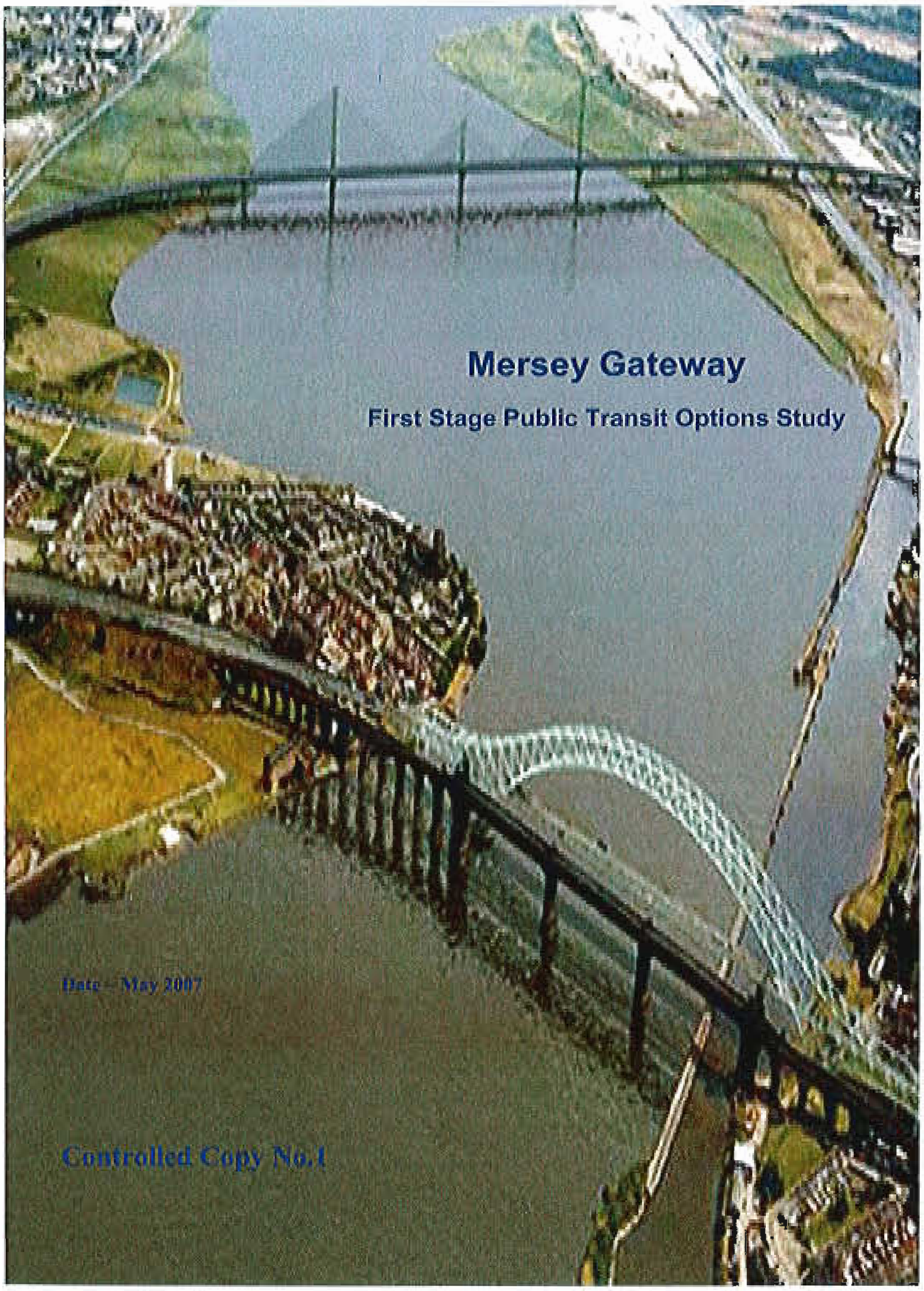
REID RAIL

THE RAILWAY CONSULTANTS



Mersey Gateway

First Stage Public Transit Options Study

Date – May 2007

Controlled Copy No.1

Document Control Sheet

Project Title: Mersey Gateway

Report Title: First Stage Public Transit Options Study

Client: Halton Borough

Report Status

Revision	Issue	Author	Date	Checked	Date	Approved	Date
	Draft issue for internal review	J Jordan	01/05/07	T Young	01/05/07	D. Reid	03/05/07
A	Draft issue for client review	J Jordan	02/05/07	T Young	02/05/07	D. Reid	03/05/07
B	Final Draft for client review	J Jordan	18/05/07	T Young R O'Neill	21/05/07	D. Reid	21/05/07
C	Revised final draft with client comments	J Jordan	01/06/07	T Young R O'Neill	03/04/07	D. Reid	04/06/07

Issue Status

Revision: C

Approved for Issue and Implementation

Project Director ....

Date ....

This report takes into account the particular instructions and requirements of our client. It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

Contents

EXECUTIVE SUMMARY

The overall objective of this study was to assess and identify potential public transport options which are likely to be both commercially viable and practically affordable and will also be complementary to, and be supported by, the Mersey Gateway scheme as a whole. This study has shown that a number of high level MG objectives are likely to be supported by improving public transport, including:

- To relieve the congested SJB, thereby removing the constraint on local and regional development and better provide for local transport needs;
- To improve accessibility in order to maximize local development and regional economic growth opportunities;
- To improve local air quality and enhance the general urban environment;
- To improve public transport links across the river.

Following on from this the detailed objectives for this Public Transport Study were as follows:

- To conduct a high level assessment of public transport options for the main corridors of cross-river movements in Halton;
- To identify those options worthy of further consideration for a range of improvements from minor bus priority to LRT and including also enhancements to heavy rail;
- To include indicative estimates of capital and operating costs and revenue in the assessment;
- To assess public transport improvements in the context of Halton Council's social inclusion, cross-river integration and Access Plan objectives;
- To include the effects of planned new developments in the evaluation;
- To present the findings in a summary table format drawing out the salient features of each option.

This high level first stage study consists of:

1. An initial Technical Options Assessment;
2. A sifting process to select preferred options based on a First Stage Demand Study; Socio-economic Assessment;
3. First Stage Demand Study of preferred options;
4. Indicative market assessment and indicative outline business case.

0.1 Alternative Technologies Examined

A top down approach has been adopted thoroughout this study in relation to the assessment and evaluation of transport technologies and systems that could be developed for the study area and to this end the following technologies have been examined:

- Personalised Rapid Transit (PRT);
- Ultra Light Rail (ULR);
- Guided busway (also including trolley bus);
- Busway;
- Light rail;
- Tram-Train;
- Heavy rail;
- Monorail.

0.2 Structure of the Report

The purpose of this working paper is to summarise the review of public transport options that could be considered for for Halton. Following this introduction, sections are included as follows:

- An initial review of the public transport options listed above;
- A description of those options rejected at the long-listing stage;

- A description of each of the options taken forward, including elements such as operation, cost and examples, both in the UK and elsewhere;
- An initial economic assessment for short listed public transport options;
- an outline of the indicative costs for light rail accessing the MG bridge;
- A summary analysis of the options suggested for short listing;
- A series of recommendations setting out the outcomes of this study

The report concludes with a set of reasoned justification for a course of action to improve public transport as as part of the Mersey Gateway Scheme.

Comment: Conclusion?

1.0 INTRODUCTION

1.1 Background

Reid Rail was commissioned in April 2007 by Gifford to undertake a preliminary high level study to identify and assess public transport options that could be taken forward as part of the Mersey Gateway (MG) scheme. The MG scheme consists of a new crossing of the Mersey and the de-linking of the existing Silver Jubilee Bridge (SJB) to cater for local traffic only.

This preliminary high level assessment is based on the extent to which the public transport options contribute to, and further enhance, Halton Council's Sustainable Transport Strategy and complement the delivery of the Mersey Gateway objectives. The study examines outline implementation strategies linked to the delivery and the potential funding available from the revenue streams generated by the Mersey Gateway Concession arrangements.

The potential for public transport improvements will vary by corridor and this study includes assessment of bus options as well as light and heavy rail options at the upper end.

The aim of this study is to assess, at a broad brush level, the potential for public transport improvements, , along the main corridors of movement in Halton, and including cross boundary movements, where relevant.

The new Bridge over the Mersey is designed to ease congestion on the existing Silver Jubilee Bridge between Widnes and Runcorn. The intention is that local traffic will use the existing and the regional traffic will use the new bridge. The structural design could accommodate a rapid transit option and indicative costs for accommodating a rapid transit /light rail option into the new bridge are included later in this study.

This first stage study examines the potential transport options that could be considered for serving Widnes and Runcorn.

1.2 Study Objectives

The overall objective of this study is to identify and assess potential public transport options and make recommendations as an integral part of the Mersey Gateway Scheme. A number of MG objectives will be achieved by improving public transport, in particular the following:

- Relieving the congested SJB, thereby removing the constraint on local and regional development and better provide for local transport needs;
- Improve accessibility in order to maximize local development and regional economic growth opportunities;
- Improve local air quality and enhance the general urban environment;
- Improve public transport links across the river.

Following on from this, the detailed objectives for this Public Transport Study are as follows:

- To conduct a high level assessment of public transport options for the main corridors of cross-river movements in Halton;
- To identify those options worthy of further consideration for a range of improvements including minor bus priority and rail based solutions and enhancements;
- To include indicative estimates of capital and operating costs and revenue in the assessment;
- To assess public transport improvements in the context of Halton Council's social inclusion, cross-river integration and Access Plan objectives;
- To include the effects of planned new developments in the evaluation;

- To present the findings drawing out the salient features of each option.

We understand that in Halton, bus services serve distinct local markets with Halton Transport mainly serving Widnes and Arriva North West the dominant operator in Runcorn. A north-south public transport corridor has been identified as a key issue for the second LTP to encourage more cross river integration.

It is clear that given that 80% of present day SJB traffic has one or both trip ends outside the Borough, a locally centred LRT scheme, unless part of the wider Merseytram network, is likely to be very difficult to ojustify as opposed to a quality bus system.

We understand that in Halton, bus services serve distinct local markets with Halton Transport mainly serving Widnes and Arriva North West the dominant operator in Runcorn. A north-south public transport corridor has been identified as a key issue for the second LTP to encourage more cross river integration. It is equally important to improve public transport links from both sides of the river to hospitals for example in Warrington.

The effect of new homes and jobs will be evaluated within the study including Widnes Waterfront and residential developments in Runcorn.

This study looks at the level of demand and service networks for the existing bus corridors and services and the existing rail routes and services in order to quantify existing and forecast future demands, and potentially thereby determine the business case for a high quality rapid transit link.

1.3 Methodology and Tasks

Key tasks that have been undertaken to support the study have included the following:

- An inception meeting with Halton Council confirmed the above objectives and has identified a long list of options to be examined;
- Two interim progress meetings;
- Production of draft and final reports, with indicative short list of alignments only at this stage;
- A meeting with Mott Macdonald to discuss their trip study and data sets;
- A review meeting with Partners and stakeholders on the short list of preferred options for detailed study.

The methodology has included the following:

- Development of a clear assessment framework for potential solutions, with definitions for tram and tram-train, through segregated Bus Rapid Transit to quality bus corridors. This is to cover vehicles, segregation, road space allocation and complementary infrastructure, suitability of the existing Silver Jubilee Bridge;
- Scoping of acceptable potential solutions with Halton Council and immediate stakeholders addressing potentially contentious issues such as road space reallocation and vehicle type;
- High-level engineering review of feasible solutions on potential alignments;
- A high-level comparative appraisal of all potentially feasible options, taking into account the scheme objectives, demand benchmarking, and NATA economic, social and environmental appraisal criteria;

Section 8 of this study has included an analysis of the market for travel within Halton followed by demand forecasting, and based on the outputs the production of cost estimates and the building of the outline business case. These are discussed in detail below.

Comment: ?????

1.4 Market Analysis

The objective of the analysis was to build a detailed picture of the market environment, the overall market for travel, the market for travel by public transport and public transport customer profiles. This is based on existing data sets. No additional data has been collected.

Outputs from the analysis provide key inputs to the demand forecast and business case for the project.

The first stage of the market study has been gathering relevant data. In order to establish robust trends we sought to gather five years of validated historical data and available validated forecasts or projections. Although this has not been possible for all categories we have gathered sufficient information to support our analysis. The following data has been examined and collated:

- Population (age and gender profiles) - 2001 census by ward also IMD and ACORN social class (map format)
- Employment / unemployment levels – employment 2004 /06, claimant count 2000/07
- Car ownership - 2001
- GDP per head – GVA/head 1995/2004
- Policy / land use / development proposals likely to impact on the market environment – location of key services in map format, retail development schemes in progress / applied for

Suitable data could not be obtained on the following:

- Training / further education
- Industrial output by sector
- Exports / imports

In terms of travel behaviour the following data has been collated (for key study area corridors):

- Travel surveys / travel behaviour statistics – MG Traffic Survey, mode of travel to work 2001 census by ward; SJB traffic counts April / May 2006
- Road traffic levels and forecast – estimated traffic flows (vehicle km) 1995/2005
- Roads investment programme - LTP
- Bus service services- published timetables
- Comparative performance e.g. journey times, congestion, reliability – published data
- Comparative costs e.g. motoring costs, public transport fares – published sample fares

The following data has been explored for public transport where available:

- Passenger volumes – MG traffic survey
- Passenger revenues – none available
- Service features – e.g. routes, frequencies, journey times, performance, prices (fares), customer facilities – published timetables, fares and transport statistics
- Recent market research – including socio-economic profiles, journey purpose, attitudes / satisfaction with existing rail services, attitudes / sensitivity to different elements of the marketing mix (e.g. destinations, journey time, frequency, price, customer service, promotion and advertising) – none available

This study has identified the likely need for a limited programme of market research, collecting data for later / subsequent stages of this work.

1.5 Demand Forecasting

We have adopted a simple demand forecasting process for this project based around the guidance and evidence published by the Department for Transport (DfT) and Commission for Integrated Transport (CfIT)

using available data sets only. The process we have used is highly transparent and can be further refined as new data becomes available.

We have compared the results from the demand forecasting process with actual patronage achieved by existing UK public transport operations. As part of this validation we have derived some basic trip rates which can be built upon in future analyses.

Output from the demand forecasting process has been used to evaluate economic benefits in relation to:

- Road de-congestion and modal split;
- Reductions in vehicle operating costs and other measurable PT operator benefits;
- Safety benefits;
- Local air quality benefits;
- Reductions in global emissions;
- Noise and vibration reductions;
- Wider socio-economic impacts i.e. employment;
- Reduction in barriers;
- Severance;
- Option values;
- Other environmental impacts – landscape, townscape, biodiversity, heritage, land and water pollution.

1.6 Indicative Outline Business Case

The outputs from the demand forecasting work stream and the cost estimates have been brought together into an outline business case appraisal framework.

This follows the DfT guidance on transport scheme appraisal and provides an indicative benefit / cost ratio calculation for the selected rapid transit option

This outline business case from the first stage study will:

- Determine if there is a viable public transport element within the MG project;
- Determine the value of a substantial upgrade of bus services;
- Determine the value of Bus Rapid Transit or a light rail solution including heavy rail options;
- Determine the value of wider community benefits of each option, including employment and accessibility across the river.

1.8 Public Transport Options Examined

A wide range of potential public transport systems have been examined for this study as follows:

- Personalised Rapid Transit (PRT);
- Ultra Light Rail (ULR);
- Guided busway (also including trolley bus);
- Busway;
- Light rail;
- Tram-Train;
- Heavy rail;
- Monorail.

More detailed descriptions of the characteristics of each of these are included later

1.9 Structure of the Report

The purpose of this study is to summarise the review of public transport options available for Halton. Following this introduction, sections are included as follows:

- An initial review of the public transport options listed above;
- A description of those options rejected at the long-listing stage;
- A description of each of the options taken forward, including elements such as operation, cost and examples, both in the UK and elsewhere;
- An initial economic assessment for short listed public transport options;
- an outline of the indicative costs for light rail accessing the MG bridge;
- A summary analysis of the options suggested for short listing;
- Conclusions and Recommendations

2.0 INITIAL REVIEW OF PUBLIC TRANSPORT OPTIONS

Comment: remove - study doesn't exist?

Add: conclusions and recommendations

2.1 Overview

An initial review of the alternative technology options listed above was undertaken, based on a detailed examination of the following:

- Spatial characteristics, to determine the ease with which each system could be integrated into the town centres in Runcorn and Widnes, the suitability for accommodation within the Mersey Gateway Bridge (MG) and potentially, the Silver Jubilee Bridge (SJB), a factor that is not necessarily required initially, but one which would allow for future system flexibility and extension;
- The possible energy technologies for each system and determine which transit technologies have been proven commercially and which provide measurable environmental benefits through low emissions and low carbon footprint;
- Vehicle capacity and system capacity matched to likely future demand including indicative networks;
- Indicative system performance for each public transport option;
- Indicative vehicle and infrastructure cost for each public transport option.

2.2 Spatial Characteristics

The table below summarises at a broad level and from a physical perspective the anticipated ease with which each system could be physically integrated into the Halton area. This analysis has taken into consideration the typical dimensions of the vehicles and their alignment requirements for operation along segregated and shared rights of way.

The table illustrates that heavy rail services would be the most difficult to integrate into the urban environment, given the requirement to operate on dedicated rights of way with full segregation. The other technologies have a lower requirement for segregation, and are potentially easier to integrate into the urban area and can share traffic lanes where necessary.

Table 2.2 Spatial Characteristics of Public Transport Options

Public Transport Option	Integration Into The Urban Environment	Typical Alignment Width	Characteristics
Personalised Rapid Transit / Ultra Light Rail	Limited to severe severance depending on proprietary system adopted. Track sharing with cyclists, bus services, taxis and emergency vehicles generally not practicable.	3.0 - 4.0	Based on published data for proprietary systems
Guided busways	Little severance (for optical and centre rail guidance) to severe severance (for kerb guidance) Track sharing with cyclists, bus services, taxis and emergency vehicles practicable for on street sections with optical and centre rail guidance. Impractical for kerb guidance	6.0 - 6.3	Rolling stock typically 2.5 metres wide. 12 metres long (rigid bus) to 18 metres long (bi-section articulated bus) for street legal operation in UK. Longer tri-section units restricted to dedicated right of way.
Busways	Little or limited severance, track sharing with cyclists, taxis and emergency vehicles practicable	8.0 – 10.0	Vehicles typically 2.5 metres wide, 12 metres long (rigid bus) to 18 metres long (bi-section articulated bus) for street legal operation in UK. Longer tri-section units restricted to dedicated right of way.
Light rail (excluding Tram-Train)	Little or limited severance. Track sharing with cyclists, bus services, taxis and emergency vehicles practicable for on street sections.	5.5 - 6.5	Rolling stock typically between 2.2 and 2.65 metres wide. Typically 35 – 60 metres long. Typically bi-section or tri-section single units or multiple unit operation. 60 metres long is maximum UK limit for in street operation
Heavy rail	Severe severance a feature of dedicated and fenced right of way	6 - 6.5	Typical for tram-trains on dedicated alignments
Monorail	Systems are normally grade separated with elevated track	Not applicable	Monorails could operate on dedicated guideways

2.3 Energy Choices for Public Transport Options

Overview

Investment in any new public transport option will necessarily be accompanied by a desire to utilise those accompanying power supply options which are energy efficient. Appendix XX examines in more detail the different power technology options that can be adopted by illustrating whether individual traction systems would be suitable for each technology.

Recommendation

This study does not exclude the application of trolleybus and dual mode technologies as a traction option for bus based rapid transit solutions for Halton. Electrification can be applied to the bus based rapid transit options described in following chapters for busways and guided buses.

However electrification of bus based rapid transit solutions is not a prerequisite to the deployment of these systems which can all be based initially on diesel or low emission bio-fuel

Electrification using trolley bus and dual mode bus of a low emission bus based rapid transit option for Halton remains as an option for the future, worthy of further investigation, subject to detail technical and investment appraisal

2.5 Operational Characteristics of Public Transport Options

There are several other factors that determine whether a particular technology would be suitable for Halton, and these are summarised in the Table 2.4 below.

Some of the key conclusions shown in the table are the limited capacity of personalised rapid transit systems and ultra light rail, whilst the costs for monorails are very high. Although it is difficult to form meaningful comparisons, the unit cost of monorails varies from £5 million to £75 million per kilometre, and is therefore significantly more expensive than the bus or rail based alternatives, for which the cost per kilometre ranges from £2 million to £15 million.

Table 2.4 Typical Performance Characteristics of Public Transport Options

Performance Characteristics	Personalised Rapid Transit	Ultra Light Rail	Guided Busway	Busway	Light Rail	Tram-Train	Heavy Rail	Monorail
Vehicle capacity	4	20-60	75-125 (based on 12m-18m articulated vehicles)	75-125	400 (based on two twin 30m units)	400 (if operating on-street)	70-400 (depending on train formation)	100
Typical system capacity per hour ('000s)	0.5-1	0.5-2	4.5-7.5	6-10	1-21	1-25	1-32	2-5
Operational speed (km/h)	25	35-60	30-60	Up to 80km/h Dependent on road conditions	Up to 80km/h	Up to 120km/h	Up to 120km/h	30-50
Vehicle cost (£m)	Not known	0.5-1.5	0.15-0.4	0.15-0.4	0.8-2.0+	1.2-2.2	1.8-3.0	Very high
Dedicated Infrastructure Cost / km (£m)	Very high	Medium / high	High	High As for highway	High	As for Light rail	Very high	Very high

3.0 LONG LIST OF PUBLIC TRANSPORT OPTIONS

3.1 OVERVIEW

Based on this high level analysis, the following criteria were used to undertake an initial sift of options to eliminate those public transport options that are unlikely to fulfil the requirements of Halton by meeting the overall objective of this preliminary study which is to assess viable public transport options which are likely to be both commercially viable and practically affordable and will also be complementary to, and be supported by, the Mersey Gateway scheme as a whole.

- commercially available, proven technology;
- cost;
- typical system capacity;
- operational speed.

The following section includes a brief description of these rejected public transport options.

Following this there is a description of the characteristics of the selected list of public transport options, including reviewing the suitability of these systems for deployment in Halton in more detail.

3.2 Rejected public transport options

3.2.1 Overview

As a result of the initial review of alternative technologies, the following were rejected:

- Personalised rapid transit (in terms of system capacity and operational speed);
- Ultra light rail (in terms of system capacity and operational speed);
- Monorails (in terms of operational speed and cost);
- Trolleybus (in terms of immediate application to selected bus options.

More detail on the reasons for rejection can be found in Appendix B.

3.3 Selected public transport options

3.3.1 Overview

As a result of the initial review of public transport options, the following were selected for further consideration and preliminary evaluation and Appendix B provides a more detailed description and overview of the options:

- Medium level Bus Priorities;
- High Level Bus Priorities;
- Bus rapid transit using guided busways;
- Bus rapid transit using buses only roads;
- Higher performance light rail;
- Opportunities for tram-train;
- Heavy rail development.

No detailed description and discussion of regular medium or high level bus priorities is included in this stage of the study since these bus priority techniques are familiar and widely practiced.

Appendix B provides a more detailed description and explanation of the above public transport options that that have been considered and evaluvarious rapid transit and bus and rail based options that have been considered as having potential for further consideration and investigation.

4.1 Overview

The Public Transport Objectives of this study have been identified as follows:

- To conduct a high level assessment of public transport options for the main corridors of cross-river movements in Halton;
- To identify those options worthy of further consideration for a range of improvements from minor bus priority to LRT and including also enhancements to heavy rail;
- To include indicative estimates of capital and operating costs and revenue in the assessment;
- To assess public transport improvements in the context of Halton Council's social inclusion, cross-river integration and Access Plan objectives;
- To include the effects of planned new developments in the evaluation;
- To present the findings in a summary table format drawing out the salient features of each option.

4.2 Major Traffic Objectives

The indicative long list of options set out below identified the major traffic objectives that any transit system in Halton should aim to serve. Following the Inception Meeting with HBC, the revised list includes all the traffic objectives identified. Those marked '*' are existing or potential modal interchanges.

Halton north of river

- Widnes town centre/Vicarage Road *(Milton Road area/Municipal Buildings/Halton College/Halton Stadium);
- Green Oaks*;
- Widnes Rail Station/Farnworth*;
- Widnes West Bank/Riverside;
- Hough Green – Rail station*;
- Widnes Waterfront;
- Ditton strategic rail freight interchange.

Halton south of river

- Runcorn High Street/Bus Station*;
- Runcorn Rail Station*;
- Halton Lea Shopping centre*/Trident retail Park/Cinema;
- The Heath Business and Technical Park/High School;
- Halton Hospital;
- Runcorn East Rail Station*/Murdishaw;
- Daresbury Science Park / Daresbury Park;
- Whitehouse;
- Manor Park;
- Astmoor;
- Weston Point / Rock Savage/Ashville.

External to Halton

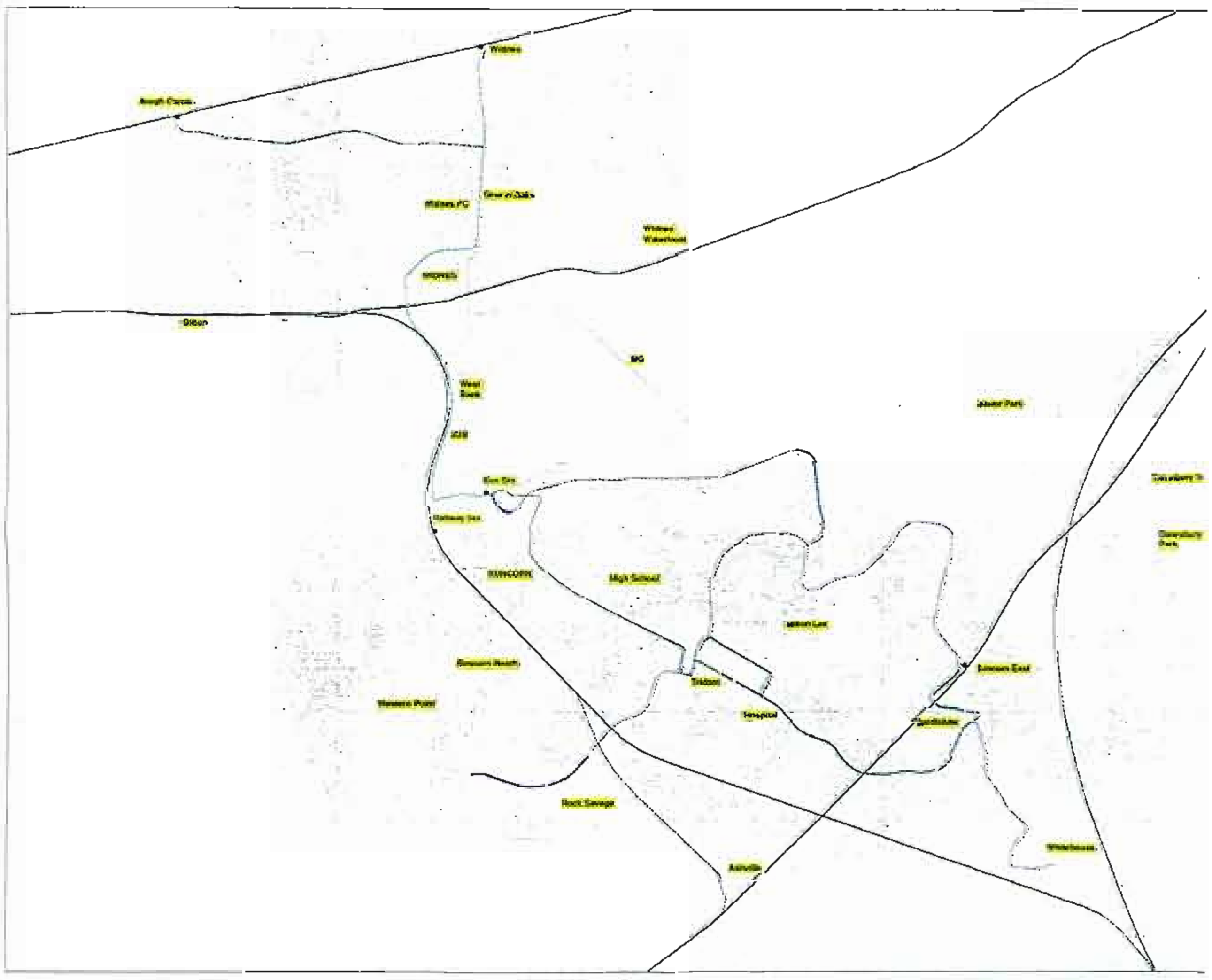
- LJLA*;
- Liverpool*;
- St Helens*;
- Warrington inc. Omega Development;
- Warrington Hospital;
- Chester*;
- Manchester*;
- Liverpool South Parkway*.

The extent to which the external traffic objectives could be included in any network will depend on the mode, the network and how it would develop and on the route options selected.

4.3 Indicative Route Options

It is not feasible to devise a transit route that serves all the defined traffic objectives.

The indicative route options are set out in Figure 1 and shcw the potential for routes aimed at serving the primary objectives and as many others as possible.


Widnes
Widnes FC
Ditton
West Bank
RUNCORN
High School
Hospital
Western Point
Rock Savage
Whitehouse

REID RAIL
THE RAILWAY CONSULTANTS

Three possible route options were defined at high level to link these traffic objectives, one via the SJB and two via the MG (see Table 4.1).

Table 4.1 Indicative route options for Halton.

Route Option	Line Description
Route A	Hough Green/Widnes Station Green Oaks Widnes town centre SJB Runcorn High Street Busway Halton Lea Murdishaw
Route B	Hough Green/Widnes Station Green Oaks Mersey Gateway Busway Halton Lea Murdishaw.
Route C	Hough Green/Widnes Station Green Oaks Mersey Gateway Busway Runcorn High Street Halton Lea Murdishaw.

There is a need to serve Runcorn old town and Runcorn rail and bus stations, and Halton Lea. It is possible to serve both objectives via the SJB so only one route is necessary, Route A, but two routes are needed via the Mersey Gateway because of the entry point to the busway at Astmoor.

All three routes were shown continuing from Murdishaw to Warrington to satisfy the need for a good transit link, particularly to serve Warrington Hospital. However, a shorter route could be devised from the north end of the transit route which would not need to re-cross the river and Manchester Ship Canal. A Halton-Warrington extension would be inter-urban in character and probably better served by a different mode rather than as an extension to the transit system, with the possible exception of a tram-train solution. A tram-train stop could be located close to Warrington District General Hospital.

4.4 Route Lengths

Route lengths have been measured and are shown in Table 4.2.

Table 4.2 Route lengths for transit route options.

Route section	Length km	Alignment type	Transit Routes
Widnes Station – Green Oaks	1.71	On-street	A, B, C
Hough Green – Green Oaks	3.79	On-street	A, B, C
Green Oaks – Widnes Town Centre	1.29	On-street	A, B, C
Widnes Town Centre – West Bank	1.21	On-street	A
Widnes Town Centre – Astmoor via MG	5.43	0.57 On-street 4.86 Segregated	B, C
Astmoor – Halton Lea	3.79	2.86 Busway 0.93 On street	B
West bank – Runcorn Rail Station via SJB	1.71	On-street	A
Runcorn Rail Station – Runcorn Bus Station	0.71	On-street	A
Runcorn Bus Station – Halton Lea via Heath	5.00	3.86 On-street 1.14 Busway	A, C
Runcorn Bus Station – Astmoor	2.21	Busway	C
Halton Lea – Runcorn East	3.93	Busway	A, B, C

The total route lengths for each Transit Route (excluding the Hough Green spur) are:

Route A: 15.56 km (10.49 on-street, 5.07 busway).

Route B: 16.15 km (4.50 on street, 4.86 segregated, 6.79 busway).

Route C: 19.57 km (7.43 on street, 4.86 segregated, 7.28 busway).

The total route lengths for each Transit Route including the Hough Green spur but excluding Widnes Station to Green Oaks are:

Route A: 17.64 km (12.57 on-street, 5.07 busway).

Route B: 18.23 km (6.58 on street, 4.86 segregated, 6.79 busway).

Route C: 21.65 km (9.51 on street, 4.86 segregated, 7.28 busway).

4.5 Journey Speeds

Typical journey speeds for the alignments types are likely to be in the region of the following:

On street - 20 km/hr
Busway - 25 km/hr
Segregated - 40 km/hr.

Applying these average speeds to the journey lengths gives the following run times (times in brackets are from Hough Green):

Route A - 44 mins. (50 mins.)
Route B - 37 mins. (43 mins.)
Route C - 47 mins. (53 mins.)

4.6 Peak Vehicle Requirements (PVR)

Applying the journey times to the route options gives the numbers of peak vehicles required as set out in Tables 4.3 to 4.5 below for service frequencies of 3, 4 and 6 transit vehicles per hour (i.e. 20 minute, 15 minute and 10 minute services).

Table 4.3 PVR for route options (3tph).

Route	Journey time (mins.)	Layover time	Total round trip time (mins.)	PVR		
A	44	12	100	5		
B	37	6	80	4		
C	47	6	100	5		

Table 4.4 PVR for route options (4tph).

Route	Journey time (mins.)	Layover time	Total round trip time (mins.)	PVR		
A	44	17	105	7		
B	37	16	90	6		
C	47	11	105	7		

Table 4.5 PVR for route options (6tph).

Route	Journey time (mins.)	Layover time	Total round trip time (mins.)	PVR		
A	44	12	100	10		
B	37	6	80	8		
C	47	6	100	10		

These tables show that Route option B would require slightly fewer vehicles while Route option C requires the same number of vehicles as Route option A. However it must be borne in mind that to provide the same level of access to major traffic objectives it would be necessary to operate both Routes B and C with a combined service. These options are for illustrative purposes and do not take account of a link to Hough Green which would also require a combined service.

These route options are indicative and would need to be developed in more detail when more comprehensive demand data is available. Operating pattern options, and optimum network options would need to be investigated.

5. INITIAL DEMAND STUDY

5.1 Overview

The purpose of this section of the study is to provide an initial scoping of potential passenger demand for the short listed public transport options which could form part of the Mersey Gateway Project.

Passenger demand will be influenced by transit route(s) which are identified in the preceding section, the existing transport needs of the catchment population, the likelihood of existing travellers switching from their current mode to alternatives. This section of the study considers these influencing factors in order to determine an outline estimate of patronage.

5.2 Existing Travel Patterns

In 2006 a series of traffic and travel surveys were conducted specifically for the Mersey Gateway project. They measured bus and rail passenger trips and traffic flows crossing the Mersey between Runcorn and Widnes.

The survey results indicate that there are in the region of 2,000 bus passengers in each direction every weekday. These journeys are spread across the entire range of services that use the Silver Jubilee Bridge (SJB), including routes serving Liverpool and Warrington.

The rail survey included passenger counts at Runcorn station and trains crossing Runcorn Rail Bridge. The results of the station counts indicate that trips between Runcorn and stations to the South represent the strongest passenger demand; journeys between Runcorn and stations to the North number about 400 a day (single journeys in both directions). Comparing this with published information about total passenger volumes at the station we can deduce that about 30 to 40 per cent of journeys starting or finishing at Runcorn cross the Mersey.

On-board passenger counts of train services crossing the Mersey suggest an estimated 2,500 passengers a day in each direction. However the survey found that the majority of these passengers were making long distance trips passing through Halton Borough.

Traffic surveys have measured about 80,000 – 85,000 vehicles movements across the Silver Jubilee Bridge each day. Of these approximately 18 per cent start and finish within Halton Borough, 38 per cent have either a start or finish point in Halton Borough and 47 per cent simply pass through the Borough having start and finish points over a much wider area. Roughly ten per cent of the vehicles are heavy goods vehicles (HGV) or buses.

We have used 80,000 -85,000 daily flows based on evidence in the SJB traffic count data, MG traffic survey and statements in the LTP. It is thought prudent to include a low – high range so as not to produce over optimistic PT patronage forecasts.

5.3 Potential Modal Switch

The most significant source of passengers for a new LRT system will be existing travellers switching from other modes, private car, bus and rail.

Writing in The Guardian in 2001 Professor David Begg, then chair of the Commission for Integrated Transport said "Trams here and in Europe have proved an attractive alternative to the car. They look new, comfortable and exciting. Watch any new scheme shortly before it comes into service and see the curiosity of the public - which cannot wait to give the scheme a try. Confidence in any new system is demonstrated dramatically by the house prices along the route corridors. In Croydon, estate agents saw prices rocket as people saw an alternative - much faster and better - way of getting to work. Those figures are confirmed by considering what has happened to car use and parking. Croydon is forecast to take 10% of traffic off the road along the corridors it serves. In Manchester and Sheffield, the equivalent figure is 20%...."

Professor Begg's assertion on modal switch from car is confirmed in guidance published by the Commission for Integrated Transport (CfIT) in 2005. The following table is an extract from the guidance and the LRT figures draw upon evidence from Sheffield, Manchester and Croydon.

5.4 Evidence on patronage transfer from car and public transport

	Light Rail	Guided Bus	Bus Lane
% transfer from car	12.5% - 20%	3%	3% - 10%
% transfer from other public transport	48% - 69%	6%	

Source: Affordable Mass Transit; Commission for Integrated Transport Sept. 2005

Considering first the road traffic flows we can estimate a range of values for modal switch for cross river travel based on the travel survey information for existing flows over the SJB and the CfIT guidance. The table below shows the calculation:

	Low	High
Daily traffic movements	80,000	85,000
Less HGV and bus movements assumed at 10%	-8,000	-8,500
Trips wholly within Halton at 18%	12,960	13,770
Potential transfer to LRT 12.5% - 20%	1,620	2,750
Trips with start or finish in Halton at 38%	27,360	29,070
Potential transfer to LRT 12.5%	3,420	3,630
Estimated number of trips to switch from car to LRT	5,040	6,380

The traffic surveys identified that more than three quarters (79%) of vehicles were single occupancy so for the purposes of this calculation we have assumed those likely to transfer to LRT will be from single occupancy vehicles. For trips wholly within Halton we have assumed the bottom end of the CfIT evidence percentage (12.5%) for the low estimate and the top end (20%) for the high estimate.

In the case of trips with either a start or finish in Halton we have assumed that only the low end of the guidance percentage range is likely to switch. Measures such as park and ride facilities at the fringes of the LRT route(s) would probably be required in order to achieve this potential.

The CfIT evidence suggests potential for bus passengers to switch to LRT is in the range of 48% to 69%. Applying these percentages to the cross river bus survey results of 4,000 trips per day would give a low estimate of 1,920 transferring to LRT and a high estimate of 2,760.

Results from the rail survey indicate that most journeys are longer distance and therefore we have assumed that potential for switch to LRT will be negligible.

Based on the above calculations we have a cross river patronage estimate in the range of 7,000 to 9,000 trips per day. However this does not take into account trips wholly within Runcorn or wholly within Widnes for which we have no evidence of existing travel patterns. However, it is evident that the two towns are self-contained each having many of the key facilities which generate local trips. Therefore we believe it is reasonable to assume that there will be as many trips on the LRT system in each of the towns as those estimated between the towns. Using this assumption applied to the cross river calculations results in an estimated daily trip rate of 21,000 – 27,000. We would recommend collection of data on trips wholly within Runcorn and Widnes so that the patronage projections can be refined in future stages of the scheme when more detailed quantitative assessments are required.

We understand it would be the intention to introduce bridge tolls on vehicles using both Mersey Gateway and Silver Jubilee Bridges. These road charges would impact on traffic flows over the bridge and the potential modal switch from road to LRT. In depth modelling, taking account of the generalised cost of all alternative modes, would be required in order to arrive at a robust projection of the tolling impact. Construction of such a model is outside the scope of this high level assessment. However, from the above analysis we can see that bridge tolls would only affect cross river traffic which we have assumed will make up a third of the total patronage. Therefore, the potential impact is limited to achieving higher modal shift rates on these flows. For this stage of the study it is probably prudent to consider the potential impact of bridge tolls as supporting the high end range of the patronage projections included above.

5.5 Generated Passenger Demand

Introduction of a new LRT system for Halton Borough would be expected to support accessibility and regeneration objectives. These include improving the ability of people to access places of work, education, health services, shopping and leisure. Key facilities include the main commercial centres of Halton Lea, Widnes and Runcorn town centres; Halton Hospital; key employment sites (Astmoor and West Bank); Colleges and Sixth Form Centres.

The route options considered for the LRT system will bring about improvements by providing direct access and connectivity to a number of the key facilities (see separate Section on option development). As such the system will be expected to generate new passenger demand.

There is little specific evidence to draw upon for estimation of likely generative effects of a new LRT system. We are able to consider growth experienced on other UK LRT systems, as newly generated demand is more likely to occur over time rather than immediately on introduction of the service. However, it is difficult to separate the generation effects from other factors such as the build-up of modal switch demand in the early period after introduction and growth due to exogenous factors such as economic prosperity.

Taking all these factors into account we believe a reasonable estimate of generated passenger demand would be in the range of 2 to 5 per cent per annum for the first three years of operation. Applying this assumption to the base estimate of 21 – 27k would give a daily patronage of 22 – 31k by the end of the third year of operation. This converts to an annual patronage in the range 7.5 million to 9.7 million trips, as summarised below.

	Low 000's	High 000's
Daily patronage from modal switch	21	27
Plus generated growth by end year 3	22	31
Weekly factor*	6.5	6
Weekly patronage	145	188
Annual patronage	7,532	9,752

* assumes weekend patronage is 75% of weekday for low estimate and 50% for high estimate (this is because the higher daily patronage is likely to rely on higher modal share in the peak which is not likely to be sustained on Saturdays and Sundays)

5.6 Comparison with Existing Light Rail Systems

In order to validate the patronage estimates we have compared them with passenger numbers and other key data for a selection of existing LRT systems in the UK. The comparisons are shown in the following table:

	Passenger Journeys(m)	Route Kilometres	Journeys per km (m)	Population	Journeys per capita
Croydon Tramlink	23	28	0.8	330,587	69
Nottingham NET	10	14	0.7	266,988	37
Sheffield Supertram	13	29	0.4	513,234	25
Halton low estimate	7	16	0.4	118,752	59
Halton high estimate	10	22	0.4	118,752	84

Although it is accepted that these comparisons are somewhat basic they do provide a broad indicator which suggests that the "high" estimate is likely to be over optimistic whereas the "low" estimate is within a range being achieved by existing systems. However, it should be noted that none of the existing LRT systems have road pricing measures as an influencing factor as would be the case with the proposed introduction of bridge tolls for both the Mersey Gateway and Silver Jubilee Bridges.

5.7 Passenger Revenue

In order to establish a passenger revenue estimate for the business case assessment we have applied an average fare to the passenger volume estimates. The fares range is derived from figures published in "Rapid Transit Monitor" updated to reflect current prices giving an average fare of 71p to £1.16 which in turn provides a passenger revenue estimate of £5.33m to £11.25m

6. INDICATIVE COSTS and OUTLINE BUSINESS CASE

6.1 Capital Costs

We understand from the MG bridge design team that the form of the bridge deck has been determined on pure structural grounds. The lower decks, which would accommodate a light rail tracks or other form of rapid transit form the bottom slab of the cross-section and the arrangement is as it is to provide the required construction depth.

It was recognised early on in the project that the bottom slab would be available for use by light rail, if this was considered feasible and economically viable. The design team estimate that there would be no major

structural implications of adding light rail and that an indicative allowance of £0.5M should cover the additional fittings (track plinths, stray current provision, etc.).

It is reasonable to assume that the light rail route would enter from the north side of the north abutment on the Widnes side and leave on the east side of the south abutment on the Runcorn side. The cost to the highway alignment would be relatively low. The indicative cost of modifying the two abutments and for providing additional bridges for crossing the St Helens Canal and the Bridgewater Canal and the Daresbury Expressway would be of the order of £7M to £10M to allow for localised approach works.

Access works should not be too extensive on the Widnes side and indicative costs are £0.25M. On the Runcorn side a fairly cost effective solution of converting the retained embankment to a cellular approach structure with a top slab for the road and a sloping lower deck for the light rail, which would then have to exit the cellular structure on one side or the other. The indicative structural costs would be of the order of £2M.

If an external ramp used, then the indicative cost would be of the order of £5M.

The accommodation costs will be broadly similar for a busway / guided busway if this was selected instead of light rail.

The overall length of the bridge is 2.285 km. The indicative cost for installing electrically insulated light rail track works on structure would be typically of the order of £800 to £1000 per single track metre or £3.5 to £4.5M for double track across the bridge.

Total system costs for the remainder of the route would be expected to be in the order of £10m - £15m per kilometre. This is a full cost amount including infrastructure (i.e. track works, power supply and stations) vehicles and depots but excluding land acquisition. Applying these cost rates to the route length excluding the bridge gives capital costs in the range £138.65m to £207.98m. A summary of capital costs for high and low estimates is shown in Table 6.1.

Table 6.1 Capital Costs Summary

	Low (£m)	High (£m)
Additional fittings for light rail	0.50	0.50
Localised approach works	7.00	10.00
Access works – Widnes side	0.25	0.25
Access works – Runcorn side	2.00	5.00
Track works – bridge	3.50	4.50
Full system costs excluding the MG bridge	138.65	207.98
Total	151.90	228.23

A comparison of indicative capital costs for the main mode options is given in Table 6.1A) All figures relate only to Route B between Widnes Station and Runcorn East via MGB and Halton Lea. The costs of works over the length of the MGB itself would probably be broadly similar for all the mode options. It has therefore been assumed that the costs for the low and high estimates given in Table 6.1A would apply to all modes. No separate cost has been given for tram-train as it would be expected to be the same as light rail for this part of the route. It should be noted that the total system costs include rolling stock for light rail but not for the bus based options as the operators would be expected to fund the vehicles.

Comment: ?? 6.1 A?

Table 6.1A Capital costs of mode options

Mode	Typical Range Capital cost per route km Low (£m)	High (£m)	Capital cost for Route B including MGB Low (£m)	High (£m)
Bus priority (Base case)	0.1	0.3	14.6	24.4
High Level Bus Priority	1	2	27.1	48.0
Busway	2	4	41.0	75.7
Guided Bus	4	6	68.7	103.4
LRT/Tram	10	15	151.9	228.2

Recommendation

The design team estimates above indicate that there would be no major structural implications of adding light rail or similar rapid transit system including the various bus rapid transit options considered in this study. We recommend that consideration is given to making budget provision for the costs of localised approach works and access works with an indicative cost of £16M as indicated in this study.

The indicative costs for the minimum accommodation works would be £6m i.e. excluding the estimated indicative cost of £10m for localised approach works and we recommend that provision is made within the MG scheme for these minimum accommodation works as a prudent future proofing measure.

We do not recommend that light rail track works are provided for, in view of the wider outcomes of this study, given that the rail / wheel profiles of light rail and tram-train vehicles are very different and that a bus based rapid transit option is not discounted in this study. Consequently such intent would be premature.

6.2 Operating Costs

Evidence published by CfIT suggests operating costs in 2003/04 of £3.79 per vehicle kilometre. This figure is based on mean 2003/04 costs for Manchester, Tyne & Wear, Sheffield, Midland Metro and Croydon as reported in *Rapid Transit Monitor* (figures include depreciation). This unit cost has been increased using a GDP deflator to reflect current prices giving a cost of £4.07 per vehicle kilometre.

We have calculated a range of costs based on the unit rate and vehicle kilometres derived from the route option data provided in section 4 of this report. The low end of the range is calculated based on route option A at three transit vehicles per hour, the high end of the range is based on route option C at six transit vehicles per hour.

Table 6.2 Operating Costs

	Low	High
Annual Vehicle Kilometres (000's)	568	1,581
Annual Operating Costs (£m)	2.3	6.4

6.3 Outline Business Case

For this first stage study the outline business case places focus on the LRT option which has the greatest potential to achieve the policy objective of modal switch and the consequent reduction in traffic congestion. It also has a high capital investment requirement, therefore, providing a good "litmus test" on the affordability of short-listed rapid transit options.

The business case assessment has been prepared taking into account Transport Appraisal Guidance (TAG) provided by the Department for Transport. Estimates of costs and benefits are consistent with Phase 1 High Level Strategic Assessment in terms of degree of detail and complexity. The assessment includes a financial appraisal of direct costs and revenues (base prices used in the appraisal are 2006/7 over a thirty year

appraisal period) the results are summarised in Table 6.3. For other impacts, financial values have not been calculated but an assessment has been undertaken on a seven point scale and is summarised in Table 6.4.

Table 6.3 Financial Appraisal Present Value Summary

Financial impacts	PV Summary £m	
Capital costs	152	228
Operating costs	45	124
Total Costs	197	352
Net additional revenue	121	256
Net financial effect	-75	-97

Table 6.4 Other Impacts

The following table provides a qualitative assessment of the impact of a rapid transit scheme over key appraisal criteria identifying specific transport objectives for Halton Borough Council. The bus based rapid transit has been assessed relative to the LRT impact. Anticipated passenger demand and the consequent reduction in road traffic levels are major influencing factors for many of the assessment criteria.

Assessment Criteria	Specific Halton Transport Objective	LRT (High range impact)	Bus Based Rapid Transit
Environment :			
Landscape	Minimise impact on historic, natural and human environment	MN	MN
Noise and Air Pollution	Improve local air quality through reduced traffic levels; support sustainable travel	MP	LP
Congestion	Relieve SJB congestion	HP	LP
Safety	Improve road safety through modal switch	MP	LP
Economy :			
Regional		LP	N
Local	Support economic growth and regeneration	MP	LP
Employment (employers)	Route options provide links to employment sites	MP	N
Employment (employees)	Route options provide links to employment sites	MP	N
Integration	Route options provide numerous modal interchange opportunities in particular Runcorn Rail Station; Runcorn bus station/High Street; Widnes town centre/Vicarage Rd	MP	LP
Passengers :			
Journey time	Economic and quality of life improvements through improving journey times for a range of trips in particular cross river trips	LP	LP

Increased accessibility	Route options provide links to key services – work; health; shopping; leisure; education and training	MP	LP
Service frequency		MP	LP
Service reliability		HP	LP
Journey Opportunities	Enhanced cross-river journey opportunities	MP	LP

KEY –
Net benefits/disbenefits for each criteria assessed are shown as **HP** = High Positive, **MP** = Medium Positive, **LP** = Low Positive, **N** = Neutral, **HN** = High Negative, **MN** = Medium Negative, **LN** = Low Negative

This preliminary high level appraisal indicates that while a light rail scheme over the MG would have a substantial negative financial effect, there is potential for the as yet unquantified other benefits to result in a positive economic effect. Bus based rapid transit would tend to have a lower level impact than the LRT option. A more comprehensive quantified appraisal would indicate whether a sufficiently high economic return could be achieved to justify the investment required.

Table 6.3 summarises the financial appraisal element of the outline business case in order to provide an indication of potential funding requirements. It does not represent a full cost / benefit analysis, no account is taken of other economic benefits, for example time savings, or other benefits that could be given a monetary value, for example safety and environmental benefits. Inclusion of these benefits could result in a positive benefit : cost ratio. The following list shows the Department for Transport's current guidance on value for money.

VfM category	Generally options which have:
Poor VfM	BCR less than 1
Low VfM	BCR between 1 and 1.5
Medium VfM	BCR between 1.5 and 2
High VfM	BCR over 2

The outcome of the business case could be influenced by a wide range of factors, for example Halton Borough Council policy on land use or complementary measures such as provision of park and ride facilities or town centre parking controls. However, it is recognised that the Borough Council's ability to introduce complementary measures is limited as the majority of town centre parking is privately owned and provided free to the user. Providing links beyond Halton, for example to Warrington or Merseyside, could also change the outcome of the business case. The addition of cross boundary destinations to the LRT route i.e. Warrington and / or Merseyside would increase demand but this would need to be sufficient to cover the higher capital and operating costs of the extended network.

Merseytram This study has specifically considered the potential for linking a Halton LRT system with the proposed Merseytram lines 2 and 3. The link to line 2 did not appear to satisfy strong public transport objectives and therefore would be unlikely to attract the passenger demand and associated benefits required to justify the costs. Line 3 has stronger public transport objectives for example Liverpool John Lennon Airport; however with an estimated capital cost for the link to a Halton system in the region of £100m it was anticipated that this line would also have a weak business case.

7.0 PUBLIC TRANSPORT OPTIONS FOR DE-LINKING THE SJ BRIDGE

When the Mersey Gateway Bridge (MGB) opens, it is proposed to close some of the approach roads to the Silver Jubilee Bridge (SJB) to reduce capacity to the level required for local traffic. A number of possible options for 'De-linking' are set out in the Report 'Mersey Gateway Silver Jubilee Bridge Delinking Options', April 2007.

Option 3C, shown in Fig. 7.1, is considered the most effective solution but Option 5, shown in Fig. 7.2, is suggested as a possible option in the longer term future as it would assist redevelopment in the area. For all Options, the existing four lane carriageway over the SJB would be reduced to a single two lane carriageway

with cycleways and footways. Option 3C is a relatively low cost option while Option 5 is a high cost option which would be more appropriate in the context of major redevelopment.

The changes to public transport services resulting from each option are set out in the Delinking report. For Option 3C it is proposed that buses would retain their existing routes which are:

Outbound towards SJB: Bus Station – High Street – Devonshire Place – Doctor's Bridge - Greenway Road – slip road to Queensway northbound carriageway.

Inbound from SJB: Queensway southbound carriageway – westerly slip road to Station Road mini-roundabout – Station Road – High Street – Bus Station.

These are shown in red on Figure 7.1. There is a northbound bus stop for outbound services on Queensway adjacent to the Railway Station and a northbound stop on Station Road, with pedestrian access to the Railway Station, for inbound services. A short section of High Street inbound from Station Road is restricted to buses.

For Option 5 buses would operate in both directions as follows:
Bus Station – High Street – Devonshire Place – Doctor's Bridge – new junction with Bridgewater Expressway – Queensway.

The requirements to meet the objectives for any high quality transit system are to minimise journey times, maximise reliability and minimise access times to major traffic objectives. In this location it would mean:

- creating a segregated public transport alignment between the Bus Station and the SJB (in effect extending the busway to the bridge);
- creating a bus/rail interchange at Runcorn Railway Station.

Options 3C and 5 do not fully achieve these objectives although Option 5 would considerably improve interchange by creating new bus stops at the same level as the station forecourt and slightly closer than the existing stops. It would be possible to provide some further improvements by extending existing bus lanes or creating new bus lanes, providing traffic signal priority, and locating bus stops closer to the Railway Station with improved pedestrian crossing facilities. Some of these are suggested in the report. (It should be noted that there is a bus lane extending along the westbound carriageway of the Bridgewater Expressway from a point about 200m west of the junction with Runcorn Spur Road, continuing along the northbound slip road to the SJB to a point about 50m north of the bus stop at the Railway Station but only the section north of the slip road from Greenway Road is used by buses, according to the published bus maps).

A further option which could potentially achieve a higher degree of segregation and improved access has been identified for further study, termed Option 3D (Figure 7.3). This would be a modified version of Option 3C incorporating some features of Option 5. It would include:

- conversion of the westerly carriageway of Queensway to busway between Bridgewater Expressway and SJB;
- provision of a signalled crossroads with the Bridgewater Expressway in place of the signalled T-junction but with only buses permitted in the north-south direction;
- restriction of Doctor's Bridge to buses only;
- construction of an at grade intersection between Queensway and Shaw Street;
- construction of a purpose built bus/rail interchange at Runcorn Rail Station;
- re-instatement of busway between Bridgewater Street and the Bus Station;
- bus priority signals at all traffic signal controlled junctions, including busway merge at SJB;
- new link road from Egerton Street to SJB (as for Option 3C).

A traffic route needs to be maintained between Runcorn Old Town and Higher Runcorn which the Shaw Street link would achieve. Traffic which would otherwise use Doctor's Bridge would be re-routed via Leira Way or Station Road. It may be feasible to retain Greenway Road underpass for some traffic movements or as a further section of busway for services to Higher Runcorn.

Option 3D would allow buses to operate in both directions directly from the Bus Station via Doctor's Bridge to Queensway. This would reduce journey length by over 40% over this section and would eliminate potential delays at the junctions with Station Road. The northbound carriageway of Queensway would become a two-way busway, retaining the southbound carriageway as a two-way all purpose road. The two carriageways would merge into a single carriageway with bus priority signals on the approach to the SJB. At the Railway Station, the station forecourt and car parking area would be re-modelled to create a bus/rail interchange with buses stopping at the station in both directions.

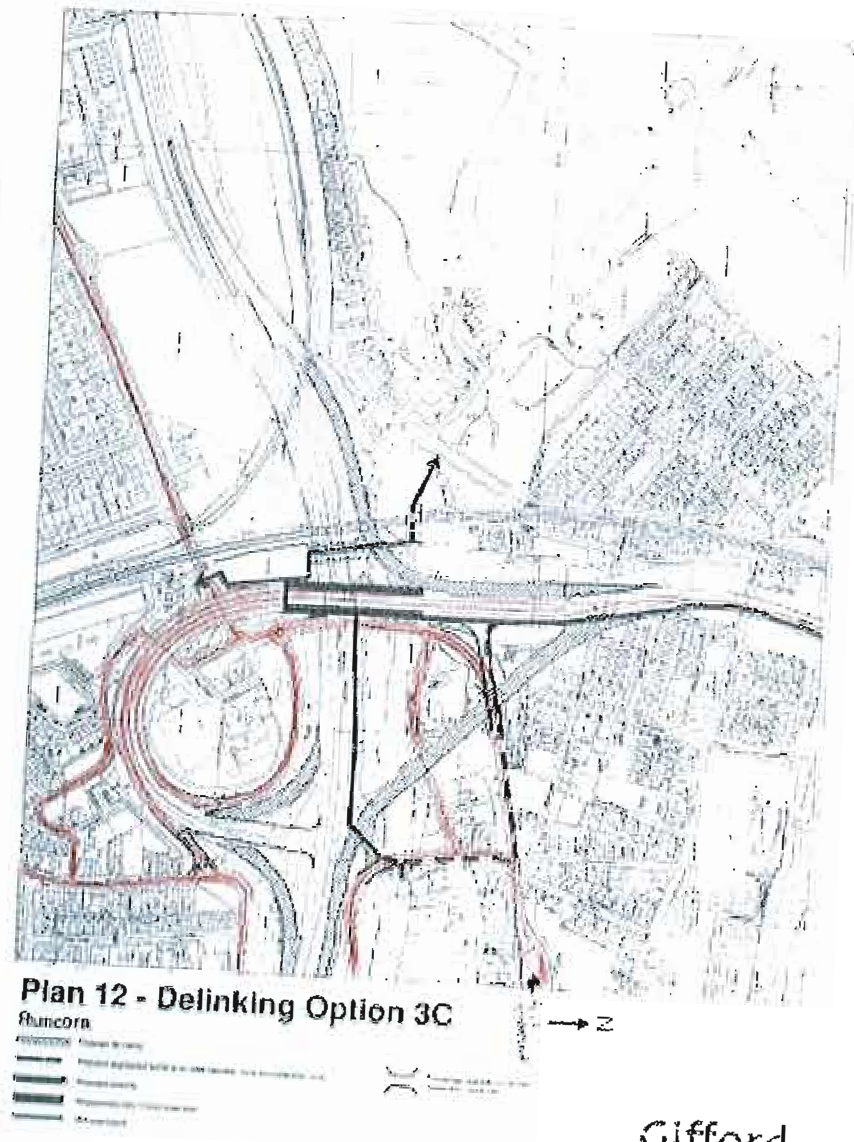
The opportunity to construct a major bus/rail/car/taxi interchange at Runcorn Station should be developed with all interested stakeholders, particularly the bus and train operators. It would be feasible to provide modest facilities at relatively low cost but there would still be some level differences between bus and rail platforms which would need careful planning. A more extensive scheme could be devised if it was possible to reconstruct the area between the proposed busway and the station entrance to minimise horizontal and vertical distances between bus and train platforms.

It is suggested that this further De-Linking Option should be investigated and, if considered feasible, discussed with bus operators, train operating companies and Network Rail.

Recommendation

It is recommended that the further de-linking options for optimising public transport benefits identified in this analysis that would provide a much higher level of segregation and integration with rail are refined and evaluated in more detail and the outcomes discussed with local bus operators and Network Rail.

Fig. 7.1 De-Linking Option 3C Showing Bus Routes To and From the SJB



Gifford

Fig. 7.2 De-linking Option 5 Showing Proposed Bus Stop Interchange Area.

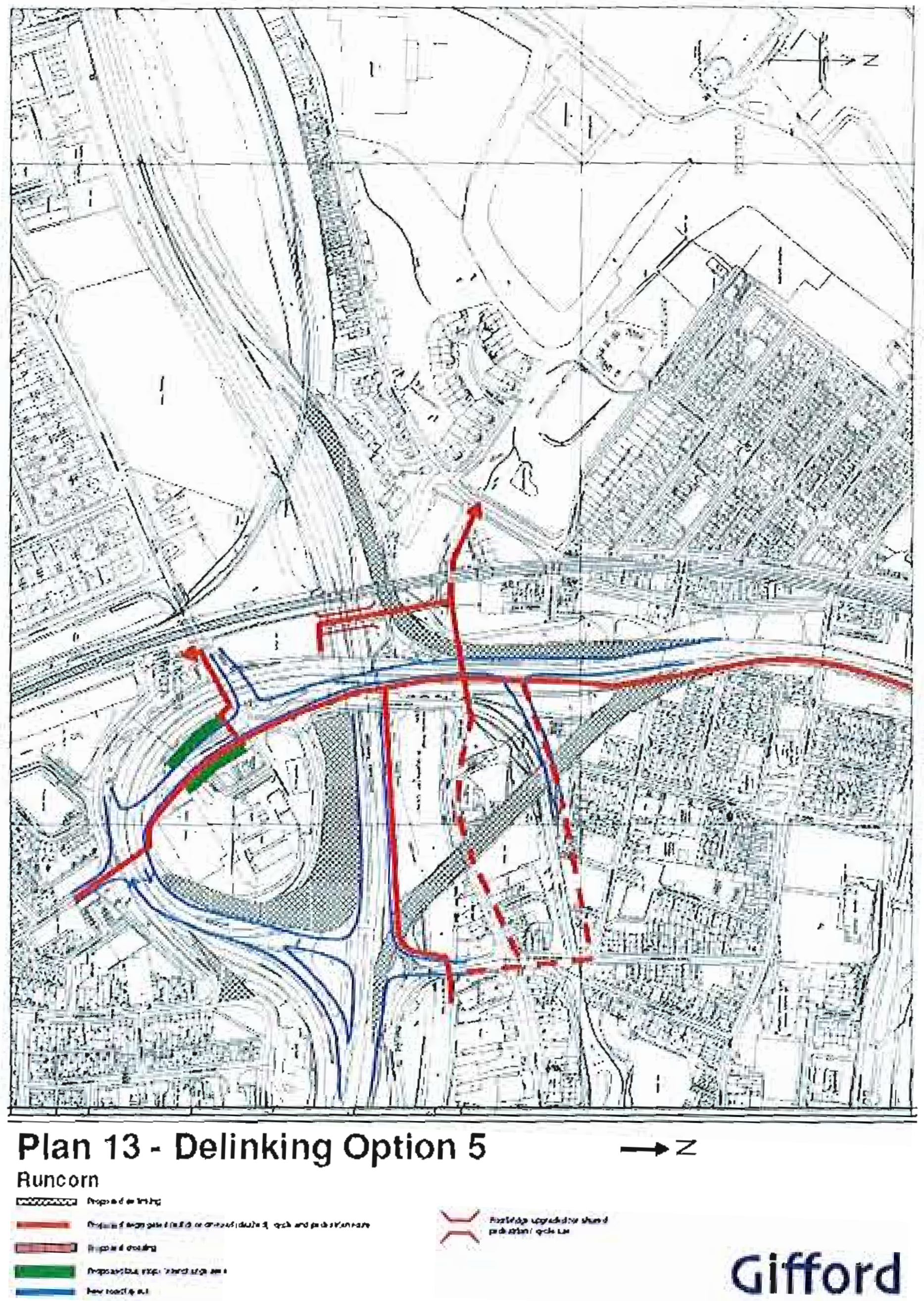
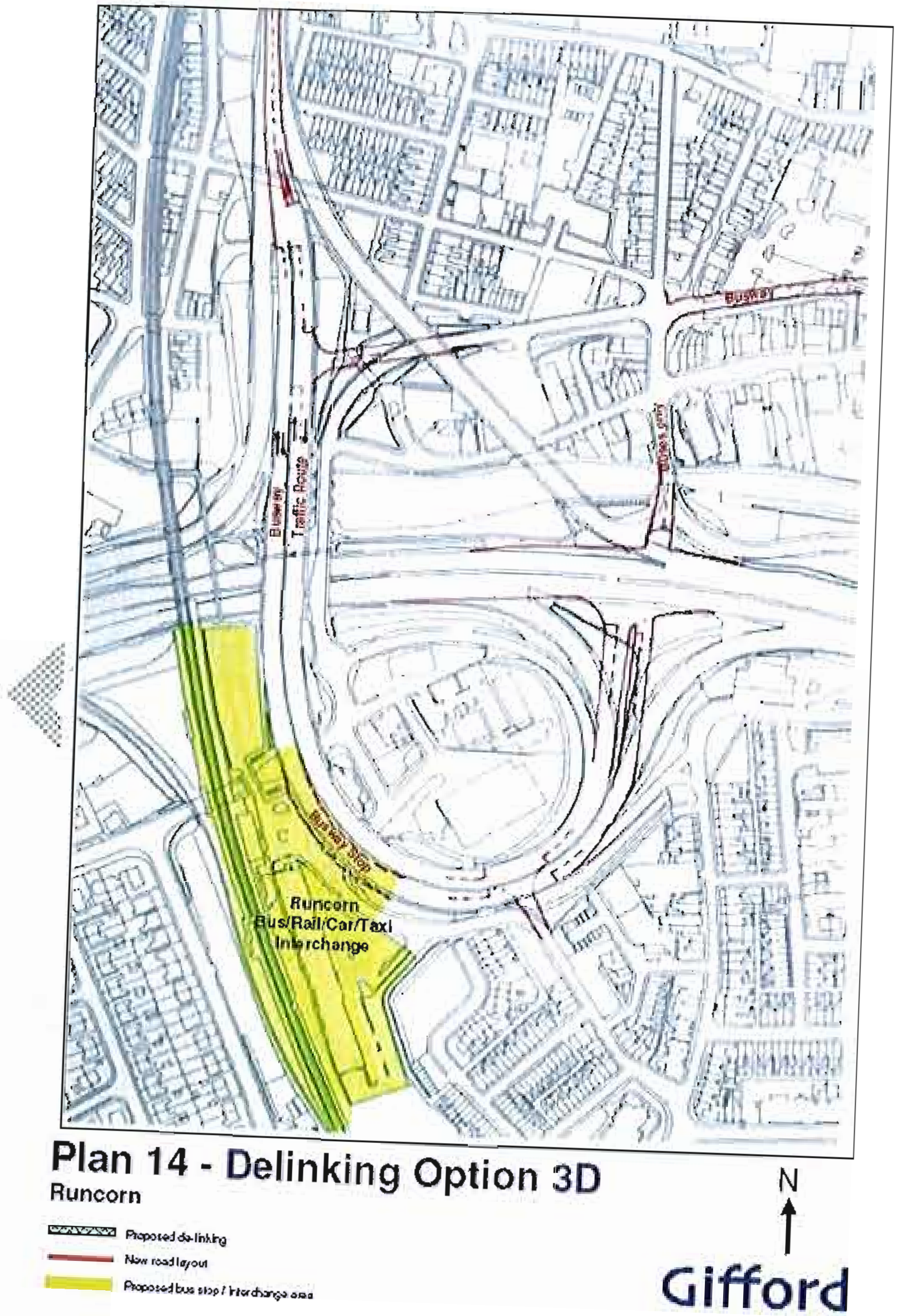


Fig. 7.3 Sketch plan of suggested De-linking Option 3D showing proposed busway extension.



8. SHORT LIST OF PUBLIC TRANSPORT OPTIONS

8.1 Overview

This study has reviewed the key characteristics of different alternative technologies that could be implemented for Halton.

The initial sift of alternative technologies rejected personal rapid transit, Ultra light rail and monorail systems, using the criteria of proven technology, cost, operational speed and line capacity.

The long list of six alternative technologies has then been reviewed in more detail, and the results of this assessment are summarised in Table 8.1 below.

Table 8.1 Suitability of Public Transport Options for Halton

Comment: Inconsiste[truncated] between table and recommended option[truncated] tramway

Application	Guided Busway	Medium & High Level Bus Priorities	Busway	Light Rail	Tram-Train	Heavy Urban Rail
High speed inter-urban line haul services	yes	yes	Possible: No Schemes Deployed	Yes	Yes	Yes
High speed urban line haul services	Yes	yes	Yes	Yes	Yes	Yes
Interoperability	1. With Local Bus Networks 2. Shared Alignment with Light Rail	1. With Local Bus Networks	1. With Local Bus Networks 2. Shared Alignment with Light Rail	1. Shared Alignment with Regular Bus 2. Shared Alignment with Guided Bus 3. Shared Alignment with Tram-Train	1. Shared Alignment with Light Rail 2. Shared Alignment with Heavy Rail	1. Shared Alignment With Tram-Train
Self contained dedicated urban corridors	Yes	Yes	Yes	Yes	Yes	Yes
Urban distributor network	Yes	Yes	Yes	Yes	Yes	No
Central area distributor network	Yes	Yes	Yes	Yes	Possible	No
Local area distributor network	Yes	Yes	Yes	Yes	Possible	No
Marginal railway lines	Yes	Yes	Yes	Yes	Yes	No
Open operator access	Yes	Yes	Yes	No	No	No
Sufficient passenger capacity	Yes	Yes	Yes	Yes	Yes	Yes
Attractive journey times	No	Yes	Yes	Yes	Yes	Yes
Service quality	Yes	Yes	Yes	Yes	Yes	Yes
City centre access	Yes	Yes	No	Yes	Yes	Yes
Market Image	medium	medium	medium	high	high	medium
Funding opportunities	Yes	Yes	Yes	Yes	Yes	Uncertain
Recommended for further consideration	Yes	Yes	Yes	Yes	Yes	No

The following paragraphs include a brief description as to the reasons behind the recommendation for further consideration included in the table.

8.2 Heavy rail options

There are four passenger rail lines passing through Halton and four stations within the Borough, as shown in Figure 8.1:

- the CLC Liverpool and Manchester line, with local and Transpennine services, running east-west to the north of the Borough with stations at Hough Green and Widnes (formerly Farnworth);
- the West Coast Main Line Liverpool branch, electrified at 25 kV ac OH, running from west to south to the west of the Borough with a station at Runcorn;
- the Helsby line, linking North Wales, Chester, Warrington and Manchester to the south of the Borough with a station at East Runcorn;
- the West Coast Main Line (WCML), electrified at 25 kV ac OH, running from north to south to the east of the Borough with no stations in the Borough.

Note; CLC is Cheshire Lines Committee, the original railway owner, and is the common identifier for this rail route

In addition there are freight only routes:

- the double track Arpley Goods line between Ditton and Arpley Junction in Warrington, running east-west through the centre of Widnes;
- the single track Runcorn Dock Branch Folly Lane Single branch line between Runcorn Junction and the Ineos Chlor chemicals plant;
- the Frodsham Branch (down Chester-Liverpool) between Frodsham Junction on the Helsby line and Halton Junction on the WCML Liverpool branch, known as the 'Halton Curve'. This route is only signalled for down (northbound) train movements.

The passenger lines are not connected within Halton and hence they do not provide for any local journeys within Halton, with the exception of Widnes to Hough Green. The freight only lines have limited use but are likely to remain in operation. The Halton curve is the subject of proposals for a new Chester – Liverpool service via Runcorn which would include upgrading the line for two way operation.

New stations have been considered at Daresbury on the WCML, Keckwick Lane on the Helsby line, Widnes South on the Arpley Goods line, Upton Rocks and Barrows Green on the Liverpool and Manchester line, Beechwood on the Halton Curve, and Ditton on the WCML Liverpool Branch. There are significant issues to resolve for all these proposals and most are dependent on other factors such as new development. Some, e.g. Daresbury, are unlikely to be feasible. Others, e.g. Keckwick Lane and Barrows Green could become more practicable if a tram-train solution was considered, as discussed in Section 8.3.

A number of upgraded or new passenger services are discussed in Halton's LTP2. A major upgrade is being considered for the Transpennine route which could open further opportunities for improved services and/or new stations. A passenger service could be considered on the Arpley Goods line between Ditton and Warrington Bank Quay but there is currently little potential demand and it is unlikely that a service would be justified unless there was some major development. As already stated, a new service between North Wales, Chester and Liverpool could be operated over the Halton Curve with a new station at Beechwood to serve the south of Runcorn and this proposal is currently being developed. Another option is the Shell Green route between Ditton and Warrington Central via a re-opened Widnes South station and the re-instatement of a former rail alignment, part of which has been sold. This would create an alternative route for Transpennine or local services between Liverpool and Warrington Central and provide a rail station closer to the centre of Widnes. A number of improvements to existing stations are envisaged to improve access, provide park and ride or other facilities.

It is not clear whether the MG bridge is designed to accommodate heavy rail trains but while it may be feasible to devise a track connection on the north side, it would be very difficult and expensive to create a heavy rail alignment at the southern end as there is no available route between the southern bridge portal at Astmoor and any of the existing or proposed rail lines to the south of Halton. In any event the potential traffic would not justify the major expenditure required for heavy rail infrastructure and it would to a large extent duplicate the existing Runcorn rail bridge.

There may be opportunities to consider running tram-train type vehicles on some heavy rail routes and this is discussed in Section 8.3. It is not considered that tram-train would be a viable option on the existing Runcorn rail bridge because it is part of the WCML and tram-train operation is unlikely to be compatible with high speed inter-city operation. It would not contribute to the intra-urban local transport needs in the Borough of Halton.

8.3 Tram-train options

Tram-trains are light rail vehicles (LRVs) which are technically compatible with operation on heavy rail tracks in shared track operation with heavy rail trains. (LRVs which operate on heavy rail alignments but not with shared track, e.g. Manchester Metrolink, are not tram-trains.). Tram-train operation is now used in Germany, Netherlands and France but the only example in the UK is the Sunderland extension to Tyne and Wear Metro. Any new application would have to be developed in close liaison with Network Rail and HMRI.

It is apparent that the introduction of European tram-train systems has significantly increased the number of passengers through a combination of improved service quality, faster overall journey times and more frequent trams. Wider social and economic benefits have also been delivered.

There could be potential for tram train operation over the MG, depending on the type and extent of the network to be developed. At the northern end it would be possible to devise a link between the tram deck on the bridge and the Arpley goods line eastwards to serve Warrington or westwards to LJLA and Liverpool. Another option could be to continue northwards on street, as envisaged for the light rail options, and then join the Liverpool and Manchester line at Widnes, eastwards to Warrington or westwards to LJLA and Liverpool. In any option, a study of available capacity would need to be undertaken and all the interfaces between heavy and light rail fully evaluated. It would be essential to discuss any concepts with Network Rail and the ORR, HMRI, at an early stage to determine which options may be worth developing.

At the southern end, the only feasible alignment for light rail vehicles is to join the Runcorn busway which would need to be converted to light rail or possibly for shared bus and tram operation. One possibility could be to join the Helsby line at Runcorn East to continue into Warrington where a separate platform would need to be provided for tram-trains. The route would need to be kept clear of the West Coast Main Line which is unlikely to have any spare capacity. It is unlikely that a link to the Halton curve would be practicable as it would conflict with the West Coast Main Line route into Liverpool and would not offer any significant benefits.

A feature of tram-trains is that they would use low floor vehicles, as determined by the characteristics of the central route section, and would therefore require low platform stations. At existing heavy rail high platform stations it would be necessary to construct additional lengths of platform at low level with ramped access between the two levels. New stations could be constructed at much lower cost than for new high platform stations. At potential terminals such as Warrington Central, new low platforms would have to be constructed clear of the main running lines. There could be scope for short on-street extensions to improve central area accessibility. There may be opportunities to provide new stations to serve specific traffic objectives, e.g. Warrington General Hospital and Daresbury Science Park, which would be more difficult to serve with heavy rail.

Tram-trains can be provided with dual power supply, usually 750V dc/25Kv ac OH or 750V dc OH/diesel, depending on the traction supply on the heavy rail routes. Tram-train with 750 Vdc OH/3rd rail is technically feasible but is difficult to make fully failsafe, particularly where an unprotected third rail may be in proximity to a low platform station. Thus tram-train operation onto the Merseyrail electric network would not be practicable.

8.4 Light rail options

Numerous examples of light rail systems throughout the world have a wide range of characteristics. They have generally been successful and stimulated a range of wider social, regeneration and economic impacts. Some former loss-making rail services have been replaced by modern, attractive light rail networks. The better frequencies and more convenient access to the city centre are the main factors that have encouraged car drivers to transfer to alternative modes and accordingly, light rail is suggested worthy of further consideration.

It is understood that the design of the MG could accommodate light rail tracks on the lower deck, within the lattice structure supporting the main traffic deck. Track connections would need to be incorporated at each end, at the north bridging across the Widnes Eastern By-pass to reach ground level near Widnes town centre to join a street running alignment to Widnes Station and Hough Green. At the southern end tracks would ramp down from deck level to the Runcorn Busway, possibly on a spiral. A delta junction would be needed to allow trams to run eastwards to Halton Lea and Runcorn East or westwards to Runcorn Bus and Rail Stations.

For light rail, there is the option of running via the SJB (Route Option A above) which reduces the length of track required to serve the principal traffic objectives.

8.5 Tramway

There is little distinction between a light rail system and a tramway except that a tramway usually has a higher proportion of street running while a light rail system has a higher proportion of segregated or railway alignment. If a north-south route was developed primarily to serve Halton itself, it would probably have more characteristics of a tramway.

8.6 Bus Rapid transit options

A number of technical options are available for guided buses which could be considered including kerb guidance, optical guidance, electronic guidance or rail guidance (GLT, guided light transit). The only form which has been used in the UK is kerb guidance (e.g. Ipswich, Leeds, Bradford, Crawley, Edinburgh) and it is unlikely that any of the other forms would be approved for UK operation. Though the limited service operating speeds mean that none of these systems are truly rapid transit.

A high frequency service would need to be operated to ensure there is sufficient capacity both for existing passengers, and accommodating future growth, particularly during the peak hour. Given the limitations about alternative guidance systems, the kerb-guided solution appears the only viable system at present.

On the other hand, the benefits of local guidance are that stop docking for boarding and alighting is guaranteed, as for light rail, but only at stops on the guideway, and guidance tends to eliminate infringements. It also permits higher speeds where there are physical constraints such as bridge piers or tunnels. If buses were to operate on the MG in place of trams they would probably need to be guided. However the benefits of equipping the existing busway with guidance are probably marginal and a kerb guided option would produce considerable severance.

Other forms of traction may be applied to busways including hybrid (diesel/electric), fuel cell, trolleybus, or dual mode (diesel and electric trolley). The benefits of electric traction are primarily environmental (low noise and emissions) but it is unlikely that the additional cost would be justified at the present time. The option to adopt other sustainable / low carbon footprint / low polluting traction forms in the future is always open as a retrofit.

Runcorn already has the only bus rapid transit system currently operating in the UK and this forms a sound basis for developing a bus based network to serve a wider part of Halton. A modest cost option would be to retain the existing busway standards using unguided buses and should be the subject of further detailed study and evaluation

This study does not exclude the application of guided bus technologies as a traction option for bus based rapid transit solutions for Halton .Overall, however, it is concluded that all of the alternative technology options to kerb guidance are presently unsuitable, or insufficiently developed, for inter-urban high performance guided busway applications in the UK, as would be required for Halton.

This certainly does not however preclude the use of bus guidance for level boarding and alighting and if buses were to operate on the MG Bridge in place of trams, a form of guidance is likely to be needed for safe operation within the limited structure gauge clearances.

The relatively low unit cost of exploiting local / site specific bus guidance for docking and providing narrow rights of way through physical bottlenecks suggests that the option should be retained for further consideration as part of further detailed study and evaluation of modernising the Runcorn busway as a option for a new north-south public transport link

8.7 High Level Bus Priorities

If a light rail or tramway alignment is planned, it would normally have a high degree of segregation from road traffic, even when running within a highway. This is to ensure that good levels of operating speed and reliability can be achieved and maintained. The same level of priority can be applied to a bus based system, much like the Runcorn busway, using the usual range of bus priority measures.

Halton's LTP2 gives reliability as a key quality feature for the bus network. A core bus network is envisaged with 'turn up and go' frequencies and a maximum use of bus priority facilities is planned. High Level Bus Priority would build on this approach but extend it to work towards a much higher degree of segregation, as applied on the Runcorn Busway. It would seek to extend the busway over the routes defined as potential rapid transit routes, either via the MGB or the SJB, or possibly both. It is probably that at least initially the majority of bus routes would continue to use the SJB with the major traffic flows transferring to the MGB. This offers the opportunity to provide very high levels of segregation for buses via the SJB and its approach roads.

The whole range of bus priority measures can be used to create operating conditions which are as close to those of a tramway as possible, within the constraints of bus technology. These measures can include fully segregated busways on separate alignments (as Runcorn Busway), segregated busways within existing highways, segregated bus lanes, with-flow and contra-flow bus lanes, bus only streets, and traffic signal priority at junctions.

The aim of High Level Bus Priority should be to maximise passenger accessibility to the network, minimise journey times and provide total protection for buses against delays due to traffic congestion or other traffic activities such as frontage servicing. It is noted that while improvements are being made to parts of the Runcorn Busway, substantial sections of busway have been abandoned. The High Level Bus Priority option would require this policy to be reversed.

8.8 Medium Level Bus Priorities BASE CASE

In practice it is often difficult to achieve the same level of priority for buses as can be achieved for trams. Buses can operate in normal traffic which reduces the capital costs of priority measures but speeds and reliability will be poorer. The level of bus priority applied can be adjusted at each part of the route to meet specific local needs or opportunities.

This form of priority is similar to that already being applied through LTP2 and would in effect form the base case, and would continue to build upon the currently planned programme of improvements including Halton's Quality Bus Corridors.

The precise form of priorities to be applied for either Medium Level Bus Priority or High Level Bus Priority would depend on a range of factors including routes selected, land availability within the highway or adjacent

to the highway, traffic management measures, passenger objectives and operational requirements. These would need to be investigated further at a detailed design stage.

8.9 Demand Responsive Transit & Para-transit Options

Where demand levels are low and patterns of demand very dispersed, some form of demand responsive system (DRT), also referred to as 'para-transit', may be the most appropriate solution. Several forms of DRT already exist in Halton including Hospital Link, Halton Dial-a-Ride, minibuses and community car schemes. These may need to be expanded and can feed into interchanges with the primary transit system.

8.10 Innovative Transit Options

Conventional urban public transport systems include bus, guided bus, trolleybus, tram, light rail, metro and suburban rail, as described above. New technology can be applied to improve and develop each of these systems.

New technology systems, or 'innovative' transit systems, are those which have been conceived and developed as a whole system with the objective of offering a better or more cost effective solution than conventional systems, or providing for specific 'gaps in the market' such as park and ride links to town centres. A brief description is provided here.

Many different innovative systems have been developed, mainly in Europe, North America and Japan, over the past half century but few have reached prototype stage and even fewer have entered commercial passenger service. Hence the risks in adopting any innovative system are high.

9.0 CONCLUSIONS AND RECOMMENDATIONS

This comprehensive study has taken a top down approach in relation to the identification of potential possible transport technologies and systems, and associated fuel and traction options for consideration to supporting economic growth accessibility and inclusivity in this borough in conjunction with the de linking of the SJB and the construction of an additional bridge crossing. .

Integral elements of the work have been an examination of costs and a preliminary broad brush demand assessment as well as a consideration of wider network issues, infrastructure and facilities for passengers.

Opportunities for introducing fixed rail transport systems such as LRT and Tram Train concepts have been examined in the study from both the physical and financial perspective. The general conclusion is that whilst fixed rail systems especially LRT can be highly instrumental in underpinning modal shift particularly from car to Public Transport, the business case to support this approach is weak at this moment in time. Furthermore the current political climate in the UK as exhibited by central government, and the intrinsic and complex funding mechanisms of the dft and associated protocols make LRT difficult to promote compared to bus based systems. Merseytravel and Leeds City Council's provide an illustration of the difficulties faced by public bodies when trying to promote LRT.

This is not to say that LRT or similar fixed rail technology should be dismissed in Halton. In fact this option could be considered in the long term once the critical mass and levels of demand for public transport in the borough have been developed and expanded in the short to medium term for example through road based transport modes that by comparison with LRT are cheaper and can be implemented within a much shorter timeframe.

Halton possesses an extensive and long established public transport network and associated infrastructure, including the unique Runcorn Busway on the south side of the Mersey which one of the UK's earliest examples of a self contained and highly segregated bus system.

The bus is the main mode of public transport mode in Halton for local trips and this is true of neighbouring authorities and conurbations including Warrington and Merseyside. Halton is connected to the regional and national coach networks however the travel opportunities that are provided by coach are relatively limited at this moment in time but could be developed and enhanced as part of an integrated transport strategy in the borough for example through the development of coach services linking Halton with Liverpool and Manchester airports.

In terms of heavy rail Halton is connected to both the regional rail network including the Merseyrail services as well as the West Coast Main Line with a key rail hub being at Runcorn. Opportunities to further develop rail based P+R .

Halton is a relatively well defined Borough in the North West Region with good highway connections to the regional and national road network although the borough does have two distinct parts on either sides of the estuary.

Increasing congestion is however creating problems for both local trips as well a traffic movement that has trip origins and destinations outside the borough. The creation of a second Mersey crossing is aimed at providing some local relief on the highway network and potentially through the proposed de-linking of the SJB there are opportunities to reaise the profile of public transport walking and cycling in the borough.

Local bus operations in Halton are dominated by two operators who have developed distinct operating territories. Services on the south side of the Mersey in Runcorn are dominated by Halton Borough Transport, services on the north side are and by Arriva in the Widnes area.

The strengthening and development of a clearly defined north to south public transport corridor has been identified as a key issue for the second LTP to encourage more cross river integration. as part of a wider regeneration strategy and opening up local employment opportunities. A and a stumbling block to this may be this historically situation with the bus operators and its obvious implications of the overall public transport network in Halton.

The public transport report identified a number of major potential traffic generators and attractors on both sides of the river and external to Halton that could form the focus of a strategic network review and a plan of action that can support a strategy that will deliver step change improvements as well as public transport access and penetration improvements in line with the regeneration strategy and the promotion of sustainability.

Existing bus network and associated assets and infrastructure offer significant opportunties for creating step change improvements that offer value for money and can be delivered swiftly compared with for example a fixed rail system such as LRT.

From a network perspective and in relation to improving opportunities for better integration and bringing about the seamless journey there are clearly a number of further improvements and enhancements that in the short, medium and long term can enable the bus network and associated services to continue to best respond and meet travel demands in Halton. This could be developed as part of a major partnership initiative involving bus operators and transport providers from both the public and voluntary sectors as well as taxi operators that would work towards the development of a clearly defined, highly visible, attractive and efficient Halton Gateway Transit Network.

Integral to this strategy and approach would be community involvement and an approach that would seek to generate ownership and buy in from the community at large but importantly raise expectations and deliver them. Being a bus based strategy this opportunity is probably more

achievable and fundable through public and private sector funding streams and finance initiatives for both capital and revenue support.

AN inherent aspect of the recommended approach in terms of physical infrastructure for public transport is that through careful planning and valuie engineering opportunities it should be possible to take forward the development of infrastructure and facilities that whilst initially designed and provided for a bus based system do not preclude for example fixed rail systems and associated technologies in the future.

In summary the recommendations are as follows:

- To adopt a bus based approach to the transport system and network in Halton that creates major step change and sustainable improvements for the community
- To make best use of existing public transport infrastructure and facilities
- Consider the most effective and appropriate funding opportunities that can support and help realise step change improvements in Halton
- Explore opportunities for improving access, penetration and support improved integration within the Halton area through new alignments and links that could be segregated and guided for maximum exclusivity and levels of self enforcement
- Explore opportunities to introduce more conventional bus priority measures including techniques
- Exploit the development of a high profile Halton Integrated Transport network and in conjunction with bus and rail operators create a strong brand image for services and facilities that foster ownership and increase awareness from within the community.
- Take forward improvements in the provision and dissemination of information and off bus ticketing based on best practice.
- Further improve and develop the bus based public transport infrastructure and associated alignments and routes in such a way that this would not preclude the introduction of fixed rail systems at some time in the future.

APPENDIX XXX

Table 2.3 Energy Supply Options for Public Transport

Note: OHLE is overhead line equipment or conductor wire used in electrification schemes, which includes various forms of construction including elastically suspended high speed systems up to 300kph as well as rigid lower speed systems up to 70 kph commonly used for light rail.

Energy mode	PRT / ULR	Guided Busway	Busway	Light Rail	Tram-Train	Heavy Rail	Monorail
Single mode Electrification using HIGH voltage OHLE	Not permitted	Not permitted	Not permitted	Off street and wholly segregated operation	Off street and wholly segregated operation	Standard traction option	Not permitted
Single mode Electrification using LOW voltage OHLE	On street operation	Line captive trolleybus	Line captive trolleybus	On street operation	Dual voltage required for on street operation	No efficiency benefit	Possible traction option
Battery Electric drive single mode	Range too limited	Range too limited	Range too limited	Range too limited	Range too limited	Range too limited	Range too limited
Diesel mechanical drive single mode	Possible traction option	Standard traction option	Standard traction option	Possible traction option	Standard traction option	Standard traction option	Possible traction option
Diesel electric drive single mode	Possible traction option	No efficiency benefit	No efficiency benefit	Possible traction option	Possible traction option	Possible traction option	Possible traction option
Flywheel drive storage devices	Range too limited	Range too limited	Range too limited	Range too limited	Range too limited	Range too limited	Range too limited
Hybrid electro-diesel dual mode	Possible traction option for non wired sections	Possible traction option for non captive trolleybus	Possible traction option for non captive trolleybus	Possible traction option for non wired sections	Possible traction option for non wired sections	Possible traction option	Possible traction option
Hybrid electric-battery dual mode	Possible traction option for limited range	Possible traction option for limited range	Possible traction option for limited range	Possible traction option for limited range	No efficiency benefit	No efficiency benefit	Possible traction option

	off line	off line	off line	off line			
Fuel cell technology	Not commercially available	Not commercially available	Not commercially available	Not commercially available	Not commercially available	Not commercially available	Not commercially viable

2.4 Trolley Bus and Dual Mode Bus Options

A trolleybus is a bus powered by high voltage electricity provided by two overhead electric conductor wires drawing electricity from an overhead line..

A dual mode bus is a trolleybus bus that can run on power from two different sources, (and is a hybrid vehicle) typically electricity from an overhead line power supply and from an on board diesel power pack, although storage battery packs and may also be used, as well as fuel cells when these become commercially available

The diesel power pack can be, typically, a mechanical transmission providing an independent driveline or it can drive an electric generator which can power the trolleybus electric motor directly when "off wire" at either full performance, or at a reduced performance. The Renault PER 180 articulated dual mode trolleybus originally used in Nancy, France, is typical of a trolleybus with a full performance diesel mechanical transmission for off wire service.

In the UK until 1984 trolleybuses, unlike motor buses, were not classified as Passenger Service Vehicles (PSV), now known as Passenger Carrying Vehicles (PCV) and were subject to separate technical and safety requirements set out by the HM Railway Inspectorate largely due to the wide scale abandonment of UK trolley bus systems.

The production of a dual mode trolleybus experimental installation in South Yorkshire in 1983 prompted a change in UK legislation classifying trolleybuses and dual mode trolleybuses, like motor buses, as Passenger Carrying Vehicles

Although trolley buses have higher ongoing operating costs compared with conventional buses, this technology offers cost savings compared with light rail. These cost savings are achieved since there is no requirement to maintain the rail infrastructure.

However, there are several limitations of trolley buses. The average operating speeds are likely to be slower than either light rail or high performance diesel busways, creating journey time disadvantages.

The analysis above demonstrates that the limited current availability of battery or fuel cell technology, so the only realistic option to use electricity in transport is to transmit power via overhead conductors (for both bus and rail). This offers a number of benefits to passengers, the wider public, and the operator:

- Passenger benefits – lowest possible noise levels, powerful but smooth accelerating and braking, good ride quality, passengers are likely to benefit from other improvements in waiting facilities and real time information;
- Public benefits – lowest possible emissions into the environment, low consumption of renewable energy sources, low levels of greenhouse gases emitted including carbon dioxide;
- Operator benefits – high mechanical reliability, lower maintenance and operating costs, operating lifetime for vehicles could be extended.

There are several potential guidance systems available for trolley and dual mode buses, where the costs are claimed to be about 50% less than the equivalent light rail schemes. Each system has been developed by national and multi-national companies. The Civis/Chrysalis uses optical guidance, whilst alternatives like Bombardier have been built and tested on other systems. Examples of the guidance systems include:

- Neoplan – entered service in Lausanne with diesel generator set. Also proposed as the N6141 DET bus tramway, a 4axle, 21m version with conductor loops 20-30mm below road surface that create magnetic fields for guidance with AC current;
- Cegelec AEG - promoted for Liverpool, which would use buried cables that guide the trolley bus by induction - conventional overhead wires would supply the traction force;

- Civis/Chrysalis - Uses painted lines on the roadway seen by a computer recognition system to steer the Trolleycoach, power supply is by double overhead wires, in preference to battery or diesel based options;
- Ansaldo Breda Stream - the most complex system, but with the potential to replace visually disruptive overhead wires, it uses a magnetic pick-up to collect power, from a flexible conductor in a 300mm x 600mmm trench;
- Bombardier GLT – example of a trolley bus that exhibits characteristics most similar to trams, but with rubber tyres, this trolley bus uses conventional rapid transit overhead wires, but has a guiding and current returning buried mono rail.

One of the advantages offered by trolley buses is the requirement not to construct and then maintain the rail-based infrastructure.

Whilst the comparisons of service quality offered by trolley buses are favourable compared with conventional diesel bus units, such comparisons are not reported for light rail-based technologies.

Consequently, the comparisons of service quality may be less favourable compared with light or heavy rail based solutions.

2.4.1 Comparative Costs of Trolley and Dual Mode Buses

Since trolley and dual mode buses do not need to operate on rails, they offer considerable savings compared with light rail systems. Although the infrastructure costs needed for the overhead wiring are more expensive, these costs can be recouped by the longer life span for trolley buses than conventional buses. Typically, trolley buses last about 30 years, whereas conventional buses have a life span of just 10 years when used on busy city centre routes.

Although the operating costs for trolley buses are slightly higher than conventional buses, this cost comparison includes the additional costs incurred for overhead wire maintenance. If the use of trolley buses can be maximised, these costs can be reduced, since the overhead wires will be used more intensively. This cost comparison does not take account of the wider environmental benefits achieved by the trolley buses.

If fuel prices rise when oil reserves become more depleted, this has the potential to make trolley buses more economical, despite the additional maintenance costs.

There are a number of similarities between trolley buses and trams, including the electric traction, energy efficiency and no pollution. However, trolley buses do not need rails to operate on, and this offers significant cost and maintenance advantages.

In North America, trolley bus infrastructure costs are about $US1 million per km for two-way routes. This offers significant cost advantages compared with light rail, ($US17 – 35 million per km). This comparison demonstrates trolley buses are relatively inexpensive compared with light rail.

There are no current examples of trolley bus technology in the UK, although system promoters have argued the technology could be successfully introduced on several routes in London, including the East London Transit and Greenwich Waterfront Transit. It was suggested that trolley buses could be initially introduced between Ilford and Barking Reach to demonstrate practicality and efficiency. Trolley buses could be integrated to provide interchange with other modes, and serve major regeneration areas.

However, there are no committed proposals to introduce trolley buses in the UK at the present time.

APPENDIX A

The following are the transport technologies that we recommend are not suitable for Halton and are not considered as part of any further option development and feasibility work .

3.2.2 Personalised Rapid Transport (PRT)

The most appropriate example of a PRT system is ULTra. ULTra is a demand responsive system of driverless automatic cabs travelling on a dedicated guideway. Passengers arrive at the ULTra stations and select their destination on the network. Passengers have the choice of travelling alone, or with up to 3 friends. Although waiting times are very short, the average speed of ULTra is about 25km/h, and therefore is slow.

There are no commercial examples of ULTra yet, although these proposals comprise a network with relatively small scale coverage, rather than an inter-urban network as envisaged in Halton.

Furthermore, there are a number of other key reasons why ULTra would not be suitable for Halton:

- Insufficient capacity to serve a busy public transport corridor into and between town centres;
- Slow journey;
- Very high capital costs given the low vehicle and line capacity.

3.2.3 Ultra Light Rail (ULR)

Whilst ULR uses lightweight vehicles with a smaller passenger capacity, these vehicles also have lower procurement costs. Vehicles are normally self-powered, and use hybrid drive technology. ULR may be particularly suited as an alternative high-quality public transport system in smaller urban centres, or reducing the public subsidy needed to support local rail lines. ULR allows:

- More frequent stopping points;
- Scope to divert from the existing rail corridor to improve access to land use development;
- The introduction of a more attractive, affordable system than the existing heavy rail.

The Parry People Mover is an example of ULR, and uses innovative 'fly-wheel' technology to power the vehicle, and has the best environmental performance of any comparable mode for short distance trips. The fly-wheel can be re-charged from an intermittent electrical supply at the station during boarding / alighting if stations are closely spaced. Alternatively, the fly-wheel could be re-charged using an on-board LPG engine, or diesel or hydrogen-fuelled engine.

To date, the People Mover has been tested on the Stourbridge branch line, but has yet to be introduced as a commercial operation. Passenger usage is low, and the journey times to Stourbridge Junction are just 3 minutes. Current versions of the People Mover have just 20 seats, with aspirations to develop a higher capacity vehicle. Furthermore, the low crash-worthiness means these vehicles can only be introduced as part of a self-contained route, it is not permitted to inter-work these vehicles with other heavy rail units. Essentially, these systems aim to offer low cost (affordable) options for marginal railways. Similar to tram-trains, they are able to operate on unshared track, with a lower requirement for signalling, controlled level crossings, fencing.

There are also proposals to introduce ULR in the Greek town of Kalamata. A 5km network with 23 stops is planned, using a fleet of 8 hybrid diesel / electric vehicles. These vehicles have capacity for 45 passengers. Six to eight services would operate per hour, with a maximum speed of 50km/h. The total cost is about £5 million, covering the marginal cost of conversion, rather than the construction of a wholly new system.

ULR could improve service quality on self-contained branch lines, or networks with short distances between stations. However, there are a number of reasons why this technology is not viable for Halton.

- Intended for conversion of marginal passenger railways otherwise;
- Requires construction / installation of dedicated right of way using railway type track;
- Limited passenger capacity;
- Generally low line speeds;
- Difficulties with inter-working within shared traffic lanes "on street";
- Difficulties with inter-working with the existing heavy rail network;
- Lack of heavy rail crash worthiness for interoperability.

3.2.4 Monorail

A monorail (or beam guidance system) comprises a single rail that acts as the track for passenger vehicles, and is usually elevated. Systems are electrically powered, so the level of pollution is low, with vehicles using rubber tyres.

Monorails have a good safety record, since they operate on a dedicated guideway separate from pedestrians or other vehicles. However, the costs of constructing monorails are significantly more expensive than other technologies, ranging from £5 million to £75 million per kilometre. It is difficult to assess the suitability of monorails to serve a busy commuter corridor into Halton, or indeed the ability of the current MG bridge design to accommodate a monorail technology. The majority of existing systems cover relatively short distances, and primarily serve tourist attractions.

One of the main exceptions is the (now elderly) monorail in Wuppertal, Germany, which is fully integrated into the rest of the city's public transport system. As mentioned earlier, the costs are significantly higher than alternative technologies, and the operating speed is typically slower than existing bus and rail, suggesting that the option is unsuitable for Halton.

APPENDIX B

3.3.2 Bus Rapid Transit Using Guided Busways

Overview

Guided busways are dedicated routes for buses, but more easily accommodated within a narrower right of way than fully segregated busways (as discussed later). Guidance can be provided in a number of different ways, usually either mechanically, optically or electronically.
Guided busway technologies have traditionally been developed in two ways:

- As a bus priority tool for local, corridor and wider urban bus networks; or,
- As a self contained rapid transit technology alternative to light rail systems.

In terms of the former, most guided busways have been implemented as a means of avoiding traffic congestion and service delays. They serve as a bus priority measure and can be incrementally added over time. Generally, these examples allow regular service buses to use the guideway if equipped with the appropriate guidance mechanism. The guided buses are generally diesel powered and identical in appearance and build specification to any other regular bus.

Guided bus technologies used in this way, using discontinuous guideway, could well be the basis of an enhanced and extended busway, particularly useful for accommodating buses on the lower deck of the MG Bridge and for delivering level boarding at bus stops.

The application as a rapid transit system is less well established. The guided busway system in Adelaide described later in this chapter is an example of a guided busway developed as a rapid transit system, albeit using an urban corridor. Whilst the busway is continuous for nearly 12km, the guided section actually stops well short of the city centre and it is therefore affected by traffic congestion. Currently, there are no continuous inter-urban guided busways in the UK or elsewhere, although inter-urban proposals do exist in the UK and a 25km guided busway is under construction in Cambridgeshire for completion in 2009.

The use of continuous guided bus technology to deliver bus rapid transit based on current experience suggests all of the available systems are slow and unsuitable for high performance rapid transit.

A. Bus Guideway Options

There are four principal groups of guided bus design and technology options commercially available at present. These are:

- mechanical guidance, usually with a choice of kerb guidance, but can be provided by means of an embedded rail;
- magnetic guidance;

- electronic guidance, using "wiggly wire" inductive technologies, similar to many automated warehousing logistics picking systems;
- optical guidance.

Only kerb guided busways are a fully established technology option and most applications have proved mechanically reliable. The other guidance options have only recently emerged as commercially available proprietary products, and some applications have suffered highly publicised teething problems including "derailment" and slow running speeds.

The most common form of guided busway is that which includes mechanical guidance, and there are a number of examples of such within the UK, as described later in this chapter. However, even with kerb guidance, new products are emerging, and some of the characteristics of these newer systems are set out in the following Table. Two examples are discussed in the following paragraphs.

Table 3.3 Alternative Guided Busway Technologies

System	Supplier and Product Features	Applications	Suitable for High Performance Inter-Urban Routes?
Mechanical kerb guidance			
Dual Mode Bus System (DMB System) Japan	Similar to Spurbus or O-Bahn system (i.e. Adelaide and Essen)	Lateral kerb mechanical guidance	Proprietary product, possible
Guided Bus System (GB System) Japan	Located on viaduct	Lateral kerb mechanical guidance	Proprietary product, experimental
Mechanical guidance by embedded rail			
Guided Light Transit	GLT developed by Bombardier	Test track at Rochforte in the Belgium Ardennes. Mechanically guided central rail embedded in the roadway	Proprietary product, Experimental
TVR (GLT)	Developed by Bombardier - ANF and Spie-Ėnertrans low floor, dual-mode diesel-electric	Mechanically guided central rail embedded in the roadway. Caen and for the Nancy dual-mode trolleybus system substitution	Proprietary product, slow operating speed
TRANSLOHR system	Developed by the Lohr-Industrie and Fiat-Ferroviara.	Prototype circulated on the Trans Val of Marne site, south of Paris, the first quarter 2001. Mechanically guided central rail embedded in the roadway. First line opened in Clermont Ferrand 2006.	Proprietary product, slow operating speed
Magnetic Guidance			
STREAM	Tested on dual-mode battery trolley bus collecting power from the track by electromagnetic activation of electric contacts embedded in the roadway	Trieste on a 3,3 km line with a 12 meters long vehicle and a 18 meters long articulated vehicle, magnetic guidance with an electric cable embedded in the roadway	Proprietary product, experimental
Inductive cable guidance			
Cegelec-AEG wire		Channel service tunnel and on a test track in Newcastle, inductive cable guidance system embedded in the roadway	Proprietary product, slow operating speed
Optical guidance			
Inductive cable guidance (CIVIS)		Iris-bus and Matra Transport International, steering linked to a video-monitoring system and a road marking recognition system. Operated in Rouen since 2001. Clermont Ferrand: optical guidance surface delineation on the roadway surface	Proprietary product, slow operating speed

REID RAIL
THE RAILWAY CONSULTANTS

A.1 Mechanical kerb guidance

The first pilot line was the self-steering, Spurbus, kerb guided busway in Essen, 1980 following a public demonstration in Hamburg a year earlier. This system was later marketed commercially by Daimler-Benz as the O-Bahn, most notably for the Adelaide to Tea Tree corridor. The research and development costs were funded as part of a contract from the West German Federal Ministry of Research and Technology (BMFT). A similar contract using "wiggly wire" inductive technologies was awarded to MAN but this project did not proceed to pilot line trials at that time.

The Essen pilot line, constructed in part along the alignment of a recently vacated metre gauge tramway, used prefabricated concrete panels supported by sleeper's fixed to bored concrete piles for the foundations. The entry points consisted of tapering steel girder rails which funnelled the buses down to the 2.60 metre wide track way.

This pilot installation was opportunistic since it replaced Essen's street running tramways with a new high performance standard gauge light rail system, including sections of underground tunnel in the congested central areas of the city. The Spurbus was intended to determine whether the equivalent delays and disruptions to the surface bus network in the increasingly congested city centre could be mitigated by constructing segregated bus guide ways along the former tramway formations.

Later trials in Essen included the installation of wooden planked guided busway in a section of shared light rail tunnel in the central area to explore the viability of reducing delays to buses by avoiding surface traffic congestion. However, the exhausts from diesel guided buses were discovered to be unacceptable when running in tunnels. Consequently, diesel-electric buses, operating as trolleybuses were tested, but the project was not pursued further.

In Essen guided buses were considered as complementary to the new light rail system, and as a solution to exploit tramway alignments to benefit the local bus network. The main lessons for kerb guided busways from Essen are:

- the reliability of the surface bus network improved using bus priority measures.
- the form of guidance was selected as regular busways would not physically fit within the vacated segregated tramway alignments;
- shared track operation in light rail tunnel required dual mode buses to avoid pollution from diesel fumes;
- guidance is only used within the congested central area;
- simple and low-tech equipment is needed to allow cheap retro-fit to the regular bus network;
- it is not possible to share track operation with light rail;
- the layout causes considerable inconvenience to pedestrians and cyclists.

Adelaide

This 11.8km long North East Busway is constructed along a linear park joining the city centre to the NE suburban shopping centre at Tea Tree Plaza. There are only two intermediate stops (one is also a bus access point) and it is the longest example of a continuous kerb-guided diesel busway. The first section opened in March 1986 and was completed in August 1989. Plans for a second guided busway have been abandoned. Other Australian cities have not adopted guided buses, but a number have made limited investments in conventional busways. Operation is line of sight throughout. In the city centre services can be delayed by buses running in mixed traffic with limited priority. Guided buses use regular roads to serve the outer suburbs. Other local services feed the busway, requiring passengers to interchange.

There are four reasons why the North East Busway represented a major policy shift compared to the Essen model:

- this technology was chosen instead of light rail for political reasons;
- it was the world's first line haul guided busway application along a major radial corridor;
- it was the first to use a continuous kerb guidance system (except in the city centre);

- the preferred light rail solution was overturned by the wider political considerations.

The outgoing Council's plans to construct a light rail line, together with a cross city centre link to a proposed upgrading of the Glenelg Tramway to the southern suburbs, was overturned by the incoming administration,. The new administration refused to allow any tramway to run on street in the city centre, essentially because of concerns about loss of highway capacity for other road users.

However, the technical reasons are relatively weak. Furthermore, it appears a relatively expensive solution to deliver quality bus services. The kerb guided busway was not allowed access to the city centre and is constructed parallel to an expressway. The guidance system does cause problems to pedestrian severance in city streets. Competing bus services running along the expressway can offer faster off peak journey times, even though the kerb guided buses can operate at speeds of up to 90km/h.

A.2 Mechanically Guided Buses Using Embedded Centre Rail

The slot guidance is a mechanism developed for steering buses. The GLT system developed by Bombardier operates in Caen and Translohr has developed a similar vehicle that comprises twin rollers that lock together to form a 'V' and fit onto a central guideway. Vehicles remain in guided mode at all times, and are powered using a pantograph mounted on the roof.

The capacity of these vehicles ranges from 80-250, with capability for 2,000-5,000 passengers per hour. Three systems have been successfully introduced in Italy, with a further example in Clermont Ferrand.

A.3 Optically Guided Buses (e.g. CIVIS)

CIVIS has developed both a guidance system, and several types of vehicles that use the guidance. The optical guidance identifies the contrast between two painted white lines on the road against the darker road surface to steer the vehicle. Several types of vehicles were developed, rigid, single articulated and double articulated.

Vehicles can either operate with electrical and hybrid power. In Rouen, France, the optical guidance was installed on a fleet of Agora articulated buses (around 50 in the fleet), but with a cost of around £230,000, these vehicles are significantly more expensive than conventional buses. It should be noted, however, that the optical guidance is only used to achieve level boarding at present; it is not used for general running along routes except to negotiate some junctions. Furthermore, the CIVIS system has had to be withdrawn twice due to concerns regarding cost and reliability.

There are several issues that reduce the attractiveness of the optical guidance system. Firstly, the maximum speed for optical guidance is just 32km/h, so the journey times could be significantly slower than the current bus service. Furthermore, the optical guidance is unlikely to be introduced in the UK, since it may have difficulty meeting the required safety standards.

A.4 Suitability of Continuous Bus Guideway as a Rapid Transit Option for Halton

As stated previously, kerb guidance is by far the most common form of guided busway technology used, and the only one used to date in the UK. However, none of the other options for emerging technologies offer significant benefits, since:

- few have been commercially deployed and operational service experience is therefore limited;
- some are near market, whilst others are deployed in pilot or trial applications;
- all are proprietary systems exclusive to one supplier group;
- they are low performance in characteristics at present;
- some may encounter regulatory (safety related) difficulties in the UK.

Recommendation

This study does not exclude the application of guided bus technologies as a traction option for bus based rapid transit solutions for Halton .Overall, however, it is concluded that all of the alternative technology options to kerb guidance are presently unsuitable, or insufficiently developed, for inter-urban high performance guided busway applications in the UK, as would be required for Halton.

This certainly does not however preclude the use of bus guidance for level boarding and alighting and if buses were to operate on the MG Bridge in place of trams, a form of guidance is likely to be needed for safe operation within the limited structure gauge clearances.

A.5 Other Guided Bus Operational Considerations

The UK has increasingly explored the potential for guided bus technology, as an alternative to the private car for rapid transit applications. This policy delivers highly visible new investment in public transport systems and can often generate additional patronage. These systems are normally carefully marketed with no mention of it being essentially a bus.

The market proposition made to potential purchasers by system suppliers and promoters is broadly that guided bus based rapid transit technologies offer greater operating flexibility and potentially lower capital and operating costs than light rail.

Guided busways are rarely selected on technical and technology grounds alone. So far, all of the recent guided bus rapid transit systems outside the UK have been introduced as either urban services, or along self contained dedicated urban corridors or as part of the urban distributor network. Except for those planned in the UK, none are inter-urban in nature.

In the UK, the maximum permitted length of a rigid bus is 12 metres and 18 metres for twin section articulated motor buses, trolley buses and hybrid buses. The maximum permitted width is 2.55 metres. There may be allowance for increased length rigid buses of up to 15 metres and some increase in permitted widths. Of the available guideway technology options, the kerb guided systems would be restrictive for requiring wider vehicles, effectively requiring guide planks to be re-gauged, and reconstruction of infrastructure.

Most kerb guided diesel bus systems have been confined to 12 metre rigid or up to 18 metre articulated buses, all 2.5 metres wide. Optical and electronic guidance technologies would be less affected. Nevertheless the later systems have all generally restricted operation to an 18 metre maximum length and a 2.5 metre width.

No guided bus system has adopted larger buses. Double articulated buses longer than 18 metres have been produced as conceptual prototypes, and have entered revenue service in Bordeaux, Geneva and other cities but not on guideway.

As detailed previously, there is presently a limited choice of commercially available guided bus technology options. With the exception of kerb guidance systems each of these mechanical, optical and electronic guidance technology choices are proprietary systems supplied by individual manufacturers. Many of these designs / intellectual properties appear to be protected by suppliers' patents or licenses.

Guided busways therefore remain on emerging technology, where the early simple mechanical kerb guidance types are the most established. Market trends show that these are being replaced by better or improved mechanical guidance products as well as sophisticated optical as well as new electronic guidance technologies.

The UK has adopted a significantly different policy framework in promoting the kerb guided diesel busways for high performance rapid transit applications, compared to elsewhere in the world. With the exception of Adelaide, these have generally only been adopted elsewhere to a limited extent as highly specialised solutions for tackling problems within the context of the local urban bus network and not as a rapid transit technology option.

The UK government has allocated £92.5million for a kerb guided busway between Cambridge, St Ives and Huntingdon and over £78 million for a kerb guided busway between Luton and Dunstable. Unusually, these are inter-urban guided busway rapid transit projects.

The only diesel guided busway used for rapid transit is limited to the 11.8km system in Adelaide, since no other equivalent kerb guided busway has yet been implemented for high speed inter-urban rapid transit.

A.6 Comparative Cost of Continuous Bus Guideways

Guided busways are generally promoted as lower cost alternatives to light rail and tramways. Although unit costs of appear to be broadly similar to those for light rail and tramways, the lower capital cost estimates are dependent on providing only limited amounts of dedicated right of way.

Similarly, the headline direct unit operating cost per vehicle can be less than for light rail and tramways. The guided bus tends to have significantly lower passenger capacity, typically 30 – 50% of modern light rail vehicle, together with a vehicle life of 12 – 15 years before renewal compared with 20 – 30 years for light rail.

Robust comparisons of capital costs for guided busways and light rail and tramways are difficult to determine. For example in Nancy (Alsace – Lorraine) the guided busway network is an incremental upgrade of the earlier dual mode (hybrid) articulated trolleybus system.

Consequently in this case, the extant trolleybus power supply and overhead line equipment was generally reused; Utilities diversions were minimal and no significant project cost allocations were made for track costs, since much of the existing bus priority measures were largely re-used. Capital works were largely for the installation of the central mechanical guidance rail located in existing carriageways.

A.7 UK Examples of Guided Bus

Kesgrave, Ipswich

A 200 metre pilot guideway with a combined foot and cycle path alongside was constructed, but the guideway could only accommodate 2.4 metre wide buses but has since been re-gauged for 2.5m buses. Regular vehicles are thereby prohibited, with traps preventing unauthorised use.

The guideway is used by a single bus route, although it seems any other operator could use it if suitable vehicles are used. The route has also been re-equipped with new bus shelters, permanent bus lanes and traffic signal detection. Detailed passenger information is available at bus stops, and via the internet.

The guided buses are high floor single deck rigid. Whilst this service has increased passenger usage, the complementary service quality improvements are an important factor in achieving these objectives.

Leeds

The construction of a £4m guided busway covering 2km of the A61 Scott Hall Road and 4km of the A64 corridor were completed in the 1990s. The scheme comprises several short sections of one-way guideway.

The Leeds approach adopts short sections of guideway on the approaches to junctions as a means for buses to avoid general traffic congestion. The guideways are constructed from reinforced concrete with separate kerbs for the buses' guide wheels. An unguided inbound contra-flow bus lane is also provided.

The guideway has reduced peak bus journey times by up to 50%, and improved journey time reliability. Between 10 – 20% of bus passengers have switched mode from car, equating to about 500 car drivers per week. Bus frequencies have been increased in response to the patronage growth. Research identified the outbound guideway saves up to 3 minutes per bus in the evening peak, with the inbound guideway saving up to 5 minutes in the morning peak.

Bradford

In 2002, 2.3km of guided busway opened, built in five sections as part of a 3.7km quality bus corridor, along the A641 Manchester Road. New pedestrian crossings, footpaths, seats set into a major landscaping

scheme were also included. The guided busway was also accompanied by a reduction in adjacent highway speed limits to 50km/h.

Sussex "Fastway"

In 2003, construction of the 24km Sussex "Fastway" kerb guided diesel busway scheme commenced. The scheme includes 9km of regular busway plus 2.5km of kerb guided busway, linking Gatwick Airport with Crawley and Horley.

West Edinburgh

In 2004, the 8km, £10 million, West Edinburgh Busways (WEBS) "Fastlink" kerb guided busway scheme opened from the city centre to Edinburgh Park. This consisted of 3.45km of on-street bus lanes plus 1.5km of twin track kerb guided busway and other bus priority measures, along with upgraded bus stops along the entire route and associated parking and traffic management measures. There are 4 stops located along the guideway sections and services were initially provided by 30 guided buses.

The guided bus system has been designed for future conversion to a light rail system, typically where street tramways are planned/laid out to be upgraded to full metro systems at some future time. It is intended to construct Line 2 of the proposed light rail system from the city centre to Newbridge on the kerb guided bus corridor. This solution is therefore:

- an interim or transient measure;
- a precursor to the adoption of light rail; and,
- a bus priority tool.

Luton and Dunstable (Translink)

The Translink guided bus proposal linking Luton, Dunstable and Houghton Regis uses part of the former rail alignment between Dunstable and Luton. In addition to serving several major residential areas in Dunstable, Houghton Regis and west Luton, Translink will provide interchange with two rail stations in the town, and provide a connection to the expanding London Luton International Airport. The guided bus will also support the wider regeneration objectives in the town, by significantly improving access to key employment sites.

Translink is expected to cut peak journey times between Luton and Dunstable by 50%, and is expected to attract about 9,000 trips per day. A public inquiry into the proposals commenced in February 2005.

Cambridge, St Ives and Huntingdon Busway (superCAM)

This proposal will use the former rail alignment between St Ives and Cambridge. About 26km of segregated bus route between St Ives and the northern fringe of Cambridge is proposed, this will also serve the proposed new settlement at Northstowe, with park and ride planned for St Ives, Northstowe and Trumpington.

Buses will operate on-street through the centre of Cambridge, supported by a comprehensive system of bus priority measures in Cambridge to reduce existing journey times. Access to the guided busway will be enforced through quality bus partnerships. The public inquiry was recently completed and construction commenced in 2006, with an expected opening date in 2009.

The financial and economic feasibility of light or heavy rail was also examined for both proposed systems in Bedfordshire and Cambridgeshire. The results demonstrated the guided busway system delivered a stronger financial case than either of the rail-based alternatives examined. This conclusion indicates guided busways provide an attractive alternative when passenger volumes are lower.

Funding has been agreed by the Department for Transport (DfT) for both schemes. It is interesting to note both routes incorporate sections of on-street running in central Luton and Cambridge to improve access to the main retail and employment centres. Both systems also extend beyond the guided busway to serve major residential developments.

B. Bus Rapid Transit Using Busways

B.1. Overview

Runcorn possesses the only Busway in the UK originally using a 22km network constructed in the 1970s to light rail dimensions, theoretically allowing conversion to light rail / tramway at some future time. This is a significant embedded investment.

It was designed to serve residential areas, schools, local centres, employment areas and the main shopping centre. The low density land use patterns were described as complementing the Runcorn busway concept as a local area distributor though extension of the busway into Widnes would be inter-urban in character like successful busway systems in the US.

Regular busways aim to replicate those features of light rail that are most attractive to customers, particularly service quality and the dedicated, physically segregated, operating alignments. They perform the same function as guided busways, and offer the additional benefit of a fully dedicated highway alignment where narrower alignments are not a physical constraint. Buses using regular busways require no technical additions or adaptations, and can be up to 18 metres long (in the UK) if they are to also operate on street (within the highway).

Physical dimensions in excess of this can only be permitted provided if:

- The bus remains captive to the regular busway;
- The regular busway is not, nor becomes, adopted highway.

Regular busway systems offer a high level of bus priority, with dedicated rights of way. They usually include highway construction works and established traffic management systems to maximise the level of bus priority.

In practice, the maximum limiting operating speeds along regular busways will be those permissible along any similar section of public highway. This means that limiting speeds of up to 100km/h may be permitted, which is considerably faster than typical guided busways although Adelaide does operate up to that speed.

Regular busways may therefore offer superior performances compared to guided busways over longer inter-urban networks. Physically segregated busways, like all segregated systems where dedicated stops and stations are provided require particular attention to design measures aimed at ensuring raising passenger confidence with regard to tackling crime and fear of crime, to a greater degree than is usually provided for on-street systems such as regular bus services. The design and security measures typically used at UK heavy rail stations and at UK light rail stations would need to be considered for adoption for any segregated bus based rapid transit scheme.

B.2. Busway Options

Busways share similar characteristics to light rail, more so than the generally lower performing guided busways, and, like light rail, can include some or all of the following:

- exclusive bus lanes, bus streets, and dedicated right of way busways;
- quicker journeys;
- less traffic delay;
- bus traffic signal priority or pre-emption;
- better service quality (service reliability and punctuality);
- complementary traffic management;
- easier access boarding/alighting patterns;
- complementary land use policies;
- better passenger facilities and amenities at enhanced bus stops;

- track sharing with emergency services.

Busway design solutions are highly diverse and include:

- operation along wholly dedicated and separate right of way,
- the use of highway median strips;
- the use of abandoned railway alignments (where lateral dimensions permit);
- bus only lanes enforced by physical kerb segregation;
- bus only lanes enforced by rigorous enforcement traffic of regulation orders.

Any extension of the current Runcorn Busway might use any or all of these approaches.

B.3. Other Busway Operational Considerations

Most regular busways are adopted highways; especially those designed within the existing highway boundaries, though not necessarily within the general running carriageway, for example, busways built within highway median strips, and within edge strips.

As with guided busways, regular busways can be constructed to serve two distinct roles:

- most commonly as a bus priority tool for local, corridor and wider urban bus networks; or,
- less commonly as a self contained rapid transit alternative to light rail and tramways.

It is in the latter context that is most relevant to Halton in this study.

Regular busways are often proposed as a means to provide a means of improving the efficiency and effectiveness of existing line haul bus services in an affordable way by conversion to rapid transit.

There is renewed interest in busways (guided or not) as a rapid transit option in the UK, Europe and the United States, given the limited capacity to fund the number of light rail and heavy rail schemes planned or proposed.

Busways may be intended as a pre-cursor to light rail, or a substitute if light rail is simply not affordable, given the recent cost escalation that makes it challenging to achieve the necessary cost benefit ratio needed to obtain Government approval.

B.4. Comparative Costs of Busways

The buses themselves are comparatively inexpensive to buy and provide the core of many towns and cities' public transport network. Diesel bus operation avoids the capital outlay for electrification costs for a regular light rail line. However, there is a perception that buses offer less comfort, convenience and speed than either light or heavy rail based technologies. The planned physical ridership capacity of a well designed busway can be equivalent to, or exceed, that of some light rail corridors.

The construction costs of the busway itself will be similar to highway construction costs. Complementary traffic management costs of busways are likely to be similar to that for light rail, for a given level of priority. However, the costs per passenger are likely to be higher, since a higher number of lower capacity buses will be required compared with light rail, for maintaining a good service level and supplying sufficient line haul passenger capacity.

B.5. Global examples of Busways

UK and European applications of regular busways tend to be as part on the urban or local bus network. The United States has possibly made the largest investments in busways which exhibit inter-urban rapid transit characteristics. Some of these numerous applications are set out below, followed by some other examples from elsewhere.

- Houston, Texas;
- Washington, DC (Shirley Highway);

- Los Angeles, California (El Monte Freeway);
- San Francisco, California (Highway 101);
- Oakland, California;
- Miami, Florida;
- Pittsburgh, Pennsylvania;
- Orlando, Florida;
- Hartford, Connecticut;
- Cleveland, Ohio;
- Eugene, Oregon;
- Charlotte, North Carolina;
- Nashville, Tennessee.

Other high performance bus systems with inter-urban characteristics include:

- Curitiba, Brazil;
- Sao Paolo, Brazil;
- Ottawa, Canada;
- Quito, Ecuador;
- Caen, France;
- Lyon, France;
- Nancy, France.

The Zuidtangent in the Netherlands is a high quality public transport connection between Ijmuiden and Weesp via Haarlem, Schiphol and Amsterdam. It offers a fast connection, with a dedicated busway for most of the route, and priority measures elsewhere to ensure reliable journey times.

Patronage levels shortly after opening were 10% higher than expected. The initial 24km route is designed to minimise the maintenance requirements, and could also be easily converted to a light rail alignment. An extension is planned, at either end of the route to extend the total to 40km.

C. Light Rail Rapid Transit

C.1. Overview

Given the context of this study for Halton, including an estuarial crossing, and supporting policies seeking improved high quality, car competitive, north-south public transport connectivity's the principal consideration within the light rail category cover both high performance urban and inter-urban light rail systems.

High performance light rail systems are generally defined as a category of light rail which aim to combine the speed and performance of modern light rail technologies with segregated high speed operation generally along easily graded, wholly segregated alignments where possible, with limited shared traffic lane running. As with many other high performance public transport options, there are no clearly defined boundaries between (line of sight) inter-urban light rail systems and heavy rail type (signalled) light metros.

In general, high performance light rail alignments in the UK incorporate 80kph line of sight operational practices (except the Tyne & Wear Metro and Manchester Metrolink railway sections). In contrast, the European and North American examples have signalled systems, even though operational maximum speeds may be very similar.

The characteristics of high performance light rail systems can be broadly summarised as:

- operation along dedicated, wholly physically segregated alignments;
- often along former heavy railway alignments;
- wholly fenced alignments with simplified railway type signalling;
- use of former heavy rail or metro alignments;
- permitted line speeds in excess of 80km/h when signalled;
- line of sight;
- limited or no operation on street;
- not usually interoperable with heavy rail;
- low or high platforms for level boarding;
- fewer intermediate stops / stations on line of route;
- electrification at higher voltages than permitted for on street applications;
- high floor or level boarding rolling stock generally heavier than typical street running tramways.

C.2. Light Rail Technology Options

Essentially higher performance light rail systems perform the same function as regular heavy passenger railways with the additional benefit of achieving higher rates of acceleration/deceleration and lower dwell times by virtue of their superior performance.

Light rail systems have the capacity to utilise more steeply graded routes than is possible with conventional heavy rail passenger services.

The table below summarises the performance characteristics of the three types of typical light rail operating systems – these are segmented by the nature of operation, rather than the type of technology.

Light rail systems technologies have been exploited in two ways, each distinctively different. These are:

- as an urban light rail system, requiring line of sight street running and inter-working with other road traffic – this is typical of the newer UK light rail systems;
- as a rapid transit technology alternative to heavy rail and metros.

Table C.2 Light Rail Characteristics

System	Performance Characteristics	Examples
Street tramways A general term applied to low to medium performance light rail throughout Europe. Common American terms used to describe trams are streetcars or trolley buses. Tramways typically use single vehicles rigid or single articulated trams and usually operate on city streets in mixed traffic.	Generally with low level or street-level platforms or simple kerbside tram stops. Limited traffic priorities. Maximum speeds limited to posted highway speed limits The speed of street tramways is relatively slow due limited traffic priorities in city streets and operating in mixed traffic. Average stop spacing 300m – 500m.	Blackpool Tramway (Starr Gate to Fleetwood)
Urban light rail Medium to high performance light rail using larger vehicles or multiple vehicles that operate on city streets or segregated rights of way, or a mixture of both. Also uses high level tram priorities, e.g.trambaan.	Operating on street and on segregated alignments. Low level or street-level platforms (if platforms at all) although there are exceptions. Significant traffic priority. Maximum speed limited to posted highway speed limits or up to 80km/h on un-signalled segregation. Average station spacing 600m – 900m	South Yorkshire Supertram Nottingham Express Transit Manchester Metrolink (city centre)
Inter-urban light rail Medium to high performance using trains of multiple vehicles operating either on the surface, viaducts, or in underground subways or tunnels. There is no track sharing or interworking with other modes, but private rights-of-way can often be shared with freight trains at night.	Fully segregated alignments, up to 80 kph line of sight. Higher speeds permitted with signalling. Average station spacing 800m – 4000m. Interurban light rail can operate at relatively high speeds when operating on segregated tracks.	Tyne & Wear Metro Manchester Metrolink Bury-Altrincham outside the city centre

There were substantial investments in light rail and similar "light" railways worldwide in the first part of the twentieth century. For the most part, except perhaps in North America, many of these were rural tramways or light railways, including many examples in France and Belgium.

Many of the conceptual approaches used by the original electrified inter-urban light rail networks in North America have resonance today, and the basic principles are still applied in present day interurban light rail applications. Most, but not all, of these inter-urban light rail lines were electrified.

Ottawa is an interesting example of a shift towards a low floor diesel light rail instead of an existing busway system. Similarly, in Holland, a number of rural and secondary passenger railways employ diesel powered interurban type light rail rolling stock. Electrification is **not** a prerequisite for inter-urban light rail applications.

There is no absolutely clear cut boundary between tram-train, as described later, and light rail, in terms of operational and network capability. Light rail can, under certain safety case or risk assessment conditions, inter-operate to some extent with heavy rail. This is complicated by the different national safety standards applied by different countries. A more detailed discussion on inter-operability can be found later in this study, dealing with tram-train.

C.3. Other Light Rail Operational Considerations

There is often strong local political support for new light rail systems, since the promoters of new systems identify the wider social and economic benefits that have occurred elsewhere. The integration of new light rail network is usually accompanied by complementary measures including extensive pedestrianisation of the city centre and parking restraint. One of the factors contributing to this support is the favourable perception of service quality. The recent report by ***pteg*** endorses this conclusion by presenting evidence that light rail is more successful encouraging car drivers to transfer than alternative modes through;

- frequent services with reliable, attractive journey times to rival the convenience of car;

- versatility to operate at high speeds on segregated sections, yet provide convenient access to the city centres;
- wider economic, environmental and safety benefits;
- high quality, comfortable, reliable vehicles that has successfully persuaded car drivers to switch;
- easy access for mobility impaired, or those travelling with children or luggage. Whilst modern accessible vehicles have been introduced, some cities still use relatively old rolling stock that offers limited accessibility.

When considering conversion of heavy rail passenger services to light rail, there are a number of potential benefits including:

- reduced cost of operation (and the potential for a reduced subsidy requirement); yet, the modern light rail vehicles offer higher quality rolling stock than that provided today;
- the potential for improved service frequencies and improved city centre accessibility;
- the restructuring of services to meet local demand and be more responsive to local trip patterns;
- the opportunity, through operating lower floor light rail vehicles, to provide more 'stations' to improve access and make better use of the rail corridor;
- opportunities for local autonomy, involvement and 'ownership' of decision-making;
- better integration of the rail corridor with other modes, as its frequency improves.

C.4. Comparative Costs of Light Rail

A range of funding mechanisms has been secured for existing UK light rail systems, which are generally more costly than bus-based solutions, but slightly less costly than a heavy rail alternative.

For example, the first phase of Metrolink was funded through a combination of Section 56 grant from the Department of Transport, and borrowings from Greater Manchester Passenger Transport Authority. The private sector has demonstrated a commitment to delivering light rail systems. This interest and support is given, despite the significant risks that are usually associated with the delivery of such systems. Promoters face a significant hurdle, in securing Government support for their project, at a reasonably early stage, and attracting private sector interest to secure the other funding sources. The difficulty in securing private sector monies will increase, if Government support is not forthcoming.

The private sector demonstrated an appetite for involvement in light rail system by contributing almost two-third of the total costs for the second phase of Metrolink to Eccles. Furthermore, the Croydon Tramlink system was funding by a Private Finance Initiative involving Amey and an off-shore company. Significant revenue shortfalls for the concessionaire meant further bank funding or restructuring was needed to continue trading. These difficulties, and the under-performance of several other systems, may have diminished the private sector appetite for such transactions. The recent National Audit Office report confirmed several systems were facing revenue shortfalls affecting UK light rail systems ("Improving Public Transport in England through Light Rail", April 2004).

Section 56 grants were secured for the initial light rail systems, but changes in the funding regime removed this funding mechanism. The Bristol and South Gloucestershire light rail system proposed hypothecating revenue from road user charging to cover the gap between operating costs and revenue. There was public support for road user charging, but only if the light rail system was complete prior to the introduction of the charging regime. At present, this scheme is not being taken forward for implementation.

The concept of 'capitalising subsidy' offers an innovative funding mechanism if light rail replaces a loss-making heavy rail service. Instead of continuing to provide financial support to cover the difference between revenue and on-going operating costs for loss-making heavy rail routes, capitalising subsidy allows the on-going revenue support to be invested in infrastructure, or the procurement of rolling stock. Both Croydon

Tramlink and parts of Manchester Metrolink have taken over former heavy rail alignments, and the subsidy previously used to financially support these services has been re-allocated to part-finance the infrastructure.

The DfT did not grant approval to three light rail schemes following a significant escalation in the schemes capital costs. Funding announcements for Manchester Metrolink Phase 3, Leeds Supertram and the South Hampshire Rapid Transit System have either been delayed or been withdrawn, with promoters required to reduce the capital costs, or seek alternative funding mechanisms or alternatives to light rail.

Dialogue between the DfT and the scheme promoters in Leeds, with some cost savings of about £250 million achieved through changes in approach to procurement and risk, and re-scoping the definition of the project failed to save the scheme.

C.5. UK Examples of Light Rail

The 11 mile Blackpool Tramway between Starr Gate and Fleetwood, has survived as a coastal tramway. Whilst the segregated alignment to Fleetwood used to exhibit inter-urban characteristics, later infill land development means this section it is now entirely urban in character and operates as a low speed street tramway. The conversion and significant extension of the Blackpool tramway into a modern urban high performance light rail system is now a key resort development theme.

Many of the newer light rail schemes in the UK exhibit inter-urban light rail characteristics along part of the route. However, the systems themselves are all urban in character. The inter-urban sections of these systems are all examples of conversion, reuse or adaptation of former heavy rail alignments. The combination of re-used railways and modern low floor high performance light rail vehicles is an increasing global trend. The utilisation of heavier rolling stock for inter-urban light rail is reducing the number of examples for fully signalled heavy rail track sharing applications. The UK systems exhibiting some inter-urban characteristics along part of their routes or alignments are:

- Manchester Metrolink (to Bury, Altrincham, Eccles);
- Midland Metro (Birmingham to Wolverhampton);
- Croydon Tramlink to Wimbledon;
- Tyne & Wear Metro with permitted heavy rail track sharing to Sunderland;
- Sheffield Supertram (Line 2 to Meadowhall);
- Nottingham Express Transit (when on railway alignment).

Tyne & Wear Metro

The opening of the Tyne and Wear Metro in 1980 connected under-used suburban railways. The system is fully segregated, with no sections of street-running. The segregated network permits a relatively high operating speed (37.8km/h), with an average spacing of 1.3km between stations. A tunnel under the city centre improves access to the main retail and employment areas in Newcastle. The network was subsequently extended to Newcastle Airport and Sunderland. The Metro revitalised local rail services in Tyneside, with the introduction of new rolling stock and more convenient city centre access.

Croydon Tramlink

Croydon Tramlink comprises a 28km network, with routes from Wimbledon to New Addington and Elmers End via Croydon. Tramlink attracts significantly higher patronage than the former rail service between Wimbledon and Croydon through a combination of higher frequencies (trams operate at least every 10 minutes) and better service quality. Although the majority of passengers using Tramlink were abstracted from bus, about a sixth of passengers have switched from car.

The service is mainly used by commuters (45%) and shopping (26%). Similar to Manchester Metrolink, the mixture of segregated alignments (Wimbledon to Croydon, and Birkbeck to Beckenham Junction) and on-street running in Croydon town centre means the average operating speeds are just 24km/h, with an average distance between stations of just 0.7km.

Manchester Metrolink

The completion of the first phase of Manchester Metrolink formed part of a wider masterplan for light rail serving the Greater Manchester conurbation. The heavy rail service was operating at a loss, offering a poor quality, unreliable service. Metrolink Phase 1 significantly improved services to Bury and Altrincham, with up to 10 trams operating per hour. The route uses much of the former heavy rail alignments, with on-street running via the city centre.

The conversion to Metrolink has provided a significantly better service. Patronage is over 80% higher, including a doubling of off-peak trips. The average operating speed is 37.7km/h. This is slightly slower than the Tyne & Wear Metro, reflecting the on-street running via the city centre.

The average gap between stations (1.1km) is also less than the Tyne & Wear Metro, and this is consistent with the close spacing of stations in the city centre. Whilst 60% of Metrolink passengers were abstracted from the former rail service, about 20% of passengers were abstracted from car. This has generated significant environmental benefits.

D. Tram-Train as a Rapid Transit Option

D.1. Overview

The tram-train concept is increasingly popular and provides a means for light rail vehicles to access and use heavy rail alignments where there is the opportunity. The essence of tram-train is heavy rail interoperability and to deliver greater accessibility within communities.

Tram-train was first introduced in Germany in the late 1970s in response to a need to improve the suburban rail track to allow shared use with light rail. This concept links urban tramways with regional heavy rail networks to deliver significantly better access to the city centre if the main rail station is located remotely from the main employment and retail areas. This is achieved by introducing heavy rail vehicles onto the urban tram alignment, trams are not extended to operate on the heavy rail network.

The first stage in developing a tram-train network was the extension of the Albtalbahn, an electric suburban light rail line from Karlsruhe to Bad Herrenalb and Ittersbach. In 1979, the network was extended through central Karlsruhe using the tram network, then north to Neureut sharing the track with freight trains on a lightly used branch line. The shared sections were electrified. Dual voltage trains were developed, using different types of cab signalling for each type of traction.

High speed inter-city trains, freight and the local tram-train services are permitted to use the infrastructure. Strong local support for tram-train within the Karlsruhe hinterland has led to the tram-train network being expanded to 470km.

D.2. Tram-train Technology Options

There are two approaches that are usually adopted within tram-train technology:

- Metro lines, where all mainline trains are replaced. There is no requirement for inter-operability compatibility with mainline trains. These lines are permitted to use regular modern high-speed tram-trains (of up to 50 mph or 80 kph maximum permitted speed on unfenced railway alignment and potentially 90 - 100 kph, subject to risk analyses). Line 2 of the South Yorkshire Supertram (Middlewood to Meadowhall) and the Bury to Altrincham lines of the Manchester Metrolink are typical examples;
- Metro lines, which require the trams to share tracks with mainline trains, passenger and/or freight, for some or all of the time.

If the different types of rolling stock are required to inter-work with each other at the same time, (rather than at different times of the day), metro vehicles must be entirely compatible with the mainline trains, and the signalling and safety systems.

Both Bombardier and Siemens have developed rolling stock suitable for tram-train. The 'Flexity Link' has been successfully introduced in Saarbrucken, to permit travel from the rural hinterland to the city centre without interchanging. The innovative rolling stock also offers a high level of passenger comfort, with air conditioned interiors. Siemens have developed similar rolling stock, and these units have successfully been introduced in Karlsruhe.

Tram-trains can tackle many of the difficulties associated with high costs for running "mainline" trains along economically and financially fragile passenger routes. Tram-train is able to address the problems of:

- poor acceleration and slow braking which restricts the number of stops to maintain line capacity – tram-train offers scope to introduce extra station stops;
- the high "mainline" train unladen weights are usually double that of similar capacity/sized tram-trains, which requires much heavier duty, and more expensive, track design standards and much higher maintenance costs, particularly for locomotive hauled trains;
- slow braking and higher weight prevent drivers stopping within "line of sight" and require expensive signalling and level crossings have to be fully protected by signals, gates or barriers – this restricts the availability of train paths, and reduces capacity. In contrast, tram-trains can run at any frequency required generally at 5 minute intervals or less;
- stations typically have underground passageways and footbridges to allow passengers to cross the line by a grade separated route; in contrast, pedestrians may walk over dedicated tram-train track sections at pelican type signalled crossings.

Tram-train can reduce or eliminate expensive signalling and track circuits. Services can be extended via new alignment, since the rolling stock performance of tram-train is superior to conventional heavy rail vehicles. It allows tram-train to climb significantly steeper gradients, and reduce the costs of identifying engineering alignments.

One of the factors contributing to the success of tram-train is often the distance from the rail station to the main employment areas. A walking distance of about 10 – 15 minutes from the main rail station is usually required to develop a successful tram-train business case. If the distance is too short, there is no particular deterrent to walk to the destination. The ability for through running and the time savings achieved are among the main benefits of the tram-train.

Consideration must also be given to the population catchments being served. Tram-train systems are not suitable for densely populated corridors in metropolitan areas, since capacities are insufficient to cater for the likely demand. Furthermore, a sparsely populated area is unlikely to generate sufficient patronage to develop a robust financial case.

D.3. Other Tram-Train Operational Considerations

Whilst most light and heavy rail systems share the same track gauge of 1435mm, they do not share a common loading (infrastructure) gauge. Careful design solutions have to be found to the problems of platform heights and widths, bridges and fixed equipment, tunnel and safe mutual dynamic passing clearances and other line-side structures when operating over both systems.

There is also a need to share platform faces, or if separate platforms are used, the problem of safe mutual clearances for both types of rolling stock when running through each differing type of platform. Wheel, tyre and track tyre specifications can significantly differ between light and heavy rail networks, to the extent that there is no safe technical solution which may be compatible with both systems.

Before the introduction of tram-train systems, there are a number of important institutional issues to be addressed before a proposal can be implemented. Ownership of rolling stock, impact on existing staff (wages and pension contributions) and operator licensing form key questions. Key delivery milestones include:

- technical acceptance – profile of the wheel-flange, electro-magnetic interference, steeping distances to the platforms, compatibility with Network Rail Group Standards;
- safety acceptance – meeting all HMRI and RVAR requirements;

- legal consideration – procuring an operators licence, and ensuring the operator has a safety case;
- appropriate contractual rights, particularly if an existing light or heavy rail franchisee has access rights.

Modifications to the current network code are likely to be needed. The introduction of new rolling stock will require a "Vehicle Change" and granted Track Access Rights. Equally "Network Change" must demonstrate that any changes proposed will not adversely affect other operators.

D.4. Comparative Costs of Tram-Train

The costs of tram-train schemes are broadly comparable to a light rail scheme, although the vehicles themselves may be more expensive. As such, therefore, tram-train is more expensive than a bus-based solution, but less expensive than an equivalent heavy rail scheme.

Many of the comments in the preceding section regarding innovative funding opportunities for light rail schemes should be equally applicable to tram-train, but these have not yet been tested in the UK.

D.5. UK Examples of Tram-Train

The Sunderland extension of the Tyne & Wear Metro involves track sharing and inter-operability. This example is described in Chapter 7 of this paper.

The Greater Manchester Strategic Rail Study recommended tram-train introduction on the line to Wigan via Atherton and on the Eastern lines to Glossop/Hadfield, Marple and Rose Hill as both short and medium term strategies.

D.6. European Examples of Tram-Train

Karlsruhe

Karlsruhe rail station is remote from the main employment and retail areas in the city, and interchange with the city's tram network was also poor. The heavy rail network was connected to the local tram routes and rolling stock modified for both types of traction. A safety case was developed to permit both freight trains and tram-train vehicles to track share. This solution minimised investment by using existing infrastructure, and offered passengers better access to the city centre without interchanging. Frequencies were improved and journey times reduced, since the new rolling stock permitted faster acceleration/deceleration.

Increasing the number of stations, and thus accessibility, and particularly station location in relation to the population and key destinations is also an important determinant influencing demand. In Karlsruhe the number of stops was increased from 8 to 36, without any loss in travel times, given the new through connections to the city centre. The frequencies were increased from about 40 to 75 trams per hour, with services continuing to operate in the late evening and at weekends.

Two routes were initially introduced:

- Karlsruhe – Bretten: 600% increase in patronage in 7 years;
- Pforzheim – Worth via Karlsruhe: 100% increase in patronage in 3 years.

Several other sections were constructed in the 1990s, including routes to Odenheim, Menzingen, Eppingen, Bretten, Muhlacker. More recently, funding constraints have restricted the opportunities to expand the network.

The operating costs of the tram-train system are significantly lower than those of heavy rail services. Overall operating costs were reduced by about 50%, although maintenance, labour and fuel costs increased.

Kassel

Kassel has a population of 200,000, with an additional 100,000 people living in the Travel to Work area. It is located on the Hannover to Wurzburg high speed rail line. In 1995, one of the tramways was extended to

Bauntal (population 25,000, with significant manufacturing employment) using a freight goods line. The increased population catchments served meant the number of daily passengers more than doubled from about 2,800 to 5,800. Siemens Duewag trams suitable for heavy rail track sharing were introduced.

Six years later, two tram lines in east Kassel were extended to Helsa via a freight-only alignment. Overhead electrification was introduced, and new stations constructed. Bombardier tram-trains were deployed on the route. The increased passenger numbers meant the level of subsidy was reduced by about 15%. There are proposals to expand the tram-train network to include towns located about 30km from Kassel, but feasibility assessments are still ongoing.

Saarbrucken

Two tram-train routes have also been developed in Saarbrucken (known as the Saarbahn). The construction of 5.1km of new track allows passengers to travel directly into the city centre from towns located up to 30km away. The first phase of the tram-train network was constructed to Brebach, with an extension to Sarreguemines. The original patronage forecasts for the route have been exceeded, with an extra 5.1 million passengers per year using the network.

The tram-train network has helped deliver wider regional economic benefits. About 50% of passengers using tram-train switched from car. The system has been operational for about seven years, and there are proposals to integrate two additional lines to serve the region. One line was completed in about six years, but construction of another alignment took about 14 years, following extensive delays after a public inquiry.

4. PUBLIC TRANSPORT ROUTE OPTION DEVELOPMENT