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.

Job number 228562-02
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1 Introduction

1.1 Background

This report presents the findings of the first stage of the study investigating the potential for a new public transport corridor linking Cardiff City Centre through North West Cardiff into Rhondda Cynon Taf (RCT). This study focuses on the corridor within the Cardiff Unitary Authority area and will be followed by a second study stage that examines the potential options for the corridor to be extended to key destinations in Rhondda Cynon Taf.

This report covers the first stage of the corridor study and therefore the draft costings and patronage figures in this report must be treated with caution as they can only be properly assessed once the options for the full corridor including RCT have been appraised. It is anticipated that further benefits could be delivered in terms of patronage and cost efficiencies as part of a wider strategic corridor.

This study has been commissioned by Cardiff Council, Plymouth Estates, Westgate Park Cardiff Limited and Castell-Y-Mynach Estate to investigate the potential forms of public transport provision that could be implemented to support new development in north west Cardiff.

The Council’s emerging Local Development Plan includes three strategic land allocations in north west Cardiff that could collectively achieve approximately 10,250 new homes and 6,500 new jobs. The locations of the three sites are illustrated in Figure 1.1.

The expectation is that each of these sites will function as sustainable communities where access by non-car modes of transport will provide an attractive range of journey making options.

Initial dialogue between the Council and the three site promoters has highlighted the advantages of a joined-up approach to transport provision. This is founded on the improved scope to deliver new public transport infrastructure that can achieve fast and reliable service connectivity to key destinations in central Cardiff as well as interchange to a range of other local, regional and national destinations. It is also aligned with the Council’s strategic aspiration to achieve better linkages to the outlying region, including a strategic park and ride facility at M4 J33.

1.2 Public Transport Options

This study provides a preliminary assessment of the physical, operational and financial practicalities of a new public transport corridor to connect the three strategic sites to Cardiff City Centre. It identifies the comparable opportunities and risks associated with three potential forms of public transport provision:
Bus Rapid Transit

*Bus Rapid Transit (BRT)* is a term used to describe a bus based transit system that provides fast, frequent and comfortable urban mobility. Services will typically involve a combination of shared on-street running with other road users and dedicated or segregated sections of a route that minimise delays from traffic conditions. High quality passenger facilities (both on and off vehicle) are important in achieving an excellent passenger experience.

Heavy Rail

*Heavy Rail* is a term that is used to differentiate conventional rail vehicles operating on the rail network from light rail (tram) systems. Cardiff has an extensive urban heavy rail network that accommodates a wide range of local and national passenger rail services. Planned investment in the Valley Lines network is expected to facilitate electrification by 2020, with associated improvements in rolling stock.

Tram Train

*Tram Train* is hybrid of heavy and light rail systems in that vehicles are able to operate both on-street and on existing heavy rail routes. This provides flexibility in how services can utilise existing routes whilst also being integrated within an urban environment. The vehicles differ from those on heavy or light rail networks and would therefore require dedicated storage and maintenance facilities. When not operating on heavy rail lines, tram trains are also able to operate on a ‘line of sight’ principle decreasing the requirement for signalling infrastructure. There are no tram trains currently operational in the UK, although a pilot route will commence service between Sheffield and Rotherham in 2016.
Table 1.1 provides a summary comparison of the operational attributes typically associated with each of the three public transport options.

**Table 1.1: Comparison of typical physical characteristics for BRT, Heavy Rail and Tram Train**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>BRT</th>
<th>Heavy Rail</th>
<th>Tram Train</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation mode</td>
<td>Busway/on-street</td>
<td>Segregated</td>
<td>Segregated/tramway/on-street</td>
</tr>
<tr>
<td>Vehicle passenger capacity</td>
<td>125</td>
<td>250</td>
<td>175</td>
</tr>
<tr>
<td>Minimum corner radii</td>
<td>20 m</td>
<td>150 m</td>
<td>40 m</td>
</tr>
<tr>
<td>Maximum gradient</td>
<td>6%</td>
<td>1%</td>
<td>3%</td>
</tr>
<tr>
<td>Maximum operating speed</td>
<td>80 kph</td>
<td>100 kph</td>
<td>120 kph</td>
</tr>
<tr>
<td>Two way corridor width</td>
<td>&gt;7.00m</td>
<td>&gt;9.50m</td>
<td>&gt;8.30m</td>
</tr>
<tr>
<td>Stop interval</td>
<td>600m+</td>
<td>1,000m</td>
<td>600m+</td>
</tr>
<tr>
<td>Integration with existing</td>
<td>High</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td>Infrastructure costs</td>
<td>Medium</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Vehicle costs</td>
<td>Medium</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Operating costs</td>
<td>Medium</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Maintenance</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
</tr>
</tbody>
</table>

Each of the three forms of provision has been assessed in the context of the infrastructure and services that may be necessary to achieve a corridor capable of effectively servicing the three strategic sites, whilst also benefitting existing nearby communities.

### 1.3 Study Area

The study area shown in Figure 1.2 represents the geographical area of search for suitable corridor alignments.

The eastern extremity of the study area is largely governed by the rail based options, which would necessitate a connection to the existing City Line to the south of Danescourt station.

Further west the study area definition has been influenced by the opportunities to utilise disused rail routes and the scope to link the three strategic sites to Cardiff in a way that could also facilitate onward connectivity to Rhondda Cynon Taf.

### 1.4 Study Objectives

The purpose of the study is to identify a recommended route alignment and form of public transport provision that can be taken forward for more detailed design development. Having regard to the Welsh Transport Planning and Appraisal Guidance (WelTAG), the process of determining the study recommendation has been influenced by the following key priorities:

- achieving convenient access to each of the strategic sites;
• minimising journey times to central Cardiff so as to provide an attractive alternative to car use for existing and new communities on the NW corridor;
• minimising passenger wait times by achieving a high frequency of service;
• deliverability, having regard to potential construction costs, external sources of funding, phasing of implementation and risk;
• the scope to cater for travel demand from existing communities;
• the potential to provide an onward extension into Rhondda Cynon Taf and attract patronage from that area; and
• the scope to intercept journeys to/from central Cardiff via park and ride facilities.

These priorities have provided a basis for comparing and contrasting the relative merits of the various options.

1.5 Report Structure

The remainder of this report is structured as follows:

Chapter 2 provides a contextual overview of the constraints and opportunities associated with achieving a public transport corridor;

Chapter 3 investigates the potential provision of a Bus Rapid Transit system;

Chapter 4 investigates the potential provision of a Heavy Rail route;

Chapter 5 investigates the potential provision of a Tram Train system;

Chapter 6 presents the findings of an assessment of the service operation achievable through Heavy Rail or Tram Train;

Chapter 7 identifies indicative headline cost estimates for the infrastructure associated with each of the corridor options;

Chapter 8 presents high level patronage forecasts for each form of transport;

Chapter 9 identifies potential funding mechanisms for delivery;

Chapter 10 provides a summary comparison of the corridor options; and

Chapter 11 identifies the concluding recommendations, including next steps.
2 Contextual Overview

At the outset of the study a review of potential opportunities and constraints was undertaken to provide a contextual basis for determining how the various corridor options could be taken forward for assessment. This has been informed by meetings with each of the site promoters and background information supplied by Cardiff Council.

The review provided an initial basis for refining the number of alignments to be taken forward for investigation. This was deemed necessary in view of the multitudinous nature of the alignments that could be contemplated within the geographical study area. It also provided a firmer understanding of the various corridor components, both physical and operational, that need to be accounted for as part of any assessment.

2.1 Opportunities

Table 2.1 provides a summary of the key identified opportunities, as illustrated in Figure 2.1.

Table 2.1: Key Opportunities

<table>
<thead>
<tr>
<th>Opportunity</th>
<th>Implication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategic site locations</td>
<td>Linear arrangement of sites between Cardiff and Llantrisant is consistent</td>
</tr>
<tr>
<td></td>
<td>with movement corridor concept.</td>
</tr>
<tr>
<td>Disused rail corridors</td>
<td>A physical precedent for heavy rail that offers scope for connectivity to</td>
</tr>
<tr>
<td></td>
<td>the existing City Line and towards Llantrisant.</td>
</tr>
<tr>
<td>Existing highway network</td>
<td>Each of the sites is closely aligned with the A4119 (Llantrisant Road)</td>
</tr>
<tr>
<td></td>
<td>radial corridor.</td>
</tr>
<tr>
<td>City Line</td>
<td>Improvements to network capacity and reliability to be completed by</td>
</tr>
<tr>
<td></td>
<td>2015, which will improve line speed on the City Line.</td>
</tr>
<tr>
<td>Valley lines electrification</td>
<td>Inclusion of the City Line offers the prospect of faster journey times by</td>
</tr>
<tr>
<td></td>
<td>2020.</td>
</tr>
<tr>
<td>Existing communities</td>
<td>There is scope to attract patronage from nearby communities including</td>
</tr>
<tr>
<td></td>
<td>Creigiau, Danescourt and Pentrebane.</td>
</tr>
<tr>
<td>Links to Rhondda Cynon Taf</td>
<td>Rhondda Cynon Taf contributes the largest volume of in-commuters to</td>
</tr>
<tr>
<td></td>
<td>Cardiff and the Llantrisant area has been identified for future growth.</td>
</tr>
<tr>
<td></td>
<td>Connectivity to Cardiff by public transport is currently limited.</td>
</tr>
<tr>
<td>Heol St Y Nyll</td>
<td>Provides a means of crossing (underneath) the M4 motorway.</td>
</tr>
</tbody>
</table>

The opportunities are reflective of the available scope to (re)connect the strategic sites to the existing road and rail networks.
2.2 Constraints

Table 2.2 provides a summary of the key identified constraints, as illustrated in Figure 2.1.

Table 2.2: Key Constraints

<table>
<thead>
<tr>
<th>Constraint</th>
<th>Implication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topography</td>
<td>Undulating nature of the terrain includes areas with steep gradients, which have a bearing on routing and achievable journey times.</td>
</tr>
<tr>
<td>Existing structures</td>
<td>Potential to adapt or improve bridge structures along the disused rail corridors.</td>
</tr>
<tr>
<td>M4 motorway</td>
<td>The configuration and scale of structures required to cross under or over the M4.</td>
</tr>
<tr>
<td>Local road intersections</td>
<td>Interactions with the highway network at Waterhall Road, Crofft Y Genau Road, Llantrisant Road, Cardiff Road, Station Road and Heol Creigiau.</td>
</tr>
<tr>
<td>City Line connection</td>
<td>Route of connection is obstructed by residential properties.</td>
</tr>
<tr>
<td>City centre road links</td>
<td>Subject to peak period congestion and afford limited scope for widening or the reallocation of road space.</td>
</tr>
<tr>
<td>Rail service timetabling</td>
<td>Current and future passenger/freight operations will have a bearing on the achievable frequency of service.</td>
</tr>
<tr>
<td>Land ownership</td>
<td>The extent of third party land acquisition required.</td>
</tr>
<tr>
<td>Severance</td>
<td>Minimising the impact of severance within the strategic sites.</td>
</tr>
<tr>
<td>Rolling stock</td>
<td>Potential procurement of new rolling stock and associated storage/maintenance requirements.</td>
</tr>
</tbody>
</table>

The means by which the above constraints can be overcome, mitigated or avoided altogether has had an important bearing on the alignment options taken forward.

2.3 Conclusions

On the basis of the above findings, it was concluded that the following scenarios should be considered for all three forms of public transport:

- re-instatement or re-use of the disused rail corridor as a route of connection to the existing city centre networks;
- deviation from the disused rail corridor to the south in order to achieve an alignment that relates more directly to the strategic sites to the north of M4 J33; and
- variations on the above as appropriate.

The potential for route alignments that run directly alongside the disused rail corridor, which could assist in preserving its environmental and ecological value, have not been investigated on account of the increased levels of severance that would be created within the development sites.
3  **Bus Rapid Transit**

Bus Rapid Transit systems encompass infrastructure, vehicles and scheduling that are used to provide a higher quality service than that on conventional bus routes. They can operate on existing roads, where road space is shared with other road users, and dedicated traffic-free routes. This enables key destinations to be served in a manner that avoids the congested parts of a network.

### 3.1 BRT Concept

The BRT service is proposed as a higher quality service than existing bus routes in Cardiff. Key elements of the concept are:

- higher average operational speeds (in comparison to existing services which are typically <18 kph);
- stop distance: 600 metres (average); and
- high frequency services (potential for up to 15 services per hour dependent on demand).

#### 3.1.1 BRT Running Way

BRT lanes will be ‘exclusive use’ for BRT/Bus vehicles within new development areas. On the existing street network (through Fairwater and Canton), there will be >50% of BRT/bus lane provision, and in particular on approaches to junctions.

For dedicated sections of the route the BRT lanes can be either adjacent to the kerbside or centrally located in the carriageway with stations constructed as ‘islands’ between the central running BRT lanes and general traffic lanes.

The allocation of dedicated road space to BRT is primarily intended to increase the journey speed and reliability of BRT services by reducing interactions with general traffic. This would increase the attractiveness of public transport in the new and existing communities, including Fairwater, Canton and The Mill (an LDP strategic site to the south of Cowbridge Road East).

The upgrade of the corridor would also achieve benefits for other routes approaching the city centre from this direction, including areas such as Culverhouse Cross, Ely and Caerau.

#### 3.1.2 Intersections and traffic signals

Major junctions on a BRT route would typically be signalised. It is desirable that crossing manoeuvres over the BRT/Bus lanes are minimised (to enhance safety and minimise BRT delay). The key elements of junction operation are thus:

- banned turns for general traffic at some junctions;
- left-in-left-out only at some minor side roads; and
- bus detection and priority at signals (within SCOOT operation).

Pedestrian/cycle crossings can be provided at-grade, although it is desirable to minimise interactions of this nature so as to achieve higher average vehicle speeds.
3.1.3 BRT Stations

BRT stations are high quality in respect of facilities (e.g. station, real time information, name plate). The placement of stations will be dependent on the Running Way (and vice-versa). Features include:

- high quality bus stops with double length shelters;
- located either on the kerbside or as an island in the carriageway dependant on the location of the running way;
- raised platforms at stations to allow level boarding;
- minimum platform length 20 metres; and
- platform width 3 metres (absolute minimum 2m).

3.1.4 BRT Vehicles

- 18 metre long articulated buses (capacity 110 -120 passengers) with the ability to operate with conventional buses during lower demand periods; and
- low floor level vehicles.

3.1.5 Ticketing System

It is essential for efficient operation of the BRT, and in particular to minimise dwell times, that ticketing does not involve cash payment to the driver. Proposals for ticketing are:

- ticket machines at all stations or alternatively on-board attendants with handheld ticket machines;
- roving ticket inspectors; and
- driver has no role in ticketing process.

3.2 Route Description and Infrastructure

3.2.1 Corridor Infrastructure

Potential routes and alignment options for Bus Rapid Transit to connect the NW corridor and LDP sites to Cardiff city centre have previously been investigated as part of a study undertaken by Arup on behalf of Cardiff Council. This investigated five potential options, including three that involved Bus Rapid Transit. Only one of these three options was recommended for further investigation. This recommendation has therefore formed a basis for the development of the proposed route shown in Appendix A.

The western section of the route consists of a new busway through the strategic sites. From Fairwater to the city centre it is proposed that the BRT infrastructure will run on-street.

For the on-street sections close to the city centre the proposed route is via Cowbridge Road East. Although this route is busier and has more significant frontage activity than the alternative of Lansdowne Road, it has been selected for the following reasons:

1 ‘Rapid Transit for Cardiff: LDP 2006-2026 Strategic Transport Infrastructure’ (April 2013)
Cowbridge Road East is a key destination as a district shopping centre, meaning that there is a proven demand for services to operate on this route;

Cardiff Council has already invested significantly in the reallocation of road space and development of public transport facilities along this route; and

The overall cross-sectional width of Cowbridge Road East is greater than that of Lansdowne Road, which affords improved potential for road space reallocation.

Table 3.1 indicates the proposed infrastructure for each section of route.

**Table 3.1: BRT Infrastructure Proposals**

<table>
<thead>
<tr>
<th>Section</th>
<th>Road</th>
<th>Infrastructure Type</th>
<th>Distance (m)</th>
<th>Proposed Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creigiau to Development Zone (North of M4)</td>
<td>Llantrisant Road</td>
<td>On-street</td>
<td>500</td>
<td>• Local widening to accommodate single bus lane</td>
</tr>
<tr>
<td>Development Zone North to J33 P&amp;R</td>
<td>Busway</td>
<td>Busway</td>
<td>1,600</td>
<td>• Local widening to accommodate single bus lane</td>
</tr>
<tr>
<td>J33 Park &amp; Ride to Busway/Waterhall Road junction (Fairwater)</td>
<td>Busway</td>
<td>Busway</td>
<td>5,000</td>
<td>• Two lane segregated busway</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Signal control at junctions where development roads cross the BRT route</td>
</tr>
<tr>
<td>Busway/Waterhall Road junction to Waterhall Road St Fagan’s Road junction</td>
<td>Waterhall Road</td>
<td>On-street</td>
<td>1,250</td>
<td>• Local widening to accommodate single bus lane</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Removal of on-street parking</td>
</tr>
<tr>
<td>Waterhall Road St Fagan’s Road junction to Western Avenue</td>
<td>St Fagan’s Road</td>
<td>On-street</td>
<td>900</td>
<td>• Local widening to accommodate single bus lane</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Removal of on-street parking</td>
</tr>
<tr>
<td>Western Avenue/ St Fagan’s Road to Ely Bridge</td>
<td>Western Avenue</td>
<td>On-street</td>
<td>400</td>
<td>• Reallocation of roadspace to give 2 x BRT lanes and 2 x Traffic Lanes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Signal control at Ely Bridge junction</td>
</tr>
<tr>
<td>Ely Bridge to Victoria Park</td>
<td>Cowbridge Road East</td>
<td>On-street</td>
<td>700</td>
<td>• Reallocation of roadspace to give 2 x BRT lanes and 2 x Traffic Lanes</td>
</tr>
<tr>
<td>Victoria Park to St David’s Hospital</td>
<td>Cowbridge Road East</td>
<td>On-street</td>
<td>1,850</td>
<td>• Reallocation of roadspace to give 2 x BRT lanes and 1 x Traffic Lanes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Traffic Lane will operate one-way eastbound</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• All on-street parking into specific intermittent laybys</td>
</tr>
<tr>
<td>St David’s Hospital to Wood Street</td>
<td>Cowbridge Road East</td>
<td>On-street</td>
<td>1,250</td>
<td>• Reallocation of roadspace to give 2 x BRT lanes and 2 x Traffic Lanes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>13.45</td>
<td>-</td>
</tr>
</tbody>
</table>
3.2.2 M4 Crossing and Route options

In addition to the main route alignment Appendix A indicates a number of potential routing options in the vicinity of the M4. These are primarily associated with the potential means of crossing the M4 and the resultant cost savings that may be achieved.

The relative merits of the various options are discussed below.

Black Option – Main route alignment: New M4 Overbridge

This alignment represents the core option as it offers the greatest potential to minimise journey time and maximise reliability.

As the Busway approaches the M4 from the east the levels would be raised, via either an embankment or structure, to a bridge with appropriate clearance over the motorway. At the skew indicated this is likely to require a bridge structure with a clear span of around 55m, although further investigation would be required to clarify this or identify alternative options.

On the north side of the M4 the Busway would turn to the west on a new section of Busway in order to enter the J33 development site with connections to serve the P&R and wider development area.

As a result of the need to construct a new overbridge, this option is the most expensive. Some reductions in cost (with associated penalties for journey time and reliability) may be possible by reducing the bridge structure to a single lane with controlled shuttle working of BRT vehicles.

The costs associated with this option are presented in Chapter 7 and provide a basis for comparison with the subsequent alternative options.

Light Blue Option: Crofft-y-Genau Road/Llantrisant Road

This option uses existing roads to turn off the disused rail corridor at Crofft-Y-Genau Road.

Crott-Y-Genau Road is a minor road with a carriageway width of around 6m. It would require improvement works to make it suitable for use by BRT for the 0.5 km section linking to the A4119 Llantrisant Road. The junction with Llantrisant Road provides significant roadspace but works (such as signalisation) to afford priority to turning BRT vehicles will be required.

The route would then follow Llantrisant Road for 1.1 km, at which point it would join the yellow route (described below) just to the south of the M4. Llantrisant Road affords a wide single carriageway, although it may be appropriate to improve the route to include bus lanes in one or both directions as part of any phased corridor implementation. Further investigation would be required to determine whether improvements of this nature are achievable.

In the event that this option is implemented, it would be essential to ensure that the remainder of the disused railway corridor is protected in order to retain the potential to upgrade the route at a later date.
When viewed in combination with the yellow route, this option presents risks in terms of journey time but may also achieve cost savings by avoiding any requirement for a new bridge across the M4.

**Yellow Option: Use of the A4119 bridge to cross the M4**

This option uses the existing A4119 overbridge to cross the M4. The route would deviate from the disused railway corridor on the approach to the M4 via a short linking section of around 0.2 km to a junction with the A4119. The junction will require measures to ensure priority for BRT vehicles.

The route would then cross the M4 on the A4119 Llantrisant Road. As noted for the light blue option, it may be appropriate to improve the route to include bus lanes in one or both directions as part of any phased corridor implementation. Further investigation would be required to determine whether improvements of this nature are achievable.

The route option would follow Llantrisant Road for around 0.7 km to the junction with Heol-St-Y-Nyll. At this point Llantrisant Road is around 0.1 km away from the site boundary of the J33 development site. The route could access the site either via an improved Heol-St-Y-Nyll (currently a narrow country lane) or via a newly formed route. Within the development site the route would serve the J33 P&R site and subsequently re-join the proposed busway alignment.

When viewed in isolation, this option presents risks in terms of journey time but may also achieve cost savings by avoiding any requirement for a new bridge across the M4.

**Dark Blue Route: Use of Heol-St-Y-Nyll**

This option spurs off the disused railway alignment to the south of the M4 and involves the construction of a new 0.8km section of Busway parallel to the M4. This would connect to Heol-St-Y-Nyll via a newly formed junction to the south of the motorway. The route would then pass underneath the M4 using the existing Heol-St-Y-Nyll route.

An initial inspection of the bridge structure indicates that with relatively minor works it is suitable for two-way operation. Traffic control and priority arrangements along Heol-St-Y-Nyll would need to be reviewed and modified as appropriate. After passing under the M4 on Heol-St-Y-Nyll the route re-joins the preferred alignment within the J33 development site.

When viewed in isolation, this option offers a lower level of risk to journey time and provides cost savings by avoiding any requirement for a new bridge across the M4.

**Green Route: Connection section to Llantrisant Road**

This option is a short linking section to connect the Busway to Llantrisant Road to enable it to be used by other bus services. By constructing a further 0.3km section of route and providing a connecting junction with Llantrisant Road it would be possible to create a (controlled) access point to the Busway for local routes serving destinations such as Creigiau, Pentyrch, Beddau and Church Village.
Enabling such routes to access the Busway without delay would increase the value for money of the infrastructure and also the level of service provided on the route.

When viewed in isolation, this option offers a low risk to journey time and, at an additional cost, achieves associated benefits for other services.

### 3.3 Proposed Bus Lane and Busway Operating Arrangements

The provision of bus lanes and bus priority is dependent on the availability of appropriate roadspace. Table 3.2 describes the proposed bus lane arrangements for each ‘type’ of street.

It is critical that on-street parking is removed from the majority of the corridor along St Fagan’s Road and Cowbridge Road East. The majority of these sections are already subject to parking restrictions. Where space permits parking could be provided in inset layby spaces adjacent to the carriageway.

The reallocation of roadspace to accommodate the bus route has implications on parking displacement and conditions for general traffic, where congestion delays for other road users could be worsened by the reduction in available roadspace. Provision of this nature is nonetheless likely to form a necessary part of achieving the requisite service reliability.
Table 3.2: Proposed Bus Lane and Busway Arrangements

<table>
<thead>
<tr>
<th>Type of Street</th>
<th>BRT Infrastructure Arrangement</th>
<th>Typical Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Busway</td>
<td>For the busway through the development sites, it is proposed that a 7m two-way carriageway is provided, with footways on both sides. It would also be desirable to include a 2-way cycle track to one side of the route. Given the potential service frequency and the need to achieve the best possible journey time, it will not be appropriate to mix with general traffic or reduce provision to a single lane. At key pinch points, such as bridges, where costs could be significant and the impact on service reliability is low it may be appropriate to reduce to a single lane over short sections. Within the development area, local roads could connect across the busway via signal controlled junctions. By including bus detection at signal junctions, minimal delay to BRT vehicle could be ensured.</td>
<td>Busway within development site</td>
</tr>
<tr>
<td>On-street BRT running way on roads where the width is 9m-11m wide</td>
<td>One bus lane with two traffic lanes, with the bus lane in the centre of the road, with direction determined according to local needs and junction congestion. Generally, bus lanes would be provided on the approach to junctions.</td>
<td>Waterhall Road, St Fagan’s Road, Cowbridge Road East through Canton.</td>
</tr>
<tr>
<td>On-street BRT running way on roads where the width is 9m-11m wide</td>
<td>Two bus lanes with a one-way traffic lane are proposed for Cowbridge Road East through Canton. A one-way traffic lane (with laybys provided as space permits) is proposed, which would necessitate traffic management to allow vehicles arriving from the east (City) to reach destinations on Cowbridge Road East. (see Figure 3.1)</td>
<td>Cowbridge Road East through Canton.</td>
</tr>
<tr>
<td>On-street BRT running way on roads where the width is at or near 12m wide</td>
<td>Two types of operation are proposed where three lanes are available. Two bus lanes, in the kerbside lanes, with 2 traffic lanes in the centre of the road (see Figure 3.2) Two bus lanes, in the centre of the road, with a traffic lane at the kerbside in both directions (see Figure 3.3).</td>
<td>Cowbridge Road East (eastern end) Castle Street Westgate Street</td>
</tr>
</tbody>
</table>

Figure: 3.1: Two BRT/Bus lanes with a one-way traffic lane
Figure: 3.2: Two BRT/Bus lanes at kerbside two traffic lanes

Figure: 3.3: Two BRT/Bus lanes in centre of road with two traffic lanes

3.4 BRT Operating Speed and Travel Time

With BRT infrastructure and operations in place, a travel speed of 30 kph will be achievable on ‘busway’ sections. For on-street sections, with significant improved infrastructure in place, a reasonable operating speed is 18 kph. On the basis of these assumptions, a total travel time of around 36 minutes from Creigiau to the city centre is considered achievable. It should be assumed that changes in the level of priority or road space allocation will all influence journey speed.
Table 3.3: BRT Route Sections Operating Speed (Creigiau to Cardiff City Centre)

<table>
<thead>
<tr>
<th>BRT Infrastructure Type</th>
<th>Road</th>
<th>Section</th>
<th>Distance (m)*</th>
<th>Operating Speed (kph)</th>
<th>Time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Busway</td>
<td>Busway</td>
<td>Creigiau to South of Creigiau LDP site</td>
<td>800</td>
<td>30</td>
<td>98</td>
</tr>
<tr>
<td>Busway</td>
<td>Busway</td>
<td>South of Creigiau LDP site to J33 Park &amp; Ride</td>
<td>1,250</td>
<td>30</td>
<td>149</td>
</tr>
<tr>
<td>Busway</td>
<td>Busway</td>
<td>J33 Park &amp; Ride to Busway/Waterhall Road junction (Fairwater)</td>
<td>5,000</td>
<td>30</td>
<td>596</td>
</tr>
<tr>
<td>On-street</td>
<td>Waterhall Road</td>
<td>Busway/Waterhall Road junction to Waterhall Road St Fagan’s Road junction</td>
<td>1,250</td>
<td>18</td>
<td>255</td>
</tr>
<tr>
<td>On-street</td>
<td>St Fagan’s Road</td>
<td>Waterhall Road St Fagan’s Road junction to Western Avenue</td>
<td>900</td>
<td>18</td>
<td>177</td>
</tr>
<tr>
<td>On-street</td>
<td>Western Avenue</td>
<td>Western Avenue / St Fagan’s Road to Ely Bridge</td>
<td>400</td>
<td>18</td>
<td>74</td>
</tr>
<tr>
<td>On-street</td>
<td>Cowbridge Road East</td>
<td>Ely Bridge to Victoria Park</td>
<td>800</td>
<td>18</td>
<td>163</td>
</tr>
<tr>
<td>On-street</td>
<td>Cowbridge Road East</td>
<td>Victoria Park to St David’s Hospital</td>
<td>1,800</td>
<td>18</td>
<td>360</td>
</tr>
<tr>
<td>On-street</td>
<td>Cowbridge Road East</td>
<td>St David’s Hospital to Wood Street</td>
<td>1,350</td>
<td>18</td>
<td>272</td>
</tr>
<tr>
<td><strong>TOTALS</strong></td>
<td></td>
<td></td>
<td><strong>13,550m</strong></td>
<td><strong>22.6 Av</strong></td>
<td><strong>2,144</strong> (36mins)</td>
</tr>
</tbody>
</table>

* Rounded to nearest 50m

The average journey speed from the data presented in Table 3.3 is 22.6 kph which compares closely with that of the Gosport – Fareham Eclipse BRT system (operated by First Bus UK). This route, recently opened in Hampshire, is comparable in how it is comprised of busway and on-street operation and achieves an average speed of 22 kph over its route.

Based on this data an outline service journey timetable is presented in Table 3.4. Timings have been rounded up to the nearest 30s.
There could also be scope for the service operation to be modified to reflect the relative strength of passenger demand. This could involve some services operating on a limited stop ‘express’ basis between the J33 park and ride site and the city centre in order to achieve a lower journey time. Some services could also be extended to other destinations, such as Cardiff Bay, as appropriate.

Service pattern variations of this nature will only be possible once there is a frequent service (of at least 6 services an hour) and sufficient demand to ensure viability.

Table 3.4: Typical BRT Journey Time (Creigiau to Cardiff City Centre)

<table>
<thead>
<tr>
<th>Timing Point</th>
<th>Time from start (mm:ss)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creigiau</td>
<td>00:00</td>
</tr>
<tr>
<td>South of Creigiau LDP Site</td>
<td>01:30</td>
</tr>
<tr>
<td>Junction 33 P&amp;R site</td>
<td>04:00</td>
</tr>
<tr>
<td>Busway/Waterhall Road junction</td>
<td>14:00</td>
</tr>
<tr>
<td>St. Fagans Road junction</td>
<td>18:00</td>
</tr>
<tr>
<td>Western Avenue</td>
<td>21:00</td>
</tr>
<tr>
<td>Ely Bridge Roundabout</td>
<td>22:00</td>
</tr>
<tr>
<td>Victoria Park</td>
<td>25:00</td>
</tr>
<tr>
<td>St. Davids Hospital</td>
<td>31:00</td>
</tr>
<tr>
<td>Wood Street (Cardiff city centre)</td>
<td>36:00</td>
</tr>
</tbody>
</table>
4 Heavy Rail Infrastructure

The heavy rail option is predicated on achieving connectivity to the City Line so as to facilitate a direct and continuous rail service operation to Cardiff Central.

4.1 Methodology

An assessment of potential alignments has been undertaken following the established criteria of Network Rail.

Track Design Handbook NR/L2/TRK/2049 & Design and Construction of Track
NR/L2/TRK/2102

It has been assumed that the rail track would ideally need to permit 50 mph vehicle speeds, as per the existing City Line into which this link will be connected. The following parameters have also been applied:

• Minimum horizontal radius – 200 m (150 m exceptional);
• Maximum vertical gradient at 50 mph - 2,300 m;
• Track gauge 1, 438 mm to 1,432 mm (this is compatible with existing Network Rail mainline track); and
• Max gradient at station – 0.200% preferred but can be exceeded.

Derived

• Width of single track corridor – Approximately 5.4m (4.7m passing through isolated structures);
• Width of double track corridor – Approximately 9.4m;
• Width of single track corridor with station platform – Approximately 9.1m; and
• Width of double track corridor with station platforms – Approximately 15.3m.

It has been assumed that single track sections will be used through existing structures in instances where it is not possible to accommodate dual tracks, although passing loops can be provided elsewhere according to route utilisation.

The use of level crossings has been resisted due to the risk of non-acceptance by approval bodies. Pedestrian footbridges and highway overbridges have instead been considered where appropriate.

100 metre long stations are proposed for the purposes of this report.

Space for Overhead Electrification equipment has been considered.

4.2 Route Options

The following route options have been examined:

• Option 1 – provision of a route along the disused Llantrisant branch rail corridor between the City Line and M4 J33;
• Option 1a – terminus to the south of the M4 motorway;
• Option 1b – terminus to the north of the M4 motorway utilising Heol St Y Nyll;
• Option 2 – continuation along the disused rail corridor east of Creigiau; and
• Option 3 - deviation from disused rail corridor to south to route through strategic sites.

Appendix B illustrates each of the alignment options and associated chainages that have been used to identify key constraints.

4.3 Route Appraisal Findings

4.3.1 Option 1a

Option 1 connects to the City Line at the site of the former connection at Kirton Close and follows the old trackbed towards Llantrisant. The track terminates at a new station south of the M4 near the existing underpass on Heol St Y Nyll.

Key considerations include the following:
1. Connection into City Line (Chainage 0 to 1200)

A mainline crossover with Network Rail infrastructure will be required to allow access to both the Up and Down City lines.

In the case of heavy rail, the new track will directly impact upon approximately 15 existing dwellings and be in close proximity to other nearby properties regardless of whether single or double track is installed.

Line speed will be limited to approximately 20mph from Chainage 0 to Chainage 400 due to constrained track geometry.

At least three existing footpaths indicated on the OS survey will have to be re-routed or replaced with footbridges.

2. The Waterhall Road Bridge (Chainage 1000)

This will have to be extensively rebuilt to achieve suitable clearance for the proposed rail alignment.

3. Pedestrian crossing (Chainage 1567) indicted on OS survey

Will have to be closed, rerouted or replaced with footbridge.

4. Pedestrian crossing (Chainage 1910) indicted on OS survey

Will have to be closed, rerouted or replaced with footbridge.

5. Proposed station (Chainage 2000)

The proposed vertical alignment in the area of the proposed station achieves a complaint alignment (although not ideal for heavy rail).
6. Proposed station (Chainage 3270)

The proposed vertical alignment in this area exceeds the maximum allowable gradient for heavy rail. Further civils works, including cuttings and retaining walls, are therefore likely to be required. These could add substantive costs and impinge upon the surrounding developable area.

7. Former Railway Overbridge (Chainage 3270)

This structure has been dismantled and it appears that only a single line could be constructed without further structural works to the redundant abutments, subject to structural assessment (railway portal approximately 4.7m wide). Widening will be necessary to accommodate a double track arrangement.

8. Existing road overbridge (Chainage 3450)

This structure is only suitable for a single track construction, subject to structural assessment (railway portal approximately 4.7m wide). Widening will be necessary to accommodate a double track arrangement.

9. Spur section (Chainage 4500 to 5300)

This alignment is proposed across land that is not former railway land and therefore land ownership issues, including Tydu Farm where the access road would be bisected, could arise.

Additionally, the existing topography in which the spur and station are located is a steep hill. A cutting and retaining walls of approximately 5 metres high will be necessary to construct a compliant station.

4.3.2 Option 1b

Option 1b is a continuation of Option 1a, although it places the station north of the M4 in utilising an existing underpass structure to cross the M4.

Option 1b is not compatible with heavy rail due to the geometry proposed to access the underpass to the north and south of the M4. Additionally heavy rail would not be able to directly access the proposed ‘Park and Ride’ area due to the tight radii.

9. Crossing M4 via Heol St Y Nyll Underpass (Chainage 5250)

The minimum dimensions of the crossing have been measured as 8.9 m wide and 5.3 m high. The width of this is sufficient for a single track but too narrow for a double track (See Appendix B), these initial measurements would need to be verified and accompanied by a structural assessment to ascertain its suitability for carrying a rail line. A full topographic survey of the area would also be required in order to accurately assess the level at which it passes beneath the M4 so that necessary civils works such as cuttings and retaining walls for the track approaches can be quantified.

4.3.3 Option 2

Option 2 connects to the mainline at the site of the former City line connection at Kirton Close and follows the old trackbed beyond Creigiau towards Llantrisant.
Key challenges include Items 1 to 8 identified for Option 1a plus the following:

10. **Crossing M4 and A4119 (Chainage 4500 to 5500)**

A railway bridge would have to be constructed to cross all lanes of the M4. This bridge will require significant civils works, including embankments, on its approaches in order to achieve a suitable clearance to the motorway carriageways. In close proximity to the proposed M4 crossing are the remnants of the high level track alignment that used to carry the railway over the A4119. These would need to be rebuilt and also involve extensive civils works.

11. **Existing road overbridge (Chainage 5500)**

This structure is only suitable for a single track construction subject to structural assessment (railway portal approximately 4.7m wide). Widening will be necessary to accommodate a double track arrangement.

12. **Existing road overbridge (Chainage 6390)**

This structure is only suitable for a single track construction subject to structural assessment (railway portal approximately 4.7m wide). Widening will be necessary to accommodate a double track arrangement.

13. **Existing road overbridge (Chainage 7250)**

This structure is only suitable for a single track construction subject to structural assessment (railway portal approximately 4.7m wide). Widening will be necessary to accommodate a double track arrangement.

14. **Existing road overbridge (Chainage 7750)**

This structure is only suitable for a single track construction subject to structural assessment (railway portal approximately 4.7m wide). Widening will be necessary to accommodate a double track arrangement.

15. **Existing road overbridge (Chainage 8580)**

Structural assessment required (railway portal assumed 4.7m wide). Widening will be necessary to accommodate a double track arrangement.

16. **Existing Bridge over the Afon Clun (Chainage 8580)**

Structural assessment required to assess suitability for reuse.

### 4.3.4 Option 3

Option 3 shares the same proposed alignment as Option 1 and 2 to Chainage 2000, with identical requirements concerning tie in with the City line via Kirton Close and rebuilding of the Waterhall Road overbridge (for both light and heavy rail).

The proposed alignment then deviates from the historic track bed taking a route to the south across the Waterhall site area and then open farmland and crossing the M4 to the east of Junction 33. The route then proceeds through the development site to the north of Junction 33 in a north westerly direction to the west of Creigiau.

This alignment was developed in order to:
• provide an alternative to comprehensive re-use of the former railway alignment;
• enable the route to more directly serve the strategic M4 J33/south of Creigiau sites with heavy rail; and
• facilitate an alternative future alignment for onward connectivity into Rhondda Cynon Taf.

When viewed as a whole the proposed alignment for Option 3 represents a major civil engineering challenge for both light and heavy rail. Those issues most problematic include the following:

• extensive cuttings;
• extensive embankments;
• associated retaining structures;
• road crossings (Croft Y Genau Road and Stockland Farm access); and
• new M4 crossing.

The scope to provide stations on this undulating alignment is limited. A suitable area exists centrally within the strategic site to the north of J33 (chainage 6300).

4.4 Conclusions

The key emerging conclusions are:

• all of the options would necessitate property acquisition to achieve connectivity to the City Line;
• Options 1 and 2 are both based on a pre-existing track alignment that is suitable for both light and heavy rail;
• there are suitable locations for stations to serve the strategic sites and existing communities;
• existing structures on the corridor will limit where dual tracking can take place without extensive bridge works, although the requirement for bridge works could be averted through provision for passing loops;
• Option 1a could be implemented without any need for a crossing of the M4, although a pedestrian or shuttle link (depending on location) to the M4 J33 P&R facility would be required;
• Option 1b is not achievable due to the geometry required to access the underpass;
• a phased approach to implementation could be adopted to introduce Option 2 at a later stage; and
• Option 3 poses greater technical complexities, although a compliant horizontal and vertical alignment is achievable at a higher cost.
5  Tram Train

Tram train technology provides an alternative means of achieving a direct and continuous rail service operation to Cardiff Central. It differs from conventional heavy rail on account of the interchangeable capability of the rolling stock, which enables vehicles to move between on-street and heavy rail networks.

5.1  UK Context

There are no current working examples of tram train systems in the UK, although a £58m pilot scheme to introduce the vehicles on the Sheffield Supertram and national rail networks was announced in 2012 by the Department for Transport. This service will become operational in 2016 for an initial two year period with a view to permanent operation. The service will use both networks seamlessly to provide three services an hour between Sheffield and Rotherham.

The outcome of this pilot operation is likely to define the future of such systems in the UK and, if deemed successful, is likely to lead to changes in the regulations that would permit similar systems to be operated elsewhere.

The current status of the technology represents a major project risk due to uncertainties over the outcomes of the Sheffield-Rotherham trial and its associated implications on delivery certainty and timescales.

As with the heavy rail option, early engagement with Network Rail will be essential.

5.2  Existing Tram Train Systems

There are working examples of Tram Train implementations in a number of European locations including Paris, Mulhouse and Karlsruhe. There are also various potential schemes yet to be taken forward.

Karlsruhe, Germany is perhaps the best known implementation of Tram Train as a result of its extensive network (400 km) and duration of operation (since the 1980s). Since its introduction the ‘Karlsruhe Stadtbahn’ network has benefitted from significant growth in coverage and patronage.

The system combines tram lines in the city of Karlsruhe (as shown in Figure 5.1) with railway lines in the surrounding countryside, serving the entire region of the middle upper Rhine valley and creating connections to neighbouring regions. The Stadtbahn combines an efficient urban railway in the city with a suburban railway, overcoming the boundary between trams/light railways and heavy railways.

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The system is operated in co-operation between transport operators, the local transport authority and the operator of the heavy rail services.

![Tram Train operation in Karlsruhe](image)

**Figure 5.1:** Karlsruhe on-street Tram Train operation. Credit: Klaus with K

### 5.3 Technical Considerations

Associated with the technology there are various considerations/decisions that would need to be made.

#### 5.3.1 Platform Height

Light Rail vehicles are typically ‘low floor’, whereas heavy rail vehicles are typically ‘high floor’. This refers to the boarding height and considerations of accessibility for passengers.

To be compatible a Tram Train system could either:

a) Use high floor rolling stock and construct new stations accordingly;

b) Adapt existing platforms at heavy rail stations to have sections which are compatible with low floor vehicles. This is likely to result in conflicts with existing operations; or

c) Operate the platform/station infrastructure differently to ensure that no heavy rail vehicles will call at stations/platforms served by Tram Train.

In view of the need to operate the corridor in an integrated manner as part of a wider system it is considered that option a) is likely to offer the best prospects.
5.3.2 Power Source

Tram Train vehicles are typically powered using the following methods. Several existing Tram Train implementations utilise dual power:

Diesel: Requires less infrastructure but has noise, operational cost and air quality implications

Overhead AC: Valley Lines electrification will use 25 KV AC

Oberhead DC: Light Rail systems typically use 750 DC

Internal electrical power supply: Battery or supercapacitor which can enable running for limited distances.

In order to be compatible with the local rail network, which is due to be electrified, it is likely that a Tram Train system for Cardiff would need to be a dual power system capable of operating from 25 kv AC and 750v DC with the ability to change power sources on route.

5.3.3 Signalling and Control

Due to the lighter nature of the vehicle in comparison to heavy rail it may be possible to utilise ‘line of sight’ control for the operation of Tram Trains when running in Tram Train only environments (such as the section between the City Line and Junction 33). This reduces the requirement for costly and complex signalling equipment, although the system will need to be compatible with conventional signalling when operating on lines used by a mix of vehicles.

It will be essential to ensure the reliability of the operation is in no way compromised so that journey times remain attractive and delays are not incurred that impact upon the wider railway network.

5.4 Methodology

In the absence of definitive UK guidance on Tram Train infrastructure, infrastructure requirements have been informed by the established criteria of Docklands Light Railway (DLR) in London.

DLR Standard ES-401

In this study, generally track shall be designed to achieve 50mph as per the existing City Line into which this link will be connected.

Minimum horizontal radius - 80m (40m exceptional)

Maximum vertical gradient – 3.00%

Minimum vertical curve radius – 1,000m

Track gauge 1,435mm (compatible with existing Network Rail mainline track)

Max gradient at station – 1.00%

Derived from DLR-Standard drawings;

Width of single track corridor – Approx. 4m
Width of double track corridor – Approx. 8.3m
Width of single track corridor with station platform – Approx. 8.5m

General assumptions:
Single track sections will be placed through existing structures where it is not possible to fit dual tracks. Passing loops can be provided elsewhere according to route utilisation.

100 metre long stations are proposed for the purposes of this assessment.

Embedded rail systems can be installed for some light rail systems allowing road vehicles to utilise the track alignment. The geometries proposed are suitable for conventional road traffic.

Space for Overhead Electrification equipment has been considered.

5.5 Route Options

The same route options were considered for Tram Train as for heavy rail, see section 4.2.

5.6 Route Appraisal Findings

5.6.1 Option 1a

Option 1 connects to the City Line at the site of the former connection at Kirton Close and follows the old trackbed towards Llantrisant. The track terminates at a new station south of the M4 near the existing underpass on Heol St Y Nyll.

Key considerations include the following:

1. **Connection into City Line (Chainage 0 to 1200)**

   A mainline crossover with Network Rail infrastructure will be required to allow access to both the Up and Down City lines.

   The new track will directly impact upon approximately 7 existing dwellings and be in close proximity to other nearby properties, regardless of either light/heavy rail or single/double track.

   Line speed will be limited to approximately 20mph from Chainage 0 to Chainage 400 due to constrained track geometry.

   At least three existing footpaths indicated on the OS survey will need to be retained.

2. **The Waterhall Road Bridge (Chainage 1000)**

   This will have to be extensively rebuilt to achieve suitable clearance for the proposed rail alignment.

3. **Pedestrian crossing (Chainage 1567) indicted on OS survey**

   An existing route that will need to be accommodated.
4. Pedestrian crossing (Chainage 1910) indicted on OS survey

An existing route that will need to be accommodated.

5. Proposed station (Chainage 2000)

The proposed vertical alignment in the area of the proposed station achieves a compliant alignment.

6. Proposed station (Chainage 3270)

The proposed vertical alignment in this area exceeds the maximum allowable gradient for light rail and therefore is impractical without further civils works, including cuttings and retaining walls which may reduce the developable land area.

7. Former Railway Overbridge (Chainage 3270)

This structure has been dismantled but it appears that only a single line could be constructed without further structural works to the redundant abutments, subject to structural assessment (railway portal approximately 4.7m wide).

8. Existing road overbridge (Chainage 3450)

This structure is only suitable for a single track construction, subject to structural assessment (railway portal approximately 4.7m wide). Reconstruction of the bridge will be required for double track.

9. Spur from Chainage 4500 to Chainage 5300

This alignment is proposed across land that is not former railway land and therefore land ownership issues, including Tydu Farm where the access road would be bisected, could arise.

Additionally the existing topography in which the spur and station are located is a steep hill. A cutting and retaining wall of approximately 5 metres high will be necessary to construct a compliant station.

5.6.2 Option 1b

Option 1b is a continuation of Option 1 which locates a station to the north of the M4 utilising an existing underpass structure to cross the M4. This option would permit a strategic P&R to be served directly.

Option 1b is compatible with light rail, with line speed limited to approximately 20mph.

10. Crossing M4 via Heol St Y Nyll Underpass (Chainage 5300)

The minimum dimensions of the underpass crossing have been measured as 8.9 m wide and 5.3 m high. The width of this is sufficient for either single or double track (See Appendix B), although these initial measurements would need to be verified and accompanied by a structural assessment to ascertain its suitability for carrying a rail line. Likewise a full topographic survey of the area would be required in order to accurately assess the level at which it passes beneath the M4 so that necessary civils works, such as cuttings and retaining walls for the track approaches, can be quantified.
5.6.3 Option 2

Option 2 follows the same route as Option 1 between the City Line and The M4 but utilises a new crossing of the M4 to follow the alignment of the former Llantrisant No.1 branch towards and potentially beyond Creigiau.

Key challenges include Items 1 to 8 identified for Option 1a plus the following:

11. Crossing M4 and A4119 (Chainage 4500 to 5500)

A railway bridge would have to be constructed to cross all lanes of the M4. This bridge will require significant civils works on its approaches in order to achieve a suitable clearance from the motorway carriageways. In close proximity to the proposed M4 crossing are the remnants of the high level track alignment that used to carry the railway over the A4119. These would need to be rebuilt and also involve extensive civils works.

12. Existing road overbridge (Chainage 5500)

This structure is only suitable for a single track construction subject to structural assessment (railway portal approximately 4.7m wide). Reconstruction of the bridge will be required for double track.

13. Existing road overbridge (Chainage 6390)

This structure is only suitable for a single track construction subject to structural assessment (railway portal approximately 4.7m wide). Reconstruction of the bridge will be required for double track.

14. Existing road overbridge (Chainage 7250)

This structure is only suitable for a single track construction subject to structural assessment (railway portal approximately 4.7m wide). Reconstruction of the bridge will be required for double track.

15. Existing road overbridge (Chainage 7750)

This structure is only suitable for a single track construction subject to structural assessment (railway portal approximately 4.7m wide). Reconstruction of the bridge will be required for double track.

16. Existing road overbridge (Chainage 8580)

Structural assessment required (railway portal assumed 4.7m wide). Reconstruction of the bridge will be required for double track.

17. Existing Bridge over the Afon Clun (Chainage 8580)

Structural assessment required to assess suitability for reuse.

18. Existing Bridge over road in Rhiwsaeson (Chainage 9430)

Structural assessment required to assess suitability for reuse.

5.6.4 Option 3

Option 3 shares the same proposed alignment as Option 1 and 2 to Chainage 2000, with identical requirements concerning tie in with the City line via Kirton.
Close and rebuilding of the Waterhall Road overbridge (for both light and heavy rail).

The proposed alignment then deviates from the historic track bed taking a route to the south across the Waterhall site area and then open farmland and crossing the M4 east of Junction 33. The route then proceeds through the development site to the north of Junction 33 in a north westerly direction to the west of Creigiau.

This alignment was developed in order to:

- provide an alternative to comprehensive re-use of the former railway alignment
- enable the route to more directly serve the strategic sites north of M4 J33 and south of Creigiau; and
- facilitate an alternative future alignment for onward connectivity into Rhondda Cynon Taf

When viewed as a whole the proposed alignment for Option 3 represents a major civil engineering challenge for both light and heavy rail. Those issues most problematic include the following:

- extensive cuttings;
- extensive embankments;
- associated retaining structures;
- road crossings (Crofft Y Genau Road and Stockland Farm access); and
- new M4 crossing.

As for option 1b it may be possible to adapt the alignment to utilise the M4 underpass via Heol St Y Nyll, although the vertical alignment that would have to be used may add further embankments and cuttings.

The scope to provide stations on this undulating alignment is limited. A suitable area exists centrally within the strategic site to the north of J33 (chainage 6300).

Whilst the greater gradient and radius capabilities of Tram Train can reduce the impact and cost of a number of these constraints they are likely to remain significant in comparison to Options 1/2.

### 5.7 Conclusions

The key emerging conclusions are:

- there are no working examples of Tram Train in the UK and there are uncertainties regarding the findings of the planned pilot study in Sheffield – Rotherham;
- all of the options would necessitate property acquisition to achieve connectivity to the City Line;
- Options 1 and 2 are both based on a pre-existing track alignment that is suitable for both light and heavy rail;
- there are suitable locations for stations to serve the strategic sites and existing communities;
existing structures on the corridor will limit where dual tracking can take place without extensive bridge works, although the requirement for bridge works could be averted through provision for passing loops;

- Option 1a could be installed without any need for crossing of the M4;
- Option 1b offers good penetration to the strategic sites to the north of J33 using existing infrastructure;

- A phased approach to implementation could be adopted to introduce Option 2 at a later stage; and
- Option 3 poses greater technical complexities, although a compliant horizontal and vertical alignment is achievable at a lower cost than heavy rail.
6 Rail Operational Assessment

This chapter presents the findings of a high level operational assessment of the heavy rail and Tram Train options for serving the north west corridor towards Creigiau. The main objectives of this exercise were to:

- identify potential rail service options and integration with existing/proposed future timetabled services, post electrification and re-signalling works in the Cardiff Valleys;
- verify the operational compatibility of the rail options with existing heavy rail services, including service timetabling and rolling stock; and
- identify potential delivery risks and implications on implementation timetabling.

6.1 Methodology

The assessment was undertaken applying the following methodology:

- Review infrastructure: A review of documentation of the planned infrastructure works for the Cardiff area re-signalling and electrification scheme has been completed.
- Document service provision: The service provision of the proposed post electrification timetable has been documented diagrammatically as a train service diagram.
- Outline available capacity: Capacity constraints in the infrastructure network were highlighted and the maximum service level outlined. New path opportunities for peak and off peak standard hour services have been detailed.
- Outline rolling stock: Additional fleet requirements, rolling stock options and capacities for suitable rolling stock requirements have been outlined.

The following data sources were used to complete the assessment:

- Planned Infrastructure upgrades (Network Rail) Improving the Cardiff and Valley Railway CASR presentation
- Post Electrification Timetable specification (Valley Lines Electrification) – MOIRA timetable extracts
- Planning Rules post upgrades (Great Western ROTP – CASR Mock Up)
- Current working timetable (Network Rail)³
- Current planning rules (Network Rail)⁴

³ http://www.networkrail.co.uk/browseDirectory.aspx?root=&dir=%5cTimetables%5cWorking%20Timetable%20(WTT)%5cMay%202012%20-%20December%202012
⁴ http://www.networkrail.co.uk/aspx/3741.aspx
6.2 Results

6.2.1 Infrastructure Review

The following schematic shows the confirmed infrastructure works for the Cardiff area re-signalling and electrification. The key upgrades for additional services are:

- doubling of the Treforest Curve, allowing more services to operate between Cardiff Central and the City Line;
- provision of additional platforms at Cardiff Central and Queen Street to allow for increased service levels through this busy central section of the Valley Lines network; and
- provision of extra platforms at Cardiff Queen Street including a bay platform to allow independent operation of the Cardiff Bay service.

**Figure 6.1: Schematic of Proposed Track Layout**

Tables 6.1 and 6.2 show the key Train Planning Rules following the re-signalling upgrades.

**Table 6.1: Standard Values (minutes)**

<table>
<thead>
<tr>
<th>Item</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Junction Margin</td>
<td>3</td>
</tr>
<tr>
<td>Platform Re-occupation</td>
<td>3</td>
</tr>
<tr>
<td>Turnaround allowance</td>
<td>3 to 5</td>
</tr>
<tr>
<td>Headway</td>
<td>3</td>
</tr>
</tbody>
</table>
Table 6.2: Specific Headways (minutes)

<table>
<thead>
<tr>
<th>Location</th>
<th>Down</th>
<th>Up</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radyr Junction to Cardiff Radyr Branch Junction (City Line)</td>
<td>5 (from 7)</td>
<td>5 (from 7)</td>
<td></td>
</tr>
<tr>
<td>Cogan Junction to Barry</td>
<td>3* (from 4)</td>
<td>3* (from 4)</td>
<td>* Following non-stop service</td>
</tr>
<tr>
<td></td>
<td>6½$</td>
<td>7$</td>
<td>$ Following stopping service</td>
</tr>
</tbody>
</table>
* Following non-stop service
$ Following stopping service

The key change is the reduced headway on the City Line section from Cardiff to Radyr, which will form part of the route to the new line. This indicates that:

- the 3 minute junction margin, headway and platform re-occupation times will allow up to 20 trains per hour (tph); and
- the 5 minute headway on the City Line will allow up to 12 tph in each direction.

It has been assumed that the new line would be a two track line with two terminal platforms, although an option to operate as a single line with passing loops would be possible depending on the level of service required.

It has also been assumed that the line would follow existing disused track bed where this is still available and would therefore limit the gradient changes that may otherwise be encountered if an alternative alignment were proposed.

Four stations have nominally been proposed on the new branch. These are:

- Keyston, an alternative to the Danescourt station to allow for a reduced service level at this station;
- Crofft Y Genau, a nominal centre for the development area;
- Capel Llanillterne, to reflect the potential for a Park & Ride station with interchange to the M4; and
- Creigiau, a sizeable town without rail services and suitable for a terminal station.

Figure 6.2 shows an assumed outline of the new route and approximate station locations used for operational considerations. This route is similar to that detailed in section 4 as option 2, although the operational issues are largely similar for all of the considered alignments as they primarily relate to the sections that are common with existing or proposed rail operations and are fundamental to all considered alignment options.
Journey times have been calculated by measuring the distance along the proposed track bed to each of the proposed stations and assuming an average speed of 24 mph, as observed by services operated by similar stock on other routes. Although the maximum speeds of Heavy Rail and Tram Train vehicles differ\(^5\), it has been assumed that the short stop intervals on the route will limit the maximum speeds allowing the same timings to be used for either option. The introduction of a greater number of stations with associated braking, dwell time and acceleration would affect these timings. Timings have been rounded up to the nearest 30 seconds to provide initial service timings. Summary details are provided in Table 6.3.

\(^5\) For instance a class 315 electrified EMU maximum speed is 75 mph in comparison to the maximum speed of a Tram Train vehicle such as the Siemens Avanto of 55 mph.
Table 6.3: Proposed Service Timings and Distances

<table>
<thead>
<tr>
<th>Location</th>
<th>Distance (miles)</th>
<th>Rounded Time (mm:ss)</th>
<th>Location</th>
<th>Distance (miles)</th>
<th>Rounded Time (mm:ss)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiff Central</td>
<td>0.0</td>
<td>00:00</td>
<td>Creigiau</td>
<td>7.7</td>
<td>30:00</td>
</tr>
<tr>
<td>Ninian Park</td>
<td>1.0</td>
<td>05:00</td>
<td>Capel Llanilterne</td>
<td>5.9</td>
<td>35:00</td>
</tr>
<tr>
<td>Fairwater</td>
<td>2.9</td>
<td>10:00</td>
<td>Crofft-Y-Genau</td>
<td>4.9</td>
<td>38:00</td>
</tr>
<tr>
<td>Fairwood Jn</td>
<td>3.1</td>
<td>11:00</td>
<td>Keyston</td>
<td>3.5</td>
<td>42:00</td>
</tr>
<tr>
<td>Keyston</td>
<td>3.5</td>
<td>12:00</td>
<td>Fairwood Jn</td>
<td>3.1</td>
<td>45:00</td>
</tr>
<tr>
<td>Crofft-Y-Genau</td>
<td>4.9</td>
<td>16:00</td>
<td>Fairwater</td>
<td>2.9</td>
<td>44:00</td>
</tr>
<tr>
<td>Capel Llanilterne</td>
<td>5.9</td>
<td>19:00</td>
<td>Ninian Park</td>
<td>1.0</td>
<td>49:00</td>
</tr>
<tr>
<td>Creigiau</td>
<td>7.7</td>
<td>24:00</td>
<td>Cardiff Central</td>
<td>0.0</td>
<td>54:00</td>
</tr>
</tbody>
</table>

6.2.2 Service Provision

Figure 6.3 shows the proposed post electrification train specification for the peak hour period. Each coloured line represents a return hourly service in each direction.

Figure 6.3: Peak Hour Train Service Schematic – Post Electrification

6.2.3 Capacity Availability

The capacity analysis has concentrated on the triangle between Cardiff Central, Grangetown and Ninian Park as this is where new services would be expected to
run. The proposed future timetable is expected to utilise the majority of the capacity through the core of the route between Cardiff Central and Queen Street.

Figure 6.4 details the utilisation of capacity on the key central area of the network and the links to the proposed new line to Creigiau.

**Figure 6.4: Capacity Utilisation of Key Infrastructure Sections – Post Electrification**

Given the standard planning value of 3 minutes for junction margins, the theoretical upper limit of capacity across a single section of track is 20tph. To operate the railway robustly and allow for external performance factors the planned 16tph service level is a realistic deliverable upper limit. The conflicting move for services between Cardiff Central to Ninian Park and Grangetown to Cardiff Central can be accommodated as no link is planned with more than 16tph.

The line headway on the City Line is 5 minutes, allowing a theoretical capacity of up to 12tph. The planned value of 6tph can therefore be accommodated and delivered with a robust level of performance.

**6.3 NW Corridor Service Options**

Two service options are presented below, which could be implemented individually or together:

- **Option A** - 2tph in each direction from Treherbert via Cardiff Central to Creigiau (with a journey time of 24 minutes and 3 stops on the new branch). This can be accommodated by extending the post electrification Treherbert to Cardiff Central service.
- **Option B** - 2tph in each direction from Coryton via Cardiff Central to Creigiau. This can be accommodated by diverting the post electrification Coryton to Radyr service to Creigiau and removing the Danescourt and Radyr station stops.

If only one of the service options is implemented, delivering 2 tph it could feasibly be operated on a single line infrastructure with passing loops.

If both service options A and B are proposed delivering 4 tph then a two track infrastructure with two terminal platforms should be implemented to ensure reliable and robust network performance.

Post electrification a standard pattern timetable for rail operations is currently envisaged. This means that either of the options work on an evenly spaced 30 minute frequency and in combination the timetable is close to an evenly spaced 15 minute frequency.

The proposed service level and capacity utilisation is shown in Figures 6.5 and 6.6.

**Figure 6.5: Peak Hour Train Service Schematic – Post Electrification with Creigiau Line**
For the proposed service options the times for services through Cardiff Central would remain un-changed and therefore no alterations to the planned timetable on the wider network would be needed.

A further option could be to alter the origin/destination of services to link the new corridor to other locations on the network beyond Cardiff Queen Street, such as locations on the Rhymney Valley or Barry Island lines. A further timetable study would be required to look in more detail at alternative service destinations.

### 6.3.1 Alternative Options

An alternative strategy would be to operate a shuttle service that terminates at Fairwater, Ninian Park, Radyr or Cardiff Central. The first three of these options do not serve the city centre and so are likely to require interchange for a significant proportion of trips.

All shuttle service options will require additional platform space in comparison to through services and, if platform occupancy is high, there may be a requirement for additional bay platform(s) to give time for the service to turn back. Shuttle services can also lead to inefficiencies in fleet size with associated operational cost impacts.

The shuttle options have merit however, particularly for Tram Train, where through services would also require further infrastructure modifications on all
shared sections of track and may be less suitable for longer journeys (as a result of vehicle facilities, ride quality and top speed).

6.4 Rolling Stock

6.4.1 Heavy Rail

It would be appropriate to operate this service with the same rolling stock as that chosen for the valley lines electrification. This would allow a single homogenous fleet to be operated with the following benefits:

- reduced overall number of maintenance spare units that would be required;
- efficiencies gained by being able to inter-operate services between different routes;
- flexibility to divert services onto different lines during disruption to services;
- benefit in terms of staff training and efficiencies in the staff rosters; and
- ability to expand fleet in future years as if demand increased.

A typical new or cascaded 3 or 4 car Electric Multiple Unit (EMU) would be appropriate on this route. This would offer around 250 seats, which is expected to be sufficient to meet initial passenger demand.

Figure 6.7: Class 315 Electric Multiple Unit

To operate each of the services options to Creigiau would require 2 additional units to be leased. Accordingly an additional 4 units would be required to operate both options A and B.
6.4.2 Tram Train

As detailed in section 5.5 there are no current examples of Tram Trains in the UK and such vehicles are not currently approved for mixed operation with Heavy Rail. Following the Sheffield to Rotherham trial that is set to commence in 2016, it is likely that there will be a review of UK policy.

Although the outcome of the review cannot be pre-empted, there is a risk that the operation of Tram Train is either rejected or involves regulations or restrictions that add further complexity to the operational practicalities. These could include signalling, crashworthiness and physical or time based segregation from certain other types of rolling stock. Any of these issues could impact upon the scope to operate the desired level of service.

The diversification of the rail network to include the operation of Tram Trains on a limited number of routes inevitably means that the Tram Train rolling stock will differ from that operating on the remainder of the network. There are therefore a number of resultant issues:

- the Tram Train fleet would be small with a higher than current provision of spare units for Tram Train Routes;
- inability to operate Tram Train units on areas of the network where their functionality has not been approved or is ill-suited (for instance high speed sections);
- dedicated staff team; and
- requirement for specialist maintenance regime which may also necessitate the need for new depot facilities.

In the event of a wider Tram Train implementation on the Valley Lines network, these issues would decrease in magnitude and would be complemented by the following benefits:

- lower vehicle weight (circa 40 tonnes compared to circa 120 tonnes for heavy rail rolling stock) incurring lower track access charge and associated maintenance; and
- lower maintenance cost of line side equipment.

The configuration of Tram Trains can vary but the passenger capacity is typically slightly higher than for equivalent heavy rail units as a result of greater proportion of standing room and no provision of toilets. An example of this is the Siemens Avanto, which can accommodate around 150 passengers as a single 24m vehicle. In the case of higher demand such vehicles can be operated as double vehicles.
Figure 6.8: Siemens Avanto dual voltage Tram Train as used in Paris

As a result of the limited availability of Tram Train rolling stock, the possible requirement for dual power and high floor vehicles, it is likely that new vehicles would be required.

To operate each of the service options to Creigiau would require 2 additional units to be leased. Accordingly an additional 4 units would be required to operate both options A and B.
7 Indicative Cost Estimates

This chapter presents the indicative cost estimates that have been identified for each of the transport options. These figures must be treated with appropriate caution as they relate only to the section of the corridor within the Cardiff Unitary Authority area.

A fuller understanding of total costs will be possible once the whole transport corridor including the potential to extend the corridor into the Rhondda Cynon Taf Unitary Authority has been investigated but it is currently anticipated that the performance of all options would improve if extended in this manner.

7.1 Infrastructure Costs

Infrastructure cost estimates have been developed using typical unit costs from comparable projects and experience elsewhere. They provide a preliminary indication of budget for the concept design and will need to be the subject of refinement as further detailed studies are taken forward.

Costs have been calculated for two-way routes to the Cardiff - Rhondda Cynon Taf boundary. The exception to this is Heavy Rail option 1a which terminates to the south of the M4. All BRT options are for two-lane routes (as recommended in Chapter 3) and, whilst single track costs are presented for the rail options (as detailed in Chapter 6) these are not recommended or considered appropriate for the level of service required.

As part of the capital costs, the following allowances have been made for preliminaries, fees and contingencies:

- contract preliminaries (15%)
- design preliminaries (10%)
- professional team fees (10%)
- construction contingencies (10%)

7.2 Costs Excluding Optimism Bias

Table 7.1 summarises the initial cost estimates for the BRT option.

Table 7.1: BRT Option Indicative Cost Estimates

<table>
<thead>
<tr>
<th>Option</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>BRT (With M4 Bridge)</td>
<td>£78 million</td>
</tr>
<tr>
<td>BRT (No M4 Bridge)</td>
<td>£76 million</td>
</tr>
</tbody>
</table>

The above cost range reflects the different approaches to crossing the M4 motorway for the BRT option.

The costs presented in Table 7.1 represent the cost of developing a system that offers the most competitive journey times and level of service, which is recommended as appropriate for this key transport corridor.
By implementing the other sub-options discussed in Chapter 3 it may also be possible to achieve a number of further cost saving options. Examples include:

- single lane sections through existing bridges;
- use of Llantrisant Road (A4119) from Croft-Y-Genau Road; and
- use of mixed traffic routes in initial phases of development.

These efficiencies may achieve a significant saving in the delivery of an initial service, although this will have to be balanced against the potential impact on the quality of service, journey time and passenger demand. It is imperative that if such efficiencies are employed, the masterplanning design of the surrounding areas should allow for the subsequent development of these sections in a way that affords them protection from traffic congestion and gives increased priority to the service as demand builds.

Table 7.2 summarises the initial cost estimates for the rail based options.

**Table 7.2: Rail Options Indicative Cost Estimates**

<table>
<thead>
<tr>
<th>Option</th>
<th>Option 1a</th>
<th>Option 1b</th>
<th>Option 2</th>
<th>Option 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tram Train</td>
<td>£36 million</td>
<td>£52 million</td>
<td>£64 million</td>
<td>£87 million</td>
</tr>
<tr>
<td>Heavy Rail</td>
<td>£42 million</td>
<td>N/A</td>
<td>£79 million</td>
<td>£101 million</td>
</tr>
</tbody>
</table>

The higher costs associated with options 2 and 3 are primarily due to the inclusion of a bridge to cross the M4 and the greater length of the route.

All of the estimates shown in Table 7.2 assume the provision of a double track solution. A single track arrangement would reduce the cost by approximately £15-30 million. It is important to note that a single track arrangement would be inappropriate in view of the desire to operate a frequent service of a least four services an hour. Any future upgrade to double track would be likely to have a disruptive and costly impact that outweighs any initial benefits.

**7.3 Costs Including Optimism Bias**

In accordance with the recommendations of WebTAG Unit 3.5.9, optimism bias of 44% (BRT option) and 66% (rail options) has been applied to the costs shown in Tables 7.1 and 7.3. The adjusted cost estimates are shown in Tables 7.3 and 7.4.

**Table 7.3: BRT Option Indicative Cost Estimates (with 44% optimism bias)**

<table>
<thead>
<tr>
<th>BRT (No M4 Bridge)</th>
<th>£109 million</th>
</tr>
</thead>
<tbody>
<tr>
<td>BRT (With M4 Bridge)</td>
<td>£112 million</td>
</tr>
</tbody>
</table>
Table 7.4: Rail Options Indicative Cost Estimates (with 66% optimism bias)

<table>
<thead>
<tr>
<th></th>
<th>Option 1a</th>
<th>Option 1b</th>
<th>Option 2</th>
<th>Option 3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tram Train</strong></td>
<td>£60 million</td>
<td>£86 million</td>
<td>£106 million</td>
<td>£144 million</td>
</tr>
<tr>
<td><strong>Heavy Rail</strong></td>
<td>£70 million</td>
<td>N/A</td>
<td>£131 million</td>
<td>£168 million</td>
</tr>
</tbody>
</table>

Optimism bias for rail schemes is attributed on the basis of the status and understanding of the project, assessed through the Network Rail GRIP process\(^6\). The GRIP process consists of eight stages of which 5 are pre-construction. WebTAG 3.13.1 (Table 2)\(^7\) sets out the appropriate level of optimism bias for each of the GRIP stages, which decreases from 66% at GRIP 1 (Output definition) to 6% at GRIP 5 (detailed design).

At present the corridor has no official GRIP status and so a GRIP 1 optimism bias of 66% has been applied. The level of detail provided in this study is more equivalent to GRIP 2 and could therefore enable a 50% Optimism Bias to be applied.

As the detail of the scheme is developed through the GRIP stages, optimism bias would be progressively reduced reflecting the increased level of confidence in the design and associated costing.

The regulatory approval required to operate Tram Train on the route is considered to primarily represent a project risk rather than a cost risk and therefore the same optimism bias has been used as for Heavy Rail.

It should be noted that all estimates assume construction can proceed as currently envisaged and do not include allowances for:

- land acquisition/compensation costs;
- risk (not included in Optimism Bias);
- accommodation works;
- costs associated with a Public Inquiry, if necessary;
- 3rd party costs/fees;
- ancillary works including traffic management, landscaping and environmental mitigation works;
- statutory approvals process likely to be required for any Tram Train operation;
- statutory fees; and
- VAT.

Whilst it is considered that the unit costs would include services protection and diversions, these costs vary significantly on a case-by-case basis and should be subject to detailed consideration in due course.

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\(^6\) [http://www.networkrail.co.uk/aspx/4171.aspx](http://www.networkrail.co.uk/aspx/4171.aspx)

7.4 **Operational Costs**

In addition to infrastructure costs the on-going operational costs are also a key consideration. These costs will affect the viability of the service and affect the need for any revenue support.

Operational costs are complex and depend on a number of interrelated factors requiring further consideration to monetise. Table 7.5 provides outline guidance on comparative costs with considerations and influencing factors.

**Table 7.5: Comparable Operational costs**

<table>
<thead>
<tr>
<th>Option</th>
<th>Cost Magnitude</th>
<th>Influencing Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>BRT</td>
<td>Medium</td>
<td>• Fuel costs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Vehicle maintenance and depot</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Higher labour requirement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Busway maintenance</td>
</tr>
<tr>
<td>Heavy Rail</td>
<td>High</td>
<td>• Track access charges (high)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Vehicle maintenance and depot</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Rolling stock lease/purchase</td>
</tr>
<tr>
<td>Tram Train</td>
<td>High</td>
<td>• Track access charges (low)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Vehicle maintenance and depot(high)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Rolling stock lease/purchase</td>
</tr>
</tbody>
</table>

For the BRT option it is likely that the introduction of the service will result in a change to existing bus services in the area, either in terms of routes or service frequency. It is understood that the vast majority of current bus routes in Cardiff are operated on a commercial basis and it is therefore unlikely there will be a resulting operational cost saving.
8 Patronage Demand Forecasts

This chapter provides an overview of the indicative patronage demand modelling exercise undertaken as a basis for comparing the three public transport options.

In common with the indicative cost estimates, it will be appropriate to review and adjust the patronage forecasts as part of the second stage of the study investigating the potential to extend the corridor to Rhondda Cynon Taf.

8.1 Demand Model

The demand model consists of three elements:

- Demand matrix;
- Journey time cost; and
- Public transport mode split.

8.1.1 Demand Matrix

A demand matrix was created for a study area covering the City Centre, western and north western parts of Cardiff, and the southern part of Rhondda Cynon Taf to represent the AM peak hour period. Figure 8.1 shows the geographic coverage of the area. The area has been sub-divided into eight sectors to ensure the data is presented in an informative manner and retains sufficient detail about the trip ends to produce indicative forecasts. The eight sectors are:

- Cardiff City Centre & Cardiff Bay
- Cardiff Central periphery (West)
- North west Cardiff
- South west Cardiff
- West Cardiff
- Miskin and Pontyclun
- Llantrisant and Talbot Green
- Beddau
The demand matrix includes trips made by future residents and users of the three strategic sites as well as any background trips that are made by existing residents and users within the study area. Trip distributions and modal split for the strategic sites have been obtained from the Council’s ‘Strategic Site Modelling Summary Sheets’. Trip distribution and modal split for background trips have been obtained from the 2001 Census Journey to Work dataset.

Table 8.1 summarises the assumptions used to identify Census Journey to Work trips that are relevant to the demand model.

**Table 8.1: Demand Matrix Assumptions**

<table>
<thead>
<tr>
<th></th>
<th>Cardiff</th>
<th>Rhondda Cynon Taf</th>
<th>Other area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportion of sustainable transport users</td>
<td>50%</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>Proportion of sustainable transport users that are public transport users</td>
<td>36%</td>
<td>50%</td>
<td>80%</td>
</tr>
<tr>
<td>Proportion of public transport users traveling in the peak hour(^8)</td>
<td>18%</td>
<td>18%</td>
<td>18%</td>
</tr>
</tbody>
</table>

The emerging LDP seeks to achieve a target of 50% of trips in Cardiff being made by sustainable modes, which include public transport, car sharing, walking and cycling. Based on the 2012 ‘Ask Cardiff Survey’ results, 36% of trips are currently undertaken by public transport. The average daily departure profile from TRICS also indicates that 18% of daily residential trips are made during the AM peak hour.

\(^8\) Arup analysis, from TRICS 2013(a)v6.11.1 database for average residential development.
peak hour. Accordingly, the model assumes that 3.2% of the demand matrix trips from Census Journey to Work are public transport trips made during the AM peak hour.

These assumptions compare favourably against the Census Journey to Work data, which indicates that 14% of all journeys to work are made by public transport. Based on the TRICS profile this implies that 2.5% of such journeys are made by public transport during the AM peak hour.

In the case of trips between Cardiff and Rhondda Cynon Taf/other parts of the UK, identical assumptions have been applied except for the percentage of public transport users. The model assumes higher use of public transport for these journeys due to the longer distance of travel and reduced prospect of other sustainable modes being used.

In order to represent demand from the proposed Park and Ride site, it has been assumed that the strategic facility would have a capacity of 500 spaces with 27% of arriving trips occurring in the peak hour (135 vehicles) and each vehicle having an occupancy of 1.2 passengers i.e. 162 passengers using the public transport service towards Cardiff city centre.

8.2 Journey Cost

The demand model distributes public transport trips to various public transport modes according to their journey times (ticketing costs are excluded from the calculation).

Journey times have been taken for an average weekday morning peak hour and have been calculated with regard to the following:

- access and egress times to and from the transport network;
- origin waiting time and transfer wait time for public transport service;
- in vehicle time;
- interchange penalties; and
- transport mode specific coefficient to represent other factors including quality of vehicle, overcrowding and service reliability.

8.2.1 Public Transport Mode Split

The model consists of three transport modes:

- existing bus;
- existing heavy rail; and
- north west transport corridor (bus rapid transit, heavy rail, or tram-train).

Mode split has been calculated by comparing journey times using a nested logit model. The model adopts a hierarchical approach to mode choice. The methodology is applied on the basis that travellers first choose whether to go by existing rail services or other services. If they choose other services, they are then...
faced with a decision as to whether to use existing conventional bus services or the transport corridor.

### 8.2.2 Service Level Assumptions

Table 8.2 sets out the assumptions which have been used to represent the alternative options for each mode of transport. These factors each have an influence on the demand forecast.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>BRT</th>
<th>Heavy Rail</th>
<th>Tram Train</th>
</tr>
</thead>
<tbody>
<tr>
<td>Journey component weighting (factor)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Walk time</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wait time</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>In-vehicle time</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicle type attribute (value)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vehicle type attribute</td>
<td>-1.7</td>
<td>-1</td>
<td>-1.5</td>
</tr>
<tr>
<td>Service level</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assumed walk time to closest station (minutes) (^{11})</td>
<td>5</td>
<td>10</td>
<td>5-10</td>
</tr>
<tr>
<td>Service frequency (per hour per direction)</td>
<td>6</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Total journey time (minutes)</td>
<td>36</td>
<td>28</td>
<td>34</td>
</tr>
</tbody>
</table>

### 8.2.3 Demand Model Exclusions

The demand model only takes account of journey time costs and does not take account of fare costs, which also impact on an individual’s mode choice. For public transport journeys involving an interchange this can be particularly relevant.

It also only accounts for journeys made by public transport modes and assumes no changes to existing public transport networks. Whilst it can forecast mode shift between the various public transport modes, it does not forecast mode shift from other modes of transport, such as private cars, walking and cycling. This element of demand may be significant on account of the improved attractiveness of public transport when compared against other modes and it is therefore important that the forecasts are viewed in this context.

### 8.3 Demand Forecasts

The demand model for public transport trips shows demand generated by:

- LDP sites;
- Park & Ride; and
- Current (background) activity.

\(^{11}\) For the section of the route between Creigiau and the City Line/Waterhall Road. Within Cardiff the existing stop pattern has been assumed.
8.3.1 Total Trips

Figure 8.1 presents the forecasted model shares for the three transport options. It is notable that all three options highlight the continuing role of existing bus services, which is most prominent in the heavy rail scenario.

**Figure 8.1: Future transport mode share – all trips**

The results of the demand forecasts indicate that Bus Rapid Transit is the most attractive option for the NW transport corridor. The Bus Rapid Transit option would attract 36% of all trips across the study area during an average AM peak period, which equates to 1,144 trips per peak hour.

Although the highest attraction would be achieved by Bus Rapid Transit, the demand forecast for Tram Train (34%, 1,081 trips) is relatively similar. Heavy Rail would be the least attractive option with demand forecasted at 24% (902 trips).

8.3.2 Strategic LDP Site Trips

An equivalent exercise has been undertaken to determine what proportion of public transport travel associated with the strategic LDP sites would involve use of existing or new services. Figure 8.2 presents the findings.
Figure 8.2: Future transport mode share – LDP sites only

The proportion of public transport trips from the new sites using the new route is higher than for the total situation at 58-74%, depending on available mode. The Tram Train appears to be the most attractive option with 244 potential LDP site users in the AM peak, although this is comparable to Bus Rapid Transit with 240 LDP site users in the AM peak. Heavy rail appears to be the least attractive option with 189 LDP site users in the AM peak.

It is notable that the forecast suggests a significant proportion of trips would continue to be made by existing public transport services. This is likely to be a result of the variety of destinations served by existing services in addition to the city centre. Use of existing rail services is low in comparison to the wider total demand, which is likely to be a result of the limited access to existing rail stations from the sites.
8.3.3 Users of the new public transport service

Figure 8.3 presents the passenger composition for each new transport option. Current activity from the Cardiff NW corridor makes up the largest portion at about 50-58% of users.

**Figure 8.3: Users of the new service**

These headline estimates should be viewed in the context of the assumption based approach that has been applied in forecasting travel demand and behaviour. Further review and development will be undertaken as part of the second stage of the corridor study to enable the potential levels of demand from the wider geographical area to be better understood.

8.4 Vehicle Capacity

It is also important to consider the forecast demand in the context of vehicle capacity for each of the modes. The figures set out above represent total peak hour demand in both directions. This demand is unlikely to be coincidental as not all passengers will travel the entire length of the route i.e. one passenger may board and alight before another boards, hence two trips are made but this only uses the space of one passenger.

**BRT**

With six services an hour utilising articulated buses a total capacity of 660 passengers per hour per direction would be available.

**Heavy Rail**

With four services an hour and assuming three carriage EMU units a total capacity of around 1,000 passengers per hour per direction would be available.
Tram Train

With four services an hour and assuming double units a total capacity of around 1,200 passengers per hour per direction would be available.

All modes offer the potential to further increase capacity from the numbers detailed above. The primary methods would be to increase frequency for BRT or to lengthen the vehicle for rail modes.

8.5 Conclusions

The demand model shows that Bus Rapid Transit and Tram Train are both attractive to residents and users of the strategic sites. In both options, the new services would attract over 70% of all public transport trips from the Strategic LDP sites. Heavy rail is indicated to be less attractive, catering for 58% of public transport trips from the sites. This difference is considered to be primarily a result of stop accessibility and the more frequent stop intervals proposed for bus and Tram Train.

Although the tram train option (calling at city line rail stations) offers lower accessibility between Fairwater and Cardiff city centre than the Bus Rapid Transit option, it offers a faster journey time in exchange.

Considering all trips on the NW transport corridor (LDP site trips, background trips and P&R trips), the Bus Rapid Transit has the highest demand forecast. This is a result of the better accessibility it would offer to origins/destinations in the densely populated areas of Canton and Fairwater.

The current demand forecasts are founded on assumptions relating to the attraction of new trips from the strategic sites that arise from the LDP mode share target and J33 P&R capacity. As part of the second stage corridor study examining extension of the route within Rhondda Cynon Taf, it is recommended that the model is validated to verify the attractiveness of the proposals against the alternative options of driving, walking and cycling.
9 **Funding Streams**

Due to uncertainties over the availability of public sector funding during the LDP period, it is likely that a wide-ranging approach to securing the finances necessary to deliver the corridor will be required. This chapter provides an overview of potential sources.

### 9.1 European Union

Cardiff forms part of the East Wales region that is currently included in the **Regional Competitiveness and Employment Programme** for the period 2007-2013. This affords opportunities to secure funding via the European Regional Development Fund (ERDF) and European Social Find (ESF). The programme is geared towards achieving economic, social and environmental prosperity, including the regeneration of deprived communities and tackling climate change.

The West Wales and the Valleys region currently qualifies for the highest level of **Convergence Programme** support. This also draws from the ERDF and ESF structural funds and explicitly includes strategic infrastructure amongst its key priorities. Although Cardiff does not form part of the region, the inclusion of Rhondda Cynon Taf is relevant in view of the aspiration for the corridor to provide onward connectivity to this area.

The EU budget covering the period 2014-2020 is the subject of on-going negotiation. Current indications suggest that there will be an overall reduction in the funding available to both regions.

The Joint European Support for Sustainable Investment in City Areas (JESSICA) initiative may provide additional scope in how it supports sustainable urban development, including transport. This is based on a system of revolving funds that are used to accelerate investment.

### 9.2 UK Government

Funding for rail infrastructure has not been devolved to Wales and remains the responsibility of the UK Government (Department for Transport).

The **Periodic Review** (PR) process for determining the budget for Network Rail takes place every five years. The draft determination for PR13, which will cover the 2014-19 period, is due to take place in June 2013. This provides an opportunity for stakeholders to influence decision making.

### 9.3 Welsh Government

The ‘**Wales Infrastructure Investment Plan for Growth and Jobs**’ (May 2012) outlines an investment commitment of £15 billion over the next decade. The need for improving transport links is included amongst the investment priorities.

The plan establishes the principle of introducing more innovative funding mechanisms to deliver public infrastructure. This is founded on the use of external sources that have greater borrowing capacity, which can in turn offset reductions in the availability of government funds. The Local Government Borrowing Initiative has previously been used to boost investment in highway improvement...
schemes. The approach adopted at the Ely Mill development in Cardiff, where a ‘not for profit’ development company was set up to secure capital funding, is identified as an exemplar that could be replicated elsewhere to unlock public funds.

The Regeneration Investment Fund, which operates within the framework of the JESSICA initiative, can also be secured to assist infrastructure projects that are consistent with the objective of encouraging sustainable development. Projects falling outside of the West Wales and the Valleys region are eligible, although the availability of the fund is currently suspended pending the outcome of an Inquiry.

The case for funding of the NW Cardiff corridor is further strengthened by the inclusion and favourable appraisal of a route on this corridor in the recent South East Wales Integrated Transport Task Force report to the Minister for Economy, Science and Transport on proposals for the delivery of the future public transport network.

9.4 South East Wales Transport Alliance (Sewta)

The Sewta Regional Capital Transport Programme provides the basis for securing funds for schemes that are directly linked to the Regional Transport Plan (RTP). Future funding constraints are likely to focus resources on key strategic priorities such as the Metro Plus concept and the creation of a networked city region. The contribution that the corridor could make to the realisation of this vision provides scope for it to be included in future RTP delivery plans.

Connections via the NW Cardiff corridor are included in a number of current Sewta documents and strategies.

The recently introduced Regional Transport Services Grant will be administered by Sewta in accordance with a bus and community transport network strategy that is due to be submitted to the Welsh Government in October 2013. This will make finding available for commercial services that can demonstrably meet the needs of communities.

9.5 CIL/Planning Obligations

Cardiff Council have committed to developing a Community Infrastructure Levy (CIL) framework in parallel with the Local Development Plan. This is expected to be set in accordance with the level of contribution necessary to deliver the required infrastructure. Planning Obligations will be used to secure any necessary local infrastructure not covered by the CIL.

Rhondda Cynon Taf County Borough Council is also in the process of introducing a CIL, with adoption currently expected in April 2014. As part of a collaborative approach there will be scope to secure contributions that are commensurate with the level of growth allocated in southern parts of Rhondda Cynon Taf (over 5,000 new dwellings and 63ha of employment by 2021). The contributions could reasonably be targeted towards the provision of a park and ride service that enables those in-commuting to Cardiff to conveniently change mode or towards the extension of the corridor into the RCT sub-region.

9.6 Alternative Sources

The use of road user charging as a source of funding to improve alternatives to car use is endorsed in the Sewta Regional Transport Strategy. Although Cardiff Council has no current plans to introduce a charging regime to discourage car use on city centre routes, this could be reconsidered in the context of a potential mechanism to help deliver major new public transport infrastructure.

The ring fencing of car parking and enforcement revenue streams could also be used, on the basis that it re-directs money collected from car users in a way that makes alternative forms transport more attractive.
## 10 Comparative Option Assessment

In order to provide a basis for assessing the relative merits of the various options, a series of comparative appraisals has been undertaken in the context of the over-arching scheme objectives. Table 10.1 summarises the emerging conclusions. Appendix C provides WelTAG appraisals of the three transport options.

### Table 10.1: Comparative Appraisal Summary

<table>
<thead>
<tr>
<th>Objective</th>
<th>Bus Rapid Transit</th>
<th>Heavy Rail</th>
<th>Tram Train</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All Options</td>
<td>Option 1</td>
<td>Option 2</td>
</tr>
<tr>
<td><strong>Convenient site access</strong></td>
<td>The BRT option offers frequent boarding/alighting opportunities, helping to maximise convenient accessibility to the service. Subject to available width, cycling and walking provision could be included directly parallel to the busway. Pedestrians would be accommodated on a footway whilst cyclists could either be accommodated on a combined cycleway/footway or on the carriageway.</td>
<td>The heavy rail option has limited stop intervals and as such offers lower levels of accessibility. There is scope to ensure that key locations are served by a station. As a result of the geometric requirements of the infrastructure, there is limited flexibility regarding the siting of stations. Cycling and walking provision is likely to be best accommodated away from the Heavy Rail alignment as a result of width requirements and the severance effect of the route, which will make connections across the line difficult by requiring underpasses or bridges.</td>
<td>The Tram Train option can achieve frequent stop intervals, thereby ensuring key locations can be adequately served. There is greater flexibility on station siting due to the less onerous geometric requirements. Subject to available width cycling and walking provision could be included parallel to the Tram Train corridor. To minimise land take this will be best provided as a combined cycleway/footway. Whilst crossings can be more readily achieved than for Heavy Rail, it is desirable to minimise these and options to route pedestrians/cyclists through development areas may have greater accessibility advantages.</td>
</tr>
<tr>
<td><strong>Minimising journey time</strong></td>
<td>The BRT is likely to achieve the slowest journey times due to sections of the route involving shared use or interactions with general traffic. This results in less reliable journey times unless dedicated infrastructure can be extensively provided along the route.</td>
<td>Heavy rail is likely to achieve the fastest journey times due to the segregated nature of the infrastructure and limited station stop frequency.</td>
<td>Tram Train journey times sit between those of heavy rail and BRT. This is primarily due to the greater station stop frequency compared to heavy rail, although the time penalty for additional stops is less than that for heavy rail due to the good acceleration and braking characteristics of Tram Train vehicles.</td>
</tr>
<tr>
<td><strong>Minimising wait time</strong></td>
<td>The frequency of BRT services is likely to be higher than for either of the rail options. Service levels can closely matched to demand. This will lower the expected wait times, although this can be compromised by reliability.</td>
<td>Wait times for heavy rail and tram train options are likely to be comparable. Four services an hour would achieve a good frequency of service. Any further improvement to this is likely to require infrastructure alterations to the wider railway network.</td>
<td></td>
</tr>
<tr>
<td><strong>Serve existing communities</strong></td>
<td>The routing flexibility of BRT affords good opportunities to serve existing communities via the existing highway network. The establishment of the corridor would also benefit other existing bus services entering the city on this corridor.</td>
<td>The potential of heavy rail to serve existing communities is limited to Creigiau due to operational constraints on the existing City Line.</td>
<td>The potential of Tram Train to serve existing communities is limited due to operational constraints on the existing City Line. The greater alignment and station siting flexibility means that there is potential to establish additional stations at locations such as Ely Mill/Cowbridge Road, as well as Creigiau.</td>
</tr>
</tbody>
</table>
### Park & Ride trip interception

The BRT option would have good potential for trip interception in terms of origin and destination, although journey time and/or reliability may make it less competitive against other transport options.

The range of locations served in the existing urban area of west Cardiff is particularly good.

The route is able to directly serve a P&R site at M4 J33.

<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a:</td>
<td>This option is attractive in terms of journey time but it does not serve as many origin/destination pairs. It does not directly serve a P&amp;R site to the north of the M4 as walking or a shuttle bus link will be required.</td>
</tr>
<tr>
<td>1b:</td>
<td>This option offers reasonable journey time and serves a range of origins and destinations but is limited to railway stations in the west Cardiff area. The route can access a P&amp;R to the north of M4 J33 directly.</td>
</tr>
</tbody>
</table>

### Onward extension

The BRT option has a high degree of flexibility for onward extensions, either via an extension to the dedicated busway or the existing highway network. Routes are not fixed by infrastructure however the level of service will typically be related to infrastructure.

<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a:</td>
<td>Onward extension would be complex and costly as this option is predicated on termination to the south of the M4</td>
</tr>
<tr>
<td>1b:</td>
<td>By use of tighter geometry than is possible with Heavy Rail, the Tram Train option would be able to penetrate the J33 site and rejoin the former rail alignment to the north of J33 passing though the South of Creigiau site with good potential for onward connectivity.</td>
</tr>
</tbody>
</table>

### Challenging nature of terrain

Challenging nature of terrain may be less problematic than heavy rail due to the improved gradient ability of Tram Train.
<table>
<thead>
<tr>
<th>Deliverability</th>
<th>Deliverability</th>
<th>Deliverability</th>
</tr>
</thead>
<tbody>
<tr>
<td>The option is technically deliverable although stakeholder pressures may risk the benefits being diluted by lower than envisaged reallocation of road space. These influences may lead to a less direct route and failure to achieve aspired proportions of road space reallocation in critical areas. Parties involved in delivery would be expected to comprise of Cardiff Council, Utilities companies, site developers, third party land owners, BRT operator. The timescales for the delivery of BRT are judged to be the shortest of the considered modes. It is judged that the route could be operational within 4 years. There is the potential for phased introduction.</td>
<td>The option is technically deliverable, although the approval bodies carry associated risks. Parties involved in delivery would be expected to comprise of Cardiff Council, Welsh Government, utilities company, site developers, third party land owners, railway franchisee, and Network Rail. The timescales for the delivery of a heavy rail route are judged to be longer than for BRT but faster than for Tram Train since no changes to regulations are required. It is considered that the route could be operational in 5 years.</td>
<td>The Tram Train option is considered to be technically deliverable however there are significant risks arising from the status of Tram Train services in the UK which are currently at a pilot stage. Further assurances and consultation with stakeholders will be required to establish feasibility. An alternative option is to consider an initial implementation with interchange to the City Line or existing bus priority corridors. Parties involved in delivery would be expected to comprise of Cardiff Council, Welsh Government, utilities company, site developers, third party land owners, railway franchisee, office of the Rail Regulator and Network Rail. The timescales for the delivery of a Tram Train route are judged to be the longest of the considered options. This arises primarily as a result of the need for regulatory approval as opposed to the infrastructure or technology involved. Timescale definition will be subject to discussions with Network Rail. Conversion of a BRT system to Tram Train would involve disruptive works in ensuring the width, corner radii and gradient of the route can be made suitable for the vehicle specification. There may be scope to minimise works of this nature when determining the design of the BRT route, although any allowances made for enabling a future Tram Train operation will continue to be subject to the above risks and stakeholder consultations.</td>
</tr>
</tbody>
</table>
11 Regional Transport Appraisal

In March 2013 the South East Wales Integrated Transport Task Force reported to the Minister for Economy, Science and Transport on proposals for the delivery of the future public transport network. The report considered a range of infrastructure, organisational and funding options for the provision of improved public transport in the region. The Task Force considered a range of potential infrastructure schemes and public transport services for the region. These schemes were developed through a review of previous proposals, development of new concepts, and were reviewed by the Task Force, a range of stakeholders, including Network Rail, and Arriva Trains Wales. Schemes were identified by geographic area and also by delivery timescale. From this process BRT and rail options (scheme references B-M-18 and R-L-07 in section 6 of the Task Force report) for the NW corridor were identified as feasible in the medium to long term.

For all schemes identified as feasible an appraisal was completed. The appraisal considered whether a scheme has the potential to contribute to a series of defined outcomes, which are listed A-G in Table 11.1. If a scheme was judged to have potential benefits it was eligible to score against this outcome. Those schemes with no benefits to an outcome recorded no score (these are identified by ‘N’ in Table 11.1).

For outcomes where a scheme was eligible to score it was subsequently appraised against the transport and environmental criteria 1-9 (listed beneath Table 11.1). Scores were awarded against each criteria in the range -3 to +3 and weighted by the maximum score (as defined in the ‘max score’ column) to give a total maximum score of 100.

In the original appraisal the rail option for the north west corridor achieved the highest score of any scheme in the region (46.67) and the express bus scheme was ranked 6th (score 35.48). In light of the further work completed for this study and the consideration of a Tram Train option, the appraisal process has been repeated. The results, presented in Table 11.1, indicate that all of the considered options continue to have excellent scores in the regional context. The score for the heavy rail option was judged not to have changed in light of the developments. The BRT and Tram Train options both score slightly higher, primarily as a result of their ability to better penetrate and serve the corridor through more frequent stop intervals and, in the case of the BRT option, excellent penetration of the existing urban area.

The appraised scores continue to suggest that the scheme has significant regional benefits and should therefore be eligible for and of interest to policy, funding and decision makers at a national and regional level.

Table 11.1: Appraisal of NW Corridor Transport Options

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Max Score</th>
<th>BRT</th>
<th>Heavy Rail</th>
<th>Tram Train</th>
</tr>
</thead>
<tbody>
<tr>
<td>A - Reduce journey times and increase service frequency for north-south</td>
<td>20</td>
<td>11.43</td>
<td>11.43</td>
<td>12.38</td>
</tr>
<tr>
<td>journeys from the periphery to employment centres</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B - Increase capacity of the transport network to deal with demand</td>
<td>20</td>
<td>8.57</td>
<td>11.43</td>
<td>12.38</td>
</tr>
<tr>
<td>and overcome pinch-points</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C - Develop a transport system that supports urban growth by improving</td>
<td>20</td>
<td>9.52</td>
<td>11.43</td>
<td>11.43</td>
</tr>
<tr>
<td>access and ease of movement</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D - Improve east-west connectivity between key settlements</td>
<td>10</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>E - Provide for inter-regional movements and interactions</td>
<td>10</td>
<td>N</td>
<td>N</td>
<td>N</td>
</tr>
<tr>
<td>F - Increase the reach of the Public Transport network to places ‘off</td>
<td>10</td>
<td>5.71</td>
<td>6.19</td>
<td>6.19</td>
</tr>
<tr>
<td>the primary network</td>
<td></td>
<td></td>
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<tr>
<td>G - Environmental Criteria</td>
<td>10</td>
<td>8.33</td>
<td>6.67</td>
<td>8.33</td>
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<tr>
<td>TOTAL</td>
<td>100</td>
<td>47.62</td>
<td>46.67</td>
<td>50.71</td>
</tr>
</tbody>
</table>

Outcome Criteria

1. Reduced journey times and improved reliability between people and employment
2. Improved access from areas of deprivation to employment, training, education and essential services
3. Improved quality and level of service for business travel and commuting
4. Promotion of smarter travel choices through integration of high quality transport modes
5. Stimulation of economic growth by providing strategic links to support new development sites
6. Increased cycling and walking provision
7. Reduce the need/distance travelled

Environmental Criteria

8. Reduced emissions through reduced congestion and provision of sustainable transport alternatives
9. Minimise the impact of transport on the natural and built environment

12 Study Recommendations

This study considers the potential to establish a new public transport service - the North West Transport Corridor - to serve several strategic development sites identified in the emerging Cardiff Council Local Development Plan. This first stage of the study has considered the potential for such a service, albeit limited to within the Cardiff Unitary Authority area. It has clearly demonstrated that there are a range of potential options to provide public transport services to support new development in North West Cardiff.

The potential to extend the corridor into Rhondda Cynon Taf is currently the subject of a second stage of this study. This will incorporate a full assessment of costs and patronage. It is currently anticipated that the performance of all of the options investigated would be improved if the corridor is extended to form a strategic regional route extending into Rhondda Cynon Taf.

All three forms of transport provision offer the potential to achieve an attractive level of service that can assume a prominent role in encouraging sustainable travel patterns amongst new and existing communities. They also all afford scope for onward extension into Rhondda Cynon Taf, thereby strengthening the role that the corridor could play in meeting regional transport needs and opening up possible new sources of funding.

The comparative option assessment has found there to be no conclusive evidence to support a specific option recommendation, although there are a number of key emerging principles that should influence future decision making. These include the following:

- achieving an attractive BRT service is dependent on the reallocation of existing road space and the ability to address any associated impacts (e.g. displacement of on-street parking);
- the BRT option has patronage and cost related advantages over the rail based options;
- the option 1a rail alignment will not fully accord with the strategic priority of connectivity to RCT, unless forming an initial phase that is later extended through the implementation of option 2;
- the option 2 rail alignment has the least direct relationship with the development sites to the north of the M4;
- the option 1b rail alignment (tram train only) achieves the most cost effective means of enabling rail services to cross the M4; and
- the additional complexity and cost associated with the option 3 rail alignment is unlikely to be justifiable when viewed against the alternative options.

In order to identify a sufficiently robust study recommendation, the following tasks should be undertaken as part of the second stage of the study:

- stakeholder consultation with Network Rail to confirm approval processes and establish whether there is ‘in principle’ support for the reinstatement of branch line connectivity to the City Line and the operation of additional heavy or tram train services;
- identification of the desirable route destination in RCT, which may have a bearing on the preferred alignment and transport mode;
• investigation of potential route alignments within RCT for each of the transport mode options;
• expert review of key structures to confirm suitability for re-use or replacement;
• detailed review of the City Line connection, to identify how impacts on residential properties (including vehicular access) can be minimised; and
• investigation of the capital/lease costs of rail vehicle fleets.

It is anticipated that the completion of these tasks will enable decisions to be made on the preferred form and alignment of the corridor.
Figure 2.1 Opportunities and constraints

- City Line
- Dismantled Railway
- Strategic Site
- Road corridors

Legend

ARUP
North West Cardiff Corridor Study

Client
Cardiff Council / Plymouth Estates / Curzon Real Estate

Job Title

Drawing Status
Preliminary

Issue Date
2013-05-17

Scale
1:41,000

Route of connection is obstructed by residential properties

There is a scope to attract patronage from nearby communities including Creigiau, Danescourt and Pentrebane

A physical precedent for heavy rail that offers scope for connectivity to the existing City Line and towards Llantrisant

Interaction with the highway network at Waterhall Rd, Crofft-Y-Genau Rd, Llantrisant Rd, Cardiff Rd, Station Rd, and Heol Creigiau

Inclusion of the City Line offers the prospect of faster journey times by 2020

Improvements to network capacity and reliability to be completed by 2015, which will improve line speed on the City Line

Subject to peak period congestion and afford limit scope for widening or the relocation of road space

The configuration and scale of structures required to cross under or over the M4

Linear arrangement of sites between Cardiff and Llantrisant is consistent with movement corridor concept

Provides a means of crossing (underneath) the M4 motorway

Each of the sites is closely aligned with the A4119 (Llantrisant Road) radial corridor

There is a scope to attract patronage from nearby communities including Creigiau, Danescourt and Pentrebane

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The configuration and scale of structures required to cross under or over the M4

Linear arrangement of sites between Cardiff and Llantrisant is consistent with movement corridor concept

Provides a means of crossing (underneath) the M4 motorway

Each of the sites is closely aligned with the A4119 (Llantrisant Road) radial corridor
Option Description: NW Cardiff Transport Corridor – Bus Rapid Transit

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Assessment</th>
<th>Distribution</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Welsh Impact Area: Economy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEE</td>
<td>No assessment has been undertaken.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EALI</td>
<td>No assessment has been undertaken. It is anticipated that the presence of a transport corridor will have significant impacts on the Economic and Location of the surrounding area. In other locations which have BRT routes uplift in nearby property value has been identified. The extent of these benefits will relate to the extent of the transport corridor and level of service.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Welsh Impact Area: Environment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Noise</td>
<td>The corridor will pass through a number of future developments and (assuming the rail modes are electrified) is likely to have the highest noise levels however the noise impact is typical of general road traffic will be present in the site and good patronage would lead to a decrease in volume and noise associated with general traffic.</td>
<td>Local/Regional</td>
<td>Neutral</td>
</tr>
<tr>
<td>Local air quality</td>
<td>In comparison to the existing situation air quality is likely to be affected on completion of the transport corridor but in isolation the transport corridor is expected to be a benefit and in comparison with a situation where there is no comprehensive public transport link from the sites, positive.</td>
<td>Local</td>
<td>Slight beneficial</td>
</tr>
<tr>
<td>Biodiversity</td>
<td>It is proposed to utilise the former Llantrisant Branch No 1 for a significant portion of the route. It is understood that this route has biodiversity value which will need to be further investigated. Other sections of the route, in particular those which are greenfield, are expected to have similar attributes and will need to be assessed at the scheme development stage.</td>
<td>Local</td>
<td>Moderate adverse</td>
</tr>
<tr>
<td>Water environment</td>
<td>No assessment has been undertaken. The route passes over a number of watercourses.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Welsh Impact Area: Social</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transport safety</td>
<td>Transport safety is likely to be primarily related to detailed design issues. There are many examples of BRT implementation which have a good safety record. The implementation of the BRT is likely to require significant infrastructure works in existing areas of the city. It is anticipated that these works would result in overall safety improvements for these areas.</td>
<td>All road users</td>
<td>Slight beneficial</td>
</tr>
<tr>
<td>Personal security</td>
<td>It is anticipated that the route, infrastructure and service provision would be designed in line with best practice guidance and would therefore consider issues of personal security from the outset leading to a secure scheme which is safe for all to use.</td>
<td>All public transport users</td>
<td>Slight beneficial</td>
</tr>
<tr>
<td>Permeability</td>
<td>The BRT option offers the best possibility for permeability, services would be able to divert on and off the core route and circulate in different areas.</td>
<td>All public transport users</td>
<td>Moderate beneficial</td>
</tr>
<tr>
<td>Physical fitness</td>
<td>Users are likely to have higher levels of physical activity than private car users in order to access a station.</td>
<td>All public transport users</td>
<td>Slight beneficial</td>
</tr>
<tr>
<td>Social inclusion</td>
<td>High quality public transport will enable users to benefit from improved accessibility to opportunities, employment and other social facility.</td>
<td>All public transport users</td>
<td>Slight beneficial</td>
</tr>
<tr>
<td>Equality, diversity and human rights</td>
<td>No positive or negative discriminatory impact on any individual equality impact group.</td>
<td>No discriminatory impact</td>
<td>Neutral</td>
</tr>
<tr>
<td>Scheme Specific Objectives:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Convenient site access</td>
<td>The BRT option offers frequent frequent boarding/alighting opportunities, helping to maximise convenient accessibility to the service.</td>
<td>All public transport users</td>
<td>Moderate beneficial</td>
</tr>
<tr>
<td>Minimising journey time</td>
<td>The BRT is likely to achieve the sweetest journey times due to sections of the route involving shared use or interactions with general traffic. This results in less reliable journey times unless dedicated infrastructure can be extensively provided along the route.</td>
<td>All public transport users</td>
<td>Moderate beneficial</td>
</tr>
<tr>
<td>Minimising wait time</td>
<td>The frequency of BRT services is likely to be higher than for either of the rail options. Service levels can closely match to demand. This will lower the expected wait times, although this can be compromised by reliability.</td>
<td>All public transport users</td>
<td>Moderate beneficial</td>
</tr>
<tr>
<td>Serve existing communities</td>
<td>The routing flexibility of BRT affords good opportunities to serve existing communities via the existing highway network.</td>
<td>Existing communities</td>
<td>Moderate beneficial</td>
</tr>
<tr>
<td>Park &amp; Ride trip interception</td>
<td>The route is able to directly serve a P&amp;R site at M4 J33. The BRT option would have good potential for trip interception in terms of origin and destination, although journey time and/or reliability may make it less competitive against other transport options.</td>
<td>P&amp;R Users</td>
<td>Moderate beneficial</td>
</tr>
<tr>
<td>Onward extension</td>
<td>The BRT option has a high degree of flexibility for onward extensions, either via an extension to the dedicated busway or the existing highway network.</td>
<td>Regional</td>
<td>Moderate beneficial</td>
</tr>
<tr>
<td>Deliverability</td>
<td>The option is technically deliverable although stakeholder pressures may risk the benefits being diluted by lower than envisaged reallocation of roadspaces. These influences may lead to a less direct route and failure to achieve desired proportions of road space reallocation in key areas.</td>
<td>Stakeholders</td>
<td>Moderate beneficial</td>
</tr>
<tr>
<td>Technical and operational feasibility</td>
<td>Sections of the route, particularly M4 crossings are likely to pose significant challenge with associated technical issues. Operationally there are few significant challenges however consideration will need to be given to whether use of the infrastructure will be available to all PSVs’ wishing to use it.</td>
<td></td>
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<tr>
<td>Financial affordability and deliverability</td>
<td>Not considered at this stage.</td>
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<td></td>
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<tr>
<td>Risks</td>
<td>Not considered at this stage.</td>
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05/09/2013
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<tr>
<td>TEE</td>
<td>No assessment has been undertaken.</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>EALI</td>
<td>No assessment has been undertaken. It is anticipated that the presence of a transport corridor will have significant impacts on the Economic and Location of the surrounding area. In other locations which have access to rail routes an uplift in nearby property value has been identified. The extent of these benefits will relate to the extent of the transport corridor and level of service.</td>
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<tr>
<td>Welsh Impact Area: Environment</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Noise</td>
<td>The corridor will pass through a number of future developments however the noise impacts of rail modes would be relatively inquiet and electrification would reduce these levels in comparison to existing diesel rail rolling stock.</td>
<td>Local/Regional</td>
<td>Neutral</td>
</tr>
<tr>
<td>Local air quality</td>
<td>Electrified railway services have no local emissions and would therefore have negligible effect in comparison to the existing situation...</td>
<td>Local</td>
<td>Slight beneficial</td>
</tr>
<tr>
<td>Greenhouse gas emissions</td>
<td>As per local air quality above. Overall emissions effect will be dependent on wider factors.</td>
<td>None</td>
<td>Slight adverse</td>
</tr>
<tr>
<td>Landscape and townscape</td>
<td>Much of the area surrounding the route corridor is greenfield however as part of the wider LDP development strategy it is considered this would alter character, the further impact as a result of the NW transport corridor is considered relatively minor.</td>
<td>Local</td>
<td>Slight adverse</td>
</tr>
<tr>
<td>Visual Effects</td>
<td>Establishing a heavy rail route on the proposed alignment may adversely affect views from some local amenities and in particular the permanence of rail related infrastructure; however, the area is relatively screened by trees many of which it may be possible to retain.</td>
<td>Local</td>
<td>Slight adverse</td>
</tr>
<tr>
<td>Biodiversity</td>
<td>It is proposed to utilise the former Llantrisant Branch No 1 for a significant portion of the route. Other sections of the route, in particular those which are greenfield, are expected to have similar attributes and will need to be assessed at the scheme development stage.</td>
<td>Local</td>
<td>Moderate adverse</td>
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<tr>
<td>Water environment</td>
<td>No assessment has been undertaken. The route passes over a number of watercourses.</td>
<td>-</td>
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</tr>
<tr>
<td>Soils</td>
<td>No assessment has been undertaken.</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Welsh Impact Area: Social</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transport safety</td>
<td>Transport safety is likely to be primarily related to detailed design issues. Railways typically have an excellent safety record with the exception of trespass. Implementation of new railways will require that any routes (pedestrian, cycle) are grade separated from the railway.</td>
<td>All road users</td>
<td>Slight beneficial</td>
</tr>
<tr>
<td>Personal security</td>
<td>It is anticipated that the route, infrastructure and service provision would be designed in line with best practise guidance and would therefore consider issues of personal security from the outset leading to a secure scheme which is safe for all to use.</td>
<td>All public transport users</td>
<td>Slight beneficial</td>
</tr>
<tr>
<td>Permeability</td>
<td>The heavy rail option offers poorest permeability. As a result of service operation and alignment challenges it is anticipated that there will be relatively few stations. These will extend travel distances to access the service. The requirement to grade separate routes is also likely to affect the permeability of the areas through which the route passes.</td>
<td>All public transport users</td>
<td>Slight adverse</td>
</tr>
<tr>
<td>Physical fitness</td>
<td>Users are likely to have higher levels of physical activity than private car users in order to access a station.</td>
<td>All public transport users</td>
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</tr>
<tr>
<td>Social inclusion</td>
<td>High quality public transport will enable users to benefit from improved accessibility to opportunities, employment and other social/facilities.</td>
<td>All public transport users</td>
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<td>Equality, diversity and human rights</td>
<td>No positive or negative discriminatory impact on any individual equality impact group.</td>
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<tr>
<td>Scheme Specific Objectives:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Convenient site access</td>
<td>The heavy rail option has limited stop intervals and as such offers lower levels of accessibility. There is scope to ensure that key locations are served by a station. As a result of the geometric requirements of the infrastructure, there is limited flexibility regarding the siting of stations.</td>
<td>All public transport users</td>
<td>Moderate beneficial</td>
</tr>
<tr>
<td>Minimising journey time</td>
<td>Heavy rail is likely to achieve the fastest journey times due to the segregated nature of the infrastructure and limited station stop frequency.</td>
<td>All public transport users</td>
<td>Moderate beneficial</td>
</tr>
<tr>
<td>Minimising wait time</td>
<td>Wait times for heavy rail and tram train options are likely to be comparable. Four services an hour would achieve a good frequency of service. Any further improvement is this is likely to require infrastructure alterations to the wider railway network.</td>
<td>All public transport users</td>
<td>Moderate beneficial</td>
</tr>
<tr>
<td>Serve existing communities</td>
<td>The potential of heavy rail to serve existing communities is limited to Cregiau due to operational constraints on the existing City Line.</td>
<td>Existing communities</td>
<td>Moderate beneficial</td>
</tr>
<tr>
<td>Park &amp; Ride trip interception</td>
<td>There are a range of alignment options under consideration. Some of these will terminate to the south of the M44 whilst others propose a new crossing of the M4 (with significant associated costs). Either option could serve a Park &amp; Ride site, via either a pedestrian/bus link to the south of the M4 or via a station close to the Park and Ride site.</td>
<td>P&amp;R Users</td>
<td>Slight beneficial</td>
</tr>
<tr>
<td>Onward extension</td>
<td>For options which cross the M4 onward extension is judged to be feasible, exact route and termination are likely to be influenced by alignment capability.</td>
<td>Regional</td>
<td>Moderate beneficial</td>
</tr>
<tr>
<td>Deliverability</td>
<td>The option is technically deliverable, although the approval bodies carry associated risks. Parties involved in delivery would be expected to comprise of Cardiff Council, Welsh Government, utilities, site developers, third party land owners, railway franchisee, and Network Rail. The timescales for the delivery of a heavy rail route are judged to be longer than for BRT but faster than for Tram Train. It is considered that the route could be operational in 5 years.</td>
<td>Stakeholders</td>
<td>Moderate beneficial</td>
</tr>
</tbody>
</table>

Acceptability, feasibility and risks:

Public acceptability: Not considered at this stage as the scheme has not been subject to public consultation.

Acceptability to stakeholders: Not considered at this stage. Delivery of a heavy rail solution would rely on the support and permission of Network Rail.

Construction issues: Detailed construction methods and issues have not yet been investigated in detail however it is anticipated that the construction would utilise conventional construction methods.

Technical and operational feasibility: Sections of the route, particularly M4 crossings are likely to pose significant construction challenges with associated technical issues. Operationally the initial findings on operational patterns and provision will require further investigation and confirmation.

Financial affordability and deliverability: Not considered at this stage.

Risks: Not considered at this stage.
Option Description: NW Cardiff Transport Corridor – Tram Train

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<td>TEE</td>
<td>No assessment has been undertaken.</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>EALI</td>
<td>No assessment has been undertaken. It is anticipated that the presence of a transport corridor will have significant impacts on the Economic and Locational Impact of the surrounding area.</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Welsh Impact Area: Environment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Noise</td>
<td>The corridor will pass through a number of future developments however the noise impacts of rail modes would be relatively infrequent and electrification would reduce these levels in comparison to existing diesel rail rolling stock.</td>
<td>Local/Regional</td>
<td>Neutral</td>
</tr>
<tr>
<td>Local air quality</td>
<td>Electrified rail services have no local emissions and would therefore have negligible effect in comparison to the existing situation.</td>
<td>Local</td>
<td>Slight beneficial</td>
</tr>
<tr>
<td>Greenhouse gas emissions</td>
<td>As per local air quality above. Overall emissions effect will be dependent on wider factors.</td>
<td>None</td>
<td>Slight adverse</td>
</tr>
<tr>
<td>Landscape and townscape</td>
<td>Much of the area surrounding the route corridor is greenfield however as part of the wider LDP development strategy it is considered this would alter character, the further impact as a result of the NW transport corridor is considered relatively minor.</td>
<td>Local</td>
<td>Slight adverse</td>
</tr>
<tr>
<td>Visual effects</td>
<td>Establishing a Tram Train route on the proposed alignment may adversely affect views from some local amenities and in particular the permanence of rail-related infrastructure; however, the area is relatively screened by trees many of which it may be possible to retain.</td>
<td>Local</td>
<td>Slight adverse</td>
</tr>
<tr>
<td>Biodiversity</td>
<td>It is proposed to utilise the former Llantrisant Branch No 1 for a significant portion of the route. It is understood that this route has biodiversity value which will need to be further investigated. Other sections of the route, in particular those which are greenfield, are expected to have similar attributes and will need to be assessed at the scheme development stage.</td>
<td>Local</td>
<td>Moderate adverse</td>
</tr>
<tr>
<td>Heritage</td>
<td>No assessment has been undertaken.</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Water environment</td>
<td>No assessment has been undertaken. The route passes over a number of watercourses.</td>
<td>-</td>
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<td>Soils</td>
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</tr>
<tr>
<td>Welsh Impact Area: Social</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transport safety</td>
<td>Transport safety is likely to be primarily related to detailed design issues. Light rail systems typically have a good safety record, the main source of safety concerns will be in mixed operation environments the design of which will be important.</td>
<td>All road users</td>
<td>Slight beneficial</td>
</tr>
<tr>
<td>Personal security</td>
<td>It is anticipated that the route, infrastructure and service provision would be designed in line with best practise guidance and would therefore consider issues of personal security from the outset leading to a secure scheme which is safe for all to use.</td>
<td>All public transport users</td>
<td>Slight beneficial</td>
</tr>
<tr>
<td>Permeability</td>
<td>The Tram Train option will offer a higher level of permeability than conventional heavy rail with the potential to accommodate relatively frequent stops. Whilst Tram Trains can operate in a mixed environment with other users it will generally be desirable to minimise the number of crossings of the transport corridor, this may lead to some severance effects but can be mitigated through good design.</td>
<td>All public transport users</td>
<td>Slight adverse</td>
</tr>
<tr>
<td>Physical fitness</td>
<td>Users are likely to have higher levels of physical activity than private car users in order to access a station.</td>
<td>All public transport users</td>
<td>Slight beneficial</td>
</tr>
<tr>
<td>Social inclusion</td>
<td>High quality public transport will enable users to benefit from improved accessibility to opportunities, employment and other social/leisure facilities.</td>
<td>All public transport users</td>
<td>Slight beneficial</td>
</tr>
<tr>
<td>Equality, diversity and human rights</td>
<td>No positive or negative discriminatory impact on any individual equality impact group. No discriminatory impact</td>
<td>Neutral</td>
<td></td>
</tr>
</tbody>
</table>

**Scheme Specific Objectives:**

<table>
<thead>
<tr>
<th>Scheme Specific Objectives</th>
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<tbody>
<tr>
<td>Convenient site access</td>
<td>The Tram Train option can achieve frequent stop intervals, thereby ensuring key locations can be adequately served. There is greater flexibility on station siting due to the less onerous geometric requirements.</td>
<td>All public transport users</td>
<td>Moderate beneficial</td>
</tr>
<tr>
<td>Minimising journey time</td>
<td>Tram Train journey times sit between those of heavy rail and BRT. This is primarily due to the greater station stop frequency compared to heavy rail, although the time penalty for additional stops is less than that for heavy rail due to the good acceleration and braking characteristics of Tram Train vehicles.</td>
<td>All public transport users</td>
<td>Moderate beneficial</td>
</tr>
<tr>
<td>Minimising wait time</td>
<td>Wait times for heavy rail and tram train options are likely to be comparable. Four services an hour would achieve a good frequency of service. Any further improvement to this is likely to require infrastructure alterations to the wider railway network.</td>
<td>All public transport users</td>
<td>Moderate beneficial</td>
</tr>
<tr>
<td>Serve existing communities</td>
<td>The potential of Tram Train to serve existing communities is limited due to operational constraints on the existing City Line. The greater flexibility in alignment and station location means that there is potential to establish additional stations at locations such as Ely Mews/Cowbridge Road, as well as Crigau.</td>
<td>Existing communities</td>
<td>Moderate beneficial</td>
</tr>
<tr>
<td>Park &amp; Ride trip intension</td>
<td>There are a number of route alignment options for Tram Train all of which are able to serve a Park and Ride site. The alignment capability of the Tram Train would allow a greater degree of flexibility in station placement than would be possible for Heavy Rail. This flexibility in station location in combination with the number of locations served and journey speed should increase the attractiveness to a variety of users.</td>
<td>P&amp;R Users</td>
<td>Moderate beneficial</td>
</tr>
<tr>
<td>Onward extension</td>
<td>The Tram Train option has good potential for onward extension via a variety of options. Use of an existing underpass could eliminate the need to provide a new crossing of the M4.</td>
<td>Regional</td>
<td>Moderate beneficial</td>
</tr>
<tr>
<td>Deliverability</td>
<td>The Tram Train option is considered to be technologically deliverable however there are significant risks arising from the status of Tram Train services in the UK which are currently at a pilot stage. Further assurances and consultation with stakeholders will be required to establish feasibility. An alternative is to consider an initial implementation with interchange to the City Line or bus priority corridors. As a result of this the timescale is considered to be the longest of the considered options. Timescale definition will be subject to discussions with Network Rail.</td>
<td>Stakeholders</td>
<td>Slight adverse</td>
</tr>
</tbody>
</table>

**Acceptability, feasibility and risks**

| Public acceptability | Not considered at this stage as the scheme has not been subject to public consultation. |
| Acceptability to stakeholders | Not considered at this stage. Delivery of a Tram Train solution would rely on the support and permission of Network Rail. |
| Construction issues | Detailed construction methods and issues have not yet been investigated in detail however it is anticipated that the construction would utilise conventional construction methods. |
| Technical and operational feasibility | Sections of the route are likely to pose significant construction challenges with associated technical issues. Operationally the initial findings on operational patterns and provision will require further investigation and confirmation. |
| Financial affordability and deliverability | Not considered at this stage. |
| Risks | Not considered at this stage. |