Milton Keynes Multi-Modal Model Update

Highway Model Traffic Forecasting Report

Milton Keynes Council

Project Number: 60516496

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Quality information

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Table of Contents

Figures

Tables

List of Appendices

1. Executive Summary

1.1 Introduction

1.1.1 Milton Keynes Council (MKC) commissioned AECOM to update the Milton Keynes Multi-Modal Model (MKMMM) in advance of the need for its use to test alternative planning options for Plan:MK. The main purpose of the model will be to provide a robust means of assessing alternative land-use options and development phasing and for this to withstand public scrutiny.

1.2 Report Purpose

1.2.1 The work AECOM was commissioned to undertake can be split into three main sections:

- Update and develop the 2016 base year multi-modal model
- Develop the forecast 2031 “Reference Case” scenario
- Develop the 2031 Plan:MK scenario/s

1.2.2 This report covers the second of these stages, developing the 2031 Reference Case. The 2031 Reference Case includes the planned growth in Milton Keynes District up to 2031, this being in the region of 20,000 dwellings and 28,000 jobs in Milton Keynes district, along with highways and rail infrastructure in Milton Keynes and its vicinity that is expected to be in place by 2031. Development in Aylesbury Vale (the South West Milton Keynes development, circa 2000 dwellings and 1000 jobs) has also been included in the Reference Case due to its close proximity to Milton Keynes.

1.2.3 The Reference Case scenario will be used to provide a baseline 2031 forecast, against which Plan:MK options can be tested. As such, the Reference Case does not include any increases in travel demand and traffic associated with Plan:MK.

1.2.4 The report details how the updated 2016 Base Year model was modified to create the 2031 Reference Case model, providing details in terms of expected changes to road and rail layout and travel demand and any assumptions made. The report also presents the impacts of the Reference Case scenario against the 2016 base scenario.

1.3 Modelling Software

1.3.1 Highway trips were modelled using the SATURN modelling software package. As it is not possible to model public transport in SATURN, public transport trips were modelled using another modelling package called Emme. The demand modelling was also run using Emme. A customised version of the Department for Transport’s Trip end model, CTripEnd, was used to produce forecast 2031 trip ends.

1.4 Supply and Demand Forecast Scenarios

1.4.1 The 2031 forecast trip ends were calculated using the trip end model containing household, jobs, population and car ownership data. Forecast figures for these data sets were produced using two different approaches:

- Within Milton Keynes district the housing and jobs growth data provided by MKC was used along with changes in the population and car ownership between 2016 and 2031 from the DfT National Trip End Model (NTEM) version 7.2.

- The housing and jobs growth for the SWMK development in Aylesbury Vale was also input explicitly with other growth in Aylesbury Vale constrained as much as possible to NTEM
- NTEM 7.2 forecast figures were used elsewhere for the housing, jobs, population and car ownership data.

1.4.2 An Uncertainty Log was developed in association with officers at MKC and this was used to derive future supply in terms of road and rail infrastructure schemes deemed appropriate to include based on likelihood. These schemes were added to the base year networks to create the reference case networks.

1.5 Variable Demand Modelling

1.5.1 To estimates the effects of changes in infrastructure and in travel costs on patterns of demand, the 2031 trip ends produced from the trip end model were input into the variable demand model which was run using both the highways and public transport forecast model networks.

1.5.2 In the highways model the forecast 'real' values of time increase between base and forecast years whereas there is a forecast reduction in vehicle operating cost, due to expectation that vehicles will continue to become more efficient. For public transport a 1% real terms increase in fares per year was assumed.

1.5.3 The impacts of the demand model on the highways traffic were that car trips with both an origin and a destination in Milton Keynes reduced by 1% in AM and PM peaks and increased by 2% in the inter-peak. Due to the tidal flows into and out of Milton Keynes in the peaks, trips into Milton Keynes in the AM reduced by 3% with trips out of Milton Keynes in the PM reducing by 2%. Conversely trips out of Milton Keynes in the AM Peak, increased by 10% and into Milton Keynes in the PM Peak increased 5%. In the Inter-Peak due to much lower levels of congestion, compared to the AM and PM peaks, both trips to and from Milton Keynes increased by 8% and 9% respectively.

1.5.4 The demand model resulted in a reduction in trips internal to Milton Keynes of 2% and 3% in the AM and PM respectively with a 1% reduction in the inter-peak. However across all three time periods public transport trips to and from Milton Keynes increase.

1.6 Volume over Capacity Ratios and Traffic Flows

Introduction

1.6.1 Capacity issues (where V/C exceeds 85%) at junctions and links are generally concentrated in peak time periods, which means that for most of the day during the inter-peak, off-peak and at weekends the network in Milton Keynes runs within theoretical capacity.

1.6.2 This section therefore concentrates on the V/C values identified for:

- 2016 Base Year – AM Peak
- 2016 Base Year – PM Peak
- 2031 Reference Case – AM Peak
- 2031 Reference Case – PM Peak

Base Year 2016

1.6.3 The V/C's for links and junctions in the 2016 Base Model are generally worse in the AM peak than the PM peak. This largely reflects in-commuting to Central MK and circulation of traffic within Central MK (including links to / from the station/shopping centre and other key destinations). Some of these capacity issues are already dealt with by the Reference Case where schemes have been identified and included within the Local Improvement Plan as Reference Case Schemes such as:

- Brinklow/Monkston roundabouts (to be signalised)
- The A421 between M1 J13 and Eagle Farm (to be dualled as part of Central Beds scheme)

1.6.4 Those junctions/links identified in just the AM or both the AM and PM peaks that are not associated with Reference Case Schemes include:

- M1 J14 and Northfield Roundabout (worse in AM Peak) entry point from the M1
- The A422 corridor including the MK entry point to the north east on the A509 – worse in the AM peak with in-commuting and pass through than in the PM peak.
- A5 at Old Stratford Roundabout to the north east entry and further to the south east at Woburn Road (both AM only)
- The A421 entry links and corridor, including those referred to above but also including MK entry at the south west and key junctions including Watling Street and Grafton Street roundabout junctions (in both peaks).
- Central MK junctions
- Watling Street junctions – (Standing Way/Chaffron Street in both peaks))

1.6.5 Note that Watling Street/Dansteed Way (Crownhill Junction) and Watling Street/Portway (Loughton Junction) are Reference Case schemes though do not have high V/C ratios in the Base Year as they are associated with growth in the Western Expansion Area.

1.6.6 The congestion issues outlined above are highlighted by Figure 1 which shows the maximum approach delay per vehicle, the sum of the delay per vehicle on each approach to the junction, and also the total vehicle delay, in 2016 base model. This plots the worst case of the AM or PM peaks.

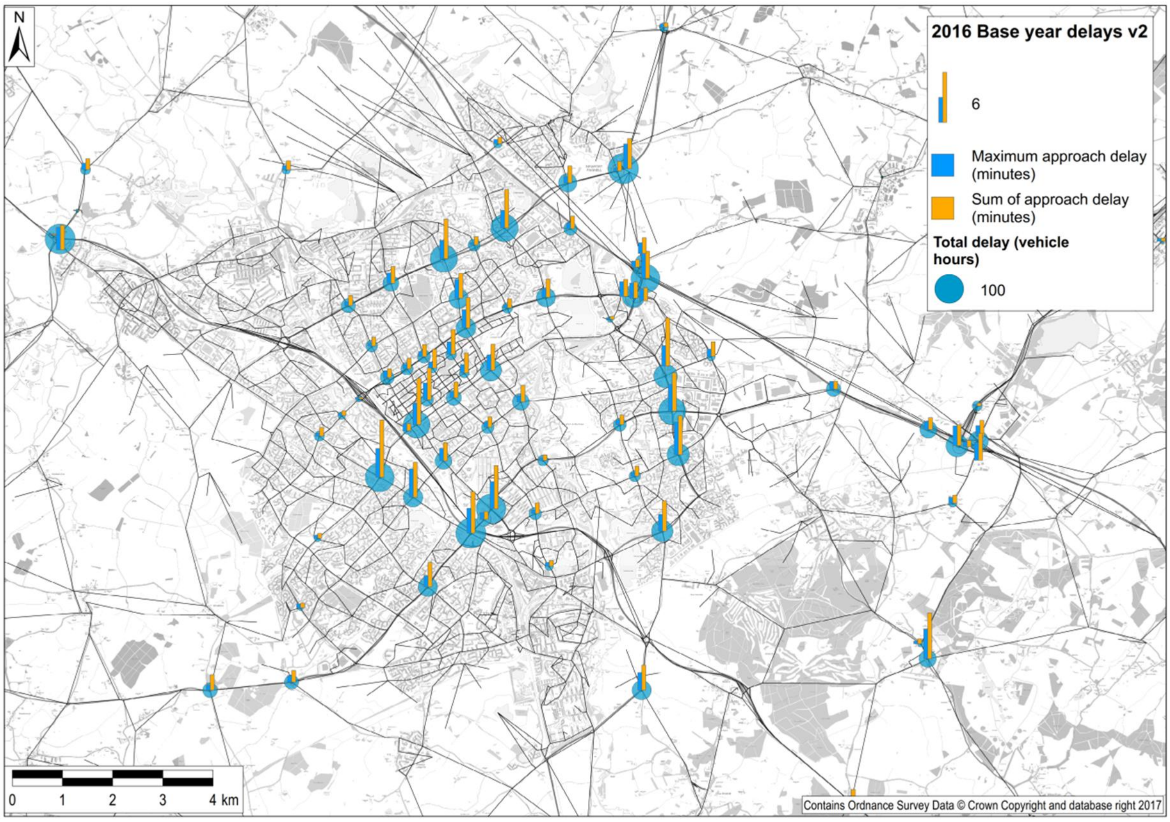


Figure 1. Junction delays 2016 Base

The Reference Case

1.6.7 Despite the impact of the demand model reducing some traffic in the model, there is still a significant overall increase in traffic between 2016 and 2031. As a result of the greater jobs growth than housing growth forecast in the 2031 Reference Case, the model shows that car journeys from the rest of Milton Keynes to central Milton Keynes increase by 28% between 2016 and 2031, with car journeys from outside Milton Keynes to central Milton Keynes increasing 46%.

1.6.8 The Reference Case shows a general worsening of the situation in both peaks. The entry point links referred to above are generally more ‘stressed’ alongside the internal MK Central network due to the greater level of in-commuting from outside of Milton Keynes.

1.6.9 Of the entry links:

- The A421 junctions are more overloaded in both the AM and PM peaks, though now worse in the PM Peak.
- The A5 links and junctions are showing V/C ratios in excess of 85% in part because traffic seeks alternative options into Milton Keynes as well as the general growth in traffic on the network. The southern entry links are also starting to exceed the V/C threshold. This issue is more pronounced, particularly to the northern area of Central MK in the AM Peak.
- The A509 from Chicheley Hill Roundabout and down to junction 14 are more overloaded and more junctions along the A422 are showing over capacity issues.

- M1 J14 in particular shows a greater level of congestion than in the Base Year with further stress at Northfield Roundabout, the next junction towards Milton Keynes.
- The Reference Case schemes at Dansteed Way (Crownhill) and Portway (Loughton) show some entry link V/C's in excess of 85% however it is likely that further design based on current forecast flows will resolve these issues.
- Watling Street's Junction with Child's Way is overcapacity in both the AM and PM Peak (as with its junction with the A421 – Elfield Park Roundabout - already referred to in the Base).
- Although the Reference Case schemes at Brinklow and Monkston roundabouts provide additional capacity to help accommodate growth there, there are still delays modelled in the Reference Case. As with Loughton junction further design work based on current forecast flows is likely to resolve these issues. In addition some of the capacity issues appear to have migrated to Walnut Tree Roundabout on the A421.

1.6.10 More of central Milton Keynes links and junctions, particularly on its perimeter, are over capacity. Although the PM is worse than in the AM Peak, there is a notable reassignment of traffic around central Milton Keynes in the AM Peak. The modelling indicates northbound traffic heading to central Milton Keynes re-routes from Marlborough Street and Saxon Street to the A5, accessing central Milton Keynes from the north using Portway. This is a result of increased flow on Childs Way causing greater delays on approaches to its junctions in central Milton Keynes.

1.6.11 The Reference Case congestion issues outlined above are highlighted by Figure 2 which shows the maximum approach delay per vehicle, the sum of the delay per vehicle on each approach to the junction, and also the total vehicle delay, in 2016 base model. This plots the worst case out of the AM or PM peaks.

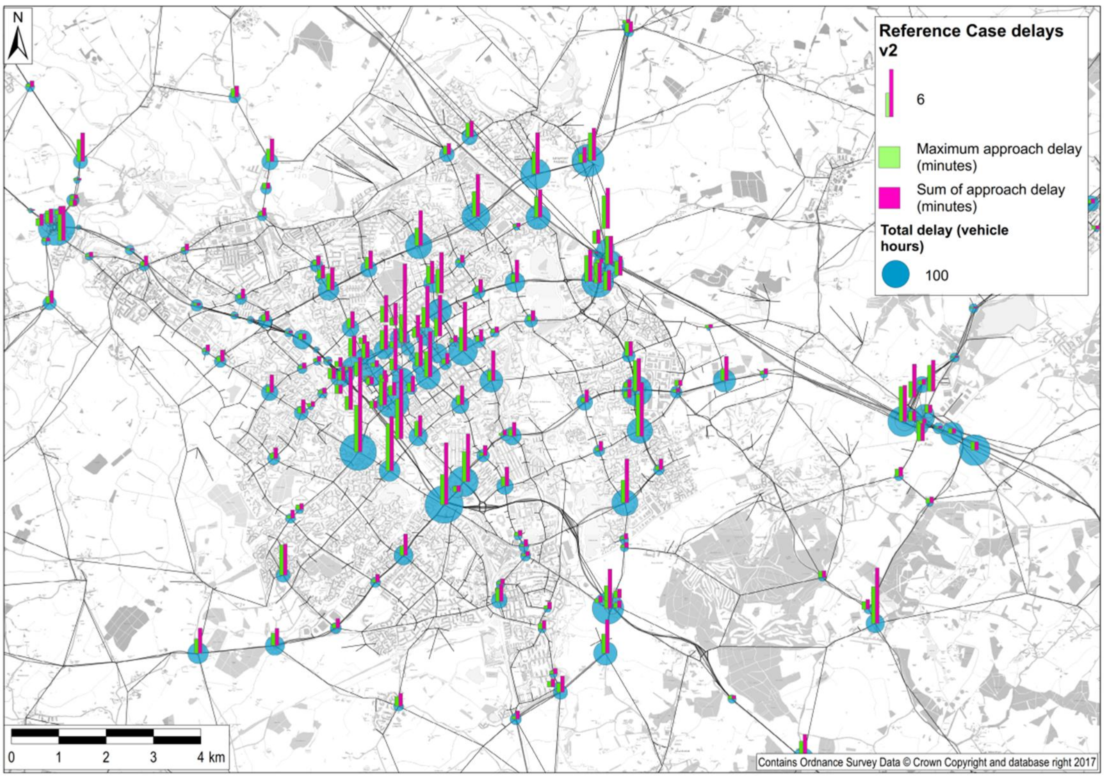


Figure 2. Junction delays 2031 Reference Case

1.7 Travel Time and Average Speeds

1.7.1 Between 2016 and the 2031 Reference Case the model shows journey times increase in general across Milton Keynes with the exception of the M1 between J13 and J15 as a result of the All Lane Running scheme and on the A421 between J13 and Eagle Farm roundabout as a result of the dualling scheme. The reference case highway assignments show that the journey times across Milton Keynes increase on average by 14% and 15% in the AM and PM Peaks respectively and 5% in the Inter-Peak. In the simulation area average network speeds decrease by 10%, 4% and 8% in the AM, Inter-peak and PM respectively.

1.8 Trip Lengths

1.8.1 Average trip lengths increase across the whole highways matrices, though changes for LGV and HGV were minimal. The increase in car average trip length is highest in the inter-peak and lowest in the AM reflecting the greater levels of congestion, which impact against lower forecast vehicle operating costs, making longer journeys less attractive.

1.9 Model Limitations

1.9.1 It should be noted that the Milton Keynes model is a strategic model where much of the highways trips internal to Milton Keynes (those that start and end within the Milton Keynes Cordon) are synthesised; i.e. based upon industry standard and accepted assumptions on trip generation rates using land use data.

1.9.2 It is also important to note that the model was not designed for use in a scheme specific assessment. For such an assessment it is recommended a revised forecast model would be produced from a recalibrated base year model using additional and more recent data and targeted to reflect a more specific geographical focus of resources and modelling effort.

1.9.3 It is important to consider that the public transport model is, as per WebTAG guidance, an incremental model which means although it provides a good indication of travel patterns at a strategic level; it will not necessarily give a definitive view of the impact of public transport measures such as East West rail. Rather it is designed to assess impact of relatively small changes to existing services rather than the addition of a completely new service.

1.10 Future Improvements

1.10.1 A feedback loop between the highways model and the Public Transport Model to automatically update the bus travel times in accordance with the changes in travel times in the highway model would improve the accuracy of forecast bus travel times.

1.10.2 The fixed speed links in the highways buffer network should be lowered to represent the impact of higher flows on average speeds in future years. This could have an impact on long distance public transport trips coming into or going out of Milton Keynes as the attractiveness of highway as a mode would be reduced.

1.10.3 It may also be desirable to incorporate modelling of Park & Ride schemes within the model suite if MKC have aspirations to increase the provision of this form of access to Central MK. Additional survey data would be required to incorporate such a model.

1.10.4 There would also be a benefit in including a parking model within the modelling suite although this would require also require appropriate additional survey data.

1.11 Conclusions

1.11.1 The modelling as outlined in this report has been carried out in accordance with the Department for Transport's WebTAG criteria as applicable, and is based on a base year model validated against observed count and journey time data. The forecast results appear sensible and plausible. As such it is considered that the Reference Case model provides a suitably robust benchmark against which to assess Plan:MK.

2. Introduction and Overview

2.1 Study Background and Objectives

2.1.1 Milton Keynes Council (MKC) has commissioned AECOM to update the Milton Keynes Multi-Modal Model (MKMMM) in advance of the need for its use to test alternative planning options for Plan:MK. The main purpose of the model will be to provide a robust means of assessing alternative land-use options and development phasing and for this to withstand public scrutiny. The goal is to develop a "Reference Case" to enable testing of plan options. This requires the model to be sufficiently well validated to a 2016 base year (compared to 2009 for the existing model) using additional and updated data sources.

2.1.2 It is also envisaged that the model will help to inform the development of the Milton Keynes Mobility Strategy document. As such the model will eventually also be required to inform bids for various kinds of transport infrastructure and other Milton Keynes initiatives though there is no specific current requirement to use the model to assess a major transportation scheme. It is likely that further development of the model will be required to provide a more robust evidence for such schemes as the model update has initially been designed to inform the consideration of the impacts of Plan:MK options.

2.2 Report Structure

2.2.1 The work AECOM has been commissioned to undertake can be split into three main sections:

- Update and develop the 2016 base year multi-modal model
- Develop the forecast 2031 Reference Case
- Develop the 2031 Plan:MK scenario/s

2.2.2 This report covers the second of these stages, describing how the 2016 base year model has been updated to 2031 and demand forecasting applied to create the forecast Reference Case scenario. The report has the following structure:

- Section 2: Overview of Base Year Model (Summary of previous work, description of the base year model set-up and key validation results);
- Section 3: Forecast Year and the Uncertainty Log (the methodology, including details of the Uncertainty log, used in producing the reference case scenario);
- Section 4: Trip End Model Forecasts (Outline of the process of developing the 2031 trips ends prior to any forecast change in costs)
- Section 5: Equilibrium Demand Forecasts (Outlines parameters used and key statistics from the demand model assignments)
- Section 6: Forecast Assignments for Reference Case (Model convergence, assignment results and observations)
- Section 7: Summary and Conclusions

2.2.3 There is also a set of appendices which include further detail including model outputs.

3. Overview of Base Year Model

3.1 Introduction

3.1.1 This section gives a brief overview of the base year model. The underlying development of the base year highway and demand models is documented in the Local Model Validation Report (LMVR)[1], with the development of the Public Transport Model in the Public Transport LMVR Technical note[2].

3.2 Base Year Model Development

3.2.1 The requirement to update the model arose from the desire of MKC to have a suitably robust evidence base upon which to test alternative planning options for Plan:MK.

3.2.2 The model was required to be capable of assessing 'variable' demand impacts of trip re-distribution and frequency shift in addition to route choice. As such the highway assignment model was linked to a bespoke variable demand model.

3.3 Base Model Description and Specification

3.3.1 On the supply side, the existing Highways model has been updated from 2009 to 2016 using SATURN version 11.3.12U. In addition to the updates the simulation network area was extended to better model the impacts of the proposed expansion areas. A public transport model sits alongside the highways model. The Milton Keynes Multi-Modal Model (MKMMM) public transport model was developed in INRO's Emme software, version 4.2.9, and covers both bus and rail modes. It is designed to model public transport in and around the Milton Keynes urban area.

3.3.2 On the demand side, a variable demand model has been developed using Emme to estimate the effects of changes in transport infrastructure and in travel costs upon patterns of demand. That is, the way travellers respond to changes in transport infrastructure other than choosing different routes which is forecast by the highway and public transport assignment models.

[1] MKMMM Local Model Validation Report v1.4, June 2017
[2] Milton Keynes Model Update - TN09 Public Transport LMVR v1, June 2017

3.4 Study Area

3.4.1 The model study area covers Milton Keynes and the proposed expansion areas.

3.4.2 For analysis purposes an area referred to as 'Milton Keynes Urban Area' has been defined as shown in Figure 3 with zones within the Milton Keynes Urban Area defined as internal, and zones outside defined as external.

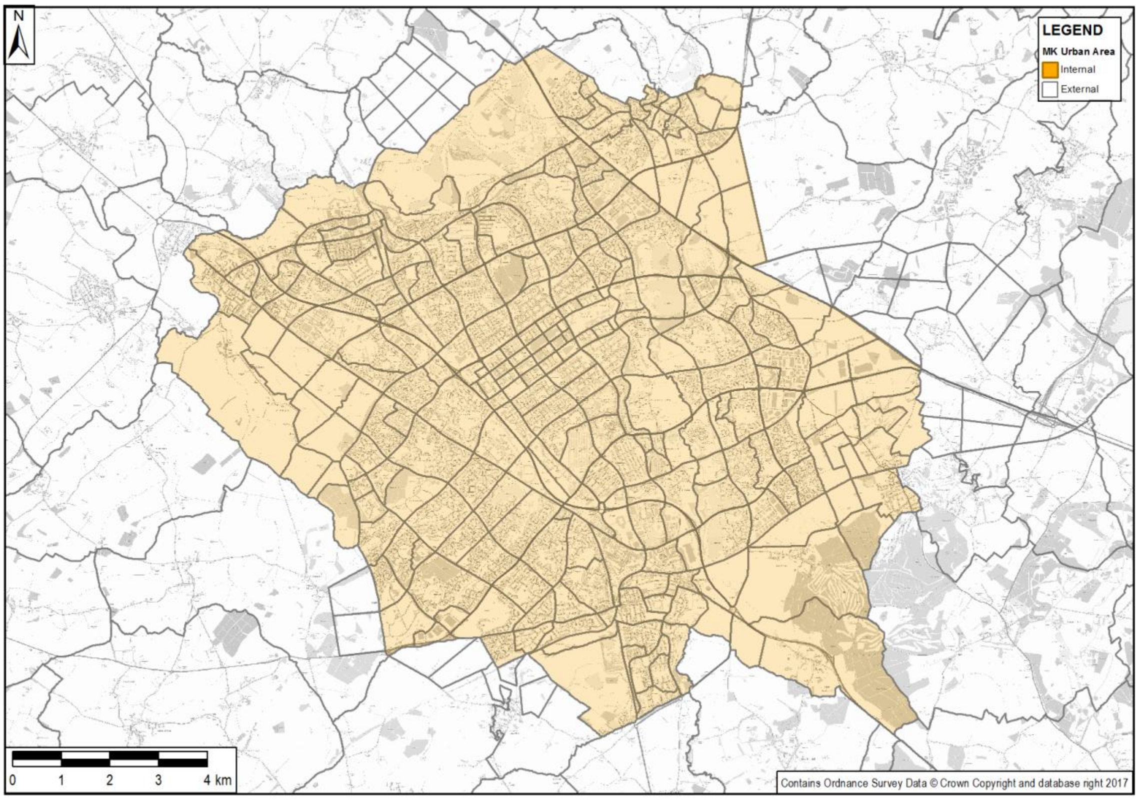


Figure 3. Milton Keynes Urban Area

3.5 Modelling Detail

3.5.1 As shown in Figure 4 the network coding is split into three levels of detail:

- The simulation area covering Milton Keynes and this has been extended to the north, east, south and west;
- The buffer network with speed flow curves which extends across the districts surrounding Milton Keynes and;
- The buffer network with fixed speeds which covers the network further beyond the hinterland around Milton Keynes.

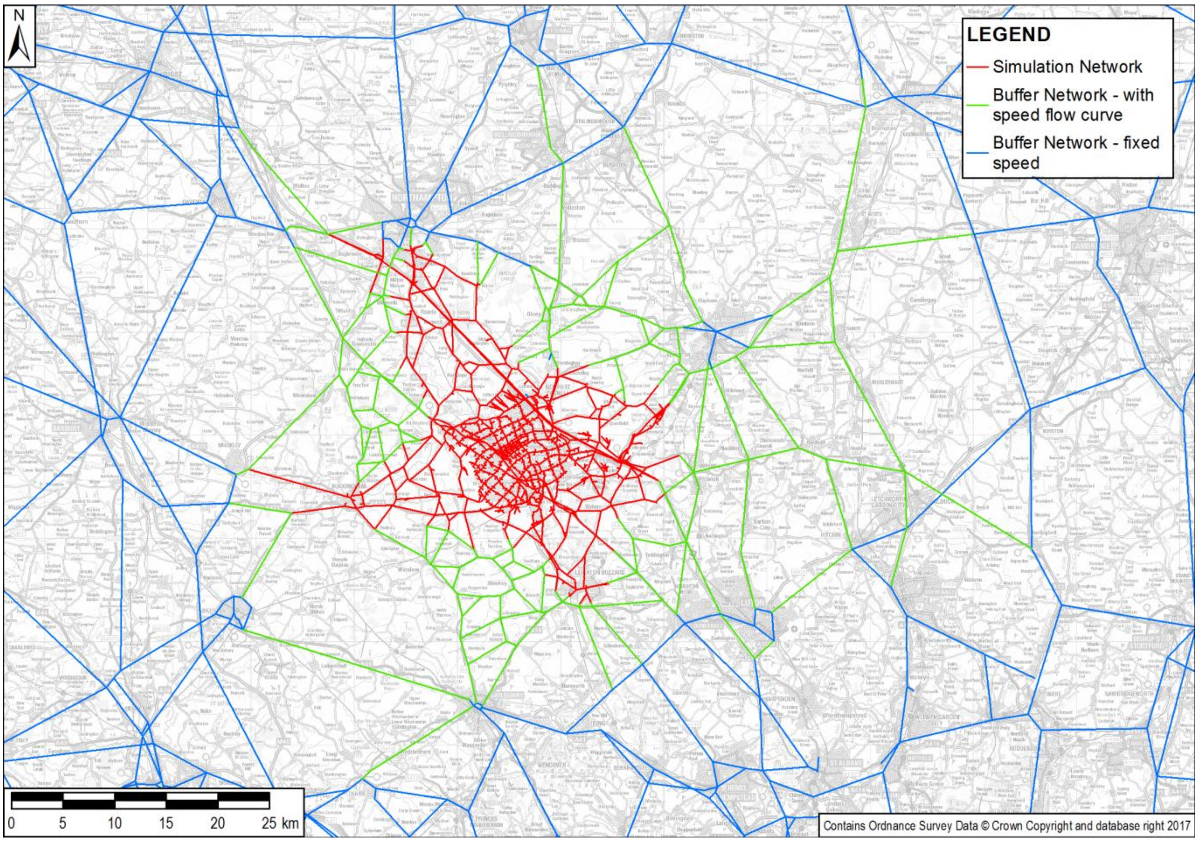


Figure 4. Network Coding Levels of Detail

3.5.2 The existing 2009 model zone system was revised, mostly in areas external to Milton Keynes, to be consistent with NTEM version 7, 2011 census and the SERTM (South-East Regional Traffic Model) zoning system. In addition zones in proposed development areas were disaggregated to provide a higher level of detail. There are 513 zones in the updated model, compared to 399[3] zones in the previous model, which are shown in Figure 5 and Figure 6.

[3] In the previous MKMMM there were a total of 523 zones but 124 of these were for representing future year developments of which only some 30 were actually used.

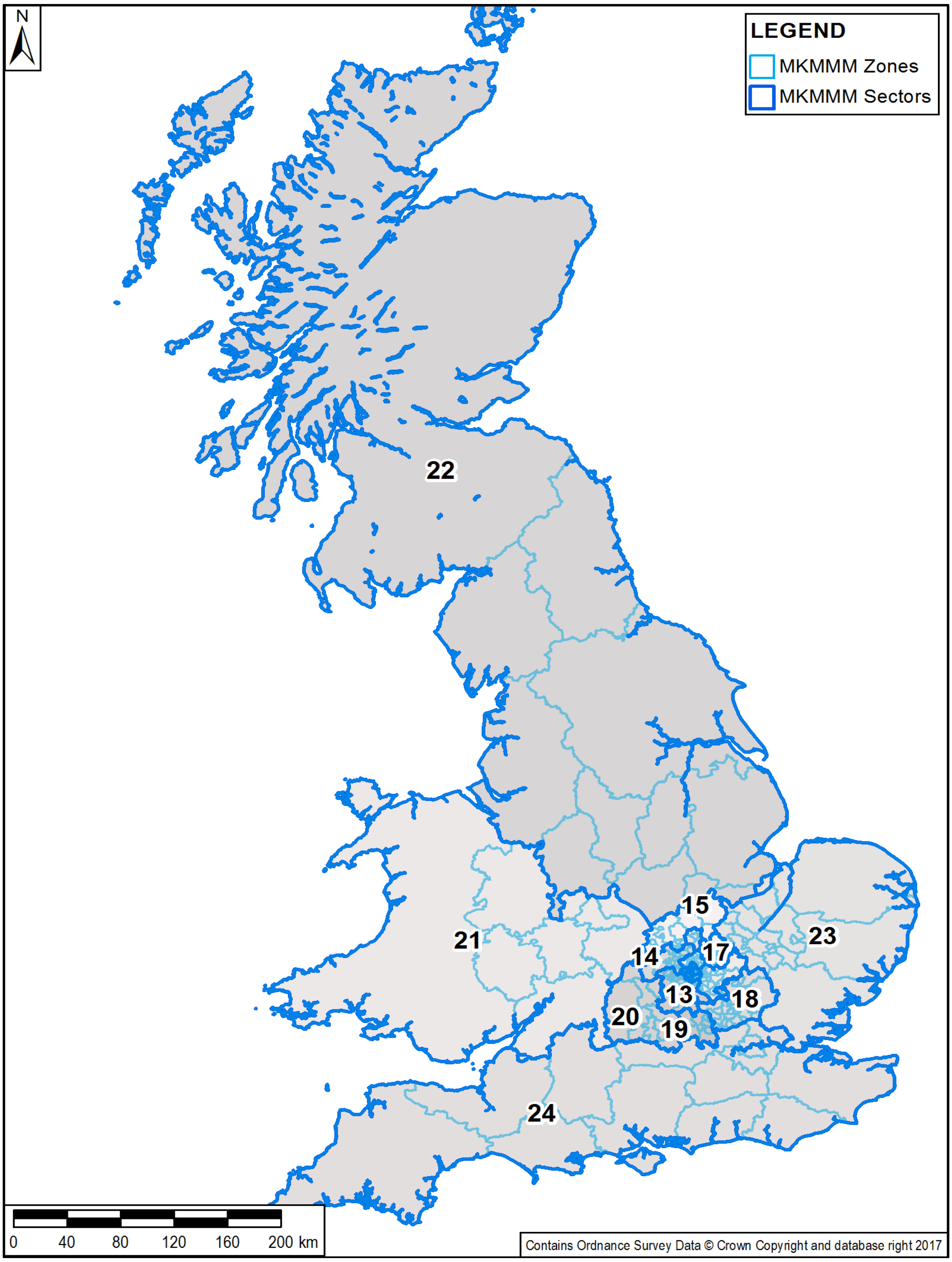


Figure 5. MKMMM Zone Plan Version 1.4 and Sectors – UK

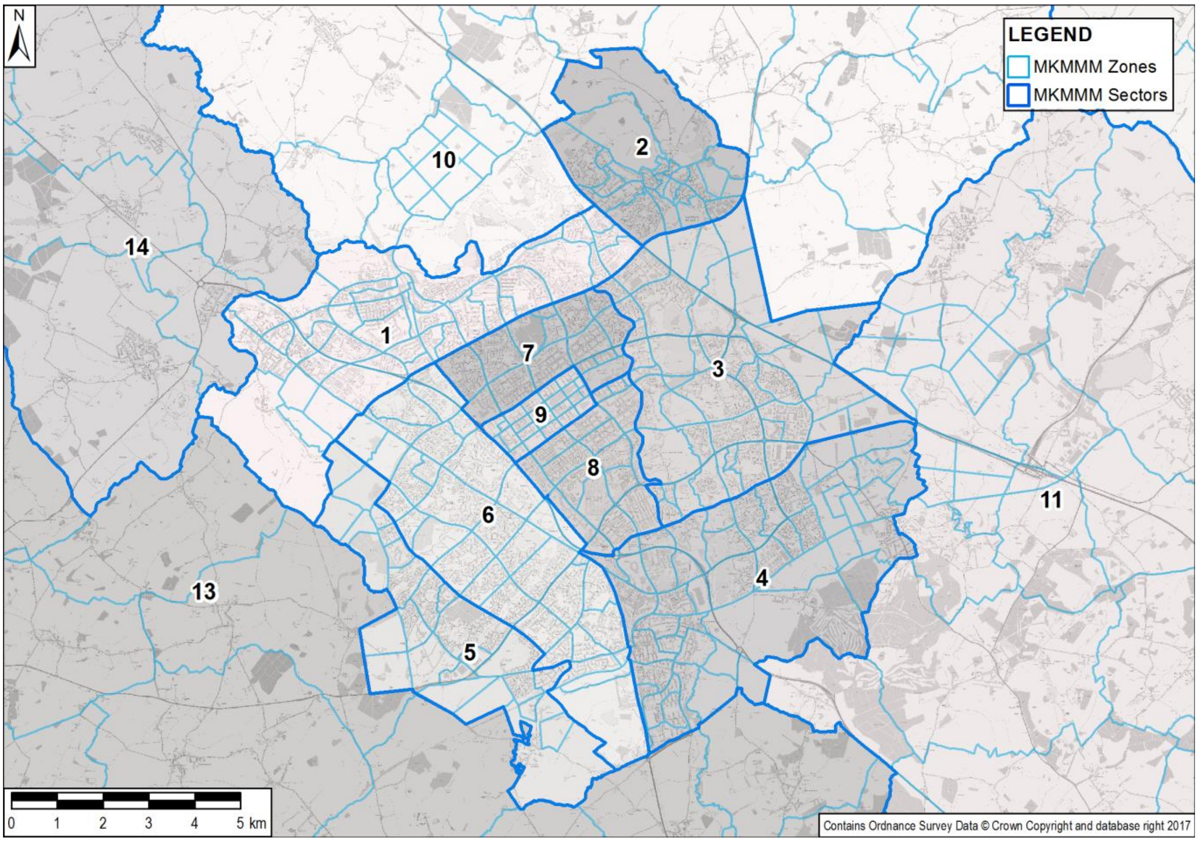


Figure 6. MKMMM Zone Plan Version 1.4 and Sectors – Milton Keynes Local Area

3.5.3 The highway network has been updated to incorporate the revised zone system. At an early stage of the model updating the 2009 inter-peak matrices were converted to the revised zone system and assigned to generate initial 'travel skim' matrices for input to the matrix building process.

3.6 Time Periods

Highways Model

3.6.1 The updated base year highways model represents an average Monday to Thursday in June 2016 even though a significant amount of new traffic data were collected in autumn 2016. This was governed by the availability of Trafficmaster journey time data (data for autumn 2016 would not have been available in time to complete the model update) and disruption to the network caused by roadworks on the A421 between Kingston Roundabout and M1 J13 in spring 2016 which meant that a later neutral period was desirable.

3.6.2 The modelled time periods in the highways model remain unchanged as most historic MKC data has been collected for 60 minute periods commencing at the start of each hour. These periods being:

- AM peak – 0800-0900;
- Inter-peak – average of 1000-1600; and
- PM peak – 1700-1800.

3.6.3 Confirmation of these peak hours can be found in section 4 of the LMVR.

Public Transport Model

3.6.4 The public transport model represents an average hour within three periods during an average weekday in 2016. The three periods are the same as those represented within the highway assignment model; but in the AM Peak and PM Peak an average rather than peak hour is represented. The modelled time periods are therefore:

- an average AM period hour (07:00 to 10:00);
- an average Inter-peak hour (10:00 to 16:00); and
- an average PM period hour (16:00 to 19:00).

3.7 Highways User and Vehicle Classes

3.7.1 The SATURN model has been built using the three vehicle classes based on what can be separately classified in traffic survey data:

- Cars;
- Light Goods Vehicles (LGV); and
- Heavy Goods Vehicles (HGV).

3.7.2 For model assignment purposes cars are defined as being one of three trip purposes, commuting, business or other. This results in there being five user classes for highway assignment purposes as shown in Table 1 along with their corresponding vehicle class:

Table 1: Model User and Vehicle Classes

User Class	Vehicle Class	Purpose
1	1	Car Commute
2	1	Car Employer’s Business
3	1	Car Other
4	2	LGV
5	3	OGV

3.7.3 Bus routes and services in and around Milton Keynes have been extracted from the Emme Public Transport Model and coded as fixed flows in the model.

3.8 Public Transport Modes of Travel

3.8.1 Table 2 below shows the transport modes represented within the MKMMM public transport model.

3.8.2 The external access mode ‘*e*’ does not represent the speed of a specific mode of travel, but has a speed calibrated to broadly reproduce traveller behaviour as well as possible. ‘*e*’ is used outside Milton Keynes only, and represents access to external rail stations (by a combination of car, walk, and bus modes).

Table 2. Transport Modes represented within the PT Model

ID	Name	Type	Speed	Description
a	Auto	Auto	-	This was used only to enable turning data to be coded in the model, with car travel only modelled in the highway assignment model.
b	Bus	Transit	-	Bus services derived from Traveline National Dataset (TNDS)
r	Rail	Transit	-	National rail services
w	Walk	Aux	5 kph	Walk used for access to bus and pure walk trips
e	External	Aux	22 kph	External connectors to railway stations at motorised speed

3.9 Highway Model Assignment Algorithm and Method

3.9.1 Assignment of trips to the highway network was undertaken using a user-equilibrium assignment according to the first of Wardrop's principles, assumed to govern the routes chosen by drivers travelling from a given origin to a given destination.

3.9.2 This principle of equilibrium is such that: '*The journey times on all the routes actually used are equal and less than those which would be experienced by a single vehicle on any unused route*'.

3.9.3 User-equilibrium, as implemented in SATURN version 11.3.12, is based on the Frank-Wolfe algorithm, which employs an iterative process based on successive all-or-nothing assignments to generate a set of combined flows on links that minimise an objective function. The travel costs are re-calculated for each iteration and then compared to those from the previous iteration. The process is terminated when the costs obtained from successive iterations do not change significantly. At this point, the model is said to have converged to a pre-defined degree. The base model convergence as measured against WebTAG criteria was shown to be acceptable in Section 11 of the LMVR.

3.10 Public Transport Model Assignment Method

3.10.1 The MKMMM public transport model uses a frequency-based deterministic assignment method in which each desired destination is assigned a single optimal strategy. A strategy consists of a decision of what to do at every node in the model network, which may be to take an access / walk mode along a specific link, wait for the first service to arrive from a defined set of services calling at the node, or alight from a service.

3.10.2 The frequency-based nature of the model is suitable for strategic assessment in relatively high-frequency situations. This describes most local and urban bus services and rail services to and from London fairly well. Because actual timetables are not represented (only the average interval between buses and trains on a service) nor are passengers' desired departure times represented in detail below the 3 or 6 hour periods, this approach is not suitable for detailed operational or timetable planning, nor is it suitable for assessing very low frequency services where interchanges may occur.

3.10.3 Although rail and bus demand were developed separately, the demand for public transport was combined within the model and mode choices were made within the assignment process, via the Extended Transit Assignment module in Emme, which utilises strategies to implement mode and route choices.

3.10.4 Strategies enable travellers to choose from a set of attractive paths before embarking on a trip, and then lets the mode that arrives first at a stop determine which path (and mode) to take. The optimal strategy is the one which minimises the 'generalised cost' of travel between an origin and destination node.

3.11 Demand Model Validation

3.11.1 As required by WebTAG Unit M2, once a variable demand model has been constructed, it is essential to ensure that it behaves 'realistically', by changing various components of travel costs and times and checking that the overall response of demand accords with general experience. If it does not, then the values of the parameters controlling the response of demand to costs should be adjusted, within reasonable bounds, until an acceptable response is achieved. This recognises the large and unavoidable uncertainties in some of the parameter values, and the importance of reflecting local conditions in relative values.

3.11.2 A number of realism tests were undertaken to demonstrate that the modelled demand responses were plausible, both in the direction and scale of change.

3.11.3 12.11.5 WebTAG Unit M2 advises that three main realism tests should be carried out with elasticities within the appropriate corresponding range:

- **Car Fuel Cost Elasticity** is the percentage change in car vehicle kilometres with respect to the percentage change in fuel cost, and for a 10% increase in fuel cost should lie between -0.35 (high) and -0.25 (low);
- **Public Transport Trip Elasticity** is the change in public transport trips with respect to the change in public transport fare, and for a 10% increase in public transport fare should like between -0.20 and -0.90
- **Car Journey Time Elasticity** is the change in car trips with respect to the change in journey time, for a single iteration run of the demand model, and should be no stronger than -2.0.

3.11.4 The results of these tests were considered acceptable. Detailed results are given in section 12.11 of the LMVR and with headline figures summarised below:

- The outturn vehicle kilometre elasticity with respect to a 10% increase in fuel costs for car is marginally above the WebTAG range at -0.361 however excluding the M1 from the analysis the elasticity becomes -0.235 which is slightly below the WebTAG criteria. This shows the significant impact of demand on the M1 in terms of sensitivity. The traffic on the M1 is likely to be taking longer trips than local traffic and is therefore more sensitive to changes in fuel costs.
- The overall elasticity of public transport demand to a 10% increase in fares is -0.237, which is within the WebTAG range, and at the lower end of this range.
- The overall elasticity of car demand to a 10% increase in journey times is -0.063, which is within the WebTAG range of being negative and no greater in magnitude than 2.

3.12 Highway Model Validation

3.12.1 This section describes the main highway model calibration and validation outcomes that are presented in full in sections 10 and 11 of the LMVR.

3.12.2 The validation of the calibration counts for the highway assignment model is good. Post matrix estimation, the calibration sites that pass the flow or GEH criteria across the 142 sites that make up the calibration screenlines and cordons are as follows:

- AM: 134, 94%
- Inter-Peak: 140, 99%
- PM: 136: 96%

3.12.3 These compare favourably with the criteria that 85% of counts pass this flow test.

3.12.4 The model was validated using data independent from the matrices and assignments. Out of the 26 validation sites the following counts passed the flow or GEH criteria:

- AM: 13, 50%
- Inter-Peak: 11, 42%
- PM: 12, 46%

3.12.5 The corresponding results broken down by the four validation screenlines were as shown in Table 3, where again the percentages are the number of counts that pass the flow criteria and ideally 85%.

Table 3. Percentage of Counts on Each Validation Screenline Passing the WebTAG Flow Criteria

Validation Screenline	Number of Sites	DMRB or GEH 'pass' percentage		
		AM	Inter-Peak	PM
Northern SB	6	67%	50%	33%
Northern NB	6	33%	33%	67%
Railway EB	7	57%	29%	29%
Railway WB	7	43%	57%	57%

3.12.6 Table 4 summarises the total flows across the validation screenlines for which the WebTAG guidance gives a target of overall modelled flow ±5% of observed and a GEH below 4 across complete screenlines.

Table 4. Overall Screenline Observed/Modelled Flow Percentage Comparison and GEH

Validation Screenline	AM		Inter-Peak		PM	
	% Diff	GEH	% Diff	GEH	% Diff	GEH
Northern SB	1%	0.8	9%	5.0	-15%	10.3
Northern NB	-7%	5.1	2%	1.3	-14%	10.7
Railway EB	-3%	2.6	0%	0.3	-1%	0.8
Railway WB	-5%	4.4	1%	0.7	2%	2.4

3.12.7 Although the number of individual counts pass the flow of GEH criteria do not meet the WebTAG guidance, the overall screenline comparisons were within 15%. The grid system in Milton Keynes makes matching of observed flows particularly challenging. Due to the limited observed data, traffic survey and signal timings, the limited timescale and the strong flow calibration and journey time validation these results are acceptable.

3.12.8 The journey time validation was very good with 23 out of 24 routes in each of the time periods meeting the WebTAG standard of ±15% which equates to 96% of the routes passing considerably higher than the requirement of 85%.

3.12.9 The convergence criteria in WebTAG M3.1 were met for the 2016 base year model assignments.

3.12.10 Overall it was considered that the LMVR demonstrated that the Milton Keynes traffic model is sufficiently robust to be taken forward into the forecasting process at a strategic level. The report demonstrated that the MKMMM was able to replicate traffic volumes and travel times to a reasonable standard of accuracy. It is important to note that the model was not designed for use in a scheme specific economic assessment for which it is recommended the model would be recalibrated with additional and more recent data and targeted to reflect a more specific geographical focus of resources and modelling effort.

3.13 Public Transport Model Validation

3.13.1 This section briefly outlines the main public transport model calibration and validation as detailed in the Public Transport LMVR Technical note.[4]

3.13.2 Validation data for bus demand was only available for two sites:

- bus stops outside of Milton Keynes Central railway station (MKC) – data collected for a single weekday in December 2015; and
- bus stops around Milton Keynes Shopping centre (The Point) – data was collected during two weekdays in September 2016.

3.13.3 Table 5 shows the performance of the public transport assignment model when the assignment is undertaken using only the matrices derived from Arriva ETM data and the synthetic bus demand for unobserved services. This analysis highlights the performance of the bus matrices in isolation.

3.13.4 This analysis shows that, using an estimate of all-day flows based on the hourly counts and modelled flows, the model provides a good fit in terms of boarders and alighters at both Milton Keynes Central and The Point. Only alighters at Milton Keynes Central fail to meet the WebTAG criteria of ±25%.

3.13.5 There is more variation between modelled and observed flows when considering individual average hours represented within the model, with around 50% of counts meeting the WebTAG guidelines. It should be noted that there is significant uncertainty in terms of the observed data as the count at Milton Keynes Central is from a single day, and the count undertaken at The Point provided observed data for only a proportion of bus services at this location.

[4] Milton Keynes Model Update - TN09 Public Transport LMVR v2, June 2017

3.13.6 It should also be noted that all changes applied to the bus matrices, networks and assignment to achieve the validation results detailed in Table 5 were global (i.e. applied to the whole model). There is reason to expect, therefore, that the model may perform broadly similarly in other areas where we have no validation data.

Table 5. Comparison of Modelled and Observed Average Hour Bus Flows – Bus Matrix Assignment Only

	Site	AM	IP	PM	All Day
Boarding	MKC	-30%	51%	3%	7%
	The Point	-11%	40%	-3%	15%
Alighting	MKC	-40%	-22%	-35%	-32%
	The Point	11%	34%	-16%	16%

3.13.7 Table 6 shows the same comparison, but including the processed rail demand data within the assignment. The results of this comparison are not at the same level as with the assignment of bus demand only, and in particular there is a significant overstatement of bus boarders and alighters at Milton Keynes Central.

3.13.8 This is due to the specification of the public transport model whereby the choice between rail and bus modes is undertaken within the assignment. This therefore means that motorised access to rail stations is not represented, and access to rail stations must be undertaken either through walking or use of one of more bus services.

Table 6. Comparison of Modelled and Observed Average Hour Bus Flows – Bus & Rail Matrix Assignment

	Site	AM	IP	PM	All Day
Boarding	MKC	117%	239%	272%	213%
	The Point	11%	49%	13%	29%
Alighting	MKC	291%	127%	110%	181%
	The Point	36%	44%	2%	32%

3.13.9 Therefore, the majority of rail demand to / from Milton Keynes Central uses bus to access the station, whereas in reality it is assumed that a significant proportion of this demand would drive to the station. There is also the possibility of double-counting within the demand matrices, as passengers who bought both a rail and bus ticket would be included in both demand matrices.

3.13.10 If a motorised access mode was coded within the public transport assignment for access to / from railway stations, this would have to be coded with a faster travel time than the corresponding bus services in order to attract demand. However, this mode would be open to all demand and therefore would attract a significant amount of bus demand from bus services onto this motorised access mode.

3.13.11 On balance, Table 5 demonstrates that the underlying processing of the bus ticket data is valid, but Table 6 shows that there is an inconsistency between the specification of allowed modes within the public transport model and those allowed in reality. The impact of this issue is likely to be greatest at Milton Keynes Central, with a smaller impact away from railway stations.

4. Forecast Year and the Uncertainty Log

4.1 Introduction

4.1.1 This section of the report outlines the methodology used in producing the Reference case for the MKMMM model, detailing the initial stages of establishing the forecast reference case scenario and compiling the 'Uncertainty Log'. The Uncertainty Log is a list of developments and transport schemes which would need to be modelled explicitly to maximise the local accuracy rather than those that are out of the area of interest and can be allowed for in general TEMPRO background growth.

4.1.2 The 2031 Reference Case scenario includes the currently planned growth in Milton Keynes district up to 2031 which includes in the region of 20,000 dwellings and 28,000 jobs with infrastructure that is expected to be in place by 2031. This growth is mostly within the currently adopted plan that extends to 2026. Plan:MK will include additional growth for the period to 2031 but modelling of that scenario is not included within this report.

4.1.3 Outside the Milton Keynes District TEMPRO growth has been applied. TEMPRO is DfT software that interrogates and computes information from their National Trip End Model (NTEM), projections in terms of demographic forecasts and trip end growth factors by traveller types. Its use to control overall forecasts ensures consistency across models nationally. Although different, the terms TEMPRO and NTEM are largely interchangeable and NTEM is the terminology generally used in this report.

4.2 Update to the Zone System

4.2.1 In the light of further information received on locations of Plan:MK growth, the zone system was updated to have a single zone representing South Caldecotte to better model the proposed Plan:MK development at that location and enable a true comparison against the Reference Case. As shown in Figure 7, this was achieved by aggregating zones 2046 and 2047 producing a larger zone 2046 and disaggregating zone 1556 with South Caldecotte now represented by zone 2047. This had negligible impact on the base year model as in 2016 no trips load from South Caldecotte.

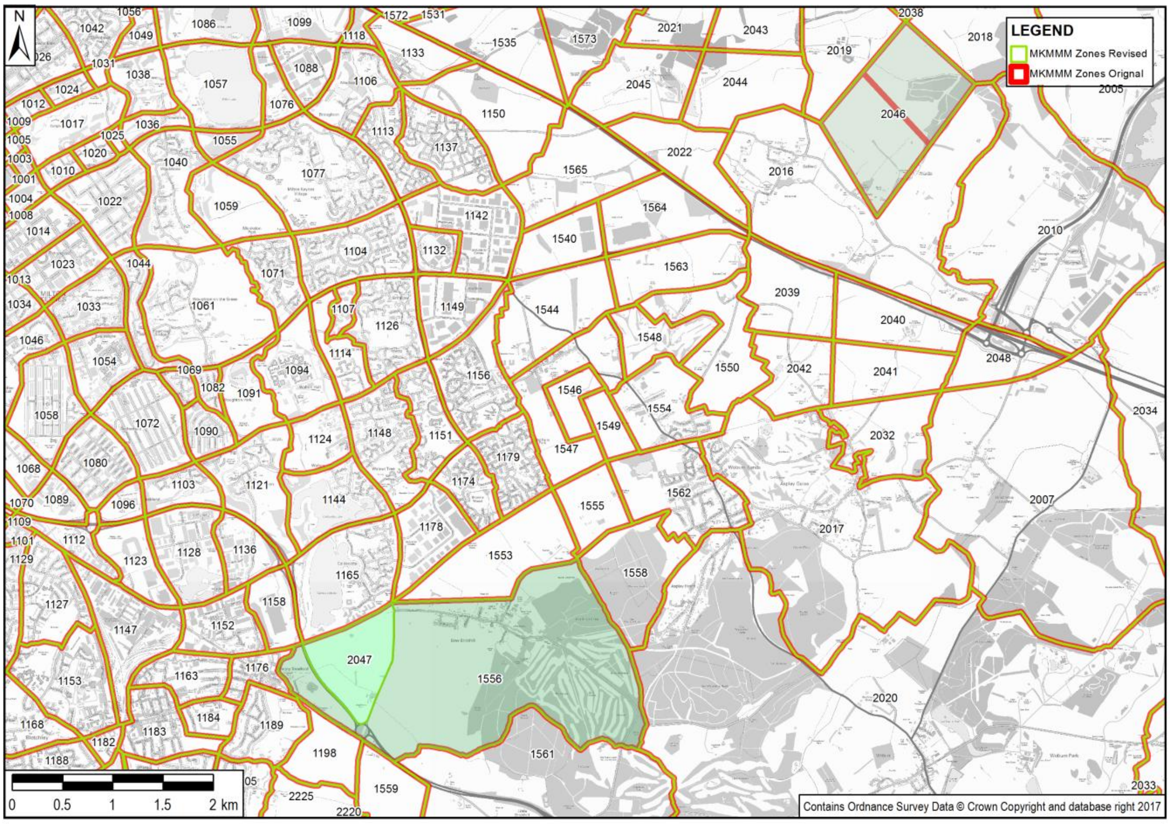


Figure 7. Updates to Zone System

4.3 Forecast Year

4.3.1 Plan:MK is intended to be delivered by 2031, as such the reference case has been built to represent this year.

4.4 Uncertainty Log

4.4.1 The purpose of the Uncertainty Log is to collate a list of future developments and scheme assumptions whilst applying a level of certainty as to how likely to be built. This is then used to inform the reference case scenario.

4.4.2 The Uncertainty Log created for this project was compiled following discussions with MKC. All the developments and schemes are categorised according to the likelihood of their construction using the four categories as outlined in WebTAG unit M4 Table A2. Although the terminology is slightly different in that WebTAG refers to a 'Core Scenario' in the context of a major infrastructure scheme or package rather than Reference Case, in essence they are the same in this case, in providing a forecast baseline or yardstick scenario from which to measure impacts of a 'Do Something' scenario intervention, which in this case is Plan:MK.

Table 7. Uncertainty Log Probability Classifications from WebTAG

Probability of Input	Status Definition	Core Scenario Assumption
Near certain (NC): The outcome will happen or there is a high probability that it will happen.	Intent announced by the proponent to regulatory agencies. Approved development proposals. Projects under construction.	This should form part of the Core Scenario.
More than likely (MTL): The outcome is likely to happen but there is some uncertainty.	Submission of planning or consent application imminent. Development application within the consent process.	This could form part of the Core Scenario.
Reasonably foreseeable (RF): The outcome may happen, but there is significant uncertainty.	Identified within a development plan. Not directly associated with the transport strategy/ scheme, but may occur if the strategy/ scheme is implemented. Development conditional upon the transport strategy/ scheme proceeding. Or, a committed policy goal, subject to tests (e.g. of deliverability) whose outcomes are subject to significant uncertainty.	These should be excluded from the Core Scenario but may form part of the alternative scenarios.
Hypothetical (H): There is considerable uncertainty whether the outcome will ever happen.	Conjecture based upon currently available information. Discussed on a conceptual basis. One of a number of possible inputs to an initial consultation process. Or, a policy aspiration.	These should be excluded from the Core Scenario but may form part of the alternative scenarios.

Source: WebTAG unit M4 Table A2. November 2014

4.5 Areas Considered

4.5.1 The trip end model is structured to allow explicit planning inputs to be entered for zones within the 'Internal' Area as shown in Figure 8.

4.5.2 In terms of development growth the primary area considered was Milton Keynes district, with strategic infrastructure schemes in the general vicinity also included, namely the M1 J11a / Dunstable Northern Bypass scheme.

4.5.3 In Aylesbury Vale, the South West Milton Keynes (SWMK) development was included due to its close proximity to Milton Keynes.

4.5.4 Originally it had been intended to input committed developments in other neighbouring districts in zones within the 'Internal' Area, however due to limited data being available (and quite often none), in part due to limited certainty on developments, due to differing formal planning time horizons, it was agreed that NTEM data should be used.

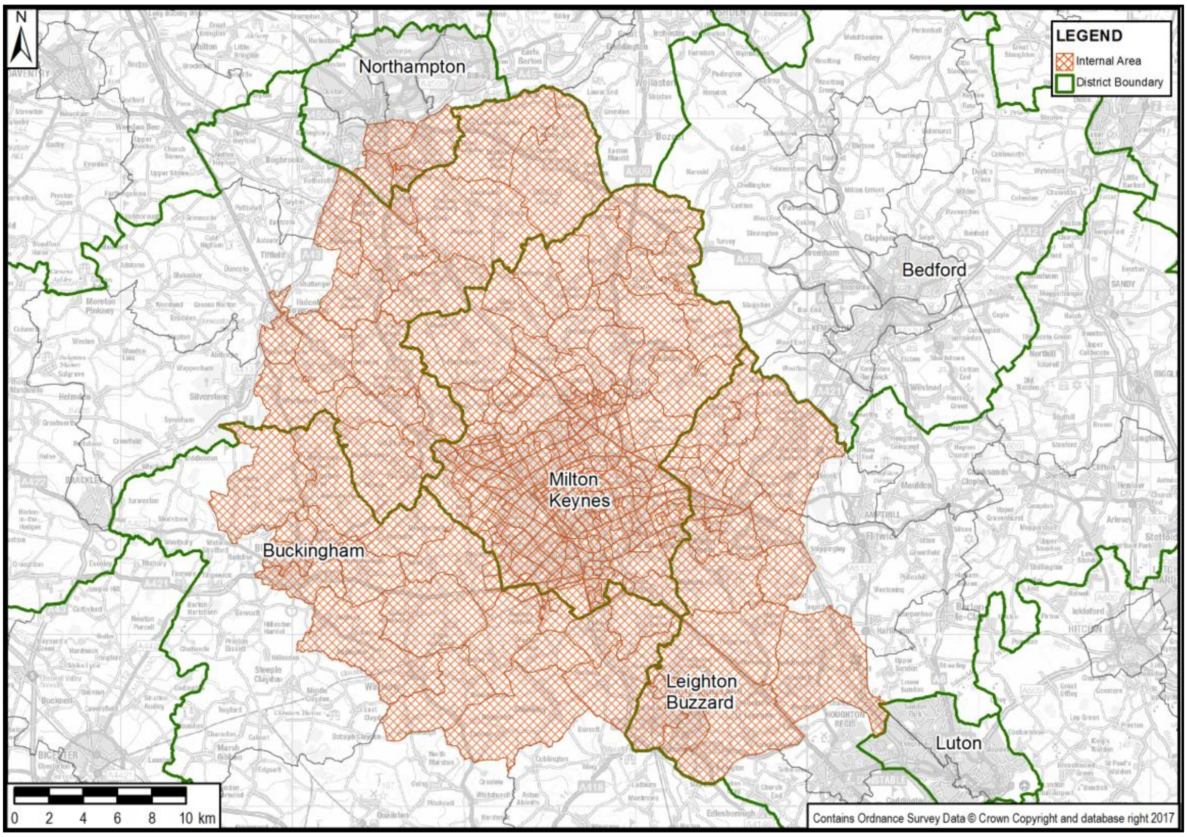


Figure 8. MKMMM 'Internal' Model Area

4.6 Explicitly-Modelled Developments

4.6.1 Planning data was provided by MKC for Milton Keynes district by model zone. In some instances there was a development that spanned multiple zones. In these cases it was assumed an even split of jobs and or dwellings across each zone within the development. Similarly if a development included multiple job categories, an even split was assumed. The dwellings growth is plotted by zone in Figure 9 and jobs growth by zone in Figure 10.

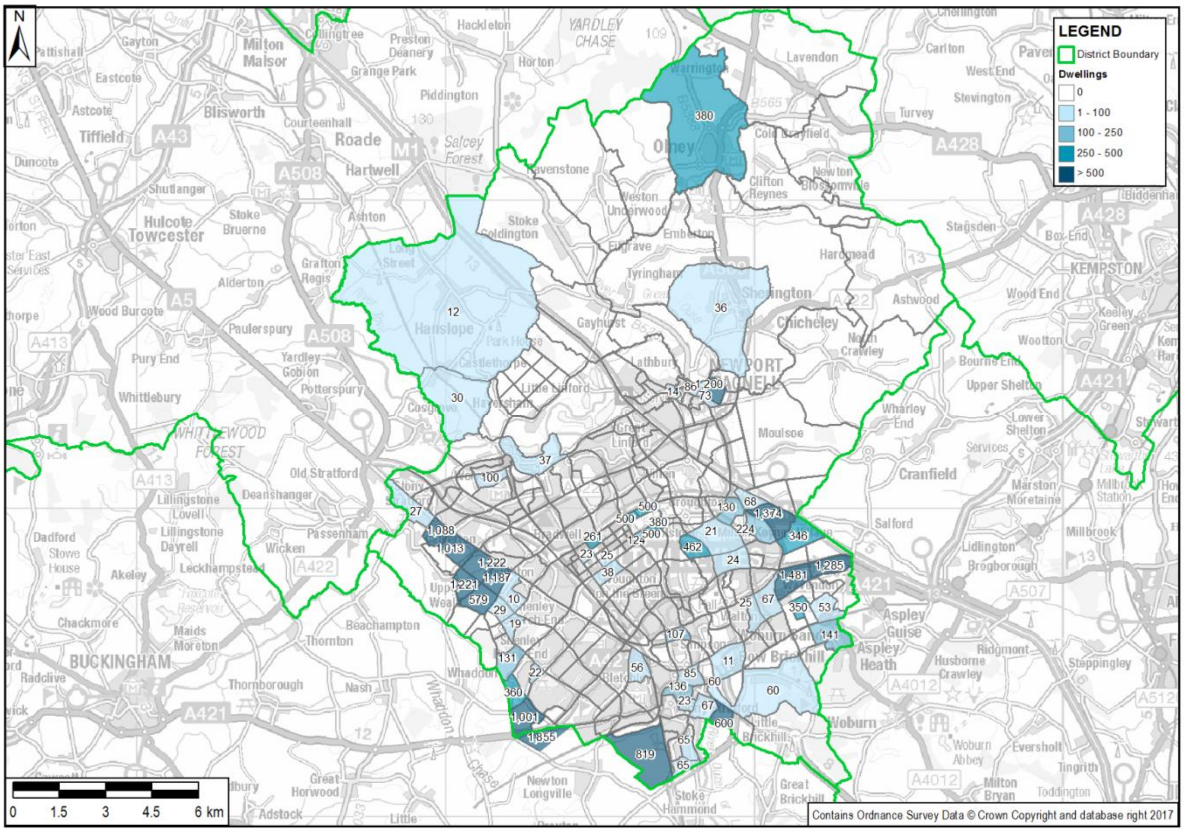


Figure 9. Dwellings Growth to 2031

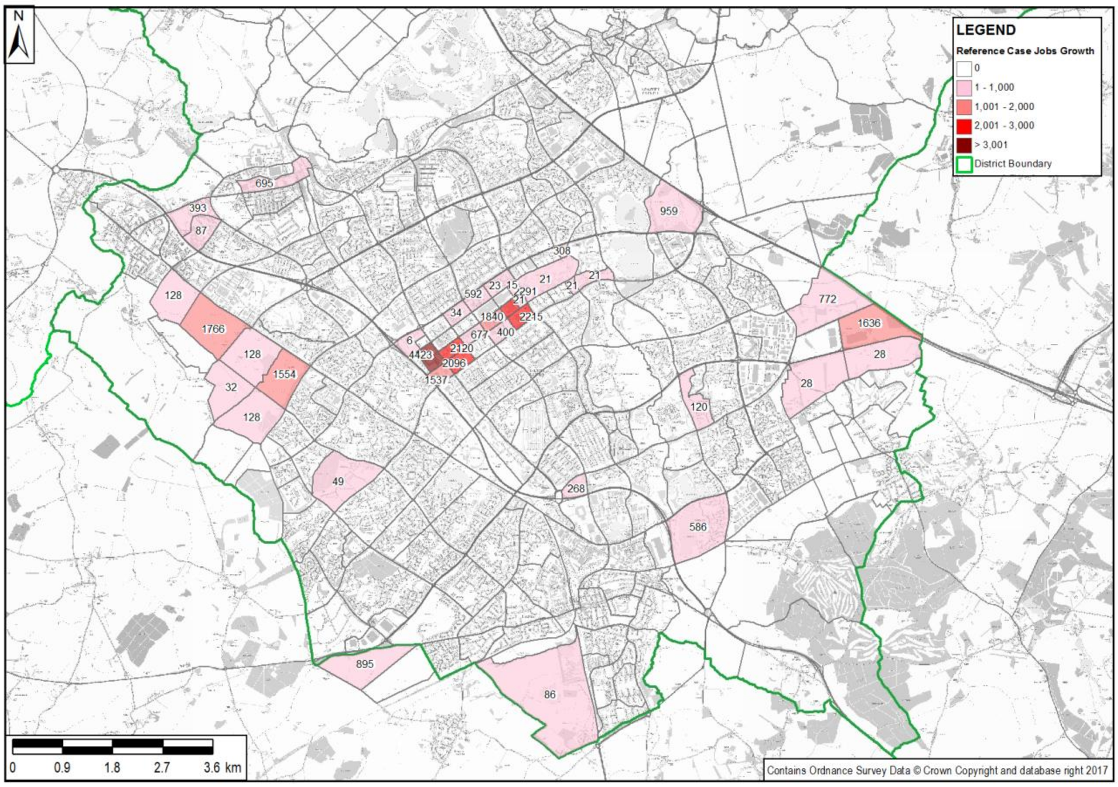


Figure 10. Jobs Growth to 2031

4.7 NTEM Adjustments for General Growth

4.7.1 As this assessment is for use in assessing the impacts of Plan:MK and not an economic appraisal of a specific scheme, the forecast growth provided by MKC has been used as given and has not been constrained to NTEM within Milton Keynes District.

4.7.2 However with the inclusion of SWMK development in Aylesbury Vale the remaining 'Internal' zones within Aylesbury Vale were constrained to NTEM in terms of dwellings growth. However, although the jobs growth was constrained as much as possible, due to the large jobs growth in SWMK there is a net increase across Aylesbury Vale in jobs growth of 160 above that of NTEM.

4.8 Modelled Schemes

4.8.1 The schemes listed in Table 8 and shown in Figure 11 are those included in the highways model. East-West rail was the only scheme added to the Public Transport Model. Apart from East-West Rail, no information was available on any proposed amendments to bus and rail services so PT routes and frequencies were assumed to remain the same as in 2016.

4.8.2 East-West rail was represented in the public transport model with the addition of hourly services in each direction between Oxford and Bedford, Oxford and Milton Keynes and between Aylesbury and Milton Keynes, all of which route via a new station added to the model at Winslow.

4.8.3 East-West rail is expected to increase the train frequency across the level crossings from one per hour in each direction to two per hour. This change was applied to the highways model by halving the cycle time, from 30 minutes to 15 minutes, at the signal nodes representing the level crossings. The inter-green time (representing the barrier down time) was kept the same, but the total green time was reduced accordingly.

Table 8 Forecast Year Transport Schemes included in Reference Case

Scheme	Delivered by
A421 Dualling	By 2031
Monkston & Brinklow Junctions	2019
Crownhill & Loughton Junctions	2019
A5 Improvements	By 2031
Bletchley Station Highway Improvements	2017
Brooklands City Street Phase 2	2017
Nova City Street	2018
Calverton Lane/Fairways	2021
Kiln Farm Junction	2016
Bridge over Broughton Brook	2018
H10 Extension	2018
V2/H4 Extension	2021
East-West Rail	2024
M1 J13-J16 SMP	By 2031
M1 J16-J19 SMP	2021
M1 J11a / Dunstable Northern Bypass	2017

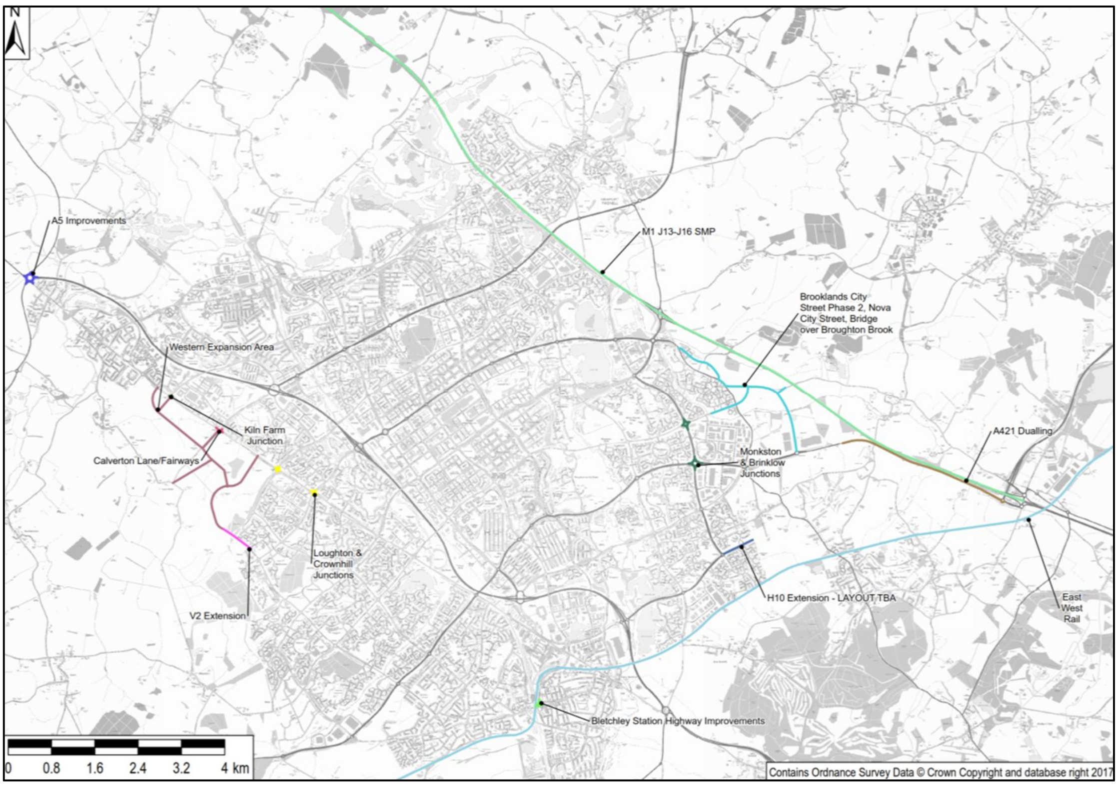


Figure 11. Uncertainty Log Schemes to 2031 included in Reference Case

5. Trip End Model Forecasts

5.1 Introduction

5.1.1 This section outlines the process of developing the 2031 demand trip ends prior to any forecast changes in costs. These are a precursor to the variable demand modelling used to derive the final reference case demand.

5.1.2 Growth in trip ends was obtained using the customised version of the Department for Transport's trip-end model, CTripEnd, used as part of the development of the base year trip matrices. The CTripEnd database was customised with a hybrid zone system which uses MKMMM zones within the model Internal Area and NTEM v7 zones elsewhere. The internal area, as shown in Figure 8, was defined as part of the base year matrix development to cover all of Milton Keynes and areas expected to be modelled as highways simulation network. This customisation allows forecast planning data supplied by MKC to be applied explicitly, with NTEM v7.2 trip end growth applied elsewhere. Although originally intended to use forecast development information for neighbouring districts to Milton Keynes for zones within the Internal Area due to limited data availability NTEM growth was applied outside Milton Keynes district by inputting the forecast population, household and jobs figures calculated from NTEM data into the Trip End model.

5.2 Trip End Model inputs

5.2.1 Within the internal area (see Figure 8) the following data was required by CTripEnd classification:

- Population, split into 11 categories:
  - PT01: children (aged 0 to 15)
  - PT02: males in full time employment (aged 16 to 74)
  - PT03: males in part time employment (aged 16 to 74)
  - PT04: male students (aged 16 to 74)
  - PT05: male unemployed or inactive (aged 16 to 74)
  - PT06: male aged 75 and over
  - PT07: females in full time employment (aged 16 to 64)
  - PT08: females in part time employment (aged 16 to 64)
  - PT09: female students (aged 16 to 64)
  - PT10: female unemployed or inactive (aged 16 to 64)
  - PT11: female aged 75 and over
- Employment, E01, split into 12 categories:
  - E03: Primary & Secondary schools
  - E04: Higher education
  - E05: Adult education
  - E06: Hotels, camp sites etc.
  - E07: Retail trade
  - E08: Health / Medical

   - E09: Services (business, other, postal/courier) & equipment rental
   - E10: Industry, construction and transport
   - E11: Restaurants and bars
   - E12: Recreation and sport
   - E13: Agriculture and fishing
   - E14: Business
- Households, E02
- Holiday Homes, E15
- Car Ownership, split into eight levels:
   - Level 1: 1 adult household with no car
   - Level 2: 1 adult household with one or more cars
   - Level 3: 2 adult household with no car
   - Level 4: 2 adult household with one car
   - Level 5: 2 adult household with two or more cars
   - Level 6: 3 or more adult household with no car
   - Level 7: 3 or more adult household with one car
   - Level 8: 3 or more adult household with two or more cars

5.2.2 Jobs data was provided by zone by MKC. In some cases an employment development straddled zone boundaries. In these cases it was assumed an even split of jobs and or dwellings across each zone within the development. Similarly if a development included multiple job categories, an even split was assumed.

5.2.3 Dwellings data provided by MKC was converted to households by using the factor of 0.976 households per dwelling, a factor derived from 2011 census data as part of the base year trip end estimates that accounts for unoccupied homes.

5.2.4 Population was calculated on an individual NTEM zone basis. Within the Milton Keynes district, the NTEM 2031 population by category to household ratio was applied to the 2031 household figures calculated from the dwellings data provided by MKC. Outside the Milton Keynes district but within the Internal area, the NTEM growth was applied at an individual NTEM zone basis but using the 2016 population proportion. This approach ensured changes in proportions of the population categories in the NTEM data would be reflected in the forecast population figures.

5.2.5 Car ownership was calculated by applying NTEM 2031 household to car ownership ratios to the households by MKMMM zone based on the NTEM zone it was within.

5.3 Trip End Model Outputs

5.3.1 The trip end model produces 24 hour trip ends by mode:

- Car,
- PT and
- Active Mode,

5.3.2 and by purpose:

- Home based employers business (HBEB)
- Home based other (HBO)
- Home based work (HBW)
- Non-home based employers business (NHBEB)
- Non-home based Other (NHBO)

5.3.3 As shown in Table 9, within the Milton Keynes Urban Area, Car production trip ends increase the most, with growth in attractions comparable across each mode and higher than growth in productions. The large employment growth as resulted in this large increase in attractions.

Table 9. Comparison of 2016 and 2031 trip ends for zones within the MK Urban Area

Mode	Purpose	Total Daily Productions				Total Daily Attractions			
		2016	2031 Ref	2031 - 2016	% Diff	2016	2031 Ref	2031 - 2016	% Diff
Car	**TOTAL**	**472,672**	**552,217**	**79,546**	**17%**	**665,297**	**856,784**	**191,487**	**29%**
	HBEB	14,926	16,230	1,304	9%	23,041	27,400	4,358	19%
	HBO	258,109	307,430	49,322	19%	398,377	527,946	129,569	33%
	HBW	119,573	127,336	7,763	6%	156,036	182,170	26,134	17%
	NHBEB	14,950	17,839	2,889	19%	13,596	16,422	2,826	21%
	NHBO	65,114	83,382	18,268	28%	74,246	102,845	28,599	39%
PT	**TOTAL**	**45,565**	**48,500**	**2,935**	**6%**	**76,804**	**98,909**	**22,105**	**29%**
	HBEB	1,446	1,427	-19	-1%	804	1,009	205	25%
	HBO	24,342	26,202	1,860	8%	59,579	76,656	17,078	29%
	HBW	13,673	12,890	-784	-6%	11,253	13,589	2,337	21%
	NHBEB	591	713	122	21%	521	692	172	33%
	NHBO	5,512	7,269	1,756	32%	4,648	6,962	2,314	50%
Active Mode	**TOTAL**	**156,091**	**170,798**	**14,708**	**9%**	**184,659**	**232,530**	**47,871**	**26%**
	HBEB	1,165	1,156	-10	-1%	999	1,131	132	13%
	HBO	107,647	116,410	8,764	8%	153,848	194,332	40,484	26%
	HBW	22,039	20,915	-1,123	-5%	14,381	16,193	1,812	13%
	NHBEB	1,487	1,767	279	19%	2,019	2,387	369	18%
	NHBO	23,753	30,550	6,797	29%	13,413	18,487	5,074	38%

6. Equilibrium Demand Forecasts

6.1 Introduction

6.1.1 This section outlines the parameters used and key statistics from the demand model assignments.

6.2 PT and highway feedback

6.2.1 As defined in the specification, there is not a feedback loop between the highways and public transport models. This means that the impact of the reference case demand on highway travel times needs to be manually applied to the bus times in the public transport model.

6.2.2 In the absence of a feedback loop the most accurate approach would be to amend the bus routes on a link by link basis, however this would be extremely time consuming and as such a more proportional approach was considered.

6.2.3 After an initial run of the demand model the change in average speed for the highways simulation area was taken for each time period and then applied to the bus journey times. Changes were only applied on bus segments (links) within the extent of the highways simulation area. This was to prevent an unrealistic reduction in bus trips on long distance routes that start in the fixed speed buffer area in which link times are not impacted by level of flow. The average change in journey times applied in this way are presented in Table 10.

Table 10. Change in Average Speed

	AM	IP	PM
2016 Average Speed (kph)	60.6	72.3	62.0
2031 Average Speed (kph)	54.6	69.8	56.8
Factor	1.11	1.04	1.09

6.3 Highways Model Future Generalised Cost Formulation and Parameter Values

6.3.1 The cost of travel is expressed in terms of generalised cost, which uses specific 'Values of Time' to convert money into time separately for each defined journey purpose, and specific ‘Vehicle Operating Costs’. SATURN uses two parameters: pence per minute (PPM) and pence per kilometre (PPK), and calculates generalised cost in minutes as:

Time + PPK/PPM x Distance + toll (pence)/PPM.

6.3.2 The values of Time (VoT) and Vehicle Operating Costs (VoC) used in the 2031 reference case highway model have been calculated from the WebTAG data book released in July 2016 and are shown in Table 11. The value of time applicable to HGV trips is uplifted by a factor of two as suggested in WebTAG Unit M3.1 paragraph 2.8.8.

Table 11. 2031 Values of Time and Vehicle Operating Costs as PPM and PPK Values

User Class	AM Peak		Inter-Peak		PM Peak	
	PPM	PPK	PPM	PPK	PPM	PPK
1: Car Commute	26.38	4.96	26.81	4.96	26.47	4.96
2: Car Employer's Business	39.34	11.17	40.31	11.17	39.91	11.17
3: Car Other	18.20	4.96	19.39	4.96	19.06	4.96
4: LGV	27.81	12.82	27.81	12.82	27.81	12.82
5: HGV	56.46	50.28	56.46	50.28	56.46	50.28

6.4 Public Transport Fares

6.4.1 A real terms increase in PT fares of 1% per annum has been assumed, as such both rail and bus fares have been factored up by 1.16 in the 2031 reference case model.

6.5 Demand Model Configuration

6.5.1 A bespoke demand model was built to model the impacts of changes in transport infrastructure and travel cost upon patterns of demand. The demand model works in conjunction with the trip-end, highway and public transport models, passing demand and costs between the components of the model suite.

6.5.2 The MKMMM demand model uses a hierarchical logit structure, with the following choice models in order of increasing sensitivity:

- trip frequency;
- motorised versus active mode (walking and cycling) choice;
- time period choice;
- car versus public transport (bus and rail) mode choice; and
- trip distribution (destination choice).

6.5.3 Full details of the structure of the demand model are in Section 12 of the Highways Model LMVR[5]

6.6 MKMMM Demand Convergence

6.6.1 The %GAP criterion of WebTAG Unit M2, Section 6.3 (relative value should be 0.1% or lower) was met or exceeded in all cases, as Table 12 shows for the 2031 Reference Case. Values are shown for all iterations from iteration two up to and including the final one.

Table 12. MKMMM Demand Model Convergence

Iteration	Aggregate %GAP
2	6.322
3	0.848
4	0.235
5	0.109
6	0.044

[5] MKMMM Local Model Validation Report V1.4 - June 2017

6.7 Key Statistics for the Reference Case Scenario

6.7.1 This section summarises the impacts of the variable demand modelling on the matrix totals, vehicle kilometres and vehicle hours for the highways model and passenger trips, passenger hours and passenger distance for the PT model.

6.7.2 The demand model represents the time periods below (as opposed to peak hours):

- AM Peak Period (07:00 -10:00);
- Inter-Peak Period (10:00 – 16:00);
- PM Peak Period (16:00 – 19:00; and
- Off-Peak Period (19:00 – 07:00).

6.7.3 During each Demand Model iteration the peak period demand is converted to an average hour for use in the PT and highways assignments. Once the demand model has converged, peak hour factors are used to convert AM Peak and PM peak period demand into peak hour demand which along with an average hour taken from the Inter-peak period and is then used to run the final highway model assignment for each time period; AM Peak, Average IP and PM Peak. (The PT model represents an average hour so factors are not required).

6.7.4 The OD matrices produced for the first iteration of the demand model are those before any impact of a change in costs is applied. To better assess the impacts of the demand model additional assignments have been run for the AM and PM peak hours using the pre-demand model matrices factored from peak period as used in the demand model to peak hour. The factors were calculated as part of the base year matrix build and are based on the calibration and validation count data set and are shown in Table 13.

Table 13. Peak Period to Peak Hour Factors

Vehicle	Proportion of Peak hour flow in Peak Period		Factor from an Average Peak Period hour to Peak Hour	
	AM	PM	AM	PM
Car	43.2%	38.6%	1.296	1.158
LGV	31.9%	32.5%	0.957	0.975
HGV	33.1%	29.3%	0.993	0.879

Matrix Totals

6.7.5 Table 14 and Table 15 below provide a comparison between trips in the pre-demand model, post demand model and base year matrices for AM and PM peak hours and the average inter-peak. These totals exclude trips that do not pass through the boundary of the Milton Keynes urban area (as shown in Figure 3), defined as external to external (ext – ext) to focus the assessment on trips to, from and within Milton Keynes.

Table 14. Highway Matrix Totals (car, all purposes excluding ext – ext Trips)

	2016	2031 Pre-Demand Model	2031 Post Demand Model
AM	57895	67500	66688
IP	34609	43264	44288
PM	60407	72849	72019

Table 15. Public Transport Matrix Totals (all purposes excluding ext – ext Trips)

	2016	2031 Pre-Demand Model	2031 Post Demand Model
AM	5296	6146	6253
IP	3831	4947	5111
PM	4896	6014	6195

6.7.6 As shown in Figure 12 applying the trip ends produced from the trip end model results in a 17% increase in car trips in the AM peak, 25% in the inter-peak and 21% in the PM peak. The impact of the demand model is to reduce car trips by 1% in the AM and PM peaks but increase them by 2% in the inter-peak. In the AM and PM peaks the decrease in fuel operating costs is outweighed by the impacts of congestion and increased travel time, whereas in the inter-peak which is less congested the reduction in operating costs has made car trips more attractive.

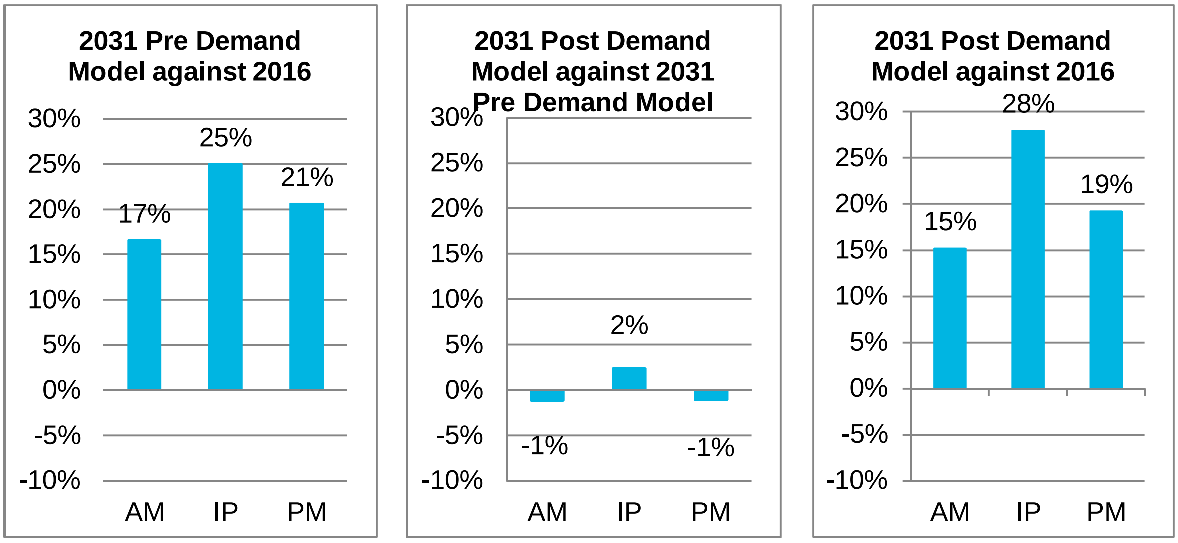


Figure 12. Percentage change in matrix totals (car, all purposes excluding Ext – Ext Trips)

6.7.7 As shown in Figure 13, the demand model increases the PT trips to, from and within Milton Keynes, by 2% in the AM average hour and 3% in the inter-peak and PM average hour.

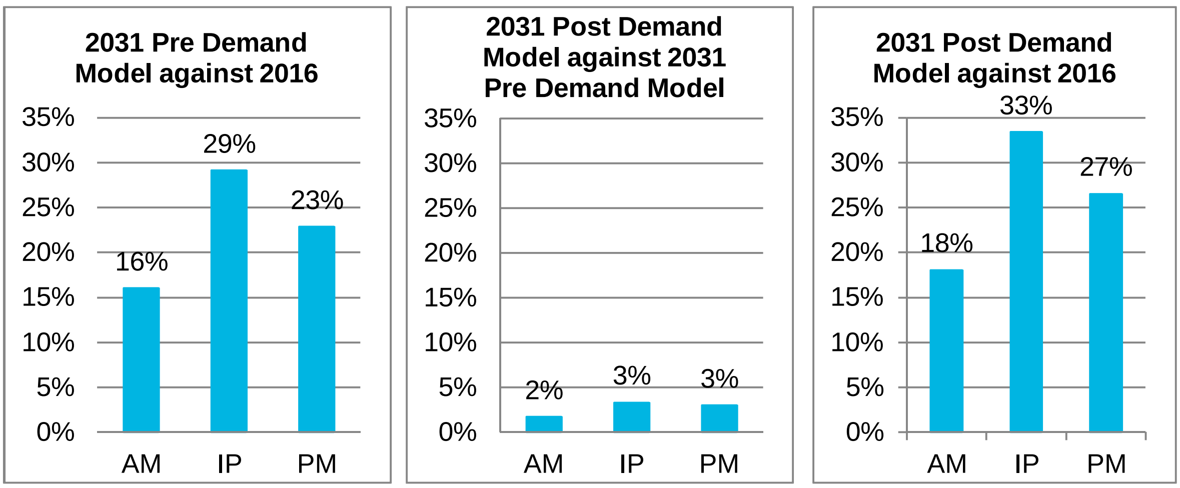


Figure 13. Percentage change in matrix totals (PT, all purposes excluding Ext – Ext Trips)

6.7.8 Further analysis by sectoring the zones in the Milton Keynes urban area as internal and outside as external was carried out. Table 16 shows that car trips travelling into Milton Keynes reduce as result of the demand model, and conversely in the PM peak trips from Milton Keynes reduce. This is due to the congestion caused by the tidal flows into Milton Keynes in the AM peak and out of Milton Keynes in the PM peak. Across all three time periods the trips within Milton Keynes urban area reduce, by 2% in AM peak, 3% in PM peak and by 1% in the inter-peak. This is due to the higher levels of congestion within Milton Keynes.

Table 16. Demand model Car trip percentage change by sector

	AM Peak Hour		Average IP		PM Peak Hour	
Sector	Internal	External	Internal	External	Internal	External
Internal	-2%	10%	-1%	9%	-3%	-2%
External	-3%	1%	8%	1%	5%	1%

6.7.9 Table 17 shows the impact of the demand model on public transport trips. Within Milton Keynes urban area there is a reduction of 4% in the AM Period and a reduction of 3% in the PM. The increase in highway journey times, and therefore bus journey times are the likely the reason for this change, with trips switching to active mode; i.e. walking and cycling, or to the inter-peak period. Although in the inter-peak the demand model has a net impact of zero per cent within Milton Keynes, it is possible some trips have switched to active mode or car cancelling out the effect of time period shift. The changes in the AM Period are the greatest due to the largest reduction in average speeds.

6.7.10 There is a larger change in the AM period as the AM period has the bigger increase in highway journey times out of the two period.

Table 17. Demand model Public Transport trip percentage change by sector

	Average AM hour		Average IP		Average PM hour	
Sector	Internal	External	Internal	External	Internal	External
Internal	-4%	8%	0%	10%	-3%	9%
External	5%	4%	10%	11%	7%	5%

Vehicle Kilometres

6.7.11 The vehicle kilometres are presented in Table 18 and Table 19 for total car users and all vehicles, approximated by Passenger Car Unit (pcu) kilometres[6], within the simulation area of the highways model, and the PT model which represents the local buses serving Milton Keynes and train journeys to or passing through Milton Keynes Central (MKC). Base year figures are included as a point of reference.

6.7.12 Car vehicle kilometres increase as a result of the demand model, with the largest increase in the inter-peak. Similarly all vehicle (pcu) kilometres also increase in the same pattern but with the magnitude reduced by the limited changes in LGV and HGV which are not subject to the demand model and in the case of HGV more likely to continue with direct routes. This suggests that although trips decrease in AM and PM, average trip length increases, partly an impact of reduced vehicle operating costs and partly down to longer routes being chosen to avoid congestion.

[6] In the model files from which these statistics are extracted, pcus are used throughout. For all user classes other than User Class 5 (HGV), vehicles and pcus are equivalent. For HGVs, each vehicle is represented by 2.5 pcu.

Table 18. Percentage change in vehicle kilometres (Car, All purposes, Simulation Network)

Time Period	2016	2031		
		Pre-Demand Model	Post Demand Model	Post - Pre demand model %diff
AM	828440	951441	994669	5%
IP	509350	630303	706276	12%
PM	875097	1034277	1086533	5%

Table 19. Percentage change in vehicle kilometres (Car, LGV, HGV (pcu), All purposes, Simulation Network)

Time Period	2016	2031		
		Pre-Demand Model	Post Demand Model	Post - Pre demand model %diff
AM	1102172	1276269	1316454	3%
IP	835646	1021559	1094172	7%
PM	1097356	1301054	1353451	4%

6.7.13 As shown in Table 20, rail passenger kilometres increase in the AM and PM average hours but decrease in the inter-peak. Bus passenger kilometres decrease in all three time periods but considerably more in the PM peak and inter-peak periods.

Table 20. Percentage change in passenger kilometres (PT, 'Internal' area only)

Time Period	Mode	2016	2031		
			Pre-Demand Model	Post Demand Model	Post - Pre demand model %diff
AM	Bus	52004	51738	50076	-3%
	Rail	396442	405686	439278	8%
	Total	448446	457425	489355	7%
IP	Bus	35326	57738	41870	-27%
	Rail	224767	266355	271497	2%
	Total	260093	324093	313367	-3%
PM	Bus	41660	57667	44011	-24%
	Rail	486855	504592	559949	11%
	Total	528514	562259	603959	7%

Vehicle Hours

6.7.14 The vehicle hours from the highways model are presented for the simulation network area only, with passenger hours from the PT model presented for all passengers within the internal area.

6.7.15 As shown in Table 21 and Table 22, for car and highways trips there is a very small increase in the AM and PM peaks with a more significant increase in the inter-peak, which reflects the increase in average trip length across each time period as well as the congestion and subsequent decrease in trips in AM and PM.

Table 21. Percentage change in vehicle hours (Car, All purposes, Simulation Network)

Time Period	2016	2031		
		Pre-Demand Model	Post Demand Model	Post - Pre demand model %diff
AM	14247	19023	19070	0.2%
IP	7440	9535	10594	11.1%
PM	14656	19725	19895	0.9%

Table 22. Percentage change in vehicle hours (All Vehicles (pcu), All purposes, Simulation Network)

Time Period	2016	2031		
		Pre-Demand Model	Post Demand Model	Post - Pre demand model %diff
AM	18193	24073	24112	0.2%
IP	11556	14549	15689	7.8%
PM	17710	23623	23821	0.8%

6.7.16 For PT, as presented in Table 23, the pattern is similar to that of passenger kilometres, the demand model increases PT passenger hours by 4% in AM, 0% in PM and reduces them by 12% in the inter-peak, in part due to car trips being made more attractive by reduced operating costs and minimal congestion in the inter-peak and also in part due to passenger kilometres reducing, i.e. trips getting shorter.

Table 23. Percentage change in passenger hours (PT, 'Internal' area only)

Time Period	Mode	2016	2031		
			Pre-Demand Model	Post Demand Model	Post - Pre demand model %diff
AM	Bus	1643	1811	1757	-3%
	Rail	2979	3033	3289	8%
	Total	4623	4844	5046	4%
IP	Bus	1133	1847	1386	-25%
	Rail	1504	1823	1830	0%
	Total	2637	3670	3216	-12%
PM	Bus	1311	1927	1523	-21%
	Rail	3371	3516	3896	11%
	Total	4682	5443	5419	0%

6.8 Summary

The demand model results in a decrease of trips in the AM and PM peak periods for cars but an increase in the inter-peak, when there are generally fewer trips and therefore overall there is less congestion. As shown in Figure 14, the overall distance travelled by car in the simulation area increases across all three time periods. This suggests that the demand model is reducing shorter distance urban trips the AM and PM peaks. Travel time only increases in the inter-peak which corresponds with the pattern of trip growth. Although the number of PT trips increase, as shown in Figure 14, the total passenger kilometres travelled and passenger hours spent within the 'Internal' area decrease for bus across all three time periods and for PT combined in the inter-peak. This suggests that as a result of the demand model PT trips by bus and by both bus and rail in the Inter-peak are shorter, which is balanced out by an increase in passenger hours and passenger distance for rail in the AM and PM periods and for car in the inter-peak.

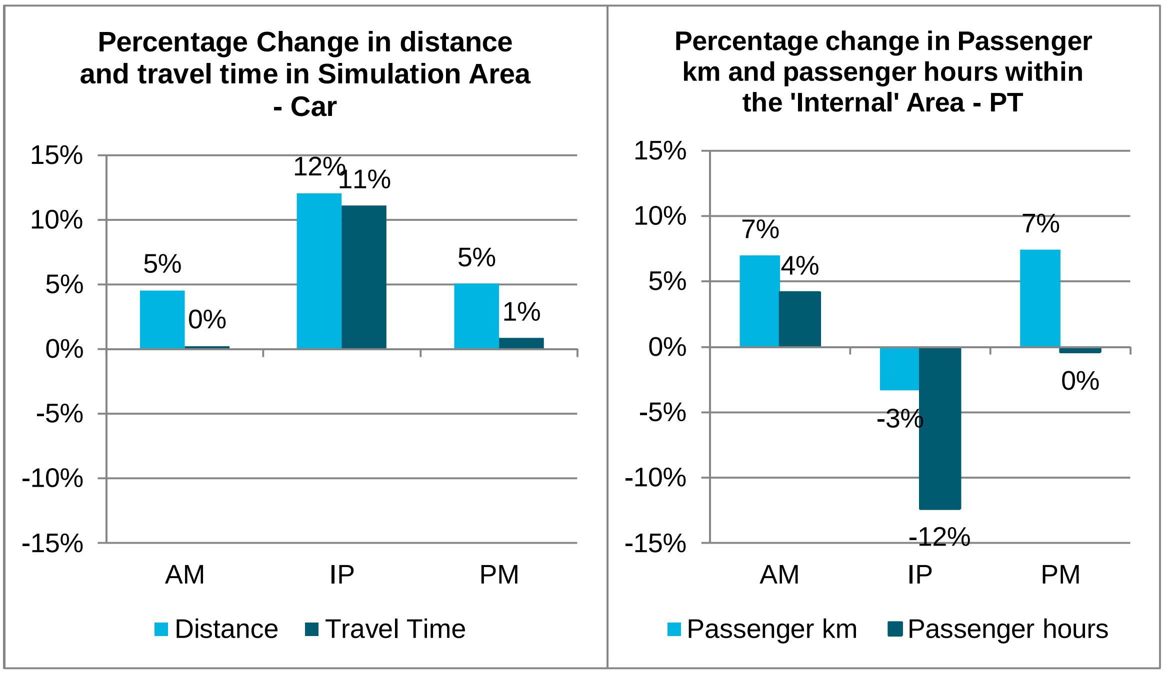


Figure 14. Demand Model impacts in terms of percentage change in distance and travel times

7. Forecast Assignments for Reference Case

7.1 Introduction

7.1.1 This section describes the results of the future year variable demand assignments including model convergence, flow and journey time changes in Milton Keynes, and the variations across the scenarios.

7.2 Highway Assignment Convergence

7.2.1 This is separate from the demand model convergence summarised in Section 6.

7.2.2 The parameter %FLOW was used to assess the convergence within the SATURN assignment model. This measures the percentage of links on which flows vary by more than a pre-defined percentage between consecutive assignment iterations.

7.2.3 Convergence was improved with the use of the parameters RSTOP, PCNEAR and NISTOP which were set at 99, 1 and 4 respectively. This defined convergence as being met when link flows on 99% of all links varied less than 1% for four consecutive iterations. This is more stringent than the WebTAG criteria for base year models as shown in Table 24.

Table 24. WebTAG Convergence Criteria for Base Mode

Measure of Convergence	Base Model Acceptable Values
Delta and %GAP	Less than 0.1% or at least stable with convergence fully documented and all other criteria met
Percentage of links with flow change (P)<1%	Four consecutive iterations greater than 98%
Percentage of links with cost change (P2)<1%	Four consecutive iterations greater than 98%
Percentage change in total user costs (V)	Four consecutive iterations less than 0.1% (SUE only)

Source: WebTAG Unit M3.1

7.2.4 WebTAG provides further guidance on model stability in Appendix C of WebTAG unit M3.1. This recommends that the Average Absolute Difference (AAD) between consecutive iterations and also the Relative Average Absolute Difference (RAAD) in link flows between iterations. It is this which is the preferred measure with a target value of 0.1%.

7.2.5 Table 25 shows a summary of convergence results for 2031 reference case and the 2016 base year model runs. The %Gap figures are all well below 0.1. All highways runs converged within 145 loops with %flows above 99. As such it can be said the highways model is well converged.

Table 25. Summary Convergence Results

	%Gap		Loops		%Flows	
	2016	2031	2016	2031	2016	2031
AM	0.0003	0.0007	35	84	99.9	99.0
IP	0.0000	0.0003	17	48	99.1	99.4
PM	0.0002	0.0009	31	145	99.6	99.3

7.3 Reference Case Variable Demand Forecast Highways Results

Traffic Flows

7.3.1 This section compares the 2031 reference case flows with those of 2016. The flow difference is plotted as bandwidths to the left side of each link by direction, with an increase in actual flow between 2016 and 2031 shown in green and a decrease in blue. It is also important to note that where links have been split to code in forecast reference case schemes then no comparison can be plotted but flows would be similar to those on adjacent links.

7.3.2 As shown in Figure 15 there is a significant amount of re-routing in the AM period. With increases on the main arterial routes such as the M1, A5, A421and A509.

Figure 15. Flow Difference – 2031 Reference case Minus 2016 AM (Actual Flow, pcu/hr)

7.3.3 As shown in Figure 16 there is a noticeable decrease in northbound flows on V8, Marlborough Street north of Childs Way and in both directions south of Childs Way, similarly there is a significant decrease in both directions on Saxon St. These flows have re-routed to the A5 and V6 Grafton Street, which run parallel. These northbound flow reductions are due to the northbound approach to the junction at both South Saxon Roundabout and South Secklow roundabouts exceeding capacity in 2031 AM reference case, caused by the increased flow on Childs Way and therefore increased flow crossing the entry.

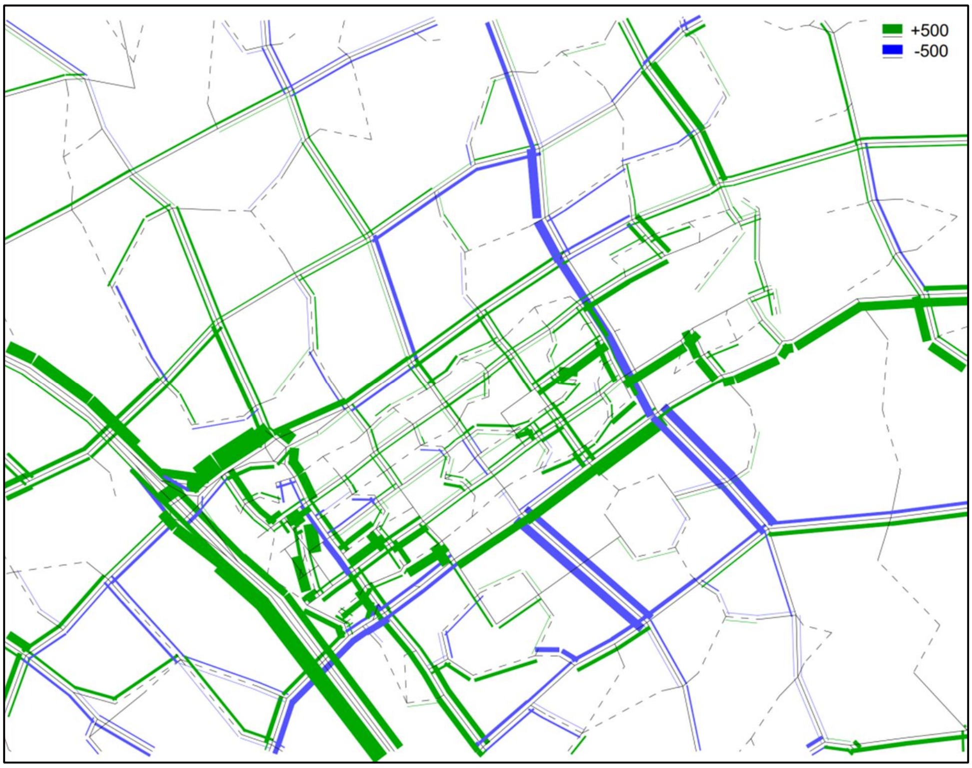


Figure 16. CMK Flow Difference – 2031 Reference case Minus 2016 AM (Actual Flow, pcu/hr)

7.3.4 Figure 17 shows there is a general uplift in actual flow in the inter-peak between 2016 and 2031. This reflects the 28% increase in trips to, from and within Milton Keynes. The trunk roads in particular have large increases in flow as do the A422, A509 and H6 Childs Way across Milton Keynes. Figure 18 shows a general uplift in flows both to and from central Milton Keynes.

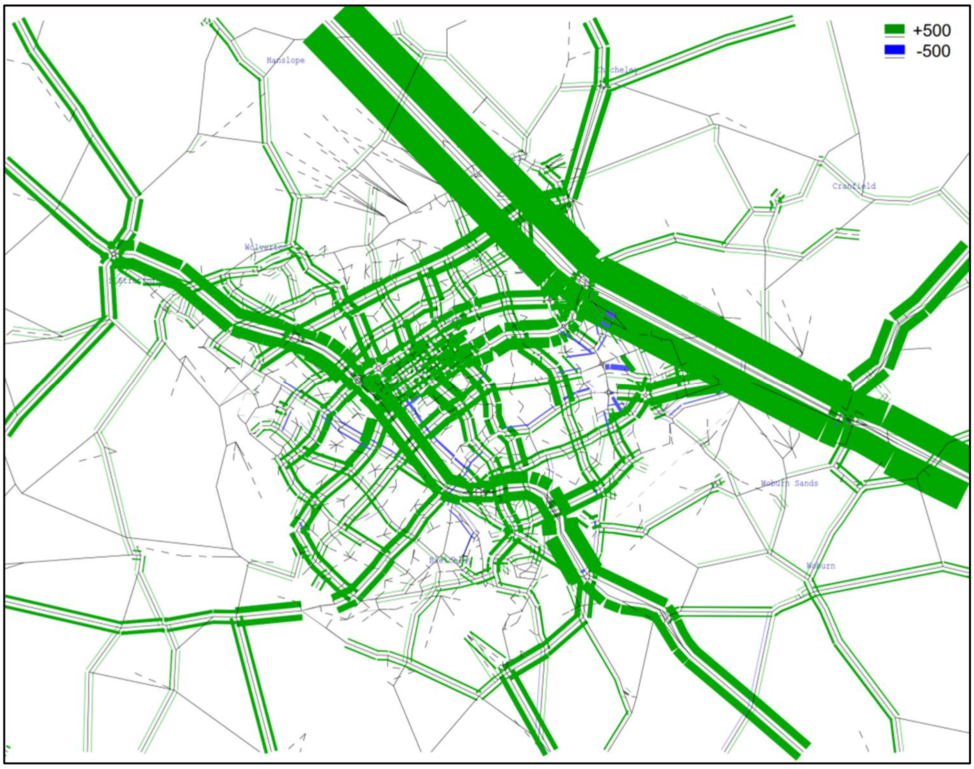


Figure 17. Flow Difference – 2031 Reference case Minus 2016 IP (Actual Flow, pcu/hr)

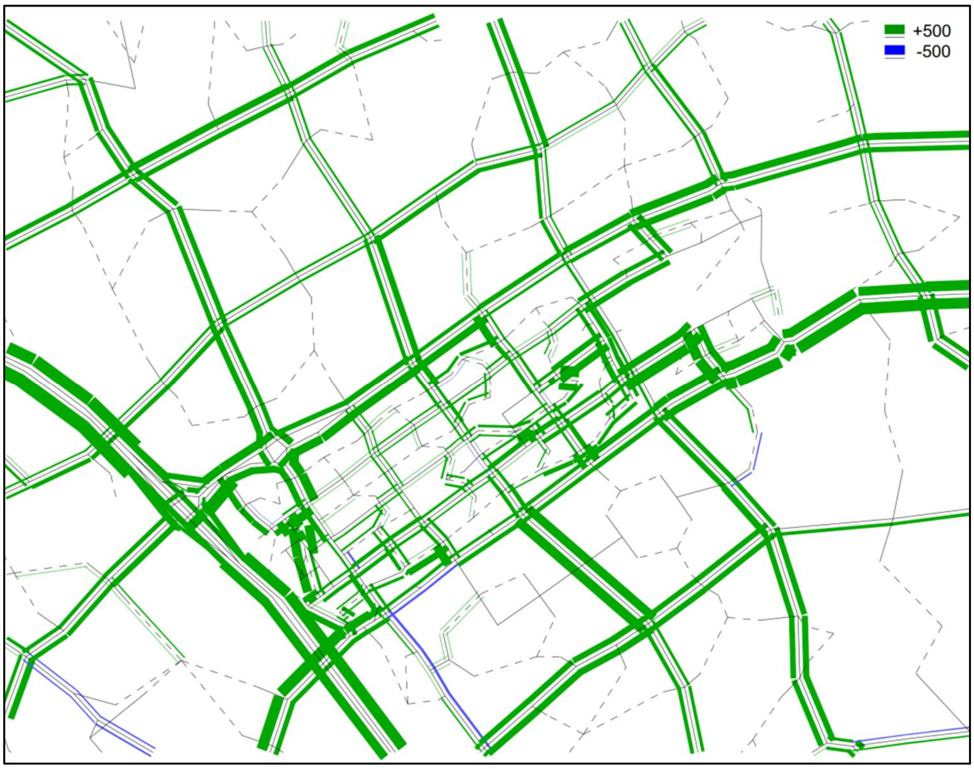


Figure 18. CMK Flow Difference – 2031 Reference case Minus 2016 IP (Actual Flow, pcu/hr)

7.3.5 As in the AM peak, it can be seen from Figure 19 there is considerable increase in flows on the A5 and M1and on the A421 to the East of Kingston Roundabout. Figure 20 shows notable increase in flow both in and out of central Milton Keynes.

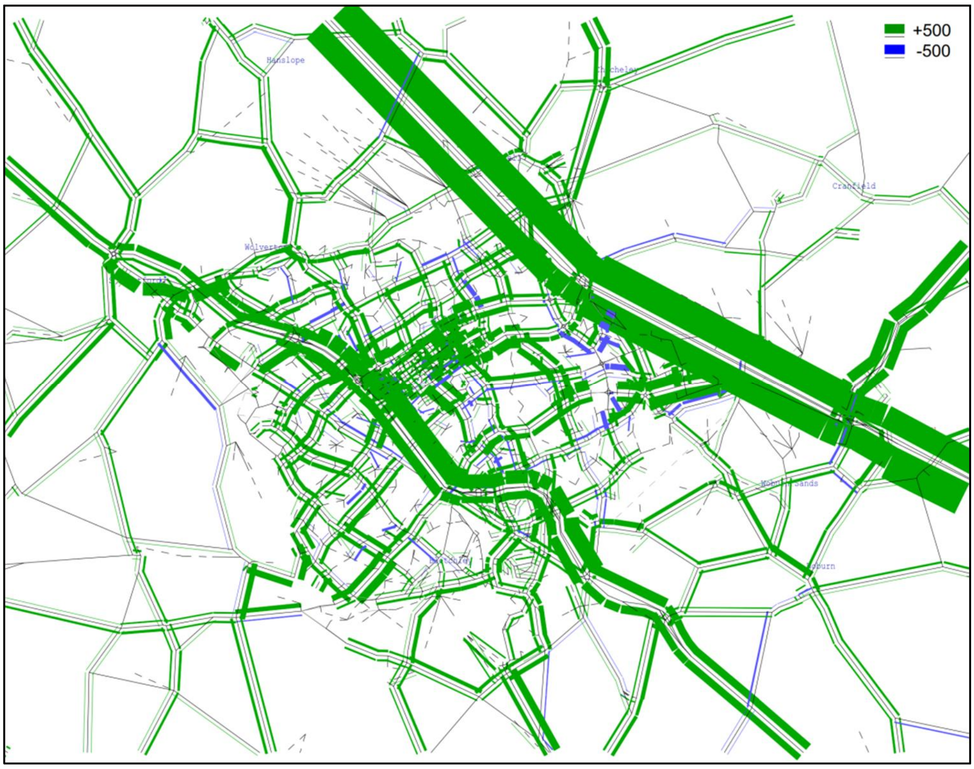


Figure 19. Flow Difference – 2031 Reference case Minus 2016 PM (Actual Flow, pcu/hr)

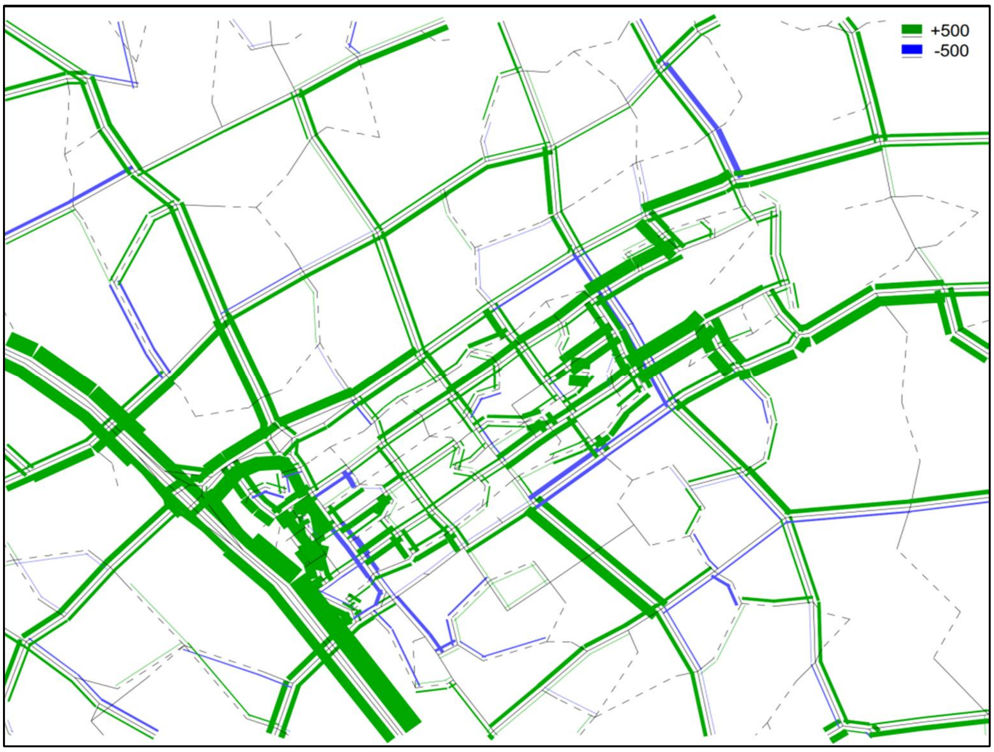


Figure 20. CMK Flow Difference – 2031 Reference case Minus 2016 PM (Actual Flow, pcu/hr)

7.3.6 In addition to actual flow comparison plots, the percentage change in actual flow crossing the cordons and screenlines used as part of the calibration and validation of the base year networks (as shown in Figure 21) has been calculated and is shown in Table 26. The inter-peak period has an uplift of around 30% across most screenlines and cordons with an increase between 55% and 63% in flow crossing the CMK cordon. The comparison for AM and PM is more varied but the flow changes across the CMK cordon are among the largest for each time period. Due to re-routing, flows crossing the Canal cordon eastbound, railway and western screenlines westbound reduce by between three and five per cent.

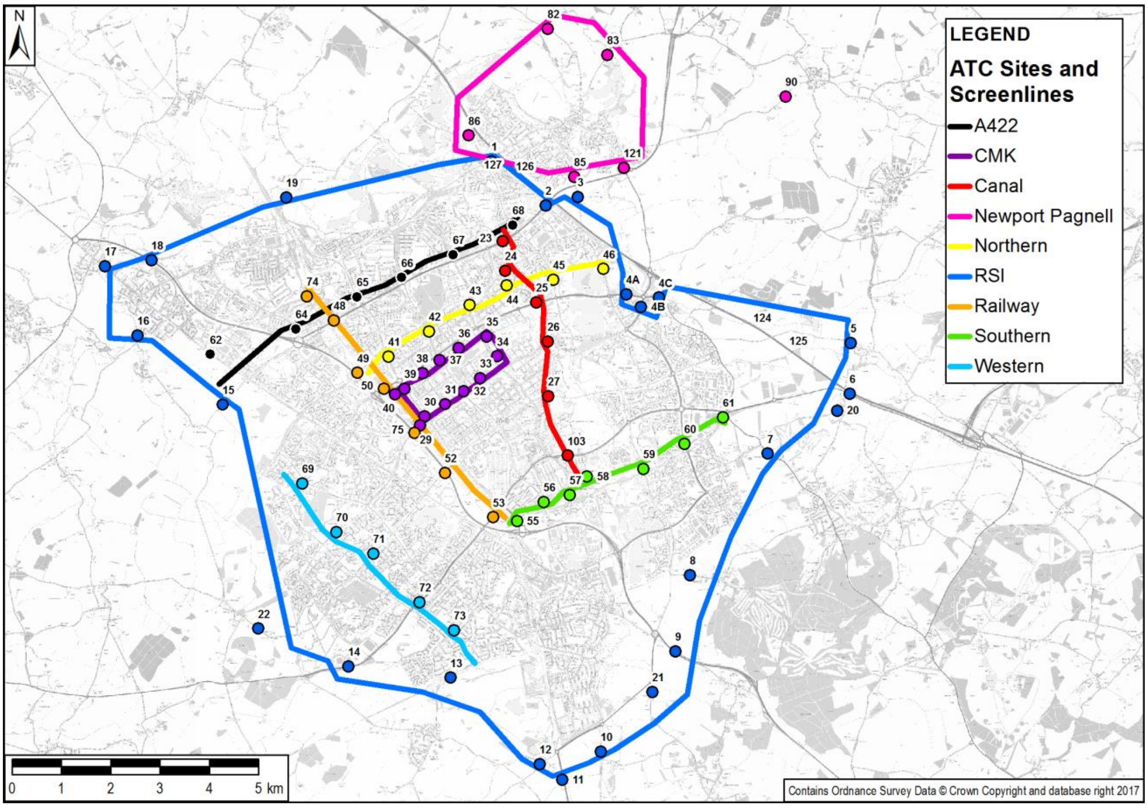


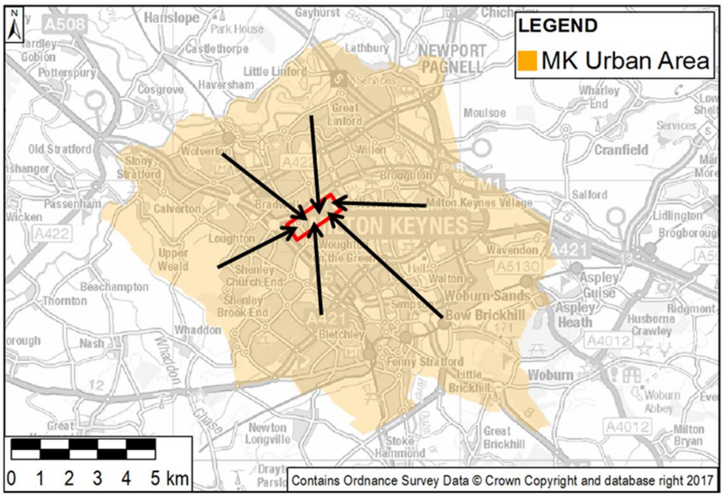
Figure 21. Highway Model Cordons and Screenlines

Table 26. Cordons and SL Flow percentage difference 2016 to 2031 Reference Case

Cordon/Screenline	AM	Inter-Peak	PM
RSI Inbound Cordon	19%	37%	23%
RSI Outbound Cordon	5%	34%	18%
Canal Eastbound	-5%	29%	12%
Canal Westbound	11%	35%	16%
CMK Inbound	35%	63%	48%
CMK Outbound	23%	55%	38%
Northern Southbound	4%	29%	19%
Northern Northbound	5%	27%	23%
Railway Eastbound	14%	29%	15%
Railway Westbound	-3%	26%	15%
Southern Southbound	13%	31%	7%
Southern Northbound	7%	29%	9%
A422 Northbound	2%	28%	11%
A422 Southbound	13%	25%	11%
Western Eastbound	11%	33%	22%
Western Westbound	0%	28%	17%
M1 Northbound	23%	28%	30%
M1 Southbound	27%	30%	26%

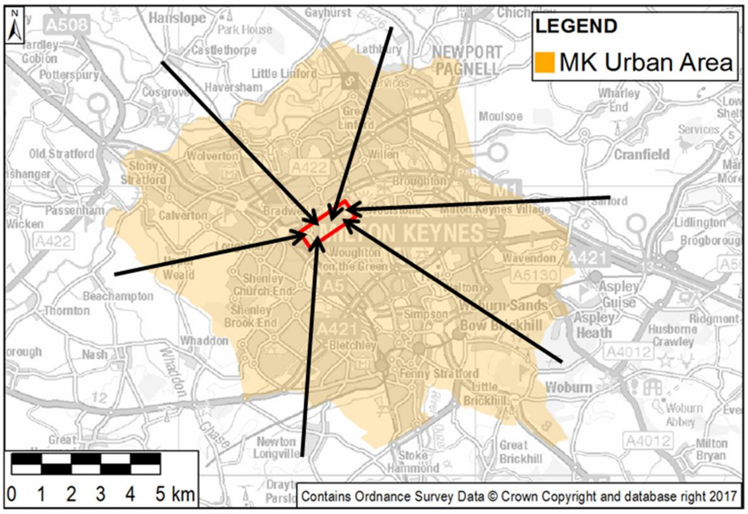
Trips to and from Central Milton Keynes

7.3.7 A select link analysis has been conducted using the central Milton Keynes cordon to enable trips to and from central Milton Keynes to be compared between the 2031 Reference Case and 2016 base year. For the AM Peak trips into central Milton Keynes have been compared and for the PM peak trips out of central Milton Keynes have been compared. The increase in trips between central Milton Keynes and outside Milton Keynes is around twice the increase in trips within the town. The results are presented below in Figure 22 to Figure 25.



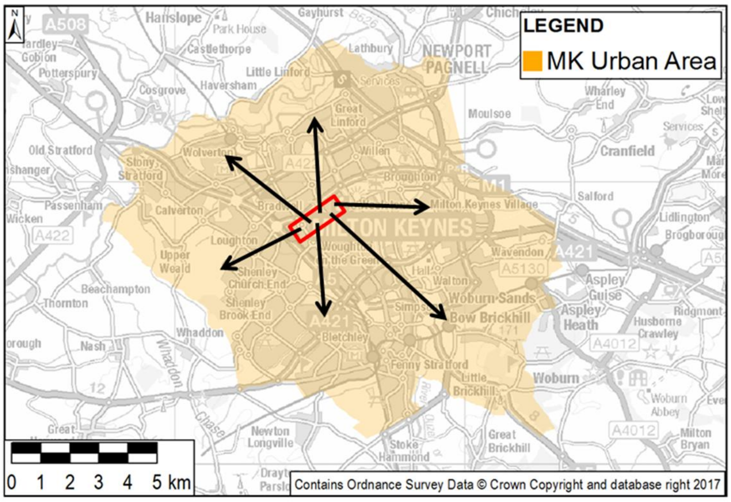
2016 Base Year	5737
2031 Reference Case	7359
Percentage Increase:	28%

Figure 22. Car trips from non-central Milton Keynes to Central Milton Keynes, AM



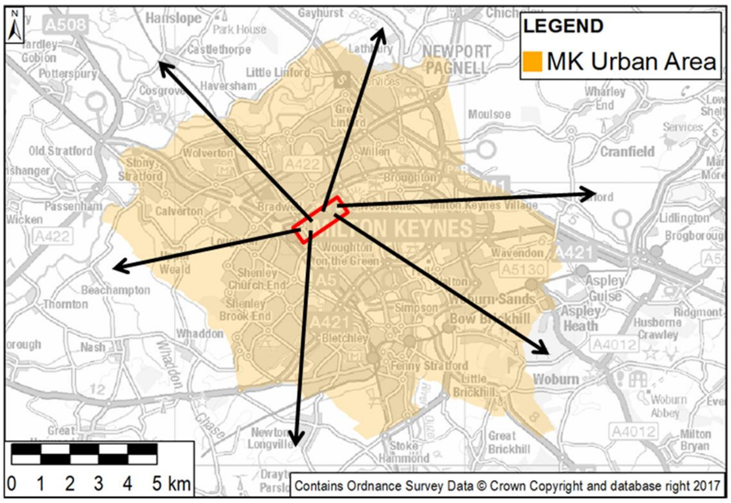
2016 Base Year:	3136
2031 Reference Case:	4574
Percentage Increase:	46%

Figure 23. Car trips from outside Milton Keynes to Central Milton Keynes, AM



2016 Base Year:	5792
2031 Reference Case:	7078
Percentage Increase:	22%

Figure 24. Car trips from Central Milton Keynes to non-central Milton Keynes, PM



2016 Base Year:	2609
2031 Reference Case:	4217
Percentage Increase:	62%

Figure 25. Car trips from Central Milton Keynes to outside Milton Keynes, PM

Volume over Capacity Ratios

7.3.8 It is generally considered that a V/C of over 85% indicates a notable level of congestion. As such plots have been produced showing average junction V/C ratio over 85%, weighted by the turn flows, and link V/C over 85%. The data has been displayed separately to give a clearer indication of where junctions and links are approaching or at capacity in the 2016 base year model, as presented in Figure 26 to Figure 28, and where in the 2031 Reference Case the junctions are similarly impacted, as presented in Figure 29 to Figure 31.

7.3.9 Capacity issues at junctions and links are generally concentrated in the peak time periods, which means that for most of the day during the inter-peak, off-peak and at weekends the network in Milton Keynes runs within theoretical capacity.

7.3.10 This section therefore concentrates on the V/C values identified for:

- 2016 Base Year – AM Peak
- 2016 Base Year – PM Peak
- 2031 Reference Case – AM Peak
- 2031 Reference Case – PM Peak

Base Year 2016

7.3.11 The V/C's for links and junctions in the 2016 Base Model are generally worse in the AM peak than the PM peak. This largely reflects in-commuting to Central MK and circulation of traffic within Central MK (including links to / from the station/shopping centre and other key destinations).

7.3.12 Some of these capacity issues are already dealt with by the Reference Case where schemes have been identified and included within the Local Improvement Plan as Reference Case Schemes i.e.:

- Brinklow/Monkston roundabouts (to be signalised)
- The A421 between M1 J13 and Eagle Farm (to be dualled as part of Central Beds scheme)

7.3.13 Those junctions/links identified in just the AM or both the AM and PM peaks that are not associated with Reference Case Schemes include:

- M1 J14 and Northfield Roundabout (worse in AM Peak) entry point from the M1
- The A422 corridor including the MK entry point to the north east on the A509 – worse in the AM peak with in-commuting and pass through than in the PM peak.
- A5 at Old Stratford Roundabout to the north ease entry and further to the south east at Woburn Road (both AM only)
- The A421 entry links and corridor, including those referred to above but also including MK entry at the south west and key junctions including Watling Street and Grafton Street roundabout junctions (in both peaks).
- Central MK junctions
- Watling Street junctions – (Standing Way/Chaffron Street in both peaks)

7.3.14 It should be noted that Watling Street/Dansteed Way and Watling Street/Portway are Reference Case schemes though do not have high V/C ratios in the Base Year as they are associated with growth in the Western Expansion Area.

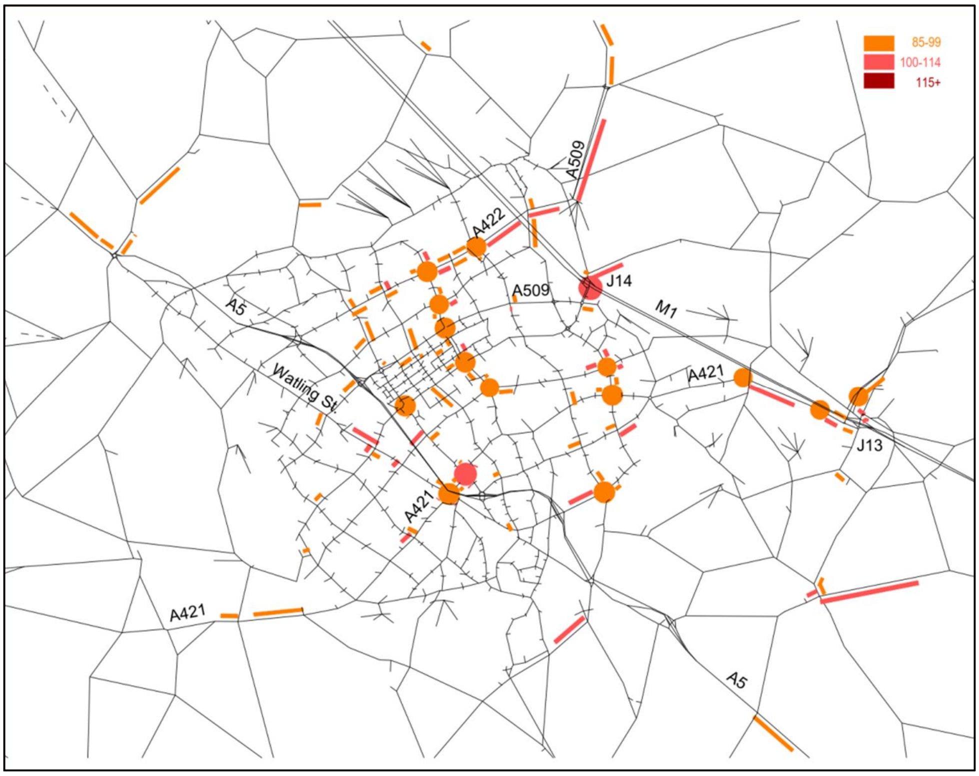


Figure 26. 2016 Base link and junction V/C over 85%, AM Peak

Figure 27. 2016 Base link and junction V/C over 85%, Inter-peak

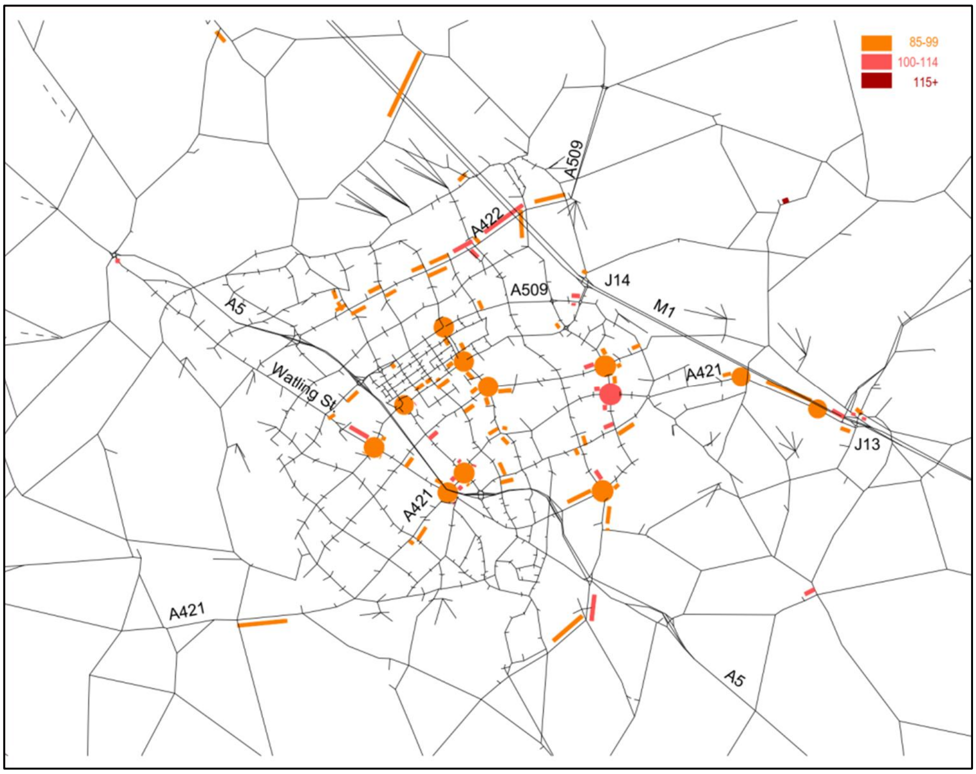


Figure 28. 2016 Base link and junction V/C over 85%, PM Peak

The Reference Case

7.3.15 The Reference Case shows a general worsening of the situation in both peaks. The entry point links referred to above are generally more 'stressed' alongside the internal Central MK network due to the greater level of in-commuting from outside of Milton Keynes.

7.3.16 Of the entry links:

- The A421 junctions are more overloaded in both the AM and PM peaks, though now worse in the PM Peak.
- The A5 links and junctions are showing V/C ratios in excess of 85% in part because traffic seeks alternative options into Milton Keynes as well as the general growth in traffic on the network. The southern entry links are also starting to exceed the V/C threshold. This issue is more pronounced, particularly to the north of Central MK in the AM Peak.
- The A509 entry links are more overloaded and more junctions along the A422 are showing over capacity issues.
- M1 J14 in particular shows a greater level of over capacity than the Base with further stress at Northfield Roundabout, the next junction into Milton Keynes.
- The Reference Case schemes at Dansteed Way (Crownhill) and Portway (Loughton) show some entry link V/C's in excess of 85% however it is likely that further design based on current forecast flows will resolve these issues.
- Watling Street's Junction with Child's Way is now overcapacity in both the AM and PM Peak (as with its junction with the A421 – Elfield Park Roundabout - already referred to in the Base).

- Although the Reference Case schemes at Brinklow and Monkston roundabouts provide additional capacity to help accommodate growth there, there are still delays modelled in the Reference Case. As with Loughton junction further design work based on current forecast flows is likely to resolve these issues. In addition some of the capacity issues appear to have migrated to Walnut Tree Roundabout on the A421.

7.3.17 It is also apparent that the capacity issues at the junctions along Marlborough Street have reduced which is consistent with the reduced flow attributable to re-routing as shown in Figure 16.

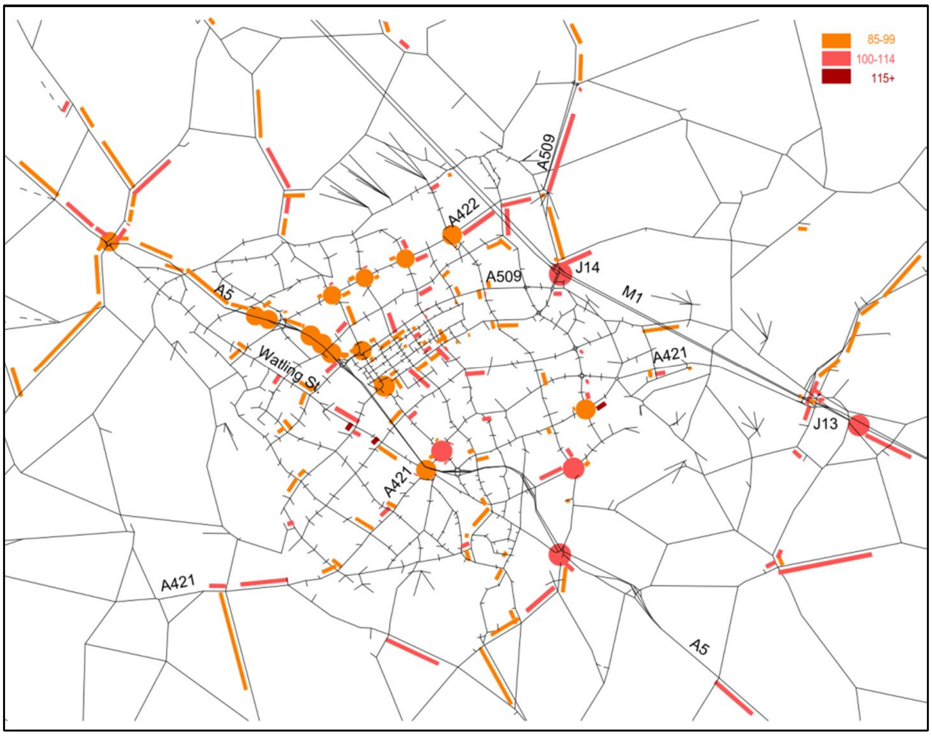


Figure 29. 2031 Reference Case, link and junction V/C over 85%, AM Peak

Figure 30. 2031 Reference Case, link and junction V/C over 85%, Inter-Peak

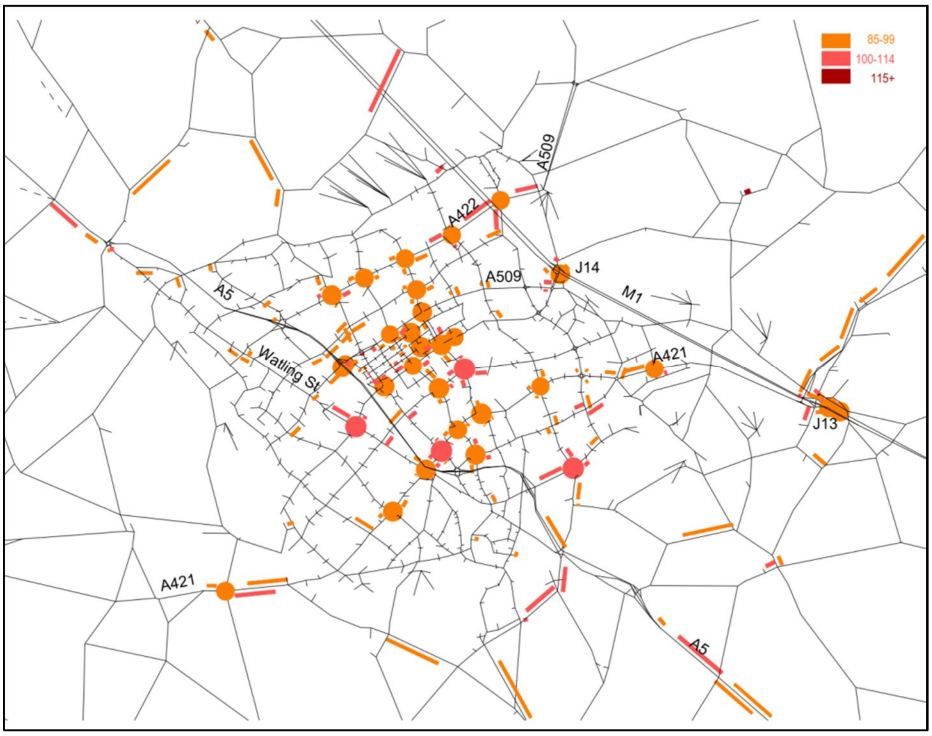


Figure 31. 2031 Reference Case, link and junction V/C over 85%, PM Peak

Junction Delays

7.3.18 The observations made from the V/C analysis are reflected in Figure 32 and Figure 33 which show the extent of delays in the 2016 base and 2031 Reference Case models respectively. The plots display the maximum approach delay per vehicle, the sum of the delay per vehicle on each approach to the junction, and also the total vehicle delay, showing plots the worst case for each junction out of the AM or PM peaks.

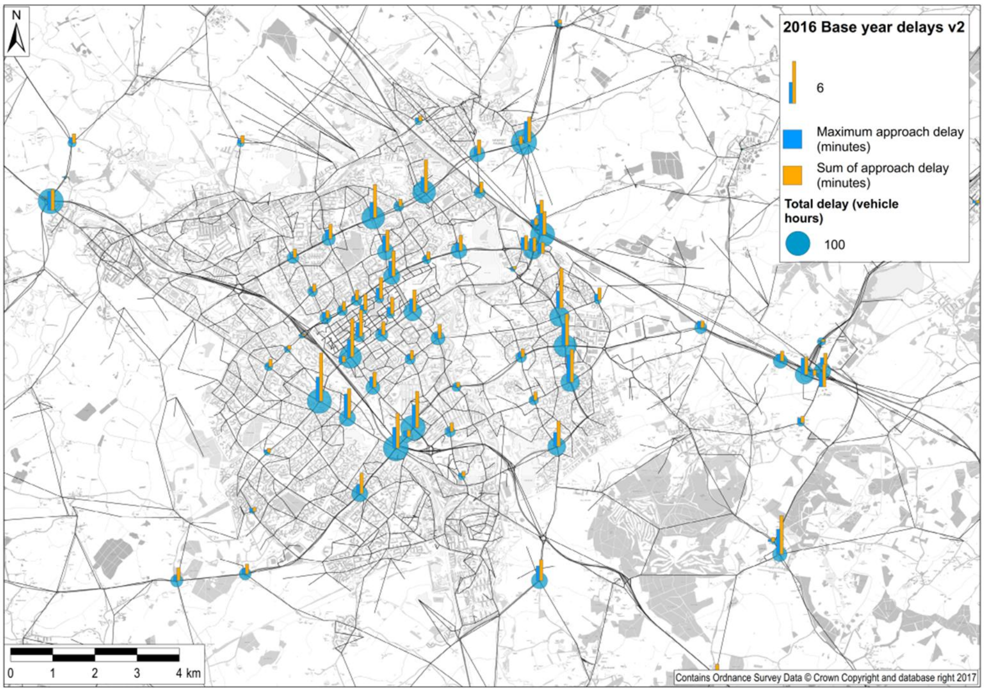


Figure 32. Junction delays 2016 Base

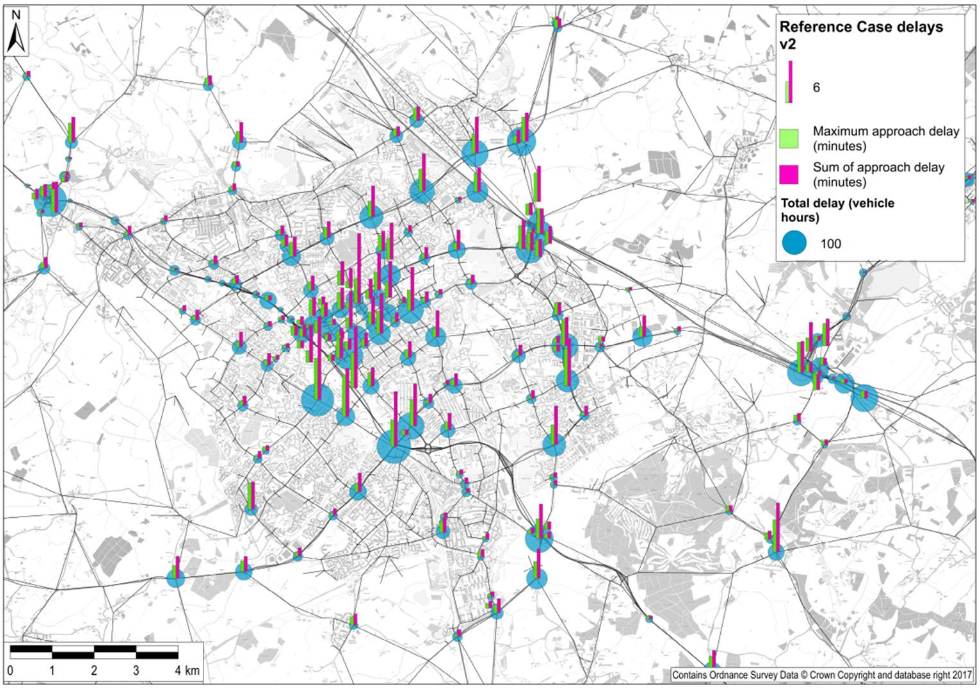


Figure 33. Junction delays 2031 Reference Case

Travel Times

7.3.19 The journey time routes used as part of the model validation as shown in Figure 34 have been used to provide a measure of the impacts of the reference case scenario on travel times. The changes in total travel time along each of the journey time routes are presented in Table 27. Overall the travel time across all routes increases by 14% in the AM peak, 15% in the PM peak and 5% in the inter-peak.

- There is little change on route 7, M1 between J13 and J15 southbound and a reduction northbound as result of the All Lane Running (ALR) scheme which has increased the capacity on that stretch.
- Similarly route 13EB, Milton Keynes Central to M1 J13 via M1 J14, also decreased in the AM because of the reduced travel time on M1. However in the IP and PM the time savings on the M1 are outweighed by increased delays on the rest of the route through Milton Keynes.
- The dualling of the A421 between M1 J13 and Milton Keynes has also reduced the impact on routes 1 and 12.
- The largest increase in journey time is on route 9 northbound in the AM peak. This is the shortest journey time route so the absolute change is smaller than on longer routes. The increase is due to the high V/C ratio at the Bletcham Way Brickhill Street roundabout.

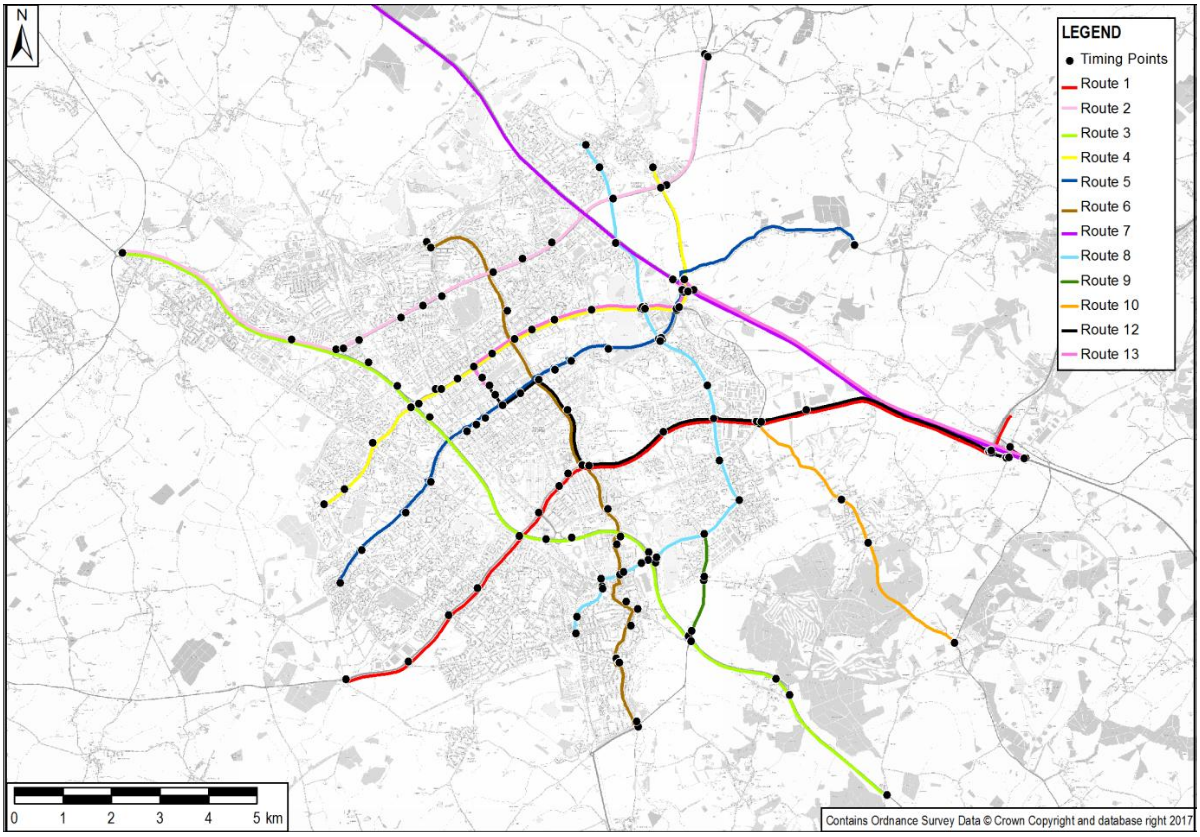


Figure 34. Journey Time Routes

Table 27. Percentage change in journey times 2016 to 2031 Reference Case

Route	Route Description	Percentage Change		
		AM	IP	PM
1EB	A421 to M1 J13	11%	8%	12%
1WB	A421 from M1 J13	15%	3%	5%
2EB	Old Stratford to Chicheley	13%	2%	22%
2WB	Chicheley to Old Stratford	18%	3%	16%
3SB	Old Stratford to Watling, Little Brickhill	9%	5%	20%
3NB	Watling, Little Brickhill to Old Stratford	26%	4%	13%
4EB	Portway/Fulmer St to Newport Pagnell	16%	3%	25%
4WB	Newport Pagnell to Portway/Fulmer St	16%	5%	15%
5EB	Moulsoe to Child's Way / Tattenhoe St.	19%	9%	18%
5WB	Child's Way / Tattenhoe St. to Moulsoe	33%	7%	17%
6SB	Saxon St. / Newport Rd. to A4146 / Stoke Rd.	4%	3%	18%
6NB	A4146 / Stoke Rd. to Saxon St. / Newport Rd.	22%	3%	8%
7SB	M1 J15 to M1 J13	0%	1%	0%
7NB	M1 J13 to M1 J15	-3%	-2%	-3%
8SB	Newport Pagnell to Bletchley	17%	8%	12%
8NB	Bletchley to Newport Pagnell	8%	7%	19%
9SB	Brickhill Street Southbound	7%	16%	14%
9NB	Brickhill Street Northbound	63%	12%	43%
10SB	A5130 through Woburn Sands SB	9%	9%	15%
10NB	A5130 through Woburn Sands NB	14%	9%	10%
12EB	MK central to M1 J13 via A421	1%	10%	32%
12WB	M1 J13 to MK Central via A421	18%	0%	10%
13EB	MK Central to M1 J13 via M1 J14	-2%	5%	40%
13WB	M1 J13 to MK Central via M1 J14	22%	5%	11%
Total		**14%**	**5%**	**15%**

Average speeds

7.3.20 The average network speeds by time period are presented in Table 28. Corresponding with the levels of congestion in the models, the largest reduction is in the AM peak where speed reduces by 10% with the least reduction in the inter-peak.

Table 28. Average speeds change

HW	AM Peak	Inter-Peak	PM Peak
Average Network Speed	-10%	-4%	-8%

Trip Length Distribution

7.3.21 Trip length distribution plots comparing the 2031 Reference Case Scenario against the 2016 base year scenario are presented in Appendix B. The plots for the AM period are also presented below in Figure 35 to Figure 37. To better assess the impacts local to Milton Keynes, only trips with origins within the Milton Keynes cordon have been analysed.

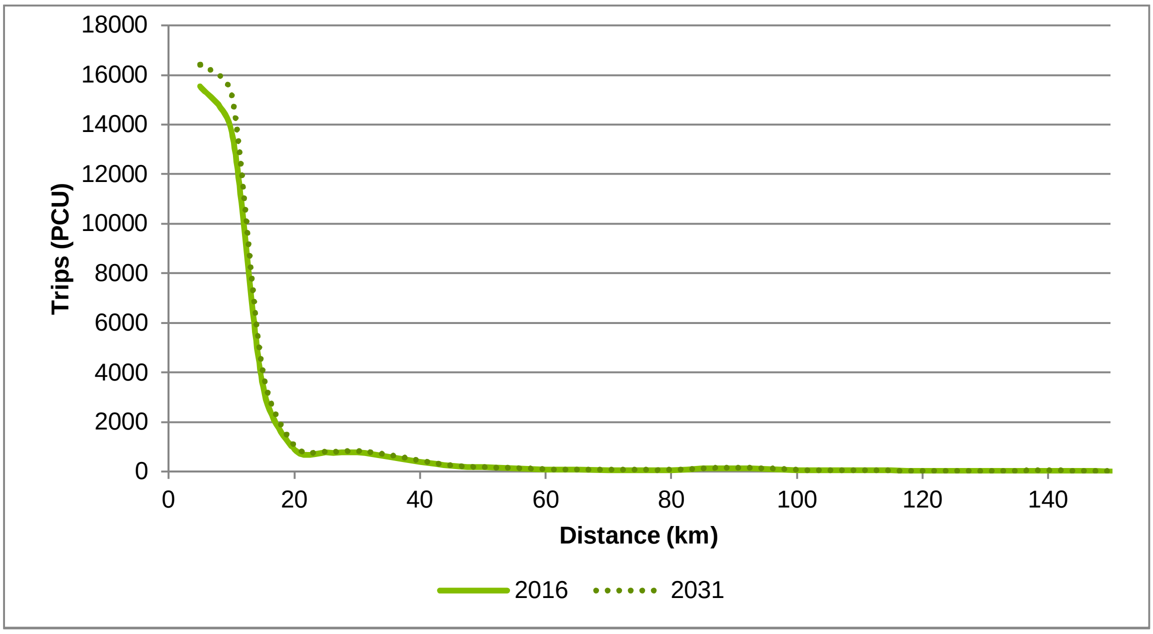


Figure 35. Trip Length Distribution 2031 Reference Case and 2016: AM Car, Trips <150km

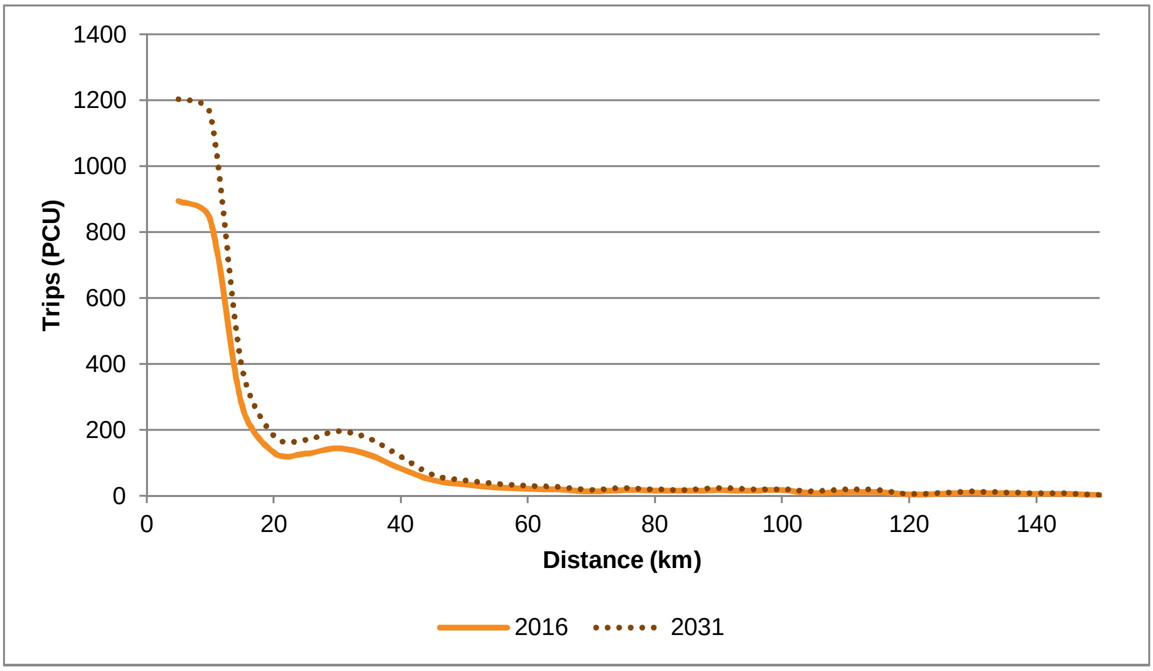


Figure 36. Trip Length Distribution 2031 Reference Case and 2016: AM LGV, Trips <150km

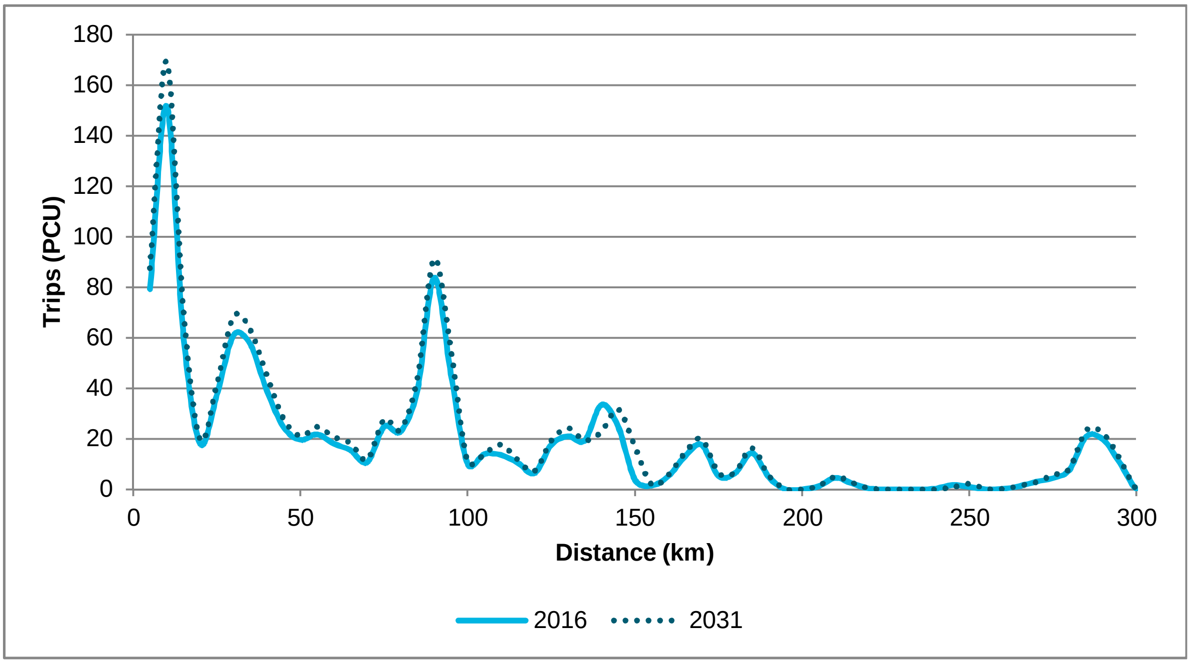


Figure 37. Trip Length Distribution 2031 Reference Case and 2016: AM HGV, Trips <300km

7.3.22 The average trip distance has been calculated for the 2031 reference case assignments and compared with that of the 2016 assignments and is presented in Table 29 to Table 31. As with the TLD plots these exclude trips originating outside of the Milton Keynes Cordon. There is little change in the mean LGV and HGV trip length with changes between 0.2 and 0.7%. There are however more significant changes for car, with a relatively smaller increase in the AM peak compared to the PM peak and inter-peak. The increase in mean trip length is as a result of the reduced vehicle operating costs and could partly be due to re-assignment to longer routes to avoid congestion.

Table 29: Change in Average Trip Length 2016 to 2031 Reference (Excluding Ext Origins): AM

	Car	LGV	HGV	All Vehicles
2016 Mean Trip Length	11.8	20.3	81.3	14.4
2031 Mean Trip Length	12.3	20.4	81.5	14.9
Percentage Change	3.8%	0.6%	0.3%	4.0%

Table 30: Change in Average Trip Length 2016 to 2031 Reference (Excluding Ext Origins): IP

	Car	LGV	HGV	All Vehicles
2016 Mean Trip Length	11.6	19.5	75.1	15.5
2031 Mean Trip Length	14.0	19.6	75.3	17.2
Percentage Change	19.8%	0.4%	0.2%	11.0%

Table 31: Change in Average Trip Length 2016 to 2031 Reference (Excluding Ext Origins): PM

	Car	LGV	HGV	All Vehicles
2016 Mean Trip Length	15.0	21.7	83.9	16.2
2031 Mean Trip Length	17.2	21.9	84.2	18.2
Percentage Change	14.8%	0.7%	0.4%	12.9%

7.4 Reference Case Variable Demand Forecast PT Results

Passenger Volume

7.4.1 This section provides indicative plots showing the changes between the 2031 reference case PT Assigned volumes, i.e. passengers, and those of 2016. As with the highway model comparison plots, an increase in actual flow between 2016 and 2031 is shown in green and a decrease in blue.

7.4.2 A comparison of the AM 2031 reference case average hour against the 2016 AM Average hour, is presented in Figure 38 and Figure 39. It can be seen that rail volumes on the West Coast mainline increase the most. Overall bus passengers increase but on some routes there is a decrease. Although increased bus journey times due to increased highways congestion is a factor, the main reason for the decrease in flows is due to the introduction of East West Rail. It can be seen that it is routes parallel to this line that decrease, for example the X5 between Oxford and Bedford. There is also a decrease in bus passengers between Bletchley in Milton Keynes Central; this is due to the increased frequency in trains between Bletchley and Milton Keynes Central as part of the East West Rail scheme.

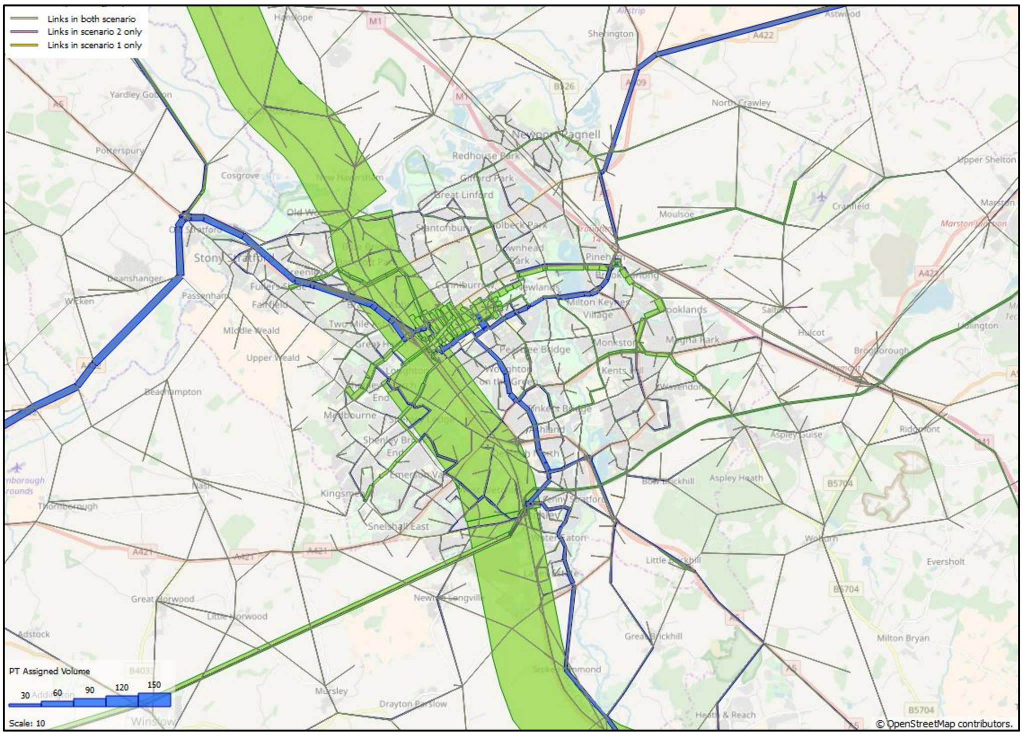


Figure 38. PT Flow Difference – 2031 Reference case minus 2016, AM (passengers/hour)

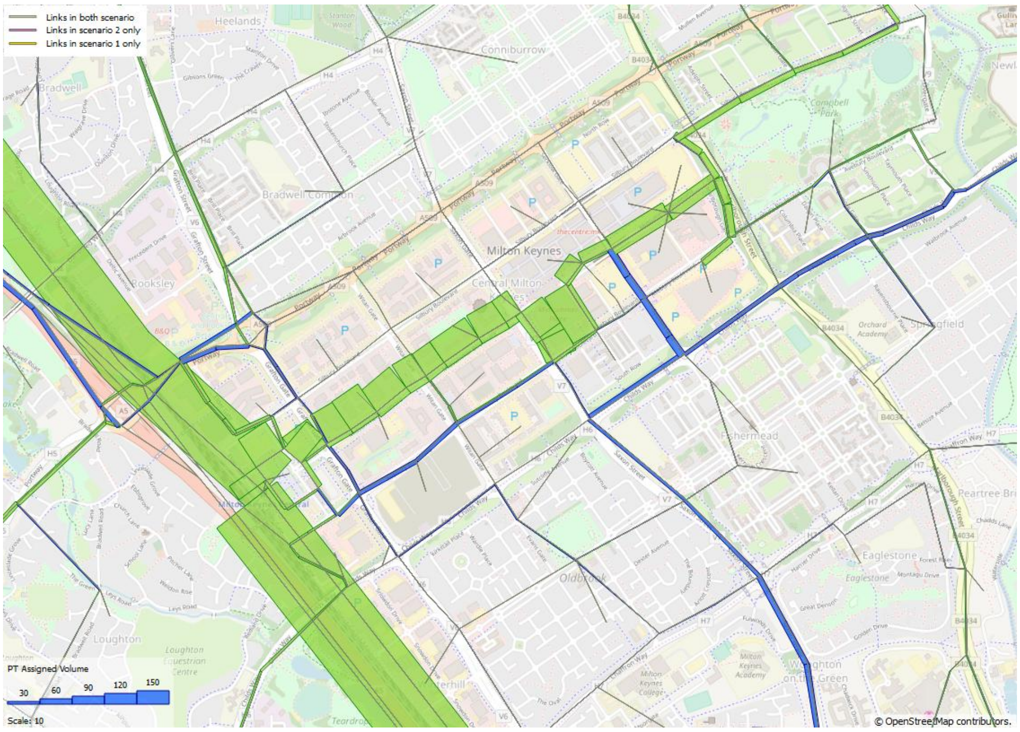


Figure 39. CMK PT Flow Difference – 2031 Reference case minus 2016, AM (passengers/hour)

7.4.3 As shown by Figure 40 and Figure 41 both Rail and bus passengers are forecast to increase between 2016 and 2031 across the extent of the Public transport network in the Inter-Peak. This is as expected due to increased trips and only a small impact on bus journey times due to a small increase in highways congestion.

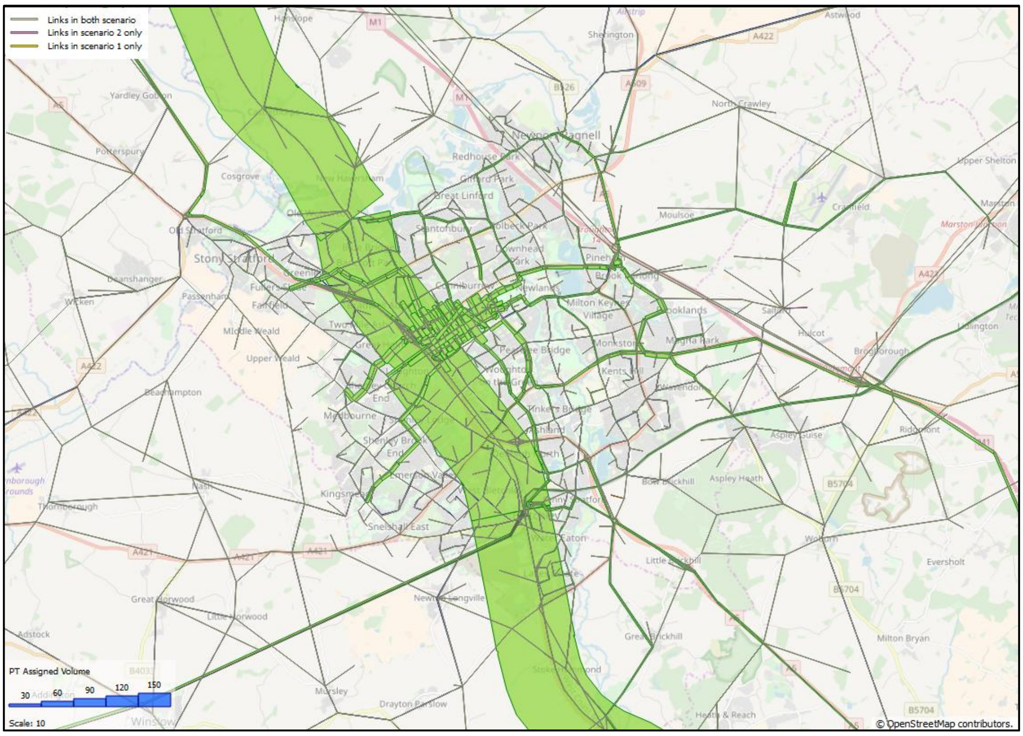


Figure 40. PT Flow Difference – 2031 Reference case minus 2016 IP, (passengers per hr)

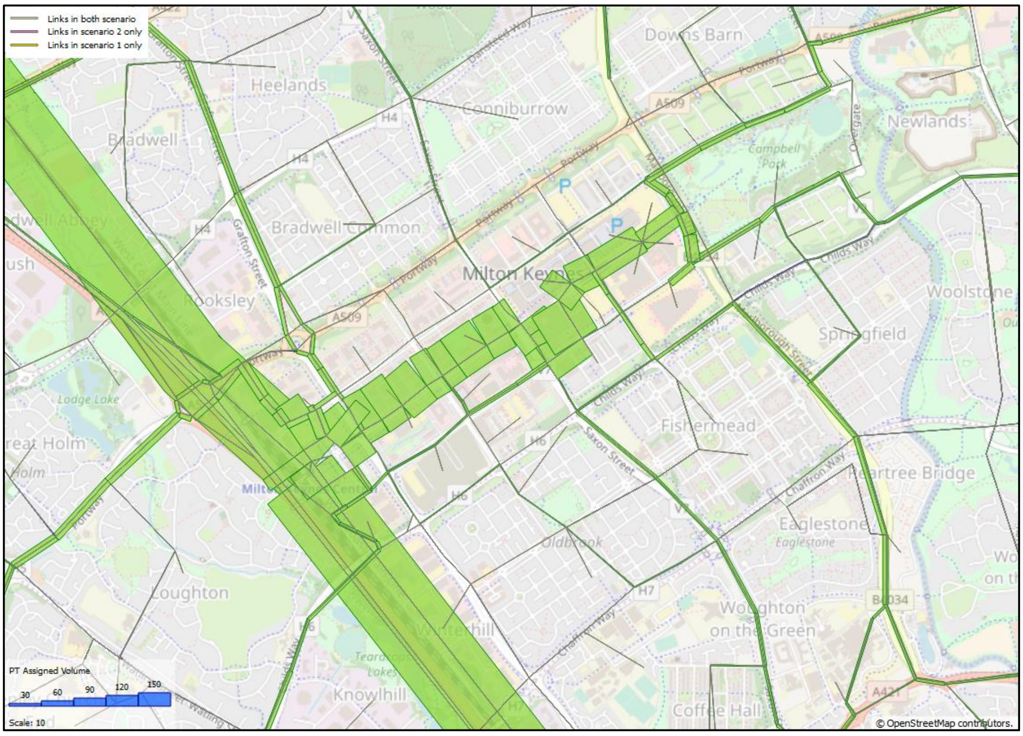


Figure 41. CMK PT Flow Difference – 2031 Reference case minus 2016, IP (passengers per hr)

7.4.4 The PM comparison plots in Figure 42 and Figure 43 show a similar picture to the AM average hour, with a fall in bus passengers on the route between Oxford and Bedford. However due to the smaller changes in journey time compared to the AM, the reductions are not to the same extent, and there is an increase in bus trips between Central Milton Keynes and Bletchley as opposed to the decrease in the AM.

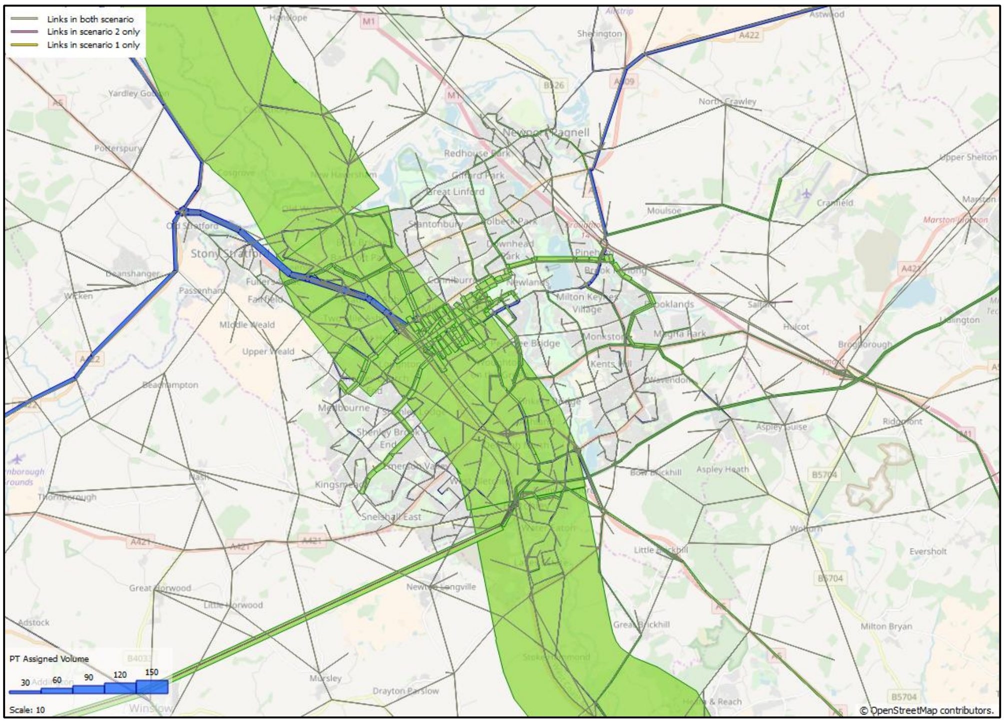


Figure 42. PT Flow Difference – 2031 Reference case minus 2016, PM (passengers per hr)

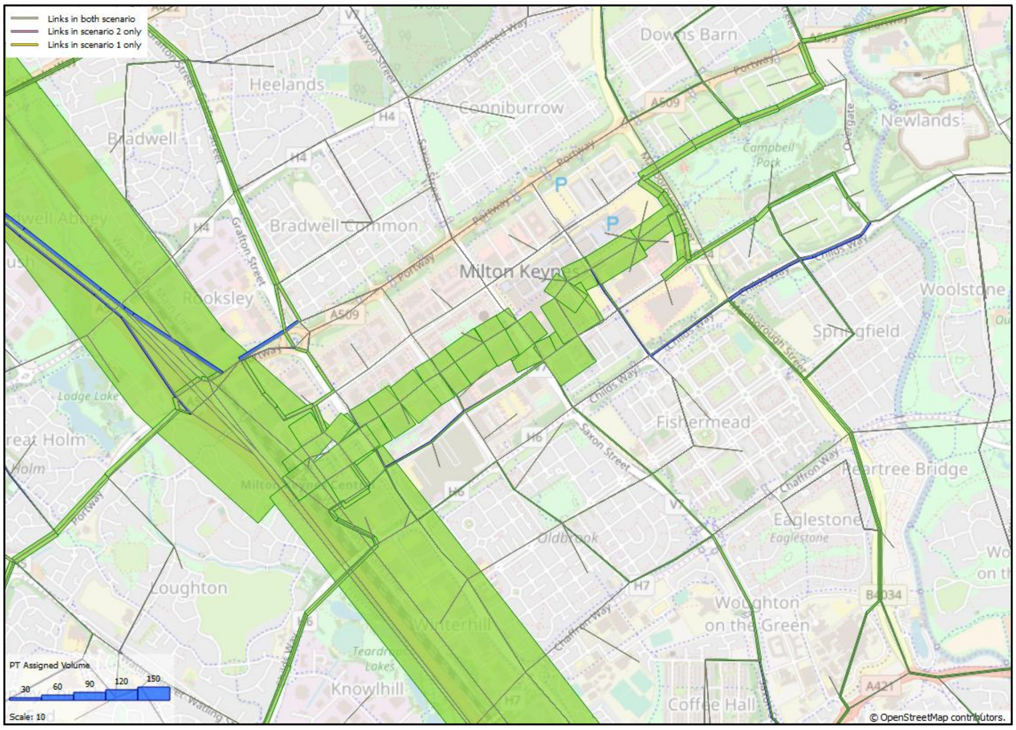


Figure 43. CMK PT Flow Difference – 2031 Reference case minus 2016, PM (passengers/hr)

8. Summary and Conclusions

8.1 Introduction

8.1.1 Milton Keynes Council (MKC) commissioned AECOM to update the Milton Keynes Multi-Modal Model (MKMMM) in advance of the need for its use to test alternative planning options for Plan:MK. The main purpose of the model will be to provide a robust means of assessing alternative land-use options and development phasing and for this to withstand public scrutiny. The objective was to develop a Reference Case to enable testing of plan options. This requires the model to be sufficiently well validated to 2016 compared with the existing 2009 model) using additional new data sources.

8.2 Reference Case

8.2.1 The 2031 Reference Case includes the planned growth in Milton Keynes District up to 2031, this being in the region of 20,000 dwellings and 28,000 jobs in Milton Keynes district, along with highways and rail infrastructure in Milton Keynes and its vicinity that is expected to be in place by 2031. Development in Aylesbury Vale (the South West Milton Keynes development, circa 2000 dwellings and 1000 jobs) has also been included in the Reference Case due to its close proximity to Milton Keynes.

8.3 Modelling Software

8.3.1 SATURN version 11.3.12U was used for the highway assignment modelling and Emme version 4.2.9 was used for the demand and public transport modelling. The Demand modelling estimates the effects of changes in infrastructure and in travel costs on patterns of demand.

8.4 Supply and Demand Forecast Scenarios

8.4.1 The 2031 forecast trip ends were calculated using the trip end model containing household, jobs, population and car ownership data. Forecast figures for these data sets were produced using two different approaches:

- Within Milton Keynes district the housing and jobs growth data provided by MKC was used along with changes in the population and car ownership between 2016 and 2031 from the DfT National Trip End Model (NTEM) version 7.2.
- The housing and jobs growth for the SWMK development in Aylesbury Vale was also input explicitly with other growth in Aylesbury Vale constrained as much as possible to NTEM
- NTEM 7.2 forecast figures were used elsewhere for the housing, jobs, population and car ownership data.

8.4.2 An Uncertainty Log was developed in association with officers at MKC and this was used to derive future supply in terms of road and rail infrastructure schemes deemed appropriate to include based on likelihood. These schemes were added to the base year networks to create the reference case networks.

8.5 Variable Demand Modelling

8.5.1 To estimate the demand the 2031 trip ends produced from the trip end model were input into the variable demand model which was run using the forecast networks. In the highways model the forecast values of time increased and there was also a change in vehicle operating cost. For PT a 1% increase in fares per year was assumed, with the fares in the modelled factored up accordingly.

8.5.2 Examination of the trips internal to the Milton Keynes cordon and those crossing the Milton Keynes cordon both prior and post the demand model run, found highways trips with both origins and destination in MK reduced in the inter-peak also but both trips to and from Milton Keynes increase by 7% and 8% respectively. In both the AM and PM peaks there was a 1% reduction in highways trips within Milton Keynes. Due to the tidal flows into and out of Milton Keynes in the peaks, trips into Milton Keynes in the AM reduced by 3% with trips out of Milton Keynes in the PM reducing by 2%. Conversely trips out of Milton Keynes in the AM Peak, increased by 10% and into Milton Keynes in the PM Peak increased 5%. In the Inter-Peak due to much lower levels of congestion, compared to the AM and PM peaks, both trips to and from Milton Keynes increased by 8% and 9% respectively.

8.5.3 The same analysis for public transport shows a reduction in trips internal to Milton Keynes of 4% and 3% in the AM and PM respectively with no change in the inter-peak. However across all three time periods public transport trips to and from Milton Keynes increase.

8.5.4 Vehicle-kilometres for car trips within the simulation area increase in all three time periods, particularly in the inter-peak, as shown in Figure 14. In contrast although passenger kilometres increase by more than car kilometres, there is a decrease in the inter-peak. These results suggest as a result of reduced vehicle operation costs average trip length is increasing in each time period of the highway model. The additional congestion in the highways model also facilitates growth in average trip length in the public transport model, however in the inter-peak as levels of congestion are much lower in the highways model, car as mode is more attractive than public transport for long distance trips.

8.5.5 For car and highways trips there is a very small decrease in average travel time in the AM and PM peaks and an increase in the inter-peak, which reflects the decrease in trips in AM and PM and increase in the Inter-Peak. In the AM and PM peaks passenger hours increase in the PT model at a greater percentage than trips increase, indicating that the average trip length is increasing. In contrast in the inter-peak there is an 12% reduction, in part due to car trips being made more attractive by reduced operating costs and minimal congestion in the inter-peak and also in part due to passenger kilometres reducing, i.e. trips getting shorter.

8.6 Trips

8.6.1 Despite the impact of the demand model reducing some traffic in the model, there is still a significant overall increase in traffic between 2016 and 2031. As shown in Figure 44, between 2016 and 2031, the number of car trips, within, to and from Milton Keynes increases from 15% in the AM Peak to 28% in the Inter-Peak. The number of Public Transport trips increase from 18% in AM Average hour to 33% in the Inter-Peak.

8.6.2 The model shows that car trips from the Milton Keynes Urban Area to central Milton Keynes increase by 28% between 2016 and 2031 with trips from outside Milton Keynes to central Milton Keynes increasing 46%.

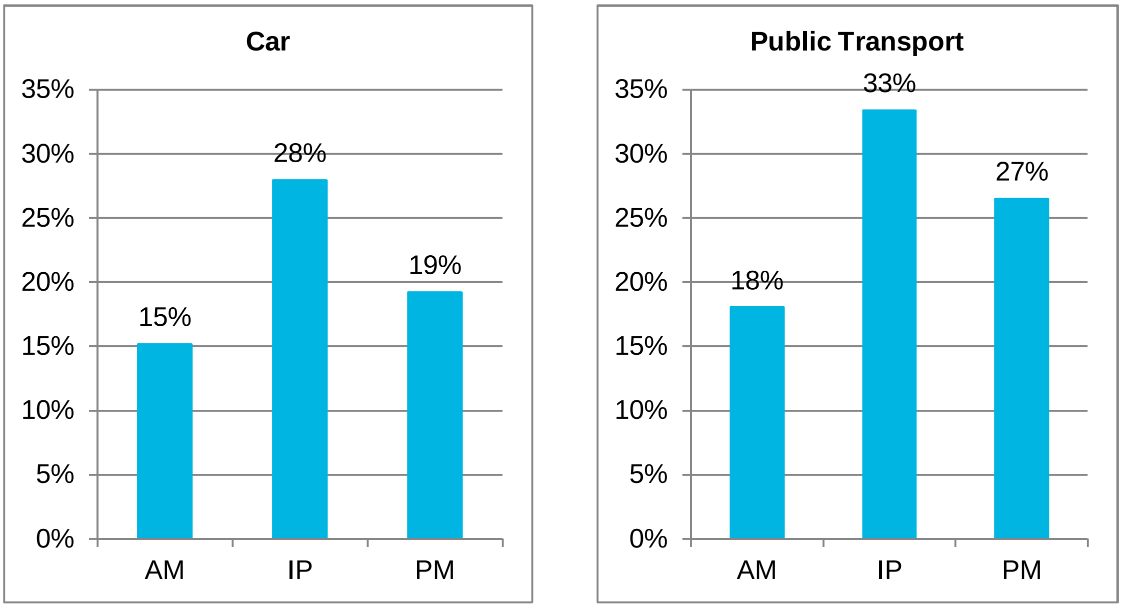


Figure 44. Percentage change in matrix totals between 2016 and 2031 Reference Case (all purposes excluding Ext – Ext Trips)

8.7 Flows and V/C Ratios

8.7.1 The reference case highway assignments show a significant increase in flow on the strategic road network such as the M1, A5, A421 and A509. There is an almost blanket increase in flow across the inter-peak highway network. However due to some significant increases in delay at key junctions there is some re-assignment in the AM and PM time periods, most notably in the AM Peak.

8.7.2 Despite the inclusion of schemes such as the A421 dualling and Brinklow and Monkston improvements, overall there is an increase in junctions with an average V/C ratio over 85% and links over 85%, particular on corridors into Milton Keynes as a result of the large increase in trips to central Milton Keynes from outside the Milton Keynes Urban Area. Due to the re-assignment in the AM peak there are some junctions where the average V/C falls below 85%, however it is important to note that certain junction arms are still over capacity.

8.8 Travel Time and Average Speeds

8.8.1 Between 2016 and the 2031 Reference Case the model forecasts increases in journey times across Milton Keynes. The exceptions being on the M1 between J13 and J15 which is due the introduction of the all lane running scheme and on the A421 between M1 J13 and Eagle Farm roundabout as a result of the dualling scheme. The Reference Case highway assignments show that the journey times across Milton Keynes increase on average by 14% and 15% in the AM and PM Peaks respectively and 4% in the Inter-Peak. In the simulation area average network speeds decrease by 10%, 4% and 8% in the AM, Inter-peak and PM respectively.

8.9 Trip Lengths

8.9.1 The average trip lengths increase across the whole highways matrix, though changes for LGV and HGV were minimal. The increase in car average trip length is highest in the inter-peak and lowest in the AM reflecting the levels of congestion which impact against the lower vehicle operating costs.

8.10 Model Limitations

8.10.1 It should be noted that the Milton Keynes model is a strategic model where much of the highways trips internal to Milton Keynes (originate and are destined within the Milton Keynes Cordon) are synthesised; i.e. based upon industry standard and accepted assumptions on trip generation rates using land use data.

8.10.2 It is also important to note that the model was not designed for use in a scheme specific assessment. For such an assessment it is recommended a revised forecast model would be produced from a recalibrated base year model using additional and more recent data and targeted to reflect a more specific geographical focus of resources and modelling effort.

8.10.3 It is important to consider that the public transport model is, as per WebTAG guidance, an incremental model which means although it provides a good indication of travel patterns at a strategic level; it will not necessarily give a definitive view of the impact of public transport measures such as East West rail. Rather it is designed to assess impact of relatively small changes to existing services rather than the addition of a completely new service.

8.11 Future Improvements

8.11.1 A feedback loop between the highways model and the Public Transport Model to automatically update the bus travel times in accordance with the changes in travel times in the highway model would improve the accuracy of forecast bus travel times.

8.11.2 The fixed speed links in the highways buffer network should be lowered to represent the impact of higher flows on link speed. This could have an impact on long distance public transport trips coming into or going out of Milton Keynes as the attractiveness of highway as a mode would be reduced.

8.11.3 It may also be desirable to incorporate modelling of Park & Ride schemes within the model suite if MKC have aspirations to increase the provision of this form of access to Central MK. Additional survey data would be required to incorporate such a model.

8.11.4 There would also be a benefit in including a parking model within the modelling suite although this would require also require appropriate additional survey data.

8.12 Conclusions

8.12.1 The modelling as outlined in this report has been carried out in accordance with the Department for Transport's WebTAG criteria as applicable, and is based on a base year model validated against observed count and journey time data. The forecast results appear sensible and plausible. As such it is considered that the Reference Case model provides a suitably robust benchmark against which to assess Plan:MK.

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