Norwich - Northern Distributor Road

Major Scheme Business Case
Sensitivity Tests for DfT

Tests 2 to 6

Volume 1 – Main Report

December 2009
Norfolk County Council

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Summary

The Department for Transport (DfT) asked for a range of sensitivity tests to be carried out in order to better understand uncertainties associated with the analysis undertaken for the Major Scheme Business Case for the Norwich Northern Distributor Route (NNDR).

Test 1 comprised investigation of dependent development using the methods given in DfT's consultation draft Transport Analysis Guidance (TAG) Unit 3.16C, Appraisal in the Context of Housing Development. Following that investigation, a revised Core Scenario was defined, and model runs and economic assessment carried out. This work is detailed in the Dependent Development and Core Scenario reports.

Tests 2, 3 and 4 are of variations of future demand for travel, to investigate the effects of lower future development, lower and higher national growth, and lower trip generation from future developments. Test 5 comprises various elements of proposals for the NNDR scheme, which include traffic management measures in Norwich City centre, and reduced speed limits on residential roads in the northern and western suburbs, as well as the new road. Test 6 involves changing the lambda parameter used for the highway trips in Variable Demand Modelling.

Full details of Tests 2 to 6, including parameters used for them, details of model results, and details of economic assessments are given in this report.

The results of these tests indicate the following:-

- Test 2 – Pessimistic Local Development – the lower development assumptions result in much smaller reductions from Core Scenario forecasts than Test 3 Low Growth.

- Test 3 – Low and High Growth – generally the model results are consistent with the traffic growth. For example, forecast average speeds are lower and higher than those forecasts for the Core Scenario.

- Test 4 – Varied Trip Rate Assumptions – the lower and higher trip generation assumptions result in much smaller changes from Core Scenario forecasts than Test 3 low and high growth.

- Test 5 – Each Element of Complementary Measures – the city centre traffic management measures have greater effects on forecasts than the traffic management measures proposed in northern and western suburbs. Significant benefit is foregone by the inclusion of the measures in the Core Scenario.

- Test 6 – Perturbing Demand Model Sensitivities - by increasing the lambda value for highway trips, there is an increase in induced traffic and consequential effects on the PVB and PVC. However these changes are quite small and occur in the same direction.

Economic assessment results are as follows:-

Sensitivity Test Number	Scenario	Benefit / Cost Ratio (BCR)	Scenario	Benefit / Cost Ratio (BCR)
1	Core Scenario	6.1	-	-
2	Test 2 Pessimistic Local Development	6.1	-	-
3	Test 3A Low Growth	4.5	Test 3B High Growth	8.2
4	Test 4A Lower Trip Rates	6.1	Test 4B Higher Trip Rates	6.2
5	Test 5A Core Scenario Without City Centre Measures	8.6	Test 5B Core Scenario Without Any Complementary Measures	8.9
6	Test 6 Varied Parameters	6.6	-	-

The Core Scenario has a positive Cost Benefit Ratio (BCR) of 6.1 which categorises the scheme as “High Value for Money” in accordance with the DfT’s Value for Money guidance. The BCRs of Tests 2 to 6 range from 4.5 to 8.9, confirming that the High category is appropriate.

1. Introduction

1.1 Sensitivity Tests

DfT asked in their letter to Norfolk County Council (NCC) dated 15 September 2009 for a range of sensitivity tests to be carried out in order to better understand uncertainties associated with the analysis undertaken for the Major Scheme Business Case for the Norwich Northern Distributor Route (NNDR). The tests were:-

1. A revised Core Scenario test that excludes dependent development from the forecasts (all further sensitivity tests to be based on this test)
2. A sensitivity test that identifies a pessimistic case in terms of local development
3. A sensitivity test to understand the effect of lower national growth (as outlined in DfT's Transport Analysis Guidance (TAG) Unit 3.15.5)
4. A sensitivity test to understand the importance of forecast trip rate assumptions
5. A set of sensitivity tests to understand the importance of each element of the complementary measures (e.g. city centre traffic management/speed limits in the northern suburbs)
6. A sensitivity test perturbing the demand model sensitivities.

This note gives details and results of work on Tests 2 to 6.

This report contains details as follows:-

Section 2 – **Test 2** Pessimistic Local Development;

Section 3 – **Test 3** Lower and Higher National Growth;

Section 4 – **Test 4** Varied Trip Rate Assumptions;

Section 5 – **Test 5** Each Element of Complementary Measures;

Section 6 – **Test 6** Perturbing Demand Model Sensitivities.

Tests 2, 3 and 4 are of variations of future demand for travel. Test 5 is of the various elements of proposals for the NNDR scheme, which include traffic management measures in Norwich City centre, and reduced speed limits on residential roads in the northern and western suburbs, and well as the new road. Test 6 is of a variation to the lambda parameter used in the Variable Demand Modelling.

1.2 Core Scenario

Sensitivity Tests 2 to 6 are based on the revised Core Scenario that was defined subsequent to initial tests for dependent development, in Test 1. Full details of the Core Scenario are given in the Core Scenario report (December 2009). Details of the initial tests for dependent development are given in the Dependent Development report (December 2009).

Generally, tabulation of results includes information for the base year 2006 and Core Scenario forecasts for comparison purposes.

1.3 Sectors for Results

The locations of model sectors used for traffic model and economic assessment results are shown in **Figure C.1** which is located in **Appendix C**.

1.4 Report Content

This report is written for readers familiar with the DfT's Transport Analysis Guidance, including the Expert units.

Numbers and percentages in the report have been rounded to aid clarity of presentation.

The report text, tables, figures and maps can be made available in larger font/ format on request.

2. **Test 2** Pessimistic Local Development

2.1 Introduction

This test is to understand the importance of assumptions made for future development.

For the Core Scenario, future development detailed in the current Joint Core Strategy (version JCS0) prepared by Broadland District Council, Norwich City Council, South Norfolk Council, Norfolk County Council, and the Broads Authority was considered. For elements of development in the JCS, the uncertainty levels in accordance with in DfT's TAG Unit 3.15.5 'The Treatment of Uncertainty in Model Forecasting' were considered, an uncertainty log prepared, and decisions made about which developments were to be included in the Core Scenario.

Future growth was constrained to TEMPRO 5.4. For this test, future development has been reconsidered, and a lower, more pessimistic, level of spatially allocated local growth has been considered and tested. In addition, for this test, the outturn public transport cost skims from the Core Scenario were fed into DIADEM. It is considered that this approach is reasonable because it is anticipated that there would be little difference between modal transfer in the Core Scenario and this test, and the proportion of net benefits attributable to public transport is low.

For this test, the outturn public transport cost skims from the Core Scenario were fed into DIADEM. It is considered that this approach is reasonable because it is anticipated that there would be little difference between modal transfer in the Core Scenario and this test, and the proportion of net benefits attributable to public transport is low.

2.2 Future Development

For the Core Scenario, classifications for each development input and period were assessed taking into account the guidance in TAG Unit 3.15.5, and including drawing on local knowledge and experience. The uncertainty log is shown in Table 2.1 below:-

Table 2.1: Core Scenario Uncertainty Log

Uncertainty log – factors affecting underlying demand			
	Input	Uncertainty	Comments
1	2006 to 2016 Houses 19,102 Business 427,070m^2	More than likely	Some 12,000 houses have already been built, have planning consent, or have planning submissions, as has part of the business development, and could therefore be classified as 'Near certain'. The land for the remainder is included in the Greater Norwich Development Partnership Joint Core Strategy Proposed submission document.
2	2016 to 2021 Houses 12,411 Business 204,095m^2	Reasonably foreseeable	Land for the housing and business is included in the Greater Norwich Development Partnership Joint Core Strategy Proposed submission document.
3	2021 to 2026 Houses 10,635 Business 372,500m^2	Reasonably foreseeable	Land for the housing and business is included in the Greater Norwich Development Partnership Joint Core Strategy Proposed submission document.
4	2026 to 2031 Houses 9,730	Reasonably foreseeable	Included in Regional Spatial Strategy

It was considered that the element planned up to 2016 should be categorised as 'more than likely', but that after this date there is more uncertainty due to the longer term, so that a 'Reasonably foreseeable' category is appropriate.

Therefore future growth for the revised Core Scenario comprises JCS housing and business development up to 2016, and TEMPRO 5.4 growth thereafter, up to 2031. The National Transport Model 2008 (NTM08) was used for growth of LGVs on employers business and HGVs.

Within the element of growth forecast from 2006 to 2016, of 19,102 houses and 427,070 m^2 of business development, some 12,000 houses have already been built, have planning consent, or have planning submissions, as has part of the business development. Details of the sizes and locations of these developments are given in **Table A.1** and **Table A.2** in **Appendix A**

These developments have been included for Test 2. The remainder of the forecast development has been excluded.

The pessimistic case development has been constrained to TEMPRO 5.4 for the test. The National Transport Model 2008 (NTM08) was used for growth of LGVs on employers business and HGVs.

2.3 Model Results

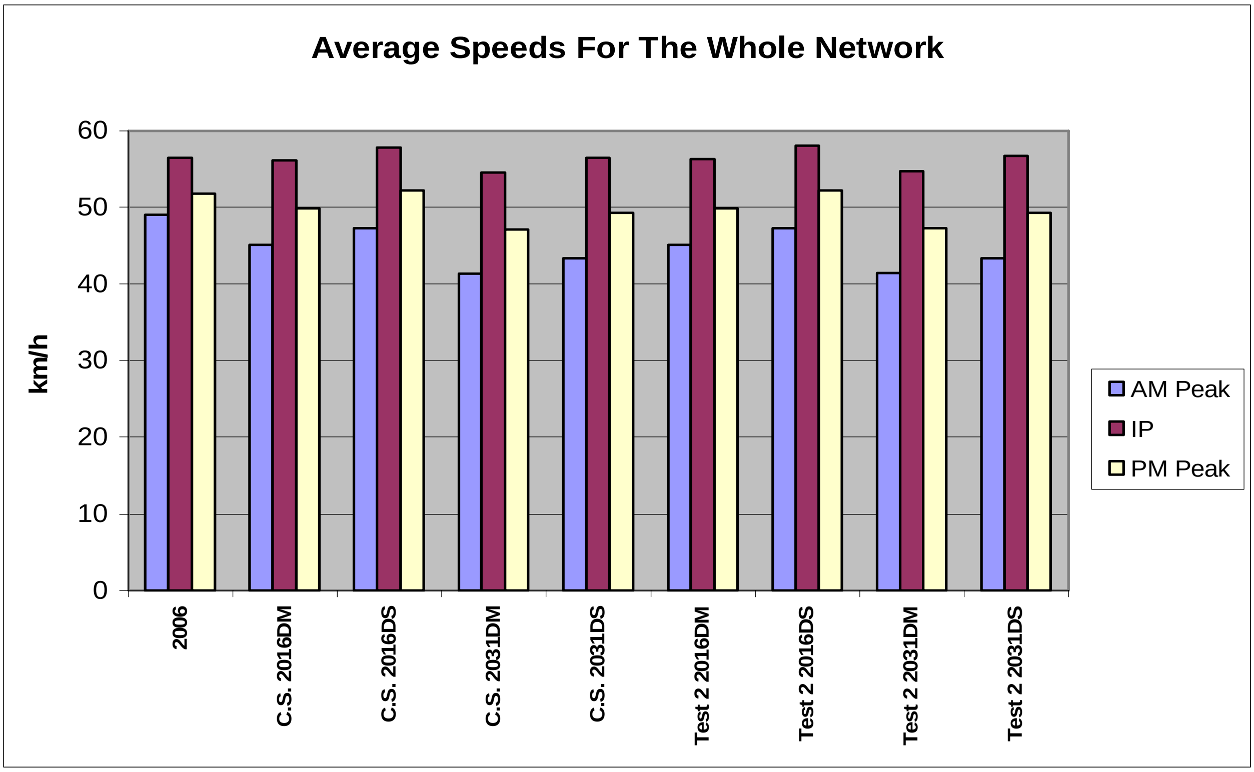
2.3.1 Average Speeds

Table 2.2 contains average speeds over the whole network (in km/h) for the pessimistic local development together with percentage changes in respect to the base year. A bar chart showing the same information for the whole network is presented in **Figure 2.1**.

Table 2.2: Network Average Speeds

Scenario	Year	Average speed (km/h)			% Difference from 2006 values		
		AM	IP	PM	AM	IP	PM
Base year	2006	49	57	52	-	-	-
Core Scenario	2016DM	45	56	50	-8%	-1%	-4%
	2016DS	47	58	52	-4%	2%	1%
	2031DM	41	55	47	-16%	-3%	-9%
	2031DS	43	57	49	-12%	0%	-5%
Test 2 Pessimistic Local Development	2016DM	45	56	50	-8%	0%	-4%
	2016DS	47	58	52	-4%	3%	1%
	2031DM	41	55	47	-16%	-3%	-9%
	2031DS	43	57	49	-12%	0%	-5%

Figure 2.1: Average Speeds for the Whole Network



In the 2006 model base year, the average speeds in the AM and PM peaks are around 50km/h, rising to around 57km/h in the interpeak period. The largest decrease in speed from the base year is the 2031 DM AM peak with the speed decreasing to 41km/h (i.e. a decrease of 16%). The only increases occur in the 2016 interpeak and PM peak with an increase of 3% and 1% respectively from the base year.

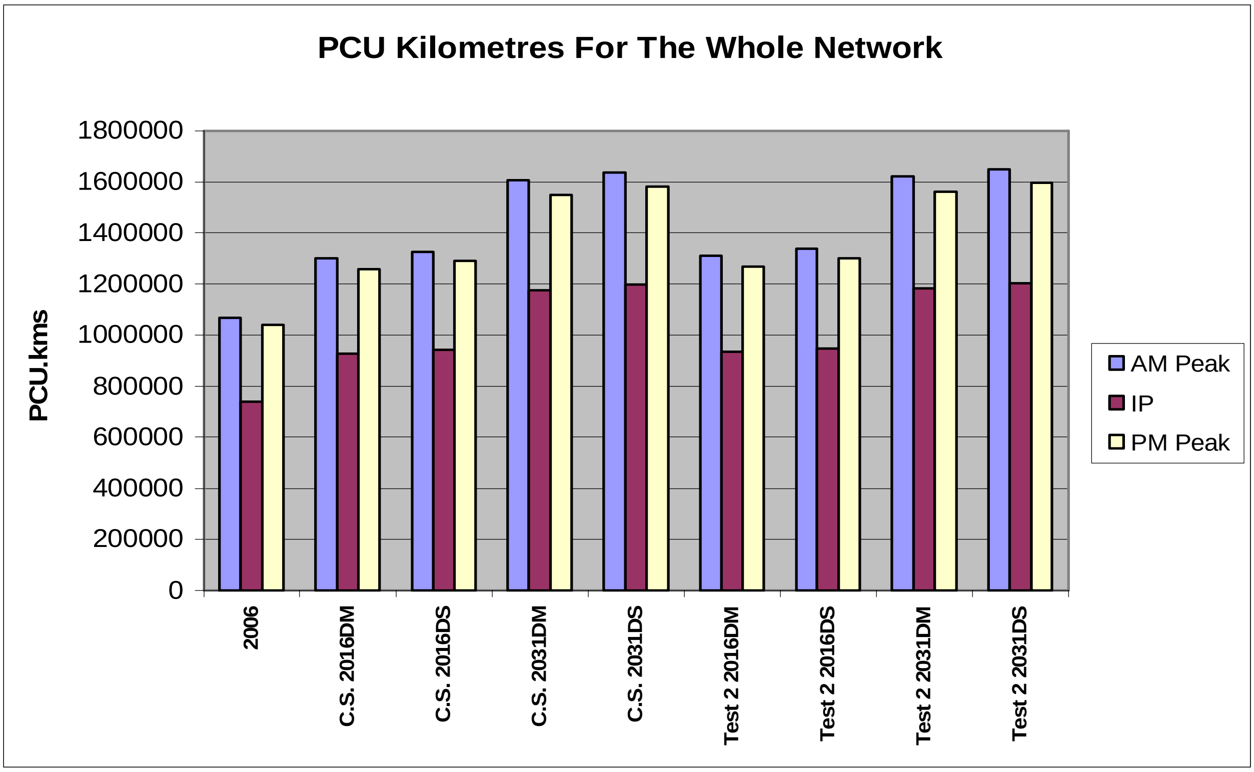
2.3.2 PCU Kilometres and Trip Lengths

Table 2.3 contains PCU.kms over the whole network with the same information presented in Bar Chart as shown in **Figure 2.2**.

Table 2.3: Network PCU Kilometres

Scenario	Year	PCU.kms			% Difference from 2006 values		
		AM	IP	PM	AM	IP	PM
Base year	2006	1068498	738836	1038919	-	-	-
Core Scenario	2016DM	1300040	926560	1257485	22%	25%	21%
	2016DS	1326814	942226	1290247	24%	28%	24%
	2031DM	1606576	1174127	1548240	50%	59%	49%
	2031DS	1636695	1197795	1583278	53%	62%	52%
Test 2 Pessimistic Local Development	2016DM	1311218	933507	1267890	23%	26%	22%
	2016DS	1338479	949046	1300428	25%	28%	25%
	2031DM	1620199	1182690	1561786	52%	60%	50%
	2031DS	1649129	1205120	1595912	54%	63%	54%

Figure 2.2: PCU Kilometres for the Whole Network



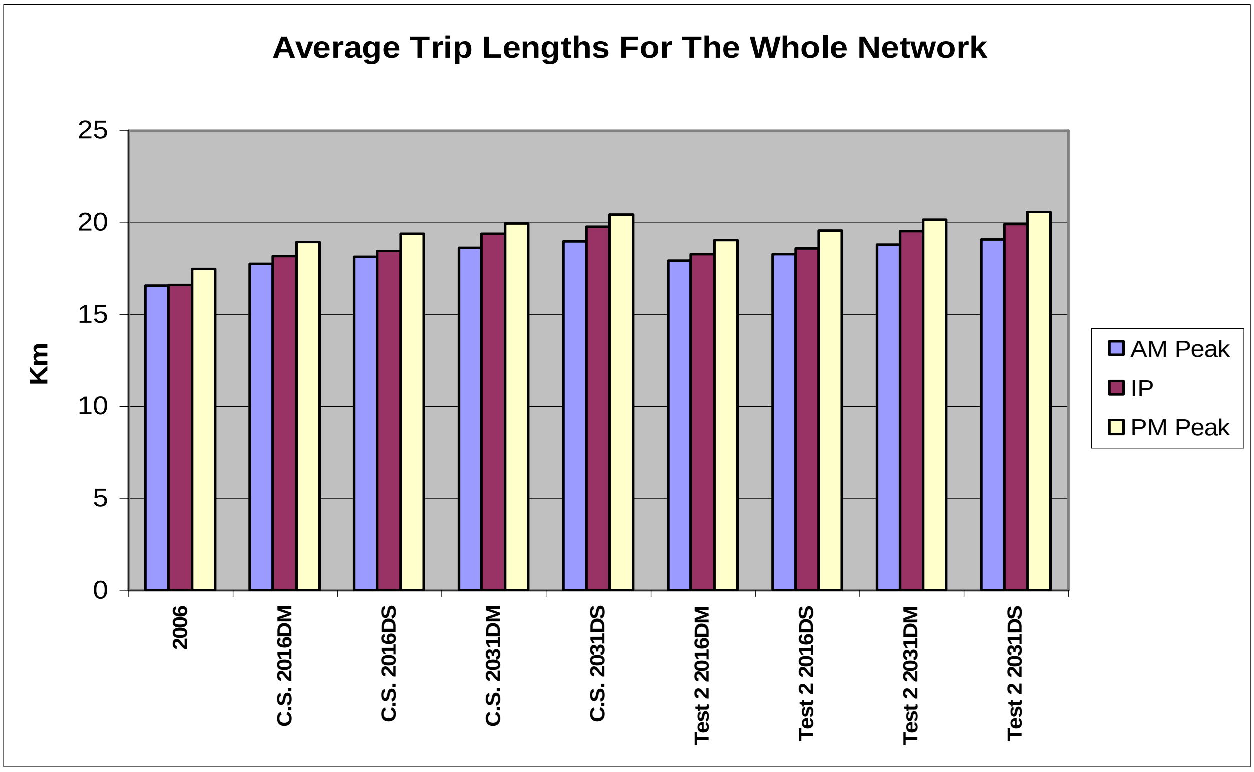
As seen from **Figure 2.2** the PCU.kms for all future forecast year scenarios have increased from the 2006 base year. The largest increases are observed in the 2031 DS scenario with an increase of 54% in the AM peak, 63% in the IP and 54% in the PM peak. In the 2016 DS forecast year, the PCU.kms have also increased between 25% in the AM and PM peaks to 28% in the IP. The increase in PCU.kms in the future DM runs are between 2% and 4% lower than the DS runs for both 2016 and 2031 forecasting years

Table 2.4 contains average trip lengths (km) over the whole network and **Figure 2.3** shows the average trip lengths for the whole network.

Table 2.4: Network Trip Lengths (km)

Scenario	Year	Average Trip Lengths (km)			% Difference from 2006 values		
		AM	IP	PM	AM	IP	PM
Base year	2006	17	17	17	-	-	-
Core Scenario	2016DM	18	18	19	7%	9%	8%
	2016DS	18	18	19	9%	11%	11%
	2031DM	19	19	20	12%	17%	14%
	2031DS	19	20	20	14%	19%	17%
Test 2 Pessimistic Local Development	2016DM	18	18	19	8%	10%	9%
	2016DS	18	19	20	10%	12%	12%
	2031DM	19	20	20	13%	18%	15%
	2031DS	19	20	21	15%	20%	18%

Figure 2.3: Average Trip Lengths for the Whole Network



In the 2006 base year, the average trip length is 17km across all peaks and rising to between 18km and 20km for both the 2016 DM and 2016 DS scenarios. The average trip length in the 2031 forecasting year has increased more compared to the 2016 scenarios. For the 2031 DM the average trip length has increased to 19km in the AM peak (i.e. an increase of 13%) and to 20km in the IP and PM peaks (i.e. an increase of 18% and 15% respectively). The corresponding figures for the 2031 DS are 19km, 20km and 21km respectively (i.e. increases of 15%, 20% and 18%).

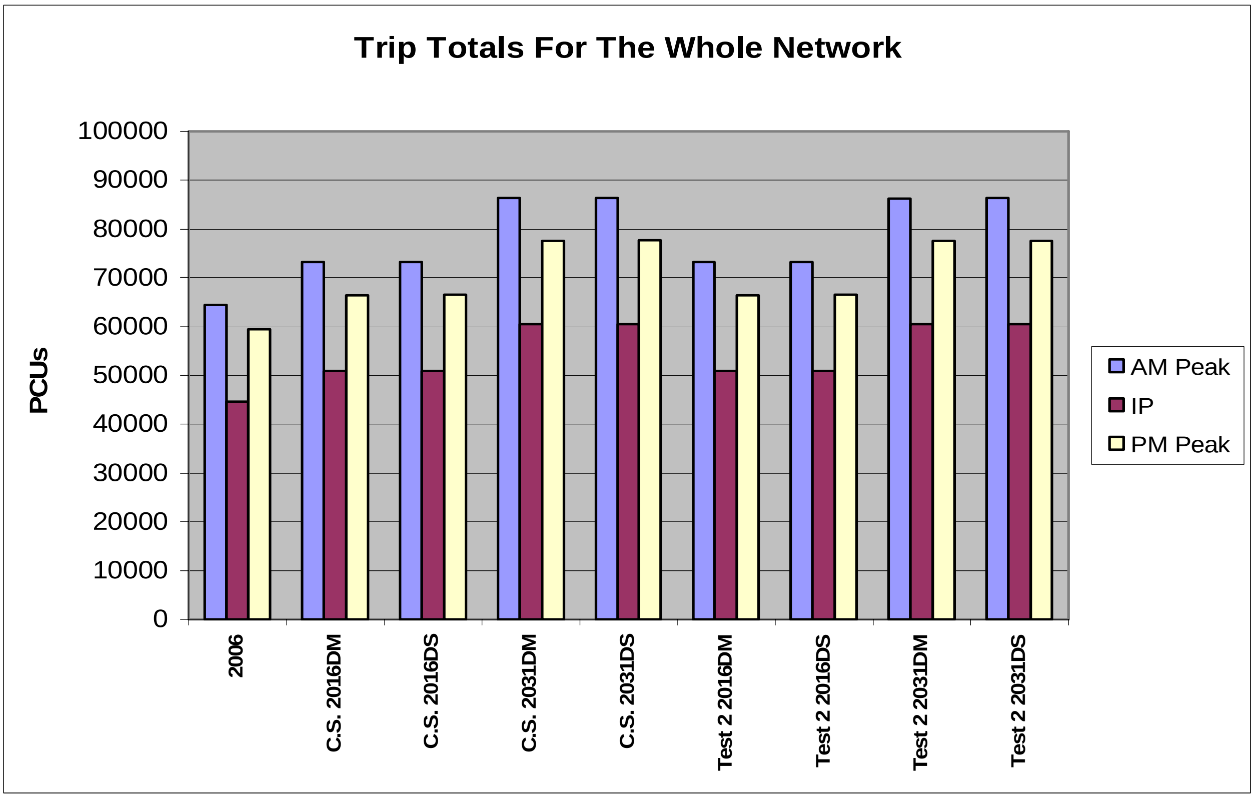
2.3.3 Total Trips

Table 2.5 contains total trips (in PCUs) over the whole network and **Figure 2.4** shows the trip totals for the whole network.

Table 2.5: Summary of Trip Totals (PCUs)

Scenario	Year	Total Trips (PCUs)			% Difference from 2006 values		
		AM	IP	PM	AM	IP	PM
Base year	2006	64480	44560	59441	-	-	-
Core Scenario	2016DM	73174	51040	66518	13%	15%	12%
	2016DS	73229	51035	66558	14%	15%	12%
	2031DM	86346	60587	77563	34%	36%	30%
	2031DS	86414	60578	77599	34%	36%	31%
Test 2 Pessimistic Local Development	2016DM	73182	51040	66520	13%	15%	12%
	2016DS	73245	51035	66562	14%	15%	12%
	2031DM	86280	60559	77520	34%	36%	30%
	2031DS	86356	60553	77569	34%	36%	30%

Figure 2.4: Trip Totals for the Whole Network



In the 2006 base year, the trip totals are 64,480, 44,560 and 59,441 for the AM peak, IP and the PM peak respectively. This shows that in the base year, the AM peak had the largest amount of traffic. A similar pattern is true for future scenarios. In the 2016 AM peak, the trip totals increase from base year to 73,182 (i.e. an increase of 13%) in 2016 DM and to 73,245 (i.e. an increase of 14%) in 2016 DS. The corresponding figures for the 2031 DM and DS runs are 86,280 (i.e. an increase of 34%) and 86,356 (i.e. an increase of 34%). The largest percentage increase is in the 2031 DM and DS IP with an increase of 36% from the corresponding peak in the base year.

2.3.4 Traffic Flows

Traffic flows for the AM, IP and PM periods in the 2006 base year, the Core Scenario and for the forecast years 2016 and 2031 are shown for selected key roads for the Pessimistic Local Development in **Tables B.1** and **B.2** of **Appendix B** and their locations are shown on a map in **Figure B.1**. Differences between traffic flows forecast for the DM and DS in the Core Scenario and Test 2 are also shown.

From the traffic flow information shown in **Table B.1 and B.2**, the difference between the inclusions of the proposed NNDR scheme against the Do Minimum scenario (i.e. Do Something minus Do Minimum) in general shows a reduction in traffic volumes across most key roads in Norwich for both 2016 and 2031 forecasting year. The most reduction occurs on the A1067 (Fakenham Road near Taverham) in both forecasting years with reductions of 556 PCUs, 472 PCUs and 671 PCUs in the AM peak, IP and PM peak respectively for 2016. The corresponding reductions in the 2031 forecasting year are 472 PCUs in the AM peak, 549 PCUs in the IP and 670 PCUs in the PM peak. Part of the A47 (section north of Watton Road) has the second most reductions in both forecasting years.

Whilst most key roads show reducing traffic between the DS and DM scenarios for both forecasting years, the A147 Inner Ring Road quadrant shows the highest increase in traffic volumes with an increase of 407 PCUs in the AM peak, 605 PCUs in the IP and 624 PCUs in the PM peak for 2016. The corresponding increases in the 2031 forecasting year are 211 PCUs in the AM peak, 483 PCUs in the IP and 620 PCUs in the PM peak. One section of the A47 Southern Bypass also show large increases in traffic volumes in both forecasting years, but only during the IP and PM peak.

Overall, the inclusion of the NNDR scheme with associated traffic management measures is forecast to result in traffic flow reductions on many radial links, with key exceptions to the A1067 near Taverham and one section of the A47 where there are more traffic in the Do Something than the Do Minimum scenario

2.3.5 Trips by Sector

Tables C.1 to **C.33** contain trip totals by sector for the 2006 base year and for the forecasting years 2016 and 2031. **Figure C.1** shows NATS model sectors.

In the 2006 base year, trip totals for the AM peak, IP and the PM peak are 64,526 PCUs, 44,680 PCUs and 59,501 PCUs respectively (see **Table C.1** to **C.3**). In the 2016 DM reference case (i.e. pre-DIADEM), the number of trips increases to 74,126, 51,257 and 67,188 respectively (see **Tables C.4** to **C.6**). The DM trip totals (i.e. post-DIADEM) are 87,251, 60,681 and 78,051 (see **Tables C.7** to **C.9**).

Tables C.10 to **C.12** show the differences in trip totals by sector between the pre-DIADEM (i.e. reference case) and post-DIADEM in the 2016 DM. In all peaks, the largest increases in the number of trips occur in the outer sectors of the study area, representing rural areas. The decrease in demand in Norwich is compensated by the increase in number of trips in the outer sectors. A similar pattern is repeated for the 2016 DS scenario (see **Tables C.25** to **C.27**).

Tables C.13 to C**.15** show the 2031 Reference Case and **Tables C.16** to **C.18** show the DM trip totals (i.e. post DIADEM). The differences between the two scenarios (i.e. post-DIADEM minus pre-DIADEM) are shown in **Tables C.19** to **C.21**. Similar to the 2016 DM forecasting year, in the 2031 DM scenario, the largest increases in the number of trips occurs in the outer sectors of the study area, representing rural areas. The decrease in demand in Norwich is compensated by the increase in number of trips in the outer sectors. A similar pattern is also observed for the 2031 DS scenario (see **Tables C.31** to **C.33**).

Tables C.25 to **C.27** show the differences in trip totals by sector between 2016 DS and Reference Case and **Tables C.31** to **C.33** show the same results for the 2031 forecasting years. Similar to the DM scenario for all peaks, the largest increase in the number of trips occurs in the outer sectors of the study area, representing rural areas, and the decrease in demand in Norwich is compensated by the increase in number of trips in the outer sectors.

2.3.6 PCU Kilometres by Sector

Information on vehicle kilometres is shown in **Tables D.1** to **D.27**.

The PCU.kms by sectors for each of the DM and DS scenarios for all forecasting years has increased compared to the base year scenario. In the 2016 DM AM peak, the increase in PCU.kms is in the range of 7% to 45%, (see **Table D.7**) while in 2031 DM for the same period, the increase is in the range of 23% to 88% (see **Table D.13**). In the 2016 IP, the increases in PCU.kms from the base year range between 6% and 42% (see **Table D.8**) and in 2031 DM IP, the increase is between 24% and 107% (see **Table D.14**). In the 2016 DM PM peak, the increase from the base year is between 3% and 37% (see **Table D.9**) and in 2031 DM PM peak, the increase is in the range of 21% to 90% (see **Table D.15**)

In the 2016 DS AM peak, the PCU.kms have increased between 6% and 51% from the base year (see **Table D.19**) and in the 2031 DS during the same period, the increases in PCU.kms are between 22% to 89% (see **Table D.25**) . In the 2016 DS IP, the increases are between of 5% to 43% (see **Table D.20**) and in 2031 the range is between 23% and 107% (see **Table D.26**). In the 2016 DS PM peak, the PCU.kms have increased to as high as 40% from the base year (see **Table D.21**) and finally in the 2031 DS the range is between 18% and 91% (see **Table D.27**).

2.4 Economics

Economic assessment has been carried out in accordance with DfT advice in TAG Unit 3.5 The Economy Objective. The cost benefit analysis was carried out using the DfT's Transport Users Benefit Appraisal Software TUBA (v1.7c) using vehicle/ passenger trips, trip distance and trip time matrices from the SATURN highway and VISUM Public Transport (PT) models.

The assessment has been carried out in accordance with the assessment of the Core Scenario, and for the same assessment period of 2016 to 2075.

2.4.1 Results - summary

The results are summarised below in **Table 2.6**. The TUBA Transport Economic Efficiency (TEE), Public Accounts and Analysis of Monetised Costs and Benefits (AMCB) tables are presented in **Figure E.1** in **Appendix E**.

Table 2.6: Test 2 Economic Assessment Summary

Scenario	Present Value of Costs (PVC, £m)	Present Value of Benefits (PVB, £m)	Net Present Value (NPV, £m)	Benefit / Cost Ratio (BCR)
Test 2 Pessimistic Local Development	86.799	527.224	440.425	6.1

The Pessimistic Local Development scenario has a positive Benefit Cost Ratio (BCR) of 6.1 which categorises the scheme as "High Value for Money" in accordance with the DfT's Value for Money guidance.

2.4.2 Results – by sector

Time benefits by sector of origin are given in **Table E.2** with the sector benefits expressed as a percentage shown in **Table E.3** in **Appendix E**. The sectors used are the same as those shown in **Figure E.2** in **Appendix E**.

The results from **Tables E.2** and **E.3** shows that there are significant disbenefits associated with the city centre traffic management measures (Sector 1).

Relatively low benefits are associated with the urban area inside the Outer Ring Road to the south-west, south-east and north-east (Sectors 2 to 4) and the suburban area to the south-east (Sector 8).

A medium level of benefits is found for the north-west urban area inside the Outer Ring Road (Sector 5), the suburban area stretching around Norwich from the south-west to the north-east (Sectors, 6, 7, 10 and

11), the rural areas to the north and south-east (Sectors 12 and 15) and the external sector representing the rest of the UK (Sector 18).

Relatively high benefits are associated with the suburban area to the east of Norwich (Sector 9) as well as the rural areas to the west, north-west and north (Sectors 13, 14 and 17) and to the north-east (Sector 16).

2.5 TUBA Warning Messages

TUBA warning messages are presented in **Appendix F**.

2.6 Conclusions

The results of this sensitivity test can be summarised as follows:

- The largest decrease in speed from the base year is in 2031 DM in the AM peak, where the speed drops to 41km/h (i.e. a decrease of 16%). In the Do Something scenario, only the 2016 IP and PM peak show an increase in speed of 3% and 1% respectively from the base year.

- The PCU.kms in all future years have increased from the 2006 base year, with the largest increase observed in the 2031 DS Scenario of between 54% in the AM and PM peak to 63% in the IP. The increase in PCU.kms in the future DM runs are about 2% to 4% lower than the DS runs for both 2016 and 2031 forecasting years and in all modelled periods.

- The average trip lengths have increased compared to the base year scenario with the longest trip length being 21km in the 2031 DS PM peak.

- Total number of trips increases in all future scenarios in respect to the base year, with the largest increase being 36% in both the 2031 DM and DS IP. The 2031 DS AM peak has the largest number of PCU trips with 86,356.

- The proposed NNDR scheme with associated traffic management measures is forecast to result in a reduction of traffic on most radial links, but with noticeable increases on the A1067 near Taverham and one section of the A47

- The patterns of results for the 2016 and 2031 Scenario for both the DM and DS runs are similar. In all peaks, the largest increase in the number of trips occurs in the outer sectors of the study area, representing rural areas, and the decrease in demand in Norwich is compensated by the increase in number of trips in the outer sectors.

- PCU.kms have increased in all scenarios for all forecast years compared to the base year, with the largest increases occurring in the 2031 forecasting year.

- The Pessimistic Local Development Scenario has a positive Benefit Cost Ratio (BCR) of 6.1. In accordance with the DfT's Value for Money guidance, this scenario is categorised as "High Value for Money".

3. **Test 3** Lower & Higher National Growth

3.1 Introduction

There are a range of inputs into forecasting where relevant figures at national levels are used. These include GDP growth, fuel price trends and vehicle efficiency changes.

This test has been carried out to assess the impacts of variations to these inputs, in accordance with TAG Unit 3.15.5, by using high and low reference traffic growth.

The term Test 3A refers to Low Growth and Test 3B to High Growth.

3.2 National Growth

TAG Unit 3.15.5 paragraph 1.4.13 gives an appropriate range for testing the effects of lower and higher national growth of + / - 2.5% for traffic forecasts one year ahead, rising with the square root of the number of years to + / - 15% for forecasts up to 36 years ahead.

Therefore the matrices for the 2016 and 2031 model years for the AM, PM and interpeak (IP) periods have been created from the 2006 base year, using an appropriate range about the central forecast calculated in accordance with the above. The central forecast matrices have been adjusted by the newly derived global factors, and separate low and high growth future year trip matrices have been produced.

These have been run through the complete demand modelling process, using DIADEM, assigning the low and high growth trip matrices to the Do Minimum and the Do Something Core Scenario networks, and TUBA runs have been carried out to assess economics.

3.3 Model Results

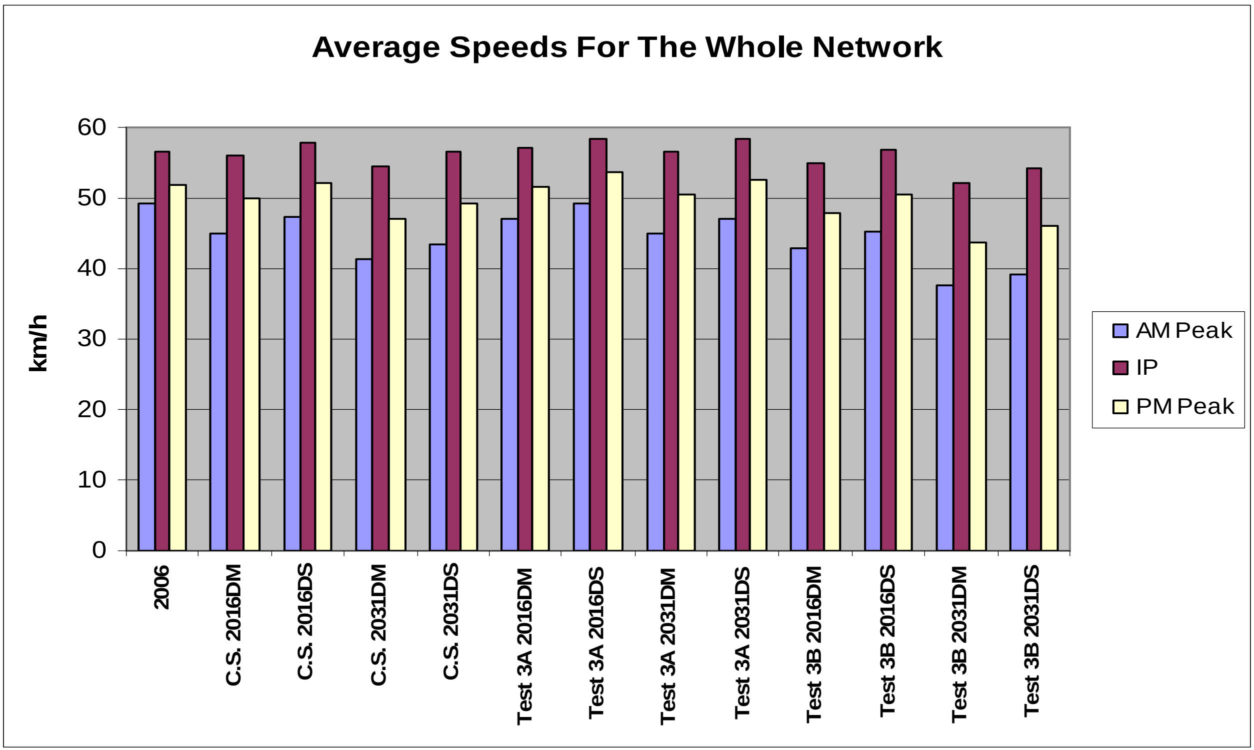
Table 3.1 contains average speeds over the whole network (in km/h) for the lower and higher national growth together with percentage changes in respect to the base year. A bar chart showing the same information for the whole network is presented in **Figure 3.1**.

3.3.1 Average Speeds

Table 3.1: Network Average Speeds

Scenario	Year	Average speed (km/h)			% Difference from Base Year		
		AM	IP	PM	AM	IP	PM
Base year	2006	49	57	52	-	-	-
Core Scenario	2016DM	45	56	50	-8%	-1%	-4%
	2016DS	47	58	52	-4%	2%	1%
	2031DM	41	55	47	-16%	-3%	-9%
	2031DS	43	57	49	-12%	0%	-5%
Test 3A Low Growth	2016DM	47	57	52	-4%	1%	-1%
	2016DS	49	59	54	0%	4%	4%
	2031DM	45	57	50	-8%	0%	-3%
	2031DS	47	59	53	-4%	4%	2%
Test 3B High Growth	2016DM	43	55	48	-13%	-2%	-7%
	2016DS	45	57	51	-8%	1%	-3%
	2031DM	38	52	44	-23%	-8%	-15%
	2031DS	39	54	46	-20%	-4%	-11%

Figure 3.1: Average Speeds for the Whole Network



In the 2006 model base year, the average speeds in the morning and evening peaks are around 50km/h, rising to 57km/h in the interpeak period. In the Low Growth Scenario (Test 3A), the largest decrease in speed from the base year is in 2031 DM in the AM peak, where the speed drops to 45km/h (i.e. a decrease of 8%). In both the 2016 and 2031 DS in the IP, there is an increase in speed of 2km/h from the base year (i.e. an increase of 4%).

In the High Growth Scenario (Test 3B), the largest decrease in speed from the base year is in 2031 DM in the AM peak, where the speed drops to 38 km/h (i.e. a decrease of 23%). The inclusion of the proposed NNDR shows a drop to 39 km/h (i.e. a decrease of 20%) in the 2031 DS Scenario.

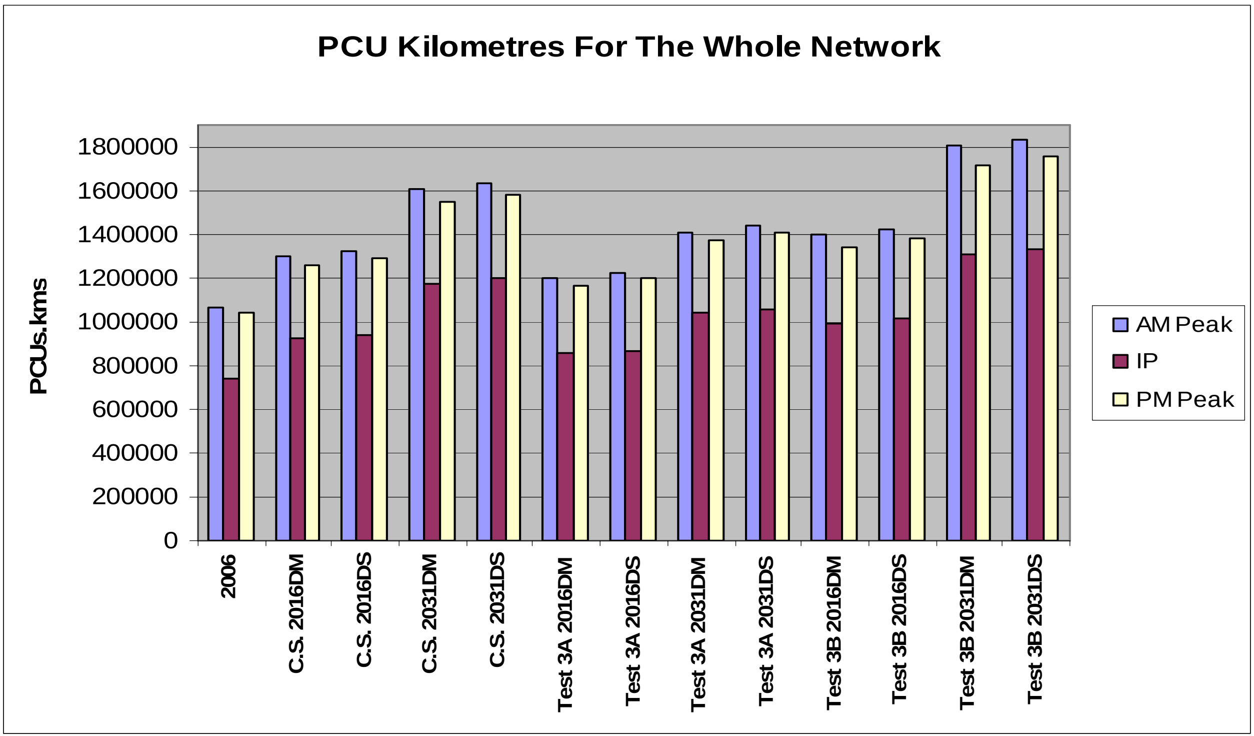
3.3.2 PCU Kilometres and Trip Lengths

Table 3.2 contains PCU.kms over the whole network for the low and high growths and **Figure 3.2** shows the same information in a bar chart.

Table 3.2: Network PCU Kilometres

Scenario	Year	PCU.kms			% Difference from Base Year		
		AM	IP	PM	AM	IP	PM
Base year	2006	1068498	738836	1038919	-	-	-
Core Scenario	2016DM	1300040	926560	1257485	22%	25%	21%
	2016DS	1326814	942226	1290247	24%	28%	24%
	2031DM	1606576	1174127	1548240	50%	59%	49%
	2031DS	1636695	1197795	1583278	53%	62%	52%
Test 3A Low Growth	2016DM	1199468	856139	1166615	12%	16%	12%
	2016DS	1225550	869905	1197626	15%	18%	15%
	2031DM	1408907	1039958	1375284	32%	41%	32%
	2031DS	1438599	1059490	1408579	35%	43%	36%
Test 3B High Growth	2016DM	1399302	995348	1343920	31%	35%	29%
	2016DS	1427241	1013331	1379961	34%	37%	33%
	2031DM	1805197	1307069	1717533	69%	77%	65%
	2031DS	1833297	1332428	1756861	72%	80%	69%

Figure 3.2: PCU Kilometres for the Whole Network



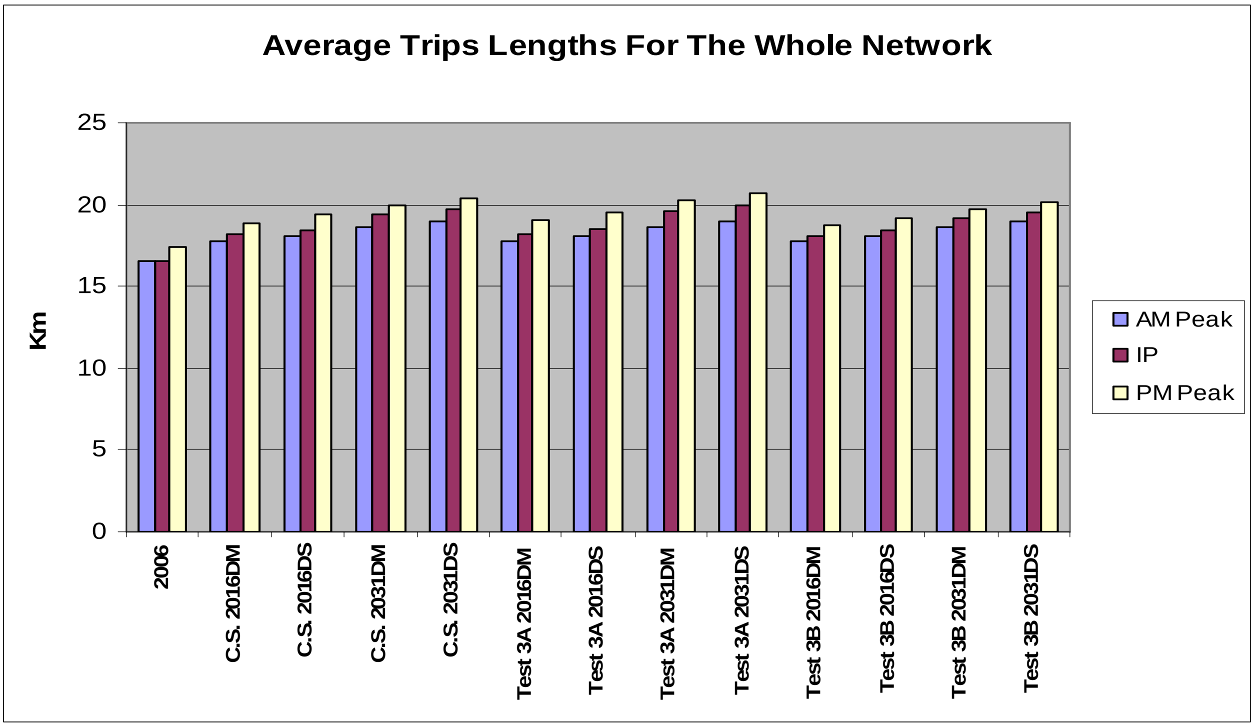
In the 2031 DS Low Growth Scenario, the PCU.kms increase by 35% in the AM peak and 43% in the IP. The PCU.kms in all future years increase from the 2006 base year, with the largest increase in the 2031 DS High Growth Scenario with an increase of 80%. The increase in PCU.kms in the future DM runs are about 2% to 4% lower than the DS runs for both 2016 and 2031 low and high forecasting years and in all modelled periods.

Table 3.3 contains average trip lengths (kms) over the whole network and **Figure 3.3** shows the average trip lengths for the whole network.

Table 3.3: Network Trip Lengths (km)

Scenario	Year	Average Trip Lengths (km)			% Difference from Base Year		
		AM	IP	PM	AM	IP	PM
Base year	2006	17	17	17	-	-	-
Core Scenario	2016DM	18	18	19	7%	9%	8%
	2016DS	18	18	19	9%	11%	11%
	2031DM	19	19	20	12%	17%	14%
	2031DS	19	20	20	14%	19%	17%
Test 3A Low Growth	2016DM	18	18	19	7%	10%	9%
	2016DS	18	19	20	9%	12%	12%
	2031DM	19	20	20	12%	18%	16%
	2031DS	19	20	21	15%	21%	19%
Test 3B High Growth	2016DM	18	18	19	7%	9%	7%
	2016DS	18	18	19	9%	11%	10%
	2031DM	19	19	20	13%	16%	13%
	2031DS	19	20	20	14%	18%	15%

Figure 3.3: Average Trip Lengths for the Whole Network



In the 2006 base year, the average trip length is around 17km in all peaks. The trip lengths in both the Low Growth and the High Growth Scenarios are very similar, with the longest forecast trip length of 21km in the 2031 DS Low Growth Scenario.

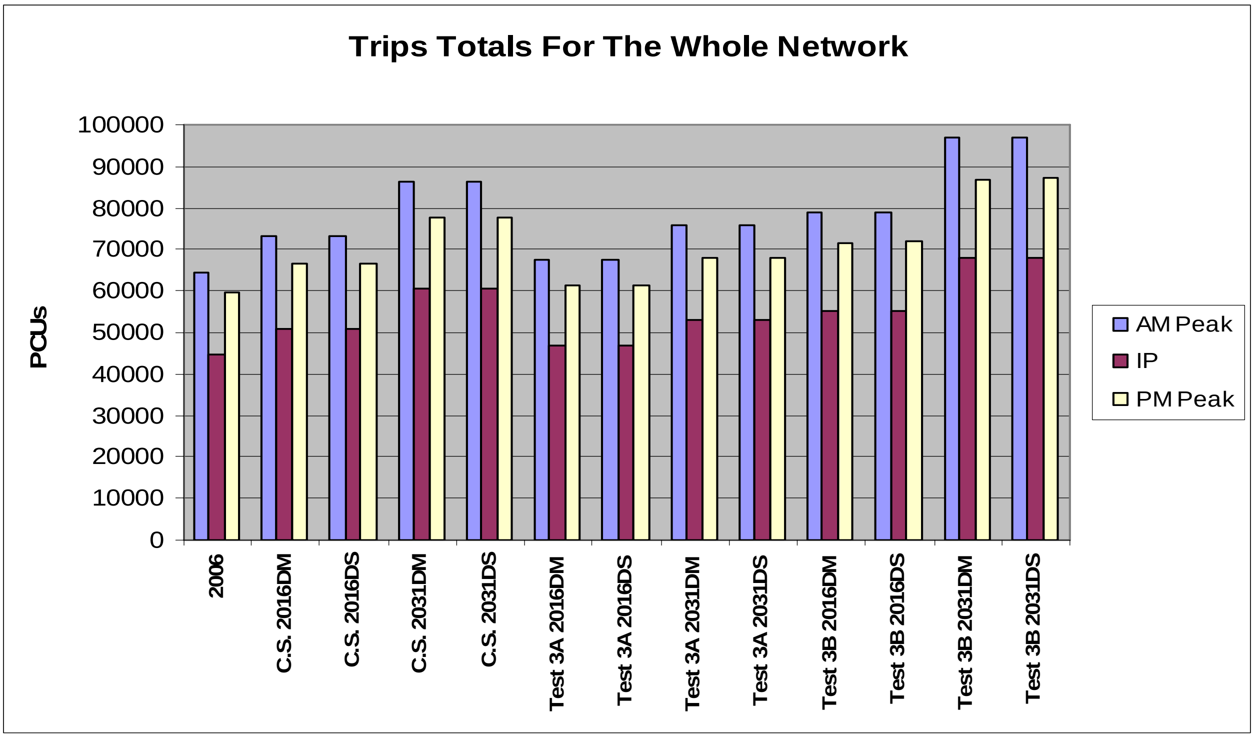
3.3.3 Total Trips

Table 3.4 contains total trips (in PCUs) over the whole network and **Figure 3.4** shows the trip totals for the whole network.

Table 3.4: Summary of Trip Totals (PCUs)

Scenario	Year	Total Trips (PCUs)			% Difference from Base Year		
		AM	IP	PM	AM	IP	PM
Base year	2006	64480	44560	59441	-	-	-
Core Scenario	2016DM	73174	51040	66518	13%	15%	12%
	2016DS	73229	51035	66558	14%	15%	12%
	2031DM	86346	60587	77563	34%	36%	30%
	2031DS	86414	60578	77599	34%	36%	31%
Test 3A Low Growth	2016DM	67516	47013	61321	5%	6%	3%
	2016DS	67543	47010	61353	5%	5%	3%
	2031DM	75730	53000	67941	17%	19%	14%
	2031DS	75762	52995	67990	17%	19%	14%
Test 3B High Growth	2016DM	78795	55062	71694	22%	24%	21%
	2016DS	78872	55055	71749	22%	24%	21%
	2031DM	96812	68101	87019	50%	53%	46%
	2031DS	96878	68091	87093	50%	53%	47%

Figure 3.4: Trip Totals for the Whole Network



In the 2006 base year, the trip totals are 64,480, 44,560 and 59,441 for the AM peak, IP and the PM peak respectively. This shows that in the base year, the AM peak had the largest amount of traffic. A similar pattern is true for future scenarios in both the Low Growth Scenario and the High Growth Scenario. In the 2016 DM Low Growth Scenario AM peak, the trip totals increase from base year to 67,516 (an increase of 5%) and to 67,543 in the 2016 DS (an increase of 5%). The corresponding figures for the 2031 DM and DS Low Growth Scenario runs are 75,730 (an increase of 17%) and 75,762 (an increase of 17%).

In the 2016 DM High Growth Scenario AM peak, the trip totals increase from base year to 78,795 (an increase of 22%) and to 78,872 in the 2016 DS (an increase of 22%) in 2016 DS. The corresponding figures for the 2031 DM and DS High Growth Scenario runs are 96,812 (an increase of 50%) and 96,878 (an increase of 50%).

3.3.4 Traffic Flows

Traffic flows for the AM, IP and PM periods in the 2006 base year, the Core Scenario and the forecast years 2016 and 2031 are shown for selected key roads for the Low Growth Scenario in **Tables I.1** and **I.2** of **Appendix I** and their locations are shown on a map in **Figure I.1**. Differences between traffic flows forecast for the DM and DS in the Core Scenario and for Test 3 are also shown. Similarly, results for the High Growth Scenario are shown in **Tables I.3** and **I.4** in **Appendix I**.

The NNDR scheme is forecast to result in large reductions in traffic flows (i.e. DS flows minus the DM flows) on the A1067 through Taverham in all modelled periods in 2016 and 2031 for both the Low Growth and High Growth Scenarios. In the 2016 Low Growth Scenario, the scheme is forecast to cause a reduction of 603 PCUs in the AM peak, 446 PCUs in the IP and 648 PCUs in the PM peak. The corresponding reductions for the 2031 forecasting year in the AM peak, IP and PM peak are 564, 515 and 698 respectively.

Similarly, for the High Growth Scenario, the proposed NNDR is predicted to result in large reductions in traffic flows on the A1067 in 2016 and 2031. In 2016, the scheme is forecast to deliver a reduction of 489 PCUs in the AM peak, 501 PCUs in the IP and 713 PCUs in the PM peak. The corresponding reductions for the 2031 forecasting year in the AM peak, IP and PM peak are 420, 569 and 597 respectively.

The scheme is forecast to result in increases in traffic flows on the A147 Inner Ring Road (IRR) south east quadrant in 2016 and 2031 for both the Low Growth and High Growth Scenarios. In 2016 Low Growth Scenario, the introduction of the proposed NNDR causes an increase of 377 PCUs in the AM peak, 605 PCUs in the IP and 690 PCUs in the PM peak. The corresponding figures for the 2031 forecasting year are 330, 568 and 661 respectively. Increases are also forecast on the A47(T) Southern Bypass in the southeast quadrant in the IP and PM peak periods, of up to 474 PCUs in the 2031 IP.

Similarly, for the High Growth Scenario, the scheme is forecast to result in increases in traffic flows on the A147 IRR quadrant in both the 2016 and 2031 forecasting years. In 2016, the introduction of the proposed NNDR causes an increase of 353 PCUs in the AM peak, 567 PCUs in the IP and 673 PCUs in the PM peak. The corresponding figures for the 2031 forecasting year are 236, 391 and 511 respectively. Increases are also forecast on the A47(T) Southern Bypass in the southeast quadrant in the IP and PM peak periods, of up to 492 PCUs in the 2031 IP peak.

In general, traffic flows forecast on links with high growth are greater than those with low growth. Some exceptions occur, due to changed junction operation with increased traffic.

3.3.5 Trips by Sector

Tables J.1 to **J.63** contain trip totals by sector for the 2006 base year and for the forecasting years 2016 and 2031 for both the Low Growth Scenario and High Growth Scenario. **Figure J.1** shows NATS model sectors.

In the 2006 base year, trip totals for the AM peak, IP and the PM peak are 64,526 PCUs, 44,680 PCUs and 59,501 PCUs respectively (see **Table J.1** to **J.3**). In the 2016 DM Low Growth reference case (i.e. pre-DIADEM), the number of trips compared to the base year increases to 68,262, 47,213 and 61,889 respectively (see **Tables J.4** to **J.6**). Similarly in the post-DIADEM the number of trips increases to 67,599, 47,042 and 61,388 (see **Tables J.7** to **J.9**).

Tables J.10 to **J.12** show the differences in trip totals by sector between the Low Growth pre-DIADEM (i.e. reference case) and post-DIADEM in the 2016 DM. In all peaks, the large increases in the number of trips occur in the outer sectors of the study area, representing rural areas. The decrease in demand in Norwich is compensated by the increase in number of trips in the outer sectors. A similar pattern is repeated for the 2016 DS scenario (see **Tables J.43** to **J.45**).

Tables J.13 to **J.15** show the 2031 Low Growth Reference Case and **Tables J.16** to **J.18** show the Low Growth DM trip totals (i.e. post DIADEM). The differences between the two scenarios (i.e. post-DIADEM minus pre-DIADEM) are shown in **Tables J.19** to **J.21**. As in the 2016 DM forecasting year, the 2031 DM has the largest number of trips increasing in the outer sectors of the study area, representing rural areas. The decrease in demand in Norwich is compensated by the increase in number of trips in the outer sectors. A similar pattern is repeated for the 2031 DS scenario (see **Tables J.49** to **J.51**).

Tables J.55 to **J.57** show the differences in trip totals by sector between 2016 DS Low Growth and Reference Case and **Tables J.61** to **J.63** show the same results for the 2031 forecasting years. As for the DM scenario, in all peaks, the largest increase in the number of trips occurs in the outer sectors of the study area, representing rural areas, and the decrease in demand in Norwich is compensated by the increase in number of trips in the outer sectors.

Overall, the patterns of results for the 2016 and 2031 High Growth Scenario for both the DM and DS runs are similar to the results obtained for the Low Growth Scenario. In all peaks, the largest increase in the number of trips occurs in the outer sectors of the study area, representing rural areas, and the decrease in demand in Norwich is compensated by the increase in number of trips in the outer sectors.

3.3.6 PCU Kilometres by Sector

Information on PCU kilometres is shown in **Tables K.1** to **K.51** for both the Low Growth and the High Growth Scenarios.

In the 2016 DM Low Growth in the AM peak, the PCU.kms change is in the range of -1% to 29% from the base year (see **Table K.7**) and in the 2031 DM, these increases are in the range of 9% to 64% (see **Table K.13**). In the 2016 DM IP, increases in PCU.kms from the base year range between -3% and 32% (see **Table K.8**) and in 2031 the range varies between 8% and 72% (see **Table K.14**). For the 2016 DM PM peak, increases in PCU.kms vary from the base year by between -6% to 28% (see **Table K.9**) and in the 2031 forecasting year, this varies between 6% and 67% (see **Table K.15**).

In the 2016 DS Low Growth in the AM peak, the PCU.kms change is in the range of -2% to 29% from the base year (see **Table K.31**) and in the 2031 DS, the increases are in the range of 9% to 66% (see **Table K.37**). In the 2016 DS IP, variations in PCU.kms from the base year are in the range of -4% to 32% (see **Table K.32**) and in 2031 the range is between 7% and 74% (see **Table K.38**). In the 2016 DS PM peak, the PCU.kms change is in the range of -8% to 31% from the base year (see **Table K.33**) and in 2031 the range varies between 4% and 70% (see **Table E.39**).

In the 2016 DM High Growth in the AM peak, the PCU.kms are increased in the range of 13% to 55% from the base year (see **Table K.19**) and in the 2031 DM, these increases are in the range of 32% to 112% (see **Table K.25**). In the 2016 DM IP, increases in PCU.kms from the base year range between 13% and 51% (see **Table K.20**) and in 2031 the range varies between 39% and 126% (see **Table K.26**). For the 2016 DM PM peak, increases in PCU.kms vary from the base year vary by between 11% and 47% (see **Table K.21**) and in the 2031 forecasting year, the range varies between 34% and 111% (see **Table K.27**).

In the 2016 DS High Growth in the AM peak, the PCU.kms are increased in the range of 12% to 62% from the base year (see **Table K.43**) and in the 2031 DS, the increases in PCU.kms are in the range of 33% to 114% (see **Table K.49**) . In the 2016 DS IP, increases in PCU.kms from the base year is in the range of 12% to 52% (see **Table K.44**) and in 2031 the range is between 38% and 126% (see **Table K.50**). In the 2016 DS PM peak, the PCU.kms increase in the range of 7% to 50% from the base year (see **Table K.45**) and in the 2031 the range varies between 30% and 113% (see **Table K.51**).

3.4 Economics

Economic assessment has been carried out in accordance with DfT advice in TAG Unit 3.5 The Economy Objective. The cost benefit analysis was carried out using the DfT's Transport Users Benefit Appraisal Software TUBA (v1.7c) using vehicle/ passenger trips, trip distance and trip time matrices from the SATURN highway and VISUM Public Transport (PT) models.

The assessment has been carried out in accordance with the assessment of the Core Scenario, and for the same assessment period of 2016 to 2075.

3.4.1 Results - summary

Costs of the NNDR were supplied by Norfolk County Council, as was the Quantified Risk Assessment (QRA). These were allocated to spend years. Optimism bias of 25% was applied. The TUBA Transport Economic Efficiency (TEE), Public Accounts and Analysis of Monetised Costs and Benefits (AMCB) tables are in **Figure L.1** in **Appendix L**.

Costs at 2009 Q3 levels are in **Table 3.5** as follows:-

Table 3.5: Test 3 Economic Assessment Summary

Scenario	Present Value of Costs (PVC, £m)	Present Value of Benefits (PVB, £m)	Net Present Value (NPV, £m)	Benefit / Cost Ratio (BCR)
Test 3A Low Growth	86.230	389.340	303.110	4.5
Test 3B High Growth	92.842	762.858	670.016	8.2

Test 3A Low Growth has a positive Benefit Cost Ratio (BCR) of 4.5 which categorises the scheme as “High Value for Money” in accordance with the DfT’s Value for Money guidance.

Test 3B High Growth also has a positive BCR, of 8.2, which also meets “High Value for Money” classification.

3.4.2 Results - by sector

TUBA sectors are shown in **Figure L.2** in **Appendix L**. Results showing the time benefits by sector of origin are given in **Tables L.1** to **L.4**. For both low and high growth tests, the results indicate a similar pattern of benefits by sector to the Core Scenario.

The results show there are significant disbenefits associated with the city centre traffic management measures (Sector 1).

Relatively low benefits are associated with the urban area inside the Outer Ring Road to the south-west, south-east and north-east (Sectors 2 to 4) and the suburban area to the south-east (Sector 8).

A medium level of benefits is found for the north-west urban area inside the Outer Ring Road (Sector 5), the suburban area stretching around Norwich from the south-west to the north-east (Sectors, 6, 7, 10 and 11), the rural areas to the north and south-east (Sectors 12 and 15) and the external sector representing the rest of the UK (Sector 18).

Relatively high benefits are associated with the suburban area to the east of Norwich (Sector 9) as well as the rural areas to the west, north-west and north (Sectors 13, 14 and 17) and to the north-east (Sector 16).

3.4.3 TUBA Warning Messages

For further details see **Appendix M**.

3.5 Conclusions

The results of this sensitivity test can be summarised as follows:

- The largest decrease in speed from the base year is in 2031 DM in the AM peak, where the speed drops to 45km/h (i.e. a decrease of 8%) in the Low Growth Scenario and reduces further to 38 km/h (i.e. a decrease of 23%) in the High Growth Scenario. The inclusion of the proposed NNDR results in a speed of 39 km/h (i.e. a decrease of 20%) from base year 2006 in the 2031 DS High Growth Scenario.

- The PCU.kms in all future years increase from the 2006 base year, with the largest increase in the 2031 DS High Growth Scenario, of between 69% in the PM peak and 80% in the IP. The increase in PCU.kms in the future DM runs are about 2% to 4% lower than the DS runs for both 2016 and 2031 Low and High Scenarios and in all modelled periods.

- The trip lengths in both the Low Growth and the High Growth Scenarios are very similar, with the longest trip length of 21km in the 2031 DS Low Growth Scenario.

- Total number of trips increases in all future scenarios in respect to the base year, with the largest increase in the High Growth Scenario of 53% in the IP, and the largest increase in the Low Growth Scenario of 19% in the IP.

- In general, traffic flows forecast on links with high growth are greater than those with low growth. Some exceptions occur, due to changed junction operation with increased traffic.

- The patterns of results for the 2016 and 2031 Low and High Growth Scenarios for both the DM and DS runs are similar. In all peaks, the largest increase in the number of trips occurs in the outer sectors of the study area, representing rural areas, and the decrease in demand in Norwich is compensated by the increase in number of trips in the outer sectors.

- In both the Low and High Growth Scenarios, PCU.km increases from the base year, with the largest increase in the High Growth IP.

- The Low Growth Scenario has a positive Benefit Cost Ratio (BCR) of 4.5 and the High Growth Scenario has a positive BCR, of 8.2. In accordance with the DfT's Value for Money guidance, both scenarios are categorised as "High Value for Money".

- Generally the model results are consistent with the traffic growth. For example, forecast average speeds are lower and higher than those forecasts for the Core Scenario.

4. **Test 4** Varied Trip Rate Assumptions

4.1 Introduction

This test is to understand the importance of assumptions made for trip rates.

TRICS data used to calculate trip rates for future developments was UK-wide data excluding results from the West Yorkshire, Tyne and Wear, Glasgow City, Greater Manchester, West Midlands, all Greater London areas and the Republic of Ireland.

Both regional and temporal variations in trip rates have been examined to check if these could indicate significant variations to be tested. As described in Section 4.2 below, neither of these gave suitable data for the test.

The 95% confidence intervals of the weighted (by size) average trip generations for highway vehicles for each residential site from the TRICS dataset used were calculated, and then subtracted and added to the average rates to obtain lower and higher trip rates. Similar calculations were carried out for business developments, and also for public transport trips. Details are given in Section 4.2 below.

Because of the relatively small numbers of HGV and public transport trips produced by the trip rates above, the HGV and public transport trips generated by proposed future development are not varied from those used for the Core Scenario in this test. The lower and higher rates calculated for Cars + LGVs have been used.

The resulting growth has been constrained to TEMPRO 5.4. The National Transport Model 2008 (NTM08) was used for growth of LGVs on employers business and HGVs.

For this test, the outturn public transport cost skims from the Core Scenario were fed into DIADEM. It is considered that this approach is reasonable because it is anticipated that there would be little difference between modal transfer in the Core Scenario and this test, and the proportion of net benefits attributable to public transport is low.

4.2 Trip Rate Assumptions

The TRICS data used to calculate trip rates for future developments was based on the geographical constraints given in Section 4.1 above. In addition, the following selection criteria were used:-

- for residential, land-use category "03 - RESIDENTIAL/M - MIXED PRIVATE/NON-PRIVATE HOUSING" was selected;
- for business, land use categories for B1 "02 - EMPLOYMENT/B - BUSINESS PARK", B2 " 02 - EMPLOYMENT/D - INDUSTRIAL ESTATE" and B8 "02 - EMPLOYMENT/F - WAREHOUSING (COMMERCIAL)" were selected;
- data for Monday - Friday only was selected;
- data includes all location types;
- data excludes the initial data from any re-surveyed sites and only includes the most recent survey at each site;
- data is from TRICS 2008(a) and uses the default period of 01/01/99 to 19/05/07;

- data for the residential and business B1 include only data between 7am and 7pm, some of the business B2 and B8 sites include 24 hour data.

Details of the average trip rates for residential and business used for each direction (in and out of the development) and time period are given in **Tables 4.1** to **4.4**.

The regional variation in trip rates was examined. The TRICS database has been interrogated to check if trip rates in the East Anglia region vary from UK-wide rates. However, it should be noted that there is no data for residential sites (in TRICS 2008(a)) for the period of 01/01/99 to 19/05/07, so a comparison could not be made.

The time variation in trip rates was also examined. The TRICS data used to calculate trip rates for future developments was for the period of 01/01/99 to 19/05/07 (TRICS 2008(a)) and the database was interrogated to check if more recent data would give different trip rates. The most recent data available (TRICS 2009(b)) indicates slightly higher trip rates than those previously calculated.

The 95% confidence intervals of the weighted (by size) average trip generations for each **residential** site from the TRICS dataset used have been calculated and applied to obtain lower and higher trip rates. For Cars + LGVs, and HGVs, these are as follows:-

Table 4.1: Lower, Average, and Higher Trip Rates for Residential Sites

Period	Direction	Cars + LGVS			HGVS		
		Lower	Average	Higher	Lower	Average	Higher
AM	In	0.068	0.111	0.153	0.001	0.001	0.002
	Out	0.208	0.249	0.290	0.001	0.003	0.005
IP	In	0.100	0.125	0.149	0.000	0.002	0.003
	Out	0.097	0.119	0.140	0.000	0.002	0.003
PM	In	0.185	0.228	0.272	0.001	0.003	0.005
	Out	0.117	0.148	0.179	0.000	0.002	0.004

The percentage variations from average are as follows:-

Table 4.2: Percentage Variations of Lower, Average, and Higher Trip Rates for Residential Sites

Period	Direction	Cars + LGVS			HGVS		
		Lower	Average	Higher	Lower	Average	Higher
AM	In	62%	100%	138%	65%	100%	135%
	Out	83%	100%	117%	38%	100%	162%
IP	In	80%	100%	120%	27%	100%	173%
	Out	82%	100%	118%	30%	100%	170%
PM	In	81%	100%	119%	18%	100%	182%
	Out	79%	100%	121%	17%	100%	183%

The 95% confidence intervals of the weighted (by size) average trip generations for each **business (B1/B2/B8)** sites from the TRICS dataset used have been calculated and applied to obtain lower and higher trip rates. For Cars + LGVs, and HGVs, these are as follows:-

Table 4.3: Lower, Average, and Higher Trip Rates for Business Sites

Period	Direction	Cars + LGVS			HGVS		
		Lower	Average	Higher	Lower	Average	Higher
AM	In	0.216	0.340	0.464	0.008	0.025	0.042
	Out	0.032	0.071	0.111	-0.002	0.010	0.022
IP	In	0.056	0.113	0.170	0.007	0.016	0.025
	Out	0.060	0.123	0.186	0.007	0.017	0.026
PM	In	0.033	0.065	0.098	0.002	0.011	0.019
	Out	0.171	0.252	0.332	0.007	0.022	0.038

The percentage variations from average are as follows:-

Table 4.4: Percentage Variations of Lower, Average, and Higher Trip Rates for Business Sites

Period	Direction	Cars + LGVS			HGVS		
		Lower	Average	Higher	Lower	Average	Higher
AM	In	63%	100%	137%	32%	100%	168%
	Out	45%	100%	155%	-20%	100%	220%
IP	In	50%	100%	150%	42%	100%	158%
	Out	48%	100%	152%	43%	100%	157%
PM	In	51%	100%	149%	23%	100%	177%
	Out	68%	100%	132%	29%	100%	171%

For residential sites, the lower and higher values for Cars + LGVs are significant when applied to the sizes of future developments, and vary by up to + / - 38% from the average values. The HGV values are small trip rates, and produce low numbers of trips when applied to the sizes of future developments. However, they vary by up to + / - 83% from the average values.

For business sites, the lower and higher values for Cars + LGVs are significant when applied to the sizes of future developments, and vary by up to + / - 55% from the average values. The HGV values are small, and produce low numbers of trips when applied to the sizes of future developments. However, they vary by up to + / - 120% from the average values.

The trip rates for public transport are presented in Table 4.5:-

Table 4.5: Trip Rates for Public Transport

Trip Rates	AM out	AM in	IP out	IP in	PM out	PM in
Household Per Unit	0.04	0.00	0.01	0.01	0.00	0.01
Business Average per 100sqm	0.00	0.03	0.01	0.01	0.02	0.00

The public transport values are small, and produce low numbers of trips when applied to the sizes of future developments.

Because of the relatively small numbers of HGV and public transport trips produced by the trip rates above, for this test, the HGV and public transport trips generated by proposed future development have not varied from those used for the Core Scenario. The lower and higher rates above for Cars + LGVs have been used.

The resulting growth has been constrained to TEMPRO 5.4. The National Transport Model 2008 (NTM08) was used for growth of LGVs on employers business and HGVs.

4.3 Model Results

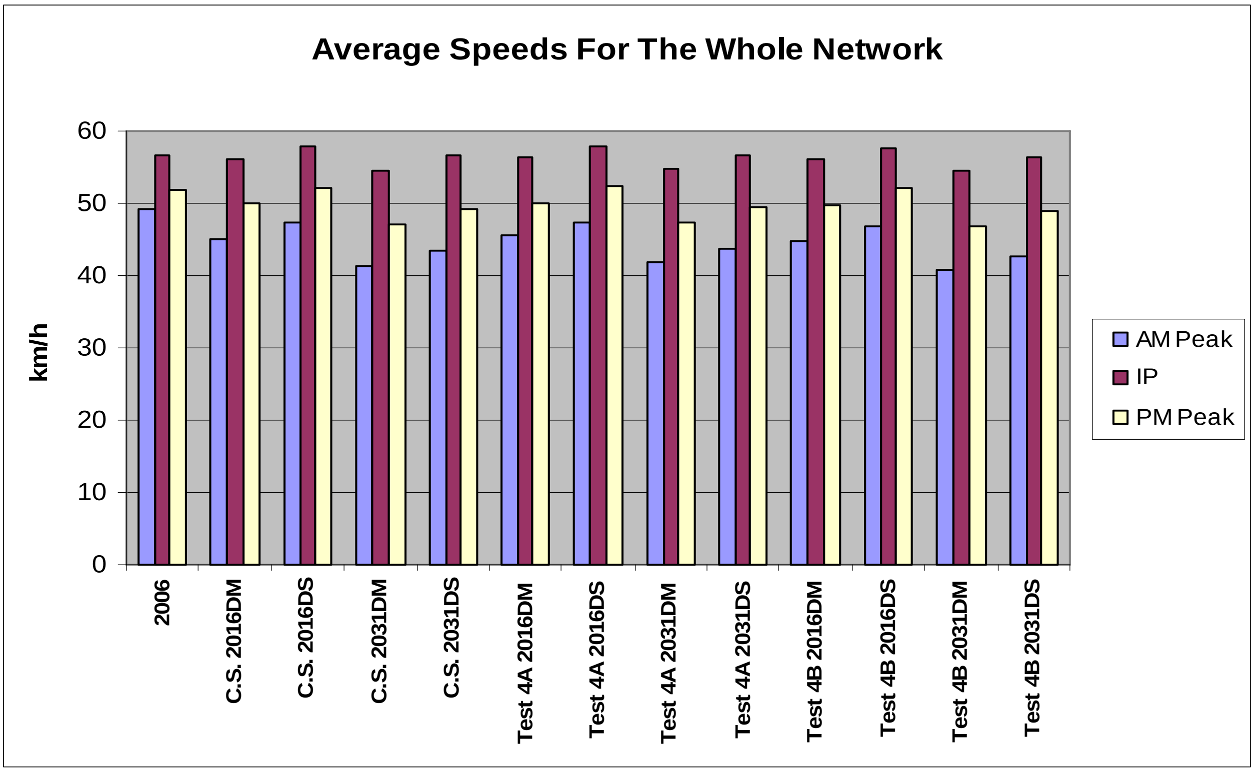
Table 4.6 contains average speeds over the whole network (in km/h) for the Lower and Higher Trip Rate scenarios together with percentage changes in respect to the base year. A bar chart showing the same information for the whole network is presented in **Figure 4.1**.

4.3.1 Average Speeds

Table 4.6: Network Average Speeds

Scenario	Year	Average speed (km/h)			% Difference from Base Year		
		AM	IP	PM	AM	IP	PM
Base year	2006	49	57	52	-	-	-
Core Scenario	2016DM	45	56	50	-8%	-1%	-4%
	2016DS	47	58	52	-4%	2%	1%
	2031DM	41	55	47	-16%	-3%	-9%
	2031DS	43	57	49	-12%	0%	-5%
Test 4A Lower Trip Rates	2016DM	45	56	50	-8%	-1%	-3%
	2016DS	48	58	52	-3%	2%	1%
	2031DM	42	55	47	-15%	-3%	-8%
	2031DS	44	57	49	-11%	0%	-5%
Test 4B Higher Trip Rates	2016DM	45	56	50	-9%	-1%	-4%
	2016DS	47	58	52	-4%	2%	1%
	2031DM	41	54	47	-17%	-4%	-9%
	2031DS	43	56	49	-13%	0%	-5%

Figure 4.1: Average Speeds for the Whole Network



In the 2006 model base year, the average speeds in the AM and PM peaks are around 50km/h, rising to 57km/h in the IP. In the Lower Trip Rates Scenario (Test 4A), the largest decrease in speed from the base year is in 2031 DM in the AM peak, where the speed drops to 42km/h (i.e. a decrease of 15%). In the 2016 DS interpeak, there is an increase in speed of 1km/h from the base year (i.e. an increase of 2%).

In the Higher Trip Rates Scenario (Test 4B), the largest decrease in speed from the base year is in 2031 DM in the AM peak, where the speed drops to 41 km/h (i.e. a decrease of 17%). The inclusion of the proposed NNDR shows a drop in speed from the base year to 43 km/h (i.e. a decrease of 13%) in the 2031 DS Scenario.

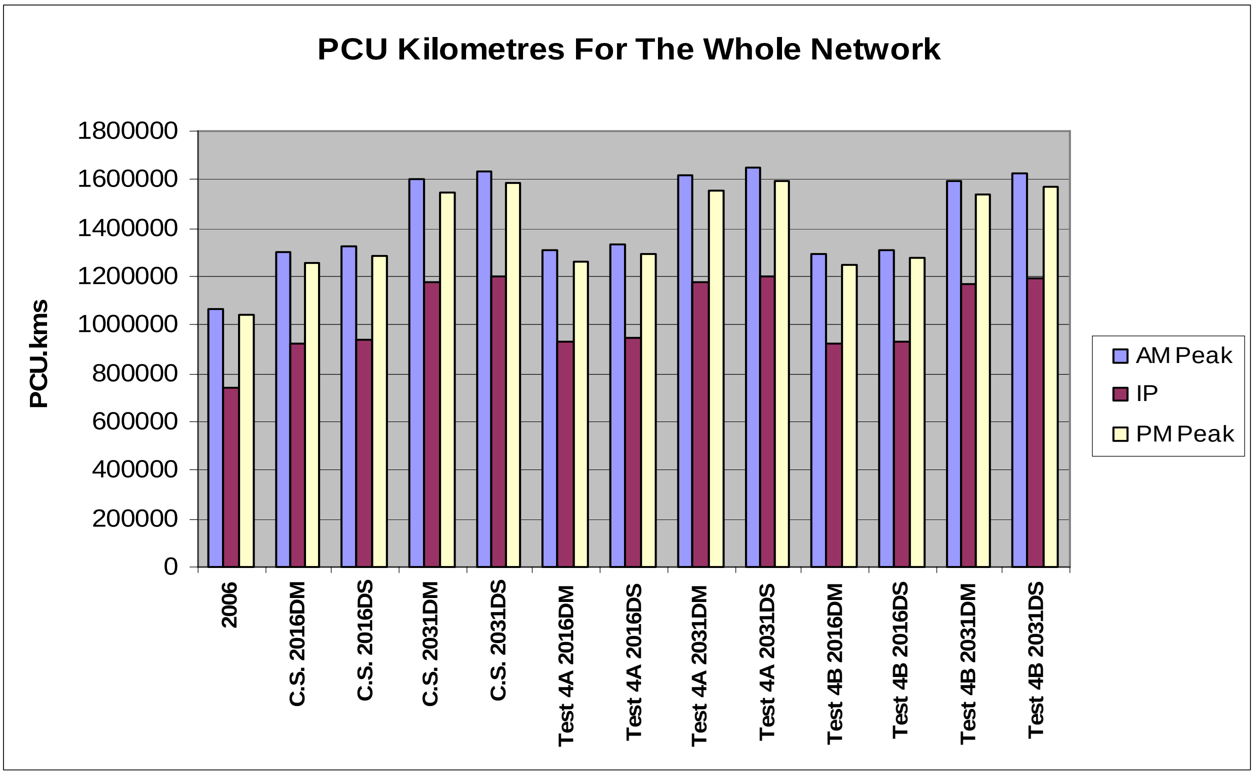
4.3.2 PCU Kilometres and Trip Lengths

Table 4.7 contains PCU.kms over the whole network for the Lower and Higher Trip Rates Scenario and **Figure 4.2** shows the same information in a bar chart.

Table 4.7: Network PCU Kilometres

Scenario	Year	PCU.kms			% Difference from Base Year		
		AM	IP	PM	AM	IP	PM
Base year	2006	1068498	738836	1038919	-	-	-
Core Scenario	2016DM	1300040	926560	1257485	22%	25%	21%
	2016DS	1326814	942226	1290247	24%	28%	24%
	2031DM	1606576	1174127	1548240	50%	59%	49%
	2031DS	1636695	1197795	1583278	53%	62%	52%
Test 4A Lower Trip Rates	2016DM	1308422	931159	1264221	22%	26%	22%
	2016DS	1335442	946638	1297054	25%	28%	25%
	2031DM	1617679	1180044	1557568	51%	60%	50%
	2031DS	1647039	1202712	1592096	54%	63%	53%
Test 4B Higher Trip Rates	2016DM	1291176	922354	1250792	21%	25%	20%
	2016DS	1313053	931440	1280189	23%	26%	23%
	2031DM	1596287	1168407	1539383	49%	58%	48%
	2031DS	1624993	1191801	1573544	52%	61%	51%

Figure 4.2: PCU Kilometres for the Whole Network



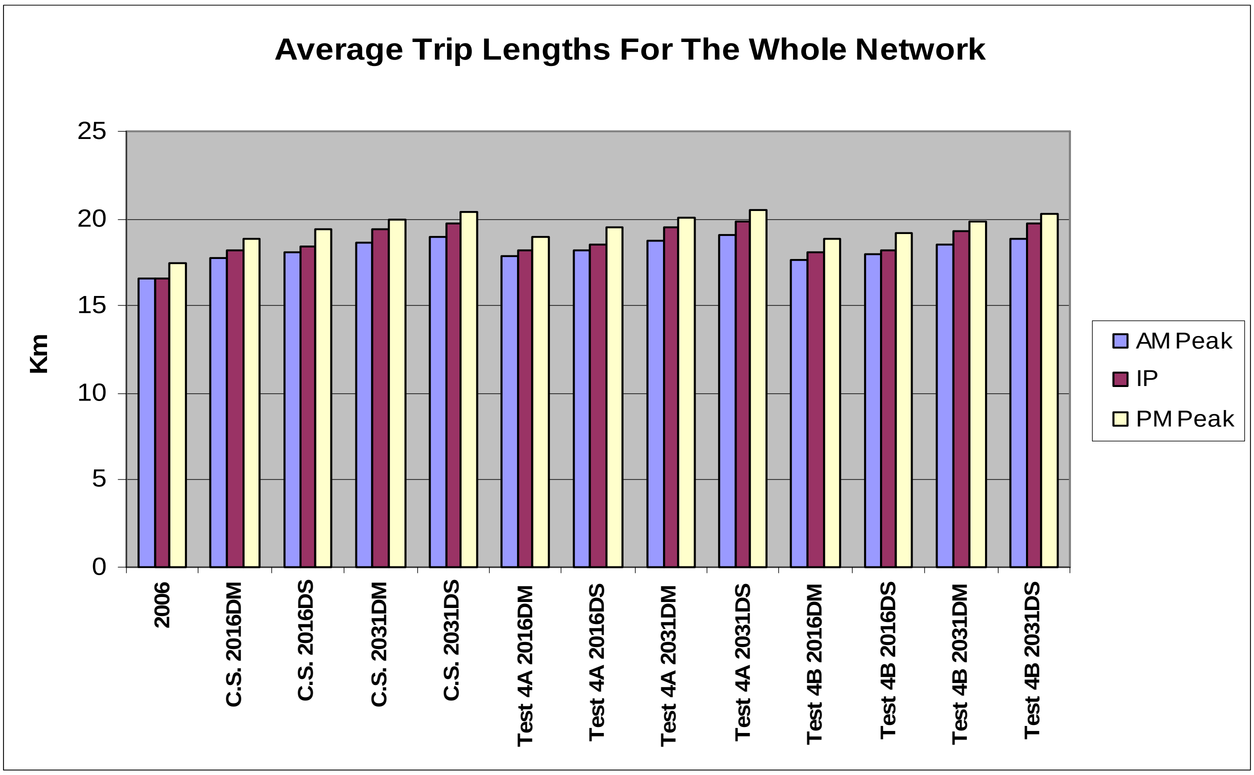
In the 2031 DS Lower Trip Rates Scenario, the PCU.kms increase by 54% in the AM peak to 63% in the IP. The PCU.kms in all future years increase from the 2006 base year, with the largest increase in the 2031 DS Higher Trip Rates Scenario of 51% in the PM peak and 61% in the IP. The increase in PCU.kms in the future DM runs are about 1% to 3% lower than the DS runs for both 2016 and 2031 lower and higher scenarios and in all modelled periods.

Table 4.8 contains average trip lengths (kms) over the whole network and **Figure 4.3** shows the trip lengths for the whole network.

Table 4.8: Network Trip Lengths (km)

Scenario	Year	Average Trip Lengths (km)			% Difference from Base Year		
		AM	IP	PM	AM	IP	PM
Base year	2006	17	17	17	-	-	-
Core Scenario	2016DM	18	18	19	7%	9%	8%
	2016DS	18	18	19	9%	11%	11%
	2031DM	19	19	20	12%	17%	14%
	2031DS	19	20	20	14%	19%	17%
Test 4A Lower Trip Rates	2016DM	18	18	19	8%	10%	9%
	2016DS	18	19	19	10%	12%	11%
	2031DM	19	19	20	13%	18%	15%
	2031DS	19	20	21	15%	20%	17%
Test 4B Higher Trip Rates	2016DM	18	18	19	7%	9%	8%
	2016DS	18	18	19	8%	10%	10%
	2031DM	19	19	20	12%	16%	14%
	2031DS	19	20	20	14%	19%	16%

Figure 4.3: Average Trip Lengths for the Whole Network



In the 2006 base year, the average trip length is around 17km in all peaks. The trip lengths in both the Lower Trip Rates and the Higher Trip Rates Scenarios are very similar; with the longest trip length of 21km recorded in the 2031 DS Lower Trip Rates Scenario.

For each modelled period (AM, IP and PM), the average trip length is calculated by dividing the total PCU.kms by the total number of trips (in PCUs). The PCU.kms values for all periods in the low trip rate scenario (Test 4A) are greater than the values in the high trip rate scenario (Test 4B). However, the total number of trips are similar for each period in the low and high trip rate scenarios. In general, average trip lengths in the low trip rate scenario (Test 4A) are slightly greater than the lengths forecast in the high trip rate scenario (Test 4B).

Examination of changes in trip lengths for each modelled period for the Core Scenario, the low trip rate scenario (Test 4A), and the high trip rate scenario (Test 4B) indicates consistent differences, i.e Test 4A trip lengths are greater than corresponding ones for the Core Scenario, and Core Scenario trip lengths are greater than corresponding ones for Test 4B. These small changes are not visible in the tables showing trip length information due to rounding.

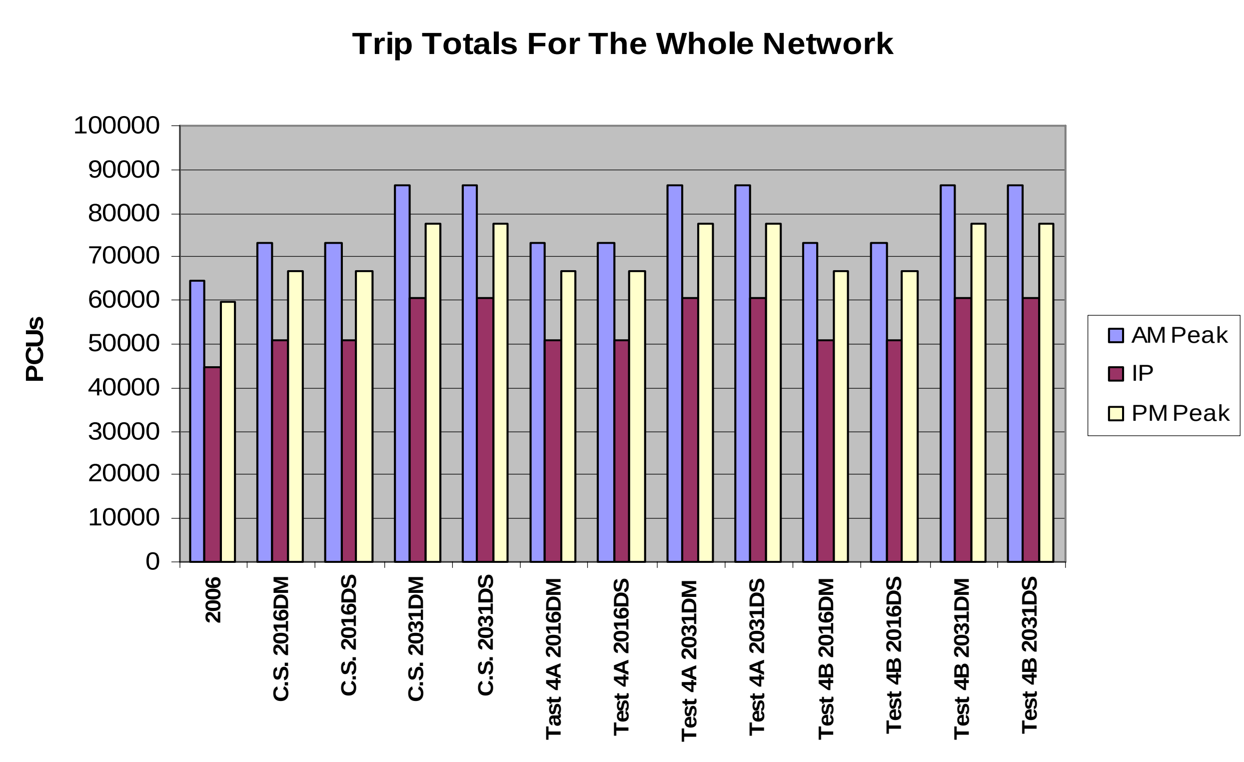
4.3.3 Total Trips

Table 4.9 contains total trips (in PCUs) over the whole network and **Figure 4.4** shows the trip totals for the whole network.

Table 4.9: Summary of Trip Totals (PCUs)

Scenario	Year	Total Trips (PCUs)			% Difference from Base Year		
		AM	IP	PM	AM	IP	PM
Base year	2006	64480	44560	59441	-	-	-
Core Scenario	2016DM	73174	51040	66518	13%	15%	12%
	2016DS	73229	51035	66558	14%	15%	12%
	2031DM	86346	60587	77563	34%	36%	30%
	2031DS	86414	60578	77599	34%	36%	31%
Test 4A Lower Trip Rates	2016DM	73199	51039	66514	14%	15%	12%
	2016DS	73255	51034	66556	14%	15%	12%
	2031DM	86323	60556	77534	34%	36%	30%
	2031DS	86399	60549	77578	34%	36%	31%
Test 4B Higher Trip Rates	2016DM	73122	51046	66500	13%	15%	12%
	2016DS	73170	51041	66538	13%	15%	12%
	2031DM	86256	60542	77521	34%	36%	30%
	2031DS	86321	60534	77556	34%	36%	30%

Figure 4.4: Trip Totals for the Whole Network



In the 2006 base year, the trip totals are 64,480, 44,560 and 59,441 for the AM peak, IP and the PM peak respectively. This shows that in the base year, the AM peak had the largest amount of traffic. A similar pattern is true for future scenarios in both the Lower Trip Rates Scenario and the Higher Trip Rates Scenario. In the 2016 DM Lower Trip Rates Scenario AM peak, the trip totals increase from base year to 73,199 (an increase of 14%) and to 73,255 in the 2016 DS (an increase of 14%). The corresponding figures for the 2031 DM and DS Lower Trip Rates Scenario runs are 86,323 (an increase of 34%) and 86,399 (an increase of 34%).

In the 2016 DM Higher Trip Rates Scenario AM peak, the trip totals increase from base year to 73,122 (an increase of 13%) and to 73,170 in the 2016 DS (an increase of 13%) in 2016 DS. The corresponding figures for the 2031 DM and DS Higher Trip Rates Scenario runs are 86,256 (an increase of 34%) and 86,321 (an increase of 34%).

4.3.4 Traffic Flows

Traffic flows for the AM, IP and PM periods in the 2006 base year, the Core Scenario and the forecast years 2016 and 2031 are shown for selected key roads for the Low Rate Scenario in **Tables P.1** and **P.2** of **Appendix P** and their locations are shown on a map in **Figure P.1**. Differences between traffic flows forecast for the DM and DS are also shown. Similar results for the High Rate Scenario are shown in **Tables P.3** and **P.4** in **Appendix P**.

The NNDR scheme is forecast to result in large reductions in traffic flows (i.e. DS flows minus the DM flows) on the A1067 through Taverham in all modelled periods in 2016 and 2031 and for both the Low and High Rate Scenarios. In 2016 Low Rate Scenario, the scheme is forecast to cause a reduction of 546

PCUs in the AM peak, 470 PCUs in the IP and 673 PCUs in the PM peak. The corresponding reductions in the AM peak, IP and PM peak for the 2031 forecasting year are 479, 551 and 683 respectively.

For the High Rate Scenario in 2016, the scheme is forecast to cause a reduction of 591 PCUs in the AM peak, 512 PCUs in the IP and 700 PCUs in the PM peak. The corresponding reductions in the AM peak, IP and PM peak for the 2031 forecasting year are 480, 547 and 695 respectively.

The scheme is forecast to result in increases in traffic flows on the A147 IRR quadrant in 2016 and 2031 for both the Low and High Rate Scenarios. In 2016 Low Rate Scenario, the introduction of the proposed NNDR causes an increase of 397 PCUs in the AM peak, 618 PCUs in the IP and 627 PCUs in the PM peak. The corresponding figures for the 2031 forecasting year are 214, 468 and 628 respectively. Increases are also forecast on the A47(T) Southern Bypass in the southeast quadrant in the IP (482 PCUs) and PM peak periods (472 PCUs) in 2016. In 2031, these increases are 530 PCUs and 571 PCUs in the IP and PM peak respectively.

Similarly, for the High Rate Scenario, the scheme is forecast to result in increases in traffic flows on the A147 IRR quadrant in both the 2016 and 2031 forecasting years. In 2016 Low Rate Scenario, the introduction of the proposed NNDR causes an increase of 399 PCUs in the AM peak, 446 PCUs in the IP and 682 PCUs in the PM peak. The corresponding figures for the 2031 forecasting year are 223, 479 and 636 respectively. Increases are also forecast on the A47(T) Southern Bypass in the southeast quadrant in the IP and PM peak periods, of up to 544 PCUs in the 2031 PM peak.

The difference between traffic flow forecast for the lower and higher trip rate tests are generally small.

4.3.5 Trips by Sector

Tables Q.1 to **Q.63** in **Appendix Q** contain trip totals by sector for the 2006 base year and for the forecasting years 2016 and 2031 for both the Low Rate Scenario and High Rate Scenario. **Figure Q.1** shows NATS model sectors.

In the 2006 base year, trip totals for the AM peak, IP and the PM peak are 64,526 PCUs, 44,680 PCUs and 59,501 PCUs respectively (see **Table Q.1** to **Q.3**). In the 2016 DM Low Rate reference case (i.e. pre-DIADEM), the number of trips increases to 74,103, 51,257 and 67,178 respectively (see **Tables Q.4** to **Q.6**) and in the post-DIADEM the number of trips increases to 73,288, 51,070 and 66,593 (see **Tables Q.7** to **Q.9**).

Tables Q.10 to **Q.12** show the differences in trip totals by sector between the Low Rate pre-DIADEM (i.e. reference case) and post-DIADEM in the 2016 DM. In all peaks, the large increases in the number of trips occur in the outer sectors of the study area, representing rural areas. The decrease in demand in Norwich is compensated by the increase in number of trips in the outer sectors. A similar pattern is repeated for the 2016 DS scenario (see **Tables Q.43** to **Q.45**).

Tables Q.13 to **Q.15** show the 2031 Low Rate Reference Case and **Tables Q.16** to **Q.18** show the Low Rate DM trip totals (i.e. post DIADEM). The differences between the two scenarios (i.e. post-DIADEM minus pre-DIADEM) are shown in **Tables Q.19** to **Q.21**. As in the 2016 DM forecasting year, in 2031 DM, the largest increases in the number of trips occurs in the outer sectors of the study area, representing rural areas. The decrease in demand in Norwich is compensated by the increase in number of trips in the outer sectors. A similar pattern is repeated for the 2031 DS scenario (see **Tables Q.49** to **Q.51**).

For the High Rate scenario, **Tables Q.55** to **Q.57** show the differences in trip totals by sector between 2016 Higher Trip Rates and Reference Case and **Tables Q.61** to **Q.63** show the same results for the 2031 forecasting years. As for the DM scenario, in all peaks, the largest increase in the number of trips occurs in the outer sectors of the study area, representing rural areas, and the decrease in demand in Norwich is compensated by the increase in number of trips in the outer sectors.

4.3.6 PCU Kilometres by Sector

Information on vehicle kilometres is shown in **Tables R.1** to **R.51** in **Appendix R** for both the Low Rate and the High Rate Scenarios.

In the 2016 DM Low Rate in the AM peak, the PCU.kms are increased in the range of 8% to 43% from the base year (see **Table R.7**) and in the 2031 DM during the same period, these increases are in the range of 23% to 88% (see **Table R.13**). In the 2016 DM IP, increases in PCU.kms from the base year range between 6% and 43% (see **Table R.8**) and in 2031 the range varies between 25% and 106% (see **Table R.14**). For the 2016 DM PM peak, increases in PCU.kms vary from the base year by between 3% to 38% (see **Table R.9**) and in the 2031 forecasting year, the range varies between 21% and 91% (see **Table R.15**).

In the 2016 DS Low Rate in the AM peak, the PCU.kms are increased in the range of 7% to 49% from the base year (see **Table R.31**) and in the 2031 DS during the same period, the increases in PCU.kms are in the range of 23% to 90% (see **Table R.37**) . In the 2016 DS IP, increases in PCU.kms from the base year are in the range of 5% to 43% (see **Table R.32**) and in 2031 the range is between 24% and 107% (see **Table R.38**). In the 2016 DS PM peak, the PCU.kms increase in the range of 0% to 41% from the base year (see **Table R.33**) and in 2031 the range varies between 18% and 92% (see **Table R.39**).

In the 2016 DM High Rate in the AM peak, the PCU.kms are increased in the range of 5% to 43% from the base year (see **Table R.19**) and in the 2031 DM during the same period, these increases are in the range of 20% to 85% (see **Table R.25**). In the 2016 DM IP, increases in PCU.kms from the base year range between 4% and 41% (see **Table R.20**) and in 2031 the range varies between 22% and 102% (see **Table R.26**). For the 2016 DM PM peak, increases in PCU.kms vary from the base year by between 2% and 37% (see **Table R.21**) and in the 2031 forecasting year, the range vary between 20% to 88% (see **Table R.27**).

In the 2016 DS High Rate in the AM peak, the PCU.kms are increased in the range of 3% and 49% from the base year (see **Table R.43**) and in the 2031 DS during the same period, the increases in PCU.kms are in the range of 19% to 88% (see **Table R.49**) . In the 2016 DS IP, increases in PCU.kms from the base year is in the range of 3% to 41% (see **Table R.44**) and in 2031 the range is between 21% and 103% (see **Table R.50**). In the 2016 DS PM peak, the PCU.kms increase in the range of 0% to 39% from the base year (see **Table R.45**) and in 2031 the range varies between 17% and 90% (see **Table R.51**).

4.4 Economics

Economic assessment has been carried out using the same methodology as the Core Scenario – see the Core Scenario report. The costs have been replicated for this test.

4.4.1 Results - summary

The results are summarised below in **Table 4.10**. The TUBA Transport Economic Efficiency (TEE), Public Accounts and Analysis of Monetised Costs and Benefits (AMCB) tables are in **Figure S.1** in **Appendix S**.

Table 4.10: Test 4 Economic Assessment Summary

Scenario	Present Value of Costs (PVC, £m)	Present Value of Benefits (PVB, £m)	Net Present Value (NPV, £m)	Benefit / Cost Ratio (BCR)
Test 4A Lower Trip Rates	87.207	529.589	442.382	6.1
Test 4B Higher Trip Rates	91.766	566.072	474.306	6.2

Test 4A Lower Trip Rates have a positive Benefit Cost Ratio (BCR) of 6.1 which categorises the scheme as "High Value for Money" in accordance with the DfT's Value for Money guidance. Test 4B Higher Trip Rates also has a positive BCR, of 6.2, which also is "High Value for Money".

4.4.2 Results – by sector

TUBA Sectors are shown in **Figure S.2** in **Appendix S**. Time benefits by sector of origin are given in **Tables S.1** to **S.4** in **Appendix S**. For both lower and higher trip rates, the results indicate a similar pattern of benefits by sector to the Core Scenario.

The results show there are significant disbenefits associated with the city centre traffic management measures (Sector 1).

Relatively low benefits are associated with the urban area inside the Outer Ring Road to the south-west, south-east and north-east (Sectors 2 to 4) and the suburban area to the south-east (Sector 8).

A medium level of benefits is found for the north-west urban area inside the Outer Ring Road (Sector 5), the suburban area stretching around Norwich from the south-west to the north-east (Sectors, 6, 7, 10 and 11), the rural areas to the north and south-east (Sectors 12 and 15) and the external sector representing the rest of the UK (Sector 18).

Relatively high benefits are associated with the suburban area to the east of Norwich (Sector 9) as well as the rural areas to the west, north-west and north (Sectors 13, 14 and 17) and to the north-east (Sector 16).

4.4.3 TUBA Warning Messages

For further details see **Appendix T**.

4.5 Conclusions

The results of this sensitivity test can be summarised as follows:

- In the Lower Trip Rate Scenario, the largest decrease in speed from the base year scenario is the 2031 DM AM peak with a decrease speed of 7km/h (15%). The 2031 DM AM peak in the Higher Trip Rate Scenario also shows the largest decrease in speed compared to the corresponding peak in the base year with a decrease of 8km/h (17%). The inclusion of the proposed NNDR (i.e. DS scenario) in both Trip Rate Scenarios has shown an increase in speed compared the DM scenario in both 2016 and 2031 forecasting years.

- The PCU.kms in both Lower and Higher Trip Rate Scenarios for all forecast years have increased compared to the base year scenario with the greatest increase being the 2031 DS for both Trip Rate scenarios.

- The trip lengths in both the Lower Trip Rate and the Higher Trip Rate Scenarios are very similar, with the longest trip length being 21km in the 2031 DS PM peak in the Lower Trip Rate Scenario.

- Trip totals have increased in all future scenarios compared to the base year with the largest percentage increase of 36% in both 2031 IP Higher and Lower Trip Rate scenarios.

- As with the other sensitivity tests, the proposed NNDR scheme with associated traffic management measures shows a reduction in traffic flows on most radial links, but increases on some sections of the A147 Inner Ring Road, one section of the A47(T) Southern Bypass, and some sections of radials used to access the new road.

- The patterns of results for the 2016 and 2031 Lower and Higher Trip Rate Scenarios for both the DM and DS runs are the same. In all peaks, the largest increase in the number of trips occurs in the outer sectors of the study area, representing rural areas, and the decrease in demand in Norwich is compensated by the increase in number of trips in the outer sectors.

- PCU.kms for the 2016 and 2031 forecast years in both Trip Rate options have increased compared to the base year scenario. The change patterns are similar in both Lower and Higher Trip Rate Scenario with the largest increases occurring in the 2031 forecast years.

- The Lower Trip Rate Scenario has a positive Benefit Cost Ratio (BCR) of 6.1 while the Higher Trip Rate Scenario has a positive BCR of 6.2. In accordance with the DfT's Value for Money guidance, both scenarios are categorised as "High Value for Money".

- The lower and higher trip generation assumptions result in much smaller changes from Core Scenario forecasts than Test 3 Low and High Growth.

5. **Test 5** Each Element of Complementary Measures

5.1 Introduction

The Norwich Northern Distributor Route scheme promoted by Norfolk County Council includes complementary measures comprising traffic management measures in the city centre, plus the northern and western suburbs. Their aim is to manage traffic volumes and speeds on the existing highway network, and to benefit sustainable transport modes such as walking, cycling and public transport.

Proposals for these traffic management measures have been developed as part of The Norwich Area Transport Strategy (NATS) and will be funded through the Local Transport Plan (LTP) and other sources including developer contributions. Where it is anticipated that schemes will be implemented before the NNDR, these have been included as part of the Do Minimum Scenario.

NCC is fully committed to delivery of those measures and recognise their importance for realisation of scheme benefits.

This test is to understand the importance of each element of the complementary measures.

For this test, the outturn public transport cost skims from the Core Scenario were fed into DIADEM. It is considered that this approach is reasonable because it is anticipated that there would be little difference between modal transfer in the Core Scenario and this test, and the proportion of net benefits attributable to public transport is low.

5.2 Complementary Measures

The measures are detailed in the Core Scenario report. The city centre measures comprise changes to existing roads, including closing some roads to vehicular traffic, one-way systems, and limiting the use of some roads to public transport. The measures in the northern and western suburbs comprise reductions of speed limits from 30 mph to 20 mph on selected residential roads currently used by significant volumes of through traffic.

Test 5A comprises model runs and economic assessment of the NNDR highway proposals plus traffic management measures in the northern and western suburbs, but excludes the proposed city centre traffic management measures.

Test 5B comprises model runs and economic assessment of the NNDR highway proposals, but excluding both the proposed traffic management measures in the northern and western suburbs, and the city centre traffic management measures.

5.3 Model Results

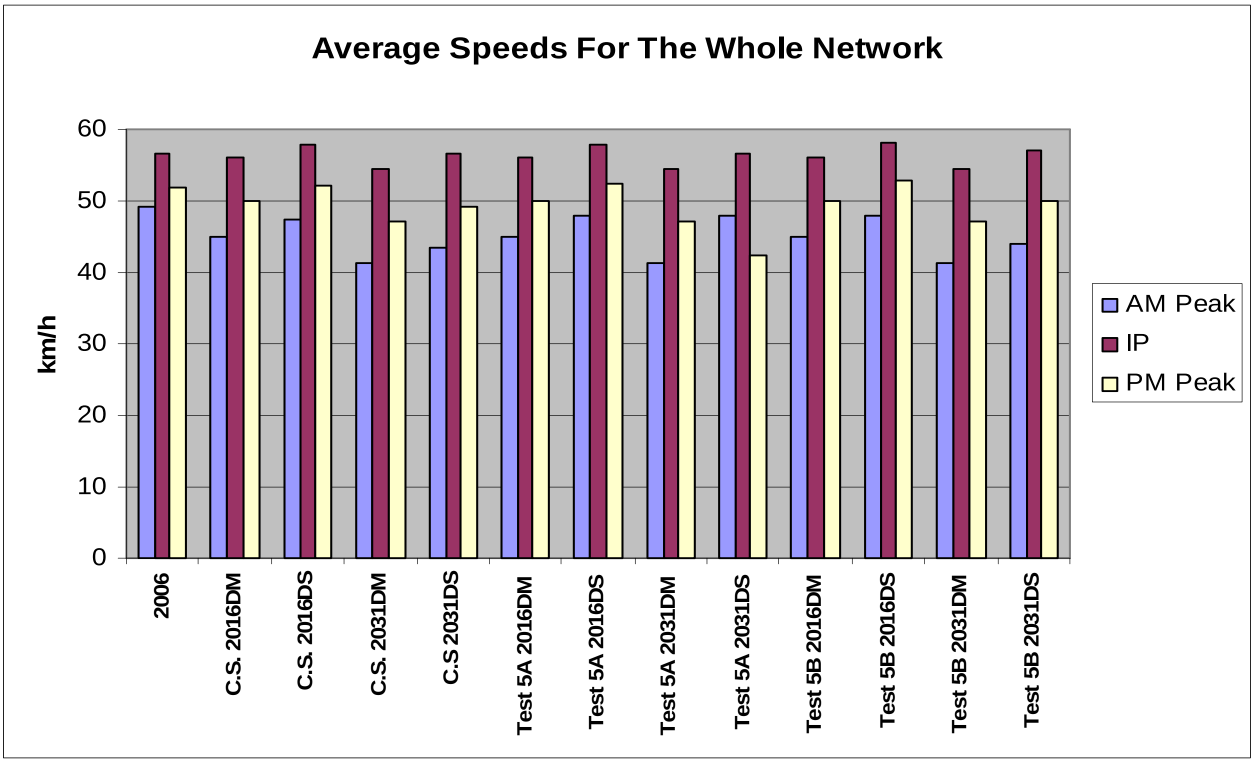
Table 5.1 contains average speeds over the whole network (in km/h) for both packages of complementary measures (Tests 5A and 5B) together with percentage changes in respect to the base year. A bar chart showing the same information for the whole network is presented in **Figure 5.1**.

5.3.1 Average Speeds

Table 5.1: Network Average Speeds

Scenario	Year	Average speed (km/h)			% Difference from Base Year		
		AM	IP	PM	AM	IP	PM
Base year	2006	49	57	52	-	-	-
Core Scenario	2016DM	45	56	50	-8%	-1%	-4%
	2016DS	47	58	52	-4%	2%	1%
	2031DM	41	55	47	-16%	-3%	-9%
	2031DS	43	57	49	-12%	0%	-5%
Test 5A Core Scenario Without City Centre Measures	2016DM	45	56	50	-8%	-1%	-4%
	2016DS	48	58	52	-3%	3%	1%
	2031DM	41	55	47	-16%	-3%	-9%
	2031DS	48	57	43	-2%	0%	-18%
Test 5B Core Scenario Without Any Complementary Measures	2016DM	45	56	50	-8%	-1%	-4%
	2016DS	48	58	53	-2%	3%	2%
	2031DM	41	55	47	-16%	-3%	-9%
	2031DS	44	57	50	-11%	1%	-4%

Figure 5.1: Average Speeds for the Whole Network



In the 2006 model base year, the average speeds in the AM and PM peaks are around 49km/h and 52km/h respectively, with an average speed of 57km/h in the IP. For Test 5A, the largest decrease in speed from the base year is the 2031 DS PM peak, where the speed drops to 43km/h (a decrease of 18%). The only increase is in the 2016 DS interpeak period with a slight speed increase of 1km/h from the base year (an increase of 3%).

For Test 5B, the largest decrease in speed from the base year is in 2031 DM in the AM peak, where the speed drops to 41 km/h (a decrease of 16%). The highest increase in speed occurs in the 2016 DS interpeak scenario with an increase of 1km/h (an increase of 3%)

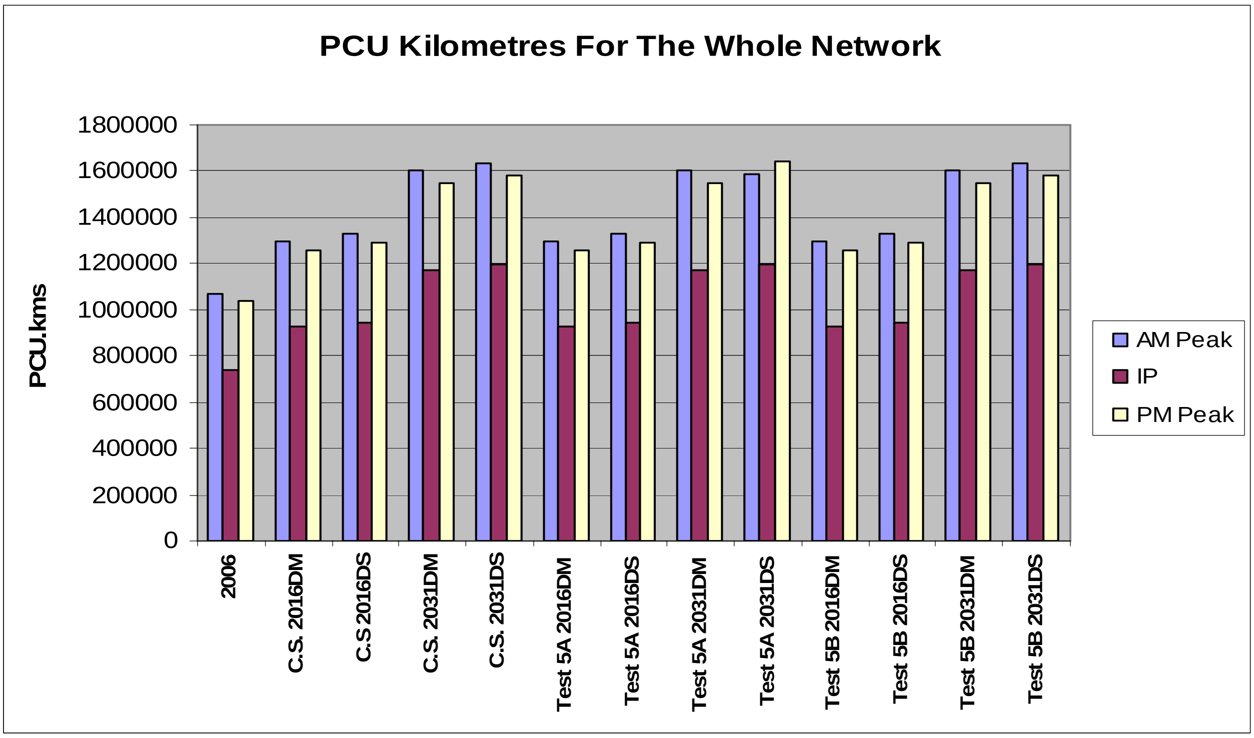
5.3.2 PCU Kilometres and Trip Lengths

Table 5.2 contains PCU.kms over the whole network for the two scenarios examined. **Figure 5.2** shows the same information in a bar chart.

Table 5.2: Network PCU Kilometres

Scenario	Year	PCU.kms			% Difference from Base Year		
		AM	IP	PM	AM	IP	PM
Base year	2006	1068498	738836	1038919	-	-	-
Core Scenario	2016DM	1300040	926560	1257485	22%	25%	21%
	2016DS	1326814	942226	1290247	24%	28%	24%
	2031DM	1606576	1174127	1548240	50%	59%	49%
	2031DS	1636695	1197795	1583278	53%	62%	52%
Test 5A Core Scenario Without City Centre Measures	2016DM	1300040	926560	1257485	22%	25%	21%
	2016DS	1325430	940980	1286912	24%	27%	24%
	2031DM	1606576	1174127	1548240	50%	59%	49%
	2031DS	1586271	1195695	1643497	48%	62%	58%
Test 5B Core Scenario Without Any Complementary Measures	2016DM	1300040	926560	1257485	22%	25%	21%
	2016DS	1324701	940195	1286592	24%	27%	24%
	2031DM	1606576	1174127	1548240	50%	59%	49%
	2031DS	1632414	1193737	1578622	53%	62%	52%

Figure 5.2: PCU Kilometres for the Whole Network



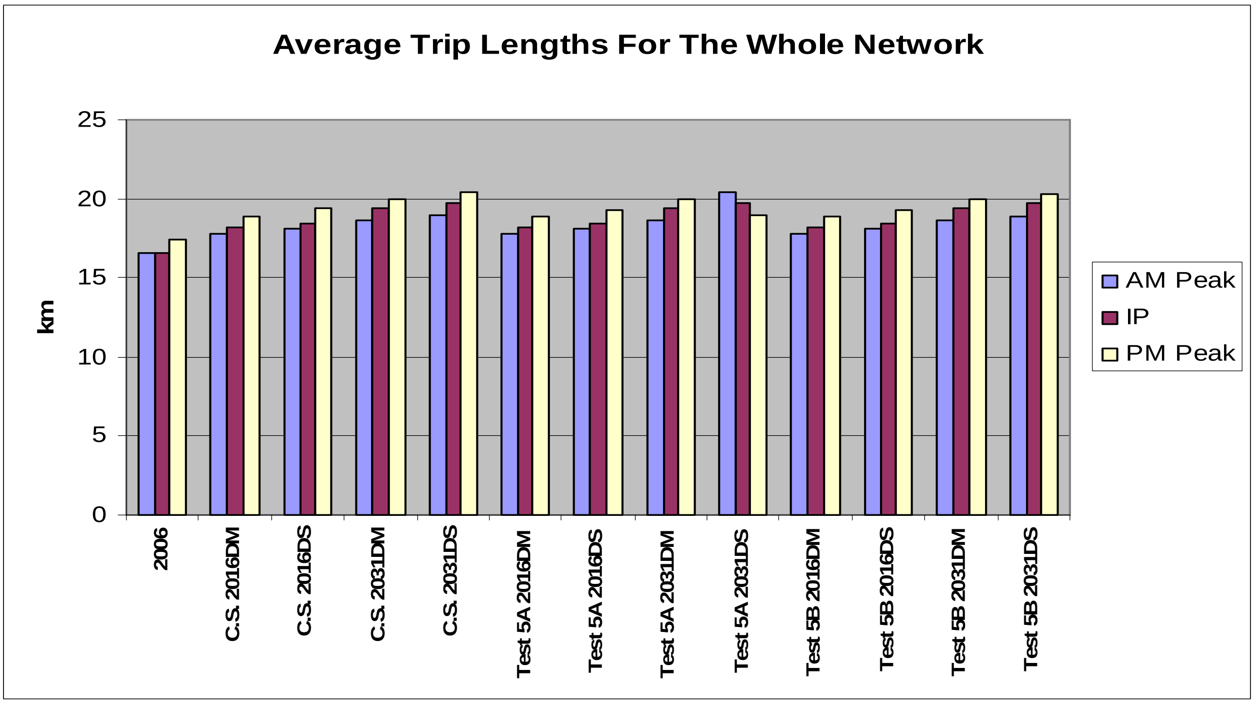
All future years have shown an increase in PCU.kms from the 2006 base year, with the largest increase for Test 5B shown in the 2031 DS runs with 62% in the IP. The AM and PM peaks see increases of 53% and 52% respectively. For Test 5A, the largest increase also occurs in the 2031 DS runs with the PCU.kms increasing by 48% in the AM peak, 62% in the IP and 58% in the PM peak. For all peak periods and test options, all DS runs (except for 2031 AM and PM for Test 5A) have a higher increase of between 2% to 3% compared to the DM runs.

Table 5.3 contains average trip lengths (km) over the whole network and **Figure 5.3** shows the average trip lengths for the whole network.

Table 5.3: Network Trip Lengths (km)

Scenario	Year	Average Trip Lengths (km)			% Difference from Base Year		
		AM	IP	PM	AM	IP	PM
Base year	2006	17	17	17	-	-	-
Core Scenario	2016DM	18	18	19	7%	9%	8%
	2016DS	18	18	19	9%	11%	11%
	2031DM	19	19	20	12%	17%	14%
	2031DS	19	20	20	14%	19%	17%
Test 5A **Core Scenario Without City Centre Measures**	2016DM	18	18	19	7%	9%	8%
	2016DS	18	18	19	9%	11%	11%
	2031DM	19	19	20	12%	17%	14%
	2031DS	20	20	19	23%	19%	9%
Test 5B **Core Scenario Without Any Complementary Measures**	2016DM	18	18	19	7%	9%	8%
	2016DS	18	18	19	9%	11%	11%
	2031DM	19	19	20	12%	17%	14%
	2031DS	19	20	20	14%	19%	16%

Figure 5.3: Average Trip Lengths for the Whole Network



In the 2006 base year, the average trip length is around 17km in all time periods. The trip lengths in both complementary measures (forecast years and scenarios) are longer than the base year with the percentage increase ranging between 7% and 23%

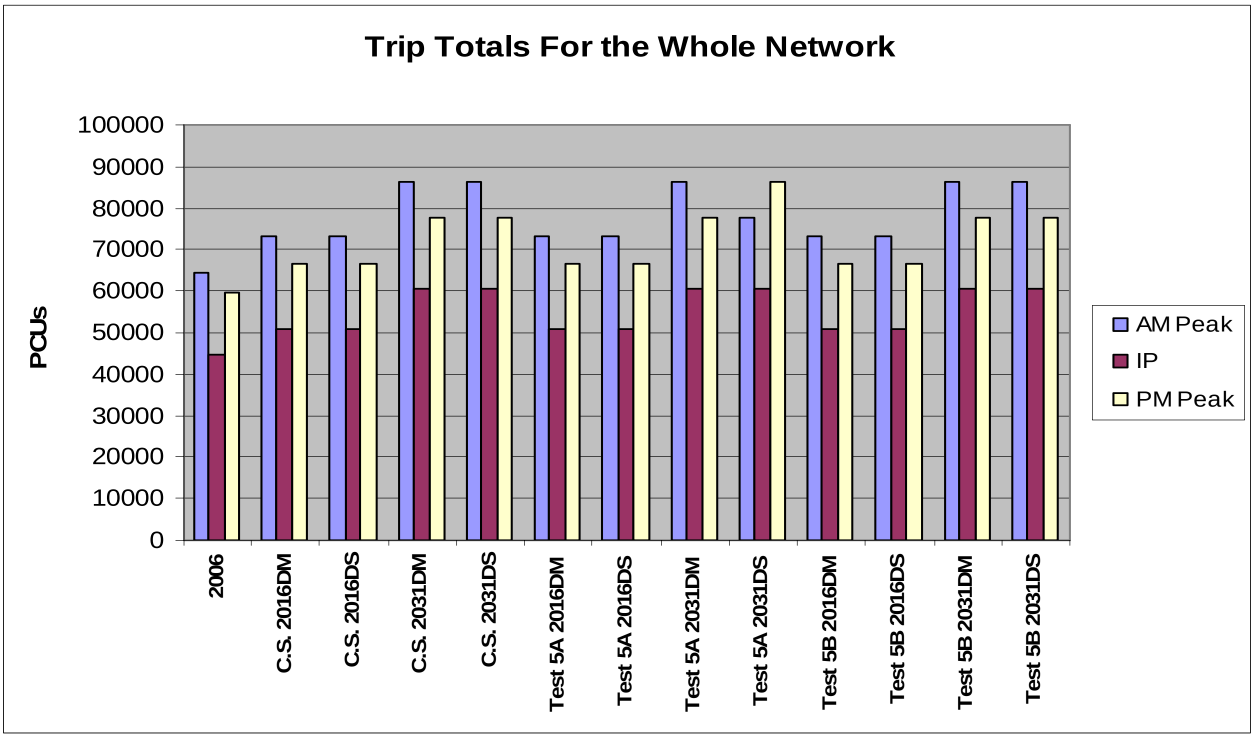
5.3.3 Total Trips

Table 5.4 contains total trips (in PCUs) over the whole network and **Figure 5.4** shows the same information in a bar chart.

Table 5.4: Summary of Trip Totals (PCUs)

Scenario	Year	Total Trips (PCUs)			% Difference from Base Year		
		AM	IP	PM	AM	IP	PM
Base year	2006	64480	44560	59441	-	-	-
Core Scenario	2016DM	73174	51040	66518	13%	15%	12%
	2016DS	73229	51035	66558	14%	15%	12%
	2031DM	86346	60587	77563	34%	36%	30%
	2031DS	86414	60578	77599	34%	36%	31%
Test 5A Core Scenario Without City Centre Measures	2016DM	73174	51040	66518	13%	15%	12%
	2016DS	73265	51046	66561	14%	15%	12%
	2031DM	86346	60587	77563	34%	36%	30%
	2031DS	77602	60595	86467	20%	36%	45%
Test 5B Core Scenario Without Any Complementary Measures	2016DM	73174	51040	66518	13%	15%	12%
	2016DS	73267	51048	66589	14%	15%	12%
	2031DM	86346	60587	77563	34%	36%	30%
	2031DS	86469	60601	77639	34%	36%	31%

Figure 5.4: Trip Totals for the Whole Network



In the 2006 base year, the trip totals are 64,480, 44,560 and 59,441 for the AM peak, IP and the PM peak respectively. This shows that in the base year, the AM peak had the largest amount of traffic. In the forecast years, 2031 DS PM peak has the highest total trips and percentage increase for Test 5A with an increase of 45% to 86,476 PCU trips. For Test 5B, the 2031 DS IP has the highest percentage increase of 36% (60601 total trips) but the largest volume of traffic is seen in the 2031 DS AM peak with a total of 86,469 PCU trips.

5.3.4 Traffic Flows

Traffic flows for the AM, IP and PM periods in the 2006 base year and the 2016 and 2031 forecast years on selected key roads for the two Complementary Measures options are shown on a map in **Figure W.1** in **Appendix W**. The flow numbers, along with calculated differences between traffic flows forecast for the DM and DS for the Test 5A are shown in **Tables W.1 and W.2.** Similar results for Test 5B are shown in **Tables W.3** and **W.4** of **Appendix W**.

The NNDR scheme is forecast to result in large reductions in traffic flows (i.e. DS flows minus the DM flows) on the A1067 through Taverham in all modelled periods in 2016 and 2031 and for both Test 5A and Test 5B. In the 2016 year for Test 5A the scheme is forecast to cause a reduction of 547 PCUs in the AM peak, 458 PCUs in the IP and 665 PCUs in the PM peak. The corresponding reductions in the AM peak, IP and PM peak for the 2031 forecasting year are 32, 538 and 1006 respectively.

For Test 5B, in the 2016 forecast year, the reductions for the AM peak, IP and PM peak are 542 PCUs, 477 PCUs and 689 PCUs respectively. The reductions in the AM peak, IP and PM peak for the 2031 forecasting year are 476, 541 and 672 respectively. The only other road to have similar level of reductions for the 2031 forecast year is the A47.

The NNDR scheme shows an increase in traffic flows on the A1151 (Wroxham Road) in the 2016 and 2031 for both Test 5A and Test 5B scenarios. For Test 5A 2016 forecast year, the increases are 36, 154 and 328 PCUs for the AM peak, IP and PM peak respectively. In 2031, the increases only occur for the AM peak and IP with 574 and 330 PCUs respectively. Trowse Bypass (A146) also forecast traffic flow increases across all peaks in both 2016 and 2031 years.

For Test 5B, significant traffic flow increases occur on the A1151 for the IP and PM peaks for both 2016 and 2031 years. In 2016 the increases are 118 PCUs for IP and 421 PCUs for PM peak. In 2031 these increases are 91 PCUs in the IP and 226 in the PM peak. Significant increases are also forecast on the A47(T) Southern Bypass in the southeast quadrant for the IP and PM peak periods with 442 and 388 PCUs respectively for the 2016 forecast year, and 181 and 398 PCUs respectively for the 2031 forecast year.

The omission of the city centre traffic management measures from the Core Scenario is forecast to result in generally lower flows on the Inner Ring Road. The further omission of the traffic management measures in the northern and western suburbs results in some traffic flow reductions but also some increases in the northern section of the Outer Ring Road.

5.3.5 Trips by Sector

Tables X.1 to **X.63** contain trip totals by sector for the 2006 base year and for the forecasting years 2016 and 2031 for both Test 5A and Test 5B. **Figure X.1** shows the NATS model sectors.

In the 2006 base year, trip totals for the AM peak, IP and the PM peak are 64,526 PCUs, 44,680 PCUs and 59,501 PCUs respectively (see **Table X.1** to **X.3**). In the 2016 DM Core Scenario without City Centre

Measures Reference Case (i.e. pre-DIADEM), the number of trips increases to 74,120, 51,262 and 67,190 respectively (see **Tables X.4** to **X.6**) and in the post-DIADEM the number of trips reduces to 73,258, 51,074 and 66,596 (see **Tables X.7** to **X.9**).

Tables X.10 to **X.12** show the differences in trip totals by sector between the pre-DIADEM (i.e. reference case) and post-DADEM in the 2016 DM. In all peaks, the large increases in the number of trips occur in the outer sectors of the study area, representing rural areas. The decrease in demand in Norwich is compensated by the increase in number of trips in the outer sectors. A similar pattern is repeated for the 2016 DS scenario (see **Tables X.43** to **X.45**).

Tables X.13 to **X.15** show the 2031 Core Scenario without City Centre Measures Reference Case and **Tables X.16** to **X.18** show the Core Scenario without City Centre Measures DM trip totals (i.e. post DIADEM). The differences between the two scenarios (i.e. post-DIADEM minus pre-DIADEM) are shown in **Tables X.19** to **X.21**. As in the 2016 DM forecasting year, in 2031 DM, the largest increases in the number of trips occurs in the outer sectors of the study area, representing rural areas. The decrease in demand in Norwich is compensated by the increase in number of trips in the outer sectors. A similar pattern is repeated for the 2031 DS scenario (see **Tables X.49** to **X.51**).

Tables X.55 to **X.57** show the differences in trip totals by sector between 2016 DS Core Scenario without any Complementary Measures and the Reference Case and **Tables X.61** to **X.63** show the same results for the 2031 forecasting years. As for the DM scenario, in all peaks, the largest increase in the number of trips occurs in the outer sectors of the study area, representing rural areas, and the decrease in demand in Norwich is compensated by the increase in number of trips in the outer sectors.

The patterns of results for the 2016 and 2031 Test 5A Scenario for both the DM and DS runs are similar as the results obtained for the Test 5B Scenario. In all peaks, the largest increase in the number of trips occurs in the outer sectors of the study area, representing rural areas, and the decrease in demand in Norwich is compensated by the increase in number of trips in the outer sectors.

5.3.6 PCU Kilometres by Sector

Information on vehicle kilometres is shown in **Tables Y.1** to **Y.51** for Test 5A and Test 5B (i.e. both Complementary Measures Scenarios).

For Test 5A in the 2016 DM AM peak, the PCU.kms have increased between 10% and 33% from the base year (see **Table Y.7**) and in the 2031 DM during the same time period, these increases are between 25% and 83% (see **Table Y.13**). In the 2016 DM IP, increases in PCU.kms from the base year range between 12% and 38% (see **Table Y.8**) and in 2031 the increase is between 31% and 101% (see **Table Y.14**). For the 2016 DM PM peak, increases in PCU.kms from the base year are between 7% and 34% (see **Table Y.9**) and in the 2031 forecasting year, the range varies between 23% and 86% (see **Table Y.15**).

In the 2016 DS in the AM peak, the PCU.kms have increased in the range of 5% to 50% from the base year (see **Table Y.31**) and in the 2031 DS during the same period, the increases in PCU.kms are in the range of 20% to 89% (see **Table Y.37**) . In the 2016 DS IP, increases in PCU.kms from the base year is in the range of 4% to 42% (see **Table Y.32**) and in 2031 the range is between 23% and 105% (see **Table Y.38**). In the 2016 DS PM peak, the PCU.kms has increase in the range of 0% to 41% from the base year (see **Table Y.33**) and in 2031 the range varies between 19% and 91% (see **Table Y.39**).

For Test 5B in the 2016 DM AM peak, the PCU.kms have increased in the range of 10% to 33% from the base year (see **Table Y.19**) and in the 2031 DM during the same, these increases are in the range of 25%

to 83% (see **Table Y.25**). In the 2016 DM IP, increases in PCU.kms from the base year range between 12% and 38% (see **Table Y.20**) and in 2031 the range varies between 31% and 101% (see **Table Y.26**). For the 2016 DM PM peak, increases in PCU.kms vary from the base year vary by between 7% to 24% (see **Table Y.21**) and in the 2031 forecasting year, the range vary between 23% to 86% (see **Table Y.27**).

In the 2016 DS scenario for Test 5B in the AM peak, the PCU.kms are increased in the range of 5% to 48% from the base year (see **Table Y.43**) and in the 2031 DS during the same period, the increases in PCU.kms are in the range of 21% to 89% (see **Table Y.49**) . In the 2016 DS IP, increases in PCU.kms from the base year is in the range of 4% to 42% (see **Table Y.44**) and in 2031 the range is between 22% and 104% (see **Table Y.50**). In the 2016 DS PM peak, the PCU.kms increase in the range of 0% to 40% from the base year (see **Table Y.45**) and in 2031 the range varies between 17% and 90% (see **Table Y.51**).

5.4 Economics

Economic assessment has been carried out in the same way as for the Core Scenario – see the Core Scenario report. Although construction costs of the NNDR without complementary measures would be lower that the full scheme, the same costs were used – this is a conservative assumption, and a more detailed assessment would result in higher NPVs and BCRs.

5.4.1 Results - summary

The results are summarised below in **Table 5.5**. The TUBA Transport Economic Efficiency (TEE), Public Accounts and Analysis of Monetised Costs and Benefits (AMCB) tables are shown in **Figure Z.1** in **Appendix Z**.

Table 5.5: Test 5 Economic Assessment Summary

Scenario	Present Value of Costs (PVC, £m)	Present Value of Benefits (PVB, £m)	Net Present Value (NPV, £m)	Benefit / Cost Ratio (BCR)
Test 5A Core scenario without city centre measures	86.896	748.040	661.144	8.6
Test 5B Core scenario without any complementary measures	91.369	811.410	720.041	8.9

Teat 5A Core scenario without city centre measures has a positive Benefit Cost Ratio (BCR) of 8.6 which categorises the scheme as “High Value for Money” in accordance with the DfT’s Value for Money guidance. Test 5B Core scenario without any complementary measures also has a positive BCR, of 8.9, which also is “High Value for Money”.

5.4.2 Results – by sector

TUBA sectors are shown in **Figure Z.1** in **Appendix Z**. Time benefits by sector of origin are given in **Table Z.1** to **Table Z.4** in **Appendix Z**. These indicate that for both tests, there are no significant disbenefits associated with the city centre, due to the omission of the city centre traffic management measures (Sector 1). Otherwise, the pattern of benefits is similar to that for the Core Scenario. Relatively low benefits are associated with the urban area inside the Outer Ring Road to the south-west, south-east and north-east (Sectors 2 to 4) and the suburban area to the south-east (Sector 8)..A medium level of benefits is found for the north-west urban area inside the Outer Ring Road (Sector 5), the northern suburban areas (Sectors, 6, 10 and 11), the rural areas to the north and south-east (Sectors 12 and 15) and the external sector representing the rest of the UK (Sector 18).

Significant benefits are associated with the suburban area to the east of Norwich (Sector 9) as well as the rural areas to the west, north-west and north (Sectors 13, 14 and 17) and to the north-east (Sector 16).

5.4.3 TUBA Warning Messages

For further details see **Appendix AA.**

5.5 Conclusions

The results of this sensitivity test can be summarised as follows:

- For Test 5A, the largest decrease in speed from the base year is the 2031 DS PM peak with the average speed dropping from 52km/h to 43km/h (decrease of 18%). The only increase in average speed occurs in the 2016 DS interpeak with a slight increase of 1km/h from 57km/h (i.e. increase of 3%). For Test 5B, the largest decrease in speed is in the 2031 DM AM peak with a reduction of 8km/h from the base year speed of 49km/h. The largest increase is again in the 2016 DS interpeak period with an increase of 1km/h (3% increase)

- The PCU.kms have all increased in all the options examined compared to the base year scenario with the largest increase being 2031DS run for both Test 5A and Test 5B. With the exception of Test 5A 2031DS AM peak and PM peak, all DS scenarios in both Test 5A and Test 5B and for all forecasting years have shown an increase in PCU.kms

- The average trip lengths for the base year are 17km across all peak periods. The average trip lengths are very similar between the scenarios in Test 5A and Test 5B with an increase ranging between 1km and 3km across all peak period.

- Trip totals have all increased in the two test options. The 2031 DS PM peak in Test 5A shows the highest total trips and with the highest percentage increase of 45% from the base year. (i.e. 59,441 PCU trips in base to 86,476 PCU trips in 2031 DS PM peak). For Test 5B, the highest percentage increase being the 2031 DS interpeak with 36% increase but the largest trip totals is the 2031 DS AM peak with 86,469 PCU trips.

- The omission of the city centre traffic management measures from the Core Scenario is forecast to result in generally lower flows on the Inner Ring Road. The further omission of the traffic management measures in the northern and western suburbs results in some traffic flow reductions but also some increases in the northern section of the Outer Ring Road.

- Trips by sectors show a similar pattern between Test 5A and Test 5B for the different scenarios. In all peaks, the largest increase in the number of trips occurs in the outer sectors of the study area, representing rural areas, and the decrease in demand in Norwich is compensated by the increase in number of trips in the outer sectors.

- In both Test 5A and Test 5B, PCU.kms by sectors have all increased compared to the base year across all peak periods.

- The Benefit Cost Ratio (BCR) for Test 5A and Test 5B are very similar with a positive BCR of 8.6 for Test 5A and a positive BCR of 8.9 for Test 5B. Both scenarios, in accordance with DfT's Value for Money guidance are considered as "High Value for Money".

- The city centre traffic management measures have greater effects on forecasts than the traffic management measures proposed in northern and western suburbs. Significant benefit is foregone by the inclusion of the measures in the Core Scenario.

6. **Test 6** Perturbing Demand Model Sensitivities

6.1 Introduction

This is a test of the sensitivity of the Variable Demand Modelling to a change in the sensitivity parameters that govern the individual demand mechanisms.

Guidance on this test is included in TAG Unit 3.10.4 section 1.7.

This test is aimed at identifying the relative effects of the various parameters on the outcome of a scheme appraisal, rather than in checking the model responses against experience.

For this test, the outturn public transport cost skims from the Core Scenario were fed into DIADEM. It is considered that this approach is reasonable because it is anticipated that there would be little difference between modal transfer in the Core Scenario and this test, and the proportion of net benefits attributable to public transport is low.

6.2 Model Parameters

This test comprised model runs using changed lambda values for the forecast years 2016 and 2031 for the morning, evening and interpeak periods.

The lambda values have been increased by +50% of the mean used for the Core Scenario runs, following TAG Unit 3.10.4, to ensure that any changes in the values are still consistent with the hierarchy. For this purpose, the changes have been made to all parameters in the same direction at the same time so that the gradation of parameter values is still consistent with the hierarchy.

The current demand mode uses DIADEM and allows distribution and mode choice. In DIADEM the distribution lambdas have been changed. As a scaling factor is included in the model for mode choice, the mode choice parameters are then automatically changed.

All distribution choice lambda values have been changed for this run, i.e. for car and PT and all different journey purposes.

6.3 Model Results

Model runs have been carried out using the transport model and methods used for work for the NNDR MSBC. Both highway and public transport modes are modelled, and Variable Demand Modelling has been carried out using DIADEM software in accordance with DfT’s TAG advice.

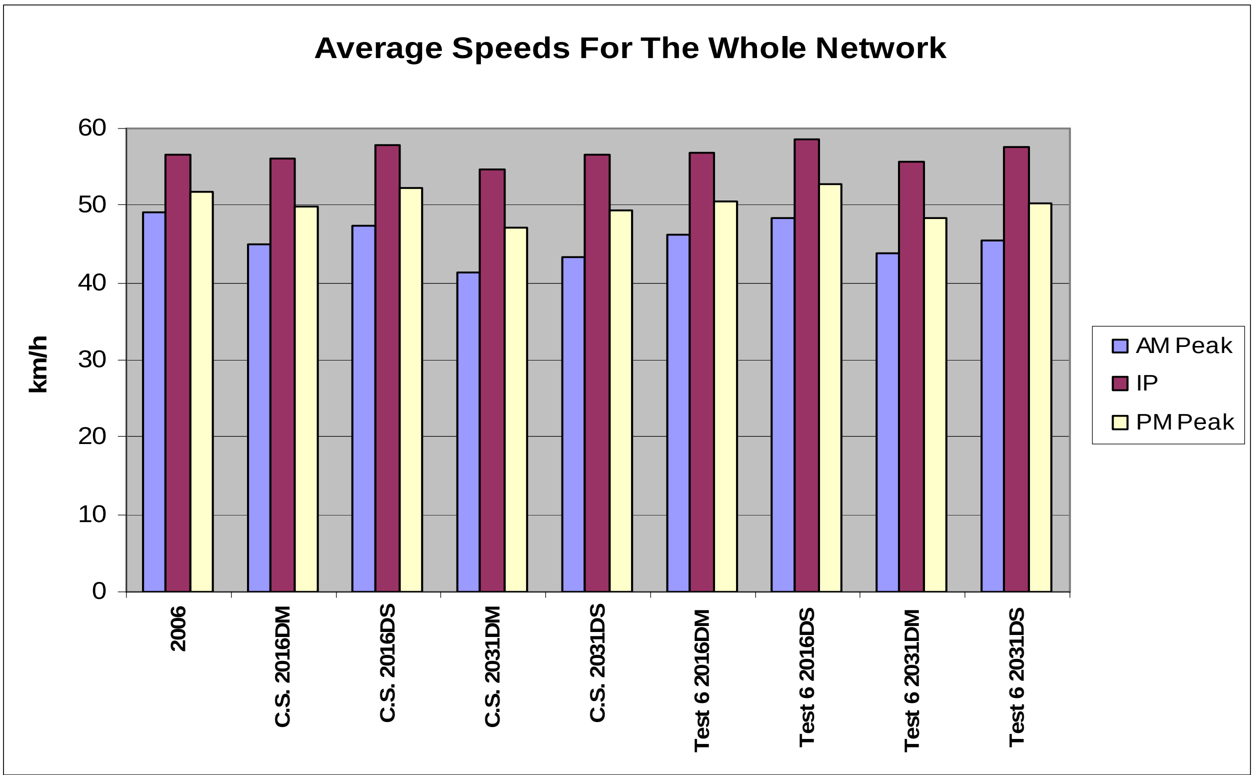
6.3.1 Average Speeds

Table 6.1 contains average speeds over the whole network (in km/h) together with percentage changes in respect to the 2006 base year. A bar chart showing the average speeds for the whole network is presented in **Figure 6.1**.

Table 6.1: Network Average Speeds

Scenario	Year	Average speed (km/h)			% Difference from Base Year		
		AM	IP	PM	AM	IP	PM
Base year	2006	49	57	52	-	-	-
Core Scenario	2016DM	45	56	50	-8%	-1%	-4%
	2016DS	47	58	52	-4%	2%	1%
	2031DM	41	55	47	-16%	-3%	-9%
	2031DS	43	57	49	-12%	0%	-5%
Test 6 Varied Parameters	2016DM	46	57	51	-6%	1%	-2%
	2016DS	48	59	53	-1%	4%	2%
	2031DM	44	56	49	-11%	-1%	-6%
	2031DS	46	58	50	-7%	2%	-3%

Figure 6.1: Average Speeds for the Whole Network



In the 2006 model base year, the average speeds in the morning and evening peaks are around 50km/h, rising to around 57km/h in the interpeak period. The largest decrease in speed from the base year is in 2031 DM in the AM peak, where the speed drops to 44km/h (i.e. a decrease of 11%). The largest increase is in the 2016 DS IP with an increase in speed of 2km/h from the base year (i.e. an increase of 4%).

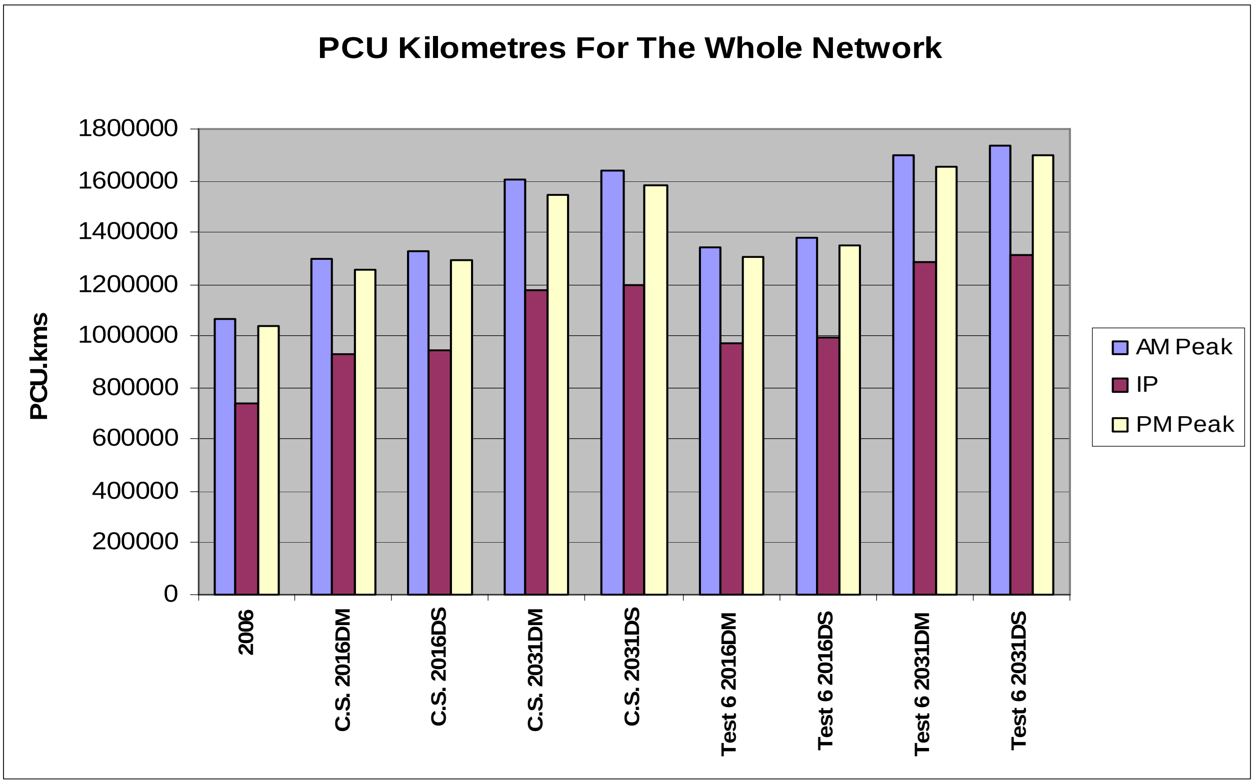
6.3.2 PCU Kilometres and Trip Lengths

Table 6.2 contains PCU.kms over the whole network and **Figure 6.2** shows the same information in a bar chart.

Table 6.2: Network PCU Kilometres

Scenario	Year	PCU.kms			% Difference from Base Year		
		AM	IP	PM	AM	IP	PM
Base year	2006	1068498	738836	1038919	-	-	-
Core Scenario	2016DM	1300040	926560	1257485	22%	25%	21%
	2016DS	1326814	942226	1290247	24%	28%	24%
	2031DM	1606576	1174127	1548240	50%	59%	49%
	2031DS	1636695	1197795	1583278	53%	62%	52%
Test 6 Varied Parameters	2016DM	1342504	975905	1308534	26%	32%	26%
	2016DS	1378048	995267	1348005	29%	35%	30%
	2031DM	1699331	1283953	1654948	59%	74%	59%
	2031DS	1735664	1311438	1695244	62%	78%	63%

Figure 6.2: PCU Kilometres for the Whole Network



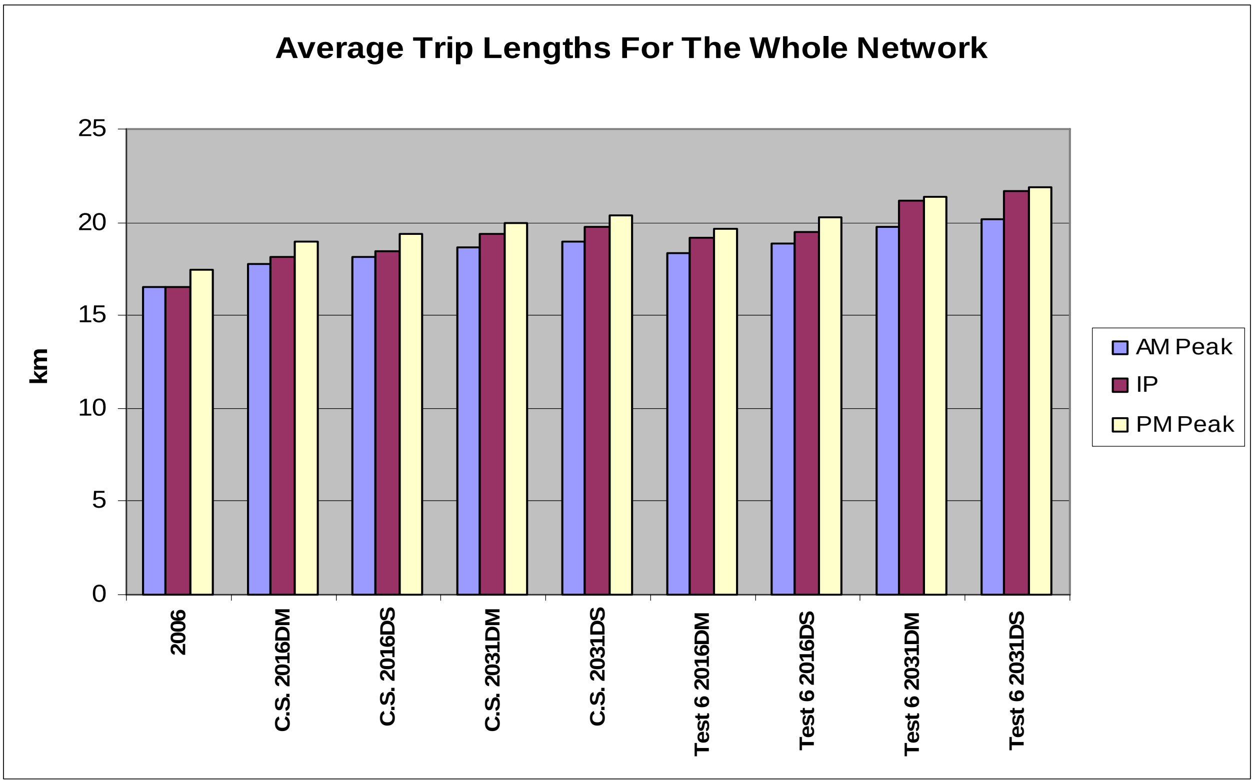
The PCU.kms in all future years increase from the 2006 base year, with the largest increase in the 2031 DS scenario, of between 62% in the AM peak to 78% in the IP. In the 2016 DS, the PCU.kms increase by between 29% in the AM and by 30% in the PM and peaks to 35% in the IP. The increase in PCU.kms in the future DM runs are about 2% to 5% lower than the DS runs for both 2016 and 2031 forecasting years and in all modelled periods.

Table 6.3 contains average trip lengths (km) over the whole network and **Figure 6.3** shows the average trip lengths for the whole network.

Table 6.3: Network Trip Lengths (km)

Scenario	Year	Average Trip Lengths (km)			% Difference from 2006 values		
		AM	IP	PM	AM	IP	PM
Base year	2006	17	17	17	-	-	-
Core Scenario	2016DM	18	18	19	7%	9%	8%
	2016DS	18	18	19	9%	11%	11%
	2031DM	19	19	20	12%	17%	14%
	2031DS	19	20	20	14%	19%	17%
Test 6 Varied Parameters	2016DM	18	19	20	11%	15%	12%
	2016DS	19	19	20	14%	18%	16%
	2031DM	20	21	21	19%	28%	22%
	2031DS	20	22	22	21%	31%	25%

Figure 6.3: Average Trip Lengths for the Whole Network



In the 2006 base year, the average trip length is around 17km in all peaks, which rises to around 18km in the 2016 AM Peak, 19 in the IP and to 20km in the PM peak for both the DM and the DS scenarios. In the 2031 DM, the average trip length increases to 20km in the AM peak (i.e. an increase of 19%) and 21km in the IP (i.e. an increase of 28%) and to 21km (i.e. an increase of 22%) in the PM peak. The corresponding figures for the 2031 DS are 20km, 22km and 22km respectively (i.e. increases of 21%, 31% and 25%).

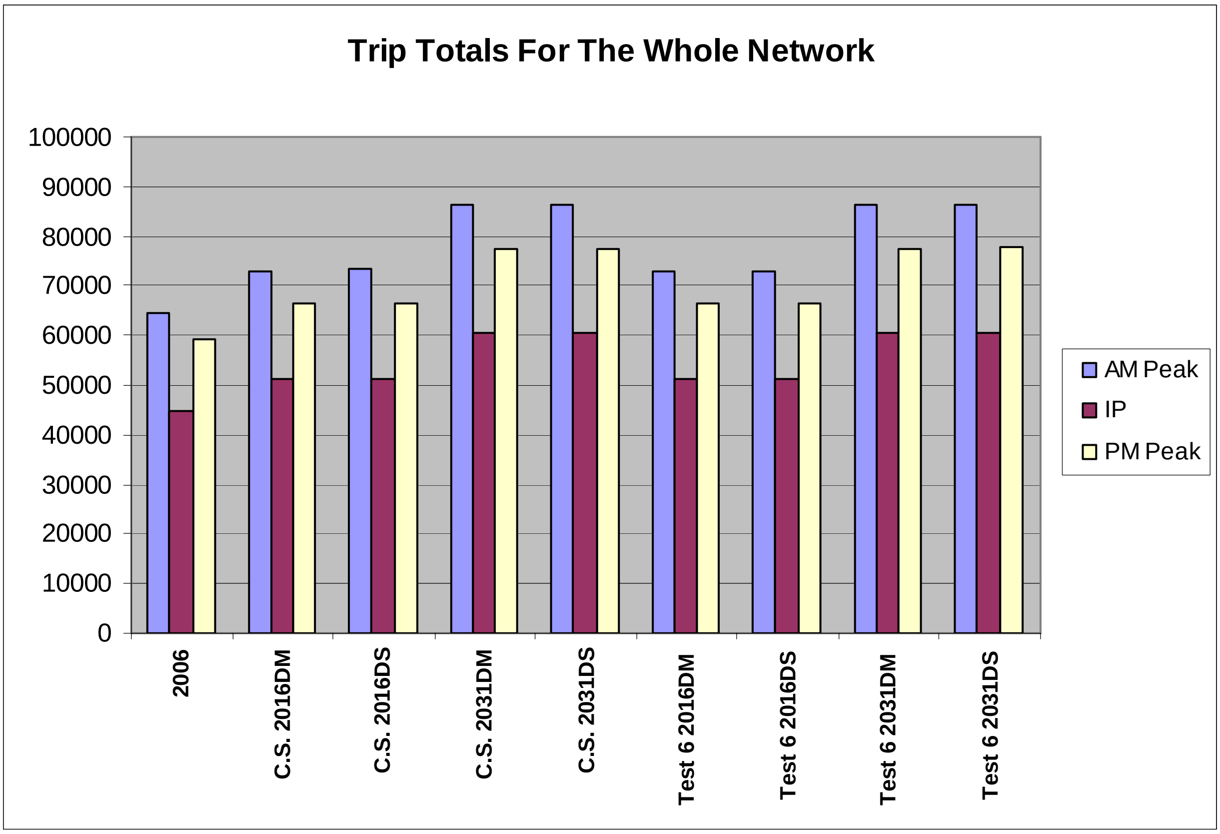
6.3.3 Total Trips

Table 6.4 contains total trips (in PCUs) over the whole network and **Figure** 6.4 shows the trip totals for the whole network.

Table 6.4: Summary of Trip Totals (PCUs)

Scenario	Year	Total Trips (PCUs)			% Difference from 2006 values		
		AM	IP	PM	AM	IP	PM
Base year	2006	64480	44560	59441	-	-	-
Core Scenario	2016DM	73174	51040	66518	13%	15%	12%
	2016DS	73229	51035	66558	14%	15%	12%
	2031DM	86346	60587	77563	34%	36%	30%
	2031DS	86414	60578	77599	34%	36%	31%
Test 6 Varied Parameters	2016DM	73101	51049	66553	13%	15%	12%
	2016DS	73176	51045	66608	13%	15%	12%
	2031DM	86156	60609	77579	34%	36%	31%
	2031DS	86248	60602	77636	34%	36%	31%

Figure 6.4: Trip Totals for the Whole Network



In the 2006 base year, the trip totals are 64,480, 44,560 and 59,441 for the AM peak, IP and the PM peak respectively. This shows that in the base year, the AM peak had the largest amount of traffic. A similar pattern is true for future scenarios. In the 2016 AM peak, the trip totals increase from base year to 73,101 (i.e. an increase of 13%) in 2016 DM and to 73,176 (i.e. an increase of 13%) in 2016 DS. The corresponding figures for the 2031 DM and DS runs are 86,156 (i.e. an increase of 34%) and 86,248 (i.e. an increase of 34%) respectively.

6.3.4 Traffic Flows

Traffic flows for the AM, IP and PM periods in the 2006 base year and the forecast years 2016 and 2031 are shown for selected key roads in **Tables DD.1** and **DD.2** in **Appendix DD** and their locations are shown on a map in **Figure DD.1**. Differences between traffic flows forecast for the DM and DS are also shown in this Table.

The NNDR scheme is forecast to result in large reductions in traffic flows (i.e. DS flows minus the DM flows) on the A1067 through Taverham in all modelled periods for both 2016 and 2031 forecasting years. In 2016, the scheme is forecast to cause a reduction of 606 PCUs in the AM peak, 504 PCUs in the IP and 694 PCUs in the PM peak. The corresponding reductions for the 2031 forecasting year are 518, 585 and 712 respectively.

The scheme is forecast to result in significant increases in traffic flows on the A147 Inner Ring Road in the southeast quadrant. In 2016, the introduction of the proposed NNDR causes an increase of 371 PCUs in the AM peak, 613 PCUs in the IP and 619 PCUs in the PM peak. The corresponding increases for the 2031 forecasting year are 203, 474 and 587 respectively. Significant increases are also forecast on the A47(T) Southern Bypass in the southeast quadrant in the IP and PM peak periods, with up to 524 PCUs in the 2031 IP.

Overall, the proposed NNDR scheme with associated traffic management measures is forecast to result in a reduction of traffic on most radial links, but increases on some sections of the A147 Inner Ring Road, one section of the A47(T) Southern Bypass, and some sections of radials used to access the new road.

6.3.5 Trips by Sector

Tables EE.1 to **EE.33** contain trip totals by sector for the 2006 base year and for the forecasting years 2016 and 2031. **Figure EE.1** shows NATS model sectors.

In the 2006 base year, trip totals for the AM peak, IP and the PM peak are 64,526 PCUs, 44,680 PCUs and 59,501 PCUs respectively (see **Table EE.1** to **EE.3**). In the 2016 DM reference case, the number of trips increases to 74,120, 51,262 and 67,190 respectively (see **Tables EE.4** to **EE.6**) and in the post-DIADEM the number of trips reduces to 73,192, 51,094 and 66,638 (see **Tables EE.7** to **EE.9**).

Tables EE.10 to **EE.12** show the differences in trip totals by sector between the pre-DIADEM (i.e. reference case) and post-DADEM in the 2016 DM. In all peaks, the largest increases in the number of trips occur in the outer sectors of the study area, representing rural areas. The decrease in demand in Norwich is compensated by the increase in number of trips in the outer sectors. A similar pattern is repeated for the 2016 DS scenario (see **Tables EE.25** to **EE.27**).

Tables EE.13 to **EE.15** show the 2031 Reference Case (i.e. pre-DIADEM) and **Tables EE.16** to **EE.18** show the DM trip totals (i.e. post DIADEM). The differences between the two scenarios (i.e. post-DIADEM minus pre-DIADEM) are shown in **Tables EE.19** to **EE.21**. As in the 2016 DM forecasting year, in 2031 DM, the largest increases in the number of trips occurs in the outer sectors of the study area, representing rural areas. The decrease in demand in Norwich is compensated by the increase in number of trips in the outer sectors. A similar pattern is repeated for the 2031 DS scenario (see **Tables EE.31** to **EE.33**).

Tables EE.25 to **EE.27** show the differences in trip totals by sector between 2016 DS and Reference Case and **Tables EE.31** to **EE.33** show the same results for the 2031 forecasting years. As for the DM scenario, in all peaks, the largest increase in the number of trips occurs in the outer sectors of the study area, representing rural areas, and the decrease in demand in Norwich is compensated by the increase in number of trips in the outer sectors.

6.3.6 PCU Kilometres by Sector

Information on vehicle kilometres is shown in **Tables FF.1** to **FF.27**.

In the 2016 DM Test 6 in the AM peak, the PCU.kms are increased in the range of 5% to 51% from the base year (see **Table FF.7**) and in the 2031 DM during the same period, these increases are in the range of 17% to 116% (see **Table FF.13**). In the 2016 DM IP, increases in PCU.kms from the base year range between 5% and 62% (see **Table FF.8**) and in 2031 the range varies between 22% and 154% (see **Table FF.14**). For the 2016 DM PM peak, increases in PCU.kms vary from the base year vary by between 2% to 52% (see **Table FF.9**) and in the 2031 forecasting year, the range vary between 19% to 124% (see **Table FF.15**).

In the 2016 DS Test 6 in the AM peak, the PCU.kms are increased in the range of 3% to 54% from the base year (see **Table FF.19**) and in the 2031 DS during the same period, the increases in PCU.kms are in the range of 16% to 120% (see **Table FF.25**). In the 2016 DS IP, increases in PCU.kms from the base year are in the range of 3% to 62% (see **Table FF.20**) and in 2031 the range is between 20% and 153% (see **Table FF.26**). In the 2016 DS PM peak, the change in PCU.kms varies between -3% to 56% from the Base Year (see **Table FF.21**). In 2031 the range is between 14% and 125% (see **Table FF.27**).

6.4 Economics

Economic assessment has been carried out in the same way as for the Core Scenario – see the Core Scenario report. The same costs were used.

6.4.1 Results - summary

The results are summarised below in **Table 6.5**. The TUBA Transport Economic Efficiency (TEE), Public Accounts and Analysis of Monetised Costs and Benefits (AMCB) tables are shown in **Figure II.1** in **Appendix II**.

Table 6.5: Test 6 Economic Assessment Summary

Scenario	Present Value of Costs (PVC, £m)	Present Value of Benefits (PVB, £m)	Net Present Value (NPV, £m)	Benefit / Cost Ratio (BCR)
Test 6 Varied Parameters	80.814	529.330	448.516	6.6

Test 6 Varied parameters has a positive Cost Benefit Ratio (BCR) of 6.6 which categorises the scheme as “High Value for Money” in accordance with the DfT’s Value for Money guidance.

While DIADEM reduces the total trips in the DM (compared to reference) it actually increases the total PCU.kms. This comes about because of a redistribution of trips to the outer sectors 10-13. One factor in this is that decreasing distance costs in the future (increasing VOT, improved fuel efficiency) offset increased congestion for long distance trips, making these destinations relatively more attractive (compared with central locations and short distance trips). Another factor is the steep increase in city centre parking charges (69% in real terms between 2006 and 2031).

This all happens in the Core Scenario and in Test 6. The increased lambda values mean that the increase in DM PCU.kms is greater in Test 6.

This explains the effect of the increased lambdas on scheme benefits is not as expected. The usual expectation is that variable demand model suppresses PCU.kms in the DM and that increasing lambda increases the level of suppression, which usually then reduces scheme benefits. That is not happening here for the above reasons.

6.4.2 Results – by sector

TUBA sectors are shown in **Figure GG.2** in **Appendix GG**. Time benefits by sector of origin are given in **Table GG.1** to **GG.2** in **Appendix GG**. These indicate that changing the lambda parameter has a disbenefits associated with the city centre traffic management measures (Sector 1). Relatively low disbenefits or benefits are associated with the urban area inside the Outer Ring Road (Sectors 2 to 4), the suburban area to the south-east (Sector 8). A medium level of benefits is found for the north-west urban area inside the Outer Ring Road (Sector 5), the northern suburban area (Sectors, 6, 10 and 11), the rural areas to the north and south-east (Sectors 12 and 15) and the external sector representing the rest of the UK (Sector 18). Relatively high benefits are associated with the suburban area to the east of Norwich (Sector 9) as well as the rural areas to the west, north-west and north (Sectors 13, 14 and 17) and to the north-east (Sector 16).

6.4.3 TUBA Warning Messages

For further details see **Appendix HH.**

6.5 Conclusions

The results of this sensitivity test can be summarised as follows:

- The largest decrease in speed from the Base Year is the 2031 DM AM peak with the average speed decreasing from 49km/h to 44km/h (decrease of 16%). An average percentage increase of 2% to 4% have been observed in the 2016 DS interpeak and PM peak.

- The PCU.kms have all increased in all the options examined compared to the base year scenario with the largest increases being in 2031DM and DS AM, interpeak and PM runs.

- The average trip lengths for the base year are 17km across all peak periods. The average trip lengths show an increase ranging between 1km and 5km across all peak periods.

- Trip totals have all increased in comparison to the Base year. The 2031 DM interpeak shows the highest total trips and with the highest percentage increase of 36% from the base year. (i.e. 44,560 PCU trips in base to 60,609 PCU trips in 2031 DM interpeak).

- Trips by sectors show a similar pattern to the other Sensitivity Tests. In all peaks, the largest increase in the number of trips occurs in the outer sectors of the study area, representing rural areas, and the decrease in demand in Norwich is compensated by the increase in number of trips in the outer sectors

- The change in PCU.kms by sectors varies between -3% and 154% for the future year scenarios and peaks examined. The largest percentage increase is in the 2031 DM interpeak with an increase of 154% from the base year.

- The Benefit Cost Ratio (BCR) shows a positive value of 6.6. In accordance with DfT's Value for Money guidance it is considered as "High Value for Money".

- By increasing the lambda value for highway trips, there is an increase in induced traffic and consequential effects on the PVB and PVC. However these changes are quite small and occur in the same direction.