i.e., costs are shared equally between them); and

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- trip frequency model – it is understood that the trip frequency element of the model is not used although the facility to switch it on or off remains. Nevertheless, the report covers the workings of this element of the model. If this element of the model is to be used in practical application the lambda values assigned should be justified.

7.6 Updating the Base Year Demand Model

Section 3 of the 2012UDM covers the updates that were applied to the Base Demand Model from TMfS07 to TMfS12. In the report, this is limited to the calculation of “incremental” matrices. This is a comparison of the base observed matrices developed for the assignment models and the “synthesised” matrices created by the demand model. These incremental matrices are then used in model forecasting to produce a set of matrices consistent with base year observations. This process is identical to that used in TMfS07. The key changes in model inputs feeding into this part of the process are understood to be a rebasing of the model to 2012, revised land use data and revised observed highway trip matrices.

Additionally, depending on the relative values of observed and synthesised matrices on an individual cell basis, one of two methods is used to calculate the incremental matrix (additive or multiplicative). It is understood that this method was used in the development of TMfS07 and has not been reviewed in the development of TMfS12. The auditors view is that, whilst this is a reasonable approach in principle, there are risks in applying a combination of methods and some evidence should be provided to allow differences between methods to be understood and a proper impression of the risks gained.

7.7 Sensitivity Tests

Section 4 of the 2012UDM reports on the sensitivity tests carried out. These are consistent with the requirements of WebTAG. The results of the tests are contained in Tables 4.1 – 4.3 of the 2012UDM. The auditor’s comments are as follows:

- the details of the model runs carried out should be included (e.g. is the model run to convergence etc.);
- it is understood that table 4.1 does not include long distance and external trips in the elasticity calculations;
- table 4.3 shows results for a Car Generalised Cost elasticity test. This is used as a proxy for the Journey time test as required by WebTAG on the basis that journey time makes up 70-80% of generalised cost. This is a reasonable approach but the auditor would suggest in future updates of the model that the prescribed test is undertaken;
- table 4.4 shows the results from the Public Transport Fare test. The model builder’s interpretation of WebTAG guidance in the surrounding text is not correct with the guidance stating that values in the range of -0.2 to -0.9 are typical with values of -0.2 for the whole market unlikely unless there is a large proportion of concessionary trips with free travel. It is noted that elasticity for combined purposes, as shown in Table 4.1 of the 2012UDM, is around -0.35 which is within the recommended range, but suggests that the model is somewhat insensitive to Public Transport Fare changes. It is recommended that this be investigated as part of future model updates and
- no information on convergence of the model is included.

7.8 Trip End Model

Section 5 covers the use of the Trip End Model to rebase the model to 2012. This made use of the existing trip model run in such a way that it produces relevant 2012 base trip ends. The auditor’s comments on this section are as follows:

- the trip ends forecasts comparisons of TMfS07 and TMfS12, provided in Table 5.1 of the 2012UDM show that 2012 trip forecasts remain broadly similar on the whole. The auditor has no concerns with these figures;
- section 5.2 notes that National Road Traffic Forecasts were used to provide information on external traffic growth and that this was unchanged since 2007. It is understood that NRTF forecasts published by DETR, 1997, have been used to derive growth forecasts. This approach should be reviewed in any update to the model; and
- section 5.3 also makes reference to smoothing matrices. It is understood that these are output from the trip end model to be input to the demand model, a process which is explained in the LATIS Trip End Model User Manual, not a subject of this audit.

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7.9 Appendices

Appendix A includes a series of flow diagrams covering the main stages in the Demand Model process. These provide a useful overview to the process.

7.10 Summary and Conclusions

It is understood that a generally “light touch” approach has been adopted by SIAS and the audit has followed an approach that is restricted to a review of the activities undertaken to carry out this update only. The issues identified are as follows:

- the overall scope of the update is considered to be appropriate and proportionate;
- the changes to the calculations of the incremental matrices compared with TMfS07 should be noted;
- analysis of the use of a combined additive/multiplicative approach to deriving the incremental matrices should be provided;
- further detail and improved reporting of the Sensitivity/Realism tests carried out should be included, as per the comment in Section 7.7;
- further details/analysis of the rebasing of the model trip ends should be provided, as per the comments in Section 7.8; and
- figure 3 in Appendix A should be explained/revise.

Considering the model and report more widely, there is a general issue that the full programme of activities undertaken by SIAS is not clearly stated in the report so, as such, it is difficult to be sure that a full understanding has been gained and that all steps have been carried out correctly. It is noted that Section 1.1 of the 2012UDM recommends that this report is read in conjunction with the TMfS07 Demand Model Development Report. However, it is suggested that the alterations made to TMfS07 to create TMfS12 are explicitly laid out using the TMfS07 report as a starting point.

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Table 20 reproduces the issues identified as part of the demand model audit categorised as follows:

- Model or reporting deficient – action to rectify required;
- Advice to model users; and
- Advice to TS on future model development.

Table 20: Summary and recommendations – demand model

Subject	Details
Model or reporting deficient – action to rectify required	
Key Model Dimensions	The interface process between the demand and assignment models should be noted and documented in the 2012UDM
Advice to model users	
Optional choice modules	The high occupancy vehicle module, time period choice module, and trip frequency module are set to OFF by default. Specific advice should be sought from the model developers before any use is made of these modules in model application.
Advice to TS on future model development	
Key Model Dimensions	PM trips are derived from interpeak trips using factors. The auditor's view is that this is not consistent with current best practice. We recommend that for any further update of TMfS, this approach is either justified or brought into line with best practice
Review of Model Operation	It should be confirmed that there is no differentiation in costs between drivers and passengers (i.e., costs are shared equally between them) in the high occupancy vehicle choice model.
Review of Model Operation	The decision to turn off the time period/trip frequency response by default should be reviewed. Their continued inclusion in the model structure should be justified.
Review of Model Operation	The use of a value of -0.5 for home-based other trips in the trip frequency model should be justified.
Sensitivity tests	Journey time sensitivity tests should be included in addition to, or instead of, the car generalised cost test.
Sensitivity tests	Public transport fare elasticity should be investigated.
Sensitivity tests	Information on model convergence should be included.
Trip End Model	Alternative sources of external traffic growth should be investigated as an alternative to NRTF.