Greater Norwich

Joint Core Strategy

Public Transport Requirements of Growth

November 2008

Norfolk County Council
County Hall
Martineau Lane
Norwich
NR1 2SG

Tel : 01603 222143
Fax : 01603 222240
www.norfolk.gov.uk

Mott MacDonald
County Hall
Martineau Lane
Norwich
NR1 2US

Tel : 01603 767530
Fax : 01603 226760
www.mottmac.com

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Executive Summary

South Norfolk District Council, Broadland District Council and Norwich City Council are working with Norfolk County Council to prepare a new planning strategy (the Joint Core Strategy) for the Greater Norwich area up to 2026.

The Joint Core Strategy has to meet the requirements of the Government's East of England Plan that sets out the number of new homes and jobs to be provided in the three districts. The plan requires 33,000 new residential dwellings and 35,000 new jobs within the Norwich Policy Area (NPA) within the period 2001 to 2021.

Meeting these growth targets will involve an unprecedented level of growth and change and require the funding and provision of extensive supporting infrastructure. The Regional Spatial Strategy (RSS) states that there will need to be '*a major shift in emphasis towards public transport across the NPA*'.

A key aspect of the work to be done in developing the Joint Core Strategy is to identify a distribution of growth within the NPA. Sustainability appraisal work has shown that a number of the ten locations initially considered for large scale growth appear to perform significantly better than others.

Norfolk County Council commissioned their partner Mott MacDonald to study the best performing growth options and investigate their potential to support a high quality public transport service. The four growth scenarios initially specified for consideration in the study are set out in the table below.

	Scenario			
Location	**A**	**B**	**C**	**D**
North East (inside NDR)	5,000	3,750	5,000	5,000
North East (outside NDR)	-	-	-	2,000
West	5,000	3,750	-	-
South West	2,000	3,750	5,000	5,000
Wymondham	3,000	3,750	5,000	3,000
Norwich	5,000	5,000	5,000	5,000
Broadland & South Norfolk fringes	3,000	3,000	3,000	3,000
Total	23,000	23,000	23,000	23,000

The Growth Infrastructure Study

An earlier report - Norwich Growth Area – Infrastructure Need and Funding Study (EDAW, December 2007) - looked very broadly at the transport infrastructure required to facilitate the planned level of growth within the NPA. This study has reviewed the key findings of that report concerning public transport infrastructure and provision of services, and the associated cost estimates.

The conclusions of the EDAW report regarding the number of additional 'turn up and go' bus services required to facilitate the planned level of housing growth are based on the absolute maximum capacity of double deck vehicles, including standing passengers. In practice, demand is not evenly distributed throughout the peak period and the practical capacity of services is less than the absolute capacity, particularly for longer journeys. We have therefore based our analysis on a practical vehicle capacity of 75% of the absolute maximum capacity in line with guidance published by the Commission for Integrated Transport.

The EDAW study proposed increases in bus mode share across the Norwich Policy Area to 13% by 2021 and 15% by 2031. However, we would suggest that to achieve these revised overall mode shares for the NPA it will be necessary to set higher public transport mode share targets for the major growth locations. It will be easier to influence travel behaviour in the new growth locations by providing high quality public transport from the outset of development than it will be to change mode choice for journeys within the existing Norwich urban area. The new growth locations should therefore be expected to outperform the existing urban area in terms of their contribution to the overall mode share target for the NPA.

In our work we have therefore assumed bus mode share targets for the major growth locations of 16% by 2021 and 20% by 2031. As a sensitivity test we have also considered stretched bus mode share targets of 20% by 2021 and 25% by 2031.

The distribution of additional bus trips between the major growth locations shows that even with the stretched mode share targets, trip volumes from individual locations in 2031 are within the level at which a high frequency bus service would be the most appropriate public transport mode to meet the travel requirements of the major housing growth locations. Up to 26 new frequent services would be required by 2031 to link developments in the growth locations with the city centre plus further new bus services linking the housing growth locations directly with employment sites.

There may be scope to accommodate some of the trips generated by growth in the North East Sector on the Sheringham to Norwich (Bittern Line) rail services. However, a previous Mott MacDonald study has identified a number of infrastructure and operational constraints on the enhancement of Bittern Line services. Removal of these constraints will require significant investment in infrastructure and rolling stock.

A brief review of the public transport infrastructure requirements identified in the EDAW study has identified the following key issues that may require early consideration or further investigation:

The implementation of Bus Rapid Transit (BRT) as an upgrade to previously improved bus routes, with dedicated road space at congested points, will require a more radical approach to bus priority including the reallocation to buses of some existing road space for general traffic. This would be at variance with existing NATS policy for the provision of bus priority measures.

Should the potential to upgrade services from BRT to Light Rapid Transit (LRT) at a later date be required this will need to be considered at the outset of the design of BRT alignments. Design to facilitate a future upgrade from BRT to LRT will require the application of different standards and a different approach to the relocation of utilities' underground services.

The railway infrastructure requirements include an increase in the frequency of Wymondham to Norwich trains and new station(s) on the Sheringham to Norwich line. However, the EDAW study has not identified all of the infrastructure improvements and the additional rolling stock that would be required to deliver these requirements.

A previous Mott MacDonald study identified the following key network constraints on the introduction of additional train services between Wymondham and Norwich:

- Platform capacity at Norwich Station;
- Bottleneck created by track layout at Norwich Station throat;
- Single track section over Trowse Swing Bridge;
- Single lead junction at Trowse Lower Junction.

Investment to remove one or more of these constraints would be required, plus up to two additional train units.

The major investment required to deliver a new station on the Sheringham line would be of little benefit without additional train capacity. There is scope to provide an additional hourly shuttle service between Norwich and North Walsham within the existing infrastructure constraints. This would require one additional train unit.

Vision for a High Quality Public Transport Connection

A vision for a high quality public transport service should start with the overall image, visual identity and branding of the service. This is fundamental to the perception of the service, particularly where a step change in quality relative to existing bus services is required, and should be co-ordinated across vehicles, infrastructure and information so that the service is perceived as an integrated system.

With bus priority infrastructure in place and a package of measures to encourage modal shift, it is likely that a service level of departures every 5-6 minutes during peak periods would be required on services to and from the city centre. A minimum daytime service interval of 10 minutes should be maintained to provide a 'turn up and go' service and hours of operation should be comprehensive so as to meet almost every journey requirement.

In developing vehicle specifications for services to the growth areas the opportunity to deliver a safe, accessible and attractive service with a quality ambience and the lowest possible environmental impact should be maximised. However, it is important that specifications are based on tried and tested technology so that the reliability of services is not compromised.

The use of vehicles with low emissions will be essential if the new services are to operate within existing Air Quality Management Areas. The vehicle specification should incorporate the 'Enhanced Environmentally friendly Vehicle' (EEV) standard as the cleanest possible diesel fuelled vehicle in current series production. The potential to implement a fleet of hybrid or alternative-fuelled vehicles should be also be explored, with costs and benefits compared against EEV as a benchmark.

Vehicle suppliers are already offering innovative variants of standard buses that can transform them in appearance, comfort and overall ambience. Any detailed specification will need to be reviewed at regular intervals, but should include:

- Air conditioning;
- High quality seating, potentially with leather seats throughout;
- DDA compliant electronic exterior route number and destination displays;
- Electronic variable message signs or colour TFT screens fitted to the interior of the vehicle to provide information to passengers during their journey;
- CCTV equipment;
- GPS tracking and communications equipment compliant with RTIG standards.

Paperless ticketing systems can make an important contribution to a high quality public transport service by offering customers a range of convenient payment options and reducing dwell times at bus stops. Smart card and mobile phone ticketing technology should be considered.

To maximise the attractiveness of the public transport service for the growth areas it will be imperative to offer a high quality journey experience from origin to final destination. The quality of the waiting environment at bus stops and interchanges is a crucial part of the overall journey experience.

The provision and design of passenger infrastructure at terminal points and at stops where interchange occurs between buses and other modes should be given a high priority as their appearance will be important in encouraging greater patronage. It is envisaged that there may be a bus station or major interchange within each of the major growth areas. This should be centrally located, adjacent to a district centre and other local facilities such as supermarkets, schools, and health centres.

Bus stops and waiting areas should be designed to complement their surroundings whilst remaining prominent, well-lit and fit for purpose in terms of size of bus, level of enclosure and sufficiency of space to accommodate all waiting passengers. Bus stations and interchanges should offer facilities to meet the needs of passengers who may be waiting for longer periods than at a regular bus stop.

The provision of real time information (RTI) at interchanges and bus stops helps to build confidence in public transport services and contributes to the overall impression of a modern and efficient service. It is particularly beneficial at major interchanges.

Suggested essential and desirable requirements for major interchanges and regular bus stops in urban and rural areas are summarised in the full report.

To provide a fast and reliable service to and from the city centre, the aim should be to provide bus priority measures at all major junctions on the radial routes used by the services for the growth areas. These may take the form of bus lanes, bus gates, selective vehicle detection at traffic signals, peak hour parking restrictions or the banning of conflicting turning movements.

The planning of the internal layout of developments within the growth areas will provide the opportunity to create Public Transport-Orientated Developments (PTODs) and to build in public transport from day one. A PTOD approach will be essential to meet stretched public transport mode share targets for the growth areas. All distributor roads within the new developments should be designed for bus services. There should be a bus stop within 400m of every property within the development.

Assessment of Growth Options

In both Scenarios A and B there is an imbalance between development to the West and East of Norwich, and development to the West is split between three locations. This pattern of development would make it more difficult to develop cross-city routes in line with operator preferences and providing better links from the growth areas to strategic employment sites and other destinations outside the city centre.

Splitting development to the West between three locations also reduces the number of homes at each location. The developments of 2,000 to 3,750 homes in Scenarios A and B are well below the size that would support a dedicated express bus service to the city centre. The development of 2,000 homes in the South West sector in Scenario A would not support a ‘turn up and go’ service operating every 10 minutes.

Scenarios C and D offer the best opportunities for developing a strong market for public transport services. The key growth locations in these options are concentrated on a South West to North East axis, creating the opportunity to implement a cross-city service at a 'turn up and go' frequency. If the growth inside and outside the NDR in Scenario D is in the form of a contiguous urban extension to Norwich, then all the developments are on a scale sufficient to support a 'turn up and go' level of service.

Scenario D is marginally the preferred option from a public transport perspective as it provides a more balanced distribution of growth between the North East and the South West/Wymondham than Scenario C, but if Scenario C is favoured for other reasons it is still a good option in terms of public transport.

The requirements for additional bus stop and interchange capacity in the city centre would be similar under all four scenarios for the location of housing growth within the Norwich Policy Area. Options have been identified for increasing overall bus stop and interchange capacity in the city centre.

The key constraints to delivering reliable, high quality public transport services between the major growth areas and Norwich city centre are:

- The width of existing highway corridors;
- Historic buildings and mature trees along radial routes into the city;
- The presence of statutory undertakers' underground services within existing highway corridors and the cost of diversion or protection of such services;
- The impact of creating conventional bus priority measures within existing road space on existing highway capacity for general traffic;
- Existing NATS Policy 16, which states that new bus priority measures on Primary Distributor roads will not introduce additional delays for other, general traffic;
- The ability of bus operators to make the investment necessary to deliver the vision for high quality public transport;
- The overall cost, including ongoing revenue costs, to the public sector of the infrastructure required to deliver the vision for high quality public transport;
- Competing demands on developers to fund non-transport infrastructure.

Six potential routes for public transport services linking the growth areas with the city centre have been identified:

- Wroxham Road / Sprowston Road;
- Salhouse Road / Gurney Road;
- North Walsham Road / Constitution Hill;

- Newmarket Road;
- Hethersett Lane / Earlham Road;
- Dereham Road.

The specific constraints affecting each of these routes are identified in the full report.

Alternative Growth Options

Following the issue of a draft report in June 2008, four further alternative options for the distribution of housing growth within the NPA were assessed using the same methodology as that for the original Scenarios A to D. This work is summarised in **Appendix A**. The key findings of this work were that:

- The development of 2,000 homes in the West sector in Option 1 would not support a dedicated 'turn up and go' service operating every 10 minutes.
- Under Option 2, the levels of demand from the West, Wymondham and Long Stratton are all below that necessary to support a dedicated 'turn up and go' service operating every 10 minutes. These levels of demand would support dedicated services operating every 15 minutes.
- Under Options 6 and 6a, the level of demand from Wymondham is similar to Option 2. However, the impact of reducing the Long Stratton Housing allocation from 2,000 in Option 2 to 1,500 in Options 6 and 6a is to further reduce the level of dedicated service that can be supported to every 20 minutes.
- Option 6a involves further dispersion of development to smaller sites in Broadland and 1,000 houses in the West sector in place of a major growth location in the North sector under Option 6. This would be the least desirable of all the four alternative options from a public transport perspective.

Out of those considered in Appendix A, Option 1 is the preferred option from a public transport perspective. This option concentrates development in the smallest number of locations and thus offers the best opportunities for developing a strong market for public transport services. All of the proposed locations for major development in Option 1 have the potential to be served by public transport priority routes and all but one are on a single axis, enabling investment to deliver a step change in public transport service quality to be largely focused on one cross-city corridor.

Delivery Issues

The starting point for the procurement and delivery of public transport for the major growth locations should be a long term masterplan for the phased development of the public transport network to serve the growth areas, including specific plans for internal public transport routes to support the principle of Public Transport Orientated Development. The network must evolve to reflect the phasing of development and changing needs of residents and businesses.

Moving home is a time when people will reconsider their travel options. To maximise this opportunity it will be essential to have high quality public transport in place prior to the occupation of the first new houses on each development. This will require some form of revenue subsidy at the commencement of services but will help to bring forward the point at which services can be sustained commercially.

The development of services will require a partnership approach involving developers and public transport operators. The full report identifies how each of the parties involved could potentially contribute to such a partnership and discusses the alternative delivery models available.

Planning agreements should anticipate a range of possible scenarios for the way in which operators respond to the market opportunities presented by major developments and incorporate an element of flexibility in the way in which developer contributions for public transport may be spent. They should also encourage the developer to play an active role in the development of public transport services rather than simply making a financial contribution for public transport provision.

Early operator involvement in the planning of the public transport network to serve the growth areas will help to mitigate potential problems with developing a robust business case for operators to invest in situations where there is uncertainty regarding the timing and progress of major developments.

Conclusions and Recommendations

There is a greater propensity for change in travel behaviour amongst those moving to a new area and this can be capitalised on through the delivery of high quality public transport services from the outset of development in the growth areas.

A holistic approach should be adopted with the aim of creating truly Public Transport-Orientated Developments (PTODs) delivering high quality services and associated infrastructure to improve the perception and attractiveness of public transport.

To create PTODs a partnership approach involving planners, developers and public transport operators will be required to ensure that public transport is at the core of the masterplan for the development. Operator involvement at an early stage can help to deliver services as soon as the first homes are occupied. Discussion will also assist in identifying any funding issues related to provision of services and infrastructure. It is recommended that this is initiated at the earliest possible development stage.

It is estimated that up to 26 new, high frequency services would be required by 2031 to link the growth areas to the city centre. This does not include services for journeys from the growth areas to strategic employment sites outside the city centre.

To allow services to operate in a timely manner a more radical approach to bus priority will be required together with the implementation of Bus Rapid Transit (BRT) schemes on the busiest corridors. This is currently constrained by NATS Policy 16. The creation of additional road space in the city is also constrained by the historic street pattern of Norwich, the many historic buildings and large numbers of mature trees.

There is potential for rail services to contribute to public transport connections from the North East and Wymondham growth areas to Norwich. Development in proximity to existing and potential new rail stations could significantly enhance opportunities and demand for this mode. However it should be noted that there are a number of infrastructure and operational constraints that would need to be addressed.

The larger development sites offer the greatest opportunity for dedicated high frequency public transport services. The preferred option from a public transport perspective is Scenario D as it provides the best possible balance of growth across the North East to South West axis coupled with developments of a size sufficient to provide strong market opportunities for high frequency bus services. For similar reasons, Option 1 is the preferred option from a public transport perspective out of the alternative options assessed in Appendix A.

The existing NATS Policy 16 acts as a constraint on the provision of the high quality and reliable bus services that will be required to deliver modal shift. To date, bus priority measures in the city have had to prove that benefits for buses are not delivered to the detriment of general traffic. A revision to this policy would allow greater flexibility for more substantial priority measures, and is imperative for the implementation of advanced measures such as BRT.

1 Introduction

South Norfolk District Council, Broadland District Council and Norwich City Council are working with Norfolk County Council to prepare a new planning strategy (the Joint Core Strategy) for the Greater Norwich area up to 2026.

The Joint Core Strategy has to meet the requirements of the Government's East of England Plan that sets out the number of new homes and jobs to be provided in the three districts. The plan requires 33,000 new residential dwellings and 35,000 new jobs within the Norwich Policy Area (NPA) within the period 2001 to 2021.

Meeting these growth targets will involve an unprecedented level of growth and change and require the funding and provision of extensive supporting infrastructure. The impact of transport choices and how movement takes place around the area is at the core of a growth strategy of this magnitude.

The Regional Spatial Strategy (RSS), which includes the Regional Transport Strategy, recognises that the scale of growth within the NPA will place a significant burden on the existing transport networks. To accommodate the growth the RSS states that there will need to be '*a major shift in emphasis towards public transport across the NPA*'.

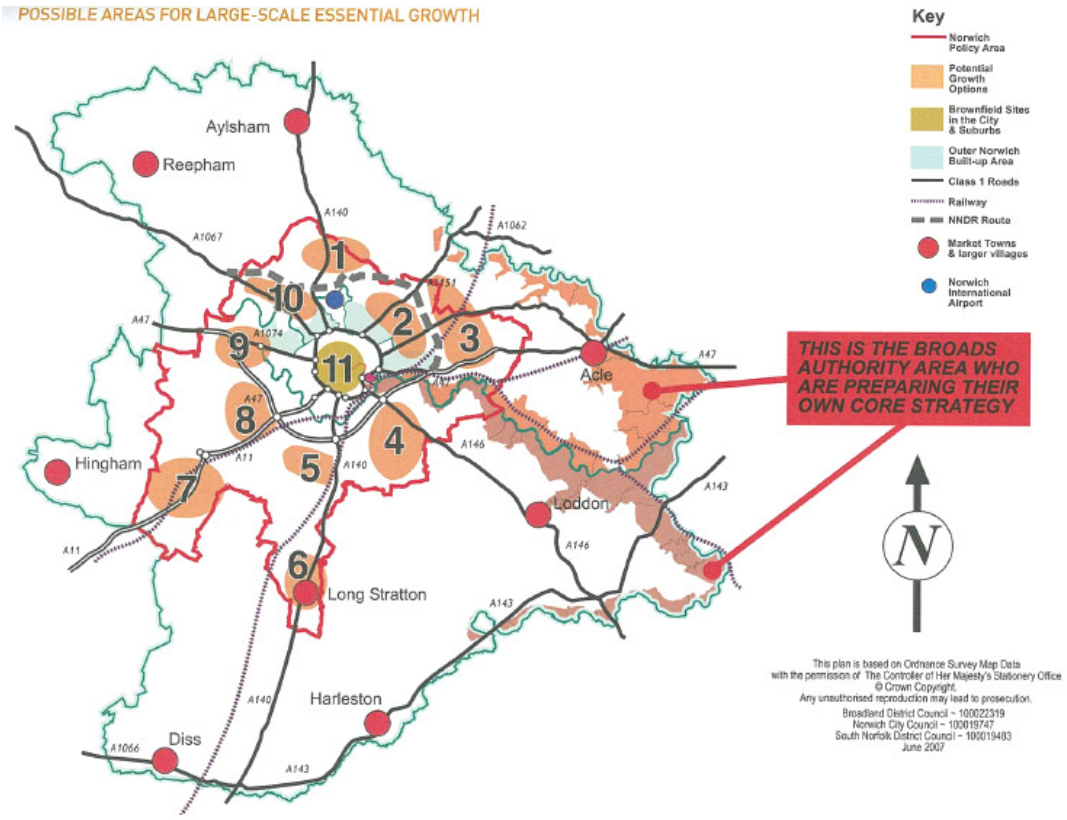
A comprehensive review of the existing public transport system will be required to achieve this modal shift. The major growth locations will need to be integrated into an enhanced public transport system and will require high quality public transport links to the city centre and other strategic employment areas (including Broadland Business Park, Norwich Airport, Longwater and Gateway 11 at Wymondham).

Norwich has been identified by the Department for Communities and Local Government as one of 29 New Growth Point areas across England. The New Growth Point status of Greater Norwich is expected to attract significant levels of grant funding from Central Government, while the growth itself will generate substantial developer contributions for infrastructure and services. There is thus an opportunity to both achieve an innovative pooling of contributions and implement a well planned programme of infrastructure delivery.

A key aspect of the work to be done in developing the Joint Core Strategy is to identify a distribution of growth within the NPA. Ten potential greenfield sites for large scale growth within the NPA have been considered (Figure 1.1). Sustainability appraisal work has shown that a number of the locations appear to perform significantly better than others. From that work a suggested list of options for growth in the NPA has been arrived at.

Norfolk County Council commissioned their partner Mott MacDonald to study these growth options and investigate their ability to be served by a high quality public transport service with a view to identifying a preferred option from a public transport perspective.

Figure 1.1: Greater Norwich - Potential Areas for Large Scale Growth



Source: Joint Core Strategy for Broadland, Norwich and South Norfolk, Issues and Options Consultation Report, November 2007

Some previous work has been carried out looking very broadly at the transport infrastructure required to facilitate the planned level of growth as part of the Norwich Growth Area – Infrastructure Need and Funding Study (EDAW, December 2007).

The key findings of the EDAW growth infrastructure study in relation to transport infrastructure are that:

- To accommodate the travel demand arising from major growth high quality public transport corridors need to be developed;
- The existing Norwich Area Transportation Strategy (NATS) is sound but will need to be strengthened and enhanced in some areas to take the Strategy to 2026 and accommodate higher rates of growth that those assumed in NATS;
- An estimate of the required public transport service capacities has been determined, so too has the need for the services to be 'turn up and go' with a minimum 10 minute daytime frequency;
- The Norwich Northern Distributor Route (NDR) is a prerequisite to growth.

This report will expand on the findings of the EDAW study and will propose specific route corridors and public transport infrastructure requirements to reflect broad patterns of development and accommodate the needs of the residents of the new growth areas. These proposals will also identify the corridors most likely to be able to cope with an increase in public transport passenger journeys and will provide evidence to support the selection of preferred growth locations.

1.1 The Brief

The study brief is to build on the EDAW growth infrastructure study and further define in general what a 'high quality' public transport connection should be. The study will define a service and vehicle specification and the general infrastructure and reliability and priority measures that would be expected for the routes.

For each of the growth options the study will:

- Identify an appropriate network of services to provide connections to the growth locations including any cross city linkages needed to connect the growth and strategic employment locations;
- Identify the need for interchanges and consider the capacity of those already in existence, particularly in the city centre;
- For the networks, identify the constraints on delivery of the required infrastructure, indicate potential solutions and consider their feasibility;
- Produce a key diagram of the services and infrastructure required highlighting the areas of constraint;
- Provide a summary of the ability to deliver the public transport required to support the option;
- Provide an overall summary comparing the options specified in the brief;
- Identify a preferred option based on this study of public transport.

The brief specifies four growth options (scenarios) for consideration in the study. Each scenario provides a total of 23,000 new properties including 3,000 in the Broadland and South Norfolk fringes to 2016, and 5,000 in Norwich between 2016 and 2026. Details of the scenarios are outlined below:

Scenario A

- 5,000 new dwellings in the North East sector inside the NDR between 2016 and 2026 (500 per annum)
- 5,000 in the West sector between 2016 and 2026 (500 per annum)
- 2,000 in the South West sector between 2016 and 2026 (200 per annum)
- 3,000 in Wymondham between 2016 and 2026 (300 per annum)

Scenario B

- 3,750 in the North East sector inside the NDR between 2016 and 2026 (375 per annum)
- 3,750 in the West sector between 2016 and 2026 (375 per annum)
- 3,750 in the South West sector between 2016 and 2026 (375 per annum)
- 3,750 in Wymondham between 2016 and 2026 (375 per annum)

Scenario C

- 5,000 in the North East sector inside the NDR between 2016 and 2026 (500 per annum)
- 5,000 in the South West sector between 2016 and 2026 (500 per annum)
- 5,000 in Wymondham between 2016 and 2026 (500 per annum)

Scenario D

- 5,000 in the North East sector inside the NDR between 2016 and 2026 (500 per annum)
- 2,000 in the North East sector outside the NDR between 2016 and 2026 (500 per annum)
- 5,000 in the South West sector between 2016 and 2026 (500 per annum)
- 3,000 in Wymondham between 2016 and 2026 (300 per annum)

1.2 Report Structure

Chapter 2 reviews the key findings of the EDAW growth infrastructure study concerning public transport infrastructure and provision of services, and the associated cost estimates.

Chapter 3 outlines a vision for high quality public transport connections for the growth areas. All aspects of service quality, ranging from vehicle specification to passenger information and infrastructure, are considered. The proposals draw on the Norwich Bus Strategy (November 2006) and other existing reports on public transport issues affecting the Greater Norwich area, including the series of bus priority feasibility studies undertaken for Norfolk County Council by Mott MacDonald.

Chapter 4 discusses the issues surrounding public transport solutions for the four growth scenarios detailed in the brief. Diagrams are presented for each scenario showing indicative service networks, infrastructure requirements and key areas of constraint.

Chapter 5 focuses on delivery issues.

Chapter 6 presents our conclusions and recommendations, including proposed next steps.

The results of an appraisal of four further options for the distribution of housing growth within the Norwich Policy Area using the methodology outlined in Chapter 2 are appended.

2 The Growth Infrastructure Study

The EDAW growth infrastructure study looked at two growth scenarios; firstly a major development of 7,500 dwellings in the North East of Norwich plus an extension of 3,500 dwellings to Wymondham, and secondly a new village of 10,000 dwellings to the West of Stoke Holy Cross and to the North East of Mulbarton. In our review of the findings of this study regarding transport infrastructure we have focused on Scenario 1 (North East Norwich and Wymondham) as this shares a number of the same characteristics as the scenarios in the brief.

The assessment of future transport infrastructure demand in the growth infrastructure study was based on the following major considerations:

- A review of the baseline transport situation and current transport policies;
- The effect of housing growth and employment growth on the quantity of vehicle trips that could potentially be generated;
- The accessibility of the locations in the proposed growth scenarios to public transport.

2.1 Housing Growth

The initial calculations in the growth infrastructure study for the potential increase in vehicle trip demand arising from the proposed level of housing growth were based on data from the TRICS database and assumed a daily trip rate of 3.136 per household.

These projections reflected the modal characteristics of the recent past rather than those that could be achieved by adopting more sustainable policies, and did not take into account the impact of the existing NATS strategy on vehicular trip generation. The total projected increase in home based vehicle trips between 2001 and 2031 under these assumptions is 49%.

A further set of calculations was made to obtain the total number of residential people peak hour trips by mode. Modal splits were derived from 2001 Census data for the Norwich area. The results showed that based on current modal share percentages, the total number of car trips would increase by 16% above 2011 levels by 2021 with a further 12% increase up to 2031. These levels of increase would lead to significant additional delays and worsening of congestion on the highway network.

In order to avoid this degree of growth in car traffic EDAW proposed a cap on the total number of car driver/passenger trips at the level that would be reached in 2011 with no changes in mode share. This was chosen on the basis that existing LTP and NATS policies should ensure that the transport network is able to cope with the level of development proposed up to 2011. As shown in Table 2.1 the total number of additional car driver/passenger trips on this basis in 2011 is 52,561.

Table 2.1: Projected Peak Hour Home-based Person Trips for 2021 and 2031 Based on Current and Revised Mode Shares, Scenario 1

Mode	Current Mode Share %	Predicted trips based on current mode share			Proposed mode share 2021	Predicted trips 2021 revised modal share	Proposed modal share 2031	Predicted trips 2031 revised modal share
		2011	2021	2031				
Walking and cycling	22	19,272	22,362	25,141	23	23,379	24	27,426
Bus	8	7,008	8,132	9,142	13	13,214	15	17,141
Home working	5	4,380	5,083	5,714	7	7,115	10	11,428
Train, taxi, and motor cycle	5	4,380	5,082	5,714	5	5,082	5	5,713
Car driver/ passenger	60	52,561	60,988	68,566	52	52,856	46	52,567
Total	100	87,602	101,646	114,276	100	101,646	100	114,276

Source: Norwich Growth Area – Infrastructure Need and Funding Study, Final Report, EDAW, December 2007

Table 2.1 also shows that keeping the number of car driver/passenger trips roughly constant at 2011 levels for 2021 and 2031 would mean reducing the car driver/passenger mode share from the current level of 60% to 52% and 46% respectively.

EDAW proposed that the required reductions in car driver/passenger mode share for 2021 and 2031 should be taken up by other modes as shown in Table 2.1. These changes in mode share are based on the following assumptions:

- A steady increase of 1% for each time period for walking and cycling;
- For bus a 5% increase by 2021 and a further 2% by 2031;
- Home working to increase by 2% in the period to 2021 and a further 3% by 2031;
- No change in train, taxi and motor cycle mode shares.

Under these assumptions buses will have to play a leading role in securing the necessary level of modal shift. Table 2.2 shows the projected increases in peak hour bus patronage for the periods 2011 to 2021 and 2021 to 2031 if the current mode share is maintained and with the assumed changes in mode share.

Table 2.2: Projected Increases in Peak Hour Bus Patronage

	2011 to 2021	**2021 to 2031**
Current mode share maintained	1124	1010
Assumed changes in mode share	6206	3927

Source: Norwich Growth Area – Infrastructure Need and Funding Study, Final Report, EDAW, December 2007

2.1.1 Requirements for Additional Bus Services

The report goes on to consider the number of additional bus services required to accommodate the projected additional peak hour bus trips with the proposed changes in mode share. The following assumptions are made:

- A ‘turn up and go’ service frequency of a bus every ten minutes;
- The use of double deck vehicles with a total capacity of around 90 passengers.

On the basis of these assumptions the absolute maximum capacity of a bus service operating at a frequency of every ten minutes is 540 passengers per hour per direction.

This capacity measure was used by EDAW to provide the following indications of the number of new ten minute headway services required to accommodate the projected additional peak hour bus trips with the proposed changes in mode share:

For the period from 2011 to 2021, based on 6,206 additional peak hour bus trips, 12 new bus services running on a ten minute headway and using double deck buses will be required.

For the period from 2021 to 2031, based on 3,927 additional peak hour bus trips, a further seven new bus services running on a ten minute headway and using double deck buses will be required.

It is not clear from the EDAW report if the intention is that these 19 new services would each access different locations, travelling on different routes. Given that the bulk of the demand could be presumed to be travelling to the city centre, it may be preferable to consider a reduced number of services operating at a higher frequency.

The definition of a 'turn up and go' service as one with a daytime service frequency of at least every ten minutes is consistent with that used in the Norwich Bus Strategy and we would concur that this is the threshold at which customers generally have enough confidence to wait at a bus stop without first consulting a timetable. This should however be a minimum frequency and, particularly during peak times, higher frequencies on individual services should be considered.

Assuming passengers arrive at bus stops at random intervals, the average wait time for a bus service is half the service frequency i.e. five minutes for a ten minute headway service. Increasing service frequency beyond the ten minute 'turn up and go' threshold up to at least five minutes delivers worthwhile reductions in wait time. Wait time savings can have a significant beneficial impact on the generalised cost of bus travel. For this reason ten minute headway services should not be the default choice and higher frequencies should be considered where justified.

Our main concern regarding the analysis undertaken by EDAW is that their conclusions regarding the number of additional 'turn up and go' bus services required to facilitate the planned level of housing growth are based on the absolute maximum capacity of double deck vehicles, including standing passengers.

The Commission for Integrated Transport's Affordable Mass Transit Guidance states:

"It is important to note that the practical capacity is significantly less than the absolute capacity. In practice therefore only 75% of the theoretical capacity should be assumed when undertaking analyses. Consideration should be given to the comfort levels for passengers, particularly in relation to the alternative travel choices available to potential passengers and the length of the journeys being made."

The practical capacity of services is less than the absolute capacity because in practice demand is not evenly distributed throughout the peak period and so additional capacity is required to avoid overloading at the height of the peak. The provision of sufficient capacity based on a 'comfortable' rather than 'crush' level of loading is particularly important for longer journeys, or routes where the vehicle may be travelling at speed, as the carriage of standing passengers on these routes may be considered unacceptable on safety grounds.

Based on a practical vehicle capacity of 75% of the absolute maximum capacity, the capacity of a bus service operating at a frequency of every ten minutes using double deck vehicles is reduced from 540 to 405 passengers per hour per direction.

The use of this capacity measure in place of that used by EDAW gives the following indications of the number of new ten minute headway services required to accommodate the projected additional peak hour bus trips with the proposed changes in mode share:

For the period from 2011 to 2021, based on 6,206 additional peak hour bus trips, 16 new bus services running on a ten minute headway and using double deck buses will be required.

For the period from 2021 to 2031, based on 3,927 additional peak hour bus trips, a further ten new bus services running on a ten minute headway and using double deck buses will be required.

2.1.2 Vehicle Requirements

Assuming an average cycle time for each service of 60 minutes, made up of a one way end to end journey time of 27 minutes plus three minutes layover time at each terminus, the peak vehicle requirement for the 16 new turn up and go bus services required by 2021 would be 96 double deck vehicles.

The further ten new bus services required by 2031 would have a peak vehicle requirement of 60 double deck vehicles.

Appendix H of the growth infrastructure report identifies a requirement for 100 additional buses by 2021, but it is not clear how this number has been derived from the figures in Chapter 3 of the main report.

2.1.3 Distribution of Additional Trips between Growth Locations

The figures from the growth infrastructure report for additional trips by mode are based on a summary of the total number of residential people peak hour trips for each mode for the Norwich Policy Area as a whole for Scenario 1 and their corresponding mode share.

The four growth options specified in the brief allocate total housing growth of 23,000 new properties to specific locations, including 3,000 in the Broadland and South Norfolk fringes to 2016, and 5,000 in Norwich between 2016 and 2026. As the Broadland and South Norfolk Fringes and Norwich City allocations are the same under all scenarios we will focus on the additional trips generated by the potential greenfield sites for large scale growth only and not the total for the NPA as a whole.

By taking the overall increase in peak hour people trips of 14,044 between 2011 and 2021, and 12,630 between 2021 and 2031 from Table 2.2 above, then apportioning these figures according to the distribution of housing growth under each of the Scenarios A, B, C and D the level of trip generation for each location under each scenario can be derived. The results of these calculations and the total number of bus trips based on the current 8% bus mode share are presented in Table 2.3 below.

Table 2.3: Geographical Distribution of Additional Trips

	Increase in Peak Hour Home-based Person Trips Based on Current Mode Share							
	2011-2021				**2021-2031**			
	Scenario				**Scenario**			
Location	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**
North East	3053	2290	3053	4274	2746	2059	2746	3844
West	3053	2290	-	-	2746	2059	-	-
South West	1221	2290	3053	3053	1098	2059	2746	2746
Wymondham	1832	2289	3053	1832	1647	2060	2745	1647
Norwich and fringe areas	4885	4885	4885	4885	4393	4393	4393	4393
Total	14044	14044	14044	14044	12630	12630	12630	12630
Total Bus Trips (@ 8% modal share)	1124	1124	1124	1124	1010	1010	1010	1010

Source: Norwich Growth Area – Infrastructure Need and Funding Study, Final Report, EDAW, October 2007

As outlined above, the growth infrastructure study proposed increases in bus mode share across the Norwich Policy Area as a whole to 13% by 2021 and 15% by 2031. However, we would suggest that to achieve these revised overall mode shares for the NPA it will be necessary to set higher public transport mode share targets for the major growth locations.

It will be easier to influence travel behaviour in the new growth locations by providing high quality public transport from the outset of development than it will be to change mode choice for journeys within the existing Norwich urban area. The new growth locations should therefore be expected to outperform the existing urban area in terms of their contribution to overall mode share target for the NPA.

We have therefore based our initial calculations for the distribution of additional bus trips between the major growth locations on bus mode share targets for these areas of 16% by 2021 and 20% by 2031. The results of these calculations are presented in Table 2.4 below.

Table 2.4: Geographical Distribution of Additional Bus Trips

	Increase in Peak Hour Home-based Bus Trips Based on Proposed Mode Share Targets for Growth Locations							
	2011-2021 (16% Bus Mode Share)				**2021-2031 (20% Bus Mode Share)**			
	Scenario				**Scenario**			
Location	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**
North East	488	366	488	684	549	412	549	769
West	489	366	-	-	549	412	-	-
South West	195	366	488	488	220	412	549	549
Wymondham	293	367	489	293	329	411	549	329
Norwich & Fringe Areas	782	782	782	782	879	879	879	879
Total	2247	2247	2247	2247	2526	2526	2526	2526

As a sensitivity test we have also considered stretched bus mode share targets for the major growth locations of 20% by 2021 and 25% by 2031. Table 2.5 presents the distribution of additional bus trips between the major growth locations based on this assumption.

Table 2.5: Geographical Distribution of Additional Bus Trips – Sensitivity Test

	Increase in Peak Hour Home-based Bus Trips Based on Stretched Mode Share Targets for Growth Locations							
	2011-2021 (20% Bus Mode Share)				2021-2031 (25% Bus Mode Share)			
	Scenario				Scenario			
Location	**A**	**B**	**C**	**D**	**A**	**B**	**C**	**D**
North East	611	458	611	855	686	515	686	961
West	611	458	-	-	686	515	-	-
South West	244	458	611	611	275	515	686	686
Wymondham	366	458	610	366	412	514	687	412
Norwich and fringe areas	977	977	977	977	1098	1098	1098	1098
Total	2809	2809	2809	2809	3157	3157	3157	3157

The distribution of additional bus trips between the major growth locations shows that even with the stretched mode share targets, trip volumes from individual locations in 2031 are within the level at which a high frequency bus service would be the most appropriate public transport mode to meet the travel requirements of the major housing growth locations.

For example, in Scenario D there are 1,816 (855 + 961) additional peak hour bus trips from the North East sector in 2031 under the sensitivity test assumptions. This compares with a maximum system capacity for a standard bus service of 2,500 to 4,000 passengers per hour per direction according to the CfIT Affordable Mass Transit Guidance report.

Considering the possibility in Scenario D of a single public transport corridor linking the North East of Norwich with the South West and Wymondham under the sensitivity test assumptions, this corridor would need to provide capacity for a total of 3,891 peak hour trips in 2031. This level of demand is still just within the maximum system capacity of a standard bus service, but sufficient to support a bus rapid transit service with a high level of segregation from general traffic. According to CfIT, such segregation can increase the maximum capacity of bus-based systems to between 4,000 and 6,000 passengers per hour per direction. As the figure of 3,891 peak hour home-based trips includes movements from both the North East and South West, the peak trip volume in any one direction on the corridor will be lower than this.

Table 2.6 below compares the system capacity of a standard bus service with those of various forms of bus rapid transit, light rail/tram and heavy rail. This indicates that a light rail/tram system would generally only be appropriate for larger peak hour passenger movements than those projected for the major housing growth locations.

Table 2.6: System Capacity

Mode / Technology	**Maximum System Capacity (passengers per hour per direction)**
Standard bus	2,500 – 4,000
Busway	4,000 – 6,000
Guided bus	4,000 – 6,000
Tram/Light Rail	12,000 – 18,000
Heavy Rail	10,000 – 30,000

Source: CfIT Affordable Mass Transit Guidance

2.1.4 Proposed Service Levels

Using bus mode share targets for the growth areas of 16% by 2021 and 20% by 2031 and the distribution of additional bus trips between the major growth locations set out in Table 2.4, we have identified the service levels and vehicle capacity required to meet the projected level of demand from each location in each of the four Scenarios A to D in 2021 and 2031.

The proposals for 2021 (Table 2.7) are largely based on the use of 12 metre semi-low floor buses with an absolute maximum capacity of 69 (44 seated plus 25 standing) and a practical capacity of 52 in accordance with the CfIT guidance. However, where such vehicles operating at five minute intervals would provide insufficient capacity to meet the projected level of demand we have proposed the use of larger vehicles in preference to increasing the service frequency beyond five minutes.

In Scenario A, the peak demand from the South West growth location in 2021 is likely to be below that necessary to support a dedicated 'turn up and go' service operating every 10 minutes, with peak demand only reaching 62.5% of the capacity of such a service. A potential solution would be to extend an existing bus route to serve this location at a 'turn up and go' frequency rather than introducing a new service.

Table 2.7: Proposed Peak Service Levels in 2021 for each Growth Scenario

Scenario	A				B				C				D			
Location	**Demand (trips per hour)**	**Frequency (minutes)**	**Practical Vehicle Capacity**	**Service Capacity (trips per hour)**	**Demand (trips per hour)**	**Frequency (minutes)**	**Practical Vehicle Capacity**	**Service Capacity (trips per hour)**	**Demand (trips per hour)**	**Frequency (minutes)**	**Practical Vehicle Capacity**	**Service Capacity (trips per hour)**	**Demand (trips per hour)**	**Frequency (minutes)**	**Practical Vehicle Capacity**	**Service Capacity (trips per hour)**
North East	488	6	52	520	366	7/8	52	416	488	6	52	520	684	5	60	720
West	489	6	52	520	366	7/8	52	416	-	-	-	-	-	-	-	-
South West	195	10	52	312	366	7/8	52	416	488	6	52	520	488	6	52	520
Wymondham	293	10	52	312	367	7/8	52	416	489	6	52	520	293	10	52	312

Table 2.8: Proposed Peak Service Levels in 2031 for each Growth Scenario

Scenario	A				B				C				D			
Location	**Demand (trips per hour)**	**Frequency (minutes)**	**Practical Vehicle Capacity**	**Service Capacity (trips per hour)**	**Demand (trips per hour)**	**Frequency (minutes)**	**Practical Vehicle Capacity**	**Service Capacity (trips per hour)**	**Demand (trips per hour)**	**Frequency (minutes)**	**Practical Vehicle Capacity**	**Service Capacity (trips per hour)**	**Demand (trips per hour)**	**Frequency (minutes)**	**Practical Vehicle Capacity**	**Service Capacity (trips per hour)**
North East	1037	3/4[(1)]	68	1088	778	5	68	816	1037	3/4[(1)]	68	1088	1453	2.5[(2)]	68	1632
West	1038	3/4[(1)]	68	1088	778	5	68	816	-	-	-	-	-	-	-	-
South West	415	7/8	60	480	778	5	68	816	1037	3/4[(1)]	68	1088	1037	3/4[(1)]	68	1088
Wymondham	622	6	68	680	778	5	68	816	1038	3/4[(1)]	68	1088	622	6	68	680

[1] – Two separate routes each operating every 7/8 minutes (8 buses per hour on each route)

[2] – Two separate routes each operating every 5 minutes (12 buses per hour on each route)

The proposals for 2031 (Table 2.8) are based on the use of higher capacity 13.5 to 15 metre single deck or 10.5 metre double deck buses with a practical capacity in the range 60 to 68. Articulated buses would also be an option at these levels of demand. Alternative vehicle specifications and capacities are discussed in detail in section 3.4.

On the basis of the assumptions made, all the growth locations, except the South West in Scenario A, and Wymondham in Scenarios A and D, have the potential to support a 5 minute or better peak service frequency in 2031.

In practice some of the demand provided for in the above proposals will be for services to the strategic employment sites rather than wholly on the main corridors linking the major growth areas with Norwich city centre. It is envisaged that in some cases dedicated public transport links will be provided between growth locations and strategic employment sites, but a proportion of trips to strategic employment sites will involve interchange to and from the main corridor services.

Dependent on the specific location of housing growth within the North East sector, there may be scope to accommodate a proportion of the additional trips generated by growth in this area on the Sheringham to Norwich (Bittern Line) rail services, using the existing station at Salhouse or by relocating this station to a site that would better serve the new development. However it should be noted that there are a number of infrastructure and operational constraints on the enhancement of Bittern Line services. These constraints are outlined in the Mott MacDonald report 'Improved Rail Services in Norfolk – Timetabling Exercise' (December 2007), which presents the results of a high-level timetable analysis to determine the ability of the present rail infrastructure to accommodate future additional rail services.

2.2 Employment Growth

An assessment of ten strategic employment sites within the NPA undertaken as part of the growth infrastructure study concluded that the sites were unequally served by public transport and walk times to access the nearest public transport service varied considerably.

- Strategic employment sites within the Norwich City boundary lie within 5 minutes walk time from public transport services with the exception of Norwich Airport (5 to 10 minutes).

- The Salhouse Road (Sprowston) and Gateway 11 (Wymondham) sites are within 5 to 10 minutes walk from public transport services, but expansion of these sites could increase this significantly.

- Walk time to public transport from the Ipswich Road (Long Stratton) and Longwater (Costessey) sites exceeds 15 minutes, but in the latter case the development of public transport services for the adjacent housing is expected to mitigate this.

There is thus an overall need to improve links from new and existing residential areas to strategic employment sites to increase the use of public transport for commuting trips. A comprehensive package of soft measures will also play a key part in changing travel patterns. Travel plans, parking restrictions and improved bus priority will all contribute to raising the profile of public transport and encouraging a modal shift.

The proposals made in the growth infrastructure study for additional public transport links and bus service capacity to serve strategic employment sites were informed by a public transport accessibility study. These proposals are summarised in the box below.

- There is a need to provide faster links to locations in the urban areas surrounding Norwich city centre and to strategic employment sites, and new links to locations in outer Norwich, especially destinations to the North, without a need to cross the city centre.
- A development of 7,500 dwellings in the North East of Norwich would require the equivalent of three new bus services running on a ten minute headway and using single deck vehicles to create the conditions necessary to encourage work trips to locations outside Norwich city centre to be made by public transport.
- An extension of 3,500 dwellings to Wymondham would require the equivalent of one new bus service running on a ten minute headway and using single deck vehicles to create the conditions necessary to encourage work trips to locations outside Norwich city centre to be made by public transport.
- These services should form an integral part of an improved public transport network serving the NPA, with good quality interchange facilities provided to enable efficient transfer between services.
- Public transport links from the existing Norwich Park and Ride sites to the strategic employment sites should be provided where there would be real benefits in reducing the length of car journeys within the NPA.

It is unclear from the EDAW report how the requirements for additional bus services to cater for work trips to locations outside the city centre have been quantified, but given the number and distribution of strategic employment sites with relatively poor public transport accessibility from the proposed housing growth locations we would concur with the need a number of new bus services linking the housing growth locations directly with employment sites in addition to services to the city centre.

Travel plans, bus priority measures and Park and Ride facilities can all play a part in reducing the number of car journeys to and from employment sites and would complement the provision of new direct bus links.

The spatial relationship between housing and employment areas in the growth areas can be controlled through the planning process and 'local' bus services provided to link the residential and industrial zones, but this does not necessarily mean that those occupying the new houses will have jobs in the adjacent employment areas. Self-contained development with low levels of in and out-commuting can be encouraged, but not guaranteed.

We have concluded that there is insufficient data available on employment trips to permit an assessment to be made of the distribution of public transport trips between the major growth locations and employment sites under each of the scenarios.

2.3 Public Transport Infrastructure Requirements

Tables 2.9 and 2.10 summarise the public transport infrastructure requirements identified in the growth infrastructure study, and their proposed phasing.

The measures phased between 2007 and 2011 represent those already considered in the Norwich Area Transportation Strategy (NATS). Those proposed for the period 2011 to 2021 are intended to represent the continuation and expansion of the existing NATS policies that would be required to deliver the proposed level of growth.

Table 2.9 identifies the requirements that would be common to all scenarios for the spatial distribution of growth within the NPA. Table 2.10 identifies specific requirements linked to a major development of 7,500 dwellings in the North East of Norwich plus an extension of 3,500 dwellings to Wymondham (Scenario 1 in the growth infrastructure study.

We have briefly reviewed these proposals and highlighted key issues that may require early consideration or further investigation.

Table 2.9: Common Transport Infrastructure Requirements arising by 2031 (Public Transport, Soft Measures)

	2007-2011	2011-2021	2021-2031
Bus	Bus priority on current bus routes in Greater Norwich	Upgrade existing 'Overground' network to Bus Rapid Transit (BRT) standard with dedicated road space at congested points	Further 7 new 10 minute frequency bus routes
	Dedicated orbital bus route for outer Norwich, serving new residential areas and strategic employment sites	12 new 10 minute frequency bus routes across NPA	Expansion of BRT network
	Increase frequency on existing bus routes, including those serving new residential areas and employment sites	High quality bus services between Park & Ride sites and strategic employment sites where beneficial	
	Quality improvements: bus stops, shelters, information, fleet	Expansion of bus network, including further orbital bus routes to link with existing radial services	
Park & Ride	Increase capacity of existing sites where appropriate	Continue expansion of capacity	Expansion of capacity if required
		New site at A146/A47 intersection	
Train	No common interventions	No common interventions	Further enhancement of rail journey times to London
LRT		Review potential to upgrade services from BRT to LRT	Subject to review: implement LRT service between Norwich city centre and strategic employment sites
Interchanges	Enhancements at all bus and train stations in Norwich	Enhancement of bus to bus interchange provision	Develop all main interchanges, including Park & Ride sites, as major hubs with access to different types of PT
		Enhancement to all stations (inc. BRT/LRT) in Norwich and along growth corridors	
Soft Measures	Better information: travel plans, marketing, awareness, car sharing etc	Better information; travel plans, marketing, awareness, car sharing etc	Better information: travel plans, marketing, awareness, car sharing etc

Source: Norwich Growth Area – Infrastructure Need and Funding Study, Final Report, EDAW, December 2007

Table 2.10: Specific Transport Infrastructure Requirements arising by 2031: Scenario 1(Public Transport, Soft Measures)

	2007-2011	2011-2021	2021-2031
Bus		4 new 10 minute frequency bus routes to serve urban extension and market town extension	
		Where appropriate, extend P&R shuttle service to serve urban extension	
Park & Ride			
Train		Improved local train service Wymondham-Norwich: 15 minute peak frequency, 30 minute inter-peak frequency	
		New station(s) on Norwich-Sheringham line to serve urban extension and Broadland Business Park	
LRT			Subject to review, implement LRT service between market town extension and Norwich city centre
Interchanges			
Soft Measures			

Source: Norwich Growth Area – Infrastructure Need and Funding Study, Final Report, EDAW, December 2007

2.3.1 Bus

The proposal for the period 2011 to 2021 for the "implementation of Bus Rapid Transit (BRT) as an upgrade to previously improved bus routes (7 routes), with dedicated road space at congested points" implies a more radical approach to bus priority that may include the reallocation to buses of some existing road space for general traffic.

This would be at variance with the existing NATS policy framework for the provision of bus priority measures. NATS Policy 16: Bus Priority Measures states:

"Bus priority measures will be focused on the core bus network. Where this core bus network is on main roads (Primary Distributors), new bus priority measures will not introduce delays for other, general traffic."

We would suggest that the effective implementation of BRT in Norwich on the scale proposed would require a policy review to permit the implementation of bus priority measures on Primary Distributor roads that may have some detrimental effect on capacity for general traffic, rather than simply "the continuation and expansion of the existing NATS policies".

2.3.2 Park and Ride

The proposals for expansion of existing Park and Ride sites and development of a new site at the A146/A47 intersection during the period 2011 to 2021 are consistent with recommendations made by Mott MacDonald in previous work on the Norwich Bus Strategy.

2.3.3 Train

The specific requirements for Scenario 1 for the period 2011 to 2021 include:

- "Increase of train frequency between Wymondham and Norwich. New frequency would be one train each 15 minutes in peak time and 30 minutes for inter peak time";
- "New station (or if required two new stations) for the Norwich to Sheringham line to serve the Urban Extension and Broadland Business Park".

The EDAW growth infrastructure study has not identified all of the railway infrastructure improvements and the additional rolling stock that would be required to deliver these requirements.

A previous study by Mott MacDonald for Norfolk County Council identified the following key network constraints on the introduction of additional train services between Wymondham and Norwich:

- Platform capacity at Norwich Station;
- Bottleneck created by track layout at Norwich Station throat;
- Single track section over Trowse Swing Bridge;
- Single lead junction at Trowse Lower Junction.

A timetabling exercise undertaken as part of this study identified potential train paths for one additional morning peak service in each direction between Wymondham and Norwich. One additional service would provide three trains from Wymondham arriving in Norwich between 0800 and 0900, but would not meet the aspiration for a train every 15 minutes at peak times.

The provision of a 15 minute interval train service between Wymondham and Norwich at peak times would require investment to remove one or more of the constraints identified above, plus up to two additional train units.

The existing hourly train service on the Sheringham to Norwich line operates with very tight turnaround times in order to permit the operation of the service with only two train units. There are also significant operational constraints arising from the predominantly single track nature of the route, with trains running beyond Hoveton & Wroxham only able to pass at North Walsham and Cromer.

Previous work has identified the difficulty of accommodating an additional station stop on Sheringham to Norwich services within the existing timetable unless some acceleration of existing journey times can be achieved to compensate for the extra stop, the new station is served in place of an existing station stop or the new station to serve the growth area is a relocated Salhouse station.

Alternatively the improved performance offered by lightweight 'tram-train' rolling stock might help to overcome this constraint. A trial of tram-trains on the national rail network is to take place on the Penistone Line between Huddersfield, Barnsley and Sheffield from 2010. If this trial is successful this type of rolling stock may become a viable option for local train services in Norfolk within the period 2011 to 2021.

The major investment required to deliver a new station on the Sheringham line would be of little benefit without investment in additional train capacity. A timetabling exercise for this line has identified that there is scope to provide an additional hourly shuttle service between Norwich and North Walsham within the existing infrastructure constraints. This service would require one additional train unit.

2.3.4 Light Rapid Transit

The proposal that the potential to upgrade services from Bus Rapid Transit (BRT) to Light Rapid Transit (LRT) should be reviewed during the period 2011 to 2021 raises issues that will need to be considered at the outset of the design of BRT alignments.

Designing alignments to facilitate a future upgrade from BRT to LRT will require the application of different standards and, for example, a different approach to the relocation of utilities' underground services. This may add to the initial cost of new rapid transit infrastructure but significantly reduce the future infrastructure cost of moving from BRT to LRT.

2.4 Public Transport Infrastructure Costs

We have undertaken a brief critical review of the indicative construction cost estimates for public transport infrastructure made by Gardiner and Theobald LLP and presented in Appendix H of the EDAW growth infrastructure study. These are summarised in Table 2.11 below.

Table 2.11: Summary of Public Transport Infrastructure Cost Estimates

Item	Cost Estimate (£ million, September 2007 prices)
Bus fleet upgrade	25.00
Extra depot	5.00
City centre interchange	6.00
Bus box work	3.00
BRT dedicated routes	65.00
Park and Ride expansion	9.00
Bus priority – radial routes	1.62
Bus priority – orbital route	0.72
Signage and lining	4.55
Other interchange facilities	3.00
Bus stops and shelters	6.75
Local rail improvements	15.00
TOTAL	144.64

Source: Norwich Growth Area – Infrastructure Need and Funding Study, Final Report, EDAW, December 2007

The review has focused on testing of the cost estimates made for key public transport initiatives against readily available alternative sources of cost information. We have also sought to identify any ancillary costs that would be necessary to deliver the requirements listed in the text of the report but have been omitted from the cost estimates, an example being the cost of the additional rolling stock required to implement improvements to local rail services.

Finally, we have considered whether and how certain costs will fall on the public sector.

2.4.1 Bus Fleet

The estimates in the EDAW report quote a capital cost of £250,000 per vehicle for new buses. There is no accompanying reference to a specific type or size of bus, although the text of the growth infrastructure study refers variously to both single deck and double deck vehicles. In practice prices will vary dependent on the type and specification of vehicle required for the service. Evidence presented by bus operators to the recent Scrutiny Review of local bus services in the Greater Norwich area (Table 2.12) indicates current costs for new full size buses varying between £120,000 and £170,000.

Table 2.12: Capital Costs for New Buses Quoted by Norwich Bus Operators (February 2008)

Operator	Full size single deck	Double deck
Anglian	£140,000 [1]	£160,000 [2]
Konectbus	over £120,000	
First	circa £170,000	

Notes: [1] – Scania Omnicity 45 seats
[2] – Scania Omnidecker 78 seats

Source: Bus operator submissions to Scrutiny Review of local bus services in Greater Norwich, February 2008

The major scheme business case submission for the Bath Transport Package (Bath & North East Somerset Council, July 2006) quotes a cost of £180,000 for a standard new bus at 2005 prices. The same document quotes a cost of £318,500 for a Wrightbus Streetcar FTR articulated bus rapid transit vehicle.

The Commission for Integrated Transport's Affordable Mass Transit Guidance quotes a price range of £120,000 to £200,000 for a conventional bus at 2002 prices.

We have concluded that the estimate of £250,000 per vehicle is more than sufficient to cover the cost of conventional diesel-powered rigid single or double deck buses built to a high quality specification, and that £200,000 per bus would be a more realistic upper estimate for such vehicles at current prices.

An allowance of £250,000 per vehicle would permit consideration of alternative fuel or diesel-electric hybrid buses.

The unit cost of new buses would only exceed the £250,000 estimate in the event of articulated bus rapid transit vehicles being selected in preference to high quality conventional buses.

Depending upon the delivery model adopted for the provision of public transport services for the growth areas, leasing of vehicles may be preferable to outright purchase.

Full size buses have a typical service life of 12 to 16 years and should be subject to mid-life refurbishment at 4 to 5 year intervals. The whole life capital cost of a new bus should include provision for two such refurbishments at a unit cost of £15,000.

2.4.2 Bus Depot Infrastructure

The EDAW report estimates include provision for an additional bus depot at a cost of £5 million. We would concur that additional bus depot capacity will be needed, but in practice this is likely to be split between multiple operators and sites. To avoid lack of depot capacity becoming a barrier to enhanced public transport provision the local planning authority should ensure that suitable sites are available in locations that are accessible to the major growth areas and will minimise dead mileage.

It is unlikely that the provision of bus depot infrastructure will fall as a capital cost to the public sector. However, in the event of a decision to adopt the Quality Contracts Scheme delivery model (section 5.1.3) it may be beneficial for the local transport authority to provide a depot site for lease to operators in order to encourage competition for a quality contract from operators without an existing depot in the area.

One specific item of depot infrastructure that it may be beneficial for the public sector to take the lead on is the provision of refuelling facilities for alternative fuel buses. The lack of a business case for operators or fuel suppliers to invest in the necessary fuel station infrastructure can be a barrier to realising the environmental benefits of alternative fuel buses.

Where new depot facilities are provided by operators, the cost will be reflected within the overhead element of the overall operating cost of services provided from that location. Where new services require pump-priming revenue funding, depot costs will be reflected within the level of financial support sought by operators for these services.

2.4.3 Interchange Facilities

The EDAW report estimates include a sum of £6 million for new city centre interchange facilities providing a total of 24 stands. Based on the references to interchange within the text of the growth infrastructure study we have assumed that these would take the form of enhancement to interchange provision in a number of locations within the city centre, rather than one new major interchange.

On the basis of our knowledge of the costs of the recent improvements to public interchange facilities in Norwich delivered through the Public Transport Major Scheme, a unit cost of £250,000 per stand would be sufficient to cover the cost of a series of new small scale interchange facilities similar to the bus interchange scheme at Norwich Railway Station completed in 2007, but would be insufficient to provide a major new off-street transport interchange, or an extension to the existing Norwich Bus Station in combination with other schemes.

Land values for potential new off-street interchange sites within the city centre will be relatively high and do not appear to be reflected within the estimate.

The EDAW report estimates include a further £3 million for new bus interchange facilities outside the city centre.

2.4.4 Bus Rapid Transit

An estimate of £65 million has been provided in the EDAW report for dedicated bus rapid transit routes based on 5 km of 'urban' routes at a cost of £5 million per km and a further 20 km of 'rural' routes at £2 million per km.

These costs fall within the range of costs for guided bus infrastructure quoted in the CfIT Affordable Mass Transit Guidance Report and reproduced in Table 2.13, although the CfIT costs are given at 2002 prices.

A benchmark figure of £2 million per km for a segregated unguided busway was given by Paul Turner of the TAS Partnership in a presentation at the 'Bus as Rapid Transit' conference on 20 March 2008.

The major scheme business case submission for the Bath Transport Package (Bath & North East Somerset Council, July 2006) quotes an estimated cost of £16.29 million at 2005 prices for a cross-city bus rapid transit corridor circa 6.5 km in length including 1.8 km of fully segregated alignment and substantial sections of dedicated route on-highway. This equates to a cost of £2.5 million per km.

The above sources would suggest that £65 million is a reasonable overall estimate for the provision of 25 km of dedicated routes for bus rapid transit within the Greater Norwich area.

We would also concur with the assumptions implicit in the build-up of the estimate that the potential to provide dedicated BRT routes within the existing urban area will be limited relative to that in the urban fringe and within the greenfield growth areas, and that the cost of dedicated BRT routes in urban areas will be significantly higher than elsewhere due to higher land costs and significant potential costs for the relocation of utilities' underground services.

Table 2.13: Comparison of Capital Costs for Bus Priority, Guided Bus and Light Rail Schemes (£ million, 2002 prices)

Cost element	Light Rail	Guided Bus	Bus Lane / Bus Priority
Land and utilities diversion	1.9 - 3.5	0.1 - 2.2	0.1
Civils and trackwork	0.6 - 5.0	1.4 - 2.3	0.2
Stops	0.1 - 1.3	0.2	<0.1
Electrical (inc. power supply & overhead line equipment)	0.4 - 1.1	-	-
Communications and signalling	<0.1 - 0.8	<0.1	0.1
Depot / Control Centre	0.6 - 0.8	0.1	-
Highway works	<0.1 - 2.1	0.1 - 2.2	<0.1 - 0.5
Traffic management	0.1 - 0.4	<0.1	<0.1
Design and management	0.5 - 1.9	0.1 - 0.3	0.1
Contingency	0.6 - 0.7	0.4	<0.1 - 0.1
Park and Ride	0.1	0.1	
TOTAL	8.6 - 14.5	2 - 5	0.7 - 0.9

Source: CfIT Affordable Mass Transit Guidance

2.4.5 Park and Ride

The EDAW report estimates include a sum of £9 million for Park and Ride expansion based on provision of an additional 5,000 parking spaces at a unit cost of £1,800 per space. This implies a cost of:

- £1.44 million for a new 800 space site
- £1.80 million for a new 1000 space site

These figures are well below the outturn costs of the most recently completed Norwich Park & Ride sites at Harford (1,088 spaces), Sprowston (792 spaces) and Thickthorn (726 spaces), all of which cost in excess of £2 million.

We would suggest that £12.5 million (£2,500 per space) would be a more realistic estimate for the provision of 5,000 additional Park and Ride spaces for Greater Norwich.

2.4.6 Bus Priority

The cost estimates for bus priority measures in the EDAW report have been built up from an assumption of nine existing core bus routes and one orbital bus route.

The figure of nine core bus routes appears to be based on the number of existing Norwich 'Overground' bus routes operated by First as set out in Table 3.3 of the growth infrastructure study report. This does not take into account the fact that while there are nine different 'Overground' route numbers, some of these (e.g. 19, 20) relate to variations of the same basic cross-city route. Nor has it been recognised that not all of the radial roads forming part of the proposed NATS Core Bus Network are served by 'Overground' routes, Newmarket Road being a prime example.

Four schemes, referred to as 'bus gates', per core route are assumed at a unit cost of £45,000. The assumption of four schemes per route appears arbitrary, and the unit cost too low in comparison to the estimates for schemes considered in the Norwich bus priority feasibility studies undertaken for Norfolk County Council by Mott MacDonald.

A further 16 'bus gates' at the same unit cost are assumed for the orbital bus route. It is unlikely that such a large number of schemes on one route would be either necessary or feasible, but this concern is mitigated by our view that the unit cost used is too low.

In addition to the 'bus gate' costs, £4.55 million has been provided for white lining and signage for bus priority measures based on a route network of 9.1 km and a cost of £50 per metre.

A further £3 million has been provided for 'bus box work' in the city centre, but the nature of the work proposed is not explained.

The addition of the 'bus gate', 'white lining and signage' and 'bus box work' cost estimates produces a total sum of £9.89 million for bus priority schemes. Using the range of costs quoted by CfIT for bus lane / bus priority schemes of £0.7 to 0.9 million per km (Table 2.13 above), this sum would be sufficient to deliver between 11.0 and 14.1 km of bus priority routes. However it should be noted that the CfIT costs are based on 2002 prices.

In summary, while the assumptions and the way in which the bus priority cost estimate has been built up are unconvincing, the total of circa £10 million arrived at would be sufficient to deliver a step change in the existing level of bus priority road space within Greater Norwich.

In practice bus corridor improvements are likely to take the form of a mix of dedicated routes and highway bus priority measures. It is also likely that in some cases the new bus corridor infrastructure will be used by both bus rapid transit and existing bus services. It may therefore be sensible to treat the bus rapid transit and bus priority cost estimates as a single pot for bus corridor infrastructure improvements.

2.4.7 Bus Stop Infrastructure

The EDAW report cost estimate for bus stop infrastructure provision is £6.75 million, based on 225 stops at a unit cost of £30,000. The number of stops is calculated from an assumption of nine bus routes each 10 km in length, with an average stop spacing of 0.4 km. This calculation fails to take into account the need for bus stops on both sides of the road, except on one-way terminal loops.

Table 2.14: Growth Infrastructure Study - Build-up of Bus Stop Cost Estimate

Stop	£2,000
Shelter	£10,000
Variable message sign for real time information	£10,000
CCTV	£8,000
Total	£30,000

Table 2.14 shows the build-up of the £30,000 unit cost. This figure is considered to be rather high. It may not be essential to provide a shelter at stops that are essentially only used as alighting points, and there may not be space at some existing bus stop sites for a shelter. However, where shelters are required, the cost of providing a fully enclosed shelter of sufficient size to accommodate all waiting passengers may exceed the allowance of £10,000 made in the estimate.

Variable message signs (VMS) for real time information can be provided much more cost effectively than indicated in the estimate. Bus stop flags with an integral VMS recently purchased by Norfolk County Council cost approximately £5,000 each.

We would question the need for dedicated CCTV equipment to be installed at every bus stop, especially if buses are fitted with CCTV. Some bus stops will be covered by existing CCTV cameras. The costs and benefits of installing CCTV at bus stops, including ongoing revenue costs, would need to be fully thought through including consideration of how such a large number of cameras could be effectively monitored. Installation of 'help points' at bus stops to enable waiting passengers to communicate with a central control room might be a more practical alternative.

We would recommend that a sum of £24,000 is used as an average unit cost for bus stops, built up as shown in Table 2.15. This average cost would allow for some variation in provision at individual stops between smaller and cheaper types of shelter and larger mini-interchange shelters.

Table 2.15: Recommended Bus Stop Costs

Bus stop with raised kerb and tactile paving	£1,500
Shelter	£15,000
Variable message sign for real time information	£5,000
Help point	£2,500
Total	£24,000

Using the assumptions made in the original estimate of nine bus routes each 10 km in length, with an average stop spacing of 0.4 km, but allowing for bus stops on both sides of the road, gives a total of 450 stops. We would therefore recommend that the cost estimate for bus stop infrastructure provision of £6.75 million in the growth infrastructure study is increased to £10.8 million (450 stops at £24,000).

2.4.8 Local Rail Improvements

The EDAW growth infrastructure study estimates include a provision of £15 million for local rail improvements, based on:

- £8 million for a new station on the Norwich to Sheringham line;
- £2 million for signalling improvements on the Norwich to Sheringham line;
- £5 million for signalling improvements and a 'lay-by' between Norwich and Wymondham.

There is a mismatch between these proposals and the constraints on the introduction of additional train services between Wymondham and Norwich identified in the Mott MacDonald report 'Improved Rail Services in Norfolk – Timetabling Exercise' (December 2007). These constraints, the enhancements required to overcome them and an order of magnitude cost estimate for each scheme are set out in Table 2.16 below.

Table 2.16: Constraints on Additional Wymondham to Norwich Train Services

Constraint	Enhancement required to overcome constraint	Estimated Cost Range (£ million)
Platform capacity at Norwich Station	New platform plus associated track and signalling works	1 – 5
Bottleneck created by track layout at Norwich Station throat	New crossover to allow simultaneous parallel movements to Platforms 3/4	1 – 5
Single track section over Trowse Swing Bridge	Replacement of existing bridge with new double track	10 – 15
Single lead junction at Trowse Lower Junction	Double junction at Trowse Lower Junction	1 – 5

Source: Improved Rail Services in Norfolk - Timetabling Exercise, Mott MacDonald, December 2007

The doubling of Trowse Lower Junction is a potential lower cost alternative to the replacement of the swing bridge, but assuming that the three schemes other than the swing bridge replacement would be required to deliver a 15 minute interval train service between Wymondham and Norwich at peak times gives a cost range of £3 to £15 million, with a midpoint of £9 million, compared with the estimate of £5 million in the growth infrastructure study.

The EDAW report estimates for local rail improvements do not take into account the cost of the additional rolling stock that would be required to deliver increases in the frequency and capacity of local rail services including the specific proposals for an increase in the frequency of services between Wymondham and Norwich. This is inconsistent with the approach taken to the estimation of costs for the provision of enhanced bus services, which includes capital costs for 100 additional buses.

The approximate leasing cost of a two car class 170 diesel multiple unit similar to those currently used on Norwich to Cambridge train services is £270,000 per annum. Up to two additional units of this or a similar type would be required to a 15 minute interval train service between Wymondham and Norwich at peak times. A further unit would be required to provide additional capacity on the Norwich to Sheringham line, making total additional train leasing costs of up to £810,000 per annum.

2.4.9 Conclusions

The conclusions of our review of the cost estimates for public transport infrastructure presented in the EDAW growth infrastructure study are summarised in the table below. This produces a total estimated cost of £169.65 million; some 17% higher than the total estimate in the EDAW report (Table 2.11).

Table 2.17: Broad Indication of Costs for Proposed Services and Infrastructure

Item	Details	Estimated Cost (£million)
Bus fleet upgrade	156 Enhanced Environmentally friendly Vehicles @ £200,000 per vehicle	31.20
Interchange	City centre improvements including Dynamic Stand Allocation (DSA) system	6.00
	2 No. Interchange facilities for NE and SW Growth Areas (4 stands with DSA at each site)	2.00
	Small interchange facility at Wymondham	1.00
BRT dedicated routes	As per EDAW report	65.00
Park and Ride expansion	5000 extra spaces @ £2,500 per space	12.50
Bus priority measures	Various bus priority measures as per EDAW report	10.00
Bus stops and shelters	450 bus stops @ average £24,000 per stop	10.80
Local rail improvements	New stations and infrastructure improvements	19.00
	Leasing charges for additional rolling stock (15 years @ £810,000 per annum)	12.15
Total		**169.65**

3 Vision for a High Quality Public Transport Connection

The brief asked us to define in general what a 'high quality' public transport connection should be, including consideration of a service and vehicle specification and the general infrastructure and priority measures that should be expected for the routes.

3.1 Image and Branding

The vision for a high quality public transport service should start with the overall image, visual identity and branding of the service. This is fundamental to the perception of the service as offering a step change in quality relative to existing bus services.

The visual identity and branding of the service should be co-ordinated across vehicles, infrastructure and information so that the service is perceived as an integrated system even if in practice different parties are responsible for operations and infrastructure.

The Kent Thameside 'Fastrack' network in the Thames Gateway area (Figure 3.1) is an excellent UK example of this approach.

Figure 3.1: Co-ordinated Branding of Vehicle and Infrastructure (Kent Thameside Fastrack)

The Nantes 'BusWay' scheme in France also demonstrates what can be achieved in terms of raising the visual appearance of essentially standard buses to stand out from an existing bus fleet. Figure 3.2 shows how the appearance of a standard Mercedes Citaro articulated bus similar to those used in central London has been transformed by a radical livery design and covering the non-steered wheels.

Figure 3.2: Nantes BusWay Vehicle

3.2 Service Specification

With bus priority infrastructure in place and a package of measures to encourage modal shift, the attractiveness of bus services from the growth areas to Norwich will result in high levels of demand, particularly at peak times. It is likely that departures would be required every 5-6 minutes during peak periods on services to and from the city centre. Within this there may be scope to operate every second service as limited stop or express and this may also affect the vehicle specification for each service. During the interpeak period a minimum daytime service interval of 10 minutes should be maintained to meet the requirement for a 'turn up and go' service.

Hours of operation for any service should be comprehensive so that public transport would meet almost every journey requirement. The existing First 'Overground' core services in Norwich generally operate for around 18 hours a day, with services commencing around 0600 and finishing just before midnight. Whilst a 24 hour service may be preferable there may not be sufficient demand during the first few years to justify this and so a service operating from 0500 to 0100 may be a more realistic aspiration. During the evening, a 20 minute service should operate from 1900 onwards, possibly reducing to half-hourly after 2300.

It is important that employers based within the growth areas and at the strategic employment sites are contacted regularly in order to ascertain the shift patterns and work trends within their workforce. By doing so, bus services and timetables can be kept in harmony with travel patterns, even extending to operating on a 24 hour basis if a clear demand is demonstrated.

3.3 Vehicle Specification

In developing vehicle specifications for the services to the growth areas the opportunity to deliver a safe, accessible and attractive service with a quality ambience and the lowest possible environmental impact should be maximised. However, it is important that specifications are based on tried and tested technology to ensure that requirements are practical and cost effective. The reliability of the service must not be compromised by innovative but unproven equipment on vehicles.

Vehicle suppliers are already offering innovative variants of standard buses that can transform them in appearance, comfort and overall ambience. This trend is likely to continue and accelerate, and so any detailed specification based on the best that manufacturers can currently offer will need to be reviewed at regular intervals.

3.3.1 Accessibility

Regulations made under the Disability Discrimination Act (DDA) require all new buses to be fully accessible to disabled people so accessibility will be a given for new vehicles of any type.

3.3.2 Emissions

The use of environmentally friendly vehicles with low emissions will be essential if the new services are to operate within existing Air Quality Management Areas in Norwich. The baseline position at the planned time for adoption of the Joint Core Strategy in early 2010 will be a clean diesel vehicle meeting the Euro V emissions standard applicable from 1 October 2009. The Euro V standard requires a reduction in emissions of oxides of Nitrogen (NOx) of over 40% relative to the current Euro IV standard (see Table 3.1). Some bus manufacturers are already offering a Euro V engine as an option on new vehicles, and at least two Norfolk operators have placed Euro V compliant vehicles in service during 2008.

In addition to the mandatory 'Euro' emissions standards, there is a more stringent, but voluntary, 'Enhanced Environmentally friendly Vehicle' (EEV) standard. This is now only slightly more stringent than the Euro V standard and some Euro V engines need little or no adjustment to meet the EEV standard.

Table 3.1: Euro IV, Euro V and EEV Emission Limits for Buses (g/kWh)

	Carbon monoxide	Non-methane hydrocarbons	Methane	Oxides of Nitrogen	Particulate matter
Euro IV (current standard)	4.0	0.55	1.10	3.5	0.03
Euro V (October 2009)	4.0	0.55	1.10	2.0	0.03
EEV (voluntary)	3.0	0.40	0.65	2.0	0.02

As an example of what is currently available on the market, VDL Bus are now offering a single deck bus chassis built to EEV standard with full production status. Five of these vehicles were delivered to operator Arriva Midlands in October 2007 for use on hospital services in Staffordshire.

It is likely that there will be further European legislation to tighten emission standards for buses from 2013/14.

We would suggest that the vehicle specification for services to the growth areas should incorporate the EEV standard on the basis that this represents the cleanest possible diesel fuelled vehicle in current series production.

The potential to implement a fleet of hybrid or alternative-fuelled vehicles should be also be explored, with costs and benefits compared against EEV as a benchmark. The need for new bus depot infrastructure as identified in the growth infrastructure report will create opportunities for specialised refuelling or recharging points to be built-in to any new depot developments. Alternative fuels are considered in more detail in section 3.6 below.

3.3.3 Interior

All vehicles should be air conditioned, and have high quality seating, potentially with leather seats throughout. Leather seating is a recent innovation in the UK bus industry to offer passengers a tangible improvement in the quality of the bus interior environment and a feature that is found in many private cars. Operators have found leather to be a practical material that is easy to clean and have not generally experienced problems with vandalism of leather seats. In specifying vehicle seating capacities a balance should be struck between maximising seating capacity and offering adequate legroom.

3.3.4 ICT Equipment

Vehicles should be fitted with electronic exterior route number and destination displays at front, side and rear in accordance with DDA standards. Electronic variable message signs or colour TFT screens should be fitted to the interior of the vehicle to provide information to passengers during their journey.

The level of crime on the public transport system in Norfolk is low, but operators are increasingly specifying CCTV equipment on new buses to provide additional security for driving staff and passengers and evidence for use in the investigation of accidents and claims. The cost of such equipment has now fallen to the point at which it should be considered as a standard feature of a 'high quality' service rather than a response to a problem of crime or fear of crime in a local area or on a specific service.

Vehicles should be fitted with GPS tracking and communications equipment to facilitate the management and control of services on a day to day basis, the monitoring of historic service performance and the provision of real time information at bus stops. Such equipment should be compliant with Real Time Information Group (RTIG) standards. This equipment can also provide a voice channel for vehicle to base communication, but the usefulness of such a facility depends on the willingness of operators to commit staff resources to the central control of services.

Ticketing systems and equipment are considered in section 3.5 below.

Transport for London have developed the concept of the 'Intelligent Bus' (I-Bus) under which all of the systems described above are fully integrated with a single computer and shared data storage medium on each vehicle. This approach to the installation of ICT equipment on vehicles is likely to be commonplace by the time that public transport connections for the major growth locations are implemented.

3.4 Alternative Vehicle Designs

We have considered a range of alternative vehicle designs that offer trade-offs between capacity, accessibility and passenger comfort.

In assessing the practical capacity of each vehicle type we have adopted the CfIT recommendation that the practical vehicle capacity for assessment of the overall capacity of the service should be 75% of the absolute maximum capacity.

3.4.1 Full Length Low Floor Bus

Based on a 12 metre low floor vehicle with a seating capacity of 44 and maximum standing capacity of 25 restricted to eight spaces to reflect the practical capacity of the vehicle as recommended by CfIT, the maximum number of passengers that can be carried by each bus is 52. For a 10 minute headway service, that represents a practical service capacity of 312 passengers per hour per direction.

Figure 3.3: 12m Full Length Low Floor Bus

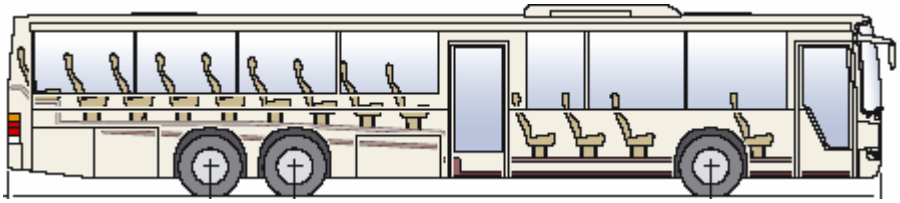
Figure 3.4: Interior of Full Length Low Floor Bus

3.4.2 Semi-Low Floor Interurban Bus

Based on a 13.5 metre interurban bus with a seating capacity of 49 and maximum standing capacity of 28 restricted to nine spaces reflect the practical capacity of the vehicle as recommended by CfIT, the maximum number of passengers that can be carried by each bus is 58. For a 10 minute headway service, that represents a practical service capacity of 348 passengers per hour per direction.

To increase the service capacity, the standing capacity could be increased or larger vehicles specified. For example, increasing the vehicle size from 13.5 metres to 15 metres can offer an extra eight seats whilst still retaining a significant level of low floor space availability.

Figure 3.5: Examples of Interurban Bus Layout and Design



3.4.3 Interurban Coach

Based on an accessible 12 metre coach with a wheelchair space incorporated within the passenger entrance, a seating capacity of 46 seats and no standing passengers, the maximum number of passengers that can be carried by each coach is 46. This would equate to a practical capacity of 34 for assessment purposes as recommended by CfIT, but we consider that it would be appropriate to use a higher ratio of practical to absolute maximum capacity of 85% for a vehicle with no standing capacity, giving a practical capacity of 39. For a 10 minute headway service, that represents a practical service capacity of 234 passengers per hour per direction.

This type of vehicle would only be suitable for use on express or limited stop services.

Figure 3.6: Examples of Coach Interior Specification and Ambience

3.4.4 Low Floor Double Deck Bus

Based on a 10.5 metre low floor double deck vehicle with a seating capacity of 69 and maximum standing capacity of 21 restricted to a practical capacity as recommended by CfIT, the maximum number of passengers that can be carried by each bus is 68. For a 10 minute headway service, that represents a practical service capacity of 408 passengers per hour per direction.

Double deck vehicles are efficient people movers but may not offer the best overall passenger experience. Customers often prefer to travel downstairs where they feel safer due to proximity to the driver and to exits. Double deck vehicles can also suffer from increased dwell time at stops with passengers exiting delaying the boarding of other passengers as they file down the stairs.

The use of such vehicles may make it more difficult to portray the new services for the growth areas as offering a step change in quality relative to existing bus services.

Figure 3.7: Low Floor Double Deck Bus

Figure 3.8: Double Deck Bus Interior with Leather Seats

3.4.5 Low Floor Articulated Bus

At this stage we have focused on the operation of any new bus services with rigid chassis vehicles. The use of articulated buses would offer extra seating capacity of up to 15 seats per vehicle (18 m articulated v. 12 m rigid vehicle) but could create problems in negotiating narrow roads and tight turns. For example, a 12 metre rigid bus has a turning clearance circle of 22.3 metres, whereas an 18.75 metre articulated vehicle requires 24.4 metres to make the same manoeuvre. Articulated vehicles also require significant additional kerb space at bus stops and interchanges and could not be easily accommodated within the historic centre of Norwich where the existing on-street bus stop kerb space is already being used to its full capacity.

A recent UK innovation in bus design has been the development of a tram-like vehicle for bus rapid transit services based on a standard articulated bus chassis but adopting a radical approach to the body design and interior layout. The Streetcar FTR vehicle developed by Wrightbus and FirstGroup is an 18.7m articulated vehicle with segregated driver's cab, air conditioning, upgraded lighting and side-on lounge style seating.

These vehicles have only 37 seats but space for 76 standing passengers. Given the length of journey and nature of the roads used it is not felt that a vehicle with such a low proportion of seating would be well suited to use on the services to the growth areas.

Table 3.2 below presents the typical dimensions and capacities of a selection of vehicle types which may be suitable for the services to and from the growth areas.

Table 3.2: Typical Vehicle Dimensions and Capacities

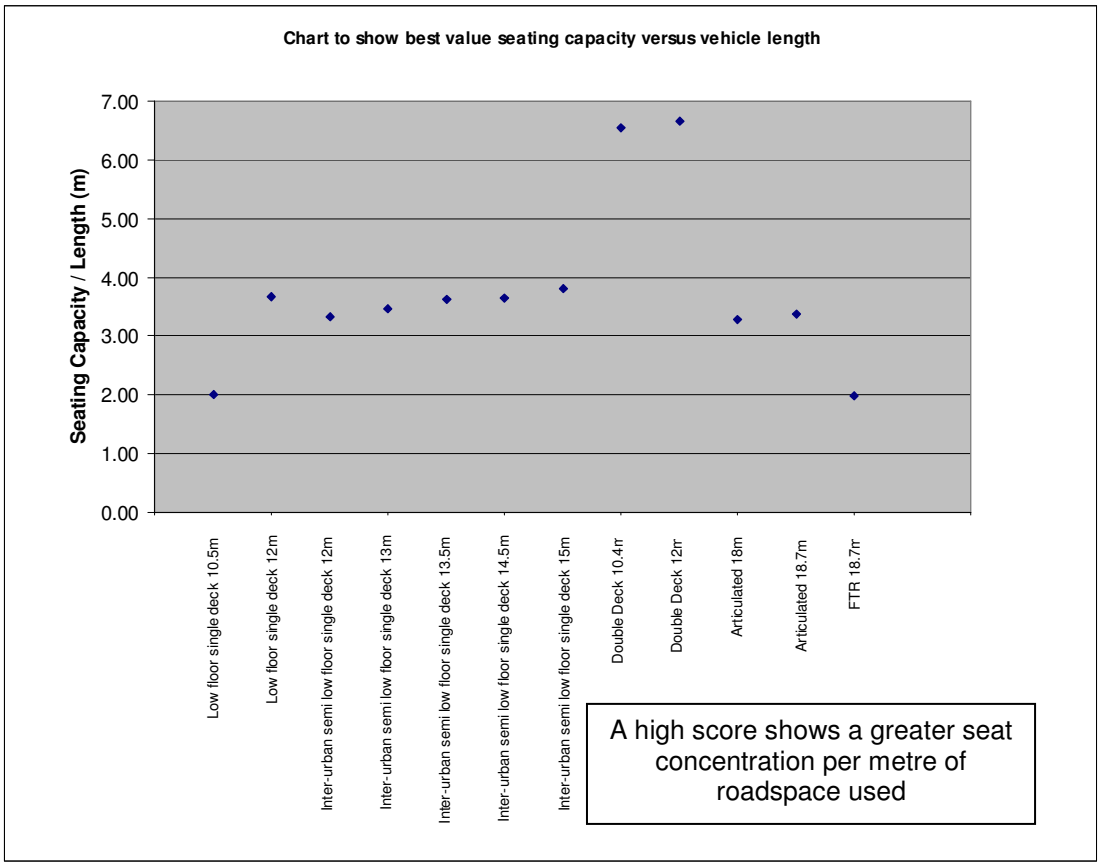
Vehicle Type	Length (m)	Seating Capacity	Standing Capacity	Seating Capacity/ Length
Low floor single deck	10.5	37	10 *	3.52
	12.0	44	12 *	3.66
Inter-urban semi low floor single deck	12.0	40	14 *	3.33
	13.0	45	16 *	3.46
	13.5	49	17 *	3.63
	14.5	53	18 *	3.66
	15.0	57	19 *	3.80
Low floor double deck	10.5	69	21	6.57
	12.0	80	44	6.66
Articulated low floor single deck	18.0	59	23 *	3.28
	18.7	63	25 *	3.37
Streetcar FTR	18.7	37	76	1.98

* Conservatively estimated, no official figures supplied

The right-hand column shows which vehicles provide the most and least seating capacity for use of a given level of road space / kerb space. As expected, double deck vehicles are the most efficient in this respect but, as discussed above, they may not offer the best overall passenger experience.

Articulated buses generally and the Streetcar FTR vehicle in particular are the least efficient vehicles in terms of seating capacity for use of road space. Such vehicles are well-suited to intensive urban operations where many passengers are travelling for short distances, operating speeds are relatively low and standing passengers can travel in relative safety, but when their limited seating capacity is combined with the issues of manoeuvrability and limited availability of city centre kerb space, these vehicles are not considered suitable for the services to and from the Growth Areas.

Figure 3.9: Comparison of Seating Capacity against Vehicle Length



3.5 Ticketing Systems

Ticketing systems can make an important contribution to a high quality public transport service by:

- Offering customers a range of convenient cash and electronic payment options;
- Improving journey speeds and reliability by reducing dwell times at bus stops.

Long bus stop dwell times associated with on-bus ticket sales and cash handling by drivers can have as great an adverse impact on journey times as that of congestion and traffic queues. The implementation of ticketing systems to assist rapid boarding by eliminating driver involvement in ticketing transactions can therefore complement the time savings delivered by bus priority measures as part of the development of a bus-based rapid transit system.

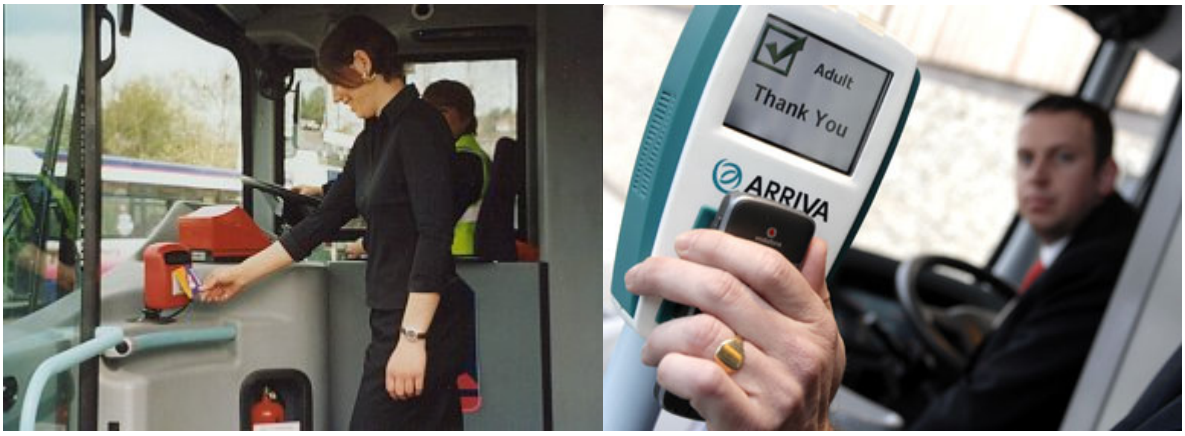
Pre-paid ticketing for local bus services has traditionally taken the form of paper tickets sold through retail outlets, ticket vending machines and (more recently) online. This approach has been successful in reducing bus stop dwell times but still involves visual inspection of tickets by the driver.

The latest paperless ticketing systems remove this constraint by using readers to check tickets upon entry and, where appropriate, exit. Two alternative technology options are available. Smart card ticketing systems have been developed over the last decade, with mobile phone ticketing technology ('m-ticketing') emerging more recently.

Both technologies offer rapid boarding times, greater flexibility for passengers and reduce the need for passengers to find and carry cash for fares. An advantage of m-ticketing is that it avoids the logistics and cost of issuing smart cards by using hardware already owned by the customer together with existing communications infrastructure and billing systems.

In the context of providing public transport services for the major housing growth areas, each new household could be issued with smart cards and/or receive information packs about the type of tickets on offer and how to use the system. Weekly, monthly, annual, multi-journey and stored value tickets should be available through these systems. The aim should be to ensure that all residents of the growth areas have a minimum of a stored value smartcard. Payment for both local bus travel and Park and Ride use should be included. This entire process could potentially be developer-funded.

Figure 3.10: Smartcard and Mobile Phone Ticketing Technology in Use

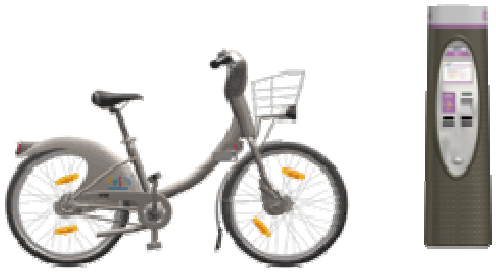


Smart cards and m-ticketing offer great potential for developing multi-operator and multi-modal integrated ticketing by offering a solution to the problem of apportioning revenue between the companies participating in an integrated ticket scheme. Such a scheme would be particularly relevant to growth in the North East sector and at Wymondham where both bus and rail options exist for travel to Norwich.

There is also scope to develop an on-street bike hire system (such as the 'Velib' system in Paris) which could involve payment being made and security deposits guaranteed via smart card or mobile phone transactions.

School transport could also be operated using a smart card system with each pupil receiving a card at the beginning of the school year. Adopting such a system for this market creates a cashless process and removes the possibility of a pupil not entitled to free travel losing his/her transport money for the journey home.

Figure 3.11: 'Velib' Cycle Rental Infrastructure



3.6 Alternative Fuel Vehicles

With the climate change agenda receiving an increasingly high profile, the provision of a public transport service using environmentally friendly vehicles will be expected by residents of the major growth areas and by stakeholders concerned about the sustainability of large scale growth on greenfield sites. Whilst not a significant driver to behavioural change on its own for the majority, there is an associated benefit or 'reward' for the user of such a service which creates a feel-good factor and sense of pride in the transport choice.

The costs, benefits, opportunities and risks of using alternatives to diesel fuelled vehicles to serve the major growth areas should therefore be considered before key investment decisions are made regarding the provision of depot infrastructure and procurement of vehicles.

While there have been numerous demonstration and research projects involving the trial operation of alternative fuel vehicles, the cost of operating such vehicles will need to be comparable with that of diesel powered vehicles for large scale market uptake to become likely in the absence of financial incentives for operators. This tipping point has yet to be reached, but recent increases in world oil prices may have brought it much closer.

The future market for alternative fuel vehicles for bus operations in the UK will be strongly influenced by:

- The commercial acceptability of such vehicles to both operators and customers;
- The future extent of access restrictions in urban centres for all but low-emission vehicles;

- The future fuel tax and subsidy regime applicable to the UK bus industry (Government proposals for changes to the current Bus Service Operators Grant are the subject of a current consultation);

- The influence of future European legislation on emissions control.

The lack of a robust business case for the provision of the necessary infrastructure to support the use of alternative fuels has frequently proved to be a barrier to their uptake. However, the planning of public transport infrastructure and services for the growth areas from first principles may offer a unique opportunity at a local level to kick-start a shift to the use of alternative fuels and provide a fleet of modern and environmentally friendly vehicles in keeping with the overall look and feel of the new developments they will serve.

An increasing number of trials have been undertaken around the world with the aim of identifying the most practical and reliable alternatives to diesel passenger transport vehicles. Table 3.3 below summarises the main options available and categorises them as emerging (E) or proven (P) technology. A high level assessment of costs, risks and environmental benefits has been made for each fuel type.

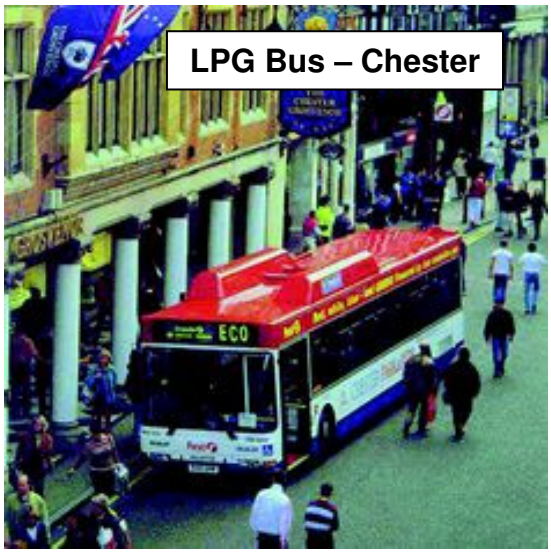
Table 3.3: Assessment of Alternative Fuels

Fuel Type	Advantages	Disadvantages
Liquefied Petroleum Gas (LPG) - P	Low CO_2 emissions, similar to diesel; generally low levels of other pollutants; low levels of engine noise; low fuel duty compared with diesel; ease of refuelling relative to CNG.	Limited but expanding refuelling infrastructure (circa 1,500 UK sites); lower fuel economy; often loss of some load space; issues regarding toxicity and the combination of high density and flammability of the gas; vehicles more expensive to purchase than diesel buses.
Compressed Natural Gas (CNG) - P	Low CO_2 emissions, similar to diesel; generally low levels of other pollutants; low levels of engine noise; low fuel duty compared with diesel. Vehicles widely used in Europe. Potential for use of biogas from municipal waste, agricultural waste or sewage sludge.	Limited refuelling infrastructure; need for dedicated refuelling equipment; lower fuel economy; loss of some load space (more than LPG); vehicles more expensive to purchase and maintain than diesel buses; buses in early UK trials proved unreliable.

Electric (Battery or Super-capacitor) - E	Zero emissions at point of use; power cost lower than fossil fuels; low noise levels.	Requires recharging systems; batteries and vehicles can be expensive; pollution created at power station not exhaust pipe unless electricity from renewable sources; limited range between charges; battery durability; super-capacitors still at experimental stage of development.
Diesel-Electric Hybrid - E	Low CO_2 and other pollutants; very fuel efficient; driving experience very similar to diesel vehicle; only fuel required is diesel therefore plentiful - no need to recharge batteries separately although some require charge stabilisation, once or twice per week; could operate within air quality management areas in zero emission battery mode; hybrid buses expected to be in series production for UK use by 2012.	New technology, so at present vehicles are expensive, also currently limited vehicle choice; but cost expected to fall if economies of scale can be realised and vehicle choice to increase within next few years (most major manufacturers displayed hybrids at Euro Bus Expo 2008). The widespread introduction of hybrids would require new skills for maintenance staff and electrical technicians.
Electric Trolleybus - P	Proven technology widely used in Europe; zero emissions at point of use; power cost lower than fossil fuels; low noise levels; acceleration and hill climbing performance superior to diesel vehicles; vehicles have high mechanical reliability and efficiency with long service life and low maintenance costs. Overhead line equipment provides sense of permanence.	Cost and visual impact of overhead line equipment; need for OLE limits flexibility; vehicles can be expensive (although whole life cost may be lower than diesel vehicles); pollution created at power station not exhaust pipe unless electricity from renewable sources.

Biofuels (Biodiesel and Bioethanol) - P	Lower CO_2 emissions on a 'life-cycle' basis plus a reduction in particulate matter and hydrocarbons; driving experience very similar to diesel vehicle; no modifications needed to most diesel engines to run on biodiesel; lower fuel duty for the biofuel component compared with diesel. Bioethanol used as a bus fuel in Sweden for 10 years. 100% biodiesel successfully used in UK trials.	Development of refuelling infrastructure still in early stages; a blend of only up to 5% biodiesel is acceptable to some engine manufacturers under existing warranties. Slight increase in NOx emissions for biodiesel compared to standard Ultra Low Sulphur Diesel.
Hydrogen - E	Offers possibility of zero emissions other than water; performance comparable with diesel vehicles; first generation hydrogen fuel cell buses successfully trialled in London; hydrogen internal combustion engines under development.	Commercially viable versions of this technology still some years away; on-board storage of hydrogen challenging; concerns regarding volatility of fuel; no distribution network currently exists for hydrogen for transport use; planning permission required for hydrogen refuelling facilities.

Figure 3.12: Examples of Alternative Fuel Vehicles



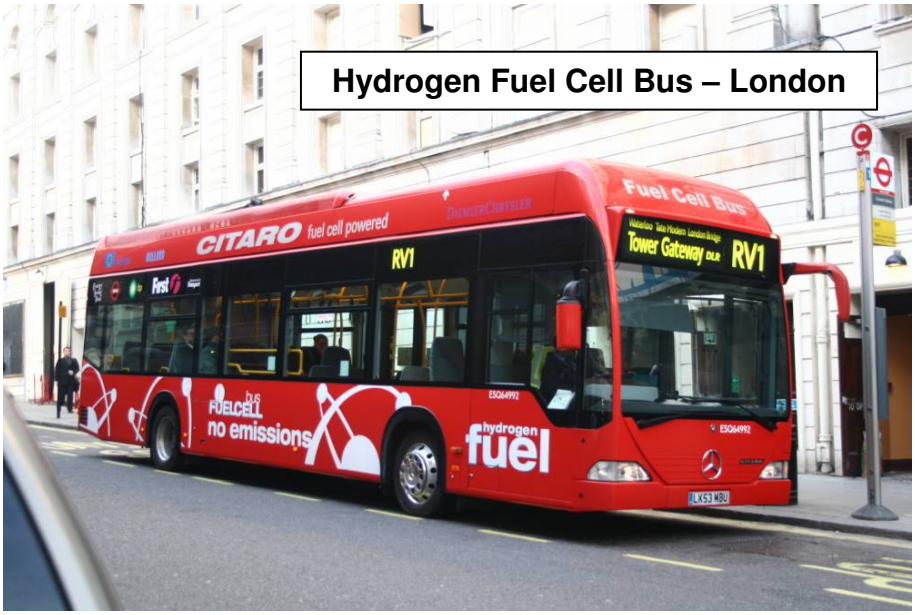

CNG Biogas
Bus – Sweden


‘Tindo’ Solar-powered Electric Bus – Adelaide
Tindo


Hybrid Bus – London
Powered by Cleaner Electric Hybrid Technology
MAYOR OF LONDON
Another red bus going green for LONDON

Trolleybus – Athens

Stagecoach 'Bio Bus' – 100% Biodiesel



Hydrogen Fuel Cell Bus – London

3.7 Passenger Infrastructure

To maximise the attractiveness of the public transport service for the growth areas it will be imperative to offer a high quality journey experience from origin to final destination. The quality of the waiting environment at bus stops is a crucial part of the overall journey experience and sets the tone for the standard of the travelling experience to come.

The specification and provision of high quality passenger infrastructure is therefore of equal importance to the specification of vehicles in influencing overall perceptions of service quality.

Passenger infrastructure should be designed as an integral element of all new developments within the growth areas and should not have to be added in retrospectively.

Bus stops and waiting areas should be designed to complement their surroundings whilst remaining prominent, well-lit and fit for purpose in terms of size of bus, level of enclosure and sufficiency of space to accommodate all waiting passengers.

Stops outside the growth areas but served by the new services should also be upgraded to ensure maximum growth potential along the full length of the routes.

3.7.1 Bus Stop Accessibility

All bus stops along the route should be fully accessible in accordance with the Disability Discrimination Act. Raised kerbs should be provided to facilitate access to low floor buses without the need for an on-vehicle ramp to be deployed. Tactile paving should be used to assist the blind and partially sighted. The following publications provide detailed guidance on the design of accessible bus stops:

- Inclusive Mobility: A Guide to Best Practice on Access to Pedestrian and Transport Infrastructure, Department for Transport, September 2002;
- Accessible Bus Stop Design Guidance, Bus Priority Team, Transport for London, January 2006.

Consideration should also be given to road markings at bus stops as a means of increasing the profile of stops. One possible approach is the use of coloured surfacing in bus stop cages as seen in the example from London shown in Figure 3.13. Research has shown that highlighting the bus stop cage indicates to other road users that the area is for buses only and is a strong visual deterrent to illegal parking.

Figure 3.13: Bus Stop with Coloured Bus Cage and Footway Guidance Line

Also shown in Figure 3.13 is a yellow footway guidance line, offset 450mm from the kerb edge and 100mm in width. Guidance lines can aid drivers on their approach to stops by providing a reference point, and can also encourage pedestrians to stand away from the kerb edge. They are particularly useful at stops where limited stop services are passing without stopping.

3.7.2 Terminal and Interchange Facilities

The provision and design of passenger infrastructure at terminal points and at stops where interchange occurs between buses and other modes should be given a high priority as their appearance will be important in encouraging greater patronage. It is envisaged that there may be a bus station or major interchange within each of the major growth areas. This should be centrally located within the growth area, adjacent to a district centre and other local facilities such as supermarkets, schools, and health centres. It is likely that it will be served by a number of local routes connecting with services to the city and beyond.

Bus stations and interchanges should offer facilities to meet the needs of passengers who may be waiting for longer periods than at a regular bus stop. As such well-lit shelter, a heated waiting area, toilets and the opportunity to purchase food or drinks should be made available to enhance the travelling experience. Where appropriate the provision of shower facilities and changing rooms should be considered to enable cyclists using the site as an interchange between modes to continue their journey in suitable attire. The provision of televisions and wi-fi access at interchange sites would further enhance their attractiveness and appeal to the commuter market.

The recently completed interchange facility at Norwich Railway Station (Figure 3.14) provides a useful model for the design of future small scale interchange facilities. A post-implementation survey has confirmed that this facility is highly rated by users.

Figure 3.14: Norwich Railway Station Interchange

There should be scope to create advertising opportunities within interchange sites, either through static advertising panels or through alternative media such as television or scrolling messages, potentially as part of a real time passenger information system. Advertising revenue has the potential to contribute significantly to the ongoing maintenance cost of interchange facilities.

Suggested essential and desirable requirements for major interchanges are summarised in Table 3.4.

Table 3.4: Infrastructure Requirements for Major Interchanges

	Essential	Desirable
Enclosed waiting area	✓	
Lighting	✓	
Heating		✓
Seating	✓	
Cycle parking	✓	
Vending machine		✓
Television		✓
Ticket vending machine	✓	
Real time information	✓	
Maps and static information	✓	
Wi-fi access		✓
Toilets	✓	
Changing rooms and lockers		✓

The provision of real time information (RTI) for all public transport modes at major interchanges will assist passengers in making the appropriate travel choices, particularly where there is a choice of different levels and modes of service leaving from the same area, for example a limited stop coach service or a stopping service operated by low-floor buses. RTI also helps build confidence in public transport services and contributes to the overall impression of a modern and efficient service.

3.7.3 Bus Stop Facilities

Regular bus stops along the whole route of the new services for the major growth areas should be upgraded to reflect the overall improvement in service quality and to attract passengers living in areas local to the route corridor. Some services from the growth areas may operate on a limited stop basis but this should not preclude the upgrade of all stops along the route to maintain a consistent image throughout.

Consideration should be given to the distance between bus stops within the growth areas and along the corridors linking the growth areas with the city centre. Industry best practice recognises a target of a bus stop every 400 metres for regular stopping services. This may be increased to 500-600m for a Bus Rapid Transit service to help minimise journey times.

It is likely that the services for the growth areas will be a combination of limited stop and stopping services. The optimal distance between stops will very much depend on whether the services are required to improve overall public transport links along the full length of the corridor served or if they are to supply a service primarily for travel to and from the Growth Areas.

Figures 3.15 to 3.17 show a range of examples of quality bus stop infrastructure.

The provision of RTI at bus stops is highly desirable. RTI will give accurate arrival times for all services passing the stop and is likely to contribute to passenger growth on all passing bus routes. RTI could also potentially give advice on the approach of limited stop buses which do not serve the stop in order to avoid passenger confusion.

Lighting could be provided either through existing mains supplies where available, or in the case of new stops there is potential to use solar power to provide flag lighting and on-demand LED lighting for the timetable panel.

Where possible some form of shelter should be provided at bus stops in order to provide waiting passengers with protection from the elements. However, it is appreciated that there may be practical difficulties in providing shelters in certain locations. As such an overall target should be set for the percentage of shelters along a route. Given the mix of urban and inter-urban stops on the proposed route corridors, a target for at least 50% of all stops to have shelters is suggested, with the remaining 50% being either major interchanges or stand-alone bus stops.

Thorough enforcement of parking and waiting restrictions at bus stops must also be considered to protect bus users from delay and inconvenience and ensure that buses can stop adjacent to the kerb. This is particularly important in residential areas where there is a greater risk of the obstruction of bus stops by parked vehicles.

Suggested essential and desirable requirements for regular bus stops in urban and rural areas are summarised in Tables 3.5 and 3.6.

Figure 3.15: Stop with Built-in Shelter, Flag and Static Information Display

Figure 3.16: Example of Bus Stop with Integrated Information Display and Electronic Variable Message Sign for Real Time Passenger Information

Figure 3.17: Example of Bus Stop with Static Information Panel

Table 3.5: Infrastructure Requirements for Regular Bus Stops – Urban Areas

	Essential	Desirable
Enclosed waiting area		✓
Covered waiting area	✓	
Lighting	✓	
Seating	✓	
Cycle parking		✓
Real time information		✓
Maps and static information	✓	

Table 3.6: Infrastructure Requirements for Regular Bus Stops – Rural Areas

	Essential	Desirable
Covered waiting area		✓
Lighting		✓
Seating		✓
Cycle parking		✓
Real time information		✓
Maps and static information	✓	

Regular bus stops along the more rural section of the routes of the new services should be upgraded to reflect the overall improvement in service standards and to attract passengers living in areas local to the route corridor. In some cases, services from the growth areas will operate on a limited stop basis but this should not preclude the upgrade of all stops along the route as a consistent look should be maintained throughout. Where possible a target of a bus stop every 400 metres should be applied in accordance with industry best practice.

The provision of RTI at these stops is highly desirable. At rural sites there is potential to utilise RTI flags as per Figure 3.18 rather than a full-sized RTI information panel.

As shown in Figure 3.19 RTI flags and bus stop lighting can be supplied with solar panels so the lack of a mains electricity supply to a site does not preclude it from being suitable for RTI.

Figure 3.18: Real Time Information Flag on King's Lynn – Hunstanton Corridor

Figure 3.19: Solar-powered Real Time Information Flag

It is essential that every stop should have a static display of timetables, route maps and location maps for every service utilising the stop, along with any relevant information such as that relating to limited stop services. All publicity provided should be branded to reflect the services at the stop. This builds upon the identity of the services and helps to create an impression of a fully integrated public transport network.

3.8 Reliability and Priority Measures

In order to provide a public transport service that offers an attractive and feasible alternative to the car, the bus must have priority over other traffic in congested areas. This enables faster journey times and improves public perception of the service amongst both users and non-users.

A package of priority measures should be put in place to ensure that the bus can reach its destination quickly and in a punctual manner. Priority measures can assist bus services in two ways; by reducing overall journey times, and by increasing reliability.

With the potential number of new journeys created by the new growth areas, it is essential to consider how priority measures can improve the public transport experience and encourage greater use of the services.

3.8.1 Highway Priorities

To provide a fast and reliable service to and from the city centre, the aim should be to provide bus priority measures at all major junctions on the radial routes used by the services for the growth areas. These may take the form of bus lanes, bus gates, selective vehicle detection at traffic signals, peak hour parking restrictions or the banning of conflicting turning movements.

The most significant existing congestion hot spots on the main radial routes linking the potential growth areas specified in the brief with the city centre include:

- **Dereham Road/Outer Ring Road Junction (West Sector)** – Outbound buses using the stretch of Dereham Road from Bowthorpe Road to the Outer Ring Road experience significant delay during the afternoon peak with average bus speeds well below 10 kph and high journey time variability.

- **A11/A47 Thickthorn Interchange (South West Sector)** – This junction is already extremely busy during the peak hours and any further new developments in this sector are likely to worsen this situation.

- **Earlham Fiveways Roundabout (South West Sector)** – This junction is particularly busy due to the proximity of the Hospital and University. The section of road from Fiveways to the Outer Ring Road suffers from high journey time variability in both the morning and afternoon peaks.

- **Newmarket Road (South West Sector)** – This road suffers from delays for inbound buses on the Cringleford Bypass during the morning peak and high journey time variability in the afternoon peak from the city centre to Thickthorn.

- **Chapelfield Road (West and South West Sectors)** – This section of the Inner Ring Road between St Stephens Roundabout and Convent Road currently suffers from bus speeds of less than 10kph in the afternoon peak.

- **Magdalen Road (North East Sector)** – Linking Sprowston Road and Magpie Road, this road suffers from bus speeds of less than 10kph during both the morning and afternoon peaks and experiences high levels of journey time variability.

- **Wroxham Road (North East Sector)** – The stretch from the Sprowston Park and Ride site to the Outer Ring Road experiences high levels of journey time variability in the morning peak.

- **Sprowston Road (North East Sector)** – High levels of journey time variability are experienced between Magdalen Road and the Outer Ring Road during the afternoon peak.

These problem locations were identified from data analysis carried out for the Norwich Bus Priority Studies undertaken by Mott MacDonald for Norfolk County Council. These studies were undertaken within the framework of the existing Norwich Area Transportation Strategy and had a short term focus on the period to 2011. While these studies did identify schemes linked to existing Growth Point projects, they did not consider longer term requirements for bus priority infrastructure linked to future housing growth.

The analysis and recommendations of the Norwich Bus Priority Studies provide a useful baseline for the development of a more radical approach to bus priority on radial routes for implementation during the period post 2011. However, the number of new journeys generated by the growth areas and the mode share targets proposed in the growth infrastructure study will require a step change from the existing level of bus priority provision and some fresh thinking on how this can be delivered.

3.8.2 Other Reliability Measures

To complement a robust package of highway measures it is also important to consider other factors impacting on overall bus journey times. These include:

- **Passenger boarding and alighting** – The speed at which passengers board and take a seat can have a big impact on overall running time.

- **Ticket purchase and validation** – Ticketing transactions involving the driver can be lengthy, particularly where the passenger may be searching for cash whilst encumbered by bags or children.

- **Passenger queries** – A general lack of information about the service and ticket options available may contribute to a greater number of enquiries made to the driver.

- **Vehicle type and suitability** – The layout of a vehicle, the number of doors, and availability of low floor access can all affect passenger boarding and alighting times.

To minimise potential delays to the service the following interventions should also be considered as part of an integrated package of reliability measures:

- Development of a smartcard or mobile phone based ticketing system as outlined in Section 3.5.

- Installation of ticket vending machines at interchanges and other key bus stops used by large numbers of passengers.

- Providing comprehensive timetable and fares information at bus stops so that customers have all the relevant information for their journey before boarding the vehicle. This will be an essential part of any pre-paid ticketing system.

- RTI can also contribute to journey speed and reliability as passengers will know when their next bus is due, the number and destination and will be better prepared to board immediately.

- The type of vehicle and chosen interior layout will greatly affect boarding and alighting times. A low floor bus will make it much easier and quicker for older people, young children, disabled people and parents with pushchairs to board and find a seat. Vehicles with multiple doors are also credited with expediting the boarding and alighting process. Double deck vehicles can be slower to board as many passengers will need to climb stairs to reach their seats and descend to alight, and this can frequently block the flow of passengers through the vehicle.

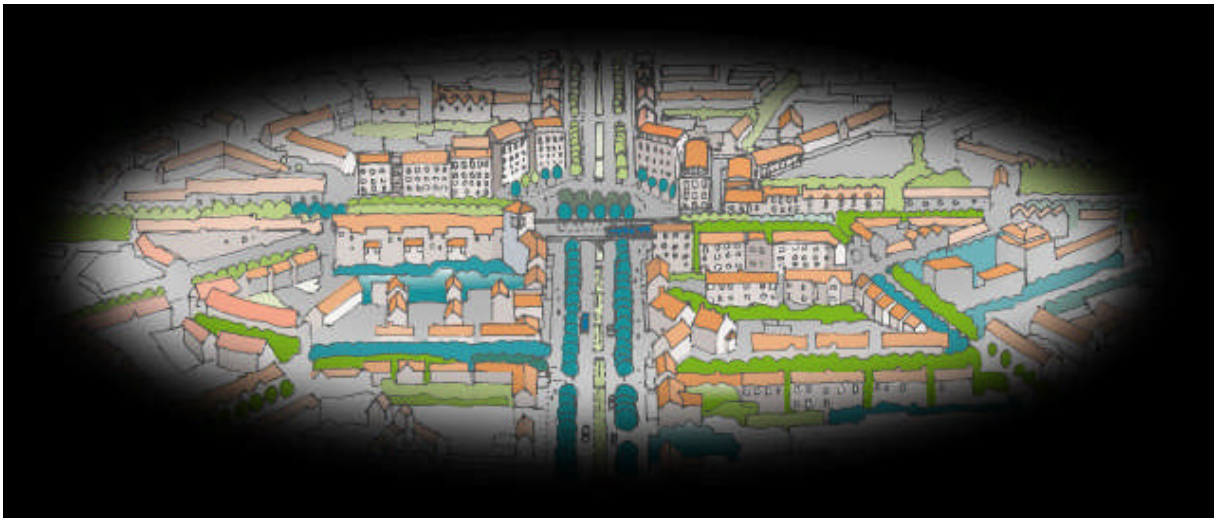
- Interurban coaches will be slower to board and alight from, but this is of less importance on limited stop/express services with few intermediate stops and for which journey quality will be the key attractor.

3.9 The Internal Layout of Growth Areas

The planning of the internal layout of developments within the growth areas will provide the opportunity to create Public Transport-Orientated Developments (PTODs) and to build in public transport from day one. This increases the likelihood of generating passenger journeys, with public transport services operating to the right places at the right times with modern infrastructure and seamless transition from mode to mode.

All distributor roads within the new development should be designed to incorporate bus services. Design considerations should include suitable street width, designated areas for bus stops, turning facilities where required and no inappropriate use of traffic calming measures. There should be a bus stop within 400m of every property within the development.

Figure 3.20: Example of Conceptual PTOD Layout



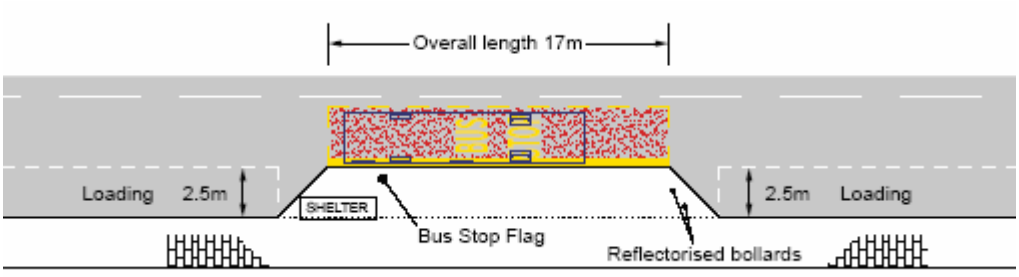
Consideration should be given to the provision of bus boarders throughout the development. A bus boarder consists of a section of pavement built out in to the road to create a narrowing of the carriageway at the site of the bus stop. The key benefits of bus boarders are:

- They create a designated area of footway for passengers waiting for the bus and minimise the kerb space required for a bus to pull in and out of a stop;
- They can deter illegal parking at the bus stop as the build out makes it more obvious that parking there would cause an obstruction;
- They raise the prominence of bus services in the area;
- They maintain the place of the bus in the traffic flow, reducing the time taken to rejoin the flow;
- They allow the bus to stop parallel with the kerb, without complex manoeuvres which in turn makes it easier for older and disabled passengers, and those with children and pushchairs to board and alight from the vehicle;
- By stopping in the correct place, at the correct angle boarding and alighting time can be reduced as passengers can easily step on and off the vehicle;
- They can be helpful in reducing the overall speed of traffic on the road;
- They are helpful in reducing the overall time spent at the bus stop.

Figure 3.21: Bus Boarder in London

Given the residential nature of large sections of the development, bus boarders offer a practical and attractive way to integrate public transport into the internal layout of the development in a way that should be consistent with road safety objectives.

Figure 3.22: Diagram of Bus Boarder



Bus priority should be incorporated into the development, with a particular emphasis placed on links to employment zones and along the entrance and exit routes to the growth area. All bus lanes would be accessible to cyclists and designated 'safer routes to school' would also feature strongly.

4 Assessment of Growth Options

Development on this scale needs careful planning to increase the viability and appeal of sustainable transport modes throughout. As discussed earlier, planning a major development from first principles generally means there are fewer constraints and greater opportunities to provide high quality public transport connections and implement measures to improve the image of public transport.

4.1 Scenarios A and B

In both Scenarios A and B there is an imbalance between development to the West and East of Norwich, and development to the West is split between three locations. This pattern of development would make it more difficult to develop cross-city routes serving the major growth locations in line with operator preferences and providing better links to strategic employment sites and other destinations outside the city centre.

Splitting development to the West between three locations also reduces the number of homes at each location. The developments of 2,000 to 3,750 homes in these scenarios are well below the threshold at which a development is likely to support a dedicated express bus service to the city centre. New 'turn up and go' public transport services for these smaller developments will take longer to reach commercial viability and thus require greater levels of pump priming revenue support.

In both scenarios there is potential for a cross-city service on a South West to North East axis, but a new stand alone service or significant extension to an existing cross-city route would be required to serve the development in the West sector.

The analysis in section 2.1 indicates that under the assumptions made the minimum size of development capable of supporting a 'turn up and go' service operating every 10 minutes is 3,000 homes. The development of 2,000 homes in the South West sector in Scenario A would not therefore support such a service. A potential solution would be to extend an existing bus route to serve this location at a 'turn up and go' frequency, but the likely outcome would be a less direct route with longer journey times.

4.2 Scenarios C and D

Scenarios C and D offer the best opportunities for developing a strong market for public transport services. The key growth locations in these options are concentrated on a South West to North East axis, creating the opportunity to implement a cross-city service at a 'turn up and go' frequency, providing journeys to the city centre from both ends of the route, as well as cross-city travel opportunities. If the growth inside and outside the NDR in Scenario D is in the form of a contiguous urban extension to Norwich, then all the developments are on a scale sufficient to support a 'turn up and go' level of service.

Figure 4.1: Indicative Network for Scenarios A and B

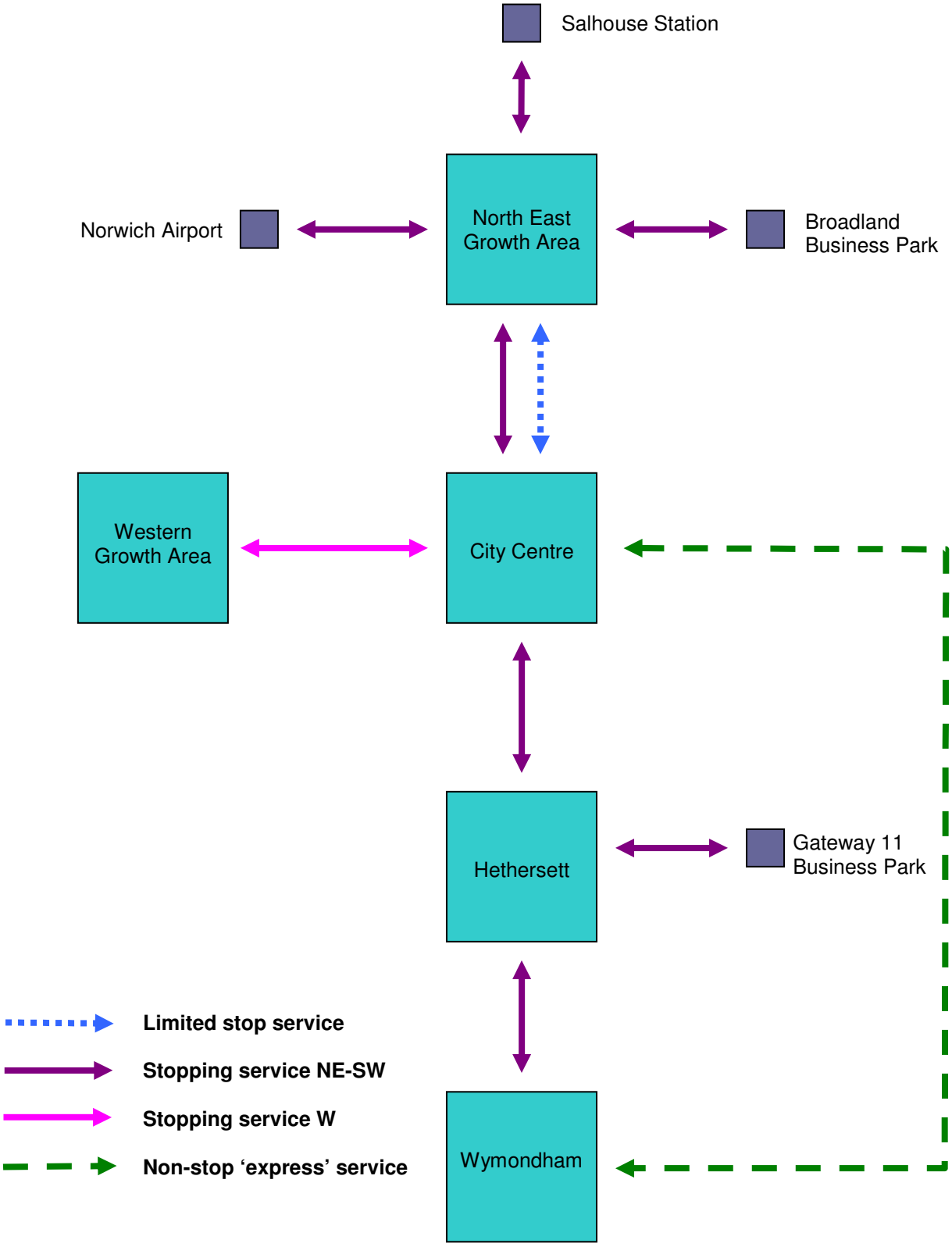
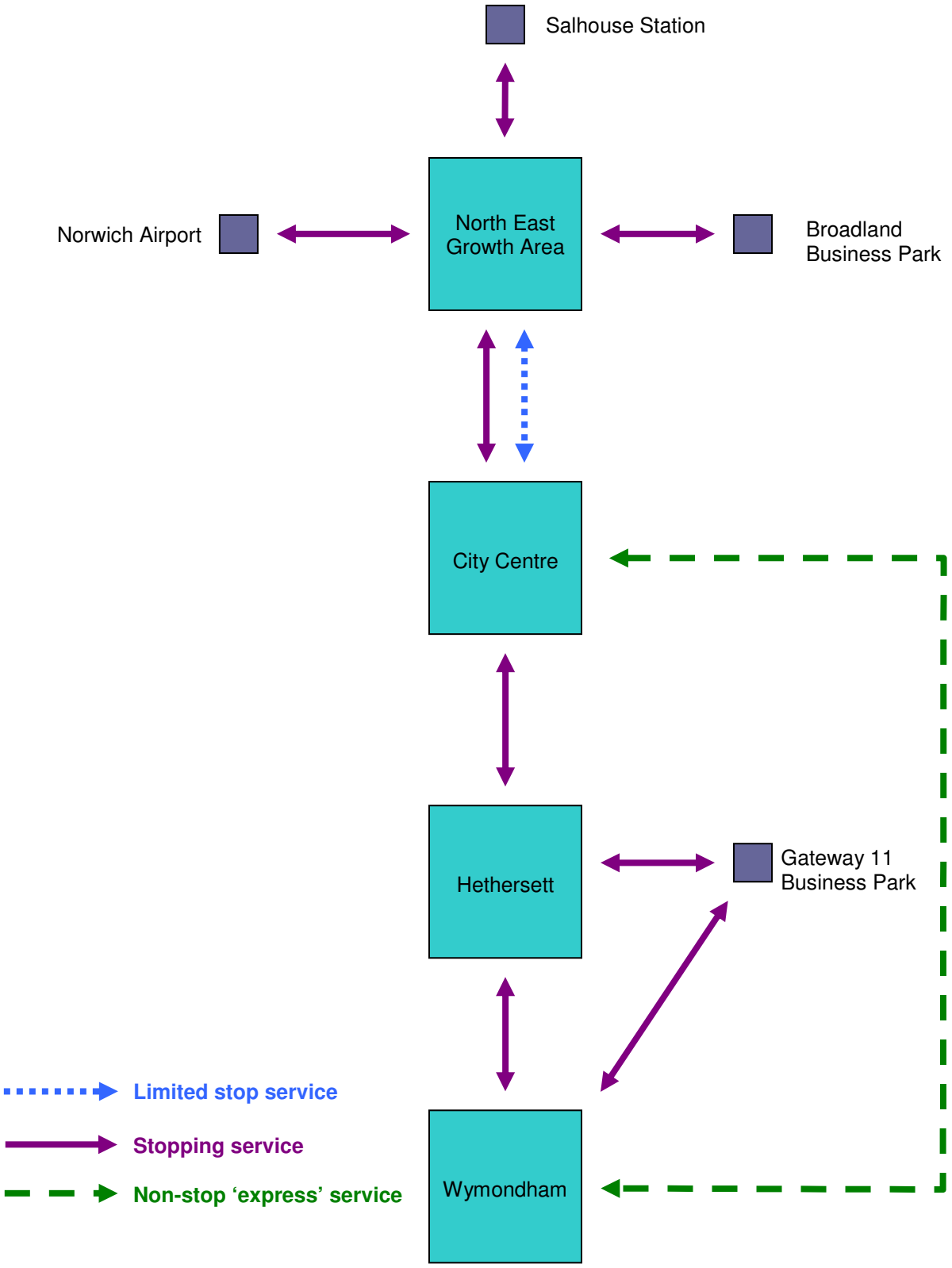


Figure 4.2: Indicative Network for Scenarios C and D



Scenario D is marginally the preferred option from a public transport perspective as it provides a more balanced distribution of growth between the North East and the South West/Wymondham than Scenario C, but if Scenario C is favoured for other reasons it is still a good option in terms of public transport.

4.3 Indicative Service Levels for Preferred Option

The indicative sample timetable below shows one option for how the morning peak service for Scenario D in the year 2021 might look.

North East GA	0600	0605	0610		0615	0620		0625	0630		0635	0640
City Centre	0625	0630	0635	0635	0640	0645	0645	0650	0655	0655	0700	0705
South West GA		0650		0655	0700		0705	0710		0715	0720	
Wymondham				0705			0715			0725		

North East GA		0645	0650		0655	0700		0705	0710		0715	0720
City Centre	0705	0710	0715	0715	0720	0725	0725	0730	0735	0735	0740	0745
South West GA	0725	0730		0735	0740		0745	0750		0755	0800	
Wymondham	0735			0745			0755			0805		

Wymondham		0600			0610			0620			0630	
South West GA	0605	0610		0615	0620		0625	0630		0635	0640	
City Centre	0625	0630	0630	0635	0640	0640	0645	0650	0650	0655	0700	0700
North East GA	0650		0655	0700		0705	0710		0715	0720		0725

Wymondham		0640			0650			0700			0710	
South West GA	0645	0650		0655	0700		0705	0710		0715	0720	
City Centre	0705	0710	0710	0715	0720	0720	0725	0730	0730	0735	0740	0740
North East GA	0730		0735	0740		0745	0750		0755	0800		0805

Key

GA = growth area

Blue = through service between the South West and North East growth areas

Developing services as proposed above would allow the use of a mix of vehicle types. This offers the potential to design individual services within the network to appeal to different market segments, which although travelling along the same route, have different travel needs and preferences.

A total of 23 vehicles would be required. The network could be operated with 23 semi-low floor interurban buses or with a fleet mix of 7 interurban coaches, 6 semi-low floor interurban buses and 10 full low floor buses.

Through travel from the North East to the South West via the city centre – These journeys could be operated by full low floor buses allowing easy access for pushchairs and wheelchairs. They would serve all bus stops and carry standing passengers if required. This service would operate every 10 minutes during both the peak and off-peak times.

Wymondham and the South West to the city centre – These journeys could be operated by high specification accessible interurban coaches. Targeted particularly at the peak-hour commuter the vehicles would feature comfortable seating with increased leg room and overhead storage, on-board wi-fi access, pull down seat back tables and television screens showing BBC news. A wheelchair space would be provided within the passenger entrance area. These vehicles would provide a luxurious, quiet and comfortable journey to the city, operating on a limited stop basis. They would be for seated passengers only and there may be scope to charge higher fares for the premium service provided.

The North East to the city centre – These journeys could be operated using semi-low floor interurban buses. These vehicles provide a combination of low-floor access with more comfortable seating and luggage space than a conventional urban bus. They could be equipped with television screens to show BBC news or similar. This type of vehicle is well suited to a mixture of urban and inter-urban travel offering a level of quality to commuters and leisure travellers. This service would operate on a limited stop basis and would carry standing passengers where required.

During the daytime interpeak period, the level of service provided could be reduced to a single 10 minute interval service operating between North East growth area and Wymondham via the city centre. This service would be maintained by low-floor buses, which are well suited to the interpeak market which typically includes a higher proportion of disabled people, older people with impaired mobility and those travelling with children in pushchairs.

4.4 City Centre Issues

The existing on-street interchange facilities in the city centre are close to capacity and there is limited spare capacity within Norwich Bus Station. Providing space for the additional facilities needed to accommodate the new services for the major growth areas is therefore a key issue to be addressed in balancing competing demands for the allocation of kerb space within the city centre.

In Chapter 2 the total number of new ten minute headway services required across the whole of the Greater Norwich area to accommodate the projected additional peak hour bus trips with the proposed changes in mode share was identified as 16 by 2021 and a further 10 by 2031. These totals exclude new services to strategic employment sites and other locations outside the city centre.

Assuming all of the above new routes serve the city centre and that the capacity of a bus stand is 12 departures per hour, the total requirement for additional bus stands in the city centre will be eight by 2021 and a further five by 2031.

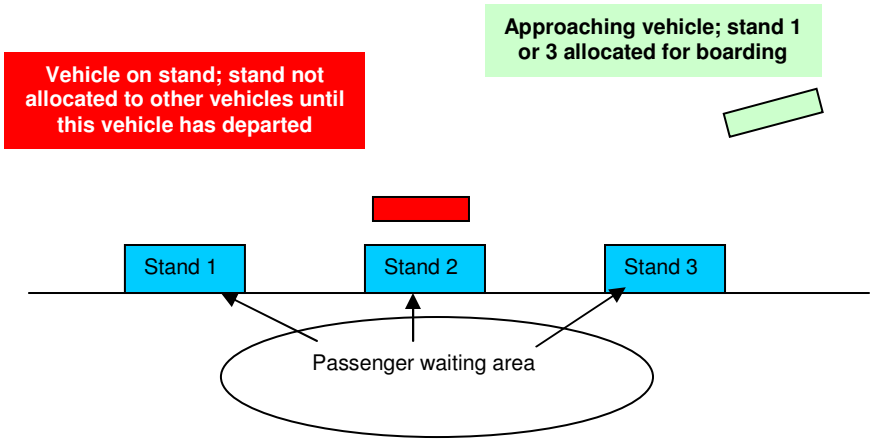
The requirements for additional bus stop and interchange capacity in the city centre would be similar under all four scenarios for the location of housing growth within the Norwich Policy Area. To increase overall bus stop and interchange capacity in the city centre the following options are proposed:

- The creation of additional bus stops in Theatre Street and Rouen Road. This would increase overall stop capacity in the city centre and provide the opportunity to review existing stopping arrangements.

- The redesign of Norwich Bus Station to provide additional departure stands adjacent to the walkway on the southern side of the bus station in the area where temporary stops were provided for Park & Ride services during the latter stages of construction of the bus station.

- The development of a Dynamic Stand Allocation (DSA) system for the Castle Meadow and St. Stephens Street on-street interchanges. This would utilise the Automatic Vehicle Location equipment currently fitted to vehicles as part of the Norfolk BusNet system. Passengers would wait in a series of holding areas based around clusters of bus stops with signs providing real time information on which stop within the cluster the bus would depart from. DSA allows the capacity of an interchange to be maximised by making efficient use of the capacity freed up when services do not run exactly as scheduled.

Figure 4.3: Diagram Showing Principles of Dynamic Stand Allocation



- The designation of St Stephens Street as a restricted street, with access limited to buses, cycles, taxis and delivery vehicles only in line with the existing traffic restrictions in Castle Meadow. Banning cars from St Stephens Street would free up some existing kerb space for additional bus stops facilities, but would require alternative locations to be found for the existing disabled parking bays. This would also have environmental benefits and provide a safer area for pedestrians. There may also be scope for further footway widening as part of such a scheme.

4.5 Constraints

The key constraints to delivering reliable, high quality public transport services between the major growth areas and Norwich city centre are:

- The width of existing highway corridors. With the current street pattern in central Norwich dating back to medieval times, many historic buildings and landmarks and large numbers of mature trees along radial routes into the city, the creation of additional road space for conventional bus priority measures is extremely difficult.

- The presence of statutory undertakers' underground services within existing highway corridors. Even where there is potential for carriageway widening to facilitate the provision of bus priority measures, the high cost of diversion or protection of underground services has frequently proved to be a barrier to the implementation of schemes.

- The impact of creating conventional bus priority measures within existing road space on existing highway capacity for general traffic. There is limited potential for reallocation of existing road space for general traffic to bus only use without creating what may be considered to be unacceptable additional delays for other traffic. There is also a policy barrier in the form of NATS Policy 16, which states that new bus priority measures on Primary Distributor roads will not introduce additional delays for other, general traffic.

- The ability of bus operators to make the investment in vehicles and ICT systems necessary to deliver the vision for high quality public transport outlined in Chapter 3.

- The overall cost, including ongoing revenue costs, to the public sector of the infrastructure required to deliver the vision for high quality public transport, including passenger infrastructure such as bus stop facilities and real time information. While there is potential for significant developer contributions to these costs it should also be recognised that there will be other competing demands on developers to fund non-transport infrastructure that will limit their ability to meet all of the infrastructure requirements outlined in Chapter 3.

Delivering the vision for high quality public transport outlined in Chapter 3 will require a step change in the provision of public transport priority measures. Ideally, to give a journey time equal to or quicker than the car, there would need to be almost continuous bus lanes and traffic signal priorities from the proposed developments to the city centre. At the very least, there should be a sufficient length of bus lane on the approach to major junctions for buses to reach the front of the queue without significant delay.

Where possible, public transport priority measures would be developed with little or no adverse impacts on general traffic or on the surrounding environment. However, many of the easy options have now been exhausted and to achieve the vision a more radical approach will be required.

It is understood that the constraint of NATS Policy 16 is being addressed in concurrent work to align NATS with the current wider policy framework, in particular the major shift in emphasis to public transport, cycling and walking in the adopted Regional Spatial Strategy. However, even if this policy barrier is removed it may be difficult to develop a strict cost benefit business case for schemes with a detrimental effect on general traffic under current guidance which attributes a greater average value of time to car users than to public transport users. The consideration of high occupancy vehicle (HOV) lanes as an alternative to conventional bus, cycle and taxi lanes may offer a solution where public transport patronage is too low to justify a bus priority scheme.

Funding the ongoing revenue costs of passenger transport initiatives has been a major issue for Norfolk County Council in recent years as the Local Transport Plan funding system means that local transport authorities are relatively 'capital rich' and 'revenue poor'. Lessons learnt have been:

- The need to identify ongoing revenue costs at the outset of projects and include them in the business case;
- The need to seek private sector partners to contribute to revenue costs. These may include public transport operators and outdoor advertising contractors.

The current level of information regarding the overall location, shape and size of each proposed development creates difficulties in identifying a physical route for the proposed bus services to follow. However, analysis of the existing road infrastructure suggests six potential routes.

From the North East Sector:

- Wroxham Road / Sprowston Road;
- Salhouse Road / Gurney Road;
- North Walsham Road / Constitution Hill.

From the South West Sector:

- Newmarket Road;
- Hethersett Lane / Earlham Road.

From the West Sector:

- Dereham Road.

4.5.1 Key Issues – North East Sector

North East Growth Area to Salhouse Station – There is an opportunity to provide direct access from the North East Growth Area to the rail network either at the existing Salhouse Station or by relocating this station to a site that would better serve the new development. However, at present there is little capacity for growth in terms of either rolling stock or infrastructure. Removing these constraints to make rail travel a viable transport option for those living in this Growth Area would require considerable investment as outlined in Section 2.3.3.

North East Growth Area to Broadland Business Park – Current traffic flows on the routes into Broadland Business Park from the North and East are not a barrier to the delivery of a reliable public transport service. However, the construction of the NDR and plans for growth around the 'Postwick Hub' will have a significant impact on traffic flows in this area. Priority public transport access to Broadland Business Park and adjacent new development may be needed in order to provide an effective route for public transport to connect the Growth Area with this strategic employment site.

North East Growth Area exit routes – As there are currently no clear plans for the shape of the Growth Area it is difficult to assess how many exit routes there might be from the development (or developments if they straddle the NDR). Given the scale of the development there is a risk that these exit routes will become congested, and so the provision of public transport priority routes as an integral part of the development will be essential.

Route corridors from the North East Growth Area to the city centre – There are a number of possible radial routes for public transport links from the Growth Area to the city centre. Data from the NATS traffic model for years both pre and post construction of the NDR indicates that the least congested corridor is that comprising Salhouse Road and Gurney Road and running across Mousehold Heath. Whilst this corridor may provide the quickest public transport route to the city centre, it will mean that a considerable proportion of the route is operating through an area where there is no housing or other major trip attractors. Consideration should be given to whether the public transport connections from the Growth Area should focus solely on providing a rapid journey for those travelling from the Growth Area, or should play a wider role in enhancing public transport for communities along the entire length of the route.

Mousehold Heath – The designation of Mousehold Heath as a Local Nature Reserve and County Wildlife Site and the St James' Pit Site of Special Scientific Interest (SSSI) located between Gurney Road and Heathgate may restrict the scope for highway improvements on Gurney Road to assist the movement of large numbers of buses.

Table 4.1 below summarises what could potentially be achieved to increase the level of public transport priority on the three potential routes identified in this sector, and constraints on the delivery of these measures.

Table 4.1: North East Sector – Potential Schemes and Constraints

Route	Potential Schemes	Constraints
Wroxham Road/ Sprowston Road	Rail link to Growth Area	Should a new station be required this will require significant investment. The project would have to go through the Network Rail GRIP process. The support of both Network Rail and the train operator would be required to progress the project. Risk of a protracted approval process.
		Current capacity on the line would need to be reviewed. Investment in additional rolling stock would be required to accommodate any significant increase in peak demand.
		Additional boarding/alighting time at the station may have impact on scheduling. There is no spare time available within the existing Bittern Line timetable to accommodate additional or extended station stops.
		Frequent bus links to the station from the Growth Area would be beneficial but may not be commercially viable.

Wroxham Road/ Sprowston Road	Bus priority access to and from the Growth Area	Provision of bus priority routes into and out of the Growth Area is essential. Relationship between access routes to developments and the NDR is unclear. The design of the NDR may constrain bus priority access where development straddles the NDR.
	Bus priority on Wroxham and Sprowston Roads	Limited scope to reallocate existing road space on Sprowston Road to bus and cycle only use, or create new priority road space. Section between Silver Road and Magdalen Road constrained by on-street parking.
Salhouse Road/ Gurney Road	Bus priority access to and from the Growth Area	Current routes in Rackheath area via Green Lane are not suitable for high frequency services with large vehicles.
	Bus priority at junction with Outer Ring Road	The junction of Salhouse Road, Gurney Road and the Outer Ring Road will require improvements to create bus priority. Environmental designations of Mousehold Heath may constrain land take for a junction improvement scheme. Stakeholder and public opposition likely.
	Bus priority route through Mousehold Heath	The Heath is well used and has a number of environmental designations. St James' Pit is a SSSI. Opposition to any scheme impacting on the Heath is likely.

Salhouse Road/ Gurney Road	Bus priority route through Mousehold Heath	Limited scope for junction improvement at Ketts Hill roundabout.
		Impact of congestion on the Inner Ring Road on delays and journey time variability. The provision of a bus lane on the IRR will result in increased congestion for general traffic, and may impact on air quality issues.
North Walsham Road /Constitution Hill	Bus priority access to and from the Growth Area	The George Hill/School Lane junction is a pinch point on this corridor. Buildings on all four corners of the junction constrain scope for a junction improvement scheme.
	Bus priority on North Walsham Road and Constitution Hill	Limited scope to reallocate existing road space to bus and cycle only use, or create new priority road space.
		On-street parking for local businesses in Magdalen Road restricts the free movement of buses.

4.5.2 Key Issues – South West Sector

Congestion on corridors from the South West to the city centre – The potential corridors for services from the South West Growth Area to the city centre are Hethersett Lane/Earlham Road and Newmarket Road. Both of these corridors suffer from congestion and high levels of journey time variability. Although there are a number of public transport priority measures for these corridors identified in the West Norwich Bus Priority Study, further sections of route and junctions would need to be treated to ensure reliable journey times for services from the South West Growth Area.

Bus only link between the N&N University Hospital and UEA – In order to reduce journey times and to improve public transport links to the Hospital and University from all areas of Greater Norwich, a bus only link could be created between Colney Lane and the University. This is not a new idea and there have been a number of previous studies undertaken into the feasibility and cost of such a scheme. The impact on the environment is a major concern as this would create a transport link through the tranquil Yare Valley and passing close to the Earlham Park Woods Local Nature Reserve. However the wider benefits to the environment in terms of the reduction in emissions due to greater public transport use may outweigh the adverse impacts on tranquillity and the landscape. The use of hybrid public transport vehicles capable of operating in a zero-emission mode in environmentally sensitive areas may also help to mitigate negative perceptions about the overall impact of the scheme on the environment.

Poor quality access to Hethersett – For public transport to link the Hethersett area with the City via Hethersett Lane/Earlham Road it must first travel along what are currently unsuitable routes for large vehicles and then cross the A47. This access would need to be considerably upgraded in order to maintain a smooth, safe and comfortable journey for passengers. Alternatively the route would have to utilise the Thickthorn Interchange. This interchange is congested and is likely to suffer an increased amount of traffic in the future, particularly during peak hours. A range of priority measures would need to be put into place to assist public transport services and enable reliable journey times.

Hethersett Growth Area exit routes – As there are currently no clear plans for the size and shape of the Growth Area it is difficult to ascertain how many exit routes there would be from the development. It is inevitable that these exit routes will become congested and the provision of public transport priority measures as an integral part of the development is essential, both to reduce the overall level of car use, and to provide punctual journeys.

Wymondham rail services – Rail services make a significant contribution to overall public transport provision in Wymondham, and there are opportunities for rail to play its part in catering for future growth, particularly through the provision of additional services between Wymondham and Norwich. However, the existing services suffer from capacity and reliability issues and the scope for additional services to accommodate the extra demand created by the development in Wymondham and the surrounding areas is constrained by the existing infrastructure.

Wymondham Growth Area exit routes – As there are currently no clear plans for the size and shape of the Growth Area it is difficult to ascertain how many exit routes there would be from the developments. It is likely that these exit routes would suffer from considerable congestion and the provision of significant public transport priority measures as an integral part of the development is essential to allow delivery of reliable public transport services. Priority access for public transport from Wymondham to the A11 may also be required and this should be considered as part of the package of transport measures to provide a sustainable development plan for the area.

Table 4.2: South West Sector – Potential Schemes and Constraints

Route	Potential Schemes	Constraints
Hethersett Lane/ Norwich Research Park/N&N University Hospital/University Campus	Bus priority access to and from the Growth Area	Current roads in Little Melton area are not suitable for high frequency services with large vehicles.
	Bus priority access from Hethersett Lane to N&N University Hospital site	Land required, but proposal included in Norwich Research Park Development Brief.
	'Cross Valley Bus Link' between Colney Lane and University Campus	Provision linked to development at Norwich Research Park. Must respect the environmental and landscape character and sensitivities of the Yare Valley. Public opposition likely.
Earlham Road	Bus priority at Earlham Fiveways Roundabout	Earlier studies have identified a number of constraints at this junction.
	Bus priority measures	Existing road width is insufficient to allow for the creation of bus lanes, but some scope to create new priority road space by road widening into verge. Impacts on existing green areas and trees.

B1172 Norwich Road, Hethersett	Bus priority access to and from the Growth Area	Provision of bus priority routes into and out of the Growth Area is essential. Relationship between access routes to developments and the existing highway network is unclear. The A47 may constrain bus priority access.
	Bus priority at Thickthorn Interchange	The existing bus lane on the B1172 Norwich Road approach to the Thickthorn Roundabout may not be sufficient in length to deliver effective priority for a high frequency bus service. The need for an extended bus lane should be considered.
Newmarket Road	Inbound bus priority on Newmarket Road	There is some scope to extend the existing inbound bus lane back towards the A47 by utilising the hatched out former nearside lane of the Cringleford bypass, but extension beyond this point will require the reallocation of existing road space.
	Outbound bus priority on Newmarket Road	There is a break in the existing outbound bus lane at the Christchurch Road / Lime Tree Road junction. Improvements may require banning of some existing turning movements at the junction and Leopold Road / Eaton Road.

4.5.3 Key Issues – West Sector

Western Growth Area exit routes – Based on the new development already in place in this area there are considerable issues surrounding exit routes from the area. A bus only exit is likely to create the best advantage for public transport and allow faster and more convenient journeys to the city centre.

Longwater Interchange – A route serving development to the West of the A47, for example at Easton, would have to utilise the Longwater Interchange. This interchange is congested and is likely to suffer an increased amount of traffic in the future, particularly during peak hours. A range of priority measures would need to be put into place to assist public transport services and enable reliable journey times.

Congestion on Dereham Road – This corridor is congested and suffers from high journey time variability which is likely to increase with the addition of extra housing. There is an existing inbound bus lane outside the Outer Ring Road, but no existing bus priority measures within the Outer Ring Road. The outbound approach to the Outer Ring Road roundabout is severely congested during the PM peak period.

Cross-city link for Western Growth Area – There is no obvious cross-city link for a new service commencing in the Western Growth Area. A new link to existing residential areas would duplicate current commercial bus services. This service may be better operated as a stand alone service from the Growth Area to the city centre.

Table 4.3: West Sector – Potential Schemes and Constraints

Route	Potential Schemes	Constraints
Dereham Road	Bus priority access to and from the Growth Area	Development of a bus only access and egress to the development site would offer significant time savings, however developers may not be keen to release land.
	Bus priority at Longwater Interchange	Unclear as major junction improvement scheme planned but design still evolving.
	Extension of existing inbound bus lane	Scope to extend the existing inbound bus lane back to and beyond the Bowthorpe Roundabout, but this will require the reallocation of existing road space.

Dereham Road	Capacity improvement at Dereham Road/Outer Ring Road junction	Land required for a junction improvement scheme would impact on allotments adjacent to junction. Stakeholder and public opposition likely.
	Bus priority within Outer Ring Road	Creation of bus lanes between the Outer and Inner Ring Roads would require reallocation of existing road space and removal of on-street parking. Opposition from local businesses likely.

4.5.4 Key Issues – City Centre and Approaches

Narrow roads into the city centre – Almost every approach to the city centre is congested, in particular Magdalen Road and Riverside Road where current journey speeds are particularly low. The historic nature of Norwich means that most roads are relatively narrow with buildings both sides. This limits the opportunity for public transport priority measures considerably, particularly when set against the constraints of NATS Policy 16 on the reallocation of road space.

Capacity issues in the city centre – The present transport infrastructure provision in the city centre is coping with current public transport service levels but offers little spare capacity. With the frequency of services required to serve the Growth Areas there would need to be a substantial increase in bus stops and bus station capacity. A number of options to increase overall bus stop and interchange capacity in the city centre are outlined in section 4.4 of this document.

Grapes Hill Air Quality Management Area – Grapes Hill has been identified as an area with poor air quality and is currently designated as an Air Quality Management Area. Whilst the introduction of a Low Emission Zone in Castle Meadow is expected to reduce emissions from buses using Grapes Hill, the levels of general traffic in this area will continue to contribute to poor air quality. The use of hybrid or alternative fuel vehicles should be considered for any new bus services introduced on Grapes Hill to assist in improving air quality and present a cleaner and more environmentally friendly alternative to the car.

Table 4.4: City Centre and Approaches – Potential Schemes and Constraints

Route	Potential Schemes	Constraints
Magdalen Road	Removal of on-street parking	On-street parking and loading for local businesses in Magdalen Road restricts the free movement of buses. Identifying an alternative parking area is difficult. Opposition from residents and business community likely.
Grapes Hill	Air quality improvements	Extending the existing Castle Meadow Low Emission Zone to cover Grapes Hill may require further investment in the existing bus fleet to ensure compliance.
	Bus priority	There is scope to create a bus lane (inbound, outbound or both) on Grapes Hill, but this would involve a major reduction in capacity for general traffic on this section of the Inner Ring Road.
Chapelfield North	Contra-flow bus lane	Potential impact on Chapelfield Gardens. Stakeholder and public opposition likely.
	Two way traffic with restriction of access to bus, taxi, cycle only	Likely to have significant traffic impacts on alternative routes. Some adverse impacts may prove difficult to mitigate.

St Stephens Street	Restriction of access to bus, taxi, cycle only	Likely to have significant traffic impacts on alternative routes. Some adverse impacts may prove difficult to mitigate.
Prince of Wales Road	Two way traffic with restriction of access to bus, taxi, cycle only	Likely to have significant traffic impacts on alternative routes. Some adverse impacts may prove difficult to mitigate.
Ketts Hill	Road widening to enable buses turning left from Ketts Hill into Bishop Bridge Road to pass traffic queued in ahead/right lane	Scope for road widening into southern verge with minimal environmental impact.
Foundry Bridge Junction	Junction improvement	The listed Foundry Bridge is a significant constraint on improving access to the City Centre from this direction. Previous studies have failed to identify an acceptable solution.
Bracondale	Outbound bus lane	Previous studies indicate scheme is feasible, but design would need to minimise impact on Bracondale Conservation Area.

4.5.5 Constraints Diagrams

The diagrams in Figures 4.4 and 4.5 below provide an overview of the constraints affecting the potential public transport priority routes into the city from the North East, South West and West growth areas.

Figure 4.4: Constraints Plan - Scenarios A and B

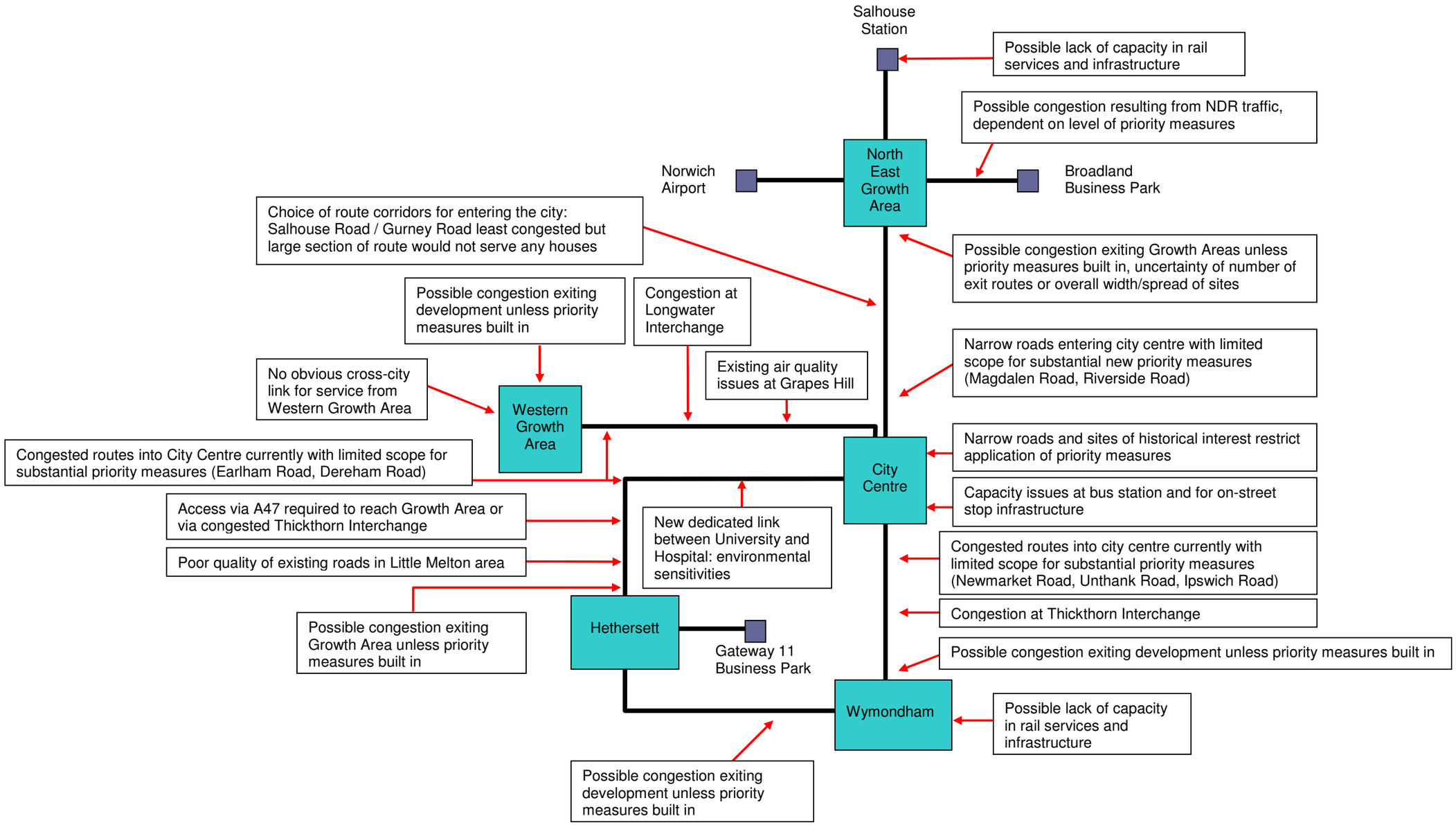
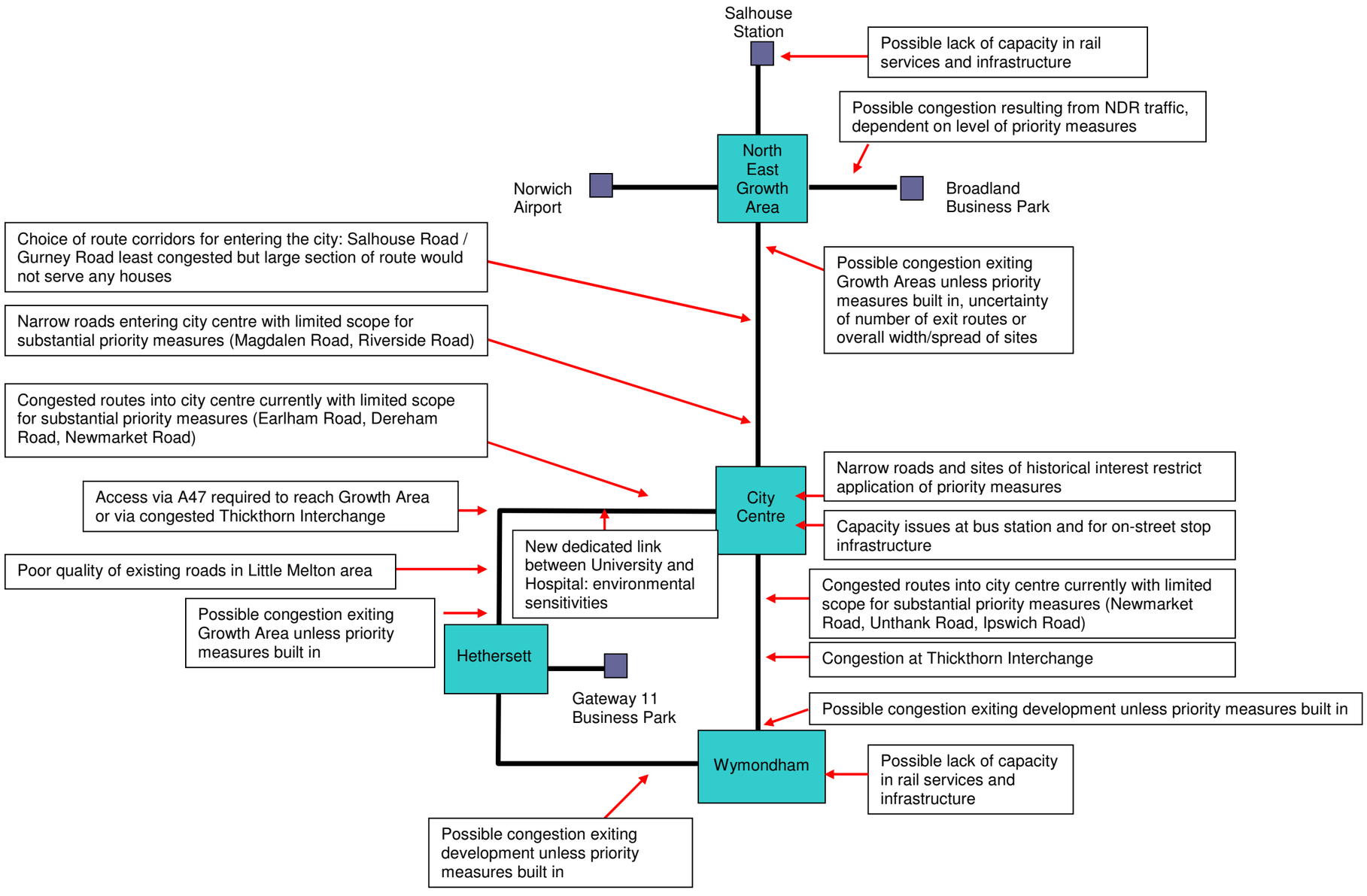


Figure 4.5: Constraints Plan - Scenarios C and D



5 Delivery Issues

The starting point for the procurement and delivery of public transport for the major growth locations should be a long term masterplan for the phased development of the public transport network to serve the growth areas. The network must evolve to reflect the phasing of development and the changing needs of residents and businesses.

Within this masterplan there should be as much clarity as possible regarding internal public transport routes within growth areas in order to support the principle of Public Transport-Orientated Development.

The high degree of flexibility offered by a bus-based system makes this mode well suited to progressive route extensions to keep pace with phased development, and is a significant benefit compared to a light rail system in these circumstances.

In order to achieve the public transport mode share targets for the growth areas it will be essential to have a high quality public transport system in place prior to the occupation of the first new houses on each development.

Implementing public transport services at this stage of development will require some form of revenue subsidy at the commencement of services but will help to bring forward the point at which services can be sustained commercially.

Development of services in this way is likely to involve a mix of public and private sector funding and require a partnership approach involving developers and public transport operators.

We have suggested below how each of the parties involved could potentially contribute to such a partnership but, as the case study presented in section 5.5 illustrates, within this approach there are a number of alternative delivery models that may be appropriate to reflect the specific characteristics of individual developments.

Developer to provide:

- All public transport infrastructure within the development to common design and quality standards that have been set out in the Local Development Framework;
- A contribution to bus priority measures and passenger infrastructure on corridors linking the growth areas with the city centre and strategic employment sites;
- Revenue funding for the operation of an attractive level of service from the first occupation of the new development until the point at which services become commercially sustainable;

- Revenue funding or a commuted sum for the maintenance of the public transport infrastructure within the development e.g. bus shelters, passenger information systems;

- Assistance with the marketing and promotion of public transport services to residents and businesses occupying the development.

Local Transport Authority to:

- Set design and quality standards for developer-provided internal public transport infrastructure;

- Design and deliver the external public transport infrastructure on corridors linking the growth areas with the city centre and strategic employment sites to an agreed programme;

- Set the specification for the new services;

- Develop a performance incentive contract regime for the new services;

- Consider use of the 'de-minimis' provisions of the Transport Act 1985 (as amended by regulations made in 2004) to negotiate incremental extension / enhancement of existing services where beneficial;

- If operators are reluctant to invest in vehicles of the required standard, consider use of developer or growth infrastructure funding to purchase vehicles for lease to operators;

- Adopt and maintain the public transport infrastructure within the development when developer responsibility for maintenance ceases.

Local Planning Authority to:

- Ensure that the principle of Public Transport-Orientated Development is enshrined within the Local Development Framework and adhered to at all stages of the planning process;

- Negotiate planning agreements with developers to deliver the necessary internal public transport infrastructure, contribute to external infrastructure improvements and support the operation of services until an agreed level of revenue/patronage is reached.

Past experience with Section 106 agreements for public transport provision to serve major developments in the Norwich area has demonstrated that such agreements should anticipate a range of possible scenarios for the way in which operators respond to the market opportunity presented by the development and incorporate an element of flexibility in the way in which developer contributions for public transport may be spent.

Some developments have attracted commercial bus services at a much earlier stage than anticipated, but it has not been possible to divert developer funding intended for the support of services to deliver public transport infrastructure improvements within the development. In other cases the slow pace at which the early phases of development have progressed has meant that services supported by developer funding for a fixed period of five years have not achieved commercial viability within this period, leaving the local authority to support the service or allow it to cease.

We would also recommend that planning agreements with developers encourage the developer to play an active role in the development of public transport services and avoid a situation where a developer can simply hand over a financial contribution and then walk away from any further involvement.

A recent innovation in such agreements is to leave the revenue risk for the public transport service with the developer so that the financial impact on public transport patronage and revenue of delays in the construction and/or occupation of the development is not borne by the operator or local authority, and the developer has a real incentive to promote public transport use.

Operators to provide:

- The management and operation of services in accordance with a performance incentive contract regime;
- Investment in new vehicles of the required standard subject to the existence of a robust business case;
- The depot and maintenance infrastructure for the additional vehicles required to serve the growth areas.

There may be issues with developing a robust business case for operators to invest in new vehicles for new services where the level of patronage is unknown and there is uncertainty regarding the timing and progress of major developments. Early operator involvement in the planning of the public transport network to serve the growth areas will help to mitigate these potential problems.

Cost-based contracts providing operators with a guaranteed revenue stream can underpin an initial investment in vehicles, but do not give the operator any incentive to promote the service.

Responsibility for marketing and promotion of the services should therefore be aligned with where the revenue risk lies.

5.1 Delivery Models

The potential delivery models for the provision of high quality public transport connections for the growth areas are briefly outlined below.

5.1.1 Voluntary Quality Partnership Agreements

The concept of a voluntary quality partnership as a means of delivering improvements to local bus services is well established and there are hundreds of such agreements in place across the UK. The term is normally used to cover any partnership agreement entered into voluntarily by one or more local authorities and one or more bus operators, but may also involve other relevant parties such as developers.

A voluntary quality partnership agreement may cover any matters on which the parties involved can reach agreement and have the ability to deliver. Where appropriate, such agreements may take the form of a legally binding document executed by all parties. This would be an appropriate approach where a quality partnership agreement is used as a mechanism to deliver commitments made in a planning agreement between a local authority and a developer.

5.1.2 Statutory Quality Partnership Schemes

Statutory Quality Partnership Schemes were introduced by the Transport Act 2000 as an alternative to voluntary quality partnership agreements as a delivery model for improvements to local bus services, but have not yet been widely used.

Unlike voluntary quality partnership agreements, a Quality Partnership Scheme (QPS) is “made” by the local transport authority after consultation with operators. The essential feature of a QPS is that the local authority provides particular facilities and sets the standard of services to be provided by bus operators as a condition of using those facilities. Once set, compliance with these standards can be enforced through the Traffic Commissioner.

Amendments proposed in the Local Transport Bill will provide additional flexibility in the implementation of a QPS to allow improvements to be phased in over a period of time and will also permit the scope of a QPS to include specification of the minimum frequency of services and maximum fares.

With the benefit of the changes included in the Local Transport Bill a QPS will offer a more practical framework for providing access to new public transport infrastructure and is therefore worth consideration as a delivery model for public transport connections for the major growth areas.

A QPS may be preferable to a voluntary agreement where there is a risk of service quality being undermined by low quality competition from an operator unwilling to participate in a voluntary agreement. A QPS could also potentially be used as a mechanism to lever a higher quality of service for the major growth areas than it would be possible to obtain through a voluntary agreement. However, there are significant risks in the adoption of such a strategy, which would be contrary to a true partnership approach and may have unintended consequences elsewhere on the public transport network.

A developer cannot be a party to a QPS, but a QPS could be made to deliver commitments made in a planning agreement between a local authority and a developer.

5.1.3 Quality Contracts Schemes

The concept of Quality Contracts Schemes was introduced by the Transport Act 2000 as a further alternative delivery model for improvements to local bus services, but no such schemes have been implemented, primarily due to the difficulty in satisfying the legal test for statutory approval of a scheme.

A Quality Contracts Scheme has the effect of suspending the deregulated market for the provision of bus services in the area concerned and enables the local transport authority to take total control of the specification of the public transport network in that area, including routes, timetables, vehicles, fares and ticketing. A QCS would therefore enable the local authority to have total control of the specification of services for the growth areas and to ensure services develop in full accordance with a long term masterplan. A QCS would also avoid the support of services through planning agreements being undermined by unexpected commercial registrations.

However, even with the changes proposed in the Local Transport Bill a QCS will not be an easy or cheap option for a local authority to take, and should generally only be considered as a fall back option in circumstances where the local authority cannot achieve its aspirations for public transport to serve the growth areas through some form of partnership approach and where there would be clear benefits to the public which would outweigh any adverse effect on operators.

A QCS for new services to a development area does at least avoid the issue of confiscation of existing business and is thus less problematic than a scheme including existing services.

As with a QPS, a developer cannot be a party to a QCS, but a QCS could be made to deliver commitments made in a planning agreement between a local authority and a developer.

5.1.4 PFI

It is conceivable that it might be possible to develop some form of PFI business model for the delivery of both public transport services for the growth areas and some of the supporting infrastructure. Some local authorities have briefly considered this approach, but none have attempted to follow it through.

5.2 Delivery Case Study – Kent Thameside Fastrack

Centred upon Dartford and Gravesend, Kent Thameside is one of the main growth areas in the Thames Gateway, with 50,000 new jobs and 30,000 new homes planned over the next 20-30 years. The area also includes the Bluewater shopping complex and the new Ebbsfleet International rail station.

The core principles of the development vision for Kent Thameside include:

- 'Public Transport-Orientated Development' – encouraging higher density development along public transport corridors thus enabling more people to live close to good public transport links
- Timing of infrastructure provision – to have attractive public transport in place before development is occupied in order to increase the probability that those occupying the development will become regular public transport users.

In accordance with these principles the Fastrack BRT system has been promoted by Kent County Council and the Kent Thameside Delivery Board as the centrepiece of an integrated transport network connecting the major development sites. A high quality bus-based solution was adopted both for engineering reasons and because of the flexibility it offers to develop the network organically over an extended period.

The Fastrack network will eventually cover some 40km, with significant sections of segregated unguided busway. Plans envisage up to 50% of the network running on segregated alignments with a further 25% using conventional bus lanes.

Two Fastrack routes are now in operation, the first of which (Route B) has been wholly publicly funded, with the second (Route A) wholly funded by a developer.

Route B

Route B, opened in March 2006, operates between Dartford and Gravesend via the Bluewater shopping complex. Of the 15km route some 7.5km is on segregated alignments, including 5.5km of almost continuous busways and priority measures between Dartford and Bluewater.

Route B is operated by Arriva under an innovative 'de-minimis' contract with Kent County Council. The 14 new buses used on the route are owned by the County Council and the provision of the vehicles to Arriva forms part of the service subsidy. The operating contract also includes a series of performance indicators based on those developed by Transport for London.

The Route B vehicles are conventional Volvo/Wrightbus 12m low floor single deck buses, but with a high quality specification and distinctive branding.

Route B has been an undisputed success, with patronage in the first year of 2.75 million against a predicted level of 1.1 million, and solid evidence of modal shift.

Route A

Route A, launched in June 2007, operates between Dartford Station and Bluewater via a major new residential and commercial development immediately to the west of the Dartford Crossing known as 'The Bridge', Crossways Business Park and Greenhithe.

The section of route within The Bridge development is a dedicated busway, accessed at the western end via a new private bridge over the M25 motorway.

In contrast to Route B, Route A is wholly funded by the developer of The Bridge, Prologis. A Section 106 planning agreement requires Prologis to provide both infrastructure and revenue funding for a Fastrack service for a period of 17 years. Operation of Route A is contracted by Prologis to Arriva, using 12 low floor single deck buses with a similar specification to that for Route B. Under this contract the revenue risk lies with Prologis.

The busway through The Bridge is of conventional highway construction, but is a private road owned and maintained by Prologis, with access physically restricted by barrier controls at each end of the busway. The barriers are activated by tags or transponders fitted to the Fastrack fleet.

The masterplan for delivery of the full Fastrack network called for a phased approach, with the project kick-started with public sector funding, but future phases wholly funded by the private sector.

The intention is therefore to follow the 'Route A' model for the delivery of the planned future expansion of the Fastrack network. Current plans include a further section of gated private busway through the Eastern Quarry development adjacent to Bluewater.

In the longer term it is envisaged that a franchise will be awarded to a private sector operator for the operation and maintenance of the entire Fastrack network once this is nearing completion and patronage levels have been demonstrated. This would involve an application for a statutory Quality Contracts Scheme or the use of alternative regulatory powers that may become available once the current Local Transport Bill is enacted.

6 Conclusions and Recommendations

To achieve the proposed public transport mode share targets for the Norwich Policy Area it will be necessary to set a higher mode share target for public transport to and from the proposed major growth locations than for existing urban areas. There is a greater propensity for change in travel behaviour amongst those moving to a new area and this can be capitalised on through the delivery of high quality public transport services from the outset of development in the growth areas.

Having reviewed the EDAW report 'Norwich Growth Area – Infrastructure Need and Funding Study', we have used the trip rate data in this report to develop a model of the projected trip volumes for each of the major growth locations under the four scenarios specified in the brief. We have applied public transport mode share targets of 16% by 2021 and 20% by 2031 to this model, and stretched targets of 20% by 2021 and 25% by 2031 as a sensitivity test. Even with the stretched targets, trip volumes from individual locations are within the level at which a high frequency bus service would be the most appropriate and cost effective solution.

It is estimated that up to 26 new, high frequency services would be required by 2031 to link the growth areas to the city centre. This does not include services for journeys from the growth areas to strategic employment sites outside the city centre.

The larger development sites offer the greatest opportunity for dedicated high frequency public transport services. The greater scope to design a Public Transport-Orientated Development will improve accessibility to services and the larger number of households will aid the earlier provision on a commercial basis of services operating at least every 10 minutes throughout the day.

There is potential for rail services to contribute to public transport connections from the North East and Wymondham growth areas to Norwich. Development in proximity to existing and potential new rail stations could significantly enhance opportunities and demand for this mode. However it should be noted that there are a number of infrastructure and operational constraints that would need to be addressed.

Road space within Norwich city centre is a major issue affecting all transport modes. Bus services from the growth areas operating at the proposed frequency of at least every 10 minutes will have a significant impact on requirements for bus stop and interchange capacity in the city centre. To allow services to operate in a timely manner a more radical approach to bus priority will be required together with the implementation of Bus Rapid Transit (BRT) schemes on the busiest corridors. This is currently constrained by NATS Policy 16. The creation of additional road space in the city is also constrained by the historic street pattern of Norwich, the many historic buildings and large numbers of mature trees.

In Scenarios A and B there is an imbalance in development to the East and West of the city. This makes the development of cross-city routes in line with operator preferences more difficult, and splitting development to the West between three locations compounds this.

Scenarios C and D are better balanced with larger growth areas to the North East and South West of the city capable of sustaining high frequency 'turn up and go' cross-city services.

The preferred option from a public transport perspective is Scenario D as it provides the best possible balance of growth across the North East to South West axis coupled with developments of a size sufficient to provide strong market opportunities for high frequency bus services.

6.1 Recommendations

Developing a smaller number of larger growth areas offers greater opportunities to build-in public transport from the outset. A holistic approach should be adopted with the aim of creating truly Public Transport-Orientated Developments (PTODs). These can deliver high quality public transport services, with associated infrastructure making public transport use simple, intuitive and attractive for both residents and visitors.

Innovations such as mobile phone ticketing technology, alternative fuel vehicles and real time information should be considered to maximise the appeal of public transport to residents of the growth areas. All of these measures will contribute to an enhanced passenger experience by offering a greater level of information, ease and speed of use and air quality improvements.

To build on the high level assessment of options for public transport priority routes in this study, it is recommended that detailed route audits are undertaken for the emerging preferred options. This will provide a greater level of detail about the impact of identified constraints and opportunities for a more radical approach to bus priority.

To create PTODs a partnership approach involving planners, developers and public transport operators will be required to ensure that public transport is at the core of the masterplan for the development. Operator involvement at an early stage can help to deliver services as soon as the first homes are occupied. Discussions will also assist in identifying any funding issues related to provision of services and infrastructure. It is recommended that this is initiated at the earliest possible development stage.

The existing NATS Policy 16 acts as a constraint on the provision of the high quality and reliable bus services that will be required to deliver modal shift. To date, bus priority measures in the city have had to prove that benefits for buses are not delivered to the detriment of general traffic. A revision to this policy would allow greater flexibility for more substantial priority measures, and is imperative for the implementation of advanced measures such as BRT.

Out of the four further options for the distribution of housing growth considered in **Appendix A**, Option 1 is recommended as the preferred option from a public transport perspective. This option concentrates development in the smallest number of locations and thus offers the best opportunities for developing a strong market for public transport services. All of the proposed locations for major development in Option 1 have the potential to be served by public transport priority routes and all but one are on a single axis, enabling investment to deliver a step change in public transport service quality to be largely focused on one cross-city corridor.

A development of 1,500 to 2,000 homes at Long Stratton as proposed under Options 2, 6 and 6a may be too small to effectively implement the concept of 'Public Transport-Orientated Development, and it will be difficult to achieve a step change between public transport mode share for the new development and the existing public transport mode share for travel between Long Stratton and Norwich.

Development at Long Stratton would work better from a public transport perspective in conjunction with development at Mangreen / Swardeston / Mulbarton (Options 6, 6a) than in isolation (Option 2). The employment at Mangreen in Options 6, 6a may help to reduce the level of commuting to central Norwich. Demand from Mangreen / Swardeston would help to support a more frequent bus service between Long Stratton and Norwich.

Investigation of the potential for rail to play a part in accommodating the additional trips generated by growth in the South area has demonstrated that the spatial relationship between the developable land at Mangreen / Swardeston / Mulbarton and the location of a potential new station at Mangreen is such that this potential is lower than first envisaged. Therefore the 'rail factor' does not provide a compelling reason to favour development in the South (Options 6, 6a) over development in the South West (Options 1, 2).

Appendix A Assessment of Alternative Options, June 2008

This Appendix presents the results of the assessment of four further options for the distribution of housing growth within the Norwich Policy Area using the methodology outlined in Chapter 2 of this report.

Table A.1: Alternative Growth Options

Location	Option 1	Option 2	Option 6	Option 6a
Norwich	4,000	4,000	4,000	4,000
Broadland smaller site	2,000	2,000	2,000	3,000
South Norfolk smaller sites	2,000	2,000	2,000	2,000
North East (Sprowston/Rackheath area)	6,000	6,000	6,000	6,000
South West (Hethersett/Little Melton area)	4,000	4,000		
South (Mangreen – Swardeston/Mulbarton area)			4,500	4,500
Wymondham	4,000	2,000	2,000	2,000
West (Costessey/Easton area)	2,000	2,000		1,000
North (St Faiths/ Spixworth area)			2,000	
Long Stratton		2,000 (to help deliver a bypass)	1,500 (to help deliver a bypass)	1,500 (to help deliver a bypass)
TOTAL	24,000	24,000	24,000	24,000

All of these options are based on total housing growth of 24,000 new properties, 1,000 more than in the scenarios considered previously. The total number of peak hour person trips used in the calculations has therefore been adjusted for the extra 1,000 houses to give figures of 14,655 between 2011 and 2021, and 13,179 between 2021 and 2031.

As the Norwich and South Norfolk smaller sites allocations are the same under all of the above options we have focused on the additional trips generated by the Broadland smaller site and the seven greenfield sites for large scale growth and not the total for the NPA as a whole.

By taking the overall increase in peak hour person trips of 14,655 between 2011 and 2021, and 13,179 between 2021 and 2031 and apportioning these figures according to the distribution of housing growth under each of the options 1, 2, 6 and 6a the level of trip generation for each location under each scenario can be derived. The results of these calculations and the total number of bus trips based on the current 8% bus mode share are presented in Table A.2 below.

Table A.2: Geographical Distribution of Additional Trips

	Increase in Peak Hour Home-based Person Trips Based on Current Mode Share							
	2011-2021				**2021-2031**			
	Option				**Option**			
Location	**1**	**2**	**6**	**6a**	**1**	**2**	**6**	**6a**
Norwich	2,443	2,443	2,443	2,443	2,197	2,197	2,197	2,197
Broadland smaller site	1,221	1,221	1,221	1,832	1,098	1,098	1,098	1,647
South Norfolk smaller sites	1,221	1,221	1,221	1,221	1,098	1,098	1,098	1,098
North East	3,664	3,664	3,664	3,664	3,295	3,295	3,295	3,295
South West	2,443	2,443	-	-	2,197	2,197		
South	-	-	2,748	2,748	-		2,471	2,471
Wymondham	2,442	1,221	1,221	1,221	2,196	1,098	1,098	1,098
West	1,221	1,221	-	610	1,098	1,098	-	549
North	-	-	1,221	-	-		1,098	
Long Stratton	-	1,221	916	916	-	1,098	824	824
Total	14,655	14,655	14,655	14,655	13,179	13,179	13,179	13,179
Total Bus Trips (@ 8% modal share)	1,172	1,172	1,172	1,172	1,054	1,054	1,054	1,054

The EDAW growth infrastructure study proposed increases in bus mode share across the Norwich Policy Area as a whole to 13% by 2021 and 15% by 2031. However, we would suggest that to achieve these revised overall mode shares for the NPA it will be necessary to set higher public transport mode share targets for the major growth locations.

It will be easier to influence travel behaviour in the new growth locations by providing high quality public transport from the outset of development than it will be to change mode choice for journeys within the existing Norwich urban area. The new growth locations should therefore be expected to outperform the existing urban area in terms of their contribution to overall mode share target for the NPA.

We have therefore based our initial calculations for the distribution of additional bus trips between the major growth locations on bus mode share targets for these areas of 16% by 2021 and 20% by 2031. Table A.3 presents the results of these calculations.

Table A.3: Geographical Distribution of Additional Bus Trips

	Increase in Peak Hour Home-based Bus Trips Based on Proposed Mode Share Targets for Growth Locations							
	2011-2021 (16% Bus Mode Share)				**2021-2031 (20% Bus Mode Share)**			
Location	**1**	**2**	**6**	**6a**	**1**	**2**	**6**	**6a**
Norwich	391	391	391	391	439	439	439	439
Broadland smaller site	196	196	196	293	220	220	220	330
South Norfolk smaller sites	195	195	195	195	220	220	220	220
North East	586	586	586	586	659	659	659	659
South West	391	391	-	-	439	439	-	-
South	-	-	440	440	-	-	494	494
Wymondham	391	195	195	195	439	220	220	220
West	195	195	-	98	220	220	-	109
North	-	-	195	-	-	-	219	-
Long Stratton	-	196	147	147	-	219	165	165
Total	2,345	2,345	2,345	2,345	2,636	2,636	2,636	2,636

As a sensitivity test we have also considered stretched bus mode share targets for the major growth locations of 20% by 2021 and 25% by 2031. Table A.4 presents the distribution of additional bus trips between the major growth locations based on this assumption.

Table A.4: Geographical Distribution of Additional Bus Trips – Sensitivity Test

	Increase in Peak Hour Home-based Bus Trips Based on Stretched Mode Share Targets for Growth Locations							
	2011-2021 (20% Bus Mode Share)				2021-2031 (25% Bus Mode Share)			
	Option				Option			
Location	**1**	**2**	**6**	**6a**	**1**	**2**	**6**	**6a**
Norwich	489	489	489	489	549	549	549	549
Broadland smaller site	244	244	244	366	275	275	275	412
South Norfolk smaller sites	244	244	244	244	275	275	275	275
North East	733	733	733	733	824	824	824	824
South West	489	489	-	-	548	548	-	-
South	-	-	550	550	-	-	618	618
Wymondham	488	244	244	244	549	274	274	274
West	244	244	-	122	275	275	-	137
North	-	-	244	-	-	-	274	-
Long Stratton	-	244	183	183	-	275	206	206
Total	2,931	2,931	2,931	2,931	3,295	3,295	3,295	3,295

The distribution of additional bus trips between the major growth locations shows that even with the stretched mode share targets, trip volumes from individual locations in 2031 are within the level at which a high frequency bus service would be the most appropriate public transport mode to meet the travel requirements of the major housing growth locations.

For example, in all options there are 1,557 (733 + 824) additional peak hour bus trips from the north east sector in 2031 under the sensitivity test assumptions. This compares with a maximum system capacity for a standard bus service of 2,500 to 4,000 passengers per hour per direction according to the CfIT Affordable Mass Transit Guidance report.

Considering the possibility in Option 1 of a single public transport corridor linking the north east of Norwich with the south west and Wymondham under the sensitivity test assumptions, this corridor would need to provide capacity for a total of 3,631 peak hour trips in 2031. This level of demand is still within the maximum system capacity of a standard bus service, but sufficient to support a bus rapid transit service with a high level of segregation from general traffic. According to CfIT, such segregation can increase the maximum capacity of bus-based systems to between 4,000 and 6,000 passengers per hour per direction. As the figure of 3,631 peak hour home-based trips includes movements from both the north east and south west, the peak trip volume in any one direction on the corridor will be lower than this.

Table A.5 below compares the system capacity of a standard bus service with those of various forms of bus rapid transit, light rail/tram and heavy rail. This indicates that a light rail/tram system would generally only be appropriate for larger peak hour passenger movements than those projected for the major housing growth locations.

Table A.5: System Capacity

Mode / Technology	**Maximum System Capacity (passengers per hour per direction)**
Standard bus	2,500 – 4,000
Busway	4,000 – 6,000
Guided bus	4,000 – 6,000
Tram/Light Rail	12,000 – 18,000
Heavy Rail	10,000 – 30,000

Source: CfIT Affordable Mass Transit Guidance

A.1 Proposed Service Levels for 2021

Using bus mode share targets for the growth areas of 16% by 2021 and 20% by 2031 and the distribution of additional bus trips between the major growth locations set out in Table A.3 (excluding Norwich and the Broadland and South Norfolk smaller sites), we have identified the service levels and vehicle capacity required to meet the projected level of demand from each location under each of the four options 1, 2, 6 and 6a in 2021 and 2031.

Table A.6: Proposed Peak Service Levels in 2021 for Alternative Growth Options

Option	1				2				6				6a			
Location	**Demand (trips per hour)**	**Frequency (minutes)**	**Practical Vehicle Capacity**	**Service Capacity (trips per hour)**	**Demand (trips per hour)**	**Frequency (minutes)**	**Practical Vehicle Capacity**	**Service Capacity (trips per hour)**	**Demand (trips per hour)**	**Frequency (minutes)**	**Practical Vehicle Capacity**	**Service Capacity (trips per hour)**	**Demand (trips per hour)**	**Frequency (minutes)**	**Practical Vehicle Capacity**	**Service Capacity (trips per hour)**
North East	586	5	52	624	586	5	52	624	586	5	52	624	586	5	52	624
South West	391	7/8	52	416	391	7/8	52	416	-	-	-	-	-	-	-	-
South	-	-	-	-	-	-	-	-	440	6	52	520	440	6	52	520
Wymondham	391	7/8	52	416	195	15	52	208	195	15	52	208	195	15	52	208
West	195	15	52	208	195	15	52	208	-	-	-	-	98	30	52	104
North	-	-	-	-	-	-	-	-	195	15	52	208	-	-	-	-
Long Stratton	-	-	-	-	196	15	52	208	147	20	52	156	147	20	52	156

Demand below level required to support a dedicated ‘turn up and go’ service

Table A.7: Proposed Peak Service Levels in 2031 for Alternative Growth Options

Option	1				2				6				6a			
Location	**Demand (trips per hour)**	**Frequency (minutes)**	**Practical Vehicle Capacity**	**Service Capacity (trips per hour)**	**Demand (trips per hour)**	**Frequency (minutes)**	**Practical Vehicle Capacity**	**Service Capacity (trips per hour)**	**Demand (trips per hour)**	**Frequency (minutes)**	**Practical Vehicle Capacity**	**Service Capacity (trips per hour)**	**Demand (trips per hour)**	**Frequency (minutes)**	**Practical Vehicle Capacity**	**Service Capacity (trips per hour)**
North East	1245	3[1]	68	1360	1245	3[1]	68	1360	1245	3[1]	68	1360	1245	3[1]	68	1360
South West	830	3/4[2]	52	832	830	3/4[2]	52	832	-	-	-	-	-	-	-	-
South	-	-	-	-	-	-	-	-	934	3/4[2]	60	960	934	3/4[2]	60	960
Wymondham	830	3/4[2]	52	832	415	7/8	52	416	415	7/8	52	416	415	7/8	52	416
West	415	7/8	52	416	415	7/8	52	416	-	-	-	-	207	15	52	208
North	-	-	-	-	-	-	-	-	415	7/8	52	416	-	-	-	-
Long Stratton	-	-	-	-	415	7/8	52	416	312	10	52	312	312	10	52	312

[1] – Two separate routes each operating every 6 minutes (10 buses per hour on each route)

[2] – Two separate routes each operating every 7/8 minutes (8 buses per hour on each route)

Demand below level required to support a dedicated 'turn up and go' service

The proposals for 2021 (Table A.6) are based on the use of 12 metre semi-low floor buses with an absolute maximum capacity of 69 (44 seated plus 25 standing) and a practical capacity of 52 in accordance with the CfIT guidance. We would propose the use of larger vehicles in preference to increasing the service frequency beyond five minutes, but none of the growth locations require anything better than a five minute interval service in 2021.

In **Option 1**, the projected peak demand from the West growth location in 2021 is below that necessary to support a dedicated 'turn up and go' service operating every 10 minutes, with peak demand only reaching 62.5% of the capacity of such a service. This level of demand would support a dedicated service operating every 15 minutes, but a potential alternative solution would be to extend an existing bus route to serve this location at a 'turn up and go' frequency rather than introducing a new service.

If growth in the West sector takes the form of contiguous extensions to the committed developments at Lodge Farm and West Costessey, the combined demand from the committed development and the additional growth may be sufficient to support a turn up and go service. Easton currently has only three buses per hour to Norwich throughout the day, with additional peak services. A feeder service from Easton to Costessey Park & Ride might be a cost effective means of delivering a turn up and go service for this area.

The projected demand from each of the North East, South West and Wymondham growth locations in 2021 is well above the threshold required to support a dedicated 'turn up and go' service, and there is potential for a cross-city service on a South West to North East axis.

In **Option 2**, the impact of reducing the Wymondham housing allocation by 2,000 and reallocating this growth to Long Stratton is that the projected levels of peak demand from the West, Wymondham and Long Stratton growth locations in 2021 are all below that necessary to support a dedicated 'turn up and go' service operating every 10 minutes, with peak demand only reaching 62.5% of the capacity of such a service. These levels of demand would support dedicated services operating every 15 minutes.

Higher levels of service could potentially be delivered by extending / enhancing the existing bus services between Wymondham and Long Stratton and Norwich, but this approach is unlikely to deliver the desired step change in service quality. There is a good existing level of service (every 15 minutes) between Wymondham and Norwich to build upon, but the main service between Long Stratton and Norwich currently operates only every 30 minutes.

If growth in the West sector takes the form of contiguous extensions to the committed developments at Lodge Farm and West Costessey, the combined demand from the committed development and the additional growth may be sufficient to support a turn up and go service.

Demand from the North East and South West growth locations in 2021 remains well above the threshold required to support a dedicated 'turn up and go' service, and there is potential for a cross-city service on a South West to North East axis.

In **Option 6**, the impact of reducing the Wymondham housing allocation by 2,000 on the projected level of peak demand from Wymondham in 2021 is similar to Option 2, with demand falling below that necessary to support a dedicated 'turn up and go' service operating every 10 minutes, but sufficient to support dedicated services operating every 15 minutes.

The projected demand in 2021 from the housing allocation of 2,000 in the North sector in this option is also below that necessary to support a dedicated 'turn up and go' service operating every 10 minutes, but sufficient to support dedicated services operating every 15 minutes.

The impact of reducing the Long Stratton Housing allocation from 2,000 (Option 2) to 1,500 in **Options 6 and 6a** is to further reduce the level of dedicated service that can be supported in 2021 to every 20 minutes.

Higher levels of service could potentially be delivered by extending / enhancing the existing bus services between Wymondham, Long Stratton, Spixworth and Norwich, but this approach is unlikely to deliver the desired step change in service quality.

The projected demand from the North East and South growth locations in 2021 is well above the threshold required to support a dedicated 'turn up and go' service, and there is potential for a cross-city service on a South to North East axis.

Option 6a involves further dispersion of development to smaller sites in Broadland and 1,000 houses in the West sector in place of a major growth location in the North sector under Option 6. This would be the least desirable of all the four options appraised in this note from a public transport perspective.

A.2 Proposed Service Levels for 2031

The proposals for 2031 (Table A.7) are based on a mix of 12 metre semi-low floor buses and higher capacity 13.5 to 15 metre single deck or 10.5 metre double deck buses with a practical capacity in the range 60 to 68. Articulated buses would also be an option at these levels of demand for the routes serving the North East, South West and South sectors.

On the basis of the assumptions made, all the growth locations except the West in Option 6a, have the potential to support a 'turn up and go' peak service frequency in 2031. However, in Options 6 and 6a demand from Long Stratton only just reaches this threshold in 2031.

In practice some of the demand provided for in the above proposals will be for services to the strategic employment sites rather than wholly on the main corridors linking the major growth areas with Norwich city centre. It is envisaged that in some cases dedicated public transport links will be provided between growth locations and strategic employment sites, but a proportion of trips to strategic employment sites will involve interchange to and from the main corridor services.

Dependent on the specific location of housing growth within the North East sector, there may be scope to accommodate a proportion of the additional trips generated by growth in this area on the Sheringham to Norwich (Bittern Line) rail services, using the existing station at Salhouse or by relocating this station to a site that would better serve the new development. However it should be noted that there are a number of infrastructure and operational constraints on the enhancement of Bittern Line services.

A.3 Development at Long Stratton - Public Transport Issues

- A development of 1,500 to 2,000 homes at Long Stratton may be too small to effectively implement the concept of 'Public Transport-Orientated Development, and it will be difficult to achieve a step change between public transport mode share for the new development and the existing public transport mode share for travel between Long Stratton and Norwich (which may well be less than the current figure of 8% for the 'Norwich area' quoted in the EDAW report).

- If the developers of housing at Long Stratton will be required to make a significant contribution to the cost of a bypass, this could be at the expense of securing sufficient developer funding to support a high quality public transport connection to Norwich.

- Development at Long Stratton would work better from a public transport perspective in conjunction with development at Mangreen / Swardeston / Mulbarton (Options 6, 6a) than in isolation (Option 2). The employment at Mangreen in Options 6, 6a may help to reduce the level of commuting to central Norwich. Demand from Mangreen / Swardeston / Mulbarton would help to support a more frequent bus service between Long Stratton and Norwich.

- Constraints on the development of public transport priority on the A140 corridor include the Dunston and Harford railway bridges and the A47 interchange. There is potential to provide a continuous bus lane on the A140 from the Harford Park & Ride site to the B1113 junction. There is potential to provide an inbound bus lane on Ipswich Road north of the Outer Ring Road but this would be at the expense of the existing on-street parking on this section of Ipswich Road. There is also potential to develop Hall Road as a bus priority route in place of Ipswich Road.

- Options 6 and 6a would require expansion of the Harford Park & Ride site or the construction of a site at Trowse to be brought forward to pull existing demand from the A146/B1332 corridor away from Harford.

A.4 Development at Mangreen – Public Transport Issues

On the face of it, an advantage of Mangreen / Swardeston / Mulbarton as a location for major development is the potential for rail to play a part in accommodating the additional trips generated by growth in this area. However, the evidence from further investigation is that it will be difficult to develop a business case for realising this potential.

There is no existing local rail service on the Great Eastern main line south of Norwich that could call at a new station at Mangreen. Discussions with railway industry stakeholders have identified a willingness to consider an additional station stop on the Norwich – London service, but have highlighted the following issues:

- The Norwich – London service has a strategic role for business travel. The current Norwich – London journey time is a political 'hot potato' and any proposal that would increase this is a problem for the train operator.

- Any increase in journey time arising from an additional stop would have adverse impacts on demand and revenue for flows to and from the existing Norwich station, which would need to be taken into account in the business case for a new station.

- The indicative cost of a station at Mangreen with platforms of sufficient length to accommodate Norwich – London trains (£8 to 10 million) is significantly higher than that for a station served by local trains only (£3 to 5 million).

- In the longer term (post 2014) there is potential to offset the impact of an additional station stop on journey times either by the introduction of new trains with improved performance or by implementing capacity or line speed improvements elsewhere on the Great Eastern main line.

There is, in principle, capacity available for a local rail service on the Great Eastern main line south of Norwich to serve new stations between Diss and Norwich, but the business case for such a service is likely to be weak. A new local service would have to generate sufficient revenue to meet the operating costs of both the new station and the two additional trainsets required to serve it at a 30 minute frequency.

Analysis of the detailed spatial relationship between the location of the majority of the developable land in the Mangreen / Swardeston / Mulbarton area and the location of a potential new station indicates that a rail service would be an unattractive option for local travel to and from Norwich relative to a high quality bus service operating on a direct route to the city centre and with an appropriate level of priority.

If the developers of housing at Mangreen / Swardeston / Mulbarton were required to fund both the cost of a new rail station and the cost of bus priority infrastructure, this would be at the expense of the ability of the developers to fund other key community infrastructure.

The constraints on the development of public transport priority on the A140 corridor, and the need for expansion of the Harford Park & Ride site or the construction of a new site at Trowse identified above are relevant to development at Mangreen as well as at Long Stratton.

A.5 Development in the South v Development in the South West

Development in the South West sector is considered preferable to development in the South sector for the following reasons:

- Development in the South West can be catered for by two public transport priority routes: **1**) via Thickthorn with enhanced bus priority measures on the A11/Newmarket Road over and above the existing extensive bus lanes; **2**) via Hethersett Lane to the Norwich Research Park with a potential direct link to the University Campus and then via Earlham Road with additional bus priority between the Inner and Outer Ring Roads.

- There are no existing bus priority measures on the A140 corridor to provide a base for the development of a public transport priority route, fewer potential routes to choose from and more constraints to overcome, with associated cost implications.

- Development in the South West offers greater potential to develop direct bus links to existing strategic employment sites including Gateway 11, Longwater and Norwich Research Park.

- Development in the South West would work well in conjunction with development at Wymondham to support a dedicated 'turn up and go' cross-city service on a South West to North East axis.

- Investigation of the potential for rail to play a part in accommodating the additional trips generated by growth in the South area has demonstrated that the spatial relationship between the developable land and the location of a potential new station at Mangreen is such that this potential is lower than first envisaged. Therefore the 'rail factor' does not provide a compelling reason to favour development in the South over development in the South West.

A.6 Recommendation

Option 1 is recommended as the preferred option from a public transport perspective out of those considered in this note. This option concentrates development in the smallest number of locations and thus offers the best opportunities for developing a strong market for public transport services. All of the proposed locations for major development in Option 1 have the potential to be served by public transport priority routes and all but one are on a single axis, enabling investment to deliver a step change in public transport service quality to be largely focused on one cross-city corridor.