ALR GROUP

Memo

From: Auckland Light Rail Group
Date: 13 September 2021
Re: Trackless Tram Overview

1. Purpose

The long list assessment process for the City Centre to Māngere (CC2M) project allowed for both a Mode and Route assessment. The option selection process eliminated Trackless Tram from progressing to the short list for the CC2M corridor. The assessment of the modes against the investment objectives and impacts criteria concluded that the Light Rail Transit (LRT) and Metro Rail modes will proceed to the Short List assessment.

This note documents the relative opportunities and risks associated with a Trackless Tram solution when compared to a street running light rail solution and the reasons why this solution did not progress to the short list for the CC2M corridor.

Based on the information presented in this note it concludes that:

- The risks and limitations outweigh the potential benefits and the Trackless Tram mode has therefore been excluded from the further analysis through the short list process.
- The key limitation of the trackless tram solution is that it is not able to meet the expected demand, leaving customers behind during peak periods and requiring those in the vehicle to experience crush load conditions over significant portions of the corridor.
- Its axle loads also require significant pavement construction along this entire corridor as the arterials and streets within the CC2M corridor were not designed for overweight vehicles. The potential to implement a rapid transit solution with minimal disruption to adjacent landowners and businesses will therefore not materialise.
- The solution also requires a slightly wider corridor when compared to light rail that creates additional impact on landowners.

2. What is a Trackless Tram?

Trackless tram is an innovation that enables large public transit vehicles with light rail like characteristics to operate on public roads without the need for a fixed guidance (e.g. rails) to be installed to guide them along the route.

There are a small number of suppliers developing trackless trams (and high capacity buses) and whilst many use emerging technologies, they all broadly have similar characteristics for comparison to light rail alternatives. Various versions of trackless trams have been trialled in many locations over several years. One of the most recent approaches to trackless trams, also known as ART, caught the attention of the international transport community when it was unveiled in Zhuzhou by China Railway Rolling Stock Corporation (CRRC) in 2017 (as shown in Figure 1). This memo uses the ART as a proxy for other trackless tram solutions in terms of comparing the mode against light rail alternatives.

The articulated vehicle is bi-directional (it has a driver cabin at each end) and comprises three sections. The intention is for the ART 'train' to be configured in several different ways – 2,3,4 and 5 car sets. However, to date the only ART configuration that has been developed (and tested) is the 3-module version.

With three carriages, the train is 31.7m long, 3.2m high and 2.65m wide and has a total weight of 51 tonnes.

It has a maximum speed of 70 km/h and has a low-floor layout to facilitate accessibility. Figure 1 below summarises the key parameters associated with a three module tram.

3-modular vehicle	
Length	31.64 m
Width	2.65 m
Full load	51 ton
max capacity	307 persons
max speed	70km/h
Max gradient of route	10%
Min turning radius	15m
Floor height	100% low-floor
Vehicle sets	=Mc1+T+Mc2=

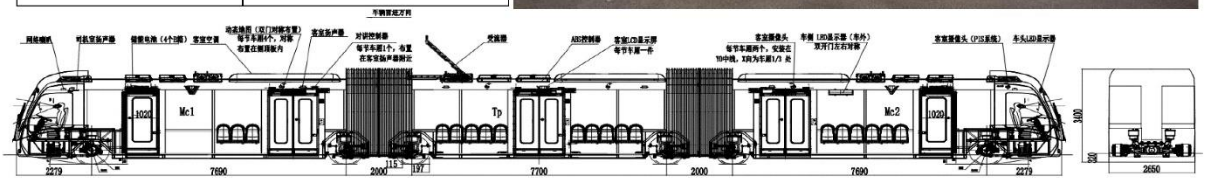

Figure 1: ART tram parameters (source CRRC Zhuzhou Institute)

3. Capacity of the 3 car system

The 32 m long ART 'tram' is fitted with 33 seats. CRRC lists the total passenger capacity (seating plus standing) at 307 passengers per 32m long ART. This assumes a density of 8 people per m^2 for the standing area. In Australasia it is more common to use an acceptable density of 4 people per m^2.

Using 33 seats and a standing density of 4 pax/m^2 indicates a capacity of 170 passengers per 32m ART.

The ART has less floor space available than a conventional LRT vehicle primarily due to the space taken up by traction equipment behind each cab that reduces the available passenger saloon length by 2 metres.

It should be noted that the interior is customisable, and the number of seats can be altered. However, a larger number of seats will reduce the standing area and decrease the overall person capacity of the 32m long ART tram.

Figure 2 illustrates the layout of the prototype vehicle in Zhuzhou.

Figure 2: Interior layout (source AT study tour)

4. Commercial operations

Since its unveiling in Zhuzhou the trackless tram system commenced commercial operations in June 2019 in Yibin, China. Services on the 17.7km Yibin T1 line runs 32m long vehicles every 10 minutes during the peak, with inter peak services operating at 20 minute headway. During the peak hour it carries 900 passengers with daily patronage of approximately 15,000.

Commercial services are also scheduled for opening in Zhuzhou during 2021. This will operate along a 7.1km route. Several systems are also under construction. These are all located in China and include:

- A 19.2km line in Harbin
- A further 14km expansion of the Zhuzhou line
- A 5km line in Wujang
- Further expansions to the Yibin line through the provision of 23km T2 line and 10km T4 line
- Two lines in Changsha. The 9.6km Dakecheng and the 17.3km Shifu line.

Figure 3: Trackless Tram in the city of Zhuzhou (source CRRC)

5. Potential benefits of the Trackless Tram system

The main benefit of the Trackless Tram is its potential to reduce infrastructure cost associated with the installation of the system when compared to a conventional steel track light rail system.

The rubber tyre operations allow for designs that utilise existing pavements without the need to install tracks associated with conventional light rail. This has the potential to reduce construction times (and less disruption to business and landowners along the corridor).

The rubber tyre operation also allows the Trackless Tram to navigate steeper grades (10%) and this brings the potential to remove expensive grade correcting infrastructure associated with light rail. Specific benefits along the CC2M corridor could be the potential to remove the K Road underpass, and to use the shoulders along the existing SH20 motorway bridge over the Manukau Harbour – negating the need for a new bridge across the Manukau Harbour.

A further benefit of the rubber tyre system is that it allows trams to veer off the 'virtual track' onto conventional pavement to avoid any temporary obstruction within its path. This enhances its ability to respond to incidents over conventional light rail.

One trackless tram can carry roughly the same amount of people transported through two double decker buses. It therefore has the potential to reduce operational costs associated with drivers.

The low floor, multi door operation also allows for enhanced boarding and alighting over double decker buses. Like light rail, stops can be located both at kerbside and within the median (central platforms) to allow for flexibility in the design of the corridor.

6. Risks and limitations associated with Trackless Tram system

There are several limitations and key risks associated with a trackless tram solution within the CC2M corridor. Some of these negate the potential benefits.

6.1 Unproven technology in high demand corridors:

The limited number (one) and relative short timeframe (2 years) of revenue generating services do not allow for comprehensive assessment of the actual whole of life costs associated with the operation of trackless tram services.

The Yibin service currently in operation is only running at a 10 minute headway with approximately 900 people per hour patronage in the peak and 15,000 per day. The CC2M corridor is forecast to carry significantly more patronage. The peak demand is forecast at 4,500 people per hour - almost 5 times what Yibin is carrying. Daily boardings on CC2M is forecast to reach 65,000 by 2051.

There is currently no example of a trial or revenue service that allow for two 3 module sets to operate together – to form a 62m long tram train.

6.2 Pavement construction:

The 3-module tram has a total weight of 51 tonnes and 6 axles.

The driven bogie has an axle load of 9t/axle, and non-driven bogies 8.5t/axle. Figure 4 below illustrates axle loading for the bogies.

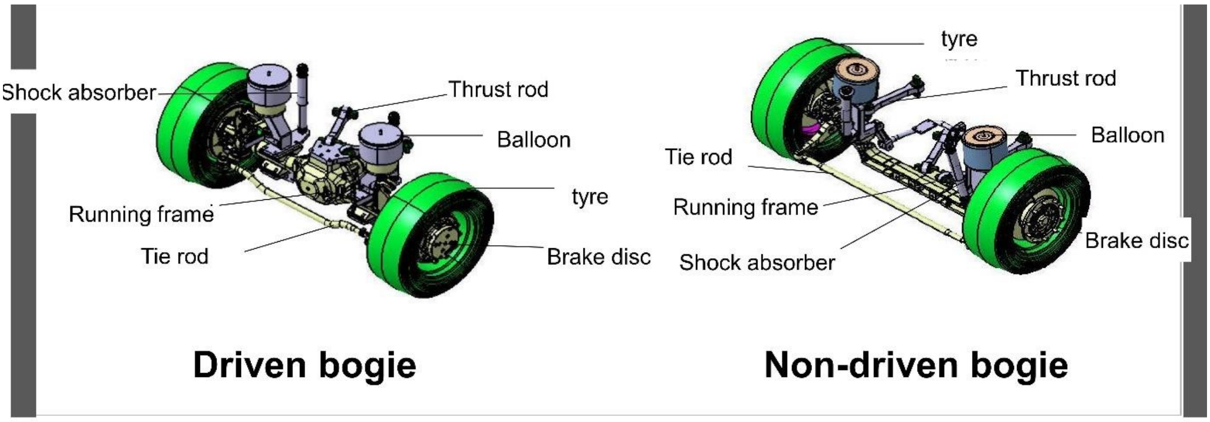

Figure 4: Axle loading (Source CRRC)

The 32m car tram will exceed the total mass and axle load as set in the *Land Transport Rule - Vehicle Dimensions and Mass 2016 - Rule 41001/201*. The maximum mass on a single axle with standard tyres is 6 tonnes, and a single axle with large tyres is 7.2 tonnes. Both the driven and non-driven bogies exceed the maximum axle load.

The ART tram will therefore not be able to run on existing pavements without the need for significant strengthening. This is typically in the form of pavement reconstruction, and therefore the system will still incur costs and property disruption associated with the reconstruction of pavements along the entire length of the route.

6.3 Additional land requirements:

The required lane width (on a straight) for the trackless tram is 3.75m compared with 3.4m for LRT lanes. The wider footprint is required as the guidance system is not mature enough to reliably keep the trackless tram from keeping to a narrower corridor width, and to enable flexibility in driver operation without a guidance system in operation. The required width is 250mm wider than our standard 3.5m lanes.

The trackless tram solution will require additional land purchase along the corridor when compared to the standard light rail solution. A further 0.7m strip of land purchase will be required along the corridor to provide the same level of service to pedestrians and cyclists along the corridor. Figure 5 below illustrates the difference in corridor requirements.

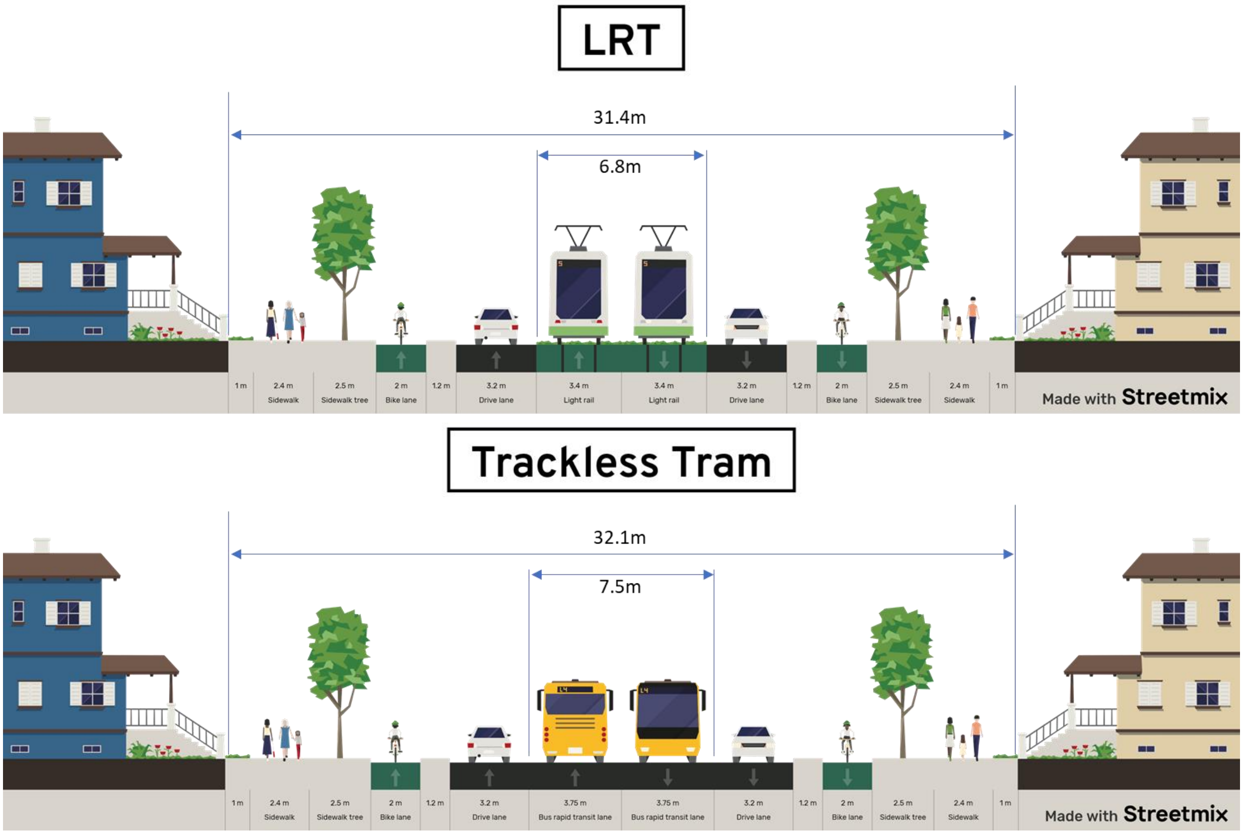

Figure 5 Cross section comparison

6.4 Slower journey times

The Trackless Tram and conventional LRT have similar floor height and can therefore operate from similar stop infrastructure.

The 32m ART vehicle has 3 double doors and 2 single doors per side. The single doors are designed for driver access even though they are situated in the passenger compartment. The ART trackless tram system has been tested and deployed using only a 32m long module, with all boarding and alighting occurring through 3 double doors.

Conventional light rail is expected to provide 66m long vehicles and will provide double the door space to enable quicker egress for reduced dwell times, especially at high boarding and alighting stops in the city centre.

The overall dwell times for light rail along the route amounts to 558 seconds. A potential 30% increase in dwell time associated with less doors on the trackless tram system will therefore add 167 seconds (~3 minutes) to the overall journey between the airport and Wynyard Quarter.

Trackless tram is specified with a top speed of 70 km/h compared to light rail's 80 km/h. The slower inter-stop speed will further increase overall journey times compared to light rail.

6.5 Capacity and customer experience

Trackless Tram provides a total capacity of 170 passengers per 3 car unit (33 seated and 137 standing). The available capacity for standing passengers is based on an acceptable density of 4 people per m^2.

Conventional light rail, using the same acceptable density of 4 people per m^2, would enable a capacity of 210 passengers per 33m long unit (64 seated and 146 standing). It is common practice to couple two light rail cars together, forming a 66m long unit. This arrangement enables total passenger capacity of 420 passengers (128 seated and 292 standing).

Demand modelling completed for a light rail option using either Sandringham Road or Dominion Road shows progressive build up of demand to reach its peak of approximately 7,550 passengers over the 2 hour morning peak as it enters the central city.

The trackless tram solution would enable a capacity of 5,100 passengers of the 2 hour morning peak using the same headway assumed for the light rail option.

Matching the trackless tram's capacity with the light rail demand profile along the CC2M corridor shows the system (running from the airport to the city) will be fully occupied by the time it reaches the Mt Roskill area. What this means is that, in peak times, a trackless tram system will have every seat filled and passengers standing for the 38 minute trip from Māngere and be so full as to leave passengers behind along the entire central isthmus corridor. The passenger demand exceeds the available capacity by a factor of 1.48.

The capacity on the trackless tram system can be increased by allowing a more frequent service pattern. A 3 minute headway is possible without bunching of the services and compromising bus and traffic volumes crossing the corridors.

The 3 minute headway will increase the total 2 hour capacity to 6,800 passengers. The capacity is however still not enough to satisfy the forecast demand, with demand exceeding the capacity by a factor of 1.11.

The modelling done for the light metro option shows even higher demand exists in the corridor, and patronage will respond if the system becomes more competitive with current forms of travel. The light metro option modelling shows a progressive build up of demand that reach a peak of approximately 13,000 as it enters the central city.

Matching the trackless tram's capacity with the light metro demand profile along the CC2M corridor shows the system (running from the airport to the city) will be fully occupied by the time it reaches the Onehunga area, and unable to collect any more passengers.

6.6 Limitations with similar systems

The limitations of systems similar to the trackless trams are also documented in a range of overseas examples including[1]:

- *Wright Streetcars were developed specifically to mimic trams with a separated driver compartment, high frequencies and dedicated stops. They were deployed in York, UK in 2006 and Las Vegas in 2008. The application of the technology into the American context has been challenging due to environmental conditions (desert) which reduces the reliability of the optical sensing technology with flow on impacts to timetabling and maintenance. This technology is being retired early due to reliability issues and availability of parts.*
- *Phileas operates in Eindhoven in the Netherlands. It has an advanced onboard electromagnetic rechargeable battery and drives on a protected bus lane, following a pre-programmed route defined by magnets built into the road at approximately 4m spacing. There were issues with the navigation system and this ultimately led to the regional authority (SRE) retiring the navigation system from use.*
- *In 2001, about 60% of the Nancy (France) tramway system operated as guided rail, the remaining 40% (11.1km line) an unguided rubber tyre trolleybus system. The line will be closed and replaced by a conventional low floor tram in early 2023, with conversion work spanning from 2020 to 2022. The system had problems with derailing vehicles, as well as heavy wear and tear of the pavement. Ride quality is also said to be poor and is not much of an improvement over a standard bus due to the four wheeled design.*
- *Caen (France) installed an electrically powered guided bus (trackless tram) system in 2002 along two routes, on a 15.7km network. The system was plagued with faults, due to design and operation, including a fatality occurring due to the vehicle being restricted to its guiding rail and unable to grip/brake in time.*

[1] The Renaissance of Light Rail, Research Paper, Australasian Railway Association, Section 2.1.3 (April 2021)

7. Impact on investment objectives and outcomes sought

The project benefits and investment outcomes are summarised in Figure 8 below.

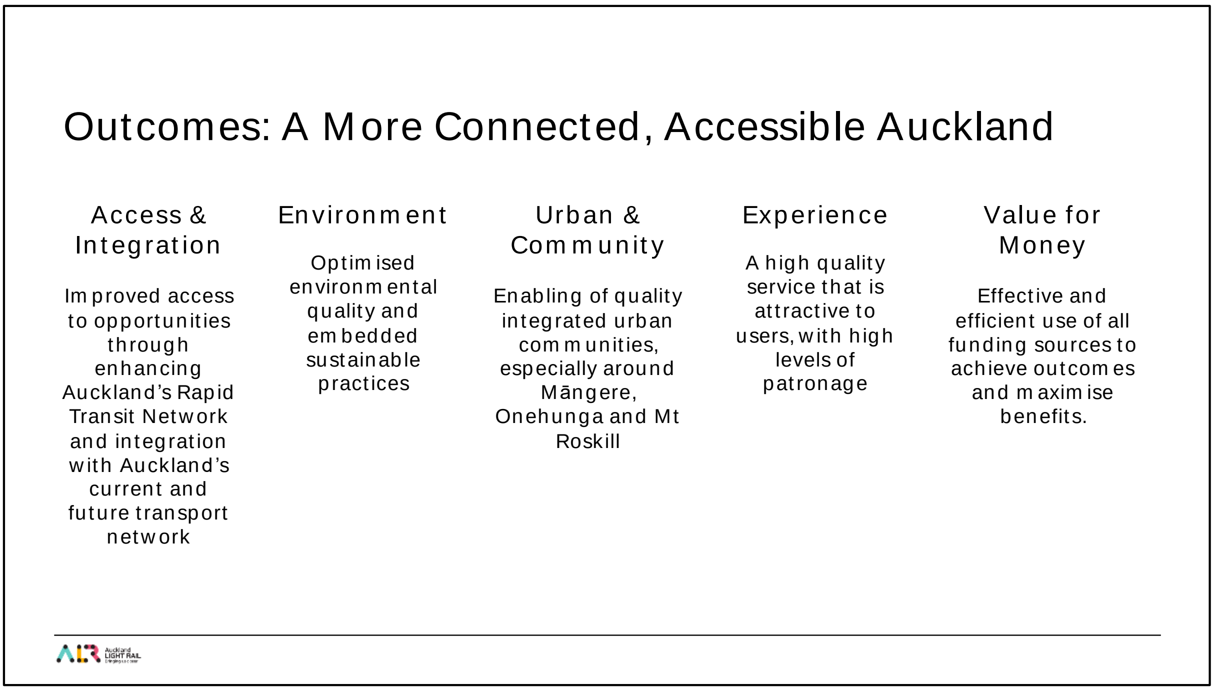

Figure 6: Auckland light rail - Outcomes

The risks and imitations associated with trackless tram noted above have the following impacts on the benefits sought from the light rail investment.

- Increased transport capacity: The trackless tram system will not be able to provide adequate capacity to meet forecast demand. The capacity constraints will impact the ability for intensification along the corridor.
- Reduced travel times: The trackless tram and associated corridor investment have the potential to reduce vehicle journey times for passengers when compared to current bus options. Some of this travel time benefit will be negated by the additional wait times on platforms due to inadequate capacity.
- Increased access to development zones: The limitation in capacity will restrict the public transport accessibility to employment areas during the peak periods with less people able to complete the journey via public transport.
- Increased community wellbeing: The Trackless Tram solution will significantly disadvantage customers boarding the system in Māngere and heading towards the city centre. These customers will have to stand for approximately 38 minutes due to the lack of available seat space. This will make accessing opportunities in the central city less attractive from locations south of the Manukau Harbour.
- Reduced emissions: The zero tailpipe emissions associated with trackless tram will reduce harmful effects linked to emissions. However, the unmet demand will limit the possibility to which this can occur in the corridor.

8. Conclusion

In summary, the risks and limitations listed above outweigh the potential benefits and the Trackless Tram mode has therefore been excluded from further analysis through the short list process.

The key limitation of the trackless tram solution is that it is not able to meet the expected demand, leaving customers behind during peak periods and requiring those in the vehicle to experience crush load conditions over significant portions of the corridor.

Its axle loads also require significant pavement construction along this entire corridor as the roads were not designed for overweight vehicles. The potential to implement a rapid transit solution with minimal disruption to adjacent landowners and businesses will therefore not materialise.

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