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TN013 - Derivation of Annualisation Factors (Car Driver + PT)

Client name	Project name	Date	Project number
Transport Scotland	LATIS Lot 1 – Modelling Support	07 October 2020	60531876

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Revision History

Revision	Revision date	Details	Authorised	Name	Position
V1.1	08 May 2018	Car Driver + PT Factors Only to Regional Model Sectors	KL	Kevin Lumsden	Director of Transport Modelling
v2.1	07 October 2020	Inclusion of Average Weekday Factors	AB	Andrew Bagnall	Senior Associate
V2.2	09 November 2020	Inclusion of caveats anticipating non LATIS application	RJC	Richard Cann	Regional Director

Introduction

Overview

In late 2017, Transport Scotland requested that AECOM/PBA produce a consistent set of national annualisation factors. These factors have been generated using data from the Scottish Household Survey (SHS) Travel Diary for the years; 2009-2010 and 2012-2016.

It is intended that these new derived annualisation factors will replace those last produced (also using SHS travel diary data) during 2009. The factors are predominantly used to convert Transport Model for Scotland (TMfS) model outputs from representations of hourly assignment flows (or cost) to annual figures.

While these factors provide a consistent approach to generating annual figures at a national level, it should be noted that there is variation in these factors over time and at the more local levels (e.g. by road, rail service, bus service etc.) which is not accounted for in this analysis.

Factors are provided for Car Driver and Public Transport (Bus+Rail) modes at national level and also for each of six sectors where each sector is broadly representative a LATIS Regional Transport Model including:

- MFTM: The Moray Firth Regional Transport Model;
- ASAM: Aberdeen Sub Area Model;
- TCRTM: Tay Cities Regional Transport Model;
- SRM: SEStran Regional Model;
- SRTM: Strathclyde Regional Transport Model; and
- CSTM12: Central Scotland Transport Model.

It should be noted throughout that sample sizes are relatively small for public transport in the less populous areas, and professional judgement should be used in the application of corresponding annualisation factors. **It is acknowledged that these factors may be utilised for applications outside the use of LATIS models, particularly in the case of annualising public transport flows, where data is typically limited. Before applying these factors a review should be undertaken using the current guidance to demonstrate that the methodology adopted is appropriate.**

This Technical Note describes the approach taken in preparing annualisation factors and then presents the factors themselves. An accompanying spreadsheet containing analysis and resultant annualisation factors is also available. Average weekday factors, derived from the same SHS datasets, are also presented.

Scottish Household Survey

The Scottish Household Survey (SHS) is a continuous survey of Scottish residents living in private homes across Scotland. The survey collects data on the characteristics, attitudes and behaviours of Scottish households, and includes a Travel Diary component. As part of the Travel Diary a random adult resident provides information on travel undertaken during the previous day, including the origin/destination, mode, timing and purpose of each leg of each journey undertaken. This travel diary data was used as the basis for deriving annualisation factors.

The SHS and Travel Diary followed a relatively consistent format from 1999 to 2011, after which point the sampling format and survey design were updated.

Travel diary data for the period 2012-2015 was requested from the SHS Team in late 2017, and then further data requested for the period 2009-2011 and 2016 to increase the sample size and confidence in results.

Sampling

In the present day, the SHS team annually conducts face-to-face surveys of circa 10,000 households distributed across Scotland. However, prior to 2012, sampling was designed to generate a complete sample every two years and provide outputs for larger local authorities during a single year.

The original two-year sampling rotation began in 1999, meaning that a full sample was gained for the period 2009-2010, but the following 2011-12 sample period was not completed prior to the new survey design being introduced. As such, a significant number of the records from the 2011 Travel Diary omit details of the local authority with which journeys are associated – particularly smaller local authorities. So as not to skew the sample towards larger local authorities, **the decision was taken to exclude 2011 data from the sample**.

Table 2.1 indicates the number of households covered by the survey, the number of persons who provided a Travel Diary and finally the number of journey stages recorded each year.

Table 2.1: SHS Sample Information

Year	Number of Households Surveyed[1]	Number of Travel Diary Responses[2]	Number of Journey Stages[3]
2016	10,470	7,044	19,719
2015	10,330	6,957	19,112
2014	10,630	7,291	20,513
2013	10,650	7,281	20,781
2012	10,640	7,060	20,314
2010	28,388	6,104	16,552
2009		6,804	18,934

Journey Stage

SHS Travel Diary outputs provide stage-based information on travel undertaken by an individual during the day preceding the Scottish Household Survey. A journey is considered to comprise multiple stages if it is punctuated by a change in mode (e.g. walk to train station then take train to city centre) or if it includes a series of destinations prior to completion (e.g. drive to cinema, then drive to restaurant, then drive home). In short, a journey can involve multiple stops and multiple modes, but a travel stage will use a single mode and have a single destination.

Mode of Travel

SHS Travel Diary respondents were asked what mode of travel they used to complete each journey stage. Various mode numbering systems were used across the annual datasets, and the various formats were aggregated into a consistent set of mode descriptors which could be applied across the whole dataset. For further details, see Appendix A.

Day of Travel

The Travel Diary outputs indicate the day of the week during which reported journey stages were completed. We added an additional field which aggregated these outputs into one of 3 categories:

1. Weekday;
2. Saturday; or
3. Sunday.

Hour of Travel

The Travel Diary data provides a start time and end time for each journey stage. An additional variable called ‘meantime’ was calculated as the mid-point between start and end time of each journey stage. This was assumed to be representative of the hour during which each stage was undertaken.

[1] Assumed equivalent to ‘Base’ number of households in Scotland's People Annual Report. See following tables Table 2.9 in 2016, Table 2.4 in 2015 & 2014, Table 2.5 in 2013 and 2012, and Table 2.4 in 2009/10.
[2] Each Travel Diary response is assigned a Unique ID, and so the number distinctive UniqueIDs present within the relevant year’s TD_STAGE dataset is considered equivalent to the no. of Travel Diary Responses.
[3] Similarly, the number of rows of data in each TD_STAGE dataset (=total rows -1) is considered equivalent to the number of stages recorded for that year.

Origin and Destination

Respondents were asked for details of the start and end location of each journey stage. The Travel Diary outputs received provided the Local Authority (LA) area in which the stage started and ended.

Each journey stage was allocated to a particular LA based on the end location. This means that stages allocated to one LA could have started inside or outside that LA, and may have been undertaken by residents of other LAs.

An additional field was generated called 'Model', which reflects the regional transport model(s) in which the end LA lies. Appendix B provides details of which LAs are assumed to be relevant to each regional model. The regional model extents are illustrated in Figure 2.1 below:

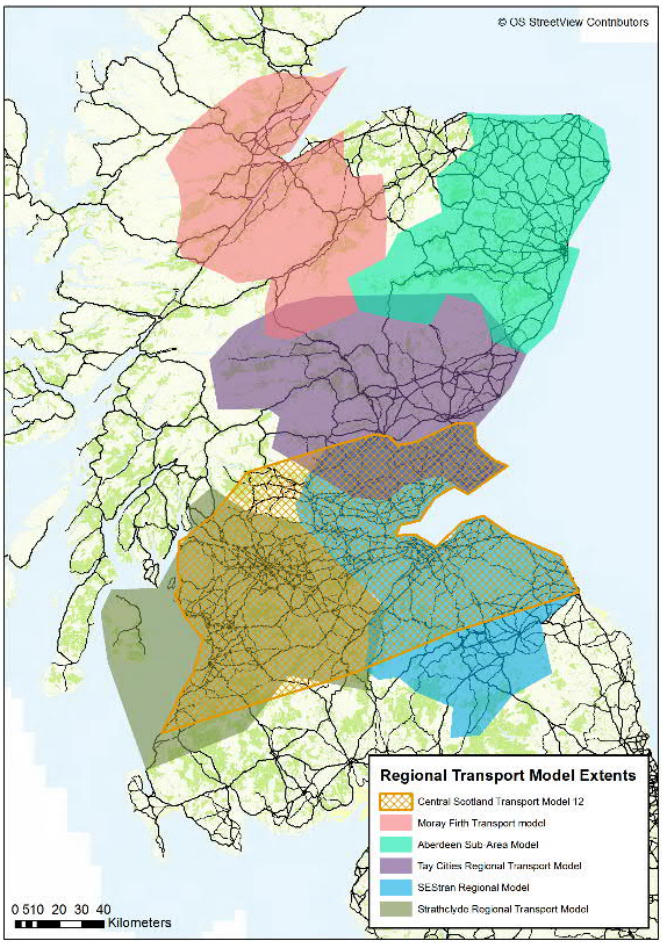


Figure 2.1: Regional Transport Model Extents

Travel Diary Weighting

The SHS Methodology and Fieldwork Outcomes 2015 report notes that weighting procedures for SHS data are required to correct unequal probabilities and response rates. Travel Diary outputs provide several alternative weighting fields, specifically including Travel Diary weight which relates to a rescaled random adult weight. The Travel Diary weight adjusts for the fact that during fieldwork a disproportionate number of surveys took place on Fridays, Saturdays and Sundays relative to other days and similarly a disproportionate number of adults in full-time employment were interviewed at the weekend.

In the annualisation data analysis, stages were weighted per the Travel Diary weight.

Data Analysis

Overview

This section sets out the approach taken to calculate annualisation factors, and then presents the annualisation factors themselves.

Representativeness of Sample and Reliability of Factors

Once SHS stages were disaggregated to reflect movements undertaken during a single hour, by a single mode and ending in a specific LA, sample sizes in many cases became quite small or zero. This meant that it was not possible to calculate annualisation factors for each mode at LA level, and other factors were based on a very small sample. The smaller the sample, the greater the likelihood of sampling error and/or a small number of non-representative observations skewing the results.

Accordingly, it is advised that caution is exercised when using annualisation factors where sample sizes are small.

While the annualisation factors presented here are all derived from the consistent source of the SHS, it is also recommended that equivalent figures for traffic are derived from the time series traffic count data stored within Traffic Scotland's National Traffic Data System (NTDS).

NDTS contains data from automatic traffic counters (ATC) that include full year data at various locations throughout the transport network. Analysing this data can provide 'actual' annualisation factors at specific locations and the data can also be averaged across a number of sites. It is anticipated that this task will be undertaken during the development of TMfS18 when such traffic count data will be processed.

Assumptions Underpinning Annualisation Factors

It was assumed that there are 365 days / 52.1 weeks per year, including nine Scottish public holidays[4]. By extension, it was assumed that each year excluding public holidays, would comprise 50.9 weeks (i.e. (365-9)/7).

Derivation of Annualisation Factors and Values

For each LA and Sector, the total number of corresponding stages (SHS 2009-10 & 2012-2016) were summed to provide a total for each hour of the day, split by mode and type of day (i.e. Weekdays, Saturdays and Sundays).

Based on the hourly stage numbers, values for the following time periods were then calculated for weekdays:

- AM Peak Period: sum of hourly values for 0700-1000;
- AM Peak Hour: hourly value for 0800-0900;
- Interpeak: sum of hourly values for 1000-1600;
- Average Interpeak Hour: average hourly value across 1000-1600;
- PM Peak Period: sum of hourly values for 1600-1900; and
- PM Peak Hour: hourly value for 1700-1800.

These time periods, for a neutral month of the year, are representative of those modelled in TMfS. Hourly values (e.g. traffic flows, passenger flows, travel costs) extracted from TMfS model runs can then be factored up to annualised figures by multiplying the TMfS value by the annualisation factor for the respective time period as follows:

Annualised Value=(AM TMfS Value*AM factor)+(IP TMfS Value*IP factor)+(PM TMfS Value*PM factor)

[4] https://beta.gov.scot/publications/bank-holidays/

Annualisation Factors

Table 3.1 presents the annualisation factors derived from SHS Travel Diary 2009-2010 and 2012-2016 data. These annualisation factors should be applied using professional judgement as to their relevance to the specific model application context and with due regard of the underlying sample size presented in **Appendix C**. In particular, it should be noted that the some of the model area factors show a greater degree of variability than others (e.g. ASAM & MFTM) reflecting the lower sample size and lower level of confidence that can be placed in the more disaggregate data. It should also be noted that the resultant annualisation factors are provided to two significant figures.

Table 3.1: Annualisation Factors by Regional Transport Model Area and Nationally

Area	AM Peak Hour to Annual		Average Interpeak Hour to Annual		PM Peak Hour to Annual	
	Car Driver	Public Transport	Car Driver	Public Transport	Car Driver	Public Transport
Aberdeen Sub-Area Model (ASAM)	620	530	3,700	2,800	620	830
Moray Firth Transport Model (MFTM)	520	530	3,200	2,500	640	830
SEStran Regional Model (SRM)	580	530	3,800	3,400	680	680
Strathclyde Regional Transport Model (SRTM)	550	560	3,900	3,000	660	630
Tay Cities Regional Transport Model (TCRTM)	600	500	3,500	2,700	690	710
Central Scotland Transport Model (CSTM12)	560	550	3,800	3,100	670	660
Scotland	**570**	**540**	**3,700**	**3,000**	**660**	**680**

It is acknowledged that these factors may be utilised for applications outside the use of the LATIS models, but within their respective geographical areas, particularly in the case of annualising public transport flows, where data is typically limited. Before applying these factors to other transport models, a review should be undertaken to ensure that they are appropriate and suitable; for example, that the modelled hours are consistent and insufficient local data is available. If required, further information on the factor derivation can be provided on request.

Average Weekday Factors

Average weekday factors were derived from the SHS hourly stage numbers, as per the annualisation factors with the exclusion of weekends. The weekday factors are representative of a single day.

Hourly values extracted from TMfS model runs can be factored up to average weekday figures by multiplying the TMfS value by the average weekday factor for the respective time period as follows:

Average Weekday Value=(AM TMfS Value*AM factor)+(IP TMfS Value*IP factor)+(PM TMfS Value*PM factor)

Table 3.2 presents the average weekday factors derived from SHS Travel Diary 2009-2010 and 2012-2016 data. As per the annualisation factors, these average weekday factors should be applied using professional judgement as to their relevance to the specific model application context and with due regard of the underlying sample size presented in **Appendix C**.

Table 3.2: Average Weekday Factors by Regional Transport Model Area and Nationally

Area	AM Peak Hour to Annual		Average Interpeak Hour to Annual		PM Peak Hour to Annual	
	Car Driver	Public Transport	Car Driver	Public Transport	Car Driver	Public Transport
Aberdeen Sub-Area Model (ASAM)	2.45	2.09	9.33	8.02	2.45	3.26
Moray Firth Transport Model (MFTM)	2.06	2.09	8.62	7.51	2.50	3.26
SEStran Regional Model (SRM)	2.27	2.08	8.84	8.33	2.66	2.67
Strathclyde Regional Transport Model (SRTM)	2.16	2.21	8.84	7.66	2.61	2.46
Tay Cities Regional Transport Model (TCRTM)	2.36	1.98	8.62	7.69	2.69	2.80
Central Scotland Transport Model (CSTM12)	2.22	2.16	8.81	7.87	2.62	2.60
Scotland	2.25	2.13	8.80	7.89	2.58	2.67

Appendix A **Mode Definitions**

Differing mode naming/numbering conventions are used within the 2009-2016 SHS Travel Diary data. Table A.1 summarises the mode naming found within each year of the data, and Table A.2 indicates the simplified mode names (consistent across datasets) allocated to each original mode category to provide a consistent basis for assessment.

Table A.1: Original Mode Definitions in SHS Data

Mode No.	2009-2010	2012-2014	2015	2016
1	Walking	Walking	Walking	Walking
2	Driver car / van	Car / Van as driver		
3	Passenger car / van	Car / Van as passenger		
4	Motorcycle / moped	Bicycle	Bicycle	Motorcycle / moped
5	Bicycle	Bus (incl. school / work and ordinary service)	Bus (incl. school / work and ordinary service)	Bicycle
6	School bus	Train / Subway	Train / Subway	School bus
7	Works bus	Other (incl. Motorcycle, moped, ferry, air, horse-riding)	Other (incl. Motorcycle, moped, ferry, air, horse-riding)	Works bus
8	Service bus	Taxi / minicab	Taxi / minicab	Service bus
9	Taxi / minicab	No answer	No answer	Taxi / minicab
10	Rail			Rail
11	Subway			Subway
12	Ferry			Ferry
13	Aeroplane			Aeroplane
14	Horse-riding			Horse-riding
15	Other			Other
16				Tram
17			Car as driver	Car as driver
18			Van as driver	Van as driver
19			Car as passenger	Car as passenger
20			Van as passenger	Van as passenger

Table A.2: Simplified Mode Category allocated to each Original Mode Category

Original Mode	Simplified Mode
Bicycle	Not Required for this analysis
Bus (incl. school/work and ordinary service)	Bus
School bus	Bus
Service bus	Bus
Works bus	Bus
Car as driver	Car Driver
Car/Van as driver	Car Driver
Driver car/van	Car Driver
Van as driver	Car Driver
Car as passenger	Car Passenger
Car/Van as passenger	Car Passenger
Passenger car/van	Car Passenger
Van as passenger	Car Passenger
No answer	No answer
Aeroplane	Not Required for this analysis
Ferry	Not Required for this analysis
Horse-riding	Not Required for this analysis
Motorcycle/moped	Not Required for this analysis
Other	Not Required for this analysis
Other (incl. Motorcycle, moped, ferry, air, horse-riding)	Not Required for this analysis
Taxi/minicab	Not Required for this analysis
Rail	Train/Subway/Tram
Train/Subway	Train/Subway/Tram
Tram	Train/Subway/Tram
Subway	Train/Subway/Tram
Walking	Not Required for this analysis

Appendix B **Model Area Definitions**

Table B.1: LAs and Corresponding Models

LA Ref	LA Name	Model(s)
100	Aberdeen City	ASAM
110	Aberdeenshire	ASAM
120	Angus	TCRTM
130	Argyll & Bute	SRTM/CSTM12
150	Clackmannanshire	CSTM12
170	Dumfries & Galloway	-
180	Dundee City	TCRTM/CSTM12
190	East Ayrshire	SRTM/CSTM12
200	East Dunbartonshire	SRTM/CSTM12
210	East Lothian	SRM/CSTM12
220	East Renfrewshire	SRTM/CSTM12
230	Edinburgh, City of	SRM/CSTM12
235	Eilean Siar	-
240	Falkirk	SRM/CSTM12
250	Fife	SRM/TCRTM/CSTM12
260	Glasgow City	SRTM/CSTM12
270	Highland	MFTM
280	Inverclyde	SRTM/CSTM12
290	Midlothian	SRM/CSTM12
300	Moray	-
310	North Ayrshire	SRTM/CSTM12
320	North Lanarkshire	SRTM/CSTM12
330	Orkney Islands	-
340	Perth & Kinross	TCRTM/CSTM12
350	Renfrewshire	SRTM/CSTM12
355	Scottish Borders	SRM/CSTM12
360	Shetland Islands	-
370	South Ayrshire	SRTM/CSTM12
380	South Lanarkshire	SRTM/CSTM12
390	Stirling	CSTM12
395	West Dunbartonshire	SRTM/CSTM12
400	West Lothian	SRM/CSTM12

Appendix C **Sample Sizes and Confidence**

As discussed in the main body of the report, the sample sizes used in the calculation of annualisation factors vary strongly by mode, time of day and area. This has associated implications for the reliability of results. Table C.1 indicates the sample size for each annualisation factor category and time period. It should be noted that there is overlap between the areas modelled in the regional models (e.g. Fife falls within SRM, TCRTM and CSTM12 areas and so Fife sample is included within each).

Table C.1: No. Stages in SHS Sample at Regional Transport Model level

Model	Weekday AM Peak Hour (0800-0859)		Weekday IP Period (1000-1559)		Weekday PM Peak Hour (1700-1759)	
	Car Driver	Bus + Rail	Car Driver	Bus + Rail	Car Driver	Bus + Rail
ASAM	567	79	1,842	333	605	53
MFTM	303	13	1,135	88	300	9
SRM	1,337	981	4,995	3,324	1,350	769
SRTM	2,034	1,798	6,716	6,645	1,879	1,433
TCRTM	716	151	3,065	596	759	98
CSTM	3,801	1,029	13,463	4,052	3,714	846
All Scotland[5]	**5,210**	**1,209**	**18,618**	**4,757**	**5,186**	**956**

[5] All Scotland sample total values include all stages from the SHS, including those where the destination is missing

Significance Levels

Consideration was also given to how much confidence could be assigned to the annualisation factors generated. Confidence or statistical significance is typically calculated based on the size of the sample in relation to total population. For example, we might be looking to compare the number of car driver stages recorded by SHS ending in Renfrewshire during the weekday AM peak hour, compared to the number which actually occurred. However, we are not aware of any data sources which can provide the level of detail required to estimate population size, and so it was not possible to calculate corresponding confidence intervals or significance levels.

Comparison with Other Data Sources

Although we were unable to calculate significance values or confidence intervals as part of our analysis, we sought to compare Travel Diary results with data from the Scottish Transport Statistics (STS) 2016 to provide some reassurance that the relative LA sample sizes were representative.

The STS provides estimates of annual rail passenger journeys by local authority and local bus passenger journeys by region, which align well with SHS results (all time periods summed together). However, STS data relating to other modes is provided in terms of travel distance, or is not at a sufficient level of spatial disaggregation to allow similar comparison.

Figure C.1 compares the proportion of SHS rail (train/Subway/tram) stages ending in each local authority with the STS proportion of Scottish rail journeys ending in each local authority.

Figure C.1: STS vs SHS – Rail

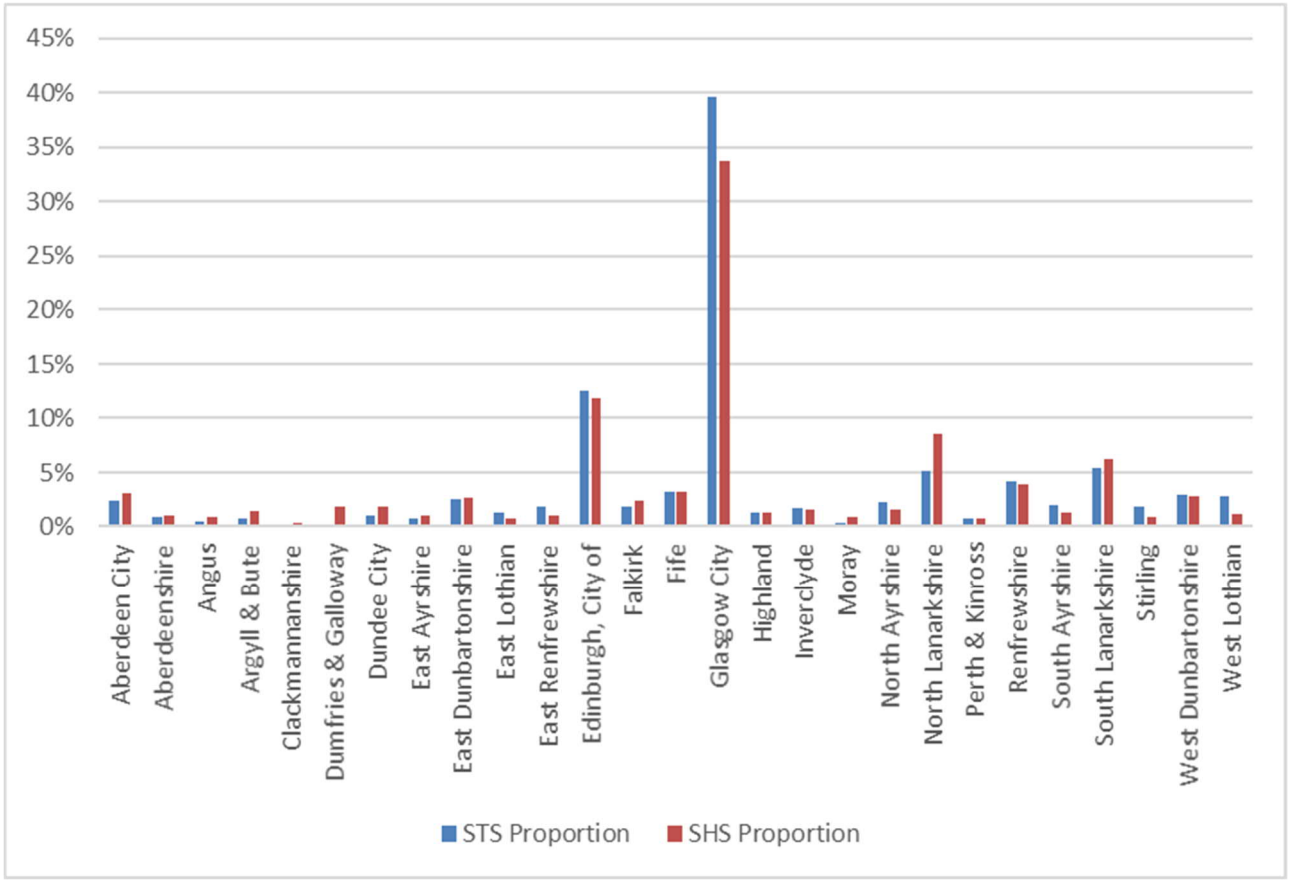
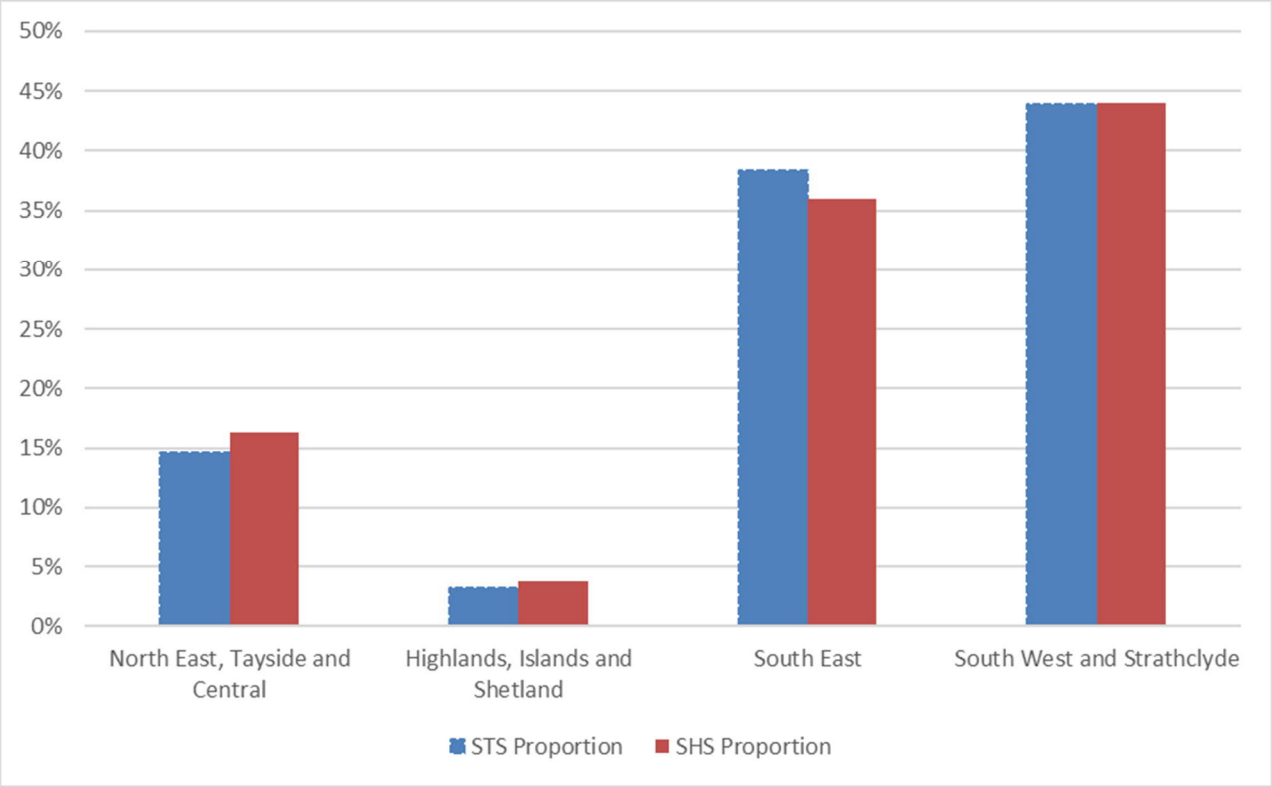


Figure C.2 compares the proportion of SHS bus (school + works + service bus) stages with the STS proportion of local bus passenger journeys ending in each STS region.

Figure C.2: STS vs SHS – Bus



In both cases, the alignment between the STS and SHS is good, although not perfect.