

TRIP END MODEL DEVELOPMENT



SYSTRA

LATIS LOT 1: STRATHCLYDE REGIONAL TRANSPORT MODEL DEVELOPMENT

TRIP END MODEL DEVELOPMENT

IDENTIFICATION TABLE

Client	Transport Scotland
Project	LATIS Lot 1: Strathclyde Regional Transport Model Development
Study	Trip End Model Development
Type of document	Final Report
Date	27/09/2019
File name	20190607_SRTM_Trip_End_Model_Report_V2.0.docx
Framework	LATIS Lot 1
Reference number	10365912/TEM/2
Number of pages	46

APPROVAL

Version	Name	Position	Date	Modifications	
1	Author	Chris Cullen Adrian Giurconiu Paul Gray	Principal Consultant Analyst Associate Director	09/06/2016	Internal draft and note to auditor
	Author	Adrian Giurconiu Paul Gray Vickraj Ramburrun	Analyst Associate Director Consultant	02/06/2017	
	Checked by	David Connolly	Director	09/06/2017	
1.8	Approved	Jeff Davidson	Associate Director	15/06/2017	Draft Report for Auditor
	Author	Paul Gray Vickraj Ramburrun	Associate Director Consultant	29/05/2019	
2.0	Checked by	Jeff Davidson	Associate Director	29/05/2019	Final Report, with Auditor comments
	Approved	Malcolm Neil	Associate Director	27/09/2019	
	Author	Paul Gray Vickraj Ramburrun	Associate Director Consultant	29/05/2019	

TABLE OF CONTENTS

1.	SRTM MODEL OVERVIEW	7
1.1	CONTEXT	7
1.2	TERMINOLOGY	8
2.	GENERAL STRUCTURE	14
2.1	OVERVIEW	14
2.2	MODEL COMPONENTS	14
2.3	INPUTS	15
2.4	OUTPUTS	15
3.	INITIAL TRIP ENDS	16
3.1	OVERVIEW	16
3.2	INPUTS	16
3.3	OUTPUTS	18
3.4	METHODOLOGY	18
4.	ROAD ASSIGNMENT SUBAREA	24
4.1	OVERVIEW	24
4.2	INPUTS	24
4.3	METHODOLOGY	25
4.4	OUTPUTS	25
5.	PT ASSIGNMENT SUBAREA	26
5.1	OVERVIEW	26
5.2	INPUTS	26
5.3	METHODOLOGY	27
5.4	OUTPUTS	28
6.	PARK AND RIDE EXTERNAL TRIPS	29
6.1	OVERVIEW	29
6.2	INPUTS	30
6.3	METHODOLOGY	30
6.4	OUTPUTS	30
7.	SPECIAL ZONES	31
7.1	OVERVIEW	31
7.2	INPUTS	31
7.3	OUTPUTS	31

8.	GOODS MATRICES	32
8.1	OVERVIEW	32
8.2	INPUTS	32
8.3	METHODOLOGY	32
8.4	OUTPUTS	33
9.	ADD-IN MATRICES	34
9.1	OVERVIEW	34
9.2	INPUTS	34
9.3	OUTPUTS	34
9.4	APPROACH	34
10.	FINAL TRIP ENDS	35
10.1	OVERVIEW	35
10.2	INPUTS	35
10.3	OUTPUTS	35
10.4	METHODOLOGY	35
11.	STRATHCLYDE INTEGRATED TRANSPORT/LAND-USE MODEL INTERFACE	37
11.1	OVERVIEW	37
11.2	INPUTS	37
11.3	OUTPUTS	38
11.4	METHODOLOGY	38
12.	OPERATION OF THE TRIP END MODEL	39
12.1	OVERVIEW	39
12.2	CATALOG KEYS	39
12.3	PARAMETERS	40
12.4	INPUT FILES: PLANNING DATA	42
12.5	INPUT FILES: TMFS DATA	43
12.6	MODULE SELECTION	45

LIST OF FIGURES

Figure 1.	SRTM Geographical Coverage Area	8
Figure 2.	SRTM and TELMOS Zone System Overlay Example	9
Figure 3.	Tours and Trip Types	11
Figure 4.	Trip End Model Structure	14
Figure 5.	Model zone to geographical area type assignment	19
Figure 6.	PT Select Link Definition Example	26
Figure 7.	Park and Ride External Trips	29

LIST OF TABLES

Table 1.	Car Availability Conversion Proportions	12
Table 2.	Demand Segment Correspondence	13
Table 3.	Car Availability Conversion Rates	20
Table 4.	Trip Attraction Rates	21
Table 5.	Simple Tour Proportion By Purpose	21
Table 6.	Non-Retired Return Rates By Purpose	22
Table 7.	Retired Return Rates By Purpose	22
Table 8.	Aggregation of Non-Simple Home-Based Trip Ends	22
Table 9.	Non-Retired Non-Home-Based Trip Rates	23
Table 10.	Retired Non-Home-Based Trip Rates	23
Table 11.	Subarea Network Renumbering Guidelines	25
Table 12.	Catalog Key Description	39
Table 13.	List of Parameters	40

1. SRTM MODEL OVERVIEW

1.1 Context

1.1.1 The development of a new regional transport model of Strathclyde (SRTM) was commissioned to provide analysis for the emerging Glasgow City Deal and support additional transport analysis through the regional transport planning process.

1.1.2 SRTM is a multi-modal ‘tour-based’ strategic transport model covering the Strathclyde area, including the eight Clydeplan Local Authorities, three Ayrshire Authorities and parts of Argyll and Bute. SRTM interfaces with the TELMoS / TMfS14 (Transport, Economic and Land-use Model of Scotland / Transport Model for Scotland 2014) national modelling hierarchy to forecast changes in population and jobs, and subsequent changes in levels of traffic and travel over time and represent demand to/from external areas.

1.1.3 The SRTM Geographical Coverage Area and road and public transport networks are illustrated by the green shaded area below, with the external network beyond this area.

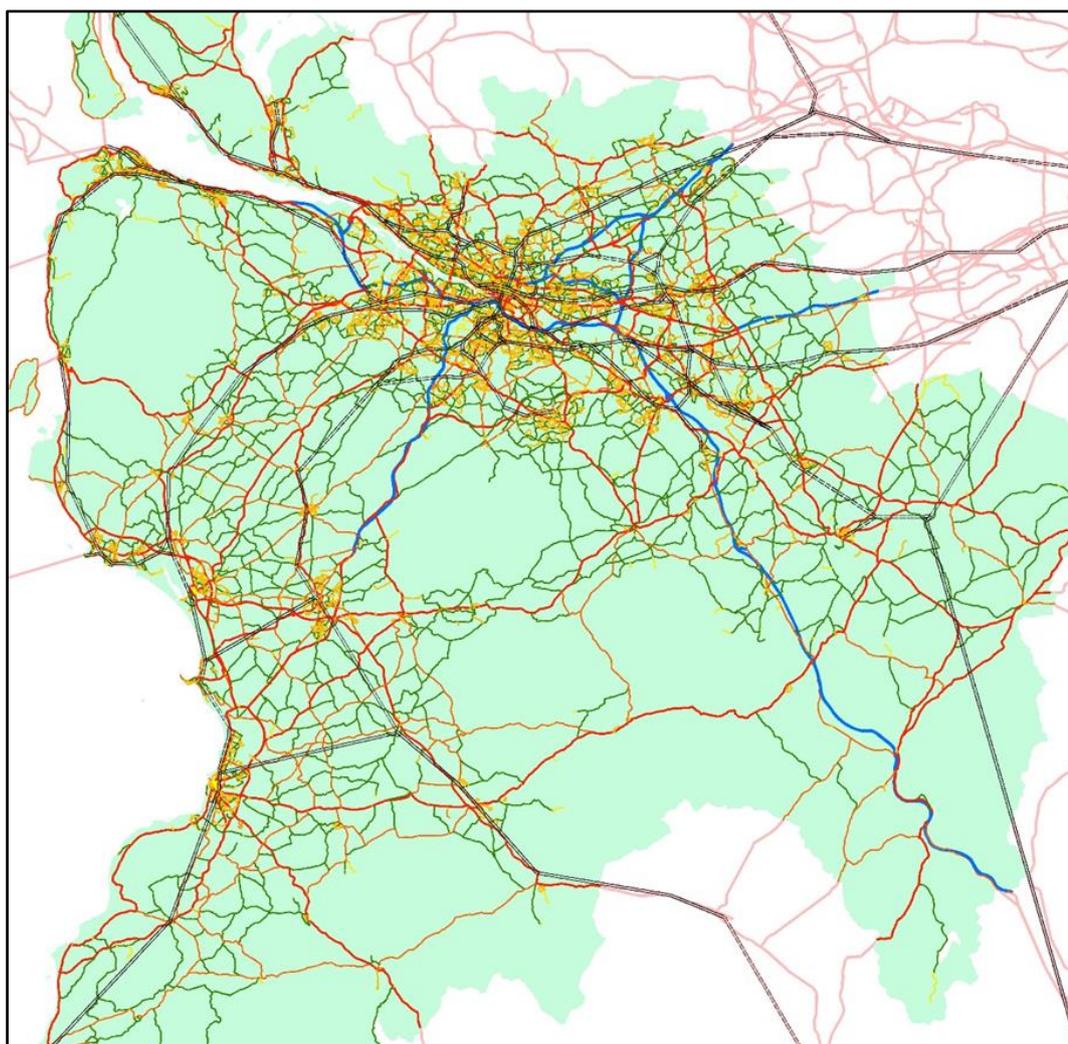


Figure 1. SRTM Geographical Coverage Area

1.1.4 The SRTM includes trip generation, demand and assignment models covering the main road and public transport modes, including park and ride interchange and parking capacity and pricing within Glasgow City Centre. The SRTM is calibrated to reflect 2014 travel conditions.

1.1.5 This note documents the trip generation module of the above structure which is scripted to accomplish the following tasks:

- calculation of all modes trip ends from planning data inputs;
- extraction of external trips from the higher level TMfS14 model;
- construction of base year trip matrices for light and goods vehicles;
- forecasting approach for goods vehicles trips from TELMoS commodity matrices; and
- forecasting routines for airport and other special zones.

1.2 Terminology

1.2.1 Before discussing the actual components of the model, it is beneficial to lay out definitions for each of the commonly used terms to avoid ambiguity.

Zone Systems

1.2.2 The trip end model is required to provide outputs in a zone system consistent with the SRTM demand and assignment models which consists of 1299 zones covering the Strathclyde area. SRTM zone numbering is structured as follows:

- Zones 1 to 1233 – Zones with planning data sourced from TELMoS;
- Zones 1234 to 1248 – Park and ride interchange point zones;
- Zones 1249 to 1254 – Glasgow Airport zone (1249) and 5 spare zones; and
- Zones 1255 to 1299 – External zones linked to TMfS outputs.

1.2.3 The main demand model zoning system (which requires planning data) was derived by forming amalgamations of Scottish Output Areas (contained within larger TELMoS zones) to prepare detailed zoning covering areas of residential and employment activity.

1.2.4 The process followed a set of rules and thresholds to generate consistent zoning across the area. Thresholds were set at a maximum of 2,000 households and 5,000 jobs per zone. The final SRTM zone system contained around an average of 800 households, and 650 jobs per zone, with only a handful of zones lying above the thresholds.

1.2.5 The planning data inputs which trip ends are derived from are supplied by TELMoS, which uses a larger zone system consistent with TMfS14. SRTM zones are contained within TELMoS zones. The SRTM zonal disaggregation data (Census total population and employment figures by Output Area, combined to SRTM zones) were used to split the TELMoS Planning data into the more detailed SRTM zoning, providing planning data at a more detailed geographical level.

1.2.6 An example overlay of the two zone systems is shown below for central Glasgow, with SRTM zones illustrated in black, and TELMoS zones shown in blue.

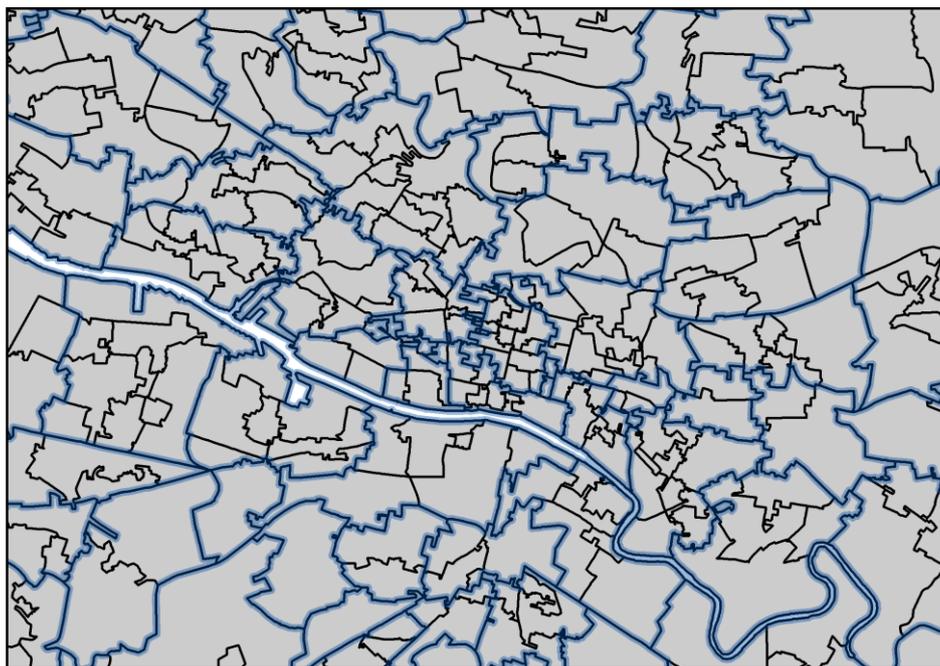


Figure 2. SRTM and TELMOS Zone System Overlay Example

1.2.7 The overlay demonstrates that generally TELMoS zones are split into several SRTM zones. This detailed geography combined with a relatively low number of households, population and/or jobs per zone, provides the detail required to represent planning data at a relatively disaggregate level. During forecasting, planning data / activity levels within each SRTM zone can also be adjusted to ensure new developments are located into the SRTM specific zone containing the proposed development site.

1.2.8 The derivation of the SRTM zone system is described further within the Demand Model Development report.

Time Periods

1.2.9 The SRTM requires 24 hour trip ends which are used to define travel for five different time periods within the SRTM demand model, including:

- AM (07:00 – 10:00);
- Lunchtime (LT, 10:00 – 13:00);
- School Run (SR, 13:00 – 16:00);
- PM (16:00 – 19:00); and
- Off-peak (OP, 19:00– 07:00).

1.2.10 This group of time periods represent the main variations in travel throughout a typical weekday, with the main commuter periods covered separately, including the peak shoulders. The inter peak is disaggregated into two separate time periods with an aim to represent some of the variations in travel associated with the school run, which can have a greater impact in some local areas. The off-peak period covers travel within the remainder of the day, and ensures the whole of a typical weekday is captured within the trip end and demand modelling.

1.2.11 This structure allows for more detailed modelling of the chosen time periods to assist the tours based modelling, and also provides transparency of how daily travel is represented. Calibration of each time period will be dependent, however, on the granularity of data available for each period.

1.2.12 The core Trip End outputs ('Demand Model inputs) are generated at the 24hr level. The goods vehicle and TMfS14 assignment external movement 'add-in' matrices are available by time period and are representative of a peak hour:

- AM (07:00 – 10:00);
- Inter-peak (IP, 10:00 – 16:00); and
- PM (16:00 – 19:00).

1.2.13 This is broadly consistent between the two models in that the AM and PM peaks are identical, and the inter peak is considered as the aggregation of LT and SR, but there is no consideration of an off-peak time period and hence TMfS14 only covers 12 hours of the day.

Modes

1.2.14 The SRTM demand model contains a mode choice model which considers five distinct modes:

- Car;
- PT;
- Park and Ride;
- Walk; and
- Cycle.

1.2.15 The trip ends produced by the trip end model therefore consider trips made by all these modes, although they do not distinguish between them in the final trip end outputs.

1.2.16 The TMfS14 assignment inputs are representative of only two motorised modes, road and PT, although they consider park and ride as part of their assignments as two separate legs (which is discussed further when deriving external matrices). TMfS14 does not consider walk or cycle in any aspect of its modelling.

Tours and Trip Types

1.2.17 Fundamental to the derivation of trip ends in the SRTM is an understanding of how tours are modelled, with a tour considered as any set of trips which begin at home and end at home. Two specific types of tour are considered:

- A 'simple' tour which travels straight from home to a single destination and then returns directly home; and
- A 'non-simple' tour which has an initial outbound trip from home to a first destination, an unspecified number of non-home-based trips to alternative destinations, and a final return home trip.

1.2.18 These trip movements are illustrated graphically below. Note that only a single representative non-home-based trip is included here, while in practice there can be multiple trips.

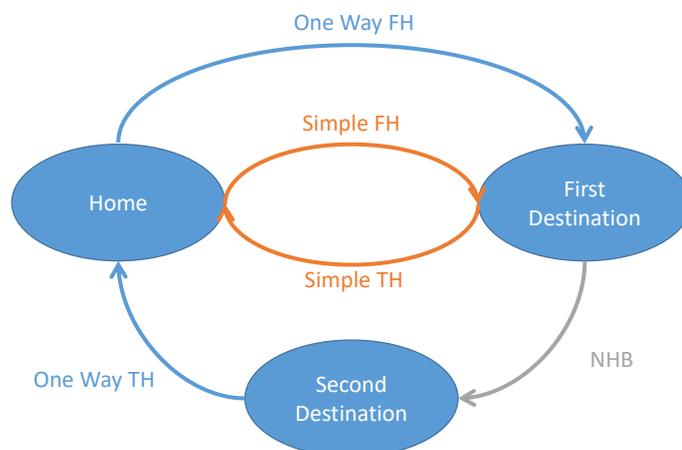


Figure 3. Tours and Trip Types

1.2.19 The SRTM demand model requires trip ends detailing the following types of trip making:

- Simple tour From Home productions;
- Simple tour From Home attractions;
- One-way (non-simple tour) home-based origins;
- One-way (non-simple tour) home-based destinations;
- Non-home-based origins; and
- Non-home-based destinations.

1.2.20 This list specifically omits any details on the simple To Home levels of trip-making which can be derived in the demand model based on the simple From Home trips.

Demand Segments

1.2.21 The SRTM demand model disaggregates total travel into particular traveller types in order to more robustly model the choices they make, and the trip end model is the first stage of defining the different types of traveller. The six travel purposes considered are:

- Home-based employer's business (EMP);
- Home-based commuters (COM);
- Home-based other (OTH);
- Home-based education (EDU);
- Non-Home-based employer's business (NHBE); and
- Non-home-based other (NHBO).

1.2.22 'Other' trips are considered as a catch-all for any purposes which do not specifically fall into the other three categories, and notably contains escort to education. Therefore, the education trip purpose solely considers those trips made by the person travelling to education establishments to be educated.

- 1.2.23 Along with travel purposes, two different economic statuses are accounted for, retired and non-retired, as defined by both survey data and planning data i.e. there is no requirement to assume retired based on an age band for instance.
- 1.2.24 Car availability is used to distinguish traveller types as it has a large impact on mode choice. This is derived based on household car ownership contained in the TELMoS planning data and survey type. Future year changes in car availability are input through the TELMoS household car availability forecasts.
- 1.2.25 The underlying assumptions to convert car ownership to car available (CAV) and non-car available (NCA) include:
 - if the number of cars per household is greater or equal to the number of adults in the household, it is assumed to have a CAV of 1 and the NCA proportion is equal to zero;
 - if a household does not have any cars, there is no car available for any of the trips made by members of that household;
 - a CAV and NCA proportion is applied as per the table below if the number of cars is less than the number of adults in the household; and

Table 1. Car Availability Conversion Proportions

JOURNEY PURPOSE	CAR AVAILABLE	NON-CAR AVAILABLE
Education	0.2	0.8
Other	0.5	0.5
Employers Business	0.8	0.2
Commute	0.7	0.3

- 1.2.26 Finally, the tour trip types noted above are used to disaggregate travellers to allow the next stage of the modelling to identify the type of traveller being represented.
- 1.2.27 Table 2 provides a clear reference for how each different purpose, socio-economic status, car availability segment, and trip type are considered together to create demand segments.

Table 2. Demand Segment Correspondence

REF	PURPOSE	RETIRED STATUS	CAR AVAILABIITY	TRIP TYPE
1	EMP	Non-Retired	All	Simple From Home
2	COM	Non-Retired	Car available	Simple From Home
3	COM	Non-Retired	No car available	Simple From Home
4	OTH	Non-Retired	Car available	Simple From Home
5	OTH	Non-Retired	No car available	Simple From Home
6	EDU	Non-Retired	Car available	Simple From Home
7	EDU	Non-Retired	No car available	Simple From Home
8	ALL	Retired	Car available	Simple From Home
9	ALL	Retired	No car available	Simple From Home
10	EMP	All	All	Non-home-based
11	Not EMP	All	Car available	Non-home-based
12	Not EMP	Non-Retired	No car available	Non-home-based
13	EMP	Non-Retired	All	One-way home-based
14	COM	Non-Retired	Car available	One-way home-based
15	COM	Non-Retired	No car available	One-way home-based
16	OTH	Non-Retired	Car available	One-way home-based
17	OTH	Non-Retired	No car available	One-way home-based
18	EDU	Non-Retired	Car available	One-way home-based
19	EDU	Non-Retired	No car available	One-way home-based
20	ALL	Retired	Car available	One-way home-based
21	ALL	Non-Retired	No car available	One-way home-based

2. GENERAL STRUCTURE

2.1 Overview

2.1.1 While each aspect of the trip end model is discussed in greater detail in the following chapters, this section describes how components fit together in an interconnecting system capable of producing correctly formatted outputs from consistent inputs.

2.2 Model Components

2.2.1 The trip end model contains the following elements:

- Initial trip ends;
- Road subarea;
- PT subarea;
- Special zones (i.e. Airport);
- Goods vehicles;
- Final trip ends; and
- Add-in matrix creation.

2.2.2 These elements are arranged as shown in the diagram below which highlights dependencies between the modules i.e. where a module requires an input from a separate element rather than from another input.

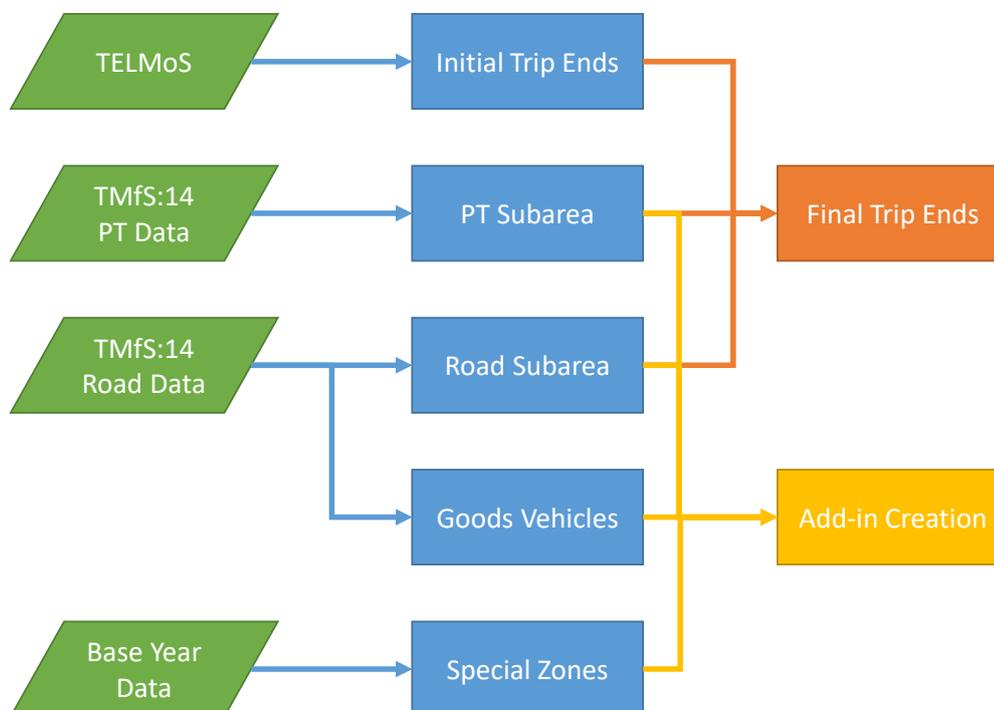


Figure 4. Trip End Model Structure

2.3 Inputs

2.3.1 The large number of model inputs can essentially be broken down into four different categories:

- Base year data which contains data from the base year SRTM model;
- TELMoS data which defines land use in a specific zone system including population, household, and jobs;
- TMfS14 road data, which includes all data required from an existing TMfS14 model run and allows a road subarea assignment process to be undertaken; and
- TMfS14 PT data, which includes all data required from an existing TMfS14 model run and allows a pseudo-subarea assignment process to be undertaken for PT.

2.4 Outputs

2.4.1 The outputs are the final trip ends which reflect 24 hour internal trip ends by demand segment and differentiated by simple and non-simple tours.

2.4.2 In addition, a series of time period specific assignment add-ins specifying trips by mode and user class is produced, which accounts for trips which are not modelled within the demand model.

3. INITIAL TRIP ENDS

3.1 Overview

3.1.1 The SRTM demand model requires 24 hour trip ends representative of all mode travel and disaggregated into appropriate demand segments. These trip ends are derived based on applying NTEM (Version 6.2) derived trip rates to planning data.

3.1.2 Note that a more recent version of NTEM (Version 7) is now available, and users should take note of the changes in assumptions and trip rate inputs between these versions.

3.2 Inputs

Planning Data

3.2.1 The major input to the Trip End Model is the planning data provided from the Transport and Economic Land-use Model of Scotland (TELMoS), consisting of two files detailing population data and attraction data.

3.2.2 Population data is available by 72 person categories, distinguished by nine person types and eight household types relating to car ownership. The person types are:

- Children;
- Males in full time employment;
- Males in part time employment;
- Males non-working;
- Males retired;
- Females in full time employment;
- Females in part time employment;
- Females non-working; and
- Female retired.

3.2.3 The household types are:

- 1 adult household with no Car;
- 1 adult household with one or more Cars;
- 2 adult households with no Car;
- 2 adult households with one Car;
- 2 adult households with two or more Cars;
- 3+ adult households with no Car;
- 3+ adult households with one Car; and
- 3+ adult households with two or more Cars.

3.2.4 The TELMoS attraction data provides information on the number of households and various types of employment, under 92 categories of land use which for the purposes of the model are grouped into the following categories:

- Households;
- Employment;
- Agriculture and fishing;

- Retail;
- Hospitality;
- Local financial;
- Education;
- Health and social services;
- Services;
- Industrial;
- Business; and
- Holiday.

- 3.2.5 These files are initially available in the TELMoS zone system, consistent with the national model TMfS14, and so there is a requirement for a test specific mapping file to attribute households, population, jobs and developments to specific SRTM zones rather than distributed generically. This process disaggregates the TELMoS Population and Household data down to the SRTM zonal level using the total population within each SRTM zone, and splits employment activities using SRTM total employment data.
- 3.2.6 The outcome of this process is that base and forecast year planning data is controlled at the overall TELMoS zonal level, and then disaggregated to represent activities across the more detailed SRTM zone system.
- 3.2.7 The use of population data provides a generally consistent means of splitting areas of residential activity between zones. Users should note that the use of total employment levels to split jobs data may not specifically represent different types of employment into specific SRTM zonal areas. For example, proportions of jobs associated with an education centre and retail park contained within the same TELMoS zone could be disaggregated into several zones, with the majority of jobs allocated to the highest employment.
- 3.2.8 The outcome of this is that, rightly, the higher trip ends (and subsequent travel levels) will follow the zones with the largest employment, but the actual type of employment activity is less certain. This limitation is associated with the lower detail available for employment data sets.
- 3.2.9 This limitation is mitigated during forecasting, whereby users can adjust planning data / activity levels within each SRTM zone to ensure new developments are located into the specific zone containing the development site.

Trip Rates

- 3.2.10 As well as these test specific planning inputs, a series of trip rates and attraction factors are stored as parameters. These are used to create trip ends by multiplying the relevant planning data and trip rate.
- 3.2.11 The use of trip rates is set up similar to previous LATIS Trip Generation models and earlier guidance, which assumed that trip rates remain stable over time. Users should note that more recent guidance suggests that trip rates can change over time. Therefore, representing potential changes to the level of trip making (i.e. associated with home working or retail trips / home deliveries) would require a further process and/or specific adjustments to vary trip rates to cater for these type of trends.

3.3 Outputs

3.3.1 The Trip End Model produces two tables which document 24 hour productions and attractions¹ for all modes. These tables are disaggregated by the same demand segments as the demand model (see Table 2).

3.4 Methodology

Total Productions

3.4.1 The first step of the Voyager model imports the raw TELMoS data and converts the zone system to be consistent with the SRTM based on proportional splits. These proportional splits are uniquely defined for production data and attraction data and can be varied during forecast year scenario testing.

3.4.2 To ensure consistency with the DfT's National Trip End Model (NTEM) trip rates, person types need to be expanded out to consider students separately. These are estimated as a proportion of part-time workers and non-working persons, with the proportions consistent throughout all model years. These proportions have been calculated on a zonal basis from 2011 Scottish census data for the base year and it is assumed these will be equally applicable for forecast scenarios unless new assumptions are derived.

3.4.3 As well as expanding the person types in the data, each zone is given a flag for 'area type' which defines which set of production trip rates are applicable for a geographical area. It is not expected these identifiers will need to be changed within test scenarios, although a mechanism is in place to ensure they can be if required.

3.4.4 Trip rates for the four home-based travel purposes are applied based on standard NTEM trip rates (Version 6.2) to produce productions by zone, person type, and household type. The NTEM rates have then been adjusted to account for the assumption that 'Education' trips (under SRTM purpose definitions) are only undertaken by children under 16; for all other person types these trips have been transferred to 'Other'. As trip rates are defined by one of eight area types based on degree of urbanization, model zones were assigned to these area types according to NTEM geodata (as shown in Figure 5).

¹ Or in the case of one-way trips origin and destination.

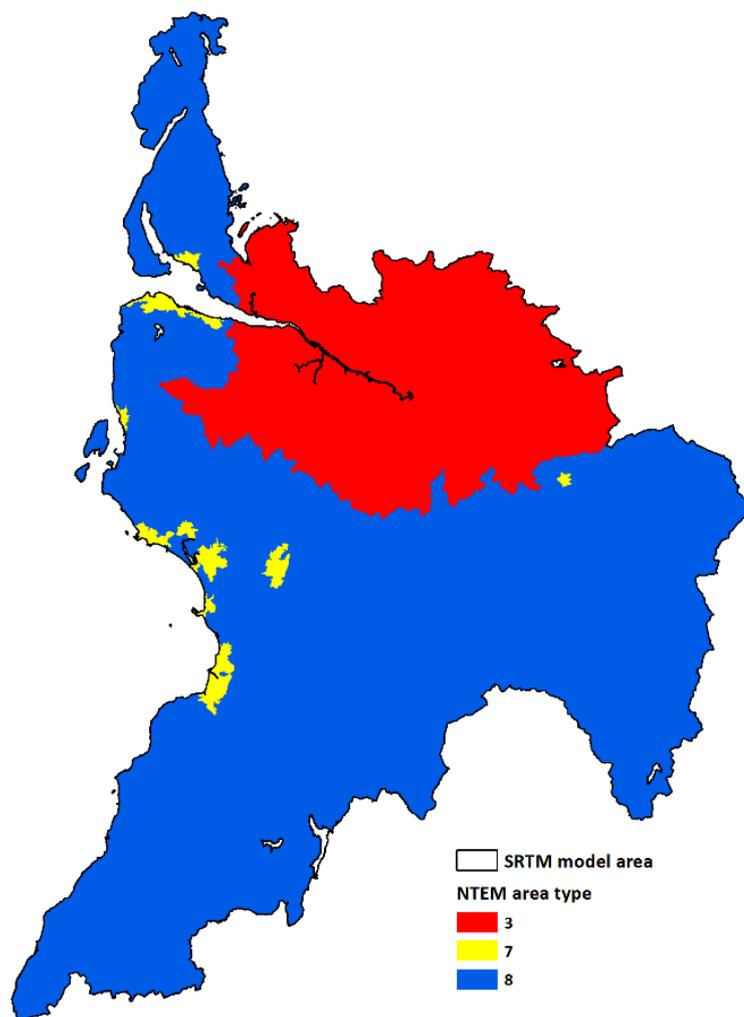


Figure 5. Model zone to geographical area type assignment

- 3.4.5 Car availability has been chosen as the main influence on travel choice as opposed to car ownership, and so a conversion from household car ownership to car availability is applied based on the likelihood that a car is available for a trip given a particular household car ownership category.
- 3.4.6 For zero car owning households, there is assumed to be no car available for any trip, while for households with at least the same number of cars as people, it is assumed that all trips have a car available.
- 3.4.7 For the remaining households, the proportion of trips which have a car available is dependent on purpose to reflect that in practice certain purposes will prioritise the use of car over others. Table 3 describes the proportion of trips which are assumed to be car available based on the household type and trip purpose. Within the model these are input individually for each zone.

Table 3. Car Availability Conversion Rates

HOUSEHOLD CATEGORY	EMP	COM	OTH	EDU
1 adult household with no Car	0.0%	0.0%	0.0%	0.0%
1 adult household with one or more Cars	100.0%	100.0%	100.0%	100.0%
2 adult households with no Car	0.0%	0.0%	0.0%	0.0%
2 adult households with one Car	80.0%	70.0%	50.0%	20.0%
2 adult households with two or more Cars	100.0%	100.0%	100.0%	100.0%
3+ adult households with no Car	0.0%	0.0%	0.0%	0.0%
3+ adult households with one Car	80.0%	70.0%	50.0%	20.0%
3+ adult households with two or more Cars	100.0%	100.0%	100.0%	100.0%

Total Attractions

- 3.4.8 Attraction data also requires an initial conversion to a consistent SRTM zone system in a manner consistent with the production data and following this, NTEM derived attraction rates are applied to the planning data to produce relative attractions for each zone for six specific purposes:
- Home-based employer’s business;
 - Home-based commute;
 - Home-based other;
 - Home-based education; and
 - Non-home-based.
- 3.4.9 Non-home based attraction rates are derived from mobile phone data using a procedure described in detail in a separate note. As non-home based rates are not differentiated by trip purpose, the split of non-home based attractions between employer’s business and other is lifted from the home-based split for these two purposes.
- 3.4.10 Note that the tendency for planning data and trip rate information to represent non-home based travel activities in less detail will generally increase uncertainty associated with the level of non-home based trip making when disaggregated at a detailed level. Using model outputs at a more aggregate level would reduce this uncertainty.
- 3.4.11 Table 4 provides the attraction rates for each purpose and employment category which have been derived from NTEM.

Table 4. Trip Attraction Rates

PURPOSE	EMP	COM	OTH	EDU	NHB
Households	-	-	3.0535	-	-
Employment	4.4431	-	-	-	-
Agriculture and fishing	-	0.4963	3.2647	-	-
Retail	-	0.4963	35.7643	-	3.3434
Hospitality	-	0.4963	0.5833	-	2.2781
Local financial	-	-	-	-	-
Education (Tertiary)	-	0.4963	43.4826	-	-
Education (Non-Tertiary)	-	0.4963	-	43.4826	-
Health and social services	-	0.4963	54.2395	-	0.6617
Services	-	0.4963	19.5396	-	-
Industry	-	0.4963	-	-	2.3086
Business	-	0.2482	-	-	1.1947
Holiday	-	-	16.3236	-	-

Note: Education journey purpose defined as pupil trips to school

Non-Simple Tours: Home-Based Legs

3.4.12 The Scottish Household Survey (SHS) was interrogated to establish the probability that a From Home trip is a simple trip, and this probability can be applied to the total productions derived above to separate into ‘simple productions’ and ‘non-simple productions’. Table 5 below shows the simple tour proportions by purpose.

Table 5. Simple Tour Proportion By Purpose

PURPOSE	SIMPLE TOUR PROPORTION
EMP	0.872
COM	0.839
OTH	0.830
EDU	1.000

3.4.13 For non-simple productions, the SHS was used to establish the return rates for each outbound purpose individually for retired and non-retired persons to allow an expanded set of trips to be derived classified by both outbound and inbound purpose as well as whether the persons were retired or not (described in Table 6 and Table 7).

Table 6. Non-Retired Return Rates By Purpose

Out Purpose	INBOUND PURPOSE				Total
	EMP	COM	OTH	EDU	
EMP	62.1%	3.1%	34.9%	0.0%	100.0%
COM	7.7%	32.5%	59.8%	0.0%	100.0%
OTH	0.2%	6.8%	93.0%	0.0%	100.0%
EDU	0.0%	0.0%	0.0%	0.0%	0.0%

Table 7. Retired Return Rates By Purpose

Out Purpose	INBOUND PURPOSE				Total
	EMP	COM	OTH	EDU	
EMP	0.0%	0.0%	100.0%	0.0%	100.0%
COM	0.0%	0.0%	100.0%	0.0%	100.0%
OTH	0.0%	0.2%	99.8%	0.0%	100.0%
EDU	0.0%	0.0%	0.0%	0.0%	0.0%

3.4.14 A similar procedure was applied to the attractions, which were scaled to overall production levels within the model to provide simple attraction levels and non-simple home-based attraction levels.

3.4.15 Aggregating productions and attractions by inbound and outbound purposes produced estimates of trip ends for From Home and To Home stages as shown in Table 8.

Table 8. Aggregation of Non-Simple Home-Based Trip Ends

P/A	DIRECTION	AGGREGATION
Production	Outbound	From Home Origins
Production	Inbound	To Home Destinations
Attraction	Outbound	From Home Destinations
Attraction	Inbound	To Home Origins

Non-Home-Based Origins and Destinations

3.4.16 Having established the number of outbound trips which will result in a non-home-based trip, the From Home destinations are multiplied by the average number of non-home-based trips separately for employer’s business and other to find the total number of non-home-based origins by purpose (as described in Table 9 and Table 10).

Table 9. Non-Retired Non-Home-Based Trip Rates

HOME-BASED PURPOSE	NHBEB RATE	NHBO RATE
Employer’s business	1.3814	0.7832
Commute	0.1670	1.6018
Other	0.0121	1.6455
Education	0.0000	0.0000

Table 10. Retired Non-Home-Based Trip Rates

HOME-BASED PURPOSE	NHBEB RATE	NHBO RATE
Employer’s business	0.0000	0.0000
Commute	0.0000	0.0000
Other	0.0000	1.3814
Education	0.0000	0.0000

3.4.17 The non-home-based destinations are then estimated by taking the NHBEB and NHBO weights derived at the same time as the other attraction weights and scaling them to the total number of internal origins.

3.4.18 Production and attraction values for the zones covering the airports, in particular airport passenger trips, are calculated through the airport module. In the base year these airport zones are exogenously provided to the model as input air travel passenger matrices, along with a table of airport annual growth values used to provide productions and attractions for these airport (special) zones during forecasting.

3.4.19 Note that employees working at the airport are represented by the commuting purpose within the standard demand modelling.

4. ROAD ASSIGNMENT SUBAREA

4.1 Overview

4.1.1 A significant component of road traffic demand within the SRTM is associated with traffic which originated or terminated outside the core demand model geographical area. To include these trips and subsequent impact to travel costs within the assignments, a process is used to add this 'external' demand to the road model matrices. TMfS14 contains the SRTM area and has a much more extensive geographical coverage across Scotland, which therefore provides a suitable parent model to derive external road trips for inclusion to the SRTM.

4.2 Inputs

4.2.1 The inputs to this stage are the road assignment outputs from a particular run of TMfS14, specifically the assigned networks and input demand matrices (peak hour representative) for three time periods (AM, IP, and PM).

4.2.2 A TMfS14 subarea network must be created which should reflect the SRTM coverage and external network links. This can be created by performing a sub-area extraction on the TMfS14 road network using a consistent polygon and renumbering the zones appropriately.

4.2.3 In order to translate the TMfS14 based zone system into the SRTM zone system, two sets of renumber mappings are used. The first solely covers the internal zones and is taken directly from the mapping described previously in 3.4.1. The latter component relates the external subarea zones to the true SRTM external zones, and should be reviewed upon each preparation of a subarea network to ensure it is either still consistent or else otherwise updated appropriately.

4.2.4 TMfS14 only considers three distinct person-based user classes (employer's business, commute, and other) and so the 'other' user class requires expansion to the SRTM definitions of 'other'², education, and retired. These are defined by a proportion file which contains the proportional splits of each expanded user class as a component of the TMfS definition of 'other', and defined uniquely by time period. These proportions are calculated by proportions prepared specifically for each time period and derived from Scottish Household Survey data

4.2.5 Finally, a number of parameters are required which should be consistent with the SRTM model including period to hour factors available by mode and time period, and Car Driver to Car User factors (similar to occupancy factors) which are available by user class and time period.

² The definitions of 'other' in TMfS14 and SRTM are not consistent and are both considered as catch-all user classes for trips which are not specifically referenced in the defined user classes.

4.3 Methodology

- 4.3.1 The road model subarea undertakes a Cube Voyager road assignment consistent with the TMfS14 approach (including all relevant parameters) with an additional input of a subarea network. This network should be consistent with the standard TMfS14 road network included in the assignment but restricted to the SRTM area which can be defined by a polygon (saved in {CATALOG DIR}\Params\Road_Subarea\Cordon.SHP).
- 4.3.2 Should this subarea network file need to be created for a future reference case, the guidelines provided below should be used to allow the renumbering in later stages to be consistent.

Table 11. Subarea Network Renumbering Guidelines

CATEGORY	RENUMBER	NOTES
Zones	+0	Keeps original zone labels
Externals	(z+1)+, where z is the number of zones in the TMfS14 network	Sets externals immediately after the original zones – there should be a minimal number of these
Nodes	+0	Keep nodes consistent. This is not strictly necessary, and should an overlap occur then simply replace it with +1000

- 4.3.3 A change to the sub area processing network cordon may be required if a new future year scheme overlaps the boundary of the SRTM coverage area within TMfS14.

4.4 Outputs

- 4.4.1 The outputs of this stage are a set of hourly time period specific assignment matrices, with seven user classes consistent with SRTM road model definition.
- 4.4.2 In addition, a set of 24 origins and destinations for both the total and external modelled areas are reported to allow adjustment to the initial trip ends to reduce them to internal trip ends.

5. PT ASSIGNMENT SUBAREA

5.1 Overview

5.1.1 The SRTM area has significant PT links extending outside the model, particularly the rail line to Edinburgh, but also bus routes crossing the model coverage boundary. To ensure the SRTM PT models appropriate levels of demand, external PT flows are extracted from TMfS14 using select link procedures to derive a subarea passenger travel matrix.

5.2 Inputs

5.2.1 The inputs to this stage are all the required inputs for a TMfS14 PT assignment including:

- Assigned road networks;
- PT assignment matrices;
- Factor files;
- Fare files;
- PT service definitions (line files); and
- PT system files.

5.2.2 These files are most easily obtained by copying the entire input directory from the relevant TMfS14 model run as well as the '.PTM' files and '.NET' files from the time period specific output PT directories.

5.2.3 In addition to the TMfS14 assignment data, a set of parameters were created to ensure consistency with the previous assignments, outlining crowding definitions and values of time.

5.2.4 A cordon is required to be drawn around the model area and this can be defined using a select link definition which should be stored in the following location:

```
{CATALOG_DIR}\TMFS_DATA\{TMFS_YEAR}\{TMFS_RUNID}\{TMFS_GROWTH}\PT\PT_S
UBAREA_CORDON.TXT
```

5.2.5 An example of this file is provided below.

```
MW[101] = SELECTLINK(L=6340-6379, 6207-6275, 6297-6101) ; South East Inbound
MW[102] = SELECTLINK(L=6379-6340, 6275-6207, 6101-6297) ; South East Outbound
MW[103] = SELECTLINK(L=6306-6220, 7211-7210) ; South West Inbound
MW[104] = SELECTLINK(L=6220-6306, 7210-7211) ; South West Outbound
```

Figure 6. PT Select Link Definition Example

5.2.6 Select links must be defined in both directions and can also span multiple links as shown below, and should be related to a working matrix (MW) which should increase sequentially and begin at 101. Note that there is a limit within the scripts of 50 select

link matrices which can be considered and using more than this will result in no output for those which extend beyond the limit, and no warning about exceeding the limit.

- 5.2.7 The renumber file described previously in section 3.4.1 is used to convert TMfS14 matrices into the SRTM zone system, and external references are supplied by a definition consistent with the subarea cordon, which relates the subarea working matrix (offset by 100 such that MW[10] relates to 1) to an external SRTM zone. The file is contained in the following location:

```
{CATALOG_DIR}\TMFS_DATA\{TMFS_YEAR}\{TMFS_RUNID}\{TMFS_GROWTH}\PT\PT_Subarea_Zone_List.CSV
```

- 5.2.8 As noted in the road subarea description, TMfS14 only considers three distinct person-based user classes (employer’s business, commute, and other) and so the ‘other’ user class need to be expanded out to the SRTM definitions of ‘other’³, education, and retired as defined by a proportion file which contains the proportional splits of each expanded user class as a component of the TMfS definition of ‘other’, and defined uniquely by time period.

5.3 Methodology

- 5.3.1 The PT subarea undertakes a TMfS14 consistent assignment for three time periods during which a select link procedure generates matrices of passenger travel across sets of links as a proxy for a subarea matrix.
- 5.3.2 These matrices are then converted to the SRTM zone system using the standard conversion file before transferring the select links to SRTM external zone locations, thus creating complete matrices in the SRTM zone system.
- 5.3.3 Although in a consistent geographic format, the user class definitions between the two models are different and so a conversion process takes place to disaggregate the TMfS14 defined ‘other’ trips into SRTM definitions of ‘other, education, and retired. These are driven by proportions prepared specifically for each time period and derived from the SHS.
- 5.3.4 Time period definitions are not entirely consistent between models, but it is simply assumed that the IP matrices from TMfS14 are applicable for both LT and SR time periods in SRTM, and there are no external trips in the OP for PT. The latter assumption is not robust, but has no impact on the running of the SRTM demand model which does not undertake an OP assignment, however should be remembered should any analysis be undertaken on externals when this may become more important.
- 5.3.5 The final step of processing produces a file reporting proportions of trip ends which are external by SRTM zone, separately for productions and attractions for use in the final trip ends step.

³ The definitions of ‘other’ in TMfS14 and SRTM are not consistent and are both considered as catch-all user classes for trips which are not specifically referenced in the defined user classes.

5.4 Outputs

- 5.4.1 The outputs of this stage are a set of time period specific assignment matrices considering five user classes consistent with the SRTM public transport assignment model. The travel demand contained in these matrices is restricted to those trips which enter or leave the external area of the model.
- 5.4.2 In addition, a set of 24 origins and destinations for both the total and external modelled areas are reported to allow adjustment to the initial trip ends to reduce them to internal trip ends only.

6. PARK AND RIDE EXTERNAL TRIPS

6.1 Overview

6.1.1 In addition to road and public transport external trips there is a need to ensure that both legs of a park and ride trip are included for trips external to the SRTM modelled area.

6.1.2 The image below illustrates park and ride trips, considering an external trip that makes use of a park and ride site within the SRTM area.

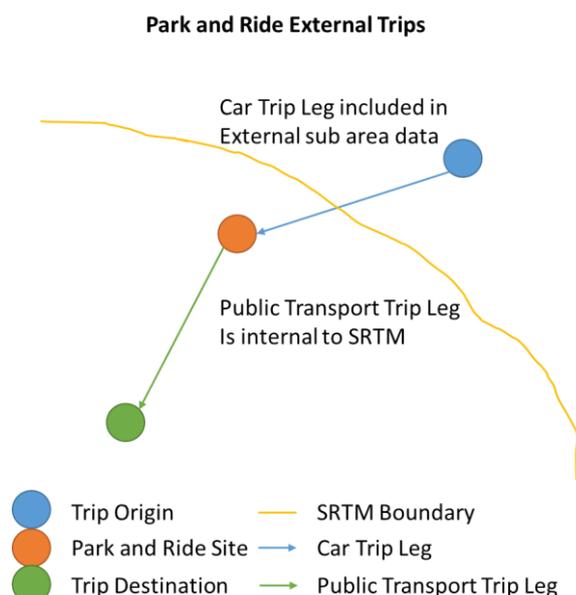


Figure 7. Park and Ride External Trips

6.1.3 The car trip leg will have already been included within the sub area definition as this is based on the assignment model.

6.1.4 The issue is that the public transport leg of the trip is internal to the SRTM area and will be required to be included within the SRTM add-ins to ensure a robust representation of public transport usage.

6.1.5 Furthermore, the park and ride site usage by trip originating external to the model is identified, enabling this to be fixed for the base year. This data is subtracted from the park and ride usage in the park and ride calibration targets to ensure that the SRTM model is targeted at trips that are entirely within the SRTM area.

6.1.6 It should be noted that the process used also take into accounts park and ride trips in the opposite direction, i.e. those trips that drive to a park and ride site within the SRTM and use public transport to reach an external destination.

6.2 Inputs

6.2.1 The inputs to the process is the TMfS park and ride site matrix, file name Proportions.MAT for each purpose and the site file with site specific information, e.g. PnRSites_{Run ID }.csv.

6.2.2 This is conventionally saved in the temporary folder and deleted at the end of a model run. We have requested a change in the script to save this file to the following location in the catalog directory, with our process setup based on this change:

```
"\RUNS\{Model Year}\{Run ID}\OUTPUT\{Growth}\PNR\HW_PnR_Demand.MAT"
```

6.2.3 This file is a matrix file of origin destination park and ride trips, with the matrix number being equivalent to the park and ride site identifier.

6.3 Methodology

6.3.1 The initial stage identifies park and ride sites within the STRM area. This identification makes it possible to separate the demand from the PnR demand matrices for only the relevant sites.

6.3.2 The next step is to expand these matrices to the SRTM zoning system resulting in a origin to destination matrix by site.

6.3.3 The car and public trans[port movements are then calculated using the same methodology as the TMfS model.

6.4 Outputs

6.4.1 The process outputs the following:

- Road trip matrices for internal to external park and ride trips where the road leg is entirely within the SRTM area;
- Public Transport trip matrices for external to internal park and ride trips where the PT leg is entirely within the SRTM area; and
- A site usage report for park and ride trips at each site, for trips that have an external trip end.

6.4.2 These output matrices are then factored to time period matrices and incorporated within the add-in matrices at the assignment preparation stage of the SRTM.

7. SPECIAL ZONES

7.1 Overview

7.1.1 There are some activities within the SRTM coverage area where the travel patterns cannot be easily replicated using standard mode and destination choice procedures as the choices made are significantly different to the rest of the modelled area, and so these are handled instead by the trip end model and passed through to the demand model as add-in matrices.

7.1.2 These trip distributions are not impacted by changes in the demand model and focus on modelling airport passenger trips at Glasgow Airport. Note that employees working at the airport are represented within the standard commuter demand model.

7.2 Inputs

7.2.1 The inputs for the special Glasgow Airport zone model are base year assignment-level trip matrices.

7.2.2 These have been defined separately for Glasgow airport. The derivation of the airport matrices are discussed within the Airport Model report.

7.2.3 These trip matrices are in origin-destination format by time period and only have trips for the rows and columns of zone 1249, representing Glasgow Airport. Note that zones 1250 to 1254 are spare zones available for other special or bespoke modelling.

7.2.4 A single growth factor is applied for the airport zone by user class for special zones if required.

7.2.5 These growth factors reside in the following file: {CATALOG DIR}\Params\Special_Zones\Special_Zone_Growth.DBF

7.2.6 The model user is required to determine these growth factors.

7.3 Outputs

7.3.1 The outputs of the special airport zone component are identical in structure to the inputs, containing peak hour assignment trips by time period for all modes for the airport zone, described in vehicles and public transport passengers where appropriate.

8. GOODS MATRICES

8.1 Overview

- 8.1.1 Goods vehicle travel behaves markedly different from personal travel, and is therefore handled within the trip end model (rather than the demand model) by generating fixed matrices of light goods and heavy goods vehicle trips for each modelled year.
- 8.1.2 The role of the goods matrix component of the trip end model is to factor a base year trip demand to an appropriate forecast year demand.
- 8.1.3 The base year goods vehicle demand is supplied as an input. The derivation of the goods vehicle matrices are documented within the mobile phone data analysis note and road model development report.
- 8.1.4 The remainder of this chapter discusses the calculation of the forecast year goods vehicle matrices, assuming the base year matrices as an input.

8.2 Inputs

- 8.2.1 The goods vehicle model is provided with the following inputs:
- base year lights and heavy goods vehicle matrices by time period from the calibrated road assignment model;
 - base year commodity matrices from TELMoS at the TMfS zoning system; and
 - future year commodity matrices from TELMoS at the TMfS zoning system.
- 8.2.2 These inputs are used to calculate growth rates using the approach described below.

8.3 Methodology

- 8.3.1 The goods vehicle forecasting application undertakes the following processes:
- Output Base Year light and heavy goods vehicle demands for internal movements to origin / destination trip ends;
 - Growth base year trip ends using TELMoS LGV and HGV commodity matrices; and
 - Furness using the base year goods demand distributions.
- 8.3.2 The resulting matrices represent the goods vehicle matrices for internal movements for each future year scenario. The level of forecast year goods trip making is therefore dependent on the future growth in goods forecast by TELMoS for each modelled zone, set against the calibrated SRTM goods vehicle travel demand distributions.
- 8.3.3 These internal goods demands are then combined with the external goods matrices as calculated through the subarea process described in Section 4.
- 8.3.4 These matrices are produced at the SRTM base year zoning system. A renumber stage is used to enable the user to expand these to an updated zoning system if required, with the user providing expansion factors. The default expansion factors were calculated from the proportion of jobs numbers sourced from the 2011 census.

8.4 Outputs

- 8.4.1 The outputs are SRTM zoned trip matrices for the appropriate forecast year for light and heavy goods vehicle matrices by hourly time period.

9. ADD-IN MATRICES

9.1 Overview

9.1.1 To ensure all outputs are in a consistent format for the demand model and to reduce the overall number of files passed across, the special zone, goods vehicle and external trips are combined into a set of add-in matrices.

9.2 Inputs

9.2.1 The inputs for this stage are the external road, Public Transport trip matrices, park and ride external trips, special zone matrices and goods vehicle trips as described in Chapters 4, 5, 6, 7 and 8.

9.3 Outputs

9.3.1 The outputs are the add-in matrices which contain complete trip matrices for all trips handled by the trip end model by user class, time period and mode.

9.4 Approach

9.4.1 This element of the model is a simple aggregation of inputs into a consistent format, with no further calculation involved.

10. FINAL TRIP ENDS

10.1 Overview

10.1.1 The outputs from the initial trip end model consider all trips to all locations, and in order to restrict the rad and PT trips to the internal demand modelled area, assumptions are used to remove the external movements from the 24 hour trip ends.

10.2 Inputs

10.2.1 The inputs for this stage come predominately from the previous elements of the model, and include:

- Initial trip ends as discussed in Chapter 3;
- Road subarea external trip end proportions as discussed in Chapter 4; and
- PT subarea external trip end proportions as discussed in Chapter 5.

10.2.2 In addition, a mode share by demand segment is read in from the parameters to be used in the processing of external trips from TMfS14.

10.3 Outputs

10.3.1 The main final trip ends consist of two tables which document 24 hour internal productions and attractions⁴ for all modes. These tables are disaggregated by the same demand segments as the demand model (see Table 2).

10.3.2 Further outputs consist of a table of zonal changes from the base year in housing, productions, employment and attractions and shapefiles with productions and attractions in their attribute data for each local authority in the SRTM model area.

10.4 Methodology

10.4.1 The proportion of external trips by mode and user class can be taken from the subarea assignments of TMfS14 networks and it is assumed that this approach correctly evaluates the *proportions* of external trips although it is recognised that the magnitudes will be inconsistent with SRTM's approach to trip end modelling.

10.4.2 It is therefore considered reasonable to remove these proportions of trips by mode from the 24 hour level trip ends, noting that TMfS14 does not cover active assignment and it is assumed that the external proportions of active trips are negligible, which in the majority of cases should prove appropriate but on the boundary of the model may result in a slight overestimation of trips.

$$PINT_{UC,CAV} = PTOT_{UC,CAV} * \left[\begin{array}{c} 1 - (MS_{Rd|UC,CAV} * EXT_{Rd|UC,CAV}) \\ -(MS_{PT|UC,CAV} * EXT_{PT|UC,CAV}) \end{array} \right]$$

Where:

$PINT_{UC,CAV}$ are the internal productions for user class UC and car availability segment CAV ;

⁴ Or in the case of one-way trips origin and destination.

$PTOT_{UC,CAV}$ are the total productions for user class UC and car availability segment CAV ;

$MS_{Rd|UC,CAV}$ is the road mode share for user class UC and car availability segment CAV ;

$MS_{PT|UC,CAV}$ is the PT mode share for user class UC and car availability segment CAV ;

$EXT_{Rd|UC,CAV}$ is the proportion of road trips which are external for user class UC ;

and
 $EXT_{PT|UC,CAV}$ is the proportion of PT trips which are external for user class UC .

10.4.3 The attractions are established in an identical manner, however, are rationalised afterwards to ensure that the total attractions in the internal model area match the total productions.

10.4.4 It is noted that non-home-based trips are not adjusted as part of this process as they are assumed to be of shorter distance and hence are more likely to remain in the modelled area, and it is also highlighted that the overall number of people entering and leaving the internal area will remain at approximately the same level and therefore the trip rates for non-home-based trips are still valid.

11. STRATHCLYDE INTEGRATED TRANSPORT/LAND-USE MODEL INTERFACE

11.1 Overview

11.1.1 An additional process of the SRTM trip end model is a tool to create outputs for the Strathclyde Integrated Transport/Land-Use Model (SITLUM) developed by SPT and TRL.

11.1.2 The outputs from this model that SITLUM requires, are the road and public transport travel cost matrices for trips external to the Glasgow City Deal area from the TMfS assignment models in its zoning system.

11.1.3 These costs are converted to the SITLUM zoning system by a renumbering and cell weighting process.

11.1.4 The requirements for the road costs as obtained from the TMfS model are journey times and distances.

11.1.5 The requirements for public transport costs are:

- Rail fare, journey time and wait time cost skims for trips with a requirement that the journey path must make use of rail modes on its path; and
- Bus fare, journey time and wait time cost skims for trips with a requirement that the journey path must use bus modes.

11.2 Inputs

11.2.1 The road assignment costs are taken from the external processes as discussed in Chapter 4 of this report.

11.2.2 The public transport inputs come predominantly from the relevant TMfS14 public transport assignment and the highway costs from the TMfS14 assignment. The public transport files include:

- Final PT network;
- Lines files;
- System file;
- Non Transit (NT) Legs File;
- Fares file, and
- Demand Matrix.

11.2.3 The factors files required as part of the public assignment stage was altered in order to establish a separate route enumeration and public transport assignment for the “rail biased” and “bus-biased” assignment.

11.2.4 As part of the interface, a zonal lookup file was established in order to convert the outputs of the TMfS14 processes to the desired SITLUM zones.

11.3 Outputs

11.3.1 The outputs for the PT costs aggregation consisted of two files for the 2 different bias types, each with a total of 36 CUBE format cost matrices (also made available in CSV format). The disaggregation of the 36 matrices is as follows:

- 3 time periods x 3 assignment user class combinations x 4 cost matrices (Composite Costs, Fares, Journey Time & Wait Time).

11.3.2 Further, the road outputs taken from skims (journey time & distance) were presented in one file in a CSV format consisting of 18 matrices (18 = 3 time periods x 3 user classes x 2 cost matrices).

11.4 Methodology

11.4.1 The PT costs were obtained using two separate enumeration and public transport assignments. The assignments stage was identical to the TMfS14 process with the exception of a change in the skimming to obtain the required travel costs and an update to the factor files to “bias” the assignment.

11.4.2 The rail-biased assignment used the flag “MUSTUSEMODE” parameter to ensure that rail-based modes are used in the evaluated routes (i.e. must use either rail or subway).

11.4.3 The bus-biased assignment used the “DONOTUSE” parameter to ensure that the evaluated routes do not use rail modes (i.e. do not use rail or subway).

11.4.4 For both the public transport and road matrices, the costs were firstly aggregated using a renumbering process in CUBE voyager (aggregating based on a zonal lookup). The totals were then divided by the number of zones in each, in order to establish an average value.

12. OPERATION OF THE TRIP END MODEL

12.1 Overview

12.1.1 The trip end model has a large number of inputs and parameters required to create a model run. A detailed list of all files required for a model scenario as well as their purpose and potential source is provided in the following section.

12.2 Catalog Keys

12.2.1 A model run is defined not only by the input data which comes from TELMoS and TMfS14, but also by a series of catalog keys, defined below in Table 12.

Table 12. Catalog Key Description

KEY	DESCRIPTION	TYPE	DEFAULT VALUE
Zones	Number of zones in the SRTM model	Integer	1,299
Externals	List of external zones in the SRTM model	Char	1,255-1,299
Model Year	Year of the test scenario	Int	14
Base year	Which year should be used as base for comparison in the final trip ends	Int	
Demand Scenario		Char	A1
Base_demand_scenario	Which scenario should be used as the base for comparison in the final trip ends	Char	
Planning_Data	2 letter scenario code for the planning data as supplied by TELMoS	Char	00
SRTM_Zone	Number of internal zones	Int	1233
TMfS_RunID	Describes the supply scenario of the TMfS14 run used for externals	Char	BN14
TMfS_Growth	Describes the demand growth scenario of the TMfS14 run used for externals	Char	BMU
TMfS_Year	Details the model year of the TMfS14 run used for externals	Int	14
TMfS_DLoop	Defines the number of demand loops of the TMfS14 run used for externals	Int	1
TMfS_Zones	Number of zones in the TMfS14 and TELMoS models	Int	799
Include SITLUM	Whether to run SITLUM application or not	Char	
SITLUM_zones	Number of SITLUM zones	Int	

12.2.2 It is recommended that users create a new scenario each time they wish to run a new trip end model test and specify the keys from scratch. Although they all have a default value each key should be considered individually to ensure it is consistent with the test.

12.2.3 The majority of keys here are used to provide references to inputs from either TELMoS or TMfS14 so their values will be dictated by the file names from previous runs. Users should not change the file names to be consistent with a catalog key, they should always change the catalog key to match the filename, both because it is typically quicker, but also because it retains an audit trail in the model run, linking back to the original external data.

12.3 Parameters

12.3.1 There are a number of parameter files contained in the ‘Params’ folder in the base year directory, and although it is highly unlikely these will need to be updated during a normal run of the model there may be specific circumstances which they could be altered. If this is the case the model should be clearly marked as having inconsistent parameters and ideally removed from the regular location to avoid test parameters being used in error.

12.3.2 A full list of parameters is provided below with a summary description.

Table 13. List of Parameters

PARAMETER FILE	DESCRIPTION
Split Road Other factors.MAT	Defines the proportional split from the TMfS14 ‘other’ category to the three user classes (‘other’, education, and retired) in SRTM for the road model subarea. Initially derived from SHS.
	Example polygon covering the SRTM area which can be used to extract a TMfS14 road subarea network.
CarUserToCarDriver.PRM	Converts vehicles to persons consistent with the SRTM approach. File should be a copy of the SRTM parameter file.
CDCU Growth.DBF	Indices of growth from a 2012 base year for CDCU factors taken from occupancy growth rates as defined in WebTAG (March 2016)
PeriodToHour.PRM	Converts peak hour trips to full period level trips consistent with the SRTM approach. File should be a copy of the SRTM parameter file.
Road Subarea Parameters.txt	File which contains the convergence variables for the road subarea assignment, initially taken from TMfS14 and should remain consistent.
Road Subarea SF Curves.txt	File which contains the speed/flow curves for the road subarea assignment, initially taken from TMfS14 and should remain consistent.
Tolling Model V1.DBF	File which contains the tolling model parameters for the road subarea assignment, initially taken from TMfS14 and should remain consistent.
HGV Speeds V1.DBF	File which contains the HGV speed definitions for the road subarea assignment, initially taken from TMfS14 and should remain consistent.

PARAMETER FILE	DESCRIPTION
GenCostTable V4.DBF	File which contains the generalised cost parameters for the road subarea assignment, initially taken from TMfS14 and should remain consistent.
Mode splits.DBF	Base year mode splits (road, PT, and active) for each 'simple' demand segment (10 in total) used to establish the weight of the road and PT subarea on the final trip ends. Taken from SHS and CTTW.
Trip rates.DBF	Production trip rates by area type, user class, and person type. Based on NTEM data.
Week-to-day_factor.DBF	Converts weekly trip rates into daily.
Car Availability Likelihoods.DBF	Car availability proportions disaggregated by SRTM zone, user class, and household car ownership. Based on NTEM data.
Simple Production Proportions.DBF	User class and SRTM zone specific proportions of productions which are classified as 'simple'. Prepared from analysis of the SHS data.
Attraction Rates.DBF	Attraction rates by purpose, and attraction variable (number of household or jobs in category). Based on NTEM data.
OD rates NR.DBF	Return purpose proportions by outbound and inbound purpose (non-retired persons only). Prepared from analysis of the SHS data.
OD rates Ret.DBF	Return purpose proportions by outbound and inbound purpose (retired persons only). Prepared from analysis of the SHS data.
NHB rates NR.DBF	Rates of NHB trips by outbound purpose (non-retired persons only). Prepared from analysis of the SHS data.
NHB rates Ret.DBF	Rates of NHB trips by outbound purpose (retired persons only). Prepared from analysis of the SHS data.
Employment Activities.DBF	Table that assigns each of 92 TELMoS employment activities to one of 13 categories.
Airport_Productions.csv	Base year productions for the airport zones
Airport_Attractions.csv	Base year attractions for the airport zones
Airport_Growth.DBF	Annual growth factors for airport zones productions and attractions
PT Crowding.txt	Crowding model code which should be consistent with TMfS14.
PT VOT Table 2.DBF	File which contains the generalised cost parameters for the PT subarea assignment, initially taken from TMfS14 and should remain consistent.
Split PT Other Factors.MAT	Defines the proportional split from the TMfS14 'other' category to the three user classes ('other', education, and retired) in SRTM for the PT model subarea. Initially derived from SHS.
Special Zone Growth.DBF	Annual growth indices for each special zone. Taken from airport masterplans for airport zones and average goods vehicle growth from TEMLoS for goods vehicles
AM Base Special Zones.MAT	AM assignment level special zone travel matrices containing all modes and user classes

PARAMETER FILE	DESCRIPTION
	(including goods). Should be consistent with calibrated base year assignment matrices and only contain trips to/from special zones.
LT Base Special Zones.MAT	LT assignment level special zone travel matrices containing all modes and user classes (including goods). Should be consistent with calibrated base year assignment matrices and only contain trips to/from special zones.
SR Base Special Zones.MAT	SR assignment level special zone travel matrices containing all modes and user classes (including goods). Should be consistent with calibrated base year assignment matrices and only contain trips to/from special zones.
PM Base Special Zones.MAT	PM assignment level special zone travel matrices containing all modes and user classes (including goods). Should be consistent with calibrated base year assignment matrices and only contain trips to/from special zones.
OP Base Special Zones.MAT	OP assignment level special zone travel matrices containing all modes and user classes (including goods). Should be consistent with calibrated base year assignment matrices and only contain trips to/from special zones.
LA_numbers.csv	Assigns zones to local authorities for the output shapefiles.

12.4 Input Files: Planning Data

12.4.1 Planning data should be available from the TELMoS land use model, and this should be placed in a standard directory,

{CATALOG_DIR}\Planning_data\{Year}\{Planning_data}

12.4.2 TELMoS provides three initial files:

- TMfS{Year}{Planning_Data}.csv, containing detailed household data for productions;
- AVZN{Year}{Planning_Data}.dat, containing employment and generic household data used to derive attractions; and
- TRFL_{Year}{Planning_Data}.csv, containing commodity movements used to estimate good matrices.

12.4.3 Along with these TEMoS inputs, three files which relate solely to SRTM must be in place, which typically will be copied from an SRTM reference case scenario:

- Zone_conversion.CSV, which is a mapping to convert TMfS14 zones to the SRTM zone system documenting the proportional split of each zonal shift for productions and attractions, with all values given as percentages summing to 100;
- Student_proportions.CSV, which details the proportional split of unemployed and part-time workers which are students on a SRTM zonal basis (these proportions are based on Scottish 2011 Census data); and
- Area_types.CSV, which defines the area type of each SRTM zone to establish an appropriate set of production trip rates to apply.

12.4.4 It is highlighted that to ensure availability for future runs, some outputs from the trip end model are created in this directory, but they do not need to be created at the beginning of a run.

12.5 Input Files: TMfS Data

12.5.1 In order to generate external movements, assignment data from a model run of TMfS14 is used, contained in a test specific directory:

```
{CATALOG_DIR}\TMFS_data\{TMFS_year}\{TMFS_RunId}
```

12.5.2 This contains a number of sub-directories for input data, road assignment outputs, PT assignment outputs, and park and ride data.

Input Directory

12.5.3 The entire input directory from the relevant TMfS14 run should be copied directly to:

```
{CATALOG_DIR}\TMFS_data\{TMFS_year}\{TMFS_RunId}\Input
```

12.5.4 All files should retain their original filenames.

Road Assignment Inputs

12.5.5 The road assignment demand matrices should be transferred from a pre-existing TMfS14 run and stored in the location:

```
{CATALOG_DIR}\TMFS_data\{TMFS_year}\{TMFS_RunId}\{TMFS_Growth}\Road
```

12.5.6 There should be three assignment matrices which should have their names unaltered:

- HYAM_{TMFS_RunId}{TMFS_Growth}{TMFS_Year}{TMFS_DLoop}.HWM;
- HYIP_{TMFS_RunId}{TMFS_Growth}{TMFS_Year}{TMFS_DLoop}.HWM; and
- HYPM_{TMFS_RunId}{TMFS_Growth}{TMFS_Year}{TMFS_DLoop}.HWM.

12.5.7 In addition to these files, the user should create a subarea network based on the original assignment network and place it in the same location with the filename {TMFS_RunId}{TMFS_Year}_SubArea.NET. This subarea network can be easily generated from the initial road network using the general polygon file contained in the Params folder: {CATALOG DIR}\Params\Road_Subarea\Cordon.SHP

12.5.8 To avoid the requirement of running the road subarea in every single scenario, the four output files from the road subarea process will be created in this folder – they are not considered as inputs and do not need to be sourced to undertake a model run.

PT Assignment Inputs

12.5.9 The PT assignment demand matrices should be transferred from a pre-existing TMfS14 run and stored in the location:

```
{CATALOG_DIR}\TMFS_data\{TMFS_year}\{TMFS_RunId}\{TMFS_Growth}\PT
```

12.5.10 There should be three assignment matrices which should have their names unaltered:

- PTAM_{TMFS_RunId}{TMFS_Growth}{TMFS_Year}{TMFS_DLoop}.PTM;
- PTIP_{TMFS_RunId}{TMFS_Growth}{TMFS_Year}{TMFS_DLoop}.PTM; and
- PTPM_{TMFS_RunId}{TMFS_Growth}{TMFS_Year}{TMFS_DLoop}.PTM.

12.5.11 In addition to these files available from a TMfS14 run, the user must define the PT cordon using two files:

- PT_SUBAREA_CORDON.txt, which contains a series of select links at each crossing point of the subarea; and
- PT_Subarea_Zone_List.CSV, which references each select link to an SRTM external zone.

12.5.12 An example of the subarea cordon file is shown below:

```
;Set these cordons from 101 onwards sequentially
MW[101] = SELECTLINK(L=6340-6379, 6207-6275) ; South East Inbound
MW[102] = SELECTLINK(L=6379-6340, 6275-6207) ; South East Outbound
MW[103] = SELECTLINK(L=6306-6220, 7211-7210, 7179-7220) ; South West Inbound
MW[104] = SELECTLINK(L=6220-6306, 7210-7211, 7220-7179) ; South West Outbound
```

12.5.13 In this example, only two cordons are used which are defined in both directions using separate lines of code and can span multiple links. The matrix numbering system must begin at 101 and proceed sequentially (101, 102, 103,...etc.). There is a formal limit of 50 select links which can be considered, equivalent to 25 zones in both directions.

12.5.14 For the subarea zone list the file should contain two columns with a first line of headers called Cordon and SRTM and must contain data for cordons 1 to 50 regardless of whether they exist or not. These columns should reference the cordon number (the MW code above minus 100), and the SRTM zone. Should not all cordons be required, simply use a dummy zone as zero trips will be associated with the non-existent cordon. An example is given below for the first set of five records with arbitrary zones.

```
Cordon,SRTM
1,12
2,24
3,36
4,48
5,60
```

12.5.15 To avoid the requirement of running the road subarea in every single scenario, the four output files from the road subarea process will be created in this folder – they are not considered as inputs and do not need to be sourced to undertake a model run.

Park and Ride Outputs

12.5.16 The Park and Ride From Home demand matrices for each purpose should be taken from a pre-existing TMfS14 run and stored in the location:

```
{CATALOG_DIR}\Program\PnR\Updated_PnR\HW\Temp\Proportions.MAT
{CATALOG_DIR}\Program\PnR\Updated_PnR\HE\Temp\Proportions.MAT
{CATALOG_DIR}\Program\PnR\Updated_PnR\HO\Temp\Proportions.MAT
```

12.5.17 There should be three assignment matrices which should have their names unaltered.

12.6 Module Selection

12.6.1 It is not expected that every aspect of the trip end model needs to be run for every single forecast year scenario update. The key components which affect the SRTM demand model trip ends are mainly associated with new planning data covering the SRTM area. Externals will likely pivot off an underlying TMfS14/TELMoS reference case, and, depending on the specific study area, will generally have less impact on the overall modelling.

12.6.2 To gauge whether or not externals should be recalculated, the following questions should be considered:

- Does a TMfS14 forecast run already exist which could be used as an appropriate Reference Case?
- Is the forecast planning data included within TMfS14 representative of the forecast data included within the main demand model area of SRTM?
- Are there future transport schemes / policies included within TMfS14 that would impact the external flows into SRTM, particularly close to the model boundary?
- Is a new set of demand available from TMfS14 which would provide a better estimate of trips for the SRTM test being considered?
- Has the mapping from the TMfS14/TELMoS zone system to the SRTM zone system or network cordon links changed from an existing run?

12.6.3 In addition, is the projected growth at Glasgow airport represented within the forecast year growth factors?

12.6.4 If a relevant and reasonably consistent set of external trips already exists then there is no strict requirement to run these aspects of the trip end model again and they can be bypassed to solely estimate internal trips. However, if there are significant changes between scenarios, which may impact the specific study area or scheme/policy test, then an updated TMfS14 run should be considered.

SYSTRA provides advice on transport, to central, regional and local government, agencies, developers, operators and financiers.

A diverse group of results-oriented people, we are part of a strong team of professionals worldwide. Through client business planning, customer research and strategy development we create solutions that work for real people in the real world.

For more information visit www.systra.co.uk

Abu Dhabi

AS Business Centre, First Floor, Suites 201-213,
Al Ain Road, Umm al Nar, P.O. Box 129865,
Abu Dhabi, UAE
T: +971 2 558 3809 F: +971 2 558 9961

Birmingham

Second Floor, 37a Waterloo Street
Birmingham B2 5TJ United Kingdom
T: +44 (0)121 233 7680 F: +44 (0)121 233 7681

Dublin

1st Floor, 12/13 Exchange Place,
Custom House Docks, IFSC, Dublin 1 Ireland
T: +353 (0)1 542 6000 F: +353 (0)1 542 6001

Edinburgh

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

Glasgow

Seventh Floor, 78 St Vincent Street
Glasgow G2 5UB United Kingdom
T: +44 (0)141 225 4400

Lille

86 Boulevard Carnot, 59000 Lille, France
T: +33 (0)3 74 07 00 F: +33 (0)1 53 17 36 01

London

Seventh Floor, 15 Old Bailey
London EC4M 7EF United Kingdom
T: +44 (0)20 7529 6500 F: +44 (0)20 3427 6274

Lyon

11, rue de la République, 69001 Lyon, France
T: +33 (0)4 72 10 29 29 F: +33 (0)4 72 10 29 28

Manchester

25th Floor, City Tower, Piccadilly Plaza
Manchester M1 4BT United Kingdom
T: +44 (0)161 236 0282 F: +44 (0)161 236 0095

Marseille

76, rue de la République, 13002 Marseille, France
T: +33 (0)4 91 37 35 15 F: +33 (0)4 91 91 90 14

Newcastle

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

Paris

72 rue Henry Farman, 75015 Paris, France
T: +33 (0)1 53 17 36 00 F: +33 (0)1 53 17 36 01

Woking

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

Hong Kong

14th Floor West, Warwick House, TaiKoo Place,
979 King's Road, Island East, Hong Kong
T: +852 2529 7037 F: +852 2527 8490

Shenzhen

Room 905, Excellence Mansion, No.98, No.1 Fuhua Road,
Futian Central Zone, Shenzhen, PRC, Post Code : 518048
T : +86 755 3336 1898 F : +86 755 3336 2060

Shenzhen - Beijing Branch Office

Room 1503, Block C, He Qiao Mansion, No. 8 Guanghua Road,
Chaoyang District, Beijing, PRC, Post Code : 100026
T : +86 10 8557 0116 F : +86 10 8557 0126

Beijing Joint Venture

Room 1507, Main Building, No. 60, Nan Li Shi Road,
Xi Cheng District, Beijing, PRC, Post Code : 100045
T : +86 10 8807 3718 F : +86 10 6804 3744

Mumbai

Antriksh, Unit no. 301, 3rd Floor, CTS Nos.
773, 773/1 to 7, Makwana Road, Marol, Andheri East ,
Mumbai 400069
T: +91 22 2647 3134
B 307, Great Eastern Summit Sector - 15, CBD Belapur Navi
Mumbai - 400 614
T: +91 22 2757 2745

New Delhi

5th Floor Guru Angad Bhawan, 71 Nehru Place, New Delhi
110019
T: +91 11 2641 3310

Noida

3/F, C-131, Sector 2, Noida-201301, U.P.
T: +91 120 432 6999

Singapore

25 Seah Street #04-01 Singapore 188381
T : +65 6227 3252 F : +65 6423 0178

Thailand

37th Floor, Unit F, Payatai Plaza Building, 128/404-405 Payathai
Road, Rajthwee, Bangkok 10400, Thailand
T : +662 216 6652 F : +662 216 6651

Vietnam

5/F Perfect Building, Le Thi Hong Gam St, District 1,
Ho Chi Minh City, Vietnam
T : +84 8 3821 7183 F : +84 8 3821 6967

SYSTRA