Tram power

Leading to better transit

Report of evidence for DfT Tram Inquiry Invited by Transport Minister Jesse Norman MP.

Submitted by Tram Power Ltd.

City Class Tram

LR55 street track

Simplified OHL

SUMMARY

Trampower has pioneered new ways of delivering tramways at lower costs, answering the criticisms of the National Audit Office and various District Auditors.

These are based on solid theoretical and practical work, including laboratory, bench and field-testing, and approval. The largest element of cost in a new tramway is the infrastructure, especially the track, which is still based on 19th designs, when roads were unpaved, and few had any underground utility services. Modern city roads are paved and capable of carrying 44tonne HGV's on 10.5tonne axle loads. The Trampower LR55 track only needs 5% of the excavation of other tracks, and under street utilities can mostly be left in place.

The Trampower simplified over head line (OHL) power supply, deliveries electricity to trams with a minimum of physical intervention and at a much lower price.

The Trampower City Class tramcar is the most energy efficient on the market. Using mass-produced components off the shelf from other industries, it delivers first and operating costs at much less than buses. Added to this trams attract people from trips by cars, which buses do not.

Examples from outside England are included to show the export potential of low cost, British made Trampower technology.

Contents

1.0 The DfT Questions ? p. 3
2.0 Introduction p. 8
3.0 History of Tram Power Ltd p.10
4.0 Reducing Infrastructure Costs p.10
5.0 Reducing vehicle and operating costs p.19
6.0 Evaluating potential schemes p.24
7.0 Promoting privately fundable schemes p.26

7.1 Preston p.27
7.2 Southwark p.28
7.3 CROST p.29
7.4 Slough p.30
7.5 Middlesbrough p.31
7.6 Londonderry p.31
7.7 Dublin Airport p.32
7.8 Limerick p.32
7.9 Liverpool p.33
7.10 Leeds p.34
7.11 Barnsley p.35
7.12 MASST: Denton – Sheffield p.35
7.13 E. Lancs Railway p.36
7.14 ELAN : Colne – Padiham p.37
7.15 Windermere – Oxenholme p.38
7.16 Chester p.39
7.17 Lancaster/Morecambe p.40
7.18 Warrington p.41
7.19 Birkenhead p.43
7.20 Hallamshire Hospital extension p.44
7.21 Aberdeen p.46
7.22 Abbey Line p.47
7.23 KENEX p.48
7.24 Bath p.49
7.25 Newcastle upon Tyne p.50
7.26 Cambridge p.51
7.27 Trafford Centre p.51
7.28 Southport. P.52
7.29 Galway – GLUAS p.53
7.30 Sutton p.55
7.31 Croydon N –S p.56
7.32 Liskeard – Looe Tramtrain p.57
7.33 Eden Tramway p.58
7.34 Isle of Wight p.58

8.0 Conclusions. P.59

1.0 The DfT Questions

The Invitation to provide evidence concluded with the following questions. These answers refer to later sections of this Report.

Q1 What is the potential scale of the opportunity for further light rail (or other rapid transit) systems to be introduced in England?

On the basis of travel demand by car, the level of congestion and level of toxic traffic pollution, nearly all settlements over 50,000 people would benefit from a tramway, which are proven to attract car trips, which bus based systems do not. The reason for this is that all potential towns have bus services that have failed to trips from cars, and are themselves significant sources of toxic air pollution. Added to this the UK is committed to reducing the production of CO_2 (DEFRA 2018), about a third of which comes from motor traffic, mostly cars.

Trams powered by renewably generated electricity and attracting trips from cars, reduce the local carbon footprint. Before 1939 there were some 220 tramways in Britain. Sadly many were built for 'Civic Pride' rather than to meet transport needs. There is a potential for about 150 tramways in Britain promoted on the basis of reducing car traffic rather than for political reasons. See also sections 2.0 and 7.0. As a comparison France opened its first new tramway (Nantes) in 1985 and has subsequently built another 28, near one a year.

Q2 Is there an appetite for new systems to be introduced in our cities and towns?

Trampower is actively involved in the promotion of over 10 schemes (Section 7.0 below). Because of the austerity regime and the lack of public funds, all are based on commercially financed and self-funding operations. In all the towns where an active tramway is being promoted, wide public support, typically about 80% is enjoyed.

Q3 Is there evidence to support this appetite?

See section 7.0 below.

Q4 What would the environmental, economic and congestion benefits be?

The commercial tramways set out in this Report will not see wider benefits appear in their accounts. These will however benefit the local and national community in several ways. This is a contribution that such tramways can confer on the areas served, in much the same way as a good food shop enables the local community to have a better diet and be healthier.

Environmental : reduced CO_2 and toxic traffic emissions (DEFRA 2017), and less ambient noise,

Economic: All the Trampower schemes are based on commercial promotion and financial viability. Wider economic benefits accruing to the whole community will not appear in the tramway accounts. These wider benefits will be:

(a) strengthening central areas by increasing footfall
(b) increasing the job market area, and the availability of labour
(c) reducing the number of people treated by NHS suffering from traffic pollution illnesses
(d) raising the value of property alongside tram lines and hence the revenue available to public authorities from property taxes.

(e) Adding transport capacity at an economic cost, a tram track provides the same passenger capacity as 3 road lanes with cars.

(f) Enabling higher development densities without the need for more parking or road capacity.

Congestion: A tramway with a 6minute frequency service provides the same passenger capacity as a 6 lane road. The average for UK tramways is at least 25% of passengers have left a car at home. In Croydon since the Tramlink opened in 2000 local traffic volumes have fallen by a fifth compared to the growth of traffic in the rest of London.

The Preston GUILD Line (Section 7.1) a Household Survey resulted in an over 40% response rate, with 80% supporting the planned tramway. On the basis of the responses from this survey it is expected that there will be about a 30% reduction in local car traffic. This is a lower figure than is typically the case in the US, where car ownership and usage is much higher, so the diversion greater. The US average is that 40% of tram passengers have switched from car (driving).

Q5 What impact would it have on jobs?

New tramways will directly create skilled jobs for operations, maintenance and management. In many town centres, trams will give better accessibility and improve connectivity, allowing land presently used for parking to be developed for value added activities. Based on US experience such regeneration can double the number of central area jobs.

Q6 Does light rail open up new housing or business developments or improve the urban fabric of the area?

Yes. There are many studies that demonstrate these benefits.

Q7 What can we learn from the experience of other countries in adopting new systems?

(a) Only promote tramways to meet transport needs
(b) Always include Park and Ride at outer (suburban) ends of lines to capture external car trips, and also local trips originating further than an acceptable walking distance from a tram stop.
(c) Make sure that tramway revenue covers operating costs, the servicing of the investment capital and provides for the depreciation and therefore the replacement of assets.
(d) Undertake Market Research to find the best routes
(e) Integrate with land use planning
(f) Operate on a commercial basis with professional management and no political interference.

Q8 What issues have helped progress light rail schemes or acted as barriers to their development?

(a) Barriers: National Audit Office Report on Tramways and "Green light for light rail". Major public investments in 'vanity' transport schemes like, new motorways, ring roads, Crossrail and HS2.
(b) Helped: Local public support, severe transport congestion or economic decline, environmental awareness, the need to improve public transport and to have an alternative to polluting buses that do not attract trips from cars.

Q9 What and where are the future opportunities here in England for new light rail systems or alternatives?

See Section 7.0 below.

Q10 What are the key issues that are preventing light rail schemes from being delivered?

The high cost and large risk of securing powers to build and operate a tramway using the Transport and Works Act makes it unlikely that privately promoted and funded tramways will become common place. This was a major criticism of the NAO Report on Trams.

For this reason Trampower has pioneered the use of Planning Applications to the Local Planning Authority, together with the Section 278 agreements (Highways Act 1980) as a way to reduce cost and uncertainty and speed the process of gaining powers to build and operate tramways. Trampower has been involved in applying for Planning Permission with two Local Authorities and has gained two tramway planning consents.

Some Local Authorities however think they should promote and operate new tramways, and do not welcome or worse discourage private promoting companies. Indeed this has been rationalised as “if private tramway goes bankrupt, will it leave the local authority with a mess to clear up ?”.

The answer to this is that no sensible private company would start building a tramway unless all the funding was in place to complete it. Once operating should revenue fail to cover operating costs, then the Receiver will sell the tramway as a going concern.

Something like this occurred in Sheffield where the loss making Supertramway was bought by Stagecoach for about £1million with a 25year repairing lease. Stagecoach turned around the finances and has been making nearly £1million surplus annually.

Either way a Local Authority will not be left with ‘a mess to clear up’. Indeed it will gain a major asset in its area, that will help to reduce traffic congestion and improve air quality, be an aid to economic regeneration and renewal, and become a way to improving the local economy, by providing an alternative to driving.

Where public authorities promote new schemes, they are constrained by the public procurement rules, which do not guarantee the best value for money and make it difficult for innovation. Many such schemes try to transfer the risks to private contractors or operators, when the biggest risk comes from the public sector, in changing policy or regulations.

For these reasons there is a dearth of British companies willing to risk the high cost of bidding for such contracts and the low chance of success. This was the major reason for Laing Construction being sold in 2001 for £1 to O’Rourke. AMEC and Balfour Beatty pulled out of the market completely.

Most new schemes will be outside London, where bus deregulation prevails. Private companies promoting new tramways will be in a competitive environment and have the best incentives to deliver cost effective and commercially viable tramways.

Local Authorities can use their Local (Transport) Plan as a vehicle for encouraging and enabling privately funded tramways to be promoted. They can further assist by helping with Traffic Regulation Orders to provide priorities for trams, which is DfT policy, and in assisting applicants gain Planning Consent for new tramways.

Q11 How can we deliver systems within a budget as has happened?

Not sure what this question means ! Who are 'we' ? DfT, the Government, Local Authorities, private companies ? The National Audit Office Report and District Auditors Reports are clear. The promoters need to have a team that is technically competent to specify and supervise the construction and equipping a new tramway at an economic cost.

A private sector promoter will have such a team, if for no other reason to reassure the funding partners that the tramway is good value for money, and can be delivered on time and to budget, so that revenue generating operations can begin to service the investment, with management that can operate the tramway viabily.

Q12 What are the key lessons from Europe in progressing light rail and in what way are these different to the U.K.?

Both the NAO Tram Report and 'Green light for light rail' are clear that UK costs are much higher than those on the continent. Typically a new tramway in France or Germany fully operational will have a CAPEX of about €15million/km (£13m/km).

Typical of UK schemes is the Metrolink extension to the Trafford Centre and costed at £350million, for a 5.5km line (£64m/km). Hopefully this will perform better than the extension to Eccles, reported to lose about £10million pa.
Rolling programmes, either within a city or across the country allow a continuity of expertise to be developed and enhanced, thus providing even better value for money.

Q13 What does the future of light rail look like with new generation transport schemes coming forward?

Bleak if dependent on public sector funding and promotion ? At the present rate of opening new publically funded tram schemes, it will take 150 years to catch up with France, assuming no new systems are built there. To catch up in 20 years will need 2 new systems built and opened every year. At the present cost of public sector schemes, is this affordable by the public purse ? And what is the opportunity cost compared to the need of the NHS, housing and schools ?

On the other hand should the DfT indicate it will encourage and support privately promoted and funded schemes, and tell Local Highway and Planning Authorities to co-operate, then private schemes will come forward and be built, like virtually all the first generation tramways.

Q14 How do you see light rail aligning with new initiatives such as autonomous vehicles; cycling and walking; and wider Mobility As A Service initiatives?

If autonomous vehicles are approved for roads, then automatic trams will be easier. The first 'robot' tram was demonstrated last year in Potsdam, and the architecture for such operations was set out in a 1987 Technical Paper. This will significantly improve the operating economics of new tramways, and make high frequency services both practical and viable. There are many tramways operating safely in pedestrian streets with cyclists.

Amsterdam – “Oxford Street” (Leidsestraat)

Being track based, pedestrians and cyclists know both that trams cannot deviate and to cross tracks at nearly right angles to avoid bike wheels being caught in the grooves. Added to this quiet tram operation makes sociable contact possible, without having to shout, and with no pollution the air is also better for healthy breathing.

Q15 How can promoters leverage funding from sources beyond central Government?

Privately promoted and funded tramways will not need Central Government funding. If this question is trying to get other funds into public sector schemes, then business rates even in Central London did not get anywhere near the cost of Crossrail. Cities outside London, especially in the North have even weaker property tax bases. Section 106 contributions from developers granted Planning Consent has also been mooted but again these are small sums.

The Trafford Centre Metrolink extension in Manchester did not get a significant contribution towards CAPEX from INTU, the owner of the Shopping Mall it serves. As in other areas, the first step is to reduce the CAPEX, so it can be afforded from public funds ? The next step is to ensure that the passenger revenue covers the operating and related costs. Both of these are areas highlighted by the NAO Report of 2004, 15 years ago.

For privately promoted and funded schemes, while Bank Rate remains low, then commercial tramways can offer returns for investors higher than Bank Deposits. Most such investors are seeking capital gains, as well as dividend or interest payments. For such schemes the model of the Tramlink in Croydon is available. Here the tramway was funded privately and after nearly ten years of service, the system was sold to TfL and the original investors recovered their capital.

There is a further way in which the public sector can act, as an enabler. Local Authorities can borrow (from the Public Works Loans Board) at low interest rates, and have lent money to private companies at an additional interest rate. The private company repays the Capital and the Local Authority gets a regular income from the additional interest charged. This is still less than can be obtained from other financial institutions, e.g. Banks. This gives a win-win deal for Local Councils.

Such an approach can be used to provide (some of) the capital needed for new tramways. Once the system is running and generating revenue, then should it wish, the Local (Transport) Authority can offer to buy the system as a going concern.

2.0 Introduction

About 18 million people in Britain are exposed to unhealthy levels of air pollution. Most of this is in urban areas, and most is a result of motor traffic toxic emissions of NOx and PMs. Buses and other heavy vehicles are proportionately the biggest polluters. At least half the PMs, which are carcinogenic, come from tyre, tarmac and brake dust. Vehicles with zero polluting engines will still exceed the WHO the 'safe' particle limit. Until then the biggest polluters are vehicles with diesel engines, and the largest vehicles with the biggest engines produce most pollution.

The cleanest diesels are the EURO 6 specification but buses on start-stop urban operation emit significant volumes of toxic pollution. In London an estimated 9000 people a year die from diseases caused by toxic traffic emissions. Nationally the figure is over 40,0000. About a fifth of the NHS budget is spent treating illnesses like asthma and bronchitis, which are preventable with clean air. Britain has the highest numbers of young people dying from asthma compared to other EU countries. This is a parallel to the 19th century epidemics of cholera and typhoid caused by dirty drinking water.

In 1980 Blackpool was still operating a first generation tramway. The last big city system, Glasgow, closed in 1962, and London ten years before that in 1952, just before the Great Smog of December 1952. At the same time France, after closing its first generation tramways, still had lines in Lille and Marseilles.

France with a similar population but smaller economy than Britain, opened a new second generation tramway (Nantes) in 1985. Since then France has opened 28 new tramways. Over the same period Britain has opened six new tramways: Birmingham, Croydon, Edinburgh, Manchester, Nottingham and Sheffield. Three proposed tramways for Leeds, Liverpool and South Hampshire were aborted in 2006. At this rate of progress it will take Britain about 150 years to catch up with France.

One of the reasons for the slow implementation of new tramways is the Report prepared by the National Audit Office which criticised tramways built with public funding for:

(a) Cost over runs
(b) Delays in completion
(c) Over optimistic forecasts of patronage and revenue
(d) Overly complex legal and contractual arrangements
(e) The need for subsidy to cover operating losses.

From 1983 a regular Conference/exhibition "Light Rail" was held in Birmingham, Blackpool, Bristol, Dublin, Edinburgh, Liverpool, Manchester, Nottingham and Sheffield. These allowed promoters, potential contractors and equipment suppliers to share experiences, and gave confidence for new tramways to be promoted and built.

Some of the themes that emerged from these Light Rail events were:

(i) few suppliers of equipment
(ii) high cost of infrastructure
(iii) the problem of 'utilities'
(iv) costly statutory approvals
(v) slow consent and unpredictable processes

As a result of these findings, Prof. Lesley switched from researching how to attract car users onto buses, to how to find solutions to the problems identified both by the National Audit Office and during the series of Light Rail Conferences that continued until 2003. An outcome of this was the publication of the "Light Rail Developers' Handbook" (ISBN 978 1 60427 048 8)

Private funding became available and Tram Power Ltd was established. Tram Power Ltd has tried repeatedly to get its value for money innovative products accepted for new publicly funded and

EU tram schemes. The procurement processes require three previous successful contracts and three years of trading. This makes it nearly impossible to get innovation into the market, when it is a public sector monopoly.

Similarly Tram Power Ltd. has applied for grant funding to develop its products but has been variously turned down as being ‘too far from market’ or ‘too close to market’. So its progress has depended on private funding and been much slowed than would otherwise have been the case.

In 2011 the Department for Transport published “Green Light for light rail” which warned that until costs are reduced to the levels enjoyed by other European Countries, little of no Government Grant aid can be expected for new tramways. Since then the Edinburgh tramway significantly over ran its budget, despite only half the planned tramway being built, escalating from £350million to £770million. More recently the second phase of the Nottingham Tramway budgeted at £320million, because of contractual disputes and the need to repair tracks failing under bus traffic, the cost is understood to be about £800million.

There is no doubt that trams are as attractive as more expensive Metros and Underground railways. The Director General of The International Public Transport Association, Pierre Laconte, summed it up. “Trams give 90% of the benefits of a Metro, at 10% of the cost”. The experience in the UK shows that at least 25% of passengers have switched from car to travel by tram. This is a significant reduction of motor traffic, especially if complementary traffic management measures prevent suppressed car traffic filling the released road space. In Croydon this resulted in a decline of traffic by a fifth.

As important as the improvement in the quality of service, trams provide a large increase in capacity. A two track tramway with a 6 minute service has the passenger capacity of a 6 lane road, where 80% of cars have only one occupant. To maximise this benefit, traffic management must include priority for trams, which is DfT policy, though many Highway Authorities seem reluctant to move from a vehicle maximising approach to passenger maximising capacity.

3.0 History of Tram Power Ltd

From the problems revealed by the Light Rail Conferences since 1983, Tram Power Ltd was set up to research, develop and promote lower cost ways to deliver new tramways. Two of the problems, high cost and disruptive infrastructure installation, and expensive vehicles were given high priority. Funding was raised from private sources and invested in research and development. Details of this are set out in the following sections.

Tram Power Ltd. also received sponsorship from PowerGen plc, which helped build the prototype City Class tram, and promote privately financeable tramways in Liverpool to serve the Airport and Edinburgh between Haymarket and Newhaven. In both cases Labour controlled authorities objected and permission could not be obtained, despite not requiring any public funding.

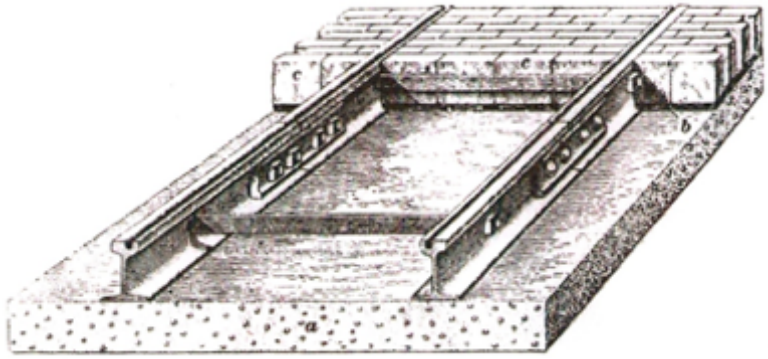
Tram Power Ltd. follows developments closely in the light rail industry not just in the UK but abroad. Tram Power Ltd has in the past applied for public funding to assist in its development work, to e.g. the Carbon Trust, DTI and RSSB but turned down every time as projects were deemed either ‘too far from market’ or ‘too near market’. So it is ironic that a lot of public money has been spent, e.g. in Long Marston to demonstrate new track forms, or develop lightweight vehicles, which Tram Power has not only achieved but already proven.

Tram Power Ltd. also sought co-operation agreements with existing vehicle builders. These find the quasi duopoly market with high prices very comfortable and see no reason to produce lower priced trams, to expand the market. The logic being that public agencies will pay whatever is demanded for new trams, even those not completely fit for purpose.

4.0 Reducing Infrastructure Costs

4.1 Track

About half the cost of a new tramway is in the provision of the infrastructure. Up to now all have been based on 19th century principles, when there were few paved roads. The only traffic was light horse carriages and virtually no under street utility plant. A wide concrete slab supports the track and distributes loads into the soil beneath.

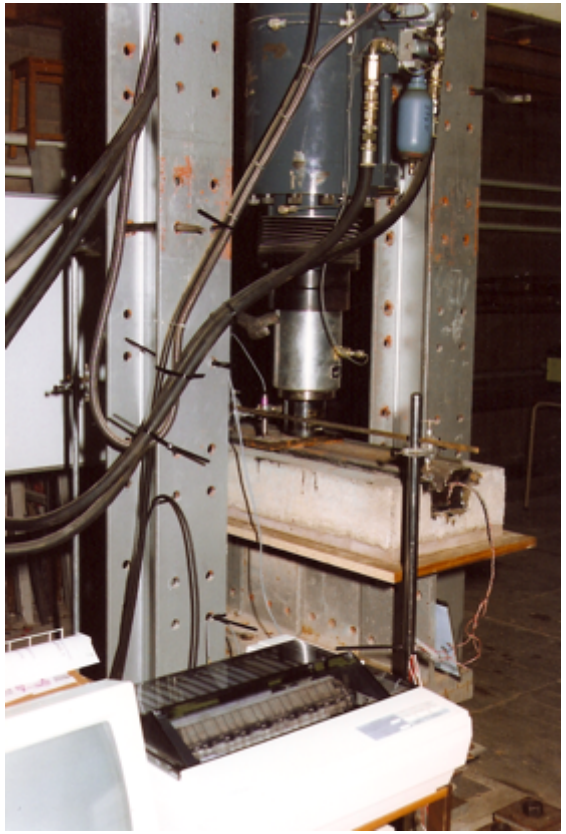


Track installation 1905

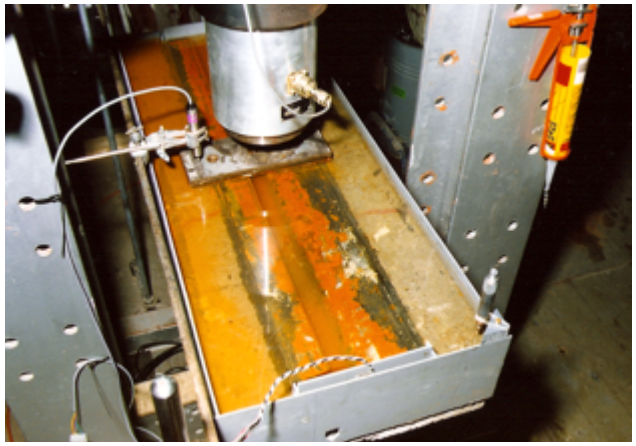
Recent tracks have further complicated matters by using mainline railway construction details, with sleepers on top of the foundation slab.

For a double track tramway this means a slab some 6m wide and about half a metre thick. Any utilities under this will be inaccessible for maintenance or repair. Utility companies therefore require relocation to places where access for maintenance and repair is possible. About a quarter of total costs can be utility relocation.

UK Urban areas now have roads that are paved and capable of carrying 44tonne HGV's with 10.5tonne axle loads. Unless there are signs of insipient failure, e.g. subsidence, plastic deformation etc., such roads do not need to be destroyed to install tram tracks. If the new tram track allows access to under street utilities, considerable cost and time savings will be possible. The key is the agreement of the utilities to leaving plant in place. The LR55 track was developed to make this possible (www.LR55.co.uk).



Under water lab tests

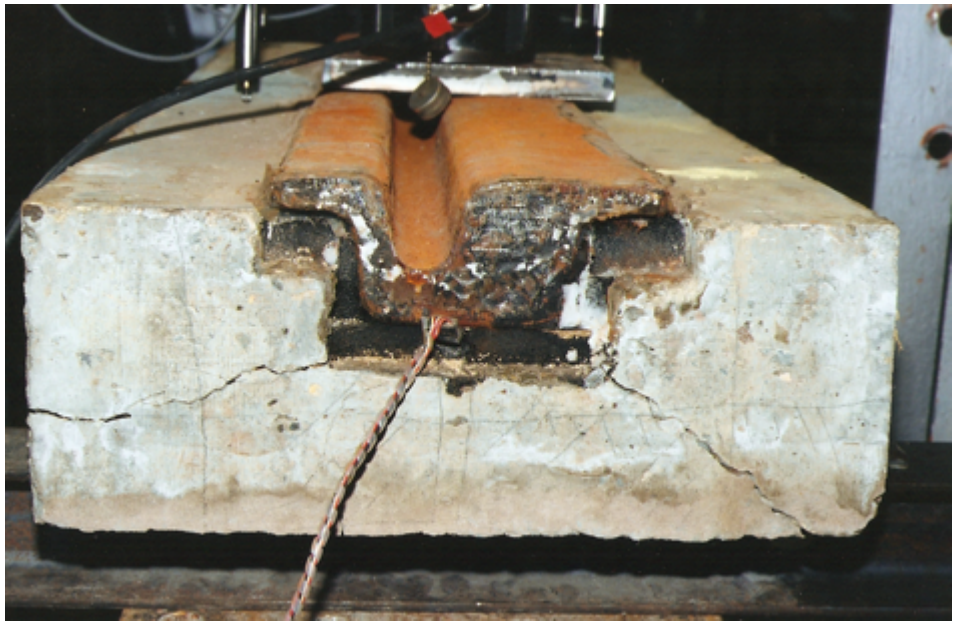


Laboratory endurance testing

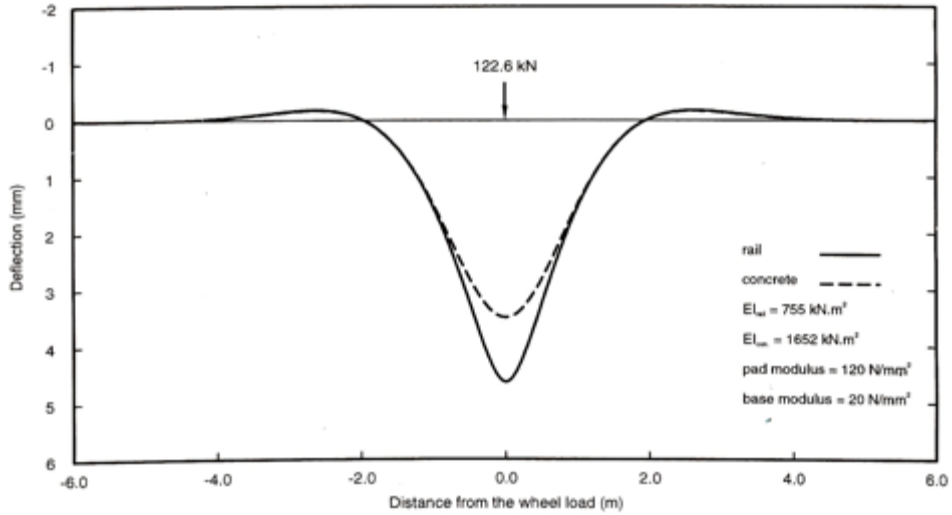
Most tram track damage is caused by heavy road vehicles, like buses and lorries. A length of LR55 track, which had been comprehensively laboratory tested, was installed in Rotherham bus station with 2500 bus impacts per day. In a year this was equivalent to 30 years exposure in a busy street.

LR55 and Ri60 rails compared

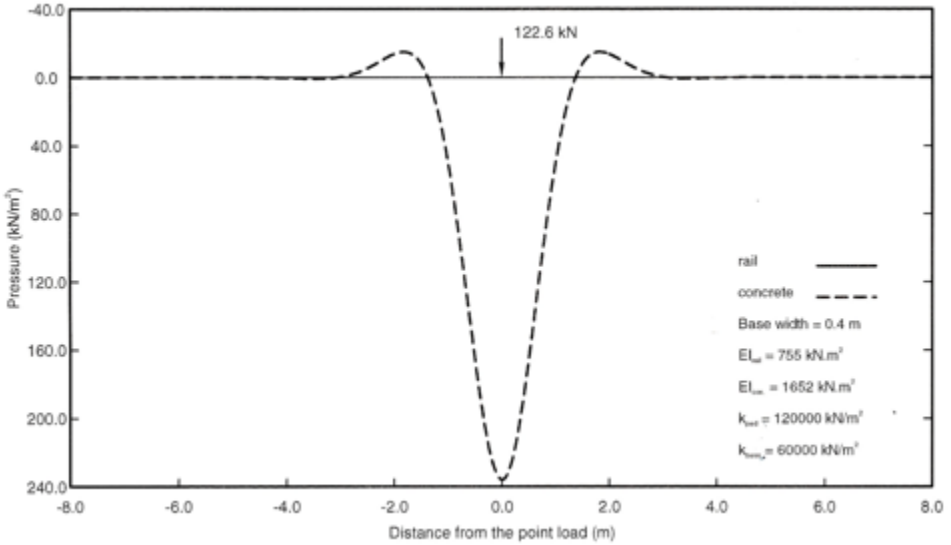
Test to destruction over 1m void



LR55 deflection under 25tonne axle load



Ground pressure under LR55 beam from 25tonne axle load.



Rotherham Bus station test site

The installed rail in Rotherham Bus Station was instrumented and data logged for nearly year, until the gauges failed after 1.5million impacts. During this period the rail was partially excavated and representatives off all utilities companies invited to inspect.

Laboratory testing to 80 tonne axle loads confirmed that LR55 rails will self support over 1m wide trenches. This allows utility companies to reach their plant, and with a safe working possession procedure offered by HMRI, trams can continue to operate.

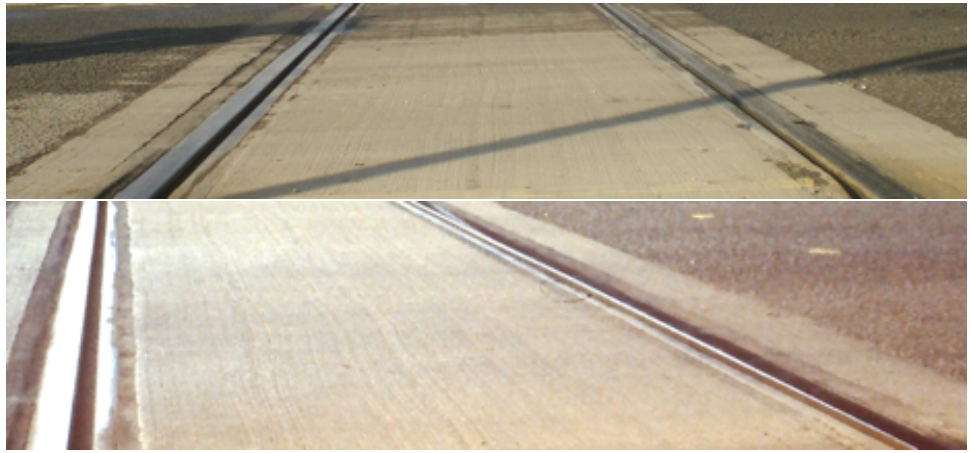
Rotherham Bus station LR55 test track

Detailed discussions were held with utilities in Edinburgh, Liverpool and most recently Preston. In each case the Utility Companies are pleased not to have their plant relocated. In some places minor adjustments to track alignment will keep access to inspection pits and manholes available.

1m wide trench under LR55 track

All laboratory tests were undertaken with 25tonne (main line) axle loads. Destructive tests over 1m wide voids failed at 59tonne axle loads. Similarly tests for the failure of the rail/beam bonding confirmed earlier work undertaken by the University of Calgary. This also showed that the bond is stronger than thermal expansion ‘pop out’ rail forces.

As a result of the success of the installation in Rotherham bus station, the LR55 Group was invited to replace girder track that had failed after 6months service on the South Yorkshire tram system. This was undertaken in March 1996 with overnight possessions from 0030 to 0530 on Friday, Saturday and Sunday. One rail at a time was replaced, and the following morning the track reopened for the first tram to the Meadowhall Terminus.



Since 1996 there has been about 200million tonnes of trams over and over 1million HGV impacts on the track. As a single track approach to Meadowhall, this is a critical part of the system. LR55 track has needed no maintenance, compared to adjacent 80lb tracks, which are regularly ground to remove corrugations.

Rail head wear is about 10mm, and there is 12mm of compacted mud in the bottom of the groove below wheel flange level. This LR55 track should be good for another 20 years.

The LR55 Group was required to provide a 6year warranty. After 6months SYPTE relieved the Group of this responsibility, as LR55 had already lasted longer than the original track and showed no signs of failure.

This installation required transition rails from the existing 80lb rails on either side. These transitions, like the plain rails, were cast and machined to the specifications required. When LR55 track was installed in March 1996, there were 100 HGV impacts per day. For the last few years this has increased to 300 per day, as major industrial developments have taken place in the area.

LR55 Track transition to 80lb rail

HGV Impact on Sheffield LR55 track

The LR55 track is regularly inspected and tests of performance have been undertaken. The noise level was found to be 10dBA lower (half) than other embedded tracks, and ground transmitted vibrations 30dB lower. The electrical resisitivity is over 1000Ωkm, ten times better than required by HMRI for stray current control.

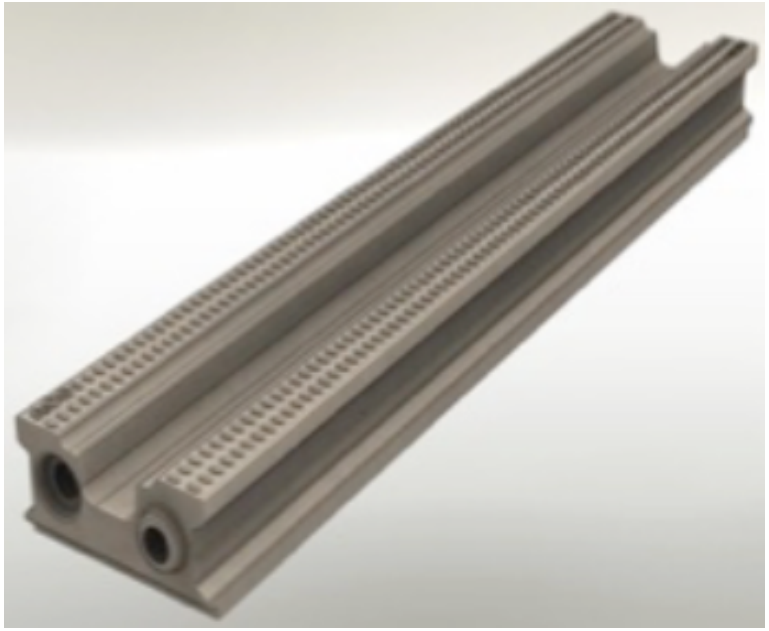
For a large tramway installation, LR55 rails need to be rolled. Discussions have taken place with several steel mills in Europe. All however require a minimum first order of about 2000 tonnes. A typical tramway will only need about 200 tonnes of rails. This impasse thankfully has been broken after discussions with British Steel, which has a specialist section steel mill at Skinningrove near Middlesbrough. This can roll a 200 tonne first order economically.

By comparison tram track in Manchester

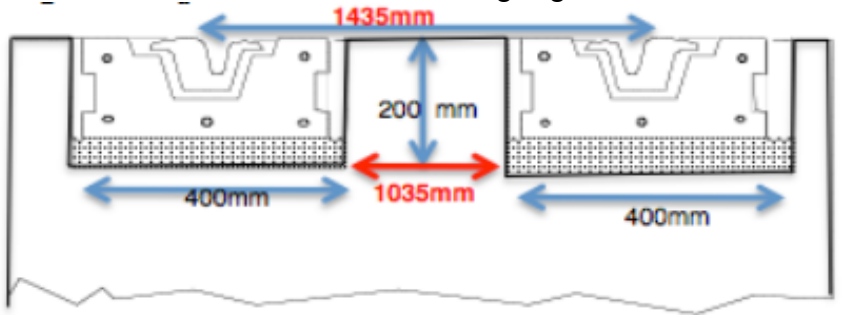
For new street tracks, the “no dig, glue in the road” LR55 system installation is a 3 stage process, requiring less than 10% of the excavation of other track forms.

The first stage is to create shallow recesses in the road surface, 200mm deep and 420mm wide.

In stage two, the stiff foundation beams are laid on a Type One layer, and then bonded into the road pavement.



Stage three has the rails welded into strings, and then bonded into the foundation beams to line, level and gauge.



23 years later, the LR55 installation in Sheffield has needed no maintenance, unlike adjacent 80lb rails, which are regularly ground to remove corrugations. The rail head wear after nearly 200million tram tonnes and 1million HGV impacts, is under 10mm, with at least another 20 years of wear remaining.

The concrete foundation beams can be pre-fabricated by many local concrete pre-casters, and then delivered to site “just in time” for installation.

Some authorities claim that tram tracks need tie bars between rails to maintain gauge. The at the street tracks of the South Yorkshire Supertramway is built without rail tie bars. It is telling that tube stations in London with fast trains have a ‘suicide pit’ between the rails, and no tie bars between the rails. This has been the adopted design for tube station for over 100years, with no record of tracks going out of gauge or trains derailing in stations.

London tube station ‘suicide pit’

The long and stiff LR55 foundation beams obviate the need for tie bars, as with the mass of the road structure, is well able to resist low lateral (curving) tram wheel forces, compared to the much larger vertical forces into the road.

LR55 track can be used for applications other than tramways. Discussions are in hand for its use in freight transfer depots, for tunnel enhancements and road level crossings.

4.2 Power Supply

Trams need power to operate. For nearly 140yeras the most economic method is the overhead wire (OHL), energised at about 750V dc. There are proprietary ground level systems that can replace OHL. These however are much more expensive to install and maintain. Installation costs are about 10 times more than OHL. These ground level systems also echo those tried in the early 20th century using metal plates between rails, made live by magnetic or mechanical forces, but were not reliable. All such ground contact systems are also vulnerable during heavy rain to short circuiting when water lies across the road and track. This is why all were replaced by OHL within 10 years of installation.

Conduit tram track construction in London

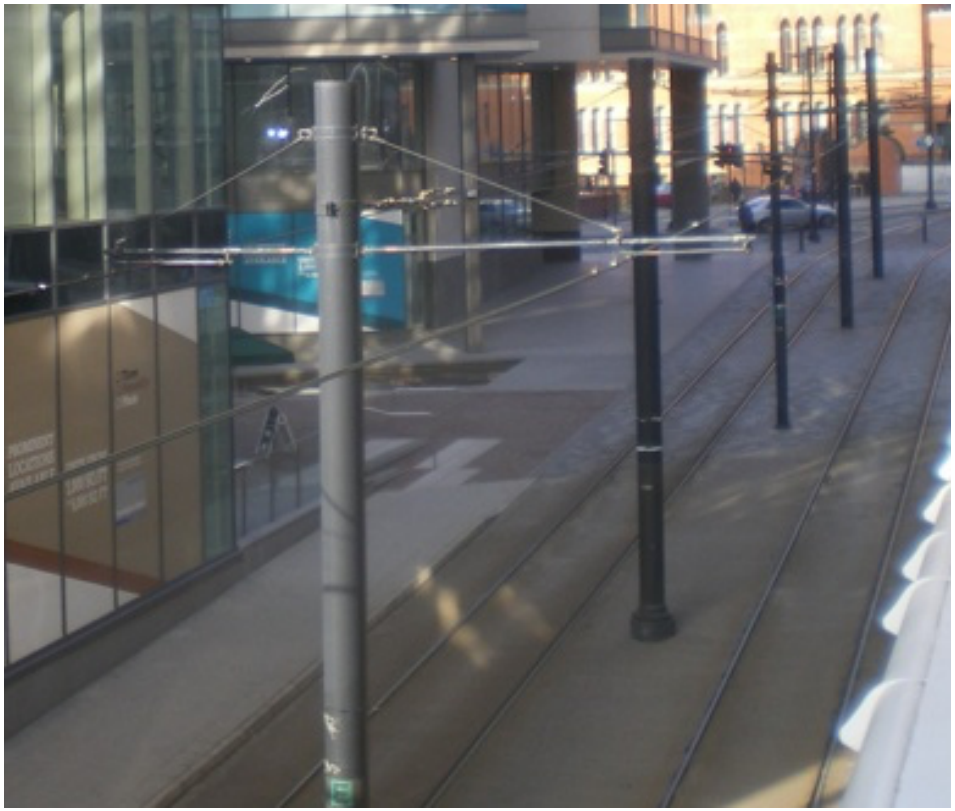
The ‘conduit’ was the only ‘ground’ system widely used. A trench between the rails is needed, with a continuous 1inch wide slot in the road surface. Under the tram a contact arm runs through the slot. It slides along energised under ground rails. This system was pioneered in Blackpool in 1885, where it was soon replaced by OHL. The conduit system was used for part of London’s tramway until it closed in 1952. The last conduit track was operated in Washington DC until that system closed in 1962. The conduit in San Fransisco houses a continuous cable that mechanically hauls trams along the track, as does that in Llandudno in North Wales.

Examples of OHL in Croydon

OHL is often criticised for visual clutter and not being aesthetically compatible with urban settings. Some new British systems have used OHL more in keeping with main line railways, e.g. Croydon and Manchester. In other European countries OHL is minimal and often directly supported from buildings lining the tramway, without the need for poles.

Apart from the aesthetics, the OHL has mechanical requirements to maintain contact with tram’s pantographs, both to avoid electric arc flashes and to minimise wear, so maximising operating life.

Poles for Manchester Metrolink



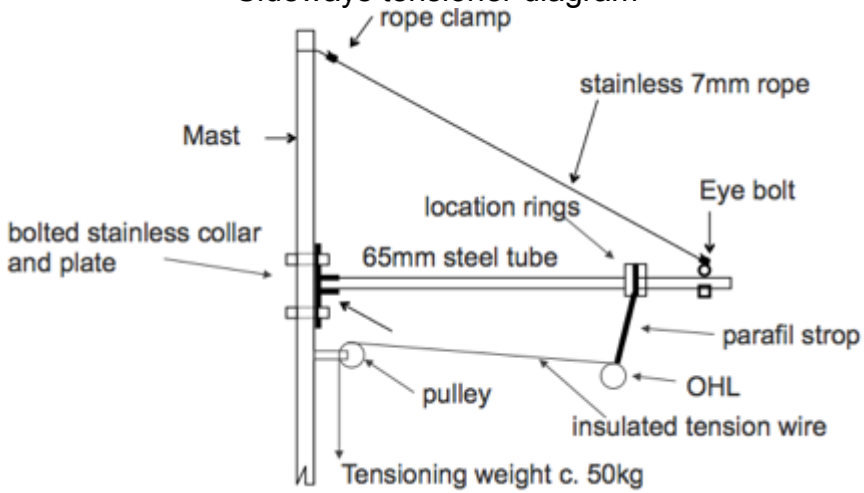
A low impact catenary has been developed by Trampower and tested. It is the subject of a patent application. This system uses two devices to ensure that the contact wire is kept to the correct alignment and at the right tension, irrespective of ambient temperature.

This new system was installed at the Carnforth Railway Centre in November 2004, where it remains without the need for maintenance. The Trampower Low impact OHL also exploits a new tensioning device, which does not require long overlaps of the contact wire, so saving in cost and produces a tension along the OHL via a low force sideways pull off.

Trampower low impact OHL compared to WCML Catenary

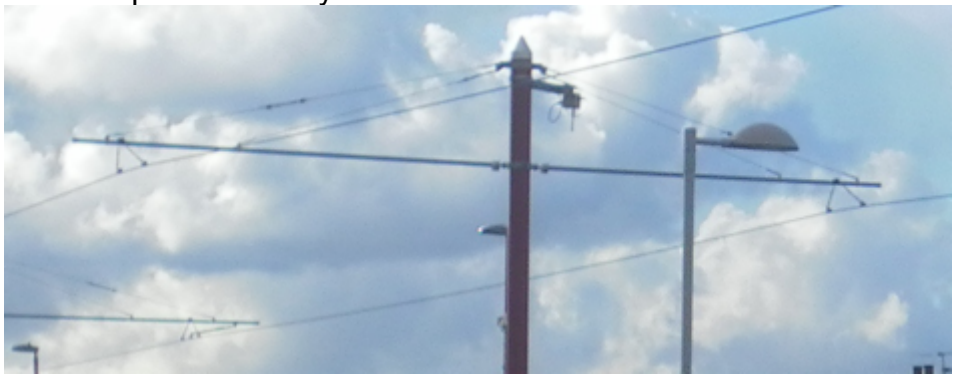
This means that the tensioning can be applied where it is most needed and so less intrusive than long ways tensioners, used for example in Croydon.
Croydon long ways tensioner

Sideways tensioner diagram



Sideways tensioner at Carnforth

Trampower OHL system on Ashton extension in Manchester



5.0 Reducing vehicle and operating costs

Compared to road the demand for rail vehicles is low, and a typical tram order is under 30. Worldwide vehicle production in 2016 was:

Type of vehicles	Number produced
All Passenger rail	20,000
Buses	200,000
Road trucks	20,000,000

On a like for like basis of capacity and performance, new buses cost about 10% of a tram. One of the reasons for the lower cost of buses is that they share parts with the mass truck market: wheels, axles, engines, gearboxes, transmissions, brakes, exhausts, suspension and controls.

Brake: Disc

Caliper

Actuator

Pads

The demand for trams will never enable mass production savings. Even during the Comecon days of the Soviet Bloc until 1990, the single tram builder, CKD Prague, built only about 1200 trams a year, compared to Icarus in Budapest which also supplied the whole Soviet Bloc and built about 12,000 buses a year.

The Tram Power City Class tram is based on the maximum use of mass produced components off the shelf (COTS) from other industries. The innovative work that Prof. Lesley and his university

team undertook was designing the interface between different COTS and the unique environment of rail tracks. The City Class project has been through a complete cycle of desk top analysis and computer modelling, laboratory and bench testing, slave vehicle operation, Mock Up market research, prototype operation and then continual development into a demonstration vehicle.

A complete supply chain is in place, and production of City Class trams will take place in NW England. A number of other rail vehicles can also be built. A proposal to replace Merseyrail trains with City Class based trains, would have been about 60% of the cost contracted with Stadler, and generated many highly skilled local jobs, as well as being a big economic stimulus in the NW.

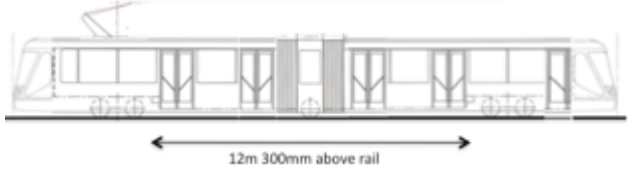
Being unable to win public funding, has meant stop-start progress for the City Class project. When the first Combino trams in Potsdam began to develop structural fatigue fractures, a Tram Power Team met the senior management of Potsdam Tramways. At the end of a day of detailed technical discussions, the Potsdam team was astonished to learn that development had been entirely privately funded. “If you had been based in Germany, the Government would have provided all the funding needed to get into production” commented Herr Weiss, General Manager.

The City Class running gear has been used for the railcar supplied by Severn Lamb to a factory in Konya Turkey for ferrying workers from the local town. In 2017 this railcar was given an award for its innovate use of automotive technology.

City Class Tram in Blackpool and Birkenhead

The innovations of the modular City Class tram were granted patent protection in 1993. Since then further development work has been undertaken to stretch a basic 29m long (200 passenger) version, to a 38m (300 passenger) vehicle needing a minimum of modification.

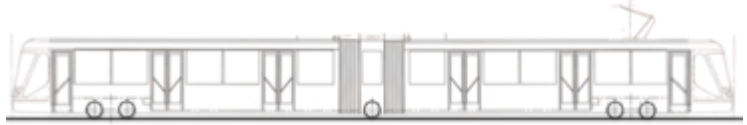
23m version of City Class Tram



Testing the Slave vehicle, a 1930 Blackpool tram to be scrapped was undertaken over two years. Equipment at one end was replaced by City Class mechanical and electrical gear. One original

bogie and drive gear was retained at the other end, in case of break down or failure of the City Class kit but never needed.

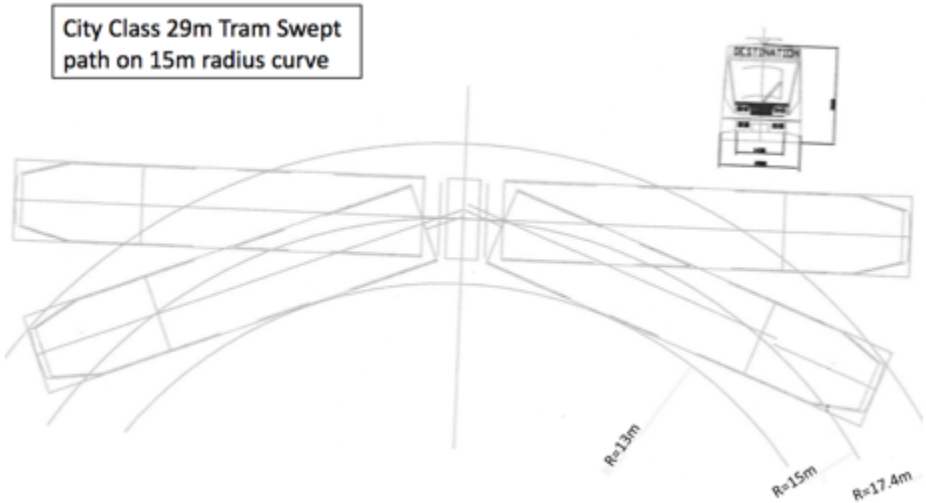
29m version of City Class Tram



38m version of City Class Tram

As this endurance running was undertaking in Blackpool, the body of the prototype was being built. The mock up was taken around the British Isles and put on public display in London, Gloucester, Dublin, Edinburgh, Blackpool. In Blackpool tram drivers also gave their feedback on the cab and its controls.

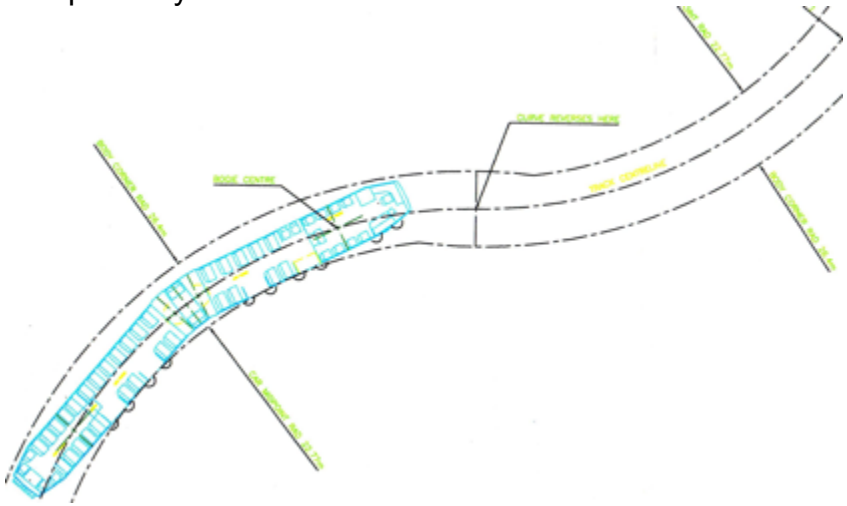
When slave-running tests were completed, the components were returned to their original equipment manufacturers (OEM) for inspection. No failure, fatigue or wear problems were identified, so duplicate equipment was built for the other end of the tram.



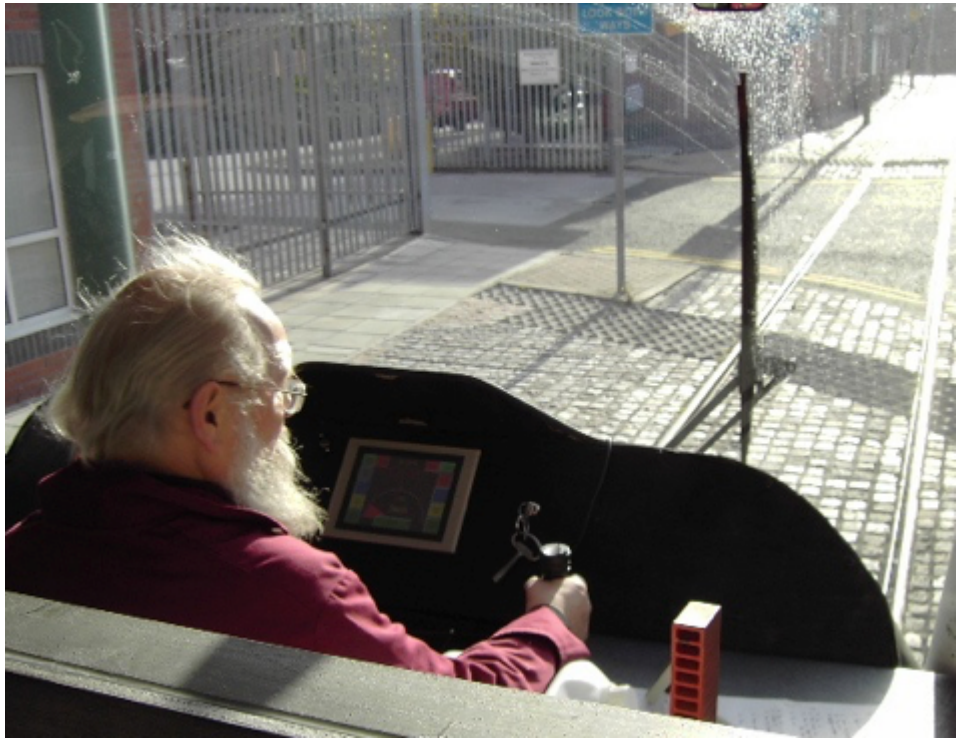
The prototype tram then ran a considerable mileage in Blackpool having first obtained HMRI consent. During this time a team from UMIST measured the power consumption of all trams in the fleet. This found that 18tonne 50 passenger trams used on average 1.5kWh/km. The 22tonne 200 passenger City Class Tram used only 1.0kWh/km. After two years and no problems, the project ran out of cash, and the tram was parked out of doors for some years.

Raising more funds enabled the tram to be completely refurbished and repainted in Blackpool colours. The refurbishment was undertaken partly in the Carnforth Railway Work Shops and partly in the Birkenhead Tram Depot. When completed it ran an intensive

testing programme on the Birkenhead tramway, averaging 80 end to end trips a day.



The Birkenhead tramway has tortuous track with a 20m radius reverse curve on an 8% gradient. The tram ran in normal passenger service and feedback from passengers was recorded. During this time with the co-operation of the local Technical College, a ‘cram a tram’ event was held with over 180 passengers. Vehicle performance was monitored, as was body deflection.



City Class Cab, with touch screen operations

An emergency evacuation was undertaken and completed in 40 seconds, with half the passengers using one of the four available doors. Afterwards the driver observed that he could not tell the difference in performance between full and empty. The ‘fly by wire’ tram optimised the performance of traction equipment, based on the live load carried.

The City Class Demonstrator tram was then transferred to Blackpool for testing prior to entering full passenger service. After three months of faultless operation and in the last week before entering service, is was set on fire by person(s) unknown. The Police concluded that it had been subject to industrial sabotage.

29m Tram articulation unit

Further sabotage occurred when it was being repaired in Blackburn. Again a separate Police investigation came to the conclusion of industrial sabotage. Since it has been completely rebuilt, it has again spent some time stored out of doors but is now under cover at the Blackpool Transport Rigby Road Depot, awaiting re-commissioning.

The low weight (2.5tonne) bogies run smoothly and after endurance testing in Birkenhead, the wheel flanges were rusted with a 10mm wide wear strip was in the centre of the tyres.

City Class interior – one of many options

In summary the 29m version of the City Class Tram weighs 22 tonnes, carries 200 passengers, 80 seated and 2 wheelchair spaces, has a low floor 300mm above the rail top and is energy efficient with average power consumption of 1kWh/km. Power savings compared to other heavier trams will cover the investment within 10years of operation. Added to this the advanced COTS power electronics provide smooth and jerk free acceleration and regenerative baking at 1.5m/s/s. With magnetic track and disc brakes, the emergency retardation is 3.3m/s/s. In Blackpool on reserved tracks north of Clevelleys it ran smoothly at 90km/kr.

6.0 Evaluating potential schemes

To answer the National Audit Office's criticisms, new tram schemes need both to reduce capital costs (CAPEX) and operate so that the passenger revenue exceeds the operating costs by enough to service the investment and provide a depreciation fund. This will allow the assets to be replaced when they wear out or become obsolete. None of the existing tram schemes are capable of meeting these requirements. This is why grant aid is continuously needed for track renewal and tram replacement.

Tram Power Ltd has developed a software package that enables a promoter easily to evaluate schemes, and so find prima facie projects that should be viable. There are three major parts of this programme. The most straightforward is the assessment of capital costs. This is based on accepted unit costs, drawn from recent experience or an industry-accredited source like SPONS[1].

The second part of the Trampower evaluation package determines the operating costs (OPEX) based on the proposed service frequency, operating speeds, layover times and the required spare vehicles, using local prices and pay rates for drivers and other staff, together with power and other material costs.

The final part of the Trampower evaluation package is the most difficult, namely the patronage and likely revenue. These calculations are based on the resident population living along the proposed tramway catchment area, the present modal split and their relative travel conditions and costs. From this the generalised cost of the tram services is compared probabilistically with the generalised cost of travel by existing modes. From this the passengers that can be attracted from car, bus, walk, cycle and if available an existing rail service to tram can be calculated. No assessment is made of the potential for patronage from external trips, nor any trip generation or destination switching. Thus the forecast patronage is conservative.

The revenue is based on the patronage and the proposed fare. This software allows sensitivity analyses to be undertaken, since both different tram fares, or service levels will alter the patronage, as will any competitive reaction by existing modes, e.g. reducing bus fares. As an example the table below shows the sensitivity to different tram fares in a northern town with a 200,000 population.

Av.Tram Fare (£)	Patronage m pa.	Revenue £m pa.
0	6	0
1	5	5
2	4.5	9
3	4	12

Similarly for a SE town of 120,000 the fare sensitivity for a tram line is:

Average tram fare	Patronage m pa	Revenue £m pa.
£0	2.4	0
£1	2.3	2.3
£2	2.2	4.4
£3	2.1	6.4
£4	2.1	8.3

This shows, as most market research confirms, that fare elasticity is low, and that the quality of service is the major determinant of tram, or other public transport mode, use.

Taking these three important outputs: CAPEX, OPEX and revenue, the Trampower evaluation package calculates the Internal rate of Return (IRR). This shows if a project is financially viable. The IRR does not include any social or environmental benefits, that are

[1] https://www.priceguidesdirect.co.uk/pub/spons-civil-engineering-and-highway-works-price-book-2019-9781138612020.aspx?gclid=EAIaIQobChMIy7OHI8K04AIVlvhRCh09gw_rEAQYAyABEgIZdPD_BwE

included in a ‘Green Book’ Cost Benefit Analysis used to justify the grant aid of public funds. If these benefits could be made into cash inputs, the IRR for privately funded tram projects would be very significant.

As it is private investors in tram schemes only need assurance that the CAPEX will be serviced at an attractive rate, competitive with other investments or bank deposits. No doubt tram investors will have pride in providing community benefits of better public transport, reduced traffic congestion, air pollution, and DDA compliant accessibility. Unfortunately these community benefits do not translate to income or revenue for the tramway.

7.0 Promoting privately fundable schemes

Tram Power Ltd has tried many times to get its value for money innovative products accepted by new publicly funded tram schemes. The procurement processes used require three previous successful contracts and three years of trading. This makes it nearly impossible to get innovation into the market, when it is a public sector monopoly. Therefore Tram Power Ltd. has been promoting privately fundable tramways, in order to create three successful contracts and so create a track record needed to win public contracts in the UK and abroad. These schemes are reviewed in turn.

Some of the schemes listed, Trampower is the direct promoter. For other schemes Trampower is an advisor or consultant.

Scheme	Status	Readiness	CAPEX £m
Preston	Active	Planning Permission	25
Southwark	Active	TFl /LBS negotiations	80
CROST		Pre-Feasibility Study	
Slough		Pre-Feasibility Study	126
Middlesbrough		Business & 1250scale	150
Londonderry		Pre-Feasibility Study	232
Dublin Airport		Pre-Feasibility Study	-
Limerick		Pre-Feasibility Study	-
Liverpool		Pre-Feasibility Study	95
Leeds		Pre-Feasibility Study	130
Barnsley		Pre-Feasibility Study	85
MASST		Pre-Feasibility Study	100
E.Lancs Railway		Feasibility Study	50
ELAN		Pre-Feasibility Study	50
Windermere	Active	Pre-Feasibility Study	50
Chester	Active	Pre-Feasibility Study	125
Lancaster	Active	Pre-Feasibility Study	70
Warrington	Active	Pre-Feasibility Study	125
Birkenhead	Active	Feasibility Study	30
Hallamshire		Pre-Feasibility Study	15
Aberdeen		Pre-Feasibility Study	-
Abbey Line		Feasibility Study	10
KENEX	Active	Feasibility Study	500
Newcastle-Tyne		Pre-Feasibility Study	60
Cambridge		Proposal	65
Trafford Centre		Pre-Feasibility Study	40
Southport		Pre-Feasibility Study	6
Galway GLUAS	Active	Business Plan	-
Sutton	Active	Pre-Feasibility Study	50
Croydon N-S		Pre-Feasibility Study	100
Liskeard- Looe		Pre-Feasibility Study	10
Eden Tramway		Pre-Feasibility Study	90
Isle of Wight		Proposal to County Council	40

7.1 Preston

Trampower is flattered that this project is mentioned in the DfT invitation to submit evidence (p.12 para 3.7). The project began with an assessment of five potential lines, using the evaluation package described in section 6.0 above. This identified one that gave the best IRR of nearly 10%pa.

Labour officers in Lancashire County Council insisted that the project be approved through a TWA Order. After taking advice from Ashursts, Network Rail's Parliamentary Agents, and since no compulsory powers were being sought, a planning application was made to Preston City Council, the local planning authority. Two Planning Consents have been obtained, and the Planning Department is comfortable in processing such applications.

This approach has been recommended to other tramway projects, since it significantly reduces the cost and time needed to obtain statutory powers to build and operate a tramway. This also addresses one of the major criticisms raised in the National Audit Commission's Report on Tramways. A draft Section 278 Agreement (Highways Act 1980) has been submitted to the Highway Authority for permission to enter roads and install tram tracks and traction poles, after Planning Consent has been granted.

The Project team meets fortnightly, and a contractor, the Eric Wright Group has been appointed to construct the tramway on the NEC Negotiated contract, with an open book relationship. This answers another NAO criticism. Planning Consultants PWA based in Preston handle the planning process. Modal TP is undertaking the traffic studies, part of which included running an articulated bus to replicate an articulated tram, across the busy Ringway intersection.

This exercise proved that a tram every six minutes across Ringway will not increased the delay to other traffic. The impact at the intersection, with and without tram priority and signal pre-emption, showed that without priority, each tram would have a passenger delay of about 25minutes.

The CAPEX for this scheme is £25million, including renewal power generation.

Over 2000 documents have been generated to support this project, including a full set of 1:1250 scale plans, a Transport Statement to the DfT Template, Ecology Studies, Noise Studies, contamination studies etc. A Business Plan is being used as the basis for raising the £25million needed to build and equip the GUILD Tramway. Included in this funding is a 'wet' lease to supply, operate and maintain the trams.

7.2 Southwark

London has a number of simultaneous transport problems:

(a) a growing population
(b) widespread breaches of safe air pollution levels
(c) decline in bus and tube patronage
(d) TfL large operating deficit

The Southwark Supertram was set up by Trampower and is working with a local Planning and Architectural Practice. The team includes a local community representative, a transport planner who worked on the Croydon Tramlink, and a structural Engineer. Subsequently Capital Super Tram Power Ltd. Has been set up as the legal vehicle to promote this tramway.

Meetings have been held with TfL, LBS and GLA. As a result of this, data from the earlier Cross River Tramway project has been shared, together with traffic data. An agreement in principle is in place to progress the project via a planning application to LBS.

Public consultations have been conducted both in street and on-line. These achieved a high level of support (c80%) and a high recognition of the impact of air pollution, personally with hospital admissions, or family, friends and neighbours suffering from air pollution illnesses. Similarly there is strong acceptance of trams, as many respondents had travelled on trams in Croydon or other places in Europe.

The CAPEX for this scheme is £80million

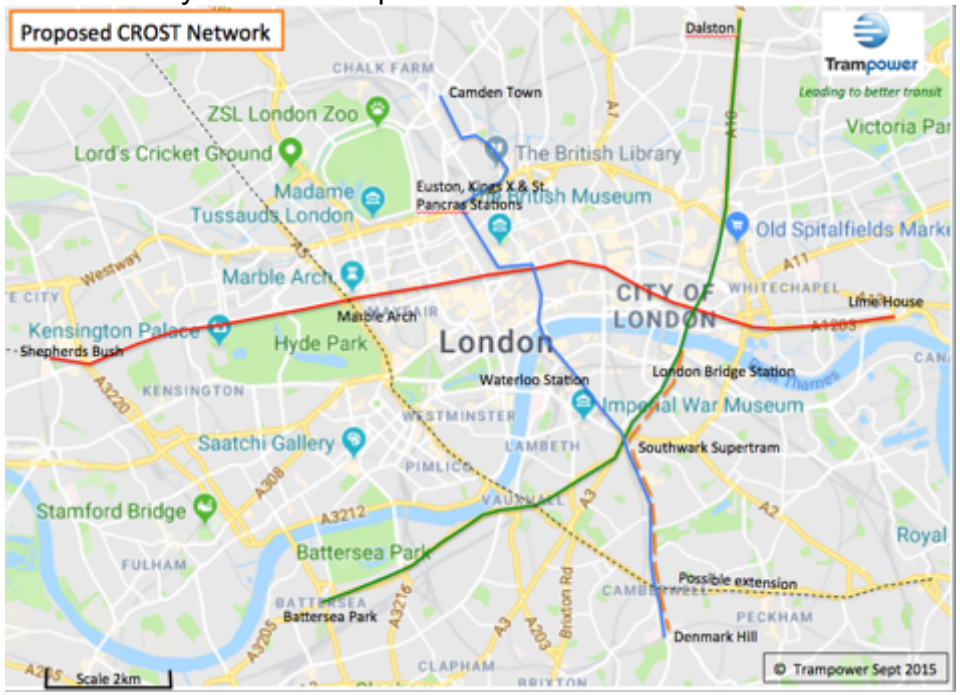
After the withdrawl of a train service between Denmark Hill and London Bridge, medical staff working in Guys and Kings College Hospitals no longer have a convenient way to travel between sites. This is causing difficulty for both Hospitals, which has been emphasised during meetings. The Supertram every 5 minutes will take about 15minutes, as fast as the old train on its circuitous route, and offer a door to door service. This will also help out-patients and visitors to both hospitals, which number about 3million pa at Kings College Hospital, the equivalent of a small airport.

Montage of Camberwell Green tram Stop

7.3 CROST

The Southwark Supertram discussed in 7.2 could be a starter line for a more extensive system in Central and Inner London, where traffic congestion and air pollution is highly toxic despite the charge zone. The Southwark Line can be extended in stages to create the Cross River, Oxford Street Tram (CROST) (www.London-trams.com).

The CROST tram system would provide a significant increase in transport capacity, and enable polluting diesel buses to be withdrawn. This will reduce operating bus costs and relieve over crowded parts of the Underground, as well as provide an acceptable alternative for some car trips present made in the area. CROST can be the basis for the gradual conversion of much of the London bus network to non-polluting operation, including Oxford Street, one the most polluted streets in Europe. This was advocated by the CILT Report “Street trams for London."



The CAPEX of CROST is likely to be about £500million, less than the cost of al Crossrail Station. Much of the network could be commercially viable and therefore not need Government capital grants. Reducing operating costs and increasing revenue by attracting car trips will improve the finances of TfL.

Like the Southwark Supertram, CROST can be promoted and funded by a private company, enabled by TfL, GLA and the local highway and planning authorities through which it operates. As well as serving main Line stations, with disability accessible trams, CROST will also reach many of the important tourist destinations, and provide a new way for visitors to travel around the Capital, which the bus service does not fulfil.

7.4 Slough

The Borough of Slough commissioned Trampower to evaluate possible tramlines in the town. A network of six lines was considered. For each the CAPEX, OPEX and revenue based on resident populations living in the catchment of the lines were calculated. This was based on a stand alone tram operation, so each line needing a Depot.

This analysis showed that only one line was financially viable, namely east to west through the town centre, and railway station, with termini at Heathrow Terminal 5 and the Slough Business Park. The CAPEX for this scheme is £million.

7.5 Middlesbrough

When Ray Mallon was the elected Mayor of Middlesbrough, a Trampower team worked in co-operation with the Transport and Planning Department of the Council. Three major route options were analysed, including converting the Middlesbrough Whitby Railway to tramway.

One line was selected with Council Officers because it was financially viable, served 40% of the town's population, the James Cook Hospital and the University, as well as the Transporter Bridge and new football stadium.

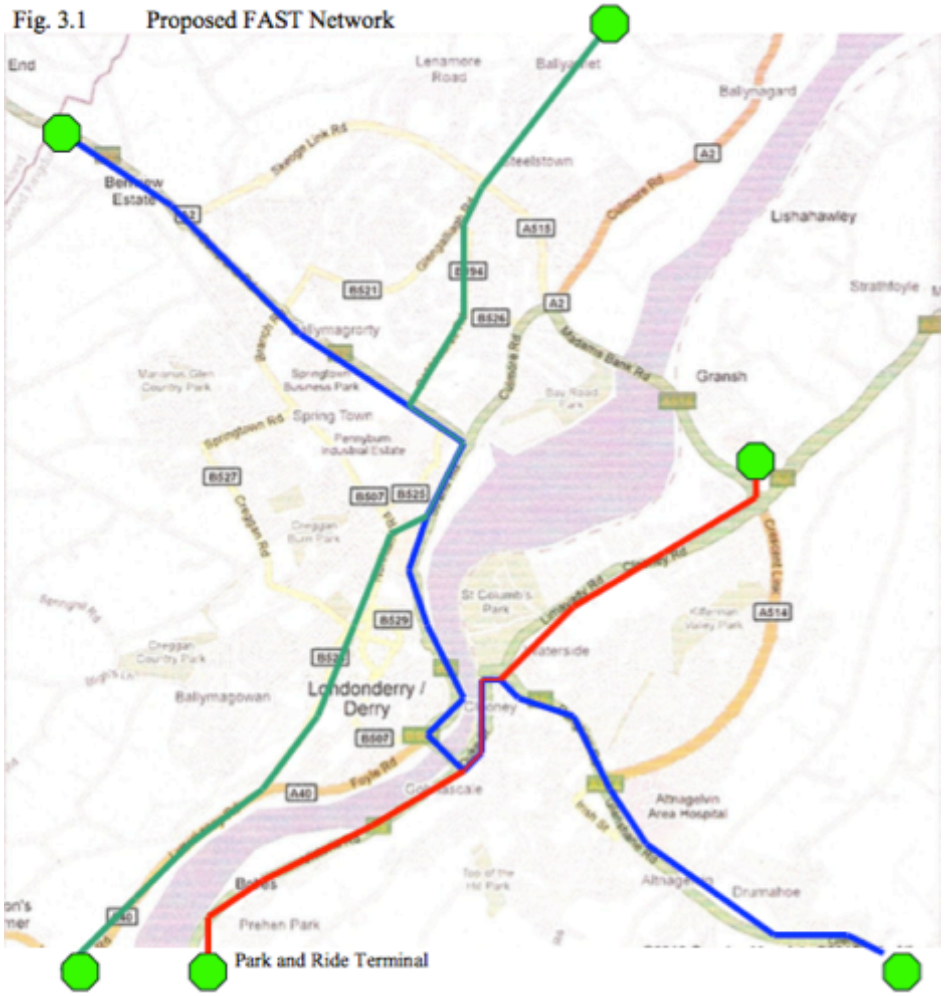
Part of this line is in street, and part on reserved track, in road medians or off street. It includes Park and Ride at the outer end, close to the A174 southerly bypass.
The CAPEX for this scheme is £150 million

Possible location for Middlesbrough Tram Depot.

7.6 Londonderry

The Chamber of Commerce invited Trampower to look at the potential for a tramway to serve the city in time for the Capital of Culture Year. This became the FAST (Foyle Area Super Tram) Service but the Council could not find a way to progress it since the estimate cost of the 3 line network was £235million. The same analysis as set out above for Middlesbrough and Slough was used for Londonderry.

Fig. 3.1 Proposed FAST Network



7.7 Dublin Airport

A Pre-Feasibility site inspection and walking a potential route was undertaken, together with discussions with Irish Railways over the sharing of a track bed, and Croak Park Stadium over the location of a tram stop. The Airport wants a Metro Line, so the project was not progressed any further.

7.8 Limerick

Limerick in the Republic of Ireland is the third largest city. With the success of the LUAS in Dublin, and Limerick's closeness to Shannon Airport, the City suffers from severe congestion and economic stagnation. An architectural practice in Limerick asked Trampower to advise on a potential tramway to help resolve the city's congestion problems, where travel by car is the dominant mode of transport.

This only progressed to a Pre-Feasibility Report.

7.9 Liverpool

Funded by PowerGen a comprehensive set of studies of potential tramways in the City, including the Feasibility of 62 route options between the City Centre and Airport were examined.

From the Feasibility Study, a Financial Evaluation was undertaken, and a Business Plan Prepared for the most viable route, between the city centre and Speke, serving the Airport. As the Plan shows other lines can then be added on a marginal cost basis, still remaining financially viable.

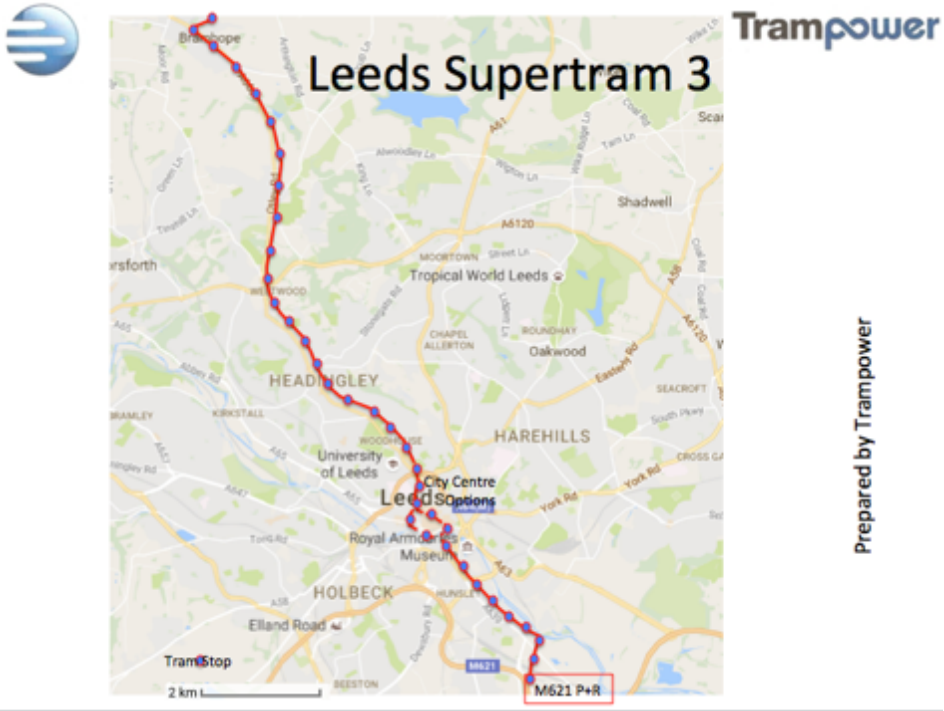
On the advice of the Dft, an application was made for planning permission to the City Council but was opposed by Merseytravel who wanted to build a guided trolleybus line to Prescott. The Planning Application was rejected and the team dispersed.

The best performing line financially is that serving Speke and Liverpool Airport. It will use former tramway central reservation for running along Mather Avenue and Speke Roads more than half the line.

The CAPEX for this first line is £95million.

7.10 Leeds

Leeds was one of the three tramway projects (with Merseytram and South Hampshire) that were cancelled after HMG Funding was withdrawn in 2005. Since then Leeds with encouragement from DfT reluctantly prepared a trolleybus scheme. This was rejected by the Planning Inspector after a Public Inquiry. The proposed Central Government Grant of £173million was however offered for another public transport project. This is being used for a multitude of small schemes in Leeds.



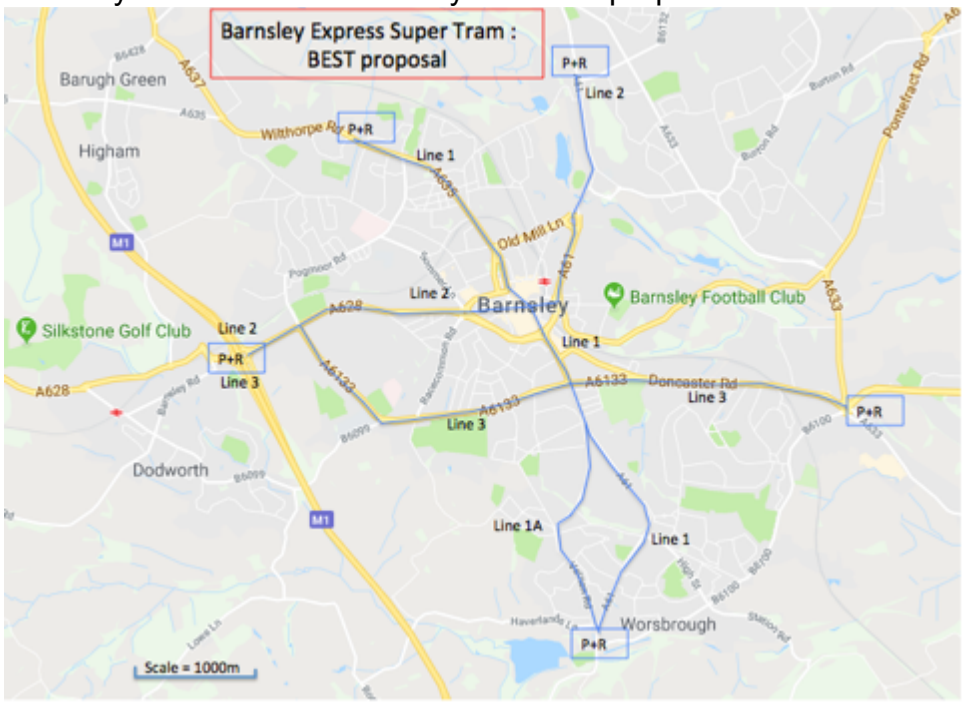
Trampower has tabled a privately fundable Supertram plan to WYPTE and Leeds City Council. This has also been discussed in detail with a WYPTE Team. The proposal is based on a self funding tramway, not needing grant aid for the capital investment.
The basis for the lower CAPEX is that most of the line will be a street tramway using the economic LR55 low impact track. LR55 does not need utilities relocated, or the roads rebuilt, and only 5% of the road excavated. This is a significant saving, when the earlier tramway plan of 2003 had £100m just for utility diversions.

One issue to be resolved is the location of a tram depot, without which the project is infeasible. The CAPEX for this proposal is £130million. The projected revenue covers the OPEX and is capable of servicing the CAPEX investment.

The City Council and WYPTE have yet to formally respond to this offer. A presentation was made more recently to a combination of the Chamber of Commerce and Local Enterprise Partnership.

7.11 Barnsley

Barnsley Express Super Tramway (BEST) was recently presented to a combined committee of the Chamber of Commerce and Barnsley Council. A three line system was proposed.



This will have a CAPEX of about £90million for a total network length of about 18km. The annual OPEX is about £3.5million.

7.12 MASST: Denton – Sheffield

The Manchester And Sheffield Super Tram (MASST) proposal will operate from the least used UK Railway Station, with one train a week in one direction. Denton Station is on the east side of Manchester near the junction of the M60 and M67 motorways. There is adequate P + R parking already provided for a community facility that has not been built, with a surface level short walk to the proposed tram stop. It will use the track bed of the former Woodhead Trans-Pennine Railway to Sheffield.

The Woodhead tunnel has three bores. Two original Victorian single bore tunnels and a 1954 twin track tunnel, which is used to carry high voltage electricity cables for the National Grid. The original single bore tunnels are available. This has been discussed with National Grid and a walk through inspection completed. The intention is that one will be used for a singe track tramway, and the adjacent for a Trans-Pennine footpath/cycle way, as well as an emergency escape route.

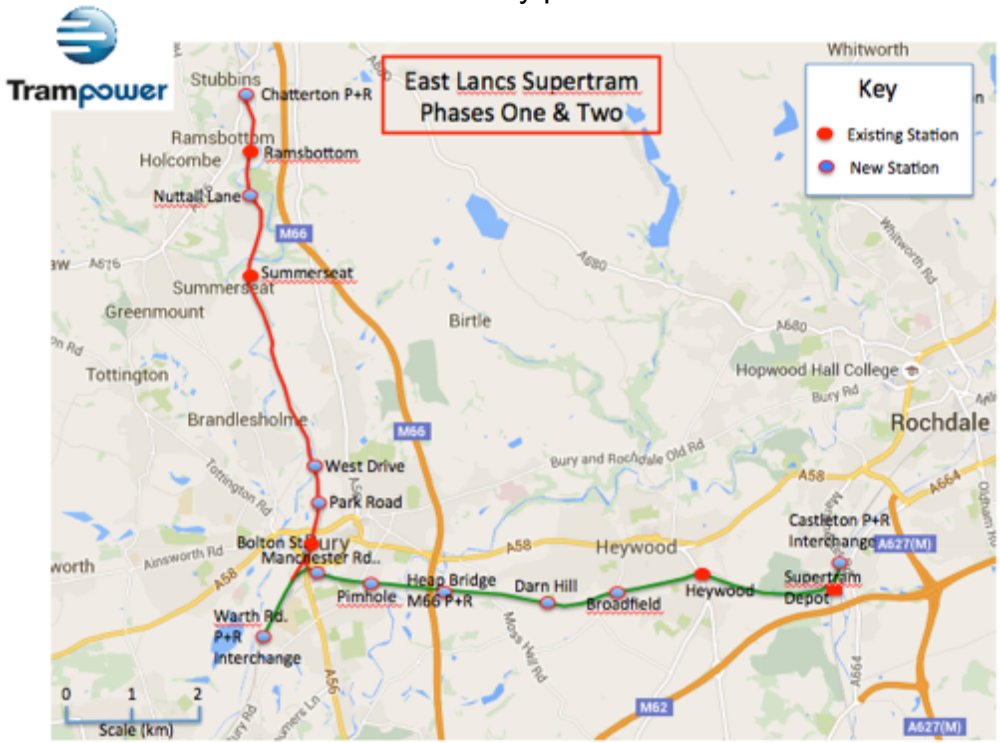
The journey time between Denton and Sheffield City centre should be under 50 minutes, with a tram every 15minutes. The CAPEX has been calculated at about £100m. As well as relieving the A67, at this frequency the Super tramway will have the capacity of a new dual carriageway, and be an all weather route. The OPEX has been determined at £2million pa.. Based on a £3 fare it will have an revenue of about £5million pa., making the line almost self funding.
Impression of tram using one of the Woodhead Victorian Tunnels.

As well as an end to end service, there is scope for local services, for example from Sheffield to Penistone, and Denton to Tintwistle, to cater for movements within their perspective conurbations. Integral to this proposal is P+R at key stations on both sides of the Pennines.

MASST will also have other benefits, including a rail interchange at Penistone to Barnsley, with a transit time of about 15minutes. This Trans-Pennine Link will greatly increase connectivity between and within Lancashire and Yorkshire.

7.13 East Lancashire Railway

This is a preserved railway between Bury, Rawtenstall and Castleton, which operates steam and diesel trains. The steam service does not operate before 10am and not every day of the year. A comprehensive study of the Steam Railway Timetable showed that electric trams could run between steam trains without disrupting the preserved service, particularly in the morning peak. This, when linked to Park and Ride, will help to relieve congestion on the M66 and M60 motorways, particularly at Simister Island, which the East Lancashire Railway parallels.



A detailed survey on the ground has identified sites for the Depot to operate the whole line, (a former goods shed at Castleton) and park and ride sites along this section. At the Castleton end interchange with the line to Rochdale provides further connectivity.

First Phase of East Lancs Supertram: Castleton – Warth Road

The tracks and track beds are owned by the Local Authorities in which they sit. The East Lancashire Railway Preservation Society leases the infrastructure and maintains it. The Plan above shows the proposed first stage of the project, modifying the railway to enable trams to operate between Castleton and Warth Road a new station on Metrolink with P+R. There will be P+R at Castleton for traffic on the M62 coming into Manchester to use a tram to Warth Road and interchange with Metrolink.

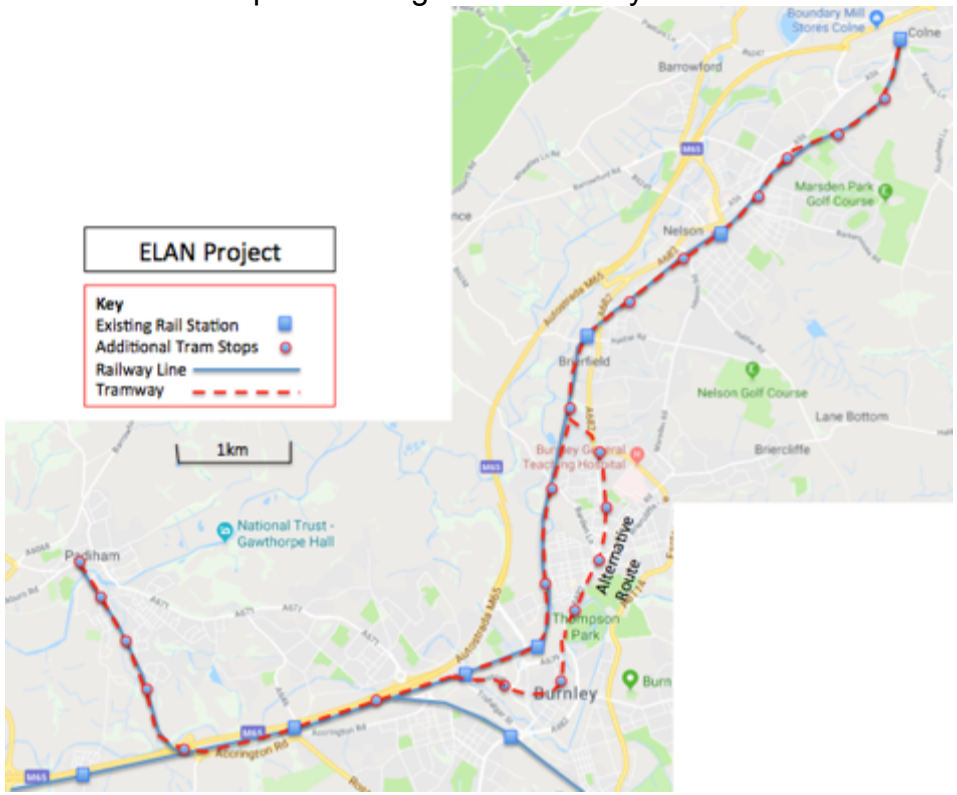
A proposal has been tabled to TfGM that the Castleton Tram could then continue non-stop to Victoria, reducing the running time by at least 8minutes ? There will also be a P+R stop at Heap Bridge for traffic travelling southwards on the M66, before it reaches Simister Island.

There will be 5 other tram stops between Castleton and Warth Road, to provide for local travel and trips into Manchester. The Preservation Society is against a complementary tram operation, as it might detract from the Victorian atmosphere of steam trains.

The CAPEX of the first phase £50million.

7.14 ELAN (Colne – Padiham)

The operating railway between Rosehill and Colne is one of the least used in the North West, with a train running every hour. Often only the driver and conductor are on board when it arrives at the Colne Terminal. The main competitor to the railway is the M65, which runs parallel and is frequently congested. The low rail frequency and dearth of stations serving the communities along the valley that have expanded since the railway opened in the 19th Century, means that most local trips are by car, despite the narrow corridor of development along the river valley.



The line does not serve Burnley well, nor the rapidly developing area on the site of the demolished Padiham Power Station. For these and related reasons a Pre-Feasibility study was undertaken to convert the line to a tramway, with an interchange stop to the Blackburn-Todmorden-Leeds/Manchester Line at Rosegrove

Station, where redundant railway sidings could also be redeveloped into a ‘green village’. ELAN (East Lancashire Accessible Network) was the title given to this project, since it will significantly improve the utility of the line, both through more stops increasing the catchment area, and with a higher frequency service, every 10 minutes.

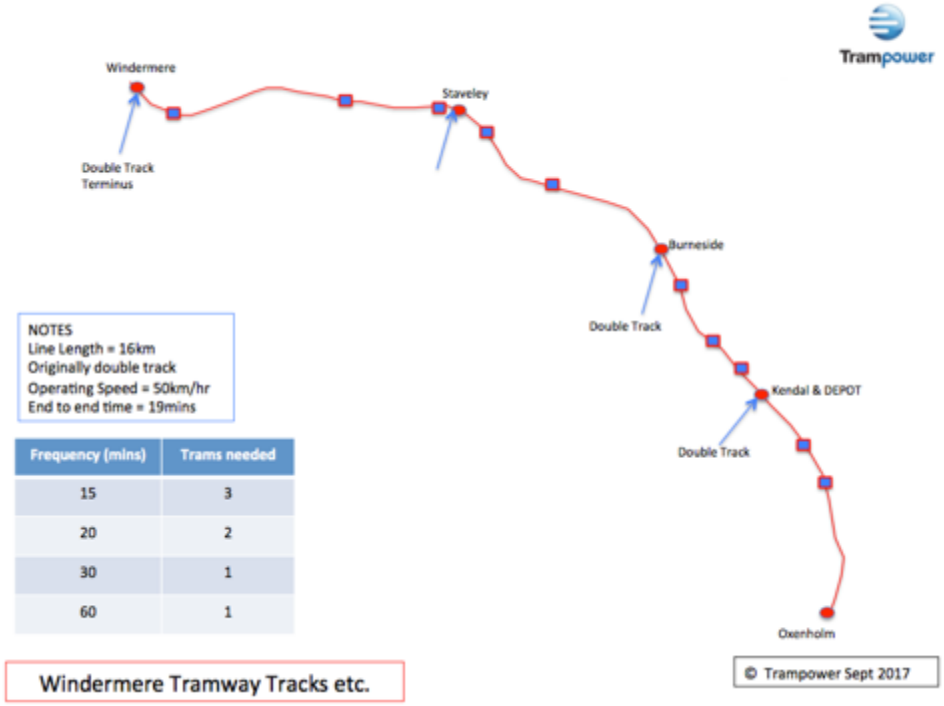
The CAPEX for this is £50million for a straight conversion of the existing railway. Adding an on street diversion through Burnley has an additional CAPEX of £35million.

7.15 Windermere – Oxenholm

This branch line railway between Oxenholm (WCML) and Windermere was opened with double tracks in 1847. Today it is operated on a signal track by a shuttle diesel railcar set, as proposals for electrification were dropped when the costs over ran on the NW electrification scheme. This means that passengers travelling out of or into the Lake District must change trains at Oxenholm. The diesel train must run a considerable distance for refuelling and maintenance, since there are no depot facilities on the line.

As in many places, settlements have expanded since the railway was built and much of the area is ill served by the few and poorly located stations. One advantage of trams is that new convenient stops are economical to build, and trams, electrically powered have a high operating speed, and so give a convenient service. This will be important for people making journeys within the area, for which the present railway service does not provide.

The railway presently carries about 400,000 passengers a year. The tramway could double this with local trips. For visitors arriving in the Lake District a tramway is likely to offer a stop nearer their destination. In Windermere where the present railway station has been cut back, so that it is further away from the centre, a tramway could be extended to serve the town more effectively, and reduce the volume of local and circulating traffic.



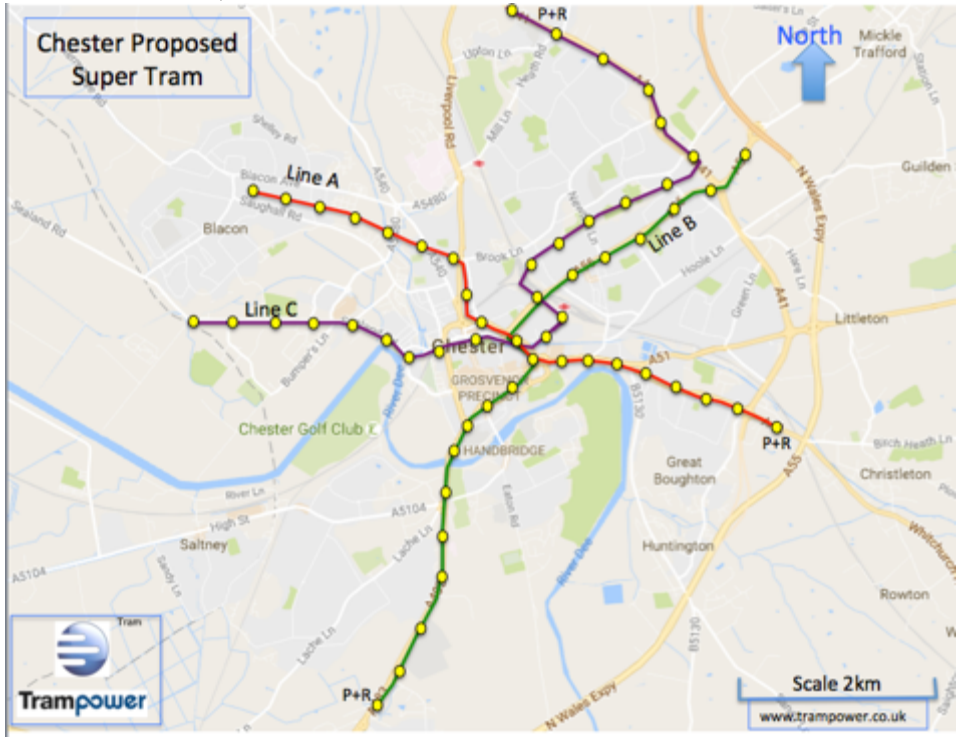
Windermere Tramway Tracks etc.

The CAPEX for converting from railway to tramway, electrification and equipping with City Class trams will be about £35million, for a 15minute frequency all day service, with an end to end time of 20minutes. The cost of extending the tramway on street to Bowness on Windermere would be another £40million but give much better connectivity to this important tourist destination.

7.16 Chester

Chester once had an extensive tramway until the 1930's, powered by a hydro-electric station on the River Dee. Twenty five years ago the transport authority (Cheshire County Council) published a report ("Chester at the Cross Roads") to address the serious traffic congestion and pollution problems in the City. That report advocated a tramway based on European practice.

The problems in Chester today are much worse and the logic remains that an electric tramway will attract enough car trips made in the city, to reduce both traffic congestion, with complementary traffic management measures, and toxic air pollution that kills over 100 people a year, and makes many more ill, at a high cost for NHS treatment, not to mention time lost due to time off work.



A pre-feasibility has been undertaken and presented to MP Chris Matheson and separately to senior planners in the Council. The likelihood of sufficient public money being available is small, so the

proposal is based on a self-funding system serving edge of city P+R facilities, as well as the main residential areas and destinations in the city.

This evaluated a potential three-line network, based on attracting trips from cars. This is important as Chester very dependent on cars for internal travel.

Mode	1981 Work Modal Split %	2011 Modal Split %
Car	54	62
Bus	19	6
Walk	19	17
Cycle	6	4

With the anticipated growth of population, this modal split cannot continue. A model for Chester is the similar sized historic city of Freiburg.

Mode	1982 Modal Split %	2012 Modal Split %
Car	38	30
Tram	11	18
Walk	35	24
Cycle	15	28

During this time Freiburg has seen population growth, attracted by its 'green' image and high tech employment. For Chester to enjoy these benefits will need investment in green transport. ?

Line	No. stops	No. trams	CAPEX £m
A	12	7	45
B	14	8	50
C	18	8	45
A + B	24	15	87
All	42	23	125

7.17 Lancaster-Morecambe

Lancaster enjoyed a tramway until the 1930's, when assets wore out, and the Council had no reserves for replacement. So cheaper new buses replaced the old trams. Then car ownership was very low so riders were 'captive'. In the last 40 years car ownership and usage has increased dramatically and bus use declined, as local trips are now made by car. This has led to rising traffic congestion and grid lock on a largely medieval street system.

Traffic movements have also increased both because of two University campuses in the City, and a growth of population. The opening of the M6 removed external traffic crossing the city but in part replaced by M6 traffic coming to destinations in Lancaster and Morecambe, which have coalesced from two separate settlements.

The decline in the holiday trade in Morecambe could be partly replaced by traffic visiting the new Eden Centre in the North on the Morecambe sea front. The Eden Centre in Cornwall has 95% of its visitors arriving by car. Even with the more modest visitor numbers envisaged about half a million annually, the roads in the area cannot accommodate such extra traffic, nor is there space in Morecambe to provide enough visitor parking.

An alternative transport mode is needed that will both attract some local car trips off the road, and also provide the capacity to meet, especially the peak, visitor numbers expected by the Eden in the North. A tramway would provide that alternative.

The transport authority (Lancashire County Council) is presently planning a Busway but has inadequate funds. A self-funding tramway will need little on no public funds for construction and operation, and will attract car trips that buses serving the new P+R facility at J.34 on the M6 clearly does not.

Line	CAPEX £m	Pax m pa.	IRR %pa
Red	35	1.9	9.0
Green	42	2.2	6.7
Both	75	4.2	8.7

The table shows that a tramway in Lancaster can be promoted on a self funding basis, as the IRR is over that required to borrow the investment funds on the market, or even from the PWLB.

7.18 Warrington

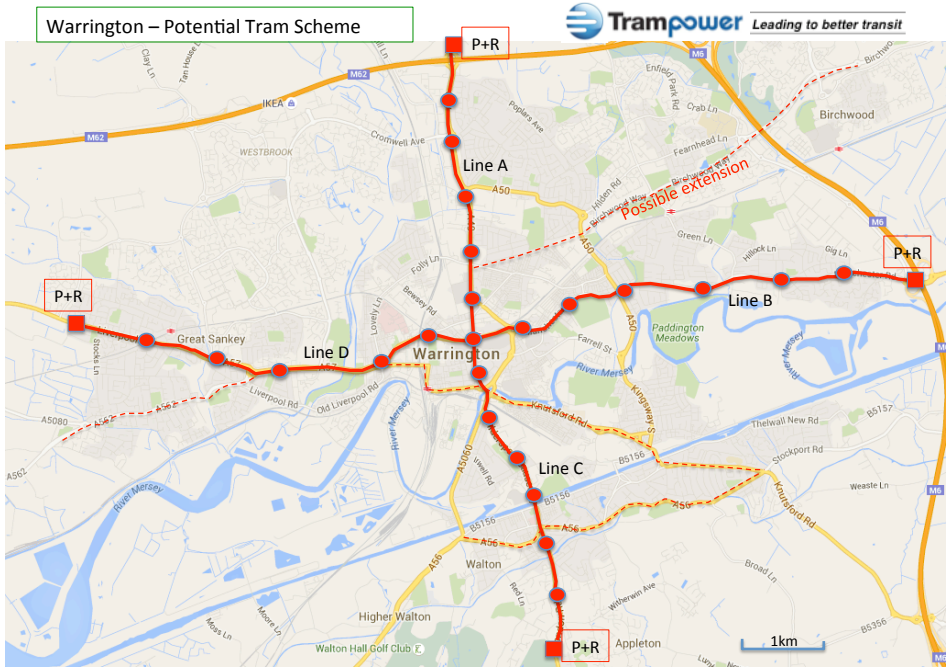
Until 1935 Warrington was served by an extensive tramway that was abandoned in favour of new buses. During its years of tram operation profits were used to reduce the rates, or to pay for other services like schools, the hospital, libraries etc.. The Council did not have a depreciation reserve to replace worn assets, especially track and the 30year old tramcars. Trams were replaced by new buses. This worked when car ownership was low, as most people did not have a choice of travel mode.

Original Warrington Tramway

In the 1960's, after petrol rationing finished and real incomes rose, car ownership became a realisable aspiration for most people in Warrington, especially as industry in the town boomed and there was full, well paid, employment.

Today the inheritance of this is that Warrington is a car dependent town, with low bus use. This was made possible during the period when Warrington was a New Town, more roads and out of centre retail developments made car use practical. The model of the nearby Runcorn New Town, with its dedicated Busway was not adopted, as bus use in Runcorn was no higher than in Warrington. The one rail line between Liverpool and Manchester that has stations within the town carries a miniscule volume of local travel.

A pre-feasibility Study considered a four line network, with edge of town P+R terminals.



This Study also considered the likely CAPEX of each line, and then in combination to form a network. As with the other proposed systems the key will be to find a suitable site for the tram depot. The original central Depot closed with the trams and is no longer available, even if it were large enough. The present bus depot is on a constrained site just south of the River Mersey with difficult access.

Line	No. stops	No. trams	CAPEX £m
A	7	5	30
B	8	7	40
C	8	5	30
D	7	6	50
A + C	14	9	55
B + D	14	12	80
All	27	21	125

This Table shows that there is synergy in combining lines to form a network, including less trams. This proposal needs a full Feasibility Study undertaken, including walking the routes to ensure practicality. The Borough Council has been asked to fund this at a likely £35,000 cost. The Borough Council is also promoting a new road on the western side of the town, which has recently been granted funding by the DfT. It will however not address the serious level of congestion caused by car dependency, the high levels of toxic air pollution, or the decline in the town centre.

Such a Feasibility Study should lead to an economic assessment, including determining the financial viability. The most difficult and sensitive part will be assessing the likely patronage and therefore fare revenue.

The Warrington Tramway could be operated by a new company, although it would make more sense for Warrington Transport to run the tramway, integrated with feeder bus services and linking the two main railway stations (Bank Quay and Central) for travel into and out of the town.

7.19 Birkenhead

Until 1938 Birkenhead had a complex tram network. This focused on the Woodside Ferry terminal, catering for the many trips made between the Wirral and Liverpool. Wallasey also had a tramway but not connected to the Birkenhead system. That focussed on New Brighton and the Seacombe Ferry Terminals for services with Liverpool Pier Head. Wallasey also abandoned its tramway at a similar time. Ironically the Mersey Road Tunnel (Queensway) opened in 1935 was designed to allow trams to operate between Birkenhead and Liverpool. But with the abandonment of the Birkenhead system, even though Liverpool retained its trams until 1957, that opportunity was never realised. Like many historic port towns, Birkenhead has a heritage of redundant docks as well as a surviving ship building capacity.

The whole of the Mersey Dock complex is now owned by Peel Holdings, which has ambitious plans to redevelop the East Float between Birkenhead and Wallasey as a mixed development of residential, retail and high tech service industries. The local road network does not have the capacity to allow these new developments to be served purely by car, and knows that buses are not an acceptable alternative and so is planning an ‘upmarket’ ”streetcar” service.

Birkenhead already has a museum tramway from Woodside Ferry Terminal to the Transport Museum. Plans commissioned from Trampower will see this extended in turn to serve the new developments and be an attraction for developers to invest in the area. This extended tramway will need a dedicated tram depot, and be designed to provide a DDA compliant service by using low floor trams, since the Museum’s historic trams are all high floor and cannot be converted to provide a DDA access.

The plan envisages a 7 day service of low floor trams, and during weekend afternoons historic trams will inter run to and from the Museum. The extended tramway will be designed so that on special occasions, and for tours using historic trams, they can operate over the whole system.

The CAPEX for the minimal first extension is £6million. The likely CAPEX for a complete network to serve the regenerated Birkenhead Docks and links to Birkenhead centre and Merseyrail will be of the order of £100million.

Proposed initial extension from the Heritage tramway

Improvements at Woodside Ferry Terminal

Low floor City Class tram on Birkenhead tramway

7.20 Hallamshire Hospital Extension

In response to an invitation from SYPTE, Trampower undertook an exercise to design and cost an extension from the present tramway near the University Stop. Two options were evaluated, one a double track branch line terminating outside the hospital, the other a single track loop, also serving the hospital, and providing a terminal operation facility.

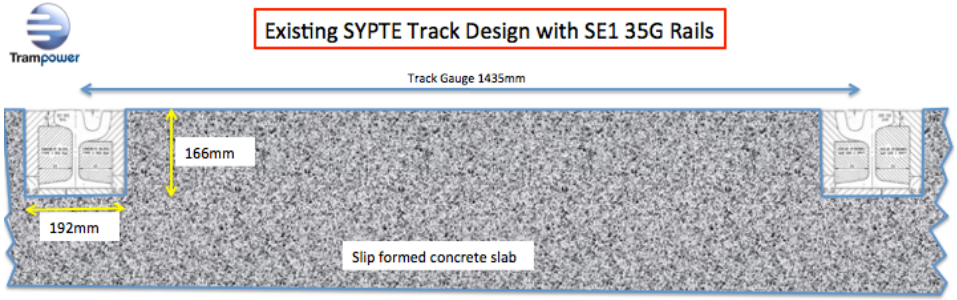
The operation of loops is always problematic for public transport, and a Royal Hallamshire loop will be no exception. Wherever the journey ends or starts on the loop, there will always be ‘wasted’ mileage and time as the tram completes the circuit. On the other hand fitting a single track tramway on these local roads will be less complex than a double track. The track length is almost the same for both, although the loop needs more poles to support the over head line (OHL) power supply, since the route length is longer. Compared to the cost of track, the OHL is less than 10% per m.

The Royal Hallamshire Hospital is a major health facility in Sheffield but presently poorly served by public transport. Extending the Supertramway will certainly give a better benefit to cost return than the recently opened tram-train extension to Rotherham ?

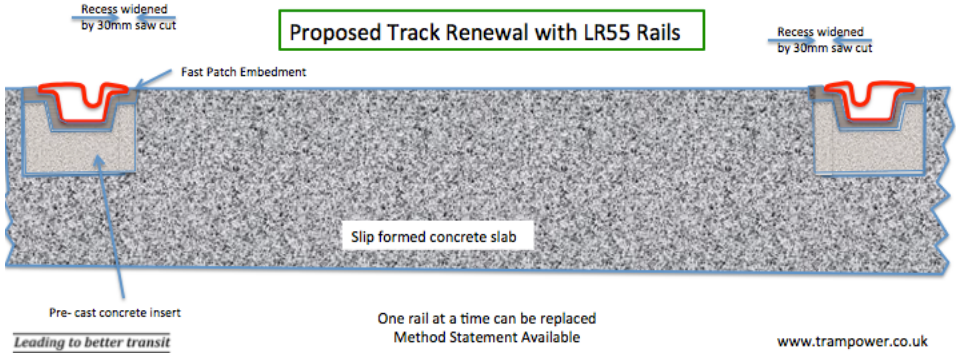
Royal Hallamshire Hospital double track extension

The CAPEX for the single track (1.6km) loop is about £15million, assuming that there are enough trams in the fleet, For the double track (0.75km) branch the CAPEX is about £12million.

Much of the track on the Supertramway, now over 24years old, is wearing badly and needing replacement. This has been costed at about £200million by SYPTE, including replacing the trams, which are wearing remarkably well. Sheffield is the site of the on-going operation using LR55 track, which after 23 years has not needed maintenance nor any repair. Replacing worn girder track with LR55 has been offered at to SYPTE.



British Steel will be happy to roll LR55 for this track replacement. This will avoid the need to import rails. The LR55 option is costed at about £80million for the whole system, with the track replacement details provided.

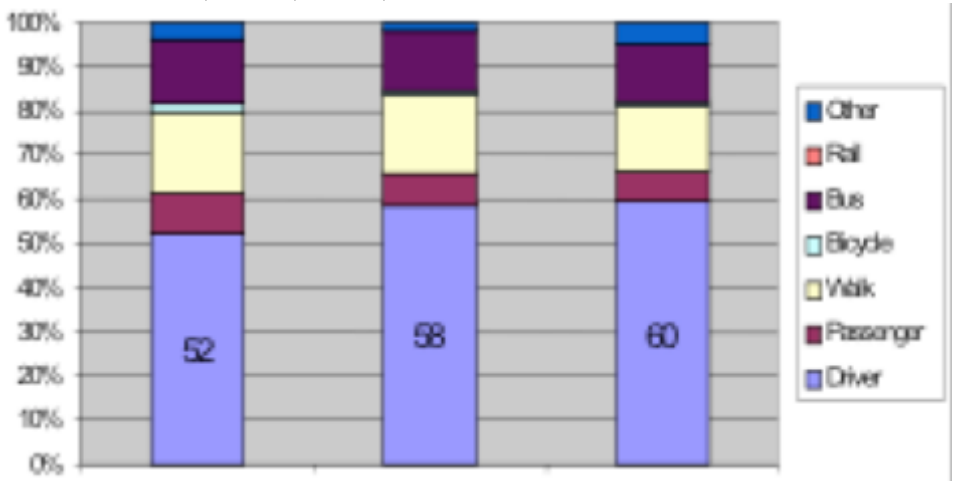


Replacement with LR55 will also remove the problem of tram wheels over running and damaging the concrete edge of the track, since this has a potential for a much more expensive foundation replacement.

7.21 Aberdeen

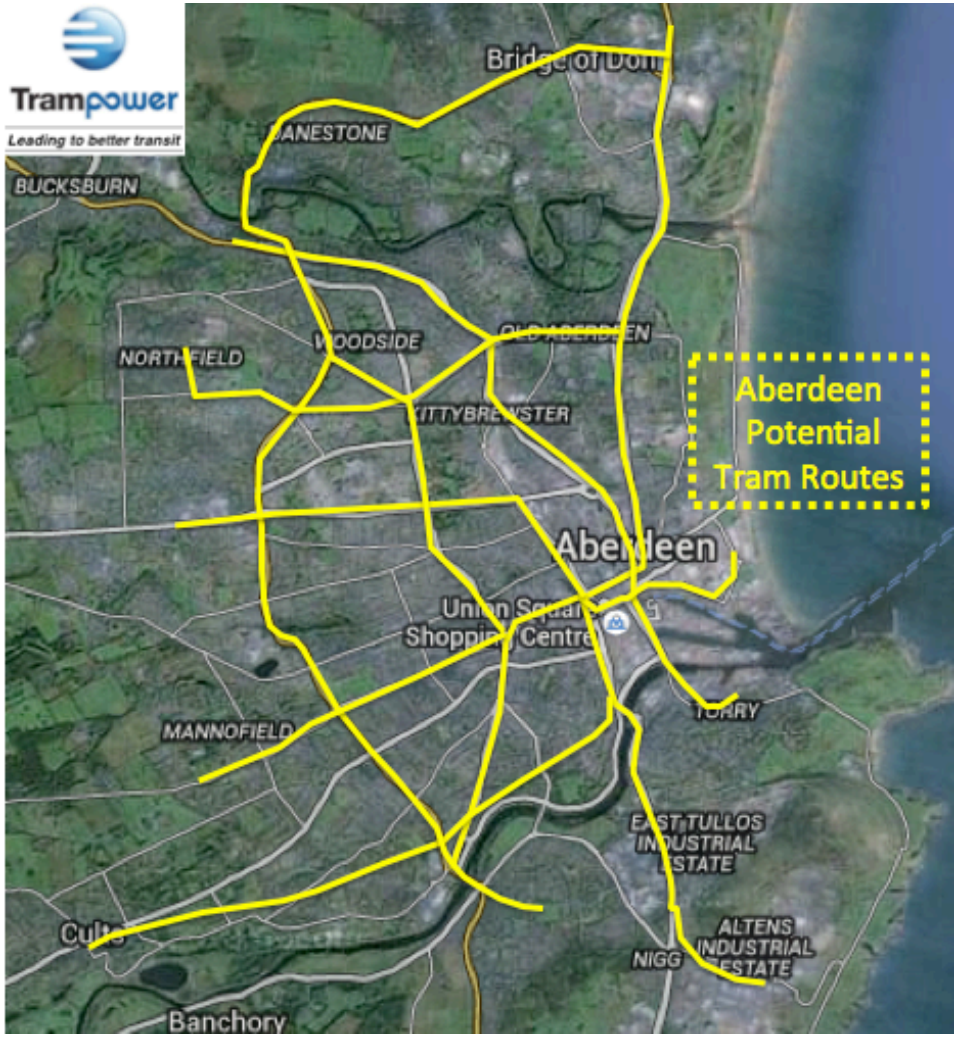
The problems in building half a tramway in Edinburgh, through severe cost over runs and the delay in opening does not invalidate the need for tramways to solve serious problems of traffic congestion and toxic pollution in other cities. The truncated tramway in Edinburgh is now carrying 6million passengers a year, and made a profit of £1.6million last year, at which rate it will take over 400 years to pay off the investment debt, assuming it is interest free. The economic opportunity cost of £770million spent on the tramway built, and another £220 million for an extension to Newhaven underlines the case to find more economical ways of building and operating tramways.

Travel to work, 2000, 2002,2004



An invitation from Aberdeen City Council led to a Pre-Feasibility scoping Study proposal.

Back ground research showed that the city was as dependent on car travel as many others, with 65% of work trips in 2004 by car and only 11% by bus. A potential network of routes for further investigation was set out. No further work has been undertaken since then.



7.22 Abbey Line

The branch railway between Watford Junction and St. Albans Abbey, has an inconvenient service because it is a single track with a ‘one train in steam’ operation. A study and site visits were undertaken to frame a proposal for converting this line into a tramway, including extending at both ends to provide better connectivity to the urban areas served. This also provides for building tram stops to serve communities built since the line opened in the mid 19th Century.

A Report was prepared and shared with National Express the then operator. This reviewed previous studies of the line, most based on tweaking the railway service, rather anything more radical. The Trampower report showed how the line could be converted to tramway operation, including converting a railway level crossing on a busy road to tramway standard with traffic signals. The present level crossing at Bushey Mill Lane causes delays of about 5 minutes for road traffic every 20 minutes or so. During the peak this leads to long queues and vehicles driving across as the barriers are closing, a clear accident risk.

With better performing trams, a regular half hourly service is possible compared to the present 45minute frequency. This requires virtually no infrastructure changes, since the electrification catenary can easily be re-energised from 25,000V ac to 750V dc, allowing trams to run on street in Watford and St. Albans.

With a passing loop half way at Bricket Wood, a quarter hourly service becomes practical, greatly increasing the utility of the line, especially with new stops to serve better the community through which the tramway passes.

The conversion to tramway would need a dedicated depot. A suitable site in the former goods yards at St. Albans Abbey Station has sufficient space and is convenient for the nature of the traffic involved. The CAPEX for this was determined at £10million.

7.23 KENEX

North Kent, between Dartford and Gravesend, and across the River Thames in south Essex Thurrock, have a similar population density to Croydon. Unlike Croydon, trips by car dominate both areas, and this is further stressed by the Dartford Crossing (Bridge and Tunnel) carrying the M25 around London. That operates to capacity and when there is an incident on the crossing about once a day, the result is grid lock on roads in north Kent and south Essex. In north Kent the County Council has built lengths of Busway (Fastrack), on which Arriva have the operating monopoly. When this contract was awarded, the expectation was that bus patronage would grow to 5million a year. For the last four years it has plateaued at 1.2million pa., and the system runs at a deficit.

Trampower prepared a sustainable tramway plan for the Ebbsfleet Garden City, both for internal trips and to connect with Ebbsfleet international station, from where there is a 15minute frequency train service into central London, and half hourly into the rest of Kent.

The CAPEX for this little tramway is about £22million. A resident population of over 6000 people is enough to make this financially viable.

Independently a group of local business people began a campaign to have a tramway built in the area. Trampower was commissioned to undertake a Feasibility Study of four potential east-west lines and one north-south linked to form a network. During this process Arriva approached the group looking to convert some bus routes, including Fastrack to tramway, as a way of going ‘up market’ and increasing patronage.

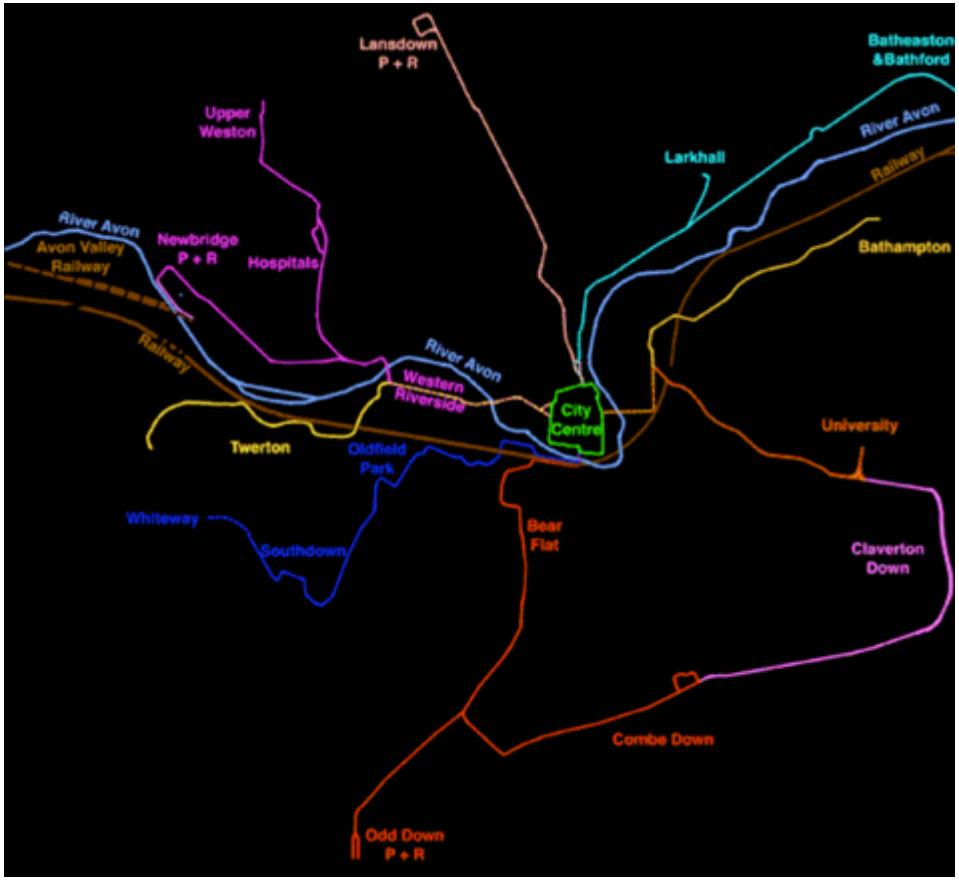
Trampower analysed these various line options and recommended one east-west line in Kent and the north-south line between Essex and Kent with an immersed tunnel under the River Thames.

The estimated CAPEX of this complete network is about £500million, with an annual OPEX of about £12million pa and a passenger revenue of over £20million pa.

7.24 Bath

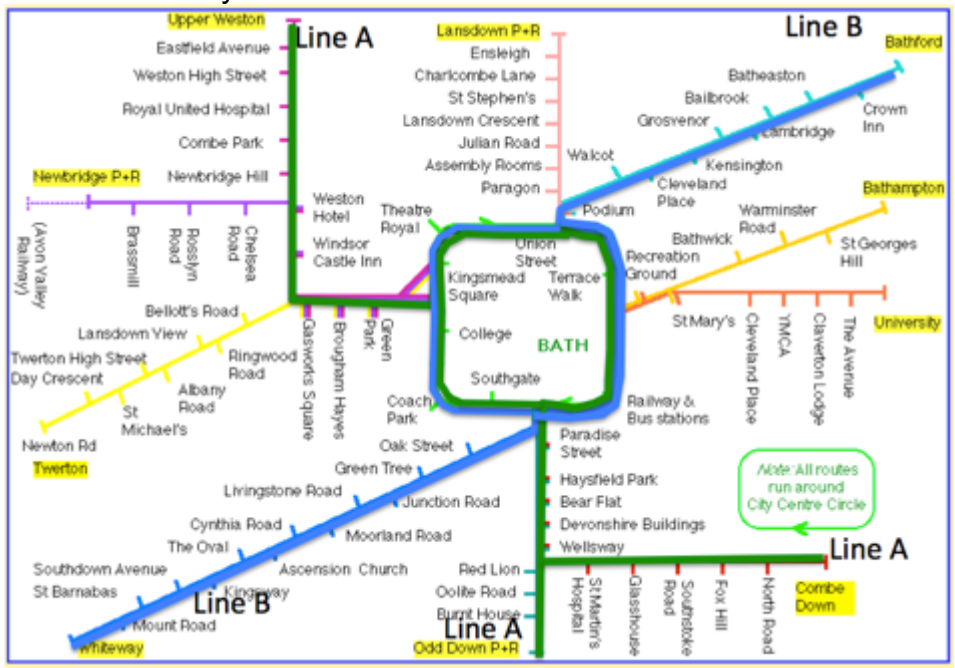
The UNESCO designated World Heritage City of Bath has its centre in the bottom of the deep River Avon gorge. This limits opportunities to improve transport to reduce the chronic traffic congestion experienced. The gorge also concentrates toxic air pollution leading to severe health problems. Presently cars carry the majority of trips made in the City, with buses only having a modal share of 6%. Until 1939 Bath had a comprehensive but un-modernised tramway that was replaced by buses.

Potential Tram Lines in Bath



Trampower has been advising a group of local people on how a modern tramway can be installed with architectural and civic sensitivity, and at a low enough cost to be funded from private investment. This advice has included evaluating a suggested network for CAPEX, OPEX and revenue based on the resident population living in each tramline catchment. From this a network of four lines was identified as potentially being commercially viability.

The Local Group has run a series of seminars and conferences to raise awareness of the potential for a tramway to attract local trips presently made by car, thereby reducing traffic levels, congestion and the level of toxic air pollution. Presentations have also been made to the City Council.

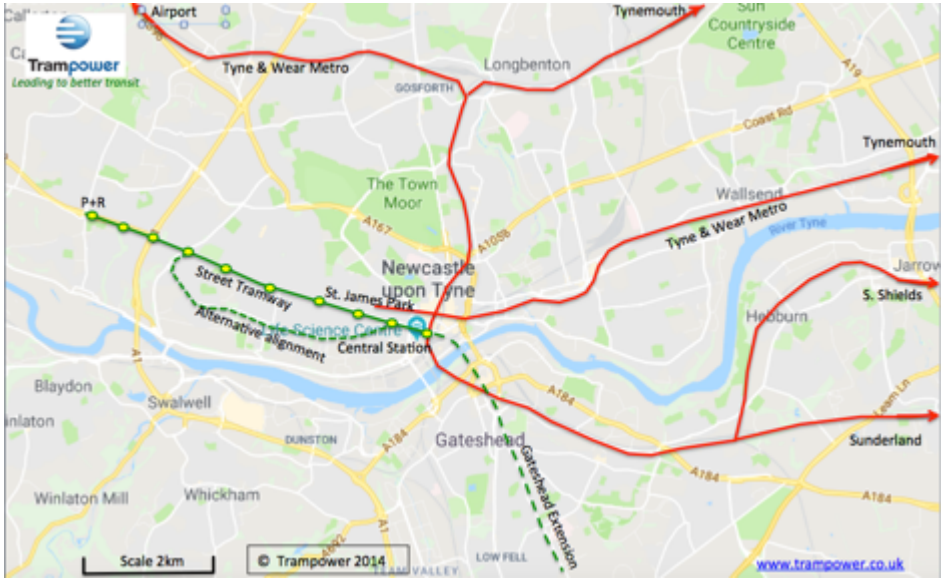


The Bath Tram Team is presently working with Council Officers to find the best way forward to achieving this important investment, and reduce severe traffic congestion and the high levels of toxic pollution experienced in the Avon gorge, in which much of the City sits.

7.25 Newcastle upon Tyne

The Tyne and Wear Metro is a major transport system in the area, which has been operating since 1981. Presently it is all off road, partly because some of the route is old railway line and partly because high floor cars are used. Manchester shows these give problems in integrating lines on road in the urban environment.

Tyne and Wear PTE was offered a Trampower on street line some time ago, between Central Station and the west of Newcastle, presently an area not served by the Metro. As Newcastle is located near the East Coast of England, there is considerable commuter traffic from the hinterland to the west. A strategic P+R facility on the west side of the city will attract a significant proportion of this traffic using the A69, relieving congesting and reducing air pollution, especially if a street running tramway enjoys priority over other traffic, as is DfT policy.



For the line serving the west of Newcastle there are two main options: The West Road or Elswick Road. A Feasibility Study and financial appraisal will show which has the best rate of return. This line also offers the opportunity of serving Gateshead better by having an extension over the High Level Bridge and then running southwards through the centre of the built up area. It too could have a P+R at the southern end.

The CAPEX just for the line through west Newcastle is about £60million.

7.26 Cambridge

The Guided Busway was built over the track bed of the former Cambridge - St. Ives railway, and has been described as a 'White Elephant' by the local MP. Part of the reason for this is the cost over-run from £116 to £181million, two years late opening and legal action between the County Council and contractors that was settled in 2013. Ridership is reported to be about 2.5million pa., of which about a third travel free with a Pensioners Concessionary Pass. This however is somewhat less than the 4m pa predicted by the contractor but 40% more than Atkins claim it should carry,

The cost of the Busway does not include the cost of the buses or the depot for maintenance and overnight parking. These were paid for by the bus operators with a 5 year operating monopoly. Another problem that arose was that the bus operators had purchased buses in time for the original opening date of 2009 but could not use them until the Busway was finally opened in August 2011.

In 2005 when the County Council decided on a busway, Tram Power Ltd. submitted a proposal to use the existing railway track converted to a tramway, install the electrification, supply the articulated trams needed to run the service, and build a depot to maintain and provide overnight storage. The cost of this offer was £65million, based on the prices of the proven Trampower technologies. This option would of course be non polluting and using renewable power generation be CO_2 free, or negative when attracted car trips are included.

The cost of converting the Busway to tram operation would now be much higher, since new track would have to be installed. It is notable that the City of Caen in France, which opted for a guided bus system is now converting to tram. The Mayor of Caen claimed a tramway would have been cheaper from the start.

7.27 Trafford Centre

The Manchester Metrolink extension to the Trafford Centre is almost complete at a cost of £350million for its 5.5km length, (£64million/km). Tram Power Ltd surveyed several routes in 2012 to serve this extension, and in particular to make use of the existing former Trafford Park Docks railway system. Including rolling stock, this was priced at £40million, which for the 5.5km length would give a price at 2019 costs of £47million, a unit cost of £8.5million per km..

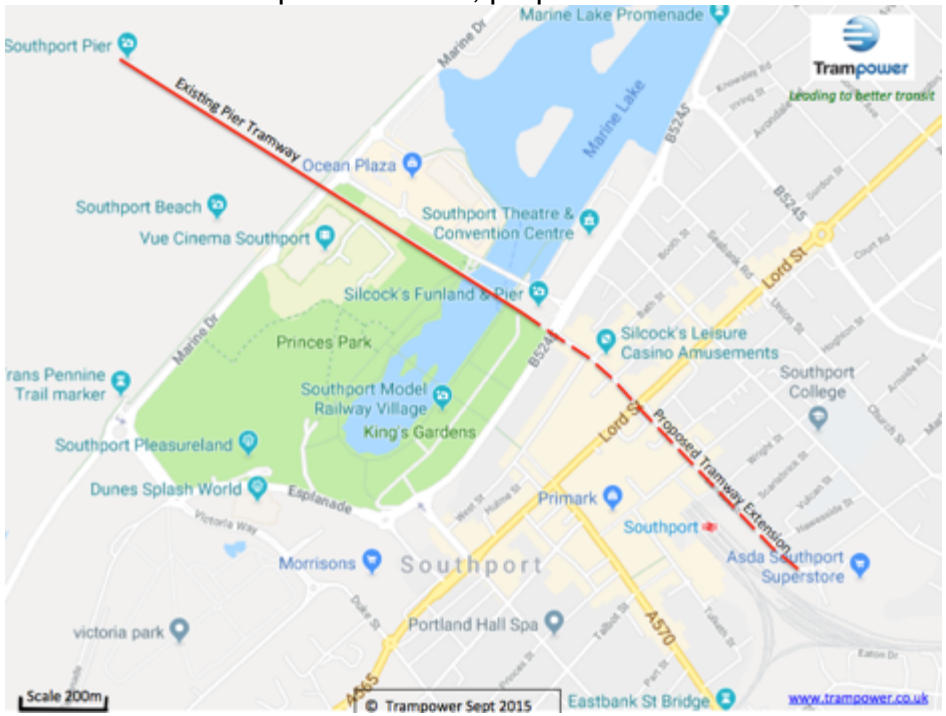
7.28 Southport

Southport received grant aid to restore the Pier as a 'Victorian' attraction, including installing a tramway along its length (1.1km the second longest in UK) and providing a tram to take visitors along it. For various reasons the tram is parked at the outer end and not in use. Visitors are ferried along the Pier by a diesel road train.

A proposal was made to Sefton Council both to refurbish the tram and extend the tramway to provide a better service in Southport including interchange with Merseyrail trains to Liverpool and other trains to Wigan and Manchester.

The CAPEX of this modest extension, including refurbishing the tram and electrification is £6million. This could of course provide the basis for a much bigger tramway to serve the whole town, not just for visitors.

Southport Pier tram, proposed extension.



7.29 Galway GLUAS

The medieval Irish City of Galway presently has a population of 85,000 but is expected to grown to 140,000 within 20years. The narrow streets within the city walls are unable to accommodate existing levels of car usage, which presently represents about 70% of all trips made in the city. In comparison bus trips account for only 8%, despite bus lanes and priorities being implemented. Galway is also hub of its hinterland and attracts many trips daily for work, shopping, education and medical services.

In 2009 Tram Power Ltd was commissioned to undertake tram studies by a local group of business people, who were impressed by the success of Dublin's LUAS tramway to attract car trips and reduce congestion. They had set up a GLUAS campaign to get a tramway into Galway. They faced officials wedded to an outer city motorway bypass and saw GLUAS as a threat to those plans. After the EU Court of Justice rejected the motorway plan on the grounds of violating protected natural habitats, the atmosphere in Galway became more sympathetic to the GLUAS Tram.

Tram Power's work included:

(a) Feasibility Study
(b) Financial Appraisal
(c) Business Plan.

GLUAS City Centre tram stop Eyre Square

The Feasibility Study examined 12 route options, all of which were walked and photographed to determine their physical practicality. This was followed by a financial appraisal, where the CAPEX of each option was calculated, together with the OPEX, and using census data on the resident population within the catchment of each line, the potential patronage revenue. From these four lines with the best Internal Rate of Return (IRR) were identified for further work. This included a local Architectural Practice drawing up a set of 1:1000 scale plans for each line, track location, stop platform positions and a potential Depot site using a closed factory.

Finally a Business Plan was prepared with the help of a local firm of Accountants, who using Irish Tax Laws and reliefs showed how the four line network could be funded using private finance from a mixture of high net worth individuals and institutions.

Plan of proposed GLUAS Network.

Since then the GLUAS group has commissioned a promotional video, and a webite (www.GLUAS.ie) sets out the key findings.

Video: https://www.youtube.com/watch?v=eZKdEM9tW2M

The GLUAS network will serve 40% of the resident population living within 400m of a tram stop, the two main hospitals, the major employment areas, the two Higher Education Establishments, the City Centre and have Park and Ride at each outer terminals. The GLUAS CAPEX will be about €200million, compared to €600million for the outer motorway bypass. Passenger Revenue will cover the OPEX and provide a surplus to service the investment capital.

The GLUAS Group remain optimistic that with the environmental benefits of lowering toxic air pollution and reducing traffic noise, added to which GLUAS enjoys the 80% support from local residents, it will be able to persuade the Council to give approval. One further environmental benefit of GLUAS will be the use of renewable power generation. The west coast of Ireland already has a number of wind generators. The River Corrib that bisects the City has the potential for hydro-electric generation sufficient to power GLUAS system.

7.30 Sutton

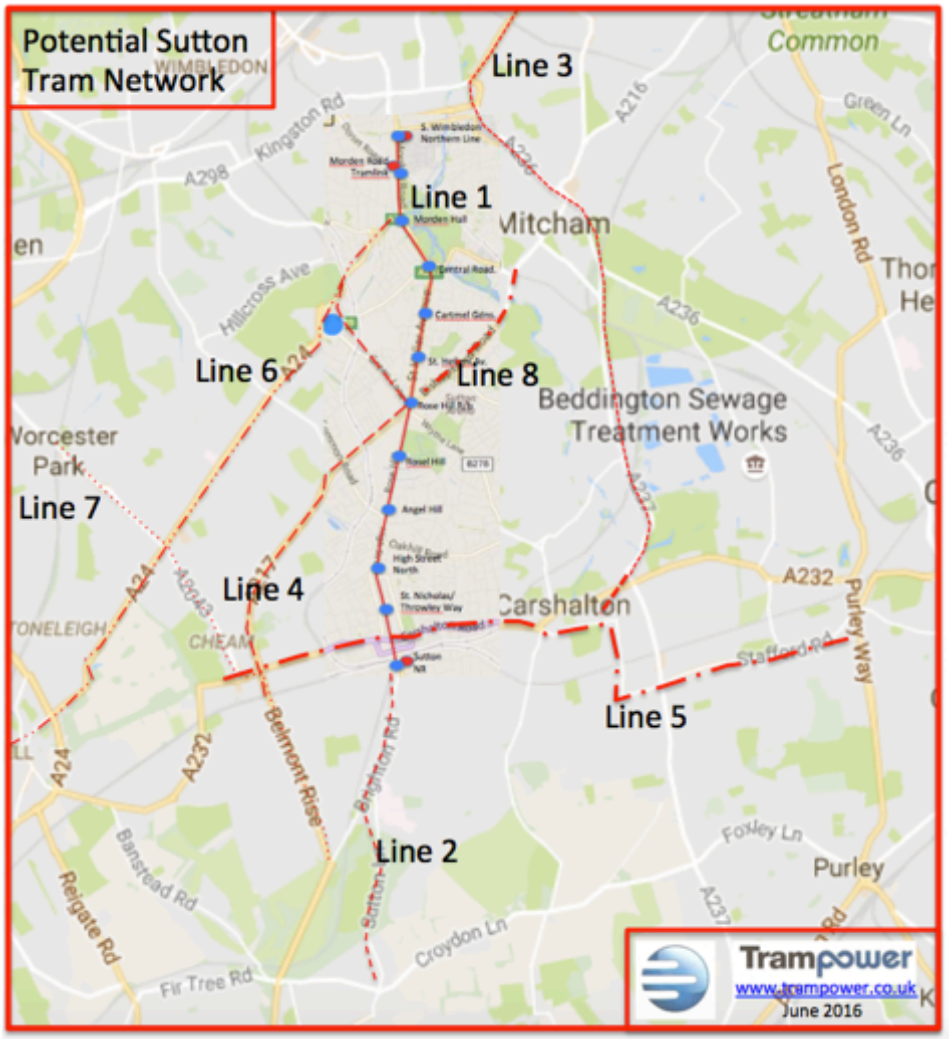
The London Borough of Sutton would like to be linked to the Tramlink system. Trampower's sister company "Capital Supertram Power Ltd" undertook a pre-feasibility study and has met with senior planning staff to discuss how a self-funding tramway might be delivered, given the committed public funding for other schemes in London.

Several route options were examined in 2016, one between S. Wimbledon Station and Sutton Station, through the town centre, another serving St. Helier Hospital, the town centre and Sutton Station. In all 6 potential lines were examined and preliminary IRRs calculated.

Line No.	IRR %pa
1	13
2	-0.2
3	3
4	1
5	15
6	2
7	5
8	13
1 + 2	9

This showed that Line 5 gave the best IRR due to serving a larger population and being a more direct line to Croydon, whereas Line 1 to South Wimbledon has marginally a lower IRR.

Subsequently TfL has undertaken a consultation exercise on a Tramlink extension for Sutton. Capital Supertram Power Ltd submitted its proposal and has received a pro-forma acknowledgement.



The CAPEX of Line 5 is estimated at £million.

7.31 Croydon N-S

The Tramlink through Croydon is a predominately east-west alignment. Before the first tramway was abandoned in 1951, the north – south route between Thornton and Purley was the busiest line with a 3minute service during the day, linked to central London with a travel time between Purley and the city centre of only 73 minutes. This tramway operated at 16km/hr and carried 7million passengers a year. Buses today also operate at 16km/hr but now there is a 4minute service 33% less.

Capital Supertram Power Ltd., sister company to Trampower has examined a route between Thornton Heath and Purley to connect with and complement the existing Tramlink system. 57,000 people live within 400m of the proposed line. With a 6minute frequency service, an estimate of 9million passengers a year is possible with trams running at 24km/hr, the same as that for the Cross River tramway, thanks to multi-door trams and faster, smooth acceleration and braking with trams. The CAPEX of this was calculated as £100million in 2014, which will deliver a 7.2long tramway (at £14million/km), with 19 stops, connections to the existing Tramlink, allowing for example Purley – Wimbledon, or Thornton Heath – New Addington services.

This new line will also significantly improve the connectivity of the centre and provide a tram service for the local major Croydon University Hospital, between the centre and Thornton Heath. The Hospital will become very accessible to a much wider area of south London.

7.32 Liskeard Looe Branch – City Class Tramtrain

On the advice of Bob Chard, a discussion was held with the chairman of the Devon and Cornwall Rail Partnership at the University of Plymouth. The Branch line is presently operated by a refurbished Class 150 diesel DMU set. It is also steeply graded so the uphill journey is slower than the downhill. This train is now over 30years old, and highly polluting.

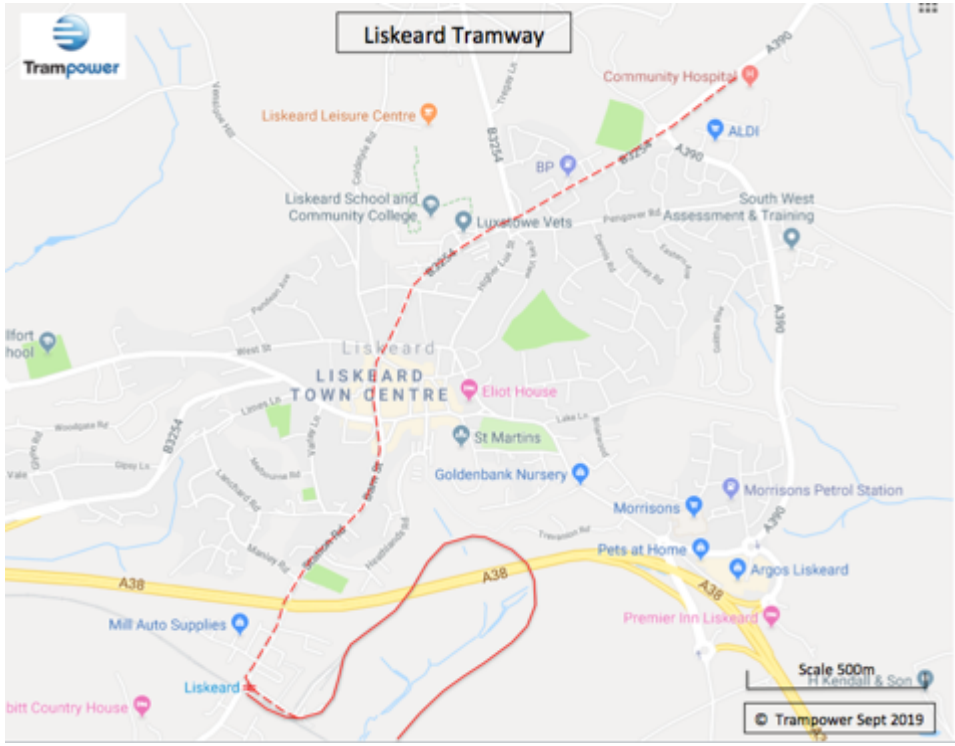
A proposal was tabled to convert the line to electric traction, using locally generated renewable power, and equipped with City Class rail vehicles that will be able to climb the steep grades more quickly than a DMU.

The present timetable is constrained by a single track operation and is irregular, departures have 63, 65,77,60,67,75,62 and 87 minute gaps. The end to end time is 29minutes to Looe and 27 from Looe.

The City Class EMU will be able to undertake the transit, including intermediate stops in about 20 minutes, so allowing a regular hourly, clock face timetable. With a passing place a half hourly service could be offered.

Patronage has increased by 99% since 2001 according to the Rail Partnership, carrying nearly 120,000 passengers pa. in 2017. A faster, smoother transit with the City Class EMU and regular clock face timetable could see the patronage double again, whilst reducing operating costs.

The cost of electrifying and supplying a City Class EMU would be about £10million. Whilst a passing place at mid point, e.g. St. Keyne would be ideal, in practice the existing reversal at Coombe Junction could also provide for the passing of trams in opposite directions. Conversion to tram would provide the opportunity to extend operations into the centre of Liskeard, which is some distance from the existing railway station.



Such a tramway extension would not only make Liskeard Station more accessible, it would encourage longer trips to be make by train, rather than car. The tramway extension would make travel within Liskeard easier, including access to the Community Hospital.

The cost of this extension, including trams running through Liskeard to Looe, would be about £20million.

7.33 Eden Project Cornwall

The Eden Project with Biomes in a former china clay pit is a large tourist attraction in Cornwall. There are over a million visitors a year but due to its isolated location over 95% arrive by car and the rest by coach. The nearest railway station is at Parr (3km) but St. Austell is a larger town though 5km away. The roads serving the area have limited capacity.

A study was undertaken of the potential of connecting the Eden Project to St. Austell, St. Blazey and Parr, giving a local electric tram service and linking to the wider rail network, including Newquay. This allows more local travel without the need for a car.

This is feasible but would require investment of about £90million. In terms of relieving local roads of peak congestion, this is less than a road widening scheme which would achieve less capacity, since a double track tramway with a 6minute service has the passenger capacity of a 6 lane road.

7.34 Isle of Wight

The Isle of Wight once had a 42mile railway network. If this only the Ryde – Shanklin Line remains in daily operation. A preserved railway has reopened part of another line as a steam operation and tourist attraction. The conversion of railways to light rail or tramway, demonstrated by the Tyne & Wear Metro, Tramlink in Croydon, Manchester Metrolink, Midland Metro, South Yorkshire Supertram and Nottingham Express Transit, with extensions to better serve major traffic destinations, shows that patronage can be greatly increased, by attracting trips from private cars, and reducing operating costs. Together these can turn a loss making railway line into a viable tramway.

The Ryde – Shanklin Railway survives on a elderly London Underground Rolling stock, presently 1938 tube trains. These could

be replaced by District Line D stock which has been replaced and remains in store seeking alternative use.

Conversion to tramway would simplify operations and allow economical extension to at least Newport and Cowes, with perhaps a later extension to Yarmouth. Added to this new tram stops can be built economically to serve places that the railway presently misses.This would greatly increase the utility of the rail network and help with the movement both of residents and visitors. Electric operation from renewable generation would further contribute to a reduction of CO_2 and toxic pollution emissions.

A proposal to investigate this was made formally to the County Council but produced no response. ‘Tramification’ would increase ridership by offering a rail service to a bigger market, reduce local traffic and also operating costs.

8.0 Conclusions

Tram Power Ltd has seriously considered the criticisms of the National Audit Office Report on Tramways. The problems faced by tramway promoters have also been analysed. Trampower has developed, tested and proven technologies that address many of these issues. Whilst tramway promotion remains a public sector monopoly, it is virtually impossible to get new ideas, technology or equipment accepted, which can reduce costs, speed implementation or reduce construction disruption. This is due to public project procurement process requiring three previous contracts.

For these reasons Trampower is involved in several active privately promoted tramway projects. Private funding will provide contracts and meet the public sector three previous contract requirement. New Trampower products adopted for these private projects can therefore show three previous applications. This will allow Trampower innovations to qualify for new publicly funded tramways and help to reduce the costs to the levels required by “Green Light for Light Rail”.

Lower costs will help get more tramways built with the limited public funds available. A combination of publicly and privately promoted schemes will help Britain to reach the level of service currently enjoyed by other countries in Europe. Tramways attract trips from cars, so reduce traffic congestion and toxic air pollution to safer health levels. Finally tramways provide stability and confidence for investors to develop property alongside new tramways.

8.1 Street tracks

The most serious issues have been tackled in turn, starting with street track, which using 19th century designs based on girder rails requires deep foundations and the relocation of under street utility equipment. Excavating the road to achieve this is disruptive, costly and time consuming. LR55 track was developed and tested by Trampower to exploit the strength of roads, capable of carrying 44tonne HGV's with 10.5tonne axle loads.

LR55 does this by needing only a shallow recess in the road surface, and a minimum of utility relocation works, as access between rails is always available. LR55 track will self-support over 1m wide trenches.

Sample LR55 beam and rail,

LR55 installed in a road

Further the long and stiff foundation beams obviate the need for tie bars, as the mass of the road structure is well able to resist the small lateral curving tram forces, compared to the much larger vertical forces into the road.

8.2 Tramcars

In comparison to the purchase price of a bus, trams are 10 times more expensive. The reason for buses having a lower cost than trams is that buses benefit from sharing mass produced components with the truck industry. Internationally ten times more buses than all passenger rail vehicles are built. Trams are made in very small quantities and bespoke.

The City Class tram developed by Trampower uses mass produced components off the shelf (COTS) from a variety of industries. Trampower has created and proven the interfaces to be able to use them in the environment of the rail industry.

Slave tram being fitted out at the Carnforth Depot.

The City Class tram has progressed from drawing board, through laboratory and bench testing to a mock up for public opinion and market research, a slave tram to test the hardware, and then a prototype trialled in Blackpool. Finally a Demonstration tram has been built which has operated and carried passengers in Birkenhead, and run in Blackpool. The City Class tram has the lowest energy consumption on the market of 1kWh per km operated, less than a quarter of competitors. These energy savings will pay for the purchase of trams in about 10 years of operations.

Mock up on display in Edinburgh

Low energy consumption has been achieved by learning from non rail based industries, where energy consumption is critical. The City Class tram is also less than half the weight of others on the market, but robust and able to carry 200 passengers in the 29m long version. It can also climb 10% gradients, and can out accelerate other trams. Braking is entirely by regeneration and recovered electricity can be fed back to the grid to power nearby trams, or used on board for heating or cooling.

Prototype running in Blackpool

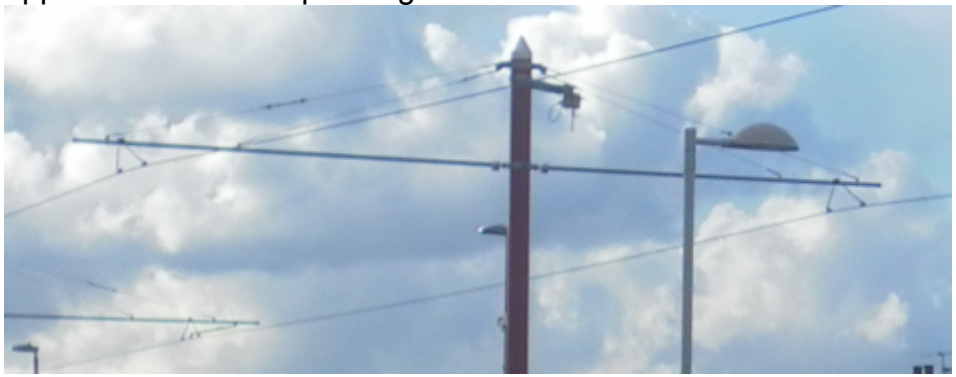
The feedback received from passengers and operating staff has been very positive, with low internal noise and smooth, jerk free riding.

Demonstrator in St. Helens Depot.

The Demonstrator is presently configured as a low floor tram (300mm above track). Variations of design include; stretching to 38m (300passengers), or a high floor for use on railway branch lines converted to tramway operation.

8.3 Power supply

One further technical product Trampower offers is a low impact over head simplified catenary. This provides the power for trams economically and with a small visual profile. Indeed with building mounted supports, no special poles are needed, further reducing costs and street clutter. This system has been in place at the Carnforth Railway centre since 2004, and has been used on the recent Manchester Metrolink extension to Ashton. A patent application on this is pending.



8.4 Project evaluation

One of the major criticisms of tramways reviewed by the National Audit Office was the under estimate of capital costs and the over estimate of passenger revenue. For this reason, the Trampower software package enables possible tramways to be quickly evaluated, not just for the CAPEX but also for the OPEX and passenger revenue, giving an IRR and IRR senstivity. This indicates if a tram line is potentially financially viable. This can also be used for a series of single or stand alone lines, or a complete network.

The Software can be used for a sensitivity analysis, both to determine the range of outputs but also to identify the key inputs that require the most effort to ensure accuracy. The table shows an example of the impact of different fares on tram patronage and revenue.

Av.Tram Fare (£)	Patronage m pa.	Revenue £m pa.
0	6	0
1	5	5
2	4.5	9
3	4	12

Compared to the quality of service, fares have a low elasticity. This means that provided an operator can maintain a reliable, frequent and speedy service, there is considerable scope for market pricing fares, as do low cost airlines, to maximise the revenue and so make privately fundable tramways financially viable.

Working with Local Authorities, tramway promoters can help to achieve local planning goals, e.g. reducing the volume of traffic and congestion, as well as the need for parking in areas with high land values. Reducing traffic volumes will also reduce the level of toxic air pollution so meeting international standards, and so help the NHS fulfil its remit of keeping the population healthy, at an economic cost.

Tramways are shown to raise land values, and therefore the local tax revenues available to urban Councils. Added to this, is the economic driver for developers seeking investment opportunities by increasing density, with fewer car parking spaces, thanks to the availability of a frequent and high capacity quality tram service, as car users are willing to travel by tram.