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Swindon Local Model Validation Report

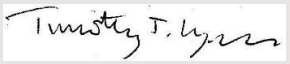
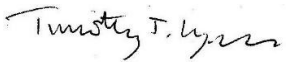
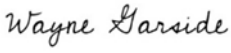
Swindon Base Year 2023 Transport Model
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1. Introduction

1.1. Overview of Swindon Transport Model

1.1.1 The Swindon Transport Model (STM) is a computer representation of the local highway network, the vehicle movements which use it, the land use zones which they travel between, the sites which generate vehicle trips, and the mechanisms which determine network performance. The STM is configured to replicate conditions in 'base year' 2023. It operates using SATURN software (version 11.6.03E), and is a progressive update of earlier versions of the STM, (specifically from 2019, 2014 and 2006).

1.2. Model Function

1.2.1 The STM approximates reality. Its function is to simulate how the local road system operates, its traffic patterns, and the travel choices made by drivers, at different times during a typical weekday, in a 'neutral' month, in 2023. Its aim is to simplify the complexities of the transport system and accurately reproduce observed conditions in 2023. If it proves reliable at base year, the STM can be projected forwards, and adapted to predict the future impact of the following:

- Growth of existing vehicle movements;
- Changes in land uses and generated trips;
- Changes to carriageway and junction layouts, capacities, and connectivity;
- New highway access arrangements for neighbourhoods and sites;
- New traffic regulations and controls;
- Variations in travel costs for road users;
- Rearrangement of car parking facilities; and
- Reallocation of highway space, to assist buses, pedestrians, and cyclists.

1.2.2 In addition, the SATURN model can provide information regarding various aspects of road use and highway network performance, such as:

- Road network 'stress', (traffic congestion and delay);
- Headroom highway capacity, relative to traffic demand;
- Route choices and journey costs, between trip origin and destination (OD) zones;
- Efficiency of network operation, in terms of realistic travel times and journey distances between zones, in congested conditions, compared with the quickest and shortest paths under free-flow; and
- Usage characteristics of a specific road link or junction, (e.g. passing vehicle types, and the selected OD movements which use it).

1.3. STM Purpose and Design Rationale

1.3.1 The STM is a highway-only platform, which will be projected forwards from 2023, to assess how future Swindon Borough Council (SBC) decisions will affect vehicle users, (who are the primary mode of travel), in Swindon. There are multiple uses for which the forecast STM could be used, but which are not yet clearly defined. However, the model will primarily be used to assess the traffic implications of new land use developments, identified in the emerging Swindon Local Plan 2023 – 2043 (draft). The STM will determine if remedial interventions are needed, to ensure sustainable travel patterns, and to maintain a satisfactory level of service on the transport system. The draft Local Plan identifies a need for around 24,100 new homes, plus new employment floorspace, in the Borough by 2043.

1.3.2 Although the STM is a highway-only model, it could be used alongside a Variable Demand Model (VDM), to forecast future variations in people's travel behaviour, (including choice of travel mode, journey destination and time of trip). Changes in behaviour may be caused by alterations to the transport system, which affect the

ease and cost of travel. The VDM would produce a forecast OD matrix of vehicle trips, to be assigned in the STM.

1.3.3 The rationale guiding the design of the STM is to balance the following attributes:

- A sufficiently detailed depiction of the Swindon road network, land use zones, and site access routes, to capture the effects of neighbourhood-scale developments, and infrastructure changes, upon traffic movements and travel costs;
- A sufficiently coarse representation of reality, to exclude localised detail where trip movement and vehicle flow data are not available to calibrate the model accurately;
- A reasonably comprehensive spatial coverage, to include all roads, junctions and land use sites, for which SBC has responsibility, and in respect of which SBC may make policy decisions and changes;
- Inclusion of strategic highway elements on the M4 and A419, which are the responsibility of National Highways, but which are likely to be affected by SBC strategies and policy decisions; and
- Restriction of the model's scope and complexity to that which can be assembled, refined and verified within agreed resources and data input constraints.

1.4. Adopted Guidelines and Standards

1.4.1 Development of the base year 2023 STM, conforms as closely as possible to advice from DfT's Transport Analysis Guidance (TAG), in respect of model functionality, scope, input data, accuracy, and testing.

1.4.2 Items of guidance which have been referenced, for key aspects of the model, are:

- TAG Unit M2.1 'Data Sources and Surveys', for collecting information to configure the model to represent the real situation;
- Catapult (Transport Systems) 'Utilising Mobile Network Data for Transport Modelling: Recommendations Paper' (April 2016), for sampling and interrogating MND, to use as input for a trip demand matrix.
- TAG Unit M3.1 'Highway Assignment Modelling' (May 2024), to determine the appropriate model scope, parameters, accuracy, and acceptability criteria.
- TAG Unit M2.2 'Base Year Demand Matrix Development' (May 2020), to source trip movement data, and to select a method of sample expansion and verification.
- SATURN Version 11.6 manual (July 2024), to build and check the model, to run the software, and to harness the model's capabilities.
- TAG Data Book V2.01 (May 2025), to derive key assignment parameters for the SATURN model, especially vehicle generalised cost of travel.

1.5. Local Model Validation Report (LMVR)

1.5.1 This LMVR is a standardised document, required under best practice advice from UK Government Department for Transport (DfT), Transport Analysis Guidance (TAG), Unit M3.1 'Highway Assignment Modelling' (May 2024). The LMVR explains the purpose and scope of the 2023 base year STM. It also outlines the inputs, procedures, guidelines, and parameters used to assemble the model, and the methods applied to test the model's accuracy. Finally it summarises the model's strengths, weaknesses, and fitness for purpose.

1.5.2 The remainder of the LMVR contains the following sections:

- **Section 1** - Model purpose and design rationale. Adopted guidelines and standards;
- **Section 2** - Model scope and characteristics;
- **Section 3** - Data sources for building and testing the model;
- **Section 4** - Model assembly, in terms of the trip matrix (travel demand), and the highway network (transport supply);
- **Section 5** - Model testing, in terms of its functionality, (correct inputs and operation), its accuracy, (outputs which match real observations), and its reliability, (stable end state);
- **Section 6** - Model summary, in terms of its strengths, weaknesses and fitness for purpose.

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2. Model Scope and Processes

2.1. Introduction

2.1.1 This section outlines the scope and application of the base year STM, in respect of its component parts, development procedure, coverage, structure, segmentation, assignment mechanisms, and performance tests. It also explains why the model format is suitable for its intended use.

2.2. Model Components

2.2.1 The STM consists of three main components:

- Travel demand;
- Transport supply; and
- Traffic assignment.

Travel Demand

2.2.2 Travel demand is represented in SATURN as a vehicle trip Origin to Destination (OD) 'matrix'. This is a numerical table in which rows represent origin zones (from which trips are generated), and columns represent destination zones (to which trips are attracted). The cells in the table represent the number of vehicles which travel between each origin and destination pair.

Transport Supply

2.2.3 Transport supply is represented in SATURN as a 'highway network' and 'zone system'. This consists of road 'links', which interconnect through junction 'nodes', and which access or terminate at OD zones (zone 'centroids'). Links are referenced by the node pair at each end of a link, and the zone which is attached to a centroid.

2.2.4 Network components have defined characteristics, which determine their effectiveness at channelling traffic in a particular direction, such as road geometry, distance, travel time, speed, the number and width of lanes, lane capacity (saturation flow, or maximum vehicle throughput per hour), 'gap acceptance', and traffic control settings (e.g. signal timings).

Traffic Assignment

2.2.5 Traffic 'assignment' in SATURN is the mechanism by which a trip matrix is loaded on to a highway network, to produce vehicle flows on each link, junction turn, and zone centroid in the model. An assignment 'algorithm', controlled by assignment parameters, determines how each vehicle trip is allocated to a specific route between an OD pair, with the objective of minimising the 'generalised cost' of the journey. The SATURN model calculates generalised cost by applying a specified value of time (pence per minute) to the assigned journey speed, a specified cost of distance to the assigned route length, a charge penalty for using certain links (e.g. for car parking), and by summing the resulting time, distance and penalty costs.

2.2.6 A SATURN assignment is a dynamic, iterative procedure, which re-assigns vehicle movements, multiple times, in response to fluctuating route costs, until an end state is achieved, whereby a required point of 'convergence' is achieved.

2.3. Model Development Procedure

2.3.1 The STM has been updated using a conventional procedure, consisting of the following steps:

- Review previous model versions and data inputs;
- Determine required new model scope, coverage, and functionality;
- Define model segmentation (sub division), by time periods, journey purposes, user classes (vehicle types, car parking categories;
- Develop a zoning system, (which consists of geographical polygons, representing trip origin and destination zones, overlaid on a map base of the modelled area), and sector plan (higher level groupings of adjacent zones);
- Identify required changes from earlier model versions, then collect and prepare new data inputs;
- Assemble a 'prior' trip matrix from recorded data sources (primarily Mobile Network Data – MND);
- Construct a model link, node and centroid (zone access) representation of the highway network;
- Run an initial 'prior' assignment to establish areas of model inaccuracy;
- Prepare and run a trip matrix estimation (ME) procedure, which complies with DfT TAG constraints, (limiting changes to the prior matrix);
  - ME is required, because typically, the prior trip matrix, if it is assembled externally to the SATURN model from MND, will have limited accuracy and a shortfall in some OD movements, when compared against alternative sources (traffic counts and trip end datasets);
- Run a 'post' assignment with the enhanced, partially estimated trip matrix, to check for improved model accuracy;
- Undertake iterative model network and trip matrix adjustments, to increase model accuracy, and to fulfil DfT TAG model calibration, validation, and convergence criteria; and
- Undertake a 'stress test' on the calibrated base year model, by running a further network assignment with the matrix trip volume uplifted by 10% – 20%, to check if the road system has a realistic amount of headroom capacity for growth before severe congestion occurs.

2.4. Physical Model Coverage

Fully Modelled Area and External Area

2.4.1 The following figure shows the extent of the STM fully modelled area of focus, which comprises the town centre, a surrounding core area, and an outer peripheral area. Everything outside of the shaded area is external to the STM.

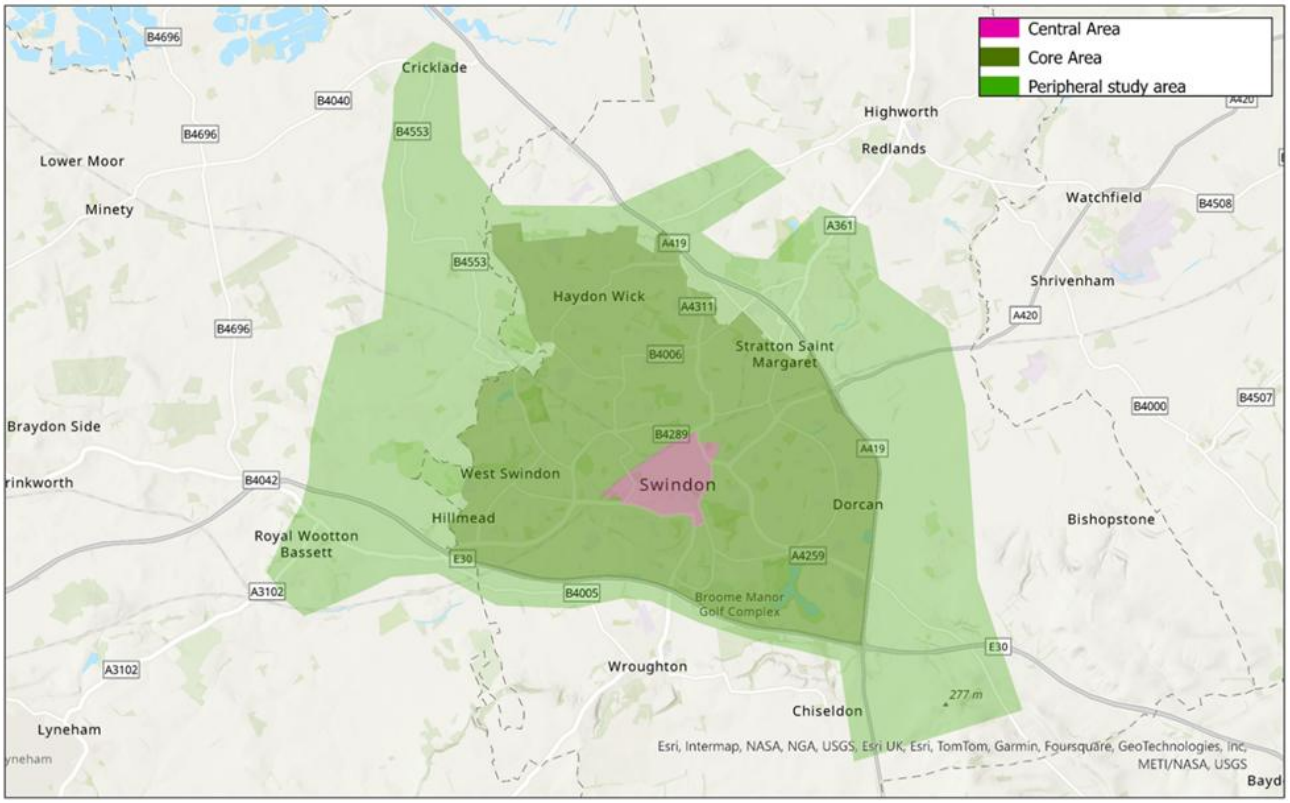


Figure 2-1: STM Spatial Area of Focus.

2.4.2 The following figure shows the perimeter, within which mobile network cells are analysed as the primary source of trip movement data for the STM travel demand matrix. It confirms that the captured mobile origin and destination cells span an area which is larger than the STM area of focus illustrated in the previous figure.

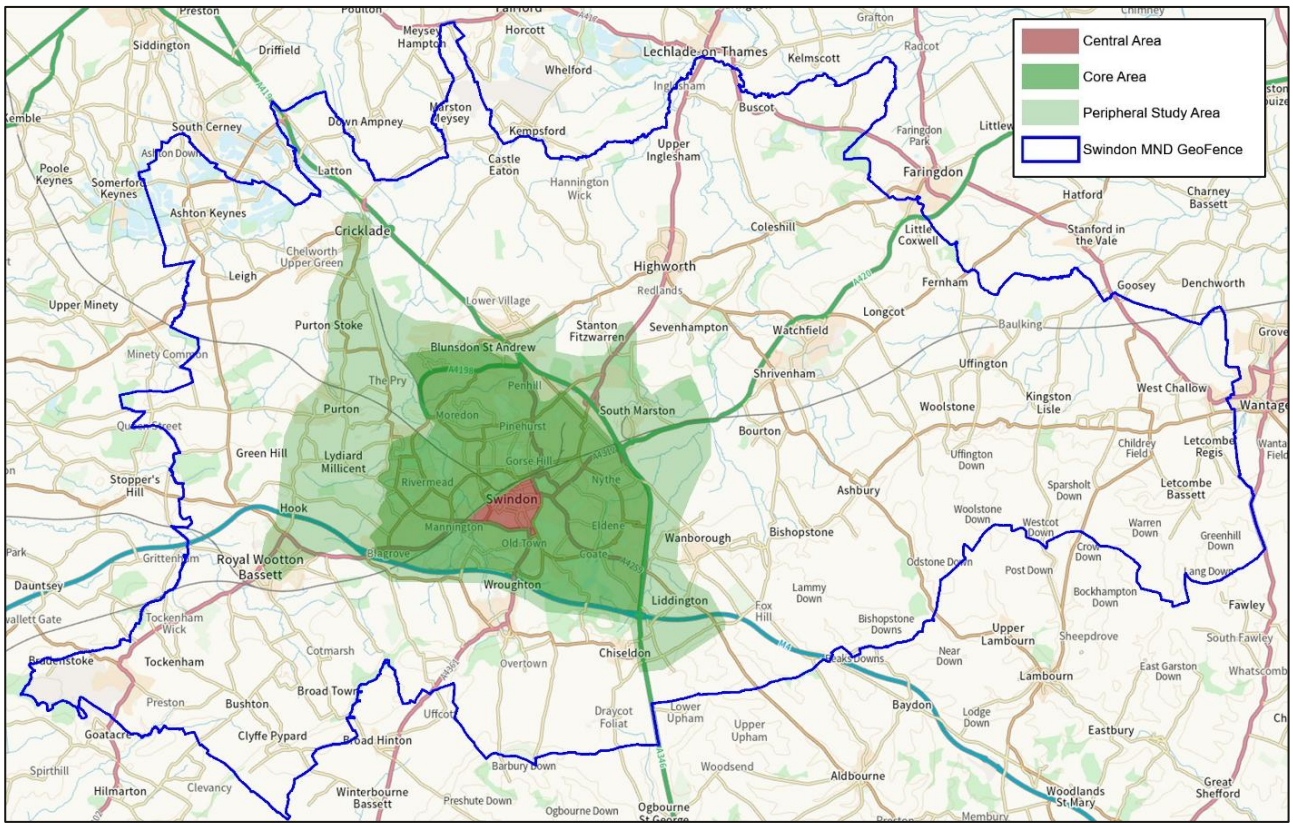


Figure 2-2: STM Spatial Area of Mobile Network Trip Data Coverage.

2.5. Model Structure

2.5.1 The structure of the STM consists of three main elements, the zoning system, the network, and centroid connectors, which link the zones and the network together.

Zoning System

2.5.2 The STM zoning system within the fully modelled area is shown in the following figure.

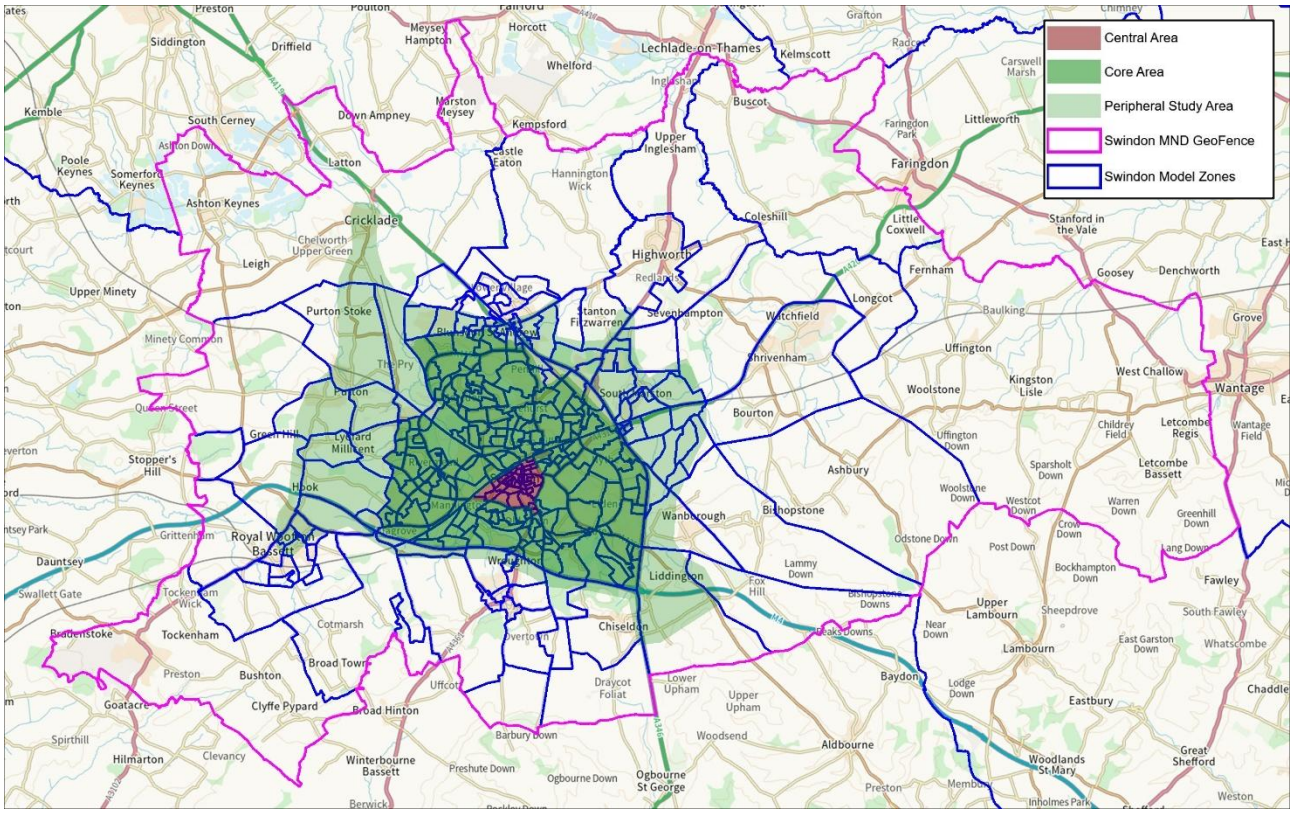


Figure 2-3: STM Zoning System Inside Fully Modelled Area (Geofence).

2.5.3 The STM zoning system outside the fully modelled area is shown in the following figure.

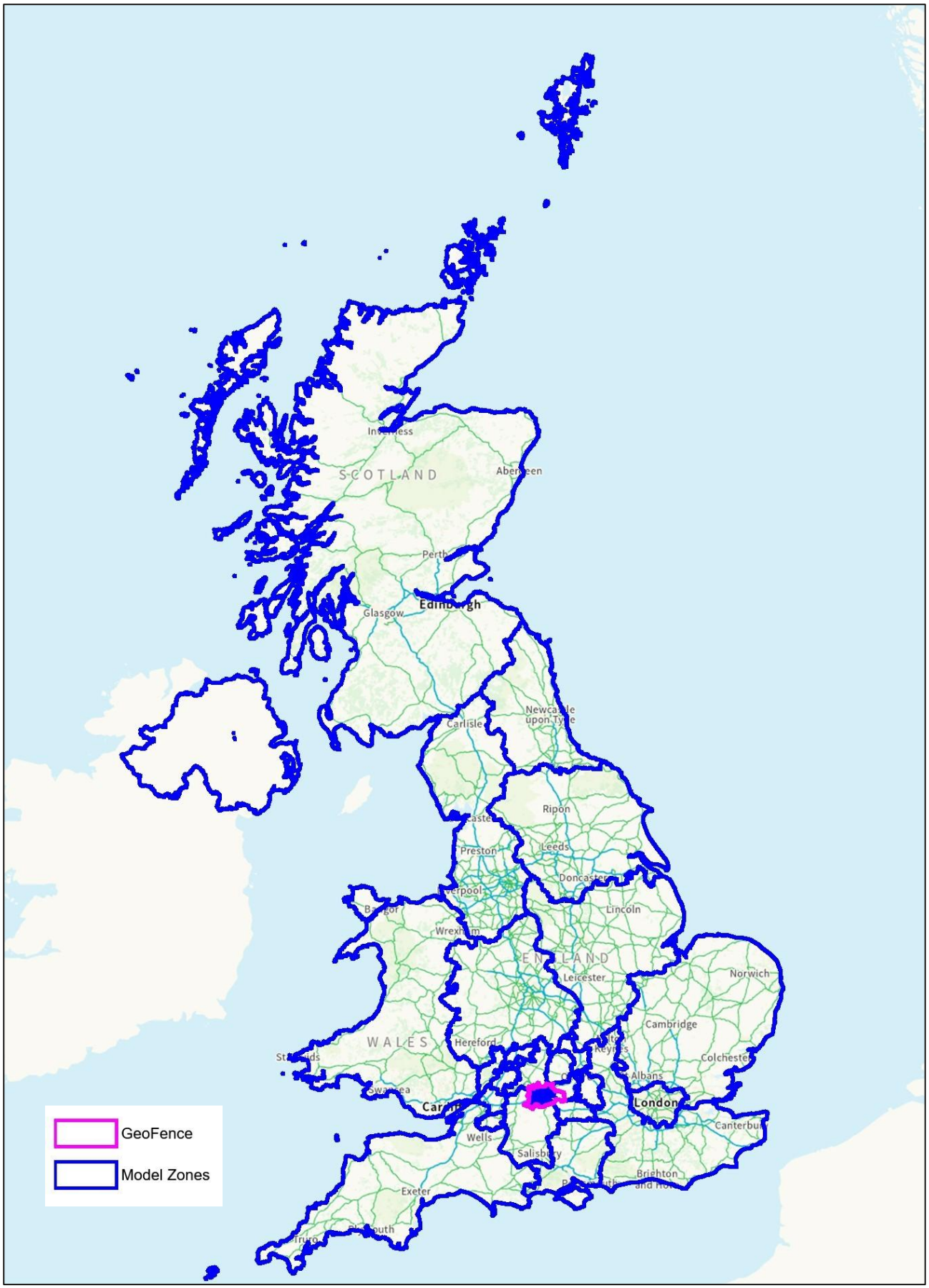


Figure 2-4: STM Wider Zoning System Outside Fully Modelled Area (Geofence).

Network Structure

2.5.4 The STM network is ‘capacity restrained’, which means there is a specified limit to the volume of traffic which can pass through a particular network link or junction before congestion and vehicle delays arise. The Swindon SATURN network is configured in two formats, ‘buffer’ and ‘simulation’.

- Roads modelled in ‘buffer’ format are coded with link distance and speed / flow / capacity characteristics, but they represent junctions as nodes, without any layout details to constrain throughput;
  - The STM buffer network area is generally characterised by large link distances between intersections, and locations where junctions are not congested and do not significantly affect route choice;
- Roads modelled in ‘simulation’ format are coded with detailed junction attributes, which impose capacity constraint and determine route choice; and may be coded with or without similar link details to ‘buffer’ links.
  - The STM simulation network area is generally characterised by small link distances between intersections, and localities where junctions are more numerous and heavily used, or where a junction layout has a substantial effect on route choices and congestion.

2.5.5 Simulation format is used within the core urban area of Swindon, where junction operation is the main determinant of drivers’ route choice. Buffer format is used in the peripheral area, where junction performance has little effect on routing of traffic.

2.5.6 In the SATURN link and junction network, most of Swindon Borough is represented in detailed ‘simulation’ format (which includes layout details for road junctions), except for the largely rural area northeast-wards from South Marston and Broad Blunsdon, (which includes Stanton Fitzwarren, Highworth, and Castle Eaton). The simulation network extends southwest-wards, outside Swindon Borough, to include Royal Wootton Bassett, and it also incorporates all of the strategic roads accessing Swindon, including the M4 to the south, and the A419 to the east.

2.5.7 Roads which are more distant from Swindon are modelled in less detailed, ‘buffer’ format (which includes link distance and speed / flow / capacity characteristics, but excludes junctions). M4 west (Bristol), Chippenham, Devizes, Marlborough, Hungerford, Newbury, M4 east (Reading), Wantage, Faringdon, Oxford, Lechlade-On-Thames, Cricklade, and Cirencester.

2.5.8 The STM simulation network structure, inside the fully modelled area, is shown in the following figure. The extent of simulation detail adequately covers the centre, core and peripheral parts of the STM area of focus.

GENERAL

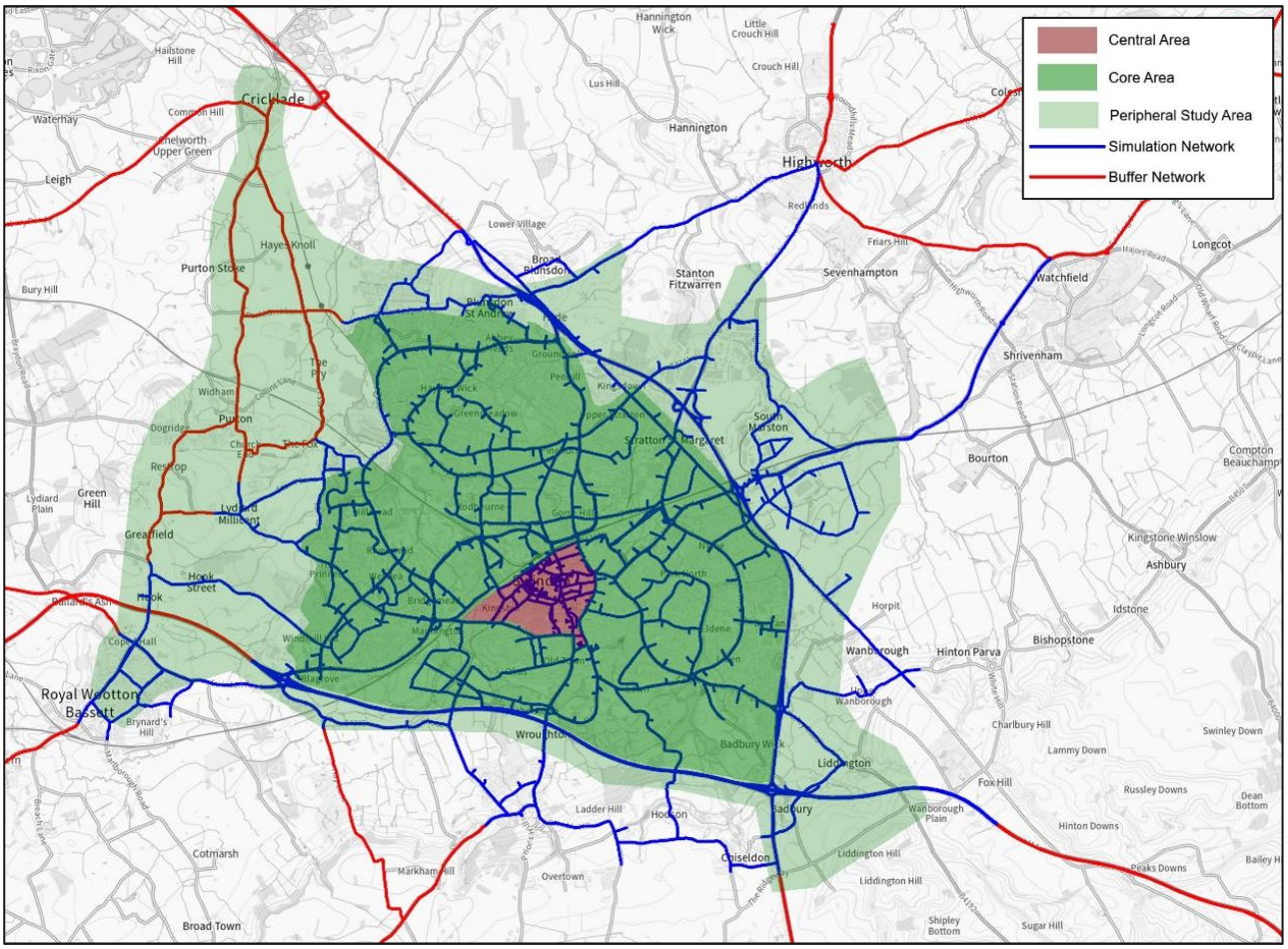


Figure 2-5: STM Simulation Network Inside Fully Modelled Area.

2.5.9 The STM wider buffer network structure, outside the fully modelled area is shown in the following figure.

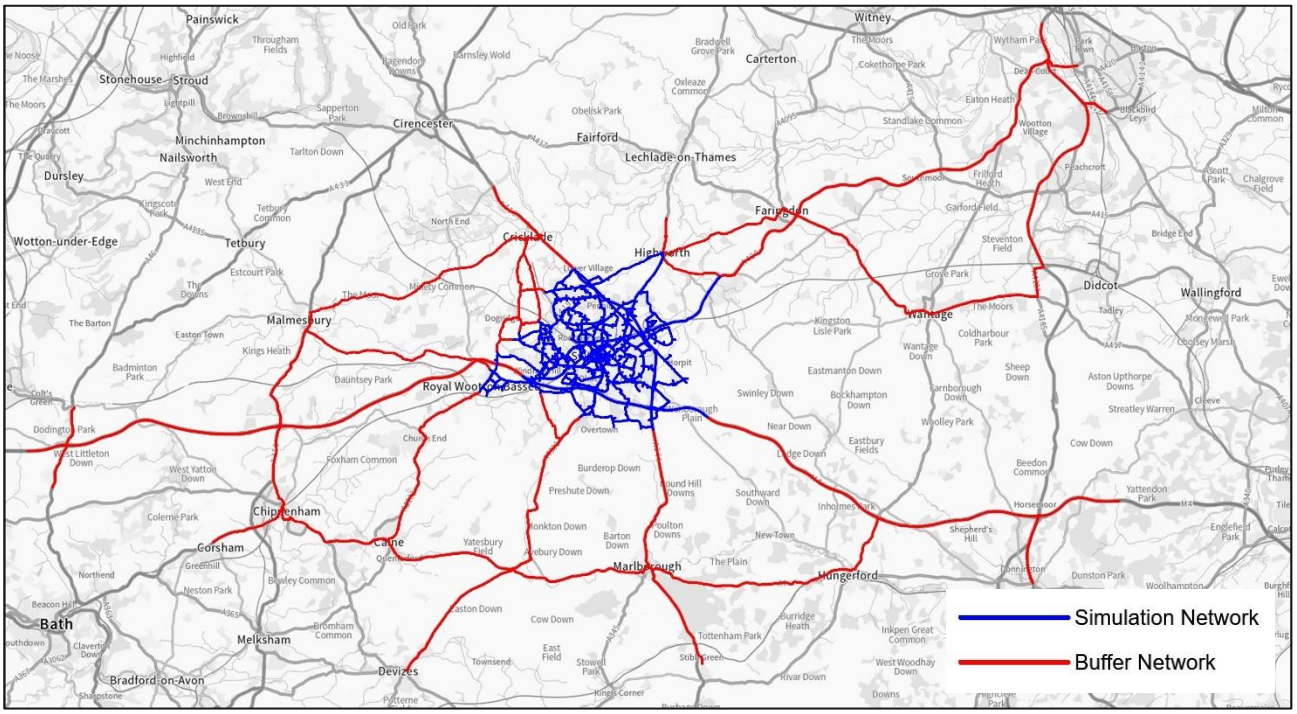


Figure 2-6: STM Buffer Network Outside Fully Modelled Area.

Car Park Sub-Model

2.5.10 A car park sub-model is included in the core area of the STM network. It simulates the role of public car parks, in Swindon town centre, as intermediate points, which many incoming drivers pass through on the way to their final destinations.

2.5.11 Its purpose is to capture the diversionary effect of car park locations on the routing of traffic, and hence reflects the realistic movement of vehicles. It does however also include some drivers who use private and on-street car parking, or drop off, at their final destination, and who are not diverted via public car parks.

2.6. Land Use Boundaries and Accesses

2.6.1 The zoning system used defines trip OD polygons is based on the earlier 2019 version of the base year STM. However, refinements are included in the 2023 model, in respect of the following:

- Correspondence between Census MSOA (to which the MND trip movements are allocated), and STM zones is adjusted to give a closer commonality of boundaries and more accurate allocation of MND to model zones;
  - However, the positioning of internal zone centroid connectors in the SATURN network is largely unchanged from the earlier STM;
- Zone centroid connections for internal zones within the study area are simplified, where necessary, but generally they are retained from the previous STM version, because –
  - The modelled zone centroids produce a realistic pattern of assigned vehicle flows, relative to the locations of input traffic counts;
- The number of external zones in the model is reduced for clarity, and to reflect the allocation of MND to simplified OD locations outside Swindon, namely Local Authority Districts (adjacent to Swindon) and GB regions (more distant from Swindon);
  - The network centroid connections for these external zones have also been simplified accordingly.

2.7. Model Segmentation

2.7.1 The base year 2023 STM is segmented into separate strands, to capture nuances of how the road system operates differently at particular times of day and for specific types of road user.

Time Periods

2.7.2 There are three modelled time periods, as follows:

- Morning Peak hour - 8am-9am;
- Inter Peak average hour - 10am-4pm; and
- Evening Peak hour - 5pm-6pm.

Journey Purposes

2.7.3 There are three modelled journey purposes, as follows:

- Commuting;
- Employers' Business; and
- Other.

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User Classes

2.7.4 There are eleven user classes (UC), representing permutations of vehicle type, journey purpose and car parking preference, as follows:

- UC1 Car, Commuting, Car Park Non-Users;
- UC2 Car, Employers business, Car Park Non-Users;
- UC3 Car, Other, Car Park Non-Users;
- UC4 Car, Commuting, Long Stay Car Park Users;
- UC5 Car, Commuting, Short Stay Car Park Users;
- UC6 Car, Employers business, Long Stay Car Park Users;
- UC7 Car, Employers business, Short Stay Car Park Users;
- UC8 Car, Other, Long Stay Car Park Users;
- UC9 Car, Other, Short Stay Car Park Users;
- UC10 Light Goods Vehicle (LGV), Car Park Non-Users; and
- UC11 Other Goods Vehicle (OGV), Car Park Non-Users.

2.8. Model Assignment Mechanisms

Overview

2.8.1 The SATURN model operates through successive, iterative feedback loops of ‘assignment’ and ‘simulation’, until a point of ‘convergence’ is reached. In simplistic terms, ‘assignment’ is the loading of vehicles, from the trip OD matrix, on to optimal network routes between zones, whereas ‘simulation’ calculates the network delays and route travel times which result from the loaded traffic.

Assignment Method

2.8.2 The end state convergence point to be attained in the STM is known as ‘Wardrop Equilibrium’. In simplistic terms, this is a point where all vehicle movements are assigned on to their most efficient (i.e. cheapest) routes between OD zone pairs, and where no movement could further reduce its travel cost by changing route. This equilibrium point reflects how drivers typically decide their routes through a road network.

Assignment Parameters

2.8.3 The model is controlled by numerous assignment parameters, some of which are set in the STM as recommended defaults, and the remainder of which are set according to local circumstances in 2023. The main parameters are the generalised costs by user class referred to below.

Generalised Cost Formulations

2.8.4 For each STM model hour (AM, IP and PM), and for each of eleven SATURN user classes, route choices in the model assignments are based on the sum of two items which constitute the generalised cost of travel:

- First, the value of travel time, in pence per minute, multiplied by the journey duration; and
- Second, the value of fuel plus non-fuel related journey distance, in pence per kilometre, multiplied by the journey length.

2.8.5 The per unit values of these items are derived from DfT TAG Data Book v2.01 (May 2025).

Value of Travel Time

2.8.6 Values of travel time, in pence per minute for STM, are derived from Table A 1.3.6:

- This table calculates the market price values of time per vehicle type and journey purpose, based on distance travelled (ppm, 2023 prices), and adjusts them to perceived costs, whereby for work journeys the indirect taxation element is removed (i.e. converted to resource cost).

Value of Fuel Related Journey Distance

2.8.7 Values of fuel related journey distance, in pence per kilometre for STM, are derived from Table A 1.3.12 and A 1.3.13, using the following formula:

$$L = a/v + b + c*v + d*v^2$$

- Where –
  - L = costs, expressed in pence per kilometre;
  - v = average speed in kilometres per hour; and
  - a, b, c, d are parameters defined for each vehicle category.
- This calculates the average vehicle fuel / energy cost formulae parameter values (ppk, 2023 prices), work and non-work, (excluding VAT);
- Average vehicle speed is derived from the 2019 base year STM, by user class.

Value of Non-Fuel Related Journey Distance

2.8.8 Values of non-fuel related journey distance, in pence per kilometre for STM, are derived from Table A 1.3.14 and A 1.3.15, using the following formula:

$$C = a1 + b1/V$$

- Where –
  - C = cost in pence per kilometre travelled;
  - V = average speed in kilometres per hour;
  - a1 is a parameter for distance related costs defined for each vehicle category; and
  - b1 is a parameter for vehicle capital saving defined for each vehicle category, (this parameter is only relevant to working vehicles).
- This calculates the non-fuel resource vehicle operating costs (ppk, 2023 prices), work and non-work;
- Average vehicle speed is derived from the 2019 base year STM, by user class.

Summary Values of Time and Distance

2.8.9 The following table shows the weekday monetary values of time (PPM), and the monetary values of fuel-plus-non-fuel related distance (PPK), which are applied in the 2023 STM assignments, segmented by vehicle types and journey purposes.

VEHICLE TYPE		JOURNEY PURPOSE	AM PEAK (8AM-9AM)		INTER PEAK (10AM-4PM)		PM PEAK (5PM-6PM)	
			PPM	PPK	PPM	PPK	PPM	PPK
Car		Work	43.50	18.96	44.58	18.27	44.13	18.79
		Commuting	29.17	10.31	29.65	9.93	29.28	10.22
		Other	20.13	10.31	21.44	9.93	21.08	10.22
LGV		Work	33.61	20.89	33.61	20.26	33.61	21.27
		Non-work	23.09	11.32	23.09	10.81	23.09	11.64
		Average	32.35	19.74	32.35	19.12	32.35	20.12
OGV1		Work	33.79	36.48	33.79	36.56	33.79	36.29
OGV2		Work	33.79	69.61	33.79	62.52	33.79	69.37
OGV	Average OGV1 OGV2	Work	33.79	52.65	33.79	49.19	33.79	52.33
	Average, Uplifted	Work	77.72	52.65	77.72	49.19	77.72	52.33

Table 2-1: STM Assignment Values of Time and Distance, by Model Hour, Vehicle Type and Journey Purpose.

2.8.10 It is noted that, in TAG Unit M3.1, the value of time for HGV accounts for the driver only. However, there are additional costs to the business owners associated with the duration of travel. To allow for this, TAG recommends multiplying the Value of time by (x2.3), in line with research undertaken by the Hague Consulting Group, (see paragraph 2.8.8 of TAG Unit M3.1). This uplift is included in the final values in the above table.

Vehicle to Passenger Car Unit (PCU) Conversion Factors

2.8.11 The SATURN model handles all traffic volumes as PCU's, in the trip matrices, validation counts, model parameters, and assignment outputs. Since the data sources, which are used to provide observed traffic inputs to the STM, are quantified as vehicles, by category, they are converted to PCU before they are applied in SATURN.

2.8.12 Conversely, traffic assignment outputs from SATURN are converted to vehicles, before comparison against the validation criteria specified in TAG.

2.8.13 A consistent set of vehicle to PCU conversion factors is used throughout the STM model building and validation process, as summarised in the following table.

CAR	LGV	OGV1	OGV2	BUS	MOTOR CYCLE	PEDAL CYCLE
1.0	1.0	1.9	2.9	2.5	0.4	0.2

Table 2-2: STM Vehicle to PCU Conversion Factors.

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Capacity Restraint

2.8.14 Capacity restraint is a principle which is applied throughout the STM network. This means that there is a specified limit to the volume of traffic which can pass through a particular network link or junction before congestion and vehicle delays arise. The primary capacity restraint mechanisms are as follows:

- Buffer network link distance and speed / flow / capacity characteristics;
- Simulation network junction attributes, (such as lane allocations, turn saturation flows, gap acceptances, and traffic signal green splits), and link distance and speed / flow / capacity characteristics on longer simulation links.

2.9. Model Performance Testing

2.9.1 Model performance testing is a process which checks three aspects of the STM, namely:

- Model functionality (verification) – checking that the STM inputs are assembled correctly, and the model operates satisfactorily;
- Model accuracy (validation) – checking that the STM outputs are realistic, compared with observed data; and
- Model reliability – checking that the end state of the STM iterative assignment is 'converged', so that if further iterations are run, the model outputs will not change substantially.

2.9.2 Criteria for testing the model's functionality, accuracy and reliability are derived from DfT TAG Unit 3.1 (May 2024). The logic applied is that if the SATURN model inputs are sound, the outputs are valid, and the assignment is converged, then the model will respond reliably to changes to its key variables, (such as trip demand, road capacity, and travel cost), and it can be used as a predictive tool.

2.9.3 This section outlines the scope of model performance tests undertaken for the STM.

Model Functionality Tests

2.9.4 STM inputs (both new and existing) are verified, to check that they are represented correctly and can be harnessed satisfactorily by the SATURN software. Amendments are made where necessary, before the assignment outputs are validated. However, some inputs are unchanged from the earlier STM model, because although they do not follow current TAG advice, they do not adversely affect the assignment accuracy. The functionality tests comprise the following:

- Checks on network coding –
  - Network connectivity and route choices between OD zones;
  - Simulation links – carriageway types, link distances, saturation flows, and speeds.
  - Simulation nodes – junction types, permitted turns, turn priorities, lane allocations, turn saturation flows, gap acceptances, merges, diverges and weaving sections
  - Traffic signal locations stages, green splits, intergreens, cycle times, and pedestrian phases;
  - Buffer links – carriageway types, link distances, saturation flows, and speed / flow / capacity indices;
  - Movement bans and penalties; and
  - Bus routes and service frequencies.
- Checks on zone accesses –
  - Any zone centroid which is modelled as accessing all of a zone, when really that link cannot access part of the zone;
  - Any zone centroid which is modelled as accessing only one zone, when really that link can also access a nearby zone;
  - Any zone which is modelled with multiple centroid accesses, since SATURN will only assign trips through one of these accesses and the others will be unused;

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- Minimising the number of zones which are modelled as being exited and entered directly along a simulation link (between A and B nodes), as a direct zone connection can inhibit comparison of modelled and counted flows during the processes of matrix estimation and model validation.

- Car park representation –
  - Checks to ensure all town centre zones are connected to car parks, via walk links;
  - Checks to ensure user class access to town centre zones is via the correct type of car park (long stay, short stay, or not public car park);
- Assignment parameters –
  - Checks on value of travel time and value of distance-related vehicle operation, for consistency with TAG Data Book v2.01 (May 2025).

Model Accuracy Tests

2.9.5 Model accuracy tests are to check that the STM final trip matrices and assignment outputs give a true picture base year travel patterns and traffic conditions in Swindon in 2023. They examine the following aspects of each of the Morning, Evening, and Inter-Peak scenarios:

- Post-estimation changes to the 'prior' trip matrix, after SATURN matrix enhancements, in terms of –
  - Individual OD zone-to-zone trips;
  - Total trips departing from each origin zone;
  - Total trips arriving at each destination zone;
  - Trip length distribution; and
  - Broader-level trip movements between model sectors;
- Accuracy of trip volumes in the post-estimation matrices, travelling between neighbourhoods, as measured by comparing assigned and counted traffic flows through groupings of 'screen-line' sites;
- Accuracy of network assigned traffic flows compared with counted flows;
- Accuracy of network assigned travel times along selected routes, compared with observed journey lengths;
- Accuracy of assigned route choices between OD zones, compared with the logical, quickest routes through the network, obtained from a web-based map application.

Model Accuracy Criteria

2.9.6 Criteria for determining the accuracy of the STM, using the above tests, are derived from TAG, and are as follows:

- For post estimation changes to a 'prior' trip matrix (after calibration adjustment):
  - Change in matrix zone to zone trips (plot of pre-ME and post-ME cell values): Slope within 0.98 and 1.02, intercept near zero, R2 in excess of 0.95;
  - Change in matrix zonal trip end totals (plot of pre-ME and post-ME trip ends): Slope within 0.99 and 1.01, intercept near zero, R2 in excess of 0.98;
  - Change in trip-length distribution (histograms of pre-ME and post-ME trip length frequency): mean within 5%, standard deviation within 5%; and
  - Change in aggregated sector to sector trips (comparison of pre-ME and post-ME grouped values): Differences within 5%.
- For validating a 'prior' trip matrix (i.e. before SATURN ME or calibration adjustment), and for validating a 'post-estimation' trip matrix (i.e. after SATURN – ME):
  - Traffic Flow Test 1 – Differences between total modelled flows and counts, forming each screen line, should be less than 5% of the counts, for > 95% of screen lines (and ME cordons), where the total flow across each screen line is the sum of flows on its component links.

- For link flow and turning movement validation, there are two alternative tests and sets of criteria, either is acceptable, Test 2 (a, b and c), or Test 3 –
  - Traffic Flow Test 2a – Individual flows within ±100 veh/h of counts, for flows less than 700 veh/h, in > 85% of cases; and
  - Traffic Flow Test 2b – Individual flows within ±15% of counts, for flows from 700 to 2,700 veh/h, in > 85% of cases; and
  - Traffic Flow Test 2c – Individual flows within ±400 veh/h of counts, for flows more than 2,700 veh/h, in > 85% of cases;
  - Traffic Flow Test 3 – GEH < 5 for individual flows, in > 85% of cases; (where GEH is used to compare modelled values (V_2) and observed values (V_1), consistently across different scales of movement, and is calculated in the following formula):

    $GEH = \sqrt{\{[(V_2 - V_1)^2] / [(V_1 + V_2) / 2]\}}$

- For network journey time validation:
  - Journey Time combined test 1 and 2 – (1) modelled times along routes should be within ±15% of surveyed times, and (2), if modelled time is > 15% greater than observed, the modelled time should be within ±1 minute of observed, on > 85% of routes.
- For network assigned route choice:
  - There are no quantified criteria for measuring route choice; instead, this test is performed using local knowledge of the Swindon road network and driver behaviour.

Model Reliability Tests

2.9.7 Model reliability tests are to check that the STM final output, after a specified number of assignment iterations, will not change substantially if further iterations are run in SATURN, for each of the AM, IP and PM hourly models. Establishing a likelihood of no change means that the STM output is satisfactorily 'converged' and is therefore robust.

2.9.8 trip matrices and assignment outputs give a true picture base year travel patterns and traffic conditions in Swindon in 2023. They examine the following aspects:

2.9.9 The scope of the model convergence tests is to check the following:

- Iterative proximity and stability statistics, at point of assignment equilibrium.

Model Convergence Criteria

2.9.1 Criteria for determining if the STM is converged, using the above tests, are derived from TAG, and are as follows:

- Proximity of the model to an optimal equilibrium convergence level, after the final assignment iteration, is indicated by variation of the costs on the final assigned routes, from those on the minimum cost routes –
  - %GAP < 0.1%
  - DELTA (δ) < 0.1%
- Stability of the final assignment iteration, compared with the previous iteration, is indicated by change in flows and costs on network links and turns –
  - Relative Average Absolute Difference in link flows (RAAD) < 0.1%
  - Links with assigned flow change < 1% (%FLOWS) > 98%
  - Turns with assigned cost change < 1% (%DELAYS) > 98%

3. Data Sources

3.1. Introduction

3.1.1 This section summarises the various data sources which have been used to develop the base year 2023 model and to test its performance.

3.1.2 The required data for the model consist of the following items:

- Trip movements (for STM matrix)
  - Origin to destination travel demands, for preparing model trip matrices;
- Land use boundaries, accesses and car parks (for STM zoning)
  - Zone polygons, representing trip origins and destinations;
  - Site entry and exit arrangements, for locating model zone connectors;
  - Car park provision, for locating vehicle trip ends at points within walking distance of ultimate trip origins and destinations;
- Highway links and junctions (for STM network)
  - Road configurations and regulations, for assembling the model network.
- Network use and performance statistics (for STM assignment testing) –
  - Traffic flow, journey time, and route choice observations, for calibrating the trip matrices and verifying the model assignments.

3.1.3 The sourcing of data for each of these items is explained further in this section. All model inputs have been verified as reliable, and adjusted for the STM, in respect of the following requirements:

- They are typical of normal weekday conditions in 2023;
- They constitute a sufficient survey sample size;
- They are sufficiently 'granular' to enable the required segmentation within the model;
- They give sufficient breadth of coverage to inform the full model area; and
- They satisfy the model data input requirements indicated in DfT TAG.

Calibration and Validation Data

3.1.4 To help ensure that the base year 2023 STM reflects actual travel conditions, as required by TAG Unit M3.1, a large amount of observed traffic data was used both to develop the model (calibration) and to check the similarity of model outputs (validation).

3.1.5 Rather than separating data into 'calibration' and 'validation' subsets, the full validation dataset was used throughout. The reasoning is that a more reliable model can be built by using maximum information to configure it and ensure its accuracy, than by withholding some useful data, which could otherwise improve the model. Withholding data reduces model precision, and will inevitably prove the model to be less than accurate.

3.2. Trip Movements

New Data Collection and Existing Sources

3.2.1 Observations of vehicle OD movements were needed, to develop trip matrices for the STM base year 2023, Morning, Evening, and Inter-Peak models. Matrices were available from earlier versions of the STM (most recently from 2019). However, given the impact of COVID-19 pandemic on changing typical travel patterns, the previous matrices were considered to be inadequate as indicators of current conditions. Instead, OD movements for the 2023 STM were sourced from Mobile Network Data (MND).

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3.2.2 Using MND to develop the STM trip matrices was justified, because MND has the following advantages for capturing trips, when handled appropriately and supported by backup data and logic checking procedures:

- Large-scale continuous coverage of trip movements during a representative month (March 2023)
  - Backup data and logic checks are used to distinguish small values, where MND privacy constraints limit the accuracy of data segmentation;
- Less costly and easier to update than other sources of trip data
  - Backup data and logic checks are used to smooth inconsistencies over time, caused by changes in the mobile network customer base and data protocols;
- Observed data from real movements, rather than self-reported trips
  - Backup data and logic checks are used, to differentiate journey purposes and travel modes, which are obscured in MND;
- High temporal resolution captures precise times when trips reach particular locations
  - Backup data and logic checks are used to identify multi-leg journeys, and to distinguish an intermediate ‘drop-off’ from a final destination in a trip chain, which can be obscured in MND;
- Broad sample from a large population, because mobile devices are held by the majority of people who travel –
  - Backup data and logic checks are used to correct skewed sampling, where the selection of mobile network providers is limited;
- Good spatial granularity of OD, where cells are densely distributed
  - Backup data used to pinpoint OD and capture missed shorter trips, where mobile network cells are sparse;
- Captures long distance and cross-boundary trips
  - Backup data and logic checks are used to screen out spurious trips created during non-travel events, (when a static device ‘flips’ between cells);
- Continuous MND integrates with other data sources
  - In-house analysts processed and checked the MND for use in STM, and verified the data against alternative sources, thereby resolving complex validation challenges, (and avoiding otherwise opaque processing by a commercial provider).

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MND Processing, Expansion and Verification

3.2.3 Several steps were taken to prepare MND for use in the Swindon model. These tasks were completed using CitiLogik technicians and comprised the following:

- Specify trip classification criteria and logic checks, to be applied to extracted MND movements;
- Establish level of segmentation (subdivision) to be applied to the processed MND records;
- Define a 'geofence' MND perimeter for the modelled area, and OD polygons, inside and outside this perimeter, to which MND records will be allocated –
  - Inside the geofence, OD are consistent with Census Middle Layer Super Output Areas (MSOA);
  - Outside, but adjacent to the geofence, OD are consistent with Local Authority Districts (LAD);
  - Outside, but further away from the geofence, OD are consistent with GB regions;
- Procure records from the mobile network provider;
- Determine optimum dates between which MND can be extracted, to capture an acceptable sample of trips, where acceptability is measured according to –
  - Sufficient number of devices contracted to the mobile provider, (i.e. for a reliable sample size);
  - Sufficient number of recorded cell-to-cell movements per device, (i.e. for a reliable trip rate);
  - Sufficient spatial coverage of cell-to-cell movements, (i.e. for a reliable span of detected trips and trip OD distribution);
  - Small daily variation in MND records, (i.e. for consistency of travel patterns);
  - Applying the above criteria, the optimum MND for the Swindon model were assembled over a 22-weekday period, from Wednesday 1st March to Friday 31st March 2023.
- Apply trip classification and logic checks to extracted raw MND records, to establish valid trip OD movements between MSOA, based on orientation of cell tower 'pings' and cell dwell times
  - If the dwell time of a device at a 'pinged' cell tower is longer than 30 minutes, a trip destination is assumed to have been reached;
- Apply sample expansion factors to the extracted MND, to convert network provider sample of users, to represent all network providers;
- Verify expanded typical daily OD movements, at MSOA scale, (but not segmented by time period, travel mode, or journey purpose, so as to avoid 'privacy' rounding of small values), by checking similarity with alternative data sources, namely – National Trip End Model TEMPro 8.1 data by MSOA, Census 2021 journey to work records by MSOA, National Travel Survey 2024 trip length information, and National Road Transport Projections 2022 (for goods vehicle kilometres travelled).
- Segment the all-travel-mode, MND-based, daily person trip OD movements into weekday periods for AM Peak 7am-10am, Inter Peak 10am-4pm, and PM Peak 4pm-7pm, for input to the SATURN matrix development procedure (see section 4.2).

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MND Geofence

3.2.4 The 'geofence' perimeter defines mobile network cells which lie within the area of focus. Hence MND movements which start, end, or pass through, cells within the geofence are assumed to be valid trip movements within the STM trip matrix, as follows:

- Trips which start and end inside the geofence – these are wholly internal movements included in the STM.
- Trips which start outside and end inside the geofence – these are external to internal movements included in the STM.
- Trips which start inside and end outside the geofence – these are internal to external movements included in the STM.
- Trips which start and end outside the geofence, but which pass through cells within the geofence – these are external to external movements which travel through the model area, and are included in the STM.
- Trips which start and end outside the geofence, and which do not pass through cells within the geofence – these are external to external movements which do not enter the model area are excluded from the STM.

3.3. Highway Links and Junctions

Network and Zoning Data

3.3.1 Information regarding road carriageway layouts, junction configurations, network connectivity and access to land use sites and neighbourhood zones is derived from three primary sources, namely:

- The earlier 2019 STM base year SATURN model;
- Google Maps and Google Streetview imagery; and
- OS Maps.

3.3.2 The zoning system used define trip OD polygons is based on the earlier 2019 version of the base year STM.

3.4. Network Use and Performance

3.4.1 Observations of network use and performance during a typical weekday and neutral month in 2023 are used to configure and validate the STM base year model. Data sources are assembled regarding highway network traffic flows, and route journey times, as described below.

Traffic Counts for Matrix Estimation and Assignment Validation

3.4.2 A large database of observed traffic flows is used in various parts of the STM. For the purpose of this LMVR all use of observed count data, to improve the model accuracy, is referred to as 'validation'. There is no separation of count datasets for undertaking matrix estimation, model calibration, and testing the STM assigned flow accuracy (validation). The rationale for this is to use as many counts as possible to develop the model, to improve its fit with observed conditions, and to check its final accuracy, rather than reserving counts, for separate validation, which could have been used to make the model more robust from the outset.

3.4.3 The collected counts are summarised as part of the assigned flow validation, in **Appendix A**. The counts consist of highway link passing counts and junction turning counts, including:

- Automatic Traffic Counters (ATC), from which average weekday hourly flows are calculated, from at least one week of data; and
- Manual Classified Counts (MCC), from which model hourly flows are derived, by vehicle category, from a single sample day.

3.4.4 All count surveys are from 2023. The analysed data has been checked for seasonality, and if necessary converted to represent flows in a neutral month, using observed seasonal adjustment factors.

3.4.5 Grouped traffic flow datasets have been assembled from the survey data, to capture directional vehicle movements in specific parts of the modelled area, including:

- Old Town New Town Screen-line – northbound and southbound;
- Purton To South Marston Screen-line – northbound and southbound;
- Swindon Central Screen-line – Eastbound and westbound;
- Upper Stratton To Coate Screen-line – Eastbound and westbound;
- Grange Park To Kingsdown Screen-line – northbound and southbound;
- Central Circular – Inbound and outbound;
- Suburban Circular – Inbound and outbound;
- Outer Circular – Inbound and outbound;
- Strategic roads – M4, A419, A4198, A420;
- Local sectors (1 – 18), in and around Swindon; and
- Town centre car park entries and exits.

3.4.6 The following figure shows the location of all traffic movement surveys used to develop the base year model, and to run matrix estimation on the prior trip matrix.

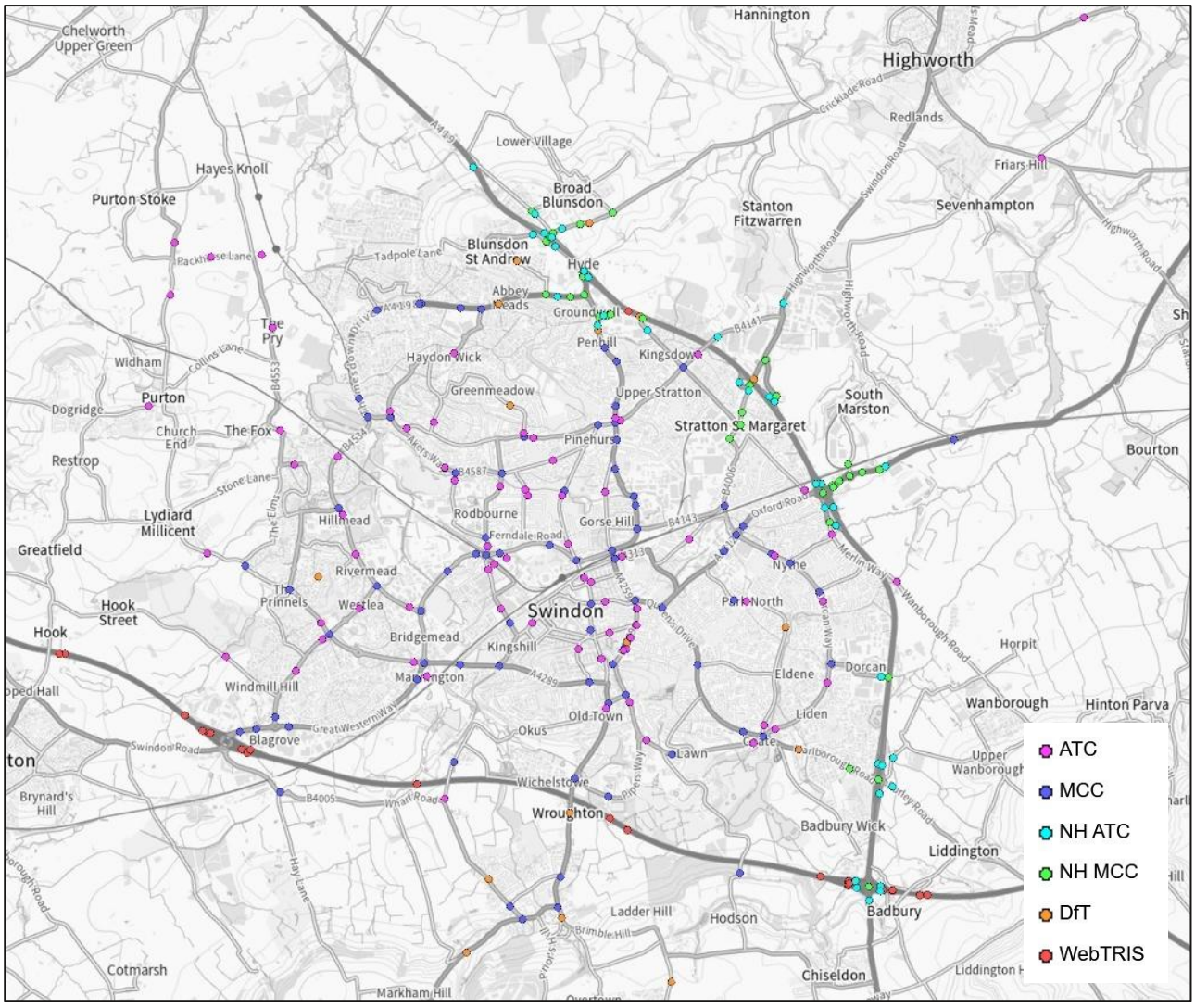


Figure 3-1: STM Traffic Count Survey Locations.

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3.4.7 The following figure shows the location of surveyed screen-lines and cordons used to validate the post-estimation trip matrix and to validate the STM base year assignments. The screen-lines and cordons are selected so that when flows through the component sites are combined, they measure total traffic movement from one part of the study area to another.

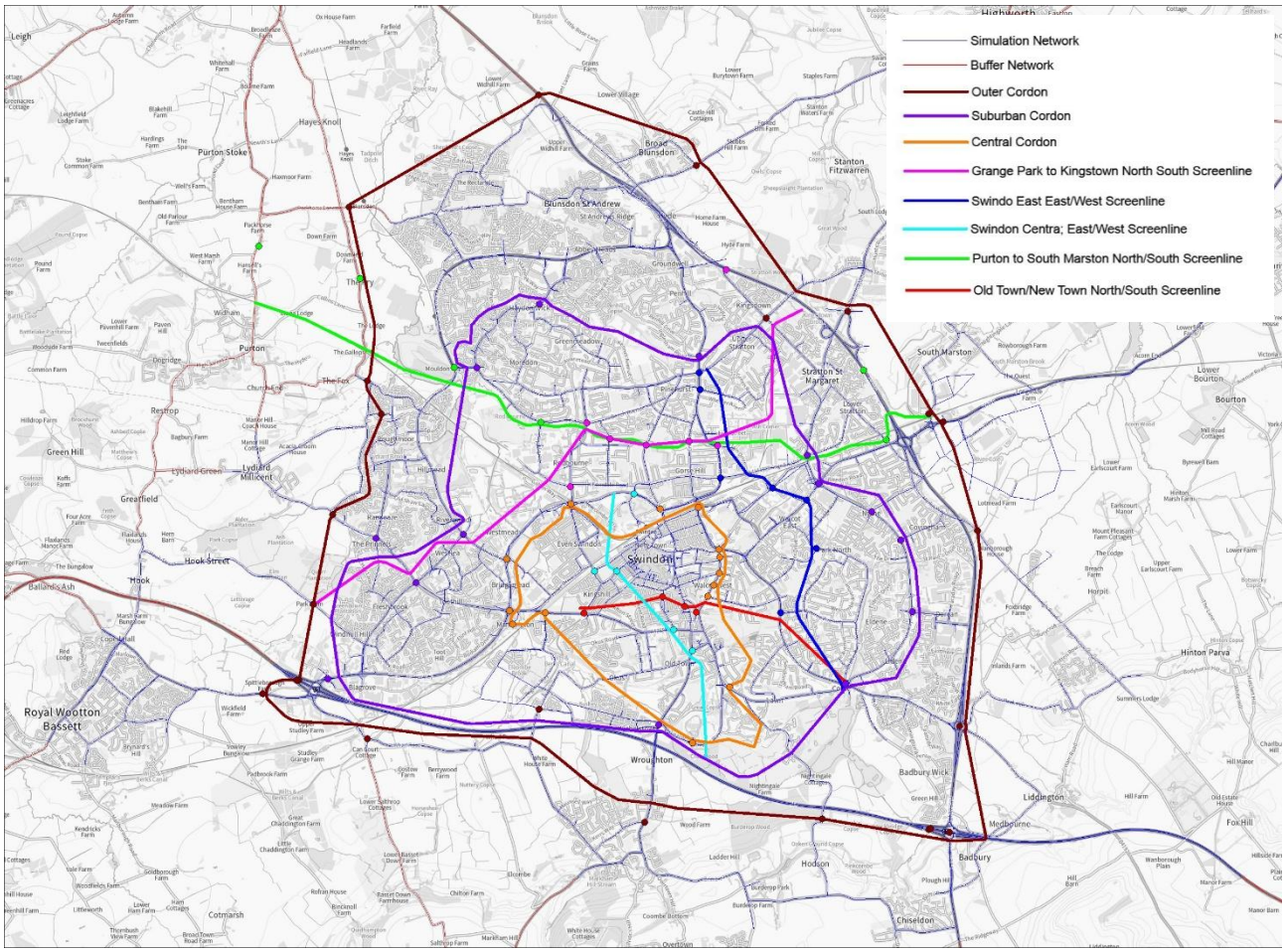


Figure 3-2: STM Traffic Movement Screen-Lines and Cordons.

3.4.8 The following figure shows the location of all individual traffic counts used to validate the STM base year assignments.

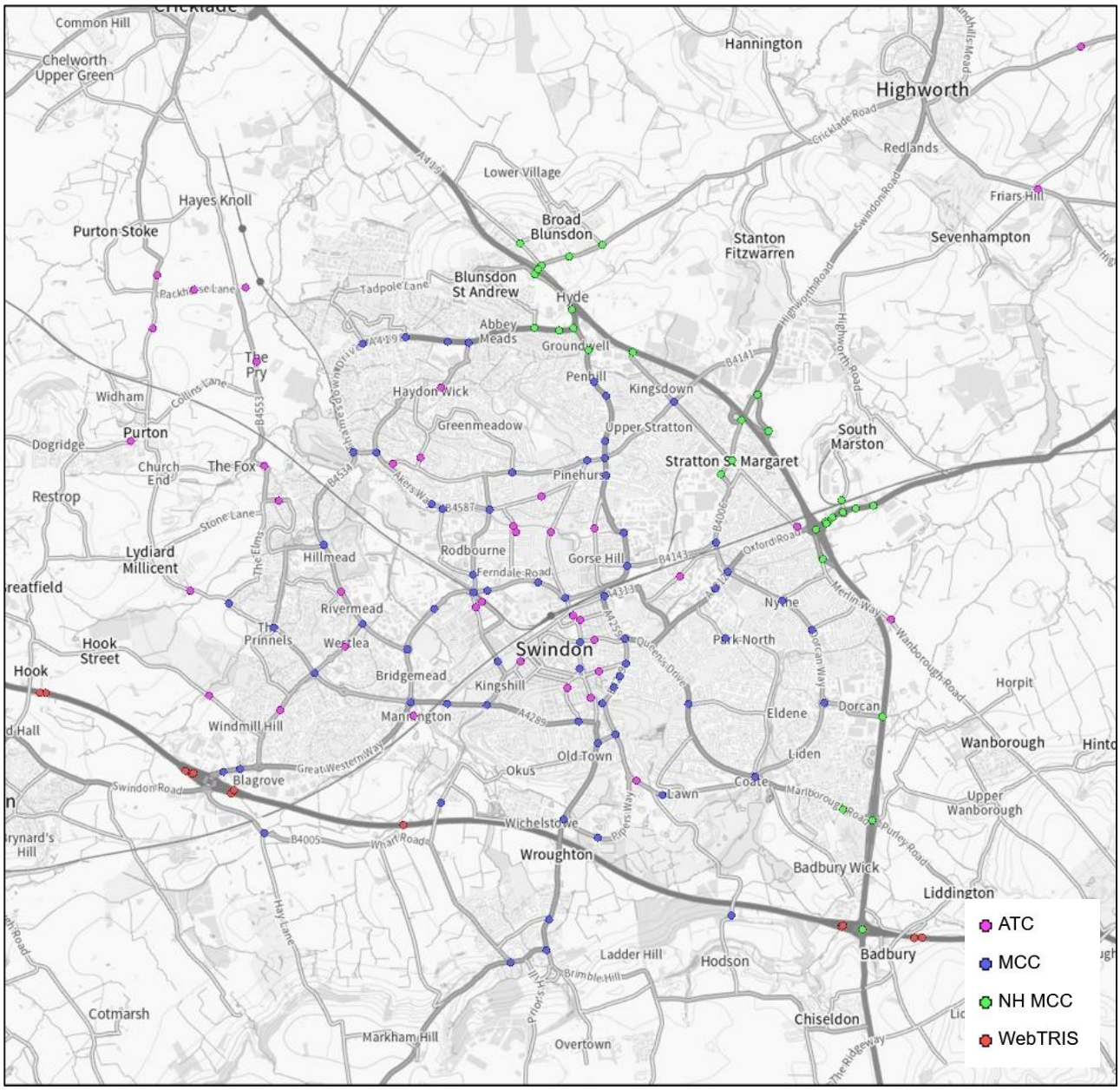


Figure 3-3: STM Traffic Counts for Assigned Flow Validation.

Journey Times for Assignment Validation

3.4.9 Typical vehicle travel times along STM network routes are derived from 'Trafficmaster' data, which were surveyed in 2023, and were provided by Teletrac Navman to SBC, via the DfT. Selection of journey time routes for validating the model is based on achieving good coverage of the area of focus and key road corridors. Data are used to inform coding of typical vehicle speeds in the SATURN network, and to test the accuracy of assigned travel times.

3.4.10 The following figure shows the position of surveyed journey time routes used to validate the STM base year assignments. Detailed timing points along each route are summarised as part of the assigned journey time validation, in **Appendix B**.

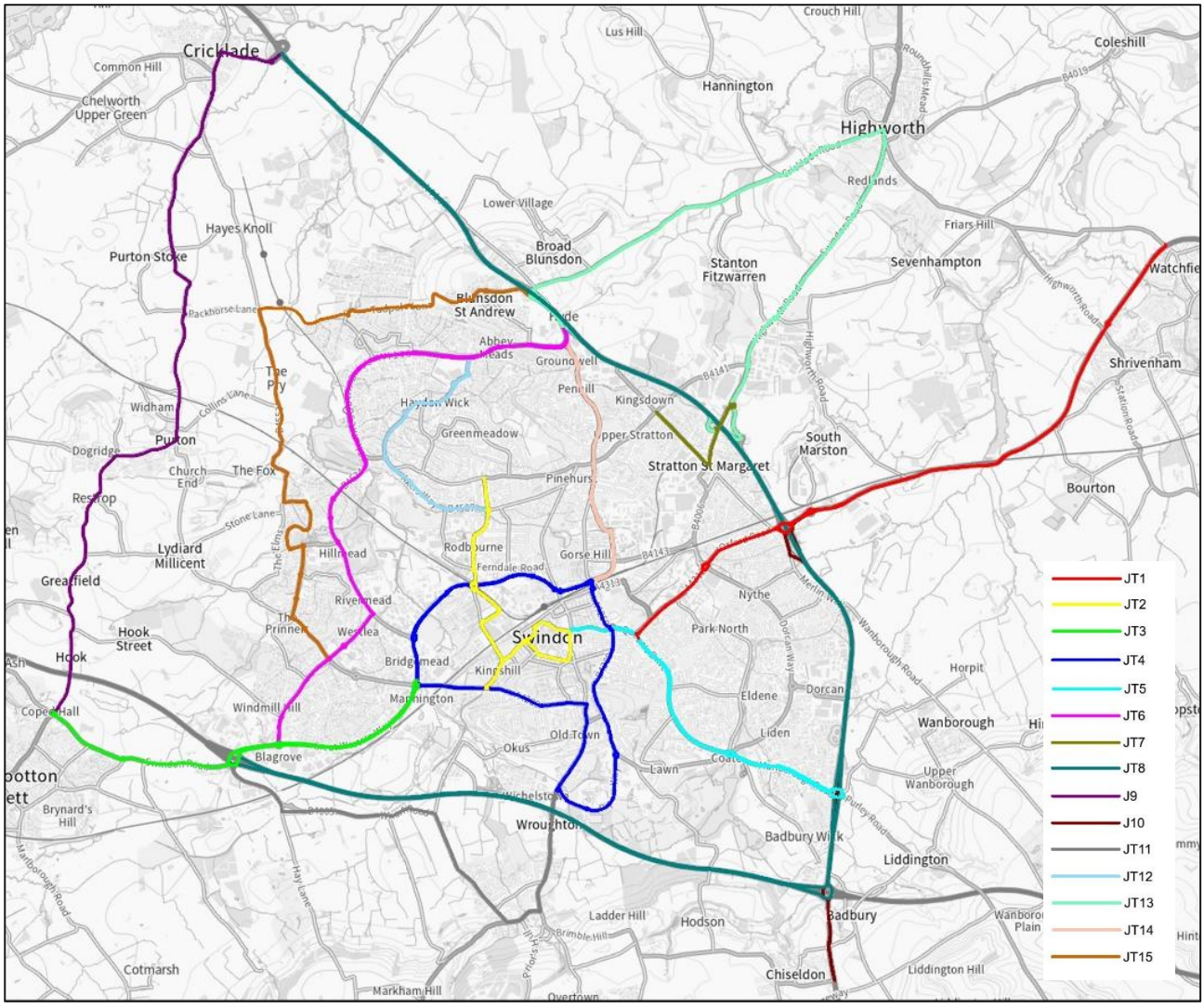


Figure 3-4: STM Surveyed Journey Time Routes for Assignment Validation.

4. Model Assembly

4.1. Introduction

4.1.1 This section explains how the data sources, in section 3, are harnessed to the STM format and function outlined in section 2, to assemble the base year 2023 model. The key elements of the model assembly are the trip matrix and the highway network, as described below.

4.2. Travel Demand – The Prior Trip Matrix

4.2.1 The procedure outlined in section 3.2, for capturing trip movement data for the STM, results in MND matrices, for weekday AM 7am-10am, Inter Peak 10am-4pm, and PM 4pm-7pm periods. In these expanded and verified MND matrices, person trip movements for all modes and purposes combined, are allocated to OD, which correspond with:

- Census MSOA in and around Swindon, inside the geofence;
- Local Authority Districts surrounding, but outside the geofence; and
- GB regions around the model periphery.

4.2.2 The MND matrices are refined to produce SATURN 'prior' matrices for assignment in the model. Creation of the STM prior trip matrices is a procedure which takes the verified MND trip matrices (outlined in section 3.2) and enhances them to:

- Reduce known weaknesses in the MND;
- Refine the MND matrix, to correspond with the more granular zoning system in the STM; and
- Make use of additional data sources to
  - Segment the aggregated person-trip MND into highway vehicles (and other travel modes, not included in the STM), model hour periods, journey purposes, and SATURN user classes;
  - Adjust, or merge with, the aggregated MND matrix, and infill partial gaps; and
  - Verify MND external to external movements which pass through the geofence.

Aggregation of MND Zones into MND Sectors

4.2.3 In places, the MND matrices are flawed by low trip samples and OD trip misallocation to MSOA, in comparison with expected demand from the National Trip End Model (NTEM 8.0) and local land use assessments. To improve the matrix reliability, flawed MND zones are grouped into broader MND sectors, which serve to:

- Introduce proxy MND movements where sampled trips are low (< 30% of expected volume), owing to poor mobile cell coverage, or scarcity of users under the selected MND provider; (this is preferable to over-factoring a small OD sample from one MSOA); and
- Smooth out MND movements which are misallocated to MSOA, owing to large mobile cells overlapping several MSOA; (this is preferable to manually re-allocating trips from one MSOA to another).

4.2.4 Applying the above principles, MND trips in the following MSOA are combined into MND sectors:

- Swindon 004, 006, 007;
- Swindon 011, 014;
- Swindon 026, 027;
- Wiltshire 001, 003; and
- Wiltshire 006, 007.

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4.2.5 Further enhancement of the MND, before input to the prior STM matrices, uses the following adjustment procedure and numbered, sequential steps:

- (1) Take MND aggregated all-purpose, all-mode, person trip matrices, segmented by MSOA and grouped MSOA (MND sectors), and by weekday periods, (AM 7am-10am, inter peak 10am-4pm, PM 4pm-7pm), as the primary input to the prior matrix;
- Use person trip end data from the TEMPro 8.1 database (i.e. from NTEM 8.0), at MSOA level, (split by mode, trip purpose and weekday period), as a control, to adjust MND OD trip ends as follows –
  - (2) To combine some flawed MND MSOA all-purpose and all-mode movements, from (1), into larger 'MND sectors', (i.e. introducing proxy OD for poorly sampled areas, and reducing MND trip misallocation, as explained earlier);
  - (4) To re-distribute trips in the synthesised 'MND sector' matrices (representing all purposes and modes, by weekday period), by applying a 'Furness' procedure, after first adjusting the TEMPro trip ends to include goods vehicles, from (3);
  - (7) To segment MND all-purpose matrices, by person modes and model AM/IP/PM hours, from (6), into commute, business and other journey purposes;
- Apply TRICS observed trip generation and attraction rates, applied to OS AddressBase land use details, to calculate hourly person trip profiles for each STM model zone, split by travel modes (including goods vehicles), which are then used to adjust MND OD trip ends as follows –
  - (3) To uplift TEMPro trip ends to include missing goods vehicle trips, which are then used to 'Furness' MND sectored trips, from (2), to all-modes;
  - (5) To adjust MND all-purpose, all-mode, weekday period trips, from (4), to model AM/IP/PM hours;
  - (6) To segment MND all-purpose, all-mode matrices, by model AM/IP/PM hours, from (5) into person mode types;
  - (8) To segment MND sector-level person trips, by purpose, mode and model AM/IP/PM hour, from (7), into STM zones.
  - (9) To convert STM person highway trips, by purpose, mode and model AM/IP/PM hour, from (8), into vehicles.
- (10) Segment the final STM vehicle trip matrices, by model hour, from (9), into SATURN User Classes, using proportions from car park survey data, which were collected in 2023;
  - This captures 11 permutations of vehicle type, (car, LGV, OGV), journey purpose (commute, business, other) and parking category (non-user, long stay, short stay); – noting that LGV and OGV are business, non-car-park users, only;
- (11) Use observed traffic flow heavy vehicle proportions, to convert STM vehicle trips, from (10), into Passenger Car Units (PCU).

4.2.6 The MSOA and grouped MSOA (MND Sector) zoning structure, which is used to enhance the processed MND records before transferring into the prior matrices, is shown below. MND Sectors inside the geofence are shown in the following figure.

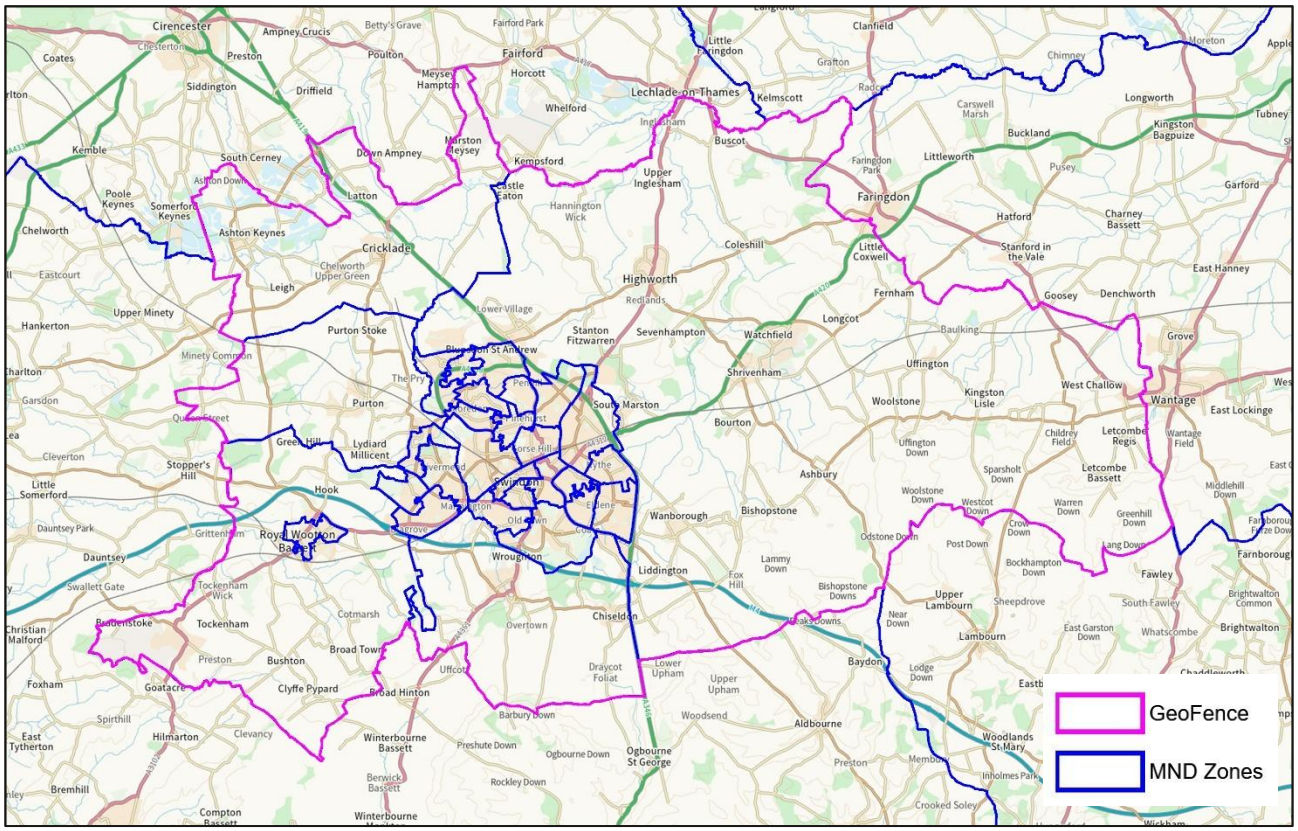


Figure 4-1: Sectoring of MND Zoning System (MSOA) Inside Geofence, for Prior Trip Matrix.

4.2.7 MND Sectors outside the geofence are shown in the following figure. This structure is identical to the external model zoning system shown previously.

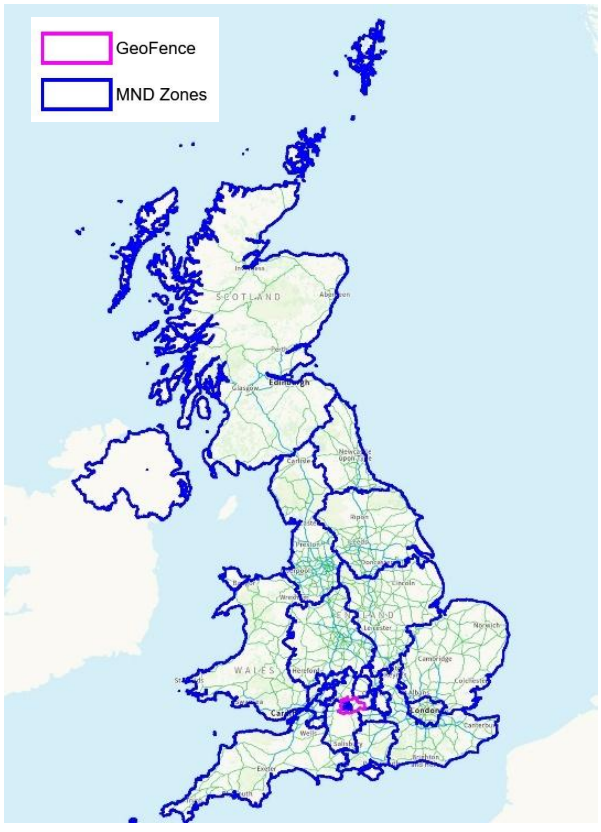


Figure 4-2: Sectoring of MND Zoning System (MSOA) Outside Geofence, for Prior Trip Matrix.

Testing The STM 'Prior' Trip Matrix

4.2.8 The prior matrices which are created for the STM AM, IP and PM models, using the above procedures, are assigned to the updated base year SATURN network. Then, TAG accuracy checks are undertaken, to establish if the prior model is reliable and gives a sufficiently good representation of the situation in 2023.

4.2.9 Since some shortcomings are present in the prior model and trip matrices, for each of the AM, IP and PM hourly periods, these are resolved using the SATURN Matrix Estimation (ME) facility, in accordance with TAG provisions..

4.3. Travel Demand – The Post-Estimation Trip Matrix

4.3.1 Matrix estimation (ME), in SATURN, is an iterative assignment procedure, which analyses how the loaded and routed OD movements from a prior matrix assignment correspond with counted traffic flows at specific points on the highway network. It then applies factors to the logical OD movements, by user class, (only where these exist in the prior assignment), based on the proportions of each OD movement which pass through a specific count site, to achieve a closer match between assigned OD movements and traffic counts. The procedure is strictly controlled, in accordance with TAG, using a combination of parameters and constraints.

4.3.2 The ME controls available for the STM are summarised below, with key parameter values noted:

- Prioritised ordering of counts in the estimation process, to match the most important movements last;
- Controlling the volume of OD movements permitted from, to and between model zones ('less than', 'equal to', or 'greater than', constraints);
- Seeding of OD matrix cells which contain zero trips in the prior matrix – (not used in STM);
- Limiting the 'XAMAX' factor which ME can apply to an OD movement in the prior matrix, during each iteration of the process;
  - An XAMAX value of 2.0 is used for STM, as this is the recommended maximum (SATURN Version 11.6 Manual, 2024);
- Requiring ME to match an overall total flow (or combined constraint, summed across several counted roads in a screen-line), by adjusting individual OD within that screen-line, without trying to match the individual counted flows; and
- Freezing certain origin or destination zones, or OD cells, to prevent ME from adjusting existing OD movements in the prior matrix – (not used in STM).

4.4. Traffic Counts for Matrix Estimation

4.4.1 Details of the traffic count data used for SATURN matrix estimation are described in Section 3, and in **Appendix A**.

4.4.2 Broadly, the same count dataset is sourced for undertaking matrix estimation as is used to test the STM assigned flow accuracy (validation). The rationale for this is to use as many counts as possible to develop the model, to improve its fit with observed conditions, and to check its final accuracy, rather than reserving counts, for separate validation, which could have been used to make the model more robust from the outset.

4.5. Post-Estimation Trip Matrix Validation

4.5.1 The final STM trip matrices, which are output from matrix estimation, are checked in two main respects:

- First, for their consistency with the prior matrices (to demonstrate that ME does not make excessive changes to the observed and refined trip movement data); and
- Second, for their replication of counted flows, when assigned on to the STM network (to demonstrate that the matrix contains realistic trip OD movements, as indicated by a close match with observed traffic volumes across the validation screen-lines; this accuracy check is documented in chapter 5.3).

Change in Matrix Zone-to-Zone Trips In Post-Estimation Trip Matrices

4.5.2 The following table summarises the similarity between the post-estimation matrices and the prior matrices, for each of the STM three scenarios, in terms of individual OD zone-to-zone trips analysed in a regression plot.

MODEL PERIOD	VEHICLE TYPE	REGRESSION SLOPE REQUIRED SLOPE 0.98 – 1.02	INTERCEPT REQUIRED INTERCEPT NEAR 0	R^2 REQUIRED $R^2 > 0.95$
AM Peak Hour 8am – 9am	Car	0.97	0.02	0.92
AM Peak Hour 8am – 9am	LGV	1.09	-0.01	0.92
AM Peak Hour 8am – 9am	HGV	0.96	0.00	0.96
AM Peak Hour 8am – 9am	All Veh	1.00	0.00	0.95
Average Inter Peak Hour 10am – 4pm	Car	0.92	0.01	0.95
Average Inter Peak Hour 10am – 4pm	LGV	1.04	0.00	0.94
Average Inter Peak Hour 10am – 4pm	HGV	0.98	0.00	0.99
Average Inter Peak Hour 10am – 4pm	All Veh	0.96	0.00	0.97
PM Peak Hour 4pm – 5pm	Car	1.04	-0.02	0.93
PM Peak Hour 4pm – 5pm	LGV	1.10	-0.01	0.97
PM Peak Hour 4pm – 5pm	HGV	0.75	0.00	0.97
PM Peak Hour 4pm – 5pm	All Veh	1.01	-0.01	0.96

Table 4-1: STM Post-estimation Trip Matrix OD Cell Comparison Against Prior Matrix – Regression Analysis.

4.5.3 The table shows that the changes to zone-to-zone trip movements, in the STM prior matrices, which are caused by applying matrix estimation, are largely acceptable in terms of TAG regression criteria.

- Considering all vehicle types combined, the required regression slope is achieved in the Morning and Evening, but is slightly low in the Inter-Peak;
- For all vehicles combined, the required intercept and R2 value are achieved in all model periods.

4.5.4 Regression plots of the change in OD trips, before and after matrix estimation, are shown in **Appendix C**.

Change in Matrix Origin Zone Trip Departures In Post-Estimation Trip Matrices

4.5.5 The following table summarises the similarity between the post-estimation matrices and the prior matrices, for each of the STM scenarios, in terms of trip departures from each origin zone analysed in a regression plot.

MODEL PERIOD	VEHICLE TYPE	REGRESSION SLOPE REQUIRED SLOPE 0.99 – 1.01	INTERCEPT REQUIRED INTERCEPT NEAR 0	R^2 REQUIRED $R^2 > 0.98$
AM Peak Hour 8am – 9am	Car	1.02	-0.78	0.96
AM Peak Hour 8am – 9am	LGV	1.01	-0.86	0.97
AM Peak Hour 8am – 9am	HGV	0.99	-0.05	0.97
AM Peak Hour 8am – 9am	All Veh	1.01	-1.15	0.97
Average Inter Peak Hour 10am – 4pm	Car	0.96	1.92	0.97
Average Inter Peak Hour 10am – 4pm	LGV	0.97	-0.27	0.96
Average Inter Peak Hour 10am – 4pm	HGV	0.98	0.01	0.99
Average Inter Peak Hour 10am – 4pm	All Veh	0.96	1.80	0.98
PM Peak Hour 4pm – 5pm	Car	1.02	-3.85	0.97
PM Peak Hour 4pm – 5pm	LGV	1.05	-1.51	0.98
PM Peak Hour 4pm – 5pm	HGV	0.83	0.76	0.97
PM Peak Hour 4pm – 5pm	All Veh	1.02	-5.27	0.98

Table 4-2: STM Post-estimation Trip Matrix Origin Zone Comparison Against Prior Matrix – Regression Analysis.

4.5.6 The table shows that the changes to origin zone departure trips, in the prior matrices, which are caused by applying matrix estimation, are slightly larger than recommended in terms of TAG regression criteria.

- Considering all vehicle types combined, the required regression slope is achieved in the Morning Peak, but is slightly low in the Inter-Peak, and slightly high in the Evening;
- For all vehicles combined, the intercept is slightly low in the Morning Peak, slightly high in the Inter-Peak, and is excessively low in the Evening Peak;
- For all vehicles combined, the R^2 is slightly low in the Morning Peak but is acceptable in the Inter and Evening Peaks.

4.5.7 Regression plots of the change in origin zone trip departures, before and after matrix estimation, are shown in **Appendix C**.

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Change in Matrix Destination Zone Trip Arrivals In Post-Estimation Trip Matrices

4.5.8 The following table summarises the similarity between the post-estimation matrices and the prior matrices, for each of the STM scenarios, in terms of trip arrivals at each destination zone analysed in a regression plot.

Model Period	Vehicle Type	Regression Slope Required slope 0.99 – 1.01	Intercept Required intercept near 0	R^2 Required $R^2 > 0.98$
AM Peak Hour 8am – 9am	Car	1.00	1.92	0.96
AM Peak Hour 8am – 9am	LGV	1.02	-1.01	0.96
AM Peak Hour 8am – 9am	HGV	0.95	0.40	0.95
AM Peak Hour 8am – 9am	All Veh	1.00	1.29	0.97
Average Inter Peak Hour 10am – 4pm	Car	1.00	-1.86	0.97
Average Inter Peak Hour 10am – 4pm	LGV	0.99	-0.61	0.96
Average Inter Peak Hour 10am – 4pm	HGV	0.98	-0.03	1.00
Average Inter Peak Hour 10am – 4pm	All Veh	0.99	-1.95	0.98
PM Peak Hour 4pm – 5pm	Car	1.02	-3.84	0.97
PM Peak Hour 4pm – 5pm	LGV	0.98	-0.52	0.98
PM Peak Hour 4pm – 5pm	HGV	0.83	0.75	0.96
PM Peak Hour 4pm – 5pm	All Veh	1.01	-4.01	0.98

Table 4-3: STM Post-estimation Trip Matrix Destination Zone Comparison Against Prior Matrix – Regression Analysis.

4.5.9 The table shows that the changes to destination zone arrival trips, in the prior matrices, which are caused by applying matrix estimation, are slightly larger than recommended in terms of TAG regression criteria.

- Considering all vehicle types combined, the required regression slope is achieved in all scenarios;
- For all vehicles combined, the intercept is slightly high in the Morning Peak, slightly low in the Inter-Peak, and is excessively low in the Evening Peak;
- For all vehicles combined, the R^2 is slightly low in the Morning Peak but is acceptable in the Inter and Evening Peaks.

4.5.10 Regression plots of the change in destination zone trip arrivals, before and after matrix estimation, are shown in **Appendix C**.

Conclusions from regression Analyses

4.5.11 The regression analyses shows that, although the overall alignment between matrices remains broadly consistent, some of the TAG recommended thresholds for slope, intercept and R^2 are not fully achieved for certain vehicle types and time periods. These variations are expected and are explained by the flaws in the data used to build the prior matrices, and the procedures used to convert that data into a form suitable for the STM detailed assignment.

4.5.12 The variations from TAG criteria arise from well-understood limitations in MND, and from the processing required to convert MND into detailed, multi-vehicle, multi-purpose matrices. These limitations mean that some

adjustment during matrix estimation is both expected and appropriate. The post-estimation matrices provide an accurate representation of observed traffic conditions and are considered fit for purpose.

Change in Trip Length Distribution In Post-Estimation Trip Matrices

4.5.13 The following table summarises the similarity between the post-estimation matrices and the prior matrices, for each of the STM scenarios, in terms of change in mean trip length.

MODEL PERIOD	MEAN TRIP LENGTH (ALL VEHICLES) – KM			
	PRE-ESTIMATION	POST-ESTIMATION	CHANGE WITH ME	% CHANGE WITH ME REQUIRED WITHIN ±5%
AM Peak Hour 8am – 9am	37.68	37.78	0.09	0.25%
Average Inter Peak Hour 10am – 4pm	51.79	51.66	-0.13	-0.26%
PM Peak Hour 4pm – 5pm	45.82	43.29	-2.53	-5.52%

Table 4-4: STM Post-estimation Trip Matrix Comparison Against Prior Matrix – Change in Mean Trip Length.

4.5.14 The analysis in Table 4-4 shows that the changes to all-vehicle average trip lengths, in the STM AM, IP and PM prior matrices, which are caused by applying matrix estimation, are broadly acceptable in terms of the TAG required maximum change of ±5%.

- The average change in trip length in the AM and IP models is within ±0.5%; and
- The average change in trip length in the PM model is within ±6.0%.

4.5.15 Table 4-5 summarises the similarity between the post-estimation matrices and the prior matrices, for each of the STM scenarios, in terms of change in the trip length standard deviation.

MODEL PERIOD	TRIP LENGTH STANDARD DEVIATION (ALL VEHICLES) – KM			
	PRE-ESTIMATION	POST-ESTIMATION	CHANGE WITH ME	% CHANGE WITH ME REQUIRED WITHIN ±5%
AM Peak Hour 8am – 9am	77.58	77.64	0.06	0.08%
Average Inter Peak Hour 10am – 4pm	96.73	96.51	-0.22	-0.23%
PM Peak Hour 4pm – 5pm	88.44	85.43	-3.01	-3.40%

Table 4-5: STM Post-estimation Trip Matrix Comparison Against Prior Matrix – Change in Trip Length Standard Deviation.

4.5.16 The table shows that the changes to all-vehicle trip length standard deviation, in the prior matrices, which are caused by applying matrix estimation, are acceptable in terms of the TAG required maximum change of ±5%.

- The average change in trip length in the AM and IP models is within ±0.5%; and
- The average change in trip length in the PM model is within ±4.0%.

4.5.17 Trip length distribution plots, before and after matrix estimation, are shown in **Appendix D**.

Change in Sector to Sector Movements In Post-Estimation Trip Matrices

4.5.18 The post-estimation and prior STM trip matrices are consolidated into five origin and destination sectors, to enable simple analysis of the change in coarse OD movements after matrix estimation. The location of the sectors is shown in the following figure.

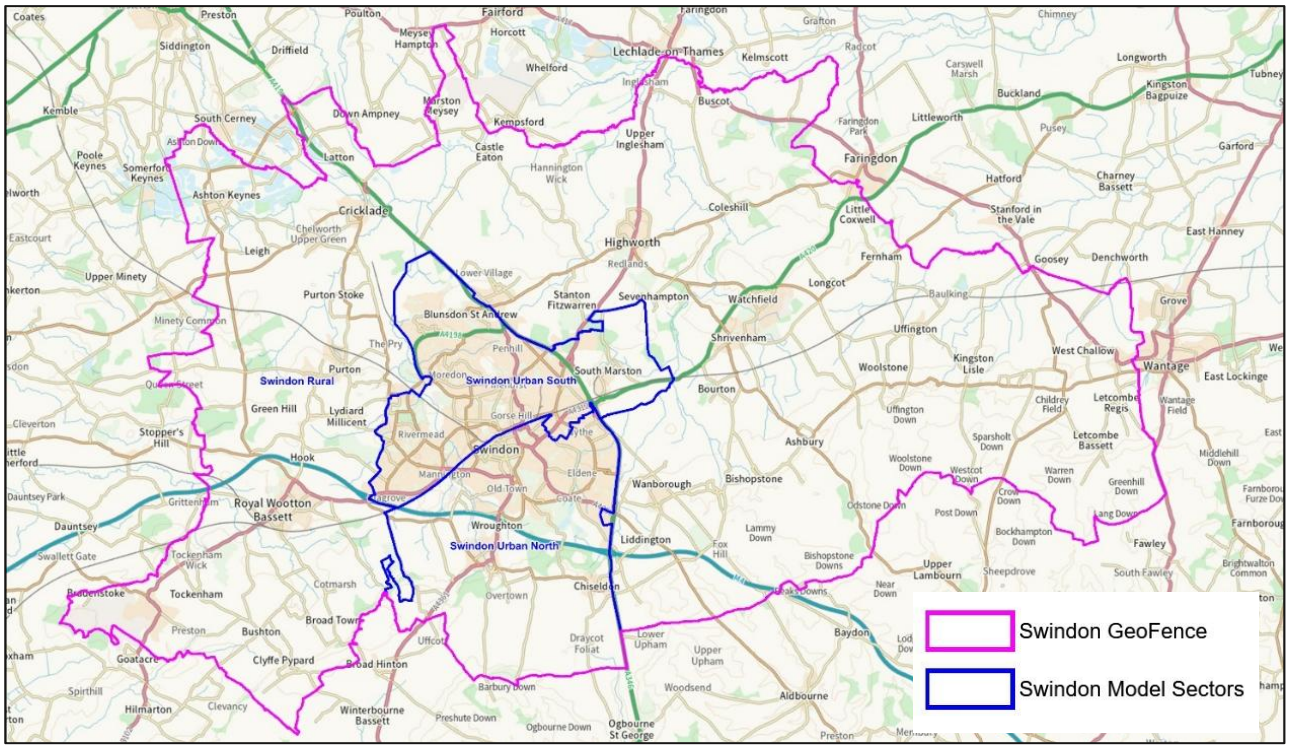


Figure 4-3: STM Trip Matrix: Sectors 1 – 3 Inside Geofence, for Analysing Matrix Changes Post vs Pre Estimation.

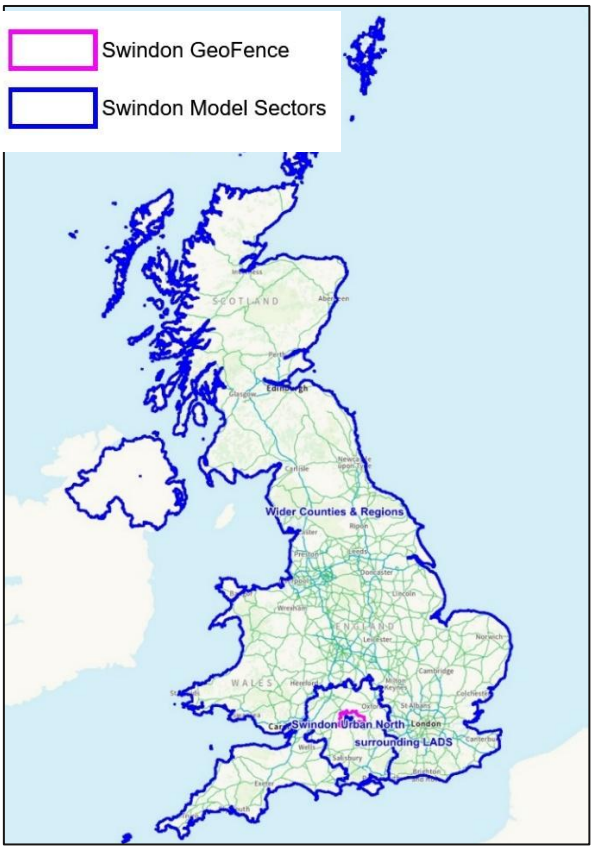


Figure 4-4: STM Trip Matrix: Sectors 4 – 5 Outside Geofence, for Analysing Matrix Changes Post vs Pre Estimation.

4.5.19 The following tables summarise the similarity between the post-estimation matrices and the prior matrices, for each of the STM scenarios, in terms of the percentage change in trip movements after matrix estimation, between five sectors.

AM Peak: % Change in Trips [Post-Estimation Matrix – Prior Matrix] / Prior Matrix					
Car	To				
From	(1) Swindon Urban South	(2) Swindon Urban North	(3) Swindon Rural	(4) Surrounding LADS	(5) Wider Counties/Regions
(1) Swindon Urban South	-3%	-11%	12%	1%	-18%
(2) Swindon Urban North	-9%	2%	4%	-2%	-6%
(3) Swindon Rural	14%	8%	-4%	-9%	-17%
(4) Surrounding LADS	21%	2%	-18%	-1%	0%
(5) Wider Counties/Regions	14%	11%	-9%	4%	-3%
LGV	To				
From	(1) Swindon Urban South	(2) Swindon Urban North	(3) Swindon Rural	(4) Surrounding LADS	(5) Wider Counties/Regions
(1) Swindon Urban South	2%	2%	34%	4%	-8%
(2) Swindon Urban North	19%	3%	21%	22%	8%
(3) Swindon Rural	23%	2%	-11%	-9%	-16%
(4) Surrounding LADS	27%	9%	-10%	-8%	-5%
(5) Wider Counties/Regions	28%	31%	-4%	-5%	-17%
HGV	To				
From	(1) Swindon Urban South	(2) Swindon Urban North	(3) Swindon Rural	(4) Surrounding LADS	(5) Wider Counties/Regions
(1) Swindon Urban South	-1%	-17%	59%	38%	56%
(2) Swindon Urban North	-10%	-16%	1%	23%	55%
(3) Swindon Rural	29%	-21%	-3%	21%	36%
(4) Surrounding LADS	52%	-20%	1%	1%	5%
(5) Wider Counties/Regions	66%	-3%	14%	7%	3%
All Vehicles	To				
From	(1) Swindon Urban South	(2) Swindon Urban North	(3) Swindon Rural	(4) Surrounding LADS	(5) Wider Counties/Regions
(1) Swindon Urban South	-3%	-10%	15%	4%	-12%
(2) Swindon Urban North	-7%	1%	6%	7%	5%
(3) Swindon Rural	15%	5%	-4%	-6%	-12%
(4) Surrounding LADS	24%	-2%	-14%	-2%	0%
(5) Wider Counties/Regions	20%	11%	-5%	3%	-3%

Table 4-6: STM Post-estimation Trip Matrix Sector-to-Sector Comparison Against Prior Matrix – Morning Peak Model.

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Inter Peak: % Change in Trips [Post-Estimation Matrix – Prior Matrix] / Prior Matrix					
Car	To				
From	(1) Swindon Urban South	(2) Swindon Urban North	(3) Swindon Rural	(4) Surrounding LADS	(5) Wider Counties/Regions
(1) Swindon Urban South	9%	-2%	14%	10%	1%
(2) Swindon Urban North	-1%	3%	2%	10%	9%
(3) Swindon Rural	0%	4%	-5%	-7%	-25%
(4) Surrounding LADS	13%	10%	-4%	-2%	-1%
(5) Wider Counties/Regions	13%	24%	0%	-2%	5%
LGV	To				
From	(1) Swindon Urban South	(2) Swindon Urban North	(3) Swindon Rural	(4) Surrounding LADS	(5) Wider Counties/Regions
(1) Swindon Urban South	10%	16%	44%	22%	20%
(2) Swindon Urban North	6%	5%	2%	16%	30%
(3) Swindon Rural	15%	6%	-12%	-4%	-10%
(4) Surrounding LADS	17%	22%	-4%	5%	-5%
(5) Wider Counties/Regions	17%	39%	-1%	-4%	-10%
HGV	To				
From	(1) Swindon Urban South	(2) Swindon Urban North	(3) Swindon Rural	(4) Surrounding LADS	(5) Wider Counties/Regions
(1) Swindon Urban South	3%	-2%	6%	19%	33%
(2) Swindon Urban North	-1%	-7%	-8%	0%	8%
(3) Swindon Rural	4%	-3%	-2%	5%	6%
(4) Surrounding LADS	18%	9%	7%	7%	3%
(5) Wider Counties/Regions	18%	17%	13%	8%	1%
All Vehicles	To				
From	(1) Swindon Urban South	(2) Swindon Urban North	(3) Swindon Rural	(4) Surrounding LADS	(5) Wider Counties/Regions
(1) Swindon Urban South	9%	0%	18%	13%	7%
(2) Swindon Urban North	0%	2%	1%	8%	12%
(3) Swindon Rural	2%	3%	-5%	-5%	-19%
(4) Surrounding LADS	14%	12%	-3%	2%	-1%
(5) Wider Counties/Regions	14%	25%	1%	1%	2%

Table 4-7: STM Post-estimation Trip Matrix Sector-to-Sector Comparison Against Prior Matrix – Inter-Peak Model.

GENERAL

PM Peak: % Change in Trips [Post-Estimation Matrix – Prior Matrix] / Prior Matrix					
Car	To				
From	(1) Swindon Urban South	(2) Swindon Urban North	(3) Swindon Rural	(4) Surrounding LADS	(5) Wider Counties/Regions
(1) Swindon Urban South	6%	-3%	32%	18%	4%
(2) Swindon Urban North	2%	1%	19%	-2%	-9%
(3) Swindon Rural	6%	17%	-3%	-18%	-19%
(4) Surrounding LADS	4%	4%	-12%	-8%	-12%
(5) Wider Counties/Regions	-12%	-4%	-23%	-12%	-16%
LGV	To				
From	(1) Swindon Urban South	(2) Swindon Urban North	(3) Swindon Rural	(4) Surrounding LADS	(5) Wider Counties/Regions
(1) Swindon Urban South	14%	15%	24%	21%	32%
(2) Swindon Urban North	10%	7%	29%	23%	38%
(3) Swindon Rural	13%	15%	-7%	0%	14%
(4) Surrounding LADS	10%	9%	2%	-13%	-10%
(5) Wider Counties/Regions	-4%	8%	-8%	-14%	-13%
HGV	To				
From	(1) Swindon Urban South	(2) Swindon Urban North	(3) Swindon Rural	(4) Surrounding LADS	(5) Wider Counties/Regions
(1) Swindon Urban South	34%	-9%	-5%	76%	130%
(2) Swindon Urban North	-11%	-11%	-15%	-14%	4%
(3) Swindon Rural	35%	-5%	-15%	25%	17%
(4) Surrounding LADS	103%	-4%	12%	-10%	16%
(5) Wider Counties/Regions	131%	11%	-5%	9%	34%
All Vehicles	To				
From	(1) Swindon Urban South	(2) Swindon Urban North	(3) Swindon Rural	(4) Surrounding LADS	(5) Wider Counties/Regions
(1) Swindon Urban South	7%	-2%	31%	20%	9%
(2) Swindon Urban North	3%	1%	19%	-1%	-3%
(3) Swindon Rural	6%	16%	-3%	-14%	-14%
(4) Surrounding LADS	7%	4%	-9%	-9%	-6%
(5) Wider Counties/Regions	-8%	-1%	-20%	-8%	-5%

Table 4-8: STM Post-estimation Trip Matrix Sector-to-Sector Comparison Against Prior Matrix – Evening Model.

GENERAL

4.5.20 In terms of the percentage change in STM trip movements, at a sector level, the above tables show the following:

- For all vehicle types combined, trips which are internal to the Swindon BC area of focus (urban south, urban north, and rural) do not change substantially through matrix estimation; here, changes are within ±20% in all models, except in Evening Peak Scenario from urban south to rural (+31%);
- This suggests that the overall volumes of vehicle trips, within the area of focus, are reasonably accurate before and after matrix estimation, although the proportionate split of vehicle types does change, and is probably less reliable in the prior matrix;
- Overall there are larger changes after matrix estimation than the preferred limit of ±5%.

4.5.1 Changes in sector-to-sector trip volumes, before and after matrix estimation, are shown in **Appendix E**.

4.6. Transport Supply – The Model Highway Network

4.6.1 The configuration of the STM highway network is largely unchanged from the most recent previous version of the model (base year 2019).

Network Configuration and Parameters

4.6.2 After extensive checking of the network coding, no substantial revisions are required to any of the following:

- Network connectivity and route choices between OD zones;
- Simulation links – carriageway types, distances, saturation flows, and speeds.
- Simulation nodes – junction types, permitted turns, turn priorities, lane allocations, turn saturation flows, gap acceptances, merges, diverges and weaving sections
- Traffic signal locations stages, green splits, intergreens, cycle times, and pedestrian phases;
- Buffer links – carriageway types, distances, saturation flows, and speed / flow / capacity indices;
- Movement bans and penalties; and
- Network fixed flows of buses.

4.6.3 The only significant modifications made to the previous STM SATURN network are in respect of:

- Internal zone centroid connectors;
- Town centre car park node and link configurations, user class penalties, and walk links to final destination zones; and
- External zones and centroid connectors.

Car Park Sub-Model

4.6.4 The town centre car park sub-model is retained, largely unchanged, from the earlier 2019 version of the STM. The purpose of the sub-model is to represent more accurately the movement of vehicles within the town centre. It captures the significant influence which car park positioning and capacity exerts on the routing of traffic. Car parks are intermediate points, which incoming drivers pass through on the way to their final destinations, distorting the direct OD routes, to which SATURN would otherwise assign the trips.

4.6.5 In simplified terms, the car park sub-model introduces additional nodes and links that designated public long stay, and short stay, car park users must pass along, to reach a walk link to their ultimate destination zone. These additional nodes and links represent the town centre car parks and have certain attributes which define their size, capacity, charge penalty, and occupancy / available spaces, during the STM modelled hours.

4.6.6 For public car park non-users, (i.e. those using on-street and private parking, or dropping off), there are alternative, direct links, which access the same ultimate destination zones. These direct links represent the normal town centre highway network.

4.6.7 The model controls which assigned vehicles use which network links by designating distinct user classes. These user classes differentiate vehicle types, journey purposes and car park long stay / short stay / non-users.

4.6.8 An indicative diagram of the car park sub-model is shown in the following figure (reproduced from the STM 2014 LMVR).

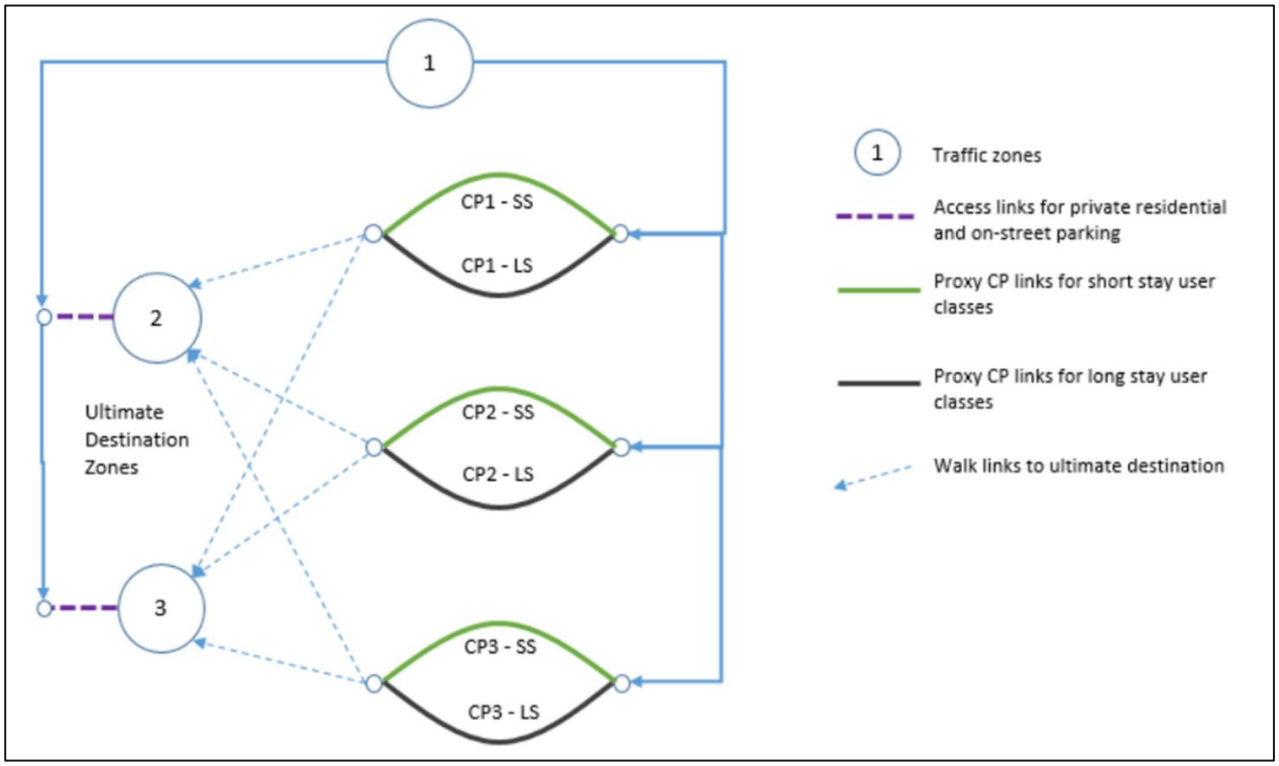


Figure 4-5: STM Town Centre Car Park Sub-Model.

4.6.9 The only slight changes made to the car park sub-model for the 2023 STM are to ensure that:

- All town centre zones are connected to car parks, via walk links; and
- User class access to town centre zones is via the correct type of car park nodes and links (long stay, short stay, users), or via car park non-user-only links and nodes.

5. Model Testing

5.1. Introduction

5.1.1 This section of the Report describes the tests undertaken on various aspects of the STM, to confirm that the base year model is functional, accurate and reliable. The scope of these tests is outlined in Section 2.

5.2. Model Functionality (Verification)

5.2.1 Outcomes from the model functionality tests, and verification of the STM inputs are summarised below.

5.2.2 Principal inputs for the STM were verified, to check that they were captured correctly and could be harnessed satisfactorily in the SATURN model. The functionality tests comprised the following:

- Network coding –
  - Network connectivity checks;
  - Link distance, travel time and speed checks;
  - Link speed flow capacity index checks;
  - Junction turning lane allocations;
  - Junction turning saturation flow checks;
  - Junction traffic signal timing checks;
- Zone accesses –
  - Checks for zone centroids that are modelled as accessing all of a zone, but which in reality do not connect with some parts of that zone;
  - Checks for zone centroids that are modelled as accessing only one zone, but which in reality also connect with nearby zones;
  - Checks for zones that are modelled as being connected to multiple centroids, even though SATURN will only assign trips through one of these accesses, which indicates that the zone should be split;
- Car park representation –
  - Checks to ensure all town centre zones are connected to car parks, via walk links;
  - Checks to ensure user class access to town centre zones is via the correct type of car park (long stay, short stay, or not public car park);
- Assignment parameters –
  - Value of travel time and value of distance-related vehicle operation, checked for consistency with TAG Data Book v2.01 (May 2025);

5.3. Model Accuracy (Validation)

5.3.1 Outcomes from the model accuracy tests, and validation of the STM base year assignment outputs are summarised below.

Validation of Assigned Traffic Flows and Post-Estimation Trip Matrices

5.3.2 A summary is provided below regarding STM performance against DfT TAG traffic flow validation requirements. This is an accuracy test for the base year model assignments, in terms of traffic flows passing through specific links and junctions, and for the post-estimation trip matrices, in terms of total traffic flows across each of 8 screen-lines, comprising 16 directional movements. It compares modelled traffic flows against observed counts.

5.3.3 Detailed comparisons of modelled and observed vehicle flows, at each count location, and by each count group, are summarised in **Appendix F**.

Morning Peak

5.3.4 The following table shows the model accuracy achieved in the Morning Peak, separately for cars, LGV, HGV, and all vehicles, respectively.

TEST	ASPECT	CRITERIA	ACHIEVING TAG CRITERIA	CAR		LGV		HGV		ALL VEH	
				NO.	%	NO.	%	NO.	%	NO.	%
1.	Difference between total modelled flows and counts (in screen line).	<5% (±) for >95% of screen lines.	Yes	15	94	12	75	13	81	16	100
			No	1		4		3		0	
2a.	Individual flows within 100 veh/h for flows less than 700 veh/h.	>85% of cases.	Yes	983	92	1,268	100	1,269	100	911	92
			No	81		1		0		82	
2b.	Individual flows within 15% for flows from 700 to 2,700 veh/h.	>85% of cases.	Yes	183	89	–	–	–	–	243	89
			No	22		–		–		30	
2c.	Individual flows within 400 veh/h for flows more than 2,700 veh/h.	>85% of cases.	Yes	–	–	–	–	–	–	3	100
			No	–		–		–		0	
3.	GEH < 5 for individual flows.	>85% of cases.	Yes	1,080	85	1,241	98	1,268	100	1,059	83
			No	189		28		1		210	
2 or 3.	Traffic flow range or GEH.	Either of the criteria	Yes	1,176	93	1,268	100	1,269	100	1,167	92
			No	93		1		0		102	

Table 5-1: STM Assigned Traffic Flow Validation – Morning Peak

5.3.5 The morning peak model satisfies the accuracy tests for Cars, for individual assigned flows (93%), and almost meets the requirement for screen-line flows (94%). The model satisfies the accuracy tests for LGV, for individual assigned flows (100%), but falls short of the requirement for screen-line flows (75%). The model satisfies the accuracy tests for HGV, for individual assigned flows (100%), but falls short of the requirement for screen-line flows (81%). The model satisfies the accuracy tests for all vehicles combined, for both individual assigned flows (92%), and for screen-line flows (100%).

Inter Peak Model

5.3.6 The following table shows the model accuracy achieved in the Inter-Peak, separately for cars, LGV, HGV, and all vehicles, respectively.

TEST	ASPECT	CRITERIA	ACHIEVING TAG CRITERIA	CAR		LGV		HGV		ALL VEH	
				NO.	%	NO.	%	NO.	%	NO.	%
1.	Difference between total modelled flows and counts (in screen line).	<5% (±) for >95% of screen lines.	Yes	16	100	14	88	10	63	16	100
			No	0		2		6		0	
2a.	Individual flows within 100 veh/h for flows less than 700 veh/h.	>85% of cases.	Yes	1,121	96	1,265	100	1,269	100	1,041	95
			No	50		4		0		52	
2b.	Individual flows within 15% for flows from 700 to 2,700 veh/h.	>85% of cases.	Yes	88	90	–	–	–	–	150	85
			No	10		–		–		26	
2c.	Individual flows within 400 veh/h for flows more than 2,700 veh/h.	>85% of cases.	Yes	–	–	–	–	–	–	–	–
			No	–		–		–		–	
3.	GEH < 5 for individual flows.	>85% of cases.	Yes	1,113	88	1,232	97	1,251	99	1,074	85
			No	156		37		18		195	
2 or 3.	Traffic flow range or GEH.	Either of the criteria	Yes	1,218	96	1,265	100	1,269	100	1,200	95
			No	51		4		0		69	

Table 5-2: STM Assigned Traffic Flow Validation – Inter-Peak

5.3.7 The inter peak model satisfies the accuracy tests for Cars, for both individual assigned flows (96%), and for screen-line flows (100%). The model satisfies the accuracy tests for LGV, for individual assigned flows (100%), but falls short of the requirement for screen-line flows (88%). The model satisfies the accuracy tests for HGV, for individual assigned flows (100%), but falls short of the requirement for screen-line flows (63%). The model satisfies the accuracy tests for all vehicles combined, for both individual assigned flows (95%), and for screen-line flows (100%).

Evening Peak

5.3.8 The follow table shows the model accuracy achieved in the Evening Peak scenario, separately for cars, LGV, HGV and all vehicles, respectively.

TEST	ASPECT	CRITERIA	ACHIEVING TAG CRITERIA	CAR		LGV		HGV		ALL VEH	
				NO.	%	NO.	%	NO.	%	NO.	%
1.	Difference between total modelled flows and counts (in screen line).	<5% (±) for >95% of screen lines.	Yes	15	94	14	88	4	25	16	100
			No	1		2		12		0	
2a.	Individual flows within 100 veh/h for flows less than 700 veh/h.	>85% of cases.	Yes	950	93	1,261	99	1,269	100	885	93
			No	68		8		0		71	
2b.	Individual flows within 15% for flows from 700 to 2,700 veh/h.	>85% of cases.	Yes	222	88	–	–	–	–	273	89
			No	29		–		–		35	
2c.	Individual flows within 400 veh/h for flows more than 2,700 veh/h.	>85% of cases.	Yes	–	–	–	–	–	–	5	100
			No	–		–		–		0	
3.	GEH < 5 for individual flows.	>85% of cases.	Yes	1,052	83	1,245	98	1,264	100	1,050	83
			No	217		24		5		219	
2 or 3.	Traffic flow range or GEH.	Either of the criteria	Yes	1,180	93	1,261	99	1,269	100	1,171	92
			No	89		8		0		98	

Table 5-3: STM Assigned Traffic Flow Validation – Evening Peak

5.3.9 The evening peak model satisfies the accuracy tests for Cars, for individual assigned flows (93%), and almost meets the requirement for screen-line flows (94%). The model satisfies the accuracy tests for LGV, for individual assigned flows (99%), but falls short of the requirement for screen-line flows (88%). The model satisfies the accuracy tests for HGV, for individual assigned flows (100%), but falls short of the requirement for screen-line flows (25%). The model satisfies the accuracy tests for all vehicles combined, for both individual assigned flows (92%), and for screen-line flows (100%).

Overall STM Traffic Flow Accuracy

5.3.10 In terms of the overall accuracy of the STM assigned flows, across all periods, the following outcomes emerge:

- For All Vehicles combined – each of the scenarios achieves the TAG flow accuracy criteria, for both individual assigned flows (92% in the Morning and Evening, 95% in Inter-Peak), and for screen-lines (100% in all);
  - This suggests that, when vehicle types are combined, the models are reasonably good representations of reality, in terms of their post-estimation total trip matrices, network configuration, and assignment parameters;
  - Combining the total screen-line flow differences [(modelled – observed) / observed] across all of the 16 directional screen-lines, the all-vehicle percentage difference is small, +0.9% in the Morning Peak, +1.4% in the Inter-Peak, and +0.5% in the Evening Peak;
- For Cars – each of the scenarios achieves the individual assigned flow requirement (93% in the Morning and Evening, 96% in the Inter-Peak), but while the Inter-Peak scenario also achieves the screen-line flow criteria (100%), the Morning and Evening Peak scenarios fall slightly short in this respect (94%) on one screen-line out of 16.

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- Combining the total screen-line flow differences [(modelled – observed) / observed] across all of the 16 directional screen-lines, the Car percentage difference is small, +1.5% in the Morning Peak, +1.7% in the Inter-Peak, and +1.8% in the Evening Peak;

- For LGV – each of the scenarios achieves the individual assigned flow requirement (100% in the Morning and Inter-Peak, 99% in Evening Peak), but each of the scenarios falls short of the screen-line flow criteria (75% in the Morning Peak, 88% in the Inter-Peak and Evening Peak), on four screen-lines out of 16 in the Morning Peak and on two in Inter-Peak and Evening Peak;
  - Combining the total screen-line flow differences [(modelled – observed) / observed] across all of the 16 directional screen-lines, the LGV percentage difference is small, -2.1% in the Morning Peak, +0.1% in the Inter-Peak, and -1.6% in the Evening Peak;
- For HGV – each of the scenarios achieves the individual assigned flow requirement (100% in all), but each of the scenarios falls short of the screen-line flow criteria (81% in the Morning Peak, 63% in the Inter-Peak, 25% in Evening Peak), on three screen-lines out of 16 in the Morning Peak and on six in the Inter-Peak and 12 in the Evening Peak;
  - It is noteworthy that, in all of the screen-lines which fail the HGV flow validation criteria, (i.e. where substantially less than 95% of screen-lines show modelled minus counted HGV flow differences of <5%, in the Morning Peak, Inter-Peak, or Evening Peak), the links with discrepancies have counted flows of <30 HGV per hour, in most instances, (or <1 HGV every 2 minutes);
  - On most of these road links, this means that a small discrepancy in the number of modelled HGVs represents a large percentage difference, which exaggerates the screen-line inaccuracies;
  - Combining the total screen-line flow differences [(modelled – observed) / observed] across all of the 16 directional screen-lines, the HGV percentage difference is small, -0.6% in the Morning Peak, -0.3% in the Inter-Peak, and -1.8% in the Evening Peak.

Validation of Assignment Journey Times

5.3.11 A summary is provided below of STM performance against DfT TAG journey time validation requirements (as described in section 2.8). This is an accuracy test for the base year model assignments (in terms of average vehicle travel times along 15 directional routes). It compares modelled journey times against observed route speeds and delays.

5.3.12 Detailed comparisons of modelled and observed journey times, at various points along each route, are summarised in **Appendix G**.

5.3.13 The tables overleaf show the model accuracy achieved in the three peak period scenarios.

Journey Time Route Ref.	Observed Journey Time (Secs)	Modelled Journey Time (Secs)	Journey Time Difference [Modelled – Observed] (Secs)	Journey Time % Difference [(Modelled – Observed) / Observed]	Modelled times within +/- 15% of Observed?	Modelled times within +/- 60secs of Observed, if >15% Higher?
JT1 Inbound	842	824	-18	-2%	Yes	-
JT1 Outbound	812	828	16	2%	Yes	-
JT2 Inbound	1210	1067	-143	-12%	Yes	-
JT2 Outbound	1114	1063	-52	-5%	Yes	-
JT3 Inbound	469	405	-64	-14%	Yes	-
JT3 Outbound	416	377	-39	-9%	Yes	-
JT4 Clockwise	1493	1412	-81	-5%	Yes	-
JT4 Anti-clockwise	1493	1348	-145	-10%	Yes	-
JT5 Inbound	586	551	-35	-6%	Yes	-
JT5 Outbound	508	464	-44	-9%	Yes	-
JT6 Southbound	1127	1063	-64	-6%	Yes	-
JT6 Northbound	928	990	62	7%	Yes	-
JT7 Inbound	317	266	-51	-16%	Yes	-
JT7 Outbound	280	244	-36	-13%	Yes	-
JT8 Clockwise	1031	1096	64	6%	Yes	-
JT8 Anti-clockwise	966	985	19	2%	Yes	-
JT9 Southbound	960	983	23	2%	Yes	-
JT9 Northbound	1085	1015	-70	-6%	Yes	-
JT10 Southbound	373	380	7	2%	Yes	-
JT10 Northbound	435	445	10	2%	Yes	-
JT11 Eastbound	700	711	10	1%	Yes	-
JT11 Westbound	736	703	-33	-5%	Yes	-
JT12 Southbound	494	494	0	0%	Yes	-
JT12 Northbound	493	438	-55	-11%	Yes	-
JT13 Clockwise	1139	1037	-103	-9%	Yes	-
JT13 Anti-clockwise	1039	944	-95	-9%	Yes	-
JT14 Southbound	618	539	-79	-13%	Yes	-
JT14 Northbound	494	566	72	15%	Yes	-
JT15 Southbound	1035	1083	47	5%	Yes	-
JT15 Northbound	1018	1137	119	12%	Yes	-
Journey Time Routes Achieving TAG Validation Criteria 1 & 2 (>85% of routes modelled within +/-15% of observed):				No. Routes:	30 / 30	
				% Routes:	100%	

Table 5-4: STM Route Journey Time Validation – Morning Peak, Average vehicle.

GENERAL

Journey Time Route Ref.	Observed Journey Time (Secs)	Modelled Journey Time (Secs)	Journey Time Difference [Modelled – Observed] (Secs)	Journey Time % Difference [(Modelled – Observed) / Observed]	Modelled times within +/- 15% of Observed?	Modelled times within +/- 60secs of Observed, if >15% Higher?
JT1 Inbound	832	809	-24	-3%	Yes	-
JT1 Outbound	817	821	3	0%	Yes	-
JT2 Inbound	1129	1063	-66	-6%	Yes	-
JT2 Outbound	1144	1074	-71	-6%	Yes	-
JT3 Inbound	403	371	-33	-8%	Yes	-
JT3 Outbound	399	366	-33	-8%	Yes	-
JT4 Clockwise	1306	1370	64	5%	Yes	-
JT4 Anti-clockwise	1323	1341	17	1%	Yes	-
JT5 Inbound	504	491	-13	-2%	Yes	-
JT5 Outbound	490	474	-16	-3%	Yes	-
JT6 Southbound	922	969	48	5%	Yes	-
JT6 Northbound	899	925	26	3%	Yes	-
JT7 Inbound	253	252	-1	-1%	Yes	-
JT7 Outbound	228	240	12	5%	Yes	-
JT8 Clockwise	1005	1045	39	4%	Yes	-
JT8 Anti-clockwise	960	951	-9	-1%	Yes	-
JT9 Southbound	910	973	63	7%	Yes	-
JT9 Northbound	955	959	4	0%	Yes	-
JT10 Southbound	368	384	16	4%	Yes	-
JT10 Northbound	430	433	3	1%	Yes	-
JT11 Eastbound	683	690	7	1%	Yes	-
JT11 Westbound	685	699	14	2%	Yes	-
JT12 Southbound	398	469	71	18%	No	No
JT12 Northbound	424	485	61	14%	Yes	-
JT13 Clockwise	1023	999	-24	-2%	Yes	-
JT13 Anti-	948	897	-50	-5%	Yes	-
JT14 Southbound	457	514	57	13%	Yes	-
JT14 Northbound	478	540	63	13%	Yes	-
JT15 Southbound	956	1073	118	12%	Yes	-
JT15 Northbound	943	1079	136	14%	Yes	-
Journey Time Routes Achieving TAG Validation Criteria 1 & 2 (>85% of routes modelled within +/-15% of observed):				No. Routes:	29 / 30	
				% Routes:	97%	

Table 5-5: STM Route Journey Time Validation – Inter Peak, Average Vehicle.

Journey Time Route Ref.	Observed Journey Time (Secs)	Modelled Journey Time (Secs)	Journey Time Difference [Modelled – Observed] (Secs)	Journey Time % Difference [(Modelled – Observed) / Observed]	Modelled times within +/- 15% of Observed?	Modelled times within +/- 60secs of Observed, if >15% Higher?
JT1 Inbound	1022	839	-183	-18%	No	-
JT1 Outbound	913	846	-67	-7%	Yes	-
JT2 Inbound	1228	1192	-37	-3%	Yes	-
JT2 Outbound	1218	1228	10	1%	Yes	-
JT3 Inbound	433	385	-49	-11%	Yes	-
JT3 Outbound	439	388	-51	-12%	Yes	-
JT4 Clockwise	1518	1391	-127	-8%	Yes	-
JT4 Anti-clockwise	1550	1350	-200	-13%	Yes	-
JT5 Inbound	549	515	-34	-6%	Yes	-
JT5 Outbound	522	478	-44	-8%	Yes	-
JT6 Southbound	1029	1135	106	10%	Yes	-
JT6 Northbound	1133	1156	23	2%	Yes	-
JT7 Inbound	284	256	-28	-10%	Yes	-
JT7 Outbound	221	244	23	10%	Yes	-
JT8 Clockwise	1013	1081	68	7%	Yes	-
JT8 Anti-clockwise	991	1012	21	2%	Yes	-
JT9 Southbound	901	1197	296	33%	No	No
JT9 Northbound	963	973	10	1%	Yes	-
JT10 Southbound	367	388	20	5%	Yes	-
JT10 Northbound	478	459	-19	-4%	Yes	-
JT11 Eastbound	712	695	-17	-2%	Yes	-
JT11 Westbound	683	699	17	2%	Yes	-
JT12 Southbound	425	483	59	14%	Yes	-
JT12 Northbound	464	511	47	10%	Yes	-
JT13 Clockwise	1128	1159	31	3%	Yes	-
JT13 Anti-clockwise	1057	905	-153	-14%	Yes	-
JT14 Southbound	497	512	16	3%	Yes	-
JT14 Northbound	601	583	-17	-3%	Yes	-
JT15 Southbound	1029	1083	54	5%	Yes	-
JT15 Northbound	982	1101	119	12%	Yes	-
Journey Time Routes Achieving TAG Validation Criteria 1 & 2 (>85% of routes modelled within +/-15% of observed):				No. Routes:	28 / 30	
				% Routes:	93%	

Table 5-6: STM Route Journey Time Validation – Evening Peak, Average vehicle.

GENERAL

5.3.14 The Morning Peak scenario satisfies the accuracy test for route journey times, as 100% of routes comply with TAG, compared with a minimum requirement of 85%.

5.3.15 The Inter Peak scenario satisfies the accuracy test for route journey times, as 97% of routes comply with TAG, compared with a minimum requirement of 85%.

5.3.16 The Evening Peak scenario satisfies the accuracy test for route journey times, as 93% of routes comply with TAG, compared with a minimum requirement of 85%.

Overall STM Journey Time Accuracy

5.3.17 In terms of the overall accuracy of the STM journey times, across all periods, each of the scenarios, achieves the TAG journey time accuracy criteria, in terms of the proportion of modelled routes within ±15% of observed, or within 1 minute if modelled difference exceeds 15% (100% in the Morning Peak, 97% in the Inter-Peak, and 93% in Evening Peak). This suggests that the models are reasonably good representations of reality, in terms of their network speed, capacity, and junction delay, and the volume of traffic and level of congestion along key routes.

5.4. Model Reliability (Convergence)

5.4.1 A summary is provided below of STM performance against DfT TAG convergence requirements (as described in section 2.8). This is test of how dependable the base year iterative assignments are, in terms of proximity (to an optimum equilibrium state), and stability (of traffic flows and travel costs) after the final model iteration.

Stability and Proximity of Model Assignments

5.4.2 The following table shows the reliability of the STM assignments achieved in the base year scenarios.

STM Model	No. Assignment / Simulation Loops at Equilibrium	Model Stability (Requirement)		Model Proximity (Requirement)		
		%GAP (< 0.1%)	DELTA (δ) (< 0.1%)	RAAD (< 0.1% Relative Average Absolute Difference in link flows)	%FLOWS (> 98% links with assigned flow change of < 1%)	%DELAYS (> 98% turns with assigned cost change of < 1%)
AM Peak Model	19	0.00100%	0.0023%	0.018%	99.8%	99.8%
Inter Peak Model	10	0.00018%	0.0011%	0.036%	99.6%	99.9%
PM Peak Model	25	0.00850%	0.0006%	0.048%	99.2%	99.6%

Table 5-7: STM Convergence – Assignment Stability and Proximity

5.4.3 In terms of the overall convergence of the STM assignments, across all periods, the following outcomes emerge:

- Each of the scenarios achieves the TAG stability criteria (%GAP and DELTA) by the end of the final assignment iteration;
- Each of the scenarios achieves the TAG proximity criteria (RAAD, %FLOWS and %DELAYS) by the end of the final assignment iteration; and
- This suggests that the model assignment outputs are reliable, and do not change substantially if further model iterations are run.

Validation of Assigned Route Choices

5.4.4 Extensive checking of the assigned routes between OD zones in the STM base year scenarios shows that they are predominantly realistic and sensible, when compared with quickest routes shown in Google Maps for the appropriate weekday hours.

5.4.5 Detailed comparisons of modelled and online route map choices are summarised in **Appendix H**.

6. Model Summary

6.1. Introduction

6.1.1 This section provides a summary of the procedure followed and standards achieved in developing the base year 2023 STM. It outlines the accuracy of the three peak period scenarios, it considers their fitness for purpose in terms of the models' intended use, and it discusses the evident strengths and weaknesses of the models.

6.2. Model Development Procedure

6.2.1 The main tasks undertaken to develop the base year 2023 STM are as follows:

- Review previous model, retain valid components and identify required changes;
- Determine required new model scope;
- Define model segmentation;
- Develop a zoning system;
- Prepare new data inputs;
- Assemble a 'prior' trip matrix;
- Construct the model highway network;
- Run an initial 'prior' assignment to establish model inaccuracies;
- Prepare and run a trip matrix estimation (ME) procedure;
- Run a 'post' assignment with the enhanced, partially estimated trip matrix;
- Undertake iterative model network and trip matrix adjustments, to ensure model accuracy; and
- Undertake a 'stress test' on the calibrated base year model.

6.3. Standards Achieved

Conformity

6.3.1 The STM conforms to best practice, set out in DfT TAG, in respect of its component parts, its accuracy and reliability, its data sources, and model techniques.

6.3.2 The STM contains the four components which constitute a conventional transport model, and which represent the main influences on transport conditions in Swindon, namely:

- Generation (and attraction) of trips at land use sites;
- Distribution of trips, between origins and destinations;
- Modal split of journeys, amongst travel modes and vehicle types; and
- Assigned route choices and movements of vehicle trips, on logical paths through the road network.

6.3.3 Model performance tests confirm the STM to be accurate and reliable, in respect if its model outputs, compared with observed conditions, in terms of:

- Traffic flows at various points on the road network;
- Journey times along selected routes;
- Logical, most-used routes between OD zones; and
- Extraction of outputs from a converged assignment, which will not alter, if further model iterations are run.

6.3.4 Appropriate use is made of input data sources, such as:

- Mobile Network Data, to capture trip OD movements;
- Link and junction traffic counts, to monitor network traffic flows, surveyed during a typical weekday in a neutral month;
- Network journey times, to monitor traffic speeds and delays; and
- Previous models, alongside, mapping and photographic databases, to identify the highway network configuration, junction layouts, land uses, and site accesses.

6.3.5 The model building and validation process applies established techniques to maximise the model functionality and precision, such as:

- Use of alternative data sources to resolve shortcomings in the MND, and create the best possible 'prior' trip matrix; and
- Use of SATURN matrix estimation, to augment the prior trip matrix, and better replicate observed trip movements, but with strict constraints the changes which ME is allowed to introduce.

6.3.6 The STM is not a multi-modal model, and does not incorporate a 'variable demand' component, to capture people's travel decisions under changing travel costs and transport options. However, the validated STM can be harnessed to a base year public transport model and variable demand model if these are required.

Accuracy

6.3.7 Model performance tests show the STM to be suitably accurate in the following respects:

- Assigned flow accuracy – for all vehicle categories combined, each of the models (AM, IP and PM), achieves the TAG criteria, for both individual assigned flows and screen-lines –
  - Individual flows – required accuracy 85%, achieved accuracy 92% in Morning Peak and Evening Peak, and 95% in Inter-Peak;
  - Screen-lines – required accuracy 95%, achieved accuracy 100% in all three peak periods;
- Journey time accuracy – each of the models (AM, IP and PM), achieves the TAG accuracy criteria, in terms of the proportion of modelled routes within ±15% of observed, or within 1 minute, if the modelled difference exceeds 15% –
  - All journey times – required accuracy 85%, achieved accuracy 100% in Morning Peak, 97% in Inter-Peak, 93% in Evening Peak.

Reliability

6.3.8 The STM is also reliable, as demonstrated by the satisfactory convergence achieved at the end of the iterative assignment process. This convergence is measured through the following tests:

- Stability – each of the models (AM, IP and PM), achieves the TAG %GAP and DELTA criteria;
- Proximity – each of the models (AM, IP and PM), achieves the TAG RAAD, %FLOWS and %DELAYS criteria.

GENERAL

6.4. Assessment of Fitness for Purpose

Model Scope

6.4.1 The scope of the STM is judged to be appropriate for its intended purposes, in terms of the following model aspects:

- Extent of the fully modelled area;
- Extent of the SATURN simulation network, which includes detailed junction arrangements;
- Inclusion of strategic roads, which approach and by-pass Swindon;
- Granularity of model zones, which capture different land uses and neighbourhoods;
- Model segmentation, by weekday modelled hours, vehicle types, user classes, journey purposes;
- Inclusion of town centre car park sub-model.

Model Currency

6.4.2 The STM is not wholly up to date, as it replicates the observed traffic situation in 2023. However, there are not known to have been significant changes to the transport network, land uses, travel patterns, or trip volumes, since 2023. Consequently, the validated base model is considered still to be 'current'.

Model Functionality

6.4.3 In terms of its capabilities and functionality, the STM is relatively straightforward. It should be effective for assessing future circumstances and changes in respect of the following:

- Growth of existing vehicle movements;
- Changes in land uses and generated trips;
- Changes to carriageway and junction layouts, capacities, and connectivity;
- Changes to available highway capacity, which affects road network 'stress', traffic congestion and vehicle delay;
- New highway access arrangements for neighbourhoods and sites;
- New traffic regulations and controls;
- Variations in travel costs for road users;
- Rearrangement of car parking facilities; and
- Reallocation of highway space, to assist buses, pedestrians, and cyclists.

Model Durability

6.4.4 In its current state, the 2023 STM should be usable for up to five years, before it requires updating. Given the relative simplicity of the model format in SATURN, it will be straightforward to update, using either of the following techniques:

- Present year validation – this will typically entail applying a nominal uplift to trip OD demands in the current 2023 STM, to reflect normal growth, and then comparing assigned outputs with newly collected traffic survey data; or
- Model Re-build – this will require creating a replacement for the existing 2023 trip matrix, (e.g. using updated MND with matrix estimation), and then re-validating the model against newly collected traffic count and journey time data.

GENERAL

6.5. Model Strengths

6.5.1 This section provides an overview of the strengths of the base year 2023 STM.

6.5.2 The model covers the Swindon BC area and includes National Highways strategic roads. This will help to enable testing of SBC strategies, policies and schemes, and will show the effect on the M4 and A419.

6.5.3 The STM is shown to be an accurate representation of reality, in terms of its assigned traffic flows, journey times and route choices. It also produces reliable outputs from its converged assignments. This implies that if the model is projected forwards, and adapted to reflect future changes in land use travel demands and highway network provision, it will give a reliable picture of future network performance. It can be used to test and compare the likely impact of new transport interventions.

6.5.4 A reasonable balance is achieved in the model development, between competing requirements, primarily:

- Matrix estimation is applied successfully in the STM to a point where it improves the model accuracy against observed data, and uses parameters which align with TAG; however, this does result in changes to the prior matrix which are greater than expected for some individual vehicle types; less distortion could only be accompanied by less model accuracy;
- Substantial parts of the model are retained from the previous 2019 version, as it was fit for purpose; however, this means that there is a slight lack of modelled detail, to the east of the A419 corridor, and some uncertainty whether the car park sub-model improves the functioning of the STM;

6.5.5 Although SATURN matrix estimation is applied to boost the robustness of the STM prior trip matrix (derived from MND), the post-estimation trip movements compare closely with counted screen-line flows. This indicates that the broad pattern of trip movements in the model is realistic.

6.5.6 Furthermore, for all vehicle types combined, the post-estimation trip matrix is reasonably similar to the prior matrix, which confirms that ME is not permitted to distort the more accurate parts of the surveyed MND movements.

6.6. Model Weaknesses

6.6.1 This section provides an overview of the weaknesses of the base year 2023 STM.

Mobile Network Data

6.6.2 It is considered that Mobile Network Data is the most suitable and resource-efficient form of trip movement information for the STM, given the limitations around sourcing alternative OD data, (e.g. from roadside interview, household survey, Census 2021 journey to work, NTEM 8.0, National Highways Regional Traffic Models, etc.). However, there are shortcomings in the MND, which are processed for the STM, and hence in the morning, inter peak and evening prior matrices. The MND weaknesses include:

- Mobile phone locations are recorded at the level of large cell areas, which frequently overlap, or cover multiple MND zones; this makes it difficult to pinpoint exactly where trips start and end; and
- MND does not capture all users equally, with sample rates varying by location, and time of day; this means that initial distribution of trips between MND zones contains inconsistencies which must be corrected using matrix estimation.

Prior Matrix Development

6.6.3 As a consequence of shortcomings in the MND, there are some known weaknesses in the method used to develop the STM prior matrices, which include:

- It is necessary to disaggregate OD between coarse mobile zones into detailed model zones; which relies on the best available land-use information and broad trip-rate assumptions, (e.g. from OS AddressBase land use data, and the TRICS trip rate database);
- Using parallel data sources is standard practice, but they are not flawless and cannot precisely capture people's travel movements; consequently some model zones in the prior matrix have too many trips, others have too few, and some have an inaccurate distribution of OD trips; matrix estimation is applied to reduce these shortcomings; and
- MND lacks clarity around vehicle types and journey purposes, so to capture the required STM user classes in the prior matrix, the MND are split using a combination of national statistics, local land-use indicators and generic trip-rate assumptions, all of which have gaps; this explains why subsequent corrections during matrix estimation cause some excessive trip changes for individual vehicle types.

Matrix Estimation

6.6.4 Matrix estimation is used to correct the unavoidable inaccuracies in the prior matrices, so that the STM can achieve better validation against observed traffic flows and journey times. However, the prior matrix limitations mean that:

- The relationship between the post-estimation and prior matrices does not form a perfect straight line; as shown by the regression analyses; nevertheless the overall comparison is similar, and the combined-vehicle matrices meet TAG criteria across most periods; this indicates that the post-estimation model is behaving logically and that the adjustments are targeted rather than excessive.

Multi-Modal and Variable Demand Aspects

6.6.5 As intended, the STM is not a multi-modal model, nor does it include a variable demand mechanism, to capture people's travel decisions under changing travel costs and transport options. However, these aspects can be developed later if necessary, and the STM can be integrated within an overall multi-modal model.

Appendix A:

Observed Traffic Flows

Count Locations and Traffic Volumes:

App_A_STM_2023_SATURN_Traffic_Count_Input_Updated.xlsm

GENERAL

Appendix B:

Recorded Travel Times

Journey Time Route Configurations and Travel Time records:

App_B_STM_2023_SATURN_Journey_Time_Input.xlsb

GENERAL

Appendix C:

Change in OD Trips Post Matrix Estimation Compared with Prior Matrix

Regression Plots and Statistics – for OD Cells, Origin Zones, and Destination Zones:

App_C_STM_2023_ME_OD_Cell_Regression_Output.xlsb

App_C_STM_2023_ME_Origin_Regression_Output.xlsb

App_C_STM_2023_ME_Destination_Regression_Output.xlsb

GENERAL

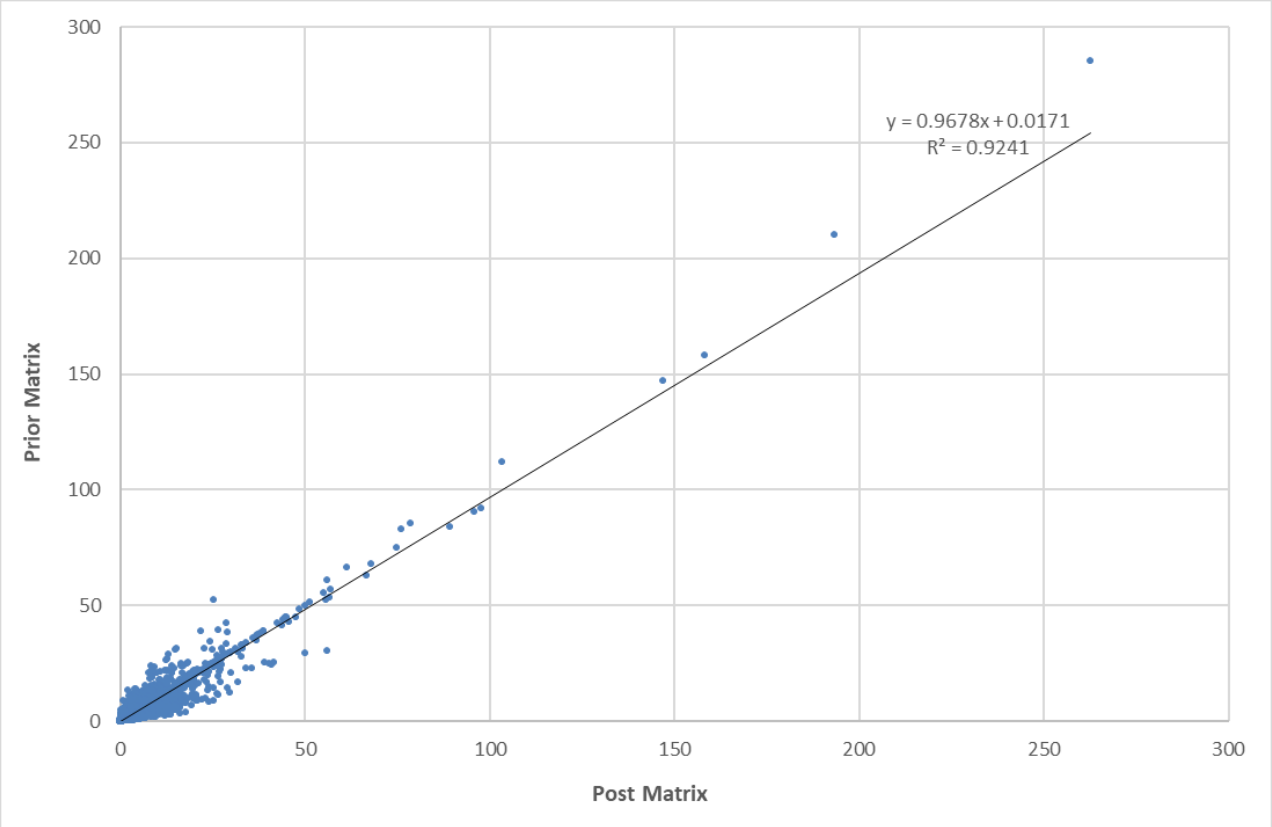


Figure 6 - Swindon 2023 Trip Matrix Cells Before / After ME: AM Car

	Modelled	WebTAG
Slope	0.97	0.98-1.02
R^2	0.92	>0.95
Intercept	0.02	Near 0

Table 8 - Swindon 2023 Trip Matrix Cells Before / After ME: AM Car

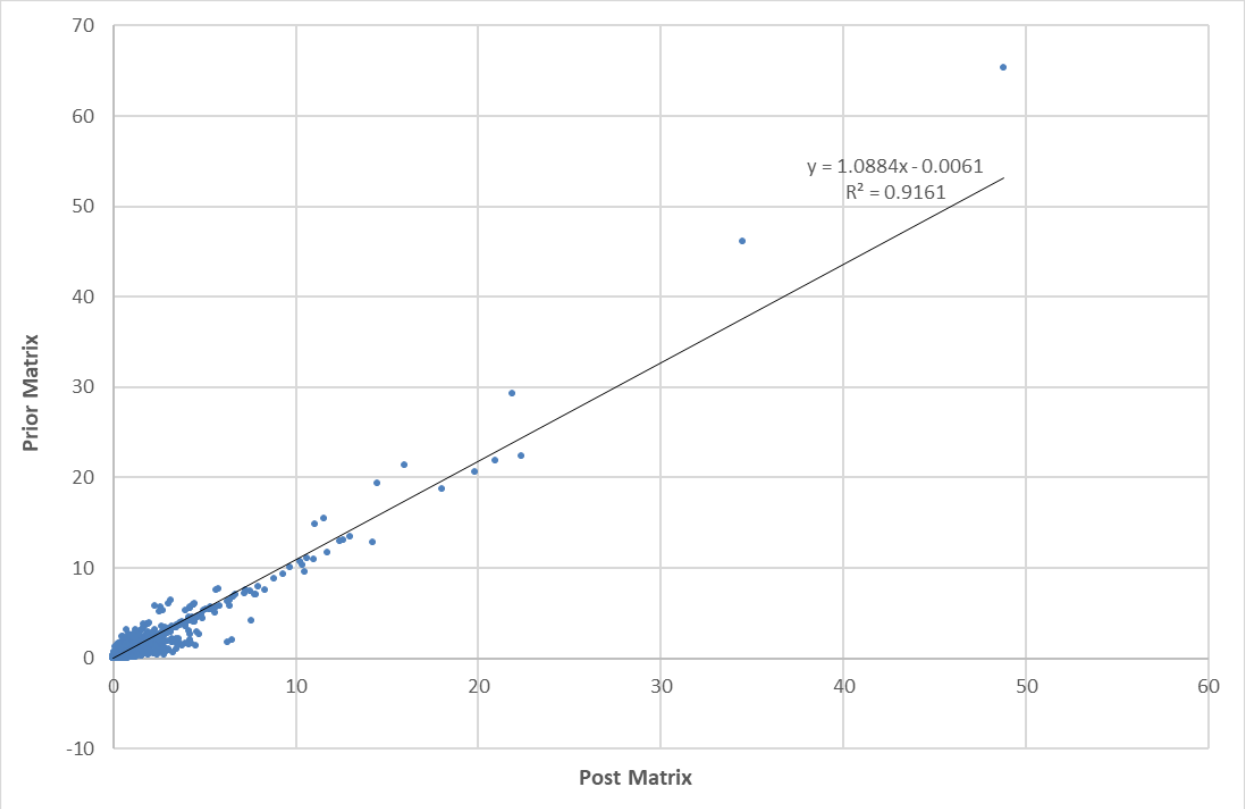


Figure 7 - Swindon 2023 Trip Matrix Cells Before / After ME: AM LGV

	Modelled	WebTAG
Slope	1.09	0.98-1.02
R^2	0.92	>0.95
Intercept	-0.01	Near 0

Table 9 - Swindon 2023 Trip Matrix Cells Before / After ME: AM LGV

GENERAL

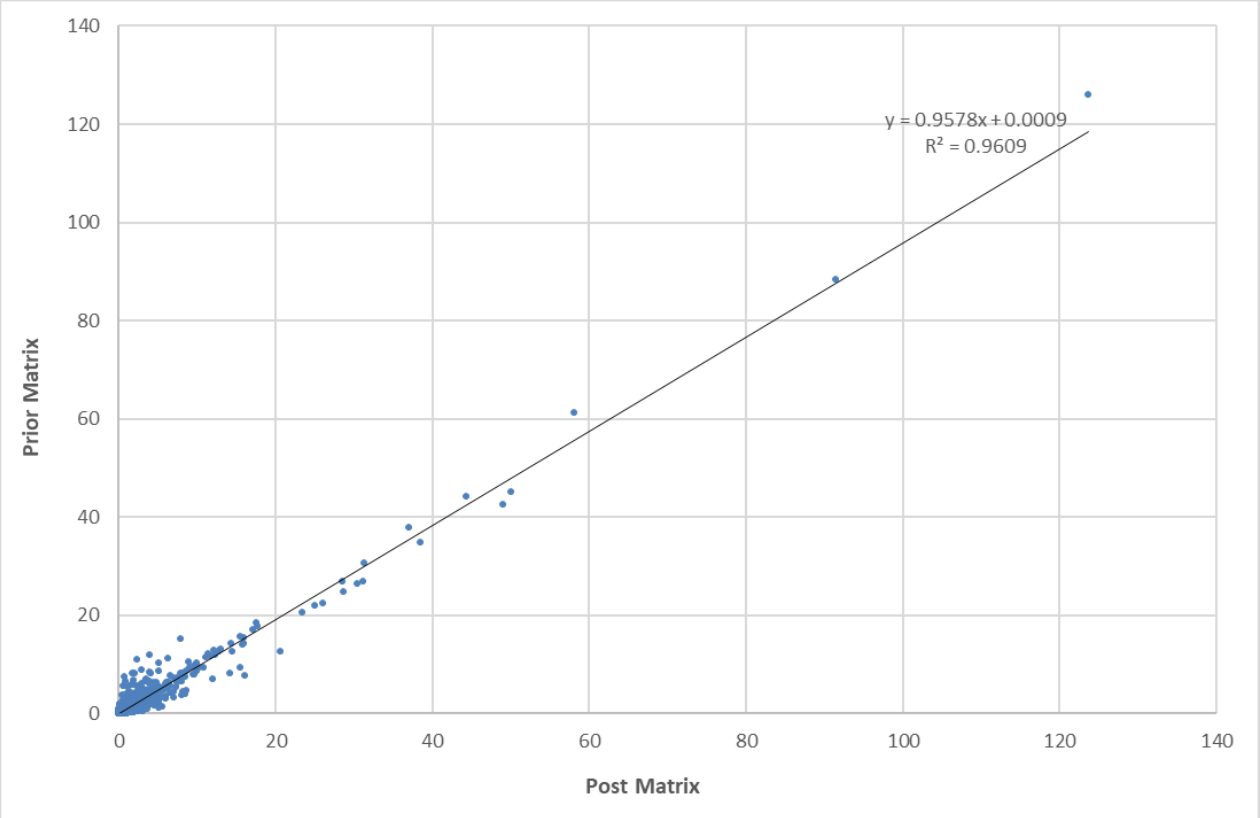


Figure 8 - Swindon 2023 Trip Matrix Cells Before / After ME: AM HGV

	Modelled	WebTAG
Slope	0.96	0.98-1.02
R^2	0.96	>0.95
Intercept	0.00	Near 0

Table 10 - Swindon 2023 Trip Matrix Cells Before / After ME: AM HGV

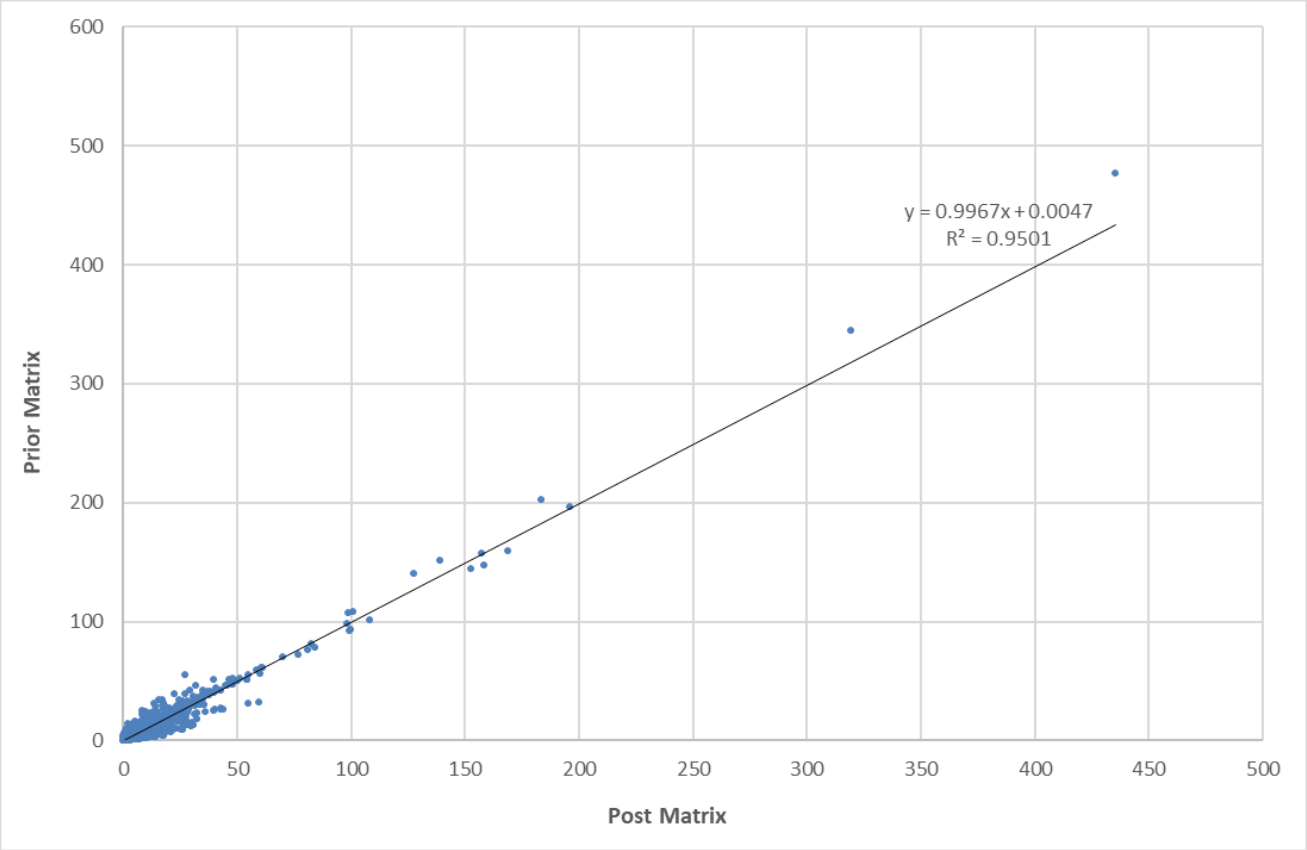


Figure 9 - Swindon 2023 Trip Matrix Cells Before / After ME: AM All Vehicles

	Modelled	WebTAG
Slope	1.00	0.98-1.02
R^2	0.95	>0.95
Intercept	0.00	Near 0

Table 11 - Swindon 2023 Trip Matrix Cells Before / After ME: AM All Vehicles

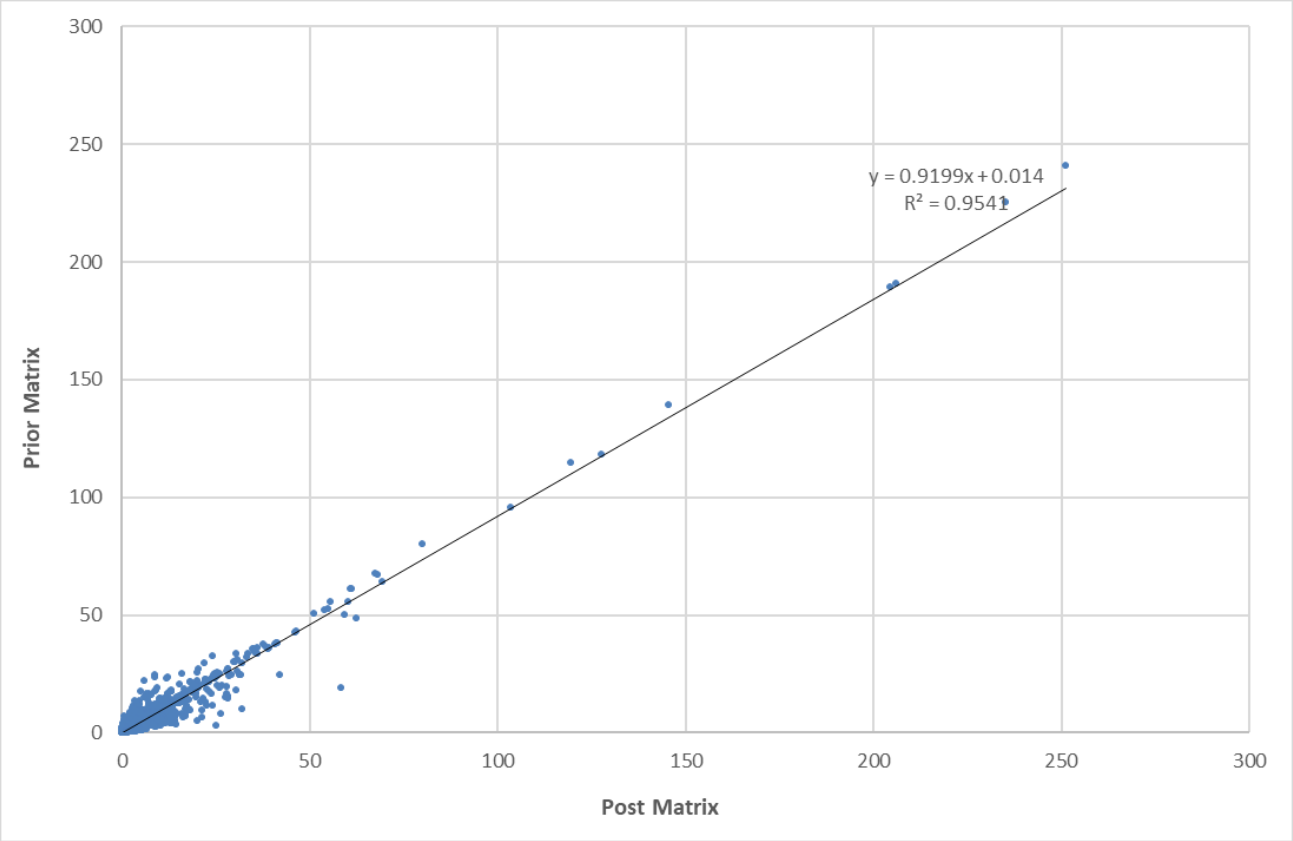


Figure 10 - Swindon 2023 Trip Matrix Cells Before / After ME: IP Car

	Modelled	WebTAG
Slope	0.92	0.98-1.02
R^2	0.95	>0.95
Intercept	0.01	Near 0

Table 12 - Swindon 2023 Trip Matrix Cells Before / After ME: IP Car

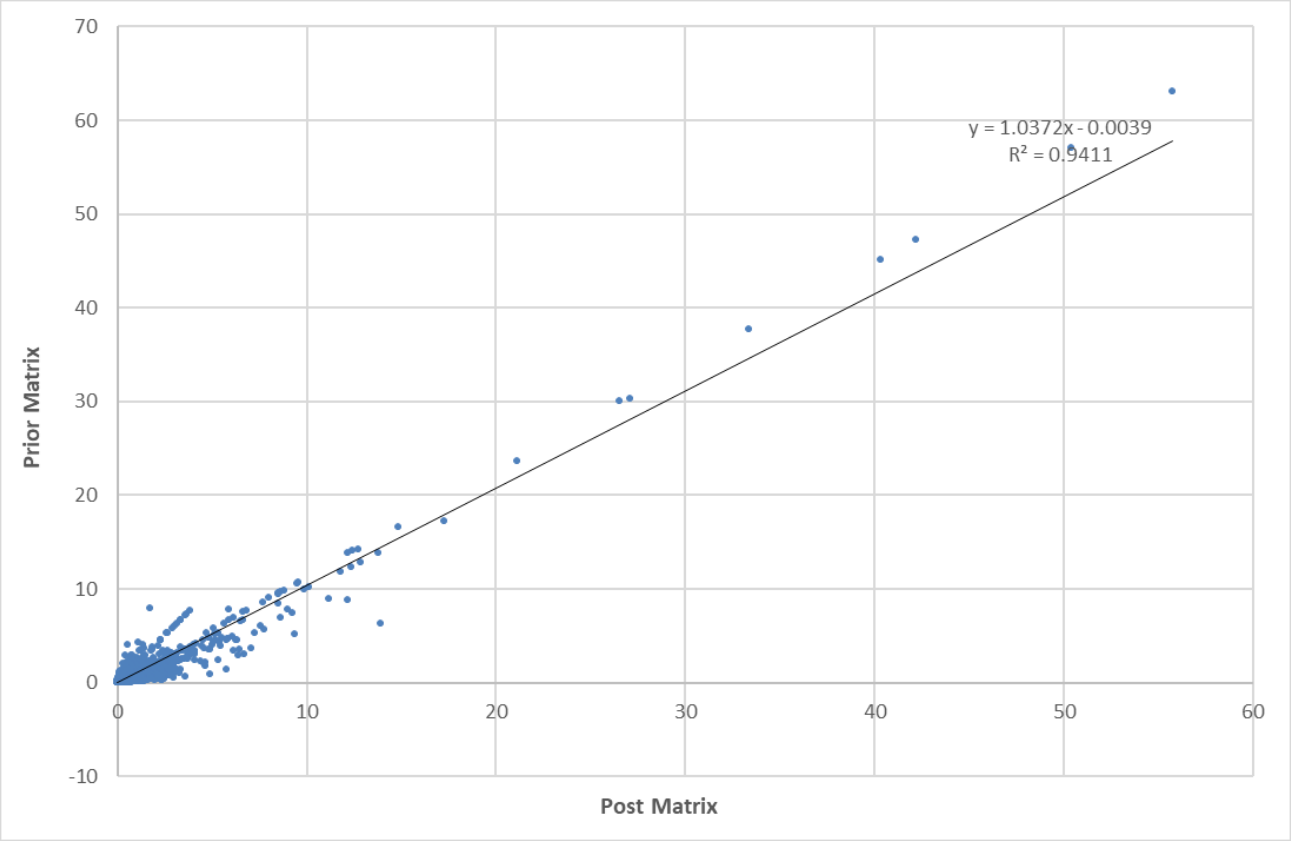


Figure 11 - Swindon 2023 Trip Matrix Cells Before / After ME: IP LGV

	Modelled	WebTAG
Slope	1.04	0.98-1.02
R^2	0.94	>0.95
Intercept	0.00	Near 0

Table 13 - Swindon 2023 Trip Matrix Cells Before / After ME: IP LGV

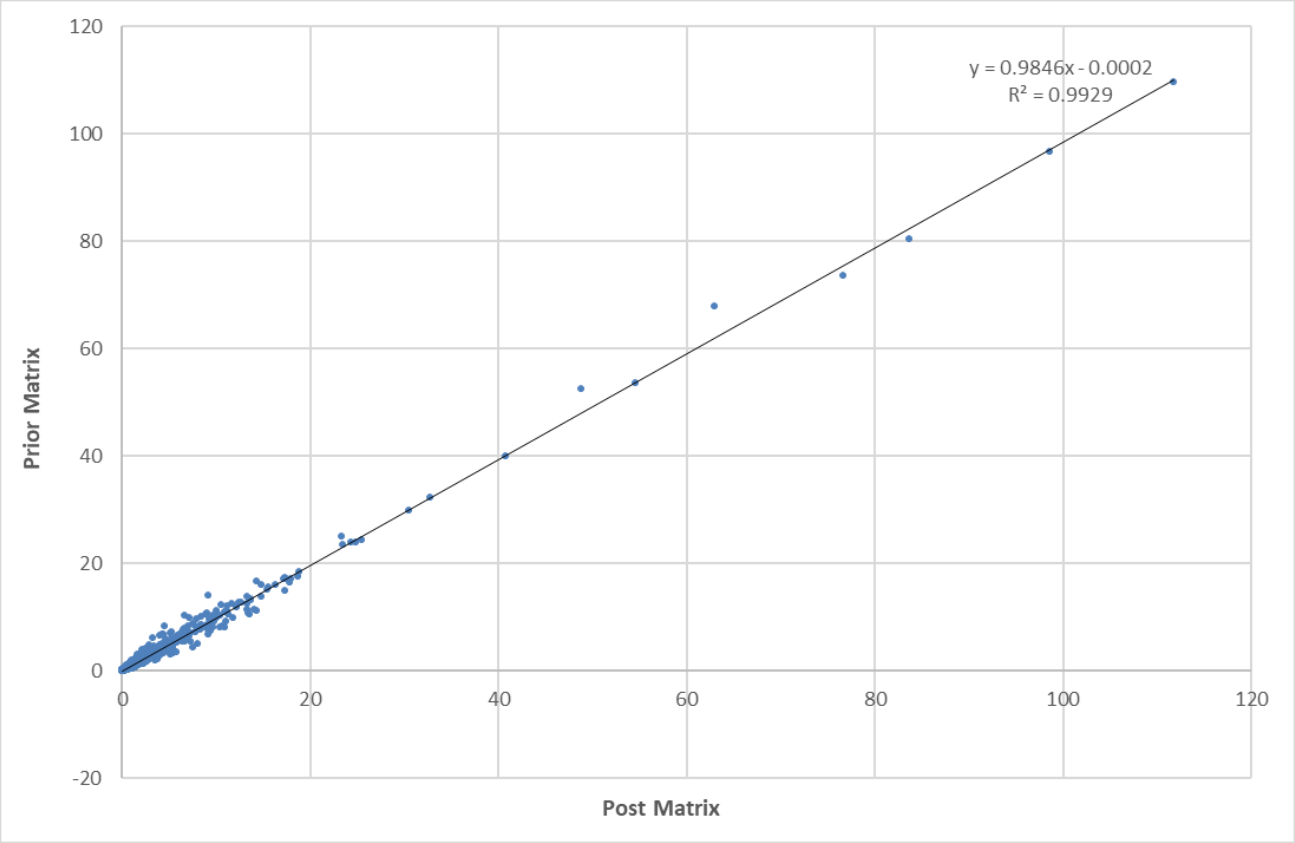


Figure 12 - Swindon 2023 Trip Matrix Cells Before / After ME: IP HGV

	Modelled	WebTAG
Slope	0.98	0.98-1.02
R^2	0.99	>0.95
Intercept	0.00	Near 0

Table 14- Swindon 2023 Trip Matrix Cells Before / After ME: IP HGV

GENERAL

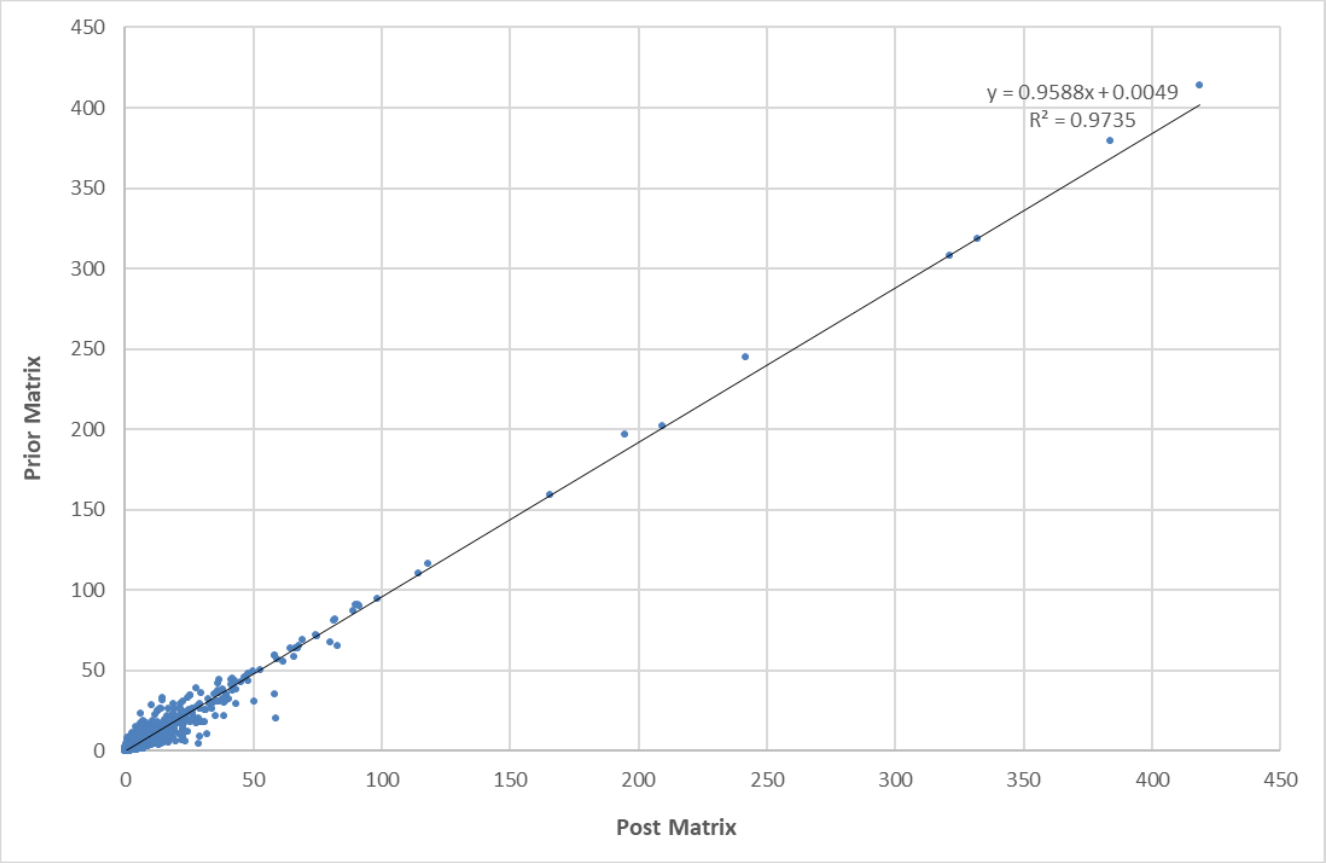


Figure 13 - Swindon 2023 Trip Matrix Cells Before / After ME: IP All Vehicles

	Modelled	WebTAG
Slope	0.96	0.98-1.02
R^2	0.97	>0.95
Intercept	0.00	Near 0

Table 15 - Swindon 2023 Trip Matrix Cells Before / After ME: IP All Vehicles

GENERAL

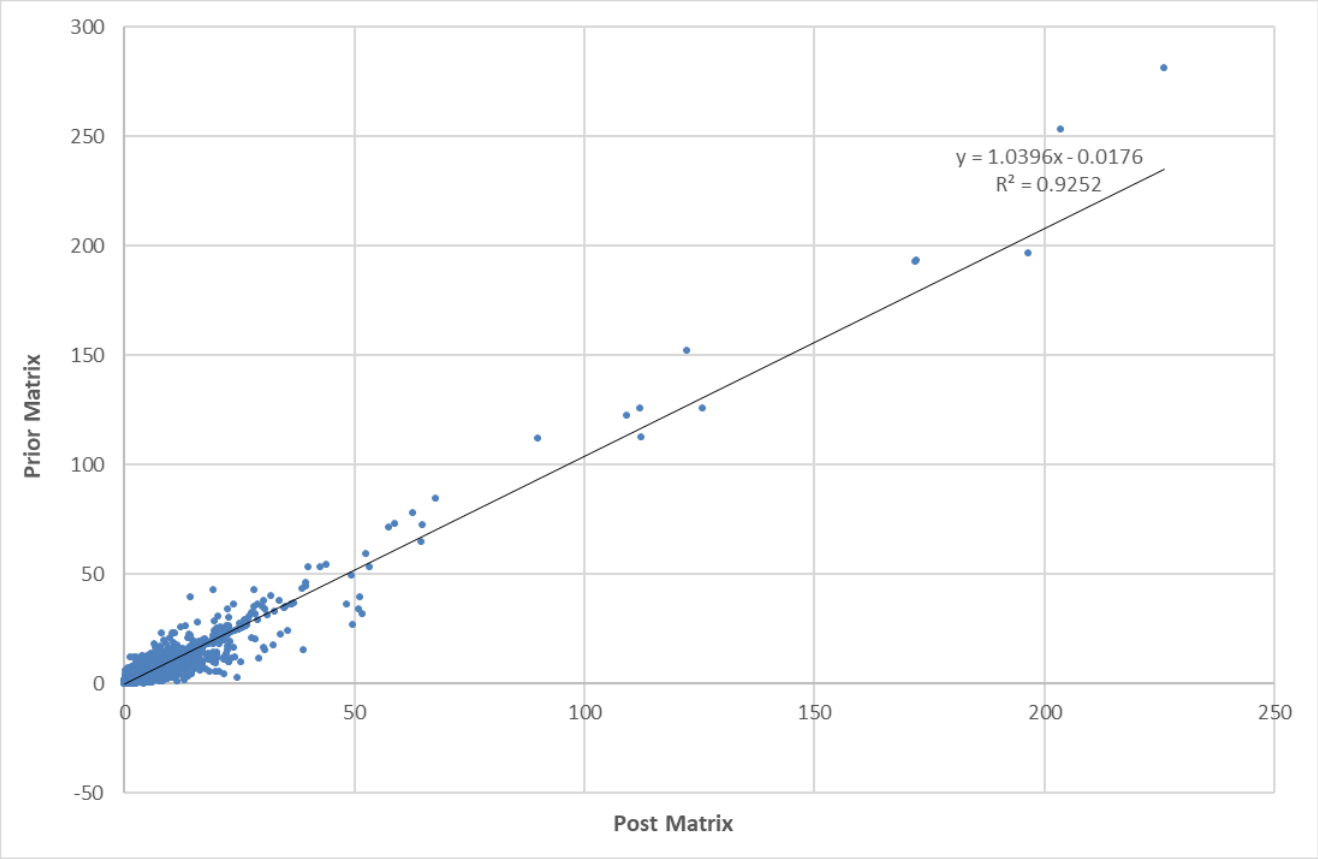


Figure 14 - Swindon 2023 Trip Matrix Cells Before / After ME: PM Car

	Modelled	WebTAG
Slope	1.04	0.98-1.02
R^2	0.93	>0.95
Intercept	-0.02	Near 0

Table 16- Swindon 2023 Trip Matrix Cells Before / After ME: PM Car

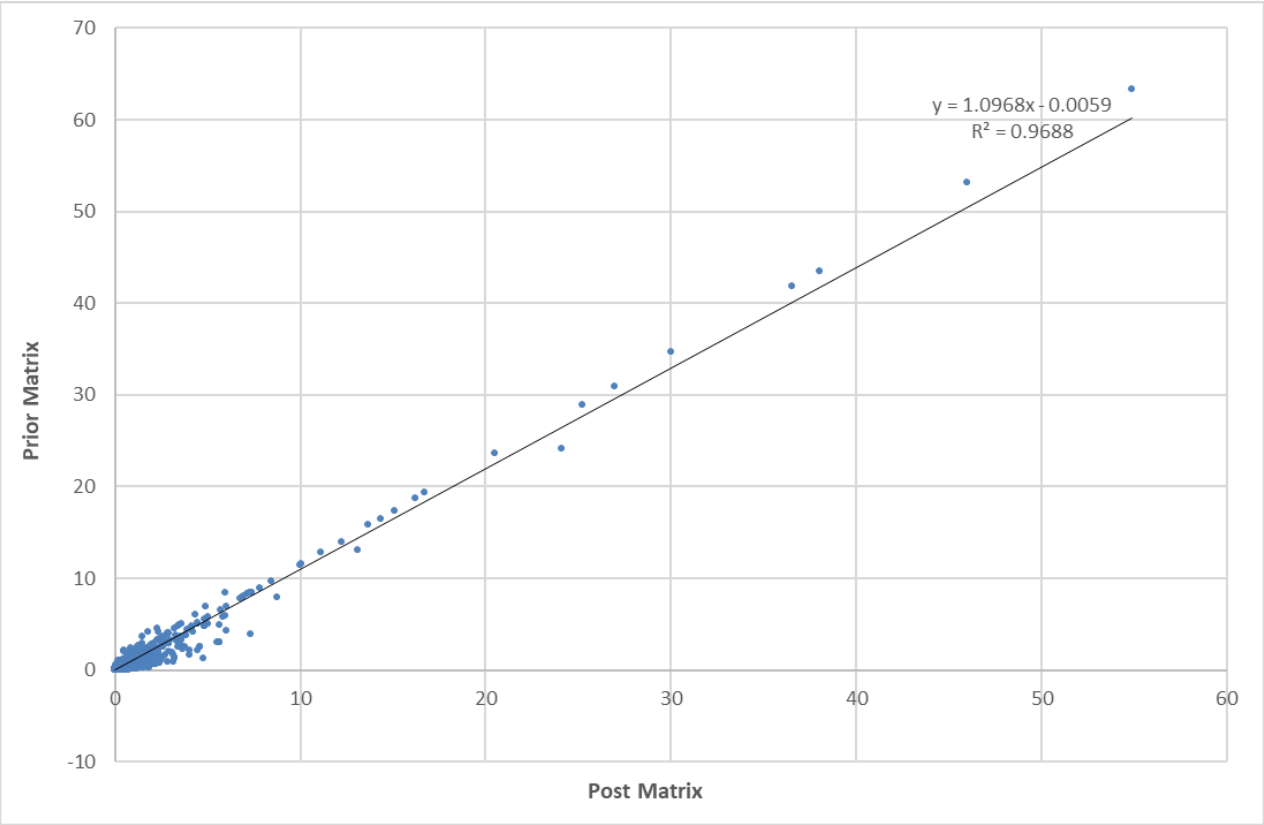


Figure 15 - Swindon 2023 Trip Matrix Cells Before / After ME: PM LGV

	Modelled	WebTAG
Slope	1.10	0.98-1.02
R^2	0.97	>0.95
Intercept	-0.01	Near 0

Table 17 - Swindon 2023 Trip Matrix Cells Before / After ME: PM LGV

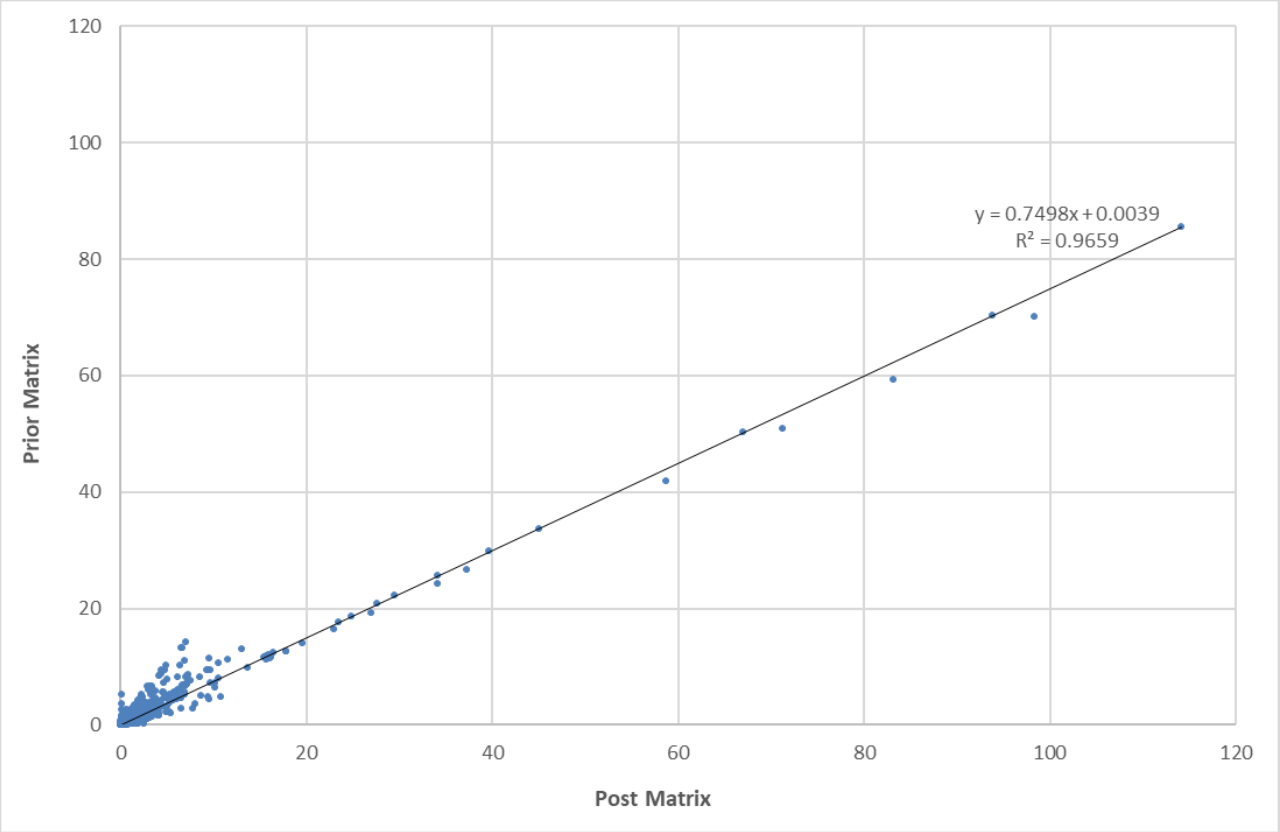


Figure 16 - Swindon 2023 Trip Matrix Cells Before / After ME: PM HGV

	Modelled	WebTAG
Slope	0.75	0.98-1.02
R^2	0.97	>0.95
Intercept	0.00	Near 0

Table 18 - Swindon 2023 Trip Matrix Cells Before / After ME: PM HGV

GENERAL

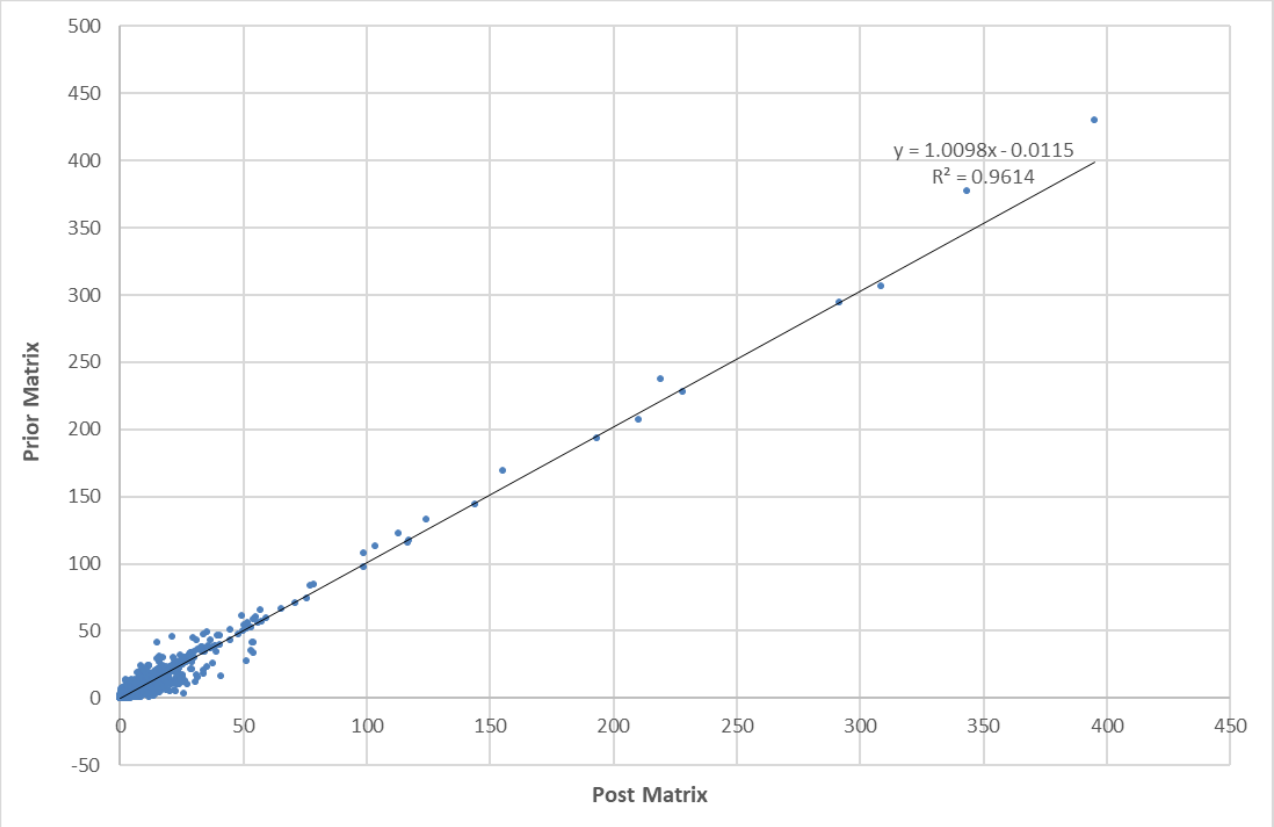


Figure 17- Swindon 2023 Trip Matrix Cells Before / After ME: PM All Vehicles

	Modelled	WebTAG
Slope	1.01	0.98-1.02
R^2	0.96	>0.95
Intercept	-0.01	Near 0

Table 19 - Swindon 2023 Trip Matrix Cells Before / After ME: PM All Vehicles

GENERAL

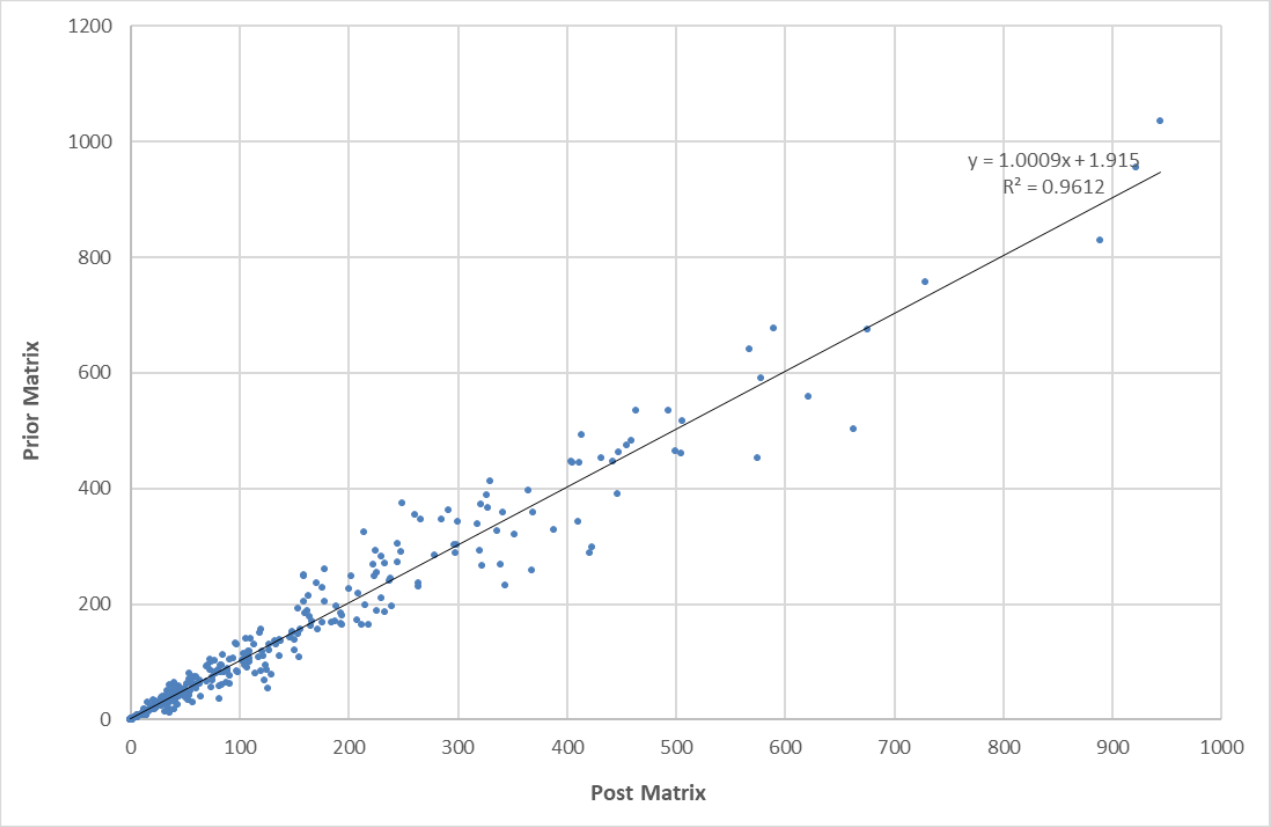


Figure 18 - Swindon 2023 Trip Matrix Destinations Before / After ME: AM Car

	Modelled	WebTAG
Slope	1.00	0.98-1.02
R^2	0.96	>0.95
Intercept	1.92	Near 0

Table 20 - Swindon 2023 Trip Matrix Destinations Before / After ME: AM Car

GENERAL

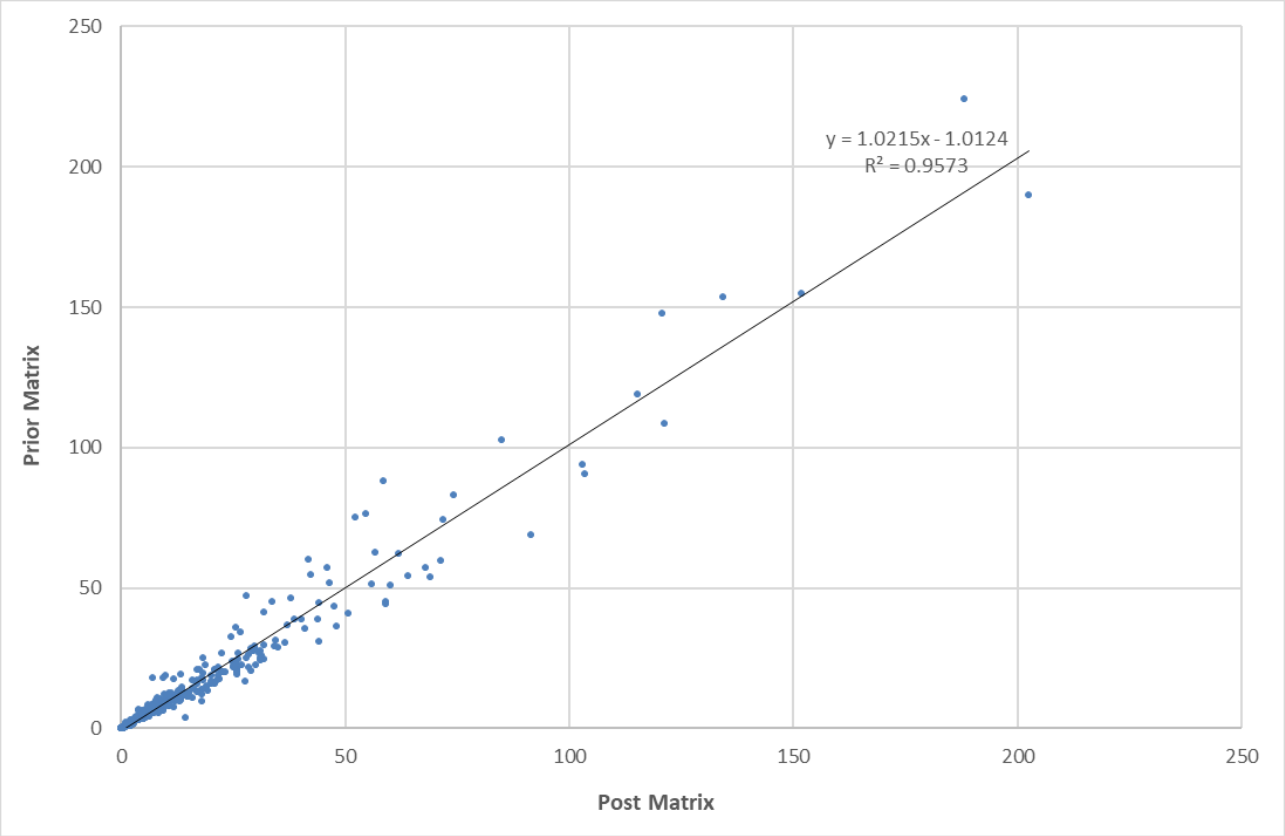


Figure 19 - Swindon 2023 Trip Matrix Destinations Before / After ME: AM LGV

	Modelled	WebTAG
Slope	1.02	0.98-1.02
R^2	0.96	>0.95
Intercept	-1.01	Near 0

Table 21 - Swindon 2023 Trip Matrix Destinations Before / After ME: AM LGV

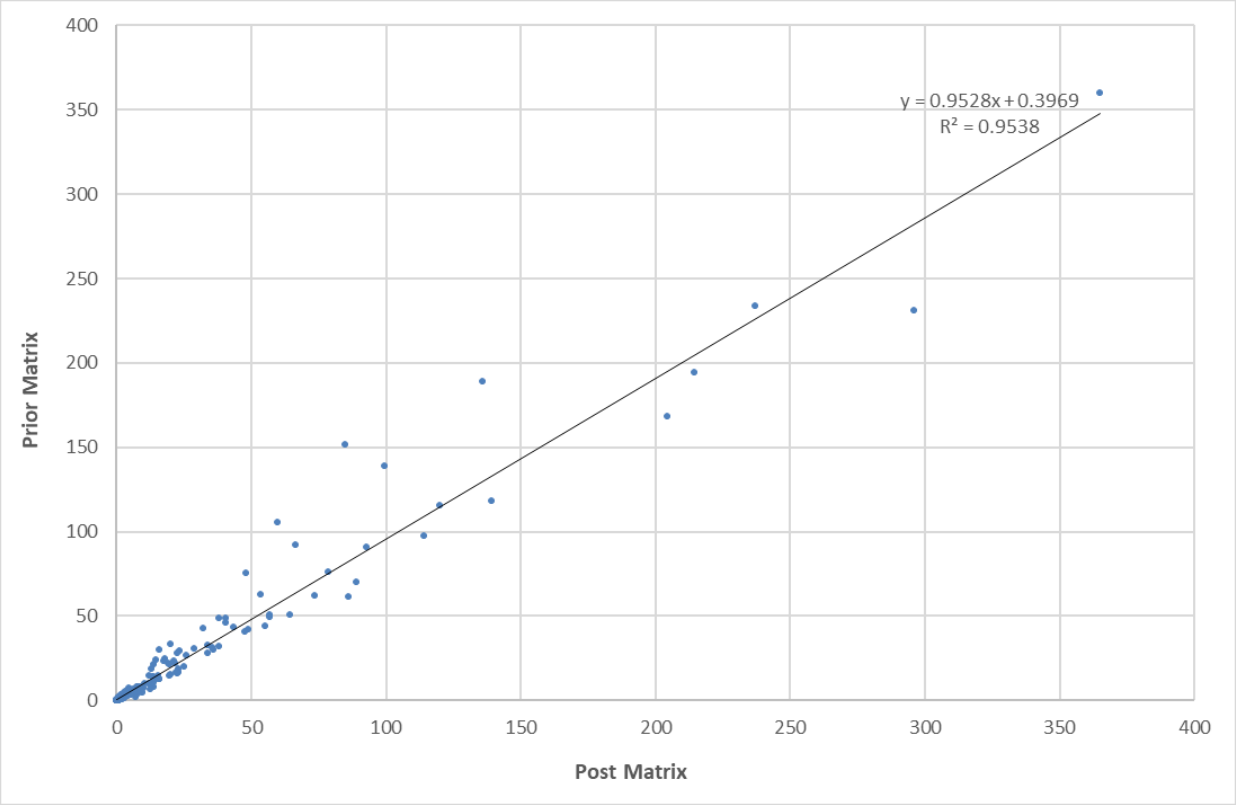


Figure 20 - Swindon 2023 Trip Matrix Destinations Before / After ME: AM HGV

	Modelled	WebTAG
Slope	0.95	0.98-1.02
R^2	0.95	>0.95
Intercept	0.40	Near 0

Table 22 - Swindon 2023 Trip Matrix Destinations Before / After ME: AM HGV

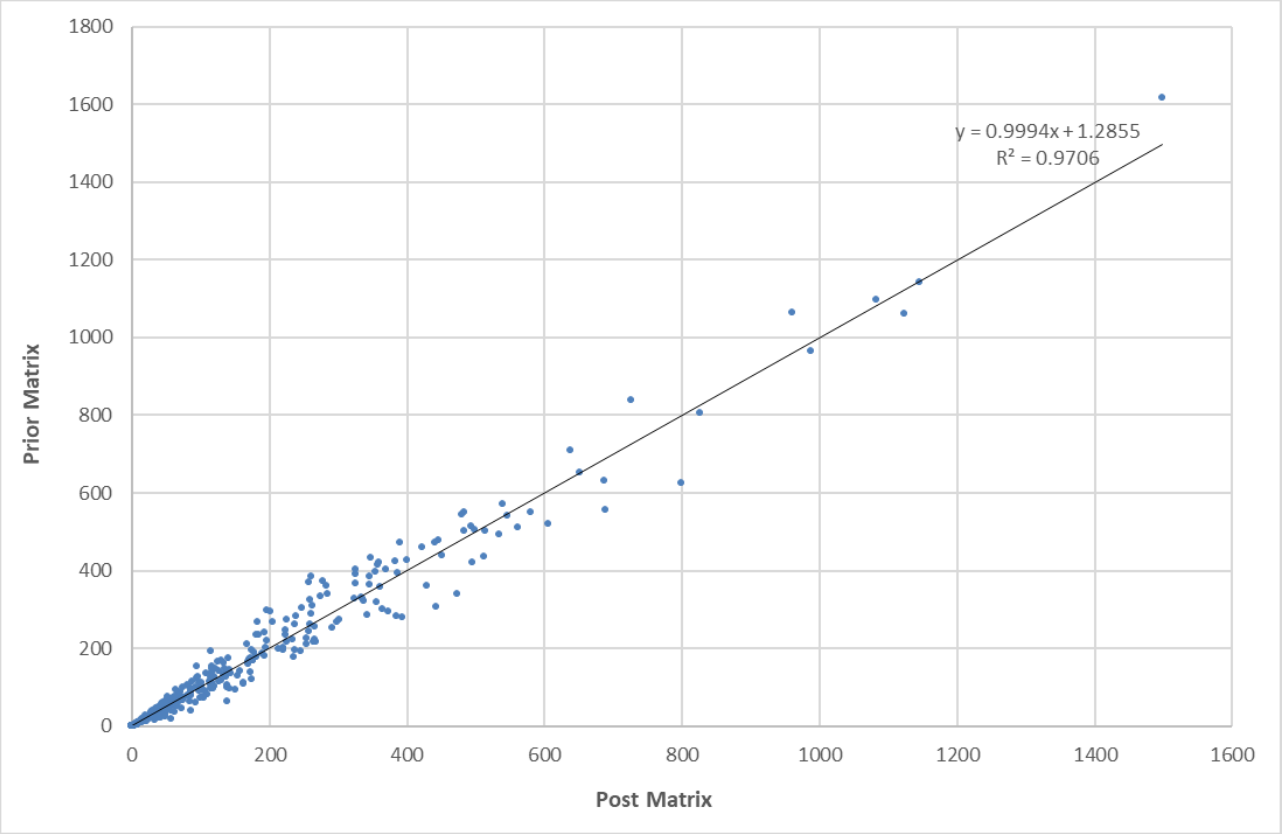


Figure 21 - Swindon 2023 Trip Matrix Destinations Before / After ME: AM All Vehicles

	Modelled	WebTAG
Slope	1.00	0.98-1.02
R^2	0.97	>0.95
Intercept	1.29	Near 0

Table 23 - Swindon 2023 Trip Matrix Destinations Before / After ME: AM All Vehicles

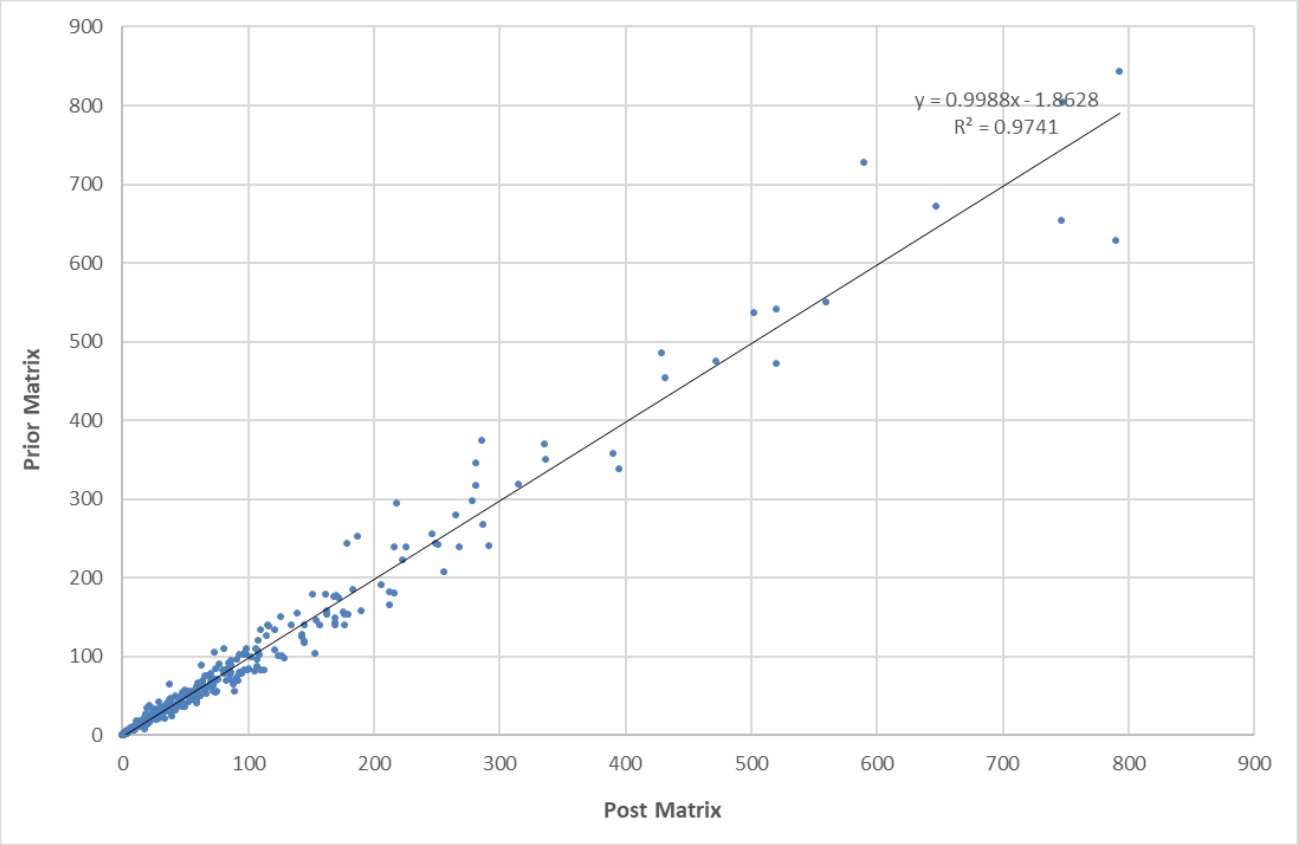


Figure 22 - Swindon 2023 Trip Matrix Destinations Before / After ME: IP Car

	Modelled	WebTAG
Slope	1.00	0.98-1.02
R^2	0.97	>0.95
Intercept	-1.86	Near 0

Table 24 - Swindon 2023 Trip Matrix Destinations Before / After ME: IP Car

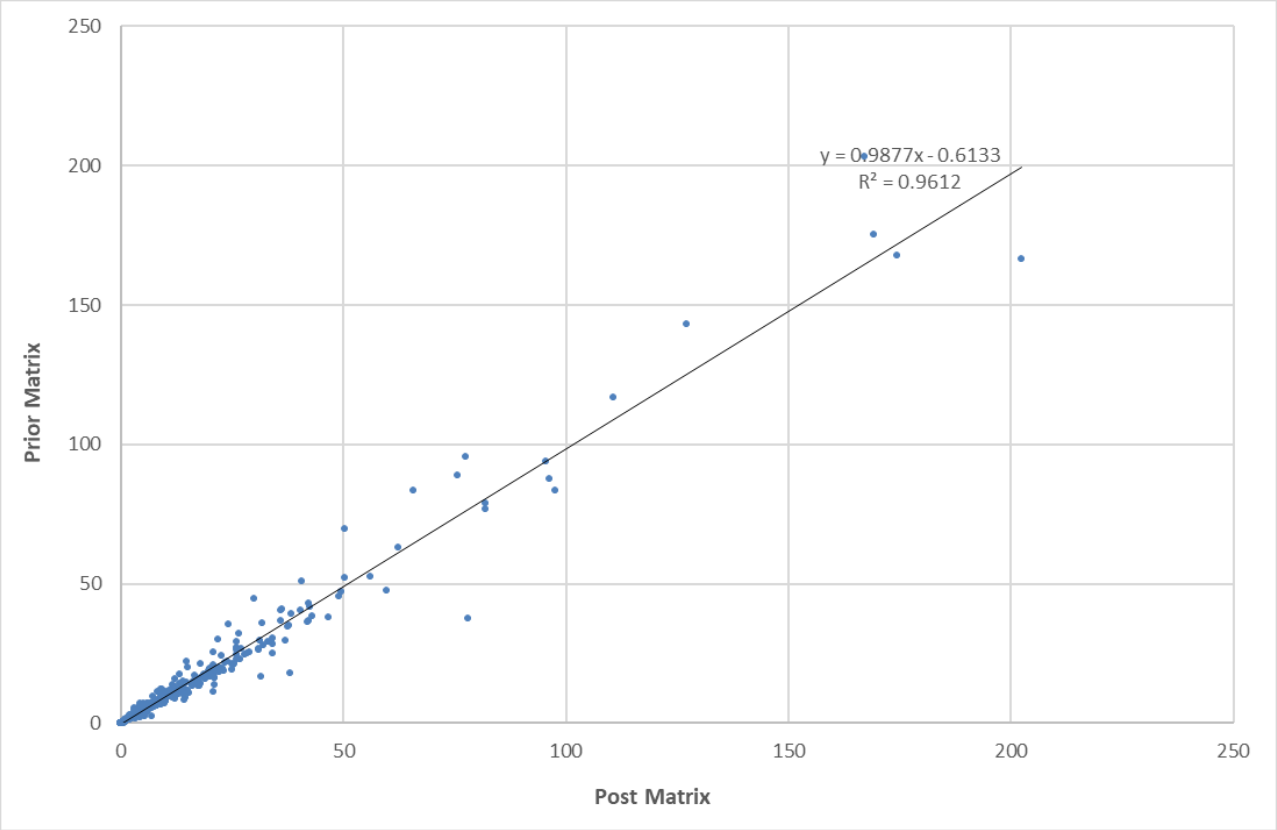


Figure 23 - Swindon 2023 Trip Matrix Destinations Before / After ME: IP LGV

	Modelled	WebTAG
Slope	0.99	0.98-1.02
R^2	0.96	>0.95
Intercept	-0.61	Near 0

Table 25- Swindon 2023 Trip Matrix Destinations Before / After ME: IP LGV

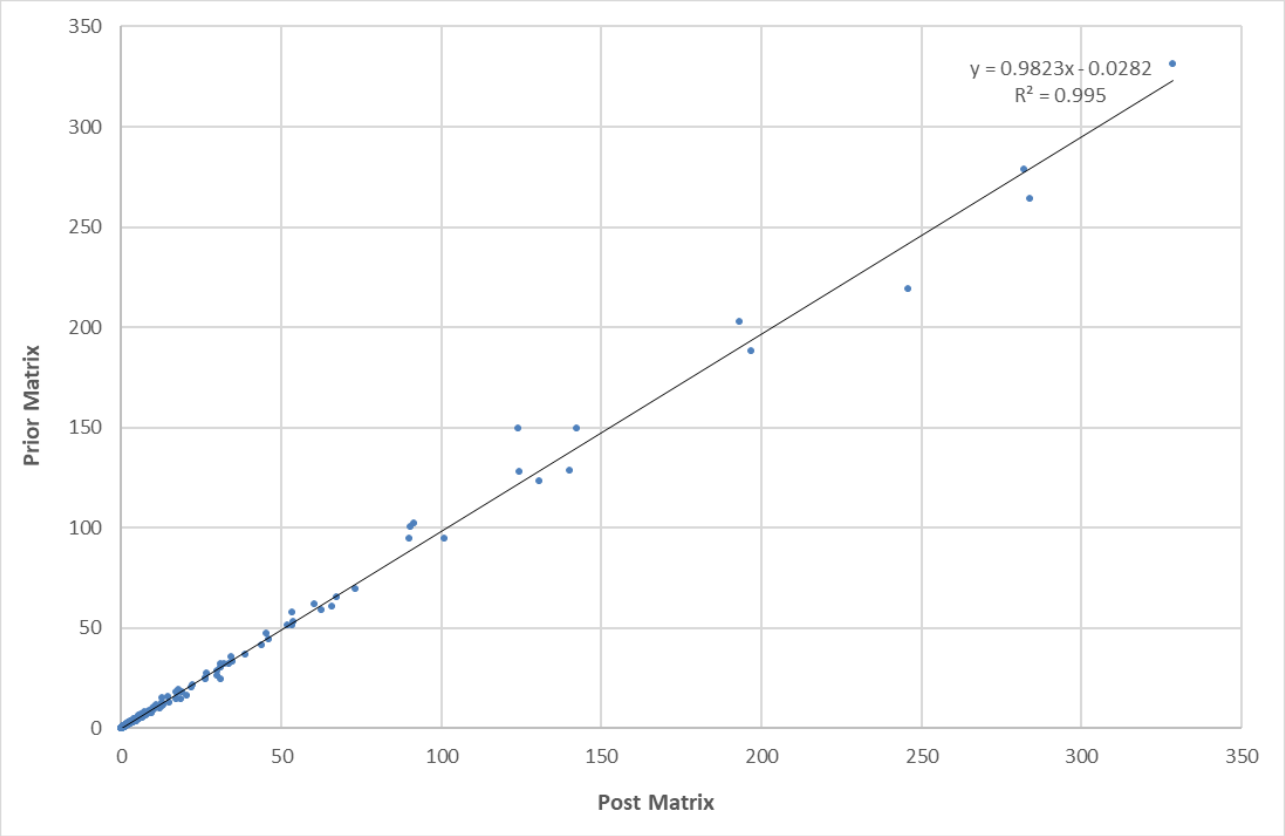


Figure 24 - Swindon 2023 Trip Matrix Destinations Before / After ME: IP HGV

	Modelled	WebTAG
Slope	0.98	0.98-1.02
R^2	1.00	>0.95
Intercept	-0.03	Near 0

Table 26 - Swindon 2023 Trip Matrix Destinations Before / After ME: IP HGV

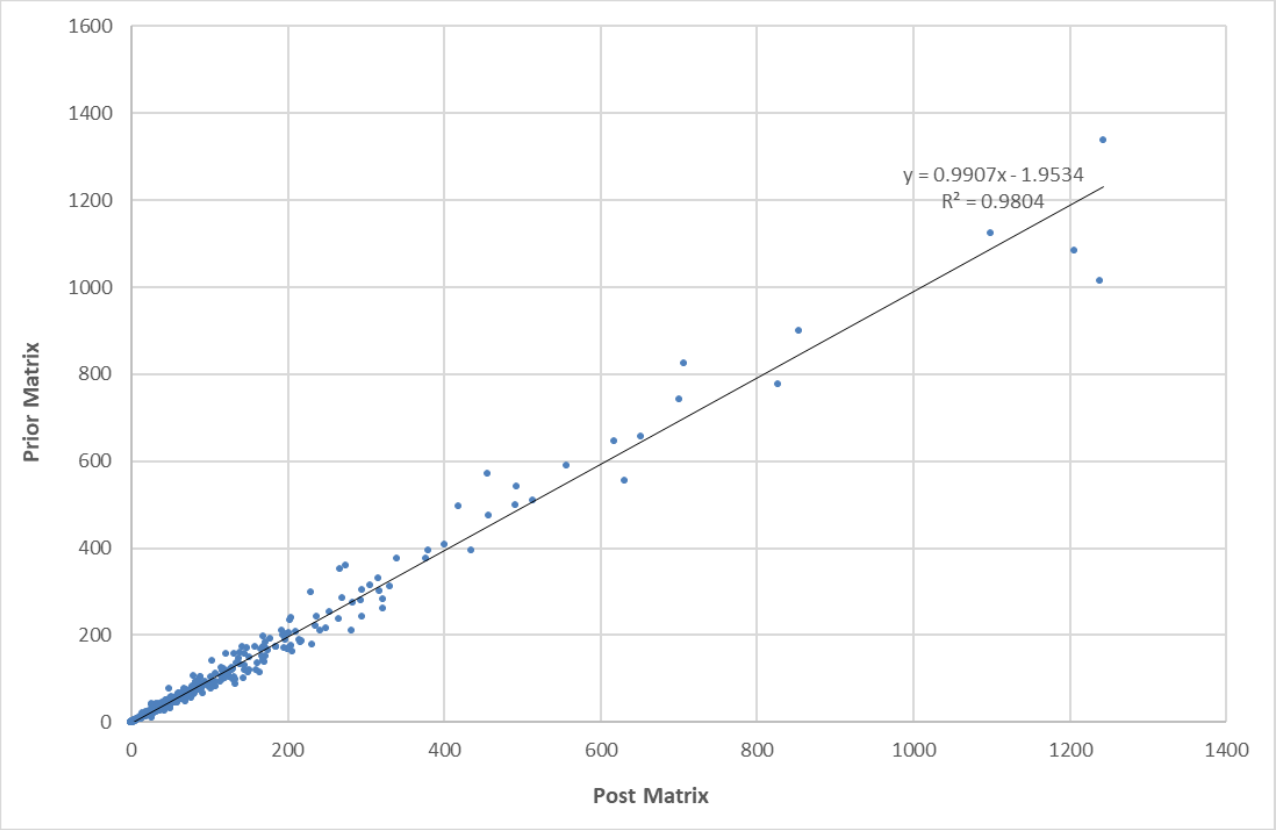


Figure 25 - Swindon 2023 Trip Matrix Destinations Before / After ME: IP All Vehicles

	Modelled	WebTAG
Slope	0.99	0.98-1.02
R^2	0.98	>0.95
Intercept	-1.95	Near 0

Table 27 - Swindon 2023 Trip Matrix Destinations Before / After ME: IP All Vehicles

GENERAL

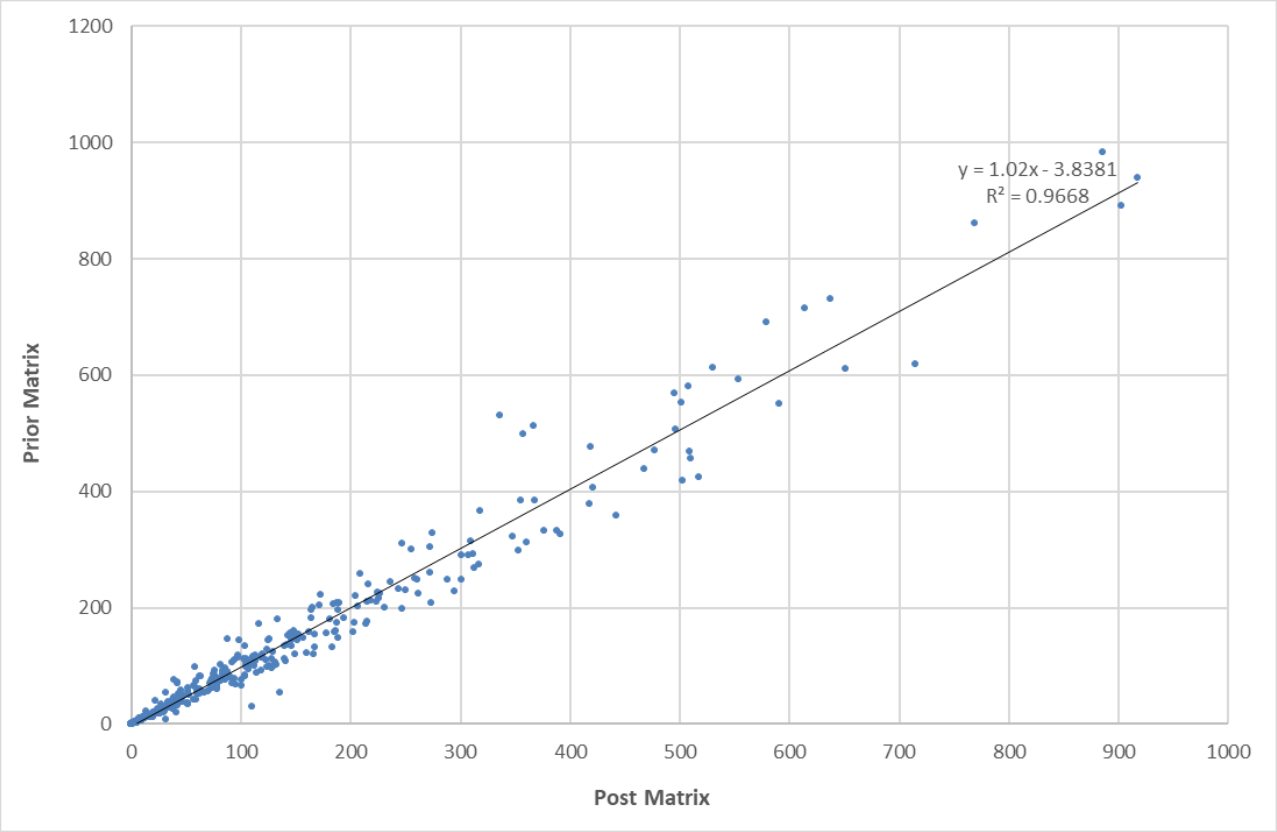


Figure 26 - Swindon 2023 Trip Matrix Destinations Before / After ME: PM Car

	Modelled	WebTAG
Slope	1.02	0.98-1.02
R^2	0.97	>0.95
Intercept	-3.84	Near 0

Table 28 - Swindon 2023 Trip Matrix Destinations Before / After ME: PM Car

GENERAL

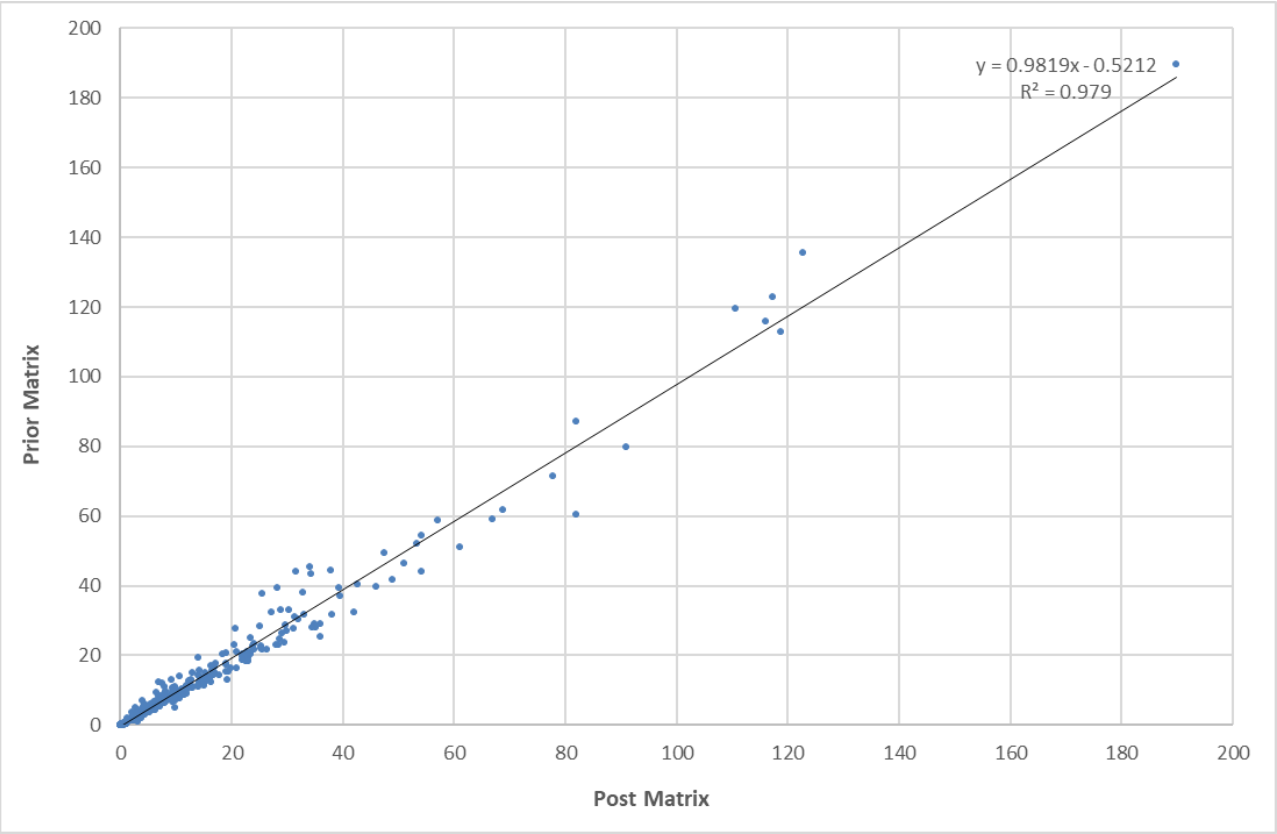


Figure 27 - Swindon 2023 Trip Matrix Destinations Before / After ME: PM LGV

	Modelled	WebTAG
Slope	0.98	0.98-1.02
R^2	0.98	>0.95
Intercept	-0.52	Near 0

Table 29 - Swindon 2023 Trip Matrix Destinations Before / After ME: PM LGV

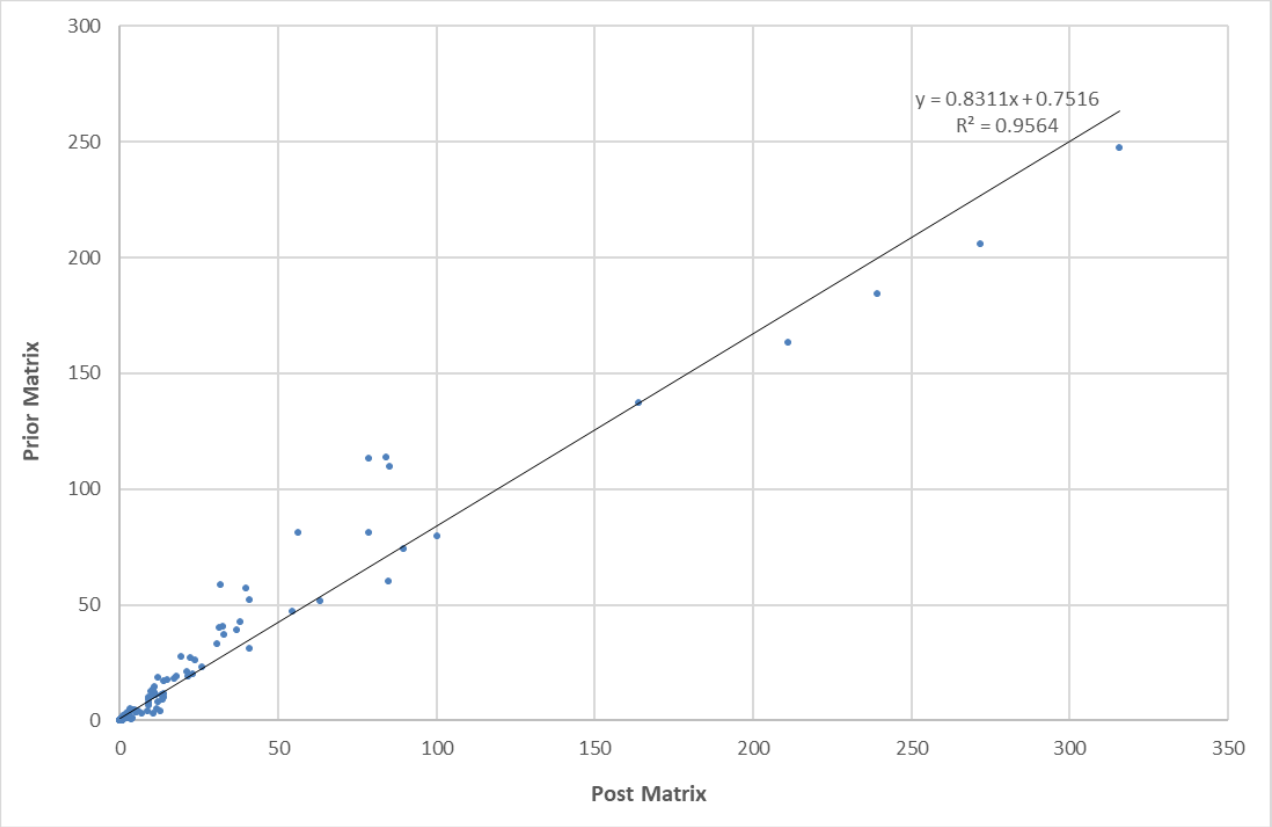


Figure 28 - Swindon 2023 Trip Matrix Destinations Before / After ME: PM HGV

	Modelled	WebTAG
Slope	0.83	0.98-1.02
R^2	0.96	>0.95
Intercept	0.75	Near 0

Table 30 - Swindon 2023 Trip Matrix Destinations Before / After ME: PM HGV

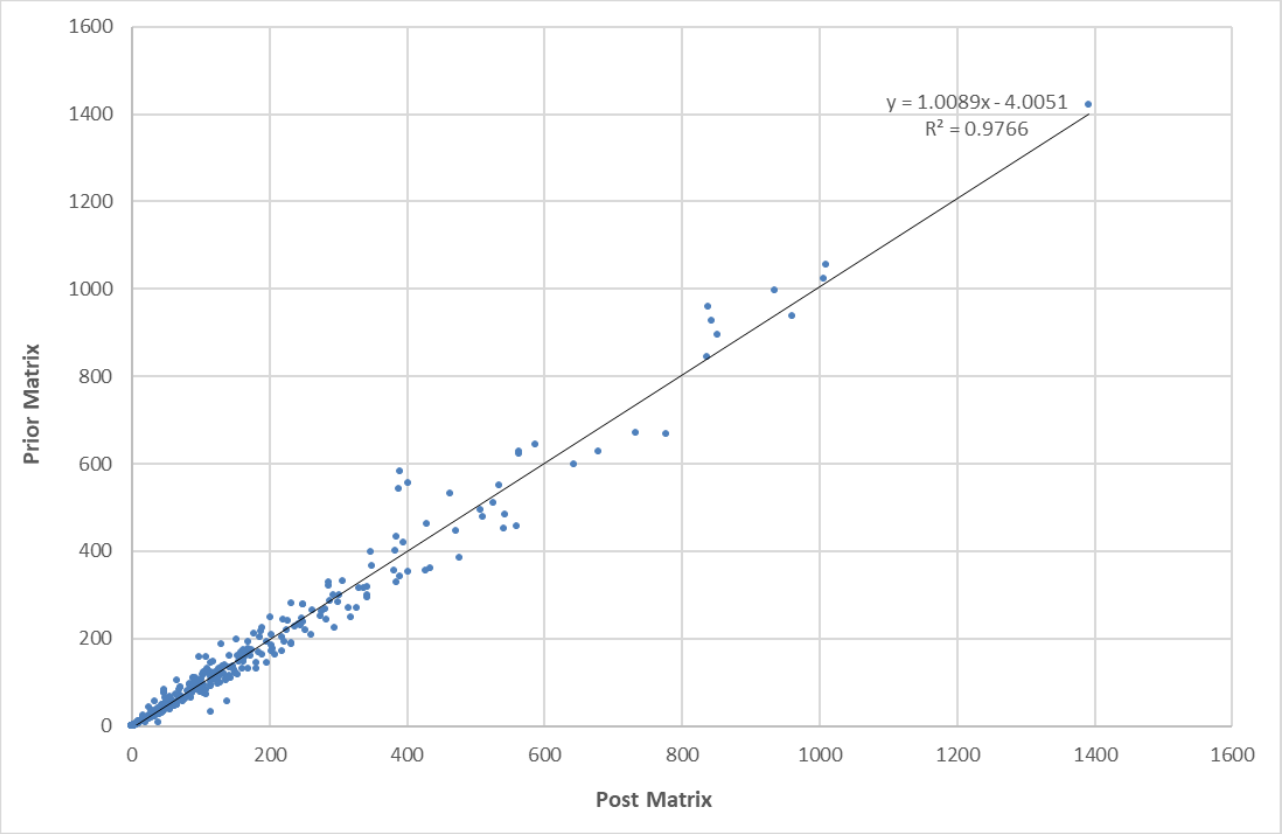


Figure 29 - Swindon 2023 Trip Matrix Destinations Before / After ME: PM All Vehicles

	Modelled	WebTAG
Slope	1.01	0.98-1.02
R^2	0.98	>0.95
Intercept	-4.01	Near 0

Table 31 - Swindon 2023 Trip Matrix Destinations Before / After ME: PM All Vehicles

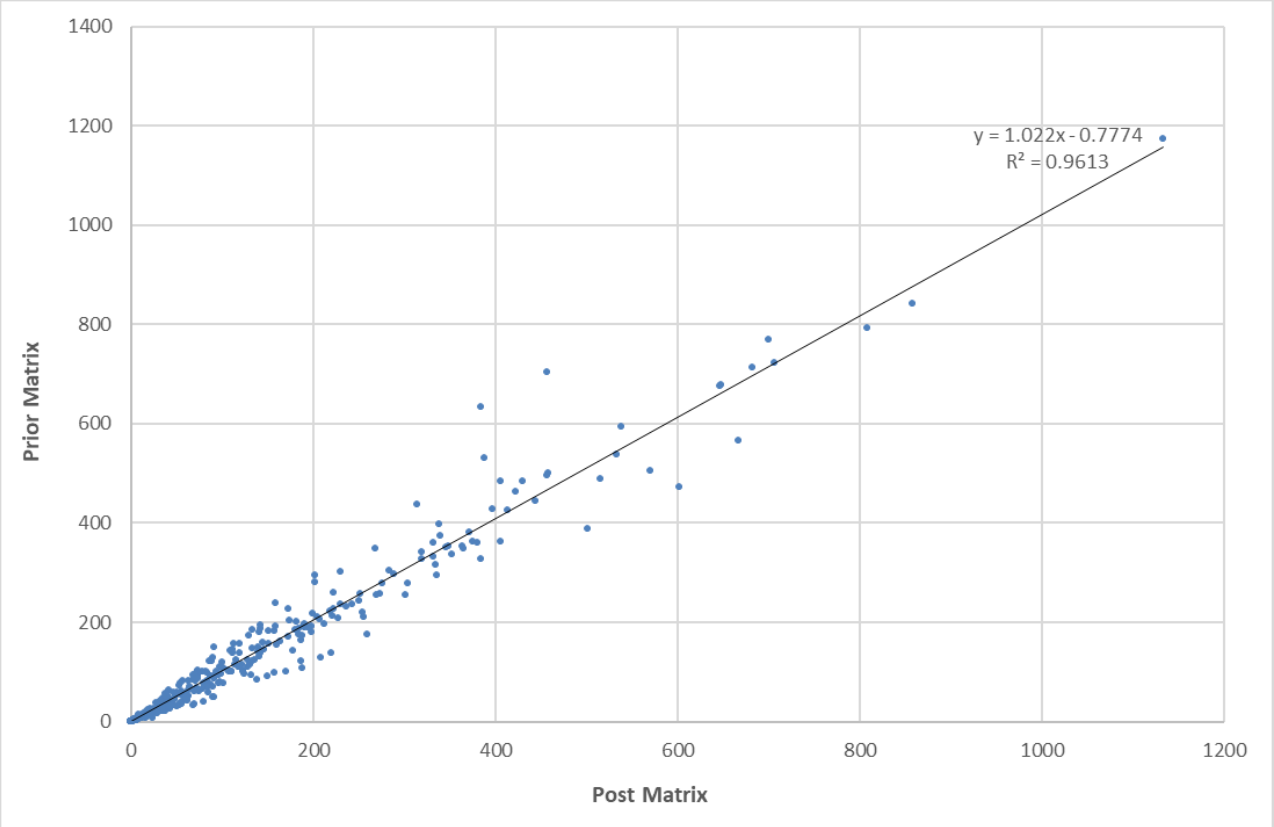


Figure 30 - Swindon 2023 Trip Matrix Origins Before / After ME: AM Car

	Modelled	WebTAG
Slope	1.02	0.98-1.02
R^2	0.96	>0.95
Intercept	-0.78	Near 0

Table 32 - Swindon 2023 Trip Matrix Origins Before / After ME: AM Car

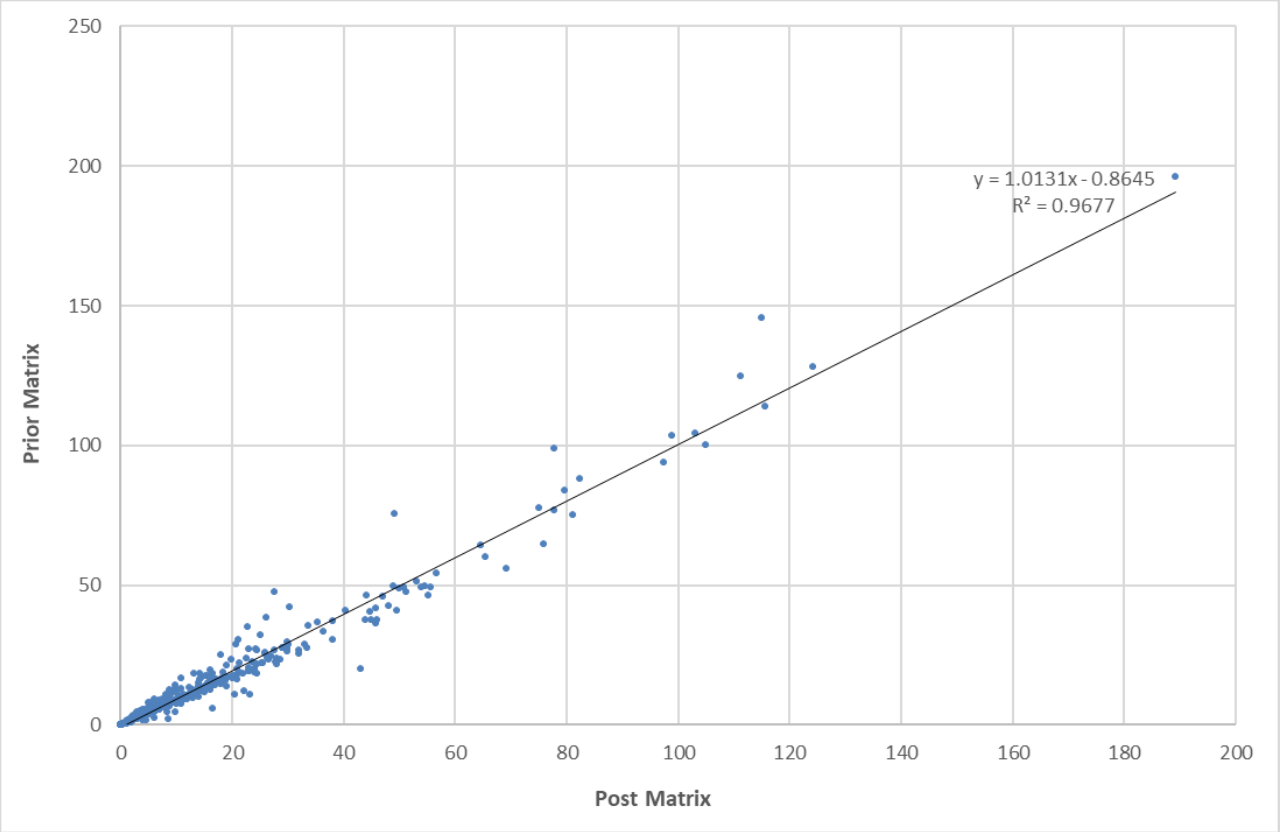


Figure 31 - Swindon 2023 Trip Matrix Origins Before / After ME: AM LGV

	Modelled	WebTAG
Slope	1.01	0.98-1.02
R^2	0.97	>0.95
Intercept	-0.86	Near 0

Table 33 - Swindon 2023 Trip Matrix Origins Before / After ME: AM LGV

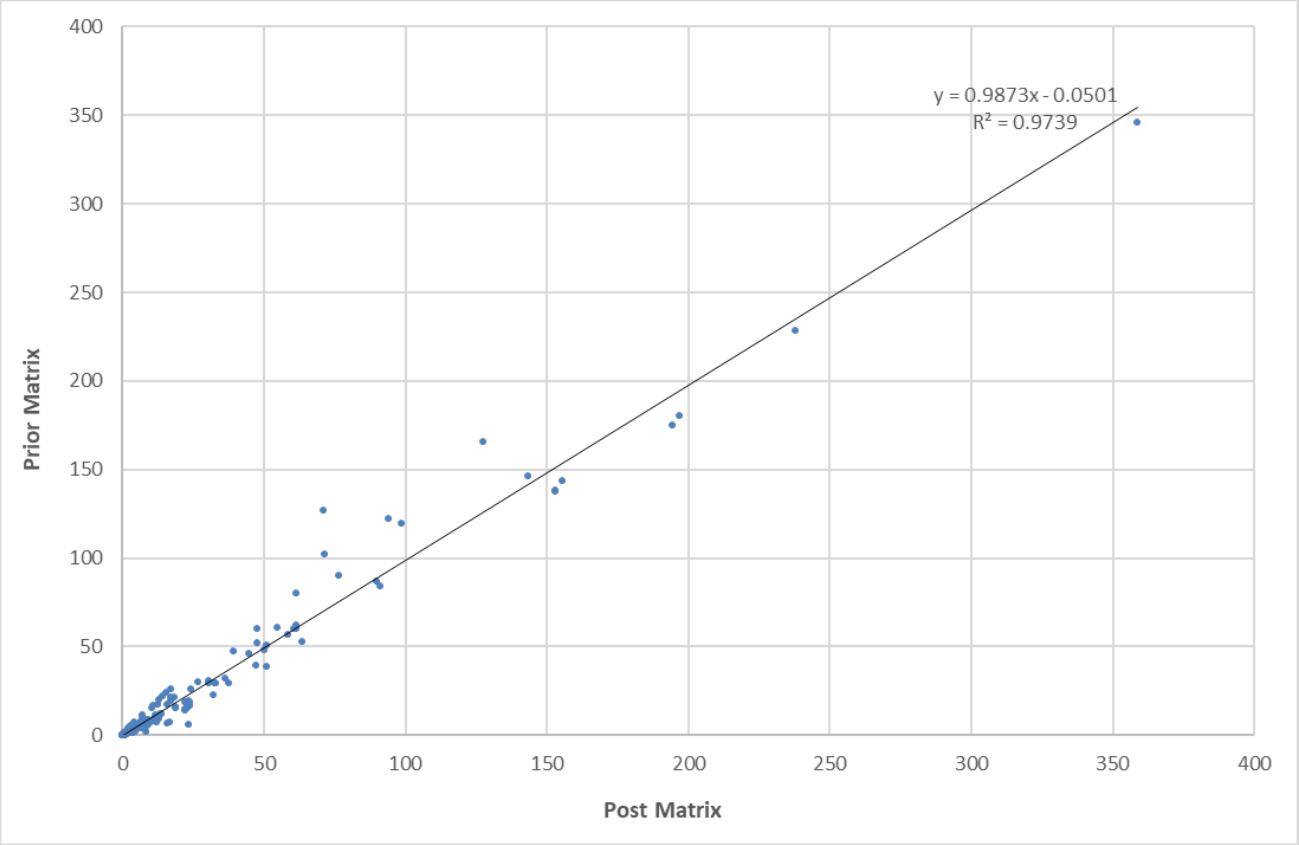


Figure 32 - Swindon 2023 Trip Matrix Origins Before / After ME: AM HGV

	Modelled	WebTAG
Slope	0.99	0.98-1.02
R^2	0.97	>0.95
Intercept	-0.05	Near 0

Table 34 Swindon 2023 Trip Matrix Origins Before / After ME: AM HGV

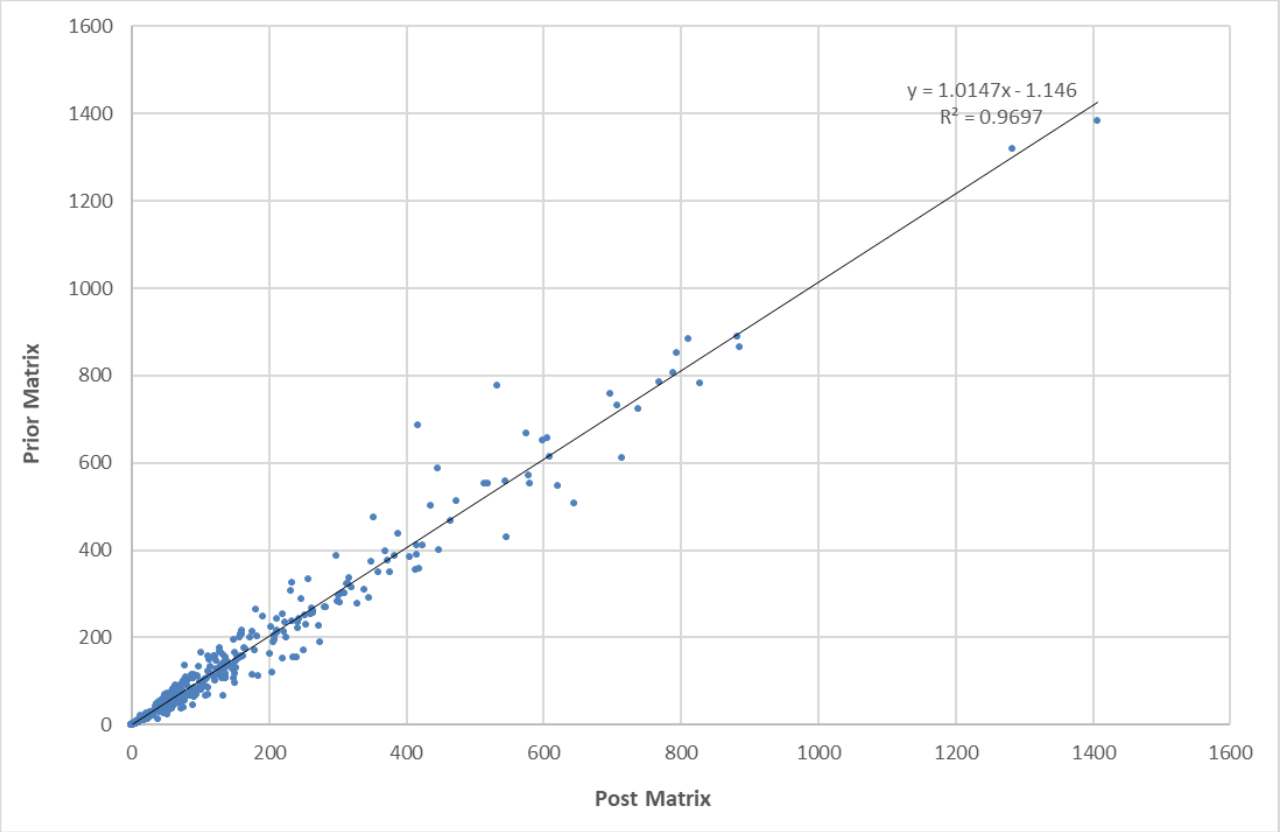


Figure 33 - Swindon 2023 Trip Matrix Origins Before / After ME: AM All Vehicles

	Modelled	WebTAG
Slope	1.01	0.98-1.02
R^2	0.97	>0.95
Intercept	-1.15	Near 0

Table 35 - Swindon 2023 Trip Matrix Origins Before / After ME: AM All Vehicles

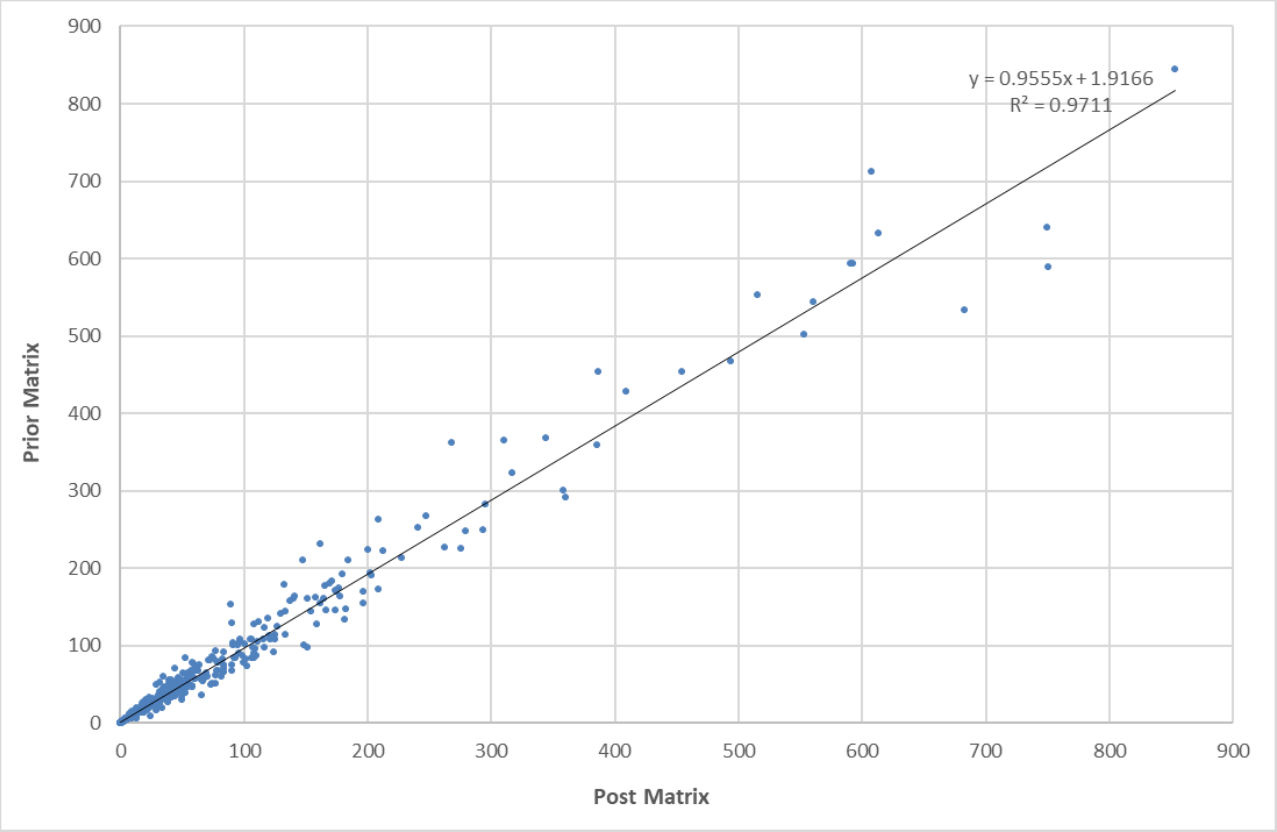


Figure 34 - Swindon 2023 Trip Matrix Origins Before / After ME: IP Car

	Modelled	WebTAG
Slope	0.96	0.98-1.02
R^2	0.97	>0.95
Intercept	1.92	Near 0

Table 36 - Swindon 2023 Trip Matrix Origins Before / After ME: IP Car

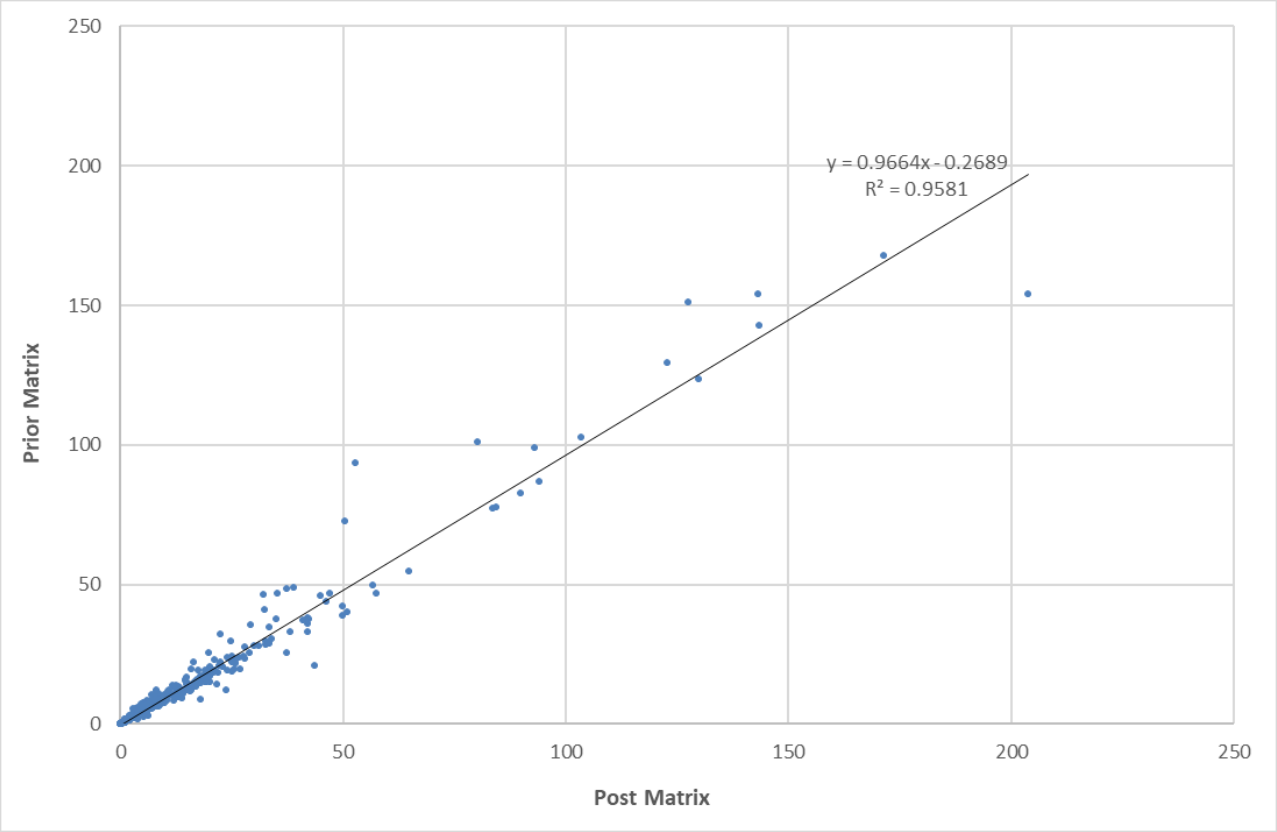


Figure 35 - Swindon 2023 Trip Matrix Origins Before / After ME: IP LGV

	Modelled	WebTAG
Slope	0.97	0.98-1.02
R^2	0.96	>0.95
Intercept	-0.27	Near 0

Table 37 - Swindon 2023 Trip Matrix Origins Before / After ME: IP LGV

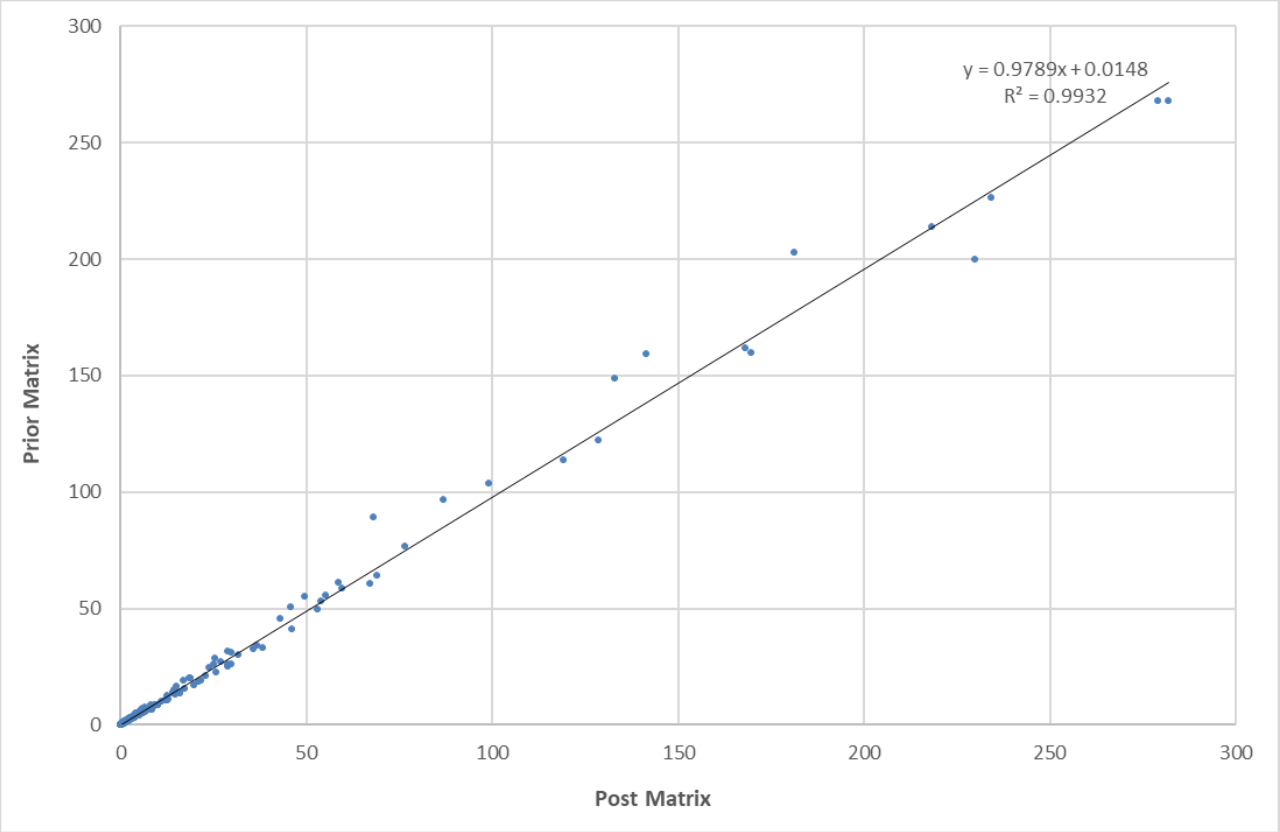


Figure 36- Swindon 2023 Trip Matrix Origins Before / After ME: IP HGV

	Modelled	WebTAG
Slope	0.98	0.98-1.02
R^2	0.99	>0.95
Intercept	0.01	Near 0

Table 38 - Swindon 2023 Trip Matrix Origins Before / After ME: IP HGV

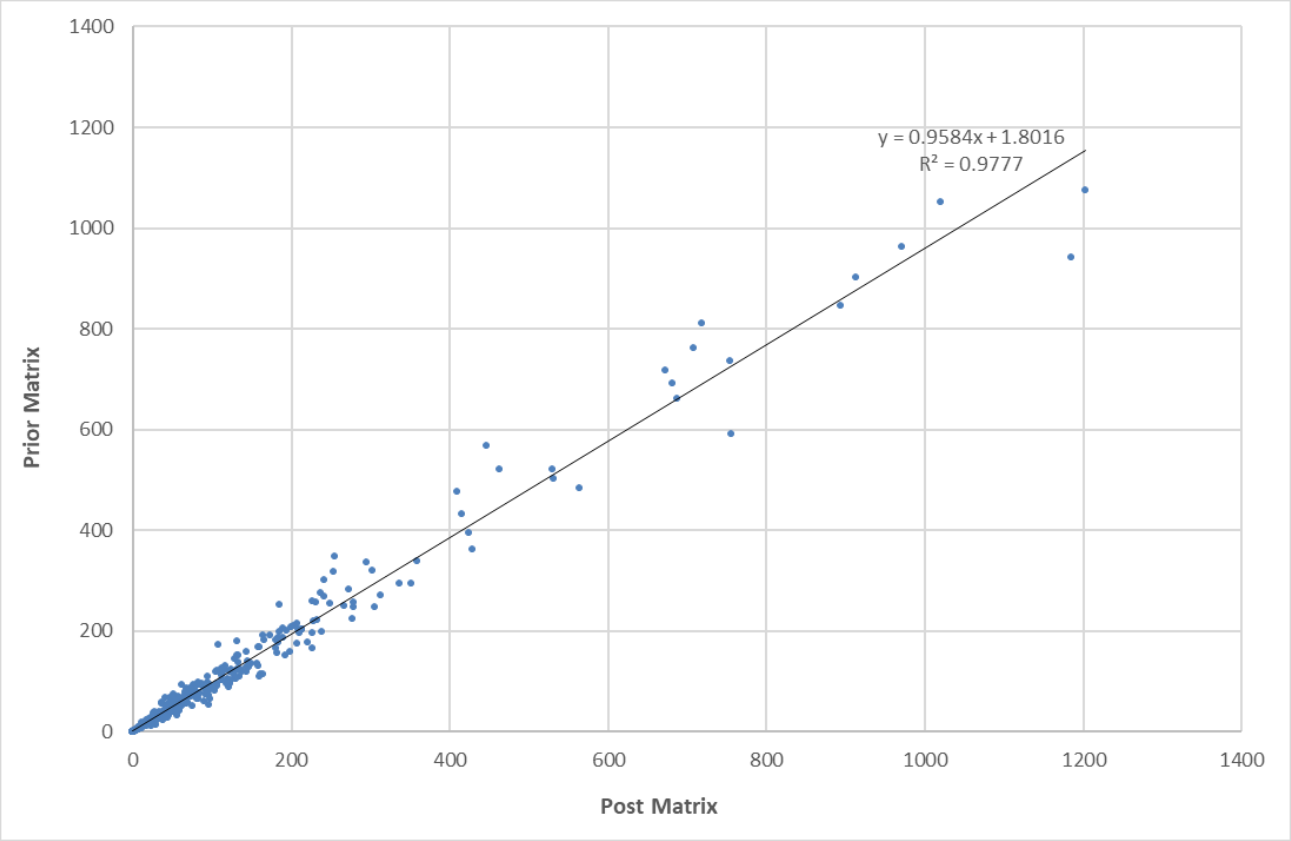


Figure 37 - Swindon 2023 Trip Matrix Origins Before / After ME: IP All Vehicles

	Modelled	WebTAG
Slope	0.96	0.98-1.02
R^2	0.98	>0.95
Intercept	1.80	Near 0

Table 39 - Swindon 2023 Trip Matrix Origins Before / After ME: IP All Vehicles

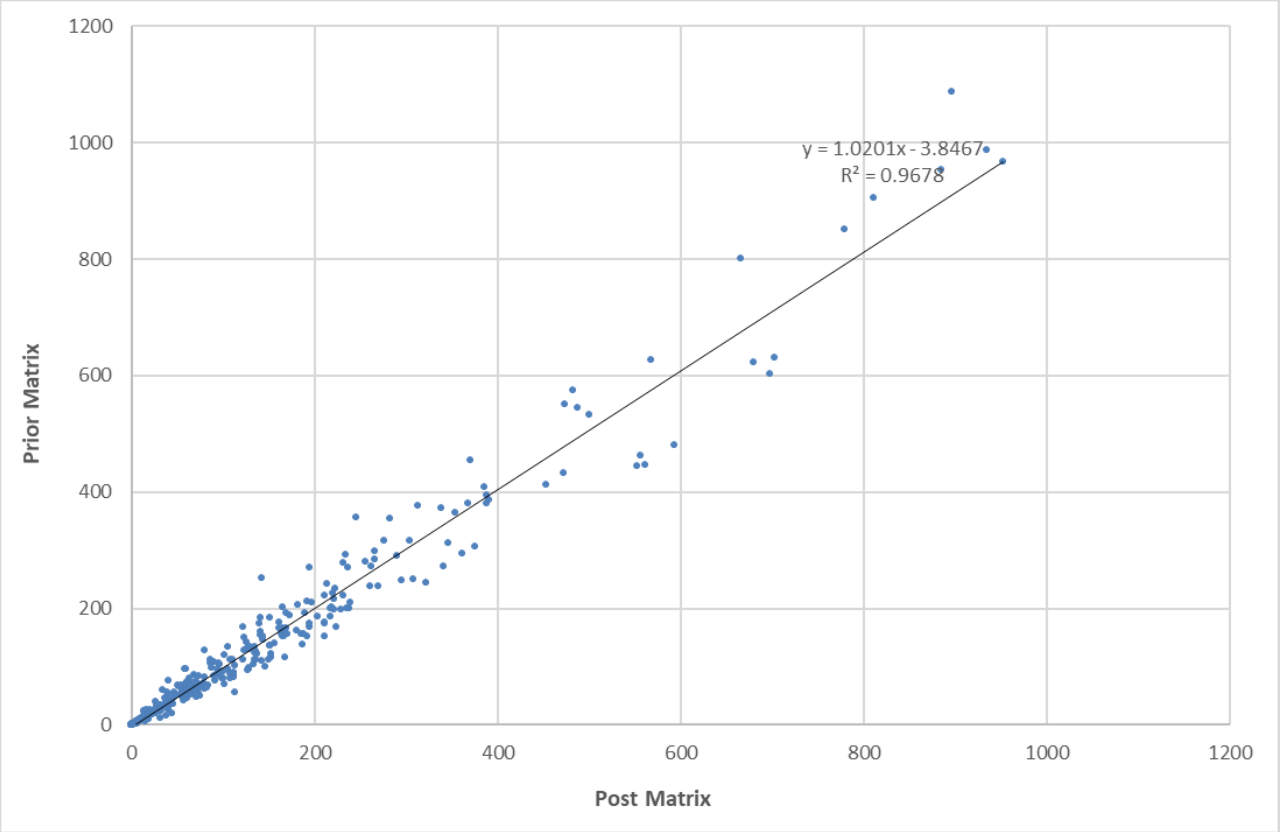


Figure 38 - Swindon 2023 Trip Matrix Origins Before / After ME: PM Car

	Modelled	WebTAG
Slope	1.02	0.98-1.02
R^2	0.97	>0.95
Intercept	-3.85	Near 0

Table 40 - Swindon 2023 Trip Matrix Origins Before / After ME: PM Car

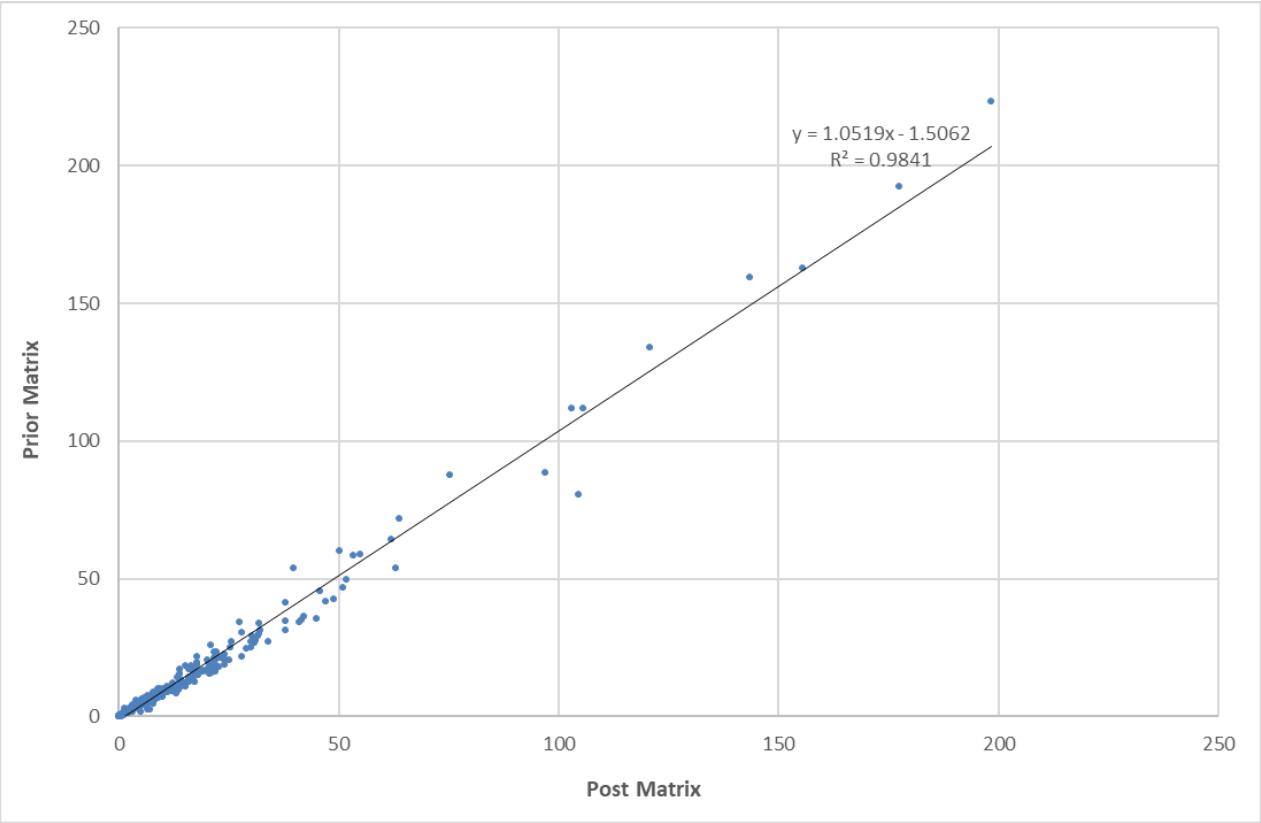


Figure 39 - Swindon 2023 Trip Matrix Origins Before / After ME: PM LGV

	Modelled	WebTAG
Slope	1.05	0.98-1.02
R^2	0.98	>0.95
Intercept	-1.51	Near 0

Table 41 - Swindon 2023 Trip Matrix Origins Before / After ME: PM LGV

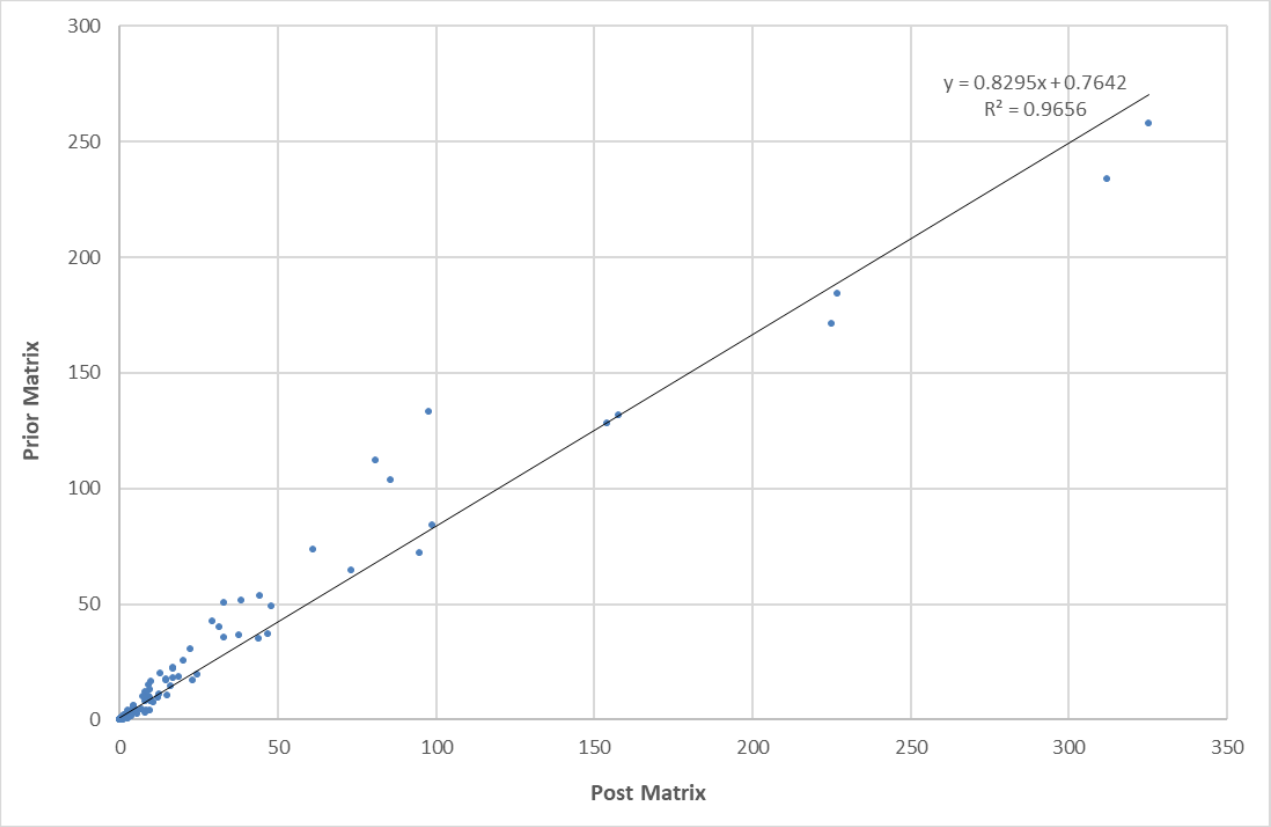


Figure 40 - Swindon 2023 Trip Matrix Origins Before / After ME: PM HGV

	Modelled	WebTAG
Slope	0.83	0.98-1.02
R^2	0.97	>0.95
Intercept	0.76	Near 0

Table 42 - Swindon 2023 Trip Matrix Origins Before / After ME: PM HGV

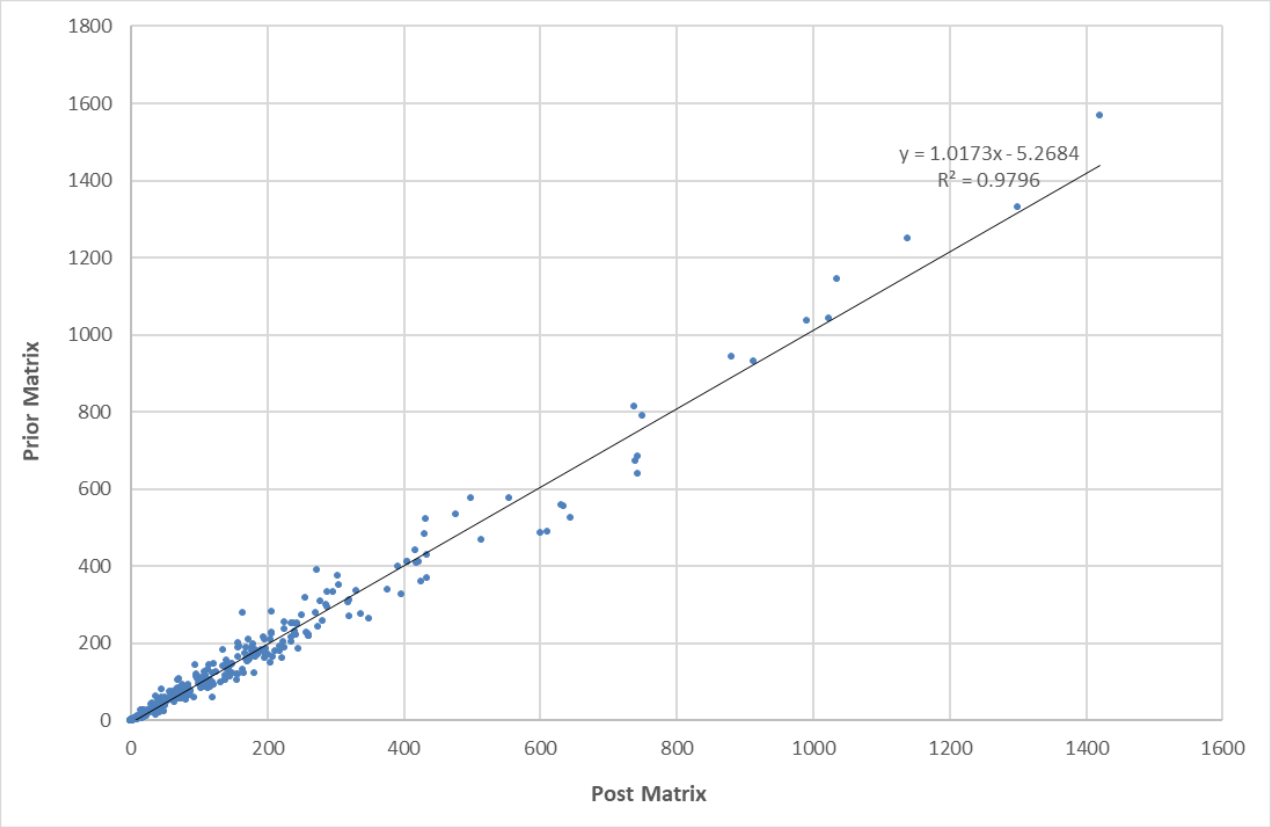


Figure 41 - Swindon 2023 Trip Matrix Origins Before / After ME: PM All Vehicles

	Modelled	WebTAG
Slope	1.02	0.98-1.02
R^2	0.98	>0.95
Intercept	-5.27	Near 0

Table 43 - Swindon 2023 Trip Matrix Origins Before / After ME: PM All Vehicles

Appendix D:

Change in Trip Length Distribution Post Matrix Estimation Compared with Prior Matrix

All Vehicles:

App_D_STM_2023_ME_Trip_Length_Distribution_Output.xlsb

GENERAL

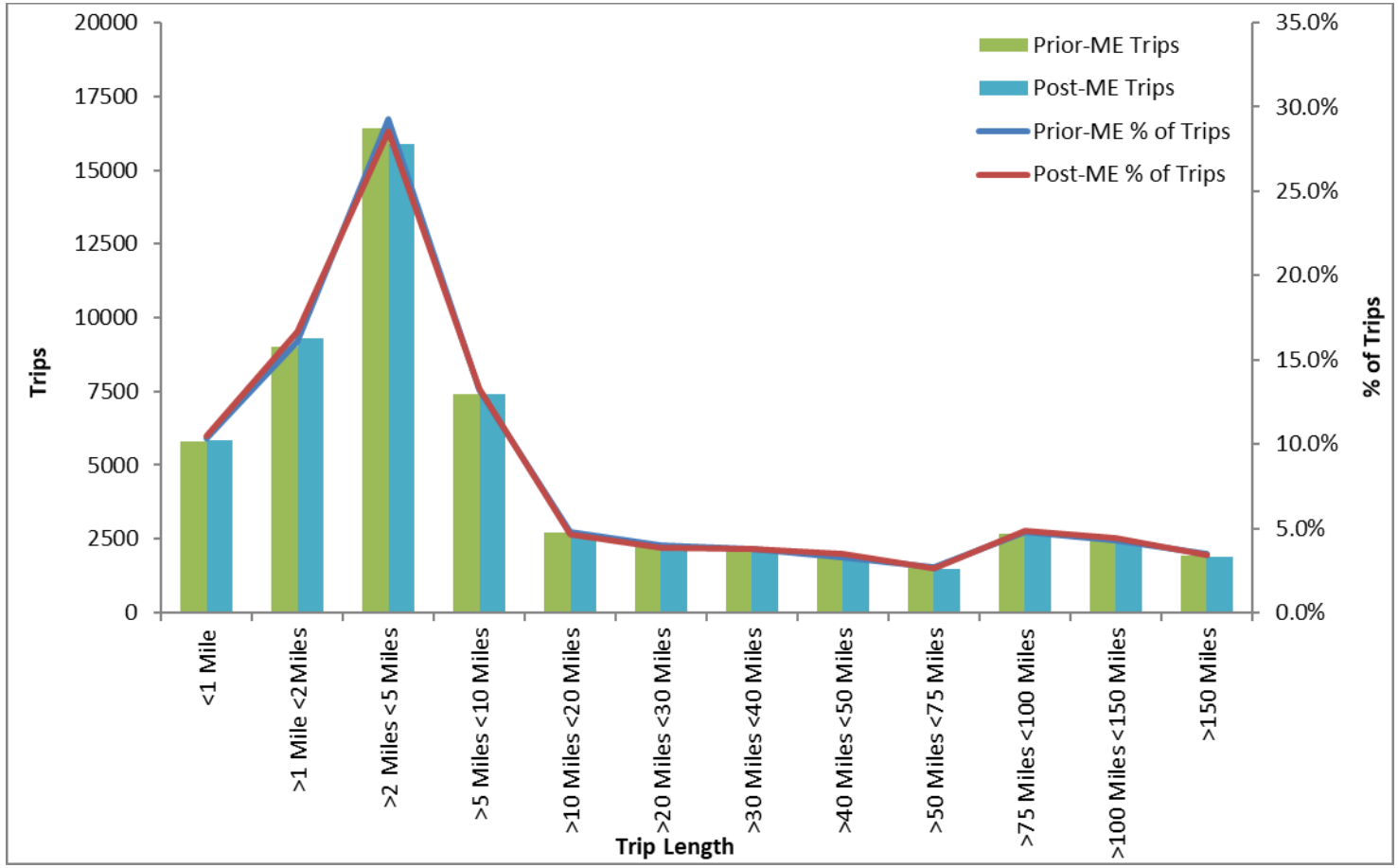


Figure 42 - Trip Length Distribution AM

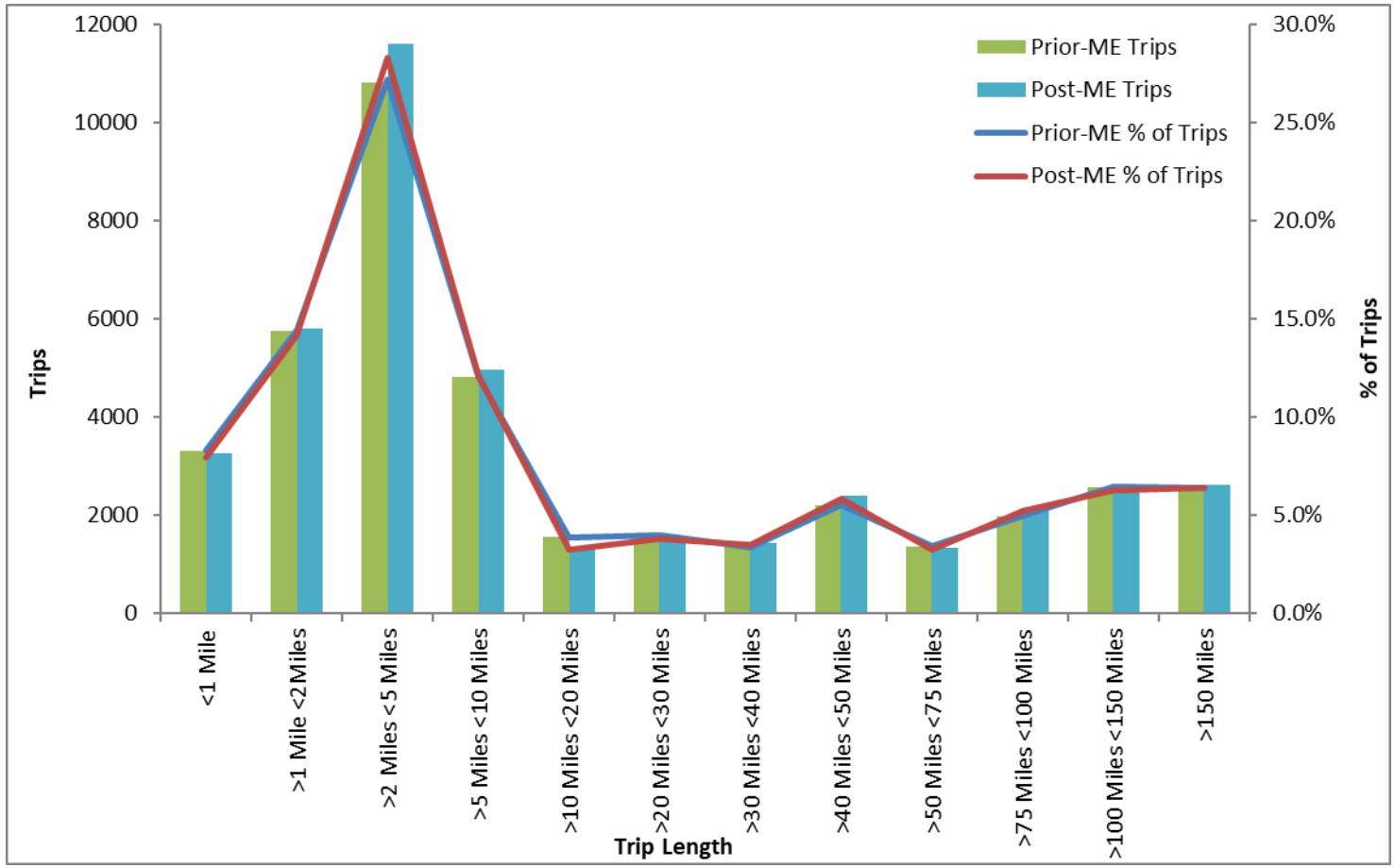


Figure 43 - Trip Length Distribution IP

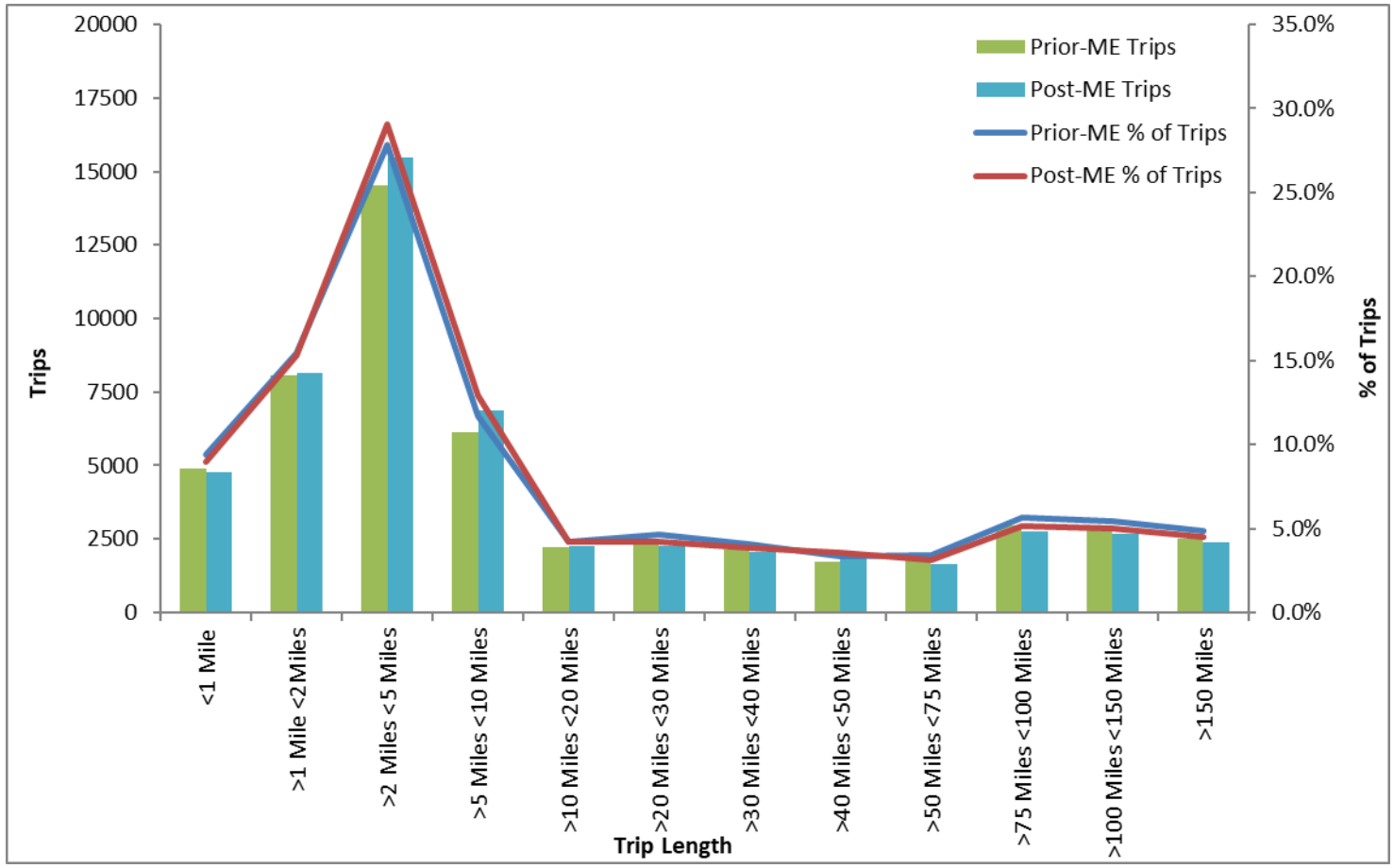


Figure 44 - Trip Length Distribution

Appendix E:

Change in OD Trips Post Matrix Estimation Compared with Prior Matrix

Sector to Sector Trip Movements:

App_E_STM_2023_ME_Sector_to_Sector_Output_Updated.xlsb

GENERAL

Prior (Car)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	7,433	4,136	954	509	329
Swindon Urban North	4,207	10,927	2,354	823	377
Swindon Rural	996	2,238	3,646	1,234	323
Surrounding LADS	532	693	999	634	873
Wider Counties/Regions	254	337	265	500	1,165

Table 44 - Swindon 2023 AM Pre-Estimation Car

Prior (LGV)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	510	509	125	109	55
Swindon Urban North	458	1,170	332	217	84
Swindon Rural	95	303	351	244	51
Surrounding LADS	85	188	209	205	226
Wider Counties/Regions	36	83	51	147	274

Table 45- Swindon 2023 AM Pre-Estimation LGV

Prior (HGV)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	118	147	30	51	26
Swindon Urban North	156	666	193	233	77
Swindon Rural	32	225	146	186	40
Surrounding LADS	63	267	199	354	370
Wider Counties/Regions	30	115	54	278	528

Table 46 - Swindon 2023 AM Pre-Estimation HGV

Prior (All)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	8,061	4,792	1,109	670	410
Swindon Urban North	4,821	12,763	2,878	1,273	538
Swindon Rural	1,124	2,766	4,142	1,664	414
Surrounding LADS	680	1,148	1,406	1,193	1,469
Wider Counties/Regions	320	535	369	925	1,967

Table 47 - Swindon 2023 AM Pre-Estimation All Vehicles

GENERAL

Post (Car)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	7,208	3,688	1,064	515	270
Swindon Urban North	3,817	11,151	2,453	807	353
Swindon Rural	1,134	2,427	3,506	1,127	267
Surrounding LADS	641	706	817	628	870
Wider Counties/Regions	289	374	241	518	1,132

Table 48 - Swindon 2023 AM Post-Estimation Car

Post (LGV)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	519	518	167	114	51
Swindon Urban North	544	1,200	400	265	90
Swindon Rural	117	308	313	221	43
Surrounding LADS	108	204	187	189	215
Wider Counties/Regions	46	108	49	140	228

Table 49 - Swindon 2023 AM Post-Estimation LGV

Post (HGV)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	118	122	48	71	40
Swindon Urban North	140	558	196	287	120
Swindon Rural	42	179	142	225	54
Surrounding LADS	96	215	200	357	389
Wider Counties/Regions	50	112	61	298	544

Table 50 - Swindon 2023 AM Post-Estimation HGV

Post (All)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	7,845	4,328	1,279	700	361
Swindon Urban North	4,502	12,909	3,049	1,358	564
Swindon Rural	1,293	2,913	3,961	1,572	364
Surrounding LADS	846	1,126	1,204	1,174	1,474
Wider Counties/Regions	385	594	351	956	1,904

Table 51 - Swindon 2023 AM Post-Estimation All Vehicles

Diff. % (Car)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	-3%	-11%	12%	1%	-18%
Swindon Urban North	-9%	2%	4%	-2%	-6%
Swindon Rural	14%	8%	-4%	-9%	-17%
Surrounding LADS	21%	2%	-18%	-1%	0%
Wider Counties/Regions	14%	11%	-9%	4%	-3%

Table 52 - Swindon 2023 AM Post-Estimation % Changes Car

Diff. % (LGV)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	2%	2%	34%	4%	-8%
Swindon Urban North	19%	3%	21%	22%	8%
Swindon Rural	23%	2%	-11%	-9%	-16%
Surrounding LADS	27%	9%	-10%	-8%	-5%
Wider Counties/Regions	28%	31%	-4%	-5%	-17%

Table 53 - Swindon 2023 AM Post-Estimation % Changes LGV

GENERAL

Diff. % (HGV)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	-1%	-17%	59%	38%	56%
Swindon Urban North	-10%	-16%	1%	23%	55%
Swindon Rural	29%	-21%	-3%	21%	36%
Surrounding LADS	52%	-20%	1%	1%	5%
Wider Counties/Regions	66%	-3%	14%	7%	3%

Table 54 - Swindon 2023 AM Post-Estimation % Changes HGV

Diff. % (All)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	-3%	-10%	15%	4%	-12%
Swindon Urban North	-7%	1%	6%	7%	5%
Swindon Rural	15%	5%	-4%	-6%	-12%
Surrounding LADS	24%	-2%	-14%	-2%	0%
Wider Counties/Regions	20%	11%	-5%	3%	-3%

Table 55 - Swindon 2023 AM Post-Estimation % Changes All vehicles

Prior (Car)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	3,453	2,581	514	316	170
Swindon Urban North	2,609	7,388	1,473	611	291
Swindon Rural	583	1,563	1,950	940	202
Surrounding LADS	321	650	972	611	821
Wider Counties/Regions	139	261	165	646	1,515

Table 56 - Swindon 2023 IP Pre-Estimation Car

Prior (LGV)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	435	390	87	72	35
Swindon Urban North	416	1,040	258	151	66
Swindon Rural	106	301	333	221	47
Surrounding LADS	77	164	223	190	233
Wider Counties/Regions	28	59	34	178	386

Table 57 - Swindon 2023 IP Pre-Estimation LGV

GENERAL

Prior(HGV)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	61	119	23	41	20
Swindon Urban North	117	701	193	246	83
Swindon Rural	21	204	104	178	35
Surrounding LADS	37	256	177	358	412
Wider Counties/Regions	13	69	26	344	663

Table 58 - Swindon 2023 IP Pre-Estimation HGV

Prior (All)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	3,949	3,091	624	429	225
Swindon Urban North	3,142	9,129	1,925	1,008	440
Swindon Rural	710	2,067	2,387	1,340	284
Surrounding LADS	435	1,070	1,372	1,159	1,466
Wider Counties/Regions	180	388	225	1,168	2,563

Table 59 - Swindon 2023 IP Pre-Estimation All Vehicles

GENERAL

Post (Car)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	3,763	2,526	588	347	173
Swindon Urban North	2,587	7,596	1,504	669	317
Swindon Rural	582	1,622	1,861	873	151
Surrounding LADS	362	716	930	598	812
Wider Counties/Regions	157	322	165	634	1,596

Table 60 - Swindon 2023 IP Post-Estimation Car

Post (LGV)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	477	452	126	87	42
Swindon Urban North	442	1,095	263	175	85
Swindon Rural	123	318	293	212	42
Surrounding LADS	90	200	215	200	221
Wider Counties/Regions	33	82	34	171	346

Table 61 - Swindon 2023 IP Post-Estimation LGV

Post (HGV)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	63	117	24	49	27
Swindon Urban North	116	654	178	246	90
Swindon Rural	22	197	102	187	37
Surrounding LADS	44	278	188	382	425
Wider Counties/Regions	16	81	29	371	670

Table 62 - Swindon 2023 IP Post-Estimation HGV

Post (All)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	4,303	3,096	738	483	241
Swindon Urban North	3,146	9,345	1,945	1,090	492
Swindon Rural	727	2,137	2,256	1,271	230
Surrounding LADS	496	1,194	1,333	1,179	1,457
Wider Counties/Regions	206	485	228	1,177	2,612

Table 63 - Swindon 2023 IP Post-Estimation All Vehicles

Diff. % (Car)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	9%	-2%	14%	10%	1%
Swindon Urban North	-1%	3%	2%	10%	9%
Swindon Rural	0%	4%	-5%	-7%	-25%
Surrounding LADS	13%	10%	-4%	-2%	-1%
Wider Counties/Regions	13%	24%	0%	-2%	5%

Table 64 - Swindon 2023 IP Post-Estimation % Changes Car

Diff. % (LGV)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	10%	16%	44%	22%	20%
Swindon Urban North	6%	5%	2%	16%	30%
Swindon Rural	15%	6%	-12%	-4%	-10%
Surrounding LADS	17%	22%	-4%	5%	-5%
Wider Counties/Regions	17%	39%	-1%	-4%	-10%

Table 65 - Swindon 2023 IP Post-Estimation % Changes LGV

GENERAL

Diff. % (HGV)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	3%	-2%	6%	19%	33%
Swindon Urban North	-1%	-7%	-8%	0%	8%
Swindon Rural	4%	-3%	-2%	5%	6%
Surrounding LADS	18%	9%	7%	7%	3%
Wider Counties/Regions	18%	17%	13%	8%	1%

Table 66 - Swindon 2023 IP Post-Estimation % Changes HGV

Diff. % (All)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	9%	0%	18%	13%	7%
Swindon Urban North	0%	2%	1%	8%	12%
Swindon Rural	2%	3%	-5%	-5%	-19%
Surrounding LADS	14%	12%	-3%	2%	-1%
Wider Counties/Regions	14%	25%	1%	1%	2%

Table 67 - Swindon 2023 IP Post-Estimation % Changes All Vehicles

Prior (Car)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	5,993	3,809	902	573	278
Swindon Urban North	3,994	11,031	1,917	915	417
Swindon Rural	891	2,239	2,542	1,037	258
Surrounding LADS	622	1,071	1,352	819	884
Wider Counties/Regions	446	684	426	981	1,644

Table 68 - Swindon 2023 PM Pre-Estimation Car

Prior (LGV)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	441	281	66	61	27
Swindon Urban North	341	847	163	115	49
Swindon Rural	102	218	197	147	33
Surrounding LADS	113	185	214	172	175
Wider Counties/Regions	80	117	66	211	362

Table 69 - Swindon 2023 PM Pre-Estimation LGV

Prior (HGV)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	10	31	4	15	7
Swindon Urban North	28	376	48	152	53
Swindon Rural	4	51	16	63	14
Surrounding LADS	14	183	70	305	298
Wider Counties/Regions	9	93	21	320	524

Table 70 - Swindon 2023 PM Pre-Estimation HGV

Prior (All)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	6,444	4,122	972	649	312
Swindon Urban North	4,363	12,254	2,129	1,181	519
Swindon Rural	997	2,508	2,755	1,247	305
Surrounding LADS	749	1,439	1,636	1,295	1,356
Wider Counties/Regions	534	894	513	1,512	2,530

Table 71 - Swindon 2023 PM Pre-Estimation All Vehicles

GENERAL

Post (Car)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	6,377	3,688	1,190	677	288
Swindon Urban North	4,079	11,135	2,283	897	381
Swindon Rural	940	2,609	2,471	852	209
Surrounding LADS	646	1,114	1,187	754	774
Wider Counties/Regions	393	657	329	866	1,384

Table 72 - Swindon 2023 PM Post-Estimation Car

Post (LGV)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	502	322	82	74	36
Swindon Urban North	376	905	211	141	68
Swindon Rural	116	251	184	147	38
Surrounding LADS	124	203	218	150	157
Wider Counties/Regions	76	126	61	180	314

Table 73 - Swindon 2023 PM Post-Estimation LGV

Post (HGV)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	13	29	4	26	16
Swindon Urban North	25	333	41	131	55
Swindon Rural	6	49	14	79	16
Surrounding LADS	29	176	79	275	345
Wider Counties/Regions	20	103	20	348	702

Table 74 - Swindon 2023 PM Post-Estimation HGV

Post (All)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	6,893	4,038	1,275	777	341
Swindon Urban North	4,480	12,373	2,535	1,170	504
Swindon Rural	1,062	2,909	2,669	1,078	263
Surrounding LADS	799	1,492	1,484	1,178	1,276
Wider Counties/Regions	489	887	410	1,395	2,401

Table 75 - Swindon 2023 PM Post-Estimation All Vehicles

Diff. % (Car)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	6%	-3%	32%	18%	4%
Swindon Urban North	2%	1%	19%	-2%	-9%
Swindon Rural	6%	17%	-3%	-18%	-19%
Surrounding LADS	4%	4%	-12%	-8%	-12%
Wider Counties/Regions	-12%	-4%	-23%	-12%	-16%

Table 76 - Swindon 2023 PM Post-Estimation % Changes Car

Diff. % (LGV)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	14%	15%	24%	21%	32%
Swindon Urban North	10%	7%	29%	23%	38%
Swindon Rural	13%	15%	-7%	0%	14%
Surrounding LADS	10%	9%	2%	-13%	-10%
Wider Counties/Regions	-4%	8%	-8%	-14%	-13%

Table 77 - Swindon 2023 PM Post-Estimation % Changes LGV

Diff. % (HGV)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	34%	-9%	-5%	76%	130%
Swindon Urban North	-11%	-11%	-15%	-14%	4%
Swindon Rural	35%	-5%	-15%	25%	17%
Surrounding LADS	103%	-4%	12%	-10%	16%
Wider Counties/Regions	131%	11%	-5%	9%	34%

Table 78 - Swindon 2023 PM Post-Estimation % Changes HGV

Diff. % (All)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	7%	-2%	31%	20%	9%
Swindon Urban North	3%	1%	19%	-1%	-3%
Swindon Rural	6%	16%	-3%	-14%	-14%
Surrounding LADS	7%	4%	-9%	-9%	-6%
Wider Counties/Regions	-8%	-1%	-20%	-8%	-5%

Table 79 - Swindon 2023 PM Post-Estimation % Changes All Vehicles

Prior (Car)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	2.6	7.2	3.5	0.3	3.4
Swindon Urban North	6.2	2.1	2.0	0.5	1.2
Swindon Rural	4.2	3.9	2.3	3.1	3.3
Surrounding LADS	4.5	0.5	6.0	0.2	0.1
Wider Counties/Regions	2.2	1.9	1.5	0.8	1.0

Table 80 - Swindon 2023 AM Post-Estimation Changes GEH Car

Prior (LGV)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	0.4	0.4	3.5	0.5	0.6
Swindon Urban North	3.9	0.9	3.6	3.1	0.7
Swindon Rural	2.1	0.3	2.1	1.5	1.2
Surrounding LADS	2.4	1.2	1.5	1.1	0.8
Wider Counties/Regions	1.6	2.6	0.3	0.6	2.9

Table 81 - Swindon 2023 AM Post-Estimation Changes GEH LGV

Prior (HGV)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	0.1	2.1	2.8	2.5	2.5
Swindon Urban North	1.3	4.4	0.2	3.3	4.3
Swindon Rural	1.5	3.2	0.4	2.7	2.1
Surrounding LADS	3.7	3.4	0.1	0.1	1.0
Wider Counties/Regions	3.1	0.3	1.0	1.2	0.7

Table 82 - Swindon 2023 AM Post-Estimation Changes GEH HGV

Prior (All)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	2.4	6.9	4.9	1.1	2.5
Swindon Urban North	4.7	1.3	3.1	2.4	1.1
Swindon Rural	4.9	2.8	2.9	2.3	2.5
Surrounding LADS	6.0	0.7	5.6	0.5	0.1
Wider Counties/Regions	3.5	2.5	0.9	1.0	1.4

Table 83 - Swindon 2023 AM Post-Estimation Changes GEH All Vehicles

Prior (Car)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	5.2	1.1	3.2	1.7	0.2
Swindon Urban North	0.4	2.4	0.8	2.3	1.5
Swindon Rural	0.0	1.5	2.0	2.2	3.8
Surrounding LADS	2.2	2.5	1.4	0.6	0.3
Wider Counties/Regions	1.5	3.6	0.0	0.5	2.1

Table 84 - Swindon 2023 IP Post-Estimation Changes GEH Car

Prior (LGV)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	2.0	3.0	3.7	1.8	1.1
Swindon Urban North	1.2	1.7	0.3	1.9	2.2
Swindon Rural	1.5	1.0	2.3	0.6	0.7
Surrounding LADS	1.4	2.7	0.5	0.7	0.8
Wider Counties/Regions	0.9	2.8	0.1	0.5	2.1

Table 85 - Swindon 2023 IP Post-Estimation Changes GEH LGV

Prior (HGV)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	0.3	0.2	0.3	1.2	1.4
Swindon Urban North	0.1	1.8	1.1	0.0	0.7
Swindon Rural	0.2	0.5	0.2	0.6	0.3
Surrounding LADS	1.0	1.3	0.9	1.2	0.6
Wider Counties/Regions	0.6	1.3	0.6	1.4	0.3

Table 86 - Swindon 2023 IP Post-Estimation Changes GEH HGV

Prior (All)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	5.5	0.1	4.4	2.6	1.1
Swindon Urban North	0.1	2.2	0.5	2.6	2.4
Swindon Rural	0.6	1.5	2.7	1.9	3.3
Surrounding LADS	2.8	3.7	1.0	0.6	0.2
Wider Counties/Regions	1.8	4.6	0.2	0.3	1.0

Table 87 - Swindon 2023 IP Post-Estimation Changes GEH All Vehicles

Prior (Car)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	4.9	2.0	8.9	4.2	0.6
Swindon Urban North	1.3	1.0	8.0	0.6	1.8
Swindon Rural	1.6	7.5	1.4	6.0	3.2
Surrounding LADS	0.9	1.3	4.6	2.3	3.8
Wider Counties/Regions	2.6	1.0	5.0	3.8	6.7

Table 88 - Swindon 2023 PM Post-Estimation Changes GEH Car

Prior (LGV)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	2.8	2.4	1.8	1.6	1.6
Swindon Urban North	1.8	2.0	3.5	2.3	2.4
Swindon Rural	1.3	2.2	1.0	0.0	0.8
Surrounding LADS	1.0	1.2	0.3	1.8	1.4
Wider Counties/Regions	0.4	0.8	0.7	2.2	2.6

Table 89 - Swindon 2023 PM Post-Estimation Changes GEH LGV

Prior (HGV)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	1.0	0.5	0.1	2.5	2.7
Swindon Urban North	0.6	2.3	1.1	1.7	0.3
Swindon Rural	0.7	0.3	0.6	1.9	0.6
Surrounding LADS	3.1	0.5	1.0	1.8	2.7
Wider Counties/Regions	3.0	1.0	0.2	1.6	7.2

Table 90 - Swindon 2023 PM Post-Estimation Changes GEH HGV

Prior (All)	Swindon Urban South	Swindon Urban North	Swindon Rural	Surrounding LADS	Wider Counties/Regions
Swindon Urban South	5.5	1.3	9.0	4.8	1.6
Swindon Urban North	1.8	1.1	8.4	0.3	0.7
Swindon Rural	2.0	7.7	1.7	4.9	2.5
Surrounding LADS	1.8	1.4	3.9	3.3	2.2
Wider Counties/Regions	2.0	0.2	4.8	3.1	2.6

Table 91 - Swindon 2023 PM Post-Estimation Changes GEH All Vehicles

Appendix F:

Assigned Traffic Flow Validation – AM, IP and PM Models

Comparison of Modelled – Observed Flow Differences Against TAG Criteria:

App_F_STM_2023_SATURN_Assigned_Flow_Validation_Updated.xlsm

GENERAL

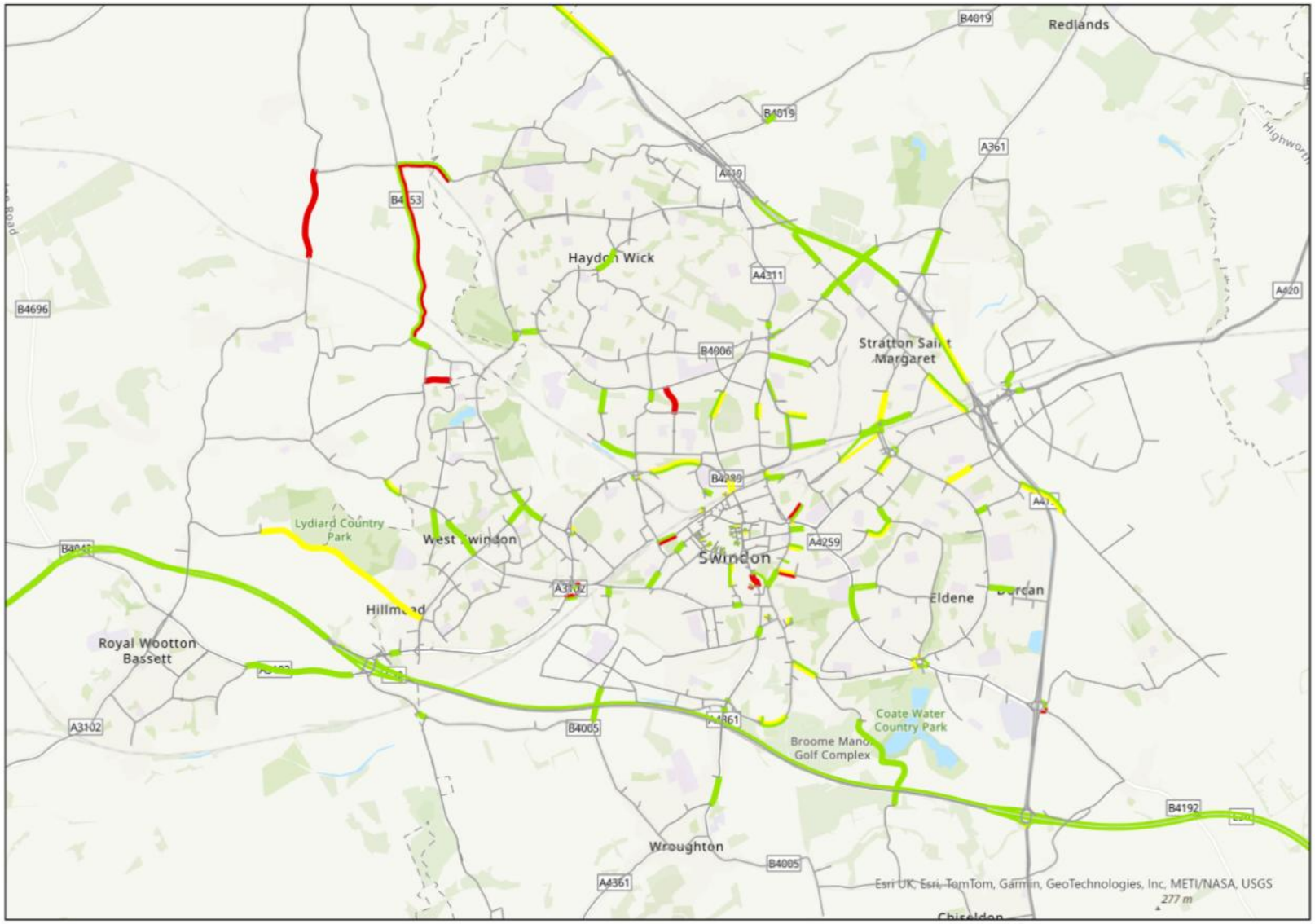


Figure 45 – STM Assigned Flow Validation: GEH AM

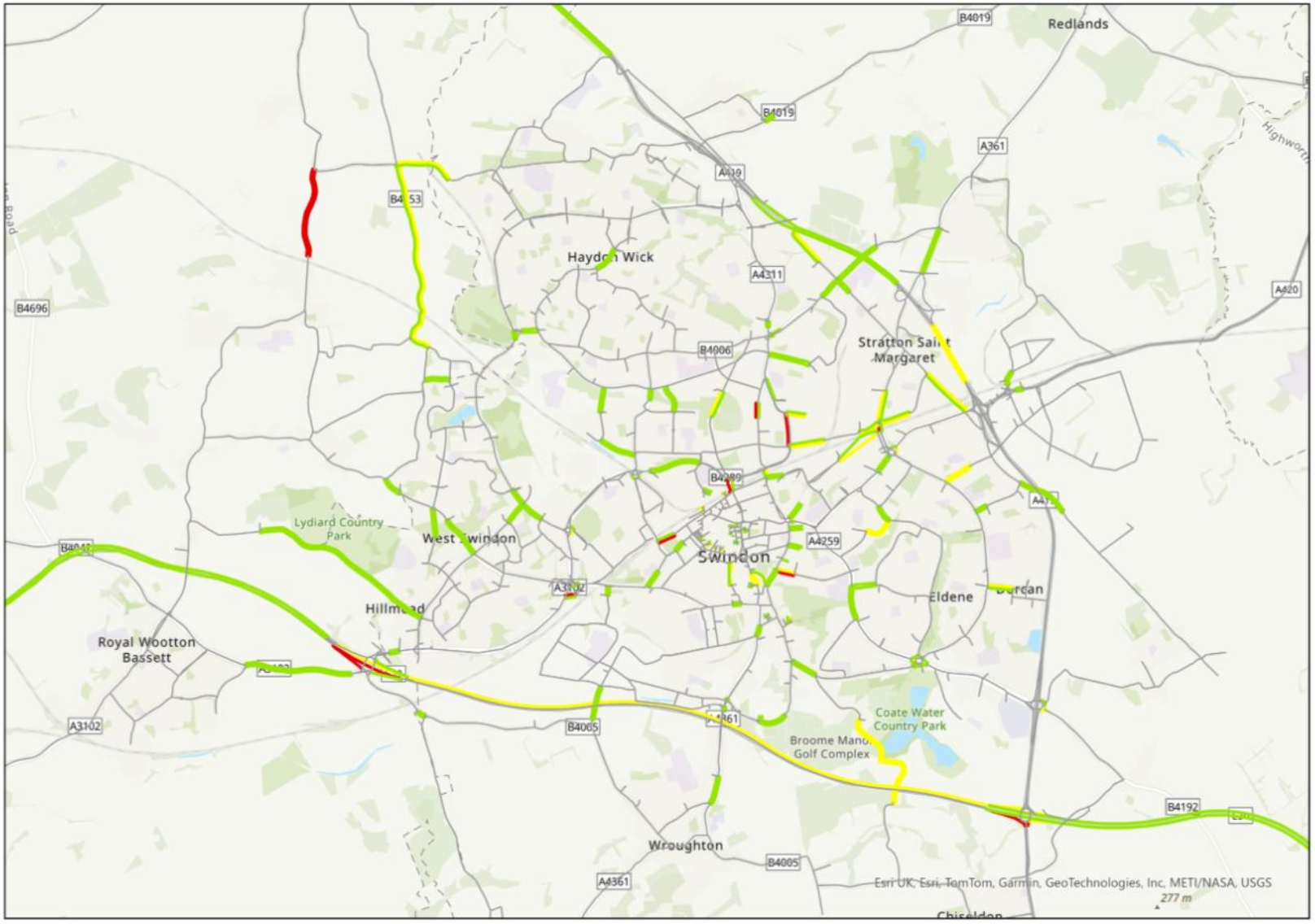


Figure 46 - STM Assigned Flow Validation: GEH IP

GENERAL

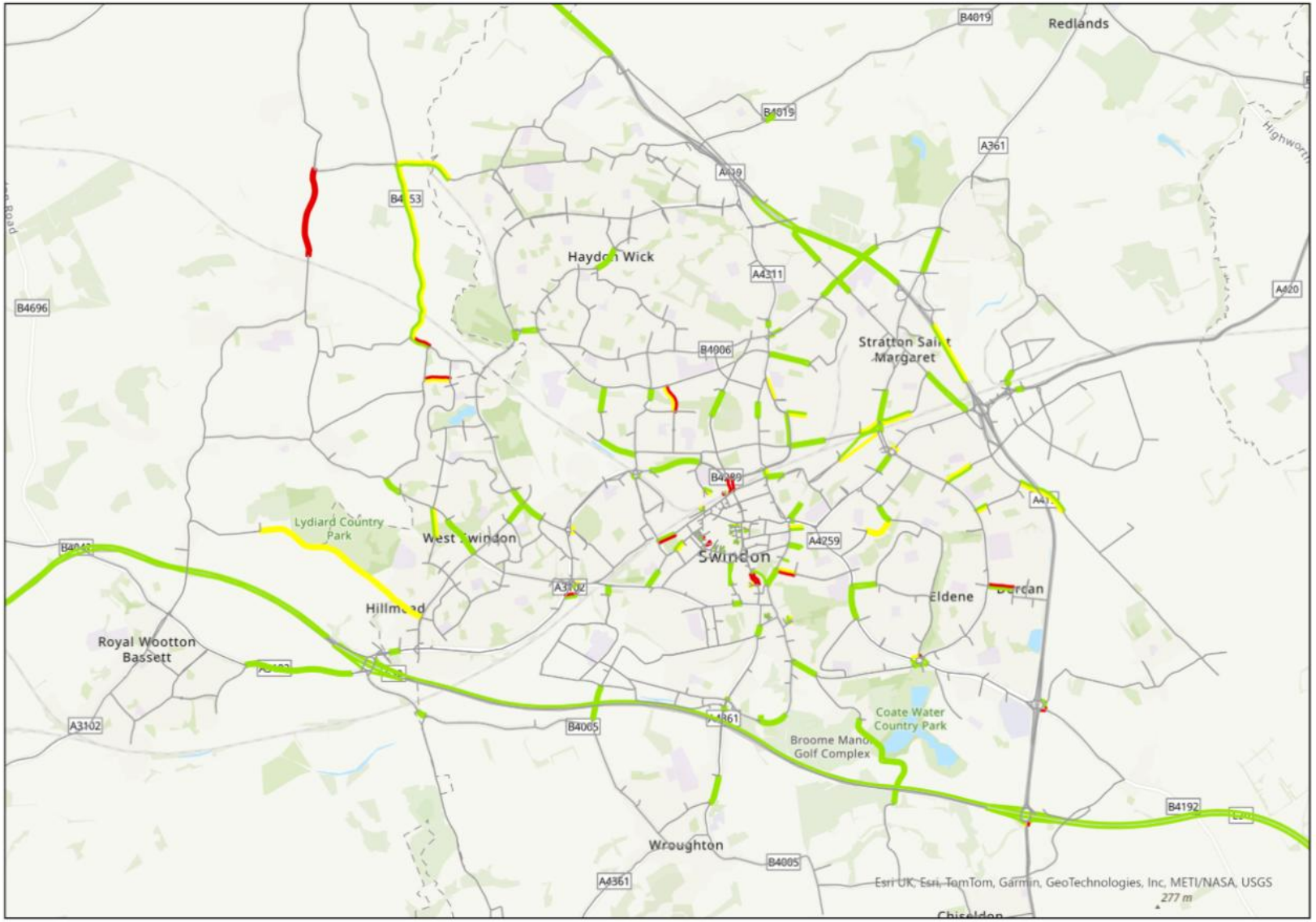


Figure 47 - STM Assigned Flow Validation: GEH PM

Appendix G:

Route Journey Time Validation – AM, IP and PM Models

Comparison of Modelled – Observed Travel Time Differences Against TAG Criteria:

App_G_STM_2023_SATURN_Assigned_Journey_Time_Validation.xlsb

GENERAL

Appendix H:

Network route Choice Validation – AM, IP and PM Models

Comparison of Modelled Routes Against Google Maps Logical Routes:

App_H_STM_2023_AM_SATURN_Route_Choice_Verification.pdf

App_H_STM_2023_IP_SATURN_Route_Choice_Verification.pdf

App_H_STM_2023_PM_SATURN_Route_Choice_Verification.pdf

GENERAL

Appendix I:

SATURN Assignment Values of time and Distance – AM, IP and PM Models

Derivation of Assignment Parameters ‘PPM’ and ‘PPK’:

App_I_STM_2023_SATURN_PPM_PPK_Rev02.xlsx

GENERAL

Appendix J:

Screen-lines and Cordons for SATURN Assignment Validation Against Counted Traffic Flows

Expanded version of LMVR Figure 3-2.

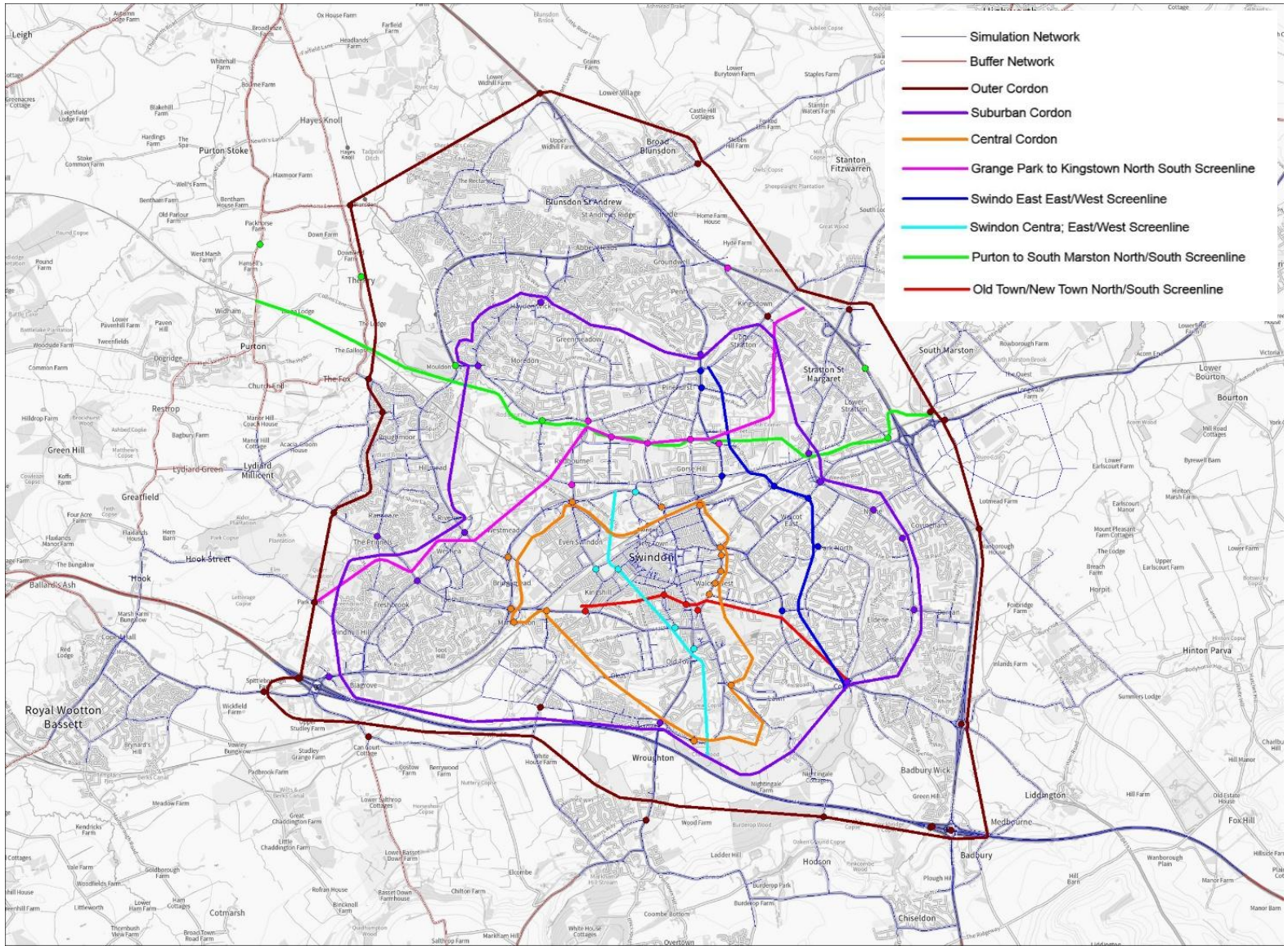


Figure 48 - STM Traffic Movement Screen-Lines and Cordons.

GENERAL