

Norwich Northern Distributor Road

Major Scheme Business Case
Sensitivity Tests for DfT

Dependent Development
Volume 1 – Main Document

December 2009
Norfolk County Council

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Mott MacDonald

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Summary

Further to Norfolk County Council's submission of the Major Scheme Business Case for the Norwich Northern Development Route (NNDR) scheme, the Department for Transport have requested that a range of sensitivity tests is carried out in order to better understand uncertainties associated with the previous analysis. Sensitivity Test 1 is of a revised core scenario that excludes dependent development from the forecasts, and all further sensitivity tests will be based on this.

Development details have been obtained from 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. An initial view of possible dependent development (that is development which could not sensibly take place without the NNDR Scheme in place) has been identified.

The Department for Transport's (DfT's) Transport Analysis Guidance (TAG) gives information about tests for dependent development in the consultation draft Unit 3.16C, Appraisal in the Context of Housing Development. Model runs have been carried out for 3 different growth scenarios: TEMPRO 5.4 growth, Scenario 1 being part JCS growth excluding dependent development, and Scenario 2 being full JCS growth. Both Scenarios 1 and 2 have been constrained to TEMPRO 5.4 totals. Runs have been carried out for the Do Minimum (DM) network (i.e. without the proposed NNDR scheme intervention) and the Do Something (DS) network with the transport intervention, for years 2012 and 2027. Whilst the consultation TAG guidance suggests using DM runs to assess dependent development, DS runs have been added to more clearly demonstrate whether the transport problems of the dependent development are addressed by the proposed scheme.

Model data presents traffic flows on key roads, including speeds, congestion indices, overcapacity and transient queues, vehicle hours, vehicle kilometres, trip lengths, junction delays and flow over capacity (V/C) plots.

The forecast operation of the DM network has been examined. In general, results are as would be expected. Speeds decrease over time, and congestion, queuing and V/C (flow over capacity) increase. The differences between results for TEMPRO 5.4 growth and the spatially-allocated growth in Scenarios 1 and 2 are generally as expected, with the spatial allocation of development generally resulting in decreased speeds and increased congestion indices. However, differences between results for Scenarios 1 and 2 are less straightforward, with some decreases in indicators (e.g. overcapacity queues) with increased spatially-allocated development (from Scenario 1 to Scenario 2).

The impact on network performance of increasing the level of spatial allocation of development has been assessed by comparing Scenario 1 (with part JCS development) with results for Scenario 2 (with full JCS development). With the addition of the scheme in Scenario 2, this compensates for the additionally defined development, in terms of network performance.

In summary, the analysis has focused on the effect of the different development scenarios on the transport system's operational performance. This has been done using global and network performance statistics. The global statistics show that generally there is not much difference between the development scenarios. In part this is because the level of development growth is always controlled to TEMPRO. The network performance statistics show that network performance is more affected in locations where development is defined, as expected.

The initial view of possible dependent development, referenced as Dependent Development A and detailed in Section 3.2 of this report, was based on judgment informed by inspection of stress levels on roads in the vicinity of proposed development. It was considered appropriate to include development sites in reasonable proximity to the NNDR scheme.

As well as the test of Dependent Development A (the Scenario 1 test), other tests were carried out, of the full JCS development (Scenario 2), and of TEMPRO 5.4 growth with no spatial allocation. A key finding of this was that the level of spatially defined development did not greatly affect network performance overall, although there were some specific local effects adjacent to proposed developments and the NNDR.

It can therefore be concluded, firstly, that the exact level of dependent development would not be important. Secondly, and more importantly, it would not be appropriate to treat any proposed future development as dependent development for assessment and economic evaluation purposes, within the methodologies and definitions given in DfT's draft consultation TAG Unit 3.16C. This refers to "exceptional" increases in travel costs, and operation of the transport network having reached "a critical point". Given the extensive and relatively fine-grained nature of the highway network in Norwich, the transport model effectively deals with exceptional forecast delays at points on the network by re-routing traffic to avoid those points, thus mitigating the effects of additional traffic. In other words, the model disperses traffic further and further across the network.

However, the tests 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 significant future transport network operational difficulties (traffic congestion and delays) that the proposed NNDR scheme would mitigate. The NNDR scheme is also forecast to bring significant benefits to residents of dwellings adjacent to roads which are forecast to be used by increasing volumes of traffic. For the above reasons it is considered that the scheme provides essential support to the implementation of the very significant development proposals in the JCS, and that in practical terms, the growth cannot be accommodated without it.

Details of the Core Scenario which has been used for the updated assessment of the NNDR scheme are given in the Core Scenario report.

1. Introduction

1.1 Sensitivity Tests

In a letter dated 15 September 2009, the Department for Transport (DfT) asked Norfolk County Council (NCC) 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

1.2 Sensitivity Test 1

This report contains the results of work on Sensitivity Test 1, comprising the development of a revised Core Scenario test that excludes dependent development from the forecasts. Methods for defining and assessing dependent development are given in DfT's Transport Assessment Guidance (TAG) consultation draft Unit 3.16c Appraisal in the Context of Housing Development (April 2009). Details and results of the Revised Core Scenario are given in the separate Core Scenario report.

Results are presented for model runs for both the DM network (i.e. without the proposed NNDR scheme) and the DS network (i.e. with the NNDR scheme) for the following growth scenarios:-

1. **TEMPRO 5.4** – growth as TEMPRO 5.4 allocated over the appropriate model zones – for comparison purposes.
2. **Scenario 1** – Part JCS **-** with the Joint Core Strategy (JCS) growth spatially allocated but excluding Dependent Development Rev A, with overall growth constrained to TEMPRO 5.4; and
3. **Scenario 2** – Full JCS - with all the JCS growth spatially allocated and with overall growth constrained to TEMPRO 5.4.

Where appropriate, information is presented for the reference case and the post-DIADEM case for comparison purposes.

Model information is presented for the years 2012 and 2027, being the Opening and Design Years used for the MSBC assessments. Some information is also presented for the base year 2006. The model periods are morning Peak (AM), interpeak (IP), and evening Peak (PM).

This report contains the following details of the model runs above:-

1. average speeds
2. congestion indices
3. average queues – overcapacity and transient
4. vehicle hours, vehicle kilometres (network wide and by sector) and trip lengths
5. number of trips (network totals and trips by sector)
6. average junction delays, and some selected junction volume/ capacity plots
7. volume/ capacity plots.

2.3 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. Future Development

2.1 Joint Core Strategy Development

Development details have been obtained from 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. JCS housing and business developments are summarised below. Full details of JCS0 future developments and assumptions are contained in **Appendix A**. The 2026 JCS0 development forecasts have been used for the 2027 forecasting year.

2.1.1 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 2.1**. Detailed information for the developments is listed in **Appendix A Table A.1**, together with a map showing their locations (see **Figure A.1**).

Table 2.1: 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 2.2 shows the business developments, types and sizes for the Broadland, Norwich and South Norfolk areas as supplied by NCC. It has been assumed that those developments are in the planning process and are therefore likely to be built by 2016. The location of business developments are shown in **Figure A.4** in **Appendix A**.

Table 2.2: Business Developments 2006-2016

No	Local Plan Development	TEMPRO Area	Development Type	Size (ha)	Developed (m^2)	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**		
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**		
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**		

2.1.2 Development between 2016 and 2021

The JCS identifies a total of 12,411 additional homes to be provided in the Great Norwich area from 2016 to 2021. A breakdown of these developments is shown in **Table 2.3** with the detailed information listed in **Appendix A Table A.2** and their locations are shown in **Figure A.2** in **Appendix A**.

Table 2.3: Forecast Housing Developments 2016-2021

	Housing Numbers
Broadland	4,095
Norwich City	1,900
South Norfolk	4,556
Windfall	1,050
Sites under 10 dwellings	810
Total	**12,411**

Table 2.4 shows the business developments, types and sizes for the Norwich, Broadland and South Norfolk areas as supplied by NCC. The location of business developments are shown in **Figure A.5** in **Appendix A.**

Table 2.4: Business Developments 2016-2021

No	Local Plan Development	TEMPRO Area	Development Type	Size (ha)	Developed (m^2)	Model Zone
1	Rackheath	Broadland	B1 / B2 / B8	2.6	9,135	15701
2	Broadland Business Park Extension	Broadland	B1 / B2 / B8	20	68,250	15902
	Total Broadland			**22.6**		
3	Guardian Road	Norwich	B1 / B2 / B8	1.1	3,675	100
4	Deal Ground	Norwich	B1 / B2 / B8	4.44	15,540	6803
5	Cremorne Road	Norwich	B1 / B2 / B8	5.22	18,270	6804
	Total Norwich			**10.76**		
6	Long Stratton	South Norfolk	B1 / B2 / B8	5.0	17,500	193
7	Colney Business Park (research)	South Norfolk	B1	9.0	31,500	12904
8	Colney Conting. (research)	South Norfolk	B1	7.0	24,500	12905
9	UEA Triangle	South Norfolk	Business Park	1.0	1,850*	12906
10	Colney Hall	South Norfolk	B1	7.5	13,875*	12908
	Total South Norfolk			29.5		

2.1.3 Development between 2021 to 2026

The JCS identifies a total of 10,635 additional homes to be provided in the Greater Norwich area between 2021 and 2026. Of these, the three local authorities have the following housing allocations. Detailed information for the developments is listed in **Appendix A**, **Table A.3** and their locations are shown in **Figure A.3** in **Appendix A.**

Table 2.5: Housing Development Assumptions 2021-2026

	Housing Numbers
Broadland	3,701
Norwich City	1,250
South Norfolk	3,476
Windfall	1,050
Sites under 10 dwellings	1,158
Total	**10,635**

For the 2021 to 2026 period, details of business development sites are shown in **Table 2.6**. Their locations are shown in **Figure A.6** in **Appendix A**.

Table 2.6: Business Developments 2021-2026

No	Local Plan Development	TEMPRO Area	Development Type	Size (ha)	Developed (m^2)	Model Zone
1	Broadland Business Park Extension	Broadland	B1		50,000	15902
2	Airport	Norwich	B1 / B2 / B8	35	122,500	12002
3	Norwich City Centre	Norwich	B1		100,000	
4	Colney Business Park (research)	South Norfolk	B1	6.0	100,000	12904
	Total				**372,500**	

2.1.4 Trip Rates

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.

2.2 Dependent Development Rev A

2.2.1 Development Details

In order to identify an initial view of possible dependent development (that is development which could not sensibly take place without the NNDR Scheme in place) to be used as a starting point for undertaking sensitivity tests (referenced as Dependent Development Rev A), changes in stress level on roads in the vicinity of proposed development sites in the 2026 DM and DS networks were inspected. Several links located in the northern part of Norwich, in the proximity of the proposed NNDR, showed increases in volume over capacity ratios from under to over 90% as a result of the Scheme. Therefore it has been considered appropriate to identify development sites in reasonable proximity to the Scheme as those for an initial test of possible dependency. The 2026 JCS0 development forecasts have been used for the 2027 forecasting year.

2.2.2 Development up to 2012

Dependent housing developments are listed in **Table 2.7**, and business developments in **Table 2.8**. The 2012 developments have been derived from the 2016 JCS figures, based on the assumption that the proposed development between 2006 and 2016 grow linearly. This means the level of development in the period 2006-2012 is 60% of 2006-2016. The locations of housing developments are shown in **Figure B.1** in **Appendix B**.

Housing developments for Windfall and for sites under 10 dwellings (as shown in Table 2.1), have been divided amongst all zones in the model, in proportion to the number of housing units allocated to these zones. **Table 2.7** and **Table 2.8** below include the proportion of these development sites.

Table 2.7: Housing developments up to 2012

No.	Development Location	Zone	2006-2016	2006-2012
1	Munnings Road, Heartsease House	113	20	12
2	Mousehold Lane, 28 (Start Rite Site)	115	41	24
3	Ives Road/Bussey Road	118	40	24
4	Hellesdon	119	44	27
5	Hellesdon, Golf Course	121	119	71
6	Hellesdon Hospital	122	40	24
7	Hellesdon, A140 corridor	123	40	24
8	Drayton	127	63	38
9	Spixworth	154	20	12
10	Between Wroxham and North Walsham Road	155	106	64
11	Rackheath Eco-Community	157	1207	724
12	Blofield	163	38	23
13	Thorpe St Andrew	166	83	50
14	Sprowston	11402	370	222
15	Old Catton	11702	87	52
16	Taverham	15101	48	29
17	Between Salhouse and Wroxham Road	15602	133	80
18	Blue Boar Lane	15602	1028	617
19	Between Plumstead and Salhouse Road	15801	133	80
20	Great and Little Plumstead	15801	330	198
	Total	**-**	**3,990**	**2,395**

Table 2.8: Business developments up to 2012

No.	Development Location	Zone	2006-2016	2006-2012
1	Hellesdon	119	1155	693
2	Sprowston	11402	15715	9429
3	Airport	12002	7245	4347
4	Horsford	15201	3010	1806
5	Broadland Business Park G. Lane	15901	151305	90783
6	Broadland Business Park Yar North	15901	2030	1218
	Total	**-**	**180,460**	**108,276**

2.2.3 Development between 2012 and 2027

For the 2027 scenario, the potential housing dependent development is considered to consist of all the sites identified in 2012, plus additional developments as shown in **Table 2.9**. As discussed before, 40% of housing developments in the period 2006-2016 have been added to the 2016-2026 figures to derive housing developments in 2012-2026. In addition, it has been assumed that no development takes place from 2026 to 2027. **Table 2.9** contains the additional spread of housing developments for Windfall and for sites under 10 dwellings as discussed above.

The locations of housing development for 2006-2012 and 2012-2026 are shown in **Appendix B**.

For the 2027 scenario, the potential business development is considered to consist of all the sites identified in 2012, plus additional developments as shown in **Table 2.10**. The business developments in 2012-2016 have been derived by applying a 40% factor to 2006-2016 figures, based on the assumption that the growth will take place linearly from 2006 to 2016.

The locations of business development for 2006-2012 and 2012-2027 are shown in **Figures B.1** and **B.2** in **Appendix B**.

Table 2.9: Housing Developments, 2012-2026

No.	Development Location	Zone	2006-2016	2016-2026	2012-2026
1	Munnings Road, Heartsease House	113	20	0	8
2	Mousehold Lane, 28 (Start Rite Site)	115	41	0	16
3	Ives Road/Bussey Road	118	40	0	16
4	Hellesdon	119	44	0	18
5	Hellesdon, Golf Course	121	119	607	654
6	Hellesdon Hospital	122	40	202	218
7	Hellesdon, A140 corridor	123	40	202	218
8	Drayton	127	63	102	128
9	Spixworth	154	20	30	38
10	Between Wroxham and North Walsham Road	155	106	1109	1152
11	Rackheath Eco-Community	157	1207	2804	3287
12	Brundall	162	0	46	46
13	Blofield	163	83	71	86
14	Thorpe St Andrew	166	370	305	338
15	Sprowston	11402	87	0	148
16	Old Catton	11702	48	202	237
17	Taverham	15101	133	100	119
18	Horsford	15201	0	30	30
19	Horsham	15401	0	30	30
20	Between Salhouse and Wroxham Road	15602	1028	1385	1438
21	Blue Boar Lane	15602	133	413	824
22	Between Plumstead and Salhouse Road	15801	330	1385	1438
23	Great and Little Plumstead	15801	198	76	207
	Total	**-**	**4,150**	**9,099**	**10,694**

Table 2.10: Business developments, 2012-2026

No.	Development Location	Zone	2006-2016	2016-2026	2012-2026
1	Hellesdon	119	1155	0	462
2	Sprowston	11402	15715	0	6286
3	Airport	12002	7245	122500	125398
4	Horsford	15201	3010	0	1204
5	Rackheath	15701	0	9135	9135
6	Broadland Business Park G. Lane	15901	151305	0	60522
7	Broadland Business Park Yar North	15901	2030	0	812
8	Broadland Business Park Ext	15902	0	118250	118250
	Total	**-**	**180,460**	**249,885**	**322,069**

It is proposed to use the above development assumptions to derive the initial trip matrices for Scenario 1. These matrices will be constrained to TEMPRO 5.4 forecasts.

3. Model Results – Network Wide

For the purpose of this exercise, model results for the following scenarios are presented:

a) 2006 base year model
b) 2012 TEMPRO 5.4 DM
c) 2012 TEMPRO 5.4 DS
d) 2027 TEMPRO 5.4 DM
e) 2027 TEMPRO 5.4 DS
f) 2012 Scenario 1 (part JCS) DM
g) 2012 Scenario 1 (part JCS) DS
h) 2027 Scenario 1 (part JCS) DM
i) 2027 Scenario 1 (part JCS) DS
j) 2012 Scenario 2 (full JCS) DM
k) 2012 Scenario 2 (full JCS) DS
l) 2027 Scenario 2 (full JCS) DM
m) 2027 Scenario 2 (full JCS) DS

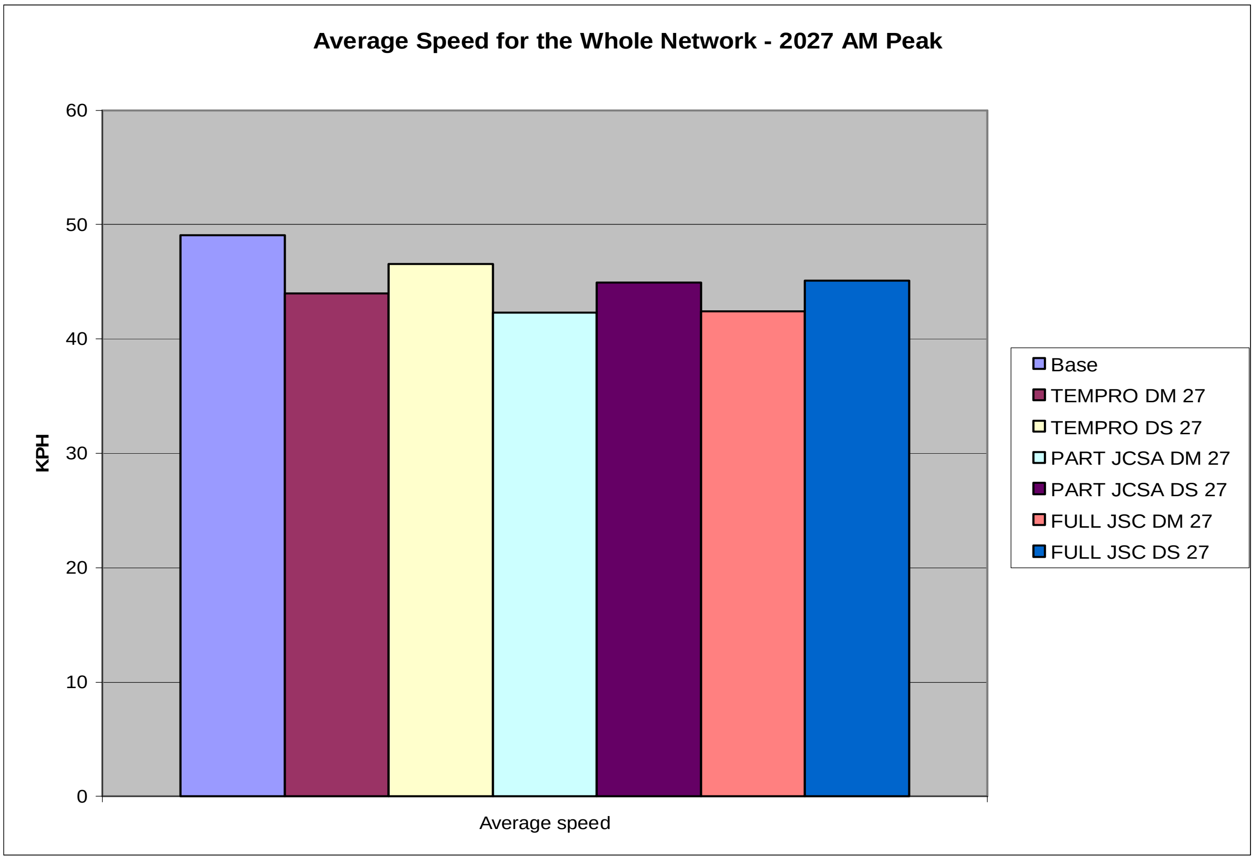
3.1 Average Speeds

Table 3.1 contains average speeds over the whole network (in km/h) together with percentage changes in respect to the base year. A bar chart showing the 2027 AM peak average speeds for the whole network is presented in **Figure 3.1**.

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	0%	0%	0%
TEMPRO 5.4	2012DM	47	56	50	-3%	-1%	-3%
	2012DS	50	58	53	1%	2%	3%
	2027DM	44	55	49	-10%	-2%	-6%
	2027DS	47	57	51	-5%	1%	-2%
Scenario 1 (Part JCS)	2012DM	47	56	51	-5%	0%	-2%
	2012DS	49	58	53	0%	3%	3%
	2027DM	42	55	48	-14%	-3%	-7%
	2027DS	45	58	50	-9%	2%	-3%
Scenario 2 (Full JCS)	2012DM	47	56	51	-5%	0%	-2%
	2012DS	49	58	53	0%	3%	3%
	2027DM	42	56	48	-14%	-1%	-7%
	2027DS	45	58	51	-8%	2%	-3%

Figure 3.1: Average Speed (km/h) – 2027 AM Peak



In the 2006 model base year, the average speeds in the AM and PM peaks are around 50kph, rising to around 57km/h in the IP. The largest decrease in speed forecast for 2027 is in Scenarios 1 and 2 (i.e. part JCS and full JCS) in the AM peak, where the speed drops to around 42 km/h (i.e. a decrease of 14%). For these scenarios in the PM peak, the speed reduces to around 48 km/h (i.e. a decrease of 7%).

In general, average speeds decrease in DM scenario in all cases. In the IP, changes in speeds are less drastic than those in the AM and PM peaks both over time and between growth scenarios.

In the 2012 DM Scenarios 1 and 2, speeds are very similar for the different growth scenarios. The same is true for the 2012 DS Scenarios 1 and 2 where the speeds are almost identical in both scenarios.

In the 2027 DM Scenario 2 speeds are less than the 2006 base year values by 6.9km/h, 0.8km/h and 3.4km/h for the AM peak, IP and PM peaks respectively. In the 2027 DS Scenario 2, speeds are less than the 2006 values for the AM and PM peaks by 4km/h and 1.3km/h, but greater in the IP by 1.4km/h.

In the 2027 DM Scenario 1, speeds are less than Scenario 2 for IP (0.8km/h) and PM peak (0.3km/h), but are greater in the AM peak (0.1km/h). In the 2027 DS Scenario 2 speeds are greater than the 2027 DM Scenario 1 by 2.8km/h, 3km/h and 2.4km/h for different peaks.

The above results show that the inclusion of the proposed NNDR results in an overall increase in vehicle speeds in different peak periods.

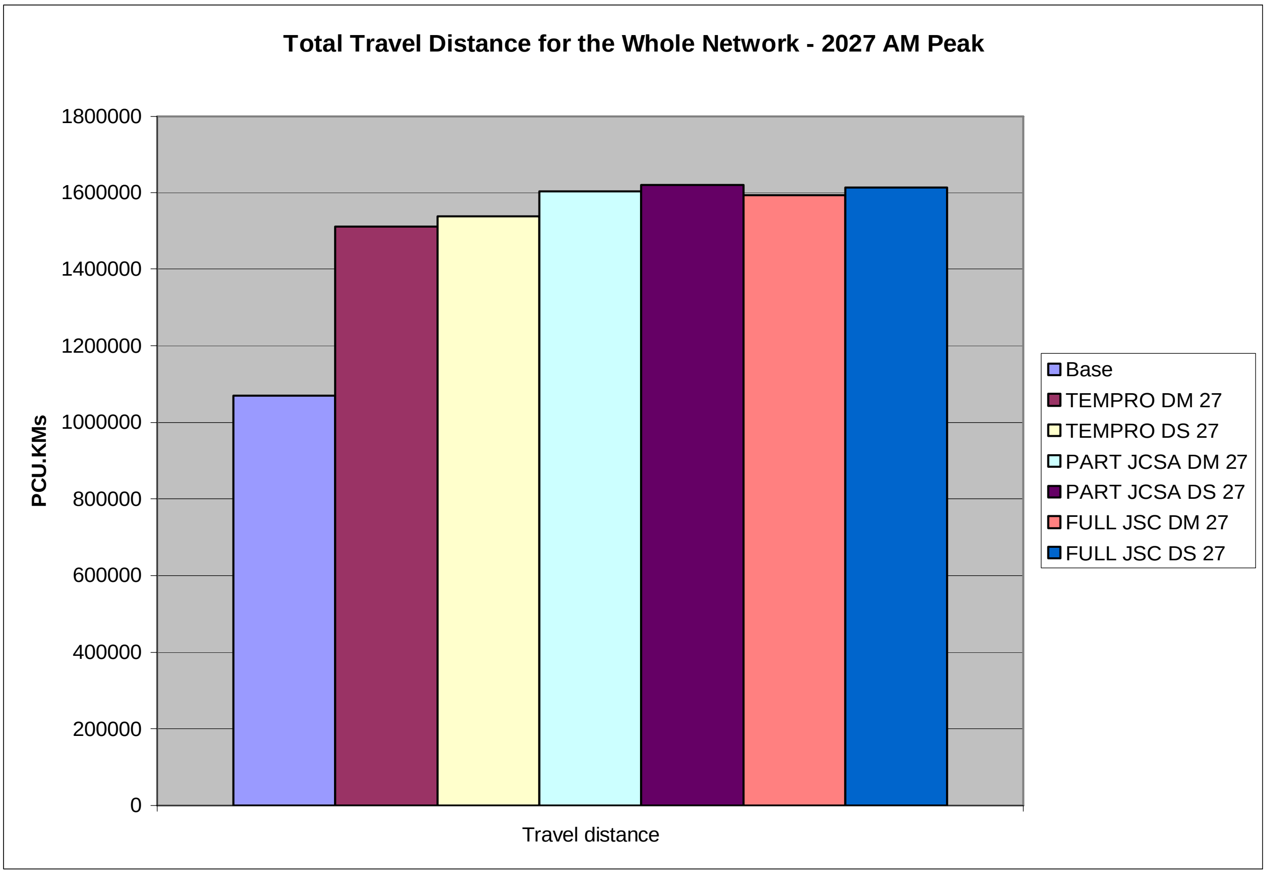
3.2 PCU Kilometres and Trip Lengths

Table 3.2 shows the PCU.kms for the whole network and **Figure 3.2** shows the PCU.kms for the 2027 AM Peak.

Table 3.2: Network Vehicle Kilometres

Scenario	Year	Vehicle Kilometres (PCU.kms)			% Difference from Base Year		
		AM	IP	PM	AM	IP	PM
Base year	2006	1068498	738836	1038919	-	-	-
TEMPRO 5.4	2012DM	1197122	850290	1166628	12%	15%	12%
	2012DS	1217943	862593	1196975	14%	17%	15%
	2027DM	1510883	1110132	1476020	41%	50%	42%
	2027DS	1538678	1130355	1505305	44%	53%	45%
Scenario 1 (Part JCS)	2012DM	1219508	861944	1181827	14%	17%	14%
	2012DS	1239354	874233	1212113	16%	18%	17%
	2027DM	1602406	1164605	1524645	50%	58%	47%
	2027DS	1619708	1189776	1555771	52%	61%	50%
Scenario 2 (Full JCS)	2012DM	1214730	859850	1178694	14%	16%	13%
	2012DS	1235163	872479	1208847	16%	18%	16%
	2027DM	1593534	1163581	1513797	49%	57%	46%
	2027DS	1612971	1186949	1539829	51%	61%	48%

Figure 3.2: 2027 AM - PCU.kms



In the 2027 AM peak DM Scenario, PCU.kms increase from around 107,000 in the base year to over 151,000 in TEMPRO 5.4, over 160,000 in Scenario 1 and over 159,000 in Scenario 2. With the DS scenario, the corresponding figures are just under 154,000, 162,000 and 161,000 respectively.

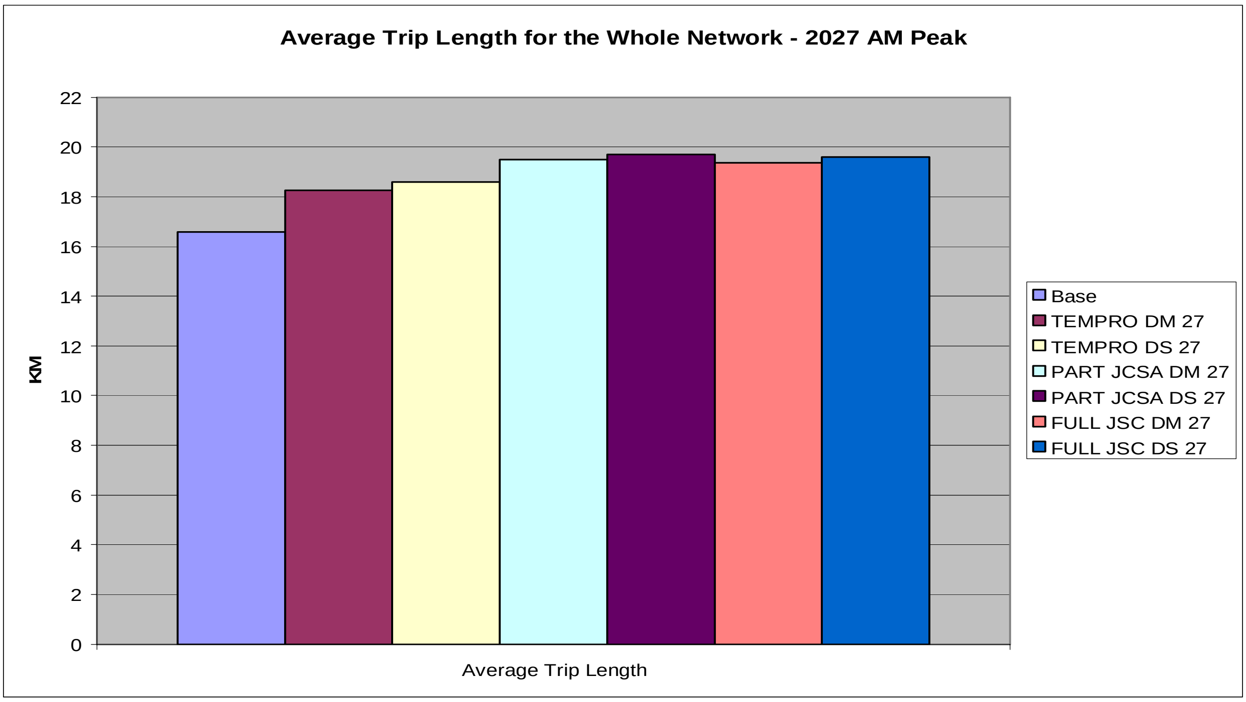
This indicates that the inclusion of the proposed NNDR results in an in crease in PCU.kms across all scenarios.

Table 3.3 shows the average trip length (km) for the whole network and **Figure 3.3** shows the average trip length for the 2027 AM Peak.

Table 3.3: Network Trip Lengths (km)

Scenario	Year	Average Trip Lengths			% Difference from Base Year		
		AM	IP	PM	AM	IP	PM
Base year	2006	17	17	18	-	-	-
TEMPRO 5.4	2012DM	17	18	18	4%	6%	5%
	2012DS	18	18	19	5%	7%	8%
	2027DM	18	19	20	10%	16%	14%
	2027DS	19	20	20	12%	18%	16%
Scenario 1 (Part JCS)	2012DM	18	18	19	6%	8%	7%
	2012DS	18	18	19	8%	9%	9%
	2027DM	20	20	21	17%	22%	17%
	2027DS	20	21	21	19%	24%	19%
Scenario 2 (Full JCS)	2012DM	18	18	19	5%	7%	6%
	2012DS	18	18	19	7%	8%	9%
	2027DM	19	20	20	17%	22%	17%
	2027DS	20	21	21	18%	24%	18%

Figure 3.3: 2027 AM – Trip Lengths (km)



In the 2027 AM peak, average trip length increases from around 16.6 km in the base year to 18.3 km in TEMPRO 5.4, 19.5 km in Scenario 1 and 19.4 km in Scenario 2. With the DS scenario, the corresponding figures are 18.6 km, 19.7 km and 19.6 km respectively. These figures indicate that the inclusion of the proposed NNDR results in an increase in trip lengths.

3.3 Congestion Indices

The Average Congestion Index (ACI) is an indication of network performance. It is the ratio of free flow speed over actual speed, averaged for all links over the simulation area, which covers built up areas in Norwich.

Table 3.4 contains a summary of ACIs for different peaks together with percentage changes between the base year and different scenarios.

Table 3.4: Average Congestion Index

Scenario	Year	Average Congestion Index (free flow speed/ actual speed)			% Difference from Base Year		
		AM	IP	PM	AM	IP	PM
Base year	2006	1.92	1.61	1.84	0%	0%	0%
TEMPRO	2012DM	2.38	1.76	2.09	24%	9%	14%
	2012DS	2.21	1.74	1.99	15%	8%	8%
	2027DM	2.87	1.89	2.51	49%	17%	37%
	2027DS	2.69	1.84	2.25	40%	14%	23%
Scenario 1 (Part JCS)	2012DM	2.40	1.75	2.11	25%	9%	15%
	2012DS	2.23	1.74	2.01	16%	8%	9%
	2027DM	2.92	1.90	2.60	52%	18%	42%
	2027DS	2.75	1.84	2.35	43%	14%	28%
Scenario 2 (Full JCS)	2012DM	2.40	1.75	2.10	25%	9%	14%
	2012DS	2.22	1.73	2.00	16%	7%	9%
	2027DM	2.90	1.91	2.59	51%	18%	41%
	2027DS	2.70	1.85	2.33	41%	15%	27%

In the 2012 DM ACIs are greater than the 2006 values by up to 25%, 9% and 15% for the AM peak, IP and PM peak respectively. Differences in ACIs between TEMPRO 5.4, Scenario 1 and Scenario 2 are small (1% or less).

In the 2027 DM ACIs are greater than the 2006 values by up to 52%, 18% and 42% for the three peak periods (AM, IP and PM). DM differences between TEMPRO 5.4, Scenario 1 and Scenario 2 are larger than 2012 by up to 5%.

In the 2027 DS Scenario 2, ACIs are greater than the 2006 values by 41%, 15% and 27% for the AM peak, IP and the PM peak respectively. In the 2027 DM Scenario 1, ACIs are almost the same as DM Scenario 2. In the 2027 DS Scenario 2, ACIs are less than the 2027 DM Scenario 1 by 11%, 3% and 15% for the AM peak, IP and PM peak respectively.

The above findings indicate the inclusion of the proposed NDR is beneficial in reducing congestion on the network.

3.4 Vehicle Queues, Link Cruise Time and Travel Time

Transient queues record the time spent by vehicles in queues which, in the case of traffic signal controlled junctions, clear during a cycle time. Over capacity queues record the extra time spent in queues at over capacity junctions waiting for the cycle in which the vehicle exits.

Free flow time is the time which could be spent travelling on links operating at their free-flow speeds to which must be added, any delays and the flow-specific extra travel time on those links with link-speed-flow curves.

The link cruise time is the sum of the previous two link times. The total travel time is the sum of both link and junction times. The units used to measure these variables are PCU.hrs. **Figure 3.4** shows the bar chart of transient queues, over –capacity queues, link cruise times and total travel time for the 2027 AM peak for the whole network.

Figure 3.4: Queues, Link Cruise Time and Travel Time – (PCU.hrs) – 2027 AM Peak

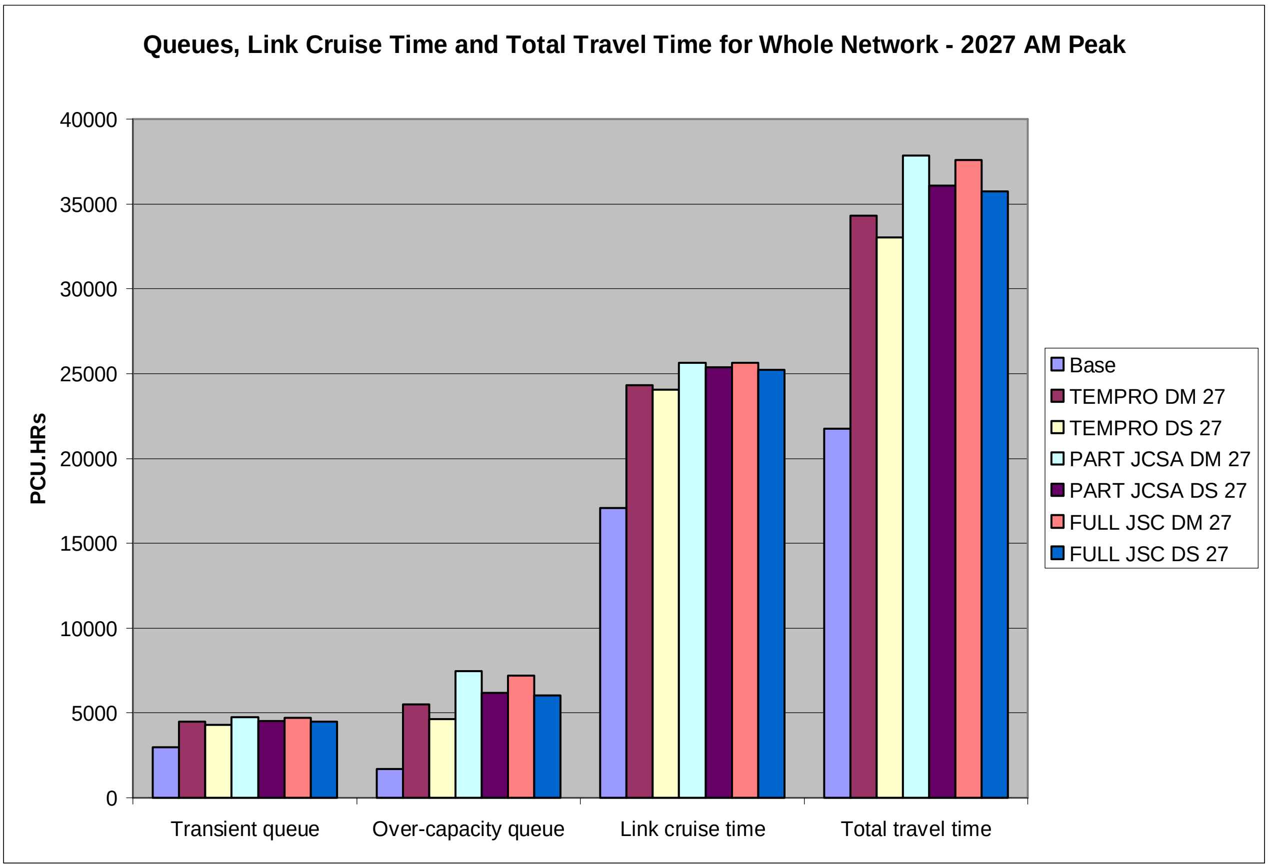


Table 3.5 shows the transient queues for the entire network (i.e. simulation and buffer nodes combined). Transient queue information for simulation nodes, buffer nodes and for the entire network is contained in **Tables C.1** to **C.3** in **Appendix C**.

Table 3.5: Transient Queues (PCU.hrs) – Total (Simulation + Buffer Area)

Scenario	Year	Total (Simulation and Buffer Areas)			% Difference from Base Year		
		AM	IP	PM	AM	IP	PM
Base year	2006	2970	1606	2832	-	-	-
TEMPRO	2012DM	3428	1915	3186	15%	19%	12%
	2012DS	3259	1801	3020	10%	12%	7%
	2027DM	4495	2598	4110	51%	62%	45%
	2027DS	4300	2428	3963	45%	51%	40%
Scenario 1 (Part JCS)	2012DM	3477	1909	3179	17%	19%	12%
	2012DS	3304	1794	3019	11%	12%	7%
	2027DM	4749	2701	4197	60%	68%	48%
	2027DS	4536	2478	4042	53%	54%	43%
Scenario 2 (Full JCS)	2012DM	3468	1914	3170	17%	19%	12%
	2012DS	3281	1788	3003	10%	11%	6%
	2027DM	4724	2666	4163	59%	66%	47%
	2027DS	4500	2453	4006	52%	53%	41%

In the 2012 DM differences between TEMPRO 5.4, Scenario 1 and Scenario 2 are small for different peak periods, with totals of some 3,500, 1,900 and 3,200 PCU.hrs for AM, IP and PM periods respectively. In the 2012 DM, queues are greater than the 2006 queues by (up to) 17%, 19% and 12% for the AM peak, IP and the PM peak respectively.

In the 2027 DM queues are greater than the 2006 queues by (up to) 62%, 68% and 48% for the three peaks. In the 2027 DM Scenario 2, queues are greater than those in Scenario 1, for the AM and PM peaks, but are slightly smaller in the IP. The maximum value in a peak period is some 4,800 PCU.hrs.

In the 2027 DS Scenario 2, queues are greater than the 2006 values by 52%, 53% and 41% for the three peaks. In the 2027 DS Scenario 2 queues are less than the 2027 DM Scenario 2 by 5%, 9% and 4% in the AM peak, IP and the PM peak respectively.

The values forecast for the 2027 DS Scenario 2 are less than those for the 2027 DM Scenario 1, by some 250, 250 and 200 PCU.hrs % in the AM peak, IP and the PM peak respectively.

Table 3.6 shows the over capacity queues for the entire network (i.e. simulation and buffer nodes combined). Over capacity queue information for simulation nodes, buffer nodes and for the entire network is contained in **Tables C.4** to **C.6** in **Appendix C**.

Table 3.6: Overcapacity Queues – Total (Simulation + Buffer Area)

Scenario	Year	Total (Simulation and Buffer areas)			% Difference from Base Year		
		AM	IP	PM	AM	IP	PM
Base year	2006	1690	92	781	-	-	-
TEMPRO	2012DM	2693	253	1479	59%	173%	89%
	2012DS	2249	230	1174	33%	149%	50%
	2027DM	5492	713	2975	225%	672%	281%
	2027DS	4647	596	2462	175%	545%	215%
Scenario 1 (Part JCS)	2012DM	3097	243	1478	83%	163%	89%
	2012DS	2652	210	1195	57%	127%	53%
	2027DM	7450	801	3471	341%	767%	344%
	2027DS	6186	669	2975	266%	624%	281%
Scenario 2 (Full JCS)	2012DM	3216	238	1423	90%	157%	82%
	2012DS	2608	206	1159	54%	123%	48%
	2027DM	7229	662	3274	328%	616%	319%
	2027DS	6015	557	2677	256%	502%	243%

In the 2012 DM differences between TEMPRO, Scenario 1 and Scenario 2 are small for IP and PM peak periods, with totals of some 250 and 1,500 PCU.hrs respectively. AM peak period values differ between scenarios, with values of some 2,700, 3,100 and 3,200 PCU.hrs for TEMPRO, Scenario 1 and Scenario 2 respectively. In the 2012 DM queues are greater than the 2006 queues by (up to) 90%, 173% and 90% for the AM peak, IP and the PM peak respectively.

In the 2027 DM the vehicle queues are greater than the 2006 queues by (up to) 342%, 766% and 339% in the three peaks, with values up to some 7,500, 800 and 3,400 in the AM peak, IP and the PM peak respectively. In the 2027 DM Scenario 1 vehicle queues are slightly larger than Scenario 2 queues, which could be due to traffic re-assignment effects over the model network.

In the 2027 DS Scenario 2, vehicle queues are greater than the 2006 vehicle queues by 256%, 502% and 224% for the different peaks respectively. In the 2027 DS Scenario 2 vehicle queues are less than the 2027 DM Scenario 1 queues by 19%, 30% and 22% for different peaks, representing some 1,500, 240 and 740 PCU.hrs in the AM peak, IP and the PM peak respectively.

The above results show the vehicle queues increases over time and the inclusion of the proposed NNDR results in a reduction of vehicle queues in all peaks.

3.5 Total Trips

The analysis of trip totals was carried out by different user classes and by sectors.

3.5.1 Analysis of Trips Totals by User Class

Tables D.1 to Table D.15 in **Appendix D** show the number of trips by nine user classes for different scenarios and **Table 3.7** show a summary of trip totals for all user classes. According to **Table D.4**, in the 2012 AM peak, with the exception of the pre-DIADEM reference case, the trip totals for the nine user classes are similar in different runs. The same conclusion can be drawn for the results obtained in the 2012 PM peak. In both peaks, the total number of trips for the reference case is higher than the other Scenarios and this is due to adjustments made by the DIADEM process.

Table D.7 contains trip totals by user classes for the 2027 AM peak. Trip totals in Scenarios 1 and 2 for each of the nine user classes are very similar, the reference case has the highest number of trips, and the TEMPRO Scenario has slightly higher number of trips than Scenarios 1 and 2. The same pattern of change can seen for the 2027 IP and PM peak results, which are shown in **Tables D.8** and **D.9**.

In summary, it can be concluded that the results show that changes in the number of trips between different user classes are very small for Scenarios 1 and 2, with the TEMPRO Scenario having slightly larger numbers of trips in 2027, and the reference case have the largest trip totals.

Table 3.7: Summary of Trip Totals

Scenario	Year	Trip Totals (PCUs)			% Difference from Base Year		
		AM	IP	PM	AM	IP	PM
Base year	2006	64,626	44,681	59,499	-	-	-
Reference Demand Pre-DIADEM	2012DM	70,192	48,628	64,014	9%	9%	8%
	2012DS	70,192	48,628	64,014	9%	9%	8%
	2027DM	83,241	57,858	74,758	29%	29%	26%
	2027DS	83,241	57,858	74,758	29%	29%	26%
TEMPRO	2012DM	69,613	48,426	63,460	8%	8%	7%
	2012DS	69,623	48,424	63,477	8%	8%	7%
	2027DM	82,827	57,785	74,440	28%	29%	25%
	2027DS	82,884	57,790	74,407	28%	29%	25%
Part JCS	2012DM	69,459	48,311	63,398	7%	8%	7%
	2012DS	69,472	48,307	63,416	7%	8%	7%
	2027DM	82,315	57,785	74,394	27%	29%	25%
	2027DS	82,321	57,746	74,503	27%	29%	25%
Full JCS	2012DM	69,447	48,421	63,405	7%	8%	7%
	2012DS	69,475	48,420	63,423	8%	8%	7%
	2027DM	82,335	57,754	74,413	27%	29%	25%
	2027DS	82,424	57,762	74,379	28%	29%	25%

4. Model Results – Junctions and Links

4.1 Junction Delays

Figures E.1 to **E.39** in **Appendix E** show plots of junction delays during different peaks and for different Scenarios.

In the 2027 DM during the AM peak, junction delays within the Norwich Inner Ring Road (IRR) are noticeable, with the largest values observed in the northern and central parts. In the PM peak, most junction delays are observed within IRR and in some junctions in the western sector. In the IP, largest junction delays are within IRR and on a few junctions on A1074.

4.2 Volume over Capacity ratios (V/Cs)

Figures F.1 to **F.39** in **Appendix F** show plots of link V/C ratios for different scenarios and different peaks and **Figures F.40** to **F.44** show five selected examples of junction V/C ratios.

In the 2006 base year, in both the AM and PM peaks (see **Figures F.1** and **F.3**), a large number of links in the central Norwich area and in southern and northern edges of the Inner Ring Road (IRR) are over-capacity.

In the 2012 DM TEMPRO 5.4, during the AM peak, the majority of over-capacity links are around the edge of IRR (see **Figure F.4**). On the Outer Ring Road (ORR), large V/C values on some links in the vicinity of the NNDR are noticeable. In the 2012 DS TEMPRO 5.4 AM peak, the addition of the NNDR results in reduction of over-capacity links in the outer edge of the IRR and on links on the ORR and in the vicinity of the NNDR (see **Figure F.22**).

In the 2012 DM TEMPRO 5.4 PM peak (see **Figure F.6**), large V/C values are observed within the IRR and on links in the vicinity of the NNDR. In the 2012 DS TEMPRO 5.4 Scenario, the addition of the NNDR results in reduction of V/C values around the NNDR, on some links in the northern edge of the IRR and on southern part of A47 (see **Figure F.24**).

In the 2012 DM TEMPRO 5.4 IP, most of the over-capacity links are located in the western edge of the IRR. In the DS Scenario, some of the congestion is removed as a result of the NNDR (see **Figure F.5** and **F.23**).

In the 2027 DM TEMPRO 5.4 AM peak, a number of links on the western edge of the IRR, and in northern and southern sections of the ORR are over-capacity (see **Figure F.7**). The addition of the NNDR in the 2027 DS Scenario, relieves congestion on the edge of the IRR and on most of the links in the ORR (see **Figure F.25**). The results for the 2027 DS TEMPRO 5.4 for the PM peak are similar to those in the AM peak, i.e. the addition of the NNDR removes some of the over-capacity links in the northern part of network (see **Figures F.9** and **F.27**).

In the 2027 DM TEMPRO 5.4 IP period, most of the over-capacity links are at the edges of the IRR and on north-west sector of the ORR in the vicinity of the NNDR (see **Figure F.8**). The addition of the NNDR in the 2027 DS TEMPRO 5.4 relieves congestion on the north-west sector of network (see **Figure F.26**).

There are only small differences between the pattern of over-capacity links in the 2012 DM Scenarios 1 and 2 during the AM peak (see **Figures F.10 and F.16**). In both Scenarios over-capacity links are observed in the centre of Norwich, around the edge of the IRR and on the southern and northern parts of the ORR. The addition of the NNDR in the 2012 DS for both Scenarios removes the congested links on the northern part of network and on some links in the northern edge of the IRR (see **Figures F.28 and F.34**).

In the 2012 DM Scenario 1, during the IP, most of the over-capacity links are located on the north-west of the ORR and on the edges of the IRR (see **Figure F.11**). The addition of the NNDR in the 2012 DS Scenario 1 during this peak, results in the removal of over-capacity links on the northern part of network (see **Figure F.29**). The same patterns of results are shown for the 2012 DM Scenario 2 during the IP (see **Figure F.17**).

In the 2012 DM Scenario 1, during the PM peak, links around the edge of the IRR, on the northern part of the ORR and on the southern part of the ORR are over-capacity (see **Figure F.12**). In the 2012 DM Scenario 2, the inclusion of all the JCS development is shown to reduce over-capacity links on the southern part of the ORR and on some of the links on the northern section of network adjacent to dependent development sites (see **Figure F.18**). The results are counter-intuitive but could be due to re-diversion of extra traffic in Scenario 2 to other routes on the network. However, for both Scenarios in the 2012 DM during the PM peak, the NNDR relieves some of the congested links on the northern part of network (**Figures F.30** and **F.36**).

In the 2027 DM Scenario 1, during the AM peak, a number of links are over-capacity in the city centre, on the edges of the IRR, on the northern and southern parts of the ORR and on the A47 to the east (see **Figure F.13**). As with the observation above, in the 2027 DM Scenario 2, during PM peak, there are less over-capacity links, including, the A47 on the southern part of network and on northern part of the ORR. Again, the results shown are counter-intuitive, bearing in mind Scenario 2 contain all development traffic whereas Scenario 1 does not include the dependent development in the northern section. However, as explained above, this could be due to model re-assignment effects, which could be checked against trip length data.

As with the results shown for previous Scenarios, the inclusion of the proposed NNDR in the 2027 DS Scenarios 1 and 2 removes almost all of the over-capacity links in the northern part of the ORR (see **Figures F.37** and **F.39**).

In the 2027 DM Scenario 1 during the IP, most of the over-capacity links are located at the edges of the IRR and on links in the northern part of ORR (see **Figure F.14**). In the 2027 DM Scenario 2, the patterns of results are the same, with the exception that there are less over-capacity links in the northern part of the ORR and the A47 on the southern part is less congested (see **Figure F.20**). Again, the inclusion of the proposed NNDR in both Scenarios reduces the number of over-capacity links (see **Figures F.32** and **F.38**).

In the 2027 DM Scenario 1, during the PM peak, over-capacity links are shown in the centre of Norwich, on the edge of the IRR, on the northern part of the ORR and on the A47 to the south of network (see **Figure F.15**). The same patterns are repeated in the 2027 DM Scenario 2 with the additional over-capacity links in the north of the ORR (see **Figure F.21**). These discrepancies could be due to traffic re-assignment effects. Again, the addition of the proposed NNDR in the DS Scenario removes some of the over-capacity links in the northern section of network (see **Figures F.33 and Figure F39**).

Junction V/C ratios for different scenarios in the 2027 AM peak are shown in **Figures F.40** to **F.44**. In the base year, three junctions on the IRR and six junctions on the ORR have V/C values of over 90% (see **Figure F.40**). The corresponding figures for the 2027 TEMPRO Scenario, the 2027 Scenarios 1 and the 2027 Scenario 2 are five and eight respectively (see **Figures F.41** to **F.43**). The inclusion of the proposed

NNDR reduces the number of over-capacity junctions to five on the ORR and for the IRR, the number of over-capacity junctions remains at four (see **Figure F.44**).

4.3 Traffic Flows

Traffic flows for AM, IP and PM periods in the base year 2006 and the forecast years 2012 and 2027 are shown for selected key roads for TEMPRO 5.4, Scenario 1 and Scenario 2 in **Appendix G**, **Tables G.1**, **G.2** and **G.3** respectively, and their locations are shown on the map in **Figure G.1**. Differences between traffic flows forecast for 2012 and 2027 for the Scenario 1 and the TEMPRO 5.4 (i.e. Scenario 1 flow minus TEMPRO 5.4 flow) are shown in **Table G.4**. Similarly, differences between flows forecast for Scenario 2 and Scenario 1 are shown in **Table G.5**.

Examination of **Table G.4** for differences between Scenario 1 and TEMPRO 5.4 forecast flows indicates that the largest differences occur on the A47 southern bypass, where Scenario 1 flows are higher. This is because the spatially allocated developments in Scenario 1 are located around the south of Norwich. There are some significant differences on other roads to the south between the A47 and the City Centre. Other, generally smaller, differences occur on radials to the north of the city and outside the ORR.

Examination of **Table G.5** for differences between Scenario 2 and Scenario 1 forecast flows indicates lesser differences the A47 Southern Bypass than those between Scenario 1 and TEMPRO 5.4. There are some significant differences on roads to the north of the city. These include increases on the A1151 Wroxham Road between the proposed NNDR and the built up area. There are some increases and decreases on various other radials to the north, and on the northern section of the ORR.

5. Model Results – By Sector

5.1 Trips

Tables H.1 to **H.57** in **Appendix H** contain information on trip totals by sectors and **Figure H.1** shows the location of these sectors in the NATS model.

Tables H.1 to **H.3** show the 2006 base year trips. Tables **H.4** to **H.12** show the 2012 number of trips in TEMPRO 5.4 reference case and in TEMPRO 5.4 scenario with the comparisons shown in **Tables H.10** and **H.12**.

In all peaks, the largest decrease in the 2012 number of trips between reference case and TEMPRO 5.4 occur in sectors representing the built-up areas of Norwich, and the largest increase in the number of trips occur in the outer sectors of the study area, representing rural areas. The increase in demand in Norwich is compensated by the decrease in the number of trips in the outer sectors.

Tables H.13 to **H.21** show the 2027 number of trips in TEMPRO 5.4 reference case and TEMPRO 5.4. The patterns of results are similar to the 2012 described above, i.e. the decrease in number of trips in the sectors in Norwich is compensated by the increase in number of trips in outer sectors.

Tables H.22 to **H.30** show the 2012 number of trips in Scenario 1 reference case and in Scenario 1 and **Tables H.31** to **H.39** show the same results for 2027. Comparisons in the number of trips in Scenario 1 and reference case indicate decrease in central sectors and an increase in the outer sectors.

Tables H.40 to **H.48** show the 2012 number of trips in Scenario 2 reference case and in Scenario 2 and **Tables H.49** to **H.57** show the same results for 2027. Comparisons in the number of trips between Scenario 2 against the reference case show a decrease in the Norwich sectors and an increase in the outer sectors.

5.2 PCU Kilometres

Information on vehicle kilometres is shown in **Tables I.1** to **I.21** in **Appendix I.**

In the 2012 DM TEMPRO 5.4 in the AM peak, the PCU.kms are increased by the range 10% to 15% from the base year. In the 2027 DM TEMPRO 5.4 during the same peak, these increases are in the range of 19% to 43%.

In the 2012 DM TEMPRO 5.4 in the IP, the increases in PCU.kms from the 2006 base year are in the range of 8% to 11% and in the 2027 DM TEMPRO 5.4 for the same peak, the corresponding increases are 16% to 32%.

In the 2012 DM TEMPRO 5.4 during the PM peak, the increases in PCU.kms from the 2006 base year are in the range of 7% to 11% and for the 2027 forecasting year for the same scenario, these increases are in the range of 24% to 30%.

The above figures show in the 2012 DM TEMPRO 5.4, the largest increase in PCU.kms is in the AM peak. The increases in PCU.km during the IP and the PM peak are very similar.

In the 2012 DM Scenario 1 during the AM peak, the increase in PCU.kms ranges from 7% to 18% and in the 2027 DM Scenario 1, during the same peak, these increases range from 18% to 52%.

In the 2012 DM Scenario 1 during the IP, the increase in PCU.kms range from 4% to 12% and in the 2027 DM Scenario 1, during the same peak, these increases range from 13% to 62%.

In the 2012 DM Scenario 1 during the PM peak, the increase in PCU.kms ranges from 1% to 13% and in the 2027 DM Scenario 1, during the same peak, these increases range from 8% to 46%.

The above figures show, in Scenario 1, the largest increase in PCU.kms from the 2006 base year to 2012 is in the AM peak and for 2027 is in the IP. The increase in PCU.kms in the PM peak is less than the other peaks.

In the 2012 DM Scenario 2 during the AM peak, the increase in PCU.kms ranges from 6% to 20% and in the 2027 DM Scenario 1, during the same peak, these increases range from 18% to 50%.

In the 2012 DM Scenario 2 during the IP, the increase in PCU.kms ranges from 4% to 22% and in the 2027 DM Scenario 1, during the same peak, these increases range from 16% to 53%.

In the 2012 DM Scenario 2 during the PM peak, the increase in PCU.kms ranges from 0% to 22% and in the 2027 DM Scenario 1, during the same peak, these increases range from 7% to 46%.

The above figures show that, compared to the base year, in the 2012 AM peak, the PCU.kms in Scenario 2 are slightly higher than those in Scenario 1, and in 2027 the order is reversed. In the 2012 Scenario 2, during the IP period, the increase in PCU.kms from the base year is larger than the increase from base year in Scenario 1, and the order is reversed in 2027. In the 2012 Scenario 2 during the PM peak, there is a smaller increase in PCU.kms from base year than the increase in Scenario 1 from base year, and in 2027, the increases from base year for both scenarios are the same.

6. Conclusions

The Department for Transport has 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). This report contains the results of work on Sensitivity Test 1, comprising the development of a revised Core Scenario test that excludes dependent development from the forecasts.

For this purpose, several model runs were undertaken with the DM and DS networks for the following growth scenarios:

1. **TEMPRO 5.4** – growth as TEMPRO 5.4 allocated over the appropriate model zones – for comparison purposes.
2. **Scenario 1** – Part JCS - with the Joint Core Strategy (JCS) growth spatially allocated but excluding Dependent Development Rev A, with overall growth constrained to TEMPRO 5.4; and
3. **Scenario 2** – Full JCS - with all the JCS growth spatially allocated and with overall growth constrained to TEMPRO 5.4.

From the outputs of model runs, relevant information was extracted to understand the behaviour of model with different scenarios. This information included: trip totals (network wide and by sector), average speed, vehicle hours, vehicle kilometres, average trip lengths, congestion indices, average queue lengths, junction delays and volume over capacity ratios.

Some key findings from the analysis are as follows:

- Over time, average speeds decrease from the model base year in different scenarios, but there are little differences between average speeds in Scenarios 1 and 2 in either 2012 or 2027 forecast years. The inclusion of the proposed NNDR results in increase in average speed in all scenarios.
- Over time, PCU hours, PCU kilometres and trip lengths all increase from the model base year, with larger increases in the DS Scenario than the DM Scenario.
- The average congestion indices in Scenarios 1 and 2 are almost the same in different forecasting years and in different peaks. The largest increase in the congestion index is in the 2027 Scenario 1 during the AM peak, which is slightly higher than Scenario 2 for the same peak.
- The largest transient queue is in the 2027 DM Scenario 2 during the AM peak, with an increase of 62% from the model base year. This reduces to 52% with the inclusion of the proposed NNDR in the DS network. The corresponding figures for the DM Scenario 1 are 60% and 53%. This indicates that the inclusion of the proposed NNDR causes a reduction in transient queue over the whole network.
- The increase in over-capacity queues from the model base year in both 2012 and 2027 is higher in Scenario 1 than in Scenario 2. This could be due to traffic distributing to other routes as a result of extra traffic generated in Scenario 2. In both scenarios, the inclusion of the proposed NNDR in the DS network results in reduction of over-capacity queues.
- There are only small changes in the number of trips amongst nine user classes and the three scenarios tested.
- The link V/C ratios show that most of the over-capacity links are located in Norwich City Centre and around the edges of the IRR, and there are little differences between the pattern of changes between Scenarios 1 and 2. The inclusion of NNDR relieves some of the congested roads on the northern part of the IRR and the ORR.

- The junction V/C ratios for the 2027 AM peak show that the number of over-capacity junctions in the DM Scenario in the IRR and the ORR are the same. The inclusion of the proposed NNDR reduces the number of over-capacity junctions in the ORR.
- In Scenarios 1 and 2 increases in PCU.kms vary according to the peak period and forecasting year.

In summary, the analysis has focused on the effect of the different development scenarios on the transport system operational performance. This has been done using global statistics and network performance. The global statistics show that generally there is not much difference between the development scenarios. In part this is because the level of development growth is always controlled to TEMPRO. The network performance statistics show that network performance is more affected in locations where development is defined, as expected.

The initial view of possible dependent development, referenced as Dependent Development A and detailed in Section 3.2 of this report, was based on judgment informed by inspection of stress levels on roads in the vicinity of proposed development. It was considered appropriate to include development sites in reasonable proximity to the NNDR scheme.

As well as the test of Dependent Development A (the Scenario 1 test), other tests were carried out, of the full JCS development (Scenario 2), and of TEMPRO 5.4 growth with no spatial allocation. A key finding of this was that the level of spatially defined development did not greatly affect network performance overall, although there were some specific local effects adjacent to proposed developments and the NNDR.

It can therefore be concluded, firstly, that the exact level of dependent development would not be important. Secondly, and more importantly, it would not be appropriate to treat any proposed future development as dependent development for assessment and economic evaluation purposes, within the methodologies and definitions given in DfT's draft consultation TAG Unit 3.16C. This refers to "exceptional" increases in travel costs, and operation of the transport network having reached "a critical point". Given the extensive and relatively fine-grained nature of the highway network in Norwich, the transport model effectively deals with exceptional forecast delays at points on the network by re-routing traffic to avoid those points, thus mitigating the effects of additional traffic. In other words, the model disperses traffic further and further across the network.

However, the tests 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 significant future transport network operational difficulties (traffic congestion and delays) that the proposed NNDR scheme would mitigate. The NNDR scheme is also forecast to bring significant benefits to residents of dwellings adjacent to roads which are forecast to be used by increasing volumes of traffic. For the above reasons it is considered that the scheme provides essential support to the implementation of the very significant development proposals in the JCS, and that in practical terms, the growth cannot be accommodated without it.

Details of the Core Scenario which has been used for the updated assessment of the NNDR scheme are given in the Core Scenario report.