2B Scheme Development and Alternatives Considered

2B.1 Introduction

This appendix sets out in more detail the process of development of the Ashton Vale to Temple Meads and Bristol City Centre rapid transit scheme ("the Rapid Transit Scheme") and alternatives considered.

As discussed in Section 2, at the beginning of 2006 the West of England Authorities began to look at the delivery of the proposed Rapid Transit Network recommended by the Greater Bristol Strategic Transport Study (GBSTS).

The first three corridors of the network were included in the South West Region's Funding Programme (RFA1) and included in the Joint Local Transport Plan (JLTP)[1]. These cross sub-region corridors run via Bristol City Centre from:

- Ashton Vale to Emerson's Green.
- Hengrove / Hartcliffe to the North Fringe.
- Bath to Cribbs Causeway.

GBSTS already considered a range of interventions or options to meet the transport problems and needs. These options included demand management and investment options (as discussed in Section 2.3).

With the strategic need for rapid transit, and the cross sub-region corridors identified, ongoing option assessment has been undertaken over the last two years developing the scheme. This option assessment work has included:

Corridors / Routes

- An assessment of possible corridors and routes within a proposed Rapid Transit Network and a priority order for potential routes to come forward as well as prioritising different corridors (routes being alignments within the main corridors identified in GBSTS). This generated a short list of corridor options.
- Further assessment of the short-listed corridor options to identify a preferred scheme alignment.

Technology / Mode

- Initial feasibility or suitability assessment of rapid transit as a mode as part of the corridor options work in 2006/2007.
- Assessment of the range of rapid transit technology options and recommendation of bus-based rapid transit in August 2007.
- Further assessment of rapid transit technology options including a route specific assessment of bus-based, Tram Train and Ultra Light Rail technologies in Summer 2008. This work confirmed the preferred technology choice as bus-based rapid transit

[1] The fourth corridor, Whitchurch to Avonmouth, was included in the GBSTS but was not included in Table 1 of the 2006 RFA allocation.

for the Rapid Transit Scheme.

Lower Cost Alternative / Next Best Alternative

- Alignment alternatives within the corridor.
- Review of option assessment work and scheme optimisation work to consider a Next Best Alternative option.

This appendix explains and summarises this assessment work undertaken. The option assessment work has consistently considered options against a common set of criteria. These are:

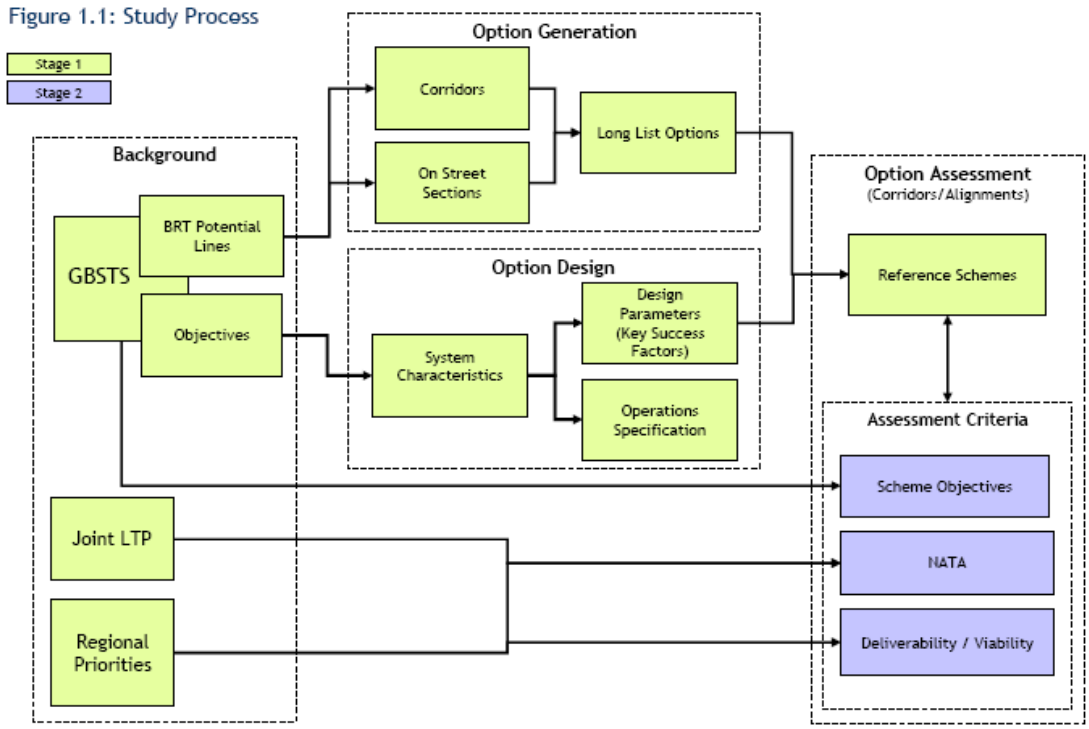
- Scheme objectives (and more scheme specific key success criteria). These are:
    - Extend choice of transport modes for all, in particular for private car drivers, to encourage a shift to public transport.
    - Promote sustainable development by providing high quality public transport links.
    - Improve access to public transport for areas that currently have poor provision.
    - Improve integration of the public transport network.
    - Promote social inclusion by improving access to employment, retail, community, leisure and educational facilities.
    - Improve safety along the corridors by reducing use of private cars.
- NATA criteria.
    - Environment: separately considered noise, landscape, townscape, heritage, biodiversity, water environment.
    - Accessibility: option values (whether the option introduces a new link in the transport system for the area it serves), severance.
    - Safety: mode shift, user and non-user security.
    - Integration: provision of transport interchanges, fit with land use policy.
    - Economy: capital costs, journey times, reliability, wider economic impacts.
- Deliverability and Viability.
    - Deliverability (ease with which the options could be implemented): third party land, interaction with National Rail infrastructure, public acceptability, political acceptability.
    - Viability (ongoing sustainability of the rapid transit system: Demand, potential for market growth, operational efficiency.

2B.2 Corridor Prioritisation

Public Transport Corridor Options Study

The West of England Authorities commissioned consultants to look at the delivery of rapid transit in the sub-region and to recommend a more detailed programme of delivery. The full report is provided in Appendix 2B(i)[2]. The consultants used an iterative multi-criteria decision making approach - applied through a series of stages, refining the criteria at each stage and filtering out options. At each stage the analysis became more detailed and criteria more refined. This process is set out in Figure 2B.1.

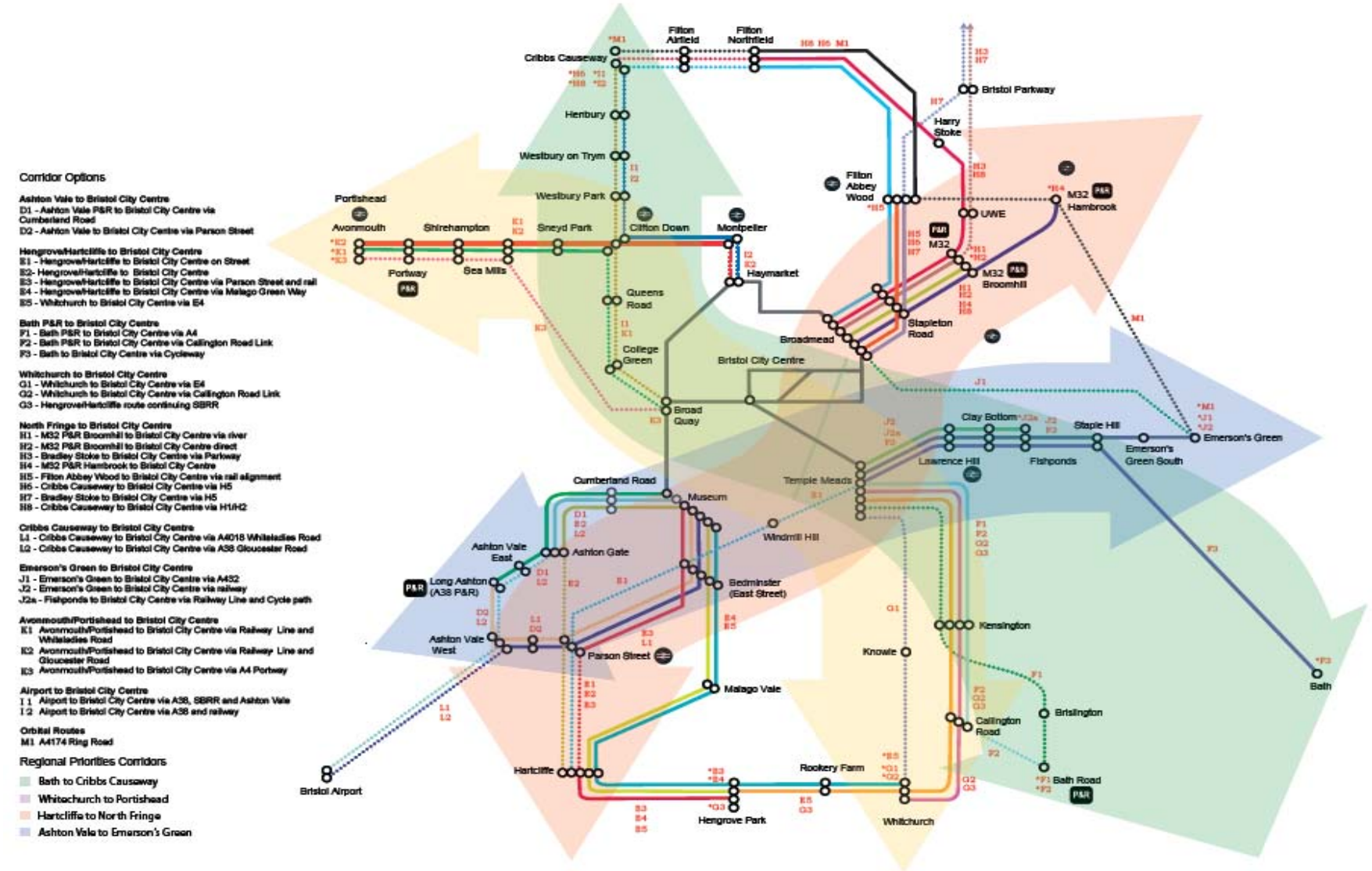
Figure 2B.1 Study Process (taken from Public Transport Corridor Options Study)



Stage 1 reviewed the policy and planning background to rapid transit and looked at all the potential routes within the identified rapid transit corridors to generate a long list of route options. A list of possible route alignments for all the rapid transit corridors was identified. This totalled 32 different route alignments, including on-street options and segregated corridors. These are shown in Figure 2B.2

[2] Greater Bristol Public Transport Corridor options, Final Report, January 2007, Steer Davies Gleave

Figure 2B.2 Long List of Route Options Considered within identified Rapid Transit corridors (taken from Public Transport Corridor Options Study)



A qualitative assessment was undertaken against the criteria set out in Section 2B.1

The options were scored against a five-point scale from 1 to 5, 1 being strongly negative and 5 being strongly positive. Options were summarised as either:

- High Impact / High Benefit.
- High Impact / Low Benefit.
- Low Impact / High Benefit.
- Low Impact / Low Benefit.

Options taken forward were those rated low impact/high benefit. This reduced the list of 32 options down to ten.

Stage 2 involved both a qualitative and quantitative assessment (where impacts and benefits could be quantified at the stage of development) against the same criteria but with the options developed to a more detailed stage. A "reference scheme" for each corridor was identified which provided as much segregation from traffic as possible to ensure an even comparison between corridors. Some high level modelling results were taken at this stage from the GBATS-2 model[3] and included in the assessment.

The consultants also concluded that:

- *There were three or four corridors which would be strong contenders for rapid transit. These met the aim and objectives for rapid transit and scored the highest in terms of deliverability. These corridors are (in no particular order):*
    - *Ashton Vale.*
    - *Hengrove/Hartcliffe.*
    - *North Fringe /Cribbs Causeway.*
    - *Emerson's Green.*
- *These options were also likely to have the strongest economic cases with benefits resulting from both rapid transit-only services as well as journey time savings for existing services utilising the rapid transit infrastructure*

[3] The G-BATS2 model is the predecessor to the current sub-region model (GBATS-3). G-BATS2 did not include BRT as a specific mode so results using rail and bus mode constants were used to identify a range of results.

The consultants recommended that to support the selection of a preferred option further work was required on issues such as:

- *Demand modelling – the G-BATS model was being updated to include rapid transit as a specific mode. Further work to be undertaken to ensure rapid transit is modelled appropriately.*
- *Capital costs – more development of detailed engineering costs.*
- *Operational specification – an initial timetable for services to be developed for modelling and assessment.*
- *Route refinement – identification of measures to mitigate impacts including more detailed alignment plans and options.*

Corridor Selection

Subsequent, more detailed work was undertaken on the four short-listed options. These are shown in Figure 2B.3. The full report is provided in Appendix 2B(ii)[4].

This work included:

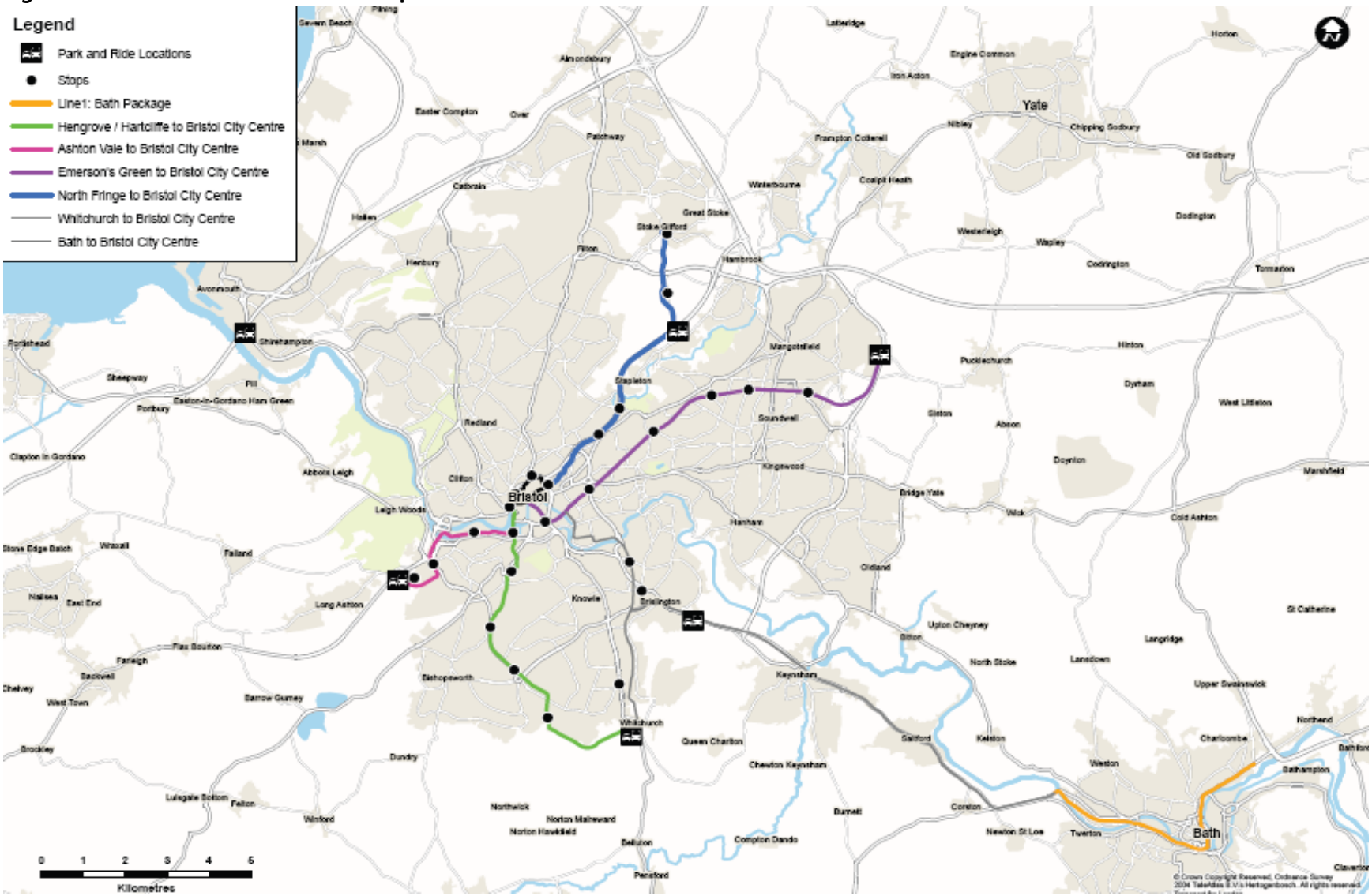
- Detailed service specification.
- Land ownership and property impacts.
- Planning and policy fit (in more detail).
- Fit with the wider West of England major schemes programme..
- Environment issues.
- Patronage/catchment.
- Fit with RFA delivery programme.

This work concluded that:

- *The Ashton Vale to Emerson's Green route should be pursued as the first rapid transit line in the regional funding programme set of schemes.*
- *This should be followed by Hengrove / Hartcliffe to the North Fringe.*
- *The link with the possible Ashton Park development of the Ashton Vale to Emerson's Green route needed to be confirmed if the site was confirmed in the Regional Spatial Strategy. The route to Long Ashton Park and Ride should be proved independently of the development.*

[4] Options Short Listing Report, May 2007

Figure 2B.3 Short -listed Corridor Options



The Project Board endorsed the selection of the Ashton Vale to Emerson's Green corridor. Following on from selection of the preferred corridor, technical work was undertaken in 2007 and 2008 including design, environmental impact and mitigation, demand and operational assessment and consultation with stakeholders.

During 2008 a review of the programme, risks and delivery issues was undertaken. As a result it was decided to take a phased approach to the delivery of the first rapid transit route and submit a programme entry application to DfT for the Ashton Vale to Temple Meads section of the corridor. The second phase, Temple Meads to Emerson's Green, has subsequently been re-phased in the latest advice to Government on regional transport priories (Regional Funding Allocation, RFA2).

2B.3 Technology /Mode

The choice of bus technology for the rapid transit network was first set out in GBSTS. The study concluded that

"further work is required to identify the type of vehicle used to operate the service but modern, low-floor, articulated buses are likely to be the most appropriate, flexible and cost effective vehicles to satisfy the requirements of the service"

The initial corridor selection work (January 2007), described in Section 2B.2, also considered technology in terms of the feasibility of a rapid transit network for the West of England and consideration of the case for the different corridors. The consultants concluded that:

- *"Initial demand modelling showed that likely patronage levels support the choice of rapid transit as the most appropriate mode for supporting this growth".*
- *"In our view there is significant opportunity to deliver a rapid transit network in Greater Bristol and these corridors are deliverable within the regional funding/investment programme timescales".*
- "*These options were likely to have the strongest economic cases with benefits resulting from both rapid transit-only services as well as journey time savings for existing services utilising the rapid transit infrastructure".*

As part of the programme of work to develop a Rapid Transit Scheme, the West of England Authorities have considered the range of different rapid transit technologies. A review of technologies was first undertaken in 2007 which looked options from monorail and light rail through to conventional buses. A subsequent study was undertaken in Summer 2008 which specifically looked at opportunities provided by newer rapid transit technologies. These reports are provided in Appendix 2B(iii) and Appendix 2B(iv) respectively.

Technology Review August 2007

The August 2007[5] review looked at a range of technologies which included:

- Monorail.
- Conventional Tram.
- Ultra Light Rail Tram.
- Trolley Bus.
- Guided Bus.
- High Quality Conventional Bus.
- Enhanced Bus.

[5] Technology Options Report, September 2007

The August 2007 review also looked at system characteristics which informed the design process such as:

- Vehicle exterior dimensions.
- Cost and the physical characteristics of a route.
- On-street running constraints.
- Mode systems & products.
- Conventional and unconventional fuel sources.
- Busway costs.

The assessment followed the Commission for Integrated Transport's (CfIT) guidance "*Affordable Mass Transit"* on technology assessment and used a similar set of criteria as for other option appraisals undertaken. These were:

- Scheme objectives.
- Local context.
- Physical opportunities and constraints.
- Deliverability.

The review summarised that:

Rapid transit covers a very wide range of public transport systems. The more bespoke vehicles, with high levels of segregation or on street priority, require the most financial investment but have a higher success rate in increasing passenger numbers and encouraging users out of their cars.

The environmental impact of any new system is likely to be an important consideration. Using vehicles with reduced carbon emissions and infrastructures that do not impose severance issues will ensure that any new system is sustainable in the long term.

The review also included information on the issue of fuel sources and concluded that:

"The ongoing development of hybrid drive systems is likely to reduce their cost and increase their capability and reliability. Therefore hybrid is likely to be a viable alternative in the next few years, subject particularly to reduction in capital cost".

The review considered the benefits and disbenefits of the different bus rapid transit technologies to select the option that best meets the scheme's objectives and represents value for money. In line with GBSTS, the review recommended a bus-based system and a range of available bus-based options were considered. It concluded that it was possible to deliver the following bus-based technologies:

- Busways.

- Kerb guided systems.
- CiViS (optical guidance) vehicle systems.

The following bus-based technologies were considered to be not at a fully commercial operation stage and need further development:

- Central rail guidance.
- Wire guided systems.
- Phileas.
- STREAM.

Technology Review July 2008

The July 2008 Technology Review[6] consisted of a:

- High Level Strategic Review of technology options – consideration of all the different public transport options had been considered firstly by GBSTS and further by the 2007 study. This review briefly looked at the range of different public transport options again by reviewing system capacities and costs.
- Technical Review of the individual technologies – looking at the application, operation, opportunities and constraints of the vehicle technologies and infrastructure.
- Comparative Assessment of the individual technologies – looking at:
    - The application of the technology to the Rapid Transit Scheme to provide in particular a cost comparison of the technologies when applied to a specific route.
    - The application of the technology on the wider Rapid Transit Network to assess the appropriateness of the technologies and the possible issues raised.

The high level strategic review concluded that the technology options of mass rapid transit, heavy rail, light rail, conventional bus and automated people movers were not appropriate technologies for the proposed Rapid Transit Scheme. The consultants went on to say that this did not mean that these technologies were not appropriate in specific circumstances but they were found to fit less well with the proposed objectives of the rapid transit scheme and they were less likely to provide a successful case for government funding for this particular scheme.

6 Technology Review, Final Report, September 2008, Steer Davies Gleave

The July 2008 review then went on to focus on Tram-Train, Light Weight Rail or Ultra Light Rail and Bus Rapid Transit. The report concluded that Tram-Train and ULR technologies:

"may provide a future suitable application as part of a public transport network in the West of England area. There would be a need for significant development work for both technologies before a major scheme application could be put forward including a better understanding of costs and risks".

Both technologies at this stage are unproven in terms of meeting the system requirements such as passenger loadings and ability to serve key destinations. The report did not discount these technologies for possible future applications but considered them undeliverable within the current regional funding allocation programme for the Rapid Transit Scheme.

The report concluded that the Rapid Transit Scheme, particularly if all elements of the system were delivered (segregation, fast/frequent services, direct access to destinations), met the scheme objectives and could be delivered within the current regional funding allocation programme. The risks associated with delivering bus rapid transit were considered to be '*considerably lower than the other two technologies*'.

Summary

A series of studies conducted over the last four years have exhaustively concluded that the technology best suited to the delivery of the scheme objectives of the West of England sub-region, best able to deliver within the appropriate timescales, most flexible to support development and economic growth and able to provide a step-change in public transport provision is high quality bus-based rapid transit. Supporting these studies is increasing empirical evidence from the application of bus rapid transit to perform to standards capable of effecting mode transfer from car to public transport and increased public transport patronage. One such example is the Fastrack scheme in the Thames Gateway.

2B.4 Routes Alignment Options

The route alignment for the Ashton Vale to Temple Meads and Bristol City centre corridor was first described in GBSTS. This set out the route as:

- *at the southern end of the route, it would serve the current park and ride site at Long Ashton and the potential new development at Ashton Vale;*
- *it is assumed that a dedicated alignment through the new development at Ashton Vale would be incorporated into its design;*
- *if associated highway infrastructure is available, some of the services could be extended from Ashton Vale to BIA, although it is anticipated that the demand would only be sufficient for a proportion of services (perhaps half) to be extended;*
- *the alignment crosses the River Avon on the disused railway bridge, the Ashton Avenue Bridge;*
- *a segregated alignment through the floating harbour – in places the alignment may not be wide enough for two-way operation for the whole length and hence it may need to be single direction with passing places along Cumberland Road;*
- *the alignment would then cross the Prince Street Bridge before running along the wide Prince Street to the Centre;*
- *in designing the route within the central area, a feature will be the identification of common sections for all rapid transit routes to enable easy interchange between lines;*

The route described is the same as the 'Preferred Rapid Transit Scheme' segregated corridor section. This route was identified largely because it makes use of a heritage railway line alignment so a high level of segregation could be achieved and has been identified as a potential rapid transit corridor in the Bristol Local Plan for many years.

Although this was set out in the GBSTS study, work has been undertaken to look at alternative alignments in the corridor. Routes were considered in the corridor selection work (January 2007) and then a separate assessments undertaken for both the segregated corridor and the City Centre section (described at 2B.5).

Options for the Segregated Corridor

Exploration of potential alternative alignments to the Rapid Transit Scheme has identified a range of potential alignments with varying levels of priority, infrastructure improvements and capital costs. The full report on these options is included at Appendix 2B(v)[7].

The following alternatives were identified and reviewed:

- Option 1 – Brunel Way to Cumberland Road (Dark Blue);
- Option 2 – Option 1 plus Commercial Road and Redcliffe Hill (Green);
- Option 3 – between Brunel Way and Hotwells, including a variant formed by a contra-flow bus lane on Merchant's Road (Light Blue); and

[7] Alignment Alternatives Report, February 2009, Atkins

- Option 4 – Ashton Vale P&R site to Hotwells via route of existing P&R bus route 903 (Orange).

These alternatives consist of:

- Variants of the main segregated corridor route (Option 1 (Dark Blue) and Option 2 (Green)).

- Use of on-street sections (Option 3 (Light Blue) and Option 4 (Orange)).

These are shown in Figure 2B.4. The preferred Rapid Transit Scheme is shown in red.

Each of the potential alternatives would benefit from the wider generic attributes of the rapid transit concept, that is:

- new high quality distinctive vehicles;

- new stops with high-quality designs and passenger facilities; and

- real-time passenger information on vehicles and at stops.

The assessment of the options included a multi-criteria analysis with the comparison of their performance against a wide range of criteria including the standard New Approach to Appraisal (NATA) components of environment, safety, economics, integration and accessibility. This is shown in Table 2B.1.

An important impact from the introduction of on-street priority measures as opposed to the segregated alignments is the effect on other traffic on the highway network. In this, it is necessary to take into account the underlying future growth in traffic which, based on the output from the traffic model in the morning peak hour for 2006 and 2016, shows a 17% increase on eastbound Hotwell Road but a 54% rise in the westbound direction. In addition, any measures which have an impact on the movement of traffic on Brunel Way would be likely to have significant disbenefits, with northbound flows on the road rising between 2006 and 2016 by 13% to 3550 with southbound flows growing by 18% to 2650. A general trend is that, with increased development in Ashton Vale and the south-west of the city centre, there is increasing contra-peak demand in the future.

Of the options, Option 4 was assessed to have the lowest implementation costs. The other three options would require the construction of a ramp between the main rapid transit alignment and Brunel Way which is estimated at £1million. Other costs would be incurred through the introduction of priority measures; these measures would also reduce the capacity available for general traffic and hence would generate potentially significant highway disbenefits.

Figure 2B.4 Route Alignment Alternatives

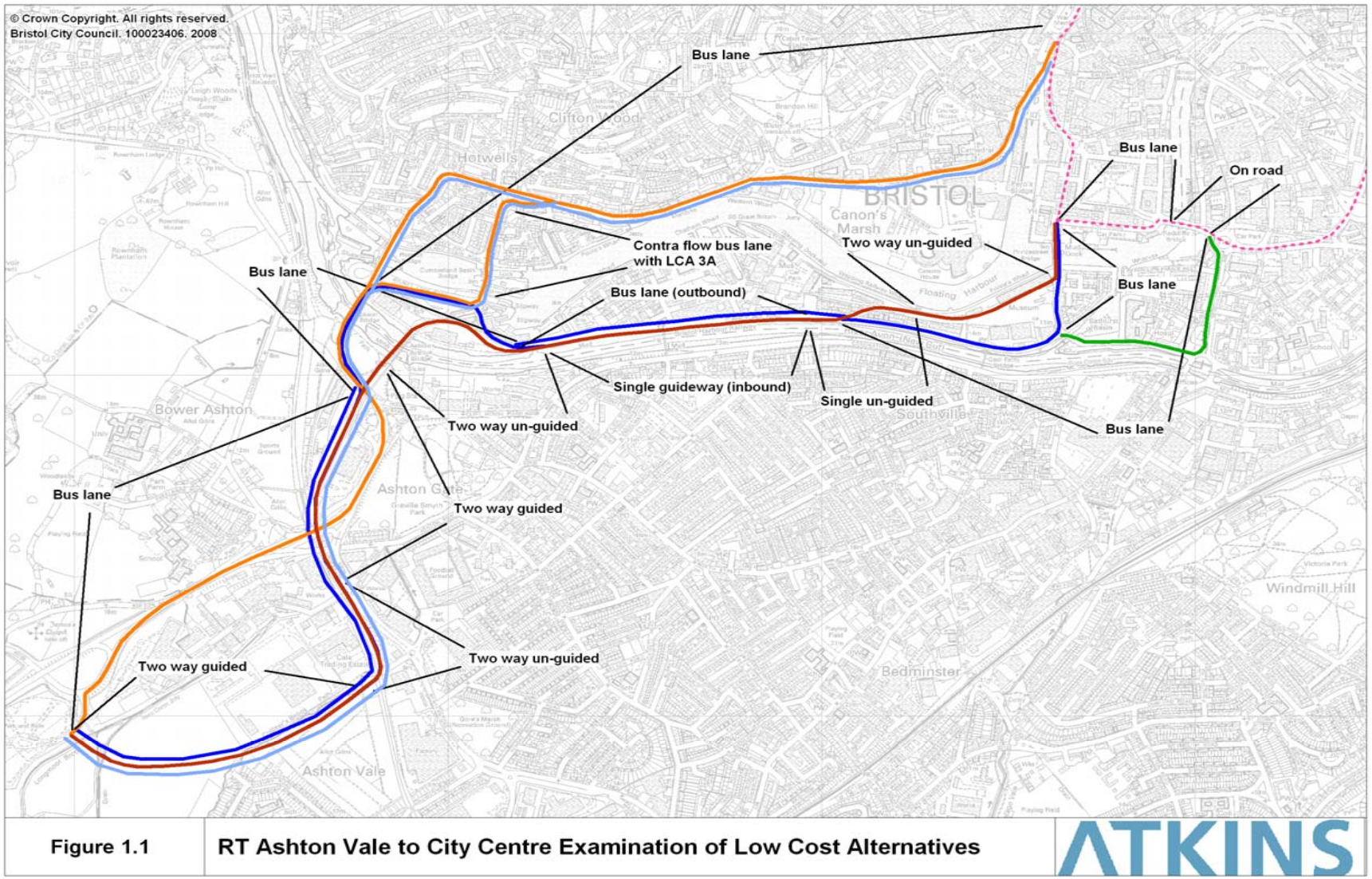


Table 2B.1 – Assessment of Route Alignment Alternatives

Criteria		Option 1	Option 2	Option 3	Option 3A	Option 4
Scheme Objectives	**Mode Shift**	Slight adverse – slight increase in journey time likely to deter P&R demand	Moderate adverse – slight increase in journey time likely to deter P&R demand. Missing stops on Prince St and The Grove on inward journey worsens significantly attraction of RT for journeys to The Centre.	Slight adverse – increase in journey time to Temple Meads, Cabot Circus and Broadmead will deter P&R and other demand. Better access to The Centre compensates for trips with destination there.	Slight adverse – increase in journey time to Temple Meads, Cabot Circus and Broadmead will deter P&R and other demand. Better access to The Centre compensates for trips with destination there.	Slight adverse – increase in journey time to Temple Meads, Cabot Circus and Broadmead will deter P&R and other demand. Better access to The Centre compensates for trips with destination there. RT links along Winterstoke Road would need to be replaced by buses.
	Sustainable Development	Neutral.	Slight adverse – due to poor access to The Centre.	Slight adverse – due to poor access to Temple Meads, Cabot Circus and Broadmead.	Slight adverse – due to poor access to Temple Meads, Cabot Circus and Broadmead.	Slight adverse – does not serve development area in Ashton Vale and Ashton Gate
	Access	Slight adverse – diversion of route from core diminishes access to Harbourside area	Moderate adverse – missing stops on Prince St and The Grove on inward journey worsens significantly attraction of RT for journeys to The Centre. Also poor access to Harbourside.	Slight adverse – poor access to southern Harbourside although better links with The Centre.	Slight adverse – poor access to southern Harbourside although better links with The Centre.	Slight adverse – poor access to southern Harbourside and Winterstoke Road although better links with The Centre.
	Integration	Neutral	Slight adverse – no integration with services on The Grove and Prince Street in inbound direction.	Slight beneficial – better connections with other public transport in The Centre although longer journey time to Temple Meads	Slight beneficial – better connections with other public transport in The Centre although longer journey time to Temple Meads	Slight beneficial – better connections with other public transport in The Centre although longer journey time to Temple Meads

Criteria		Option 1	Option 2	Option 3	Option 3A	Option 4
	Social inclusion	Neutral	Neutral	Neutral	Neutral	Slight adverse – Ashton Gate and Winterstoke Road no longer served.
	Safety	Moderate adverse – reduced capacity on Brunel Way and merge of ramp onto Brunel Way to increase likelihood of accidents.	Moderate adverse – reduced capacity on Brunel Way and merge of ramp onto Brunel Way to increase likelihood of accidents.	Moderate adverse – reduced capacity on Brunel Way and merge of ramp onto Brunel Way to increase likelihood of accidents. On-street running on Hotwell Road increases possibility of accidents.	Moderate adverse – reduced capacity on Brunel Way and merge of ramp onto Brunel Way to increase likelihood of accidents. On-street running on Hotwell Road and alterations to Hotwell Road/Merchant's Road junction likely to increase delays, raise vehicle conflicts and increase potential accidents.	Slight adverse – on-street running on Hotwell Road increases possibility of accidents.

Criteria		Option 1	Option 2	Option 3	Option 3A	Option 4
NATA	**Environment**	Moderate adverse – lower traffic speeds on Brunel Way to increase emissions. Construction of ramp likely to increase wider impacts.	Moderate adverse – lower traffic speeds on Brunel Way to increase emissions. Construction of ramp likely to increase wider impacts.	Moderate adverse – lower traffic speeds on Brunel Way and Hotwell Road to increase emissions. Construction of ramp likely to increase wider impacts.	Moderate adverse – lower traffic speeds on Brunel Way, Hotwell Road and Merchant's Road likely to increase emissions. Construction of ramp likely to increase wider impacts.	Slight adverse – lower traffic speeds on Brunel Way and Hotwell Road likely to increase emissions.
	Accessibility	Slight adverse – diversion of route from core diminishes access to Harbourside area	Moderate adverse – on inward journey, missing stops on Prince St and The Grove worsens significantly attraction of RT for journeys to The Centre. Also poor access to Harbourside.	Moderate adverse – stops on Harbourside and Winterstoke Road would no longer be served, Hotwell Road corridor would be served by other bus routes if not RT. The Centre receives better access than with RT, although Temple Meads, Cabot Circus and Broadmead suffer.	Moderate adverse – stops on Harbourside and Winterstoke Road would no longer be served, Hotwell Road corridor would be served by other bus routes if not RT. The Centre receives better access than with RT, although Temple Meads, Cabot Circus and Broadmead suffer.	Slight adverse – stops on Harbourside would no longer be served, Hotwell Road corridor would be served by other bus routes if not RT. The Centre receives better access than with RT, although Temple Meads, Cabot Circus and Broadmead suffer.
	Safety	Moderate adverse – reduced capacity on Brunel Way and merge of ramp onto Brunel Way to increase likelihood of accidents	Moderate adverse – reduced capacity on Brunel Way and merge of ramp onto Brunel Way to increase likelihood of accidents	Moderate adverse – reduced capacity on Brunel Way and merge of ramp onto Brunel Way to increase likelihood of accidents. On-street running on Hotwell Road increases possibility of accidents	Moderate adverse – reduced capacity on Brunel Way and merge of ramp onto Brunel Way to increase likelihood of accidents. On-street running on Hotwell Road. Alterations to Hotwell Road/Merchant's Road junction likely to increase delays, raise vehicle conflicts increase potential accidents.	Slight adverse – on-street running on Hotwell Road increases possibility of accidents.

Criteria		Option 1	Option 2	Option 3	Option 3A	Option 4
NATA	**Integration**	Neutral	Slight adverse – no integration with services on The Grove and Prince Street in inbound direction.	Slight beneficial – better connections with other public transport in The Centre although longer journey time to Temple Meads	Slight beneficial – better connections with other public transport in The Centre although longer journey time to Temple Meads	Slight beneficial – better connections with other public transport in The Centre although longer journey time to Temple Meads
	Economy	Moderate adverse – increased capital cost due to construction of ramp to Brunel Way. Journey time disbenefits on highway network due to reduced capacity on Brunel Way. Slightly longer journey time for RT passengers.	Moderate adverse – increased capital cost due to construction of ramp to Brunel Way. Journey time disbenefits on highway network due to reduced capacity on Brunel Way. Longer overall journey time for RT passengers, especially for destinations at The Centre.	Moderate adverse – increased capital cost due to construction of ramp to Brunel Way. Journey time disbenefits on highway network due to reduced capacity on Brunel Way and along Hotwell Road. Longer overall journey time for RT passengers, especially for Temple Meads, Cabot Circus and Broadmead. Better journey times for destinations in The Centre, although lengthy route there and impact on highway traffic.	Moderate adverse – increased capital cost due to construction of ramp to Brunel Way. Journey time disbenefits on highway network due to reduced capacity on Brunel Way, along Hotwell Road and Merchant's Road and at key junctions. Longer overall journey time for RT passengers, especially for Temple Meads, Cabot Circus and Broadmead. Better journey times for destinations in The Centre, although lengthy route there and impact on highway traffic.	Slight adverse – journey time disbenefits on highway network due to reduced capacity along Hotwell Road. Longer overall journey time for RT passengers, especially for Temple Meads, Cabot Circus and Broadmead. Better journey times for destinations in The Centre, although lengthy route there and impact on highway traffic.

Criteria	Option 1	Option 2	Option 3	Option 3A	Option 4
Deliverability	Moderate adverse – increased delays due to design, approval and construction of ramp to Brunel Way.	Moderate adverse – increased delays due to design, approval and construction of ramp to Brunel Way.	Moderate adverse – increased delays due to design, approval and construction of ramp to Brunel Way.	Moderate adverse – increased delays due to design, approval and construction of ramp to Brunel Way.	Slight beneficial – based on existing bus routes
Viability	Moderate adverse – increased capital costs and greater impact on highway network with likely increased congestion.	Moderate adverse – increased capital costs and greater impact on highway network with likely increased congestion. Poorer access to The Centre weakens case.	Moderate adverse – increased capital costs and greater impact on highway network with likely increased congestion.	Moderate adverse – increased capital costs and greater impact on highway network with likely increased congestion.	Slight beneficial – based on existing bus routes

Conclusions from the review were:

- for options using Brunel Way, the costs of ramps to connect with the rapid transit alignment on the disused rail line could amount to £1million and hence this favours Option 4 which does not use Brunel Way;

- there are significant potential impacts on Brunel Way and Hotwell Road from the removal of existing highway capacity through the introduction of bus lanes for the rapid transit options – due to the predicted volumes of traffic on these roads the journey time disbenefits to traffic could be large and hence because the objective of Option 4 has been to restrict bus lanes to sections where the impact on other traffic is minimised, Option 4 would therefore be more beneficial;

- Option 3A would significantly change the operation of the Cumberland Basin gyratory, would have repercussions on the effective movement of general traffic through the gyratory;

- the introduction of bus lanes on Hotwell Road and Anchor Road with Option 3 would require the removal of significant numbers of existing parking spaces;

- Option 2 via Redcliffe Hill has disbenefits from a longer journey time and hence the likelihood of increased operating costs;

- the multi-criteria analysis has highlighted that, in general, the options perform more poorly than the preferred scheme route, with adverse impacts in terms of modal shift, access, safety, impact on the environment and journey time savings; and

- Option 4 performs better in the multi-criteria analysis because, compared with the other options:

    - it produces better integration with other bus services in The Centre,

    - by running on street along Hotwells Road it does not create additional delays to general traffic or the potential for additional accidents,

    - it avoids the capital cost of the ramp to Brunel Way,

    - it has a higher level of deliverability and viability,

This study recommended that Option 4 should form the basis for the Lower Cost Alternative option for the appraisal of the preferred Rapid Transit Scheme

2B.5 City Centre Options

Services in the city centre section of the scheme are an important part of the success of the Rapid Transit Scheme in terms of accessibility, integration and journey time reliability. A number of options have been considered. The main options were:

- Option 1 – Minimal works option which simply used the existing bus priority in the city centre with some modest improvements. Services run in a 'horse-shoe' inbound and outbound on the same alignment.

- Option 2 – Significant works and the reorganisation of bus services and car traffic circulation with increased segregation in The Centre, known as the 'radical option'.

- Option 3 – 'Loop Option' (preferred scheme) where services would run in an anti-clockwise direction around the key centre locations. This option looks to significantly improve the interchange at Temple Meads and fit with planned development at Redcliffe and Temple Quay as well as the redevelopment of Temple Meads Station being pursued by Network Rail.

The options are shown in Figure 2B.5.

City Centre Option 1 – 'Minimal Works'

The city centre route Option 1 would consist of on-street running segregated as far as possible using conventional bus lanes and selective vehicle detection at signals. Additional bus lanes would be added to existing priorities in the city centre at:

- New bus priority measures and turning area in The Friary adjacent to Bristol Temple Meads Railway Station.

- Northbound on Temple Way between Temple Circus Gyratory and Temple Back.

- Northbound and southbound on Temple Way between Temple Bridge and the Temple Way underpass.

- Southbound on Temple Way from Old Market roundabout to Temple Way underpass.

- Westbound on The Haymarket and Rupert Street from Bond Street to The Centre.

In addition the Horsefair would be made bus only during the main part of the day.

Stops in the city centre would be provided at:

- The Centre.

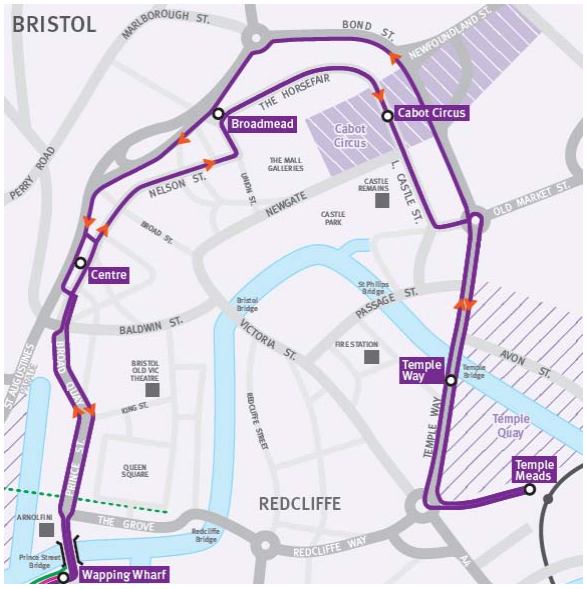
- Broadmead.

- Cabot Circus.

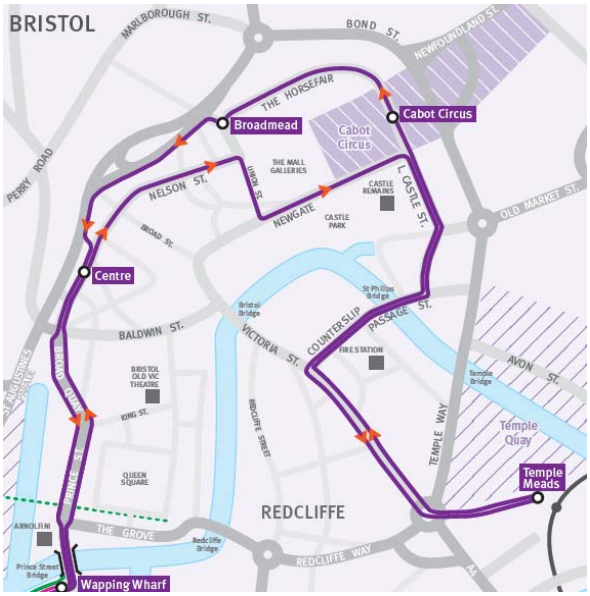
- Bristol Temple Meads.

Figure 2B.5 City Centre Options

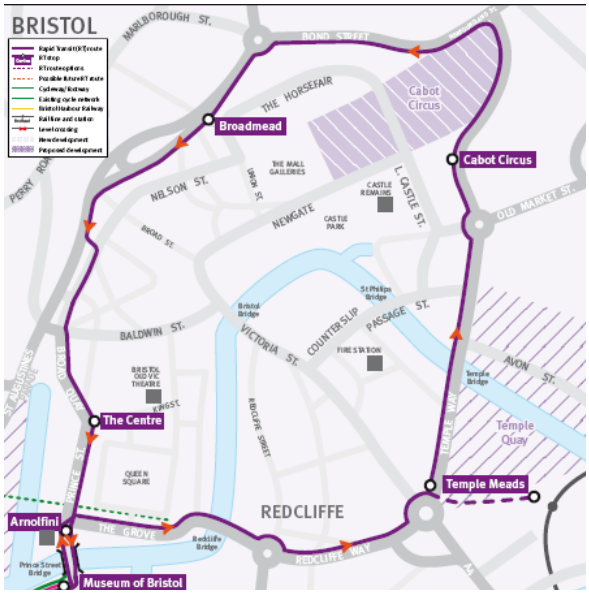
OPTION 1 – Minimal Works Option



OPTION 2 – Radical Option



OPTION 3 – Loop Option



City Centre Option 2 – 'Radical Option'

The City Centre Option 2 also consists of on-street running but with a higher degree of separation from general traffic. This is achieved by means of significant junction improvements to enhance the capacity around the city centre for general traffic along with other measures to discourage through traffic from entering the centre. Separation from other bus routes is also provided by the provision of new bus lanes and diversion of some routes.

From the Bristol Temple Meads stop, the route is shared with general traffic along the Friary. The route crosses (with priority) a new signalised junction at Temple Circus. It then follows a series of bus lanes northbound along Victoria Street and turns right at the junction with the Counterslip. General traffic would be prohibited from turning right at this junction.

The route enters the Broadmead shopping centre via Tower Hill and Lower Castle Street. It is proposed that the Broadmead gyratory is reversed to overcome alignment problems at the junction of Broad Weir and Lower Castle Street.

After the Broadmead shopping centre, the route joins Rupert Street at the junction with Union Street and follows west and then south into The Centre which would be prohibited for general traffic. All bus stops would be offline to avoid impeding the new service.

After The Centre the route would be segregated through Broad Quay and Prince Street before crossing the Prince Street Bridge. It is proposed that general traffic would also be using Broad Quay and Prince Street having gained access via a new link across the centre from St Augustine's Parade. However only buses, cyclists and pedestrians would be allowed to use Prince Street Bridge. General traffic would use The Grove and Redcliffe Way to Redcliff Hill.

In the opposite direction, the route also has a segregated bus lane to The Centre. There, it would be fully segregated until it reaches Nelson Street which would be shared with local traffic. The route would follow Union Street southwards until turning left into Newgate. The route would benefit from almost continuous segregated bus lanes through Broad Weir, Lower Castle Street and Tower Hill to Passage Street. The route would then be shared with local traffic to Victoria Street. Only buses would be allowed to turn left at this junction. Local traffic wishing to turn left would have to use Temple Street.

Southbound, in Victoria Street, the route would benefit from a nearly continuous segregated bus lane. At the new signalised junction it would cross (with priority) into the Friary. It would unload passengers then turn to stop at the Bristol Temple Meads stop.

Stops in this option would be provided at:

- The Centre.
- Broadmead.
- Cabot Circus.
- Bristol Temple Meads.

City Centre Option 3 – 'Loop Option'

Option 3 provides bus priority to support services running on an anti-clockwise loop around the City Centre. Services from Ashton Vale would turn right at The Grove in an easterly direction. Priority for rapid transit would be ensured by the provision of a new bus lane along the Grove and new traffic signals at the junction of The Grove with Welsh Backs.

The route re-crosses the Floating Harbour via the Redcliffe bascule bridge and follows Redcliffe Way towards a new transport interchange at Temple Meads.

The new interchange at Temple Meads will allow the rapid transit route to stay to the left of Temple Way and avoid the time delay and disruption to general traffic of crossing this major through route. A high quality public space and pedestrian link with Bristol Temple Meads Railway Station is part of the proposed development around the station.

The alignment follows Temple Way northwards along a new bus lane up to and around the Old Market Street signalised junction that would ensure priority was given over general traffic. To the north of The Old Market Street Junction there would be a stop to serve the new Cabot Circus retail centre and then the alignment would follow existing bus priority provision along Bond Street.

To the west of the Bond Street, there would be a stop to serve the Broadmead area and provide access to Bristol Bus Station, hospitals, retail etc. The alignment would then continue along a new bus lane provided along The Haymarket and Rupert Street that would allow the rapid transit to pass existing bus stops that cannot presently be relocated. General traffic would be restricted to a single lane.

In The Centre to the east of the Cenotaph, there would be a new bus lane to allow the rapid transit vehicle to pass existing bus stops. This bus lane would be continued through to Broad Quay that is already reserved for public transport vehicles. There would be a southbound stop at Broad Quay to pick up passengers from the Harbourside and the Centre. Finally the loop would be completed by the provision of a new bus lane along Prince Street, towards Prince Street Bridge.

Stops on this route would be provided at:

- Arnolfini.
- Bristol Temple Meads.
- Cabot Circus.
- Broadmead.
- The Centre.

Assessment of City Centre Options

Qualitative and some quantitative assessment of the options has been undertaken. As with the other option appraisals the options were considered against the scheme objectives, NATA criteria and deliverability considerations. In summary the results were:

- Option 1 – has minimum benefits, providing some increased segregation but not addressing the issues of improved interchange with buses in The Centre or with rail/ bus at Temple Meads Railway Station. Option 1 is the lowest cost at £1.7m (current prices, excluding risk) and has no impacts outside the existing highway boundary and therefore would be unlikely to attract objection.

- Option 2 – has good benefits providing a high level of segregation but is the highest cost of the options. The total cost estimate of £34 million (current prices, excluding risk) is unaffordable within the available funding and these costs were likely to be more than the benefits delivered. Consultation with key stakeholders showed that there could be significant opposition to works in The Centre.

- Option 3 – has good benefits at a much reduced cost compared with Option 2 at £9.6 million (current prices, excluding risk). This option was developed in response to stakeholder input and has substantial local support.

Table 2B.2 sets out the appraisal of the city centre options.

Importantly, as set out in Section 3, the appraisal undertaken does not quantify reliability benefits. Therefore a qualitative assessment was undertaken looking at the level of segregated route which could be provided as part of the different options. It should also be noted that modelling of Option 1 and Option 2 was undertaken on a previous version of the model.

Table 2B.2 – Assessment of City Centre Options

Criteria		Option 1 – Minimal Works	Option 2 – Radical Option	Option 3 – Loop Option
Scheme Objectives	**Mode Shift**	Reliability – 40% route kms in city centre segregated from other traffic.	Reliability – 43% rapid transit route kms in city centre segregated from other traffic. In addition more restrictions on general traffic in the central area should provide additional reliability.	Reliability – 65% rapid transit route kms in city centre segregated from other traffic.
	Sustainable development	Links city centre with key development areas.	Links city centre with key development areas.	As per (1) and (2) but also serves proposed development at Redcliffe.
	Access to areas with poor provision	Provides fast, frequent reliable public transport alternative for trips from south west of the urban area in to Bristol City Centre and around the City Centre. Runs via City Centre before linking to Temple Meads as per current bus services.	Provides fast, frequent reliable public transport alternative for trips from south west of the urban area in to Bristol City Centre and around the City Centre. Runs via City Centre before linking to Temple Meads as per current bus services.	Provides fast, frequent reliable public transport alternative for trips from south west of the urban area in to Bristol City Centre and around the City Centre. More direct access with Temple Meads Station for Ashton Vale area which is currently poorly connected (around 3.5 miles currently takes over 30minutes by public transport).
	Integration	No improvement to interchange with bus at The Centre. Provides interchange at Temple Meads with rail only.	Provides improved interchange with bus at The Centre. Provides interchange at Temple Meads with rail only.	No improvement to interchange with bus at The Centre. Provides interchange at Temple Meads with rail and bus.
	Social Inclusion	No significant difference between the options.	No significant difference between the options.	No significant difference between the options.
	Safety	No significant operational difference.	No significant operational difference.	No significant operational difference.

Criteria		Option 1 – Minimal Works	Option 2 – Radical Option	Option 3 – Loop Option
NATA	**Environment**	General improvement due to mode shift to public transport. No significant impacts. Most works within highway boundary.	General improvement due to mode shift to public transport. Impacts limited to works associated with new bus interchange at The Centre such as Townscape/Public Realm impacts. Some potential impacts due to ground works but should be limited.	General improvement due to mode shift to public transport. More significant potential impacts associated with new bus and rail interchange such as archaeology, ground water. Some potential impacts due to ground works but should be limited.
	Accessibility	Provides fast, frequent reliable public transport alternative for trips from south west of the urban area in to Bristol City Centre and around the City Centre. Links city centre with key development areas.	Provides fast, frequent reliable public transport alternative for trips from south west of the urban area in to Bristol City Centre and around the City Centre. Links city centre with key development areas.	Provides fast, frequent reliable public transport alternative for trips from south west of the urban area in to Bristol City Centre and around the City Centre. Links city centre with key development areas. Provides more direct access with Temple Meads Station. Also serves proposed development at Redcliffe
	Safety	No significant operational difference. Relatively straight forward construction works.	No significant operational difference. More involved construction works with new bus interchange.	No significant operational difference. More complex construction works with new interchange.
	Integration	No improvement to interchange with bus at The Centre. Provides interchange at Temple Meads with rail only.	Provides improved interchange with bus at The Centre. Provides interchange at Temple Meads with rail only.	No improvement to interchange with bus at The Centre. Provides interchange at Temple Meads with rail and bus.
	Economy	Capital Cost (2008 prices, excluding risk) = £1.7m BCR >2	Capital Cost (2008 prices, excluding risk) = £34m BCR < 0	Capital Cost (2008 prices, excluding risk) = £9.6m BCR >2

Criteria		Option 1 – Minimal Works	Option 2 – Radical Option	Option 3 – Loop Option
Deliverability	Construction Works	Relatively straight forward on-street works.	Relatively straight forward on-street works. More complex works associated with bus interchange at The Centre. More significant construction impacts for traffic management city wide.	Relatively straight forward on-street works. Significant construction works associated with new bus / rail interchange. More significant construction impacts for traffic management but limited to Temple Meads area.
	Acceptability	Less support from stakeholders as improvements in city centre largely limited to bus lane extensions.	Less support from stakeholders. Works required to The Centre for bus interchange not widely supported and potentially controversial with impact on sensitive public spaces.	Strong support for route via Redcliffe and new Temple Meads interchange.
Viability		Routes can be used for all bus services so should contribute to viability of wider bus network as well as rapid transit. Route less segregated so less operational benefit.	Routes can be used for all bus services so should contribute to viability of wider bus network as well as rapid transit. Route more segregated so more operational benefit.	Routes can be used for all bus services so should contribute to viability of wider bus network as well as rapid transit. Most segregation provided with highest operational benefit. Facilitates service interchange at Temple Meads.

2B.6 Next Best Alternative

In relation to a Next Best Alternative Scheme (NBA) DfT major scheme guidance states that:

"The Department requires that all major schemes move toward a final appraisal of the preferred option and a 'fully worked up' lower cost alternative. For larger majors a 'next best' alternative may also need to be carried through the appraisal process. In these cases promoters should enter into discussion with the Department to determine the exact requirements for their scheme.

Alternative options should include, for public transport schemes, different technologies, such as bus based schemes instead of light rail; or lower cost alternatives, such as bus lanes or shorter lengths of busways compared to fully segregated busways".

The testing of alternatives has been a significant part of the scheme development work in determining the preferred Rapid Transit Scheme. As such a there has not been a single NBA scheme but a series of NBAs looked at in terms of the different scheme elements. This was discussed with DfT officers who advised that an incremental approach to NBA assessment would be acceptable and advised that this should include alternative technologies.

The range of different alternatives looked at during scheme development has included:

- Technology Options. The assessment of technology alternatives is explained in Section 2B.2 with detailed reports provided in Appendices 2B(iii) and 2B(iv). Assessment of the two next best alternatives identified in the 2008 Technology Review is explained further below.

- Corridor alignments. The assessment of corridor alignment alternatives is explained in 2B.3 with the detailed report in Appendix 2B(v).

- Alignment Options both on the segregated corridor and city centre. This is explained in Section 2B.4 and 2B.5 respectively.

- Scheme Details. The assessment of some of the scheme specific elements is explained below.

Technology

The 2008 Technology Review looked at the wide range of rapid transit technologies (Appendix 2B(iv)). On the basis of capital cost and carrying capacities it eliminated those options on either end of the rapid transit spectrum. The report concluded that these technologies were likely to fit less well with the objectives of the scheme and less likely to provide a successful case for government funding for this particular scheme. The 2008 Review focused on Tram-Train, Light Weight Rail or Ultra Light Rail and Bus Rapid Transit.

The 2008 Technology Review looked at these three technologies for a common route, that being the City Centre Option 1 route which was the minimal city centre works route as described above in Section 2B.5. This route excluded the proposed interchange at Temple Meads and provided significantly less segregation from general traffic in the city centre. The capital costs quoted in the 2008 Technology Review were based in 2008 prices and excluded

risk.

Tram-Train

Tramtrain was developed in Germany to enable tram style services to be developed over the wider suburban heavy rail network, making use of improved proximity and connectivity of existing tram networks within urban centres. Tramtrain is a vehicle solution not an independent mode such as bus or tram. The vehicles are capable of operating on both the heavy rail network and on urban low floor tram networks, which depending on the location and application, requires the ability to work on differing overhead line power supplies and possibly independently through the use of on board diesel generators.

There are currently no Tramtrain schemes within the UK. The Tyne and Wear Metro extension to Sunderland does incorporate some aspects of Tramtrain in that it runs on the heavy rail network in conjunction with rail services. A trial of Tramtrain in the UK is to be undertaken by Network Rail on the 37-mile Penistone Line between Huddersfield and Sheffield. The current service will be replaced using five Tramtrain vehicles between 2010 and 2012 and will look at the environmental, operational, passenger and lifecycle benefits along with the technical suitability of the technology. The vehicles may then be trialled on the Sheffield Supertram network to assess the suitability to a UK tram network.

Tramtrain's key benefit is the ability to use existing rail infrastructure to operate on, and then use tram infrastructure to provide the connection to city centres. In the case of the rapid transit scheme, a city centre network would need to be constructed out to the main rail termini. As a result it has many of the same issues that light rail options presents. Alternatively, Tramtrain in the UK may have more of a focus on better utilising branch lines on the existing national rail network with an aim of improving frequencies and reducing cost of provision and operation.

Tramtrain vehicles provide the highest capacity of the modes reviewed. It is though, also the most expensive. Vehicles cost in the order of £2.8 million to £3.2 million each. The estimated cost of delivering the infrastructure on the Ashton Vale to Temple Meads via Bristol City Centre route is in the range of £90million to £110million (for the equivalent route as the proposed BRT route). The total scheme cost would be in the range of £118 million to £142 million. This excludes costs such as land, environmental works and contingency, includes vehicles and is in 2007 prices.

Light Weight Rail

Light Weight Rail has been developed by Parry People Movers (PPM) as an intermediate mode between bus and tram and is also being promoted by Sustraco/Ultralight Rail. The aim is to provide a lower cost intermediate mode which could run in place of branch line services on the national rail network or a low cost alternative to tram technology.

The PPM system has been trialled on a number of segregated routes and will operate a two vehicle branch line service in Stourbridge from December 2008. The vehicles will have a capacity of 50/60 people and will be powered predominantly utilising a flywheel charged by LPG. The PPM system has successfully managed to obtain dispensation from Network Rail's Railway Group Standards (which facilitates its operation) as it is not connected to the rest of the rail network.

The promoters of Hybrid Ultra Light Rail (HULTS) have proposed a Light Weight Rail system between Bristol and Long Ashton Park and Ride are at a concept stage and could use a similar vehicle to the Stourbridge scheme. Vehicles would cost in the order of £300,000 to £350,000 each.

The key benefits of this technology are its proposals to run on lower emission fuels and provision of a fixed rail system at a lower cost than light rail systems. The HULTS report[8] states that fuel consumption could be up to 40% below that of a standard bus.

Deliverability is a significant concern with this technology as, to date, only development vehicles have been produced and trialled on a number of short rail routes, where the vehicles operation can be segregated from other uses. Some of the operating issues that would need significant investigation to determine the cost and risk include:

- System capacity – single unit vehicles do not have sufficient capacity to carry the required number of passengers on the proposed rapid transit system. The promoters state that vehicles can be coupled together but the PPM bogie technology upon which the vehicle would rely is also currently a concept and has not been developed. The development of this vehicle would require a radical redesign of the current PPM vehicles. Without the ability to run two vehicles together, or build a higher capacity vehicle, this system would have insufficient capacity to deliver the rapid transit service. Therefore development of an appropriate vehicle would be essential.

- Utility diversion – the main issue with utilities is their ongoing access and serviceability. In order to prevent disruption to service and expensive works, utilities are usually moved out of the path of fixed rail systems. This adds significantly to the capital costs (in the order of £20% of total costs). HULTS promoter state that utility diversions would not be necessary and that services would need to be diverted when access or work were required. The proposed ULR track was discussed with local Utility Companies at a meeting in July 2008. The representatives of the Utility Companies were not in principle against the concept of a track which could run on top of their assets within the highway but raised a number of issues including the need for planned and emergency access to utilities and the different requirements for different types of utilities. In addition its is likely that the Utility Companies would be looking to the owner of the track, the Local Authorities, to be responsible for undertaking and paying for any reinstatement works creating an ongoing cost for the Local Authorities.

- The system is untested in passenger operation including, importantly, how it integrates with other general traffic. The technology does not have a UK Safety Case for this type of operation. This is of course obtainable but introduces an element of risk to costs and delivery.

Light Rail systems are currently costing in the order of £10 to 15 million per kilometre and have increased significantly over the last few schemes developed. A conventional tram scheme therefore has an average cost in the order of £12 million per km. The HULTS promoter notes a cost of £3 million (for the track). Removing both the electrification and all the utilities cost from the average tram cost could account for a possible reduction of 33% in

[8] HULTS, Scott Wilson, 2008 (see appendices of Technology Review, Final Report, September 2008, Steer Davies Gleave (2B(iii))

the cost of construction producing a track cost of approximately £8 million. The removal of all but the site preparation, highway and trackwork costs results in a cost of £5 million compared to the proposed £3 million rate.

An estimate of costs has therefore been undertaken on three bases: firstly, the HULTS promoter cost of £3 million per km, secondly, the HULTS promoter cost of £3 million per km plus an allowance for structures and highway works required in the city centre and thirdly, an estimate based on low cost tram costs.

Using HULTS £3 million per km estimate the total scheme costs would be in the order of £38 million (2007 prices). Using the HULTS promoter cost but adding in an allowance for structures and highway works provides a cost in the order of £45 million (2007 prices). Our estimation of costs per kilometre for this system, based on current tram costs but allowing for the proposed reductions proposed by HULTS for track work is in the order of £103 million. These all exclude costs such as land, environmental works and contingency but include vehicles and are in 2007 prices

A summary of the differences from the 2008 Technology Review is set out in Table 2B.3.

Tramtrain would only provide additional benefit over that of a tram route if it were able to be integrated with and operate on the existing rail network in the area. There are significant deliverability issues with the implementation of Tramtrain in the UK, and potentially capacity issues on the existing rail network in the West of England area. A significant amount of work would need to be undertaken to identify the opportunities and constraints for the adoption of the technology in the area.

Tramtrain vehicles provide the highest capacity of the modes reviewed. It is though the most expensive and if it were only deliverable on dedicated routes separated from the existing rail network, electrified tram technology would be more appropriate and more deliverable for a similar cost.

Light Weight or Ultra Light Rail could provide a low capacity, environmentally friendly transport system. At this stage in its development there are still considerable unknowns and in our opinion, the technology would need to be tested further before it could be available to be applied to rapid transit network of the size and nature proposed in the West of England.

A full quantification of the benefits of these two technologies has not been undertaken. The capital cost estimates for both options were in excess of the available funding but also at least double and potentially up to four times the cost estimate for the bus rapid transit equivalent which would need the same increase in the level of benefits delivered by these technologies to give a comparable benefit to cost ratio. Table 2B.3 sets out the qualitative comparison of the benefits of the different technologies.

Table 2B.3 – Assessment of Technology Options (Table 5.2 Appendix 2B(iv))

Assessment Criteria		Tram-Train	Light Weight Rail	Unguided BRT	Guided BRT
Key Measures	Mode Shift	✓✓	✓✓	✓✓	✓✓
	Reduced Congestion	✓ Restricted Network	✓ Lower ultimate capacity	✓✓ Access to wider sub-region	✓✓ Access to wider sub-region
	Economic Growth	✓	✓	✓✓	✓✓
General Criteria	Penetration of City Centre	✓✓ very high cost	✓✓ high cost	✓✓ runs on existing streets	✓✓ runs on existing streets
	Accessibility to Sub-region	✓	✓	✓✓✓	✓✓✓
	Maintains road network capacity	✓	✓	✓✓	✓✓
	Restricts access to segregated alignment	✓✓	✓✓	✓	✓✓
	Provision to leave and join Alignments	×	×	✓✓	✓✓
Vehicle Criteria	Step Free	✓✓	✓✓	✓✓	✓✓
	Gap Free	✓✓	✓✓	✓	✓✓
	Vehicle Capacity	✓✓✓	✓	✓✓	✓✓
	Route Capacity	✓✓✓	✓	✓✓	✓✓
	Speed	✓✓	✓	✓✓	✓✓
	Doors	✓✓✓	✓	✓✓	✓✓
	Runtime Excluding Interchange	✓✓	✓ unproven	✓✓	✓✓
	Road Junctions	✓	✓	✓	✓
	Gradients	✓✓	✓ unproven	✓✓✓	✓✓✓
	Perception of Quality	✓✓✓	✓✓ unproven	✓✓	✓✓
	Maintenance and Depots	new facilities required	new facilities required	existing facilities could be used	existing facilities could be used

Assessment Criteria		Tram-Train	Light Weight Rail	Unguided BRT	Guided BRT
Deliverability	Capital Cost	×××	××	×	×
	Vehicle Costs	×××	××	×	×
	Technology Maturity	✓ but not in UK	×× still under development	✓✓	✓✓
	Risk	×× untested technology in the UK	××× untested technology new untested infrastructure construction	✓✓ Accepted technology standard highway construction	✓ Accepted technology standard highway construction
	Procedural Process	×× significant procedural issues to be resolved	×× procedural issues to be resolved	✓✓ well established	✓✓ well established
Environmental	Visual	similar impact	similar impact	similar impact	similar impact
	Maintains existing cycle and pedestrian facilities	✓✓	✓✓	✓✓	✓✓
	Severance	similar impact	similar impact	similar impact	similar impact
	Land Take	similar impact	similar impact	similar impact	similar impact
	Noise	×× diesel only	×	×	×
	Emissions	×× diesel only	×	×	×
Operation	Vehicle Recovery	××	××	✓	×
	Integration with Heritage Railway	✓✓✓	✓✓	✓	✓
	Service Competition	×	×	✓	✓

Table 2B.4 Comparison Appraisal Summaries for Technology Alternatives

Objective	Sub-Objective	Tram-Train	Light Weight Rail	Bus Rapid Transit
Environment	Noise	- (no significant difference between alternatives) Tram-Train would cause a slight increase in noise along the route. Could be some impact with wheel noise.	- (no significant difference between alternatives) Tram-Train would cause a slight increase in noise along the route. Could be some impact with wheel noise.	- (no significant difference between alternatives) Tram-Train would cause a slight increase in noise along the route
	Local Air Quality	✓✓✓ Mode shift reduces impacts from cars. Lower emissions at source.	✓ to ✓✓✓ Potential mode shift reduces impacts from cars. Lower emissions at source.	✓✓ Mode shift reduces impacts from cars. Use of low emission vehicles will reduce impacts.
	Greenhouse Gases	✓✓✓ Mode shift reduces impacts from cars. Lower emissions at source.	✓ to ✓✓✓ Potential mode shift reduces impacts from cars. Lower emissions at source.	✓✓ Mode shift reduces impacts from cars. Use of low emission vehicles will reduce impacts at source.
	Landscape	xx Overhead power source introduces intrusion in landscape.	- Slight adverse impact on land use, land cover and visual amenity however, baseline environmental capital along the route is low and opportunities for mitigation exist.	- Slight adverse impact on land use, land cover and visual amenity however, baseline environmental capital along the route is low and opportunities for mitigation exist.
	Townscape	xx Overhead power source and rails within city centre introduces intrusion in townscape.	- to ✓ Scheme could potentially increase street clutter, careful design will provide the opportunity for mitigation and positive impacts. Rails within city centre introduce some intrusion in townscape.	- to ✓ Scheme could potentially increase street clutter, careful design will provide the opportunity for mitigation and positive impacts.

Objective	Sub-Objective	Tram-Train	Light Weight Rail	Bus Rapid Transit
	Heritage of Historic Resources	- (no significant difference between alternatives) Some potential impact on the setting of Listed Buildings, Scheduled Monuments and Conservation areas. Involves works to listed structures.	- (no significant difference between alternatives) Some potential impact on the setting of Listed Buildings, Scheduled Monuments and Conservation areas. Involves works to listed structures.	- (no significant difference between alternatives) Some potential impact on the setting of Listed Buildings, Scheduled Monuments and Conservation areas. Involves works to listed structures.
	Biodiversity	- (no significant difference between alternatives) Negative impacts on the Bower Ashton Mineral Railway SNCI through land take. Partial mitigation is possible.	- (no significant difference between alternatives) Negative impacts on the Bower Ashton Mineral Railway SNCI through land take. Partial mitigation is possible.	- (no significant difference between alternatives) Negative impacts on the Bower Ashton Mineral Railway SNCI through land take. Partial mitigation is possible.
	Water environment	- (no significant difference between alternatives) Potential flood risk impact without mitigation.	- (no significant difference between alternatives) Potential flood risk impact without mitigation.	- (no significant difference between alternatives) Potential flood risk impact without mitigation.
	Physical fitness	- (no significant difference between alternatives) The scheme would encourage additional walking and cycling journeys as a result of the segregated route along the alignment and increased public transport trips.	- (no significant difference between alternatives) The scheme would encourage additional walking and cycling journeys as a result of the segregated route along the alignment and increased public transport trips.	- (no significant difference between alternatives) The scheme would encourage additional walking and cycling journeys as a result of the segregated route along the alignment and increased public transport trips.
	Journey ambience	- (no significant difference between alternatives) High quality facilities, surrounding environment and passenger information will reduce traveller care and stress and improve views.	- (no significant difference between alternatives) High quality facilities, surrounding environment and passenger information will reduce traveller care and stress and improve views.	- (no significant difference between alternatives) High quality facilities, surrounding environment and passenger information will reduce traveller care and stress and improve views.

Objective	Sub-Objective	Tram-Train	Light Weight Rail	Bus Rapid Transit
Safety	**Accidents**	✓✓✓ Mode shift reduces impacts from cars and associated reduction in road accidents. Additional pedestrian benefits as a result of priority measures and improved crossing facilities and by cyclists as a result of the cycle route along the segregated alignment.	✓ to ✓✓✓ Potential mode shift reduces impacts from cars and associated reduction in road accidents. Additional pedestrian benefits as a result of priority measures and improved crossing facilities and by cyclists as a result of the cycle route along the segregated alignment.	✓✓ Mode shift reduces impacts from cars. Use of low emission vehicles will reduce impacts. Additional pedestrian benefits as a result of priority measures and improved crossing facilities and by cyclists as a result of the cycle route along the segregated alignment.
	Security	- (no significant difference between alternatives) Increased use of CCTV and high standard of lighting at bus shelters provides high levels of security for passengers.	- (no significant difference between alternatives) Increased use of CCTV and high standard of lighting at bus shelters provides high levels of security for passengers.	- (no significant difference between alternatives) Increased use of CCTV and high standard of lighting at bus shelters provides high levels of security for passengers.
Economy	**Public Accounts**	xx Costs associated with scheme construction, ongoing maintenance and loss in indirect tax revenue.	x Costs associated with scheme construction, ongoing maintenance and loss in indirect tax revenue.	✓ Costs associated with scheme construction, ongoing maintenance and loss in indirect tax revenue.
	TEE	✓✓ Travel time benefits resulting from the reduced journey times. Higher fleet investment and ongoing operating costs which would require higher revenues or longer investment period.	✓✓ Travel time benefits resulting from the reduced journey times. Higher fleet investment costs which would require higher revenues or longer investment period. Ongoing operating costs untested.	✓✓✓ Travel time benefits resulting from the reduced journey times. Providers experience ongoing operating costs which are offset by increased revenue.
	Reliability	✓✓✓ Segregated system would provide improved reliability for bus and rapid transit.	✓✓✓ Segregated system would provide improved reliability for bus and rapid transit.	✓✓ Priority measures and segregated section will provide improved reliability for bus and rapid transit.

Objective	Sub-Objective	Tram-Train	Light Weight Rail	Bus Rapid Transit
	Wider Economic Benefits	✓✓ Improved journey times and reliability will promote regeneration particularly by improving accessibility by directly serving key existing hubs of employment in the City Centre and at Temple Quay and Redcliffe. Less wider benefit to areas not within area of infrastructure.	✓✓ Improved journey times and reliability will promote regeneration particularly by improving accessibility by directly serving key existing hubs of employment in the City Centre and at Temple Quay and Redcliffe. Less wider benefit to areas not within area of infrastructure.	✓✓✓ Improved journey times and reliability will promote regeneration particularly by improving accessibility by directly serving key existing hubs of employment in the City Centre and at Temple Quay, Redcliffe and facilitating development and employment at Ashton Park and Bristol International Airport.
Accessibility	**Option Values**	✓✓ Additional transport option available in the south west of Bristol through walk access or P&R.	✓✓ Additional transport option available in the south west of Bristol through walk access or P&R.	✓✓✓ Additional transport option available in the south west of Bristol through walk access, bus access or P&R.
	Severance	- (no significant difference between alternatives) The provision of walking and cycling routes along the alignment will offset any increase in severance caused by the route itself.	- (no significant difference between alternatives) The provision of walking and cycling routes along the alignment will offset any increase in severance caused by the route itself.	- (no significant difference between alternatives) The provision of walking and cycling routes along the alignment will offset any increase in severance caused by the route itself.
	Access to the transport system	Around 15000 within 600m rapid transit stop. Wider population served by bus services.	Around 15000 within 600m rapid transit stop. Wider population served by bus services.	Around 15000 within 600m rapid transit stop. Wider population served by bus services.

Objective	Sub-Objective	Tram-Train	Light Weight Rail	Bus Rapid Transit
Integration	Transport interchange	✓✓✓ Interchange with existing transport hubs at Temple Meads, Bristol Bus station (indirectly) Long Ashton P&R and potentially Portishead rail services.	✓✓✓ Interchange with existing transport hubs at Temple Meads, Bristol Bus station (indirectly) Long Ashton P&R and potentially Portishead rail services.	✓✓✓ Interchange with existing transport hubs at Temple Meads, Bristol Bus station, Long Ashton P&R and potentially Portishead rail services.
	Land Use Policy	✓ less flexibility to serve wider sub-region development	✓ less flexibility to serve wider sub-region development	✓✓✓ flexibility to extend to wider sub-region
	Other government policies	✓✓✓ Positive impact on health, environment, local communities and transport policies.	✓✓✓ Positive impact on health, environment, local communities and transport policies.	✓✓✓ Positive impact on health, environment, local communities and transport policies.

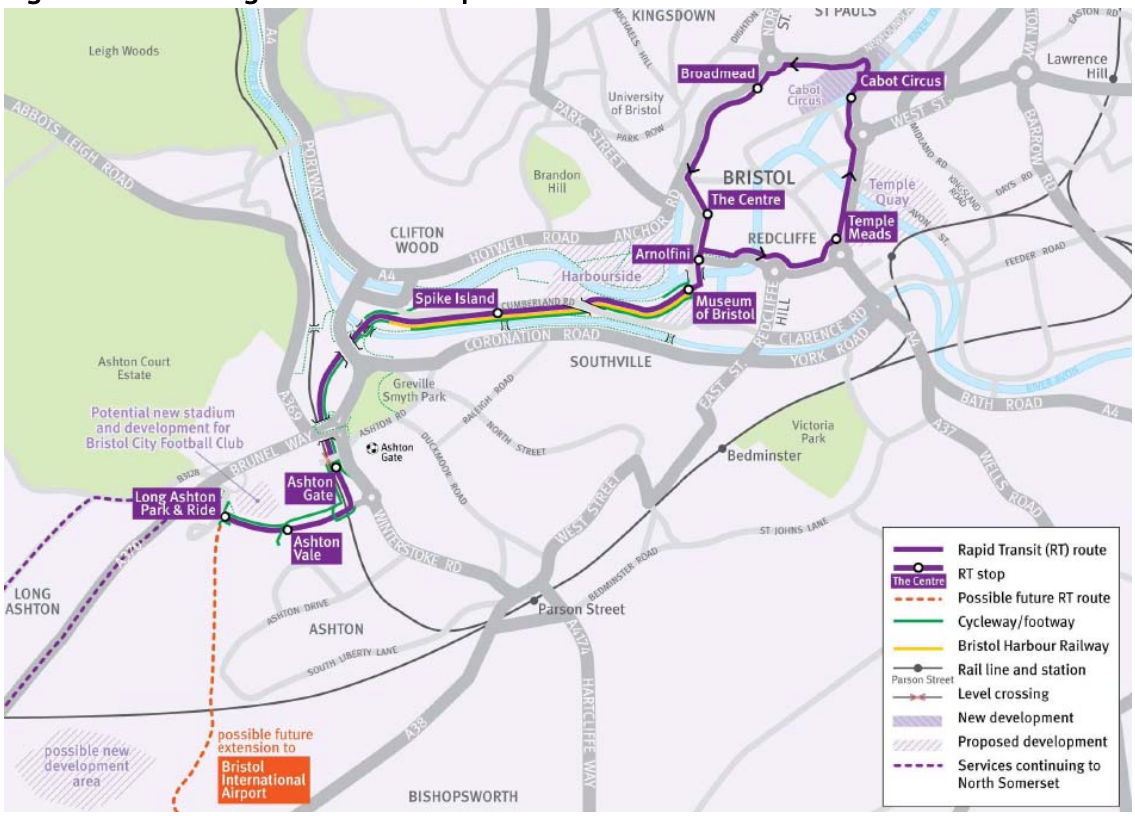
2B.7 Specific Scheme Elements

The Project Team undertook a scheme optimisation or value engineering as part of the scheme development. This exercise involved a review of the entire alignment but focussed on higher cost and risk items, these were mostly structural works. Specific scheme elements of which options were reviewed in detail included:

- Crossing of the Portbury Freight Line.
- Provision of 100% two-way running on the segregated corridor.

These are described below. The overview route plan is shown in Figure 2B.6 for reference.

Figure 2B.6 Long List of Route Options Considered



Crossing of the Portbury Freight Line

The route between the proposed stops of Ashton Vale and Ashton Gate crosses the Portbury Freight Line. The proposed crossing is at the location of the current uncontrolled pedestrian right of way crossing north of Colliters Brook.

The freight line has around 12 planned freight paths per day and use of those paths varies by season. North Somerset Council and local stakeholders have aspirations to re-open the freight line to passenger services (known as the "Portishead Railway Line project"). This scheme is now identified in the advice to Government from the South West region on regional funding priorities (RFA2). The proposal is to run two passenger trains per hour between Portishead and Bristol Temple Meads.

The original Rapid Transit Scheme design provided for an at-grade crossing of the freight line. The capital cost estimate for this option was £2.5 million which would involve a new rapid transit/rail signalised crossing.

Network Rail and the Office of the Rail Regulator expressed concern about the plans for an at-grade crossing noting that they would not support any additional at-grade crossings on the rail network. Concern was also expressed about the limitation this may place on line capacity. The proposed crossing is located just south of an existing at-grade crossing at Ashton Vale Road. Due to the proximity of the two crossings Network Rail advised that the signalling for these would need to be co-ordinated such that with a train approaching either signal would result in closure of the entire section from north of Ashton Vale Road to south of the proposed crossing. This would significantly increase the length of time rapid transit services could be held at a red signal.

A grade separated option was subsequently proposed with a capital cost estimate of £3 million. This option will introduce a larger structure with additional construction and visual amenity impacts. In view of the potential constraint on rapid transit services and the likely objection by Network Rail and the Office of the Rail Regulator it was agreed that the grade separated option would be included in the preferred Rapid Transit Scheme.

Provision of two-way Running on the Segregated Corridor underneath Cumberland Road Skew Bridge

In order to provide an attractive reliable system to achieve a high level of mode shift a design aspiration throughout development of the Rapid Transit Scheme has been to maximise the level of two-way segregated running from general traffic.

The section of the route between east of the proposed Spike Island stop and west of the proposed Museum of Bristol stop requires the route to cross underneath Cumberland Road. The underpass/bridge is very constrained and there is insufficient width for a two-way rapid transit route as well as retaining the existing cyclist and pedestrian path. Three alternatives were considered:

- Two-way rapid transit route removing or redirecting the existing cyclist and pedestrian path.
- One-way (shuttle working) rapid transit route retaining the existing cyclist and pedestrian path.
- Widening of the existing structure to provide both the two-way rapid transit route and the existing cyclist and pedestrian path

The retention of the existing cyclist and pedestrian path was considered fundamental to meeting the scheme objectives of providing sustainable transport options and consistent with the desire to provide a parallel walking and cycling facility within all the corridors of the proposed Rapid Transit Network. Removal of the existing cyclist and pedestrian path would be locally controversial and unlikely to be supported. The Project Team therefore looked at the implications of retaining the existing cyclist and pedestrian path.

A review of the engineering works required to widen the existing structure identified:

- Due to the geometry of the road and railway alignment widening the alignment would require movement of the retaining wall of the River Avon New Cut. This could potentially result in impacts on the water course and in other areas the Environment Agency has stopped this type of intrusion into the watercourses due to the effects of water movement.

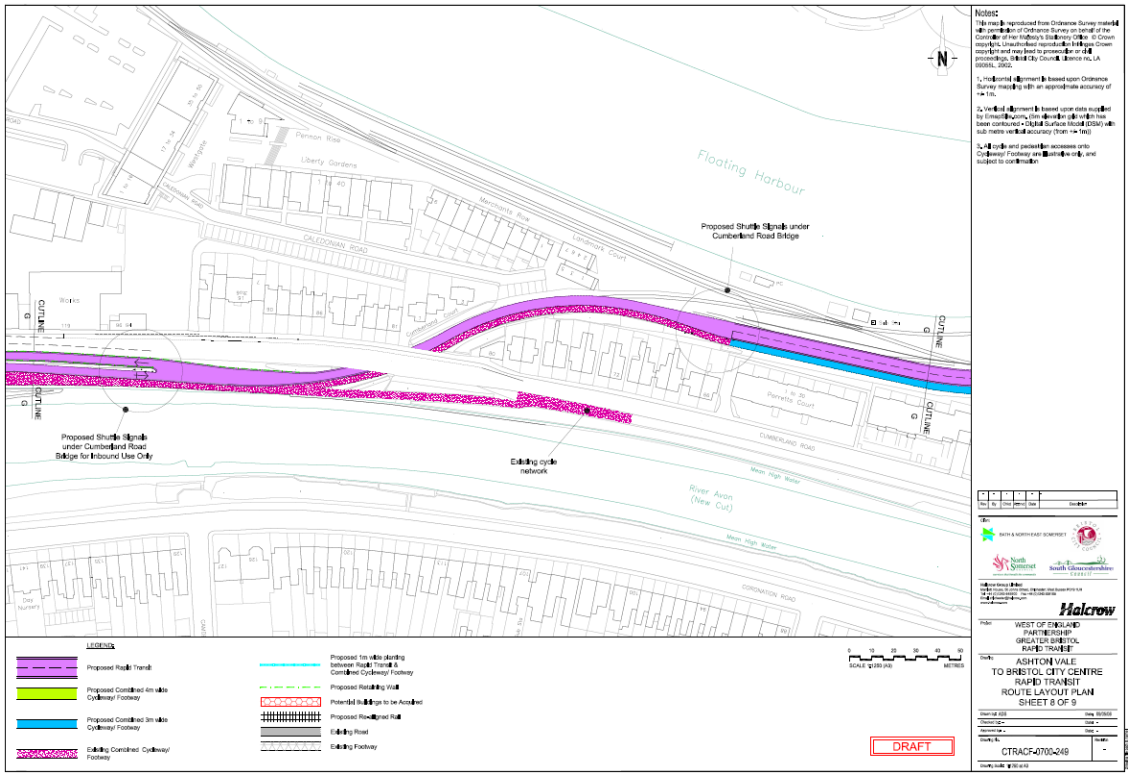
- In addition these works could result in the need for property acquisition. Both sides of the underpass are bordered by residential property.

- The capital cost estimate for these works was between £10 million and £15 million excluding any potential land costs.

The alternative was to provide a section of one-way shuttle operation through introduction of signals. This section is shown in Figure 2B.7. The total length of the one-way shuttle section is about 260 metres.

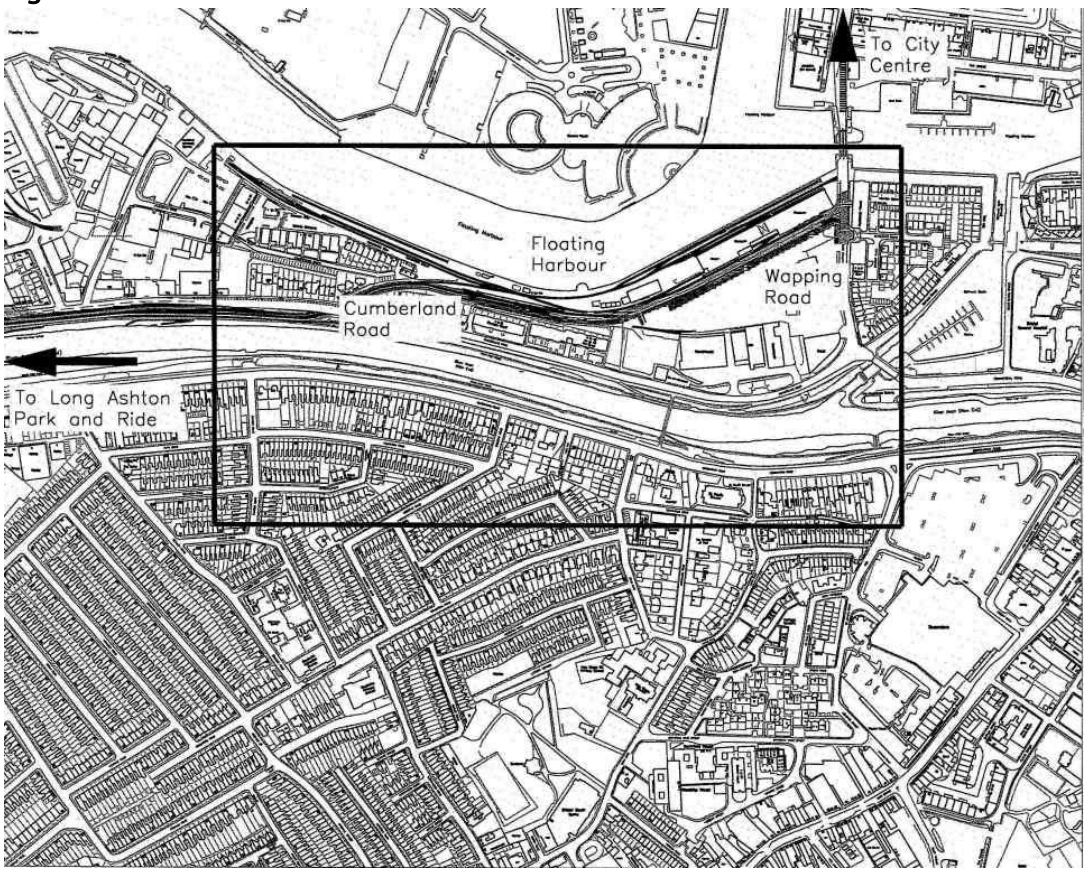
Discussion with a local bus operator about this alternative raised concern about the impact of this section on the overall reliability of the system particularly potential queuing of services .

Figure 2B.7 Route Section on One-Way Shuttle Operation under Cumberland Rd Bridge



For the purposes of the assessment the Bristol City Centre S-Paramics model was extended to include the Rapid Transit alignment through this section. The model section was 1080m of the route running east run Wapping Road. This is shown in Figure 2B.8

Figure 2B.8 Model Area



The tests undertaken included the following scenarios;

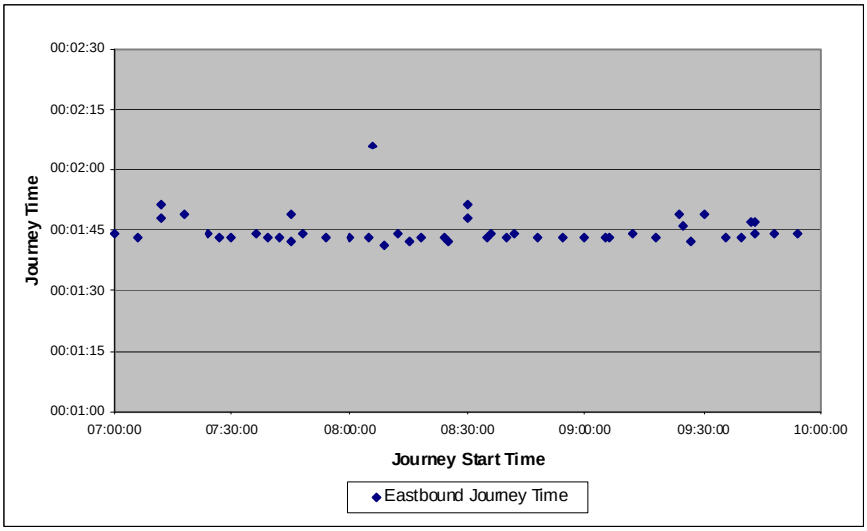
- A rapid transit service every 6 minutes in both directions, plus some additional bus services.
- Increasing the headway to determine what level of buses could feasibly use the route.
- Services bunching before they reach the section of shuttle working. The services were input to bunch at 30 second intervals which is more onerous and also less likely than a likely service scenario.

A summary of the results is shown in Figure 2B.9. The graphs show the modelled time for services to pass through the model area (1080m). The graphs show that in all three tests the shuttle working did not result in significant variation in the journey time through the section modelled. The consultants drew the following conclusions from the analysis:

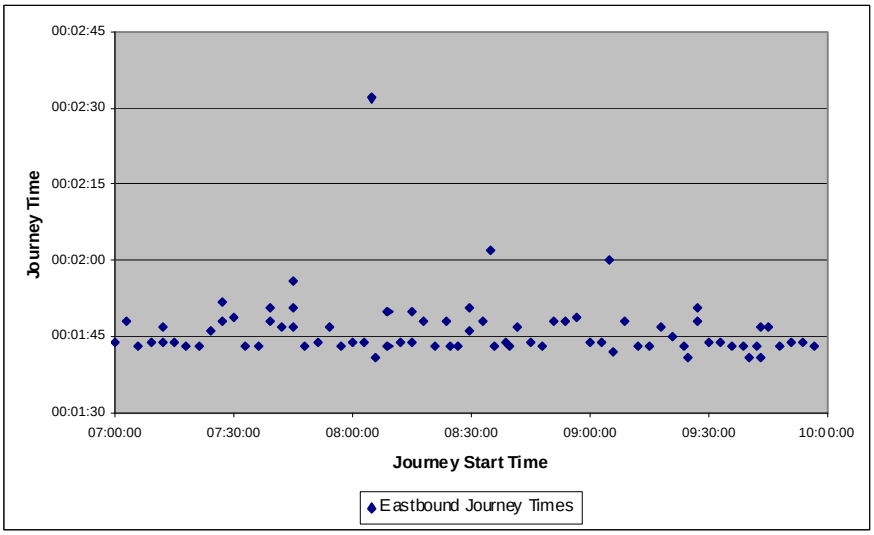
- At the proposed service level, the results indicate that the shuttle signals work well. With both the fixed timetable tests and the demand matrix tests the number of buses experiencing delay is very small and the level of delay is up to a maximum of 40 seconds.

Figure 2B.8 Summary Results from S-Paramics Analysis

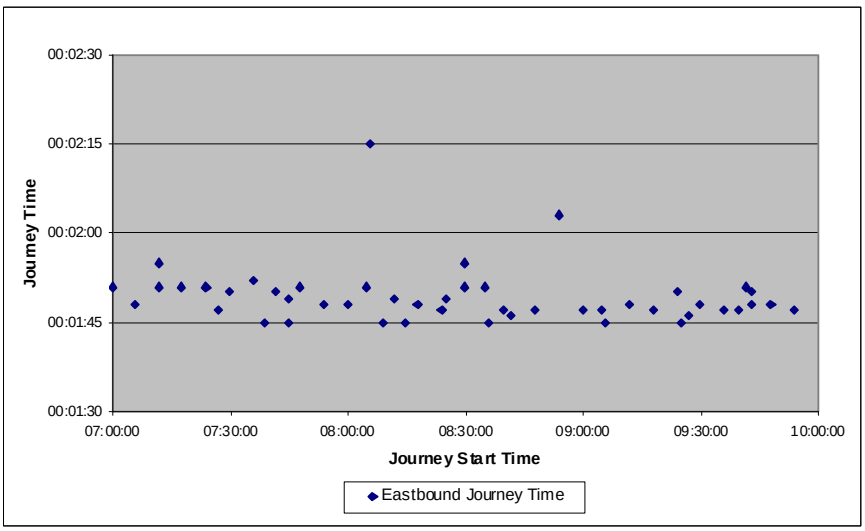
Eastbound Journey Time with 6 Minute Headway



Eastbound Journey Time with 3 Minute Headway



Eastbound Journey Time with Bus bunching both directions



- The results indicate that the shuttle signals work well with a service level of 15 Rapid Transit services per hour and still works reasonably well up to 20 Rapid Transit services per hour. This appears to be about the maximum number of buses that could feasibly use the Rapid Transit route before delays are experienced by more than half the services.

- Services can not be guaranteed to avoid any delay, as this is inherent where shuttle signals are required, especially over a distance of 260m.

- At most levels of frequency, the maximum delay will be around 40 seconds. This is equivalent to the approximate time taken for a vehicle to clear the shuttle-working section. This will occur if vehicles arrive simultaneously from each direction.

- It may be possible to refine the operation of the signals further by co-ordinating operation with the signals at Wapping Road or with service stops along the segregated route.

Given the analysis showed that there was minimal impact on the reliability of the services and constraint on system capacity it was considered that the additional cost and impacts of widening in to the River Avon New Cut were not justifiable. The preferred scheme therefore includes the one-way-shuttle working option.

2B.8 Summary

In summary:

- The development of the Rapid Transit Scheme commenced in 2006.

- The Rapid Transit Scheme is a result of a comprehensive strategic study undertaken which looked at a range of interventions to meet the current and future needs of the sub-region and identified a rapid transit network as part of the solution.

- The scheme development work has included a comprehensive review of options as part of developing the preferred Rapid Transit Scheme. A series of 'next best' options have been considered in terms of corridors, routes within corridors, technology choice and specific scheme elements.

- A series of studies conducted over the last four years have exhaustively concluded that the technology best suited to the delivery of the scheme objectives of the West of England sub-region, best able to deliver within the appropriate timescales, most flexible to support development and economic growth and provide a step-change in public transport provision is high quality bus-based rapid transit. Supporting these studies is increasing empirical evidence from the application of bus rapid transit to perform to standards capable of effecting mode transfer from car to public transport and increased public transport patronage.

- In the city centre three options were considered which varied significantly in terms of the size of the proposed works. The preferred scheme provides significantly improved segregation for services in Bristol City Centre, addresses the issue of interchange at Temple Meads Railway Station and has strongly support from stakeholders.

Appendices

2B (i) – Greater Bristol Public Transport Corridor options, Final Report, January 2007, Steer Davies Gleave

2B (ii) – Options Short Listing Report, May 2007

2B (iii) – Technology Options Report, September 2007

2B (iv) – Technology Review, Final Report, September 2008, Steer Davies Gleave

2B (v) – Alignment Alternatives Report, February 2009, Atkins