


Norwich - Northern Distributor Road

Major Scheme Business Case
Sensitivity Tests For DfT

Core Scenario

Volume 1 – Main Report

December 2009
Norfolk County Council

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Mott MacDonald

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Volume 2

Summary

Further to Norfolk County Council's submission of the Major Scheme Business Case (MSBC) for the Norwich Northern Distributor Road (NNDR) scheme, the Department for Transport requested that a range of sensitivity tests be carried out in order to better understand uncertainties associated with the previous analysis.

Test 1 included 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. The results of that work are reported in the Dependent Development report.

Following that investigation, a revised Core Scenario was defined, and model runs and economic assessment carried out, building on the previous work reported in the MSBC and the Traffic Forecast Report. The model runs were carried out in accordance with DfT's guidance on Variable Demand Modelling. Details of the Core Scenario runs, including parameters used for them, details of model results, and details of the results of the economic assessment, are given in this report.

Highway and public transport networks have been updated with changes to the existing transport system classified as 'near certain' or 'more than likely' in accordance with TAG Unit 3.15.5, and an uncertainty log has been produced covering schemes and developments. The NNDR scheme comprises the proposed highway to the north and east of Norwich, together with complementary traffic management measures in the city centre and the northern and western suburbs. In work for the MSBC, details of the city centre measures were not known, and they were represented in the model by a proxy penalty. Subsequently, proposals for the measures have been developed, and these have been modelled in the Do Something scenario.

The programme for the NNDR has changed since submission of the MSBC, and therefore new forecasts have been produced for revised forecast years 2016 and 2031.

Results indicate that, without the NNDR scheme, numbers and lengths of trips are forecast to increase in future, by up to 36% and 17% respectively above base year 2006 values in 2031. With the scheme, numbers of trips are forecast to generally increase by small amounts compared to the situation without the scheme, by up to around 70 trips in the AM peak in 2031; lengths of trips are forecast to generally increase by up to 3% in both 2016 and 2031. Total network distance travelled by vehicles, expressed as PCU kilometres, is forecast to increase significantly without the scheme, by up to up to 59% in 2031. With the scheme, additional increases of up to 3% are forecast.

Average speeds are forecast to reduce without the scheme, by up to 16% below base year 2006 speeds in 2031, with maximum reductions occurring in the AM peak period. The NNDR scheme is forecast to mitigate these reductions, so that the reduction in the AM peak in 2031 is forecast to be 12%. In the interpeak period in 2031 the average network speed with the NNDR scheme of 57 km/h is forecast to be the same as in the base year 2006.

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.

Examination of trip data by sector shows that, 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.

Economic assessment of the scheme indicates that disbenefits associated with the city centre traffic management measures are forecast. However, these are forecast to be greatly outweighed by significant benefits associated with the suburban areas to the north, and the rural areas to the east, north and west.

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. This is significantly higher than the BCR of 2.6 given in the MSBC, and reasons for the change have been considered.

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 (MSBC) for the Norwich Northern Distributor Road (NNDR). The tests were:-

1. A revised core scenario test that excludes dependent development from the forecasts (all further sensitivity tests will 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 WebTAG 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. town centre traffic management/speed limits in the northern suburbs)
6. A sensitivity test perturbing the demand model sensitivities

This report contains the results of work on the revised Core Scenario that was defined subsequent to initial tests for dependent development. The revised Core Scenario forms the basis for the subsequent sensitivity tests.

The work on the revised Core Scenario builds on the previous work carried out for the MSBC, which was reported in the MSBC report (July 2008) and the Traffic Forecast Report (May 2008). This report gives results of the revised Core Scenario assessment, which replace the results in the previous reports. However, in general the methods and parameters in the previous reports have been used.

1.2 Sensitivity Test 1

The Dependent Development (December 2009) report gives details of work carried out to investigate dependent development within the methodologies given in DfT's 'for consultation' draft Transport Analysis Guidance Unit 3.16C 'Appraisal in the Context of Housing Development'. This work resulted in the conclusion that it would not be appropriate to treat any proposed future development as dependent development, within the methodologies and strict definitions given in TAG Unit 3.16C, for assessment and economic evaluation purposes. However, the work did identify that the Joint Core Strategy (version JCS0), prepared by Broadland District Council, Norwich City Council, South Norfolk Council, Norfolk County Council and the Broads Authority, would result in future transport network operational difficulties (traffic congestion and delays) that the proposed NNDR scheme would mitigate.

1.3 Revised Core Scenario

An Uncertainty Log of future development included in the Joint Core Strategy proposed submission document has been compiled in accordance with DfT's TAG Unit 3.15.5 'The Treatment of Uncertainty in Model Forecasting'. Classifications for each development input and period have been assessed taking into account the guidance, and drawing on local knowledge and experience. The uncertainty level was considered for housing and business developments. It was considered that the elements planned up to 2016 should be categorised as 'more than likely', but for the period 2016-2031 there is more uncertainty such that a 'reasonably foreseeable' category is appropriate.

Therefore future growth for the revised Core Scenario comprises JCS housing and business development up to 2016 (item 1 in the uncertainty log), and TEMPRO 5.4 growth thereafter, up to 2031.

The work carried out to investigate dependent development was based on the forecast years used for the NNDR Major Schemes Business Case, of 2012 Opening Year and 2027 Design Year. The programme for the NNDR scheme has been reappraised, and the Core Scenario test has been carried out for a 2016 Opening Year and a 2031 Design Year.

This report contains details as follows:-

- Section 2 – the Do Minimum situation
- Section 3 – the Do Something i.e. the Do Minimum with the addition of the scheme
- Section 4 – model results
- Section 5 – economics
- Section 6 – conclusions

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. Do Minimum

A Do Minimum (DM) scenario is required as a reference upon which to assess the effects of the proposed scheme measures. As such it includes schemes and measures that have been implemented between 2006 (the model base year) and 2009 and those post-2009 changes to the existing transport system classified as 'near certain' or 'more than likely' in accordance with TAG Unit 3.15.5.

This section summarises the assumptions that have been adopted in the Do Minimum scenario for the Revised Core Scenario.

2.1 Highway

In terms of the Do Minimum, schemes and measures can be divided into three main areas:

- Junction improvements - measures to improve the operation or safety of junctions
- Pedestrian improvements - measures to facilitate pedestrian movement and safety e.g. pedestrian crossings
- Traffic management and safety schemes - measures to reduce traffic intrusion into residential and commercial areas and reduce traffic speeds

2.1.1 Network

The Do Minimum network assumptions are based on significant schemes that are planned to be completed up to and beyond 2016. The opportunity has been taken to update the Do Minimum network from that used for the MSBC with several minor network changes that have been implemented since the development of the previous MSBC Do Minimum model. Information on planned schemes in Norwich City, North Norfolk, South Norfolk and Broadland has been provided by Norfolk County Council. Details of future schemes in the remaining districts of Norfolk are not included as the model detail in these outlying districts is relatively coarse, and therefore inclusion of schemes would have minimal effect in the Greater Norwich area.

Table 2.1 Error! Reference source not found.shows the schemes identified and their certainty classification in accordance with TAG Unit 3.15.5. All schemes that are near certain or more than likely have been included in the Do Minimum. The locations of all the highway schemes in the Do Minimum are highlighted in **Figure A.1** in **Appendix A**.

Table 2.1: Uncertainty Log – Factors Affecting Supply of Transport

	Input	Uncertainty	Included in the model	Comment
1	Boundary Road widening of eastbound carriageway with one additional lane between ASDA / Whiffler Road Junction and City View Road	Near certain	Y	
2	Hall Road Mini Roundabout by B&Q changed to larger roundabout	Near certain	Y	
3	Taverham Road / The Street / Sandy Lane priority junction change from a priority junction to a mini-roundabout	Near certain	Y	
4	White Woman Lane / B1150 junction signalisation (undertaken 2007)	Near certain	Y	
5	Aylsham Road / Boundary Road traffic signal staging update	Near certain	Y	
6	Colman Road / South Park Avenue traffic signal staging and timing update	Near certain	Y	
7	Whitefriars Roundabout updating of roundabout geometry as part of Norwich Growth Point – it is assumed for inclusion into the Do Minimum network for 2026 forecast year only.	Near certain	Y	
8	Costessey Interchange Improvements replacing two current roundabouts with one large at A47 as part of Norwich Growth Point (included in Do Minimum network for 2026 only)	Reasonably foreseeable	N	
9	Magdalen Road, Norwich St Clements Hill junction to Sprowston Road	Hypothetical	N	Feasibility stage - details not yet developed

	Input	Uncertainty	Included in the model	Comment
10	Norwich, Outer Ring Road and Inner Ring Road junction improvements	Hypothetical	N	Not yet identified
11	Mile Cross Lane / Catton Grove Road, Norwich Outer Ring Road junction improvements	Hypothetical	N	Not yet identified
12	Sweet Briar Road / Drayton Road / Blackberry Court, Norwich Outer Ring Road junction improvements	Hypothetical	N	Not yet identified
13	Hall Road Roundabout Improvements, Norwich (B&Q S278). New layout and lane allocations	Near certain	Y	
14	Tuckswood Roundabout Improvements, Norwich (B&Q S278)	Hypothetical	N	No works at Tuckswood
15	Barrack Street / Kett's Hill Roundabout; Heartsease Roundabout, junction and road improvements (Norwich Growth Point Partnership)	Hypothetical	N	Dependent on outcome of the growth point bid
16	Harvey Lane Traffic Signals - Pedestrian Phase (Thorpe House School)	Hypothetical	N	Feasibility stage
17	A1242 Harvey Lane / Thorpe Road, Norwich Traffic signal modifications	Near certain	Y	
18	A147 Foundry Bridge / Riverside Road, Norwich Traffic signal modifications	Hypothetical	N	No details yet available
19	Anglia Square / St Augustine's / Duke Street Roundabout, Norwich - junction and road improvements (Norwich Growth Point Partnership)	Near certain	Y	

	Input	Uncertainty	Included in the model	Comment
20	Bowthorpe Road, Norwich Farrow Road to Dereham Road safety and speed management	Near certain	Y	
21	Jex Road, Norwich Road safety and speed management	Near certain	Y	
22	Arlington Road, Norwich Road safety and speed management	Near certain	Y	
23	C261 Reepham Road, Hellesdon Puffin Crossing	Hypothetical	N	Under discussion - may not be implemented
24	Salhouse Road, Sprowston Toucan Crossing	Hypothetical	N	Not likely to be implemented in near future
25	Thickthorn Roundabout Improvements	Hypothetical	N	No details available
26	B1108 Colney Road Improvement (Norwich Growth Point - funded from hospital S106 contribution)	Hypothetical	N	No details available
27	Lodge Farm, Costessey Traffic signals, footways and toucan crossing (S278 funding)	Hypothetical	N	No details available
28	Pedestrian crossing improvements to signalised junction of Thorpe Road/Harvey Lane	Near certain	Y	
29	Pedestrian crossing improvements to signalised junction of Unthank Road/Colman Road	Near certain	Y	
30	St Augustine's Street one way and new link through Anglia Square to resolve Air Quality Issues	Near certain	Y	
31	Ber Street/Thorn Lane/Brooke Place - Road safety and speed management scheme	Near certain	Y	
32	Traffic Calming on West End and The Street in Costessey	Near certain	Y	
33	New Toucan Crossing on Salhouse Road at Falcon Road East	Near certain	Y	

	Input	Uncertainty	Included in the model	Comment
34	New Toucan Crossing and footway and cycleway on A1067 Fakenham Road near Kingswood Avenue	Near certain	Y	
35	Traffic calming at Kingswood Avenue (Hinks Meadow)	Near certain	Y	
36	Westlegate closure	Near certain	Y	

2.1.2 Parking Charges

Norwich City Council has no published policy on future car parking charges and much of the parking supply in the city centre is commercially owned and operated. Therefore, in the absence of further information, car parking charges are assumed to increase in line with the GDP values published in WebTAG 3.5.6.

2.2 Public Transport

It is assumed that the public transport network remains as it is in the base year. Assumptions have been made in terms of how bus and rail fares change in the future. Overall, it should be noted that there are no major changes to the public transport network in the Do Minimum.

Error! Reference source not found.**Table 2.2** and **Table 2.3** show the factors affecting supply of public transport and factors affecting cost of public transport. In these tables, all schemes that are near certain or more than likely have been included in the Do Minimum.

Table 2.2: Uncertainty Log – Factors Affecting Supply of Public Transport

	Input	Uncertainty	Included in the model	Comment
1	Norwich Bus Strategy	Hypothetical	N	Not currently adopted
2	Increase in frequency on the number of bus routes to reflect a minimum level of service	More than likely	Y	

Table 2.3: Uncertainty Log – Factors Affecting Cost of Public Transport

	Input	Uncertainty	Included in the model	Comment
1	Public Transport: Bus and Rail Fares	More than likely	Y	The public transport fares are based on Retail Price Index (RPI), using the following assumptions: For bus: RPI +1.8% per annum For rail: RPI +1% per annum
2	Rail Services	Hypothetical	N	No information is available indicating significant changes from base year.

2.3 Future Development

Norfolk County Council planners have provided details of developments included in the JCS, up to 2026 in Norwich, Broadland and South Norfolk, for the following periods:-

- 2006 to 2016
- 2016 to 2021
- 2021 to 2026

Total development for the period 2026 to 2031 in Norwich, Broadland and South Norfolk is given in the Regional Spatial Strategy.

An Uncertainty Log of these developments has been compiled in accordance with TAG Unit 3.15.5 and this is shown in **Table 2.4**Error! Reference source not found.. Classifications for each development input and period have been assessed taking into account the guidance, and including drawing on local knowledge and experience.

Table 2.4: Future Development 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

The uncertainty level was considered for land for the housing and business development included in the Greater Norwich Development Partnership Joint Core Strategy proposed submission document. 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 such that a 'reasonably foreseeable' category is appropriate.

Therefore future growth for the Core Scenario comprises JCS housing and business development up to 2016 (Item 1 in **Table 2.4**Error! Reference source not found.), and TEMPRO 5.4 growth thereafter, up to 2031. For LGVs on employers business and HGVs, National Traffic Model 2008 (NTM08) forecasts have been used.

2.3.1 Development Details

Details of sizes and locations of developments have been obtained from the JCS, and are detailed below.

2.3.2 Development up to 2016

The JCS identifies a total of 19,102 additional homes to be provided in the Greater Norwich area between 2006 and 2016 as summarised in **Table 2.5**Error! Reference source not found.. Detailed information for the developments is listed in **Table A.1** and their locations are shown on a map in **Figure A.2** in **Appendix A**.

Table 2.5: Forecast Housing Developments 2006-2016

	Housing Numbers
Broadland	3,366
Norwich City	6,885
South Norfolk	6,133
Windfall	1,680
Sites under 10 dwellings	1,038
Total	**19,102**

Table 2.6 Error! Reference source not found. overleaf shows the business developments, types and sizes to be provided in the Greater Norwich area between 2006 and 2016. Their locations are shown in **Figure A.3** in **Appendix A**.

2.3.3 Development between 2016 – 2031

As described before, the future growth for the Core Scenario comprises of JCS housing and business development up to 2016 (item 1 in **Table 2.4**Error! Reference source not found.), and TEMPRO 5.4 growth thereafter, up to 2031. For LGVs on employers business and HGVs, NTM08 forecasts have been used.

2.3.4 Rackheath Ecotown

Trip rates by land use for future developments have been derived from the TRICS database. For the Rackheath Ecotown these trip rates have been reduced by 50% to reflect Ecotown principles, as detailed information has not yet been developed and agreed. **Figure A.4** in **Appendix A** shows the location of Rackheath Ecotown.

2.3.5 TEMPRO 5.4

The future trip matrices were created using the growth for JCS housing and business development up to 2016 (item 1 in **Table 2.4**Error! Reference source not found.), and TEMPRO 5.4 growth (for cars and LGVs on trip purposes commute and other) and NTM08 (for LGVs on employer's business and HGVs) thereafter, up to 2031, to create 2031 matrices. In both forecasting years the total number of car and LGV (on trip purposes commute and other) trips was constrained to TEMPRO 5.4.

Table 2.6: Business Developments 2006-2016

No	Local Plan Development	TEMPRO Area	Development Type	Size (ha)	Developed (m2)	Model Zone
1	Hellesdon	Broadland	B1 / B2 / B8	0.33	1,155	119
2	Sprowston	Broadland	B1 / B2 / B8	4.49	15,715	11402
3	Horsford	Broadland	B1 / B2 / B8	0.86	3,010	15201
4	Broadland Business Park, Green Lane	Broadland	B1 / B2 / B8	43.23	151,305	15901
5	Broadland Business Park, north	Broadland	B1 / B2 / B8	0.58	2,030	15901
	Total Broadland			**49.49**	**173,215**	
6	Old Hall Road	Norwich	B1 / B2 / B8	1.64	5,740	91
7	Site at Kerrison Road	Norwich	B1	1.00	3,500	6705
8	Deal Ground, Trowse	Norwich	B1	4.34	15,190	6803
9	Cremorne Road	Norwich	B1 / B2 / B8	3.45	12,075	6804
10	Livestock Market, Hall Road	Norwich	A1 / B1 / B2 / B8	6.37	22,295	9102
11	Airport	Norwich	B1 / B2 / B8	2.07	7,245	12002
	Total Norwich			**18.87**	**66,045**	
12	Wymondham	South Norfolk	B1 / B2 / B8	15.37	53,795	520
13	Longwater (Costessey)	South Norfolk	B1 / B2 / B8	15.79	55,265	12601
14	NRP	South Norfolk	Research	8.00	28,000	12902
15	Colney Conting. (research)	South Norfolk	B1	7.00	24,500	12905
16	Colney Hall	South Norfolk	B1	7.50	26,250	12908
	Total South Norfolk			**53.66**	**187,810**	
	Total for all areas			**122.02**	**427,070**	

3. Do Something

The Do Something (DS) scenario represents a scenario with the NNDR plus associated complementary traffic management measures in the city centre and the northern and western suburbs in place.

3.1 Highway Network – NNDR

The proposed NNDR is shown in **Figure B.1** in **Appendix B**. The NNDR starts in the west at a new junction on the A1067 north of Taverham and ends in the east of Norwich at the Postwick Interchange on the A47(T). The total length of the proposed NNDR is approximately 20km, which includes two grade separated junctions, with A47(T) at Postwick and with A140 Cromer Road.

3.2 Highway Network – City Centre

In conjunction with the NNDR, complementary traffic management measures are proposed for Norwich city centre, with the aim of discouraging through car trips and reducing the dominance of traffic in certain areas. In work for the MSBC, details of the measures were not known, and they were represented in the model by a proxy penalty applied to all vehicles travelling into the city centre from the Inner Ring Road. Subsequently, proposals for the measures have been developed, andwere included in the Transport for Norwich: A summary of our plans for the future: Consultation October 2009. **Figure B.2** in **Appendix B** shows current proposals, and these have been modelled in the Do Something scenario.

3.3 Traffic Management

It is anticipated that the proposed NNDR could potentially lead to an increase of through traffic on roads in the area of Taverham and Thorpe Marriott from and leading to the NNDR. To reduce adverse traffic effects at the Drayton Community School the closure of part of Drayton Lane has been assumed in the network coding as part of the proposed NNDR junction strategy. In addition, 20mph speed limits are proposed on selected links in the northern and eastern suburbs of Norwich as well as in Taverham. The location of the speed restrictions and the banned link are shown in **Figure B.3** in **Appendix B**.

4. 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. The DIADEM model assesses the modal split and re-distribution responses.

4.1 Network Wide

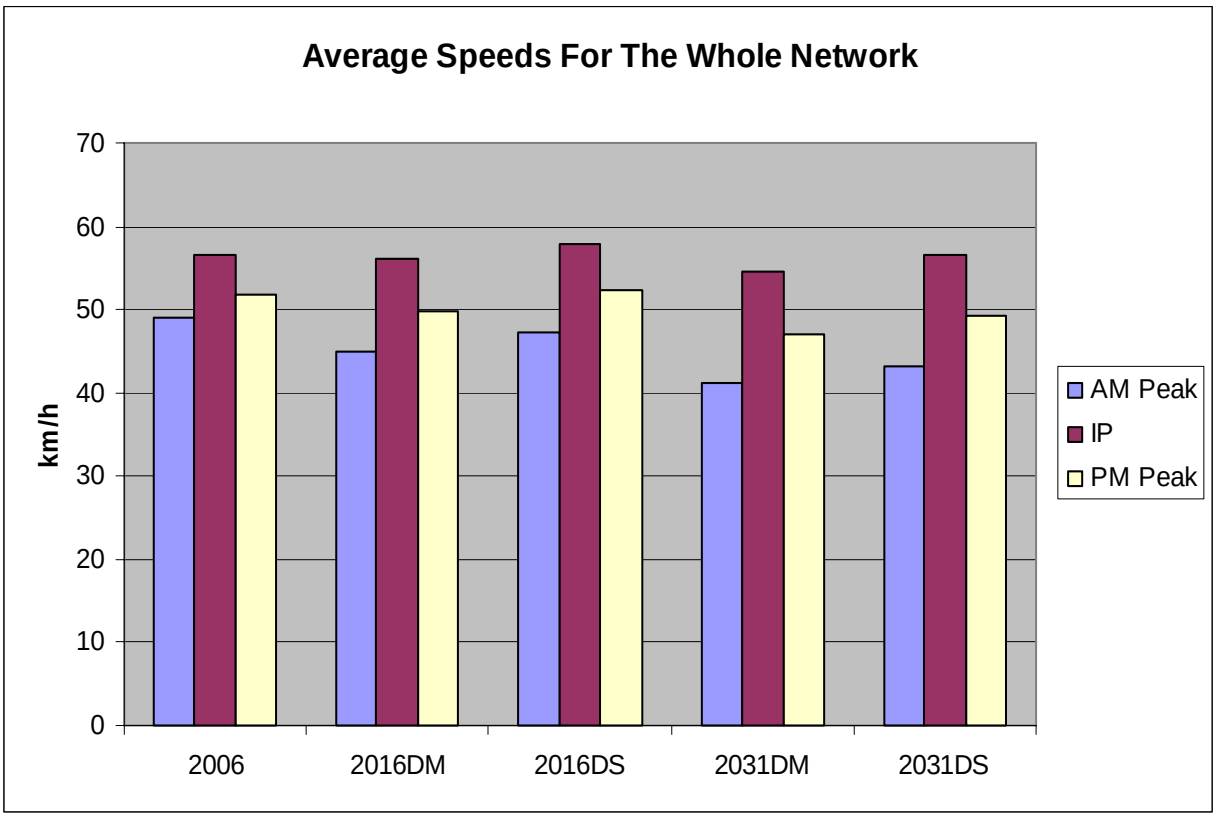
4.1.1 Average Speeds

Table 4.1 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 4.1**.

Table 4.1: 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%

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 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 41km/h (i.e. a decrease of 16%). In the 2016 DS in the IP, there is an increase in speed of 1km/h from the base year (i.e. an increase of 2%).

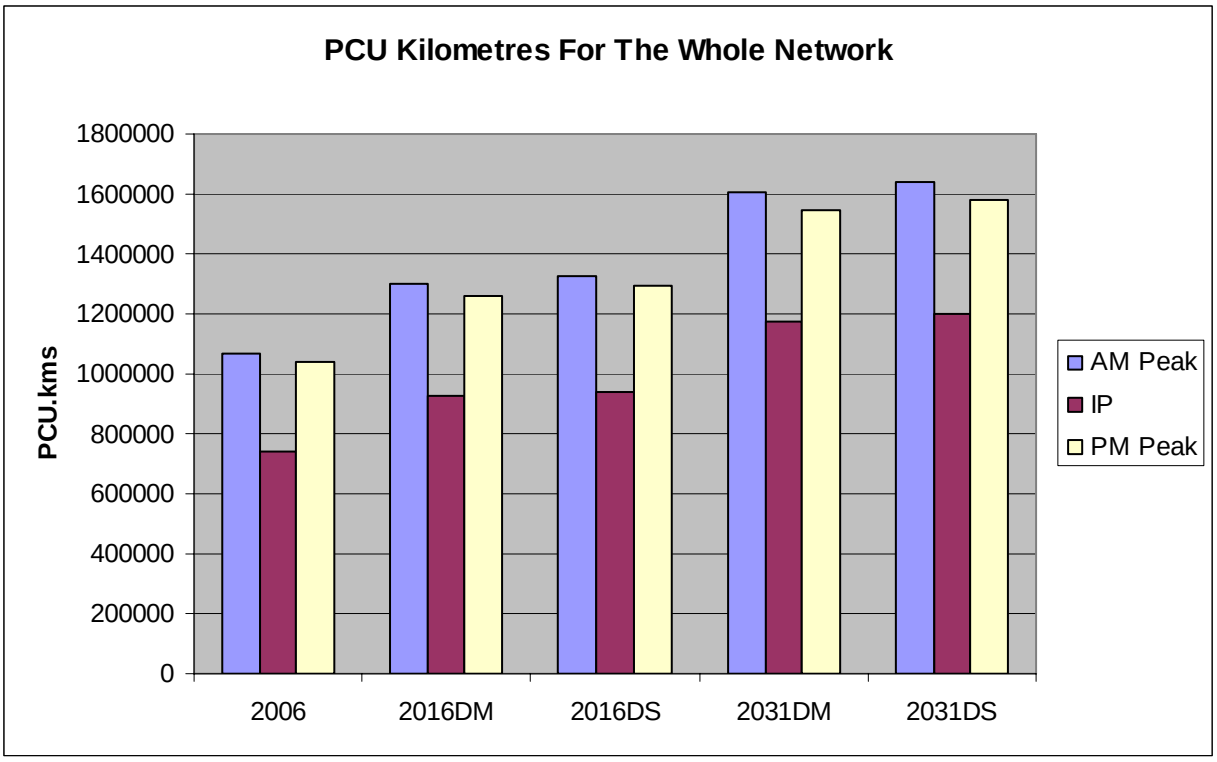
4.1.2 PCU Kilometres and Trip Lengths

Table 4.2 contains PCU.kms over the whole network and **Figure 4.2** shows the same information in a bar chart.

Table 4.2: 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%

Figure 4.2: 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 52% in the PM peak to 62% in the IP. In the 2016 DS, the PCU.kms increase by between 24% in the AM and PM peaks to 28% in the IP. The increase in PCU.kms in the future DM runs is about 3% lower than the DS runs for both 2016 and 2031 forecasting years and in all modelled periods.

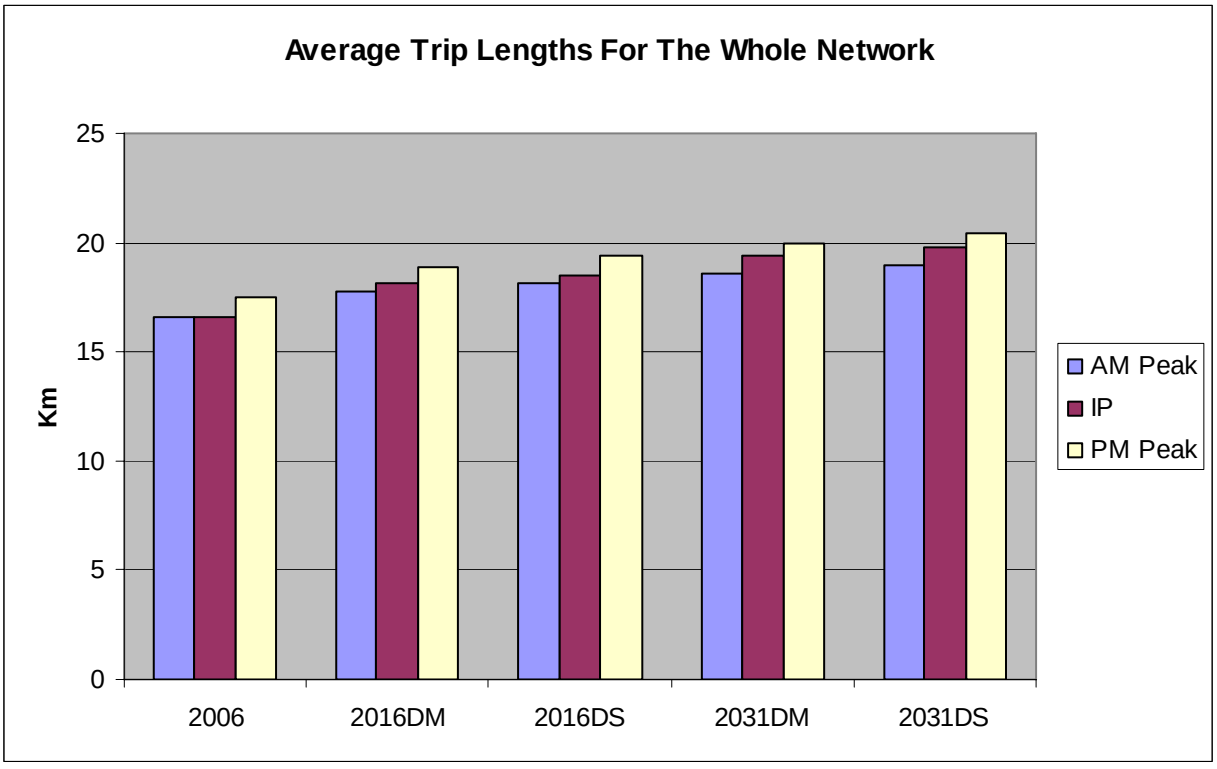
Table 4.3 contains average trip lengths (km) over the whole network and **Figure 4.3** shows the average trip lengths for the whole network.

Table 4.3: 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%

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 and IP and to around 19km in the PM peak for both the DM and the DS scenarios. In the 2031 DM, the average trip length increases to 19km in the AM peak (i.e. an increase of 12%) and IP (i.e. an increase of 17%) and to 20km (i.e. an increase of 14%) in the PM peak. The corresponding figures for the 2031 DS are 19km, 20km and 20km respectively (i.e. increases of 14%, 19% and 17%).

Figure 4.3: Average Trip Lengths For The Whole Network



4.1.3 Total Trips

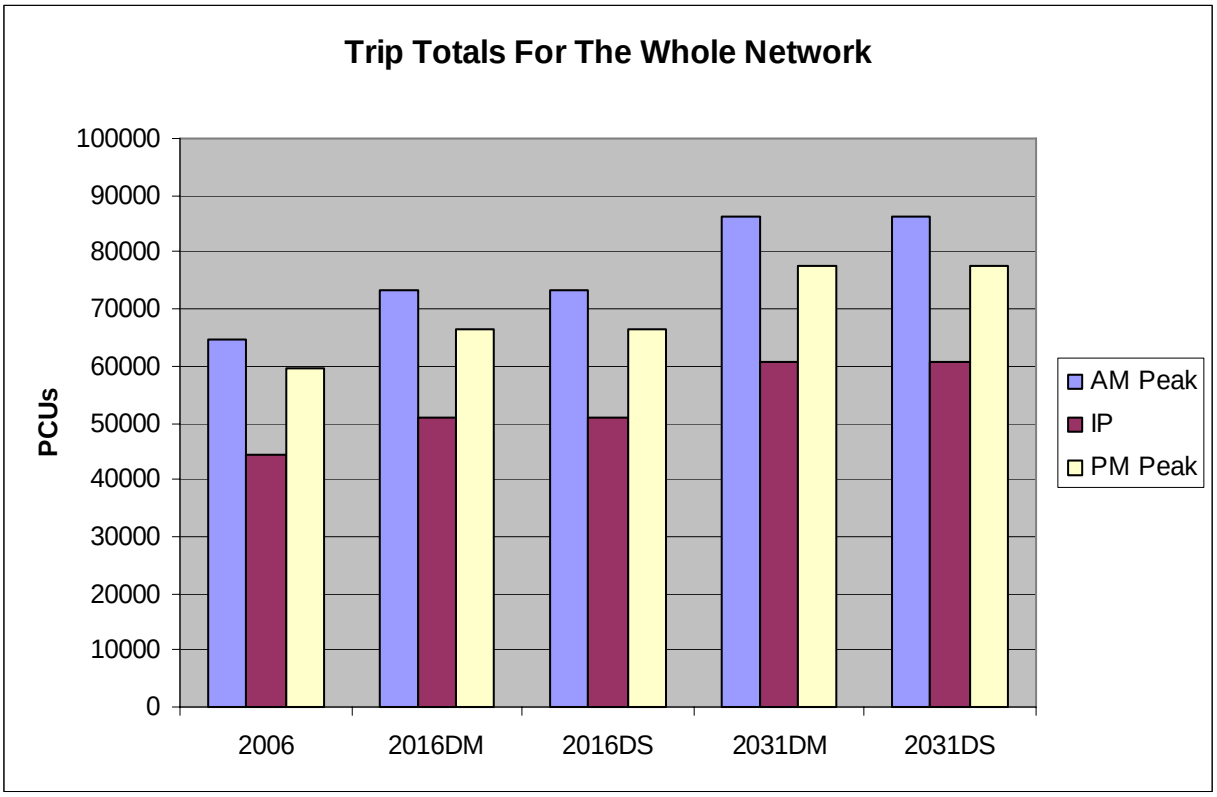
Table 4.4 contains total trips (in PCUs) over the whole network and **Figure 4.4** shows the trip totals for the whole network.

Table 4.4: 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%

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 has the largest amount of traffic. The same pattern is true for future scenarios. In the 2016 AM peak, the trip totals increase from base year to 73,174 (i.e. an increase of 13%) in 2016 DM and to 73,229 (i.e. an increase of 14%) in 2016 DS. The corresponding figures for the 2031 DM and DS runs are 86,346 (i.e. an increase of 34%) and 86,414 (i.e. an increase of 34%).

Figure 4.4: Trip Totals For The Whole Network



4.2 Links

4.2.1 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 the Core Scenario in **Table C.1** of **Appendix C** and their locations are shown on a map in **Figure C.1**. Differences between traffic flows forecast for the DM and DS are also shown in this Table.

In general, traffic flow increases from the base year are larger in the IP than the other peaks for all scenarios. This is mainly due to suppression effects, which has a larger impact during the AM and PM peaks than the IP.

The NNDR scheme is forecast to create 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 deliver a reduction of 559 PCUs in the AM peak, 474 PCUs in the IP and 669 PCUs in the PM peak. The corresponding figures for the 2031 forecasting year are 477,550 and 692 respectively.

On the A1067 at Point 3, the forecast traffic flows in the 2016 DM increase by between 2% in the AM peak and 18% in the IP from the 2006 base year. The corresponding forecast flow increases in the 2031 DM are 6% and 27% respectively. The addition of the NNDR results in forecast reductions of traffic from the base year in all periods, with the largest decrease of 9% in the 2016 AM peak and a decrease of 4% in the 2031 AM peak.

On the A1067 at Point 4 to the northwest of Point 3, the forecast reductions in traffic flows in the DS scenario are substantially larger than those at Point 3, with the largest forecast decrease of 50% in both the 2016 DS and 2031 DS during the AM peak. Between Points 3 and 4, a large volume of development traffic which is included in the DS scenario is forecast to join the A1067, and pass through Point 4 to access the proposed NNDR, resulting in larger forecast reductions in traffic at Point 3 than Point 4.

On the A1151 at Point 8, without the NNDR the majority of traffic travels between the northeast and the ring roads and city centre. With the addition of the proposed NNDR, this section of road is forecast to carry traffic between the east, northeast, and north and the ring roads and city centre, resulting in forecast increased traffic flows in the DS scenario when compared to the DM and the base year scenarios.

On the A1242 at Point 9, in the base year and the DM scenario, traffic originating from the east utilises this section of road to access the ring roads and city centre. In the DS scenario, traffic which in the DM used the ring roads to travel to the north and west of the city, is forecast to use the proposed NNDR, resulting in a reduction in traffic flows at this point on the network.

The scheme is forecast to result in significant increases in traffic flows on the A147 Inner Ring Road (IRR) in the southeast quadrant. In 2016, the introduction of the proposed NNDR shows an increase of 410 PCUs in the AM peak, 620 PCUs in the IP and 644 PCUs in the PM peak. The corresponding figures for the 2031 forecasting year are 218,476 and 623 respectively. Examination of forecast traffic movements passing though Point 20 on the IRR indicates that the increases result from the city centre traffic management measures.

Significant increases are also forecast on the A47(T) Southern Bypass in the southeast quadrant in the IP and PM peak periods, of up to 557 PCUs in the 2031 PM peak. Examination of forecast traffic movements

passing though Point 24 indicates that increases on this section of the A47(T) Southern Bypass result from north/south movements using the eastern section of the NNDR.

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.

4.3 By Sector

4.3.1 Trips

Tables D.1 to **D.33** in **Appendix D** contain trip totals by sector for the 2006 base year and for the forecasting years 2016 and 2031. **Figure D.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 D.1** to **D.3**). In the 2016 DM Core Scenario reference case (i.e. pre-DIADEM), the number of trips increases to 74,120, 51,262 and 67,190 respectively (see **Tables D.4** to **D.6**) and in the Core Scenario Trip Totals (i.e. post-DIADEM) the number of trips reduces to 73,258, 51,074 and 66,596 (see **Tables D.7** to **D.9**).

Tables D.10 to **D.12** show the differences in trip totals by sector between the Core Scenario 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. The same pattern is repeated for the 2016 DS scenario (see **Tables D.25** to **D.27**).

Tables D.13 to **D.15** show the 2031 Core Scenario Reference Case and **Tables D.16** to **D.18** show the Core Scenario DM trip totals (i.e. post DIADEM). The differences between the two scenarios (i.e. post-DIADEM minus pre-DIADEM) are shown in **Tables D.19** to **D.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. The same pattern is repeated for the 2031 DS scenario (see **Tables D.31** to **D.33**).

Tables D.22 to **D.24** show DS Core Scenario trip totals for 2016, and **Tables D.28** to **D.30** show the same trips for 2031.

Tables D.25 to **D.27** show the differences in trip totals by sector between 2016 DS Core Scenario and Reference Case and **Tables D.31** to **D.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.

4.3.2 PCU Kilometres

Information on PCU kilometres is shown in **Tables E.1** to **E.27** in **Appendix E**.

In the 2016 DM Core Scenario in the AM peak, the PCU.kms are increased in the range of 6% to 43% from the base year (see **Table E.7**) and in the 2031 DM during the same period, these increases are in the range of 22% to 86% (see **Table E.13**). In the 2016 DM IP, increases in PCU.kms from the base year range between 6% and 42% (see **Table E.8**) and in 2031 the range varies between 24% and 104% (see

Table E.14). For the 2016 DM PM peak, increases in PCU.kms from the base year vary by between 3% and 37% (see **Table E.9**) and in the 2031 forecasting year, the range varies between 21% to 89% (see **Table E.15**).

In the 2016 DS Core Scenario in the AM peak, the PCU.kms are increased in the range of 5% to 49% from the base year (see **Table E.19**) and in the 2031 DS during the same period, the increases in PCU.kms are in the range of 21% to 89% (see **Table E.25**) . In the 2016 DS IP, increases in PCU.kms from the base year are in the range of 4% to 42% (see **Table E.20**) and in 2031 the range is between 23% and 105% (see **Table E.26**). In the 2016 DS PM peak, the PCU.kms are increased in the range of 0% to 41% from the base year (see **Table E.21**) and in 2031 the range varies between 17% and 91% (see **Table E.27**).

5. Economics

5.1 DIADEM Convergence

The DIADEM convergence measurements (%relative GAP) for the core scenario test are generally below a target of 0.2%. However some of the models runs could not reach this target, even though DIADEM Algorithm 1 used many sub iterations to try to improve convergence.

WebTAG guidance suggests that steps should be taken to improve convergence if the % relative Gap is above 0.2%. The assignment convergence has been checked, but this exceeds DMRB guidance on network wide model convergence statistics, with a post-simulation SATURN gap value of less than 0.05% in almost all cases. Therefore it is not expect that network wide assignment convergence would be an issue. Improvements to the demand model convergence using a fixed step length in place of Algorithm 1 has also been tested, but this did not manage to improve convergence further. Consequently the robustness of the benefits relative to the convergence 'noise' has been investigated.

First, the scale of the scheme benefits relative to the whole network costs was considered. This sensitivity statistic is produced by TUBA, which demonstrates that it is relatively large for a network of this size (over 1.4% for the Core Scenario), so that convergence is less likely to be a problem. This sensitivity statistic can be divided by the gap value to obtain the 'stability ratio', which the WebTAG suggests should be at least 10. This value is 13.2 in 2016 and 6.9 in 2031 for the core scenario. Consequently it is not expected that further improvements in demand model convergence to have a substantial effect on the benefits.

Secondly, the impact on the economics has been tested using the earlier iterations of the demand model which had worse convergence. The effect of this is shown in **Table 5.1** below for tests on the core scenario with relative gaps of 0.2% to 0.3% in Test A and 0.5% to 0.6% in Test B. Even with these much worse convergence levels in all the model scenarios, the benefits and BCR ratios are not greatly affected.

Table 5.1: Core Scenario with Variable GAP Percentages

		Core Scenario	
	"Best"	Test A	Test B
1. Convergence gap (%)			
2016 DM	0.11	0.28	0.51
2031 DM	0.27	0.27	0.52
2016 DS	0.1	0.22	0.64
2031 DS	0.14	0.24	0.56
2. TUBA sensitivity (PVB/DM TC%)			
2016	1.45	1.45	1.50
2031	1.86	1.94	1.93
3. Stability ratio (2./1.)			
2016	13.18	5.18	2.34
2031	6.89	7.19	3.45
PVB (£m)	£533,724	£551,515	£544,267
BCR (PVB/PVC)	6.1	6.2	6.0

In conclusion the model economics are robust despite some of the model scenarios failing the target relative gap for demand modelling.

5.2 Economic assessment

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 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. Economic parameters in the version of the Economics file issued in April 2009 have been used.

The assessment has been carried out generally in accordance with the assessment for the MSBC and the content of this report focuses on changes made to the appraisal methodology since the submission of the MSBC.

The programme for the scheme has been revised, with the 60 year appraisal period from 2016 to 2075 being used.

The TUBA Annualisation Factors to represent the period 07:00 – 19:00 on Mondays to Fridays throughout the year have been calculated, and details are given in **Appendix F**.

5.2.1 Costs

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 revised scheme programme includes construction of the Postwick Hub (the interchange between the NNDR and the A47 (T) at Postwick) during 2010 to 2011, with the main NNDR following during 2013 to 2015. Scheme costs have been re-apportioned over the period to reflect the revised scheme programme.

Costs at 2009 Q3 levels are in **Table 5.2** as follows:-

Table 5.2: NNDR costs at 2009 Q3 levels

Year	Works	QRA	Land (inc fees)	Development, management & supervision
2009/10	£2,788,559	£345,296	£972,820	£2,718,000
2010/11	£15,453,759	£1,771,722	£1,000,000	£1,060,000
2011/12	£2,930,666	£370,059	£500,000	£1,000,000
2012/13	£5,664,444	£715,256	£1,200,000	£500,000
2013/14	£26,564,288	£3,354,306	£3,875,000	£1,000,000
2014/15	£29,236,242	£3,691,290	£8,000,000	£1,000,000
2015/16			£1,000,000	£0
Total	£82,637,958	£10,247,930	£16,547,820	£7,278,000
			Total	£116,711,708

Additional costs for complementary traffic management measures in the city centre and northern and western suburbs (£1.7m) and for an extension to the Park and Ride site at Postwick (£4.1m) have been included.

The treatment of inflation applied to construction costs has been revised since the submission of the MSBC, due to updated TAG guidance. TAG Unit 3.5.9C (September 2009) states that due to the changing economic climate, the previous advice that construction costs would be subject to real inflation to 2014 is no longer valid. The updated guidance advises that no real construction inflation should be applied to construction costs to 2014. Paragraph 2.1.2 TAG Unit 3.5.9C is as follows:-

"2.1.2 Promoters should take care to form base cost estimates using realistic assumptions about real cost changes, e.g. cost increases above or below RPI growth. The inflation rates relevant to the delivery of transport schemes were higher than general inflation rates over the period 2006 to 2008. More recently, and related to the world recession, many commodity prices and scheme tenders have been falling, or rising at lower rates. Independent projections suggest immediate change is unlikely, and that significant cost increases may not occur for some time. It is difficult to generalise and suggest inflation rates applicable to all schemes. However, under current circumstances it seems unreasonable to adopt central case projections which include capital costs rising above general inflation. It is therefore suggested that base cost projections should incorporate the most recent relevant actual indexation, and then, as a default, assume no change in real costs up to 2014. This is still consistent with an absolute increase in scheme costs of 14% by 2014, and is, in comparison with industry projections, still relatively high."

No real construction inflation has been applied to the construction costs detailed in **Table 5.2** above.

Costs for future maintenance have been derived in accordance with those for the MSBC, but based on the revised programme.

5.3 Results – summary

The results are summarised below in **Table 5.3**. The TUBA Transport Economic Efficiency (TEE), Public Accounts and Analysis of Monetised Costs and Benefits (AMCB) tables are in **Table G.1** in **Appendix G**.

Table 5.3: Core Scenario 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)
Core Scenario	87.172	533.724	446.552	6.1

The Core 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.

This is significantly higher than the BCR in the MSBC of approximately 2.6. The reasons for the increase in BCR include:-

- Revised economic parameters in TUBA, e.g. cost of time;
- Revised growth forecasts, taking into account the JCS;

- Revised modelling of traffic management measures in the city centre, based on current proposals;
- Revised annualisation factors.

5.4 Results – by sector

TUBA sectors are shown in **Figure G.1** in **Appendix G**. Time benefits by sector of origin are given in **Table G.2** in **Appendix G**. The sectors used are shown in **Table G.3** in **Appendix G.** These indicate 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), the suburban area to the south-east (Sector 8), and the external sector representing the rest of the UK (Sector 18).

A medium of 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) and for the rural areas to the north and south-east (Sectors 12, 15 and 17).

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 and north-west (Sectors 13 and 14) and to the north-east (Sector 16).

5.5 TUBA warning messages

For further details see **Appendix H**.

6. Conclusions

A revised Core Scenario has been defined. The Do Minimum situation, without the NNDR scheme in place, includes significant highway schemes which have been classified as near certain or more than likely in an uncertainty log in accordance with TAG Unit 3.15.5. Future increases in parking charges have been considered and forecast. Changes to public transport have also been considered and an uncertainty log compiled.

Both residential and business future developments in the JCS have been included in an uncertainty log. The future growth for the Core Scenario comprises JCS developments up to 2016, and TEMPRO 5.4 growth thereafter. Traffic generated by the proposed Rackheath Ecotown has been assumed to be reduced from what would otherwise be expected, in accordance with Ecotown principles.

The Do Something situation, with the scheme, includes the NNDR highway plus associated complementary traffic management measures. As detailed proposals for the city centre traffic management measures have been developed since submission of the MSBC, and are currently out to public consultation, their details have been included in place of the proxy penalty used for the MSBC. Traffic management measures in the northern and western suburbs have been included as they were for the MSBC.

Model runs have been carried out using the transport model and methods used for work for the NNDR MSBC, with Variable Demand Modelling in accordance with DfT's TAG advice.

Results indicate that, without the NNDR scheme, numbers and lengths of trips are forecast to increase in future, by up to 15% and 9% respectively above base year 2006 values in 2016, and up to 36% and 17% respectively in 2031. With the scheme, numbers of trips are forecast to generally increase by small amounts compared to the situation without the scheme, by up to around 70 trips in the AM peak in 2031; lengths of trips are forecasts to generally increase by up to 3% in both 2016 and 2031. Total network distance travelled by vehicles, expressed as PCU kilometres, is forecast to increase significantly without the scheme, by up to 25% in 2016 and up to 59% in 2031. With the scheme, additional increases of up to 3% are forecast.

Average speeds are forecast to reduce without the scheme, by up to 8% below base year 2006 speeds in 2016, and by up to 16% in 2031, with these maximum reductions occurring in the AM peak period. The NNDR scheme is forecast to mitigate these reductions, so that the reduction in the AM peak in 2031 is forecast to be 12%. In the interpeak period in 2031 the average network speed with the NNDR scheme of 57 km/h is forecast to be the same as in the base year 2006.

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.

Examination of trip data by sector shows that, 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.

Economic assessment of the scheme indicates that disbenefits associated with the city centre traffic management measures are forecast. However, these are forecast to be greatly outweighed by significant benefits associated with the suburban areas to the north, and the rural areas to the east, north and west.

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. This is significantly higher than the BCR of 2.6 given in the MSBC, and reasons for the change have been considered.