TRAMS FOR BRISTOL

Building Back Better

PRE-FEASIBILITY STUDY

Building on the TfGB Rapid Transit Plan to propose a Primary Tram Network Phased over 10-15 years

Design by MikeWhelan.net

Published June 2021

LIGHTWEIGHT COMMUNITY TRANSPORT

LightRail (UK) Ltd

CONTENTS

1 INTRODUCTION AND SUMMARY 4

2 WHY TRAMS FOR BRISTOL? 7

2.1 The rapid transit challenge 7
2.2 Urban transport, carbon neutrality 2030 and toxic air pollution 8
2.3 Large-scale switch from car journeys to relieve congestion – to buses or trams or both? 11
2.4 The costs and benefits of tram-led and bus-led public transport 13
2.5 Evolving tram technology and costs- vehicles and track systems 14
2.6 Providing socially inclusive and active travel 18
2.7 Building back better with trams - the 21st century public transport game changer 19

3 TRANSPORT FOR GREATER BRISTOL RAPID TRANSIT PLAN 20

3.1 An integrated network of tram, local rail and bus services 20
3.2 A phased programme of indicative tram routes 21
3.3 TfGB Rapid Transit Plan 2020 and emerging WECA and BCC rapid transit policies 23
3.4 The further development of the TfGB Rapid Transit Plan 25

4 PRE-FEASIBILITY ASSESSMENT OF POTENTIAL STARTER TRAM LINES 26

4.1 Starter Line operational by 2026 29
4.2 Components of the pre-feasibility assessment method of 3 potential lines 32

5 PRE-FEASIBILITY LINE ASSESSMENTS 41

5.1 Phase 1 Line 1: M5 Junction 16 via Gloucester Rd A38 to City Centre Carousel Hub 42
5.2 Line 2: City Centre Carousel Hub via Bath Rd to Globe Inn Park + Ride 59
5.3 Line 3: City Centre Carousel Hub to Airport via Parson St Station and BS13 Circular 65

6 CONCLUSIONS & RECOMMENDATIONS 70

7 CREDITS 75

Index of Tramway Maps

Fig. 5 - Schematic Diagram 27
Fig. 6 – Proposed tram lines overlaid onto existing local rail and MetroBus BRT network 28
Tramway Map 1 Line 1 (north section) and Line 1a Cribbs Causeway Loop 46
Tramway Map 2 Line 1 Filton to Bristol Rovers FC 48
Tramway Map 3 Line 1 Bristol Rovers FC to Carousel Hub 49
Tramway Map 4 Line 1 City Centre Carousel Hub 52
Tramway Map 5 Line 1b Southmead Hospital Local Tramway Loop 58
Tramway Map 6 Line 2 to Bath, passing through Strategic Development Locations 62
Tramway Map 8 Line 2 and Line 2a Knowle-Callington Rd Hospital Local Tramway Loop 64
Tramway Map 9 Line 3 to Airport and Line 3a BS13 Bishopsworth - Imperial Park Circular 65

1 INTRODUCTION AND SUMMARY

This report is a contribution to the Zero West/Transport for Greater Bristol (TfGB) *Moving Bristol Forward* campaign to promote public awareness of the need for a transformational public transport system – one which effectively responds to the city's climate emergency and air quality crisis, is accessible to all, and delivers both improved public health and inclusive economic prosperity.

The project was commissioned from Lightweight Community Transport Ltd (LCT) who worked in partnership with Light Rail (UK) Ltd to prepare this report. Within the limits of a small grant, plus significant pro-bono inputs from both LCT and LR (UK) the project brief was to deliver a report with four components:

- the case for re-introducing trams as the core component of a 21st century sustainable public transport system for Bristol;
- an assessment of the contribution of the TfGB 2020 report Rapid Transit Plan for Bristol to the ongoing public transport debate in Bristol;
- a pre-feasibility assessment of two TfGB proposed pilot tram routes; and
- recommendations for Zero-West/TfGB's future work to promote a transformational public transport system for the Bristol city region.

Thus Section 2 draws on the contemporary debate about the scope and components of a sustainable public transport system. It presents the 'in principle' argument that a public transport system capable of drastically reducing pollution and congestion in Bristol cities must be a mass transit system based on a tram-plus-local train network, complemented by orbital Bus Rapid Transit (BRT) routes and feeder bus routes. Such a system would deliver, over a 5–15-year development period, a game-changing switch of a substantial proportion of passengers in major transport corridors from rubber-wheeled vehicles to 'steel-on-steel' vehicles. This approach to transforming public transport is proving increasingly successful in the UK cities that have developed and are now extending their tram networks, which are complemented by radically modernised local rail and bus services.

Within this perspective, Section 3 reviews the TfGB Rapid Transit Plan 2020 in terms of its contribution to the urgently needed transition from the 'in principle' case for a Bristol tram network to the practicalities of developing proposals for a tram network as the core component of a mass transit system for the Bristol city region. This assessment highlights the Plan's innovative strategic proposals for a fully integrated public transport system of tram, local rail and bus services. The potential viability of this strategy is demonstrated by its detailed identification of an indicative multi-modal network of public transport routes.

The review concludes that this substantial and professionally informed work makes a convincing case for the West of England Combined Authority (WECA) and the Bristol City Council (BCC) to undertake a full appraisal of the tram option for the busiest and most congested major transport corridors. This option should be compared systematically with the Bus Rapid Transit (BRT) option which has thus far dominated transport policy making and with any emerging proposals for underground rapid transit.

The section concludes by identifying key issues that need to be more fully developed by this pre-feasibility study, in order to support the Zero West/TfGB public transport campaign, in the context of the forthcoming WECA consultation on proposals for a city region mass transit system. The key nation-wide issues are the need to take on board the new science of non-exhaust emissions (NEE - tyre and road dust) and the emergence of a third generation of trams using innovative vehicle and track technology. The specific local issues are the need to build planned urban development more fully into passenger demand forecasting, take full account of the MetroBus and MetroRail network development programmes and develop sophisticated community engagement processes to generate public support.

Sections 4 and 5 take the TfGB advocacy of a tram network a stage further by creating a pre-feasibility study method and applying it to assess the practicality of installing tramlines three of the four most heavily congested and polluted radial corridor routes in the city. The outcome is a vision of the phased development of a Bristol Primary Tram Network. Section 4 sets out the key features of the assessment method developed for this project. It focuses on the Zero West/TfGB target of having first tramline in operation within 5 years as a Starter Line for the phased development of a Primary Tram Network over a period of 15 years.

Fig. 5 (p.16) shows a suggested Primary Tram Network with three first phase radial corridor routes, linked to a city entre Carousel Hub to provide cross-city connectivity, together with their second phase Local Tramway Loop Line extensions. Line 1 runs from a proposed Park + Ride at M5 junction 16, south via the Gloucester Rd A38 to, and including, the city centre Carousel Hub, with second phase Loop Lines 1a and 1b to Cribbs Causeway and Southmead Hospital respectively. This operational arrangement, facilitated by double track lines, could deliver a 6 trams per hour service throughout the shoulder operating period, Of the 6 hourly trams numbers 2, 4, and 6 would go round the Local Tramway Loops. Trams 1, 3 & 5 would maintain the mainline service but would be re-joined by trams 2, 4, and 6 for the journey along the Gloucester Rd. This operational practice would apply across the three lines and the Carousel.

Line 2 runs along the A4 Bath Rd from the Carousel Hub via Bristol Temple Meads to a proposed Park + Ride at Hicks Gate, and thence, via Keynsham and Saltford, to a second proposed Globe Inn Park + Ride. The second phase Line 2a is the Knowle-Callington Rd Hospital Local Tramway Loop.

At the request of Zero West the project also undertook an assessment of a third possible Line 3 to serve the BS13 area. As a second phase line, it goes from the Carousel Hub along the A38 to the A4174 where the BS13 Loop Line turns off to Imperial Park, Hartcliffe and Bishopston, to re-join the second phase A38 Line 3 to the airport.

Section 5 presents the results of applying the pre-feasibility study method to the three lines. The lines are presented on a Google Map base (with indicative tram stops) which shows the urban character of the catchment areas of the routes. An accompanying narrative focuses on the key components of the pre-feasibility assessments: potential passenger demand, the many issues involved in the re-allocation of road space - including tram track space requirements and standards and tramline navigation. Design standards for tram stops are set out and in appropriates locations they are conceived of as Community Transport Hubs, combining them with Bike+Ride and Scoot+Ride facilities. Where the opportunity arises, these hubs could be integrated with community-based neighbourhood plans which promote ‘low traffic neighbourhoods’ as part of ‘15-20-minute liveable neighbourhoods’.

The concluding section 6 provides suggestions for the further development of two interlinked dimensions of the ongoing Zero West/TfGB campaign. The next stage of the TfGB technical advocacy work will be to provide community-informed response to the summer 2021 WECA consultation on Mass Transit options. In parallel it will be essential to develop both city-wide and neighbourhood focused community engagement to generate public support for the re-introduction of trams.

2 WHY TRAMS FOR BRISTOL?

The interlocking environmental, economic, and social consequences of car dependent movement in the Bristol city region are increasingly unsustainable: high levels of fossil fuel consumption and toxic air pollution, congested roads and long journey times with their negative impacts on the city's economy, unequal access to reliable and affordable travel opportunities and low levels of active travel. This legacy of 20th century car-based city development can only be dealt with by making car travel the least attractive option rather than the first choice for most urban journeys.

Fig. 1 - Trams use road space more efficiently than buses or cars

1 tram = 3 buses = 177 cars

2.1 The rapid transit challenge

The creation of an integrated public transport system is an unavoidable necessity if people are to be persuaded to leave their cars for most trips. The experience of other UK cities provides evidence that a successful public transport network must be framed around a rapid (mass) transit system which:

- can move large numbers of people on journeys within the city and the wider city region;
- can run separately to other traffic;
- could include several different modes of transport - tram, train, and bus; and
- could run both overground and underground.

The key strategic transport policy issue facing Bristol now is the choice of the mix of public transport modes which will most effectively deal with the following range of contemporary urban issues.

In global health terms it is now widely understood that an effective response to the climate emergency requires the elimination of the fossil fuel consumption of the internal combustion engines used in cars, buses and other vehicles, which threatens the planet by generating tail pipe carbon dioxide (CO^2) emissions.

In public health terms there are three key issues:

1. toxic pollution from tailpipe emissions – NOx, CO, PM10 and unburnt fuel;
2. the not yet widely understood, but increasingly urgent, need to reduce damage to public health by reducing both the toxic air pollution caused by Non-Exhaust Emissions (NEE) from rubber tyre dust and the volume of micro-plastics released from tyre abrasion which enters surface water and contributes to marine plastic pollution; and
3. the increasingly understood need to improve levels of active travel - walking, cycling, and scootering.

In economic terms there are two key issues:

1. congestion, which worsens air pollution, results in unproductive time and exacerbates the inherent economic inefficiency of only *one* person per car[1], compared with some 70 passengers per bus and 200-300 in a tram; and
2. urban investment incentives provided by the permanence of tram lines and associated political commitment, which supports regeneration at appropriate locations along their length within the city, and enables large-scale city extensions which are not car-dependent.

In social terms there is both a general and a more specific issue:

- the need for lower income groups, an ageing population, people with disabilities, and people with babies and young children to have **equal access** to safe, reliable, and affordable travel - which provides better connectivity to jobs, schools, health and education facilities and to opportunities for leisure and recreation;
- the importance of eliminating '**travel poverty'** caused by people spending a disproportionate amount of their limited income on congested, long journeys from the south of the city to poorly paid jobs north of the river.

This section now argues that the development of 21st century public transport system, structured around a tram-led rapid transit system, integrated with local rail services and orbital bus services supported by feeder bus routes, will deliver the most effective response to the transport challenges posed by Bristol's longstanding dependency on car travel.

2.2 Urban transport, carbon neutrality 2030 and toxic air pollution.

The need to reduce the greenhouse gases produced by fossil fuel powered car and bus travel has been long understood by environmentalists and transport planners. After many years of campaigning the importance of dealing with CO^2 pollution now enjoys an increasingly high level of public awareness and is widely accepted by decision makers as an essential requirement for meeting climate change targets. This is reflected in the UK government's recent decision to bring forward its target date for the prohibiting the sale of new fossil fuel powered cars from 2040 to 2030.

[1] 80% of car journeys carry no passengers.

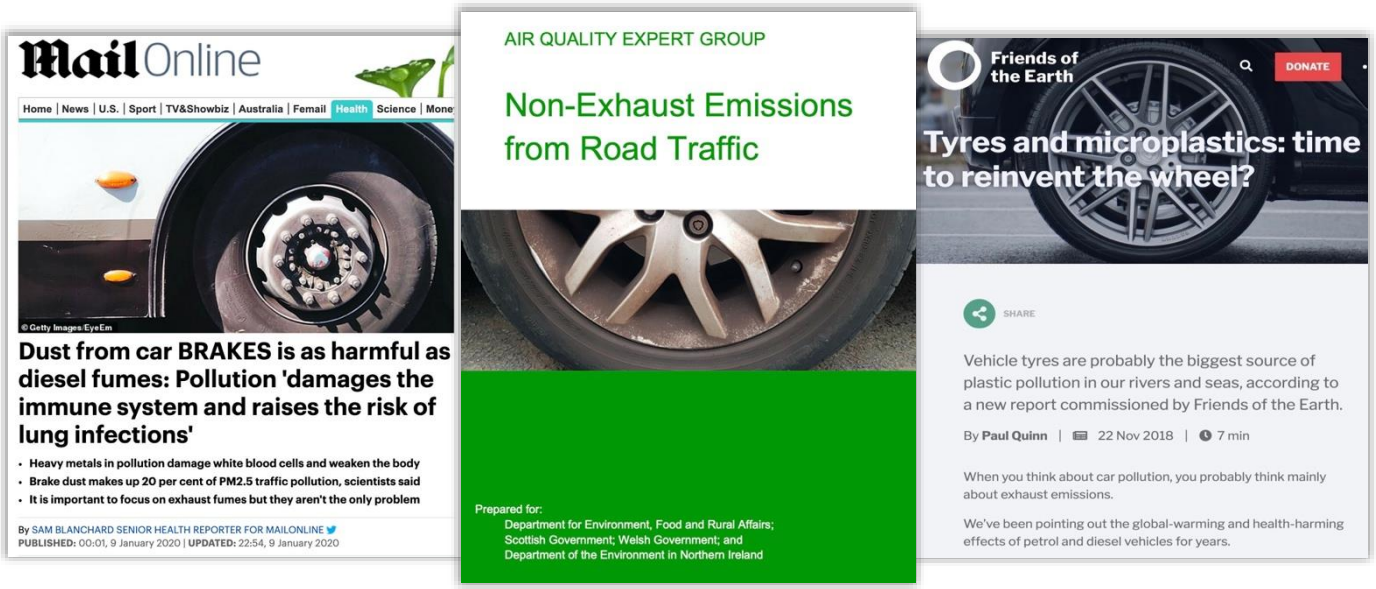
Tail-pipe emissions and climate change

Transport accounts for some 20% of Bristol's carbon emissions. The city will not meet its climate change target of carbon neutrality by 2030 unless it rapidly and substantially reduces the use of both fossil-fuelled cars and buses. The transition to electric vehicles (EVs) is now clearly gathering momentum. Electric cars and buses correctly labelled *'carbon neutral'* (but incorrectly labelled *'zero emission'*) will substantially reduce fossil fuel consumption by 2030.

In March 2021, the government pledged £12bn to deliver the National Bus Strategy target of a transition to zero carbon buses. But it should be noted that these new bus fleets will need replacing within 12-15 years - at the then higher prices. There is no equivalent 'National Tram Strategy'.

This transition to EVs will deliver a substantial reduction of CO^2 and NO^2 ***tail pipe emissions*** from the internal combustion engine and thus will contribute massively to the de-carbonisation of transport within the foreseeable future. It will also contribute to the improvement of air quality by reducing NO^2 emissions, particularly in urban transport corridors. Yet less than a decade ago such a transformation was widely regarded as unrealistically ambitious.

Toxic non-exhaust emissions (NEE)- the uncomfortable transport truth



Although EVs are correctly understood to be substantially 'carbon neutral', it is a dangerous misunderstanding to regard them as 'zero emission'. The uncomfortable truth is that whilst the transition to EVs will eventually eliminate CO^2 and NO^2 exhaust emissions, it will not reduce the damage to public health caused by the much more highly toxic ***non-exhaust emissions*** (NEE). These are the PM10 and PM2.5 particles which, together with 'fine particulates, are released into the air from tyre wear, brake wear, road surface wear and the resuspension of road dust by road vehicles. These pollutants produce localised climate change which is a public health risk and contribute to marine pollution.

But this critical air pollution issue is far less widely understood by politicians, planners, and the general public than the impact of CO^2 emissions on climate change. The urban pollution impact of NEE was initially known as **'the Oslo effect'**, when scientists in Norway first identified them in 1988. A strong UK campaign led by Light Rail UK (LR-UK) and the Light Rail Transit Association (LRTA) finally brought the issue to the attention of the UK government.

In 2019 an Air Quality Expert Group (AQEG) report to DEFRA on non-exhaust emissions radically updated scientific understanding of the toxic NEE air pollution generated by road transport, and its contribution to ambient particulate matter in the air associated with human ill-health and premature mortality.

The report points out that whilst legislation has been effective in driving down emissions of particles from the exhaust of internal combustion engine vehicles, the NEE proportion of road traffic emissions has increased.

> ***'To achieve further gains in PM2.5 and PM10 air quality in relation to road transport requires attention to reducing non-exhaust emissions, not solely a focus on exhaust emissions.'***[2]

Appropriate measures have been included in the current Environment Bill. However, the legislation has been delayed, but the weight of the scientific evidence will soon ensure the necessary reforms needed to put WHO air quality standards for NEE into law. In the meantime, a second report to government in 2021 identified **tyre wear as the largest source of micro-plastic pollution** in the UK. https://www.stantec.com/en/ideas/the-largest-source-of-microplastic-pollution-in-the-uk-tyre-wear.

The reduction of toxic NEE air pollution and micro-plastic pollution are new imperatives for urban transport policy, which require a major reduction in the miles travelled by rubber wheeled cars, buses and white van delivery vehicles servicing retail premises. The substantial reduction of car miles travelled in urban areas to reduce traffic congestion requires an attractive public transport system and an attractive, safe, direct and pollution free cycle network. The reduction of pollution from white delivery vans could also be reduced by the use of cargo trams for local freight distribution.

Whilst trams produce Fe pollution, steel particles are heavy, fall to earth and rust. Moreover, the use of regenerative braking systems means that block braking is only used to reduce speed from 5 mph to zero which reduces this form of pollution to insignificant levels,

But NEE production is directly proportional to vehicle weight. Buses are therefore especially problematic because electric buses with on-board batteries are 24% heavier and create 37% more NEE pollution than the fossil fuel powered buses they replace.

Thus, the effective reduction of NEE pollution and congestion requires a **'steel wheels on steel rails'** led public transport system (trams and trains) - with no pollution at point of use – rather than one dominated by fleets of 'low carbon' buses.[2]

In Bristol, recent research has revealed that 300+ people a year die from air pollution with many thousand more suffering serious health conditions caused by or worsened by levels of air pollution, which exceed WHO guidance. The annual cost of the health impact of air pollution in the city is estimated to be up to £170m. In 2019 the Mayor hosted an air pollution summit and emphasised *'…how vital it is to act quickly to improve health and save lives…'*[3]. The council has responded by establishing a ***Clean Air Zone.***

The city's emerging transport policies should now be more fully aligned with the strengthening of city's air quality policies, by introducing ***Low Emission Zones (LEZ***) and ***Automatic Number Plate Recognition (ANPR)*** systems.

2 Defra NEE Report July 2019 and a second report Micro Plastics in Road Transport March 2021
3 https://www.theguardian.com/environment/2019/nov/18/air-pollution-kills-bristol-health

This should be in the context of the Council formally recognizing the contradiction that, as the welcome transition to EV's progressively reduces the city's carbon footprint, the continuing high levels of private car use and bus-dominated public transport will increase the levels of toxic NEE pollution, particularly but not exclusively, along and in the vicinity of the city's major transport corridors.

This points clearly to the need for a public transport system for Bristol which is **'tram and train'** led and therefore genuinely **'emissions free at the point of use'.**

2.3 Large-scale switch from car journeys to relieve congestion – to buses or trams or both?

The need to drastically reduce the number car journeys to reduce toxic air pollution will soon be much more fully acknowledged, albeit reluctantly in the face of the car and bus lobbies. This will add significantly to the longer standing argument that reducing car journeys is the only realistic way to reduce traffic congestion, which worsens fuel consumption, increases air pollution, and has serious negative economic and social impacts.

Reduce congestion by building more roads?

But an enduring counter argument which remains is that the way to deal with congestion is to build more roads and improve existing roads to increase the capacity of the road network. This despite the fact that for many years transport analysts have demonstrated that building more roads increases the number of journeys which eventually leads back to congestion - the construction of London's orbital M25 being the textbook example.

Decades of accumulated evidence notwithstanding, the government has recently announced the biggest ever road building programme. But in the face of substantial criticism the government is struggling to reconcile this huge £27bn public investment in roads with its climate policies.

Bus-led public transport?

However, a more plausible current policy perspective is that the number of car journeys should be reduced by developing a bus-led public transport system which uses modernized bus fleets to deliver improved services. There will of course always be a need for car journeys where passenger demand is low, particularly in rural and semi-rural areas, and for some groups (not least blue badge holders) in urban areas.

Bus patronage has generally suffered a half-century long decline and in many cities and towns buses are regarded as a 'failed mode'. However, bus services will always be needed, particularly on the many local urban routes where passenger demand will not support a tram service.

The challenge is to improve the quality and affordability of these services, particularly for residents without a car. But even the most intensive bus service such as on the A45 Coventry Corridor, failed to achieve a greater modal switch than 9% and could not be sustained by the operator. A more typical level of modal switch is ±5%.

Prior to the pandemic, Bristol was experiencing continual growth in bus use and cycling, and walking levels had remained high compared with other major cities. In this context the Council launched ***Bristol Streets - Transport Corridor Improvements*** for 'rapid bus routes' in 2020[4]. This initiative has identified and prioritised a list of eight, mainly radial, transport corridor priorities and improvements will be delivered one corridor at a time. WECA has allocated £15m to be spent by 2023 with a further £15m from 2023 to 2027.

4 https://travelwest.info/projects/bristol-streets-transport-corridor-improvements

The programme was launched in March 2020 and preliminary work started on the first route – the A37/A4018 Transport Corridor following the No.2 bus route from Stockwood through the city centre to Cribbs Causeway. The work will focus on areas where congestion is a particular issue by re-allocating road space for both buses and cyclists, providing safe crossing points and attractive streetscapes and implementing traffic management measures to improve journey time and reliability. In these improved corridors the council takes the view that car users '… may choose to make the switch which will help reduce congestion and improve air quality'.

The key issue is whether such upgraded bus services can deliver the transformational modal shift from cars to public transport which is needed to substantially reduce urban congestion? The evidence suggests that they cannot: nationally only ±5% of increased bus passengers are former car drivers. The attractions of more comfortable 'carbon neutral green buses' travelling along improved transport corridors are unlikely to increase this figure significantly. Thus, most bus services will remain running on still congested roads which will continue to limit the frequency and reliability of their services. A limited increase in the percentage of former car drivers using rapid bus routes will affect only a small proportion of the total number of car travellers and will therefore not significantly reduce congestion.

The council recognises the limitations of these corridor improvements and is planning to build on them by developing plans for ***Bus Rapid Transit (BRT)*** services. Mass transit lines were included in the ***City Centre Framework*** adopted by the Council in 2020[5]. In the context of a city centre upgraded MetroBus loop, two BRT routes are proposed: one from the M32 through the city centre and south to Redcliffe and beyond; a second from Keynsham through the centre and out west via Harbourside. These routes '… *will use MetroBus for design life and then update to high quality tram style buses*.'

Running on segregated routes that are connected to Park + Ride sites, such BRT services may well increase the percentage shift from car travel to bus travel. However, with a capacity initially limited to 70 or so per bus and eventually 100 or so for 'tram style buses', it will need a large fleet of buses to move the huge number of passengers needed to reduce congestion. Nonetheless, it has very recently been reported that the most recent BRT service in the UK - the ***Bus Glider*** in Belfast - has attracted a higher than previously experienced percentage of former car drivers. This figure has been achieved by an intensive feeder bus system and according to DfT Northern Ireland has managed ±8% modal switch in the peak hours.

In sharp contrast to the limited and uncertain performance of modernised bus services, there is clear evidence from tram networks operating in other UK cities that an average of 25% of tram passengers have left a car at home for that trip, but not given up driving for other trips.

Thus, the need for such a transformative modal shift from car travel to public transport in order to substantially reduce congestion and pollution, points to a mass transit system which combines tramlines and local rail services.

However, given the 5–15-year timescale for constructing a tram network there is clearly a case for BRT to be deployed as an interim measure. In this scenario the two BRT routes identified in the City Centre Framework would be designated as Public Transport Pathways (PTP). They could use metro buses for their design life not to be succeeded by 'tram style buses', but to be converted to tram lines. It will be important to undertake 'before and after' impact studies of these BRT routes, to assess the extent to which they have attracted passengers who have switched from car use to buses.

[5] https://www.bristol.gov.uk/documents/20182/239443/City+Centre+Framework+June+2020.pdf/a6519cd3-96a1-34f6-e775-2442eac3410c

*Best practice in the UK and European countries points to a public transport system which combines **radial tram routes through the city centre** to provide cross city routes (supported by feeder bus services) **and upgraded BRT bus services on orbital routes**.*

2.4 The costs and benefits of tram-led and bus-led public transport

Operating costs

The cost of drivers dominates operating costs. One bus driver can serve up to 70 passengers whereas one tram driver can serve 200 plus. This means substantially **lower operating costs per kilometre** for trams compared with buses. In Croydon each tram carries 1.3m passengers per year, whereas London buses carry 0.3m passengers per year.[6]

Moreover, **trams are more energy-efficient than buses** - a significant economic advantage. Like modern battery driven electric buses, they use renewable energy rather than fossil fuels. But all rail systems have the huge advantage of low energy use because of the very low rolling resistance of steel wheel on steel rail. This inherent energy efficiency advantage is enhanced by the fact that trams are the most easily electrifiable and efficient form of transport, using one electrical conductor on the rail with a simple overhead wire to complete the circuit, giving very high energy efficiency of around 90%.

A tram needs less power per kilometre than a bus, because it is lighter per axle and does not carry its own energy supply. Even if the option of on-board power is used, the energy efficiency of low rolling resistance remains in play. This may well be important in heritage building Conservation Areas where overhead wires may be considered unacceptably intrusive.

Capital costs – vehicles and track

But the capital costs of tram infrastructure are clearly much higher than for buses. A tram vehicle - depending on the choice of technology - costs about 5-8 times more than a bus. However, modern high-quality buses have an operational life of 12-15 years on the front line before being 'cascaded' to secondary uses, such as peak extras and country routes[7]. In contrast, trams last over 30 years before being 'cascaded' to secondary uses - for example in Europe this process can extend the useful life of trams by a further 30 years (60 years in total). The trams in Sheffield are now nearly 30 years old and the Tyne & Wear Metro rail cars are only just being replaced after 40 years, albeit having had several refurbishments during that time - some Blackpool trams have been in operation for over a century. However, tracks have to be installed and eventually replaced - on average after about 30 years.

***Trams have higher capital costs but lower operating costs than buses**, so at some level of ridership trams become cheaper. The industry norm is that the crossover is about 1,800 – 2,000 passengers per hour. Thus, **on busy routes the costs are lower.**[8]*

6 https://publications.parliament.uk/pa/cm200405/cmselect/cmtran/378/37805.htm
7 Confederation of Passenger Transport Statement 2021 - https://www.cpt-uk.org
8 https://publications.parliament.uk/pa/cm200405/cmselect/cmtran/378/37805.htm

Fixed tram infrastructure and urban investment

There is significant and increasing evidence that the costly substantial fixed infrastructure brings important economic benefits which, to some extent, also offset the costs. This permanence is important for land use planning and stimulating commercial property investment along the route. Tram lines give both private and public sector investor confidence by providing long term certainty of predictable high levels of connectivity. In sharp contrast, bus services can be withdrawn at 90 days' notice. This physical infrastructure also provides a very visible and positive iconic image for the future of the city.

The importance of investor confidence is evidenced by the experience of tram networks in other cities. For example, in Croydon the tram network has generated substantial regeneration investment[9]. Similarly, the 2021 evaluation of the performance of the Manchester Metro has demonstrated inward investment of substantially more than would have been expected without the tram network. Moreover, house prices have increased significantly within 400m of tramlines.[10]

In addition to stimulating and supporting regeneration, tram networks can deliver major city extensions which are not car dependent e.g. Freiburg[11] in south-west Germany. Thus, tram transport is a potentially important part of the policy response to the increasing pressure to move on from the continuing development of car dependent estates.

2.5 Evolving tram technology and costs- vehicles and track systems

The oft quoted reason for the failure of successive governments to fund any new city tram networks since 2009 has been the high up-front capital cost of tram vehicles and tracks, compared with the cost of upgrading bus services and establishing Bus Rapid Transit (BRT) systems. Major tram infrastructure investment must be made over several years before paying passengers generate revenue.

The counter arguments set out above, that higher capital costs are offset by lower operating costs is based on the experience of tram systems currently operating in UK cities. However, emerging new tram technologies – for both vehicles and track systems - are set to **significantly reduce both capital costs and operating costs.**

Pre-formed track and pedestrian-friendly paving can simply be installed into a shallow trench on a "concrete float"
Example image shows rapid installation of prefabricated rail slabs with reclaimed cobble stones - placed evenly for comfortable walking. Optionally mounted on an elastic support to reduce noise and vibrations. Rails are welded together. Slabs fixed with fluid concrete. Suitable for rapid, night-time installation in areas accessible by large cranes.

9 J Siraut Economic and regeneration impacts of Croydon Tramlink, https://www.witpress.com/Secure/elibrary/papers/UT04/UT04085FU.pdf
10 Metrolink Phase 3 Monitoring and Evaluation. Second Report March 2021, https://tfgm.com/corporate/metrolink-phase-3
11 https://www.academyofurbanism.org.uk/freiburg-charter/

Tram technology evolved dramatically between the first generation of trams - which were taken out of service in the 1960s - and the second-generation trams which have come into use since the 1990s in Croydon, Nottingham, Sheffield, Tyne and Wear Metro-link, Manchester Metro, Edinburgh, and the Midland Metro. These second-generation trams are being continually improved and are being planned for use in extensions to tram networks. Thus, the Wednesbury to Brierley Hill Midland Metro extension, in the early stages of construction, is using conventional second-generation light rail technology. It has a budget of £450m+ to create 14km of track on a previous railway alignment - this is at a cost of around £32m per km.

However, a third generation of tram vehicle and track technology is emerging which is much more cost effective than second generation technology. This third-generation technology can be profiled as an interrelated package of innovations which include the following:

- **lighter vehicles** – typically 20 tonnes compared to the 40 tonnes currently in service
  - reduces fuel consumption and infrastructure wear
- **different track construction methods**
  - much shallower trenches for prefabricated installation
  - much less disturbance of utilities which are now accurately located by much improved ground radar technology sweeps, enabling selective decisions about the utilities which may need to be re-located and those which can remain
  - more rapid installation with no need for long periods of road closure
- **new propulsion systems**
  - improved Overhead Line Technology
  - larger capacity, better value, on-board energy storage systems - including batteries, flywheels, and super capacitors
  - wider range of fuels - including hydrogen and biomethane and the transition to greener electricity.

Thus, in sharp contrast to the costs of £25-£30m+ of current extensions to existing UK tram networks, the Coventry Very Light Rail (VLR) target costs are envisaged to be ***only £10m per km*** to provide a 70 passenger capacity shuttle tram system at an affordable cost, with a target operational date of 2023.[12] Moreover, the vehicles are planned to be operated without a driver in the longer run, which will dramatically reduce operating costs. This technology could possibly be applied in the development of a Bristol tram network if one or more shuttle services are eventually incorporated in the system, for example as part of the long-term development of the Cribbs-Patchway New Neighbourhood (CPNN) on the former Filton Airfield site, or to serve the North East Keynsham urban extension.

There are third generation trams which are available now which illustrate the type of vehicle which may be used for a future Bristol tram network. A Trampower City Class tram with a capacity of 200 passengers has been fully tested and operated for a year in Blackpool. It can operate with overhead lines or with on-board power if required. The Californian TiG/m has a carrying capacity of 100-300 passengers - in semi-autonomous mode. It is currently operational in Doha. It can run with overhead lines or on-board power.

[12] N Small & N Mallinson *VLR Coventry's Vision for Future Mobility* Tramways and Urban Transit (TAUT) September 2020

Fig. 2 - Examples of Third-Generation "Ultra" or "Very Light Rail"

Power Supply Options: Simplified Overhead Lines (OHL) or Self-propelled
On-board electricity generation options include: Battery, Hydrogen, CNG, LPG, Bio-diesel, Biomethane

Compact example 1: Coventry VLR Shuttle
Capacity: 50 (20 seated)

Manufacturer: Consortium incl. TDI, Transcal, etc.
Based in the Midlands, UK

Compact example 2: TiG/m MRV-3
3 x 100 passenger vehicles operated by one 'driver' using semi-autonomous control

Manufacturer: TiG/m
Based in California, operate internationally

Articulated example 1: Trampower City Class
Capacity: 200

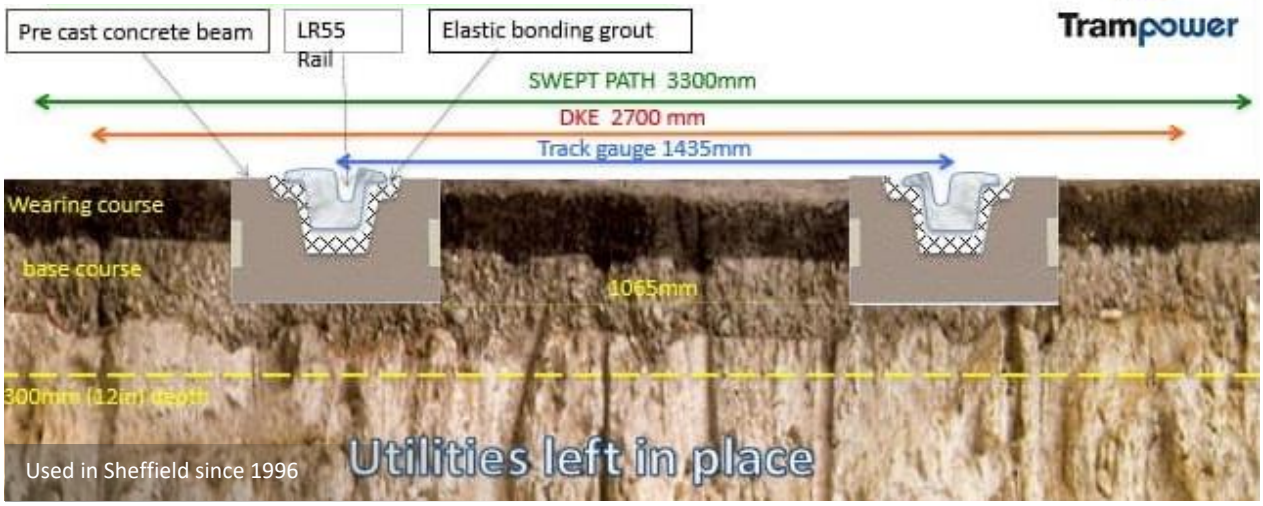
Manufacturer: Trampower Ltd
Based in Merseyside, UK

Articulated example 2: TiG/m MRV-4
Capacity: 200

Manufacturer: TiG/m
Based in California, operate internationally

Trampower LR55 Rapid Track Installation Steps:

1: cut small recess, 2: glue foundation beams, 3: glue rails



LR55 "glue-in-road" tracks by Trampower Ltd
Wholesale road closure is not required and installation can be done outside peak hours.

The conventional wisdom of second-generation tram technology is that the installation of track requires the relocation of all utilities (gas and water mains etc.), typically adding at least 25% to the cost of the tramway. The contrast with third generation technology is illustrated by Trampower Ltd who are confident that they can install a tramline in Southwark at much lower costs, using LR55 'glue-in' track technology. This technology does not require the closure of the road in which the track is being installed and does not require the re-location of all utilities. It can be installed at the rate of 100 m per week, without the need for complete closure of any roads and by keeping traffic moving by temporary management measures (see **Fig. 2** above). LR55 tracks have been in service since 1996 on a section of the Sheffield tramway, **without the need for any maintenance**

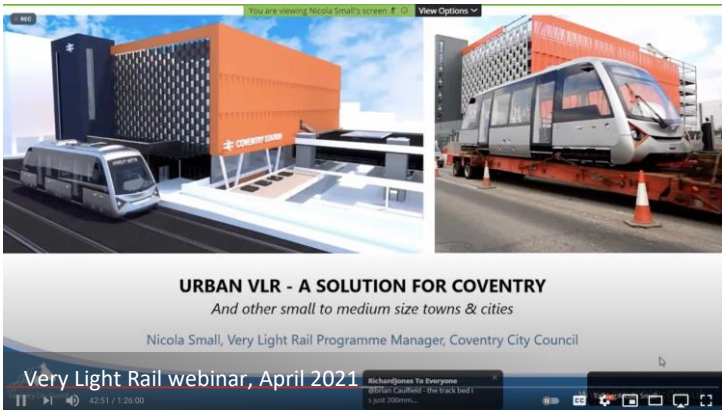
Moreover, autonomous guided trams may soon further drastically reduce operating costs. Already the TiG/m tram is operating a computer linked system in Doha which enables 1 driver to simultaneously operate three x 100 passenger trams.

Thus, there is a very real prospect that the costs of third generation trams and track systems could be less than half those of the second-generation technology.

Finally, both Trampower and TiG/m are clear that their reduced capital and operating costs in relation to revenue from fares and sponsorship mean that their tramline projects will give a high rate of return which will enable them to be financed entirely by private sector investors.

The Southwark Supertram project. which Trampower Ltd are currently discussing with LB Southwark illustrates the key features of third generation tram and track technology. www.southwark-supertram.co.uk

It is essential that WECA and BCC fully evaluate the prospective impact of these new technologies on the relative costs and benefits of a tram-led / bus-led rapid transit system for Bristol.



A recent webinar featuring presentations by several of the main proponents of 3rd-gen technologies including Coventry VLR and TiG/m is available at: https://youtu.be/ITnpNhfL_GE

2.6 Providing socially inclusive and active travel

From the point of view of overall tram network design, it is important that the phased development takes account of the need to serve lower income city neighbourhoods, as well as enabling long distance commuters to switch from their cars to trams. This involves the recognition and identification of *transport poverty*, for example in BS13, where many residents spend a disproportionate amount of their income travelling long distances through the city centre to employment centres such as Avonmouth.

Tram networks serve a diversity of passenger groups more flexibly than buses.

Similarly, the importance of 'hop-on' and 'hop-off' tram journeys on the main transport corridors should be considered in the calculation of passenger demand. At peak hours, the priority for shortening commuter journey times will require the operation of limited stop services. However, outside peak hours, stops could be more frequent. This would respond to what is being recognized in the industry as the "Rochdale Pattern' – the number of short journeys recorded on the Manchester Metro line between Manchester Victoria and Rochdale town centre. The line is catering for people on local shopping trips or day-time visits to leisure and cultural facilities.

Trams serve a wide diversity of passengers and are required to be DDA compliant[13] to higher standards than buses.

Trams provide easier, level boarding access for people with disabilities or reduced mobility and multiple spaces for shopping bags, push chairs, wheelchairs and walking aids. They also provide spaces for cycles, albeit in limited numbers. For a diverse range of passengers, trams provide a welcomed smoother ride. All these qualities combine to generate much higher levels of passenger satisfaction than buses.[14]

These factors are instrumental in persuading a range of both commuters and travellers using their cars for day-to-day shorter trips to leave their cars at home for many of their journeys.

Moreover, the attractiveness of the tram is important in terms of promoting and facilitating more active travel. Thus, it is important to design walking, cycling and scootering networks within neighbourhoods with routes which provide access to the tram network, where tram stops are provided with cycle and ride and scootering and ride facilities.

13 Disability & Discrimination Act 1995
14 Transport Focus Light Rail and Tram Statistics England 2018/19-gov,uk , https://assets,publishing,service.gov.uk

2.7 Building back better with trams- the 21st century public transport game changer

Transport is both the maker and breaker of cities. The public tram network played a major role in the making of Bristol until the first generation of trams were superseded by buses and private cars. Many of the city's streets and their adjacent neighbourhood were built along tram routes. The massive post war growth in car ownership drove and continues to drive the decline of bus-led public transport. Cars are now threatening to break Bristol.

The game-changing re-introduction of the tram network, which may include both second-generation conventional trams now operating in most major UK cities and the emerging third generation of ultra-light trams, would be the making of 21st century post-pandemic Bristol.

The phased re-introduction of a tram network would be fully integrated with and complement the acceleration of the ongoing upgrading of the city's local rail network. Thus, the rapid transit component of the public transport system would be provided predominantly by 'steel on steel', primarily radial tramlines, integrated with TramTrain, or local train services. But this would be in the context of Interim BRT routes in major traffic corridors which would eventually be upgraded to tramways, and modernised bus services on routes where demand is insufficient for trams. The tram and bus routes would be fed by the systematic provision of routes for cyclists and pedestrians to promote active travel.

This section has demonstrated that there is an overwhelming 'in principle' case for the development of a such a public transport system for Bristol. But to date the only effort in the public domain which examines how this 'in principle' case could be put into practice in Bristol is the TfGB Rapid Transit Plan 2020.

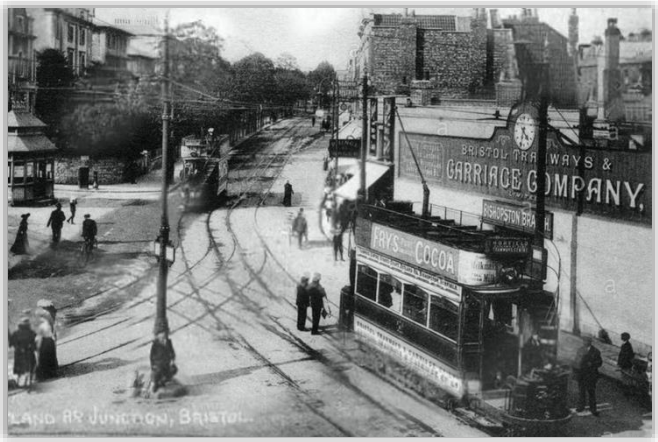


Fig. 3 - First generation technology | Potential third generation technology
Junction of A38 Gloucester Rd and Zetland Rd

3 TRANSPORT FOR GREATER BRISTOL RAPID TRANSIT PLAN

Bristol's dependency on private car use is unsustainable. People must be persuaded to get out of their cars and on to public transport for most of their journeys, in the context of incentives for increasing active travel. Public transport must become the attractive alternative to the car. It is now fully acknowledged by policy makers in the Bristol city region that a network of mass transit routes is essential to reduce congestion and pollution to the level needed to meet contemporary climate change and air quality targets and in doing so promote socially inclusive economic prosperity.

The fundamental policy issue for WECA, as the transport authority, is the strategic choice of rapid transit system for the future public transport network. The basic options are a Bus Rapid Transit (BRT) led system using segregated bus lanes in combination with upgraded local rail services, or a tram-led system using re-allocated road space (supplemented by tram-trains running partly on roads and partly on railway lines), combined with upgraded local rail services.

For some routes, one option is the interim provision of a Bus Rapid Transit service, with a planned subsequent upgrade to a tramway as the tram network evolves and expands. A tram-led system focused on radial arterial transport corridors will need to be complemented by BRT services on orbital routes and by feeder bus routes to the tramways to extend their geographical reach.

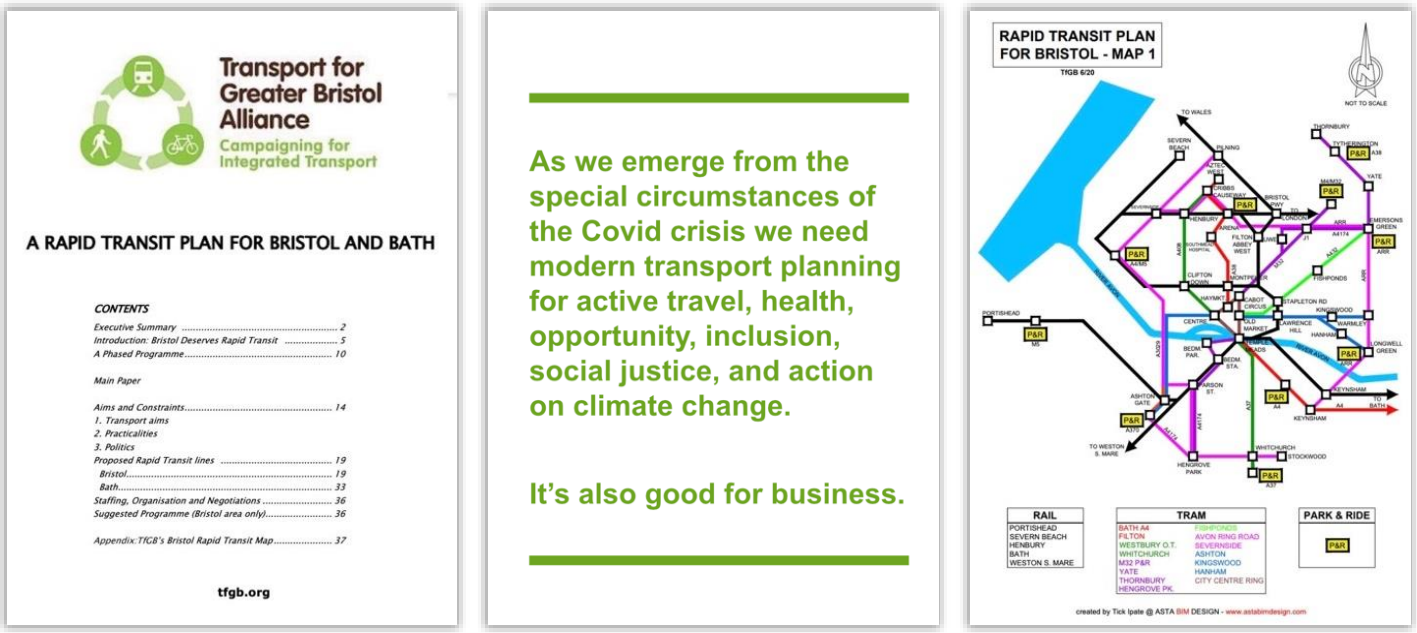


Fig. 4 - TfGB Bristol-Bath Rapid-Transit-Plan pdf

3.1 An integrated network of tram, local rail and bus services

In this context, as a voluntary and independent campaigning group, TfGB have used their technical skills and detailed understanding of the transport geography of the city to create an outline *Rapid Transit Plan 2020.* This argues the case for a tram and train-led rapid transit system complemented by an expanded MetroBus network and feeder bus routes and outlines an indicative network of some 20 potential rapid transit routes. The TfGB rapid transit network is illustrated schematically in **Fig. 5**, in relation to a proposed expanded provision of park and ride facilities.

Thus, the Plan proposes returning several strategic freight lines to passenger use, including those to Portishead, Avonmouth and Tytherington, together with upgrading existing rail services to Bath and Weston Super Mare. It acknowledges the planned MetroWest upgrading of local rail services, but doubts that the prospective services will take sufficient people out of their cars. The Plan also acknowledges the need for the continued development of some radial and orbital bus services, using dedicated bus lanes and bus priority traffic signals - not least on routes which are not sufficiently busy to warrant a tram service - or as an interim measure pending an upgrade to a tramway.

But the ground-breaking innovation of the Plan is its core proposal that several of the most congested major roads should be developed as on-street tram rapid transit routes. These would be connected to a network of more localised tram lines and linked to an improved rail system and serviced by feeder buses on less busy routes. These rapid transport corridor routes would be supplemented by the eventual re-purposing of some major commuter roads to include tramways, notably the M32 and the A4174 (Avon Ring Rd).

In principle this approach has two decisive strategic advantages over the BRT-led option. First, as summarized in section 2 above, the evidence from existing tram networks, in similar sized UK cities, is that the tram-led rapid transit option attracts substantially more people from their cars on to public transport than BRT. It therefore more effectively reduces congestion which, by reducing idling time, would also reduce pollution from tail-pipe emissions. In particular, a higher proportion of longer distance commuters would be likely to use the proposed increase in the strategically located and expanded Park + Ride facilities.

Second, in combination with improved rail services, a tram network would shift the balance of Bristol's public transport away from a reliance on rubber-wheeled buses generating toxic non-exhaust emissions (NEE) to a system dominated by more energy efficient 'steel-on-steel' railways and tramways with no toxic emissions. This issue is not dealt with in the BRT Plan.

Thus, as the Plan continues to evolve, the case for trams should be strengthened by emphasising the contribution of tram-led rapid transit to the improvement of air quality. The choice of priority transport corridors should be explicitly informed by and linked to the very high concentration of pollution shown along the main arterial roads in the BCC Air Quality Management Area map.

More fundamentally, the issue of continuing and increasing non-exhaust emissions (NEE) from buses must be built into the TfGB Rapid Transit Plan, especially as battery-driven 'zero-carbon' buses are heavier than the conventional buses they will replace and thus generate more toxic NEE emissions.

3.2 A phased programme of indicative tram routes

The Plan applies the principles of an integrated tram-led strategy at route level to catalogue a comprehensive schedule of some 20 potential rapid transit routes, each described in a brief note. The list includes more than a dozen proposed tram lines - most of them are tram upgrades of current bus routes and many follow fairly closely the city's former on-street tram network. The tram routes are connected to upgraded suburban and heavy rail lines and include some important TramTrain proposals.

In addition, drawing on the TfGB Bus Plan[15], the proposed rapid transit routes are complemented by proposals for Metro-bus orbital lines (inner ring, middle ring and outer ring) and sub-radial bus routes. Moreover, the Rapid Transit Plan stresses the need to complement these major bus services with an innovative network of bus feeders for the tram and rail network, including circuit routes for the single-decker buses and/or mini-buses - such as those successfully used by Community Transport.

The Plan rightly envisages the phased construction of the proposed tram network in a carefully planned and prioritized programme over a decade or more, with each line building on the success of previous ones. This timeline is consistent with the recent experience of modern tram network construction in other UK cities. But from the point of view of promoting effective community engagement to generate public support for the re-introduction of trams.

Moreover, the emphasis on the crucial importance of selecting the first line that is relatively straightforward to deliver, with the expectation that a successful first service will generate strong support for network extensions, also chimes with the evidence of the need to 'get it right first time' in other cities.

The phasing was expressed in two tranches, which, following WECA terminology, was referred to collectively as ***MetroWest***. The first schemes will build on Bristol's bus and rail network and include a Severnside tramline, on a route to be initially developed as an interim MetroBus service, alongside trial services on orbital MetroBus routes and improvements to three local rail lines.

The second tranche proposes the re-establishment of a tram an extensive tram network in Bristol, 'requiring a longer design time and greater political will' (p11). This is comprised of four proposed tram lines: the re-purposing of the M32 as tram line after a period as a MetroBus route; a line from Aztec West to the city centre, to be subsequently extended as a city centre circuit; a tram upgrade of MetroBus Route M1 from Hengrove Park to Temple Meads and a tram line from Temple Meads along the A4 to Bath.

The Plan is a substantial achievement. It deserves to be recognized and drawn on as a significant and positive contribution to the ongoing development of proposals for a Bristol Rapid Transit network. It makes a strong 'in principle' case for a game-changing re-introduction of trams in Bristol and by identifying a comprehensive list of potential routes takes the first major step towards the design and delivery of a 21st century tram network.

The authors state '*our Plan is not final or complete. It cannot be. It is well considered and indicative and needs to be developed and implemented by a team of professional planners supported by political commitment by decision makers' (p2) and '…it is not the answer, but it is a start'.* Both these statements stand up to scrutiny, especially as it is clear the Plan is a living document.

The Plan establishes a convincing case for major policy making resources to be allocated to a full appraisal of the trams and local rail option for major, heavily trafficked transport corridors to be rigorously evaluated against a bus-led Bus Rapid Transit BRT and the provision of underground rapid transit services, both of which currently have significant political and professional support.

15 https://tfgb.org/wp-content/uploads/2020/08/TfGB-Bus-Plan-revised-2020.pdf

3.3 TfGB Rapid Transit Plan 2020 and emerging WECA and BCC rapid transit policies

Transport policymaking for the Bristol city region is led by the West of England Combined Authority (WECA) working with Bristol, Bath and North East Somerset, North Somerset and South Gloucestershire councils. The emerging *Joint Local Transport Strategy (JLTP*) obviously needs to make the maximum extent possible contribution to the realisation of the *BCC One City Climate Change Action Plan* target of carbon neutrality by 2030, not least by facilitating the shift to electric vehicles to reduce CO^2 emissions.

Evolving transport policies need to be fully aligned with the existing and emerging *spatial development strategies* of the constituent WECA planning authorities. These strategies will guide the implementation of mixed-use regeneration projects on inner city brownfield sites and substantial housing and employment developments in suburban and peripheral locations, both within and outside the city boundaries.

The Bristol city region will experience substantial growth during the next 10-15 years - driven by its dynamic economy and central government pressure to meet housing delivery targets. Thus, urban regeneration and expansion will have a major impact on future patterns of passenger demand and without an effective rapid transit system it will not be possible to manage this growth, in a way which will significantly reduce current unacceptable levels of congestion and pollution.

The recently published *Bristol Public Transport Network Vision* [16] presents indicative rapid transit routes which are strikingly similar to those proposed in the TfGB Plan. The orange lines are flexibly described as *'over or underground rapid routes'*.

The underground option has a significant level of political support and has attracted local publicity. But it is highly unlikely that a feasibility study will demonstrate the viability of an extremely expensive underground component.

It should be remembered that in 1987 an Act of Parliament was obtained to build the Avon Metro Underground, but it did not progress because it was not economically viable.

> A Bristol underground is likely to cost at least twice and possibly up to ten times more per kilometer than a tramway.

16 www.bristol.gov.uk/streets-travel/mass-transit-public-transport-plans

Moreover, although travel speeds are higher than surface tramways, underground lines do not achieve the same level of modal switch from cars. This is because the stops are further apart, which reduces their catchment area for people walking acceptable distances to use them and most trips are less than 3 miles.

The prospects of an underground component seem to be rendered increasingly unlikely by the recent announcement that Transport for London (with powers and resources that greatly exceed those of WECA) has recently postponed the extension of the underground further into north Southwark. The Council agreed in March to review the option of a tramline – the privately financed *Southwark Supertram*[17] proposed by Trampower Ltd in the context of the need to act as soon as possible to relieve congestion and pollution in the areas.

The possibility of re-introducing trams will soon become a matter of major public interest when BCC and WECA engage in extensive and formal public consultations on emerging proposals for the future of the Bristol public transport network. From summer 2021 policy choices about rapid transit for Bristol will be in the public domain and high on the agenda of local politicians. In this context it will be important that the development of the TfGB Rapid Transit Plan links its strategies proposals more explicitly to both the existing strategic land use planning policies of BCC and the emerging transport policies of BCC and WECA.

This is the rapidly evolving policy making context of the Zero West and TfGB collaborative campaign project *Moving Bristol Forward* which is promoting a tram-led public transport system. Our project was commissioned firstly to fully articulate the 'in principle' case for a Bristol tram network. Secondly, the project was designed to help the TfGB Rapid Transit Plan to move to its next stage by undertaking a pre-feasibility assessment of two of its potential pilot routes – from the north to the city centre, and from Bath to the city centre. In addition, we were asked to identify and assess a route from the airport to the city centre which would serve some of the low-income neighbourhoods in the BS13 area.

However, whilst the TfGB Rapid Transit Plan acknowledges that the implementation of a tram-led rapid transit system will need to demonstrate public support which will require *'maximum public involvement from the start, using suitably attractive materials to convey the essential ideas*' (p18) it went no further. However, the initial community engagement work undertaken by Zero West has indicated potentially strong public support for the preliminary consideration of a third potential pilot/starter route from the city to BS13.

17 www.Southwark-Supertram.co.uk

3.4 The further development of the TfGB Rapid Transit Plan

Section 2 of this report has provided the basis for strengthening the 'in principle' case for trams in the further development of the 2020 TfGB Plan. The key themes and issues which this study has developed to take the TfGB Rapid Transit Plan to the next level can be summarised as follows:

- The need to take fully into account the air pollution challenges for mass transit which recent and evolving scientific research on non-exhaust emissions of tyre dust has brought into policy debates and draft legislation – raising the very real prospect of restrictions on the use of rubber wheeled buses, especially in busy urban transport corridors;
- The emergence of a third-generation tram technology – vehicles and tracks - which potentially reduces the cost per km of tramway installation by up to 50%;
- the importance of building planned urban growth and regeneration into assessment of passenger demand, which requires the full integration of spatial development planning and transport planning;
- the need to fully build on the progress of the planned and committed programmes to develop the MetroBus and Metrolink networks; and
- the critical importance of effective public consultation and effective community engagement in the tramway development process at all stages – over a 5-7 year period from pre-feasibility studies to the receipt of the first fares on the first line.

These issues have been addressed in this pre-feasibility study designed for this project to further develop TfGB 2020 Rapid Transit Plan. Section 4 develops proposals for a phased development of a Bristol Primary Tram Network such that it is consistent with the legally required procedures for the construction of tramlines and includes a proposal for the first tramline to be operational by 2026. Section 5 applies the pre-feasibility methodology developed for this project to assess the case for the three potential tram lines to be included in the proposed Bristol Primary Tram network and taken forward to the feasibility study stage.

4 Pre-Feasibility Assessment of Potential Starter Tram Lines

The 'in principle' case for a tram-led rapid transit system was presented in section 2 of this report. The brief review of the TfGB Rapid Transit Plan in section 3 concluded that it had made considerable progress towards applying the 'in principle' case to Bristol. This section takes forward the development of the TfGB Plan by proposing a three phased development of a Bristol Primary Tram network which includes the Zero West/TfGB target of an operational tramline by 2026 and is consistent with the statutory procedures which govern the tram line development process. It then sets out the components of the pre-feasibility assessment method for the three tramlines included in the **Proposed Primary Tram Network shown** in Fig. 5 Schematic Diagram**.** On the following page, Fig. 6 shows the proposed tramlines in relation to the evolving MetroBus BRT network and the rail network.

The development and application of the assessment method for this limited study took place under Covid restrictions which prevented on-site visits. This meant inevitably time-consuming reliance on Google Earth and route-planning software, complemented by Zoom meetings with Zero West and TfGB colleagues who provided transport planning insights, community engagement experience and essential local knowledge.

The purpose of this pre-feasibility study is to test the suitability of the proposed Phase 1 routes for full feasibility studies. The outcome of the application of the pre-feasibility method is set out in Section 5 which indicates that there are no engineering, re-allocation of road space, or traffic management issues which would preclude the provision of an on-street tramway along each of the three routes - there are no apparent showstoppers. However, in some locations space will be tight. This will require an imaginative combination of tramway design and traffic management along the three routes (including residents only parking), linked to the choice of vehicle technology - the type of tram and track.

Moreover, four sets of parallel measures will be necessary to reduce traffic levels on the proposed radial tram routes:

1. an acceleration of the Metro-West programme to upgrade the city's underutilised suburban rail network which will be progressively integrated with the evolving tram network;
2. a co-ordinated programme of peripheral Park + Ride sites;
3. a city centre Workplace Parking Levy, together with Residents Only Parking Zones; and
4. a network of cycle ways supported by Bike + Ride and Scoot + Ride stops along the radial tramways.

Fig. 5 - Schematic Diagram of Proposed Primary Tram Network

Tram stops are spaced every 400m (approx.) - within cycling and walking distance of substantial residential catchment areas with easy access to major retail and employment locations, health, and educational facilities, both existing and planned, and the local rail network.

Tram stops are co-located with bus feeder-stops, 'bike+ride' and 'scoot+ride' facilities to provide 'community transport hubs' which attract tram passengers and encourage active travel within adjacent 15–20-minute liveable neighbourhoods.

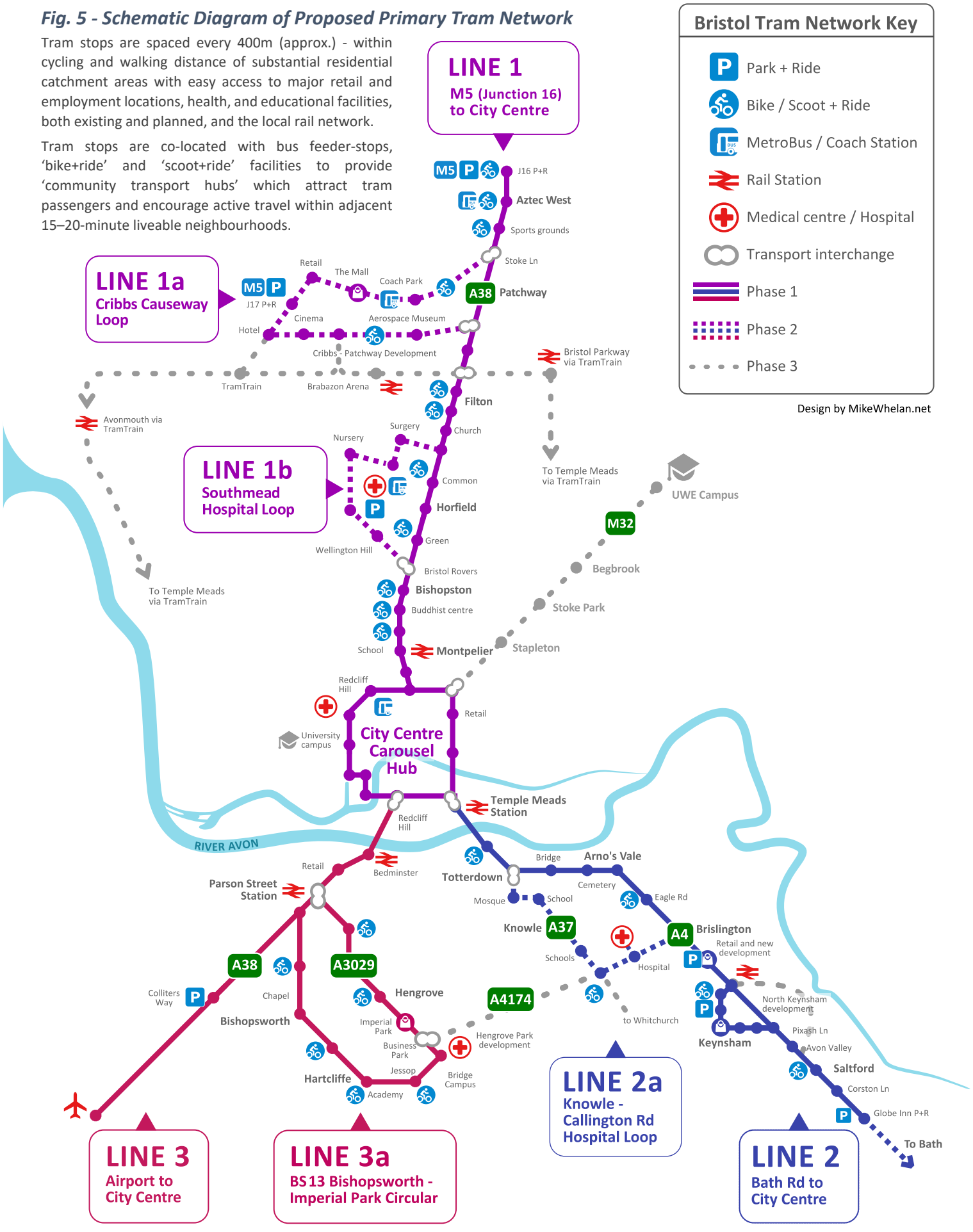
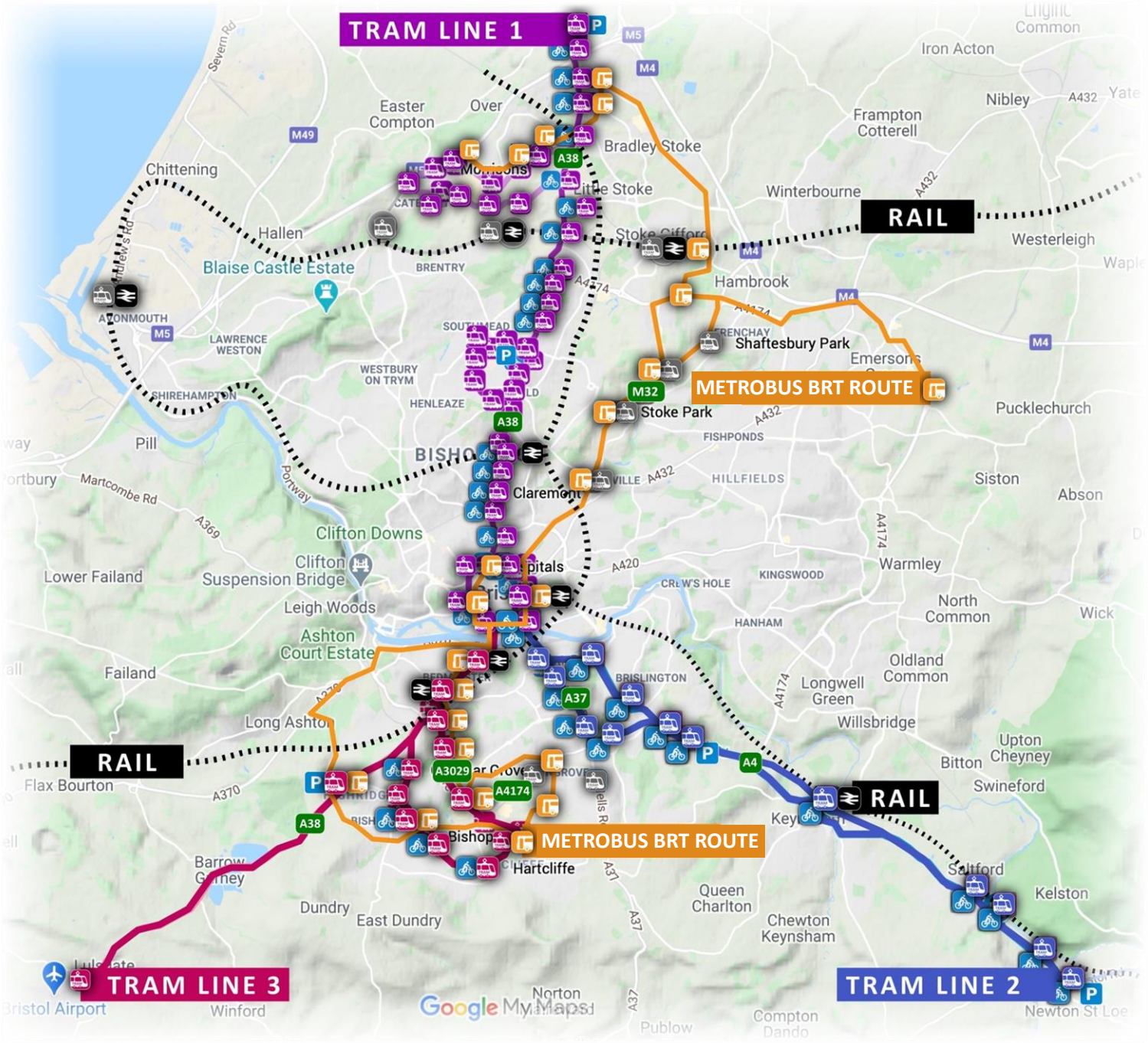


Fig. 6 – Proposed tram lines overlaid onto existing local rail and MetroBus BRT network



4.1 Starter Line operational by 2026

The Zero West/TfGB alliance campaign aims to see Bristol's first tram line in operation within 5 years. The selection of the first tramline will be crucial. Experience in other UK cities and abroad shows that the popularity of the first line has invariably led to public pressure for line extensions. For example, the construction of the first Edinburgh tram line was initially highly controversial, essentially because of poor decision making and project management. However, the city to airport line eventually proved very successful. It has carried 6.5 million passengers over its 9-mile length and made a profit. This resulted in public pressure for the extension of the network, such that construction has begun on Line 2 to Leith and beyond, as the first stage in a major network expansion. All the other tram networks in the UK have experienced similar political and public pressures for network extension following the successful operation of the first line. This network expansion process has been sustained over a number of years, as exemplified by the ongoing extension of the Midlands Metro into east Birmingham. In simple terms, experience of the quality of the service changes attitudes from *'we don't want it where we live'* to *'when can we have one?'*

Thus, it will be essential to choose a first tramline as the **Starter Line to be delivered by 2026-27**, in the context of a proposed **Primary Tram Network** designed to be of sufficient scale to generate a major reduction in car use, which would be predicted to exceed that of a Bus Rapid Transit network.

The first tram line needs to reduce more pollution and congestion than buses

However, during this period the ongoing development of the MetroBus network would provide interim improvements in connectivity on routes to be upgraded to tramways and orbital routes which would supplement the radial Primary Tram network.

The progressive delivery of the three primary network routes by 2031 would demonstrate the case for the implementation of phases 2 and 3 in the period 2031-2040 to deliver the **Bristol City Region Tram Network**, with the capacity to deliver the dramatic reduction in the use of rubber-wheeled EV cars and buses that is essential to deal with pollution, congestion, and unequal access to public transport travel opportunities.

The 2020 TfGB Plan identified four possible 'pilot' tram lines. The initial brief for this study was to assess two of them, both major corridor routes for commuters from outside the city: the Gloucester Rd (A38) from the M5 to a City Centre Circuit/Carousel, and the Bath Rd (A4) from the city centre to the city boundary and beyond to Bath. This brief was extended to include a third route from the city centre to the airport, but via a BS13 circular route from Bedminster, Parson St Station, Bishopsworth and to Hengrove Park and Imperial Park - returning to the city centre via the A3029. The purpose of the circular route is to provide access to high quality public transport for both the lower income neighbourhoods on the route and the growth area of Hengrove Park.

Fig. 5 shows the proposed Primary Tram Network with three first phase Lines 1, 2 & 3 along the radial corridor routes linked to a city centre Carousel Hub to provide cross-city routes, with their second phase local tramway loops off Lines 1 & 2. In addition, the M32 is proposed as an interim BRT route which would eventually be re-purposed as a tram route.

LINE 1
M5 Junction 16 via Gloucester Rd
to City Centre Carousel Hub
± 10.5 km

Line 1a
Cribbs Causeway
Local Tramway Loop
± 7.5 km

Line 1b
Southmead Hospital Local
Tramway Loop
± 3.2 km

City Centre Carousel Hub
± 4.1 km

LINE 2
A4 Bath Rd Globe Inn Park+ Ride
to City Centre Carousel Hub
± 13.7 km

Line 2a
Knowle - Callington Rd Hospital
Local Tramway Loop
± 3.7 km

LINE 3
Airport
to City Centre Carousel Hub
± 11.6 km

Line 3a
BS13 Circular from Parson St
Station to Imperial Parkway
± 8.2 km

All three tramlines would be street running, sharing with other vehicles as appropriate, but with traffic management priority for trams.

Thus, this proposed network builds on the TfGB Plan which rightly emphasizes the crucial importance of phasing the transformation of Bristol's public transport system, in the context of integrating the proposed Bristol Tram Network with the MetroWest suburban rail network and MetroBus routes.

The TFGB Tranche 1 initial Schemes propose the accelerated upgrading of existing MetroWest local rail lines and the development of MetroBus orbital bus routes, all envisaged as delivering a challenging 10–15-minute frequency 'to rival the car alternative'. The TfGB Plan proposes the delivery of some of these upgraded schemes within 5 years, with potential future conversion to tram lines.

Tranche 2 is the proposal for *'...**re-establishing a tram system**....'* which will require *'... longer design time and greater political will'* (p11) but gave no further information on the tram system development processes involved. The seven proposed priority routes include the MetroWest Filton Line and the MetroWest City Centre Ring which, in combination, have much the same alignment as Line 1 M5-City Centre. The MetroWest Bath Line is similar to Line 2. However, there is much less common alignment between the MetroWest Hengrove Park Line and Line 3.

The prospects of delivering the Zero-West/TfGB target of a **Starter Tramline within 5 years,** to kickstart the renaissance of a Bristol tram system, will be governed by a tram system development process that is dominated by statutory consents and funding procedures which can be summarized in four stages:

Stage 1: from Pre-feasibility Study (to identify starter routes), through Feasibility Study (routes evaluation and selection of preferred routes) to ***First Stage Consultation*** (on the principles of the proposed network), and Local Authority funding ***application*** to Department of Transport.

Minimum 12 months

Stage 2: begins with funding approval, subject to meeting all subsequent statutory processes, which focus on a second stage consultation followed by an application for ***Traffic & Works Act Order*** (TWAO) which is subject to a Public Inquiry.

Minimum 18 months

Stage 3: approval following a public inquiry releases government funding which enables the Local Transport Authority to specify and commission the ***detailed design*** of the tramways and depots.

Minimum 12 months

Stage 4: implementation construction of the tramway, procurement of vehicles and development of operational capacity.

Minimum 24 months

Total minimum time is 5 years, 6 months from Pre-feasibility Study to Starter Line in operation

Source: https://uktram.org/documents/#generalguidancenotes

Thus Zero-West/TfGB are now campaigning at the beginning of Stage 1. This pre-feasibility project builds on the outline TfGB Rapid Transit Plan to identify Primary Tram Network routes for Feasibility Studies. In summer 2021 WECA will launch a First Stage Consultation on the results of their £1.5m consultancy project commissioned '*to assess the potential options for a mass transit system and its benefits for the region'.* If this includes a proposed tram network, with Feasibility Studies of preferred routes, it would be possible for Stage 1 to be completed by an application to DfT for funding in late 2021 or early 2022.

Within this timeline are formal statutory consultations and a Public Inquiry which are key events in the process of getting public 'buy in'. But this indicative timeline also makes it clear that there will be two distinct phases of community engagement which will require a carefully planned and coherent community engagement strategy to be sustained over 5-6 years.

The first stage is building community support when the evolving tram network is still 'on the drawing board' - a period of some 3 - 4 years when the focus is on vision, route maps, images of trams etc., and the ongoing processes which underpin these abstractions. This stage started with the launch of the ***Zero West/TfGB Moving Bristol Forward*** campaign in the run-up to the May Mayoral elections. It will gather momentum from summer onwards with the WECA consultation on its options for the development of a Mass Transit Network.

It is important for all parties to recognise that the Stage 1 process will require the development of an ***agreement on the principles of the proposed tram network - shared by all WECA authorities' officers and politicians - and has public support.***

Building such a consensus during the next 9-12 months will be an absolute requirement for meeting the Zero West/TfGB target of an operational Starter Line by 2026.

The second phase of community engagement will focus on the reality of a 2-year construction period for the first line before anybody rides a tram. This will involve enabling the local communities to keep the constructors and public authorities 'feet to the fire' to minimise disruption and keep to a delivery programme.

In this context it is reasonable for Zero West/TfGB to campaign for a Greater Bristol Tram Network to be developed in three phases:

Phase 1	Starter Line operational by 2026-27
Phase 2	Primary Tram Network completed by 2031
Phase 3	Bristol Regional Tram Network substantially completed 2031 -2040

Loop Lines and Line Extensions to the primary tram lines

The popularity of the first line will lead to public pressure for extensions

The Line 1 and Line 2 local Tramway Loop Lines are proposed as a second phase of tram system development, which would follow on from the construction of Lines 1 & 2.

These Loop Lines would support the business case for Lines 1 & 2. They will:

- increase the level of passenger demand by servicing major educational, health, leisure, and retail facilities, along with concentrations of other employment opportunities – either existing or planned for development during the implementation of the tram network;
- increase the catchment area of the tram lines by including more existing residential areas which are now predominantly car-dependent and new residential neighbourhoods to avoid the development of more car- dependent neighbourhoods.
- reduce inequalities in access to public transport by including lower income residential neighbourhoods; and
- future proof the evolving tram network in the context of evolving post-pandemic travel to work patterns.

However, as an interim measure some of these proposed tram line routes would be upgraded to deliver improved rapid transit MetroBus services to achieve an initial reduction in car journeys.

4.2 Components of the pre-feasibility assessment method of 3 potential lines

The assessment method includes three basic components: potential passenger demand, re-allocation of road space and the location and multiple purposes of tram stops.

4.2.1 Potential passenger demand

All three routes start and end with existing major traffic generators and carry substantial commuter traffic. There are some limited traffic statistics readily available for arterial traffic corridors in the Bristol Transport Strategy 2019 which, in combination with the analysis in the TfGB Rapid Transit Plan, are sufficient to justify the choice of routes for this Pre-feasibility Study.

As Bristol is a fast-growing city[18], a basic review of planned development has been built into the passenger demand assessment for each line. Thus, the Cribbs-Patchway New Neighbourhood will generate additional demand for Line 1; the massive Temple Quarter/St Phillips Marsh Regeneration Programme and the major urban extensions at Brislington will generate demand for Line 2; the Bedminster Regeneration Area and the ongoing and planned growth of population and employment at Hengrove Park will increase demand for Line 3. In addition, the second phase Local Tramway Loop Lines will further future-proof demand.

It should also be noted that in mixed-use urban areas passenger demand from commuters is supplemented by **significant off-peak demands**. Trams are cheaper than buses to run for long hours and the pattern of passenger demand in city systems such as Manchester Metrolink has evolved as:

06.00 - 09.30	**morning in-bound commuters**
07.30 - 09.00	school peak
09.30	concessionaires start for many types of journeys, such as shopping, visiting family and friends, etc. It is clear that a high number of passengers in this group are attracted by the ease of getting on and off trams
	concessionaires return home in late afternoon
15.00 - 16.30	school peak return homeward
16.30 -19.00	commuters travel home
from 20.00	evening leisure travellers to venues along the line of route and the city centre – retuning home on a late tram service
	a night-time travel service can be used to reduce the depot space for trams - a practice in several cities which supports the 24hr economy.

However, it is important to stress that robust passenger demand forecasts, using proven methodologies, will be a key component of the Business Case which will need to be developed in subsequent Feasibility Studies. This issue is discussed further in Section 5 (below).

4.2.2 Re-allocation of road space

Trams are a very flexible form of transport that can operate on shared streets among other vehicles and pedestrians, but also on reserved tracks either alongside the road or on a private right of way like a railway. The 'grass track option' in use in many continental cities has obvious environmental and aesthetic advantages. This flexibility facilitates the re-allocation of road space to introduce tram lines.

The re-allocation of substantial road space in major traffic corridors to accommodate tram lines is essential for the creation of a tram network that will deliver a quality of service which will be sufficiently attractive to persuade private car users to switch to public transport – the acid test for an effective rapid transit system.

The TfGB Plan notes that there is a view among Bristol's policy makers that some of Bristol's heavily congested roads, not least the Gloucester Rd, would simply not be physically capable of accommodating tram lines. Thus, the primary task of the pre-feasibility study is to establish (subject to a physical survey) that each primary route can accommodate a tram line, whether double track or single, interlaced (which allows operation along a predominantly single track line, see photos below), centrally located or to one or both sides.

18 Bristol - The Future City https://youtu.be/XIk9bVXN2JM

Road sharing

For most of their length the Primary Network routes run through built-up areas. Therefore, this assessment assumes the tramlines will generally be ***road sharing*** i.e., continually used by other vehicles – buses, cars, and cycles. This will be subject to *dedicated Right of Way (ROW)* priority being given to trams by a combination of traffic management arrangements and minimum use of segregated lanes.

Trams and pedestrians in Amsterdam shopping street

Approach to the tram stop well signed and alerting drivers by its visual presence.

Passengers and cyclists cross the three-lane Rd protected by Zebra crossing and where required.

An example where the road narrows and is shared with pedestrians, bicycles bus and taxi only

Bus & Tram Public Transport Pathway (PTP) Centre of Croydon

An example of a strictly controlled delivery bay for LGVs below 18 tonnes.

However, in considering the total time to complete journeys (TTTC) city speed limits will be applied to tramlines. Nonetheless, the TTTC for trams will on average be quicker than buses, and trams will generate zero pollution, in sharp contrast to the NEE pollution of buses.

Finally, in line with normal tram network practice LGVs over 18 tonnes will be prohibited along the tram line routes.

Road sharing- tramlines and cyclists

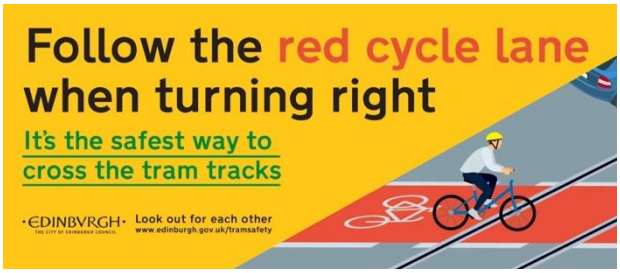
It must be fully acknowledged that cyclists may focus on the perceived hazards more than the promise of improved cycling conditions on far less congested roads. However, as these images demonstrate, a combination of physical measures, signage and a willingness to embrace adjustments to new cycling conditions can ensure safety and reap the benefits of the major reduction in motorised traffic, whilst providing convenient access to trams for longer journeys.

From the outset, it will be essential to **involve cycling organisations in the design** of the tramways and the development of awareness and training courses.

Scooters, bikes and trams can - with care - share road space

Crossings not less than 45° should be engineered in at time of construction to ensure cycle safety

Edinburgh Road Management: "Red Paths" for safe cyclists" to cross tram tracks at a safe angle



Clear and unambiguous signage

Good road discipline and highway code compliance will reduce hazards around tramlines

Sheffield & Manchester provide training courses and reminder visuals

A busy Bike + Ride stop serving both directions

Former three lane road space re-allocated as a bus, tram & bike interchange including Bike + Ride

Tram track space requirements and standards

A single tram track requires 3.41m '***swept path clearance'***. This standard has been applied to the three tram lines to assess whether a double track of 6.82m can be accommodated, either centrally located or to one or both sides of the road, or whether short, interlaced sections can enable double track to be provided by dealing with stretches of roads where space is limited. This assessment found that it is unlikely that interlaced sections will be necessary on the proposed routes, but at detailed design stage they may be built in, for example to facilitate pedestrianisation.

The assessment also considered whether it will be necessary to provide for *'**traffic pinch points***' where, for short stretches, the available road space narrows to two lanes. In these locations traffic signals will give trams priority in the two central lanes, whilst other vehicles are paused in the outer two. For both *'pinch points'* and road junctions ***transponders*** on the trams will trigger traffic lights for cars, buses and vans. The study did not identify a need for these measures, but this would need to be confirmed at full feasibility stage.

Road Narrows (10.5m) to form a 'Tram Pinch' Midland Metro, Wolverhamton Rd.

Road space immediately after 'Tram Pinch' re-allocated for delivery vehicles.

Manchester

The need for localised ***traffic diversions*** to reduce the volumes of cars and buses along short narrow stretches of the tramways at peak periods may only be necessary during the tramway construction phase.

On the stretches of the lines where ***tram segregation*** is essential for the effective operation of the tramline, ***trambahns*** would be installed, which prevent vehicles using the road space allocated to the tramline.

Amsterdam

Shared Trambahn: Note, the broken white lines indicate that traffic in the right-hand lane including cyclists give way to trams

A8 West Princes Street Line, Edinburgh

Re-allocated road space: Public Transport Pathway (PTP)

The impact of re-allocation of road space on existing residential ***car parking provision***, must be considered, and will need be supported by ***residents only parking zones.***

Minimum disruption to existing property along the tramlines will be essential to minimise opposition and avoid expensive/compulsory acquisition.

Tramline navigation and tram technology

The routes were assessed to ensure that the tramlines will enable trams to navigate the routes efficiently, by applying industry norms for bends, gradients, and road junctions, particularly roundabouts.

Bends and curves

For tramlines to be installed in relatively narrow roads it will be essential to select trams with a small radius curve so that the trams can navigate relatively tight bends on the route. The Atkins Bath Trams Project assumed the use of conventional vehicle technology with a minimum radius curve of 25m, which would require the demolition of corner buildings. In contrast the Ultra-Light Rail Trampower City Class Tram and TiG/m trams can comfortably go around 15m radius curves.

Gradients

Similarly, the Atkins feasibility study proposed 6.5% gradients without any justification, despite referring to the fact that the Sheffield tram network includes 10% gradients. Both the City Class Tram and the TiG/m can climb 10% plus gradients with a full passenger load of 200. The three Primary Tram Routes for Bristol proposed in this pre-feasibility study were assessed to ensure, subject to more detailed survey, that gradients would not exceed 10%.

Fig. 7

Top-left: Tramlines on steep incline in Birmingham

Top-right: Start of a hilly pedestrian precinct in Croydon

Bottom-left: TramPower City Class negotiating a tight hill twist in Birkenhead, Wirral

Road junctions

Junctions between the proposed tram lines and other roads, particularly roundabouts, were assessed to ensure the practicality of the dedicated right of way (ROW) needed for efficient tram operations.

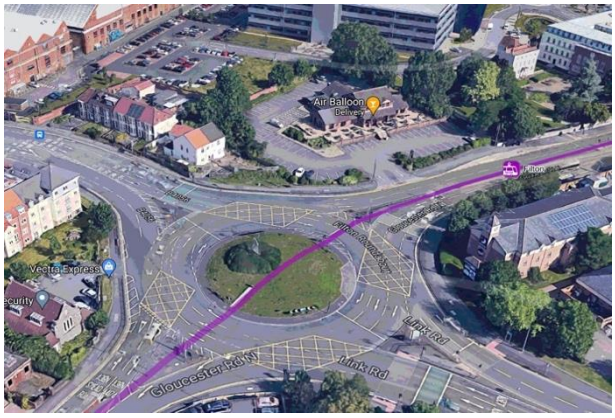


Fig. 8 - An example of how the tram could pass through the centre of Filton roundabout (North Bristol)

Tram route through *roundabout* on *Trafford Park Metrolink Line*, Manchester

Right turn, Midland Metro, Wolverhampton Rd

Large tram depot in Manchester

Depots- number, site requirements and potential locations

Identifying sites for the location of depots for tram rolling stock storage and maintenance is often the most contentious issue which will have to be resolved in the feasibility study. The first depot must be adjacent to the first line, with space on the site for expansion, The choice of sites will be determined in the full Feasibility Studies. However, at this stage it appears that it may well be necessary to have a minimum of two depots to service the suggested Primary Tram Network and eliminate dead mileage - one north of the city centre and one to the south:

1. ***A northern depot in the Cribbs Causeway area -*** will initially serve Lines 1 & 2 in Phase 1 of the tram network development and eventually the Phase 3 TramTrain Line.
2. ***A southern depot -*** *will be needed to serve line 3, plus line 2* when the Phase 3 link between Line 2 and Line 3 is completed.

4.2.3 Tram network management to deliver equal access for a diversity of passengers to affordable and reliable public transport.

Public Transport Pathways (PTPs)

These will be designated at an early stage in the development of the tram lines, within the corridor routes of the proposed Primary Tram Network. For example, the central two lanes of a 4-lane road would be reserved as a PTP and allocated for a Bus Rapid Transit (BRT) service, prior to an upgrade to a tram route. This would allow continued two-way local traffic movement in the outer two lanes, albeit at the expense of on street parking spaces and kerbside bus only lanes.

Thus, the designation of PTPs at an early stage will support the initial phases of the transformation of the city's public transport system which focus on upgrades to MetroBus service and the MetroWest local railway lines.

Dual purpose stops on primary tram lines

All the radial tram lines would cater for longer distance commuters, many of whom would come in from outside the city, using peripherally located Park + Ride facilities. In peak hours, these services would be operated on a limited stops basis to minimise journey times. But these lines will also cater for *hop-on* & *hop-off* shorter journeys with more stops operating in non-peak hours.

This will ensure that the primary routes provide an attractive alternative for both commuters and for Bristol residents for whom an alternative to the car for day-to-day shorter journeys is needed. This approach is designed to help generate the necessary level of passenger demand by attracting a combination of different groups of travellers at different times of the day - a balance between the types of passengers that will vary between the routes.

Location and design of tram stops- general criteria

Tram stops will be a standard 300m long, partly under cover, and are designed to provide level access for the benefit of people with disabilities and passengers with heavy luggage/shopping baskets (in compliance with the Disabilities and Discrimination Act 1995). They should also meet the following design standards to be:

- diagonally opposite each other at traffic-light-controlled road junctions -enabling green wave technology which give trams priority and at an average of 400m apart along the tramline - subject to local geography.
- within cycling and 400m walking distance of substantial residential catchment areas particularly those which include lower income neighbourhoods.
- facilitating walking distance access to existing major employment and retail locations, health and educational facilities, and recreational facilities – including both existing facilities and planned development; and
- providing walking distance access, where practicable, to the local rail stations.

Fig. 9 – Above: Tram & Bus interchange. Below: convenient multi-modal features

Tram stops as Community Transport Hubs

A proportion of tram stops are co-located with:

- feeder bus services stops
- 'bike + ride' and 'scooter + ride' facilities which both attract tram passengers and encourage active travel within adjacent 15–20-minute liveable neighbourhoods,
- walking and cycling routes, possibly as key component of Low Traffic Neighbourhoods, and are integrated with neighbourhood plans

Note: the tram stops indicated on route maps are situated adjacent to popular destinations and/or existing bus stops, but need to be subject to a local on-site survey.

5 PRE-FEASIBILITY LINE ASSESSMENTS

This section sets out the application of the pre-feasibility study method to the three tramlines included in the Potential Primary Tram Network. For each line there is first a brief explanation of the rationale of the route with reference to its role in the phased development of the tram network shown in **Fig. 5 Schematic Diagram (p.27)**

This is followed by Tramway Route Maps for sections of each line, which are accompanied by a description of the three components of the pre-feasibility assessment.

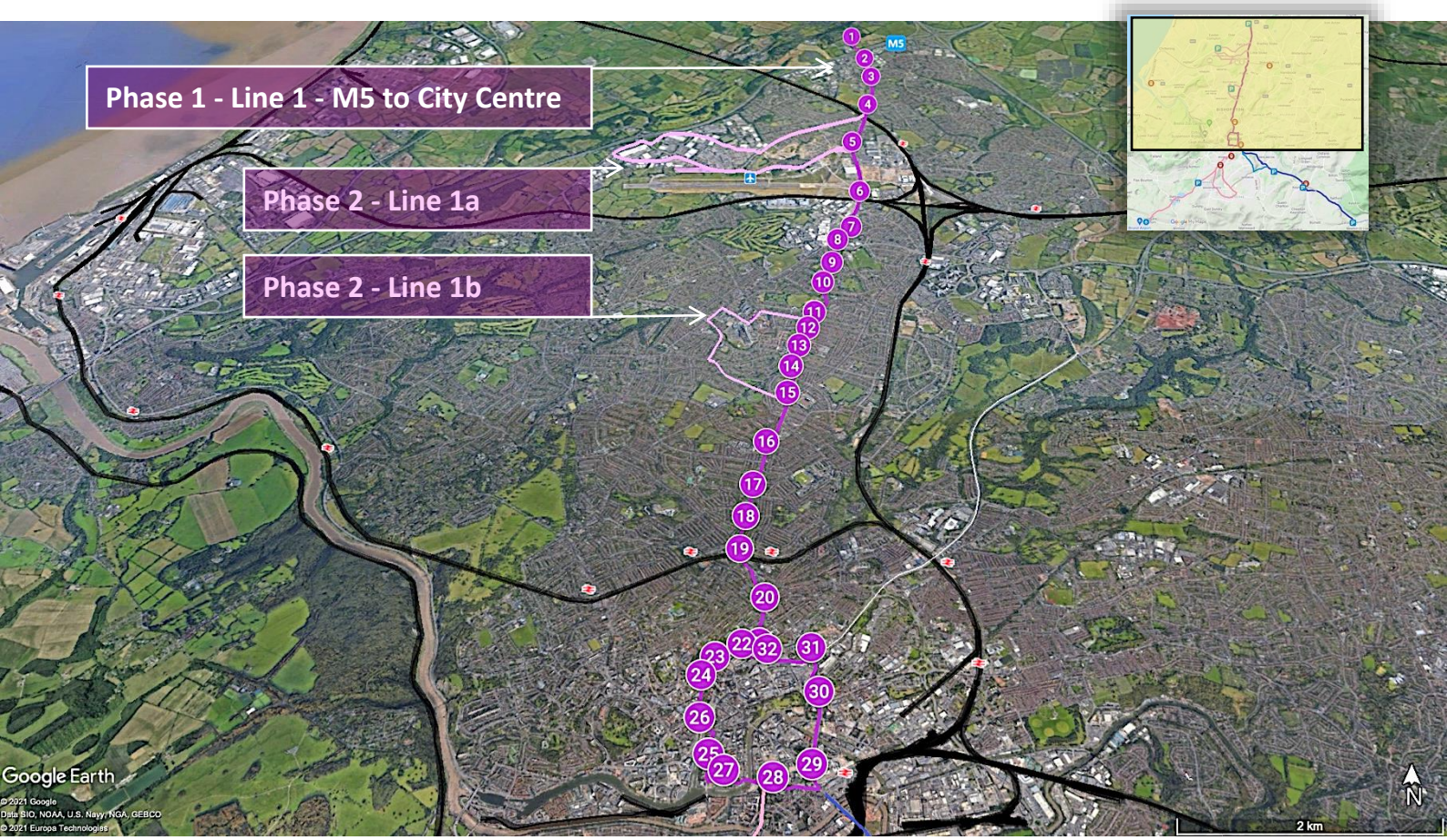
- potential passenger demand
  - with reference to both existing and planned development
- re-allocation of road space
  - Road sharing, tram track space requirements, tramline navigation and tram technology; and
- tram network management
  - Public Transport Pathways (PTPs) shared by trams and buses, and shared bus and tram stops as community transport hubs.

It should be noted that this proposed Bristol Primary Tram Network cannot be a stand-alone plan. In order to deliver essential tram priority on-street, it is necessary to deal with the issue of current and possible on-going general traffic levels. Thus, several parallel policies are required:

- a republished and revised **Greater Bristol Commercial Vehicle Drivers Atlas** (in new sat-nav format) to direct essential access traffic to the most appropriate routes
- the expansion of Bristol's set of **Park + Rides** - to be served by tram -notably on the M4/M32/Avon Ring Rd, A38 (north and south) and A37
- a **Workplace Parking Levy** (as in Nottingham where it raises £9m pa and public perception is positive);
- similarly the completion of the inner Bristol ring of **Residents Parking Zones**; and
- the **closure of major and minor car-commuter rat-runs** which are currently carrying up to half of the city's rush-hour traffic, albeit often unmonitored.

These policy measures are essential to help curb Bristol's traffic congestion and worsening air pollution especially in less well-off inner areas.

For these reasons, this proposed **Bristol Primary Tram Network** should be read in tandem with **TfGB's Bristol Traffic Management Plan** and **Parking Plan** (accessible at *www.tfgb.org, Campaigns, Bristol Transport Plan*) and specific links to traffic management proposals for each of the proposed tramways are made in the following sections of the report. Future consultations on the development of the Bristol Rapid Transit Plan should be seen as an opportunity to secure public acceptance of these otherwise sometimes controversial measures that are of themselves essential to help curb Bristol's traffic congestion and worsening air pollution especially in less well-off inner areas.



5.1 Phase 1
Line 1: M5 Junction 16 via Gloucester Rd A38 to City Centre Carousel Hub

As shown on the Network Schematic and aerial map, this line has three components:

- **Phase 1 Line 1 from M5 Junction 16 to, and including, the City Centre Carousel**. This is designed to provide a rapid transit service along the A38 North, to minimise the congestion and pollution which is caused primarily by commuter traffic in peak hours from outside Bristol.
- **Phase 2 Line 1a Cribbs-Patcham New Neighbourhood (CPNN) Local Tramway Loop** is designed to provide a tramway network which will integrate Cribbs Causeway area within the emerging Cribbs-Patchway New Neighbourhood (CPNN) – with TramTrain link to local rail network. This will contribute to the business case for Line 1.
- **Phase 2 Line 1b Southmead Hospital Local Tramway Loop** will substantially improve the public transport service to both the hospital and the residential neighbourhoods adjacent to the proposed tramway, thus contributing to the business case for Line 1.

5.1.1 Line 1 potential passenger demand

The A38 North is a key route into the city which is subject to high levels of congestion and pollution. The 2019 Bristol Transport Strategy BTS identifies it one of the busiest transport corridors in the city. Pre-Covid a minimum of 40,000 people per day used the route between 7am and 7pm - an average of over 3,000 per hour. Cars account for 61% of vehicles and 38% of travellers, buses 4% of vehicles and 32% of travellers, cycles 20% of vehicles and 5% of travellers with 3,500 bikes per day on the busiest section and 14% of journeys are on foot. Bristol Transport Strategy 2019 (BTS p.64)

In addition, there are significant rat-runs closely paralleling the A38 at both north and south ends of the route from Filton to the city centre. In 2000 these generated some 22-24,000 vehicles per day (vpd): notably 15,000 vpd on Ashley Down Rd, 12,000 vpd on Southmead Rd, 14,000 vpd on Kellaway Ave, 6,000 vpd on Cranbrook Rd, and significant numbers on Filton Ave (*Bristol Local Transport Plan, 2001/2-2005/6, Appendix 4.1*).

Thus, the total corridor traffic is significantly larger than the BTS figures quoted above. This demonstrates the need for wider corridor traffic management and Rd hierarchy considerations be considered in parallel with rapid transit planning.

Moreover, it also demonstrates the need for the integration of orbital bus services, to cater for significant nearby, but off-tramline destinations, including UWE, Henleaze, Bristol University, the MoD and Abbey Wood station. If corridor traffic management and tram-bus integration strategies are not pursued, the positive impact of the Line 1 tramway on persuading travellers to switch from their cars will be much reduced.

The minimum volume of demand needed for a viable tramway is approximately 3,000 passengers per hour dependent on operation. Given this volume of traffic and the potential for modal shift from long car journeys and unreliable and uncomfortable bus journeys it is highly likely that pre-Covid volume of passengers will be more than sufficient to justify a tramway.

The industry norm for the selection of corridors as tram routes rather than bus routes is 3,000-11,000 passengers per hour. Thus, with this volume of travellers currently using this corridor it is very likely that the potential volume of passengers would justify the introduction of a tramway, which would provide a 6-minute service i.e., 'turn up and go and get there on time'.

There is some uncertainty about post-COVID travel conditions, for example, will a move away from 5 days a week commuting reduce overall demand? But there can be no doubt that the impact of the development of the **Cribbs-Patcham New Neighbourhood CPNN** and the adjacent **Filton Enterprise Area** will substantially increase the number of journeys into, out of and around northwest Bristol which is currently substantially served by the A38. This area is included in the proposed Phase 2 Line 1a.

The 2014 Cribbs/Patchway New Neighbourhood Development Framework established detailed planning guidance for the delivery of some 5,700 new homes and 50ha of employment land providing hundreds of jobs. In 2018 South Gloucester Council signed a Development Agreement with the four major landowners, which includes funding the coordinated delivery across the whole of the CPNN of the transport infrastructure needed for private car use, public transport and active travel. Given this Development Agreement, planning consent was granted for the first phase of some 2,700 dwellings which is now under construction. This includes developer funding for a Cribbs-Patchway MetroBus extension and a new Filton North railway station – both to be operational by 2023 – supporting the YTL branding of the area as 'Bristol's best-connected new neighbourhood'. The key features of this major development are available at https://brabazon.co.uk/explore.

Rapid Transit Options for A38 North – buses, trams and underground

According to the 2019 Bristol Transport Strategy (BTS) (p.64) current levels of congestion restrict the average inbound morning peak speeds for cars on the A38 to 9 mph – the same as that achieved by cycling. The current public transport option is bus travel which is restricted to 6 mph. Congestion means that the A38 suffers from heavy air pollution and is included within the Bristol Air Quality Management Area.

The bus lanes along the route are not continuous and congestion continues to cause delays which are exacerbated by large numbers of people slowly boarding busy buses. The BTS asserted that *'…given a lack of road space which on the A38 North narrows to just 13metres…'* there was no further scope for increasing public transport priority *'…without extremely radical measures…'* (p64). But It then further asserted that 'without a significant reduction in traffic on-street trams would likely be stuck in congestion' and that construction of the tramway would bring *'…several years of disruption and road closures.*

But these somewhat dismissive statements ignore the possibility of a tramline reducing car traffic dominated congestion, of giving trams right of way on shared road space and the contemporary experience of minimising disruption during the construction of extensions to tram networks in UK cities. Moreover, many cities successfully run trams along streets very similar to this relatively narrow stretch of the Gloucester Rd and this study demonstrates at pre-feasibility level that this is possible.

From this perspective the Bristol Transport Study gave priority to initial feasibility work *'…exploring underground options which would follow the A38 North and serve Southmead Hospital, Cribbs Causeway and Aztec West'*, cutting peak journey times from Aztec West to the city centre to under 25 minutes, with reliable high-capacity trains at 2-minute intervals.

However, it acknowledged that whilst an underground system is technically deliverable, it would cost £3-4billion to construct the three lines system (City Centre to North Fringe following the A38 North, City Centre to East Fringe and City Centre to Airport) and could take up 20 years to deliver. This level of costs has prompted Transport for London to withdraw from the proposed extension of the London Underground south from the Elephant and Castle in Southwark.

Bristol is committed to being carbon neutral by 2030.

The city cannot wait 20 years for a £4billion underground

5.1.2 Line 1 re-allocation of road space

The BTS acknowledged the clear need to move radically beyond the current limited bus priority arrangements to deal with the pollution and congestion on the A38 North. Building on the BTS, the WECA 2021 Transport Delivery Plan bus programme is investing in further short-term bus priority improvements in the A38 North corridor to be delivered by 2025. But the evidence from other cities in the UK and abroad[19] is that even an eventual radical Bus Rapid Transit scheme would not attract sufficient car users to reduce congestion. Nor would it reduce the up to half of traffic-related emissions resulting from tyre and road dust.

The current priority for the underground option for the A38 North Corridor rests on the assumption that it is not feasible to install a tramway along the A38. But this pre-feasibility assessment indicates that it is technically possible to re-allocate the required road space to accommodate a double tram line from the M5 Junction south and around a City Centre Carousel Hub. However, the challenges of re-allocating road vary considerably along this route and are explained below by reference to four sections of Line 1 shown on Tramway Maps 1-4.

Throughout its length Line 1 is double track and the tramway follows the natural path of the Rdway. The tram lines go through roundabouts, with the obvious exception of the Bear Pit on the City Centre Carousel Hub.

In order to reduce pollution and manage traffic flows, vehicles 18 tonnes and above will be rerouted away from this transport corridor and restricted largely to the M5, M4, M32 and Avon Ring Rd. [20]

Tram stops are placed at approximately 400m intervals - subject to local survey and traffic requirements - and where practical are co-located with bus stops. But during peak hours a limited stop service will be in place to deliver a faster commuter service - with tram stops being served by short-route integrated peak-hour feeder buses.

> It is estimated that the journey time from the M5 Park+Ride Junction to the City Centre Carousel would be approximately **50-55 minutes by tram** compared with 100 minutes by bus.

19 https://www.imperial.ac.uk/media/imperial-college/research-centres-and-groups/centre-for-transport-studies/Success-and-Failure-in-Urban-Transport-Infrastructure-Projects.pdf
20 .www.tfgb.org, > Campaigns > Bristol Transport Plan

Line 1 M5 Junction 16 to Filton roundabout – Tramway Map 1

Passenger demand from South Gloucestershire city centre commuters in combination with the traffic generating employment centres adjacent to the tramway will ensure a high level of ridership in this section.

The Gloucester Rd line begins at the proposed Park + Ride (P+R) site at M5 Junction 16 which will serve inbound commuters to the city centre from South Gloucestershire. A second M5 Park+Ride opportunity exists at M5 Junction 17 by Cribbs Causeway, equally servable by the corridor tram service.

From the P+R, the tramway will follow the road under the motorway on the A38. The first 4 stops on the line would give tram access to in-bound commuters from the Bradley Stokes neighbourhoods on the east side of the A38. To the west, the Aztec West Business Park is poorly served by public transport and thus generates heavy car traffic. The tramway would give a much quicker journey to work for the many of the 7,000 workers from city neighbourhoods to the south, who could connect to an improved feeder bus service around the business park loop road. South of Aztec the tramway would serve the Patchway Community College.

Further south across the railway line, three tram and bus stops will serve the rapidly expanding employment centres of the Filton Enterprise Area and the eastern end of the Cribbs-Patcham Brabazon development, facilitating access for their workers. One will be at Hayes Way, a second at the junction with the new Cribbs Patchway Metrobus extension linking to the Cribbs Causeway shopping centre, and a third will serve the aerospace works west of the A38 and the Filton residential neighbourhood to the east.

Fig. 10 - Public Transport Pathway (PTP) Tram and Bus track-sharing

Road space re-allocation in this first section will be straightforward. Here the A38 is a dual carriageway road, and the trams will run at the maximum speed consistent with road speed restrictions. Further investigation is needed to ascertain whether the central reservation is used for the double track, or the two outer lanes in order to provide for the high-speed running, particularly in bound after leaving the motorway.

A traffic management and calming regime will be required, specifically designed, implemented and enforced from the M5 J16 to the Filton Roundabout. In this section there appears to be only one set of pedestrian-operated traffic lights for crossing the A38 just south of Aztec Roundabout.

From the Aztec Roundabout to the Filton Roundabout trams will run in the central carriageway with traffic light protected pedestrian crossing points to the central carriageway. This will act as a traffic calming system and reduce pollution by slowing down car traffic.

Fig. 11 - central reservation tram stop with pedestrian controlled traffic lights

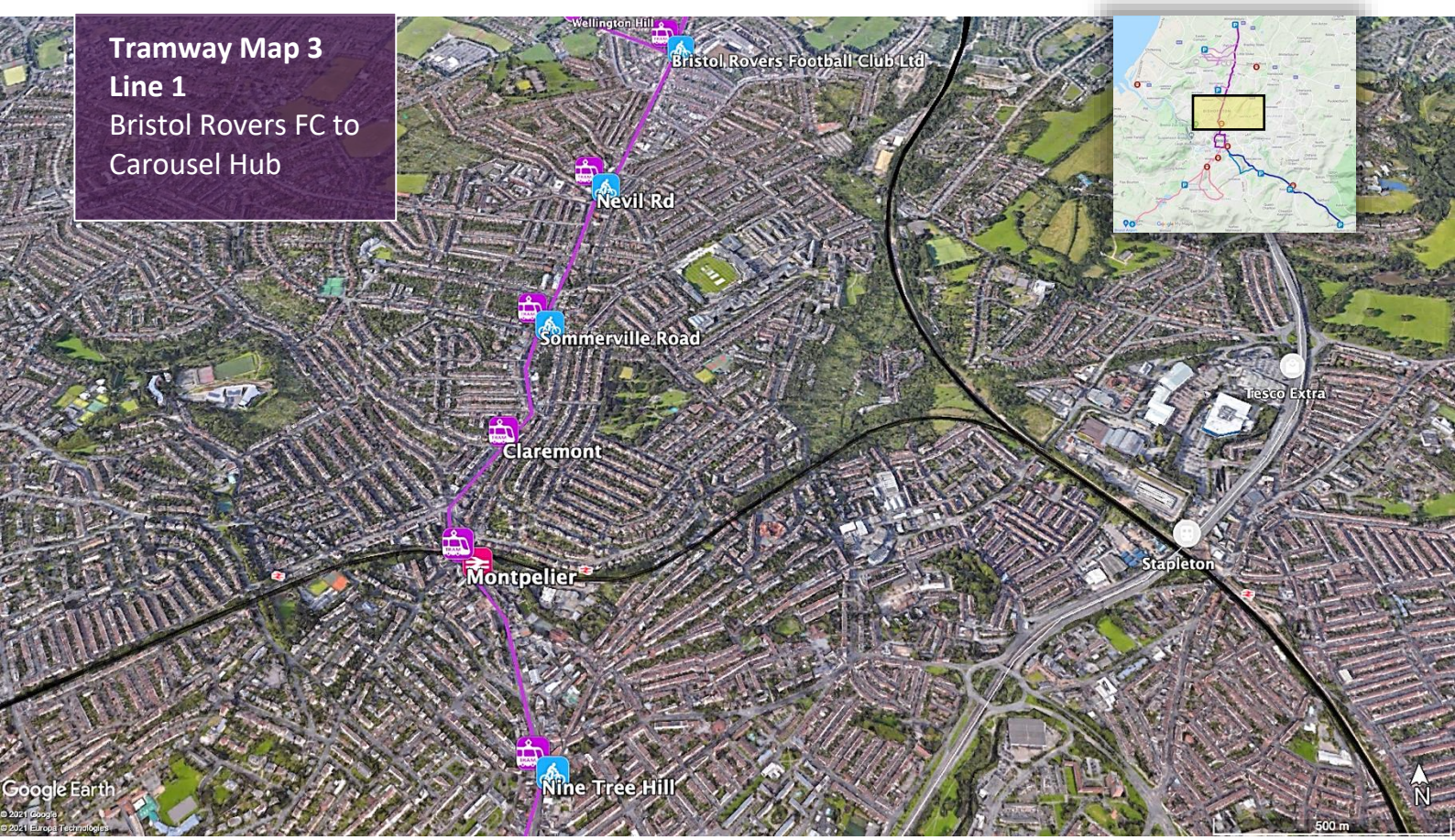
Line 1 South of Filton roundabout to Bristol Rovers FC- Tramway Map 2

Passenger demand will be generated from the Northville and Horfield neighbourhoods to the east and the Monks Park and Henleaze neighbourhoods north and south of the Southmead hospital. Tram stops would be co-located with the bus stops for the bus services to Southmead Hospital.

Road space re-allocation would be more challenging in this section which reduces for most of its length from a dual carriageway to a 4-lane road or less. Here a double track bus/trambahn Public Transport Pathway (PTP) in the centre two lanes will be protected by one of two options: either a thick white painted line in the road or a raised concrete rumble warning strip concrete barrier.

A sensitively designed traffic management and parking scheme will be needed for several short retail sections of this tramway route to provide for parking to be re-located to side roads or, where possible, newly created local off-street car-parks, along with provisions for delivery vehicles less than 18 tonnes in weight.

Fig. 12 - simulated model of dual-track tramway on narrow section of upper Gloucester Rd (A38) south of Filton Rd



Line 1 Bristol Rovers FC to City Centre Carousel Hub- Tramway Map 3

Passenger demand. This southernmost section of the A38, in particular where the road narrows to three lanes, is itself a destination, characterized by independent retailers, restaurants, cafés and bars including Bishopston and Stokes Croft shopping and leisure centres. As such, in addition to commuting journeys, the tramway will be characterized by hop-on-hop off journeys, outside peak periods, for shopping and will be used by residents enjoying the local night-time economy. Thus, there would be 5 stops between the Bristol Rover FC stop and the Carousel Hub, including one at Montpelier Station to connect with the local railway network. These stops would serve the densely developed residential neighbourhoods both east and west of the tramway.

Road space re-allocation. This section will be the most challenging. However, using Google Earth it is not possible to locate any section which narrows to 13m as claimed in the 2019 Bristol Transport Strategy. Where the A38 narrows to a three-lane road the photo montage illustrations demonstrate how a dual track tramway can be accommodated in this relatively narrow road space, whilst sharing with other vehicles.

Along this section of Line 1, three tramway design issues will need to be given particular attention to secure public support for radical change. It will be necessary to develop a sophisticated community engagement process to fully involve both local businesses and local residents in the development and evaluation of several design options.

At the same time, it is already desirable to stop up inappropriate parallel car-commuter rat-runs through residential areas, notably Ashley Down Rd and Cromwell Rd. While this might tend to push more traffic onto the tram route, the latter can be assisted by ‘green wave’ traffic signals for tram priority and peak-hour servicing-parking control.

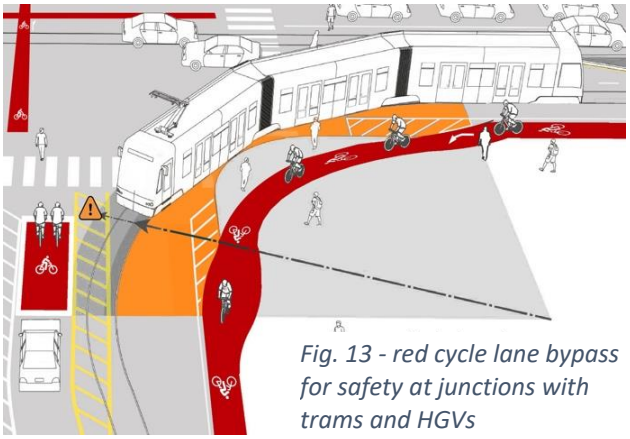


Fig. 13 - red cycle lane bypass for safety at junctions with trams and HGVs

Cycling space. The A38 is the most popular cycle route in the city, with some 3,500 bikes a day on the busiest sections of the corridor, accounting for 5% of travellers. Yet at the moment there is inadequate provision of cycle lanes and particularly a dearth of cycle lanes in this section of the A38. The road space re-allocation design should be seen as an opportunity to improve conditions for cyclists, in a situation where the introduction of the tramway will substantially reduce vehicular traffic. A range of measures should be explored in consultation with cycling organisations including, for example, the provision of protected red pathways, especially for turning at junctions.

Traffic management and parking in shopping areas. There will inevitably be a reduction in the availability of on-street parking, with priority given to blue badge holders, but this will be in the context of the tram providing an attractive alternative to using cars to access local facilities. The management of deliveries to retail and commercial premises will have to be carefully planned, drawing on experience of new ideas, such as supplementing delivery bays with ***'cargo tram'*** options, where at certain times of day trams replace delivery vehicles.

Passengers and cargo (concept for Bristol)

Dedicated cargo tram (Netherlands)

Out of peak hours, passenger-carrying trams could also be used for the delivery of goods. However, to be truly effective, new technologies for fast loading, unloading, and inter-modality once the goods arrive at a station need to be implemented. Logistics can be organised through strategic placement of stops, plus an online platform to schedule delivery routes and manage available capacity and storage. Legal and liability issues must be considered when transporting people and goods together.[21]

The Road Haulage Association has expressed concern that the Bristol Clean Air Zone (CAZ) ban on large lorries will increase the number of large vans in the city centre.[22] However, if trams are integrated with last-mile delivery schemes (i.e. *Zedify*[23]), the council would strengthen the case for the efficacy of the CAZ. In a Frankfurt trial, modelling showed 89 delivery vehicles can be replaced per day, resulting in a significant reduction in congestion and pollution.

21 www.citylogistics.info/projects/using-trams-for-parcels-in-frankfurt-d-the-lessons-learned/
22 commercialfleet.org/news/latest-news/2019/11/21/bristol-caz-could-impact-800-000-plus-commercial-vehicles
23 www.zedify.co.uk/bristol

Whilst the tramway is being constructed, financial compensation should be provided to cover temporary losses in businesses revenue. Experience in UK cities has shown that this has gone long way to securing local support.

Detailed local regeneration plans will be needed for key sections of the tramway, especially those which accommodate local retail and commercial businesses. These plans would be co-designed with local stakeholder groups including residents' organisations and local Business Improvement Districts (BIDS).

Fig. 14 - Improving the streetscape

to create a more pleasant experience for pedestrians and improving the immediate environment of small businesses

It is possible to cut one tram-track at a time for minimal traffic disrupting and no diversion of services. Photo: pipe-laying in Bath

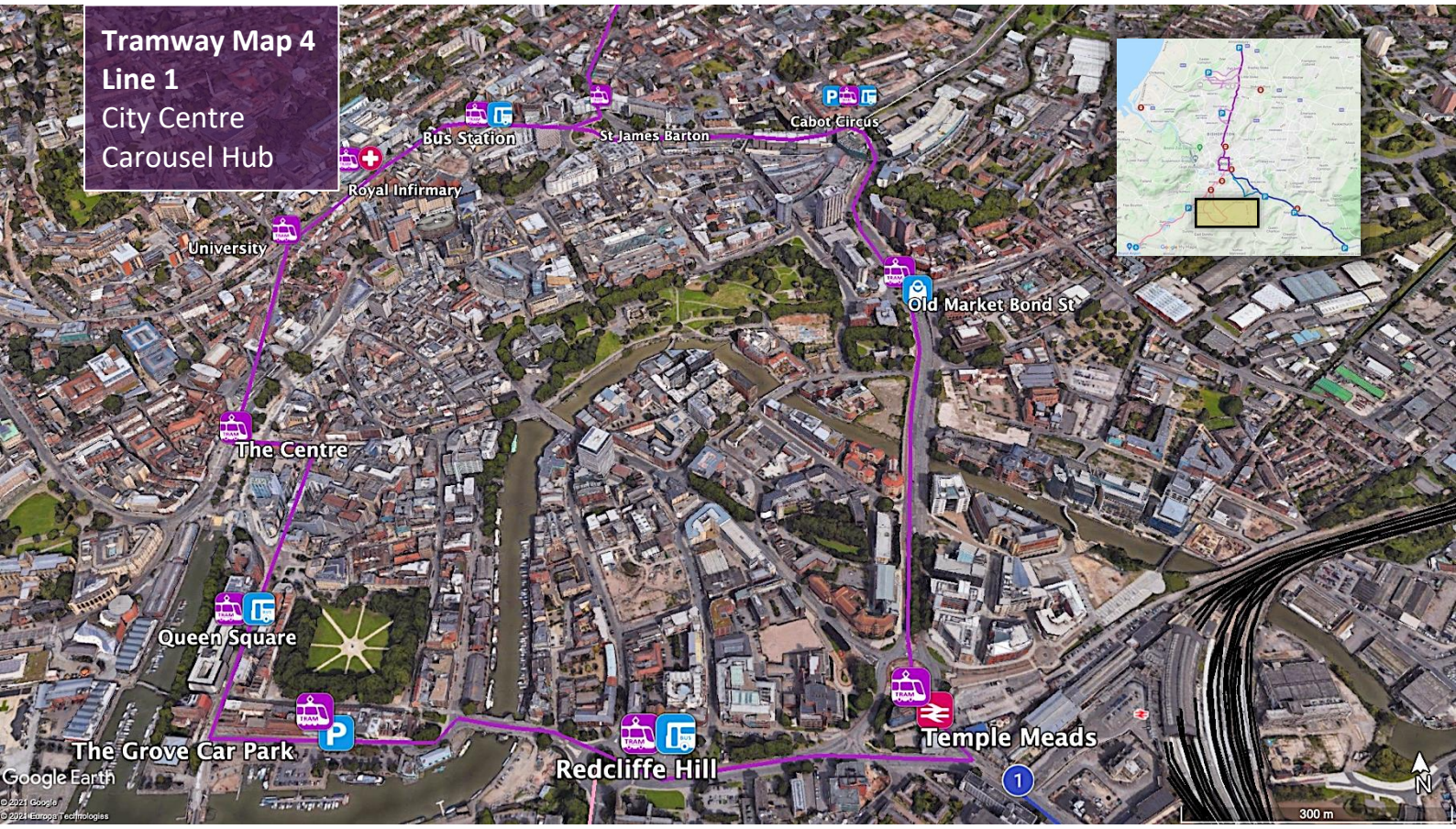
'Shopping-friendly' tram-only section Photo: Nottingham city centre.

Improved streetscape and decorative overhead tram lines. Photo: Melbourne.

Cultural events such as 'Fleetwood Tram Sunday' (which attracts 70,000 visitors) can generate tourism and commercial activity for local businesses.

Archive photo of a dual-track tramway, 295 Gloucester Rd (A38).

Dual-track tramway could be re-introduced on the same narrow section of A38, whilst sharing with other vehicles.



Phase 1 Line 1 City Centre Carousel Hub

The City Centre Carousel Hub is, by definition, the essential core of the proposed primary tramway network, both in terms of improving movement in and around the city centre and eventually enabling cross-city journeys by tram. The tram Carousel will achieve what Bristol has long needed; a frequent city centre circular public transport service for its rather spread out city centre. A shuttle bus route crossing from the Triangle to Temple Meads Station, via Park St, Centre, Baldwin St and Victoria St would complete this provision.

The proposed Carousel Hub tramway is currently a partial Metrobus anti-clockwise bus lane loop, with large sections still without a bus lane. A major aim of the Council City is to complete the city centre bus lane network. Thus the *2020 City Centre Framework* (ref fig 6 p18,19 & p31) sets out the planned completion of what will be the bus City Centre Loop by 2025. By 2030 it is envisaged that the City Centre Mass Transit scheme will be in place, paving the way for the completion of Bristol Bus Rapid Transit network by 2035 (ref fig 6 p19 & p31).

However, there is a medium-term tram alternative. The **evolving city centre Bus Rapid Transit route could be re-purposed by the conversion of the route to the City Centre Carousel Hub,** as a key component of the proposed Bristol Primary Tram Network.

This alternative should be assessed by a feasibility study which compares this option with the current proposals, a comparison which should be part of the upcoming WECA consultation on mass transit options.

As proposed in the *City Centre Framework,* the bus City Centre Loop will have 6 stops, which will include those that will be interchanges with the proposed Primary Tram Network routes: Temple Meads (Line 2), Old Market, Cabot Circus, Haymarket, The Centre and St Mary Redcliffe (Line 3) - Line 1 will join the Carousel at St James Barton.

These key interchange stops would be enhanced when the tramway replaces the Metrobus BRT. But at this stage connectivity within the centre would be further enhanced by 5 additional stops at the Coach Station (Stokes Croft), the Royal Infirmary, the University of Bristol (Medical Library), Queen Square (Princes Street) and The Grove (car park).

In line with common practice in cities elsewhere, the Carousel Hub will be double track and will allow for simultaneous clockwise and anti-clockwise movement as trams come in from Line 1 and return north - providing an initial and transitional 10-minute service in each direction. As Lines 2 and 3 come into service the frequency will be successively reduced to 5 minutes, 2.5 minutes and ultimately 1 minute. The trams used will have 100, 200 or 300 passenger capacity. They will provide a comfortable and reliable ride for a diversity of residents (including those using wheelchairs and buggies) and tourists with luggage arriving at Temple Meads, the Coach Station and from the airport.

The planning and development of the Carousel Hub will be a key component of a post-pandemic adaptation of the current plans for the city centre. There will be a reduction in the volume of commuting and sustained growth of on-line retailing. However, the resilience of the city centre would be substantially enhanced by a tram network which increases access to and enjoyment of the city centre, as a focus of cultural and leisure activities shared by both residents and tourists. The tram network would create opportunities for pedestrianisation and public realm improvement which would improve its attractiveness to tourists, in the context of post-pandemic promotion of the city as a destination for both domestic and international tourist, to boost the £1.4bn tourist industry which supports some 30,000 jobs. Moreover, the tram network could be developed to encourage city-centre based tourists to visit historic and natural attractions in other parts of the city – not least by the use of sightseeing or restaurant cars (see Fig. 15).

In parallel with the planning of the tram network, Bristol urgently needs a city centre traffic reduction plan on a scale similar to that already largely achieved in Bath. Considerable progress recently has been made, with the Bristol Bridge bus-gate and the stopping of cross-traffic in the Centre from Baldwin St. Further action is needed which will eventually assist tram priority. The most obvious needs are a bus-gate on Park St, the closure of Prince St Bridge, the removal of all cross-centre car movements, and the removal of as much traffic as possible from Upper Maudlin St passing the Bristol Royal Infirmary - possibly by making it one-way except for emergency vehicles and public transport vehicles, with Lewin's Mead. See the *TfGB Traffic Management Plan*. Consultation on a proposed tram network should be linked to a consultation on a Bristol City Centre Access Plan which would include such measures.

Fig. 15 - Examples of how trams are enhancing city centres around the world


Mobile Restaurant Tram, The Hague


Decorative tram-stop and zero-emission TiG/m MRV-4, California


Zurich

Sightseeing trams, Hong Kong (courtesy of tripadvisor.co.uk)

Before & After (Amsterdam)

Amsterdam's congested streets before trams

Tourists and shoppers enjoying pedestrian-friendly tramways

Phase 2 Line 1a Cribbs-Patchway New Neighbourhood (CPNN) Local Tramway Loop

From the outset the planning authorities recognized that 5,700 new homes and several hundred new jobs would bring some 7,000 additional cars into the area and that sustainable development would require viable alternatives to the private car for a high proportion of journeys made by the new residents and workers.

Thus, the Development Agreement provides for a network of cycle ways within the area which connects north to Cribbs Causeway and south to the city centre. Planning consent for the first 2,700 dwellings brought with it a 'mini-rapid transit network' with two core components: a Cribbs-Patchway MetroBus extension from the A38 along the east-west primary distributor road and thence to Cribbs causeway, as the BRT core of an Electric Vehicle bus service; and a new Filton North railway station, providing access to the local rail network with a 15-minute journey to Temple Meads. Both innovations will be operational by 2023 – and the first houses are now under construction.

The extent to which this combination of sustainable travel modes reduces the local use of the additional cars in the CPNN area will be clear by the mid-2020s. Transport industry experience suggests that whilst it is likely that car trips will have been reduced, the rapid growth of homes and jobs in the CPNN may well by then be adding to the problems of congestion on the A38. However, by this time, if selected as the 'starter line', the Gloucester Rd tramway could be operational. In this case the CPNN bus network could be acting, in part, as a feeder service to the tramway, thus further reducing CPNN generated car journeys. This scenario supports the business case for Line 1 of the proposed Primary Tram Network.

But in a second scenario the proposed Phase 2 Line 1a Cribbs-Patchway New Neighbourhood Loop offers the prospect of fully integrating this strategic growth area of north-west Bristol into the proposed Primary Tram Network. An indicative CPNN tramway design - Tramway Map 1 - includes both the existing development north of Merlin Rd/Hays Way and the redevelopment of the former airfield.

Fig. 16 - low impact tram tracks in CPNN (photo: city centre reservation, Barcelona)

A loop line would leave the A38 Line 1 at the Stoke Lane interchange to run along Highwood Rd, with 2 stops to serve the residential areas to the north. Then it would turn right along Highwood Lane, with 4 stops (including the coach park) to serve the Cribbs Causeway Centre from the north, to the M5 Junction 17 and a proposed Park + Ride, possibly in the Catbrain area. The tramway then returns along the Merlin Rd, with 3 stops to serve the Centre from the south and the proposed CPNN new development to the south, to the San Andreas roundabout. From there the Loop line would then re-join Line 1 via Hayes Rd with 3 stops serving the residential development to the north and the new development to the south.

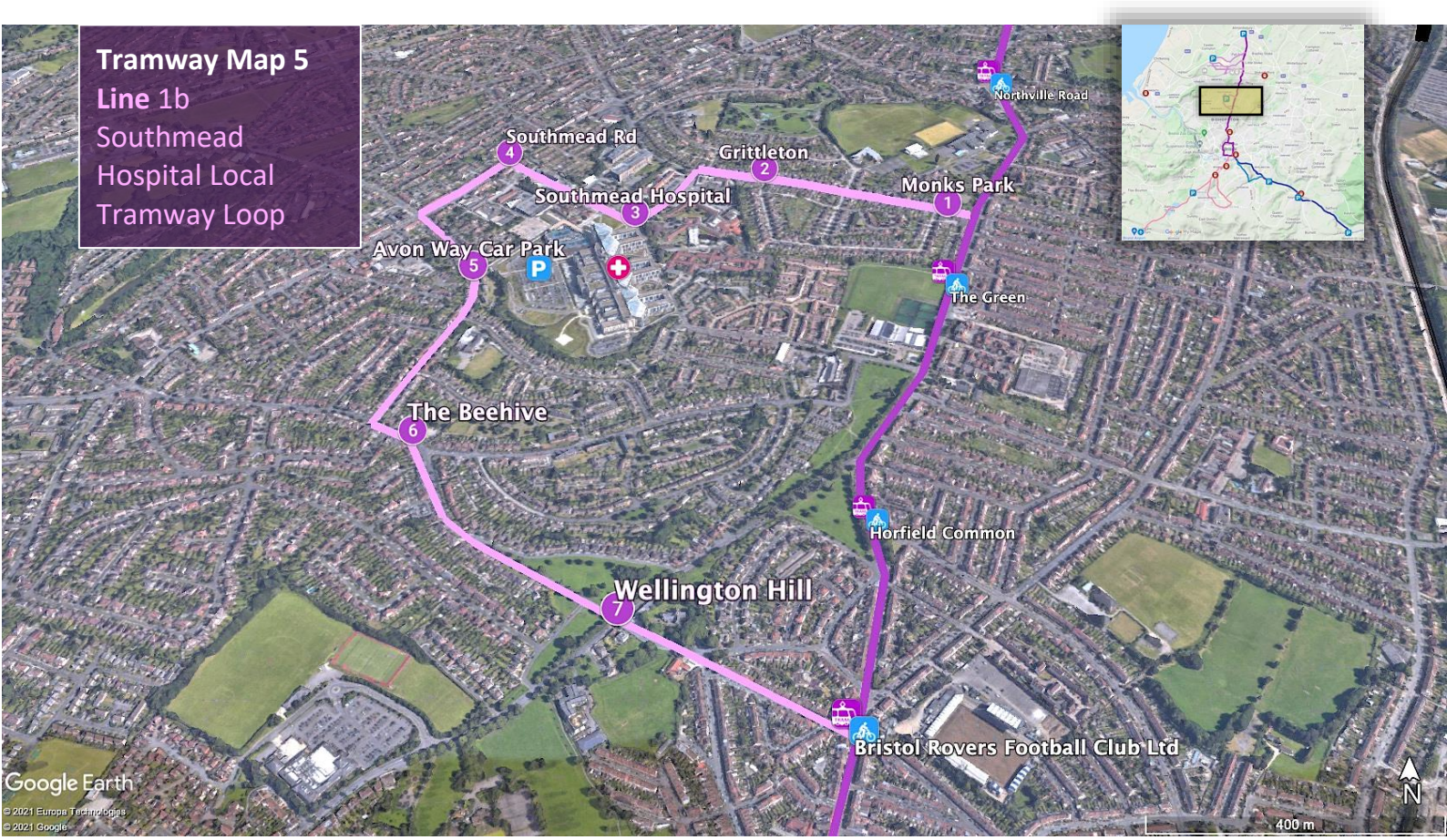
However, there are a number of routing options in this area, including serving a possible Park + Ride at M5 Junction 17 adjacent to the relocated Bristol Zoo (Wild Place). These would need to be assessed in a feasibility study, which would involve full consultation with local retail and commercial concerns who are likely to be highly supportive.

A major development of the proposed Primary Tram Network would be the upgrading of CPNN east-west Bus Rapid Transit to a tramway and the use of TramTrain technology would be used to link the whole of the CPNN tramway network to the railway line to the south. Thus, for example a tram would be able to go direct from the Cribbs Causeway area, through the new CPNN development to the local railway line east to Bristol Parkway and south to Temple Meads. It would also be possible to travel west to the upgraded Severn Beach Line to Avonmouth or via Montpelier to Temple Meads and thence to Bath.

This relatively new technology enables trams to share railway lines on sections of the Sheffield, Manchester and Tyne & Wear Metros and is currently being planned for use on the Cardiff Metro.

The prospective medium-term application of TramTrain technology in the Cribbs-Patcham New Neighbourhood Area should be assessed in a full feasibility study as it will further strengthen the business case for Line 1 of the proposed Primary Tram Network.

Fig. 17- Examples of TramTrains (Sheffield) and a tram terminus at a major retail centre similar to The Mall Cribbs Causeway. The bottom image shows Manchester's Metrolink Line which may be expanded to include TramTrains.



Phase 2 Line 1b Southmead Hospital Local Tramway Loop

The loop line will leave the A38 Line 1 at the Monks Park interchange and go via Grittleton Rd to the centre of the hospital site, from which it runs out on to the Southmead Rd. From that point the tramway turns south down Kingsholm Rd and via stops at the Avon Way Car Park, The Beehive and Wellington Hill, finally re-joining Line 1 at the Bristol Rover FC interchange. This route will serve the needs of visitors, patients and staff and provide a regular, on-time, 6-minute public transport alternative to the private car, with its ever-increasing need for substantial fee-paying car parking provision.

In addition to serving the Hospital, this choice of route will provide a high-quality public transport service for the residential areas adjacent to the hospital. This will be an improvement for the Southmead and Henleaze neighbourhoods which are some of the city's lower income neighbourhoods and are poorly served by bus services.

5.2 Line 2: City Centre Carousel Hub via Bath Rd to Globe Inn Park + Ride

As shown on the Primary Network Schematic this line has two components:

Phase 1 Line 2 City Centre Carousel Hub via Bath Rd A4 to Globe Inn Park and Ride:
This Line is designed to provide a rapid transit service between Bristol and the city boundary with the potential for an extension into Bath. It would initially be developed as a Bus Rapid Transit service as an interim measure prior to upgrading to a tramway.

Phase 2 Line 2a Knowle – Callington Rd Hospital Loop:
This will substantially improve the public transport service to the Knowle neighbourhoods and also the hospital, thus contributing to the business case for Line 2.

Tramway Maps for Line 2:

Tramway Map 6 Line 2 Brislington Rd Park+Ride to Globe Inn Park+Ride

Tramway Map 7 Line 2 and Line 2a Knowle-Callington Rd Hospital Local Tramway Loop

The A4 Bath Rd corridor was identified in the 2019 Bristol Transport Strategy for development as a future rapid transit link to serve Bristol, Keynsham, Saltford and Bath. The City Centre Framework has since emphasized the importance of the A4 from the city centre towards Bath as the south-east section of a cross-city MetroBus route from a Portway P+R to an A4 P+R at Hicks Gate, relocated from the existing Bath Rd P+R at Brislington. This route is planned for upgrading to deliver a Bus Rapid Transit scheme by 2025, providing high quality, high frequency services on a segregated route.
- WECA Transport Delivery Plan February 2021

*But there is a medium term tram alternative. As with the city centre MetroBus loop, the Bus Rapid Transit from the city centre towards Bath, would be an interim solution, prior to **re-purposing this BRT route as Primary Tram Network Line 2**.*

This option will need to be assessed in feasibility study which compares the tram mode with the Bus Rapid Transit mode.

5.2.1 Line 2 Potential passenger demand.

The volumes of long-distance commuting reflect the developing economic interdependence of Bath, Keynsham, and Bristol. Potential passenger demand is supplemented by residents commuting shorter distances into the city from the new riverside high-rise housing in Arnos Vale, Kensington Park and Brislington together with 'hop on and hop off' local journeys. Assessing and taking account of the post-pandemic adjustments to these movement patterns will be an essential component of the full feasibility study for this route.

The levels of traffic on this route will be significantly increased by the scale of development currently proposed in the emerging WECA Joint Spatial Development Strategy and Local Plans of Bristol City Council and Bath & NE Somerset Council - at the Temple Meads Quarter, the Brislington Bath Rd Park+Ride and in Keynsham.

TfGB have raised the possibility of an alternative connection between Line 2 and the station via the A4 St Philips Causeway, as a strategic component of redevelopment of St Philips Marsh. A pre-feasibility study of this option should also be undertaken in the context of the ongoing evolution of a Development Framework for the Temple Quarter and St Phillips Marsh Regeneration Programme, to integrate the proposals of the landowners in the area. This proposes the delivery of 10,000 new homes and 22,000 new jobs over the next 15-20 years and the early phases of development are underway. The University of Bristol Temple Quarter Campus – for 3,000 students and 800 staff – is due to be completed in 2023. The Temple Island site - formerly earmarked for an arena - has planning approval for 500 new homes, two office blocks, a 350-room hotel and a conference centre.

5.2.2 Line 2 re-allocation of Road space

The pre-feasibility level assessment indicates that there are no engineering, re-allocation of road space, or traffic management issues which would preclude the provision of an on-street tramway along the proposed A4 route, with some limited opportunities for off-road construction between Keynsham and the Globe Inn Park+Ride.

The tramway will be double track for the whole of its 16-mile length, except for a short section at the Bath Rd-Eagle Rd junction and part of the route through Keynsham.

Fig. 18 - tram stops can be positioned near steep hills and cycle-hire docking stations

Trams can carry cyclists up steep inclines.

Whilst there are hilly sections on the route, such as Bristol Hill, none will preclude trams which have the capability of climbing 10 % gradients with a full load of 200+ passengers.

Line 2 leaves the Carousel at Temple Circus turning south to join the A4 via Temple Gate. This study proposes mass transit to be provided by a Primary Tram Network which includes a multi-mode interchange at the refurbished station. Tramway Map 5 shows the Temple Mead Station stop at the junction with the Approach Road, However, it would be physically possible for the tramline to go up the Approach Road to the station entrance. This would fully meet requirements of providing mass transit access for people with disabilities, carrying luggage or wheeling a buggy. A Friary entrance to the station would also be an option.

In the context of the evolution of the 2020 City Centre Framework, the feasibility study for Line 2 should fully evaluate these options, not least because a multi-mode interchange could obviate the need for a major multi-storey station car park.

The second stop would serve the redevelopment in the next 5 years of the Temple Island site for 500 new homes, two office blocks, a 350-room hotel and a conference centre. The third stop at Totterdown bridge stop would provide access to the tramline from the long established Totterdown neighbourhood to the south and the planned longer term large-scale redevelopment of St Philips Marsh north of the river.

The Arno's Vale Paintworks stop would serve the recently constructed high-density, high-rise, riverside housing development. The Arno's Court, Eagle Rd and Bristol Hill stops would serve the Kensington neighbourhoods.

At the Bath Rd/Eagle Rd junction the double track would split into a single track running south on Bath Rd and a single track running north along Eagle Rd.

Double track running would resume down Bristol Hill past the Callington Rd junction to the Brislington Retail Park, which would also serve the industrial estates and the Brislington Park+Ride when, as a Strategic Development Location (SDL), it is redeveloped for 500 new homes.

As part of (or in parallel with) the feasibility study for Line 2, it would be highly desirable to consult on closing the several car-commuter rat-runs that parallel the A4, namely Broomhall Rd, Whitby Rd and Crews Hole Rd - see TfGB Bristol Traffic Management Plan. As this would tend to push residual car traffic onto the Bath Rd, there may be need of 'green wave' tram priority traffic signal operation in this section.

In the context of the detailed planning of the SDL to create the proposed ***Bath Rd, Brislington New Neighbourhood*** (which will extend from the industrial estates to the city boundary), the feasibility study for Line 2 should also assess options for off-highway routing between the current Bath Rd P+R and proposed Hicks Gate P+R.

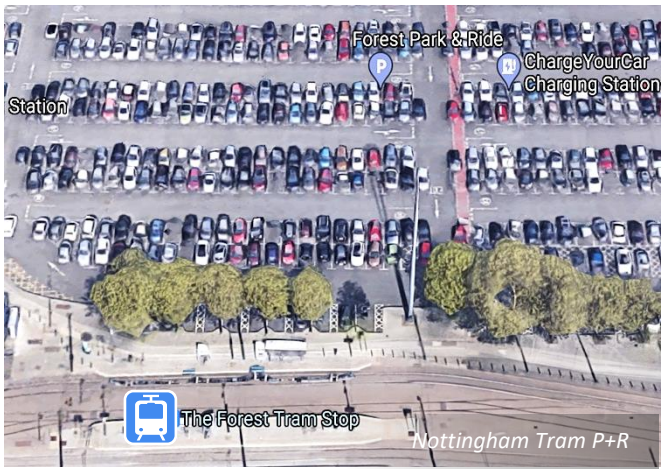
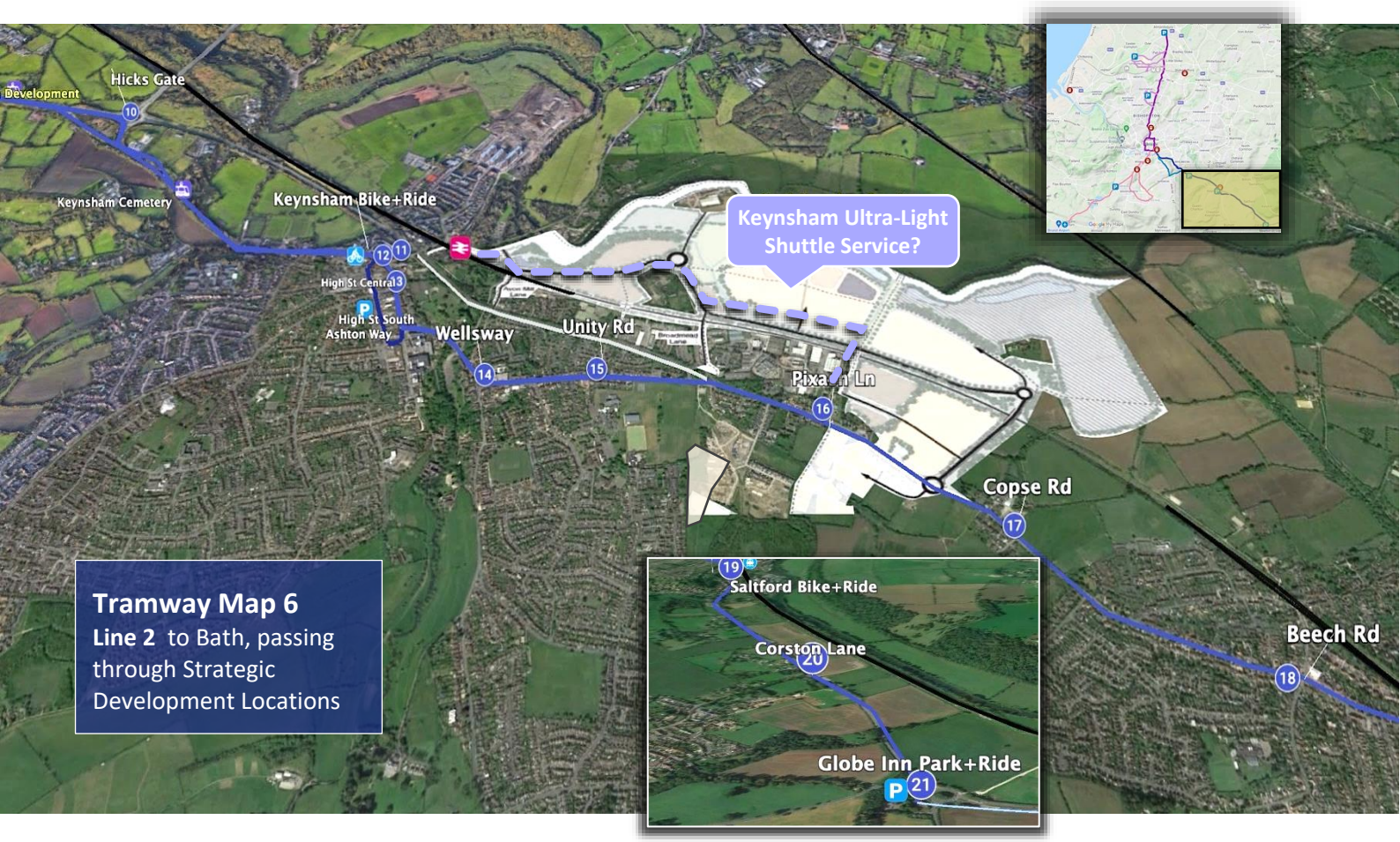


Fig. 19 - Example of a well-used Park+Ride tram stop with EV charging stations



From the Hicks Gate P+R (10) stop Line 2 would continue along the A4 bypass, but leave it to go into ***Keynsham Town Centre***, via The Avenue, up to the Station Rd bridge over the bypass. After turning right into Station Rd (11) running past the B+R stop (12) the tramway turns left at the Bristol Rd roundabout to run single tracked into the High Street (13 - High St Central Stop).

The route then turns left, to run double tracked up Bath Hill, and left at the Wellsway (14) stop at the junction with Bath Rd, which it follows via the Unity Rd (15) stop, serving the adjacent residential areas and the Wellsway School. The route re-joins the A4 bypass at the Bath Rd/Broadmere Lane roundabout, from where it goes to Saltford. The Beech Rd (18) central Saltford B+R (19) stops provide tram access for Saltford residents. The Corston Lane (20) and Globe in P+R (21) stops provide access from the western suburbs of Bath.

Trams from Bath to Bristol will leave the A4 at the Bath Rd/Broadmere Lane roundabout and travel along the Bath Rd to turn right into Bath Hill. At the High Street roundabout, the tramway turns left, runs single tracked in Temple Street, left into Rock Rd and right into Ashton Way. It crosses over Charlton Rd into Danes Lane, and turning right on to the A4175 to re-join the mainline via the Station Rd stop, which gives pedestrian access to Keynsham railway station.

This ***Keynsham Town Centre Circular*** would be a 'first mile-last mile' tram connector to Keynsham railway station - a transformative public transport link which would encourage more car drivers to switch to fast peak travel time trains into the city centre, rather than drive up the A4 or catch a Rapid Transit Bus.

But crucially, it would also provide the basis for the transformative pedestrianisation and regeneration of the High Street, providing the certainty needed for private investment in businesses providing employment, alongside public investment to upgrade the public realm.

Moreover, planning of this proposed tram circular should be integrated with the ongoing detailed planning of the *North Keynsham SDL* urban extension. The Council has fully recognised that *…'current traffic congestion in Keynsham is high, journey reliability is poor, and the network is saturated'*[24]. Thus, options have been detailed for an essential new Rd link connecting the A4175 to the north of Keynsham, through the urban extension to the A4 Bath Rd to the east of Keynsham. A route will be determined as part of the production of the *Bath and North-east Somerset Local Plan* – with a statutory public consultation in late 2021 and government approval of the Plan in 2022-2023, as part of the WECA Joint Spatial Development Strategy.

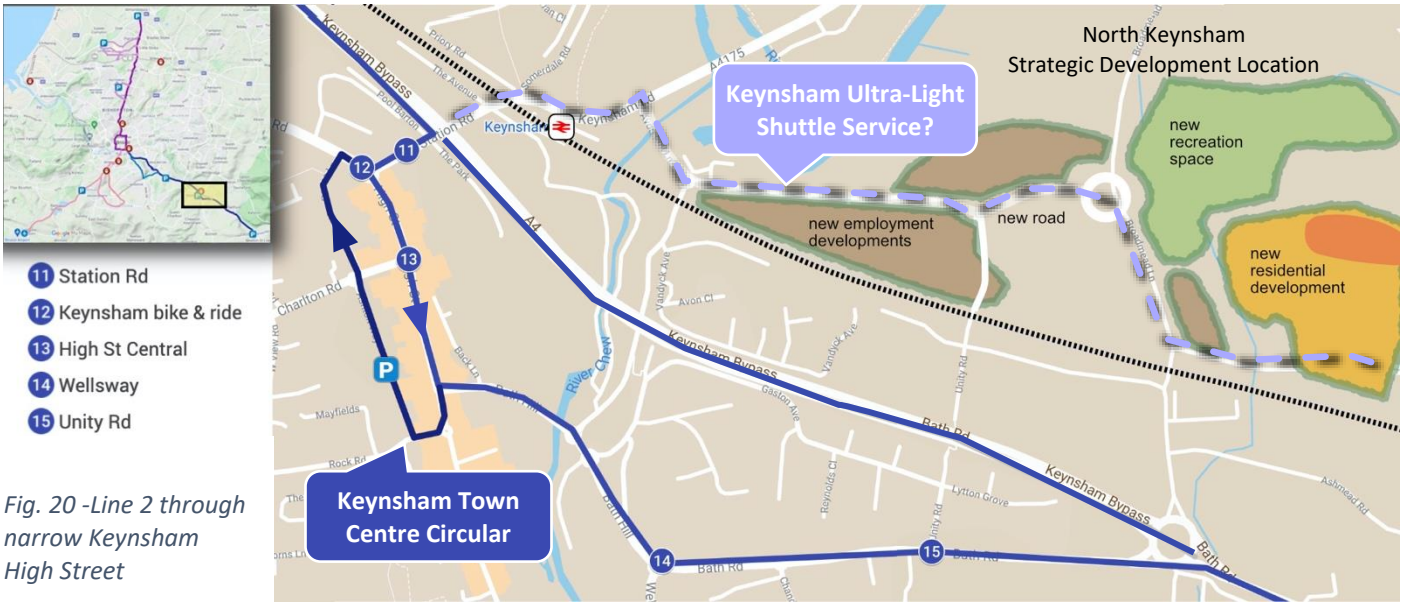


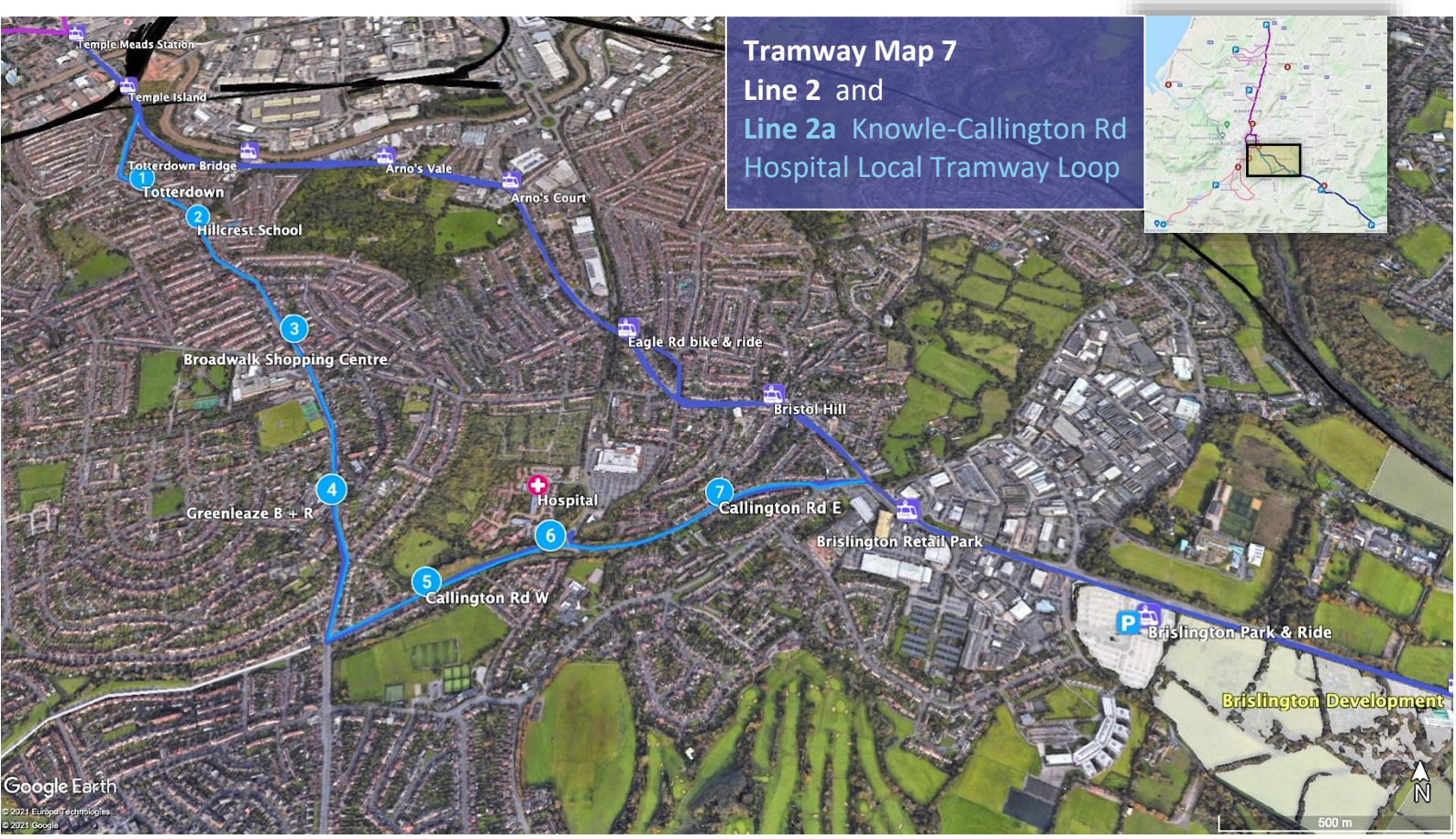
Fig. 20 -Line 2 through narrow Keynsham High Street

In this context this study proposes that a feasibility study is undertaken to assess the viability of proposed Line 2 Keynsham Town Centre route being linked with a single track loop line through the North Keynsham urban extension to provide a ***Keynsham Ultra-Light Shuttle* Service**. This would integrate the new urban neighbourhood with the town centre both physically and symbolically, reduce congestion and provide a reliable modern alternative to the otherwise inevitable increase in car journeys.

Battery-powered shuttle, Testing in Coventry, 2021

Moreover, such a link could establish the first phase of a future integrated ***Keynsham Tramway System*** which would serve both the existing Keynsham neighbourhoods south and west of the town centre and the major urban extension to the north-east. As such it could be the basis of a ***Keynsham 2036 Vision*** in which housing and employment growth would be accommodated in a way which would generate tram passengers, minimise car dependency, create opportunities for pedestrianisation and public realm improvement in the town centre and in so doing enhance the attractiveness and identity of the town.

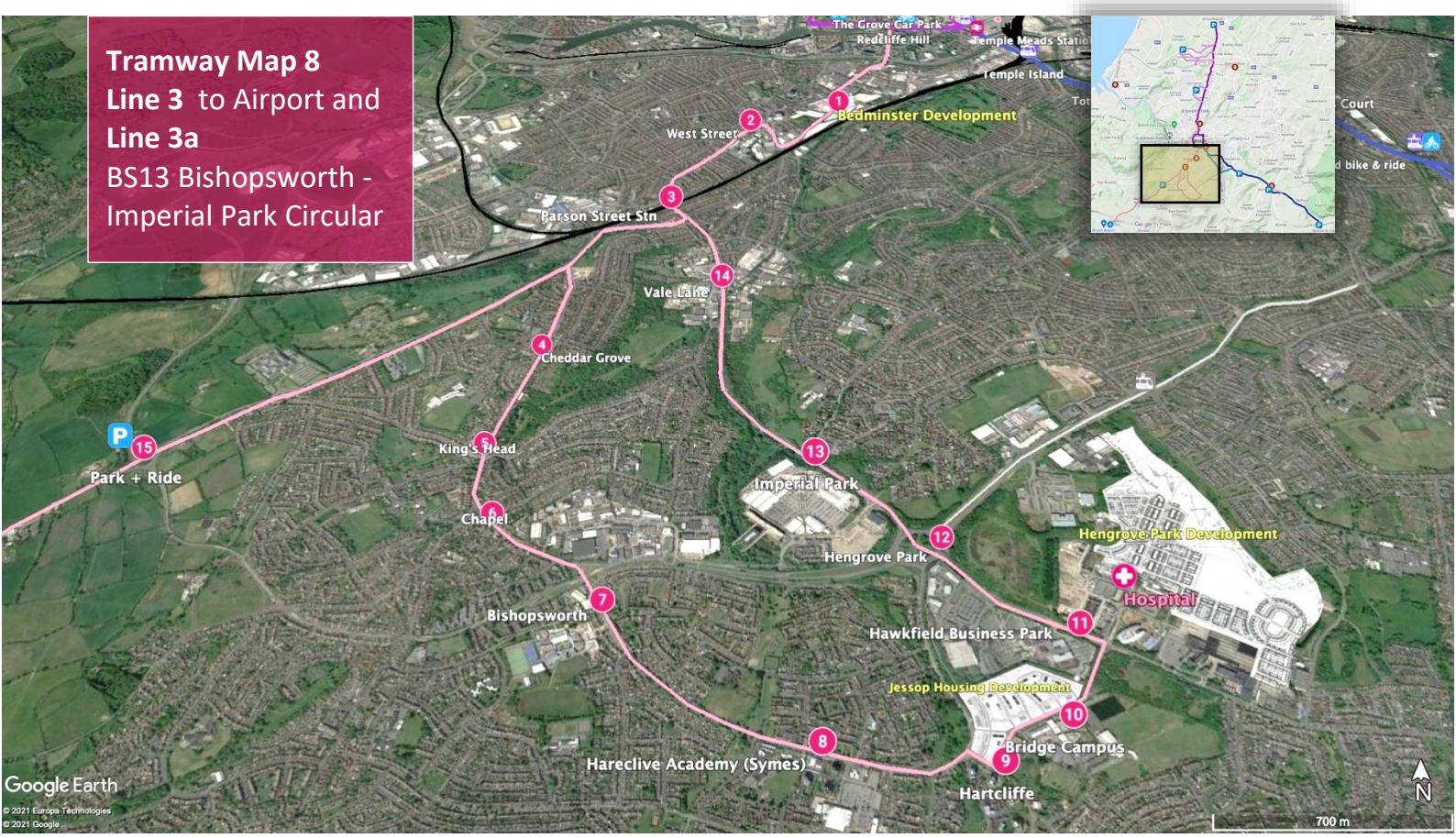
[24] Bath & NE Somerset Local Plan 2016-2036 Consultation
https://beta.bathnes.gov.uk/sites/default/files/2020-01/banes_local_plan_2018_final_website.pdf



Line 2a Knowle-Callington Rd Hospital Loop - Tramway Map 7

The Loop Line leaves the Bath Rd the junction with the A37 Wells Rd, which it follows south (along a former tram line) to Callington Rd. The Totterdown (1) and Hillcrest School (2) stops serve the inner city Totterdown neighbourhood, whilst the Broadwalk Shopping Centre (3) and Greenleaze Bike+Ride (4) stops provide tram access for the suburban Knowle neighbourhoods.

The Callington Rd West (5) stop gives access to the nature reserve and the Bear's Bridge Sports complex. Further east the Marmalade Rd roundabout (6) stop provides access to the Hospital and the superstore – a location which needs careful design to see trams could go up to the hospital entrance and the superstore car park. The final Callington Rd East (7) stop serves residential areas north and south of the Rd. As the Bristol tram network expands in the longer term, the Wells Rd section of the loop line could be extended south to Whitchurch and west along the A4174 to join Line 3a Bishopsworth - Imperial Park Circular.



5.3 Line 3: City Centre Carousel Hub to Airport via Parson St Station and BS13 Circular

The Bristol Transport Strategy 2019, following the emerging WECA Joint Local Transport Plan, identifies the City Centre to Airport route as one of four rapid transit routes and states that *'…there are various options for this route including tram and underground options'* and that *'…an underground option could divert to serve south Bristol, linking to a new Park& Ride on the A38 before emerging overground along the A38 to the airport'* (p65), In March 2021 Bristol Mayor published a schematic: *Bristol Public Transport Vision*[25] which shows this option as one of its four 'over or underground rapid routes'.

5.3.1 Line 3/3a: Potential passenger demand

In this context this study was asked to identify and undertake a pre-feasibility assessment of a tramway route that would serve the B13 area of south Bristol, which is badly served by public transport and includes low-income neighbourhoods. The route was identified jointly with Zero West inputs and is shown as Tramway Map 8 (Line 3).

The A38 South currently provides for commuters from North Somerset and airport users, together with shorter distance commuters from the Bedminster area. Line 3 would serve these groups with a Park+Ride at the junction of the A38 and A4174 at Colliters Way.

25 Schematic
https://www.newcivilengineer.com/latest/what-bristols-proposed-4bn-underground-rail-network-could-look-like-16-03-2021/
Video illustration
https://www.itv.com/news/westcountry/2021-03-11/going-underground-how-bristol-and-bath-commuters-could-be-travelling-to-work-by-tube-in-ten-years-time

A mass transit link from the city centre to the airport along the A38 raises environmental issues in that it may encourage increased air travel. However, the addition of the proposed 3a circular would both provide high quality public transport for BS 13 and add substantially to the business case for Line 1.

The reality is that a standalone BS13 line without a rapid transit line to serve A38 commuters and the airport would simply not secure government approval, but there would be a strong business case for the combination of Line 3 and Line 3a. The business case should also consider the option of constructing Line 3a as the first phase, because there is considerable local stakeholder support for this circular route, or constructing it simultaneously with the line to the airport. This proposal needs to be subject to a full feasibility study and compared with the option of an inevitably far more expensive underground link from the city centre south to Hengrove and west to the proposed A38 Park+Ride at Colliters Rd.

Overall figures of likely passenger demand were not available to this study. However, it is reasonable to propose that there would more than sufficient demand and therefore revenue from a combination of three sources:

First, the current population of the BS13 neighbourhoods served by Line 3a would be considerable. Moreover, this would deliver a high-quality public transport service to some of the city's lower income areas, from which residents travel long distances, either by car or long slow bus journeys, to low paid jobs in the city centre or Avonmouth.

Line 3 will go through the Bedminster Green regeneration area, which lies between the East Street Bedminster Town centre and the railway line. The City Council has established a Development Framework to co-ordinate the redevelopment of 5 key privately owned sites – the Bedminster Green Framework. This will promote the development of a new, high rise high density urban quarter, which will both bring an uplift to the town centre and create the opportunity to improve the railway station. Up to 2,000 new homes will be built and the first development of 300 homes has recently been approved. The construction of Line 3 would provide long term security for this regeneration process.


Bedminster Green

Parson St Station

Second, the **continuing intensification of commercial and industrial development** south of Parson St Station in the trading estates on both sides of Hartcliffe Way, together with the intensification of the Cater Rd trading estates, and Imperial Park, will all generate increasing journeys to work, many of whom would switch from private cars to public transport.

The third source of passenger demand will be generated by the **large-scale development of new housing in the Hengrove Park area,** where a 350-home development is currently under construction, with a further 1,400 plus in the development pipeline with outline planning consent.


Hengrove Park

Bristol Public Transport Network Vision: the south-east quadrant void

However, a wider analysis suggests that the feasibility studies for a Bristol public transport network would also need to evaluate a third strategic rapid transit option for south Bristol. The recently published Bristol Public Transport Vision apparently makes no strategic public transport provision for the south-east quadrant of the city, between a proposed 'over or underground rapid route' due south and west to the airport and one running and south-east to Bath.

In the context of the longer-term development of this study's proposed Bristol Primary Tram Network, as shown in Fig. 5 Schematic Diagram. Line 3a could be linked eastward along Hengrove Way to join Line 2a at the junction with the A37, which would connect it via Callington Rd to the A4.

This would complete a tramway connection between the A38 south of Parson Street Station and the A4 at Brislington, via Hengrove Park.

Furthermore, in combination with the extension of the Line 2a A37 section south to Whitchurch, this proposal would provide a tramline alternative to constructing the proposed final link in the orbital ring Rd A4174 between the A4 and the A38. This South Bristol Link Rd would run from the proposed Hicks Gate Park+Ride, through Stockwood to Whitchurch where it would separate the existing urban area from the 2000 homes southern urban extension at the proposed Whitchurch Strategic Development Location. This urban extension, served by a major Rd building project, is strongly opposed[26] by the residents along its route (characterised as the Wrong Rd) and will be a contentious issue in the statutory consultations on the WECA Joint Spatial Development Strategy (JSDS) and the Bath and North-East Somerset Local Plan in the second half of 2021, to be followed by Public Examinations in 2022.

From Whitchurch two routes west for the south Bristol Link Rd will be the subject of Public Examinations. Having crossed the A37 at Whitchurch, the first is a route north-west to Hengrove Park and then west to the A38. But the proposed extension west of Line 2a to join line 3a at Hengrove Park, combined with the extension south to Whitchurch, would provide a less disruptive tramway alternative to serve both the large-scale regeneration of Hengrove and the urban extension of Whitchurch.

The second route west from Whitchurch would skirt the southern boundary of the built-up area of the city to the A38, thus completing the orbital route from the A38 north round the eastern city suburbs to the A38 south. But it would also provide the opportunity for an innovative dual mode link Rd between the A4 and the A38 where the new Rd space is shared with trams, which could be compared with a BRT – Paris has an orbital tramline.

5.3.2 Line 3/3a re-allocation of Road space

The following pre-feasibility assessment indicates that there are no engineering, re-allocation of Rd space, or traffic management issues, which would preclude the provision of a double tracked on-street tramway along the proposed route, shown on Tramway Map 8, but a tram bridge would be needed over the new A1474 to connect Bishopsworth and Hartcliffe.

[26] https://www.bristolpost.co.uk/news/bristol-news/south-bristol-residents-demand-update-3415115

Line 3 leaves the Carousel at the Redcliffe roundabout, running south across the Bedminster Bridge, to a stop at Bedminster Parade to serve the superstore and adjacent neighbourhoods. Then it turns south into Dalby Avenue, with a stop to connect with Bedminster Station and from there along the A38 Malago Rd to turn left into St John's Rd. This is a Public Transport Priority route which is part of the new MetroBus route M1.

Line 3 will go through the Bedminster Green regeneration area which lies between the East Street Bedminster Town centre and the railway line. The City Council has established a Development Framework to co-ordinate the redevelopment of 5 key privately owned sites. This will promote the development of a new, high rise high density urban quarter, which will both bring an uplift to the town centre and create the opportunity to improve the railway station. Up to 2,000 new homes will be built and the first development of 300 homes has recently been approved. The construction of Line 3 would provide long term security for this regeneration process and provide enhanced access to the rail network.

From Malago Rd the tramway would turn left into the B3120, down to the roundabout junction with the B3122, then right into Bedminster Rd to follow the gyratory around Parson Street Station, with appropriate tram stops north and south of the station.

Travelling south the tramway Line 3a turns off into the Bishopsworth Rd to go via stops at Cheddar Grove, King's Head Lane and Chapel to Bishopsworth, serving residential areas on both sides, together with the Cheddar Grove and Bedminster Down Schools.

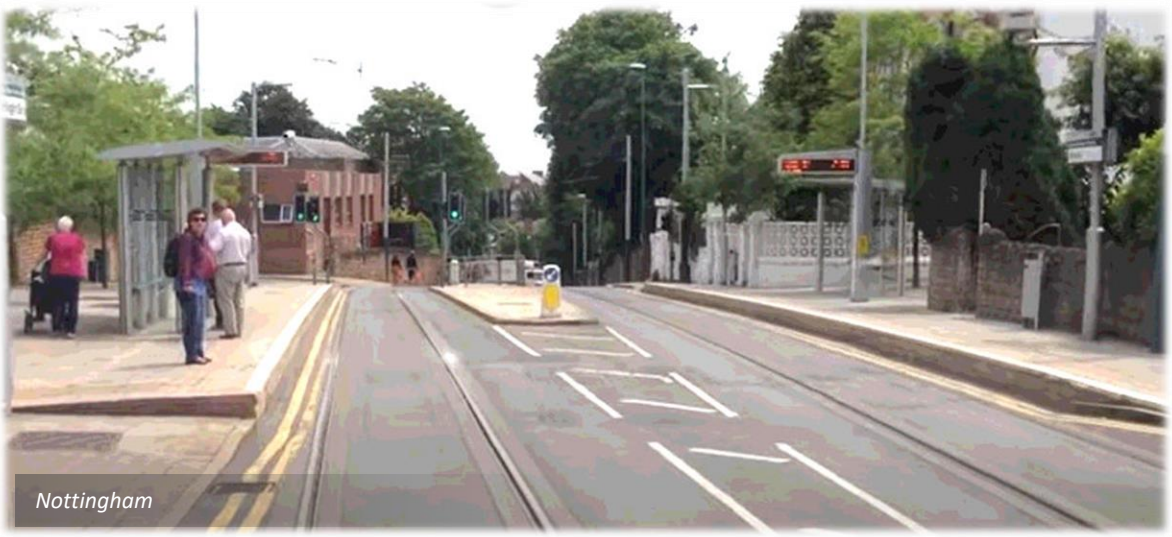


Fig. 21 - Example of a narrow road tram stop. All traffic share, cyclists routed behind tram shelter

From a Bishopsworth centre stop, the tramway route goes down Whitchurch Rd, with a stop to serve the superstore and the trading estate, to a tram bridge over the new A 4174 into the Hartcliffe neighbourhoods, via Hareclive Rd, with a stop to serve the Hareclive Academy and the superstore. The tramway route then goes into the major redevelopment/growth area of Hengrove Park.

The tramway crosses the junction with Hawkfield Rd to a stop in William Jessop Rd - to serve the 350 homes under construction on the site of the former City of Bristol College - and then to the junction with Whitchurch Lane. A detailed design would be needed for the tramway to provide full access to the South Bristol Hospital via the Boulevard and to the adjacent 1400 plus homes planned for construction in Hengrove Park. This should be undertaken in consultation with the Hengrove and Whitchurch Park neighbourhood Planning Forum whose adopted Neighbourhood Plan includes this key development area.

From the hospital/Hengrove Park area, the tramway would go to the A4174-A3029 roundabout, to travel north-west along the Hartcliffe Way A 3029, via a stop to serve Imperial Park and the Inns Court neighbourhood and a stop at the junction with Vale Lane to serve the trading estates. Line 3a BS13 Loop then re-joins the Bedminster Rd and the tramway route north to the city centre.

From the point at Bishopsworth Rd where tramline 3a turns off the A4, the Line 3 route would go to the airport via a new Park+Ride at the Colliters Rd junction of the A38 and the A4174.

6 Conclusions & Recommendations

This limited project first developed an 'in principle' case for a 'tram plus local train' rapid transit system for Bristol. Within this 'steel on steel' perspective the project then assessed and built on the Transport for Greater Bristol (TfGB) 2020 *Rapid Transit Plan for Bristol* to propose the phased development of a potential *Bristol Primary Tram Network,* over 10-15 years, with a first line operational within 5-7 years.

This outline tram-based rapid transit proposal will support the Zero-West/TfGB engagement in the range of public consultations on transport and spatial planning policies which are scheduled to start in summer 2021 and be followed by formal public examinations in 2022. WECA will be consulting on the outcome of their £1.5m consultancy project commissioned to identify options for mass transit, assessing routes that will have the highest volume of passengers and connect with existing and planned bus services. In parallel WECA will be consulting on the Joint Spatial Development Strategy which will confirm the location of planned housing and employment for the next 15 years. On the same timescale both Bristol City and Bath & North-East Somerset Councils will be consulting on their emerging Local Plans which will provide detailed proposals for major development in key locations.

This final section of the report summarises the main conclusions of this project and provides some pointers for the development of the Zero-West/TfGb Moving Bristol Forward campaign as it engages in this unprecedented period of public consultation on the city's future transport system.

The scope and limitations of the pre-feasibility study

A pre-feasibility study method was developed which focused on a preliminary assessment of potential demand, the reallocation of Rd space (from private cars to public transport and active travel) and tram network management - the designation of Public Transport Pathways (PTPs) and multi-purpose tram stops. This method was applied to assess two potential commuter 'starter lines' - along the A38 North from a proposed Park+Ride near the M5 to the city centre and from a proposed Park+Ride at the Globe Inn on the A4 Bath Rd to the city centre. A third radial route was identified and assessed along the A38 South to the airport which includes a Bishopsworth - Imperial Park circular to serve the BS13 area.

It became clear that a city centre Carousel would be necessary to maximise cross-city connectivity and that second phase Local Tramway Loops would provide high quality public transport services for hospitals, shopping and recreational/leisure facilities, together with a diversity of inner city and suburban neighbourhoods.

The overall conclusion is that the proposed Bristol Primary Tram Network, with its phased development of three core tram lines, should be subject to a full feasibility study, which would compare it to other network options for the development of a mass rapid transit system for Bristol.

The pre-feasibility assessments of **passenger demand** indicate that a combination of medium and long-distance commuting (albeit possibly reduced post-pandemic) and the off-peak ridership generated by both existing and planned residential and commercial areas through which the tramways would pass, will almost certainly be sufficient to justify the installation of tramways. But it will be a key task of the full feasibility studies to develop robust passenger demand forecasts, using industry proven methodologies, as a key component of the business case for each of the three lines, together with an initial assessment of the cost of physical works, rolling-stock and staffing, and an estimated timeline to operation.

The **re-allocation of Rd space and tram network management assessments** indicate that there are no engineering or traffic management issues which would preclude the provision of an on-street tramway on each of the three routes. However, it is clear that the proposed Bristol Primary Tram Network will not be successfully delivered without a series of traffic management measures to establish essential tram priority on-street to deal with current and ongoing general traffic levels. These measures will include an expanded network of Park & Ride sites, the completion of the ring of residents Parking Zones, reducing rat-runs and a Workplace Parking Levy.

Furthermore, it should be noted that in some critical sections of the routes, notably the southern section of the A38 Line 1 and the City Centre Carousel Hub, these assessments could not involve site visits and their validity must therefore be tested in full feasibility studies. In these sections, in particular, it will be essential to develop and deliver a ***'best practice' community engagement process*** to secure the support of local businesses and residents, as anything less could result in long delays at the first stage of the tram network development process.

Choice of Starter Line

The choice of starter line will require a comparative assessment of the financial benefits and costs of the three lines, in the context of an assessment of their social and environmental cost and benefits. This assessment should also evaluate the option of developing Lines 1 and 2 simultaneously - the course of action adopted in the construction of the Manchester Metro, which came to be known as 'the big bang approach'. This comparative assessment and choice of the starter line will be the core of the full feasibility studies. Some of the key Issues which have emerged in this study that will need to be considered are set out below.

Line 1

The volume of traffic on the A38 North suggests that passenger demand, and therefore revenue, will be high - although there is some uncertainty about post-pandemic levels of commuting. However, the realistic prospect of demand being supported by the Cribbs-Patchway New Neighbourhood Local Tramway Loop could well future-proof high demand, depending on the evolution of travel behaviour patterns in the CPNN. Moreover, the application of TramTrain technology would link the CPNN tram network to the rail network and thence to Bristol Parkway and Temple Meads.

But the installation of Line 1 will be a complex task, not least because the southernmost section of the A38 North, where space is tight, will require the application of a full range of imaginative tramway design and traffic management techniques, in the context of a 'state of the art' community engagement process to win public support.

However, experience in other cities suggests that investment in public transport and associated public realm improvement in the southern section of the A38 and the city centre would stimulate private investment alongside and close to the tram routes – experience which needs to be synthesised and fully shared with local businesses and residents.

Moreover, from the point of view of a vision of 21st century Bristol there may be much to be said, not least politically, for strategically linking the increasingly high profile and dynamic growth of the South Gloucestershire Cribbs-Patchway New Neighbourhood (CPNN) at the northern end of Line 1 to the post-pandemic recovery and growth of the Bristol city centre at its southern end.

In advance of the development of Line 1, it will be important to introduce a Bus Rapid Transit route along the M32 from a major suburban Park+Ride site to the city centre. Combined with city centre parking restrictions/charges, this would deliver an initial reduction in city centre congestion prior to the construction of the City Centre Carousel. This route could then be repurposed as a tramway which would further increase the number of car drivers switching to public transport.

Line 2

As with Line 1 the pre-pandemic volumes of traffic suggest that passenger demand and therefore revenue will be high. Whilst there is a question about a potential reduction in Bath-Bristol commuting levels, this may well be offset by the increased passenger demand which will be generated by Temple Quarter and St Phillips Marsh Regeneration Programme, and the urban extensions at the Brislington New Neighbourhood and the North-East Keynsham. The simultaneous construction of the proposed Keynsham Town Centre Circular and the A4 bypass tramway Moreover, the proposed second phase Knowle-Carrington Rd Hospital Loop would future proof the line.

There is much to be said for Line 2 as a more straightforward project to construct and operate than Line 1, and it would benefit both Bristol and Bath, not least because there is strong and evidenced support in Bath for the development of a tram system. However, the proportion of passengers who are Bristol residents may well be lower than Line 1, as there will be less opportunities/incentives for local 'hop and hop off' journeys during off-peak hours. Moreover, this route is currently proposed to be developed as Bus Rapid Transit route, which would be an appropriate interim measure prior to repurposing as a tramway, after the completion of Line 1.

This study was not required to examine an alternative possible Line 2 routing via the Temple Quarter / St Philip's Marsh redevelopment zone, and the old Whitchurch railway alignment, though it is understood that others are doing such an assessment for comparison.

Line 3

This line serves two groups of potential passengers. The first is the business and tourist airport travellers and north Somerset commuters. The second comprises Bristol residents and businesses in BS3 and BS13. The section of the tramway from the city centre to Parson Street Station will serve both airport passengers and commuters, along with the lower income inner city Bedmington neighbourhoods where it will support the regeneration of a new urban quarter. Beyond Parson Street Station the Bishopsworth-Imperial Park Circular will serve both the existing lower income neighbourhoods and the major growth in population and employment in the Hengrove area.

A full feasibility study will assess the total passenger demand. But it will also need to answer the question *'who benefits from Line 3?'* by analysing the likely relatively high proportion of low-income passengers and include this dimension of analysis in the comparative feasibility studies with Lines 1 and 2. This breadth of analysis will be necessary in order to judge the equality impacts of the three lines.

Bristol- a third generation tram city?

Bristol now has the opportunity to be the first major UK city to both embrace the emerging third generation tram technology and the relatively new pollution science of non-exhaust emissions. Such a transformational tram-led public transport system will effectively address the legacy of congestion and pollution by delivering a much higher level of modal shift from private cars to public transport than is possible with Bus Rapid Transit-led system

Tram technology is on the cusp of revolutionary change. The recent and accelerating development of Ultra-light / Very Light vehicles and track systems heralds the arrival of third generation tram technology. The fact that the city has lagged behind comparable cities in the UK means that it now has the opportunity (as has Leeds) to leapfrog the second-generation technology which they have employed and be the first major UK city to develop a ULR/VLR tram network, equivalent to, but on a larger scale than that now being developed in the smaller city of Coventry.

This would mean that the per kilometre costs of a Bristol tram network could be up to 50% less than the costs incurred in the cities which are currently extending their second-generation tram networks. Moreover, it would decisively advantage serving BS13 by tramway, rather than underground.

Moreover, in taking this opportunity Bristol could also be the first major city to take fully and explicitly into account the new and emerging science, which establishes the threat of pollution from non-exhaust emissions as a key driver of a 'steel on steel' tram and local rail public transport system.

Moving Bristol Forward- next steps

The conclusions outlined above provide some pointers for the development of the Zero-West/TfGB Moving Bristol Forward campaign.

Moving Bristol Forward

Independent technical advocacy

The next stage of TfGB's independent technical advocacy of a tram-based rapid transit system could be developed around a series of action points which may include the following:

- developing a basic factual assessment of the cost effectiveness of the emerging third generation tram technology to be used to inform local politicians and community organisations about the opportunity which this presents to the city;
- promoting Bristol's opportunity to develop as a tram city in parallel with its already evolving role as a 'cycle city' - TfGB should develop accessible material which demonstrates that trams and cyclists can move around the city in harmony, drawing on the experience of both UK tram network cities and cities abroad such as Ghent;
- promoting widespread understanding of the dangers of allowing the accelerated growth of highly toxic non-exhaust emissions (fine particulates) to parallel the reduction of greenhouse emissions which will be achieved through the transition to electric cars, buses and commercial vehicles;
- providing a basic summary of the technical processes which will be involved in achieving the aim of having a first tramline operational in Bristol within the next 5-7 years;
- establishing and promoting a brief evidence-based analysis of the changing patterns of travel behaviour which result in tram services being far more effective than modernised bus services in persuading car owners to switch to public transport; and
- undertaking an assessment of the tram route potential (combined with Park+Ride) of the Avon Ring Rd and M32, including possible 'de-motorwaying' of the latter.

Continuing community engagement – 'build back better by bringing back trams'

There is an opportunity for Zero-West to draw on TfGB's technical advocacy to develop a 'hearts and minds' campaign to win public support for the phased development of a Bristol tram network, which could include the following:

- joint work to maximize public and community engagement in WECA's first stage public consultation on options for developing rapid transit system which is scheduled for this summer;
- distilling and promoting the 'steel on steel' cost effectiveness and proven modal shift arguments which underpin the case for re-introducing trams;
- engaging with cycling organisations to share evidence from cities, both in the UK and abroad which demonstrates that cyclists have adapted to sharing Rd space with trams, and are enjoying the reduced levels of traffic congestion;
- securing funding to enable community representatives to visit cities which have established tram networks that are currently being extended; and
- developing a pilot neighbourhood case study visioning project which would explore the potential of a tram based public transport system to support the further development of cycle and feeder bus networks, in the context of promoting the delivery of 15–20-minute low car neighbourhoods.

Ghent Mobility Plan 2030, Belgium

7 CREDITS

This report was co-authored by
Professor Mike Gibson, Chair LCT Ltd and
Jim Harkins, Chair LR (UK) Ltd

Additional research, editing, custom maps, 3D modelling, illustrations, image enhancements and graphic design by MikeWhelan.net (MW Creative Services). Image license: CC-SA-BY-NC-ND

Cover Image by Mike Whelan:

Location is south of Gloucester Rd, on A38 near city centre, under Cheltenham railway bridge near Montpelier Station.

Inset archive photo was taken in 1936 - exactly 90yrs before the proposed new line, in the same location, and travelling on a similar route.

Main image: common, *Very Light Rail* trams superimposed onto Google Streetview of Bristol. Destination labels are for both ends of Line 1. The image indicates space for other Rd users and signs for the adjacent rail station.

The realistic tram model (coloured purple) used in computer simulations throughout this report is based on the *Alstom Citadis* low-floor, light rail series: Length: 21m. Width 2.5m. The Tram-Train on the bridge is based on a *Dualis*. Alstom trams have a variety of power supply options: OHL pantograph / third-rail / batteries or electro-diesel. Variations of the *Citadis* are featured in real-world use throughout the report.

Other image credits:

Fig. 1 – adapted from bathtrams.uk

Fig. 2 – complied by Mike Whelan, images and data from trampower.co.uk, tig-m.com, coventry.gov.uk and railway-technology.com

Fig. 22 – https://tfgb.org/wp-content/uploads/2020/09/TfGB-Bristol-Bath-Rapid-Transit-Plan.pdf

Fig. 11 – courtesy of westmidlandsmetro.com

Fig. 14 – Melbourne image courtesy of www.twenty20.com. Free for editorial use. Fleetwood, Blackpool image courtesy of www.visitfleetwood.info

Fig. 15 – courtesy of hoftrammm.nl, streetcar.la, tripadvisor.co.uk and beeldbank.amsterdam.nl

Fig. 17– courtesy of www.constructionews.co.uk

Image on final page - https://www.eltis.org/sites/default/files/c1_scheirs_mobility_policy_ghent.pdf

Base maps and satellite imagery by Google Earth

Tram turning data and cycle safety diagram adapted by MikeWhelan.net, based on: nacto.org/publication/transit-street-design-guide/intersections/transit-route-turns/turn-radii/

Archive photos courtesy of www.bestofbristol.co

NEE articles: courtesy of MailOnline, Air Quality Expert Group and friendsoftheearth.uk/sustainable-living/tyres-and-microplastics-time-reinvent-wheel

All other images courtesy of Wikimedia Commons (CC-BY-SA) and LR (UK) Ltd