Shropshire Council

SHREWSBURY NORTH WEST RELIEF ROAD

Local Model Validation Report

TR002
DECEMBER 2017

DRAFT

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1 INTRODUCTION

1.1 BACKGROUND

1.1.1. WSP (formerly Mouchel) was commissioned by Shropshire Council (SC) in March 2017 to undertake traffic modelling and economic appraisal in support of an Outline Business Case (OBC) for the proposed North West Relief Road (NWRR) in Shrewsbury.

1.1.1. The provision of a river crossing in the north-west sector of Shrewsbury has been the subject of various studies by Shropshire Council and its antecedents for many years. Links between the north and west of Shrewsbury are very poor; this affects local commuters and longer distance business and freight traffic, moving between the northern business areas and the North West, and Wales.

1.1.2. Detailed investigations into the provision of a north-west relief road began in the mid-1980s, and versions of a scheme were included in Local Plans and successive TPP and LTP documents, as well as forming part of an outline TIF package in 2007 that was not submitted. Extensive preparatory work was undertaken for a possible MSBC in 2010, which was also not submitted.

1.1.3. An outline business case for Oxon Link Road that forms a new road between the A5 Shrewsbury Bypass and the B4380 Holyhead Road was prepared in 2015. This scheme is within the Marches LEP £75m Growth Deal, to be delivered in 2016-2021, and effectively forms Phase 1 of the NWRR.

1.1.4. The Shrewsbury North-West Relief Road (NWRR) will provide a new single carriageway road in the north-west quadrant of Shrewsbury. Together with the A5 and A49 bypasses, the Oxon Link Road and the Battlefield Link Road, the NWRR would provide the missing link to provide a complete outer bypass of Shrewsbury.

1.1.5. The main effect of providing a NWRR will be to allow long distance through traffic to avoid the town completely. It will also enable other journeys to transfer to more appropriate routes within the town's road hierarchy, thus releasing highway capacity by freeing-up road space on the north and west approaches to the town centre.

1.2 TRAFFIC MODELLING

1.2.1. Traffic modelling and economic appraisal has been carried as part of the preparatory work for the TIF, MSBC, although the models used to support these studies are significantly out of date. The traffic forecasts used to assess the Oxon Link were based upon SATURN model representing a base year of 2014, although the underlying demand information is from 2009. This model therefore does not comply with the WebTAG requirement that trips with both trip ends within the study area are based on survey data that is less than six years old.

1.2.2. A new traffic model was therefore required to assess the proposed Shrewsbury North West Relief Road (NWRR). The traffic model was developed using the SATURN software for a base year of (2017).

1.2.3. The model study area was defined to capture the impacts of the proposed scheme. It covers the County of Shropshire and surrounding towns, including Welshpool to the west and Telford to the east. The coverage of the model is described in more detail in Chapter 3.

1.3 PURPOSE

1.3.1. This report details the development and validation of Base Year traffic model. It describes the surveys and data used for the model development, and methods used for the development of the trip matrices. It presents the results of the model validation with reference to Department for Transport's (DfT) WebTAG guidelines.

2 MODEL SPECIFICATION

2.1 INTRODUCTION

2.1.1. This Chapter provides an overview of the main characteristics of the traffic model that was developed for the purpose of supporting the Outline Business Case for the Shrewsbury North West Relief Road.

2.2 STUDY AREA

2.2.1. The extent of the study area was defined from a consideration of the potential impacts of the proposed scheme, primarily in terms of changes in traffic routeings and flows. This was assessed using the existing SATURN traffic model of Shrewsbury as described in section 1.2.1 above.

2.2.2. The scheme was coded into the model and a traffic assignment was carried out and flow changes assessed. This indicted indicates that the majority of the impacts were internal to Shrewsbury i.e. within the outer ring road. It was therefore determined that this area should form the basis for the detailed modelling i.e. the SATURN simulation area.

2.2.3. The detailed simulation area is presented in Figure 1 below. The study area primarily includes all of Shrewsbury with the A5 Felton Roundabout in the North West, Ellesmere Roundabout and the Battlefield Roundabout in the North, A5/ A49 Preston Island Roundabout in the East and A5 corridor in the South.

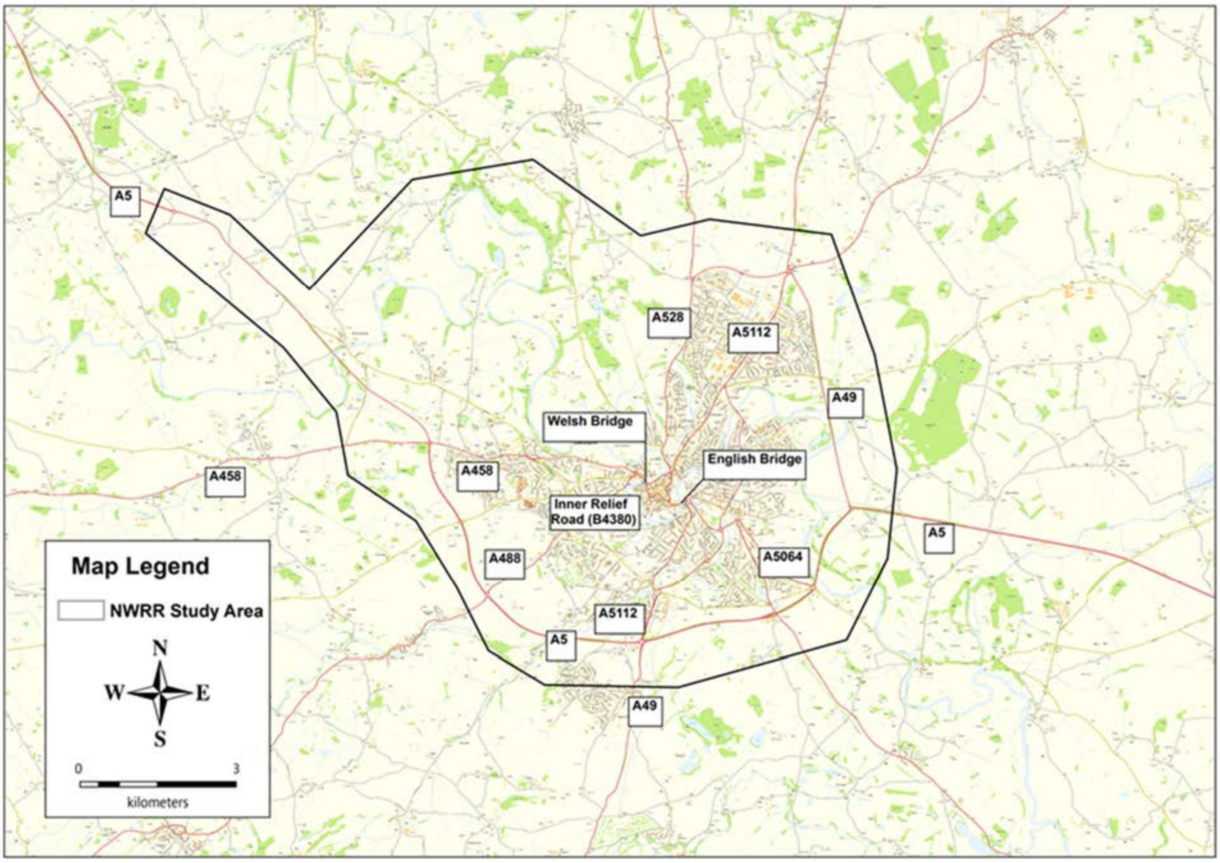


Figure 1 Detailed Study Area

2.2.4. The wider study area covers the County of Shropshire and encompasses Welshpool and Telford. The remainder of England, Wales and Scotland are modelled as external loading points. The wider study area is illustrated in Figure 2.

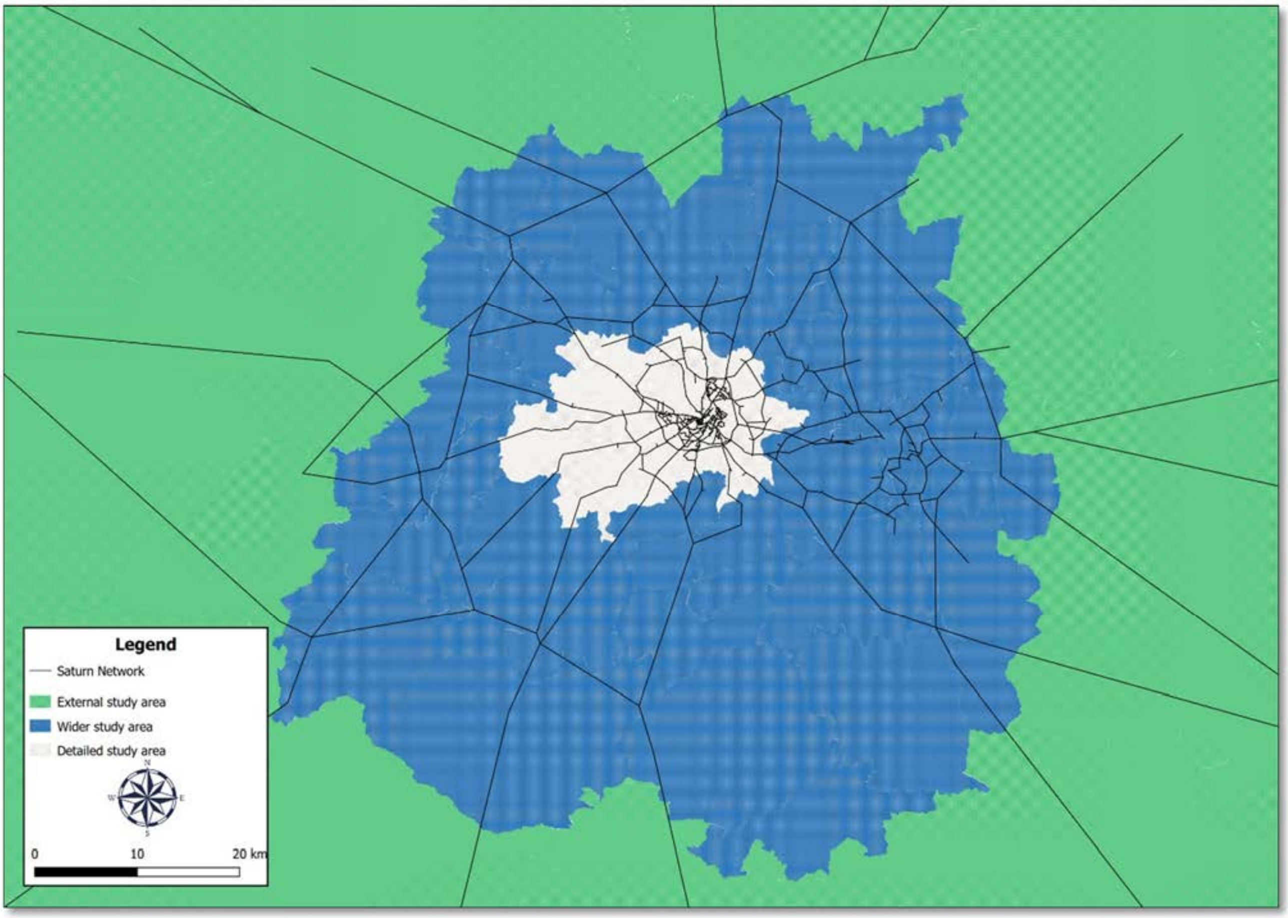


Figure 2 Wider Study Area

2.3 MODEL ZONING STRUCTURE

2.3.1. The model zone system is based on the latest census output area boundaries. Within Shrewsbury town centre the zoning system is fine and specific access roads from residential and commercial areas have been used as a basis for connecting zones to the network via centroid connectors.

2.3.2. The detailed study area that forms the basis of the simulation and includes Shrewsbury town centre and the area within the ring road as illustrated in Figure 1, is represented by 268 zones. For the inter-urban sections surrounding the study area the zones were also relatively detailed in order to represent the smaller urban areas. Zones were then drawn progressively larger and less detailed further away from the study area.

2.3.3. Zones in the External Area, which have a large geographical coverage and significant demand associated with them, will generally be connected to major routes to enter the network.

2.3.4. The model zones are illustrated in Figure 3. In total there are 416 zones within the model, comprising 291 internal and 125 external zones.

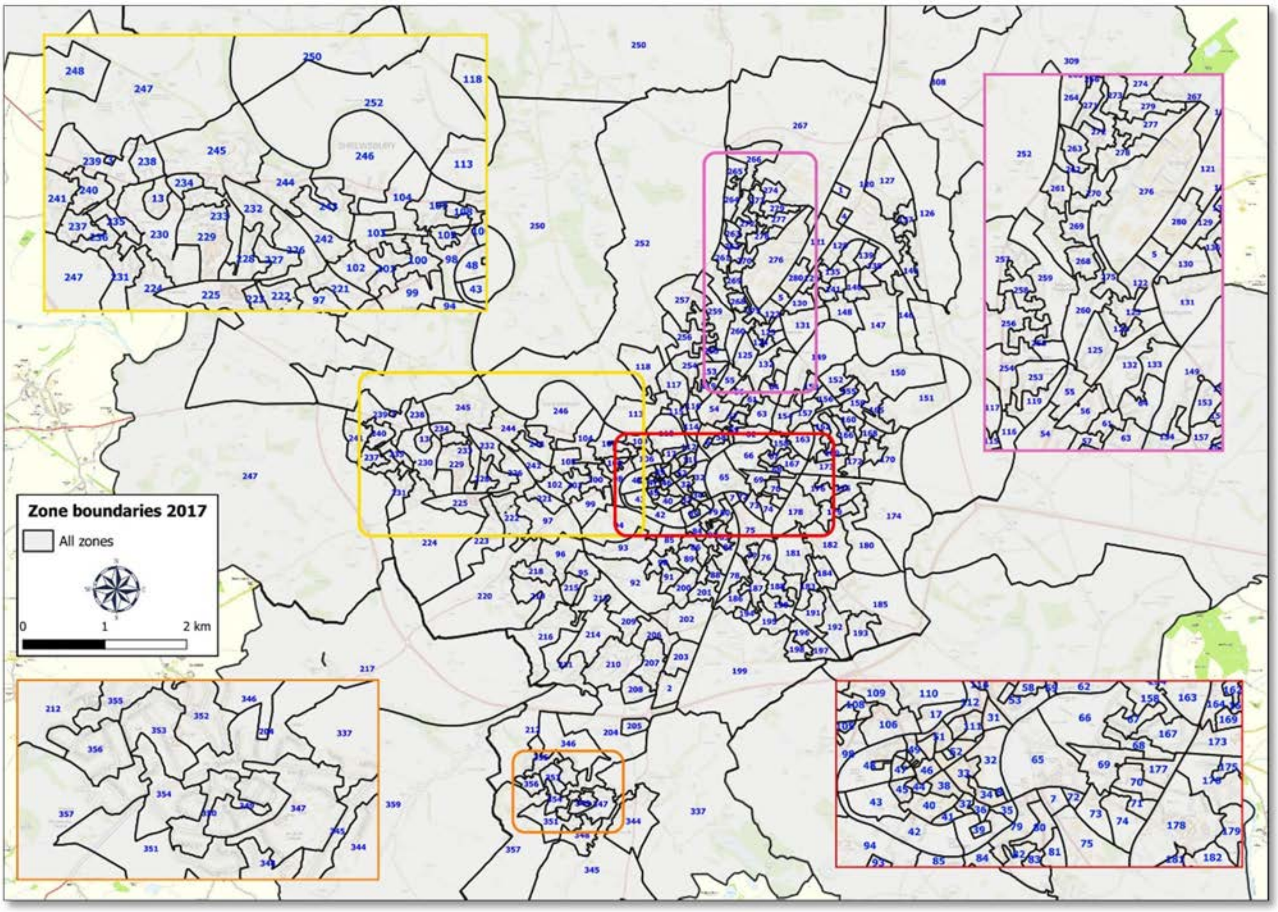


Figure 3 Model Study Area Zones

2.4 TIME PERIODS

2.4.1. The peak hour with respect to both the AM and PM peak period were established with reference to traffic flow profiles. The traffic flow dataset was drawn from the Automatic Traffic Counters (ATCs) carried out as part of the 2017 survey programme and 2017 WebTRIS data which is described in Section 3.2 and 3.3. The counts were selected in order to provide a spread across the model study area.

2.4.2. The daily traffic profile based upon average Monday to Friday flows from the ATC's and WebTRIS data is presented in Figure 4. The Monday to Thursday and Monday to Sunday profiles are also included for comparison. This shows that traffic flows are high between 07:00 to 10:00 hours and 16:00 to 19:00 hours and therefore defined the model AM and PM peak period. The period between 10:00 and 16:00 was defined as inter-peak period.

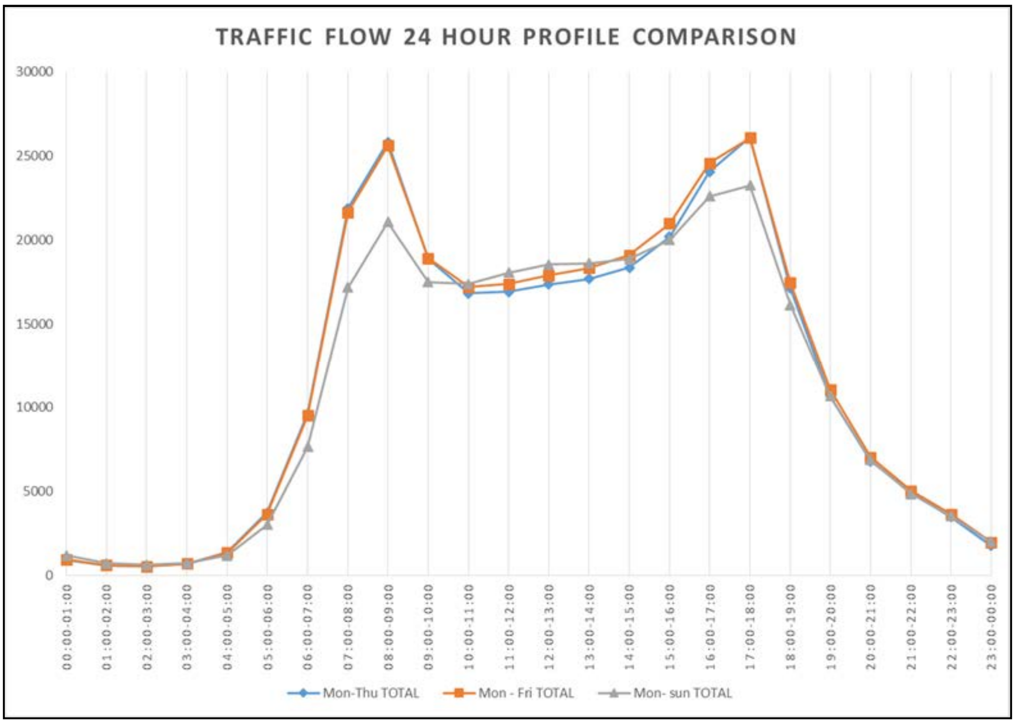


Figure 4 24 Hour traffic flow profile

A further analysis of the traffic flow data was carried out to determine peak hour traffic flows. The analysis is presented in Figure 5 for the AM peak and Figure 6 for the PM peak.

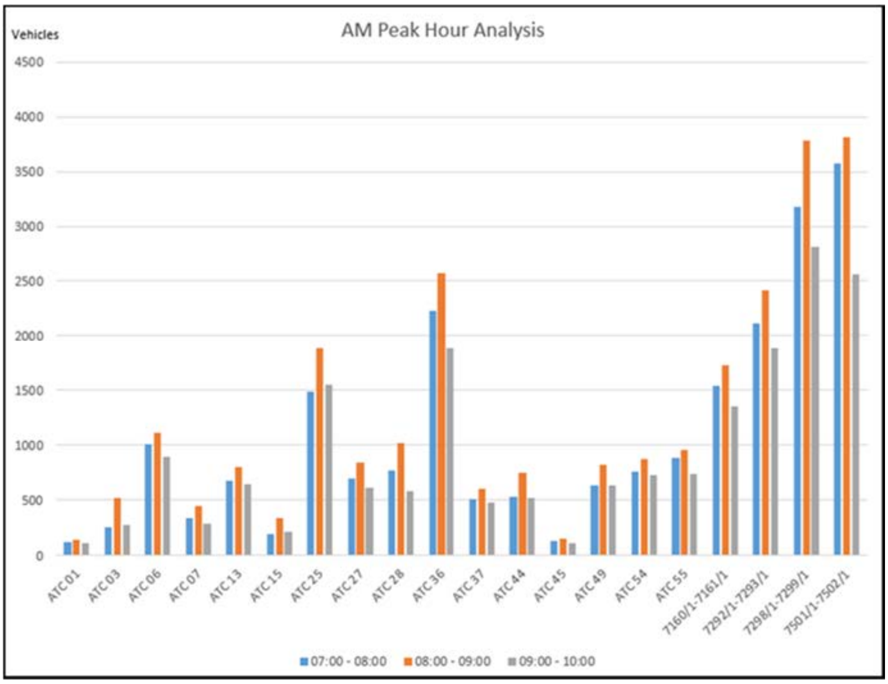


Figure 5 Analysis of AM peak period flows

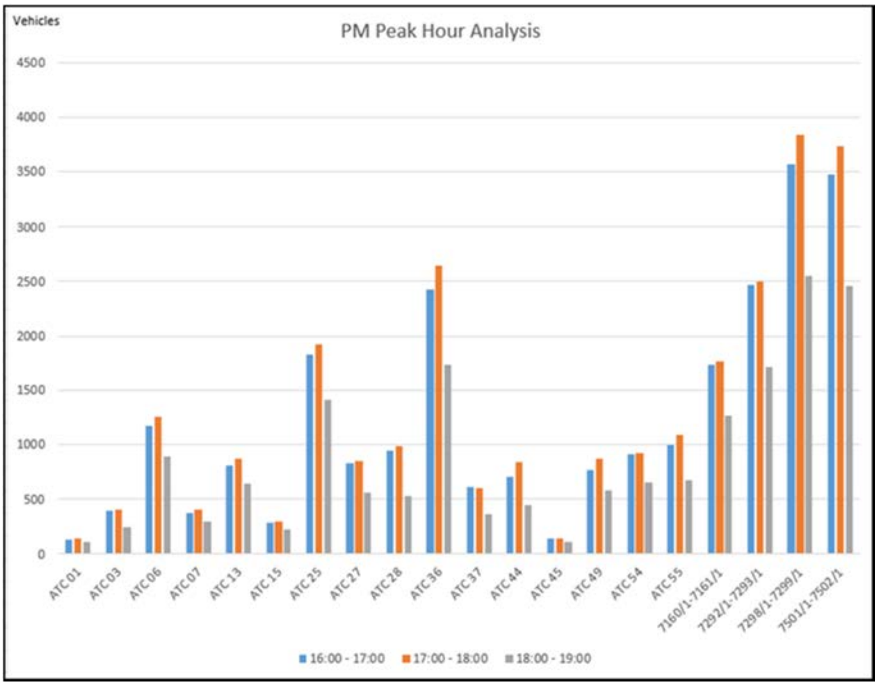


Figure 6 Analysis of PM peak period flows

2.4.3. Figure 5 and Figure 6 show that that 08:00 to 09:00 hours for AM peak and 17:00 to 18:00 hours for PM peak are consistently higher within the respective peak periods across all sites and were therefore adopted for the model time periods.

2.5 VEHICLES CLASSES AND TRIP PURPOSES

2.5.1. Separate matrices were developed for various combinations of vehicle type and trip purpose. This recognises the different characteristics of trips and facilitates distinction in some of the modelling processes.

2.5.2. The combination of vehicle types and trip purposes are known as user classes and are defined as follows:

- Cars – Journey from home to work, and vice versa (“Commute”)
- Cars – Employers Business
- Cars – Other trip purposes
- Light Goods Vehicles
- Heavy Goods Vehicles (including Medium Goods Vehicles)

2.5.3. Further details of the vehicle categories are provided in the Shrewsbury North West Relief Road, Data Collection Report, dated December 2017 (Ref TR001).

2.6 HIGHWAY NETWORK

2.6.1. The traffic model network is divided into simulation and buffer areas. The simulation area incorporates detailed coding of junctions to facilitate the modelling of queues and delays and to take account of roads that are used as alternatives (rat-runs).

2.6.2. Outside the simulation area, a buffer area comprises a coarser network of links to model routes used by longer distance traffic to and from the study area.

2.6.3. Further details of the network are provided in Chapter 4.

2.7 MATRIX DEVELOPMENT

2.7.1. The base matrix was developed using mobile phone network data (MND) as the primary source. This was obtained from Citi LogiK who supplies mobile phone data from Vodafone.

2.7.2. The MND was supplemented by other data sources. This included Trafficmaster survey data for HGV trips, and Car Park interview surveys to derive trips to and from car parks within Shrewsbury town cntre. Synthetic trip matrix procedures were also used, principally for infilling the unobserved car trips internal to the study area.

2.7.3. In addition, the RSI data was also utilised for the matrix build. While it had initially been the intention to use the RSI data for verification of the MND, it was considered that since the accuracy and reliability of the RSI data in relation to potential trips using the NWRR was higher than the MND, the RSI data should be utilised.

2.7.4. The sources of data used to develop the trip matrices are described in Chapter 3 and the procedures adopted to develop the base trip matrices are described in detail in Chapter 5.

2.8 MODEL CALIBRATION AND VALIDATION

2.8.1. Calibration of the Base Year (2017) traffic model was based upon an iterative process of adjusting network descriptions, including speeds and junction capacities.

2.8.2. Matrix estimation was used to refine the matrices developed from the survey data to more closely match observed traffic flow data.

2.8.3. The validation process involved checking the network to verify that the network structure was accurate and that the characteristics of the network were suitably represented in the model. A number of range and logic checks were undertaken, including routeing checks.

2.8.4. Assignment validation was then undertaken by comparing modelled traffic flows (links and turns) and journey times with observed data with reference to the DfT WebTAG validation criteria.

2.8.5. Details of model calibration are provided in Chapter 6 and the link flow and journey time validation statistics are presented in Chapter 7.

3 DATA COLLECTION

3.1 INTRODUCTION

3.1.1. The data to support the development and validation of the traffic model for the Shrewsbury NWRR comprised data:

- obtained from a programme of traffic surveys carried out in Shrewsbury in spring 2017
- commissioned directly from other parties, including mobile phone network records
- derived from other sources. This included Traffic Master data from the Department for Transport (DfT) and WebTris traffic count data.

3.1.2. At the outset of the study, the relative merits of using various data sources to develop matrices of vehicle movements within the study area were considered. This is documented in the Appraisal Specification Report which was submitted to the Department for Transport in April 2017.

3.1.3. Following a discussion with the DfT in May 2017, it was determined that the mobile phone data would provide good coverage across the study area and would represent a cost effective approach and should therefore be used as the primary data source for the development of the trip matrices. Citi Logic was subsequently commissioned to provide Mobile Network Data (MND), from mobile phone records.

3.1.4. This section describes the spring 2017 programme and the other data collected or commissioned for the study and the utilisation of each data set in the model development process. Further details of the processing and analysis of the survey data is provided in the 'Shrewsbury North West Relief Road, Data Collection Report' (WSP December 2017).

3.2 2017 TRAFFIC SURVEY

3.2.1. A programme of traffic surveys was carried out in Shrewsbury during spring 2017. The survey programme is summarised in Table 1.

3.2.2. Although all surveys were initially planned for completion during March 2017, some surveys had to be repeated or postponed for the reasons identified in Table 1 below.

Table 1 2017 Survey Programme

Survey Type	Method	Location	Date	Duration	Notes
Automatic Traffic Counts (ATC)	Automatic	81 Sites	March-May '17	2-3 complete weeks per site over 24 hours	
Manual Classified turning Counts (MCC)	Video-Manual	63 Sites	March '17 & for one additional site April '17	One day, 12 hour survey	
Roadside Interview (RSI)	Manual	3 Sites	May '17	One day, 12 hour survey	Postponed from March '17 due to availability of police
Car Park Interview	Manual	21 Sites	March '17		8 sites re-surveyed in May '17 due to initial low capture rates
8 sites resurveyed in May '17	One day, 12 hour survey				

3.2.3. Details of each of the surveys and the purpose to which the data were required is set out below:

3.2.4. **Automatic Traffic Counts (ATC).** These were carried out at 81 sites across the study area covering a continuous period of 3 weeks. The ATC data was used for:

- model calibration and validation,
- expansion of Roadside Interview Survey records,
- identifying the peak periods of travel demand.

3.2.5. **Manual Classified Counts (MCC).** These comprised counts at 64 location throughout the study area on links and at junctions to derive turning movements. The MCC data was used in model calibration and validation including checking for route choice.

3.2.6. **Car park Interviews**. Interviews were carried out at 19 locations in car parks surrounding Shrewsbury Town Centre, together with supporting MCC counts. The locations are shown in Figure 7. The car park interviews provided trip origins for trips to town centre car parks and Park and Ride (P&R) sites and was used as a source of data for developing the trip matrices.

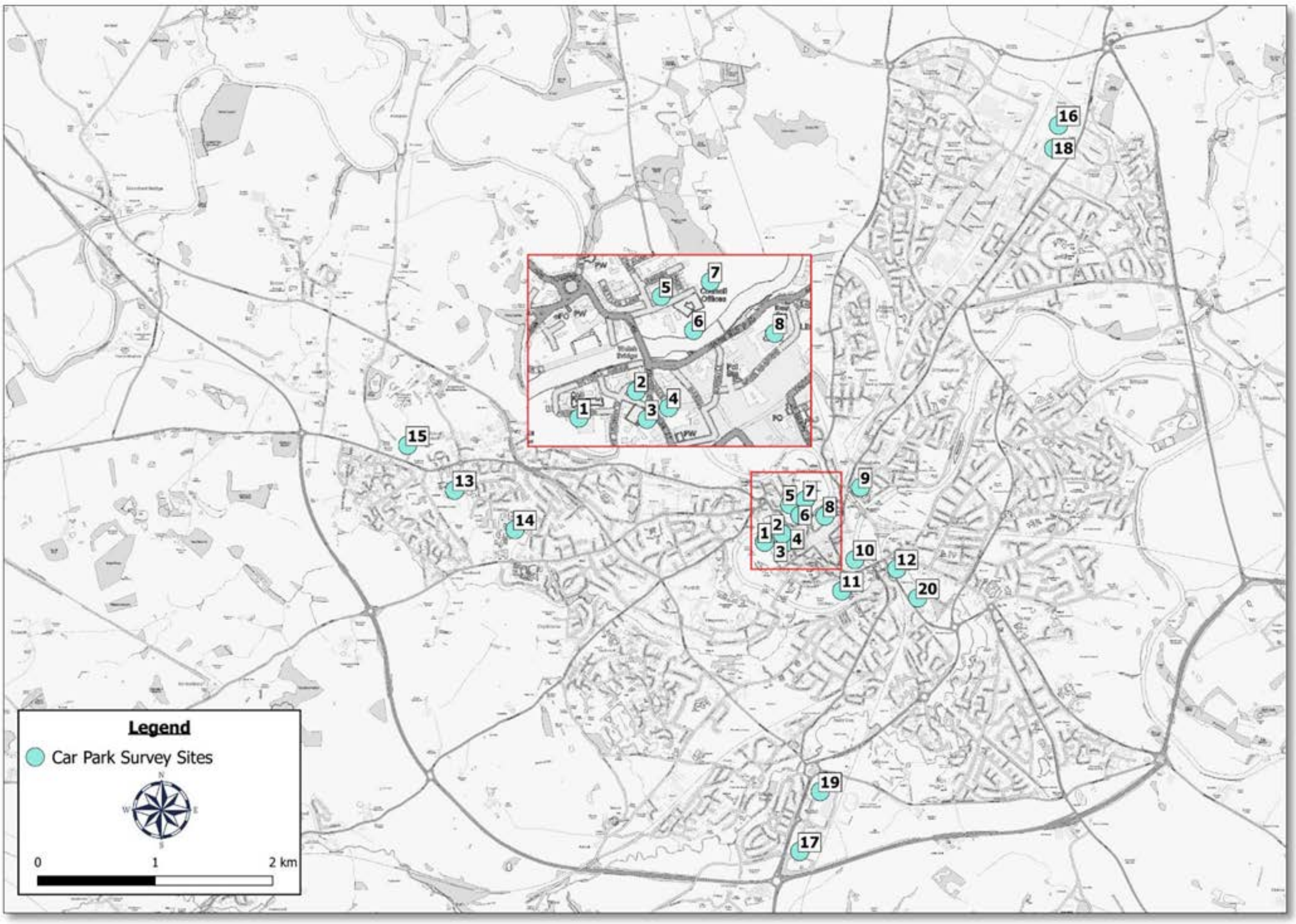


Figure 7 Location of Car Park Interview Surveys

3.2.7. **Automated Number Plate Recognition (ANPR).** This comprised 5 sites on key radial routes into Shrewsbury as illustrated in Figure 8. The ANPR data was used to identify strategic through traffic movements for the routes to the proposed NWRR scheme.

Figure 8 Location of ANPR and RSI sites

3.2.8. **Roadside Interview Surveys (RSI).** These were carried out on 3 sites detailed in Table 2 and illustrated in Figure 8. The RSI's captured Origins and Destinations of trips passing through key locations which will be directly impacted by the proposed NWRR scheme and were used as a source of data for developing the trip matrices.

Table 2 RSI Locations

Site Ref	Road	Location	Direction	Grid Reference
RSI 1	A528 Ellesmere Road	Layby to the North of Mount Pleasant Road	NB	315930N 349720E
RSI 2	A458 Welshpool Road	Near B4380 Holyhead Road/ The Mount Junction	WB	313280N 346340E
RSI 3	B4380 Roman Road	South of Upper Road/ Roman Road Junction	NB	310820N 348930E

3.3 OTHER DATA SOURCES

3.3.1. Data was either obtained or commissioned from a number of other sources for use in the model development. This data and its application for the model development is described below.

3.3.2. **Mobile Phone/Network Data (MND).** Mobile phone data was obtained from Citi Logik who supplied information from Vodafone Users. The data collection period ran for five weeks, from 22nd February 2017 to 4th April 2017, excluding 22nd and 23rd February, 10th to 13th March and 29th March owing to outages on the Vodafone network. This period consisted of five weeks, resulting in 27 working days (Monday – Friday) and 10 weekend days (Saturday-Sunday).

3.3.3. Vodafone customers communicate their positions with the networks of Vodafone cells every time they use their mobile phones and through ad-hoc events generated by the network and applications running on smart phone devices. Each such communication is registered by one of the network cells as an 'event' with attributable to it unique and anonymous user ID, a timestamp, a local area code (LAC) and the cell's ID.

3.3.4. The MND provided by Citi Logik included O/D information for person trips categorised by mode as follows:

- Motorised Trips made by road, including Cars, LGV, HGV and Buses. .
- Trips taken by rail
- Non motorised trips taken as slow mode, including pedestrian journeys.

3.3.5. The MND provided Origin and Destination data by mode and purpose for trips to, from and within the study area which was used as one of the main sources for the development of the trip matrices.

3.3.6. The MND required further checking and verification prior to its application for matrix development. An initial verification process was carried out by Citi Logik and is reported in 'TN02 Mobile Phone Data Verification' (Citi Logik June, 2017). Further checks and analysis of the MND was carried out by WSP and reported in 'Shrewsbury north West Relief Road: Review of Mobile Phone Data' (WSP, October 2017).

3.3.7. **Traffic Master.** Traffic Master data was provided by the DfT and included Origin/Destination as well as Journey time data. The OD data was provided for all trips associated with Traffic master's fleet of vehicles that either started or ended within the Shropshire boundary based upon data from journeys from 1st September 2014 to 31st August 2015. The Traffic Master Origin and Destination data was used for the development of the HGV trip matrices.

3.3.8. The journey time data was provided for a number of routes covering both local and strategic highway network within the study area, and was used for deriving cruise speeds, identifying junction delays and for model validation. Following advice from the DfT regarding known errors with the March 2017 Traffic master journey time information, the dataset corresponding to March 2016 journey times was used in model development.

3.3.9. **WebTRIS.** This data was obtained from Highways England and comprised some 20 ATC link counts on dual carriageways and motorways. This data was used for model calibration and validation.

3.3.10. **Traffic Signal Data** – data covering the phasing and timings was obtained for all traffic signals within the model area to accurately code the highway network.

4 HIGHWAY NETWORK DEVELOPMENT

4.1 INTRODUCTION

4.1.1. The network is a representation of the transport highway system within the study area. The network comprises a system of nodes connected by links. The nodes mostly represent junctions and the links represent homogenous stretches of road between junctions.

4.2 HIGHWAY NETWORK DEFINITION

4.2.1. The 2009 Shrewsbury model, based upon the SATURN highways assignment modelling software was the starting point for developing the 2017 base model network. This included updating to the latest version of SATURN (11.3.12W).

4.2.2. The model provides an accurate representation of the existing highway network Shrewsbury and the surrounding area and the model network incorporates all major and principal routes as well as local roads that are used as rat-runs.

4.2.3. The network has been modelled at two levels of detail; a simulation network in the study area where the junctions are coded and the junction delays are modelled in detail, and a network outside the simulation area where only the links are modelled.

4.2.4. Within the simulation area, the modelled network includes all 'A' and 'B' class roads and most minor roads with traffic volumes more than one hundred vehicles per hour. In urban areas, residential roads which act as distributor routes or rat-runs are also included in the model.

4.2.5. Within the simulation network, the junctions have been coded in detail so that the existing traffic capacity can be simulated explicitly and the effects of the traffic on queues and delays are properly represented.

4.2.6. The extent of the simulation network within the study area is shown in Figure 1 in section 2.2.

4.2.7. Outside the simulation area, the network has been defined to reflect the routeing of longer distance traffic. The extent of the external model network is shown in Figure 2 in section 2.2.

4.3 NETWORK INVENTORY

4.3.1. Details for the 2017 base year network were obtained from the following sources:

- Signal timings - taken from on street observations in 2017 plus detailed traffic signal plans obtained from Shropshire Council
- Lane arrangements and stop line widths – measured from plans and site visits.

4.3.2. In order to verify that the modelled network correctly represented the current base year, a number of checks were undertaken, as follows:

- Correct loading of zone centroids to the network.
- Link length checks
- Routeings through the network
- Network hierarchy and speed flow definition
- Lane sharing and lane use

4.3.3. These checks are described in further detail in section 4.8 below.

4.4 LINK LENGTHS AND SPEED FLOW CURVES

4.4.1. The roads were modelled as links in SATURN. All of the links were assigned accurate distances together with a link category to define its characteristics.

4.4.2. Highway links within the central urban area of Shrewsbury (defined broadly as being within the Inner Ring Road cordon) were coded with fixed cruise speeds derived from observed Traffic master night time speeds. All other links outside of the central urban area were allocated speed flow curves, to reflect the relationships between traffic volumes and link speeds.

4.4.3. Link types and speed flow curves were allocated with reference to TAG Unit M3.1 Appendix B which specifies the speed/flow relationships used in COBA (the DfT's link-based Cost Benefit Analysis software). Speed-flow curves were allocated to links in the network based on:

- their location and function (urban, suburban, rural, village);
- type of the road, (dual or single carriageway);
- number of lanes on the road;
- road classification (motorway, A, B, C);
- quality of the road (good, average, poor);
- speed limit; and
- extent of frontage development.

4.4.4. The above information was gathered from a combination of maps and plans, inventories and site visits.

4.4.5. HGV speeds were limited to 97 km/hr (60mph) through the use of CLICKS parameter.

4.5 JUNCTION MODELLING

4.5.1. Within the simulation area, the junctions were modelled in detail to represent the effects of traffic flows on delays and queues. Each junction was coded by using detailed information which included:

- junction type (signalised, priority, roundabout);
- number of arms;
- allowed turns;
- turning capacities based on geometric parameters;
- traffic signal details (stage/ phase arrangements and timings);
- vehicle circulating capacity and travel time (for roundabouts).

4.5.2. Data for junction layouts was obtained from the inventory surveys, Google earth and site visits.

4.5.3. In excess of 900 priority junctions were coded in the simulation network. These include large roundabouts which were modelled as a series of priority nodes.

4.5.4. Roundabout capacities were estimated based on the geometry of the roundabouts, folowing the relationships given in the TRL report RR35.

4.5.5. A total of 64 roundabouts were modelled, including around 14 large roundabouts. The large roundabouts were modelled as a series of priority junctions.

4.5.6. All of the signalised junctions within the study area were modelled in detail. The signal data was provided by Shropshire Council and included details of minimum green time, maximum green time, inter-green time and junction layouts with turning allocations, phases and stages. This information was input into SATURN for the three time periods (AM, IP and PM). There are a total of 40 signalised junctions within the study area.

4.6 ZONE SYSTEM

4.6.1. A detailed zone system was developed for Shrewsbury town Centre and for the road network within the ring road.

4.6.2. For the remainder of Shropshire the zone system was also relatively detailed in order to represent the smaller urban areas. Zones were then drawn progressively larger away from the study area.

4.6.3. The zone system within was designed to be consistent with the local government (District) boundaries and the Parliamentary Constituency boundaries. Within Shrewsbury, ward boundaries were adopted where practical.

4.6.4. The model zones are illustrated in Figure 3 in section 2.3. In total there are 416 zones within the model, comprising 291 internal and 125 external zones.

4.7 CENTROID ZONE CONNECTORS

4.7.1. The loading of traffic onto the network from zones was achieved through the use of centroid connectors at appropriate locations.

4.7.2. The loading points and types of connector were determined specifically for each zone. The appropriate length of the connector in each case was based on the distance to the mid-point of the zone. The appropriate speed was then assigned based on the network characteristics within the zone.

4.7.3. For the external zones (outside the study area), the loading points were attached to the appropriate locations at the edge of the network. The distance and speed for these connectors were estimated using GIS information.

4.8 NETWORK CHECKS

4.8.1. During the network building process, all warnings and errors generated by SATNET program were reviewed and addressed as appropriate. In addition, model networks were imported to GIS and a series of further logic and range checks were undertaken. These included:

- Model parameters
- Physical characteristics of the coded network (junction type, number of arms and lanes, lane usage);
- Properties assigned to the network (distances, cruise speeds, speed-flow curve free flow speeds, link capacities, HGV restrictions);
- Anomalies with traffic signal data;
- Loading points of every zone;

4.8.2. An examination of the network and zone boundaries confirmed that each zone centroid had been loaded within its geographical zone boundary.

4.8.3. The link lengths were checked against the GIS network and a further check was made against the coded link length of the reverse direction.

5 MATRIX DEVELOPMENT

5.1 OVERVIEW

5.1.1. This chapter describes procedures used to develop the base year trip matrices for the SATURN traffic model utilising the data sets that were described in Chapter 3.

5.1.2. The development of the trip matrices from the various data sources is described, including how the data sets were utilised for various sectors of the matrices and combined to form the 'prior' matrices. This chapter also describes the refinement of the 'prior' matrices using matrix estimation techniques, to produce the final base year matrices for model validation.

5.2 DATA FOR MATRIX DEVELOPMENT

5.2.1. The data for the matrix development utilised the following data sets:

- Mobile Network Data (MND) from Vodaphone mobile phone records supplied by Citi Logik;
- Roadside Interview survey data from 3 sites in Shrewsbury carried out in spring 2017;
- Car Park Interview data from car parks in Shrewsbury town centre in spring 2017; and
- Traffic Master data provided by the Department for Transport (DfT).

5.2.2. The data is described in detail in Chapter 3, and the processing of the data is described in the Shrewsbury North West Relief road, Data Collection Report.

5.2.3. The base matrices were developed using MND as the primary source. The MND provided O/Ds for trips to and from and passing through the study area. There were limitations with respect to the reliability of the MND with respect to some of the internal movements and therefore these trips had to be synthesised. This is described in section 5.3 below.

5.2.4. The other data sets were used in the matrix development process as follows:

- RSI data provided partial coverage of movements to and from external sectors which included some Internal to External and External to Internal movements (it should be noted that ANPR was used to derive the return trips i.e. non-interview direction. This is described under Stage 1 in section 5.3 below.
- Car park interviews provided data on trip origins/destinations to and from town centre car parks to be used for the development of the base year model trip matrices.
- MCC data and ATC data were utilised for model calibration and validation. In addition, the MCC data was used to identify the proportion of LGV and HGV trips from the mobile phone dataset. This is described under Stage 1 in section 5.3 below.
- Trafficmaster data provided coverage of LGV and HGV trips external and internal to external trips relative to Shrewsbury and the study area.

5.2.5. Figure 9 illustrates the coverage of the various data sets in terms of how this relates to the development of the car matrices for the various sectors, internal (I) and external (E), of the model.

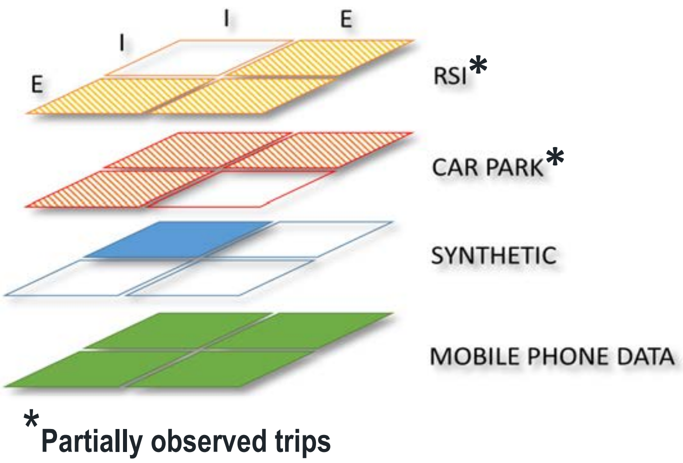


Figure 9 Data sources used in development of car trip matrices

5.2.6. It is acknowledged that the quality of the mobile phone data varies, for example the data is less reliable in terms of shorter distance trips, particularly within Shrewsbury town centre. This is discussed in more detail in the Shrewsbury North West Relief Road, Review of Mobile Phone Data. As a consequence, a synthetic matrix was developed to infill the unobserved internal to internal trips. This is discussed under Stage 4 in section 5.3 below.

5.3 MATRIX DEVELOPMENT PROCESS

5.3.1. The matrix development process involved 4 main stages.

- **Stage 1:** Development of observed trip matrices using MND
- **Stage 2:** Development of observed matrices from other data sources
- **Stage 3:** Creation of Synthetic Matrices for Internal Trips.
- **Stage 4:** Merge Observed and Synthetic Matrices to create ‘Prior Matrices’.
- **Stage 5:** Refine ‘Prior’ matrices to crease final base year matrices through the application of matrix estimation.

5.3.2. An overview of the matrix development process is presented in illustrated in Figure 12. The methodology adopted for each Stage is detailed below.

I. STAGE 1: DEVELOPMENT OF MATRICES FROM NMD

The first stage in the process involved the development of ‘observed’ trip matrices from the MND, This involved the following steps.

Step 1: Build person trip matrices from NMD.

Using the NMD, trip matrices were developed for 4 purposes (HBW, HBO, NHBW and NHBO) and for 3 time periods (AM peak Inter-Peak and PM peak). This included journey by Car, LGVs and HGV’s and bus passengers. Rail trips were excluded.

Step 2: Combine person trip matrices.

The HBW and HBO were combined to create Home Base person trip matrices, and NHBW and NHBO were combined to create Non Home Based trip matrices.

Step 3: Remove Bus Trips from HB and NHB matrices.

TEMPro data was used to derive the ratio of bus trips to total trips by purpose (HB/NHB), by time period and by zone. This ratio was applied to each zone to remove the bus trips from the matrices output from Step 2. This resulted in an average hourly matrix of private car trips for each purpose (HB/NHB) for each time period.

Step 4: Remove HGV trips from NHB matrices

A factor was calculated using the ratio of the Trafficmaster HGV trips to the total NHB MND matrices to derive the percentage of HGV trips for each zone (at sector level). This process involved the conversion of Trafficmaster data into person trips. The ratio was applied to the NHB trips to separate the HGV's from the Car/LGVs.

Step 5: Produce Car Purpose Matrices for Commute, Business and Other.

TEMPro data was used to derive the purpose split (commuter/business/other) for HB and NHB car/LGV person trips. The split was calculated for each MND zone for each time period by HB and NHB purpose and the factors were applied to the HB and NHB matrices to produce the Commute, Business and Other matrices.

Step 6: Convert from Person Trips to Car Trips by Purpose.

The person trip matrices by purpose output from step 6 were converted into vehicle matrices using the car occupancy factors taken from NTS 2015.

II. STAGE 2: DEVELOPMENT OF OBSERVED MATRICES FROM OTHER DATA SOURCES

The next stage involved developing matrices of observed movements from the other data sources that included RSIs, Car Park Interviews and Traffic Master data.

Step 1: Develop Matrices from RSI Data

Trip matrices by purpose were developed from the processed RSI data for the trips between A458 and A538/A5112 to the north west of Shrewsbury.

Step 2: Develop Matrices from Car Park Interview Data

Trip matrices by purpose were developed from the processed Car Park Interview trip records. This included trips to and from the major car parks within Shrewsbury town centre and therefore provided partial coverage of internal to internal and internal to external trips relative to the study area.

Step 3: Develop LGV/HGV Trip Matrices

Traffic Master Data was used as the initial data source for building the LGV / HGV matrices. An initial validation against observed data demonstrated an under-reporting of HGV trips compared against the observed totals. This highlighted a need for refinement of the matrices developed from the Traffic Master data.

The process of refinement, utilised the 2009 HGV matrices, from the previous Shrewsbury model. The Traffic Master LGV and HGV matrices were sectored and the distribution of HGV trips from the Traffic Master data compared against the 2009 post matrix estimation matrices at sector level.

This highlighted HGV trips between the internal to external (I-E) and external to internal (E-I) zones of the model that were not captured within the Traffic Master data.

Conversely, the Traffic Master LGV matrices also showed a higher proportion of LGV trips compared to the 2009 post matrix estimation matrices.

A possible explanation for this discrepancy is that since the Traffic Master matrices had been developed based on observed GPS sourced data, some of the observed OGV1 vehicle may have been classified as LGV trips instead of HGV.

The 2017 HGV matrices developed from the Traffic Master data were therefore refined by infilling the unobserved trips from the LGV matrices are as follows:

- I-E and E-I OD trips were extracted from the 2017 unexpanded HGV Traffic Master matrices.
- The unobserved OD pairs in the HGV matrices were infilled utilising the 2017 unexpanded LGV matrices.
- The infilled matrices were then expanded to the 2009 HGV (I-E) and (E-I) matrices trip length totals

- The I-E and E-I trips there then combined with the remaining I-I and E-E trips to create to prior 2017 HGV matrices.

A similar approach was applied to refine 2017 LGV prior matrices (I-E) and (E-I) trips movements. The LGV trip totals were adjusted to the 2009 post matrix estimation LGV (I-E) and (E-I) trip length totals. These were then combined with the remaining I-I and E-E trips to create to prior 2017 LGV matrices.

III. STAGE 3: DEVELOPMENT OF SYNTHETIC MATRICES

A synthetic matrix was developed, primarily to infill the gaps in the short distance trips from the MND within Shrewsbury Town. The primary data sources for the synthetic matrix were TEMPro data and land use data. The synthetic matrices were developed using a gravity model adopting the following methodology;

Step 1: Trip Ends were derived from TEMPro by journey purpose and by time period for the Shrewsbury study area.

Step 2: The synthetic matrix build was carried out at OD level by time period based on TEMPro trip ends. The distribution was derived using the assignment costs of the mobile phone data. The process was applied iteratively.

The synthetic matrix was also used to estimate rail access/egress trips. TEMPro rail trip ends for zones in Shrewsbury (located at least 1 mile away from the train station) and its immediate surroundings were used to derive the volume of car trips that would be generated by rail travellers to and from the rail station. This was added to the synthetic matrices.

IV. STAGE 4: DEVELOPMENT OF PRIOR MATRICES

The 'Prior' matrices were based upon combining and merging the observed matrices developed from the MND and other observed data sets in Stages 1 and 2 and the synthetic matrices described in Stage 3. This process sought to utilise the data for each sector that provided the highest quality or reliability.

The starting point for the development of the prior matrices was the car trip purpose matrices developed from the MND (Stage 1, Step 6). The following processes was adopted:

Step 1: Addition of synthetic matrix. The synthetic matrix was added to the MND purpose matrices to replace/infill the internal to internal trips within Shrewsbury town centre. It is noted that the MND did not provide a complete coverage of all internal to internal trips, primarily due to the granularity of the data.

Step 2: Addition of car park matrix. The car park trip matrices were added to the matrices output from Step 1 above thereby replacing the trips to and from the car park zones that had been derived either from the synthetic matrices or from the MPD.

Step 3: Addition of RSI matrix. The RSI matrix was added to the matrices output from step 2 above and therefore replaced the trips derived from the MND for movements between A458 and A538/A5112 to the north west of Shrewsbury.

This process involved assigning the matrices output from step 2 to the network and carrying out a select link analysis to identify the trips passing through the specific RSI locations. These trips were removed and replaced with the matrix of trips developed from the RSI data.

The matrices output from this stage were the 'Prior' matrices which formed the basis for further refinement as described in Stage 5 below.

V. MATRIX REFINEMENT AND FINAL MATRICES

Matrix estimation (ME) was undertaken using SATME2 module of SATURN. Trips from the prior matrices were adjusted based on the observed link counts to produce an estimated set of post matrices.

The inputs used for the ME process were:

- Network files
- Aggregated prior matrices that were classified as Lights and Heavies.
- Observed traffic count data from ATC, WebTRIS and MCC video survey from the spring 2017 survey programme, classified as Lights and Heavies.

Matrix estimation was carried out on individual vehicle types that comprised Light vehicles (combined UC1, UC2, UC3 and UC4) and Heavy vehicles (UC5) matrices in accordance with WebTAG Unit 3.1.

The ME process was carried out as follows:

Step 1 – Assign the prior matrices to the network
Step 2 – Extract origin destination path files
Step 3 – Estimate the prior matrices against the observed traffic counts using SATME2.
Step 4 – Reassign the estimated matrix
Step 5 – Check for convergence. If converged: stop and if convergence is not achieved, steps 1 to 4 were repeated.

The convergence criteria applied during matrix estimation process was consistent with WebTAG Unit M3.1. The changes brought by matrix estimation were monitored by user class by time period through scatter plots of matrix zonal cell values and trip ends.

In addition to this, trip length distributions and sector to sector level matrices comparison between post and prior has been also carried out. These results are reported in section 6.4 below.

6 MODEL CALIBRATION

6.1 OVERVIEW

6.1.1. Model calibration is the iterative process of reviewing and adjusting the model's network or trip matrices so that modelled traffic flows, speeds, junction delays and routeings through the network provide a reliable match to observed data.

6.1.2. The calibration procedure for the Shrewsbury NWRR model involved the following processes:

- Checks to ensure that link speeds on the network were realistic;
- Checks to ensure that delay calculations at junctions were realistic
- Adjustment and checking of the network to ensure plausible routeing of traffic;
- Refinement of network parameters (e.g. capacities) to match modelled data (e.g. traffic flows and journey times) to observed data.
- Use of matrix estimation to adjust the prior trip matrices to match observed traffic flows from link and turning counts.

6.1.3. As noted in Section 5.3 above, the calibration process incorporated a matrix estimation procedure to aid in the development of trip matrices that contained travel patterns reflecting observed traffic counts.

6.1.4. The matrix estimation procedure is described in detail below.

6.2 MATRIX ESTIMATION

6.2.1. Matrix estimation is a process that adjusts the travel pattern for compatibility with the observed traffic counts to produce a matrix which 'best fits' the observed counts. The matrix estimation procedure was undertaken within SATURN, in order to improve the prior matrix using observed traffic counts.

6.2.2. The matrix estimation procedure within SATURN applies an objective function which, through successive iterations, is minimised in order to arrive at an optimal solution to improve the fit between modelled flows and counts.

6.2.3. The matrix of trips input to matrix estimation is known as the 'prior' matrix and the matrix of trips output from matrix estimation is termed the 'post' matrix. The post matrix will therefore contain a better representation of the individual trip movements on counted links, compared to the prior matrix.

6.2.4. The matrix estimation process utilised observed traffic count data derived from the ATC and MCC data collected in spring 2017 and the WebTRIS data. In accordance with guidance set out in section 8.3.5 of TAG Unit M3, the counts used for ME were grouped and applied at the screenline level.

6.2.5. A total of seven screenlines were defined for the purpose of model calibration. The screenlines are illustrated in Figure 10.

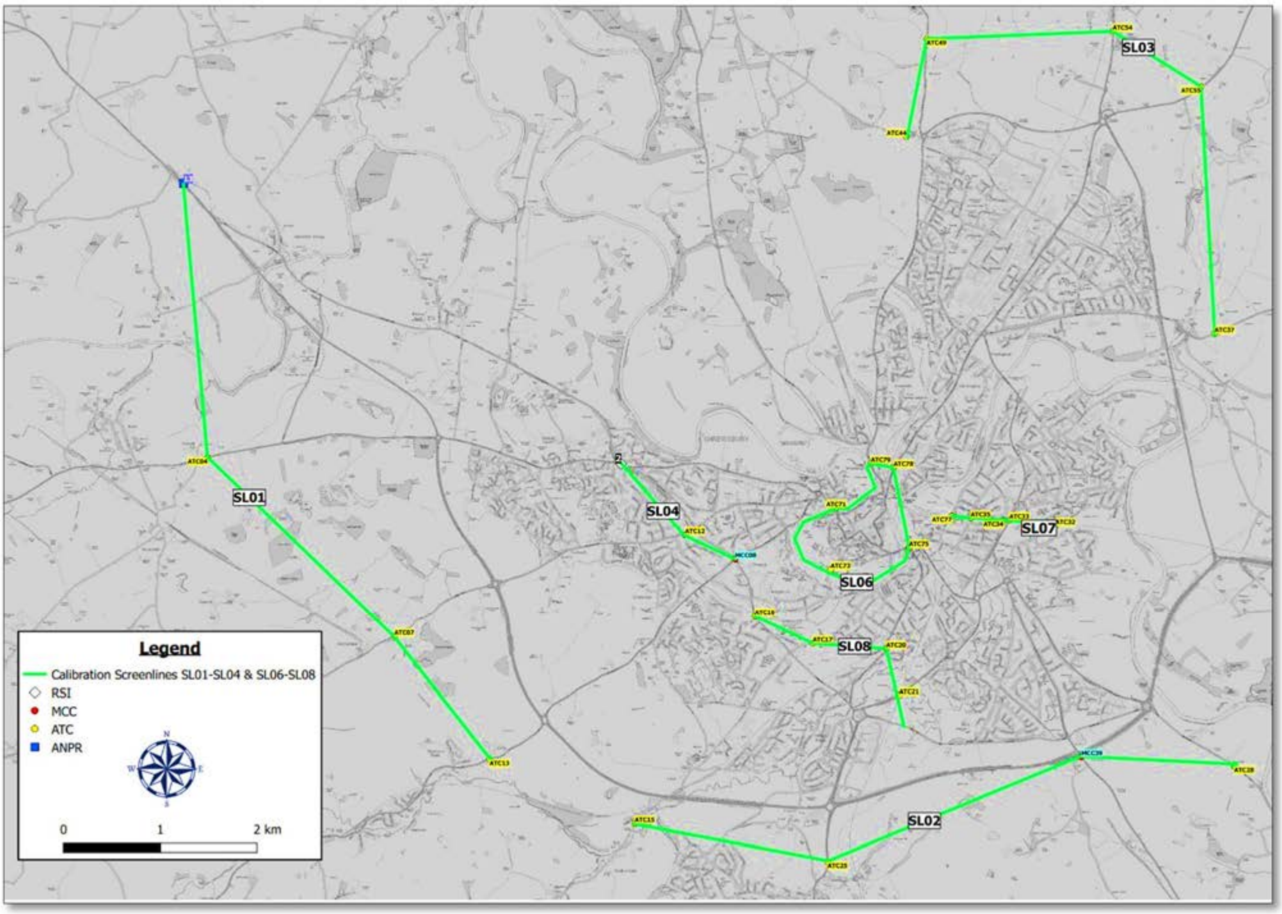


Figure 10 Screenlines Adopted For Matrix Estimation

6.2.6. A further two screenlines were defined for the purpose of model validation. These were retained independent from model calibration and the model performance across these screenlines is described in Section 7.2.

6.2.7. The screenlines for both model calibration and validation were designed to capture the main movements within the study area. Screenlines 1, 2 and 3 are intended to capture movements entering the outer ring road, Screenline 4 and validation screenlines 5 and 9 capture movements likely to be directly affected by the NWRR scheme. Screenlines 7 and 8 further capture traffic traversing north-south within Shrewsbury and finally screenline 6 forms a cordon around the historic town centre.

6.3 CALIBRATION RESULTS

6.3.1. A comparison of the observed and modelled flows following the application of the matrix estimation process is presented in Table 3 to Table 5 for the AM, Inter-peak and PM peak periods respectively.

Table 3 Screenline Calibration - AM Peak

Screenline	Direction	Observed	Modelled	Mod - Obs	% Diff
SL01a	West Inbound	2596	2523	-72	-3%
SL01b	West Outbound	1671	1621	-50	-3%
SL02a	East Inbound	2693	2660	-33	-1%
SL02b	East Outbound	1675	1626	-49	-3%
SL03a	North Inbound	2376	2373	-4	0%
SL03b	North Outbound	1635	1618	-17	-1%
SL04a	West Inner Relief Road – Inbound	1665	1596	-69	-4%
SL04b	West Inner Relief Road - Outbound	1358	1341	-18	-1%
SL06a	Town Centre Inbound	2793	2730	-63	-2%
SL06b	Town Centre Outbound	2221	2155	-66	-3%
SL07a	Northbound	1339	1330	-10	-1%
SL07b	Southbound	1682	1647	-34	-2%
SL08a	Eastbound	2723	2665	-58	-2%
SL08b	Westbound	2357	2268	-89	-4%

Table 4 Screenline Calibration - Inter Peak

Screenline	Direction	Observed	Modelled	Mod - Obs	% Diff
SL01a	West Inbound	1630	1566	-64	-4%
SL01a	West Outbound	1609	1558	-51	-3%
SL02a	East Inbound	1506	1465	-41	-3%
SL02a	East Outbound	1458	1428	-30	-2%
SL03a	North Inbound	1474	1461	-12	-1%
SL03b	North Outbound	1511	1498	-14	-1%
SL04b	West Inner Relief Road – Inbound	1145	1131	-13	-1%
SL04b	West Inner Relief Road - Outbound	995	989	-6	-1%
SL06a	Town Centre Inbound	2092	2041	-51	-2%
SL06b	Town Centre Outbound	2150	2091	-60	-3%
SL07a	Northbound	1154	1118	-36	-3%
SL07b	Southbound	1200	1173	-27	-2%
SL08a	Eastbound	1995	1900	-95	-5%
SL08b	Westbound	2112	2023	-89	-4%

Table 5 Screenline Calibration - PM peak

Screenline	Direction	Observed	Modelled	Mod - Obs	% Diff
SL01a	West Inbound	1827	1777	-50	-3%
SL01a	West Outbound	2696	2659	-37	-1%
SL02a	East Inbound	1912	1885	-26	-1%
SL02a	East Outbound	2222	2242	20	1%
SL03a	North Inbound	1835	1819	-16	-1%
SL03b	North Outbound	2472	2446	-27	-1%
SL04b	West Inner Relief Road – Inbound	1461	1468	6	0%
SL04b	West Inner Relief Road - Outbound	1316	1323	6	0%
SL06a	Town Centre Inbound	2194	2162	-32	-1%
SL06b	Town Centre Outbound	2547	2497	-51	-2%
SL07a	Northbound	1560	1522	-38	-2%
SL07b	Southbound	1451	1417	-33	-2%
SL08a	Eastbound	2336	2287	-48	-2%
SL08b	Westbound	2761	2700	-60	-2%

6.3.2. Table 5 show that across all screenlines, the modelled flows compare well with observed flows, with no differences greater than 5%.

6.4 TESTS OF VALIDITY OF MATRIX ESTIMATION

6.4.1. WebTAG guidance on the application of matrix estimation, set out in Section 8.3 of TAG Unit M3.1, advises that the changes brought about by matrix estimation should not be significant. The validity of the matrix estimation process comprises two main checks:

- An analysis of the changes to the prior matrix resulting from the matrix estimation process
- An analysis of the prior and post ME trips totals across the screenlines and cordons along which roadside interviews were undertaken and the screenlines and cordons used in applying count constraints in the matrix estimation process

6.4.2. The changes between the prior and post ME trip matrices were assessed using the criteria set out in Section 8.3.13 of TAG Unit M3.1. This comprises:

- Matrix zonal cell values, prior to and post matrix estimation, with regression statistics (slopes, intercepts and R2 values);
- Zonal trip ends, prior to and post matrix estimation, with regression statistics (slopes, intercepts and R2 values);
- Trip length distributions, prior to and post matrix estimation, with means and standard deviations; and
- Sector to sector level matrices, prior to and post matrix estimation, with absolute and percentage changes.

6.4.3. The criteria by which the significance of the changes brought about by matrix estimation may be judged are presented in Table 6.

Table 6 WebTAG Criteria for Matrix Estimation

Measure	Significance Criteria
Matrix zonal cell values	Slope within 0.98 and 1.02 Intercept near zero R^2 in excess of 0.95
Matrix zonal trip ends	Slope within 0.99 and 1.01 Intercept near zero R^2 in excess of 0.98
Trip length distributions	Means within 5% Standard deviations within 5%
Sector to sector level matrices	Differences within 5%

6.4.4. The prior and post ME matrix totals for the AM, Inter-Peak and PM Peak are shown in Table 7.

Table 7 Results of Matrix Estimation

All vehicle totals	Prior	Post	% change
AM peak	49087	52882	8%
Inter-Peak	40105	41194	3%
PM Peak	46399	50639	9%

6.4.5. Table 7 shows that the difference between post and prior matrix totals ranges from 9% in the PM peak to 3% in the Inter-Peak.

6.4.6. It is acknowledged that the differences in the AM and PM peak prior and post ME totals is above the 5% guidelines set out in WebTAG. However, the results of the screenline calibration presented in Table 3 to Table 5 demonstrated that across all screenlines modelled flows compared well with observed flows.

6.4.7. A more detailed analysis of the changes in trip patterns was carried out through a sector to sector analysis. This was based upon comparing the prior and post ME trip totals between a total of 5 sectors which are illustrated in Figure 11.

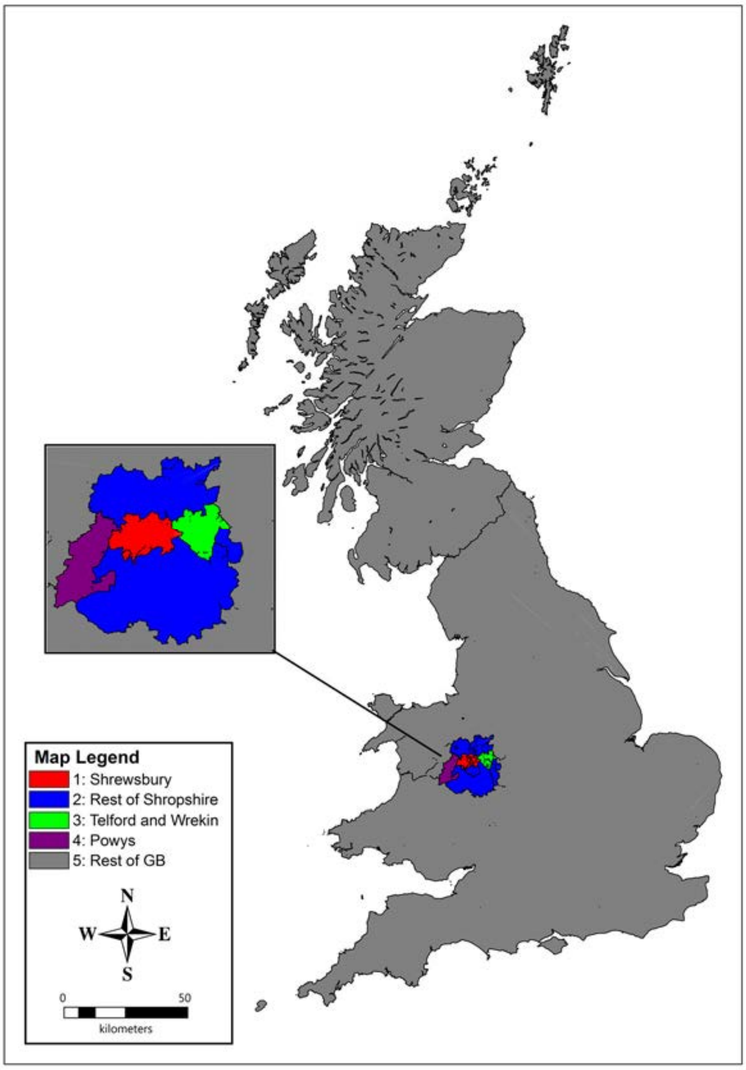


Figure 11 Matrix Estimation Sector to Sector Analysis

6.4.8. The detailed results of the sector to sector comparison are presented in Appendix A and summarised in Table 8 below.

Table 8 Summary of Sector to Sector Comparison

Time Period	No of sector movements with <5% change	% of sector movements with <5% change
AM peak	15 out of 25	60%
Inter-Peak	16 out of 25	64%
PM Peak	9 out of 25	36%

6.4.9. Table 8 shows that that percentage of sector to sector movements where the change as a result of matrix estimation is within 5% ranges from 36% in the PM peak to 60% in the AM peak and 64% in the inter-peak.

6.4.10. A more detailed breakdown of the sector to sector comparison presented in Appendix A reveals that the highest differences between prior and post ME totals are for movements to Sector 1 in the AM peak, and from Sector 1 in the PM peak.

6.4.11. The results of the analysis of the change in matrix zonal cell values and zonal trip ends against the WebTAG stability criteria are presented in Table 9.

Table 9 WebTAG Tests for Change in Matrix Zonal totals

	Zonal Cell Values		Zonal Origins		Zonal Destinations	
	Target	Achieved	*Target*	Achieved	Target	Achieved
AM Peak						
Intercept	Near 0 % of Median	-0.003	Near 0 % of Median	-0.883	Near 0 % of Median	-0.156
Slope	Within 0.98 and 1.02	0.969	Within 0.99 and 1.01	0.962	Within 0.99 and 1.01	0.934
R squared	> 0.95	0.9751	> 0.98	0.9928	> 0.98	0.9883
Inter-Peak						
Intercept	Near 0 % of Median	-0.001	Near 0 % of Median	-0.18	Near 0 % of Median	-0.556
Slope	Within 0.98 and 1.02	0.987	Within 0.99 and 1.01	0.979	Within 0.99 and 1.01	0.997
R squared	> 0.95	0.9834	> 0.98	0.9941	> 0.98	0.9927
PM Peak						
Intercept	Near 0 % of Median	-0.002	Near 0 % of Median	0.478	Near 0 % of Median	-0.257
Slope	Within 0.98 and 1.02	0.943	Within 0.99 and 1.01	0.896	Within 0.99 and 1.01	0.926
R squared	> 0.95	0.957	> 0.98	0.9873	> 0.98	0.9868

6.4.12. Table 9 shows that the WebTAG test criteria for the changes in matrix zonal totals have either been met or are very close to being achieved in most cases. However, it is acknowledged that in the AM and PM peak, the values for intercept and slope for zone origins and destinations do not meet the WebTAG criteria.

7 MODEL VALIDATION

7.1 INTRODUCTION

7.1.1. The test of a model's 'fit for purpose' is carried out by examining the extent to which the model reproduces observed conditions. Validation of the Shrewsbury model was based upon a comparison of observed against modelled traffic flow and journey time data.

7.1.2. The wealth of traffic count data covering the study area provided a stringent test of the model's performance.

7.1.3. The validation of traffic flows was a 2-stage process. The first stage involved a comparison of observed and modelled flows across 2 screenlines that are shown in Figure 12 below. These were designed to capture traffic movements between key sectors and therefore represented a robust test of the trip matrix. These screenlines provided independent data for model validation and were separate from the 7 screenlines used for the model calibration which are illustrated in Figure 10 and described in Section 6.2 above.

7.1.4. The second stage involved validation on other links within the model using independent data i.e. data not used in the development of the model.

7.2 SCREENLINE VALIDATION

7.2.1. For validation of the trip matrix, WebTAG advises that comparisons of modelled flows and counts should be taken at screenline level. Screenlines are typically comprised of 5 or more links capturing traffic along a particular axis or between sectors.

7.2.2. The validation criterion and acceptability guideline for screenline flows are defined in section 3.2.5 of TAG Unit M3.1 which is reproduced in Table 10.

Table 10 WebTAG Screenline Validation Criteria

Criteria	Acceptability Guideline
Differences between modelled flows and counts should be less than 5% of the counts	All or nearly all screenlines

7.2.3. The 2 screenlines used for validation were developed in order to capture the main movements between the south-west and-north east of the study area that are likely to be affected by the proposed NWRR. The validation screenlines are illustrated in Figure 12.

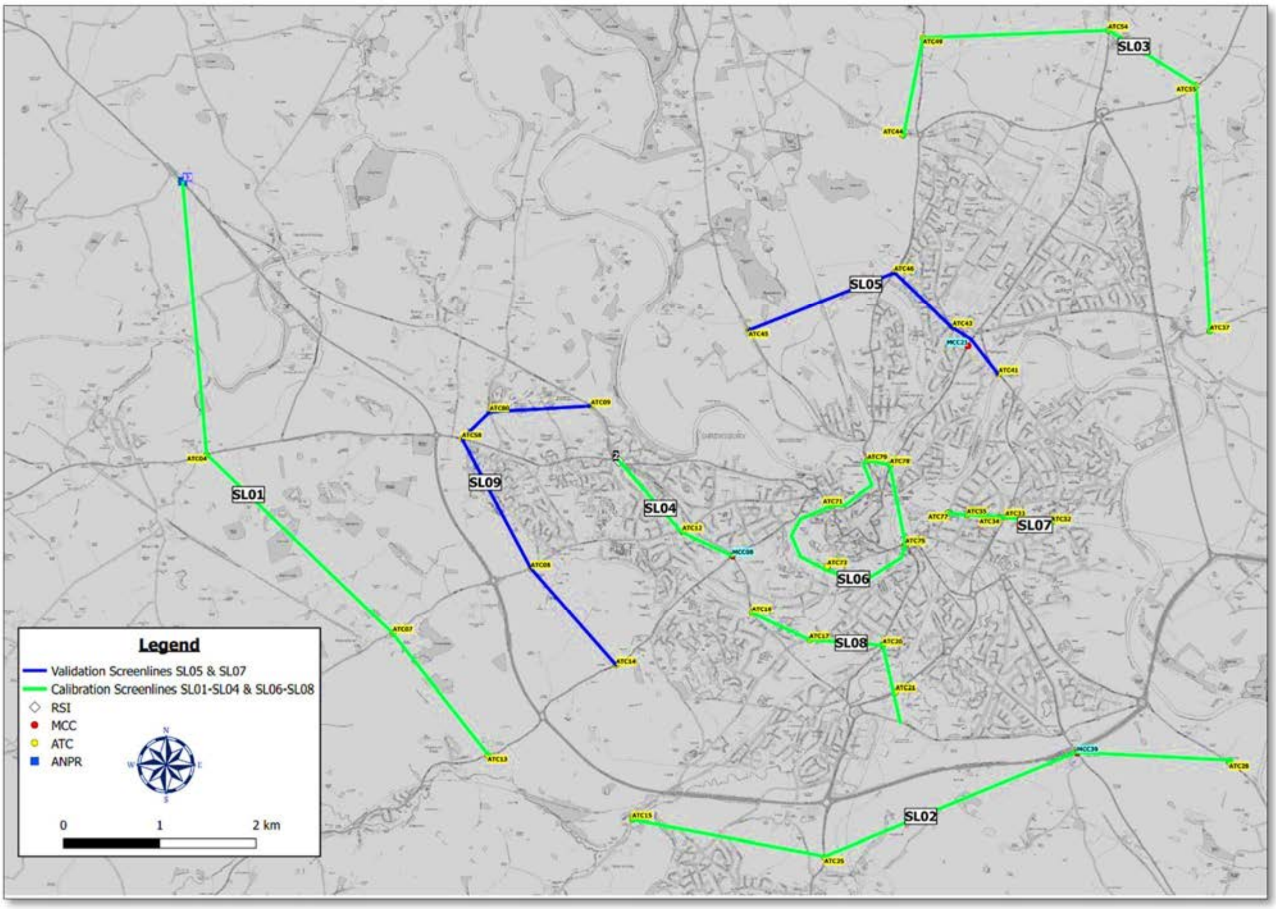


Figure 12 Screenlines for Model Validation

7.2.4. The results of the screenline are presented in Table 11 to Table 13 for the AM, Inter-Peak and PM peak respectively

Table 11 Screenline Flow Validation AM Peak

Screenline	Direction	Observed	Modelled	Mod - Obs	% Diff	GEH
SL05a	East Inner Relief Road – Inbound	3268	3480	212	6%	3.65
SL05b	East Inner Relief Road - Outbound	3351	3224	-126	-4%	2.2
SL09a	Inbound	2263	2300	37	2%	0.77
SL09b	Outbound	1228	1449	221	18%	6.05

Table 12 Screenline Flow Validation Inter-Peak

Screenline	Direction	Observed	Modelled	Mod - Obs	% Diff	GEH
SL05a	East Inner Relief Road – Inbound	2913	2845	-68	-2%	1.28
SL05b	East Inner Relief Road - Outbound	2917	2712	-206	-7%	3.88
SL09a	Inbound	1036	1118	83	8%	2.52
SL09b	Outbound	1017	1010	-7	-1%	0.21

Table 13 Screenline Flow Validation PM peak

Screenline	Direction	Observed	Modelled	Mod - Obs	% Diff	GEH
SL05a	East Inner Relief Road – Inbound	3645	3540	-105	-3%	1.75
SL05b	East Inner Relief Road - Outbound	3243	3105	-138	-4%	2.44
SL09a	Inbound	1437	1441	4	0%	0.10
SL09b	Outbound	1642	1752	110	7%	2.68

7.2.5. Table 11 to Table 13 shows that the flows across both screenlines are low. The low flow totals means that the WebTAG guidelines of a less than 5% difference between modelled and observed totals is a very stringent test. This is because small absolute differences can result in relatively high percentages making the guidelines difficult to satisfy.

7.2.6. The GEH statistic is designed to provide a weighting in accordance to scale of traffic flow and is calculated as follows;

$$GEH = \sqrt{(VO - VA)^2 / (0.5 * (VO + VA))}$$

where VO = observed traffic flow and VA = assigned traffic flow.

7.2.7. The GEH statistics were calculated for each screenline total and these are also included in Table 11 to Table 13.

7.2.8. While the GEH statistic is no longer used as a test for screenline totals within WebTAG, the GEH is considered a valid test for the model in view of the low screenline flows. It should be noted that earlier guidance contained within the Design Manual for Roads and Bridges (DMRB) Volume 12, Table 4.1 Traffic Appraisal in Urban Areas (since withdrawn) indicates a GEH of 4 or less would be an acceptable criteria for validation of screenline flows.

7.2.9. The results of the screenline comparisons for each of the modelled time periods can be summarised as follows:

AM PEAK

7.2.10. Table 11 shows there is an excellent match between modelled and observed flows on Screenline 5 (outbound) and Screenline 9 (inbound), where differences are less than 5%. The difference between modelled and observed flows on Screenline 5 (inbound) is 6%, although the GEH is less than 4. Taking into account the relatively low flow the comparison is considered satisfactory.

7.2.11. The modelled total for Screenline 9 (outbound) is 18% higher than the observed total, with a GEH of 6. While this compared less favourably than the other screenline totals, nevertheless the observed flow on this screenlne is low and the differences are not regarded as significant.

INTER-PEAK

7.2.12. Table 12 shows there is an excellent match between modelled and observed flows on Screenline 5 (inbound) and Screenline 9 (outbound), where differences well within 5%.

7.2.13. The difference between modelled and observed flows on Screenline 5 (outbound) is 7% and on Screenline 9 (inbound) is 8%. In both cases, the GEH is less than 4 and taking into account the low flows the comparison is considered satisfactory.

PM PEAK

7.2.14. Table 13 demonstrates an excellent match between modelled and observed flows with differences of less than 5% for all screenlines with the exception of Screenline 9 (outbound), where modelled flows are 7% higher than observed. The GEH value for Screenline 9 (outbound) is less than 4 and therefore the comparison is considered satisfactory.

7.3 LINK FLOW VALIDATION

7.3.1. The validation criterion and acceptability guidelines for link flows and turning movements are defined in section 3.2.8 of TAG Unit M3.1 and is reproduced in Table 14 below:

Table 14 WebTAG Link and Turning flow Validation Criteria

Criteria (Hourly Modelled Flows)	Acceptability Guideline
Individual flows within 100vph (flows<700vph)	85% of all cases
Individual flows within 15% (flows 700-2700vph)	85% of all cases
Individual flows within 400vph (flows>2700vph)	85% of all cases
GEH statistic: individual flows GEH<5	85% of all cases

7.3.2. The link flow validation comprised a comparison of modelled and observed flows on the individual links on screenlines 5 and 9 for which independent data is available.

7.3.3. The assigned base year model flows from the model were compared with observed traffic counts to assess the accuracy of the model and the extent to which WebTAG criteria were achieved.

7.3.4. A detailed comparison of modelled and observed flows for the individual sites on Screenlines 5 and 9 is presented in Appendix B. The results are summarised in Table 15 below.

Table 15 Summary of validation for links on screenlines

Measure	AM Peak	Inter-Peak	PM Peak
Link Flow Criteria (Cars)	80%	95%	90%
Link Flow Criteria (All Vehicles)	80%	100%	85%
GEH < 5 (Cars)	75%	90%	90%
GEH < 5 (All Vehicles)	75%	95%	90%

7.3.5. The results presented in Table 15 show that, in the AM peak, 80% of links meet the WebTAG link flow with 75% meeting the WebTAG GEH criteria which therefore is below the WebTAG guidelines. However, in the Inter-Peak and PM peak, the percentage of links achieving the link flow and GEH criteria range from 85% to 100% which is well within WebTAG guidelines.

7.4 JOURNEY TIME VALIDATION

7.4.1. Validation of journey time is carried out to determine how well model journey times match observed times.

7.4.2. The observed data was extracted from Traffic Master journey time dataset for March 2016.

7.4.3. A total of 32 routes (16 by direction) were defined for the purpose of the journey time validation. The journey time routes are shown in Figure 13.

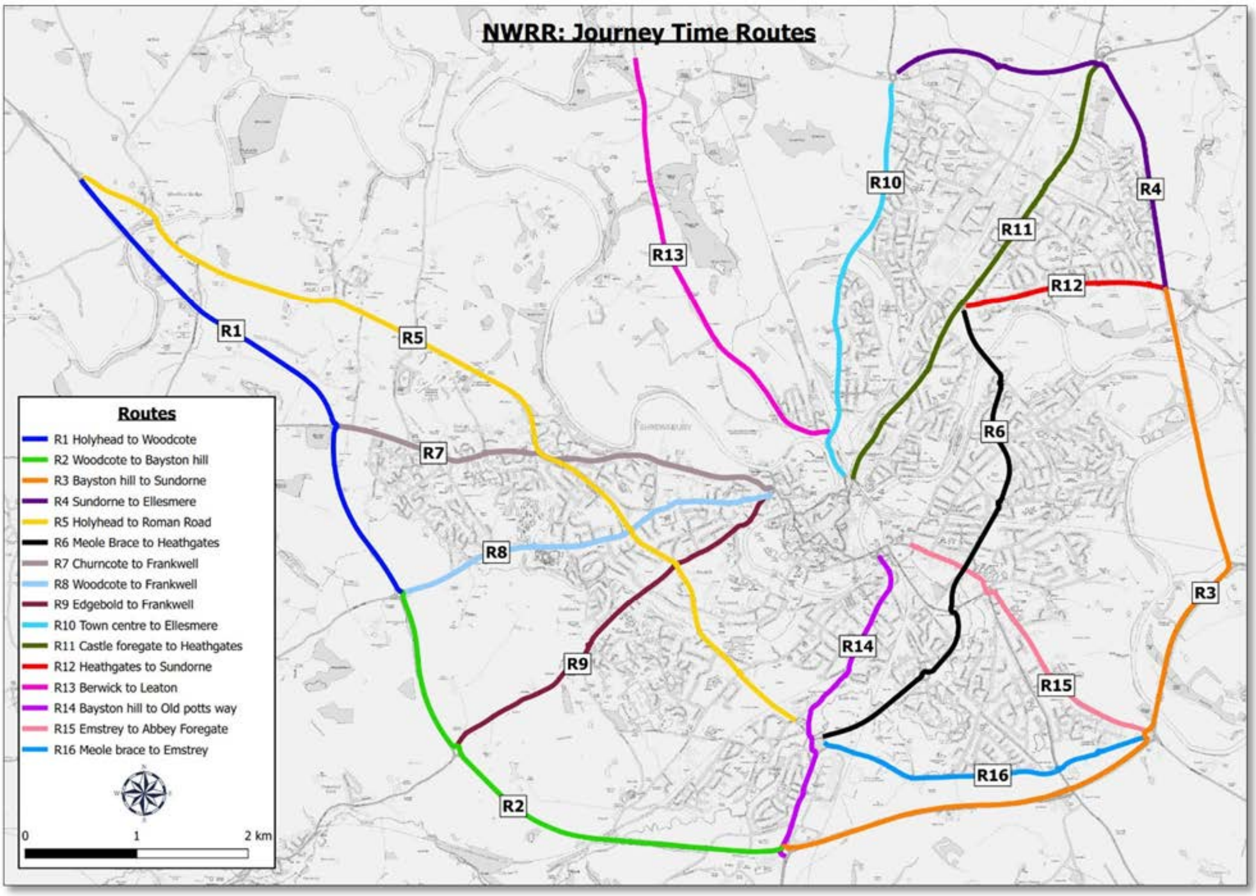


Figure 13 Journey Time Routes

7.4.4. The validation was assessed using the WebTAG validation guidelines as set out in section 3.2.10 of TAG Unit M3.1. The guidelines are set out in Table 16 below.

Table 16 WebTAG Journey Time Validation Criteria

Criteria	Acceptability Guideline
Modelled times along routes should be within 15% of surveyed times (or 1 minute, if higher than 15%)	> 85% of routes

7.4.5. The detailed results of the validation of the modelled journey times for the morning peak hour, inter-peak and evening peak hours for each individual route are presented in Appendix C and summarised Table 17 below.

Table 17 Journey Time Validation Summary

Time Period	Routes within 15% or 1 min	
	Number	Percentage
AM	26/32	81%
Inter-peak	31/32	97%
PM	28/32	88%

7.4.6. Table 17 shows the number and percentage of routes that achieve the WebTAG criteria of modelled times within 1 minute or 15% of observed journey times.

7.4.7. This demonstrates that for the PM and inter peak periods, in excess of 85% of the journey time routes are within the criteria and the journey time validation satisfies the WebTAG Guidelines. In the AM peak, 26 of the 32 routes (81%) achieve the WebTAG guidelines.

7.4.8. In the AM peak, southbound routes 13 and 10 fall outside of the criteria as the AM peak model is overestimating delay at the southern end of A528 Ellesmere Road. In all three time epriods, the model is showing insufficient delay at the southbound A49 approach to Sundorne roundabout and therefore this route does not meet the journey time validation criteria in all three time periods.

7.4.9. Elsewehere on the network, the journey time validation is very good, although there are some localised discrepancies around the Meole Bace area (affected by road works in March 2017) influencing the journey time validation along Route 14 (northbound in the AM and PM) and Route 6 (wwhere the model is over-predicting southbound delays in the AM peak period.

7.5 ROUTE CHOICE VALIDATION

7.5.1. The assignment stage of the modelling process estimates the routes chosen by traffic to get from their origin to their destination. As in real life, traffic will typically have a choice of routes available to them, and the model will assign traffic on the routes with the lowest generalised costs.

7.5.2. The route choice will depend on a number of factors including:

- appropriateness of the model network and model zone structures
- appropriateness of modelled link lengths and travel times
- accuracy of the modelled demands

7.5.3. WebTAG recommends that a selection of O/D pairs are examined which traverse the model network and are likely to be impacted by the proposed scheme. A total of 37 O/D pairs were examined and the modelled route choice was compared to recommended Google routes for AM, IP and PM. The comparisons are presented in Appendix D. This demonstrates that for the vast majority of assessed O/D pairs (in excess of 85%) the modelled routes match well to those identified by Google route planner.

8 SUMMARY AND CONCLUSIONS

8.1 SUMMARY

8.1.1. This report has described how the traffic model for the Shrewsbury NWWR has been developed and validated to a 2017 present year. The purpose of the validation is to assess the accuracy of the traffic model against independent data and to demonstrate its suitability as a forecasting and appraisal tool to support an Outline Business Case submission for the Scheme.

8.1.2. The model development process incorporated MND, RSI's Car Park Interviews together with a synthetic matrix methodology to develop the base year trip matrices. Various measurement and recording checks were carried out on the basic inputs to the highway network model and visual checks on the routeing of trips across the model network.

8.1.3. The validation process involved comparisons of observed and modelled flows over a number of screenlines and major road links together with a comparison of modelled and observed journey times. The comparisons were assessed using the DfT WebTAG criteria that provide acceptability guidelines for the validation of link flows, screenline totals and journey times.

8.1.4. The validation of screenlines showed that within all time periods, a majority of modelled screenline totals were within 5% of observed totals. While WebTAG guidelines require that nearly all of the modelled screenline totals lie within 5% of observed totals, the fact that flows across screenlines are low makes the 5% target difficult to achieve.

8.1.5. The GEH statistic, although no longer used within WebTAG for screenline validation, was nevertheless considered a relevant indicator since it provides weighting in accordance with the scale of traffic flow. A value of less than 4 had previously been considered acceptable for screenline validation.

8.1.6. One of the GEH values for the screenlines was above 4 in the AM, while all GEH values were below 4 in the Inter-peak and PM peak.

8.1.7. The results of the link flow validation presented in this report demonstrate that the model either meets or is close to achieving the WebTAG link flow and GEH criteria on the individual sites on the screenlines. These are considered the most important links within the network as they are most relevant to the planning of the scheme.

8.1.8. The journey time comparisons also demonstrate that the accuracy of the traffic model with at least over 85% of routes complying with the WebTAG criteria in the inter-peak and PM pean and over 80% of routes complying in the AM peak. This, together with the earlier checks on network routeing, demonstrates that the model provides an accurate and realistic representation of travel times for the three time periods.

8.2 CONCLUSIONS

8.2.1. The results of the model validation process have demonstrated that the model performs well, particularly on those links that are most relevant to the planning of the proposed scheme. It can be concluded that, overall, the model validation process demonstrates that the base year traffic model provides a very good representation of the current traffic demands and conditions in the Study area. It therefore provides a reliable basis from which to prepare forecasts of future traffic growth and scheme appraisal.

Appendix A

SECTOR TO SECTOR COMPARISON

Sector	1 Shrewsbury	2 Rest of Shropshire	3 Telford	4 Powys	5 Rest of GB
1 Shrewsbury	19%	2%	28%	0%	30%
2.Rest of Shropshire	34%	0%	1%	-1%	1%
3 Telford	35%	-6%	0%	-5%	-1%
4 Powys	21%	-1%	-6%	0%	10%
5 Rest of GB	33%	1%	0%	0%	-1%

Table 18 Sector Analysis Percentage flow change – AM peak

Sector	1 Shrewsbury	2 Rest of Shropshire	3 Telford	4 Powys	5 Rest of GB
1 Shrewsbury	10%	5%	5%	9%	4%
2.Rest of Shropshire	6%	0%	-1%	2%	0%
3 Telford	19%	-3%	0%	-14%	-2%
4 Powys	4%	-1%	-6%	0%	0%
5 Rest of GB	8%	-1%	-1%	-2%	-4%

Table 19 Sector Analysis Percentage flow change – Inter Peak

Sector	1 Shrewsbury	2 Rest of Shropshire	3 Telford	4 Powys	5 Rest of GB
1 Shrewsbury	11%	32%	30%	64%	58%
2.Rest of Shropshire	12%	2%	-1%	4%	4%
3 Telford	48%	6%	0%	65%	1%
4 Powys	8%	0%	55%	0%	16%
5 Rest of GB	38%	5%	0%	15%	6%

Table 20 Sector Analysis Percentage flow change – PM peak

Appendix B

LINK FLOW VALIDATION

Appendix B.1

SCREENLINE 5 AM PEAK

			Cars				
Name	Site Location	Direction	Observed	Modelled	Mod - Obs	Difference	GEH
SL 05a East Inner Relief Road Inbound	B5067 Berwick Road	Southbound	108	52	-56	-52%	6.29
	A528 Ellesmere Road	Southbound	299	273	-26	-9%	1.54
	Mount Plesant Road	Southbound	535	558	23	4%	0.99
	A5191 Ditherington Rd North	Entry	856	1025	169	20%	5.52
	A5112 Telford Way	Southbound	1130	1212	83	7%	2.42
Total			**2927**	**3120**	**193**	**7%**	**3.51**

Name	Site Location	Direction	Observed	Modelled	Mod - Obs	Difference	GEH
SL 05b East Inner Relief Road Outbound	B5067 Berwick Road	Northbound	40	55	15	37%	2.17
	A528 Ellesmere Road	Northbound	603	476	-127	-21%	5.45
	Mount Plesant Road	Northbound	438	475	38	9%	1.76
	A5191 Ditherington Rd North	Exit	904	953	49	5%	1.61
	A5112 Telford Way	Northbound	1082	961	-121	-11%	3.77
Total			**3067**	**2921**	**-146**	**-5%**	**2.66**

			All Vehicles				
Name	Site Location	Direction	Observed	Modelled	Mod - Obs	Difference	GEH
SL 05a East Inner Relief Road Inbound	B5067 Berwick Road	Southbound	114	53	-61	-53%	6.64
	A528 Ellesmere Road	Southbound	324	325	1	0%	0.04
	Mount Plesant Road	Southbound	572	625	53	9%	2.16
	A5191 Ditherington Rd North	Entry	1056	1130	74	7%	2.23
	A5112 Telford Way	Southbound	1202	1347	145	12%	4.07
Total			**3268**	**3480**	**212**	**6%**	**3.65**

Name	Site Location	Direction	Observed	Modelled	Mod - Obs	Difference	GEH
SL 05b East Inner Relief Road Outbound	B5067 Berwick Road	Northbound	45	60	15	33%	2.03
	A528 Ellesmere Road	Northbound	647	520	-127	-20%	5.28
	Mount Plesant Road	Northbound	458	535	76	17%	3.43
	A5191 Ditherington Rd North	Exit	1057	1050	-7	-1%	0.21
	A5112 Telford Way	Northbound	1144	1060	-83	-7%	2.51
Total			**3351**	**3224**	**-126**	**-4%**	**2.21**

Appendix B.2

SCREENLINE 5 INTER-PEAK

			Cars				
Name	**Site Location**	**Direction**	**Observed**	**Modelled**	**Mod - Obs**	**Difference**	**GEH**
SL 05a East Inner Relief Road Inbound	B5067 Berwick Road	Southbound	52	37	-15	-29%	2.22
	A528 Ellesmere Road	Southbound	339	320	-19	-5%	1.03
	Mount Plesant Road	Southbound	459	437	-23	-5%	1.06
	A5191 Ditherington Rd North	Entry	827	857	31	4%	1.05
	A5112 Telford Way	Southbound	957	977	20	2%	0.64
Total			**2634**	**2628**	**-6**	**0%**	**0.11**

Name	Site Location	Direction	Observed	Modelled	Mod - Obs	Difference	GEH
SL 05b East Inner Relief Road Outbound	B5067 Berwick Road	Northbound	42	31	-11	-27%	1.86
	A528 Ellesmere Road	Northbound	413	401	-12	-3%	0.59
	Mount Plesant Road	Northbound	404	395	-9	-2%	0.43
	A5191 Ditherington Rd North	Exit	840	772	-68	-8%	2.39
	A5112 Telford Way	Northbound	947	903	-44	-5%	1.45
Total			**2645**	**2501**	**-144**	**-5%**	**2.83**

			All Vehicles				
Name	**Site Location**	**Direction**	**Observed**	**Modelled**	**Mod - Obs**	**Difference**	**GEH**
SL 05a East Inner Relief Road Inbound	B5067 Berwick Road	Southbound	57	45	-12	-20%	1.63
	A528 Ellesmere Road	Southbound	366	362	-4	-1%	0.22
	Mount Plesant Road	Southbound	492	471	-21	-4%	0.97
	A5191 Ditherington Rd North	Entry	981	927	-53	-5%	1.73
	A5112 Telford Way	Southbound	1017	1039	22	2%	0.69
Total			**2913**	**2845**	**-68**	**-2%**	**1.28**

Name	Site Location	Direction	Observed	Modelled	Mod - Obs	Difference	GEH
SL 05b East Inner Relief Road Outbound	B5067 Berwick Road	Northbound	46	34	-13	-27%	1.98
	A528 Ellesmere Road	Northbound	456	453	-3	-1%	0.15
	Mount Plesant Road	Northbound	432	434	2	0%	0.09
	A5191 Ditherington Rd North	Exit	977	842	-135	-14%	4.46
	A5112 Telford Way	Northbound	1006	949	-57	-6%	1.83
Total			**2917**	**2712**	**-206**	**-7%**	**3.87**

Appendix B.3

SCREENLINE 5 PM PEAK

			Cars				
Name	**Site Location**	**Direction**	**Observed**	**Modelled**	**Mod - Obs**	**Difference**	**GEH**
SL 05a East Inner Relief Road Inbound	B5067 Berwick Road	Southbound	58	56	-2	-3%	0.21
	A528 Ellesmere Road	Southbound	603	497	-105	-17%	4.50
	Mount Plesant Road	Southbound	542	506	-36	-7%	1.57
	A5191 Ditherington Rd North	Entry	1050	1116	66	6%	2.00
	A5112 Telford Way	Southbound	1160	1122	-38	-3%	1.13
Total			**3412**	**3297**	**-115**	**-3%**	**1.99**

Name	Site Location	Direction	Observed	Modelled	Mod - Obs	Difference	GEH
SL 05b East Inner Relief Road Outbound	B5067 Berwick Road	Northbound	81	88	7	9%	0.79
	A528 Ellesmere Road	Northbound	472	394	-78	-17%	3.74
	Mount Plesant Road	Northbound	437	472	35	8%	1.66
	A5191 Ditherington Rd North	Exit	905	871	-34	-4%	1.16
	A5112 Telford Way	Northbound	1165	1018	-147	-13%	4.46
Total			**3060**	**2843**	**-217**	**-7%**	**3.99**

			All Vehicles				
Name	**Site Location**	**Direction**	**Observed**	**Modelled**	**Mod - Obs**	**Difference**	**GEH**
SL 05a East Inner Relief Road Inbound	B5067 Berwick Road	Southbound	62	61	-1	-2%	0.13
	A528 Ellesmere Road	Southbound	627	555	-71	-11%	2.93
	Mount Plesant Road	Southbound	571	527	-43	-8%	1.85
	A5191 Ditherington Rd North	Entry	1178	1205	27	2%	0.78
	A5112 Telford Way	Southbound	1207	1191	-17	-1%	0.48
Total			**3645**	**3540**	**-105**	**-3%**	**1.75**

Name	Site Location	Direction	Observed	Modelled	Mod - Obs	Difference	GEH
SL 05b East Inner Relief Road Outbound	B5067 Berwick Road	Northbound	86	92	7	8%	0.72
	A528 Ellesmere Road	Northbound	489	431	-59	-12%	2.74
	Mount Plesant Road	Northbound	452	531	79	17%	3.55
	A5191 Ditherington Rd North	Exit	1004	965	-39	-4%	1.25
	A5112 Telford Way	Northbound	1212	1087	-125	-10%	3.69
Total			**3243**	**3105**	**-138**	**-4%**	**2.44**

Appendix B.4

SCREENLINE 9 AM PEAK

Name	Site Location	Direction	Cars				
			Observed	Modelled	Mod - Obs	Difference	GEH
SL 9a Inbound	B4380 Holyhead Road	Eastbound	317	290	-26	-8%	1.50
	Shepherd's Ln	Southbound	29	28	-1	-4%	0.21
	A458 Welshpool Rd	Eastbound	649	571	-78	-12%	3.14
	B4386 Oak Rd	Eastbound	734	883	149	20%	5.24
	A488 Hanwood Road	Eastbound	422	379	-43	-10%	2.15
Total			**2150**	**2152**	**1**	**0%**	**0.02**

Name	Site Location	Direction	Observed	Modelled	Mod - Obs	Difference	GEH
SL 9b Outbound	B4380 Holyhead Road	Westbound	127	222	95	75%	7.19
	Shepherd's Ln	Northbound	29	17	-12	-42%	2.52
	A458 Welshpool Rd	Westbound	412	358	-53	-13%	2.72
	B4386 Oak Rd	Westbound	257	392	134	52%	7.45
	A488 Hanwood Road	Westbound	313	303	-11	-3%	0.61
Total			**1139**	**1292**	**153**	**13%**	**4.39**

Name	Site Location	Direction	All Vehicles				
			Observed	Modelled	Mod - Obs	Difference	GEH
SL 9a Inbound	B4380 Holyhead Road	Eastbound	334	323	-10	-3%	0.56
	Shepherd's Ln	Southbound	32	36	4	13%	0.74
	A458 Welshpool Rd	Eastbound	691	614	-77	-11%	3.01
	B4386 Oak Rd	Eastbound	759	931	172	23%	5.92
	A488 Hanwood Road	Eastbound	448	395	-53	-12%	2.56
Total			**2263**	**2300**	**37**	**2%**	**0.77**

Name	Site Location	Direction	Observed	Modelled	Mod - Obs	Difference	GEH
SL 9b Outbound	B4380 Holyhead Road	Westbound	137	239	103	75%	7.50
	Shepherd's Ln	Northbound	32	17	-15	-46%	2.95
	A458 Welshpool Rd	Westbound	447	395	-53	-12%	2.58
	B4386 Oak Rd	Westbound	276	459	183	66%	9.56
	A488 Hanwood Road	Westbound	336	339	3	1%	0.15
Total			**1228**	**1449**	**221**	**18%**	**6.05**

Appendix B.5

SCREENLINE 9 INTER-PEAK

			Cars				
Name	**Site Location**	**Direction**	**Observed**	**Modelled**	**Mod - Obs**	**Difference**	**GEH**
SL 9a Inbound	B4380 Holyhead Road	Eastbound	138	122	-16	-12%	1.42
	Shepherd's Ln	Southbound	16	12	-4	-24%	0.99
	A458 Welshpool Rd	Eastbound	300	259	-41	-14%	2.47
	B4386 Oak Rd	Eastbound	292	390	98	33%	5.29
	A488 Hanwood Road	Eastbound	204	210	6	3%	0.44
Total			**950**	**993**	**43**	**5%**	**1.38**

Name	Site Location	Direction	Observed	Modelled	Mod - Obs	Difference	GEH
SL 9b Outbound	B4380 Holyhead Road	Westbound	108	107	-1	-1%	0.05
	Shepherd's Ln	Northbound	16	10	-6	-39%	1.73
	A458 Welshpool Rd	Westbound	338	240	-98	-29%	5.79
	B4386 Oak Rd	Westbound	295	325	30	10%	1.72
	A488 Hanwood Road	Westbound	177	190	14	8%	1.03
Total			**933**	**872**	**-61**	**-7%**	**2.02**

			All Vehicles				
Name	**Site Location**	**Direction**	**Observed**	**Modelled**	**Mod - Obs**	**Difference**	**GEH**
SL 9a Inbound	B4380 Holyhead Road	Eastbound	150	151	0	0%	0.03
	Shepherd's Ln	Southbound	17	15	-3	-16%	0.67
	A458 Welshpool Rd	Eastbound	331	299	-32	-10%	1.80
	B4386 Oak Rd	Eastbound	316	430	115	36%	5.95
	A488 Hanwood Road	Eastbound	221	223	2	1%	0.13
Total			**1036**	**1118**	**83**	**8%**	**2.52**

Name	Site Location	Direction	Observed	Modelled	Mod - Obs	Difference	GEH
SL 9a Outbound	B4380 Holyhead Road	Westbound	119	114	-5	-4%	0.47
	Shepherd's Ln	Northbound	17	10	-7	-41%	1.92
	A458 Welshpool Rd	Westbound	373	287	-85	-23%	4.69
	B4386 Oak Rd	Westbound	316	373	57	18%	3.05
	A488 Hanwood Road	Westbound	192	226	34	18%	2.36
Total			**1017**	**1010**	**-7**	**-1%**	**0.21**

Appendix B.6

SCREENLINE 9 PM PEAK

			Cars				
Name	Site Location	Direction	Observed	Modelled	Mod - Obs	Difference	GEH
SL 9a Inbound	B4380 Holyhead Road	Eastbound	218	241	23	11%	1.51
	Shepherd's Ln	Southbound	21	12	-9	-43%	2.22
	A458 Welshpool Rd	Eastbound	444	339	-105	-24%	5.31
	B4386 Oak Rd	Eastbound	312	421	109	35%	5.70
	A488 Hanwood Road	Eastbound	377	328	-49	-13%	2.62
Total			**1372**	**1341**	**-31**	**-2%**	**0.85**

Name	Site Location	Direction	Observed	Modelled	Mod - Obs	Difference	GEH
SL 9b Outbound	B4380 Holyhead Road	Westbound	167	190	23	14%	1.69
	Shepherd's Ln	Northbound	21	28	7	31%	1.33
	A458 Welshpool Rd	Westbound	610	535	-75	-12%	3.13
	B4386 Oak Rd	Westbound	517	570	53	10%	2.27
	A488 Hanwood Road	Westbound	267	309	41	16%	2.44
Total			**1582**	**1631**	**49**	**3%**	**1.21**

			All Vehicles				
Name	Site Location	Direction	Observed	Modelled	Mod - Obs	Difference	GEH
SL 9a Inbound	B4380 Holyhead Road	Eastbound	228	270	42	18%	2.65
	Shepherd's Ln	Southbound	22	19	-4	-16%	0.81
	A458 Welshpool Rd	Eastbound	467	355	-111	-24%	5.50
	B4386 Oak Rd	Eastbound	326	458	132	41%	6.69
	A488 Hanwood Road	Eastbound	394	339	-55	-14%	2.88
Total			**1437**	**1441**	**4**	**0%**	**0.10**

Name	Site Location	Direction	Observed	Modelled	Mod - Obs	Difference	GEH
SL 9b Outbound	B4380 Holyhead Road	Westbound	174	232	58	33%	4.08
	Shepherd's Ln	Northbound	22	28	6	26%	1.14
	A458 Welshpool Rd	Westbound	635	553	-82	-13%	3.37
	B4386 Oak Rd	Westbound	533	608	75	14%	3.13
	A488 Hanwood Road	Westbound	278	332	54	19%	3.08
Total			**1642**	**1752**	**110**	**7%**	**2.68**

Appendix C

JOURNEY TIME VALIDATION

Appendix C.1

JOURNEY TIME VALIDATION (AM)

Routes	32	
Passed	26	81%

ID	Name	AM Peak Observed (s)	AM Peak Modelled (s)	Diff	%	Pass?
R1A	R1A Holyhead to Woodcote SB	247	207	-39	-16%	Yes
R1B	R1B Woodcote to Holyhead NB	208	215	7	3%	Yes
R2A	R2A Woodcote to Bayston hill EB	295	246	-49	-17%	Yes
R2B	R2B Baystonhill to Woodcote	208	195	-13	-6%	Yes
R3A	R3A Baystonhill to Sundorne NB	447	497	50	11%	Yes
R3B	R3B Sundorne to Baystonhill SB	414	402	-11	-3%	Yes
R4A	R4A Sundorne to Ellesmere NB	311	188	-123	-40%	No
R4B	R4B Ellesmere to Sundorne SB	435	216	-219	-50%	No
R5A	R5A Holyhead to Roman Road SB	653	602	-50	-8%	Yes
R5B	R5B Roman Road to Holyhead NB	588	611	22	4%	Yes
R6A	R6A Meole Brace to Heathgates NB	385	370	-15	-4%	Yes
R6B	R6B Heathgates to Meole brace SB	326	392	66	20%	No
R7A	R7A Churncote to Frankwell EB	381	393	12	3%	Yes
R7B	R7B Frankwell to Churncote WB	368	387	19	5%	Yes
R8A	R8A Woodcote to Frankwell EB	340	354	14	4%	Yes
R8B	R8B Frankwell to Woodcote WB	319	326	7	2%	Yes
R9A	R9A Edgebold to Frankwell EB	290	243	-47	-16%	Yes
R9B	R9B Frankwell to Edgebold WB	262	244	-18	-7%	Yes
R10A	R10A Town centre to Ellesmere NB	326	296	-30	-9%	Yes
R10B	R10B Ellesmere to Town centre	358	557	199	55%	No
R11A	R11A Castle foregate to Heathgates NB	590	551	-38	-6%	Yes
R11B	R11B Heathgates to Castle foregate SB	633	599	-34	-5%	Yes
R12A	R12A Heathgates to Sundorne EB	186	181	-5	-3%	Yes
R12B	R12B Sundorne to Heathgates WB	224	190	-33	-15%	Yes
R13A	R13A Berwick to Leaton NB	264	209	-54	-21%	Yes
R13B	R13B Leaton to Berwick SB	287	408	121	42%	No
R14A	R14A Bayston hill to Old potts way NB	381	310	-71	-19%	No
R14B	R14B Old potts way to Bayston hill SB	374	403	29	8%	Yes
R15A	R15A Emstrey to Abbey Foregate NB	324	302	-22	-7%	Yes
R15B	R15B Abbey Foregate to Emstrey SB	303	277	-26	-9%	Yes
R16A	R16A Meole brace to Emstrey EB	210	207	-3	-2%	Yes
R16B	R16B Emstrey to Meole Brace WB	199	220	20	10%	Yes

Appendix C.2

JOURNEY TIME VALIDATION (INTER-PEAK)

Routes	32	
Passed	31	97%

ID	Name	Interpeak Observed (s)	Modelled (s)	Diff	%	Pass?
R1A	R1A Holyhead to Woodcote SB	217	198	-19	-9%	Yes
R1B	R1B Woodcote to Holyhead NB	216	206	-10	-5%	Yes
R2A	R2A Woodcote to Bayston hill EB	224	189	-35	-16%	Yes
R2B	R2B Baystonhill to Woodcote	208	182	-26	-12%	Yes
R3A	R3A Baystonhill to Sundorne NB	388	400	12	3%	Yes
R3B	R3B Sundorne to Baystonhill SB	379	374	-6	-1%	Yes
R4A	R4A Sundorne to Ellesmere NB	231	181	-50	-22%	Yes
R4B	R4B Ellesmere to Sundorne SB	262	190	-72	-27%	No
R5A	R5A Holyhead to Roman Road SB	561	576	15	3%	Yes
R5B	R5B Roman Road to Holyhead NB	623	573	-50	-8%	Yes
R6A	R6A Meole Brace to Heathgates NB	340	344	3	1%	Yes
R6B	R6B Heathgates to Meole brace SB	325	357	32	10%	Yes
R7A	R7A Churncote to Frankwell EB	332	368	35	11%	Yes
R7B	R7B Frankwell to Churncote WB	322	374	52	16%	Yes
R8A	R8A Woodcote to Frankwell EB	306	330	25	8%	Yes
R8B	R8B Frankwell to Woodcote WB	308	312	4	1%	Yes
R9A	R9A Edgebold to Frankwell EB	292	235	-58	-20%	Yes
R9B	R9B Frankwell to Edgebold WB	281	240	-40	-14%	Yes
R10A	R10A Town centre to Ellesmere NB	297	296	-1	0%	Yes
R10B	R10B Ellesmere to Town centre	357	374	17	5%	Yes
R11A	R11A Castle foregate to Heathgates NB	599	549	-50	-8%	Yes
R11B	R11B Heathgates to Castle foregate SB	585	570	-14	-2%	Yes
R12A	R12A Heathgates to Sundorne EB	171	179	8	5%	Yes
R12B	R12B Sundorne to Heathgates WB	201	178	-24	-12%	Yes
R13A	R13A Berwick to Leaton NB	231	209	-22	-10%	Yes
R13B	R13B Leaton to Berwick SB	332	277	-55	-17%	Yes
R14A	R14A Bayston hill to Old potts way NB	330	304	-26	-8%	Yes
R14B	R14B Old potts way to Bayston hill SB	371	347	-24	-6%	Yes
R15A	R15A Emstrey to Abbey Foregate NB	260	264	5	2%	Yes
R15B	R15B Abbey Foregate to Emstrey SB	274	262	-12	-4%	Yes
R16A	R16A Meole brace to Emstrey EB	210	199	-11	-5%	Yes
R16B	R16B Emstrey to Meole Brace WB	216	214	-2	-1%	Yes

Appendix C.3

JOURNEY TIME VALIDATION (PM)

Routes	32	
Passed	28	88%

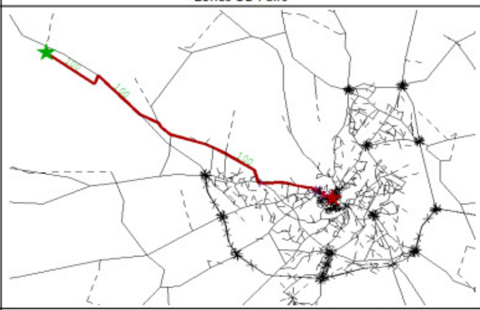
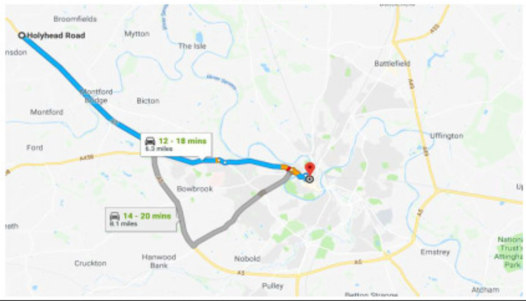
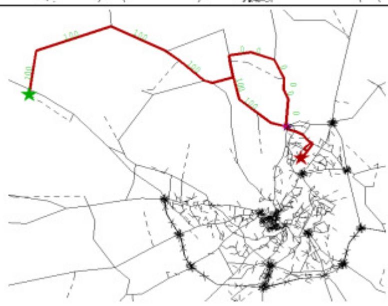
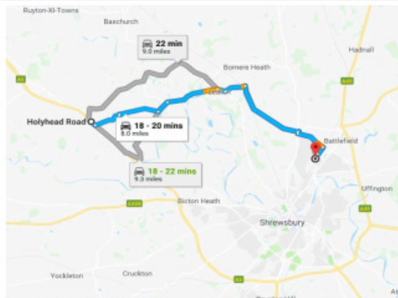
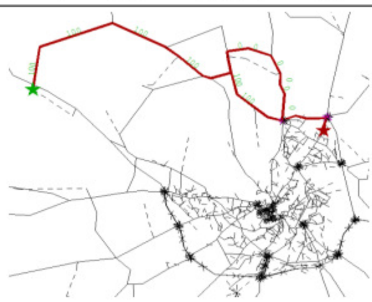
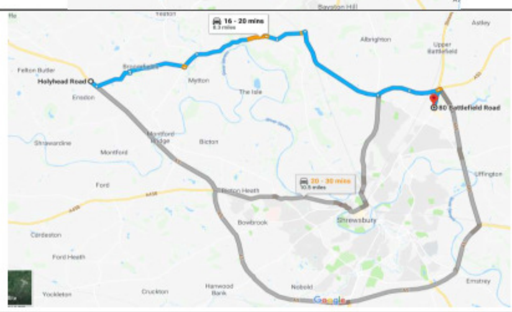
ID	Name	Observed (s)	Modelled (s)	Diff	%	Pass?
		PM Peak				
R1A	R1A Holyhead to Woodcote SB	209	199	-10	-5%	Yes
R1B	R1B Woodcote to Holyhead NB	216	224	8	4%	Yes
R2A	R2A Woodcote to Bayston hill EB	242	196	-45	-19%	Yes
R2B	R2B Baystonhill to Woodcote	305	197	-109	-36%	No
R3A	R3A Baystonhill to Sundorne NB	434	458	24	6%	Yes
R3B	R3B Sundorne to Baystonhill SB	478	417	-61	-13%	Yes
R4A	R4A Sundorne to Ellesmere NB	254	199	-56	-22%	Yes
R4B	R4B Ellesmere to Sundorne SB	419	201	-218	-52%	No
R5A	R5A Holyhead to Roman Road SB	566	606	40	7%	Yes
R5B	R5B Roman Road to Holyhead NB	615	616	1	0%	Yes
R6A	R6A Meole Brace to Heathgates NB	335	359	24	7%	Yes
R6B	R6B Heathgates to Meole brace SB	322	382	59	18%	Yes
R7A	R7A Churncote to Frankwell EB	356	372	17	5%	Yes
R7B	R7B Frankwell to Churncote WB	370	443	73	20%	No
R8A	R8A Woodcote to Frankwell EB	337	338	1	0%	Yes
R8B	R8B Frankwell to Woodcote WB	302	320	18	6%	Yes
R9A	R9A Edgebold to Frankwell EB	262	237	-25	-10%	Yes
R9B	R9B Frankwell to Edgebold WB	296	245	-52	-17%	Yes
R10A	R10A Town centre to Ellesmere NB	334	296	-38	-12%	Yes
R10B	R10B Ellesmere to Town centre	366	416	50	14%	Yes
R11A	R11A Castle foregate to Heathgates NB	574	564	-9	-2%	Yes
R11B	R11B Heathgates to Castle foregate SB	630	581	-49	-8%	Yes
R12A	R12A Heathgates to Sundorne EB	196	186	-10	-5%	Yes
R12B	R12B Sundorne to Heathgates WB	209	187	-23	-11%	Yes
R13A	R13A Berwick to Leaton NB	264	211	-53	-20%	Yes
R13B	R13B Leaton to Berwick SB	287	282	-5	-2%	Yes
R14A	R14A Bayston hill to Old potts way NB	386	318	-68	-18%	No
R14B	R14B Old potts way to Bayston hill SB	379	382	3	1%	Yes
R15A	R15A Emstrey to Abbey Foregate NB	272	281	9	3%	Yes
R15B	R15B Abbey Foregate to Emstrey SB	282	292	10	4%	Yes
R16A	R16A Meole brace to Emstrey EB	195	206	11	6%	Yes
R16B	R16B Emstrey to Meole Brace WB	224	233	10	4%	Yes

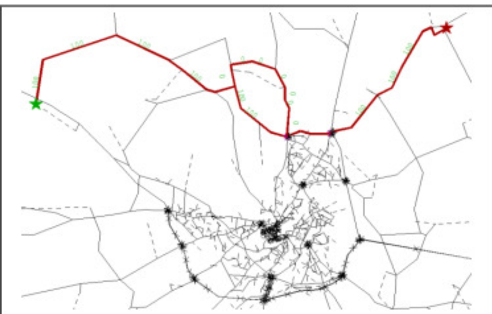
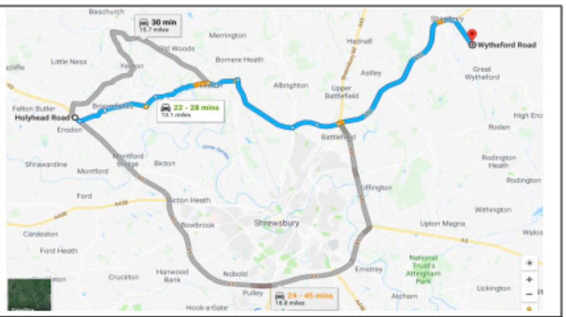
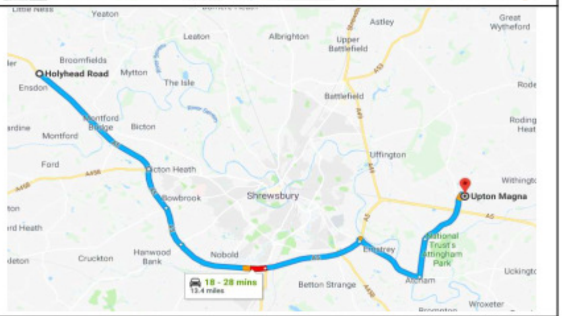
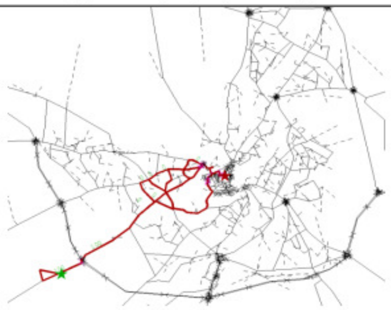
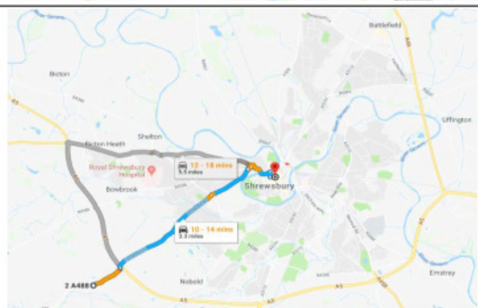
Appendix D

ROUTE VALIDATIONS

Appendix D.1

ROUTES VALIDATION (AM)

Origin	Destination	Zones OD Pairs	Google Locations
373	52		
373	276		
373	120		

373	310		
373	145		
217	52		

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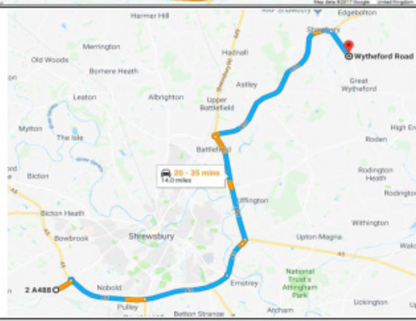
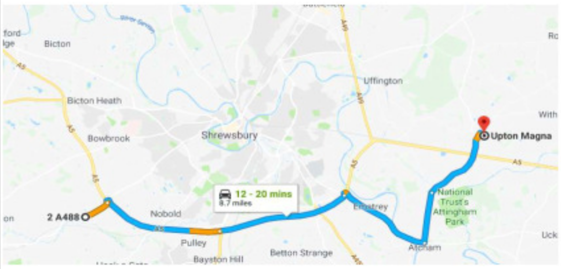
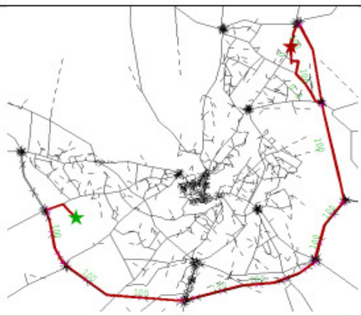
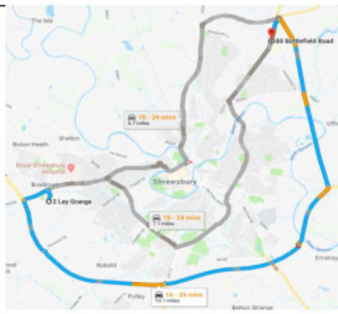
217	310		

217	145		
224	120		
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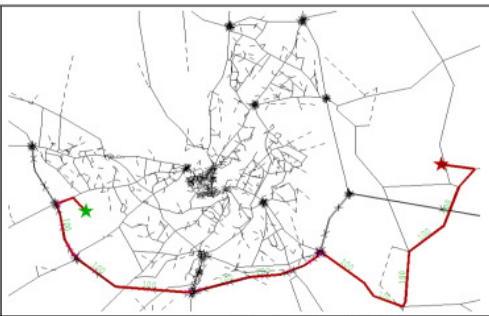
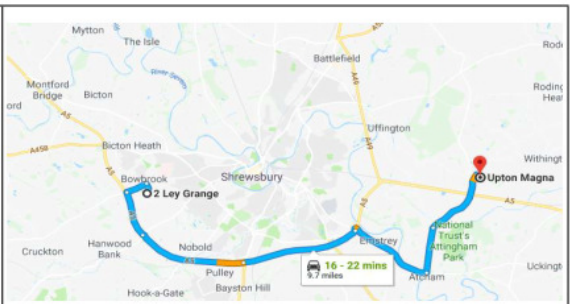
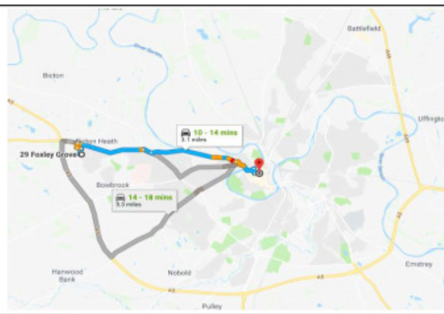
224	145		
241	52		
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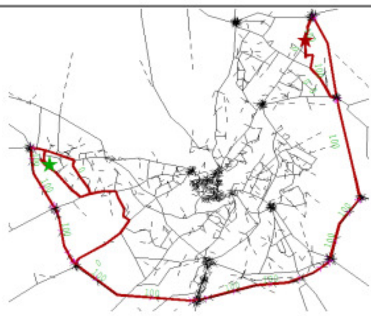
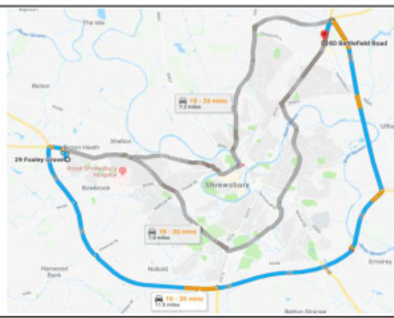
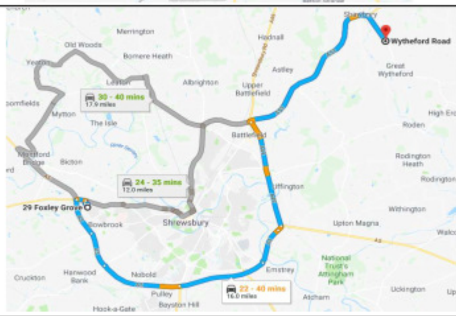
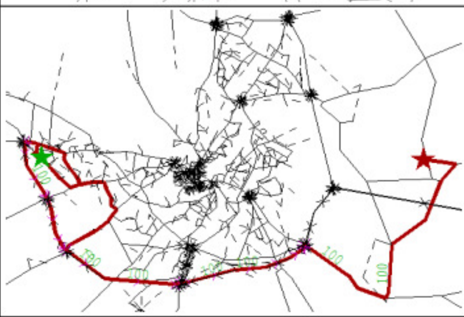
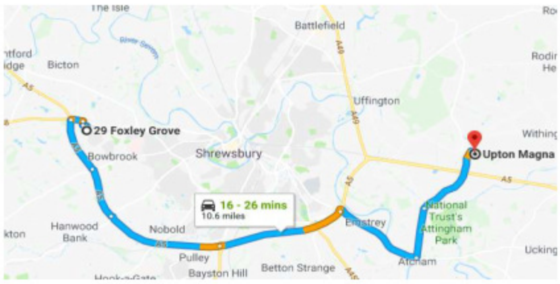
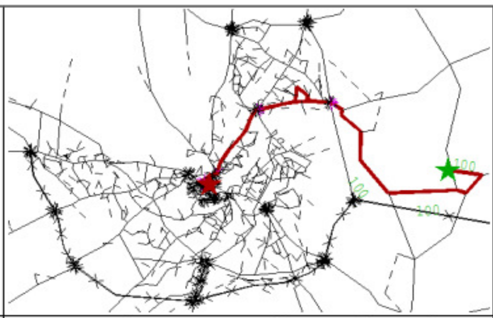
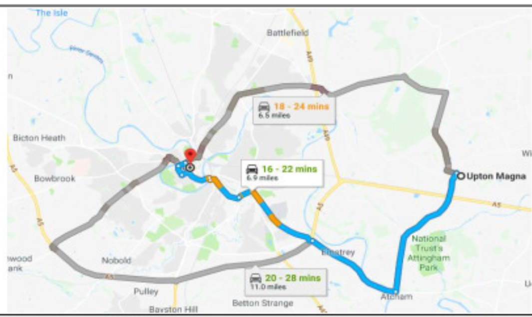
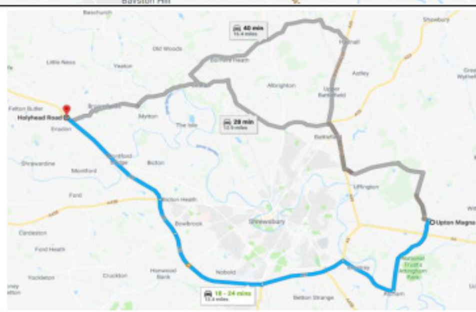
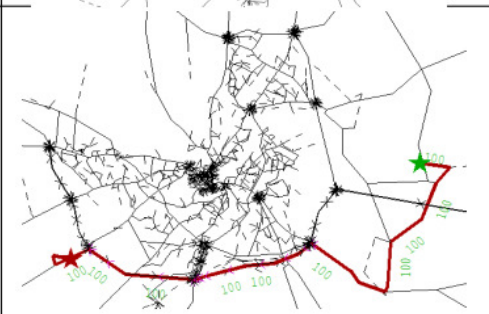
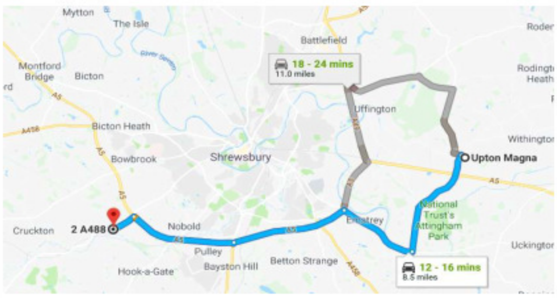
241	120		
241	310		
241	145		

145	52		
145	373		
145	217		

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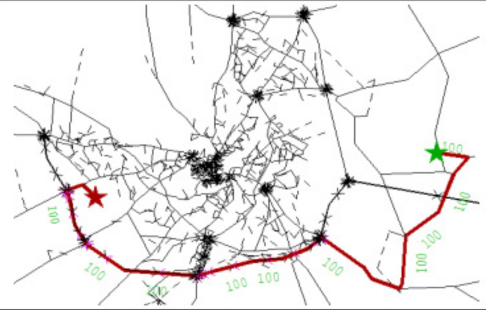
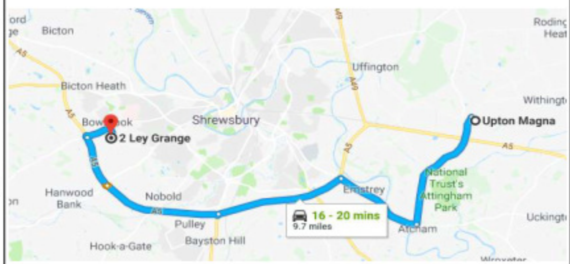
<tr><td>145</td><td>224</td><td></td><td>
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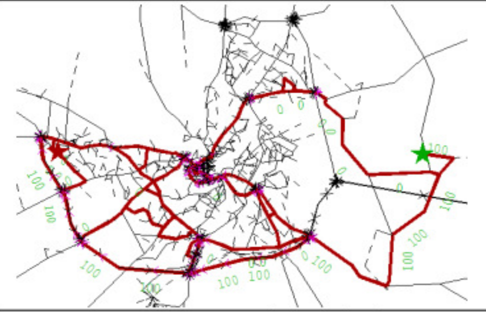
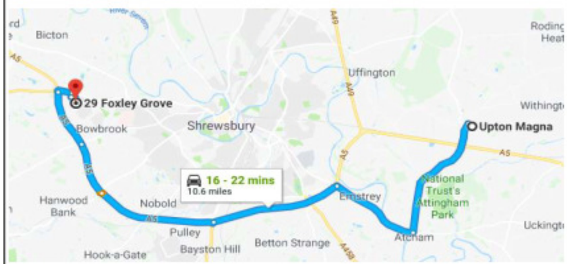
<tr><td>145</td><td>241</td><td></td><td>
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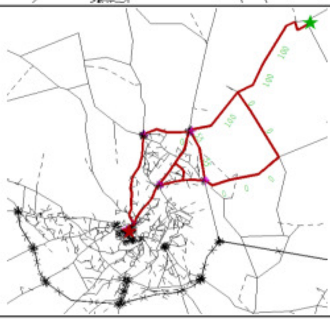
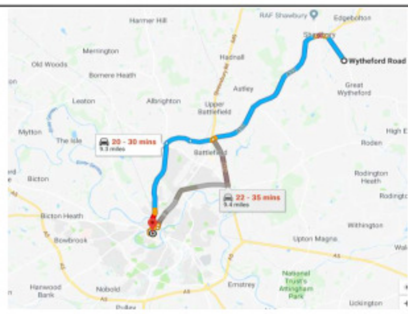
<tr><td>310</td><td>52</td><td></td><td>
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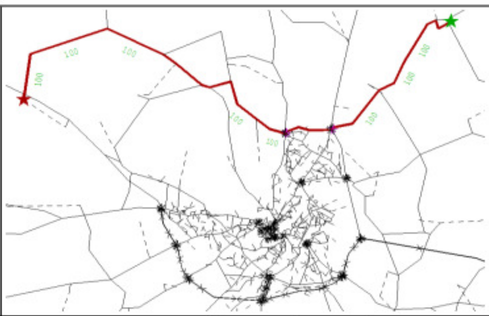
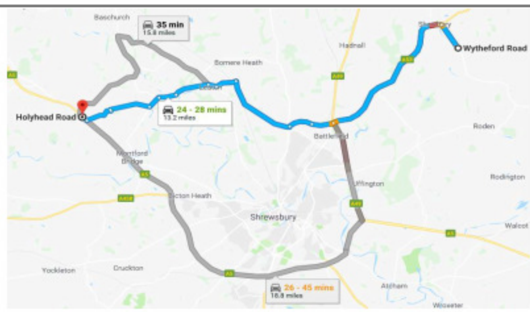
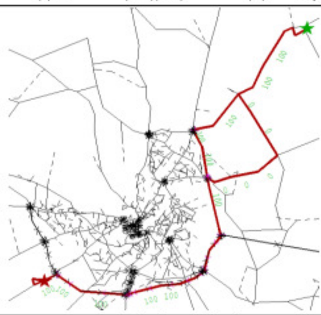
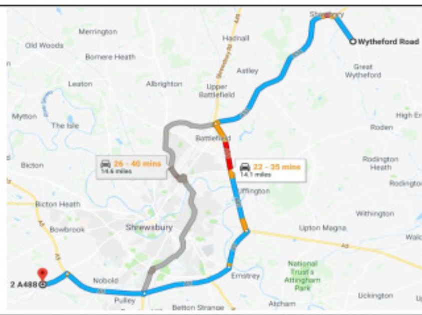
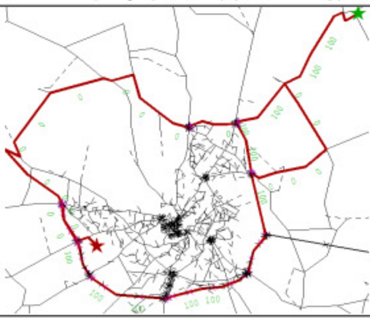
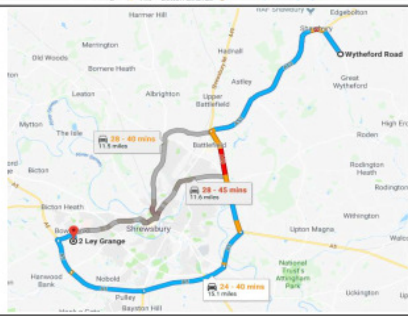
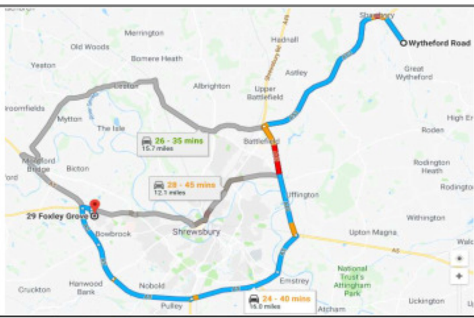
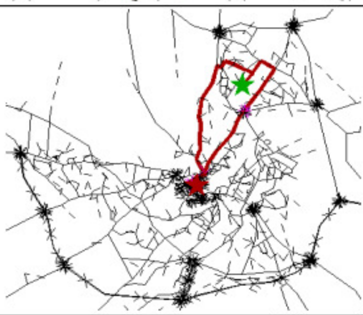
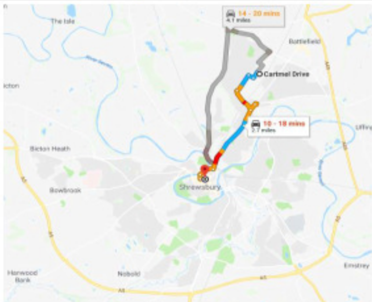
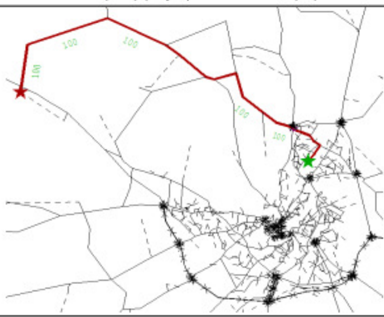
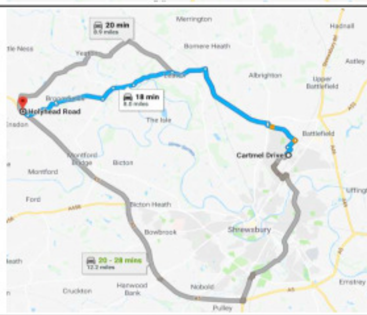
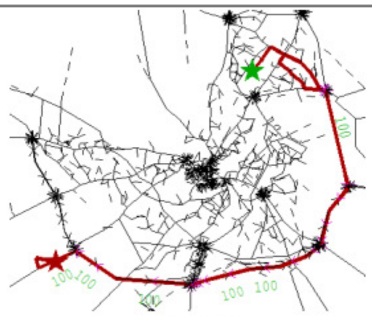
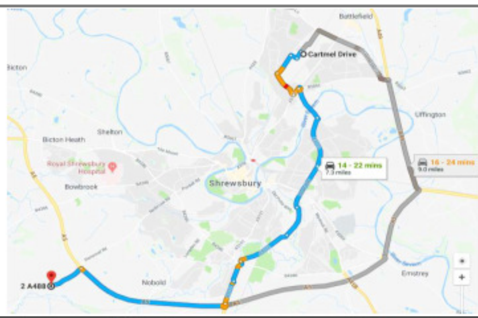
310	373		
310	217		
310	224		

310	241		
276	52		
276	373		

276	217		
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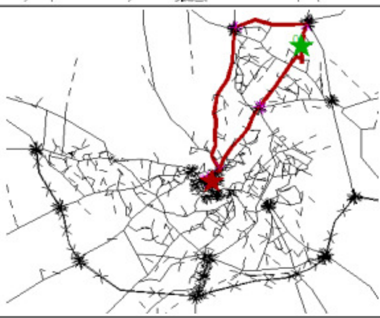
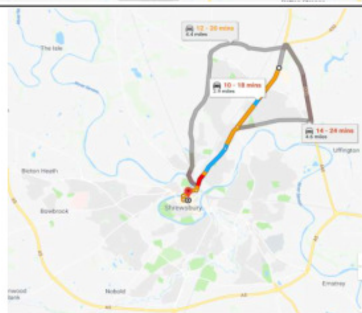
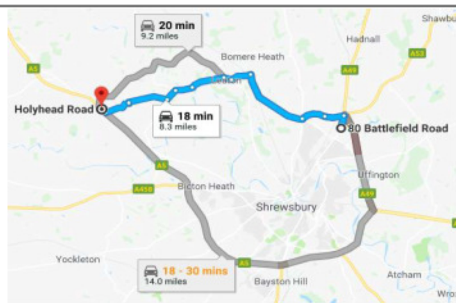
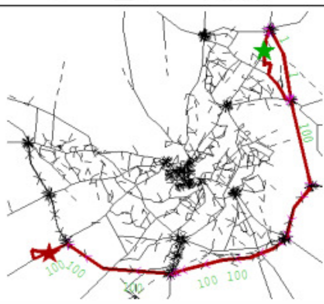
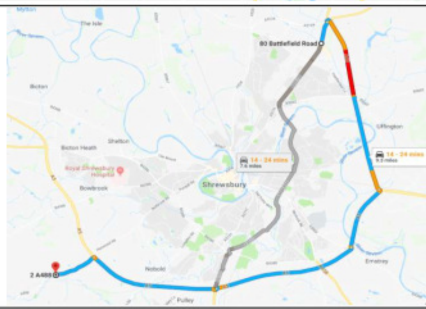
120	52		

120	373		
120	217		
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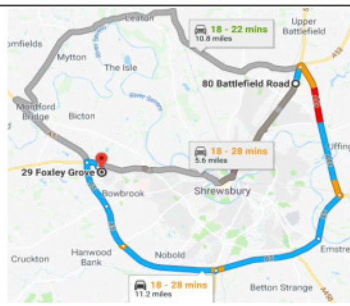
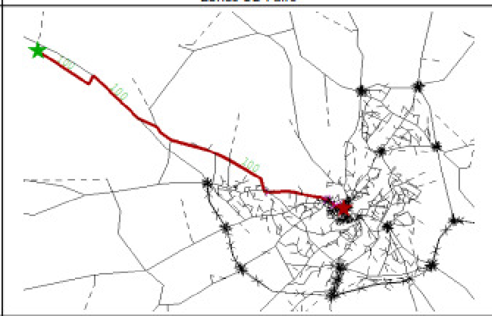
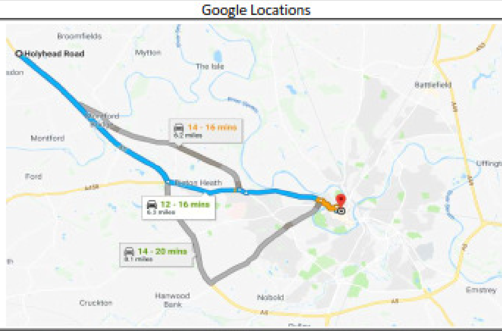
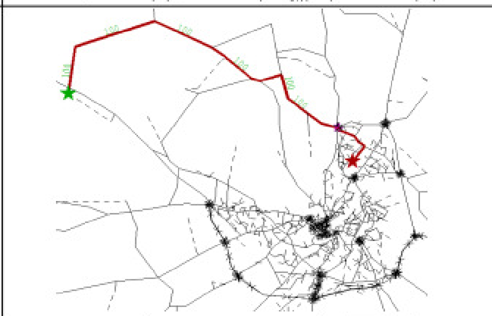
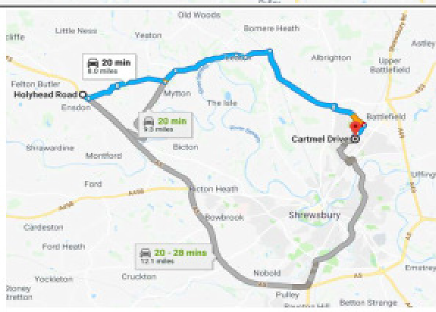
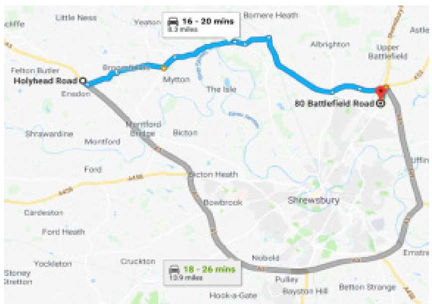
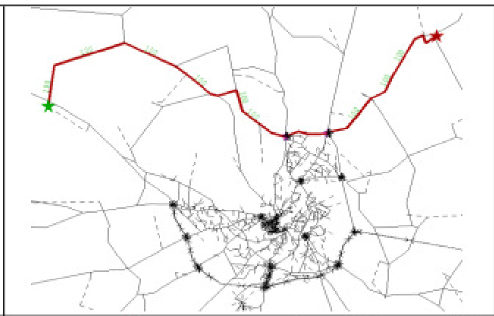
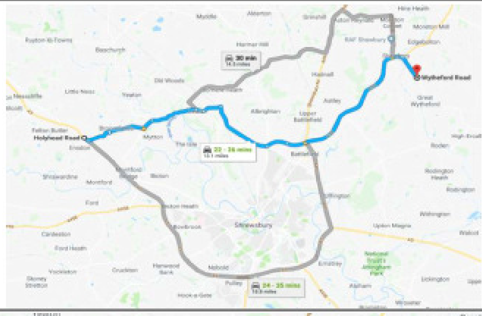
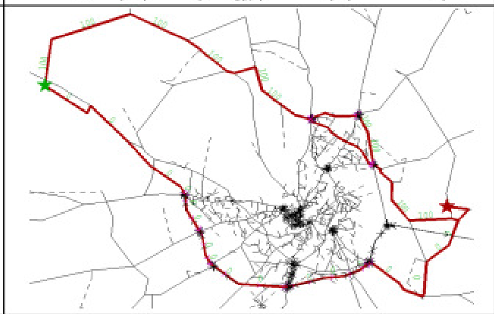
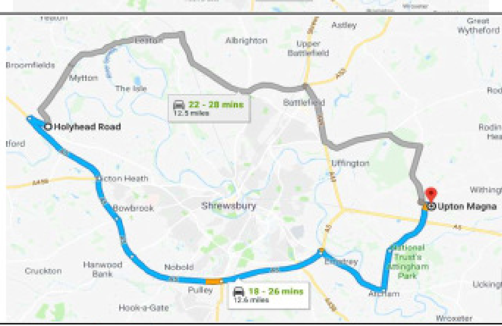
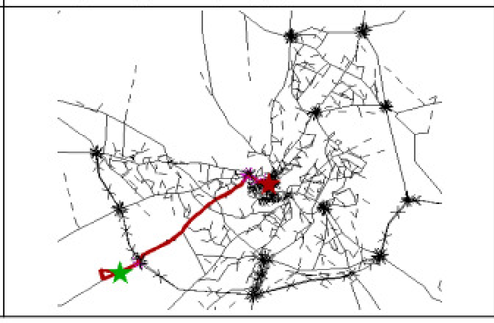
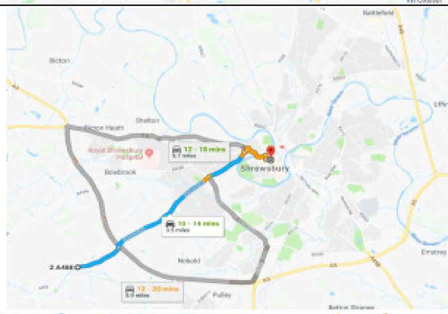
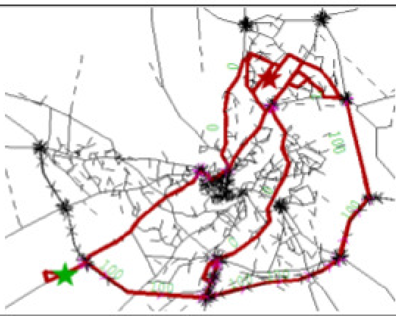
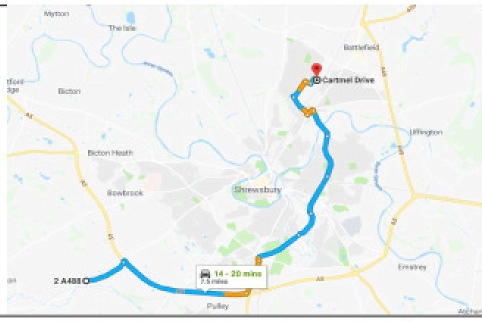
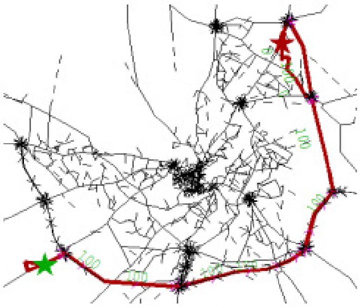
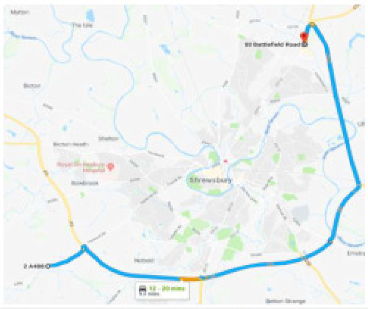
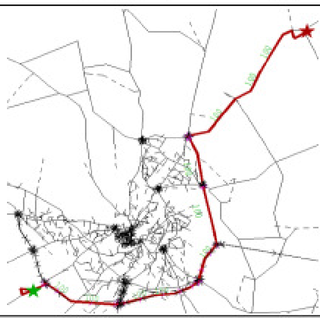
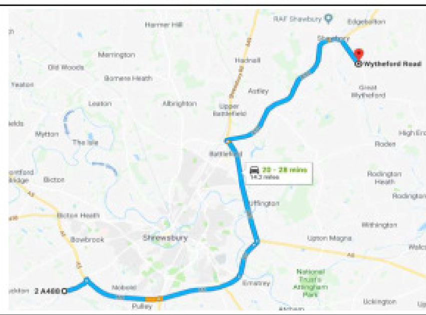
120	241		

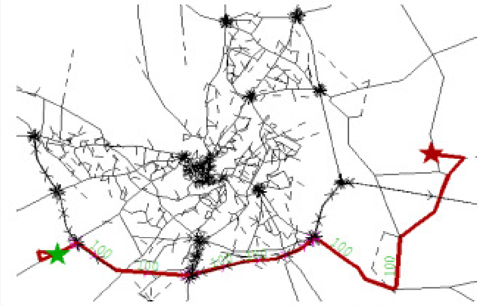
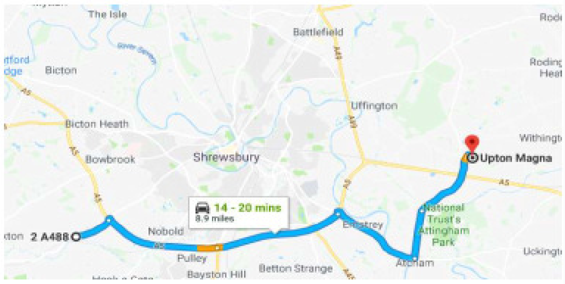
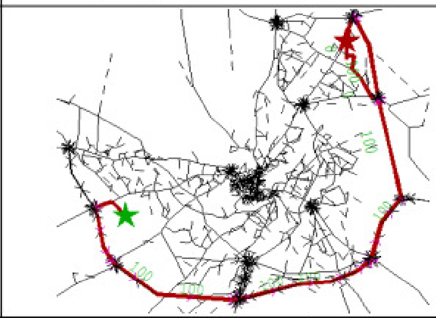
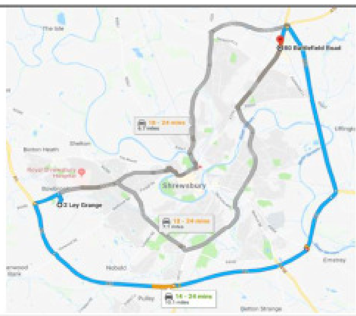
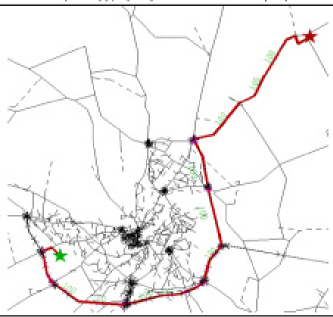
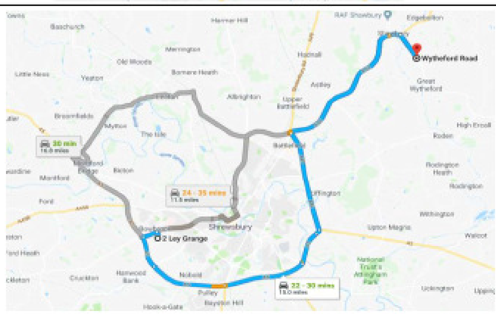
Appendix D.2

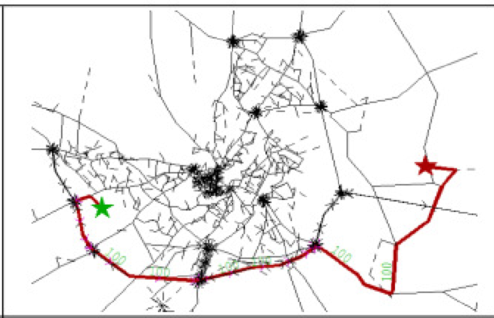
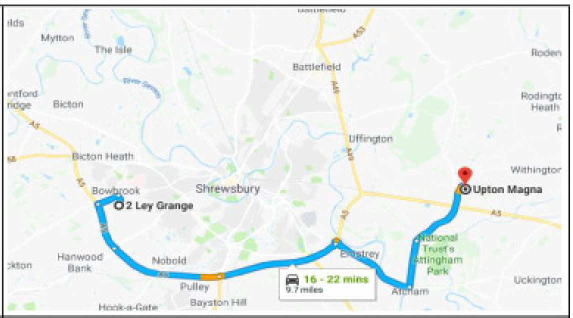
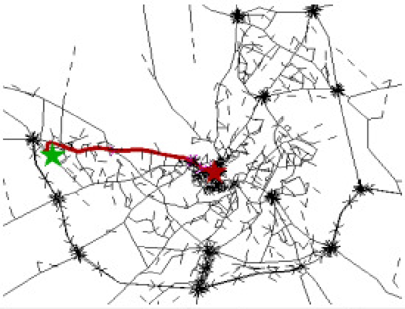
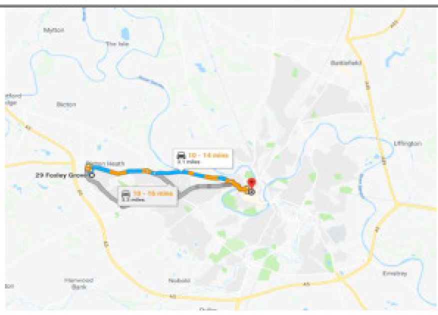
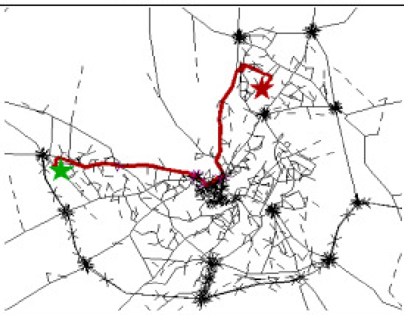
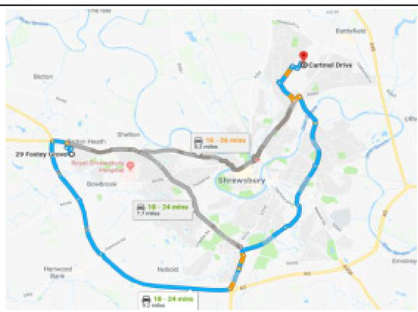
ROUTES VALIDATION (INTER-PEAK)

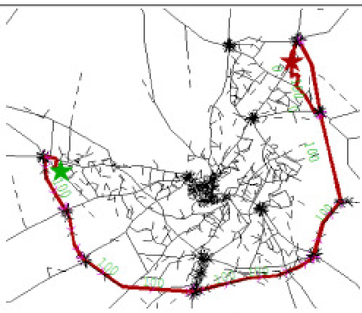
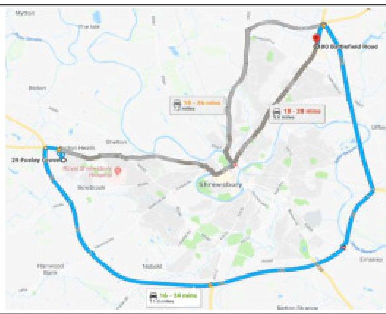
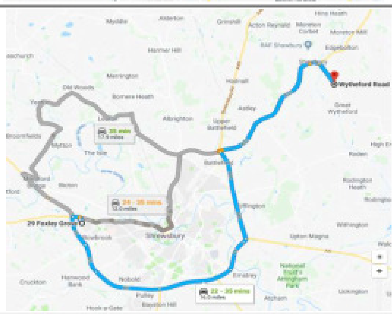
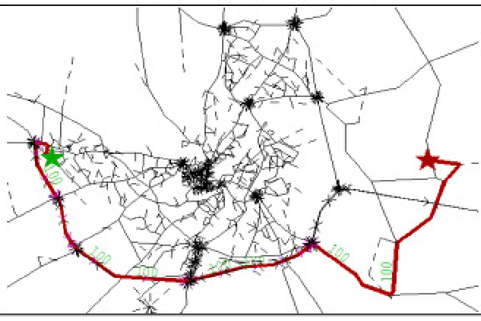
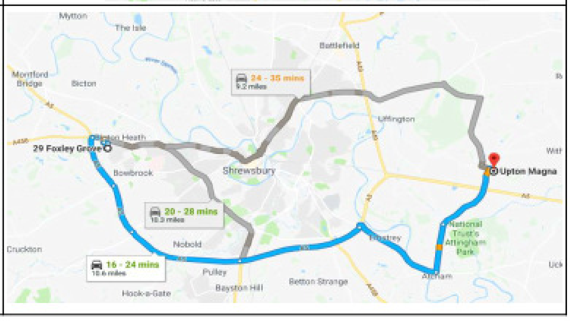
Origin	Destination	Zones OD Pairs	Google Locations
373	52		
373	276		
373	120		

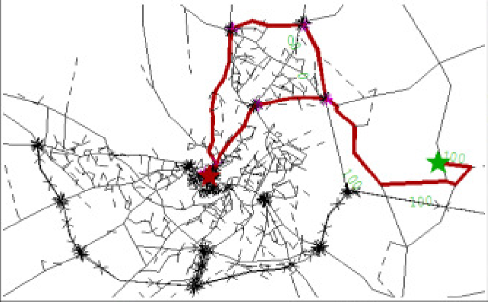
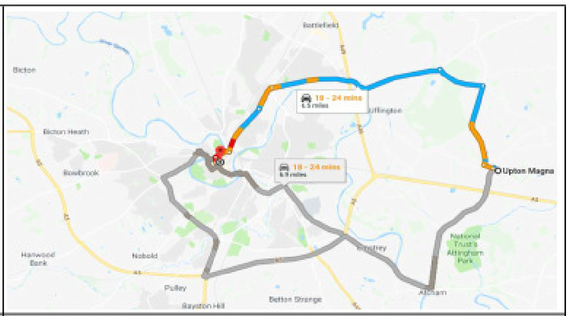
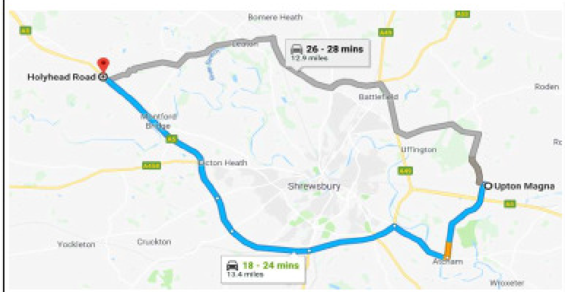
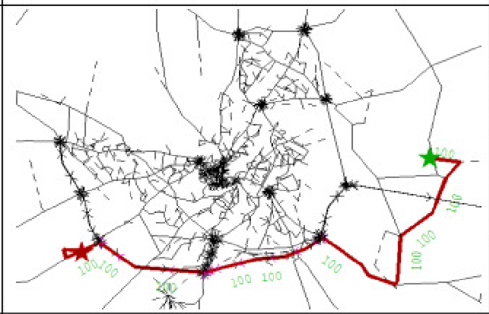
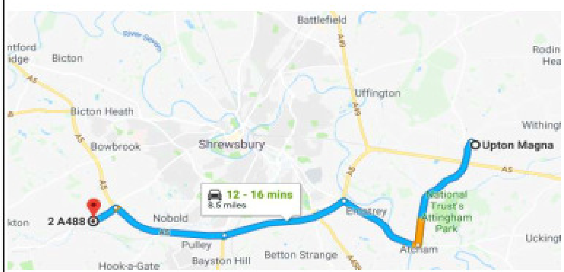
373	310		
373	145		
217	52		

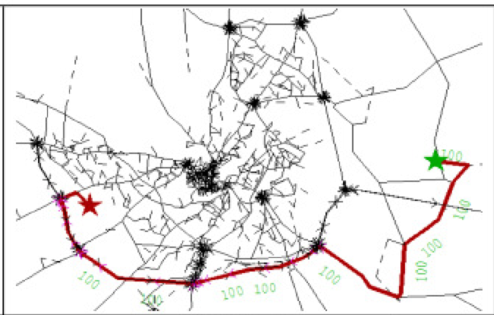
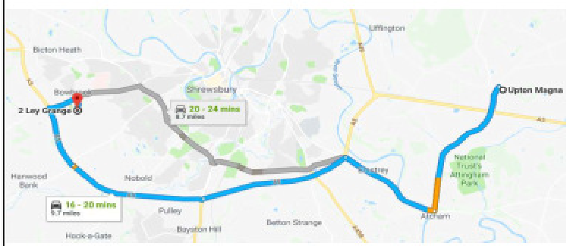
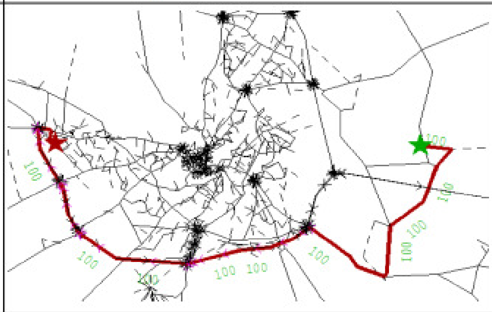
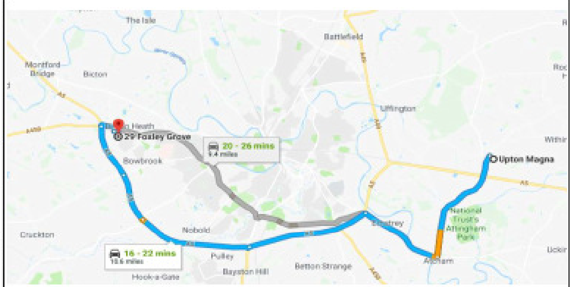
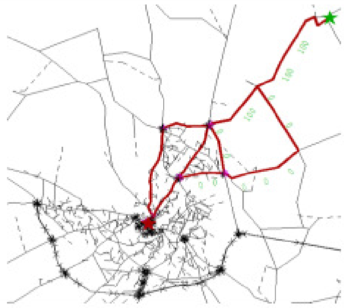
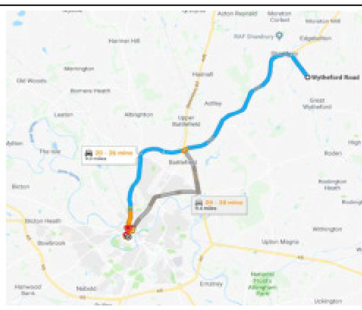
217	276		
217	120		
217	310		

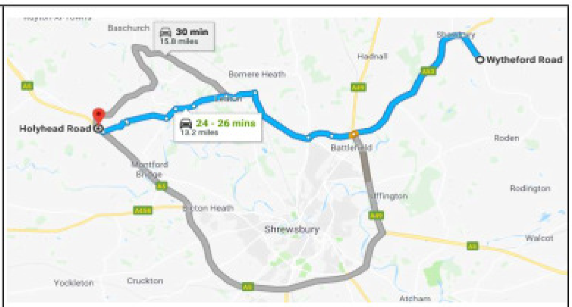
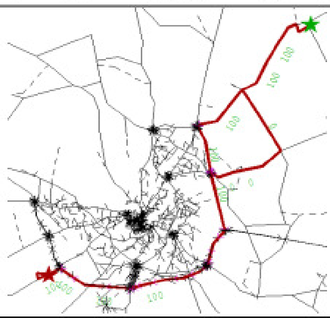
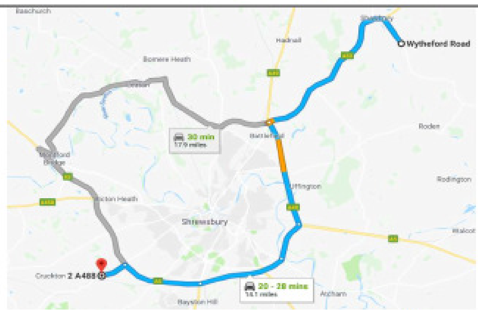
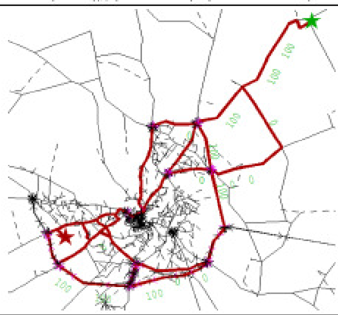
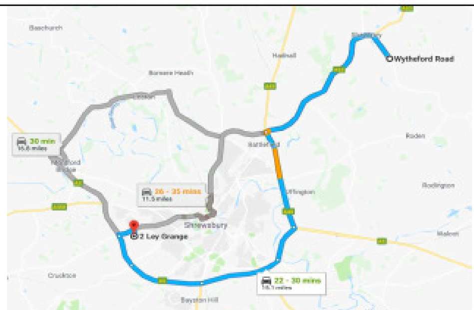
217	145		
224	120		
224	310		

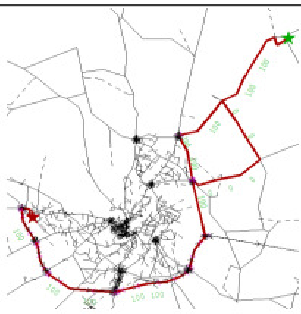
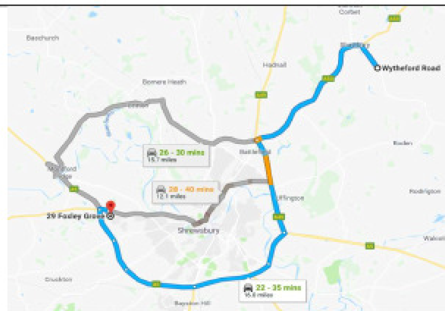
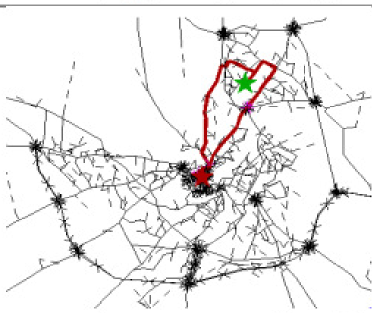
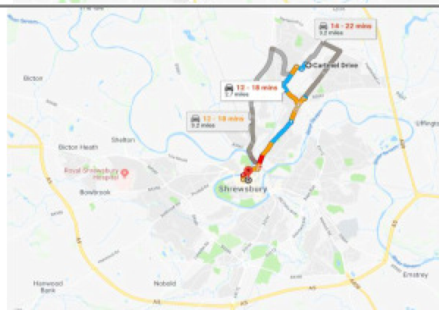
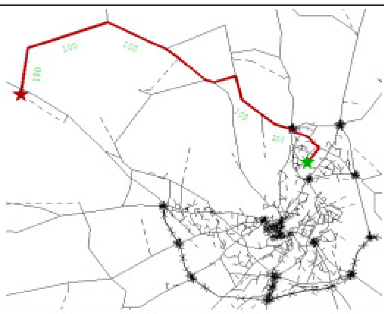
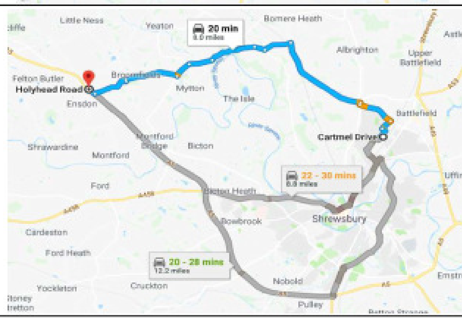
224	145		
241	52		
241	276		

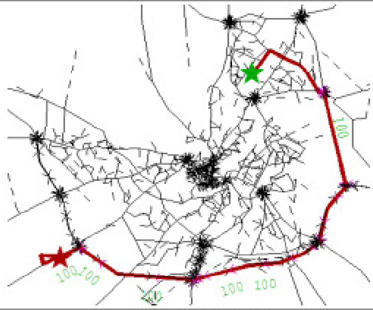
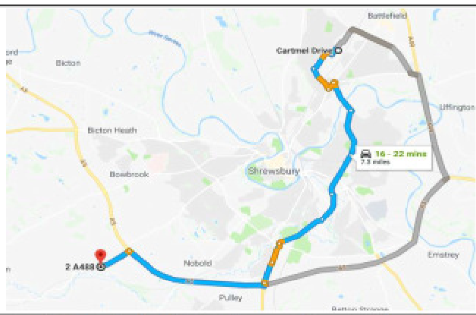
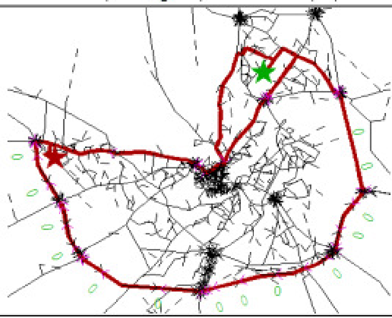
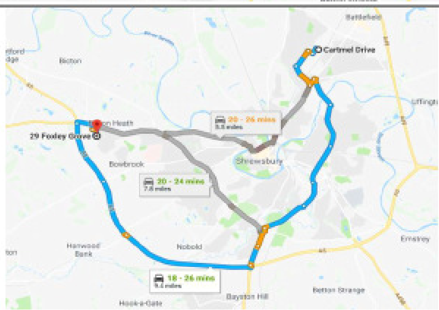
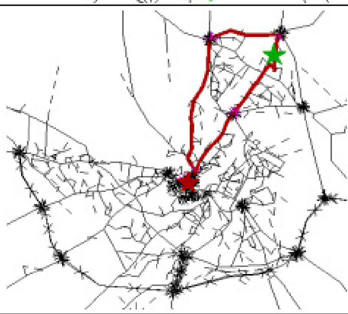
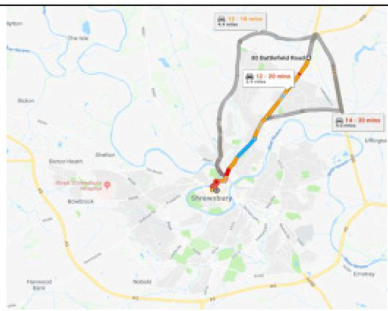
241	120		
241	310		
241	145		

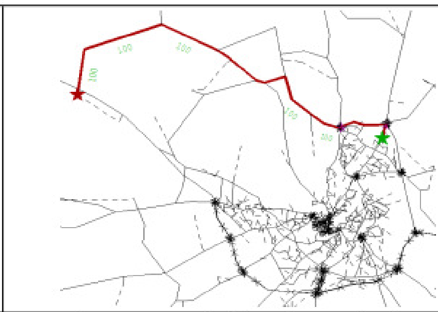
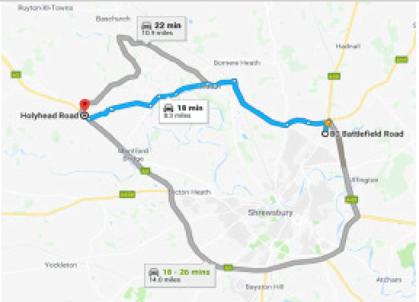
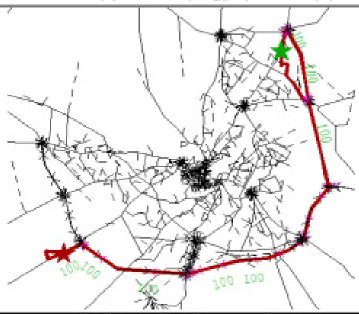
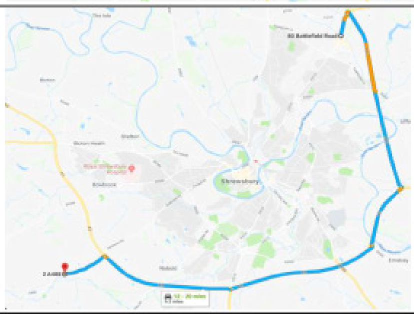
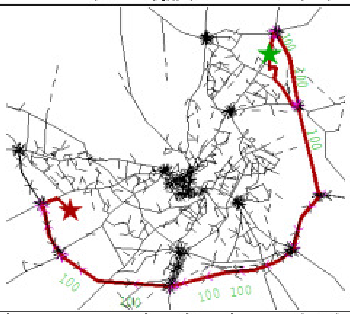
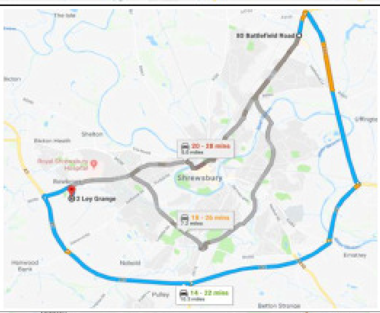
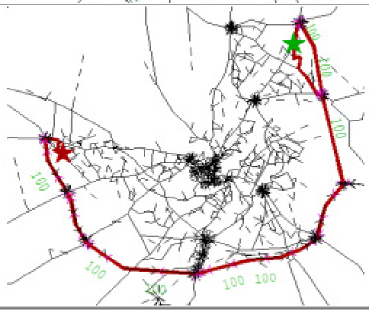
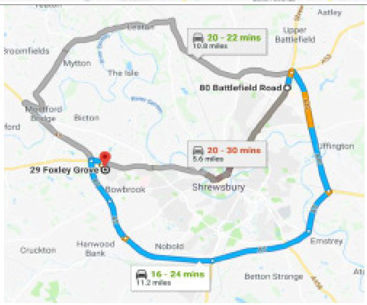
145	52		
145	373		
145	217		

145	224		
145	241		
310	52		

310	373		
310	217		
310	224		

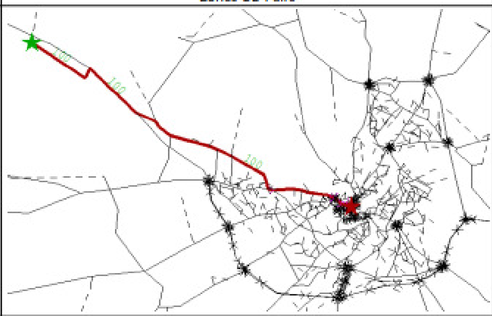
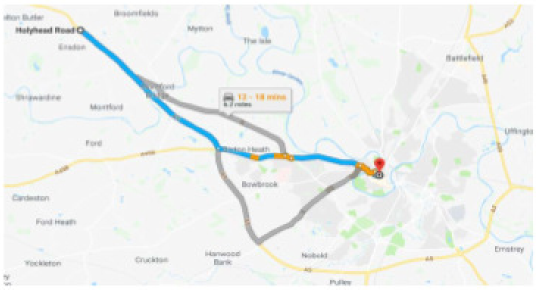
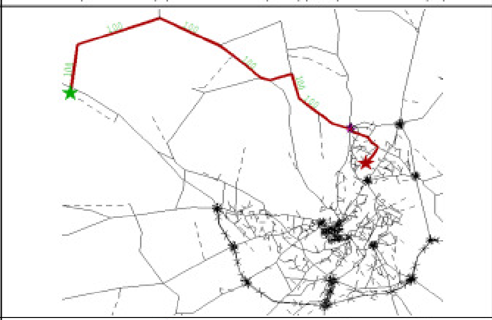
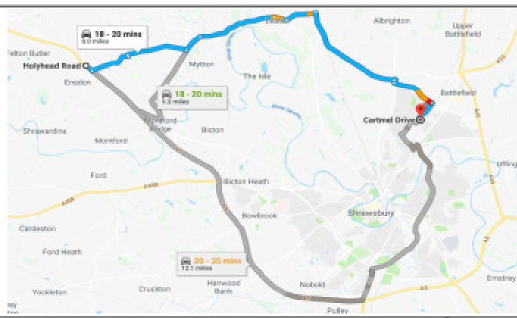
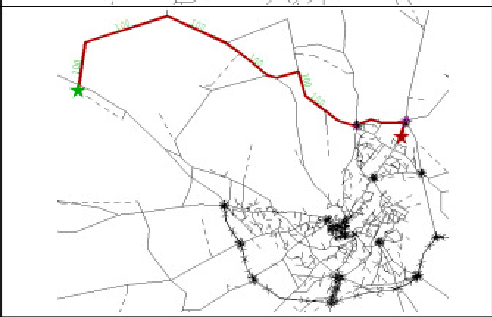
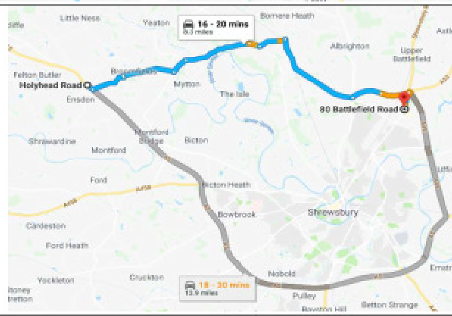
310	241		
276	52		
276	373		

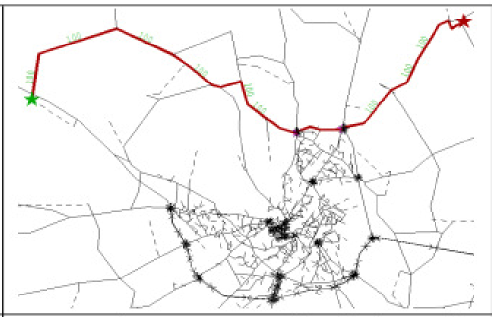
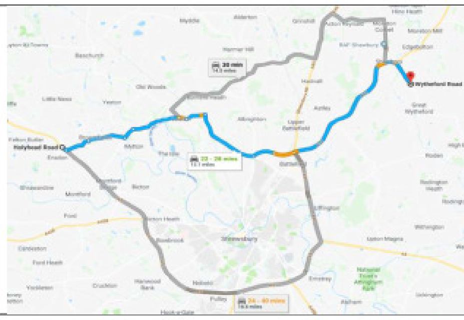
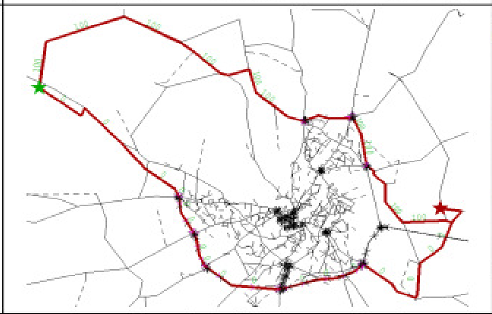
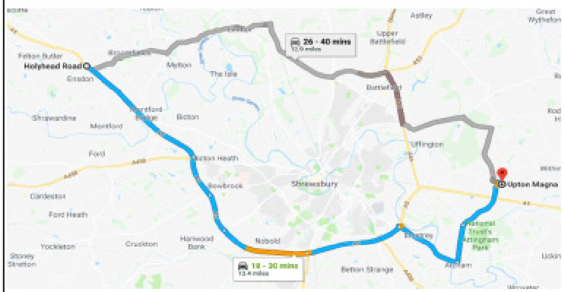
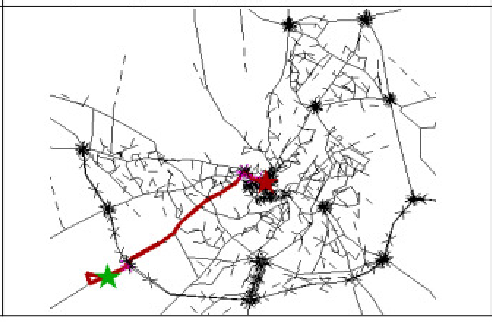
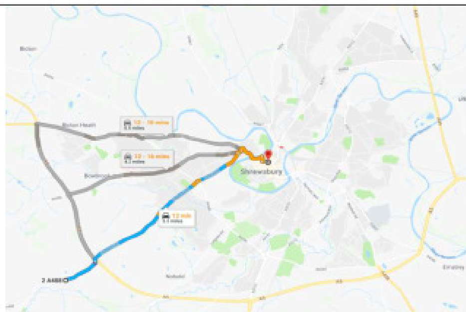
276	217		
276	241		
120	52		

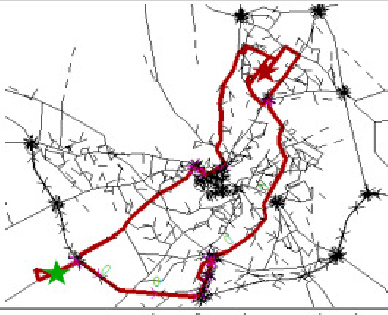
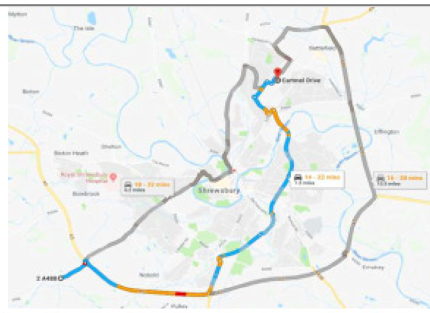
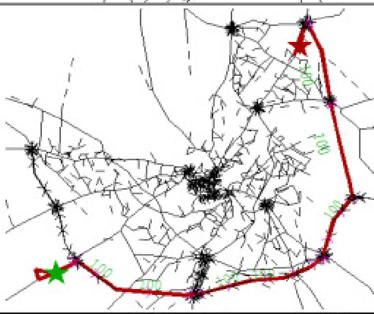
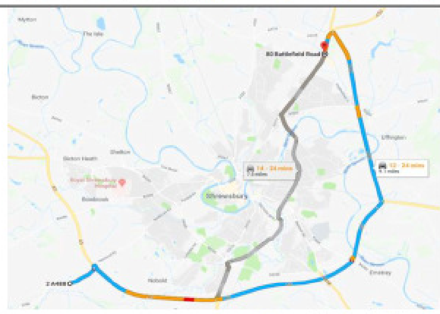
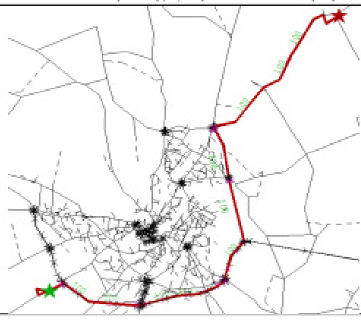
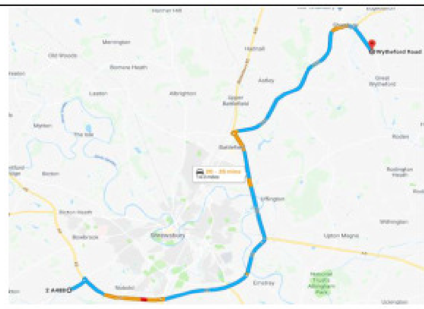
120	373		
120	217		
120	224		
120	241		

Appendix D.3

ROUTES VALIDATION (PM)

Origin	Destination	Zones OD Pairs	Google Locations
373	52		
373	276		
373	120		

373	310		
373	145		
217	52		

217	276		
217	120		
217	310		

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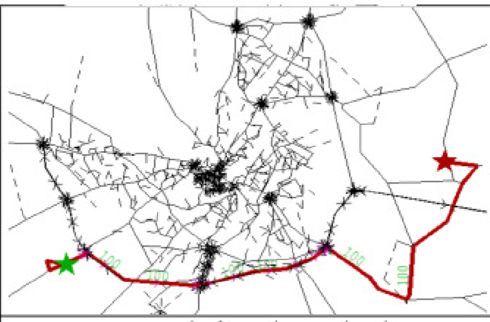
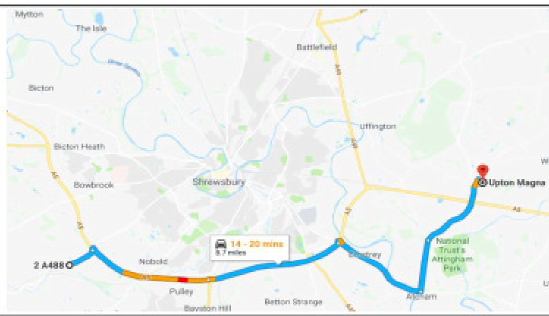
<tr><td>217</td><td>145</td><td></td><td>
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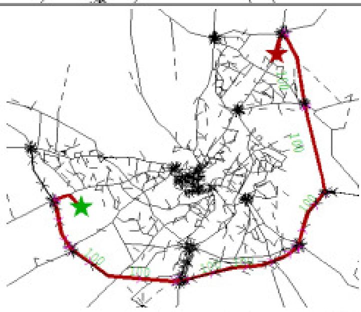
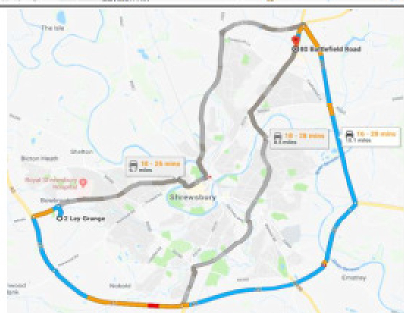
<tr><td>224</td><td>120</td><td></td><td>
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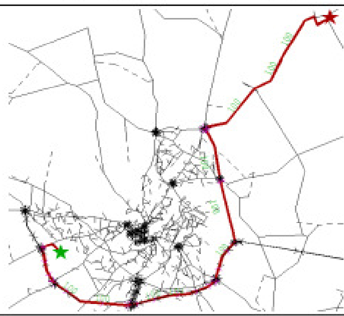
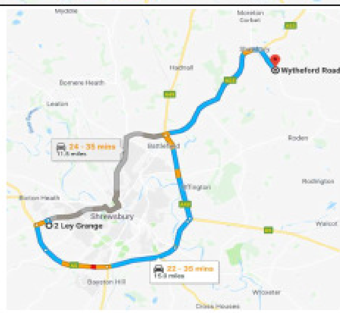
<tr><td>224</td><td>310</td><td></td><td>
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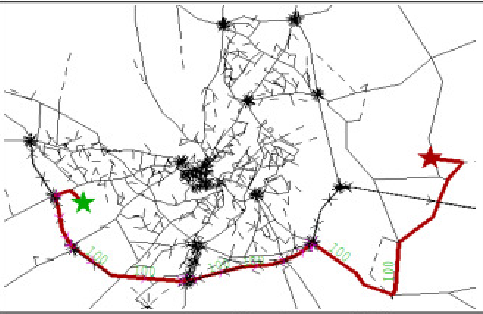
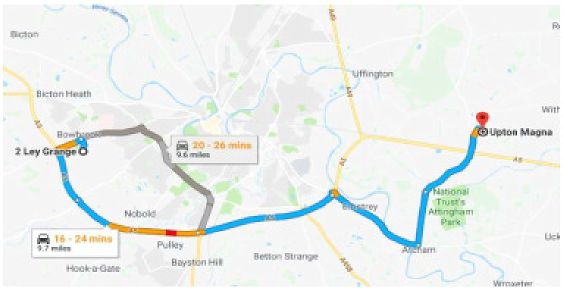
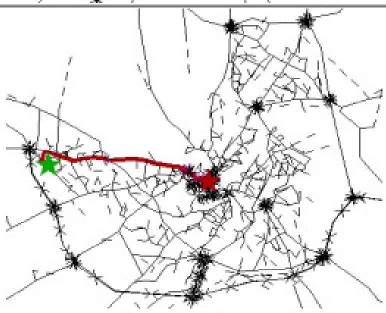
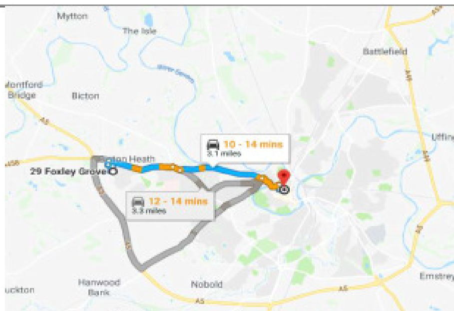
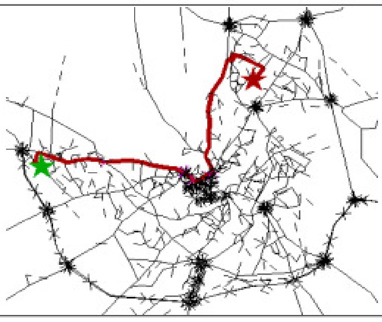
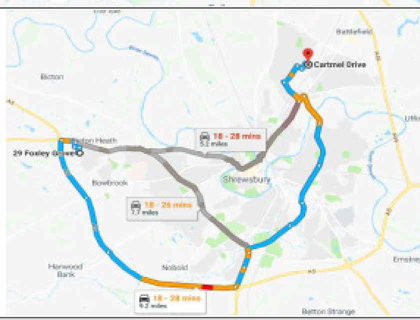
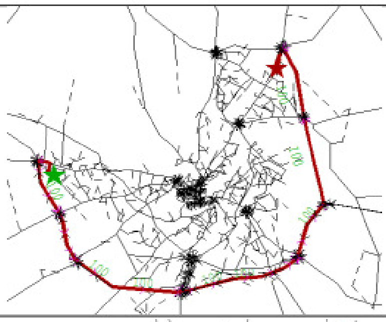
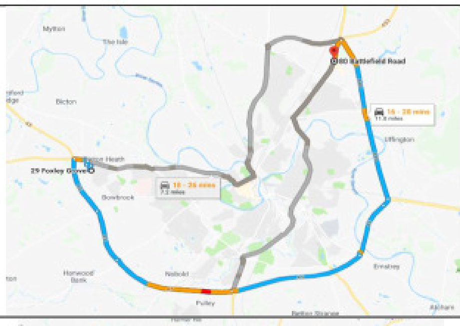
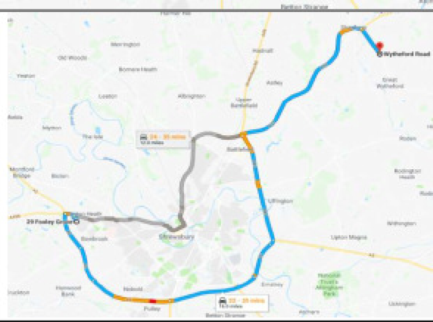
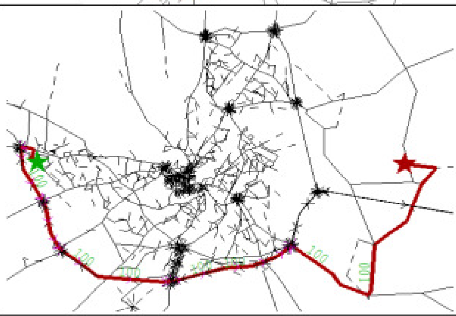
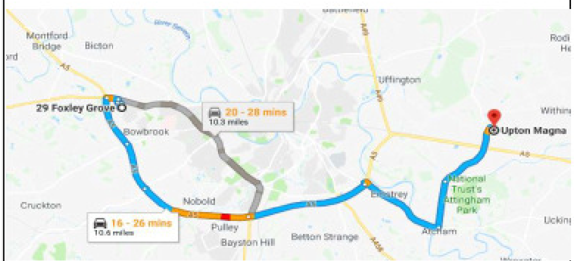
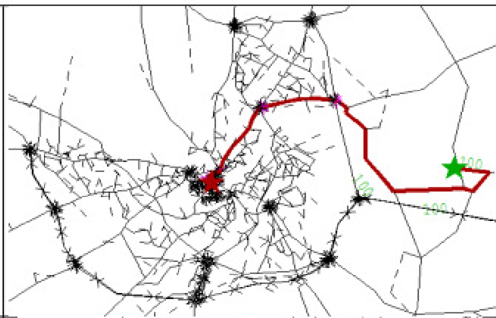
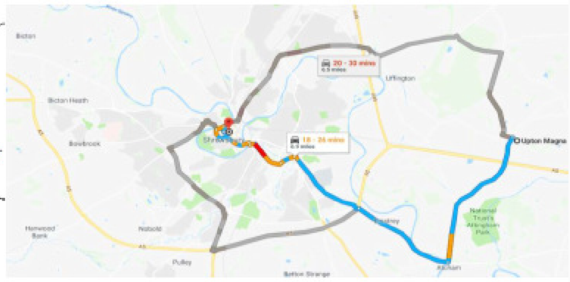
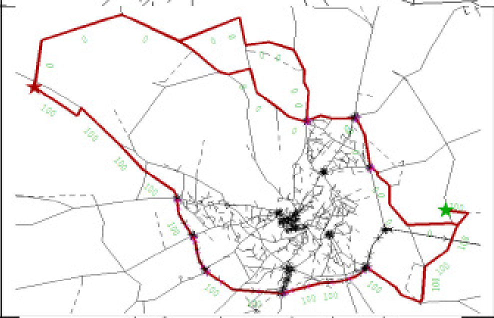
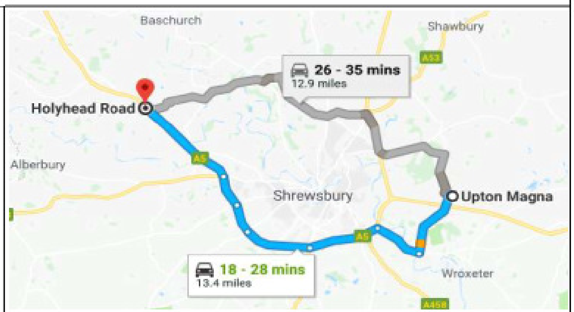
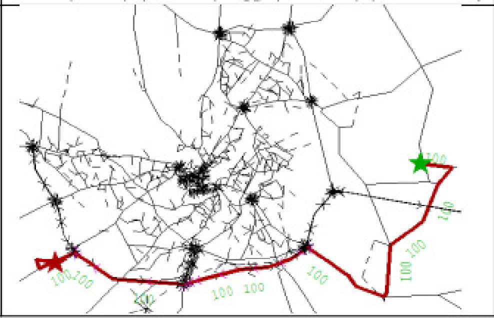
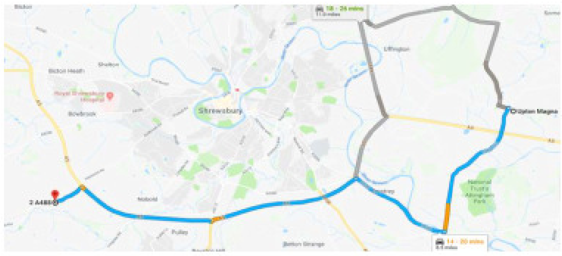
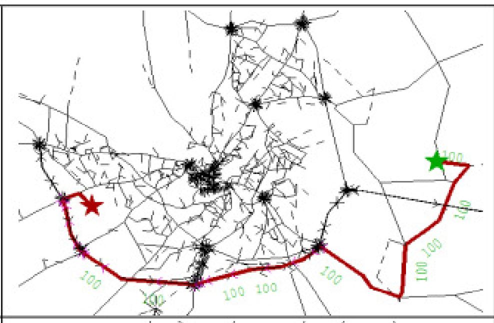
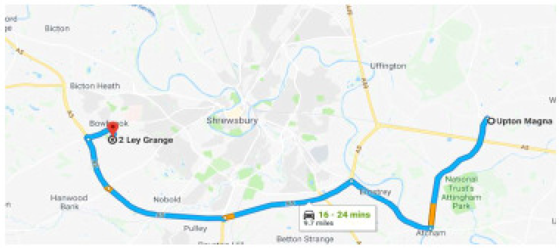
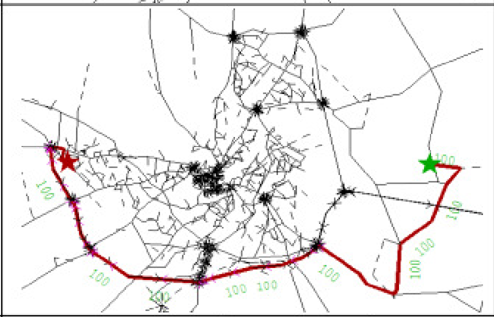
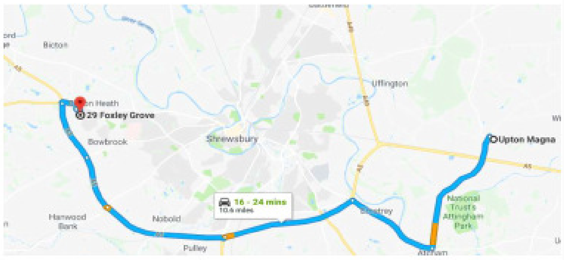
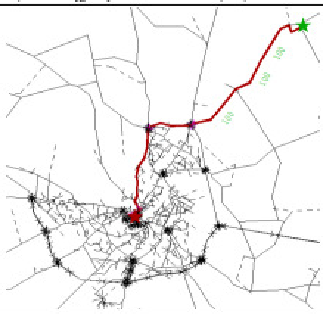
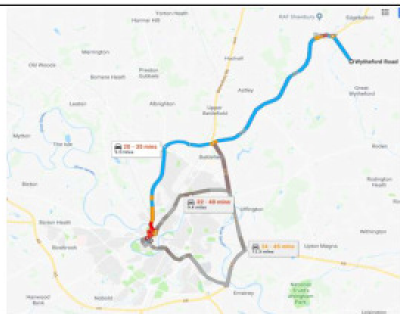
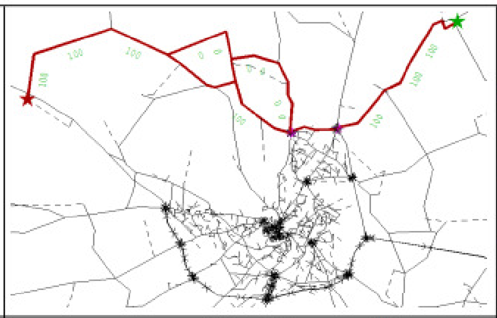
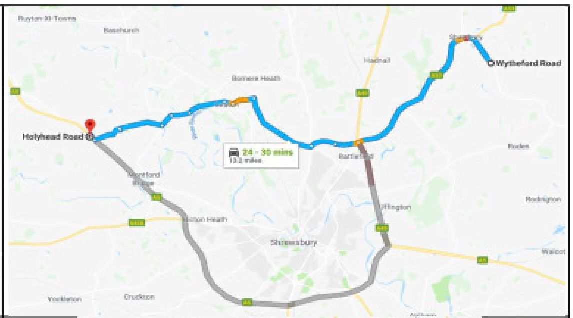
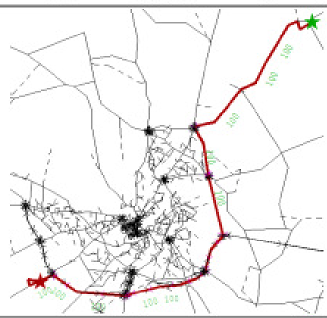
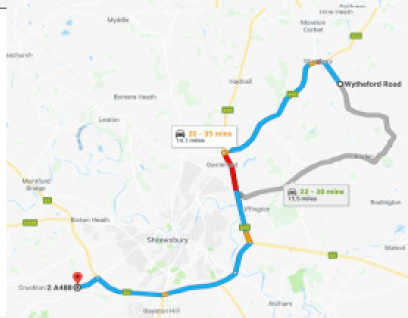
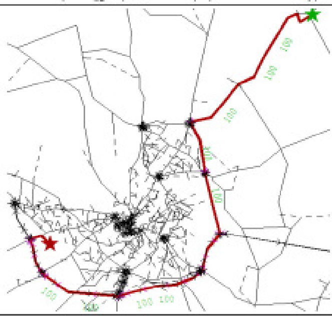
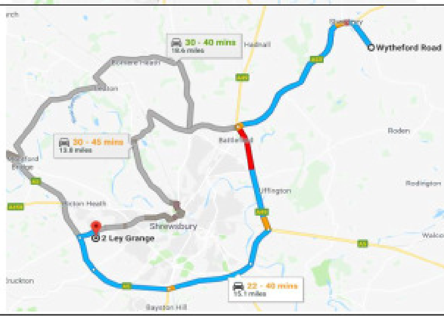
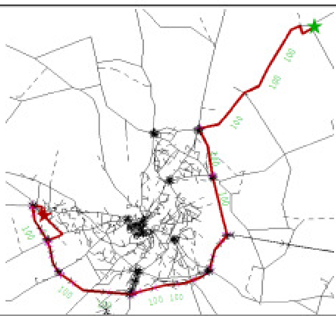
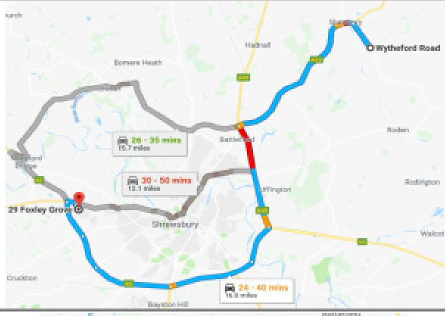
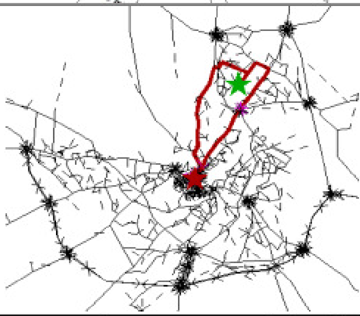
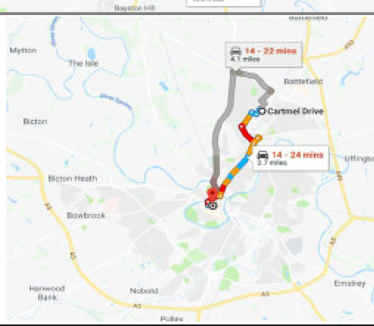
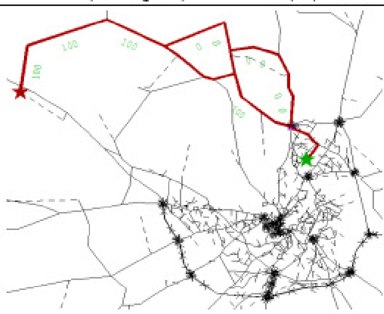
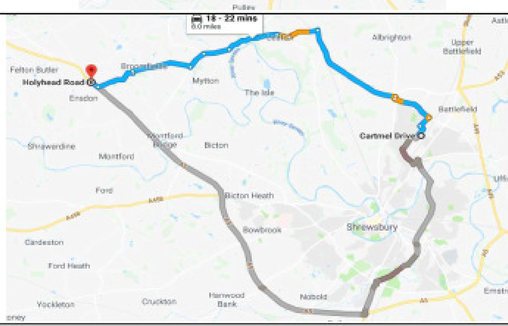
224	145		
241	52		
241	276		

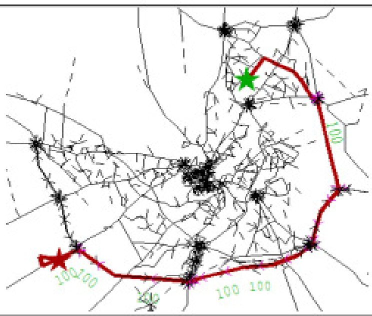
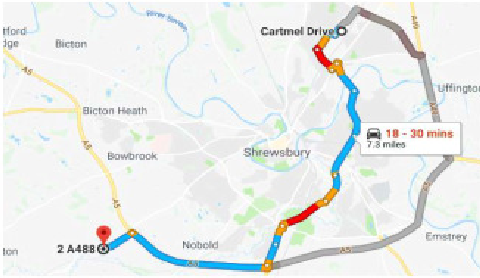
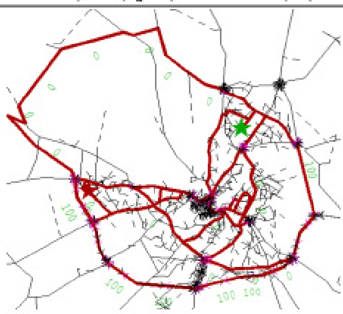
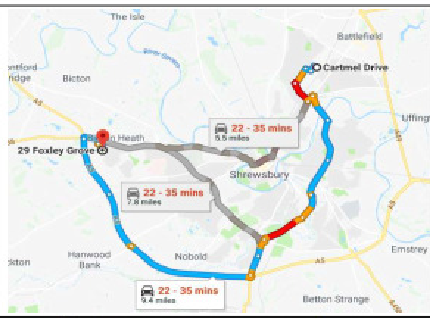
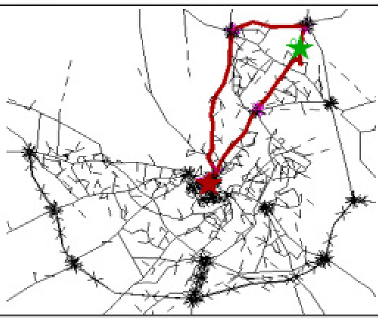
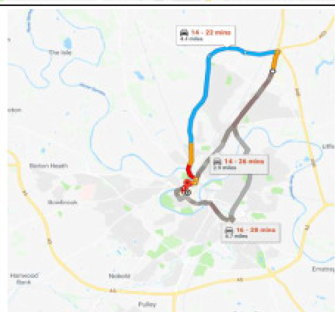
241	120		
241	310		
241	145		

145	52		
145	373		
145	217		

145	224		
145	241		
310	52		

310	373		
310	217		
310	224		

310	241		
276	52		
276	373		

276	217		
276	241		
120	52		

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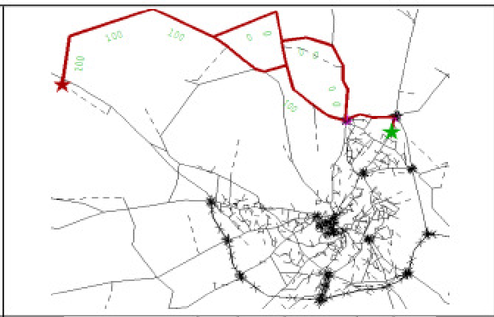
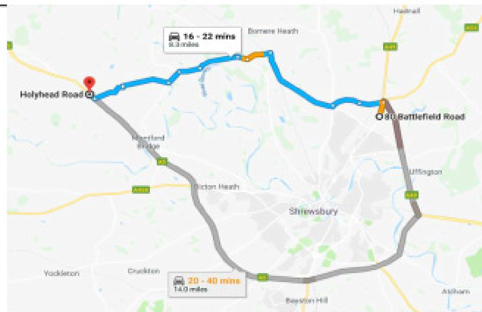
<tr><td>120</td><td>373</td><td></td><td>
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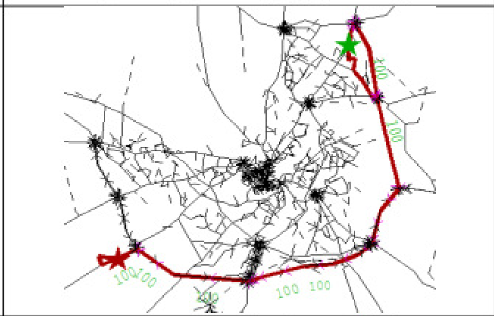
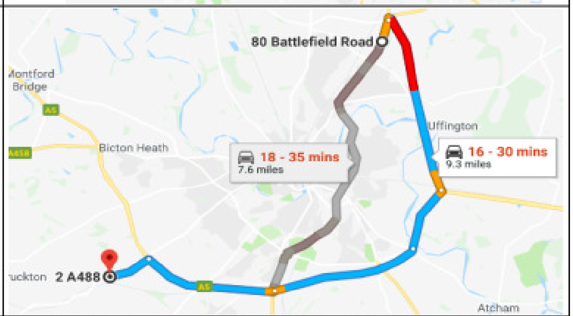
<tr><td>120</td><td>217</td><td></td><td>
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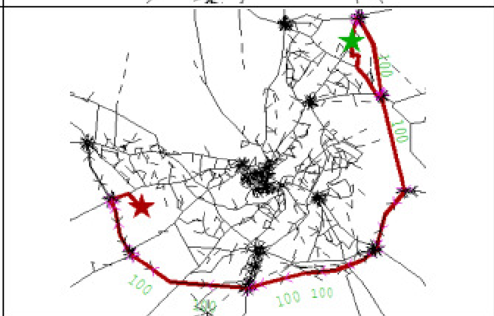
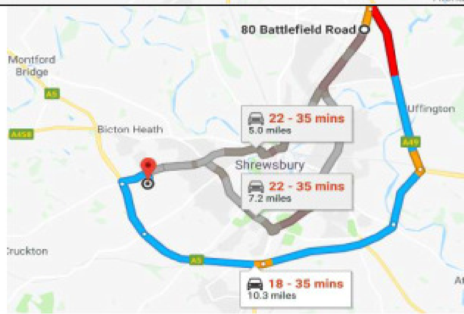
<tr><td>120</td><td>224</td><td></td><td>
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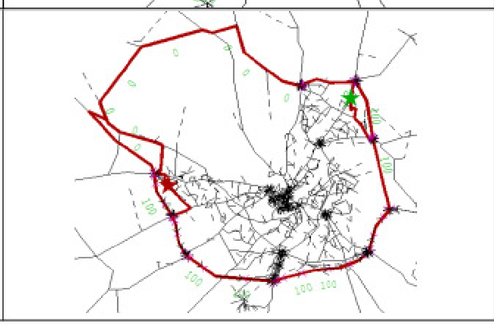
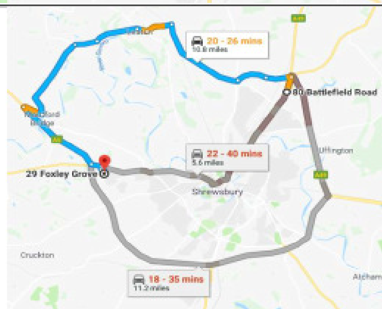
<tr><td>120</td><td>241</td><td></td><td>
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