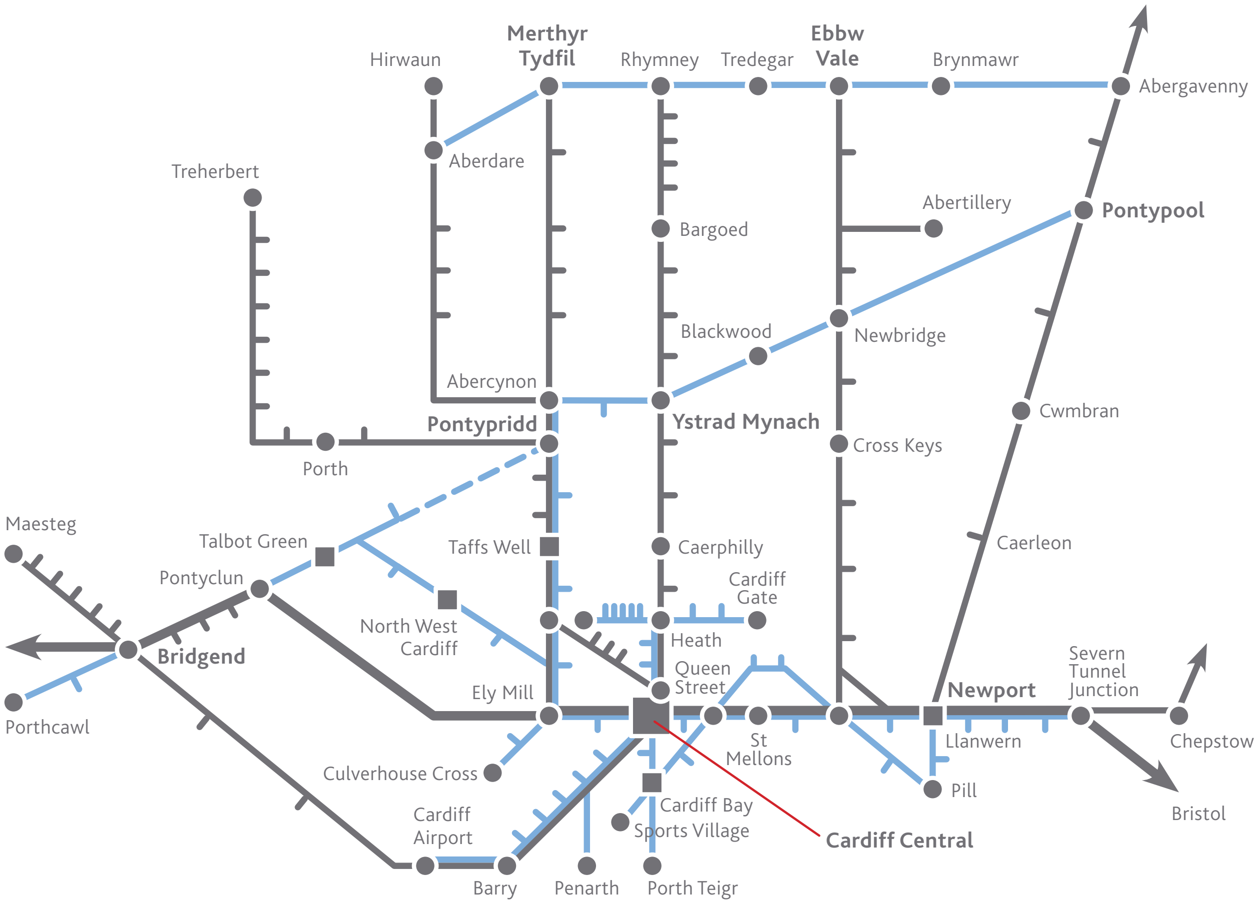
Report to the Minister for Economy, Science and Transport



A Cardiff Capital Region Metro:

Impact Study:

Metro Modal Study

October 2013

Jones Lang LaSalle®
the urbanists a powelldobson company
M&G Barry Consulting
CAPITA
steer davies gleave

CAPITA SYMONDS

Metro Modal Study

FINAL Report | September 2013

successful people, projects and performance

CAPITA SYMONDS

Project No: CS/060195 Doc Ref: CS/060195 Rev:

Client: Welsh Government
Issue Date: September 2013

Metro Modal Study
FINAL Report

	Name	Signature	Date
Author	Alison Walker/David McCallum	a Walker D. McCal	30/09/2013
Checker	Katerina Ermilova		30/09/2013
Approver	David McCallum	D. McCal	30/09/2013

Issue Record

Rev	Date	Description/Comments	Author/Prepared by:	Approved for Issue by:

Contents

Chapter **Page**

List of Figures

List of Tables

Glossary – Modal Definitions

Mass Transit

‘An urban public transport system which provides a ‘turn-up and go’ service. This requires a maximum headway between vehicles of 10 to 15 minutes or a minimum frequency of 4-6 services per hour over core sections of route, providing a minimum capacity per direction of typically 300 passengers per hour (pph) for bus based systems and 800 pph for rail based systems’. (Affordable Mass Transit, Commission for Integrated Transport)

Light Rail

An electric railway system, characterised by its ability to operate single or multiple car units along exclusive rights-of-way at ground level, on aerial structures, in subways or in streets, able to board and discharge passengers at station platforms or at street, track, or car-floor level and normally powered by overhead electrical wires. Tram, Tram Train, Light Rail Transit systems are examples of light rail. For the purposes of this report Light Rail Transit has been grouped with Metro systems and Tram and Tram Train reviewed separately. There are also examples of Ultra Light Rail which is an intermediate transport system that uses self-powered or externally powered trams/railcars with or without some form of energy storage.

Bus Rapid Transit

System based on standard buses including on street priority measures (routes which are predominately based around bus lanes and junction priority) and/or segregated operation e.g. guided busways. A key differentiation from existing bus services for the purposes of this study is an increased stop spacing of 800m or greater compared to 400m or less for conventional bus.

Tram

Passenger vehicle operated on a track (tramway), where the speed of operation allows the vehicle to stop within the distance a driver can see ahead (line of sight operation). Trams may operate as:

- Integrated, on-street tramways (tracks laid within highway and pedestrians and/or vehicles can also use the tramway),
- Segregated on street tramways (tracks laid within highway boundary but vehicles segregated so that they can only cross at designated crossing points)
- Off street tramways (tramway wholly separate from the highway)

Tram – Train

A Tramcar that can operate within both an on-street tramway and the heavy rail network. Vehicles are equipped to interface with heavy rail system (signalling, power, control and telecommunications). They are typically powered by overhead lines and have high acceleration and braking rates compared to trains to allow line of sight operation and have a higher crash-worthiness rating than a standard tram.

Light Rail Transit & Metro

Light rail transit (LRT) is typically an urban form of public transport using steel-tracked fixed guideways that operate primarily along exclusive rights of way and have vehicles capable of operating as a single train or as multiple units coupled together.
A metro system is defined as an urban, electric passenger transport system with high capacity and high frequency of service, which operates in a segregated alignment. In its wider context it is used to describe a ‘turn up and go’ urban based mass transit service with a frequency of at least 4-6 services an hour.

Heavy Rail
Traditional railway operated by heavy diesel or electric vehicles with (in the UK) high platforms. Segregated track system with signals as a method of control.

Personal Rapid Transit
A fleet of automatic driverless cabs travelling on their own guided network.

1. Technology Review

1.1 Bus Rapid Transit

Vehicle Type

1.1.1 Conventional Buses which may be fitted with a guidance system (generally guide wheels to use a kerb based system). Emphasis is on modern, accessible, environmentally friendly buses and additional facilities such as WiFi, real time passenger information, air conditioning and on board power supplies.

Train Length/ Capacity/ Seating: Standing Ratio

1.1.2 Length and seating: standing ratio varies slightly by manufacturer but a standard bus is usually around 12m long and an articulated bus is around 18m long. Seating to standing capacity also varies by manufacturer and vehicle type. For example an Optare 'MetroCity' bus has a seating to standing ratio of 1: 1.4 (i.e. more people standing) whereas a 'Versa' has a ratio of 1.5: 1 (i.e. more people sitting down).

Typical Frequency

1.1.3 Frequency is generally six buses or more an hour in each direction (10 minute frequency), although some routes may reduce this during the evenings or weekends.

Capacity

1.1.4 Capacity also varies by vehicle manufacturer and type but typically may have a total capacity of 60 people (standard bus) to 80 (articulated). For a 6 buses/hr this equates to 360 to 480 passengers per hour per direction (pphpd).

Propulsion (Diesel/ Electric)

1.1.5 Vehicles can be diesel powered, bio-fuel, hybrid or electric (trolley bus). The majority of buses are diesel powered. Hydrogen buses have been used in London. It is likely that new 'green' propulsion solutions will become more popular in future.

Infrastructure Characteristics

1.1.6 Varying degrees of segregation can be provided:

- Conventional Buses with limited segregation within the existing highway (e.g. high occupancy vehicle lanes, with flow bus lanes, Red Routes or bus access to pedestrian areas); standard bus lanes require 6-8m for two-way operation or 3-4.25m for one-way operation.
- Conventional Buses with maximum segregation (e.g. construction beyond highway boundary, contraflow bus lanes, bus only sections, bus gates, bus lanes with raised kerbs); A busway requires a width of 8-13m (two-way), kerb guidance may not be effective where there are frequent side roads, junctions, pedestrian crossings and bus stops.
- Guided buses with limited segregation using an external guidance system at key locations only; Guided busways typically require 5.8-6.2m wide carriageways for two-way operation.

- Guided bus with maximum segregation using an external guidance system and dedicated raised kerb bus lanes or fully segregated busways (8-13m wide) with segregation or priority at congested junctions.

Characteristics of area served (e.g. density)

1.1.7 Guideways using kerbs are more suited to areas where there are fewer junctions and pedestrian crossings therefore may not be the best solution for city centres where there is a dense road network or significant number of residential streets. This type of segregated guideway may be more suited to outer areas. Standard bus lanes can be used more extensively within cities and radial routes provided there is sufficient road width.

Stations and station frequency

1.1.8 Stops are generally frequent and more comparable to a standard bus route; typically these may be every 500m.

High or low floor

1.1.9 Buses operating will be modern, low floor vehicles allowing level access from the footway. Generally vehicles with multiple entry/exit points will be used to speed up boarding and alighting.

Cost of construction (average per km)

1.1.10 Cost of construction varies depending on the degree of segregation and alteration required to the existing highway network and traffic control systems. Conversion of disused rail routes is also possible although this is likely to have the highest cost due to the need for completely new highway formation. Infrastructure cost is typically between £2.7million and £4.3 million per km and is a higher standard than conventional bus routes.

Station costs

1.1.11 Most stops can be provided as enhanced bus stops with real time passenger information and on street waiting shelters. Bus Rapid Transit will need its own brand identity and infrastructure will be differentiated from the standard bus network. A stop may cost in the region of £200,000 to provide. Stops are a higher standard than a normal bus route to increase differentiation from conventional buses. Existing or new bus stations with extended facilities (toilets, ticket office, covered waiting rooms, cafe) will be required at key interchange points with other routes and modes.

Route length

1.1.12 Route length is likely to be constrained by vehicle speeds and journey times. Whilst a guided bus may be able to travel faster than normal traffic the distance between stops is likely to constrain the maximum speed of the vehicle (decelerating, stopping and accelerating up to every 500m). In dense urban areas routes tend to be between 5km and 20km. A longer guided busway (for example, up to 50km) with limited stops may be applicable to more sparsely populated rural routes; however the maximum speed of the vehicle will still be constrained by route conditions and the requirement for safe line of sight stopping distances where hazards may be encountered.

Governance/ Operation/ Maintenance

1.1.13 Infrastructure is usually owned by the highway authority and maintained as part of the highway network or under contract to a third party. Operation is usually as a tendered service by a bus operating company. Operations are governed by the same arrangements as conventional buses with a Traffic

Commissioner overseeing provision. A Quality Contract or Quality Partnership may be required to ensure that services using the route comply with minimum standards and maintain the image of the service and limit the use of guided sections of the route.

1.1.14 Examples

Name	**Crawley Fastway**	**Cambridgeshire**
	Guided Busway (link to Gatwick Airport)	Guided Busway
Date constructed	2002-2005	2007-2011
Cost at construction	£35 million	£181 million (2010)
Route Length	24km (including 10.9km segregated busway, 2.2km guideway)	16 miles (25km) busway (40km total route)
Number of stations/ stops	48 (approx)	34 (includes park and ride stops)
Station spacing (route/ stations)	0.5km (average)	0.7km (average)
Cost per km (cost/ route)	£1,460,000 per km	£7,240,000 per km
Total users	6,000 passengers per day (2005/6)	2,500,000 (2011)
Average users per station	125 passengers per day	73,530 passengers per stop
Vehicle Manufacturer	Scania OmniCity	Volvo Eclipse Alexander Dennis Enviro400

Cambridgeshire Busway

1.1.15 Bus rapid transit vehicle manufacturer include Scania OmniCity, Volvo Eclipse, Van Hool, Tata Marcopolo.

Advantages:

1.1.16 The system is flexible in terms of capacity and use of existing highway as well as dedicated guideway. Bus Rapid Transit is compatible with existing bus technology. Vehicles are relatively low cost and the technology is generally well established.

Disadvantages:

1.1.17 Bus Rapid transit may not be perceived by users as significantly different from conventional buses. For this reason infrastructure and branding is usually modelled on tram systems. Current operations use diesel buses therefore still contribute towards pollution in city centres. Options for reducing this include alternative fuels or trolley buses (Leeds is currently developing a scheme which uses trolleybuses: electric buses with overhead cables). Bus Rapid Transit is not compatible with the existing heavy rail network or alignment and conversion would have high costs.

1.2 Ultra Light Rail

Vehicle Type

1.2.1 Ultra Light Rail (ULR) is system that uses self-powered or externally powered trams or railcars with or without energy storage. Vehicles have lower axle weights than Light Rail, thus infrastructure costs can be reduced. There may be no external electrification, overhead wires, sub-stations and cables. It is, therefore, potentially easier to route and find cheaper alignments. The flexibility of ultra light allows a variety of alignments to be used. These can range from pedestrian areas, use of parts of the public highway, newly constructed segregated routes and converted conventional heavy railways to viaducts and tunnels. The Parry People Mover (PPM) used on the Stourbridge Town Shuttle is an example of Ultra Light Rail where Class 139 PPM vehicles are approved for use on the branch section of the national rail network.

Train Length/ Capacity/ Seating: Standing Ratio

1.2.2 The Class 139 car length is 9.6m and they operate as single car ’trains’. These can accommodate 20 seated passengers and 30 standing passengers. A higher capacity vehicle is currently under development.

Typical Frequency

1.2.3 Existing operations run at six services an hour. Signalling restrictions and train path availability will be the main constraints to the number of services per hour

Capacity

1.2.4 A Class 139 Parry People Mover can carry around 50 passengers in total, on a 10 minute frequency this equates to 300 passengers per hour per direction.

Propulsion (Diesel/ Electric)

1.2.5 Propulsion can be by a variety of power sources; units are either self-powered via an engine or externally powered via a 70v DC power supply. A small LPG or diesel powered engine with flywheel restorative energy technology is provided on the existing system used in the UK.

Infrastructure Characteristics

1.2.6 Units are designed to run on UK heavy rail infrastructure (1435mm track gauge) although the units do not operate on the same track as heavy trains and require a degree of segregation. In principle the units could be used on tram infrastructure (operating under line of sight) or on new alignments (new track can be lighter weight than conventional rail and therefore less expensive).

Characteristics of area served (e.g. density)

1.2.7 Typically the areas the Parry People Mover is suitable for are former branch line environments with a number of small settlements along the route. The PPM is unlikely to be suitable for high density urban areas with high demand due to the low capacity of the vehicles. The PPM can operate on standard gauge track with a maximum radius of 15m and maximum gradient of 1 in 15.

Stations and station frequency

1.2.8 In principle the higher deceleration and acceleration of the PPM means that stations could be spaced more closely than traditional heavy rail and maintain journey times, however, the limited capacity is likely to restrict the number of stations that can practically be accommodated on a route. The Stourbridge example operates as a shuttle service between two stations (1km of line). Stations can be as close as every 800m.

High or low floor

1.2.9 Vehicles are high floor to utilise heavy rail infrastructure with platforms being required to be approximately 900mm high to provide level access. Vehicles have the potential to be adapted to run on light rail infrastructure as low floor vehicles.

Cost of construction (average per km)

1.2.10 Where pre-existing rail track is utilised there are limited capital costs. New track does not need to be to the same specification as heavy rail therefore costs per km are lower. There are no schemes where new rail has been built and infrastructure costs are not readily available.

Station costs

1.2.11 Vehicles can use existing station platforms where available, again with limited additional capital cost. Where new stations are required solely for PPM use platform length is substantially less than for standard rolling stock resulting in lower cost stations. Potentially a new single platform halt station with short platform could be provided for around £250,000.

Route length

1.2.12 Route length is likely to be determined by the overall journey time as a combination of number of stops and maximum speed (65 km/hour). The current operation is relatively short at 1km of route.

Governance/ Operation/ Maintenance

1.2.13 Regulation still falls to the ORR and approval of any new infrastructure needed will be required from Network Rail (with certain derogations from railway group standards). The existing Stourbridge PPM service is operated by specialist operating company under sub-contract to main train operating company for the region. It is estimated by the manufacturer that the maintenance and operating costs of a PPM are around half of that of a conventional train.

1.2.14 Examples

Name	**Stourbridge Town Shuttle**
Date constructed	2008
Cost at construction	N/A
Route Length	1km
Number of stations/ stops	1 (no intermediate stops)
Station spacing (route/ stations)	1km
Cost per km (cost/ route)	N/A
Total users	557,502
Average users per station	557,502
Vehicle Manufacturer	Parry People Movers

Parry People Mover

Manufacturers

1.2.15 Ultra light rail vehicle manufacturers include Parry People Movers.

Advantages:

1.2.16 Ultra light rail has the advantages that it is lower cost and more flexible than heavy rail.

Disadvantages:

1.2.17 Use of Ultra Light Rail is not compatible with heavy rail operations (there is a requirement for separation from the heavy railway due to differences in crashworthiness). Vehicles also have limited capacity and there has been limited application of the technology in the UK.

1.3 Tram

Vehicle Type

1.3.1 Vehicles are electrically powered and rail-guided passenger transport systems. Trams are typically operated on street (or largely on-street) and are separate from the National Rail Network. Trams usually have multiple door operation and are articulated.

Train Length/ Capacity/ Seating: Standing Ratio

1.3.2 Trams are usually 30m to 40m long with a high ratio of standing to seated passengers reflecting the shorter journeys they cater for. The number of passengers standing may be 2.5 to 3.3 times the number of seats depending on the tram and its configuration. Trams may be operated in pairs to increase capacity.

Typical Frequency

1.3.3 Typical frequency of tram operations is around 6 an hour or a tram every 10 minutes. More frequent operation (up to 30 trams an hour) is also possible.

Capacity

1.3.4 Capacity per vehicle will vary slightly depending on vehicle manufacturer and internal configuration but will be from around 200 (30m vehicle) to 300 (40m vehicle). For six vehicles an hour this equates to 1200 to 1800 passengers an hour.

Propulsion (Diesel/ Electric)

1.3.5 Vehicles operate using an electric propulsion system via overhead cables or third rail. Current is usually 750 DC.

Infrastructure Characteristics

1.3.6 Track gauge is 1435mm and within on street sections is generally inlaid into the highway to form a level surface. Tram routes may also use segregated sections off highway e.g. using former rail routes (Croydon, Nottingham, Manchester). Power supply is usually via overhead cables but can be via a third rail with appropriate neutral sections. Track includes switches and crossovers to allow vehicles to change tracks. Vehicles are fitted with flanges to maintain contact with the rail and check rail is provided where radii are tight. Signalling is usually required for junctions where vehicle road crossings operate; this is integrated with the traffic signal system. Line of sight operation and relatively short stopping distances require a less prescriptive control system than heavy rail. Trams can operate on track up to a maximum gradient of 10% and typically a minimum radius of around 15 - 20m. Maximum speed is 50mph (segregated route) or 20/30 mph (on street).

Characteristics of area served (e.g. density)

1.3.7 Trams generally operate within dense urban environments but may also extend to their suburbs or other destinations such as airports on the outskirts of a city.

Stations and station frequency

1.3.8 Stations generally consist of level or slightly raised boarding platforms (depending on whether high or low floor trams are used), with a shelter and real time passenger information. Crossing of the track is normally at grade and does not require expensive bridge or subway infrastructure. Frequency of stations is usually 500m to 800m but stops can be more widely spaced depending on the nature of the area served e.g. stops may become more infrequent as a route progresses from city centre to suburbs to outskirts of city.

High or low floor

1.3.9 Vehicles are either low floor with level access from platforms or high floor. The latter is common for systems converted from former heavy rail e.g. Manchester. Low floor is preferred for all new systems as better for accessibility and avoids the need for high platforms in a street environment. There is no significant platform structure required to accommodate vehicles, stations require only a raised kerb to allow level access to the vehicles.

Cost of construction (average per km)

1.3.10 Cost of construction may vary depending on the level of infrastructure required, e.g. road crossings. Providing the power supply for the trams is likely to be a significant element of the cost. Capital infrastructure out-turn costs are £5 million to £25 million per km, depending on the complexity of the scheme and scale of items such as earthworks, structures and utilities diversions. The latter can be significant for on street sections.

Station costs

1.3.11 Stations are mostly halt type with the main costs being the shelter and real time passenger information system provision, particularly when converting existing heavy rail routes. A small number of key interchange destinations may provide extended facilities but these usually at existing bus or rail stations. The cost of a station may be between £100,000 and £1,300,000 depending on the size and level of facilities provided.

Route length

1.3.12 Route length may vary from a few kilometres within a city centre to twenty or more kilometres where a suburb or key destination outside a city is served.

Governance/ Operation/ Maintenance

1.3.13 In the UK the Office of Rail Regulation has produced a set of technical guidance notes for Tramway in the UK which outlines good practice. Trams will also be required to comply with highway regulations and obtain relevant highway and planning approvals. A Transport and Works Act approval may be required to progress a new Tramway. The majority of UK systems are owned by Local Authorities/ Integrated Transport Authorities. Operation and maintenance of the tram network is usually tendered via a contract to a third party operator.

Name	**Lyon, France**	**Nottingham Express Transit**	**Manchester Metrolink**	**Edinburgh Tram (Line 1)**
Date constructed	2001 (first two lines)	2004 (first line)	1992 (Phase 1, 30.9km)	2013/2014 (proposed)
Cost at construction	€185.3 million (line T4, 10km in 2009, 18 stops)	£200 million (first line)	£145 million	£714m (Line 1a 18.5km)
Route Length	62km (all routes)	14km	73.4km (all routes)	15 ½ km linear route
Number of stations/ stops	95	23	69	15
Station spacing (route/ stations)	650m (average)	608.7m (average)	1.1km (average)	1.2km (average)
Cost per km (cost/ route)	€18.5 m per km	£14.3m per km	£4.7m per km (mainly heavy rail to tram conversion)	£38.6m per km
Total users	250,000 per day	25,000 per day	25 million annually	N/A
Average users per station	2630 passengers per day	1086 passengers per day	362,318 passengers annually	N/A
Vehicle Manufacturer	Alstom Citadis	Bombardier Transportation	AnsaldoBreda and Bombardier Transportation	CAF (Construcciones y Auxilliar de Ferrocarriles)

Manchester Metrolink

Manufacturers

1.3.14 Tram vehicle manufacturers include Bombardier, CAF and Alstom.

Advantages:

1.3.15 Tram infrastructure is significantly cheaper than heavy rail. Trams are also able to operate on street to give penetration into urban areas without the cost of tunnels etc.

Disadvantages:

1.3.16 Requires a network segregated from the existing heavy rail system.

1.4 Tram-Train

Vehicle Type

1.4.1 Visually vehicles resemble a Tram being high density articulated vehicles typically powered by overhead electric line. The vehicles have high acceleration and braking rates.

Train Length/ Capacity/ Seating: Standing Ratio

1.4.2 Vehicles are normally three car articulated vehicles to ensure they can negotiate the on-street network, typically 35m long (40m length is usually considered the upper limit for on-street operation). A tram-train vehicle typically has 80 seats and 120 standing (4 persons m2) giving a similar total capacity to a two-car heavy rail diesel multiple unit (DMU) but with a lower seating: standing ratio suited to passengers travelling short distances on frequent services. However, they have a reduced range of total capacity as for on street running length is limited to 1 or 2 units (70-80m) compared to heavy rail which can be configured with more than two unit however frequencies are normally higher to give a similar capacity.

Typical Frequency

1.4.3 Tram-train vehicles are suited to providing a high frequency service with frequent stops and shorter journeys. Four services an hour (15-minute headway) is usually considered a minimum.

Capacity

1.4.4 Capacity on the heavy rail network is likely to be a limiting factor on frequency. The tramway network is less constrained by the signalling system, for example a segregated system can provide over 30 trams an hour. For four services an hour a 2-car DMU would provide a capacity of 800 passengers an hour compared to 1200 provided by a 35m tram-train, although the DMU would accommodate a higher proportion of seated passengers and could be extended to provide increased capacity.

Propulsion (Diesel/ Electric)

1.4.5 Propulsion is via electric overhead cables, vehicles can be dual voltage to allow operation on street and heavy rail infrastructure. Diesel and electric bi-mode trains have been used in some locations but are bespoke vehicles and have increased capital and maintenance costs.

Infrastructure Characteristics

1.4.6 Infrastructure is a mixture of heavy rail and tramways. The UK heavy rail uses a standard 1435mm track gauge (new construction, existing track is 1432mm), where lines are electrified this is usually via 25kV AC overhead lines. Platform height is 915mm. Single face platforms are a minimum of 2500mm or 3000mm (where speeds are more than 100mph), although due to historic variations in standards these dimensions are not always achieved at stations. Standard tramway track gauge is 1435mm and vehicles use a flange to contact with the rails. Track may be grooved or non-grooved. Tracks are usually laid into the highway and form a level surface. Tram platforms are level with the floor of the vehicle and are usually a minimum of 1500mm wide. Both rail types use switches and crossings to allow changes in the track used and direction at junctions. Heavy rail vehicles require long distances to stop and operate under a signalling system which usually operates under a block system where a single vehicle is allowed within a section of track. Tram vehicles operate under a line of sight system and can stop in a shorter distance. Vehicles are powered by 600/750V DC overhead current. Platforms are usually around 350mm in height. Where low floor vehicles are used there is the issue of needing to provide high and low platforms on the heavy rail network, if high floor vehicles are used then high platforms will be required for the tramway sections. Stations used by both heavy rail and tram-trains may require additional fencing between tracks to deter passengers crossing the line as this may be more attractive with lower platforms.

Characteristics of area served (e.g. density)

1.4.7 Usually operate within city centres and a relatively short distance beyond in tram mode, may extend to suburbs or outlying population centres in train mode.

Stations and station frequency

1.4.8 Usually serve several stops within the city rather than a central railway station. Average distance between stops on European routes is 2.1km. This is higher than a typical street tram (reflecting in part the longer routes and higher speeds on the heavy rail network) but still has a dense stopping pattern consistent with operating characteristics of a tram.

High or low floor

1.4.9 Vehicles are usually low floor and require a platform height of 300-380mm. At existing heavy rail stations this may involve a platform extension to provide dual height access and accommodate all vehicle types likely to use the station. Tram-trains with high floors are also available.

Cost of construction (average per km)

1.4.10 If tram trains use existing infrastructure which is already electrified rather than require totally new track the costs may be relatively modest (around £1 million per km). If electrification is required costs will be substantially increased.

Station costs

1.4.11 Station costs are generally lower than heavy rail stations as platforms do not need be as long or high. Existing heavy rail station platforms will need adapting to provide a low level platform. Vehicle costs are likely to be higher than a conventional train as traditional economies of scale in the procurement process may not be applicable.

Route length

1.4.12 Generally routes are relatively short (73% are less than 40km from city centre). Longer routes tend to link a number of centres with passengers making shorter journeys rather than travelling the whole length.

Governance/ Operation/ Maintenance

1.4.13 Regulation will be by the ORR and Railways and Other Guided Transport System Regulations (ROGS) will apply (or derogations will be required) order to gain safety verification and acceptance. On street infrastructure will have an interface with the highway and will be likely to require Highway Authority approval (particularly for road surface, signing and pedestrian interface issues).

1.4.14 Tram-train systems are used in a number of European cities, most widely known and established is the Karlsruhe Tram-Train in Germany. There is also a UK trial planned to explore the application of the technology and required adaptations for use in a British context. This is for the area between Rotherham and Sheffield and is due to commence services in 2015/16.

1.4.15 Examples

Name	**Karlsruhe Germany**	**Rotherham to Sheffield Route**	**Rhonexpress (Lyon Airport Link)**
Date constructed	1992 (service operation)	2015 (planned)	2008 - 2010
Cost at construction	Estimated €30 million for 2.2km extension in 2011	£60 million	€120 million
Route Length	76km	36.5 miles	22 km (8.5km new)
Number of stations	357	20	4
Station spacing (route/ stations)	Average 0.2 km	Average 1 station per 1.8 mile	Average 5.5km
Cost per km (cost/ route)	€1,363,636 per km (2011 extension)	£1.03 million/ km	€14 million/ km (£12 million/ km)
Total users	176.6 million (2010)	N/A	1,000,000 (est.)
Average users per station	494,700	N/A	250,000
Vehicle Manufacturer	Vossloh	Vossloh	Stadler Rail Tango

Alstom Regio Citadis Tram Train

Manufacturers

1.4.16 Tram-train vehicle manufacturers include Vossloh, Stadler Rail & Seimens.

Advantages:

1.4.17 Tram-trains have the ability to operate on street and use the existing heavy rail network infrastructure. They offer the potential for cheaper extensions to the existing network compared to heavy rail.

Disadvantages

1.4.18 Frequency may be constrained by heavy rail network capability.

1.5 Light Rail Transit & Metro

1.5.1 Light Rail Transit and metro systems have been considered together as they are fully segregated systems. Full metro systems have higher capacities than Light Rail transit systems and there are a number of intermediate systems including ‘Light Metro’. In the context of this technical review light rail transit is the most applicable technology to South Wales in terms of capacities. Other forms of light rail, Tram and Tram Train have been considered separately as they have different operating characteristics.

Vehicle Type

1.5.2 Vehicles are electric multiple units with sliding doors running on segregated rail tracks. Modern vehicles have public address systems and regenerative braking systems and air conditioning systems. Vehicles are often designed to operate within tunnels and overground sections of track. The most widely known metro system in the UK is the London Underground.

Train Length/ Capacity/ Seating: Standing Ratio

1.5.3 Trains are usually high capacity, high frequency services designed to carry large numbers of people. Generally six to eight car formations are used but some lines may only use four. Carriages are generally between 16m and 18m long. There is some seating but the majority of passengers will be standing, the ratio of standing passengers to seated is generally between 3:1 and 4:1.

Typical Frequency

1.5.4 Generally the services operate at no less than 6 per hour (10 minute frequency) but there may be up to 12 services per hour on some routes. Stations or junctions on several routes may have a train every couple of minutes.

Capacity

1.5.5 Tyne & Wear metro trains have a maximum capacity of 300 people per 2 car unit and normally operated in 4 car formation at a 12 min frequency (3,000 passengers per hour) with a peak frequency of 3 mins (12,000 passengers/hr). Total capacity for a tube train varies between 500 and 1000 (4 car to 8 car) giving a maximum capacity of around 6,000 off peak (10 min frequency) and up to 30,000 passenger/hr (2 min peak frequency).

Propulsion (Diesel/ Electric)

1.5.6 Power supply is electric usually via a third rail (London Underground has a fourth rail system) or overhead catenary.

Infrastructure Characteristics

1.5.7 The system operates on a dedicated, grade separated track system. Metro systems are typically underground or elevated in centre or on surface in suburbs. Suburban routes may be converted from heavy rail and infrastructure in generally similar; however, Metro trains can operate within tighter radii. A comprehensive signalling system is required to cope with the high volume of trains on the network. Tunnels for underground systems may be deep generally requiring boring techniques, although shallower tunnels may be constructed using cut and fill methodology.

Characteristics of area served (e.g. density)

1.5.8 Metro systems usually operate in dense urban areas serve high transport demand where space for overground systems is more limited. Systems may extend into the suburbs but this is only likely to be cost effective where there is significant demand due to the cost of construction and operation.

Stations and station frequency

1.5.9 Station frequency can vary depending on the density of demand. Generally an average of 500m to 800m spacing is desirable.

High or low floor

1.5.10 Vehicles are high floor with platforms accordingly elevated to provide level access. Modern stations often have barriers with doors which prevent unauthorised access to the track and only open when a train is in the station.

Cost of construction (average per km)

1.5.11 Average costs per km depend on the degree of tunnelling involved. Where tunnelled, costs for full metros are unlikely to be less than £35-£70million per km. Light Rail Transit costs are significantly cheaper particularly where converting existing heavy rail infrastructure.

Station costs

1.5.12 Station costs for Light Rail transit are similar to heavy rail for a similar length due to the similar characteristics (platform height, DDA compliant access with at grade crossings). Costs for underground stations are significantly higher due to tunnelling and access requirements and need to comply with stringent fire safe requirements.

1.5.13 Route length

Route length can vary from a few kilometres to a few dozen kilometres. In London the shortest route is less than 2.5km long whereas the longest is 74km. The total tube network is 402km (249 miles), with an average route length of 36.5km.

Governance/ Operation/ Maintenance

1.5.14 UK light rail transit & metro systems are regulated by Office of Rail Regulation in line with Railway and Other Guided Transport System Regulations 2006. Operation and maintenance of infrastructure is usually by a third party or specially established transport partnership.

1.5.15 Example; The Newcastle Metro Infrastructure is owned by Newcastle Integrated Transport Authority (Nexus). The system is operated by DB Regio Tyne & Wear Ltd (a subsidiary of Deutsche Bahn and a part of Arriva UK Trains).

1.5.16 Transport for London is the statutory body set up to manage the transport systems within the capital. London Underground Limited is the subsidiary company responsible for operation of the underground trains. The LU Asset Performance team manages the upkeep and repair of eight of London Underground's lines. Tube Lines carries out the maintenance of the track for 3 lines under the Public Private Partnership contract.

1.5.17 Examples

Name	**London Underground, Jubilee Line Extension**	**Newcastle Metro**	**Docklands Light Railway**
Type	Metro	Light Rail Transit	Light Rail Transit
Date constructed	1993 - 1999	1974 – 1980	1987
Cost at construction	£3.5 billion	£100 million (Sunderland extension in 2002)	£77 million (Initial route, 13km with 15 stops)
Route Length	16km	74.5 km (46.3 miles) 42km heavy rail conversion, 13km original new track, 18.5km extension to Sunderland)	34km
Number of stations/ stops	11	60	45
Station spacing (route/ stations)	1.45km	1.24km	0.75km
Cost per km (cost/ route)	£218,750,000 per km	£5.4 million per km	£5.9million per km
Total users	127,584,000 (whole of Jubilee line – 27 stations)	103,835 per day	300,000 users per day (2012). Over 86million users in 2011.
Average users per station	4,725,000	1730 per day	6666 per day
Vehicle Manufacturer	Alstom	Metro Cammell (bought by Alstom)	Bombardier

Tyne & Wear Metro

Manufacturers

1.5.18 Metro vehicle manufactures include Bombardier, Alstom & CAF,

Advantages:

1.5.19 Light Rail transit has less onerous engineering parameters than heavy rail making it cheaper to construct and easier to fit into the urban fabric (vehicles are capable of traversing tighter radii and steeper gradients).Operational performance is better than heavy rail with lighter weigh stock giving improved acceleration and journey times. Hybrid operation is possible with heavy rail;

Tyne & Wear Metro shares track with heavy rail between Newcastle and Sunderland. Separation from heavy rail services is through signalling controls

1.5.20 Underground operation does not require reallocation of on street space in what may be a densely built urban environment with limited space to accommodate additional infrastructure. Metro systems can accommodate a high frequency of services giving a significant capacity per hour and can re-use existing heavy rail routes where separated from heavy rail traffic.

Disadvantages:

1.5.21 Tunnelling is expensive, and above ground operation requires sufficient space for a segregated route. Capacity for a full metro system would be excessive for South Wales routes.

1.6 Heavy Rail

Vehicle Type

1.6.1 Vehicles are one of three main types: locomotive hauled, diesel multiple units (DMU) or electric multiple units (EMU). Multiple unit sets are self-contained for power, with a driving position at each end and are split into various classes depending on power supply, maximum speed, number of vehicles which operate in formation, seating capacity, vehicle weight, vehicle length, coupling compatibility and operational flexibility. There are currently 64 different rolling stock classes. Each section of line will have clearance to run certain types of rolling stock depending on the route characteristics, usually constrained by structural clearances. DMUs are typically constructed as 2 or 3 units. EMUs are typically 3 or 4 car units. Overhead powered electric vehicles need to be a minimum length of 3 cars. Units can be coupled together to provide trains which are up to 12 cars long.

Train Length/ Capacity/ Seating: Standing Ratio

1.6.2 Vehicle length varies by class of vehicle but is usually between 20 and 23m. There is generally a high seating to standing capacity although this varies by class type and internal configuration. For modern sliding door stock, it is typically approximately 35% of the number of standard class seats (i.e. standing to seating ratio of 1.35: 1), this is reduced to 20% for long distance stock (ratio of 1.2: 1). For heavy rail routes with ‘metro’ characteristics stock can be configured for a higher standing to seating ration e.g. ‘Overground’ in London.

Typical Frequency

1.6.3 Train frequency varies significantly from infrequent rural services (which may have only one or two services a day) to more frequent intercity and suburban services (which may have 4-6 services an hour). Train configuration can be adjusted to suit the frequency and demand on a route. Maximum frequency is generally constrained by train path availability on track sections where different routes converge (flat junctions).

Capacity

1.6.4 Capacity varies between the different classes of unit. Electric Multiple Units (EMU) typically have a higher capacity than Diesel Multiple Units (DMU). A 2 car DMU has a typical capacity of 200 (seating plus standing), a 3-car EMU has a typical capacity of 300 (seating plus standing).

Propulsion (Diesel/ Electric)

1.6.5 Diesel and Electric trains operate on different parts of the network. Diesel trains can also operate ‘under the wires’ on electrified sections. The majority of the UK rail network is run with EMUs (66%). However in Wales the majority of trains are DMUs. Current proposals are for electrification of the South Wales mainline and valley lines by 2019.

Infrastructure Characteristics

1.6.6 Track is generally laid on sleepers and ballast within segregated corridors. Rail may be continuous welded rail or jointed track. Standard track gauge is 1435mm (for new construction), track radius is generally no less than 400m (with 200m being the minimum standard). Stations are ideally located on straight track or where there is a maximum radius of 1000m. Platform height is 915mm. Single face platforms are a minimum width of 2500mm or 3000mm (where speeds are more than 100mph). However, due to historic variations in standards these dimensions are not achieved at all stations. Signalling operates on a block system with line side colour light signals to communicate with train drivers. Each route has a classification to identify which types of trains are cleared to run on it due to structural clearances and other restrictions. Where lines are electrified the UK standard is 25kV AC overhead lines. Level crossings are used where the highway crosses the rail network at grade, a variety of systems are in operation from open level crossings with warning lights to fully automated barrier crossings. Telecommunication systems are based on the GSM-R system which is a dedicated network for the rail industry, masts are provided along the track to convey the signal and by 2014 the network is expected to cover the whole of Great Britain.

Characteristics of area served (e.g. density)

1.6.7 The characteristics of the area served vary greatly. Heavy Rail has the flexibility to adjust the rolling stock used to suit the service speed and capacity requirements of geographically different areas, e.g. rural services compared to commuter or intercity services.

Stations and station frequency

1.6.8 The number of stations per route varies depending on its nature. There are approximately 2,530 stations on the network. The UK average number of stations per route km is 0.16 (or a station every 6km). Within the South Wales area the average station spacing is a station every 3.8km, although actual spacing varies from 1.3km to 18.8km.

High or low floor

1.6.9 Vehicles are high floor. Modern platforms are 915mm high (from track level), to allow reasonably level access. On train ramps are sometimes needed to allow wheelchair access. Historic development of the rail network and variation in standards over time has resulted in some disparity in platform heights, more commonly with rural, lesser used stations.

Cost of construction (average per km)

1.6.10 May be more expensive where tunnels, bridges and other structures are required or where complex signalling and interface with existing services. Typical cost of track renewal may be £0.9 to £1.4 million per mile (£0.7 to £0.9 million per km).

Station costs

1.6.11 Station costs vary significantly depending on the size and scale of the station including associated interchange facilities, car parking and platform accesses for multiple track stations. A simple unmanned halt may be in the region of £2 million pounds to build whereas a larger, manned station maybe tens to hundreds of millions depending on scale. Refurbishment of Swansea station cost around £7.6m and St Pancras Station cost around £600m. Typically new stations with car parks in South Wales have cost £2-3 million for single platforms and £3-5 million for two platform stations.

Route length

1.6.12 The heavy rail network in the UK has approximately 15,740km of route open for traffic. 5,261km of which is electrified (2011/12). Individual routes can vary from short branch lines to long intercity routes.

Governance/ Operation/ Maintenance

1.6.13 Network Rail is responsible for the ownership and maintenance of the rail infrastructure (track, signalling, bridges, tunnels, level crossings, viaducts) and 17 of the biggest stations. Operation of services and is via franchises to Train Operating Companies who also operate the majority of stations on the network. The Office of Rail Regulation (ORR) oversees the safety and economic regulation and ensures compliance with various regulations. Most UK rolling stock is owned by Rolling Stock Companies (RoSCO) and leased to train operating companies (TOC) rather than directly owned.

1.6.14 Examples

Name	**Robin Hood Line from Nottingham, to Mansfield and Worksop**	**Chase Line from Birmingham to Walsall**	**Ebbw Valley Line from Ebbw Vale to Cardiff**	**Stirling – Alloa – Kincardine Rail Link**	**Edinburgh – Galashiels (Waverly route)**
Date constructed	1991-1994 (reopened)	1989-1998	2006-2008	2008	Under construction, expected partial re opening 2015
Cost at construction	£28 million	N/A	£48milion	£70million	£294 million
Route Length	31.5 miles (50km)	14 miles (22.5km)	18 miles (29km)	21km	56km (48km from new construction)
Number of stations	13	6	6	1	10 (including Tweedbank after Galashiels. 7 new stations)
Station spacing (route/ stations)	3.8km	3.75km	4.8km	N/A	5.6km
Cost per km (cost/ route)	£0.56 m (1994 prices)	N/A	£2.67m (2008 prices)	£3.3m	£6.1m
Total users	1,185,374 (2011/12)	678,412 (2011/12)	772,754 (2011/12)	401,000 (2011/12)	N/A
Average users per station	91,182	113,068	128,792	N/A	N/A

Siemens ‘Desiro’ EMU

Manufacturers

1.6.15 Heavy rail vehicle manufacturers include Seimens, CAF, Alstom, Hitachi, and Bombardier.

Advantages:

1.6.16 Heavy rail in the South Wales context has the advantage of being compatible with the existing network (good availability of vehicles, components, etc). Routes can be used by freight and/or passenger services.

Disadvantages:

1.6.17 Heavy rail infrastructure has a high capital cost. Services are also expensive to operate (generally requiring significant subsidy). Infrastructure is also relatively inflexible and it is costly to increase capacity.

1.7 Personal Rapid Transit

Vehicle Type

1.7.1 A series of computer-driven vehicles known as pods operate the system. Ultra pods are rubber-tyred, battery-powered vehicles, easily capable of carrying 4 passengers and their luggage. Maximum speed is 40 km/h. Level entry allows easy access for wheelchairs and pushchairs. Vehicles include CCTV and emergency communication systems within the pod and also feature automatic vehicle protection systems which prevent collision with other pods on the guideway.

Train Length/ Capacity/ Seating: Standing Ratio

1.7.2 Pods are 3.7m long and 1.45m wide. All passengers are assumed to be seated, although a pod will also accommodate a wheelchair, pushchair or luggage.

Typical Frequency

1.7.3 The system is demand responsive. A pod on existing systems can operate at approximately 30 second intervals, resulting in up to 120 vehicles an hour.

Capacity

1.7.4 Individual pods are designed to carry four people plus luggage. Operating at 120 vehicles an hour a system would carry up to 480 passengers an hour.

Propulsion (Diesel/ Electric)

1.7.5 Vehicles are battery powered electric pods. Recharging is usually required at stations/ stops.

Infrastructure Characteristics

1.7.6 Ultra pod system guideways are flat driveable surfaces that are at least 1.6m wide, with 0.25 metre kerbs that are used for optical navigation. The guideway features no mechanical elements or power systems, with the exception of embedded transponders. Cabling for the system is cased within a covered tray that runs along the centre of the guideway. The system is lightweight and quick to set up, individual pieces can be fabricated off-site and then transported to be assembled in-situ, minimising assembly time and cost.

1.7.7 Different materials can be used for guideway construction depending on the particular application; examples include steel with pre-cast concrete plank, fibreglass grid floor, or a simple concrete/asphalt base if at ground level.

Characteristics of area served (e.g. density)

1.7.8 The only existing system operating in the UK serves as an airport car park link (Heathrow T5); however, the system is also considered suitable for densely populated urban areas and is being developed for Amrikar in India.

Stations and station frequency

1.7.9 Station frequency can be varied to suit the nature of the route. A point to point fixed destination system can be employed with few or no additional stops or a route can provide stops at urban frequency (up to 500m). The Ultra pods station comprises the following main elements:

1. Berth – vehicle docking point, interfaces, buffer and charging equipment
2. Passenger interface – each berth features a destination selection console, communications, and automatic doors
3. Plinth – a raised floor for passenger-level access to vehicles

4. Envelope – the overall station building
5. Canopy – passenger area roof and vehicle solar shading

High or low floor

1.7.10 Vehicles are low floor. Stations require a small plinth to ensure level access for boarding/ alighting.

Cost of construction (average per km)

1.7.11 As a basic guide, a complete Ultra pod system, including guideway, stations, vehicles and control systems will cost approximately between $7-$15 million US dollars per km to construct (£4.6 – £10 million), however individual project costs can vary considerably depending on factors relating to the surrounding environmental setting, integration requirements and the expected system usage.

Station costs

1.7.12 The most significant cost elements of a station are the shelter/canopy and the computerised passenger interface. Terminal station will require multiple-berths that are typically within or attached to a host building. In such instances canopy and parts of the envelope may not be required but otherwise the same elements are employed.

Route length

1.7.13 Current route lengths have been up to 4km.

Governance/ Operation/ Maintenance

1.7.14 The only operational system is currently operated by a private owner as part of their internal transport system. Responsibility for operation within the wider public realm does not currently have a precedent and would need to be the subject of negotiation and agreement. The Ultra pod system is required to comply with the appropriate sections of the Railway and Other Guided Transport Systems (ROGS) guidelines overseen by the Office of Rail Regulation.

1.7.15 Examples

Name	**Heathrow Ultra**	**Morgantown West Virginia University**
Date constructed	2005-2011	1975
Cost at construction	£30 million	$120 million
Route Length	3.8km	8.7 miles
Number of stations	2	5
Station spacing (route/ stations)	3.8km No intermediate stops (link between business car park and terminal)	2.8km (average)
Cost per km (cost/ route)	£7.9 million	$8.6 million per km
Total users	900 per day	30,000 per day
Average users per station	450 per day	6,000 per day

Vehicle Manufacturer	Ultra Global part	Boeing

Heathrow Ultra

Manufacturers

1.7.16 Personal rapid transit vehicle manufacturers include Ultra Global part, Boeing.

Advantages:

1.7.17 Personal Rapid Transit systems can operate multiple routes and can negotiate tight radii.

Disadvantages:

1.7.18 PRT requires dedicated guideway (Tram and BRT can share existing highway). There is no existing operation in an on street environment so is not proven in these circumstances particular in a public (trial only) as opposed to controlled environment. PRT is not compatible with heavy rail.

1.8 Other Systems

1.8.1 There are a number of other bespoke systems for providing fixed links, for example between airport termini. Aerial cableways are common means of transit in mountainous regions, best known for their application in ski resorts (Chairlifts, Gondolas and Cable cars) but can also be used in cities e.g. Emirates Air Line crossing of the Thames in London or for simple ground based people mover systems between fixed points e.g. Birmingham Airport AirRail Link (which uses the same basic concept as a funicular or cable car). These modes are relatively limited in application in South Wales with the exception of a potential link to Cardiff Airport and have therefore not been included in the assessment exercise but are included in this review for completeness.

Vehicle Type

1.8.2 Cabins or Cars are attached to a moving cable. For aerial cableways higher capacity systems use detachable cabins allowing slower loading operations whilst maintaining cable speed. The Birmingham AirRail has two independent rope-hauled parallel tracks and a two-car passenger unit operating on each track. The journey time is approximately 90 seconds. The AirRail Link is essentially a scaled-down version of the Toronto LINK Train which utilises the same technology to connect various destinations within Toronto Pearson International Airport.

Train Length/ Capacity/ Seating: Standing Ratio

1.8.3 Gondolas and Chairlifts use a high number of relatively low capacity cabins typically 4 to 20 people per cabin either all seated or part seated. Cable cars can carry up to 200 people in twin deck configuration all standing. Funicular and ground based ropeways typically 50 people per car with 2 cars in operation. The AirRail Link trains operate at a maximum speed of 36kph with capacity for 54 passengers per train distributed evenly between the two cars.

Typical Frequency

1.8.4 Gondolas usually operate continuously albeit speed and hence capacity can be varied. Ground Based ropeways typically operate at least 4 ph or on demand.

Infrastructure Characteristics

1.8.5 Cableways length are governed by the practical length of cable. However gondolas can be comprised of a series of linked systems with gondolas moving from one ropeway to the next.

Characteristics of area served (e.g. density)

1.8.6 The majority of cableways are for transport and leisure use (skiing/sightseeing in mountainous regions). In urban situations they are usually used for links between fixed points or where obstacles need to be overcome.

Cost of construction (average per km)

1.8.7 The AirRail link cost £18.8m/km using existing infrastructure from an earlier maglev system.

Station costs

1.8.8 Most systems have 2 stations although intermediate stations can be provided.

Route length

1.8.9 Typically up to 1km but systems can be linked. The AirRail Link is 585m and connects Birmingham International Airport with Birmingham International Railway Station and the National Exhibition Centre.

Governance/ Operation/ Maintenance

1.8.10 Normally owned and operated by a 'lift company' which may be public or privately owned who undertake day to day inspection and maintenance.

Name	**AirRail Link, Birmingham Airport**
Date constructed	2003
Cost at construction	£11millon
Route Length	585m
Number of stations	2 (Airport and railway station)
Station spacing (route/ stations)	N/A
Cost per km (cost/ route)	£18.8 / km
Total users	3 million per year
Average users per station	N/A
Vehicle Manufacturer	Doppelmayr Garaventa Group

Manufactures

1.8.11 Cableway system manufacturers include Doppelmayr Garaventa Group, Poma

Advantages:

1.8.12 Aerial cableways are capable of crossing over obstacles, enabling land under the route to be used for other purposes. Ground based systems provide a simple means of providing a fixed link between 2 points.

Disadvantages:

1.8.13 Aerial cableways can be affected by wind. Initial capital investment can be high and they have more limited operational flexibility compared to other modes.

1.9. Summary of Modal Characteristics & Application

1.9.1 **Table 1** shows a comparison of the main modal characteristics with the addition of bus for comparative purposes.

Standing: Seating Ratio & percentage seated.

1.9.2 Heavy rail is conventionally designed with a high proportion of seating with relatively few standees and most passengers seated for their entire journey, typically over 80%. Conventional buses are similar however in urban situations internal layouts with lower seating (circa 60%) and higher standing capacity may be used.

1.9.3 Tram, tram train and Light Rail Transit and Metro systems are designed with a low proportion of seating circa 30% for maximum capacity and a higher proportion of short journeys.

1.9.4 Bus Rapid transit and high capacity bus systems (e.g. bendy buses) typically fall between tram and conventional bus at 33% - 67% seated. The ‘ultra’ PRT system is all seated.

Train and Vehicle Capacity & Frequency

1.9.5 Vehicle & train capacity is dictated by a combination of standing: seating ratio and total length (given a fixed width). A higher proportion of standing to seating gives increased capacity for the same area, but at the expense of reduced passenger comfort.

1.9.6 The main constraint on vehicle length and thus capacity is for on street applications bus, tram train and tram. Conventional buses are up to 12m in length and bendy buses up to 18m limiting capacity to 100-150 people. Tram and tram train are typically 30-35m long giving a maximum capacity of 200-220 people per tram/tram –train at 4 people per m2. In on street applications tram/tram –trains are limited to 2 units. The lower individual capacity of BRT (bus), tram and tram train is offset by higher frequency of operation compared to heavy rail for the equivalent level of demand. This is particularly suited to high frequency urban ‘turn up and go’ operations with moderate demand levels.

1.9.7 Ultra light rail operations offer similar frequency and capacity to a conventional bus. PRT is characterised by lower capacity vehicles at a high frequency albeit this is a demand driven system.

1.9.8 Heavy rail, light rail transit and metro train length is limited by system capacity (platforms, passing loops etc). In the UK heavy rail urban trains may be up to 12 cars but in the South East Wales ‘Valley Lines’ network this is between 2 and 6 car operation depending on route. Heavy rail frequencies are lower compared to tram for the same overall passenger capacity.

1.9.9 Tram, Tram Train, Light Rail Transit (and Metro) systems are typically operated at frequencies of 6 trains per hour or higher with a minimum of 4 trains per hour off peak. However peaks frequencies can be up to 30 trains an hour on fully segregated alignments. BRT operation typically is in the range of 4 – 12 vehicles an hour, while Conventional Bus and Train have lower minimum frequencies.

Hourly Capacity

1.9.10. Hourly capacity in passengers per direction per hour (ppdph) is a combination of vehicle or train capacity and frequency. A transport system is usually designed to meet the peak hour capacity requirement with off peak operation using a reduced frequency or reduced train length. Since it is generally easier to operate trains of similar length to avoid splitting and joining units the normal approach is to reduce frequency.

1.9.11 Full Metro operations have the highest capacity due to a combination of high train capacity (due to a high proportion of standing) and high frequency. However at between 5,000 – 30,000 ppdph this is generally outside the range of flows seen in South Wales.

1.9.12 The light rail modes; Tram, Tram Train and Light Rail Transit operate in a similar capacity spectrum 1,200 – 13,000 ppdph with light rail transit operating at a slightly higher range due to fully segregated alignments and (normally) higher capacity trains. Existing heavy rail operations cover a similar spectrum (600 – 14,400 ppdph) albeit from a lower base for legacy reasons.

1.9.13 Conventional Bus, PRT and Ultra light rail operate at a wide range in the lower end of the capacity spectrum (50 – 1000 ppdph) with BRT (450 – 1800 ppdph) bridging the gap into the lower half of the light rail spectrum.

Segregation

1.9.14 Heavy Rail and Light Rail Transit, Metro and PRT require fully segregated alignments. BRT, Tram and Tram Train can operate in both mixed on street and segregated alignment although fully segregated alignments offer high capacity potential.

Station/Stop Spacing.

1.9.15 There is a direct relationship between stop spacing and average journey times. High frequency stops mean a higher proportion of travel time is spent stopped at stations and, therefore, average speeds are reduced and journey times increased. The average speed of a bus in an urban situation with stops every 400m and no segregation is around 12mph compared to 25-30mph for a heavy rail system with average stop spacing of 4km due to lower stopping frequency and segregated alignment.

1.9.16 Tram, Tram Train and Light rail transit and Metro systems use lighter weight faster acceleration rolling stock compared to heavy rail and are better suited to closely spaced stopping patterns. In particular Tram and Metro stops are typically 500m -800m apart as is BRT. Tram Train and Light Rail Transit are similar with spacing of up to 2km, reflecting longer distance operations. Heavy Rail is suited to average stop spacings over 4km.

Table 1 - Modal Comparison

Mode	Length	Standing: Seating Ratio	% Seated	Typical Frequency (per hour)*		Capacity per Vehicle/Train		Hourly Capacity		Propulsion	Infrastructure Characteristics	Stop/Station Spacing
				Min	Max	Min	Max	Min	Max			
Conventional Bus	8 - 12m Per Vehicle	0.2 to 0.4:1	60-80%	2	10	40	100	80	1000	Diesel or Hybrid	On street	400m
Personal Rapid Transit	3.7m Per Vehicle	0:1 (100% seated)	100%	10	120	4	6	40	720	Electric/ Battery	Segregated	500m
Bus Rapid Transit	12 -18m Per Vehicle	0.2 to 0.5:1	33-67%	6	12	75	150	450	1800	Diesel or Hybrid	On-street or segregated**	500m - 800m
Ultra Light Rail	9.6m Per Vehicle	0.5 to 1	67%	2	10	50	50	100	500	Electric	Segregated	800m
Tram	30 - 40m Per vehicle	2.5 to 3.3: 1	30 - 40%	6	30	200 1x	400 2x	1200	12000	Electric	On-street or segregated**	500m – 800m
Tram – Train	35 - 40m Per vehicle	2.5 to 3.3:1	30 - 40%	4	30	220 1x	440 2x	880	13200	Electric	On-street or segregated**	800m – 2km
Light Rail Transit & Metro	16 - 18m Per Car	3 to 4:1	25 - 33%	6	30	600 4 Car	1000 8 Car	3600	30000	Electric	Segregated	500m – 800m
Heavy Rail	20 - 23m Per Car	0.2 to 0.35:1	75 - 85%	2	12	300 3 car	1200 12 car	600	14400	Diesel/ Electric	Segregated	6km (ave).

* These are typical values, which reflect the main range for systems in use in Europe

** Segregation needed for higher frequencies

2. Metro Intervention Corridors

2.1 Principal Corridors and Strategic Transport Network

2.1.1 **Table 2** provides a breakdown of the principal corridors forming the Strategic transport network in the region.

2.1.2 The principal corridors have been split into sections to take account of differing characteristics for example; demand increases towards Cardiff and Newport requiring greater capacity.

2.1.3 For each corridor the main highway corridor, orientation, characteristic (urban or rural) presence of an existing rail alignment, current strategic public transport mode, corridor length and stop spacing has been idendtified. As detailed demand information is not generally available for all modes existing bus and rail frequencies and traffic flows have been identified. In addition strategic development sites and proposed metro interventions (new stations) together with the future stop spacing have been noted.

2.1.4 The emphasis on the analysis is on strategic corridors appropriate for 'metro' services for regional scale journeys. All corridors are served by local bus services with frequent stops to a greater or lesser extent including some limited stop/express services which compete with existing rail services in the same corridor but these have only been considered where there is no rail alternative. The exception is the Cardiff – Newport corridor due to the separation between the corridors and different settlements served.

2.1.5 Corridors serving the Cardiff Urban area have been grouped separately (although there is overlap with the overall route, (i.e. Cardiff – St Mellons with Cardiff - Newport), as they are sufficiently long and serve a sufficiently densely populated area to consider mass transit rather than bus based solutions which are not so applicable in other urban settlements due to their smaller scale.

2.1.6 The corridor characteristics have been used to inform the selection of a preferred mode for each corridor (See below)

2.1.7 The existing situation is shown in **Figure 1.**

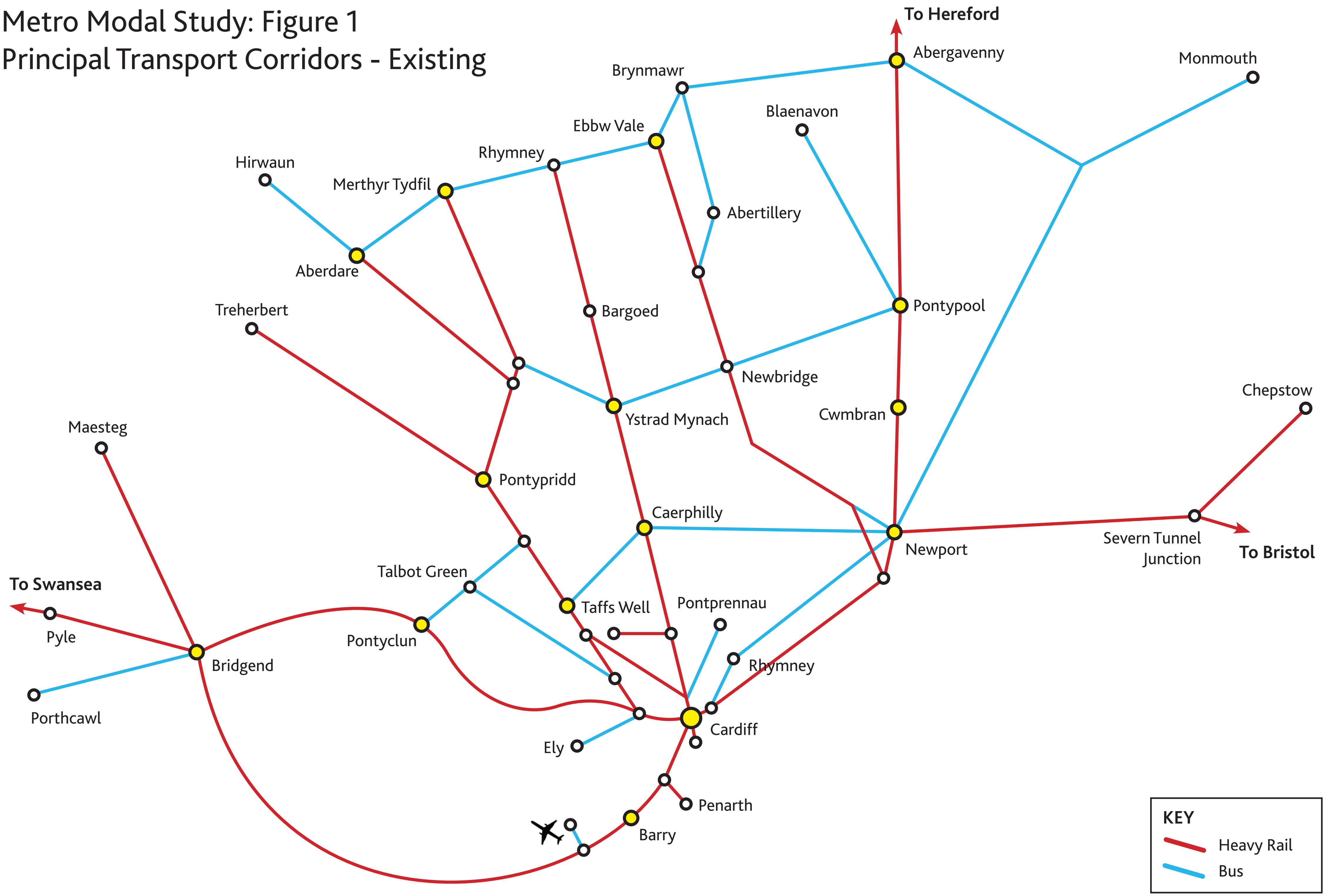
2.1.8 The rail network predominately serves North – South routes with the exception of the South Wales Mainline/Vale of Glamorgan line. The remaining corridors are served by bus services including longer distance coach services to Monmouth.

Table 2: Principal Corridors

Ref	Corridor	Road	Orientation	Potential Settlements Served	Characteristic	Existing rail alignment	Current Public Transport mode	Corridor length (miles)	Current No. of Stops	Proposed Stops	Current Stop spacing (average km)	Proposed Stop Spacing (km)	Rail Freq	Bus Freq	Traffic Flows	Major Development	Proposed Stations
	West																
1	Porthcawl to Bridgend	A4106/A473	E-W	Porthcawl	Rural	Lifted	Bus	6.6	14		0.8	0.8	-	3	11,692		
	Maesteg Valley																
2	Maesteg to Bridgend	A4063	N-S	Maesteg, Garth, Tondu, Sarn, Wildmill	Semi - urban	Passenger	Heavy Rail	8.25	6	8	2.2	1.7	1	4	13,372		
	Western Mainline Corridor																
3	Pyle to Bridgend	A48	E-W	Pyle	Semi - urban	Passenger/ Freight	Heavy Rail	6	1	1	9.6	9.6	0.5	4	62,613		
4	Bridgend - Cardiff	M4, A48/ A473/ A4119	E-W	Bridgend, Pencoed, Llanharan, Pontyclun	Semi - urban	Passenger	Heavy Rail	20.25	4	6	8.1	5.4	4	2	76,331	Bridgend Industrial estate and Plot G11, Bridgend Industrial estate	Brackla, St Fagans
5b	Bridgend - Barry - Cardiff (via Airport)	B4265/ A4226	E-W	Bridgend, Llantwit Major, Rhoose, Barry, Barry Island, Cadoxton, Dinas Powys, Eastbrook, Cogan, Grangetown	Rural	Passenger	Heavy Rail	19	3	4	10.1	7.6	1	0	9,355	St Athan EZ	Bridgend College Station
	Taff Valley																
6	Treherbert - Pontypridd	A4061	N-S	Treherbert, Ynysowen, Treorchy, Ton Pentre, Ystrad Rhondda, Llwynypia, Tonypandy, Dinas Rhondda, Porth	Semi - urban	Passenger	Heavy Rail	10.75	10	11	1.7	1.6	2	2	13,416	Pontypridd Town Centre	Hopinstown
7	(Hirwaun) - Aberdare - Pontypridd	A4059/ A4233	N-S	Hirwaen, Aberdare, Cwmbach, Fernhill, Mountain Ash, Penrhiwceiber, Abercynon, Trehafod	Rural	Passenger	Heavy Rail	11	6	9	2.9	2.0	1	2	18,179	Pontypridd Town Centre	Cwmbach N, Trecynon, Hirwaun
8	Merthyr - Pontypridd	A470	N-S	Merthyr, Pentrebach, Troed-y-Rhiw, Merthyr Vale, Quakers Yard, Abercynon	Semi - urban	Passenger	Heavy Rail	11.5	5	6	3.7	3.1	2	4	28,992	Pontypridd Town Centre, Pentrebach Industrial Site, Pentrebach Hoover site	Gylncoch
9	Pontypridd - Cardiff	A470	N-S	Pontypridd, Treforest, Treforest Estate, Taff's Well, Radyr, Llandaff, Cathays	Semi - urban	Passenger	Heavy Rail	7.5	4	6	3.0	2.0	6	6	75,924	Pontypridd Town Centre, Treforest Industrial estate	Upperboat, plus Gabalfa or Maindy
	Rhymney Valley																
11	Rhymney - Bargoed	A469	N-S	Rhymney, Pontlottyn, Tir-Phil, Brithdir	Semi - urban	Passenger	Heavy Rail	4.5	4	4	1.8	1.8	1	3	8,367		
12	Bargoed - Ystrad Mynach	A469	N-S	Bargoed, Gilfach Fargoed, Pengam, Hengoed, Ystrad Mynach	Semi - urban	Passenger	Heavy Rail	6	4	4	2.4	2.4	4	5	9,719		
13	Ystrad Mynach - Caerphilly	A469	N-S	Ystrad Mynach, Llanbradach, Aber, Caerphilly	Semi - urban	Passenger	Heavy Rail	5.25	4	4	2.1	2.1	4	6	27,460	Caerphilly Town Centre	inc energlyn
14	Caerphilly - Cardiff	A468/ A470	N-S	Caerphilly, Lisvane & Thornhill, Llanishen, Health High Level	Urban	Passenger	Heavy Rail	7.75	4	6	3.1	2.1	4	4	10,479	Caerphilly Town Centre	Crwys Road, Roath Park
	Ebbw/Western Valleys																
17	Ebbw Vale - Llahilleth	A467	N-S	Ebbw Vale, Llanhilleth,	Semi - urban	Passenger	Heavy Rail	5.5	3	3	2.9	2.9	1	1	16,533	The Works, Ebbw Vale and Northern Corridor, Ebbw Vale	
18	Brynmawr - Abertillery - Llanhilleth	A467	N-S	Brynmawr, Abertillery, Llanhilleth	Semi - urban	Lifted/Road	Bus	*8*	9		1.4	0.8	-	2	12,096		
19	Llanhilleth - Cardiff/ Newport	A467	N-S	Llanhilleth, Newbridge, Risca, Crosskeys, Rogerstone	Semi - urban	Passenger	Heavy Rail	23.75	6	7	6.3	5.4	1	3	22,137		inc Pye Corner, Crumlin
	Eastern Valley & Marches																
21	Blaenavon - Pontypool	A4043	N-S	Pontypool, Abersychan, Blaenavon	Semi - urban	Road/Lifted	Bus	*7*	6		1.9	0.8	-	6	6,079		
22	Abergavenny - Pontypool	A4042	N-S	Pontypool, Little Mill, Govilon, Abergavenny	Semi - urban	Passenger	Heavy Rail	9.5	1	2	15.2	7.6	2	1	12,515	Mamhilad & Sites C1/C2 Mamhilad	Mamhilad
23	Pontypool - Newport	A4042, A4051	N-S	Newport, Caerleon, Cwmbran, Pontypool	Semi - urban	Passenger	Heavy Rail	10	2	5	8.0	3.2	2	6	27,972	Sebastopol	Caerloen, Sebastopol, Llantarnam
	East																
24	Monmouth - Newport	A449	N-S	Monmouth	Rural	Road	Bus	*25*	11		3.6	3.6	-	2	24,797	South East Newport Industrial Area, Llanwern Steelworks	
25	Monmouth - Abergavenny	A40	E-W	Abergavenny, Monmouth	Rural	Road	Bus	*18*	9		3.2	3.2	-	1	12,123		
26	Chepstow - Severn Tunnel Junction	A48	N-S	Chepstow, Calidicot	Rural	Passenger	Heavy Rail	7.5	2	2	6.0	6.0	1	2	4,319	Fairfield Mabey, Chepstow	
	Eastern Mainline Corridor																
27	Severn Tunnel Junction - Newport	M4, M48	E-W	Magor, Langstone, Llanwern	Urban	Passenger/ Freight	Heavy Rail	10	1	4	16.0	4.0	1	4	75,855	South East Newport Industrial Area, Llanwern Steelworks	Llanwern, Maindee, Magor
28	Newport - Cardiff (north route)	M48, A48	E-W	Newport Road - Llanrumney - St Mellons - Tredegar Park	Urban	Road	Bus	*13.5*	9		2.4	0.8	-	6	21,203	South East Newport Industrial Area, Cardiff Central EZ, Housing NW of Pontprennau Cardiff and Hosuing NE of Pontprennau Cardiff	
29	Newport - Cardiff (south route)	A48	E-W	Roath - Rhmney - St Mellons - Marshfield - Coedkernew	Urban	Passenger/ Freight	Heavy Rail	11.75	1	6	18.8	3.1	6	6	66,890	Celtic Springs Business Park (EM1iii)	Pengam, Rhymney, St Mellons, Coedkenew, Newport West ()
	Heads of Valleys																
30	Abergavenny - Brynmawr	A465	E-W	Abergavenny - Brynmawr	Semi - urban	Road	Bus	*8.5*	6		2.3	0.8	-	2	19,777		
31	Brynmawr - Ebbw Vale	A465	E-W	Brynmawr - Ebbw Vale	Semi - urban	Road	Bus	*2.5*	4		1.0	0.8	-	2	11,500	The Works, Ebbw Vale and Northern Corridor, Ebbw Vale	
32	Ebbw Vale - Rhymney	A465	E-W	Ebbw Vale - Rhymney	Semi - urban	Road	Bus	*6*	9		1.1	0.8	-	2	24,275	The Works, Ebbw Vale and Northern Corridor, Ebbw Vale	
33	Rhymney - Merthyr	A465	E-W	Rhymney - Merthyr	Semi - urban	Road	Bus	*6*	5		1.9	0.8	-	3	26,465		
34	Merthyr - Hirwaen/ Aberdare	A465	E-W	Merthyr - Hirwaen/ Aberdare	Semi - urban	Road	Bus	*6.5*	4		2.6	0.8	-	2	23,474	Pentrebach Industrial area, Pentrebach Hoover Site	
	Mid Cross Valleys																
10	Abercynon/Treharris - Ystrad Myanch	A472	E-W	Nelson/Trelewis/Treharris	Semi - urban	Freight/ Blocked	Bus	4	16	2	0.4	3.2	-	1	14,079		Nelson, Trelewis
15	Ystrad Mynach - Newbridge	A472	E-W	Blackwood	Semi - urban	Road	Bus	5	6		1.3	0.8	-	-	17,091		
20	Newbridge - Pontypool	A472	E-W	Pontypool	Semi - urban	Road	Bus	7	8		1.4	0.8	-	2	17,675		
	Southern Cross Valleys																
39	Pontyclun - Llantrisant - Pontypridd	A473	E-W	Talbot Green, Llantrisant, Church Village	Urban	Freight/ lifted	Bus	*7.5*	8		1.5	0.8	-	4	21,830	Llantrisant Retail Parks, Llantrisant Business Park, Treforest Industrial estate, Pontypridd Town Centre	
40	Nantgarw - Caerphilly	A468	E-W		Urban	Lifted/ Blocked	Bus	*2.5*	3		1.3	0.8	-	5	36,394	Caerphilly Town Centre	
16	Caerphilly - Newport	A468	E-W	Bassaleg, Rhiwderin, Machen	Semi - urban	Freight/lifted	Bus	*11.5*	10	4	1.8	4.6	-	4	10,435	Caerphilly Town Centre	
	Cardiff Urban Area																
29A	Mainline (Cardiff - St Mellons)	A48/ M48/ M4	E-W	Splott, Roath, Rumney St Mellons	Urban	Passenger/ Freight	Heavy Rail	5	1	3	8.0	2.7	6	10	38,067		Pengam, Rhymney, St Mellons
28A	A48 East (Cardiff St Mellons)	A48/ B4487	E-W	Splot, Roath, Rumney St Mellons	Urban	Road	Bus	5.5	10		0.9	0.8	-	10	19,926		
35	North East (Cardiff - Cardiff Gate)	A469	N-S	Roath, Llanderyn, Pontprennau, Cardiff Gate	Urban	Road	Bus	7.5	7		1.7	0.8	-	4	17,387	Housing NW of Pontprennau Cardiff and Hosuing NE of Pontprennau Cardiff	
14A	Rhymney Line (Cardiff - Lisvane)	A470	N-S	Cathays, Roath Park, Heath,	Urban	Passenger	Heavy Rail	2.5	4	6	1.0	0.7	4	8	15,777		Crwys Road, Roath Park
14B	Coryton Line (Cardiff - Coryton)	B4562	E-W	Cathays, Roath, , Heath, Llanishen , Whitchurch, Coryton	Urban	Passenger	Heavy Rail	4.75	7	9	1.1	0.8	2	8	31,959		

9A	Taff Vale Line - (Cardiff to Taffs Well)	A470	N-S	Cathays, Gabalfa, Lladaff, Radyr	Urban	Passenger	Heavy Rail	**5**	4	5	**2.0**	**1.6**	6	6	75,924		Gabalfa or Maindy
36	City Line (Cardiff - Radyr)	A4054	N-S	Fairwater, Danecourt, Radyr	Urban	Passenger	Heavy Rail	**4.75**	4	5	**1.9**	**1.5**	2	4	21,048		Victoria Park,
37	NW Corridor (Cardiff - Pontyclun & Beddau)	A4232	E-W	Cardiff, Danecourt, Craigeau to Talbot Green, Beddau & Church Village	Urban	Lifted	Bus	13.75	5	16	**4.4**	**1.4**	-	4	10,929		Victoria Park, plus 10 stations
38	A48 West (Caridiff - Culverhouse Cross)	A48	E-W	Ely, Culverhouse	Urban	Road	Bus	3	6		**0.8**	**0.8**	-	9	17,641	Land in NWW Cardiff/Land at Jn 33	
	Cardiff - Barry	A4055	E-W		Urban	Road	Bus	*5*	6		**1.3**	**0.8**	-	6	52,850		
5a	Cardiff - Barry (& Airport)	B4265/ A4226	E-W	Rhoose, Barry, Cadoxton, Dinas Powys, Eastbrook, Cogan, Grangetown	Semi - urban	Passenger	Heavy Rail	**8.5**	7	7	**1.9**	**1.9**	4	0	9,355	Barry Waterfront, Barry Town Centre, Sports Village, Cardiff Bay	
41	Cardiff - Penarth	A4160	N-S	Penarth	Urban	Passenger	Heavy Rail	**4.5**	3	4	**2.4**	**1.8**	4	8	33,949	Sports Village, Cardiff Bay	Plus 1.2km extension to Forrest Road
42	Cardiff to Cardiff Bay	A470	N-S	Cardiff - Cardiff Bay	Urban	Passenger	Heavy Rail	**1**	1	2	**1.6**	**0.8**	5	10	2,750	Cardiff EZ, Roath basin, Cardiff Bay	
	Airport Link																
	VoG to Airport				Semi - urban	Road	Bus			1							Cardiff Airport Terminal

Metro Modal Study: Figure 1
Principal Transport Corridors - Existing



2.2 Key Characteristics of existing corridors

Overview of Corridor length and stop spacing

2.2.1 The main corridors are all under 30 miles/48km in length.

2.2.2 On rail routes, existing stop spacing on the Valley lines Network averages 4km (compared to 6km nationally). The main line and Marches line have much lower stop spacings (>8km) due to the closure of most intermediate stations in the Beeching area, limiting local accessibility to the rail network.

2.2.3 Parts of the existing rail network have very high stop spacings for heavy rail operation – less than 2km including the Treherbert line, Rhymney line (north of Bargoed and in Cardiff) and Coryton line.

2.2.4 Stop spacing on bus routes reflects their predominant use by local services and semi urban nature are generally between 0.4km and 2km. Exceptions include the predominantly rural route to Monmouth at 3-4km.

Overview of Existing frequencies and demand

2.2.5 There is a general correlation between higher public transport frequencies and traffic flows allowing for different routings between modes. However public transport frequencies compared to traffic flows are higher relatively in Cardiff suggesting a higher modal share.

2.2.6 The majority of the rail routes have frequencies of 2 trains per hour, with higher frequencies where these services combine – up to 6 trains per hour south of Pontypridd and 4 trains per hour south of Caerphilly on the Rhymney line and to Barry. Maesteg and Ebbw Valley lines only have 1 train per hour.

2.2.7 Existing peak hour rail demand varies between 150 and 1100 people per direction per hour on the main Valley lines network. Peak flows are Caerphilly – Cardiff and Taffs Well – Cardiff. With the exception of the South Wales mainline, flows are generally at the lower end of the range for urban heavy rail or metro operations which may in part be a consequence of the low service frequencies.

2.2.8 Bus frequencies are generally proportionate to rail frequencies on shared corridors. Bus only corridors typically have frequencies of 2-4 buses an hour with significantly higher frequencies within the Cardiff urban area (up to 10 buses/hour)

3. Selection of Preferred mode by corridor

3.0.1 **Table 3** sets out an assessment of the suitability of each corridor by potential strategic mode.

3.0.2 As noted previously this only considers a single strategic mode for each corridor (with the exception of Cardiff - Newport or where routes overlap).

3.1 Assessment Criteria

Infrastructure

3.1.1 This assesses the suitability of the existing infrastructure to accommodate the mode. Whilst totally new infrastructure could of course be constructed, this is in most cases cost prohibitive so a common sense approach has been taken. In urban areas higher transport flows might justify investment in new 'greenfield' construction. However, this has been considered unlikely to be practicable outside these areas other than where use can be made of former rail corridors in these areas (including highway corridors for BRT), but only those which are largely intact (noted as lifted) and not those which are largely lost or with serious impediments in terms of subsequent development (noted as blocked).

3.1.2 Converting existing heavy rail corridors to BRT (or PRT) was not considered cost effective (particularly when light rail modes would offer similar frequency and capacity).

Separation

3.1.3 Tram operations are not compatible with heavy rail operation on the same line without physical separation (i.e. separate tracks in the same corridor) due to differences in Crash worthiness requirements. Light rail transit is also preferably fully separated from heavy rail operation but can share tracks where additional signalling separation is provided to reduce risk (e.g. Sunderland operations of Tyne & Wear Metro). Tram – Train within certain constraints can operate in heavy rail corridors.

3.1.4 The ability to separate corridors from the main heavy rail corridors has been assessed and the key constraints (mainline passenger and freight operations) noted.

Segregation

3.1.5 As noted previously Heavy Rail and Metro and PRT (and other modes) require fully segregated alignments. BRT, Tram and Tram Train can operate in both mixed on street and segregated alignment. Fully segregated alignments offer high capacity potential.

Table 3 - Principal Corridors; Preferred Strategic Mode by corridor

	Existing Route Information						Infrastructure Constraints			Heavy Rail						BRT						Tram						Tram - Train						Light Rail Transit						Ultra Light Rail						PRT						Preferred Mode	Next Best Alt (if appplic.)
	Current Strategic Mode	Existing Rail Alignment	Service Frequency	Existing Stop Spacing (km)	Proposed Stop Spacing (Km)	Corridor Length (miles)	Can be separated from Heavy Rail Network	Constraint	Fully Segregated or mixed Alignment	Infrastructure	Segregation	Peak Capacity	Stop Spacing (km)	Corridor Length	Overall suitability	Infrastructure	Segregation	Peak Capacity	Stop Spacing (km)	Corridor Length	Overall suitability	Infrastructure	Segregation	Peak Capacity	Stop Spacing (km)	Corridor Length	Overall suitability	Infrastructure	Segregation	Peak Capacity	Stop Spacing (km)	Corridor Length	Overall suitability	Infrastructure	Segregation	Peak Capacity	Stop Spacing (km)	Corridor Length	Overall suitability	Infrastructure	Segregation	Peak Capacity	Stop Spacing (km)	Corridor Length	Overall suitability	Infrastructure	Segregation	Peak Capacity	Stop Spacing (km)	Corridor Length	Overall suitability		
West																																																					
Porthcawl to Bridgend	Bus	Lifted	3	0.8	0.8	6.6	Yes	non	Mixed/Seg	Y+	Y+	Y	P	Y	N	Y+	Y	Y	Y	Y	Y	Y+	Y	Y	Y	Y	P	Y+	Y	Y	Y	Y	P	Y+	Y	Y	Y	Y	P	Y+	N	Y	Y	Y	N	Y+	N	Y	Y	N	N	BRT	Tram Train
Maesteg Valley																																																					
Maesteg to Bridgend	Heavy Rail	Yes	1	2.2	1.7	8.25	Partially	Freight	Segregated	Y	Y	Y	P	Y	P	N					N	N	Y	Y	Y	Y	N	Y+	Y	Y	Y	Y	Y	Y+	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	N	N					N	Tram Train	Heavy Rail
Western Mainline Corridor																																																					
Pyle to Bridgend	Heavy Rail	Yes	0.5	9.6	9.6	6	No	Mainline	Segregated	Y	Y	Y	Y	Y	Y	N					N	N					N	N	Y	?	P	Y	N	N	Y	?	P	Y	N	N					N	N					N	Heavy Rail	-
Bridgend - Cardiff	Heavy Rail	Yes	4	8.1	5.4	20.25	No	Mainline	Segregated	Y	Y	Y	Y	Y	Y	N					N	N					N	N	Y	N	P	Y	N	N	Y	N	P	Y	N	N					N	N					N	Heavy Rail	-
Bridgend - Barry - Cardiff (via Airport)	Heavy Rail	Yes	1	10.1	7.6	19	No	Mainline & Freight	Segregated	Y	Y	Y	Y	Y	Y	N					N	N					N	Y+	Y	?	P	Y	P	Y+	Y	?	P	Y	P	N					N	N					N	Heavy Rail	?
Taff Valley																																																					
Treherbert - Pontypridd	Heavy Rail	Yes	2	1.7	1.6	10.75	Yes	non	Segregated	Y	Y	Y	P	Y	P	N					N	Y+	Y	Y	Y	Y	P	Y+	Y	Y	Y	Y	Y	Y+	Y	Y	Y	Y	Y	Y+	Y	N	Y	Y	N	N					N	Light Rail Transit	Tram Train
(Hirwaun) - Aberdare - Pontypridd	Heavy Rail	Yes	1	2.9	2.0	11	Partially	Freight	Segregated	Y	Y	Y	P	Y	P	N					N	N	Y	Y	Y	Y	N	Y+	Y	Y	Y	P	P	Y+	Y	Y	Y	Y	Y	N	Y	N	Y	Y	N	N					N	Light Rail Transit	Tram Train
Merthyr - Pontypridd	Heavy Rail	Yes	2	3.7	3.1	11.5	Partially	Freight	Segregated	Y	Y	Y	P	Y	P	N					N	N	Y	Y	Y	Y	N	Y+	Y	Y	Y	P	P	Y+	Y	Y	Y	Y	Y	N	Y	N	Y	Y	N	N					N	Light Rail Transit	Tram Train
Pontypridd - Cardiff	Heavy Rail	Yes	6	3	2.0	7.5	Partially	Freight	Segregated	Y	Y	Y+	P	Y	P	N					N	N	Y	Y	Y	Y	N	Y+	Y	Y	Y	Y	Y	Y+	Y	Y	Y	Y	Y	N	Y	N	Y	Y	N	N					N	Light Rail Transit	Tram Train
Rhymney Valley																																																					
Rhymney - Bargoed	Heavy Rail	Yes	1	1.8	1.8	4.5	Yes	non	Segregated	Y	Y	Y	P	Y	P	N					N	Y+	Y	Y	Y	Y	P	Y+	Y	Y	Y	P	P	Y+	Y	Y	Y	Y	Y	Y+	Y	Y	Y	Y	P	N					N	Light Rail Transit	Tram Train
Bargoed - Ystrad Mynach	Heavy Rail	Yes	4	2.4	2.4	6	Yes	non	Segregated	Y	Y	Y	P	Y	P	N					N	Y+	Y	Y	Y	Y	P	Y+	Y	Y	Y	Y	Y	Y+	Y	Y	Y	Y	Y	Y+	Y	N	Y	Y	N	N					N	Light Rail Transit	Tram Train
Ystrad Mynach - Caerphilly	Heavy Rail	Yes	4	2.1	2.1	5.25	Partially	Freight	Segregated	Y	Y	Y	P	Y	P	N					N	N					N	Y+	Y	Y	Y	Y	Y	Y+	Y	Y	Y	Y	Y	N	Y	N	Y	Y	N	N					N	Light Rail Transit	Tram Train
Caerphilly - Cardiff	Heavy Rail	Yes	4	3.1	2.1	7.75	Partially	Freight	Segregated	Y	Y	Y+	P	Y	p	N					N	N					N	Y+	Y	Y	Y	Y	Y	Y+	Y	Y	Y	Y	Y	N	Y	N	Y	Y	N	N					N	Light Rail Transit	Tram Train
Ebbw/Western Valleys																																																					
Ebbw Vale - Llanhilleth/Newbridge	Heavy Rail	Yes	1	2.9	2.9	5.5	Yes	non	Segregated	Y	Y	Y	P	Y	P	N					N	N	Y	Y	Y	Y	N	Y+	Y	Y	Y	P	P	N	Y	Y	Y	Y	N	N					N	N					N	Heavy Rail	
Brynmawr - Abertillery - Llanhilleth	Bus	ifted/Blocked	2	1.4	0.8	8	Yes	non	Mixed/Seg	Y+	P	Y	P	Y	P	Y+	Y	Y	Y	Y	Y	Y+	Y	Y	Y	Y	P	Y+	Y	SO	Y	P	P	N	Y	SO	Y	Y	N	Y+	P	Y	Y	Y	P	Y+	N	Y	Y	N	N	Heavy Rail & BRT	BRT & ULR
Llanhilleth/ Newbridge - Cardiff/ Newport	Heavy Rail	Yes	1	6.3	5.4	23.75	No	Mainline & Freight	Segregated	Y	Y	Y	Y	Y	Y	N					N	N					N	Y+	Y	Y	Y	P	P	N	Y	Y	Y	Y	N	N					N	N					N	Heavy Rail	
Eastern Valley & Marches																																																					
Blaenavon - Pontypool	Bus	No/Blocked	6	1.9	0.8	7	N/A		Mixed/Seg	N					N	Y+	Y	Y	Y	Y	Y	Y+	Y	Y	Y	Y	P	Y+	Y	Y	Y	Y	P	Y+	N	Y	Y	Y	N	N					N	Y+	N	?	Y	?	N	BRT	Bus
Abergavenny - Pontypool	Heavy Rail	Yes	2	15.2	7.6	9.5	No	Mainline	Segregated	Y	Y	Y	Y	Y	Y	N					N	N					N	N	Y	Y	Y	P	N	N	Y	Y	Y	Y	N	N					N	N					N	Heavy Rail	
Pontypool - Newport	Heavy Rail	Yes	2	8	3.2	10	No	Mainline	Segregated	Y	Y	Y	P	Y	P	N					N	N					N	N	Y	Y	Y	P	N	N	Y	Y	Y	Y	N	N					N	N					N	Heavy Rail	
East																																																					
Monmouth - Newport	Bus	No/Blocked	2	3.6	3.6	25	N/A		Mixed	N					N	Y+	Y	SO	Y	Y	N	N					N	N					N	N					N	N					N	Y+	N	Y	?	N	N	Bus	
Monmouth - Abergavenny	Bus	No/Blocked	1	3.2	3.2	18	N/A		Mixed	N					N	Y+	Y	SO	Y	Y	N	N					N	N					N	N					N	N					N	Y+	N	Y	?	N	N	Bus	
Chepstow - Severn Tunnel Junction	Heavy Rail	Yes	1	6	6.0	7.5	No	Mainline	Segregated	Y	Y	Y	Y	Y	Y	N					N	N					N	Y+	Y	Y	Y	P	P	N	Y	Y	Y	Y	N	N					N	N					N	Heavy Rail	
Eastern Mainline Corridor																																																					
Severn Tunnel Junction - Newport	Heavy Rail	Yes	1	16	4.0	10	No	Mainline	Segregated	Y	Y	Y	Y	Y	Y	N					N	N					N	Y+	Y	Y	Y	Y	Y	Y+	Y	Y	Y	Y	P	N					N	N					N	Heavy Rail	Tram Train
Newport - Cardiff (north route)	Bus	No	6	2.4	0.8	13.5	N/A		Mixed	N					N	Y+	Y	Y	Y	Y	Y	Y+	Y	SO	Y	Y	P	Y+	Y	SO	Y	Y	P	Y+	N	Y	Y	Y	N	N					N	Y+	N	?	Y	N	N	BRT	
Newport - Cardiff (south route)	Heavy Rail	Yes	6	18.8	3.1	11.75	No	Mainline	Segregated	Y	Y	Y	P	Y	P	N					N	N					N	Y+	Y	Y	Y	Y	Y	Y+	P	Y	Y	Y	P	N					N	N					N	Tram Train	Heavy Rail
Heads of Valleys																																																					
Abergavenny - Brynmawr	Bus	No/Blocked	2	2.3	0.8	8.5	N/A		Mixed	N					N	Y+	Y	Y	Y	Y	Y	Y+	Y	SO	Y	Y	P	Y+	Y	SO	Y	Y	P	Y+	N	Y	Y	Y	N	N					N	N	N	Y	Y	N	N	BRT	-
Brynmawr - Ebbw Vale	Bus	No/Blocked	2	1.0	0.8	2.5	N/A		Mixed	N					N	Y+	Y	Y	Y	Y	Y	Y+	Y	SO	Y	Y	P	Y+	Y	SO	Y	Y	P	Y+	N	Y	Y	Y	N	N					N	N	N	Y	Y	Y	N	BRT	-
Ebbw Vale - Rhymney	Bus	No/Blocked	2	1.1	0.8	6	N/A		Mixed	N					N	Y+	Y	Y	Y	Y	Y	Y+	Y	SO	Y	Y	P	Y+	Y	SO	Y	Y	P	Y+	N	Y	Y	Y	N	N					N	N	N	Y	Y	?	N	BRT	-
Rhymney - Merthyr	Bus	No/Blocked	3	1.9	0.8	6	N/A		Mixed	N					N	Y+	Y	Y	Y	Y	Y	Y+	Y	SO	Y	Y	P	Y+	Y	SO	Y	Y	P	Y+	N	Y	Y	Y	N	N					N	N	N	Y	Y	?	N	BRT	-
Merthyr - Aberdare	Bus	No/Blocked	2	2.6	0.8	6.5	N/A		Mixed	N					N	Y+	Y	Y	Y	Y	Y	Y+	Y	SO	Y	Y	P	Y+	Y	SO	Y	Y	P	Y+	N	Y	Y	Y	N	N					N	N	N	Y	?	?	N	BRT	-
Mid Cross Valleys																																																					
Abercynon/Treharris - Ystrad Myanch	Bus	ifted/Blocked	1	0.4	3.2	4			Mixed/Seg	Y+	Y+	Y	P	N	P	Y+	Y	Y	Y	Y	Y	Y+	Y	SO	Y	Y	P	Y+	Y	SO	Y	Y	P	Y+	N	Y	Y	Y	N	N					N	Y+	N	Y	Y	Y	N	BRT	-
Ystrad Mynach - Newbridge	Bus	No/Blocked	4	1.3	0.8	5	N/A		Mixed	N					N	Y+	Y	Y	Y	Y	Y	Y+	Y	SO	Y	Y	P	Y+	Y	SO	Y	Y	P	Y+	N	Y	Y	Y	N	N					N	Y+	N	Y	Y	Y	N	BRT	-
Newbridge - Pontypool	Bus	No/Blocked	2	1.4	0.8	7	N/A		Mixed	N					N	Y+	Y	Y	Y	Y	Y	Y+	Y	SO	Y	Y	P	Y+	Y	SO	Y	Y	P	Y+	N	Y	Y	Y	N	N					N	Y+	N	Y	Y	?	N	BRT	-
Southern Cross Valleys																																																					
Pontyclun - Llantrisant - Pontypridd	Bus	Freight/Lifted	4	1.5	0.8	7.5	Yes	non	Mixed/Seg	Y+	Y+	Y	N	Y	N	Y+	Y	Y	Y	Y	Y	Y+	Y	Y	Y	Y	P	Y+	Y	Y	Y	Y	Y	Y+	N	Y	Y	Y	N	Y+	N	?	Y	Y	N	Y+	N	Y	Y	?	N	Tram Train	BRT
Nantgarw - Caerphilly	Bus	No/Blocked	5	1.3	0.8	2.5	N/A		Mixed/Seg	N					N	Y+	Y	Y	Y	Y	Y	Y+	Y	Y	Y	Y	Y	Y+	Y	Y	Y	Y	Y	Y+	N	Y	Y	Y	N	N					N	Y+	N	?	Y	Y	N	BRT	
Caerphilly - Newport	Bus	Freight/Lifted	0	1.8	4.6	11.5	Partially	Freight	Segregated	Y+	Y	Y	P	Y	P	N	Y	Y	Y	Y	N	N	Y	Y	Y	Y	N	Y+	Y	Y	Y	Y	Y	Y+	P	Y	Y	Y	P	N	Y	?	Y	Y	N	Y+	N	Y	Y	N	N	Tram Train	Heavy Rail
Cardiff Urban Area																																																					
Mainline (Cardiff - St Mellons)	Heavy Rail	Yes	6	8	2.7	5	No		Segregated	Y+	Y	Y	P	Y	P	N					N	N					N	Y+	Y	Y	Y	Y	Y	Y+	Y	Y	Y	Y	P	N					N	N					N	Tram Train	Heavy Rail
A48 East (Cardiff - St Mellons)	Bus	No/Blocked	10	0.9	0.8	5.5	N/A		Mixed	N					N	Y+	Y	Y	Y	Y	Y	Y+	Y	Y	Y	Y	Y	Y+	Y	Y	Y	Y	Y	Y+	N	Y	Y	Y	Y	N	N	Y	Y	Y	N	Y+	N	N	Y	?	N	BRT	Tram Train
North East (Cardiff - Cardiff Gate)	Bus	No/Blocked	4	1.7	0.8	7.5	N/A		Mixed	Y+	Y+	Y	N	Y	P	Y+	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	N	Y+	Y	Y	Y	Y	Y	Y+	Y+	Y	Y	Y	P	N	Y+	Y	Y	Y	N	Y+	N	Y	Y	?	N	BRT	Tram Train
Rhymney Line (Cardiff - Lisvane)	Heavy Rail	Yes	4	1	0.7	2.5	Partially	Freight	Segregated	Y	Y	Y+	N	Y	P	N					N	N					N	Y+	Y	Y	Y	Y	Y	Y+	Y	Y	Y	Y	Y	N	Y	N	Y	Y	N	N					N	Light Rail Transit	Tram Train
Coryton Line (Cardiff - Coryton)	Heavy Rail	Yes	2	1.1	0.8	4.75	Partially	Freight	Segregated	Y	Y	Y	N	N	N	N					N	N					N	Y+	Y	Y	Y	Y	Y	Y+	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	N	N					N	Tram Train	Light Rail Transit
Taff Vale Line - (Cardiff to Taffs Well)	Heavy Rail	Yes	6	2	1.6	5	Partially	Cardiff west	Segregated	Y	Y	Y+	P	Y	P	N					N	N					N	Y+	Y	Y	Y	Y	Y	Y+	Y	Y	Y	Y	Y	N	Y	N	Y	Y	N	N					N	Light Rail Transit	Heavy Rail
City Line (Cardiff - Radyr)	Heavy Rail	Yes	2	1.9	1.5	4.75	Partially	Cardiff west	Segregated	Y	Y	Y	P	P	P	N					N	N					N	Y+	Y	Y	Y	Y	Y	Y+	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	N	N					N	Tram Train	Light Rail Transit
NW Corridor (Cardiff - Pontyclun & Beddau)	Bus	Lifted	4	4.4	1.4	13.75	Partially	Cardiff west	Mixed/Seg	Y+	Y+	Y	P	Y	P	Y+	Y	Y	Y	Y	Y	Y+	Y	Y	Y	Y	Y	Y+	Y	Y	Y	Y	Y	Y+	N	Y	Y	Y	N	N	N	Y	Y	Y	N	Y+	N	Y	?	N	N	Tram Train	BRT
A48 West (Cardiff - Culverhouse Cross)	Bus	No/Blocked	9	0.8	0.8	3	N/A		Mixed	N	N	Y	P	N	N	Y+	Y	Y	Y	Y	Y	Y+	Y	Y	Y	Y	Y	Y+	Y	Y	Y	Y	Y	Y+	N	Y	Y	Y	N	N	N	Y	Y	Y	N	Y+	N	N	Y	Y	N	BRT	Tram Train
Cardiff - Barry (& Airport)	Heavy Rail	Yes	4	1.9	1.9	8.5	No	Mainline & Freight	Segregated	Y	Y	Y	P	Y	P	N					N	N					N	Y+	Y	Y	Y	Y	Y	Y+	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	N	N					N	Tram Train or Light Rapid Transit	Heavy Rail
Cardiff - Penarth	Heavy Rail	Yes	4	2.4	1.9	4.5	Partially	Cardiff west	Segregated	Y	Y	Y	P	P	P	N					N	N					N	Y+	Y	Y	Y	Y	Y	Y+	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	N	N					N	Tram Train	Light Rail Transit
Cardiff Central & QS to Cardiff Bay	Heavy Rail	Yes	5	1.6	1.8	1	Yes	non	Mixed	Y	N	Y	P	N	N	Y+	Y	Y	Y	Y	Y	Y+	Y	Y	Y	Y	Y	Y+	Y	Y	Y	Y	Y	Y+	N	Y	Y	Y	N	Y+	N	Y	Y	Y	N	N					N	Tram Train	Tram or BRT
Airport Link																																																					
VoG to Airport	Bus	No	1		0.0	1	Yes	non	Mixed/Seg	Y+	Y+	Y	P	P	P	Y+	Y	Y	Y	Y	Y	Y+	Y	Y	Y	N	N	Y+	Y	SO	Y	P	P	Y+	Y	SO	Y	P	P	Y+	Y+	?	Y	Y	P	Y+	Y+	Y	Y	Y	Y	PRT or Cableway	Heavy Rail or Tram T

Peak Capacity

3.1.6 This is an assessment of the fit of the mode with the peak capacity requirement. Where the mode capacity exceeds the peak capacity requirement this is noted as sub optimal.

Stop Spacing

3.1.7 This is an assessment of the modes suitability for the proposed stop spacings on the corridor including planned new stations for existing rail routes. For existing bus routes these are not considered to be <800m for strategic services.

Corridor Length

3.1.8 This is an assessment of the appropriateness of the corridor length for the mode. For example; Heavy rail is designed for longer distance journeys. Tram is practically suited to journeys < 15miles and PRT under 7.5 miles.

Overall Suitability

3.1.9 Based on the assessment criteria and overall RAG score was developed for each mode and from this the preferred and next best alternative mode identified.

3.2 Analysis & Key findings

3.2.1 The majority of the existing Valley Lines network was originally designed primarily for moving heavy freight. Current passenger operations which have gradually been extended over the years have remained heavy rail due to a combination of legacy arrangements, availability of rolling stock and network interfaces and other constraints including ongoing freight flows.

3.2.2 The using of light rail technology for the Valley lines network has been considered in the past, however, constraints to this have been:

- Lack of electrification
- Signalling immunisation costs for electrification
- Existing freight flows include Coal on the Cwmbargoed Branch/Rhymney Line, Stone Traffic on the Machen Branch/Ebbw Valley Railway, Coal Traffic from Hirwaun on Aberdare/Taff Vale Branch and Freight on Maesteg line south of Tondu.
- Existing mainline heavy rail passenger operations including interfaces at Cardiff Central and Cardiff West Junction
- Line capacity for higher frequency operations

3.2.3 The completion of Cardiff Area Signalling and Newport Area Signalling Renewal schemes together with an associated package of other improvements, including increased separation of Valley lines and other rail traffic through Cardiff Central station together with the Valley lines electrification project will remove a large number of these constraints. Consequently, this use of light rail modes is now a consideration on the existing heavy rail network.

3.2.4 Based on demand information readily available the majority of public transport corridors in the study area have current peak hour capacities of between 150 - 1200 ppdph. Given average growth rates of 4- 6% per annum mean any new proposals need to consider capacities of at least 2- 2.5x this to cater for the next 20 years demand (i.e. 400-3000 ppdph).

3.2.5 Metro intervention proposals to extend of the population catchment within 1.2km of a strategic services by almost 60% through provision of new stations to improve local accessibility and provision of new routes would increase demand on core corridors further. This places the majority of the principal corridors forming the strategic network in the capacity range for BRT, Light Rail, Tram Train and Light Rail transit (on the main corridors). They would also be better suited to the stop spacings on the network allowing for metro interventions compared to heavy rail. Full Metro is not applicable as system capacities are oversized.

3.2.6 BRT is well suited to existing highway based corridors with lower flows where priority measures can be progressively developed to support it. Key corridors include Cardiff – Newport northern corridor, the mid Cross Valleys corridor, Heads of Valley corridor and Blaenavon to Cwmbran (and possibly Newport). BRT is also an alternative mode to tram or tram train for new rapid transit routes in Cardiff. The rural routes to Monmouth have very low passenger flows and limited congestion and are best served by existing bus and coach operations.

3.2.7 On the existing heavy rail network there are constraints on the choice of modes for passenger operation due to need to accommodate continuing freight services such as Cwmbargoed to Aberthaw Coal Trains. In particular, whilst tram would provide the appropriate capacity, its use is still constrained by difficulties of achieving full separation from freight operations particularly in the short to medium term. In addition, the existing stations at Central and Queen Street are well situated in the centre of Cardiff so there is less immediate need for new on street routes except where to bypass existing heavy rail lines for capacity reasons. Whilst tram would be ideal for new rapid transit in Cardiff it is also less suited to longer journeys over 15 miles.

3.2.8 Tram Train addresses the main restrictions on Tram use with similar benefits although would also benefit in terms of greater separation from the heavy rail system operationally. Its ability to operate on street and use tight radii as with trams in particular makes it appropriate for new alignments such as the north west corridor from Cardiff where this would help reduce construction costs and enable potential on street operation to by pass congested areas such as Cardiff west junction. The main technical issue to be addressed is whether to use high or low floor vehicles,

3.2.9 Light Rail Transit would also be appropriate to the main corridors in capacity terms particularly, if configured internally in terms of seating provision for longer distance journeys in the range of 10 – 30 miles from the north mid valleys catchment area which are less suited to tram and tram train, although the latter is not ruled out. Light Rail Transit would be particularly appropriate as a replacement to existing heavy rail operations in the core Valley lines network using high platform stations where operations on are fully segregated alignments and can be largely physically separated from heavy rail operation except for limited freight traffic where signalling separation could be used.

3.2.10 Heavy rail will have a continuing role on a number of parts of the network which cannot easily be separated from existing heavy rail operations or where heavy rail has specific advantage, such as improved comfort for longer distance journeys and higher speeds. Whilst heavy rail operations also falls into the identified capacity range this would be with longer trains at lower frequencies (typically 2tph) which would not address the objectives of a ‘turn up and go’ service at an affordable cost. Similarly it is less well suited to the stop spacings on many parts of the core Valley lines network compared to light rail modes.

3.2.11 No specific applications have been identified for ultra light rail, however it could be a consideration for shuttle operations to serve short branch lines. PRT has not been identified as suitable for any of the principal transport corridors largely due to difficulties of integrating it into the existing urban fabric, capacity capability and concerns over its use in an uncontrolled environment. However, it would be well suited to provide a link between Cardiff airport and new Station on the Vale of Glamorgan line in particular given its flexibility to allow for future changes to the airport terminal arrangements. An alternative would be a ground based cableway system.

3.3 Future Network Proposals

3.3.1 In developing future Network proposals two future scenarios have been considered.

Scenario 1 - Limited Separation

3.3.2 This scenario is largely based on the ‘status quo’ with majority of services remaining integrated with the heavy rail network with the development of a number of ‘tram-train’ services and limited separation on routes into Cardiff and along the South Wales main line relief lines to Newport.

3.3.3 A potential network is illustrated in **Figure 2** based on this scenario.

3.3.4 This scenario whilst representing an improvement on the existing situation particularly for routes around Cardiff, it is however unlikely to fully satisfy the Metro project aims of provide the region with a high quality, high capacity ‘turn up and go’ network as Heavy rail frequencies would be lower for the same capacity as Tram Train or Light Rail transit.

Scenario 2 - Maximum Separation

3.3.5 Maximum physical and signalling separation of the Valley line network from the Heavy rail network will be used to enable the replacement of Heavy Rail with a combination of tram train and Light Rail transit rolling stock on the core Valley lines network together with tram train on other routes.

3.3.6 The remainder of the Network which interfaces with main line operations would remain as heavy rail. There would be a total of 3 rail modes, Heavy Rail, Tram - Train and Light Rail Transit. BRT provide the main mode on the majority of the remaining Network

3.3.7 PRT or a Cableway fixed link could be used to link the Airport to the Vale of Glamorgan Line or alternatively a direct rail link provided (albeit with lower frequency of service).

3.3.8 A potential network is illustrated in **Figure 3** based on this scenario.

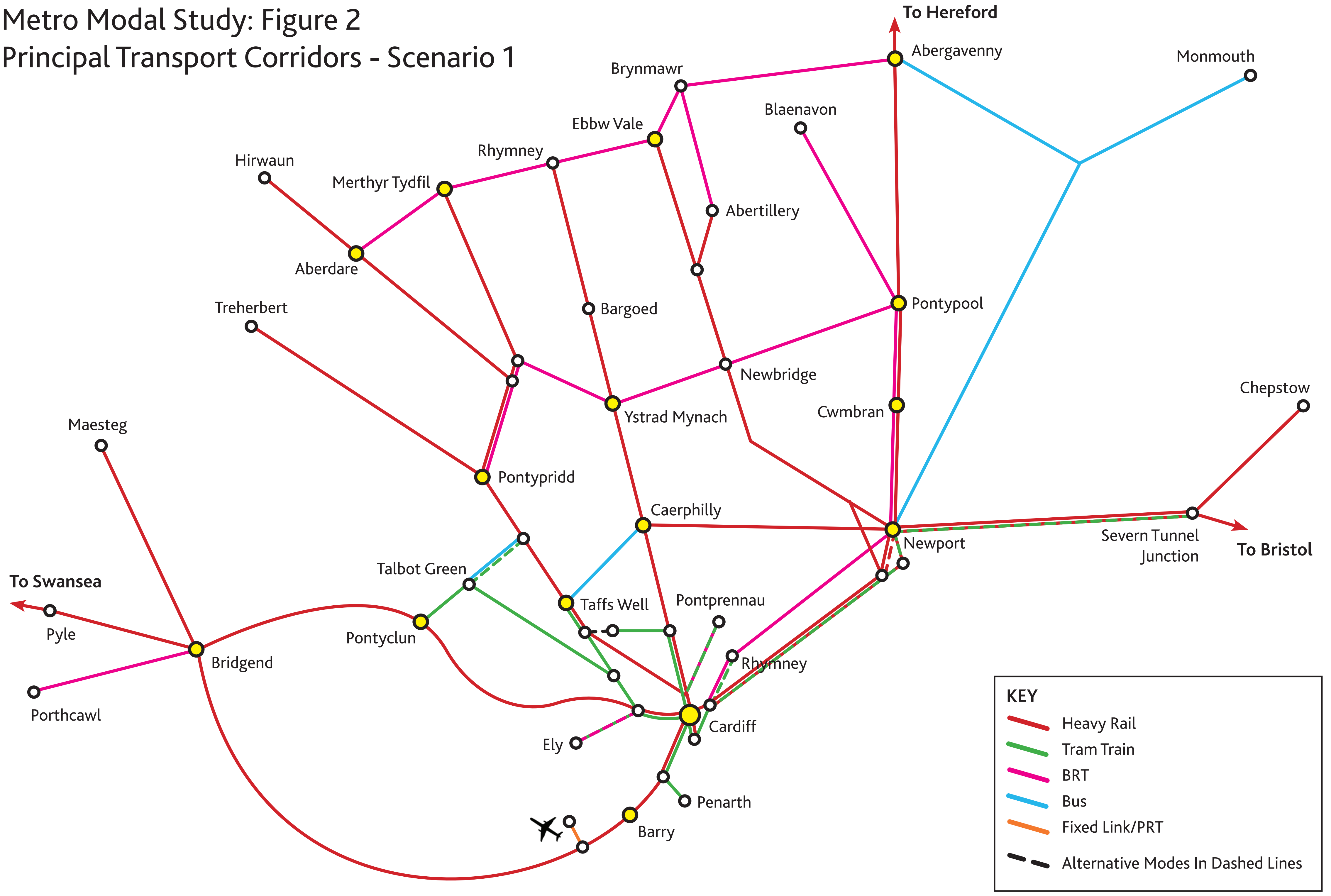
3.3.9 There are a number of intermediate scenarios between these two options, with scenario 2 potentially a longer term development of scenario 1 subject to other factors and change in potential constraints.

3.3.10 The following network is likely to remain heavy rail only operation in all scenarios:

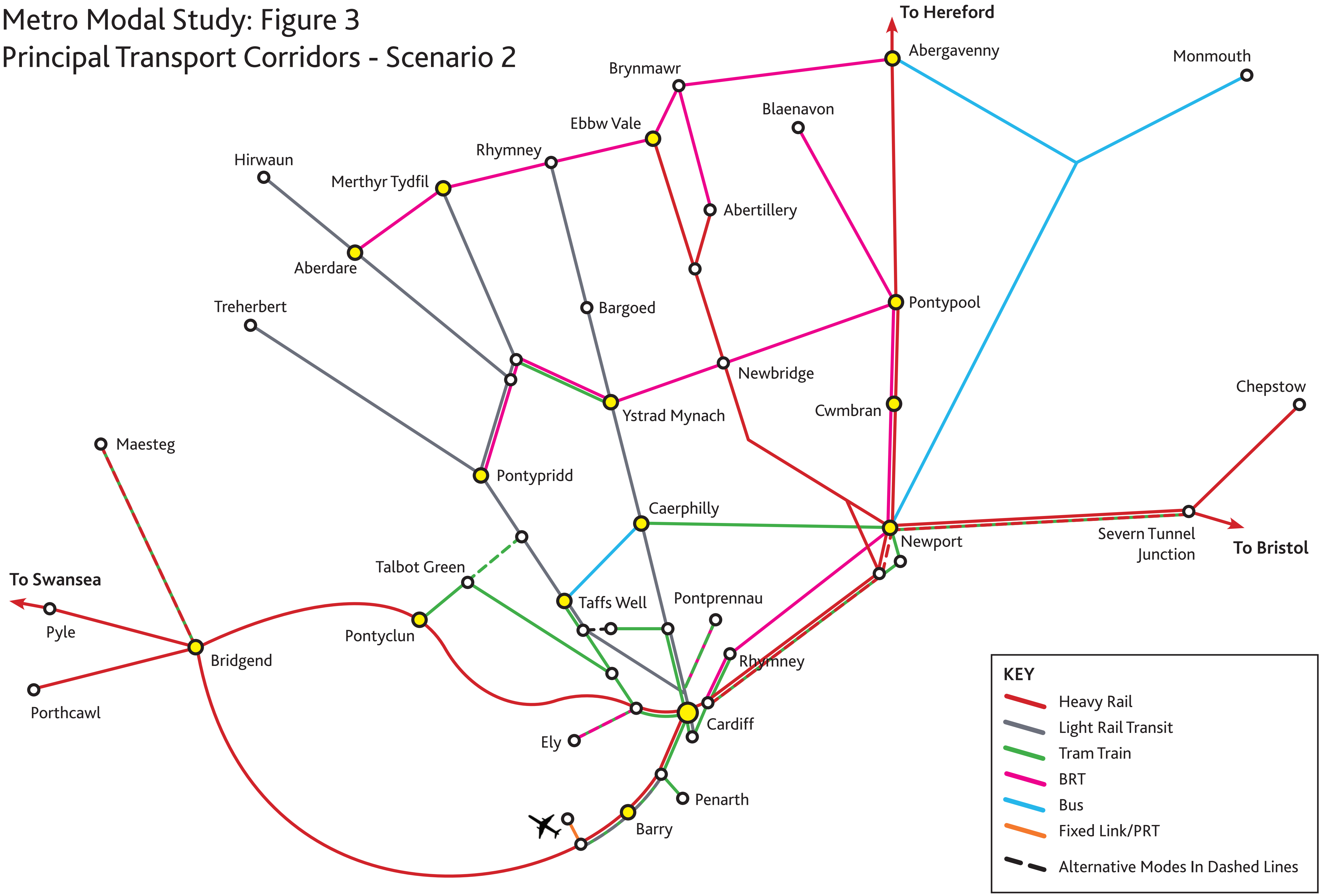
- South Wales Mainline West of Cardiff (and main lines East of Cardiff)
- Marches Line
- Gloucester Line
- Ebbw Valley Line
- Vale of Glamorgan Line (used as a diversionary route for the Main Line)

3.3.11 The Maesteg line could remain as heavy rail or be operated as a shuttle to Bridgend using Tram train operation which would also support possible extension of the line to Caerau.

Metro Modal Study: Figure 2
Principal Transport Corridors - Scenario 1



Metro Modal Study: Figure 3
Principal Transport Corridors - Scenario 2



4. Network Issues & fit with current programs

4.1 In determining the appropriate mode for each corridor consideration needs to be given to a number of network wide issues and implications created by the introduction of new modes to existing bus and heavy rail systems

4.2 These include;

- Governance arrangements including infrastructure ownership and operation and maintenance of the new modes
- Degree of separation from the heavy rail network achievable
- Rolling Stock Requirements and fit with existing Valley lines Electrification and planned DMU Fleet replacement timescales
- Available products & High or Low floor system

Governance Arrangements

4.3 Governance arrangements for managing the ownership, operation and maintenance of new routes such as the proposed northwest corridor need to be considered. This also includes operation of BRT routes and how their operations are procured within the current deregulated bus environment in Wales. This also has potential implications for the next Rail franchise, for example one option for operating strategic BRT routes would be to include them in the Rail franchise specification.

4.4 If a decision is made to operate the majority of the Valley Lines network as a light rail operation, as proposed in scenario 2 with greater separation of the core Valley Lines network from the existing heavy rail network (albeit maintaining freight operations), then managing and operating the network as an unified entity needs to be considered which may mean taking it out of the existing heavy rail ownership arrangements in a similar manner to other urban light rail operations; Manchester Metrolink, Tyne & Wear Metro etc. This could include the Rhymney Line, Taff Vale Line, Treherbert, Merthyr and City Lines, Cardiff Bay Branch and potentially the Penarth Line.

4.5 In addition, whilst existing heavy rail and bus operations are technically well understood new modes will inevitably pose new issues in a South East Wales context and care will need to be taken to capture lessons learnt experience from similar projects elsewhere some of which have experienced significant problems in their implementation.

Rolling stock Requirements and fit with Valley Lines Electrification

4.6 **Table 4** Summarises the rolling stock implications for each scenario.

4.7 Current rolling stock consideration for the Valley Lines Electrification (VLE) is based on cascaded 3 car Electric Multiple Units (EMUs) although new build EMUs may also be considered. In view of the electrification timescales with completion by 2019 and ongoing trial of Tram Train operation it may be difficult to progress more than small scale tram train application on the network in that timescale.

4.8 However, cascaded stock would have a lifespan of no more than 15-20 years during which time it could be steadily replaced by Tram Train or Light rail transit stock as lines are converted and displaced stock used for improving services on remaining routes e.g. Ebbw Valley, Maesteg or Marches line if electrified. If new rolling stock is ordered for VLE it may be more difficult to make a business case for subsequent light rail conversion of the core Valley lines network, therefore, scenario 1 is a more likely outcome. However, given a likely ongoing UK national program of electrification there should be a ready market for surplus stock.

4.9 A further issue in respect to Valley Lines Electrification is the choice of electrification system where provision of 750v DC rather than 25kv AC on low speed routes such as the Cardiff Bay branch or Coryton branch may be more economic and better suite future tram train proposals than the planned 25kv system if tram train was agreed and could be introduced at completion.

4.10 The introduction of new modes will bring with it a number of high fixed costs including the provision of appropriate maintenance facilities. It is also more economic to operate larger common fleets. This means that there needs to be a ‘critical mass’ of new routes. For these reasons tram – train proposals to Cardiff bay need to be linked with either Coryton line, Radyr or North west corridor or relief line proposals to derive a core network of sufficient size. Likewise implementation of light rail transit on the core Valley line network.

Low or High Floor Vehicles?

4.11 A key decision in whether to implement proposed new lines such as the north west corridor as high floor (915mm high platforms as per existing rail network) or low floor (350mm platform use on modern tram systems).

4.12 Low floor systems would be the first choice, legacy issues aside due to lower construction cost, vehicle availability and improved aesthetics. However interfacing with the existing rail network would require either dual height platforms or reconstruction existing stations to lower platform heights.

4.13 A high floor system avoids interface issues with the existing network but incurs increased costs for new routes. Existing tram train products are low floor. Unless high floor tram train stock can be economically procured one option is to split the system between high and low floor operations with limited number of interface stations with dual height platforms. Under scenario 2 high floor light rail transit would be used on the core valley lines network.

Table 4. Potential Service and Rolling Stock Requirements.

Route	Services Requirements		Rolling Stock Requirements			Comments
	Existing Freq	Potential Freq min)	Do min	Scenario 1 - Min separation	Scenario 2 - Max separation	
Cardiff Bay Branch	5 tph	>6tph	EMU	Tram -Train	Tram -Train	
Coryton Branch	2 tph	>4tph	EMU	Tram –Train	Tram –Train	
City Line	2 tph	>4tph	EMU	Tram –Train	Tram –Train	Proposed segregation of City Line with NW corridor
Merthyr , Treherbert & Aberdare Lines	2 tph per line, 6 tph total	4 tph (>6 tph total)	EMU	EMU	Light Rail Transit	Potential Network extension Aberdare to Hirwaun
Rhymney Line	1- 3 tph	>4tph	EMU	Light Rail Transit	Light Rail Transit	
Penarth Line	4 tph	>4tph	EMU	EMU	Light Rail Transit	
VoG, Barry and Airport	1 tph VoG (3 tph Barry)	>4 tph to Airport	EMU	EMU	EMU/ Light Rail Transit	
Ebbw Valley Line	1 tph	>4 tph	EMU	EMU	EMU	Newport Service and Potential Network extension to Abertillery
Maesteg Line	1 tph	2 -4 tph	EMU	EMU	EMU/Tram Train	Potentially operated as shuttle to Bridgend
Cardiff – Abergavenny	1 – 1.5tph	2-4 tph	DMU	EMU	EMU	Potential route electrification
Cardiff – Chepstow	1 tph	2-4 tph	DMU	EMU	EMU	See below
Cardiff – Newport – STJ/ Chepstow (Relief Lines) #1	New Service	>4tph	None	EMU	EMU	Includes potential electrification to Chepstow
Cardiff – Newport - STJ Relief Lines # 2	New Service	>4 tph	None	Tram – Train	Tram – Train	Includes extension via Cardiff Bay/ Newport centre. Development of 1.
Cardiff – Pontyclun /Beddau	New Service/Line	>4 tph	None	Tram – Train	Tram – Train	New route from City Line
Further Cardiff RT. Pontprennau, St Mellons, Culverhouse Cross	New Service/Lines	>4tph	None	Tram – Train or BRT	Tram – Train or BRT	Longer term proposal
Newport – Caerphilly & Ystrad Mynach to	New Service/ Line	2-4 tph	None	Tram - Train	Tram - Train	Longer term proposal
Cardiff – Newport,	New Service/	>4 ph	Bus	BRT	BRT	

Brynmawr - Abertillery	Line					
Mid Cross Valley	New Service/ Line	>4 ph	Bus	BRT	BRT	
Heads of Valley	New Service/ Line	>4 ph	Bus	BRT	BRT	
Blaenavon – Cwmbran - Newport	New Service/ Line	>4 ph	Bus	BRT	BRT	
Abergavenny – Monmouth and Newport - Monmouth	<1 ph	<1 ph	Bus	Bus	Bus	
Vale of Glamorgan Line to Cardiff Airport	New service/line	>4 ph	Bus	PRT or Cableway	PRT or Cableway	

5. Conclusions

5.1 The metro project aims to provide the region with a high quality, high capacity 'turn up and go' Metro network.

5.2 The main elements of this are;

- Increase of frequency on routes to a minimum of 4 tph (where affordable).
- Provision of new stations and stopping services to improve access to the network, combined with limited stop services on core routes.
- Extensions to the existing rail network with new services to serve key urban settlements
- Improved interchange with other modes inc Bus/BRT, Car, Cycle etc

5.3 The main operational implications of this are;

- Increased rolling stock requirement due to higher frequencies and introduction of new services
- A requirement for new types of rolling stock optimised around urban mass transit high frequency/ frequent stopping characteristics/tight radii etc to provide new and existing services more cost effectively including on street operation in the form of BRT, Tram Train and Light Rail Transit.

5.4 This study has identified the principal corridors in the region which together form the strategic route network and reviewed which is the most appropriate mode to perform the strategic public transport function for regional scale travel. This is as distinct from the denser network of local bus services and with which the metro network will need to interface.

5.5 Two future network scenarios have been developed.

5.6 Scenario 1 is largely based on the 'status quo' with majority of services remaining integrated with the heavy rail network with the development of a number of 'tram-train' services and limited separation on routes into Cardiff and along the South Wales main line relief lines to Newport.

5.7 However; although this scenario represents an improvement on the existing situation particularly for routes around Cardiff, the retention of heavy rail operation on the core Valley lines it is unlikely to fully satisfy the Metro project aims to provide the region with a high quality, high capacity 'turn up and go' network at an economic cost as heavy rail frequencies would be lower for the same capacity as Tram Train or Light Rail transit.

5.8 Scenario 2 is, therefore, based on maximum physical and signalling separation of the Valley line network from the Heavy rail network will be used to enable the replacement of Heavy Rail with a combination of tram train and Light Rail transit rolling stock on the core Valley lines network together with tram train on other routes. Scenario 2 could be a development of Scenario 1.

5.9 There are also a number of network wide issues and implications created by the introduction of new modes to existing bus and heavy rail systems which need to be addressed including:

- Determining appropriate Governance arrangements including infrastructure ownership and operation and maintenance of the new modes and their networks. This is also relates to the degree of separation from the heavy rail network achievable.
- Rolling Stock Requirements and fit with existing Valley lines Electrification and planned DMU Fleet replacement timescales. In particular, the opportunity to replace proposed cascaded stock with new tram – train and light rail transit over its remaining lifespan and whether tram train could replace some heavy rail stock at commencement of electric services.
- Whether to introduce new Tram Trains as a Low floor system or high floor system, if available at economic cost.

5.10 Whilst consideration has been given to broad capacities in preparing this report, detailed future passenger demand modelling and capacity calculations are required to ensure future network proposals fit with demand levels and to help determine fleet requirements to meet peak demand over the next 20 -40 years. There are also detailed technical considerations associated with each corridor which also need to be explored in more detail together with preparation of business cases to be able to confirm a final decision on the preferred mode by corridor.

References

The following information was used in the preparation of this report

Network Rail Passenger Rolling Stock RUS
Network RUS: Alternative Solutions (Draft for consultation)
Tram – Train Trial interim learning report (Network Rail)
Affordable Mass Transit (CfIT)
Tramway Technical Guidance Notes (ORR)
UK Tram Briefing Paper: Costs of Light Rail Schemes
UK Tram Advice Note for promoters considering a light rail scheme
UK Tram Advice Note for promoters considering ultra light rail
Manufacturer web sites

successful people, projects and performance

www.capitasymonds.co.uk

St David's House, Pascal Close, St Mellons, Cardiff, CF3 0LW Tel: 02920 803500

Supporting documents:

- Appendices to Main Report
- Metro Interventions Appraisal Report
- Metro Spatial Map
- Regeneration and The Metro
- Station Design Guidelines (Ebbw Vale)
- Metro Funding and Financing Independent Advice
- Metro Economic Impacts

Study led by Mark Barry of M&G Barry Consulting and included Capita, Powell Dobson Urbanists, Jones Lang LaSalle and Steer Davies Gleave

Jones Lang LaSalle
the urbanists a powelldobson company
M&G BARRY CONSULTING
CAPITA
steer davies gleave

www.metroconsortium.co.uk