Trackless Trams and Transit Activated Corridors in Perth

Mid-Tier Transit and Urban Regeneration

CORE REPORT

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SBEnrc 1.62 Sustainable Centres of Tomorrow: People and Place

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This research would not have been possible without the ongoing support of our core industry, government and research partners:

Contents

1 INTRODUCTION

1.1 Purpose of this Report

This report presents the finding of the Perth Case Study of the SBEnrc 1.62 project referred to as Sustainable Centres of Tomorrow: People and Place. This part of the Report – called the Core – contains all the detailed background. The Overview Report sets out a short version for use by stakeholders and decision-makers. It goes beyond the detail in this report by showing a potential expansion of Trackless Trams and Transit Activated Corridors into the whole of Perth. It is presented as a post-Covid Recovery proposal.

This study seeks to establish the case for mid-tier transit[1] in Perth and to illustrate the potential city shaping and redevelopment opportunities that this could present. The study has focused on a particular suite of new mid- tier transit technologies referred to as trackless tram systems (TTS). These new electric technologies have emerged and offer a high standard of service that is more readily implementable and at a lower cost than traditional light rail solutions; at the same time they are significantly better than bus services and hence are likely to help with urban regeneration not just transport outcomes.

This Case Study has been supported by the 'Perth Consortium' - made up of Curtin University, City of Canning, Town of Victoria Park, City of Perth, and City of Stirling. This consortium has commissioned the investigations as part of their commitment to achieve their planning and development outcomes, which are focused on increasing liveability, vitality and urban renewal. These Councils and the University are part of the inner ring of the Perth metropolitan area, which is committed to meeting increased urban density targets as part of the central sub-region[2]. At present these urban renewal priorities are not integrated with any program for delivery of transit systems that could unlock the potential of the centres and corridors within this region.

The bulk of this study has been undertaken in a different economic and social context pre the Covid 19 world crisis. The need to plan for a more resilient and sustainable urban environment is now more crucial and innovations in transit, communications and energy technologies are being adopted more rapidly in response. There will likely be a trend and need to re-localise (more people working from home and having goods and services delivered, more local services and open space within walking distance or micro-mobility distance). This will provide a more efficient utilisation of resources be it human, built infrastructure or economic and help to address financial constraints as we transition to an altered model of urban living.

1.2 About this Report

The report has 5 more sections, which cover the following areas of the study process:

- Section 2 presents a context and background to the study process, highlighting the links to related bodies of work,
- Section 3 considers the Perth strategic context and our readiness for mid-tier transit,
- Section 4 outlines the drivers for changes, looks at the maturing of the technologies and how these are being applied elsewhere and the risks of being slow to respond,

[1] Mid-tier transit are traditionally light rail transit (LRT) and bus rapid transit (BRT) – here we are considering the option of the Trackless Tram System – which are electric, high capacity, have multiple wide doors and level boarding, these run in dedicated lanes with signal priority providing speed and ride quality.
[2] WAPC and Dept of PLH (2018) Perth and Peel @ 3.5 million

- Section 5 looks at the application of trackless trams as the option for mid-tier transit and draws on stakeholder perspectives and transport modelling to examine this integrated transport and housing system, and its application in Perth, and
- Section 6 documents what we have learnt from this study and proposes the next steps.

2 BACKGROUND

This section briefly places this project within the context of previous investigations, highlights the range of stakeholders who have been engaged and documents the study process.

2.1 Relationship to Previous and Associated Projects

The Sustainable Built Environment National Research Centre has supported research in this area for several years. Thus the project builds on other work, in particular it draws on experience gained in project 1.55 Integrated Cities: Procuring Transport Infrastructure through Integrating Transport, Land Use and Finance, which produced the report – 'Delivering Integrated Transit, Land Development and Finance: A Guide and Manual with application to Trackless Trams'[3]. In 2018 the Perth Consortium (made up 5 local authorities and Curtin University) came together to support investigations into the potential of Trackless Trams and funded the study 'Trackless Trams from Concept to Reality' which was done in parallel to the SBEnrc program (by consultants Marie Verschuer and Neville Binning). These two reports and with associated films and media attention, have attracted Australian and international attention and recognition[4].

This case study sits within the current SBEnrc project 1.62 – called Sustainable Centres of Tomorrow – which is focusing on how to create better connected and integrated centres using land development opportunities and how innovations in transit technology (such as trackless trams and associated innovations in local transport), housing and place-making, can be integrated into urban transformation projects, particularly those that can include affordable and public housing.

Further, this case study project sits alongside three other case studies which are evaluating similar opportunities, all in different urban contexts, including:

- Wyndham City – an outer Melbourne Local Government area facing growth management challenges,
- City of Liverpool – seeking to optimise the linkages between its City Centre and the new Western Sydney Airport, and
- Townsville – a regional City in Queensland seeking to establish stronger links between its City centre and its University and health precincts.

Collectively, this case study and those highlighted above, illustrate the opportunity provided by new forms of mid-tier transit – in this case the trackless tram – which is part of a coalescence of advancements of transport technologies, communications and energy systems. The technology appears to present not only a series of good transport opportunities along main roads through its capacity and 'last mile' integration, but it provides a unique ***opportunity to achieve the city shaping transformational change*** required to meet the needs of our cities. In particular there is a serious need to help solve the problem of the 'missing middle' – the redevelopment opportunities of middle suburbs where the development model of infill has failed and a new more integrated precinct-scale solution is needed. The primary way that the city shaping will occur in this new model is along Transit Activated Corridors – as summarised in Box 1.

[3] See Project webpage: http://sbenrc.com.au/research-programs/1-55/

[4] The links to films and publications since the two reports are:
https://www.facebook.com/greenpeace.international/videos/357699401718122/
https://theconversation.com/why-trackless-trams-are-ready-to-replace-light-rail-103690
https://research.curtin.edu.au/story/could-trackless-trams-replace-light-rail/
https://www.createdigital.org.au/trackless-trams-solve-light-rail-problems/?utm_source=ExactTarget&utm_medium=email&utm_campaign=EDM-20190319

Box 1. CORRIDORS, NODES and PLACES associated with TRANSIT ACTIVATED CORRIDORS for TRACKLESS TRAMS

Transit Activated Corridors are main roads that attract urban development through providing a strong mid-tier transit focus and therefore can enable significant development around new station precincts. A key part of the planning and design of Transit Activated Corridors is the establishment of **Corridors, Nodes and Places** that are needed for any city or local area that is wanting to introduce a mid-tier transit system such as Trackless Tram System (TTS) involving local urban regeneration. The **Corridors** are the big scale overview that shows where a transit system is best located to provide a good transport solution and where some good urban regeneration potential exists. The **Nodes** are where the most obvious urban regeneration exists and hence should likely be where a station is placed. The **Places** are where detailed design will optimise the integration of the TTS to a range of accessibility and sustainability outcomes. These terms are used frequently today to help establish Movement and Place Strategies in cities following similar work in the UK and Europe.

2.2 Key Stakeholders

As part of the project the study team and the Consortium partners undertook various briefings and workshop processes with a whole range of stakeholders including, representatives from:

- Existing transit / bus network operators (including Keolis Downer, Swan Transit, Transdev, Comfort Delgro)
- Public Transport Authority
- Department of Transport
- Department of Planning, Land and Heritage
- Development WA
- Department of Communities
- Western Australian Planning Commission
- Property Council
- Main Road WA
- Western Power
- Western Australian Local Government Association

The value of this wide engagement process has been that it has built awareness of the investigation process, identified some of the system wide challenges and identified the associated land development opportunities and city shaping potential of implementing a mid-tier of public transport in the Perth central sub region.

2.3 Study Process

The study process for this project has been linked into a wider investigation agenda about the city shaping potential of the Trackless Trams (summarised in Appendix 1). Key elements of that wider process as they relate to this project along with key parts of this study process are summarised below.

2.3.1 Wider Study Process

The key study elements from the wider process have been:

- **A literature review** as part of the Core SBEnrc 1.62 project – which presents a framework of core principles and practices that can be used to help create the best outcomes from the

regenerating centres and corridors around transit systems. This includes seven core principles and twenty-one associated core practices to ensure urban design and infrastructure development priorities are addressed. These principles (Table 2.1) and core practices (Appendix 2) have been used to inform the various workshops held for all the case studies. (See SBEnrc 1.62 – Sustainable Centres of Tomorrow: A Precinct Design Framework of Principles and Practices - Report https://sbenrc.com.au/research-programs/1-62/).

Core Principles	Core Practices
1. Precinct safety and accessibility The development should be safe and healthy for people waiting to access transport nodes	▪ Human centred design ▪ Walkable urban design ▪ Place and movement design
2. Carbon neutral - positive approach The development should aim for carbon positive, being at least zero carbon, in both power and transport	▪ Solar passive design ▪ Solar active design ▪ Carbon neutral analysis
3. Local shared mobility The development should encourage diverse local modal services to access the transit service, with defined spaces	▪ Local mobility design ▪ Feeder transport design ▪ Mobility as a service
4. Property diversity The density and urban mix should contribute to urban regeneration	▪ Community engaged planning ▪ Agglomeration economy analysis ▪ Financial modelling
5. Property affordability The development should include diverse property options to provide affordable living as well as affordable housing	▪ Social housing analysis ▪ Life cycle assessment ▪ Sustainability operational analysis
6. Nature-loving and biodiverse spaces The development should include and connect biophilic and biodiverse greenspaces, supporting endemic species and habitat	▪ Biophilic design ▪ Water sensitive design ▪ Landscape oriented design
7. Inclusive, integrated, place-based planning Planning, design and implementation (operation, maintenance) should involve diverse stakeholders and all tiers of government to provide an integrated place-based approach.	▪ Joined up governance analysis ▪ Partnership analysis ▪ Procurement options analysis

Table 2.1: Framework for Regenerating Urban Centres and Corridors with core design/planning practices [Source: (Caldera et al., 2019)]

- **Study Tour** - This was conducted June 2019 to China and Europe and it involved industry specialists and case study partner representatives and provided an opportunity to experience, view and evaluate the current and emerging global technologies in electric public transit systems, inclusive of trackless trams as well as seeing the latest approaches in transit oriented development in Europe – (See SBEnrc 1.62 - Public Transport Technical Tour – Summary Report https://sbenrc.com.au/research-programs/1-62/).

- **Preparation of a Frequently Asked Questions report** – which compiles the most frequently asked questions for those interested in Trackless Trams to better understand the advantages

and limitation of the technology and the areas where further research is needed. Information has been sourced from manufacturers, literature review and from study tours conducted in 2018 and 2019 to view and evaluate the emergent and latest technology suited to the provision of mid-tier prioritised public transit. (See SBE 1.62– Frequently Asked Questions and Myths of Trackless Trams … https://sbenrc.com.au/research-programs/1-62/).

2.3.2 Perth Case Study Process

This body of work has provided the background and insights within which this case study has been developed. The steps in this case study investigation included:

1. **Consortium and Stakeholder Risk Workshop**. Following on from the report 'Trackless Trams – Concept to Reality', a risk workshop was undertaken in January 2019 to bring consortium members and stakeholders together to explore the findings of that Report and identify and assess strategic risks and opportunities associated with conducting a trackless tram trial in Perth. This workshop highlighted the potential and implementation challenges of moving from concept to reality – focusing mainly on:
    - The need for collective leadership in the form of a resourced and structured body to take ownership and responsibility to take the ideas forward
    - The importance of an ongoing process to engage and appropriately manage the diversity of views of stakeholders
    - The risk of the loss of opportunity of not moving forward for Perth to take a lead on trialling and testing these forms of mid-tier transport systems as part of a wider culture of innovation.

    This workshop formed an important input into the thinking behind this study, highlighting the value of the Consortium's role in continuing to develop the concept and rationale for introducing mid-tier transit systems and how they could help with urban regeneration in a new and helpful way.

2. **Consortium and Stakeholder Workshop.** This was called the Scarborough to Cannington Transit Activated Corridor and was held in October 2019 with the aim of identifying opportunities to unlock the redevelopment potential in the inner/ middle ring of Perth with transit activated corridors (TACs). The workshop aimed to:
    - Define a wider network and Movement as a Service (MaaS) opportunities and integrated redevelopment opportunities,
    - Identify a number of 'preferred routes' for a transit activated corridor from Cannington to Scarborough, and
    - Establish route scenarios for a SNAMUTS assessment (see point 3 below).

    This workshop was attended by approximately 50 representatives of stakeholders highlighted in Section 2.3 along with the Consortium members. The workshop provided an opportunity for important insights to be shared from a state and local government perspective along with the property sector on the challenges and development opportunities. Participants were asked to consider ideas about the look and feel of a transit activated corridor in relation to corridors, nodes and place, and identify ideal transit solutions to support urban infill. While the primary purpose of the route identification process was directed to the primary route between Scarborough and Cannington, which was used as an input into the SNAMUTS analysis (see below), secondary routes were also identified and are documented in Appendix 3.
    The key perspectives coming from the various workshops are summarised in Section 5.1 below.

3. **Accessibility assessment using SNAMUTS.** This process utilises the Spatial Network Analysis for Multimodal Urban Transport Systems (SNAMUTS) tool[5] to quantify and visualise the added value of implementing a Trackless Tram corridor for metropolitan Perth's public transport system as a whole. The outputs of stakeholder workshop held in October 2019 served as inputs into the SNAMUTS tool providing alignment details and a set of assumptions around operational performance (commercial speed and frequencies), network integration/adjustments and interoperability of Trackless Trams with the existing public transport system was determined. This assessment allowed for projections to be made about urban intensification potential, identifying targets for additional residents and jobs in the catchment areas of the corridor and nodes along the routes. These development targets were derived on the basis of input from the Consortium members, based on their local knowledge and urban planning schemes. Various routes were analysed along with preliminary assessment of how bus routes might be reconfigured to provide an overall optimisation of the system. An initial assessment was undertaken and presented to consortium members in December 2019, before a final report was issued to members in early February 2020. A summary of this is provided in Section 5.2

4. **Implementation Challenges and Opportunities Assessment**. Following on from the SNAMUTS assessment of the various route options, a meeting was held with each of the Consortium partners to undertake a qualitative assessment of the routes in terms of a set of qualitative criteria which aimed to assess the implementation opportunities and challenges along the various parts of the route. This assessment has served to identify key potential urban renewal development opportunities, and the level of difficulty or ease within which implementing a trackless tram along the routes assessed would occur. A summary of the findings of this assessment is provided in Section 5.3.

[5] See www.snamuts.com for a detailed description of the SNAMUTS tool

3 PERTH STRATEGIC CONTEXT

3.1 Planning for Urban Growth in the Central Sub-Region

'The Perth and Peel regions are now going through a critical period of transition.…While Government, in conjunction with local government, will take the lead, effective implementation can only be achieved through a whole-of-community commitment.' Eric Lumsden Perth and Peel @ 3.5 million.

The urban transition referred to above is not confined to Perth alone but is impacting communities everywhere. Broader than urban development, the impacts of climate change, urbanisation and population growth are occurring at a time of rapid industrial change (Newman, 2020). The potential transformational change is becoming evident as more consumers take up advances in renewable energy, alternative forms of mobility and become more reliant on communication technology such as smart phones for everyday activities.

This section provides an overview of the local, state, national and international strategic and policy settings relevant to planning for future urban growth in the Perth central sub-region. It asks how are governments and regulators responding to the opportunities and threats of this environmental and technological future and what can this project do to assist, particularly how new technology can assist with the problem of the 'missing middle' in Perth's development.

3.1.1 Perth and Peel@3.5million

The WAPC document Perth and Peel@3.5million is a strategic document released in March 2018 that sets out growth targets and frameworks to define the urban form for the next 30 years.

The population of the combined regions of Perth and Peel is expected to increase by around 70 percent from 2.1 to 3.5 million people by 2050. Perth and Peel@3.5 million is a suite of land use planning and infrastructure frameworks comprising the Central, North West, North East and South Metropolitan Peel frameworks. These frameworks are designed to guide the creation of connected communities - where people want to live, work and socialise. Significantly, all frameworks advocate for a greater reliance on public transport to support the predicted growth.

The strategy encourages significantly greater infill development with almost half of the required 800,000 new homes (a minimum of 380,000) is to be built through infill development. The majority of these are within the Central sub-region which includes most of the 'missing middle' suburbs developed in the immediate post war period and now in need of redevelopment. This includes Perth Consortium's study area.

A survey commissioned by the WAPC in 2013 found that 67% of people prefer to live in the Central sub regions but more than half cannot do so due to lack of housing affordability. Perth and Peel@3.5million identifies the need to address this issue of how future infill growth will need to make much better use of existing infrastructure and amenities and promote increased density and diversity of mixed-use development in the middle suburbs. In particular, turning key transport corridors into multi-functional corridors is crucial in the development of a more compact city. Thus Transit Activated Corridors are a strategic solution to the major issue of Perth's planning.

3.2 Department of Transport – Perth and Peel@3.5million Transport Network Plan

Accompanying the Perth and Peel@3.5million land use planning documents is the Perth and Peel@3.5million Transport Network Plan. This document recognises the need to plan for a transport network that will drive urbanisation around infrastructure and enable high levels of accessibility for work, education and other activities.

The Transport Plan sets the strategic direction and together with a number of projects across the Transport Portfolio, aims to support efficient and effective movement of people and parcels integrated with land uses and linking key economic and employment opportunities. The Plan recognises and seeks to resolve the inevitable pressures that the projected significant population increase will place on all levels of existing road and rail networks across Perth and Peel. Outlined below are the key elements of that report which are of most relevance to the TAC.

3.3 Public Transport

Achieving the most efficient use of current and proposed transport networks, services and social infrastructure is a critical element of planning for this future population growth within a consolidated urban form. To accommodate future population growth and ensure efficiency of the transport system is not compromised, the sub-regional frameworks recognise the need to integrate urban and employment nodes with transport infrastructure and services, including upgrading and adding new transport infrastructure to the network.

The integration of key centres with high quality public transport networks is a fundamental principle and the State's focus has prioritised METRONET to support this transport objective and its vision to deliver sensitive, sustainable and vibrant communities. This strategic infrastructure investment linking centres and providing high capacity corridor transit will provide an opportunity for improved infill development along major north-south corridors but has not much link to the middle suburbs as it is mostly linking the far outer suburbs. These far outer suburbs have little redevelopment potential and not much medium density market.

The Transport Portfolio is working with the Western Australian Planning Commission (WAPC), through the Department of Planning, Lands and Heritage to deliver an integrated approach of land use planning and infrastructure provision to try and find a solution that enables redevelopment closer in to the central parts of Perth.

The map below (Figure 3.1 Priority Transit Route) shows the Central sub-region 2050 Public Transport Network. These priority routes coloured green on the map are potentially TACs. Many of these routes where identified by stakeholders at the Consortium and Stakeholder Workshop in October 2019. Although the map has not been confirmed as a major policy direction the Transport Network Plan has begun the process of focussing on how Main Roads corridors particularly those that go East-West, can be major targets for improved transit and improved urban regeneration. To do this requires a different strategic approach that has been developing in Europe and in other Australian jurisdictions called Place and Movement.

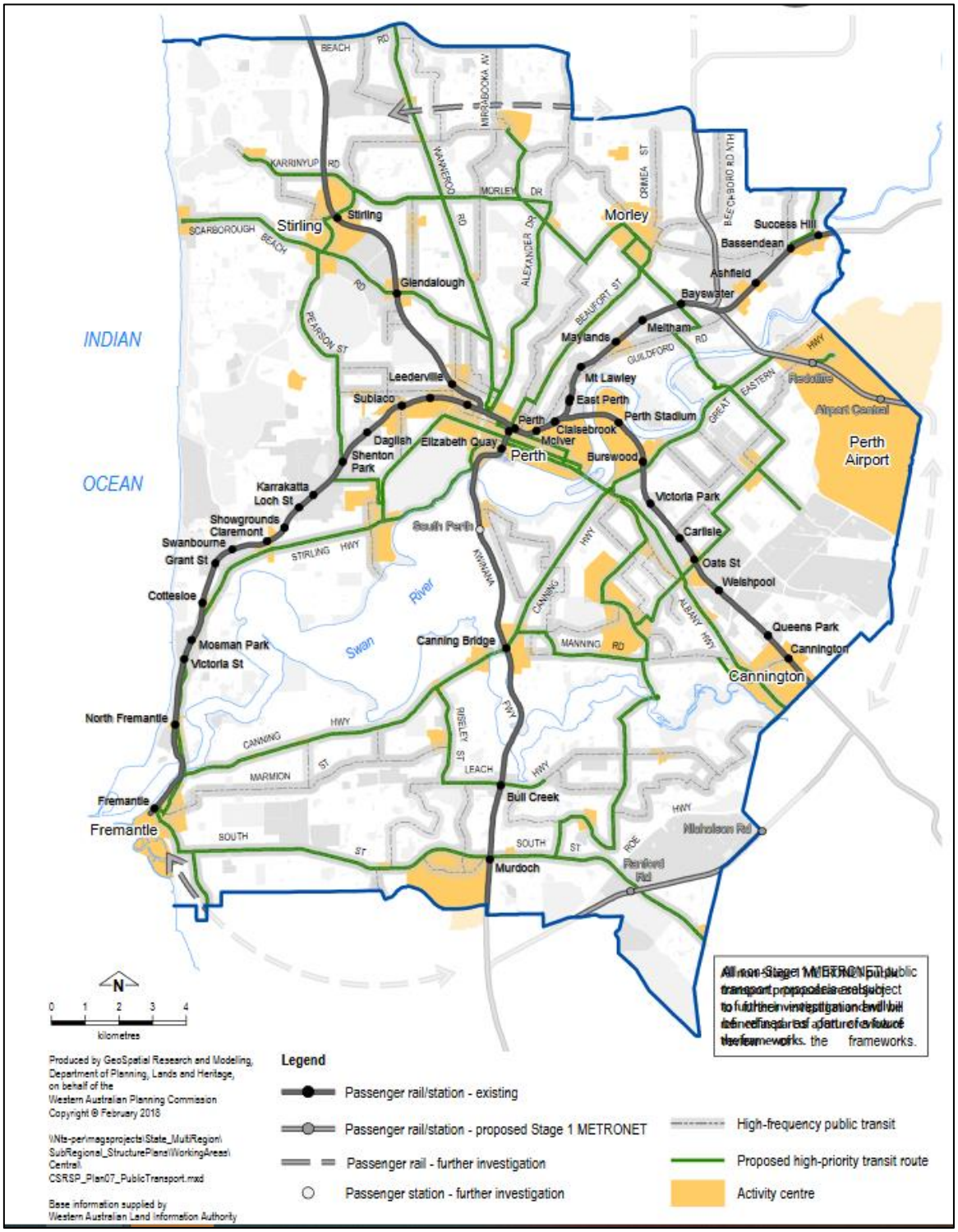

Figure 3.1 Priority Transit Routes Source: Perth and Peel@3.5million Transport Network Plan

3.4 Place & Movement Strategies & Transit Activated Corridors

The Department of Transport in 2020 has moved into the second stage of preparing a Place and Movement Strategy for Perth. Stage one undertaken in 2019 was a review of strategies elsewhere and how these are applicable in the Perth context. The second stage will involve cross sectoral and stakeholder engagement to assist with developing guidelines to help frame Perth's own strategy.

The idea of corridor priority for movement is well established as illustrated by various reports such as Austroads' 2017 research report, Prioritising On-Road Public Transport, and the PTA's Bus Planning and Design Guidelines for Efficient People Movement – all have identified that a whole of corridor approach is needed.

The guiding principle of our study is that of a Transit Activated Corridor (TAC) that incorporates place as well as movement and can be seen as a way of implementing a Place and Movement Strategy.

Since the introduction by Transport for London in 2013 of their policy called 'Street Families', a movement and places framework has gained traction worldwide. These frameworks recognise that streets are not only about moving people from A to B, but in many contexts also act as places for people and public life. The Movement and Place framework enables the 'place' prioritisation of streets to create walkable, liveable centres as well as how other streets can be primarily movement corridors where place is not as important. The TAC approach tries to integrate the two into one corridor by having a fast transit system along the corridor which slows down at stations and enhances place-oriented precincts where walkability is a high priority.

However, the delivery of such strategies remains limited still as they need much more integration with private sector urban development practices and funding/financing, an integration into new kinds of partnerships with all levels of government, an openness to a range of new transit technology and electric micro-mobility and a new way of bringing all this together in terms of multi-purpose governance. All of this goes beyond most transport policy and practice along main roads. It is the purpose of Study to inform the development of this new approach and promote a demonstration project that includes mid-tier transit together with active transit and micro-mobility and urban development in a demonstration Transit Activated Corridor.

3.5 Public Transport: Major Road Corridor Review 2018

In 2018 the PTA prepared a corridor review of 24 road corridors (Figure 3.2) within the metropolitan region, including roads under consideration in this study. The review identified bus priority opportunities to achieve the best public transport outcomes for Perth. This is a step towards enabling a TAC approach to future urban development.

The study found that many areas of the existing road network were congested or at capacity and that with the anticipated growth it is imperative that bus priority corridors be improved to enable the efficient movement of people and the provision of urban development that provides for goods and services into the future.

In 2019 the Public Transport Authority commenced engagement with local governments and stakeholders in response to the major corridor review. The following section outlines the relevance of why the review was undertaken.

3.5.1 Why the Review was Undertaken

Transperth bus services currently carry more than 55 per cent of the daily patronage (measured as trips, it is less when distances are included) across the Transperth public transport network. Transperth's bus network offers an important link to connect people to the train service as well.

Two significant independent investigations, (the Committee for Perth's 2016 report, Get a Move on! and The WA Auditor General's 2017 report, Planning and Management of Bus Services) identified the need for transit improvements to improve journey time and reliability to drive positive patronage growth and also asset performance and service affordability.

Figure 3.2 Transit Corridor Review, Source PTA

Buses offer the ability to efficiently move large volumes of people; however, this efficiency is diminishing as a direct result of buses having to share road corridors which are becoming increasingly congested with general traffic. This makes bus travel less convenient, slower, more costly and acts as a barrier for commuters to utilise public transport. The provision of bus transport is evolving with more countries adopting a network configuration supported by high priority corridors. These corridors lend themselves to a mid-tier transit system that provides improved network legibility, travel times, cost efficiency and improved levels of service in comfort, frequency and reliability.

Our research has identified that additional to the traffic priority measures identified in the review, the redesign of the service to provide a mid-tier transit network would also provide significant place and movement development opportunities and amenity.

Appendix 4 provides a summary of the Public Transport: Major Road Corridor Review 2018 report relevant to this study. It contains commentary, maps and performance tables for sections of the study route Scarborough to Canning. The relevance of this report to the Study is the action that is being already undertaken by the PTA and Department of Transport to improve road based public transit. This corridor report together with the Place and Movement planning are important first steps in the transition to a modern transit system and integrating a mid-tier transport.

3.6 Summary

'Sustainable growth requires a shift in our strategic land use planning approach and a readiness to explore and plan for new urban growth opportunities.' Perth and Peel @3.5 Million

The section above outlines the strategic context from agencies at the State and Local level responsible for urban development and the planning and provision of transport infrastructure. As stated in the context of urban growth a sustainable future requires a shift in how we currently do things, better utilising our existing assets, actively engaging with new technologies and planning for transformative change.

As confirmed by the Perth Consortium and State government and stakeholders in strategic documents and through engagement undertaken during this study, density targets within the central subregion cannot be realised without significant changes in urban mobility. A mode shift to public transport is considered an imperative and the adoption of innovative transit technologies provides a realistic, affordable and efficient opportunity for new urban mobility that will make a significantly improved opportunity to enable urban regeneration where it is clearly needed. There is recognition of the importance of priority corridors to improve transport efficiency and the work done has identified the need for improvement along all corridors that comprise the study area. This transport recognition now needs to be firmly integrated with the planning recognition of the need for better urban regeneration in the middle suburbs.

The concept of a TAC incorporating place, movement and investment with a collaborative delivery mechanism such as a City Deal potentially, offers the environment needed to meet the pressures of urbanisation and opportunities for utilising a new technology-driven transition.

4 DRIVERS OF CHANGE

"For the first time in a century, we have mobility technology that won't just incrementally improve the old system but can completely disrupt it... A total redesign of the surface transportation system with humans and community at the centre." Jim Hackett, Ford CEO[6]

This section focuses on presenting the key drivers that are ushering in a new agenda of how land use and transport should be considered and integrated from a planning, design and operational perspectives and the economic cost of being slow to respond to the changing social, environmental and technological environment.

The need for taking a new approach has come about because of the emergence of a complementary suite of innovations in technology and new business models have the potential to transform how people and goods move around our cities and will create an environment conducive to rapid social and economic change. Without a clear vision for our desired future and collaboration across all sectors of society there is a risk that the changes will further fuel the inequity already apparent in our rapidly urbanising communities. Additionally, there is a need and an opportunity to evaluate societal and infrastructure needs in light of the post Covid19 landscape where online shopping, working from home and re-localisation will likely change demands on our transport and land uses.

4.1 Responding to Climate Change – IPCC and Sustainable Development Goals

The Paris Agreement and the Sustainable Development Goals were both adopted by Australia and every other nation in 2015. All states are needing to deliver the objective of climate resilient development that would enable net zero emissions by 2050 along with providing more 'inclusive, safe, resilient and sustainable cities'. Cities, local governments and state governments, as well as large corporations and institutions like universities are all attempting to make changes consistent with these goals. Professional groups like UDIA, Property Council and PIA have been suggesting that net zero emissions goals can be met in the built environment.

Global leadership in this arena has moved to Europe in the last decade and their cities have made significant moves to decouple economic growth from greenhouse emissions, but Australia is not that far behind even though there is no Federal strategy guiding this process[7]. The Climate Knowledge Innovation Community has been establishing ways to achieve new economy outcomes in the climate and sustainable development area and in particular suggest that we now should be finding portfolios of projects that overlap and enable multiple goals. TAC is such an idea.

The new economy is likely to see a strong growth in the integrated application of solar, batteries, electro-mobility (in all forms including mid-tier trans and micro-mobility for local links) and smart city technologies. Together they can create zero carbon transport and urban development that contributes to a resilient grid and provides the basis of many co-benefits in health, reduced air pollution, and reduced urban sprawl, as well as significant growth in new economy jobs[8].

[6] UK Department for Transport, The Future of Mobility Urban Strategy: Moving Britain Ahead, 2019
[7] Newman, Beatley and Boyer, (2017) Resilient Cities, Second Edition.Overcoming Fossil Fuel Dependence
[8] Newman, (2020) COVID, CITIES and CLIMATE: Historical Precedents and Expected Transitions for the New Economy

4.2 Urban Policy Initiatives in Australia

This section provides a brief summary of current urban policy initiatives in Australia that relate to the focus of this report.

4.2.1 Federal Initiatives – City Deals and Infrastructure Australia

City Deals are a mechanism that supports collaboration. With the uncertainty resulting from a disruptive technological advancement in transport and energy infrastructure there is a need for a systems approach that supports shared risk and reward models. A City Deal is well suited to provide this support. The following description of city deals advantages and process has been drawn from a paper written by Newman et al (2020)[9].

A 'City Deal' enables a more bottom-up approach to infrastructure planning and provision. These new approaches will be important for involving private funding to help fund the capital costs involved in quality transit projects[10]

The Australian Federal Government has followed the success of the UK City Deal policy and has created a program based on this concept to encourage urban renewal (Australian Government, 2018). The City Deal program includes requirements to enable:

- An agreement between the three tiers of government, setting out a plan for the City Deal to accomplish innovation, affordable housing and sustainability outcomes.
- Greater community involvement and support for any projects, and
- Involvement of the private sector, including innovative financing that integrates transit and land development, and with supporting funds from local and state government, with the Federal Government providing a risk guarantee[11].

Another key feature of the City Deal approach is it provides an effective mechanism to align the policy intent of the different tiers of government. This provides greater clarity to the private partner, reducing risk, and facilitates co-ordination with other government programs.

City Deals are well-suited to facilitating Transit Activated Corridors, as they can provide increased regulatory certainty or guidance along the corridor, by aligning the objectives of the different tiers of government and can enable the private sector to obtain their finance. Agreements can also be reached with multiple levels of government to provide associated public infrastructure work such as recharge services for stations where electric battery recharging is needed. All of this is likely to increase value in projects[12] [13] .

Recovery Funding that follows the disruption to the economy due to the Covid pandemic will also require the kind of models set out for the City Deal. Such recovery projects will need partnerships and

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[9] Peter Newman, Sebastian Davies-Slate, Daniel Conley, Karlson Hargroves, and Mike Mouritz (2020) From TOD to TAC The Transport Policy Shift to Transit Activated Corridors along Main Roads with New Technology Transit Systems. (submitted to Transport Policy)

[10] Newman et al., (2017b). The Entrepreneur Rail Model: Funding urban rail through majority private investment in urban regeneration. Research in Transportation Economics. DOI: http://dx.doi.org/10.1016/j.retrec.2017.04.005.

[11] Glazebrook and Newman, 2018. The City of the Future, Urban Planning (ISSN: 2183–7635) Volume 3, Issue 2, Pages 1–20. DOI: 10.17645/up.v3i2.1247.

[12] Sharma, R. and Newman, P. (2017) Urban Rail and Sustainable Development Key Lessons from Hong Kong, New York, London and India for Emerging Cities. Transportation Research Procedia, 26, 92-105.

[13] Davies-Slate, S. and Newman, P. (2018) Partnerships for Private Transit Investment—The History and Practice of Private Transit Infrastructure with a Case Study in Perth, Australia. Urban Science, 2, 84-104.

even more importantly will require substantial private sector involvement using innovative technology if they are to be about creating new economy jobs. They also need innovation and sustainability credentials to be part of the new economy.

The proposed TAC, Canning to Scarborough, which is the subject of this study is well suited to this model. This middle suburb-inner city-central city route provides an infrastructure project with important metropolitan centre linkages and opportunities for cross sectoral collaboration in energy, transport, development and housing introducing innovation and industry that can support economic recovery.

4.2.2 Development Industry - Creating Great Australian Cities

The development sector has been a strong advocate for more coordinated and longer run investment in city building to help bridge the gap in the way Australian cities are planned and management in comparison to other comparable jurisdictions. In 2018 the Property Council in partnership with Urbis released a series of policy reports – Creating Great Australian Cities[14]. This work reviewed the mega trends facing the Australian cities in the so called 'metropolitan century', highlighting that Australian Cities have been "less well serviced by high capacity infrastructure, and less coordinated and less well managed than others around the world"[15]. The Property Council's work highlighted the need to further enhance and mature systems of coordination and urban governance highlighting the 'city deal' model as part of wider agenda of strengthening urban management.

Further, they argue for the strengthening of "metropolitan scale institutions, enhanced long term investment systems and leadership across the tiers of government, working alongside civic minded business leaders and engaged citizens". Their arguments are largely based on a review of comparable cases studies which point to the value of long term bi-partisanship around cooperation on urban policy and investment. Without these shifts they assert Australian cities will lose their competitive and lifestyle advantages.

4.3 Coalescence of Breakthrough Technologies

As outlined in the global section above, a coalescence of breakthrough technologies is occurring with simultaneous advances in vehicles, energy systems, communications, artificial intelligence and machine learning at a time when we have growing demands for mobility in our expanding and densifying cities. These new technologies have matured to provide cheaper alternatives to the existing technologies.

The following section looks at how technologies are shaping the future of mobility.

[14] Clark, G. and Moonan, T. (2018) Creating Great Australian Cities. Property Council of Australia and Urbis.
[15] Clark and Moonan (2018) ibid p.8

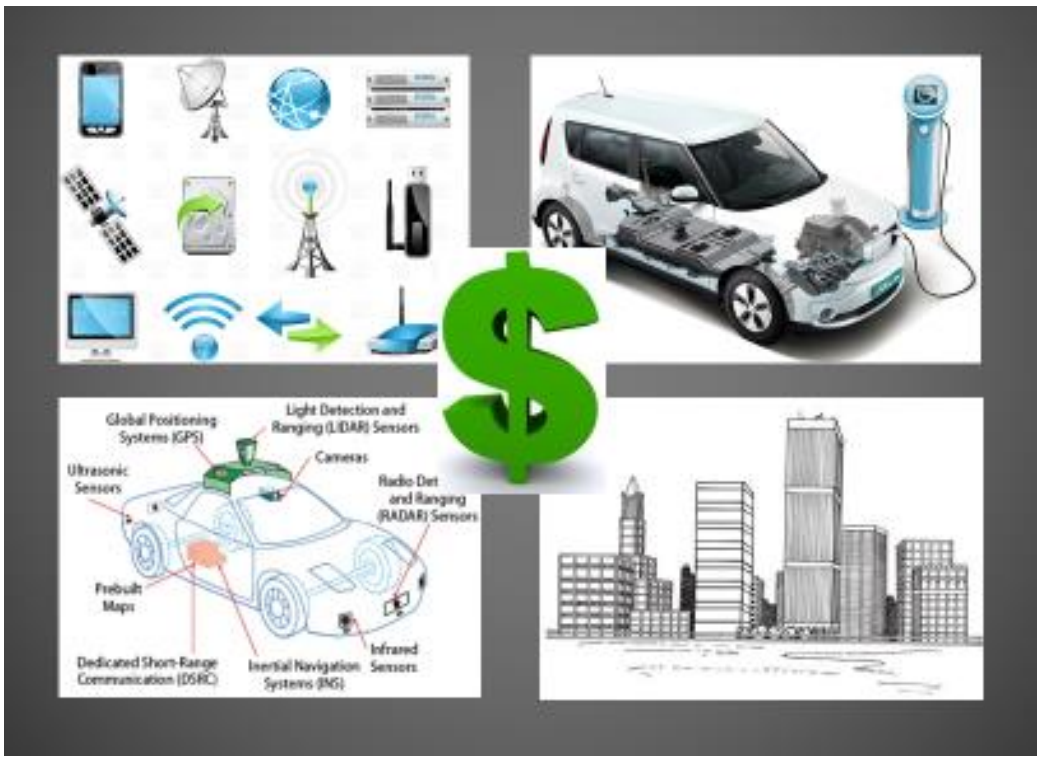

Figure 4.1 Coalescence of Breakthrough Technologies (Source: Authors)

4.4 Global Transit Investment

The pressure from growing urbanisation and the failure of road systems to cope with traffic continues to feed significant global investment in rail with over US$1.4 trillion project in 2019-2025. The case for rail is its enormous efficiency, one metro line can carry more than 70 times as many passengers as a city street with cars. Rail is electric and in a dedicated corridor provides a swifter journey particularly at peak times. The key disadvantages of rail projects are the expense and the time they take from planning to completion.

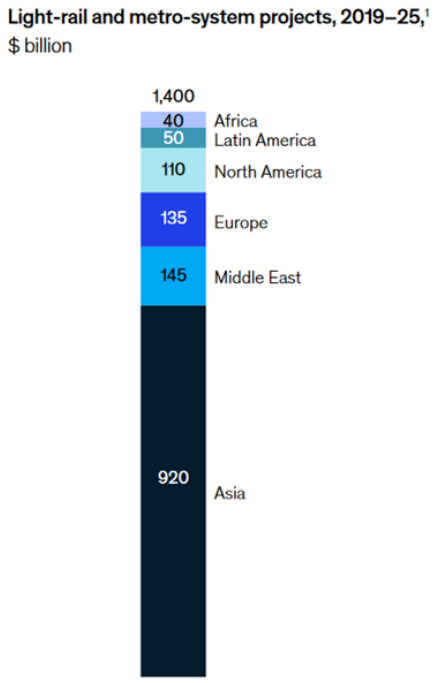

Figure 4.2 Global Investment in New Rail
(Source: McKinsey)

The disadvantages of cost and construction have resulted in many LRT projects in medium sized cities including the Perth Max light rail failing to be progressed. In 2017 a proposal to spend $9 billion on a mass-transit system in Nashville Tennessee, including 26 miles of light rail was rejected by voters who questioned the rationale to spend so much money on traditional transit when mobility technologies were rapidly changing.

One area of rapid increase is electric micro-mobility:

'New modes of transport are changing how people get around. Micro mobility in the form of electric scooters and shared bicycles, for example, can convert a 30-minute walk into a ten-minute ride.'[16] In the US 46% of

[16] Eric Hannon, Colin McKerracher, Itamar Orlandi, and Surya Ramkumar, "An integrated perspective on the future of mobility," October 2016,

car journeys go just 3 miles or less, which can simply be replaced by micro-mobility and 30% of micro-mobility riders are doing just that (Ajao, 2019).

The other area is shared mobility. In Perth in 2019 with the launch of Uber share an on-demand trip can be procured at a similar cost or cheaper than public transport for inner suburban travel. Such technologies are taking passengers away from bus and rail. A recent survey by the McKinsey Center for Future Mobility found that 35 percent of Europe's e-hailing passengers and 20 percent of those in the United States had switched from rail.[17]

Depending on how robotaxis are regulated, they could put another dent in PT ridership as travellers choose door-to-door options. A switch to ride hailing or autonomous transit would impact the viability of public transport systems. The city of New York, for example, forecasts a 10 percent drop in subway ridership due to ride-hailing services, a cost of hundreds of millions of dollars in lost revenue.

Yet new forms of transport do not need to negatively impact PT and micro-mobility and ride hailing could be used to support PT ridership as demonstrated in the Brisbane Future Transport KPMG report discussed later in section 4.8. China, USA, New Zealand and many other places around the world have has success with integrating ride hailing services with PT subsiding this for last mile transit. This reflects the shift to a Mobility as a Service (MaaS) paradigm.

4.5 MaaS

Mobility as a Service (MaaS) is a communication-enabled technology that promises the idea of "seamless mobility". A MaaS transport system seamlessly integrates different modes of transit and technologies including intelligent traffic systems and advanced rail signalling to provide a more efficient and accessible transport system. In addition to time and cost efficiencies it is estimated that the infrastructure would accommodate a 30 percent increase in traffic while cutting travel times by 10 percent.

Changes in transport technology that enable MaaS are:

1. Data and communications technologies to assist travellers to plan multi-stage journeys in real time.
2. Vehicles capable of communicating with each other and with infrastructure allowing network operators and users in real time optimise fleet and network management.
3. Increasing levels of data are supporting advances in artificial intelligence and machine learning necessary to enable fully autonomous operation of vehicles, traffic management and delivering on demand and a need responsive public transport network.

MaaS is service rather than infrastructure focussed, it provides the tools for people to plan their own trips using the full suite of public and private transit options available. There are no demonstrations of these systems yet available but it is possible to make systems that could work to enhance the operational efficiency of TAC's.

4.6 The Inefficiency of Ride Hailing

A 2018 study in the US found that on demand ride hailing vehicles put 2.6 new vehicle miles on the road for each mile of personal driving removed adding to congestion.[18]

[17] McKinsey and Company, Transit Investments in the Age of Uncertainty, March 2020
[18] Bruce Schaller, The New Automobility: Lyft, Uber and the Future of American Cities, July 2018

Another paper 'Ride Hailing is a Problem for Climate' [19] prepared by Union of Concern Scientists looked at the carbon emissions of ride hailing the key findings were:

- Ride-hailing trips have a much higher carbon impact than the trips they replace—the average ride-hailing trip produces an estimated 69 percent more carbon emissions than the trips it replaces.[20]
- Compared to a private car trip, a non-pooled ride-hailing trip produces about 47 percent more carbon emissions.
- A pooled ride-hailing trip shared between two passengers is similar in emissions to a private vehicle trip, and about 33 percent lower polluting than a non-pooled ride-hailing trip.
- Electrifying ride-hailing vehicles would dramatically improve the climate emissions of ride-hailing trips. An electric ride-hailing trip would cut emissions by about 50 percent compared to a private vehicle trip; a pooled, electric ride-hailing trip would lower emissions by nearly 70 percent compared to a private vehicle trip (or about 79 percent compared with a non-pooled ride-hailing trip).
- On average, bus and rail travel have lower carbon emissions than car travel in either a private vehicle or in a pooled or non-pooled ride-hailing vehicle. However, using ride-hailing to connect to transit can be a good low-carbon choice. For example, a pooled ride-hailing trip connecting to the train, where the ride-hailing trip is a quarter of the total trip length, can be more than 50 percent less polluting than a private vehicle trip.

4.7 Transport Autonomy

Improved sensing technology, computing power and software engineering are leading to increasing levels of automation in transport, across many different modes. There is significant investment in vehicle autonomy with self-disclosed investment in the US between 2010 and 2018 reported to be in excess of $40 billion. The time frame for estimated adoption of fully autonomous vehicles is varied but semi-autonomous vehicles are becoming commonplace. The UK's Department of Transport released the Future of Transport Urban Strategy in March 2019, this strategy estimated that 50% of new vehicles in Britain will be connected to some kind of sensor system by 2020.

Across the globe we already have smart vehicles with autonomous technologies including lane keeping, braking and autonomous parking all without driver intervention, increased connectivity will further enhance vehicle capabilities including trip planning, traffic management and incident avoidance. As the level of automation increases so will road safety and travel affordability and efficiency.

Currently aerial drones are supporting police and emergency services surveillance and response and are used by infrastructure providers for asset checks and maintenance. There are delivery services using drones and aerial taxi services are being trialled. One report estimated that the global market for urban aviation, including commercial drones and vertical take-off and landing (VTOL) services could be worth $1.5 trillion by 2040.

On the roads as in the air improved batteries and motors are facilitating the introduction of new forms of micro-mobility, providing ever more options for the movement of people and goods. These include electric scooters, electrically assisted pedal cycles (e-bikes) and e-cargo bikes. Light electric vehicles could carry out 10-15% of delivery vehicle trips in cities, according to one study.

[19] Ride Hailing is a Problem for Climate https://www.ucsusa.org/resources/ride-hailing-problem-climate accessed 1 April 2020

[20] Phillip King, The Australian, Study finds ride-hailing services increase emissions more than private cars, article 9th March 2020

As this technology matures over the next decade new ways of transporting people and goods will be increasingly adopted providing a more effective use of roads space. It is currently not common practice for road and rail projects to consider the impact of these emerging technologies[21], but the pace at which they are being developed and adopted by consumers provides an asset risk for future road and rail infrastructure projects.

In order to see how autonomous vehicles will be fitted into cities and into innovations like a TAC it is important to see that different parts of cities will work better with AV's and some parts will work worse. Central cities are functioning better whenever the traffic is removed from streets and the opportunity for walkability and pedestrian activity to flourish is provided[22]. The reason for this is that central cities are strong centres for knowledge economy jobs which flourish wherever face-to-face contact is enabled[23] [24]Autonomous vehicles going round and round central city streets will not facilitate this important economic activity and will most likely to be kept to very specific access ways. Also some main roads with high use of AV's that form an impenetrable barrier of fast-moving cars, will also not be appreciated in all such corridors. A TAC on the other hand could have the equivalent of 6 lanes of traffic proceeding down the corridor but in the station precincts they would slow down and be able to pick up passengers delivered by micro-mobility and AV shuttles[25].

4.8 Electric Mobility

Rapidly falling battery prices, improvements in energy density and electric motors and developments in alternative fuels have the potential to reduce emissions across a range of modes. Companies, cities and countries worldwide are getting behind the transition to cleaner transport. Over 1 million electric vehicles were sold in China in 2018. According to one forecast, over half of new car sales globally will be electric by 2040.[26] This raises questions about grid stability in the future and most cities are now moving towards battery systems to enable recharge and grid resilience.

Electric transit, especially electric buses and mid-tier Trackless Trams, are also growing rapidly. Instead of being a threat to grid stability they can be in a position to create new sources of revenue for the transit system through grid resilience. As outlined in Box 2 below electric transit mobility provides the opportunity for diversification of revenue streams for public transport providers but also grid integration for land developers and local communities.

These examples demonstrate the emerging opportunities associated with electro-mobility and its integration with other urban systems. As pointed out by Newman et al 2020[27].

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[21] A McKinsey Analytics study looking at if agencies were considering future innovative transport looked at 10 projects around the globe and only 1 (Singapore Land Transit Authority) made mention of possible effects of autonomous vehicles on transit ridership.

[22] Gehl, J. (2013). Cities for people: Island press.

[23] Newman and Kenworthy, 2015 Newman, P. and Kenworthy, J. (2015) The End of Automobile Dependence: How Cities are Moving Beyond Car-based Planning, Island Press, Washington DC.

[24] Glaeser, E (2011) The Triumph of the City, how our greatest invention makes us richer, smarter, greener, healthier and happier, (Penguin, London, United Kingdom).

[25] Peter Newman, Sebastian Davies-Slate, Daniel Conley, Karlson Hargroves, and Mike Mouritz (2020) From TOD to TAC The Transport Policy Shift to Transit Activated Corridors along Main Roads with New Technology Transit Systems (Submitted to Transport Policy).

[26] Bloomberg New Energy Finance (2018). Electric Vehicle Outlook 2018 (online). Available at: https://about.bnef.com/electric-vehicle-outlook/

[27] Peter Newman, Sebastian Davies-Slate, Daniel Conley, Karlson Hargroves, and Mike Mouritz (2020) From TOD to TAC The Transport Policy Shift to Transit Activated Corridors along Main Roads with New Technology Transit Systems (Submitted to Transport Policy).

… “all of the new transit technologies will be electric with last mile linkages being electric as well. Thus, each of the precincts will need to have a station with potential to recharge a Trackless Tram, LRT or BRT and a set of buildings with potential to collect solar energy (or create Hydrogen for use in Fuel Cell Vehicles). Thus, the whole corridor can be part of the power system and indeed with battery storage at stations there is potential for them to be Recharge Hubs for all the micro-mobility and autonomous shuttles feeding into the station”.

Box 2 Diversification of Revenue Streams

“Interestingly I learned when in Shenzhen with Shenzhen Bus Group that from the process of becoming the first fully electric bus fleet in the world, the most untold/challenging aspect was the land and land value consideration for depots. After pushing through and being first, they are now in a position where they have a series of charging depots across the city, that were implemented for the buses, but they are now offering charging and maintenance to all other electric vehicles within the city (garbage trucks, taxis, private vehicles). So, entrepreneurially, in this way they have diversified their business and created the opportunity for new revenue streams. This could be the same for a Transit Activated Corridor node.

In Santiago, Chile (the world’s second largest fully electric bus fleet), the power/electricity companies are the ones providing finance for the electrification of the buses. Because they see this as a huge opportunity.” Daniel Conley PhD Candidate University of Adelaide – March 2020.

This diversification of revenue streams is important when seeking to provide a resilient transit system. Hong Kong MTR has done this successfully through incorporating land development as part of rail expansion. The Covid 19 pandemic lockdown has reduced commuter travel both on road and rail severely impacting the revenue gained from fares and tolls. The Los Angeles Metro is anticipating a shortfall of roughly $700 million, the Toronto Transit Commission reports losing fare revenue of nearly $20 million a week and Britain has nationalised commuter rail services for at least six months to save its franchisees from insolvency. Yet MTR report “Overall, our business is resilient,” Jacob Kam, CEO of Hong Kong’s MTR. Kam explained that even though the coronavirus outbreak had driven ridership down by 40 to 50 percent, “We have a balanced portfolio… And, of course, we have a substantial business outside of Hong Kong.”[28] In 2018 MTR Corporation reported annual revenue of $6billion and a profit of $4billion.

4.9 Last Mile On-Line Delivery Opportunities

On-line deliveries are growing rapidly, particularly during the pandemic. Many cities around the world are grappling with the congestion caused by the increase in delivery vans. London despite the gains made from the restrictions of cars into the city core has growing congestion resulting from delivery vehicles.

Although this issue is yet to plague Perth it is growing and is likely to become an issue. Transport for NSW is part of a collaboration to identify innovations that can help it address the issues associated with last mile parcels, particularly on-line parcel deliveries. In the rapidly growing e-commerce industry, Sydney is experiencing never-before-seen volumes of deliveries into the already crowded CBD. Light Commercial Vehicles (LCVs) account for 12% of traffic in the Sydney CBD and improving the efficiency with which these and other Last Mile Parcels methods could reduce congestion, lower the cost of parcels and improve the customer experience is an imperative.

[28] https://reasonstobecheerful.world/hong-kong-transit-coronavirus accessed 17/4/20

Transport for NSW and the Sydney Coordination Office in association with the Transport Digital Accelerator has sought to encourage businesses to prepare for the future and is supporting various initiatives to mitigate the impacts of changes occurring in the CBD and on the network. They have developed the following set of problem statements (see Box 3[29]) and presented this as an Innovation Challenge to industry, individuals and research organisations. The aim is to develop new digital products with the focus being on positively influencing the behaviour of the drivers of Light Commercial Vehicles (LCVs).

It is possible that TAC could provide a solution for on-line deliveries.

Box 3 Last Mile Parcels – Problem Statements (Source: Transport for NSW)

How might we build a system that allows the government to monitor how parcels are delivered in the CBD? So that we have a deeper understanding of how to improve parcels movements going forward for government and delivery operators.

How might we reduce the number of kilometres travelled by LCVs in the CBD?

- How might we reduce the number of trips that LCVs make in and out of the CBD?
- How can we create awareness of the bigger transport picture?
- Maximise positive behaviours?
- Make deliveries more efficient?
- Encourage greater end to end collaboration?

4.9.1 Can Transit Activated Corridors help with on-line deliveries?

Some futurologists foresee ground based and aerial delivery drones riding on corridor transit and making deliveries to stations or door to door. Scania has vehicles under development that can transform from a passenger vehicle to a parcels vehicle or service vehicle at off peak utilising the corridor when passenger demand is low. The CRRC ART (Trackless Tram) vehicle could also have carriages dedicated to parcels at off-peak times.

The value in a TAC is that it would have a regular and flexible transit service that could take parcels from a central location to a Delivery Hub in each station. As this station precincts will be where innovative micro-mobility and AV shuttles will be servicing the catchment around the station then it will be possible for an AV small delivery van could regularly move around the precinct delivering parcels. This was witnessed by the world in Wuhan when food and medicine deliveries were made along corridors by such small unmanned robotic vehicles. Such a future is beginning to be imaginable.

4.10 Post the Pandemic

While there is great uncertainty around Post Covid 19 living, there is likely to be additional demand for local and last mile integration as increased numbers of people seek to work from home at least some of the time. There is likely to be a greater appreciation of local shops and services so a re-localisation of suburban centres as well as TAC centres is likely. These could lead to a move towards active and micro mobility options and eventually a return to transit as virus concerns alleviate and people move further towards a non-car dependent lifestyle. The inclusion of last mile parcels on mid-tier transit for example utilising the last carriage of a TT vehicle for delivery bots and the integration of energy systems will assist in the viable operations of a frequent shared corridor transit network for people as well as on-line deliveries. All of this will help increase the value of re-urbanization in the middle suburbs. The example of MTR integration with land development and Shenzhen's integration with energy systems

[29] https://opendata.transport.nsw.gov.au/last-mile-freight-innovation-challenge

all provide examples of how to provide a more financially and demand-resilient transport network fully integrated into the re-localization strategy.

4.11 The Price of Doing Nothing

There is a high price to be paid for doing nothing or not planning for the transformative changes that will occur due to the coalescence and maturity of complementary technologies in communications, energy and transport.

A systems transition approach can assist to harness the opportunities and shape the transformation so that it is managed and provides the optimum benefit for the whole community. It involves a collaborative approach proactively engaging with a wide array of actors, including firms, consumers, policymakers, innovators, and civil society groups.

Transition is hard to predict and typically, as it unfolds strategies, motivations and resources change. New kinds of transport and technology are injecting unprecedented uncertainty into mobility planning. Some broad trends, however, can be predicted with reasonable confidence:

- Passengers are adaptable and will seek out the most convenient forms of transport for them; new technologies can mean people will see new opportunities to shift into a transit mode because it is quicker and more comfortable or they will move to one of the new precincts that is closer to transit and to their destinations in the central area.
- Companies will base their new offerings on risk, innovation and regulation and may choose to invest in a TAC due to the new opportunities provided for a value-driven proposal.

In 2019 a report commissioned by the Queensland Government sought to quantify the cost of autonomous mobility as a disruptive technology on the provision of public transport[30]. KPMG who authored the report, estimated the cost of doing nothing where the majority of vehicles remained in private ownership as are the vehicles of today, would result in a negative cost of $21.5b. If an improved public transport service was provided utilising digital technologies that integrate modes and enable seamless mobility and personalised trip planning e.g. MaaS, ridership would increase and network operations become more efficient and return on investment could be $45.7 b.

Failure to shape the implementation of emerging technologies and services could mean that we miss out on the opportunities presented above. Unintended consequences could lead to worse outcomes for society, the environment and the economy.

4.12 The Value of Corridors and Mid-Tier Transit

Road based public transport in Perth is provided by buses that run in mixed traffic with some peak priority lanes. In response to congestion and economic cost of public transport provision and other drivers there is a trend towards the adoption of mid-tier transit comprised of both BRT and LRT where frequency, dedicated lanes and signal priority provides a high level of service and attracts greater patronage.

There is increasing use of battery electric vehicles providing systems that are quieter and emissions-free. New micro-mobility (scooters, e-bikes etc.) and shared personal transit integrated with corridor transit are providing efficient last mile solutions. Micro mobility also has the advantages of reducing the noise, pollution, safety and amenity impacts of vehicles in residential areas and the economic impacts flowing from street activation (e.g. greater interaction between commuters and businesses).

[30] KPMG, Disruptive Mobility, 2019

These vehicles are also cost effective providing affordable living and can provide health benefits associated with active transport.

The tour conducted in association with the Study identified the importance of integrating place and last mile modes with the second-tier transit. The group visited cities where second-tier transit has been introduced Malmo, Paris, Vauban and Amiens all were examples where there was good integration with other modes and urban form. In Malmo and Amiens multiple bus routes had been rationalised to a few high priority corridors. It was too early to assess the success of Amiens but in Malmo as in Metz, Belfast and several other cities this network redesign had resulted in a 30% increase in ridership, decreased operating costs and positive community response. Routes were well integrated with other modes including rail, pedestrian and cycle infrastructure. The mid-tier transit vehicles are stylised, tram like and distinctive. Stops were integrated with other modes and in some case also provided parcels lockers.

4.13 Summary

Being aware and planning for and assisting a system-wide transition can avoid the negative costs associated with doing nothing or being a laggard. It provides economic, social and environmental benefits. There is a role for government in assisting this transition and working with communities and private sector players to ensure that it is a planned transition that provides best use of assets and an equitable outcome.

Huge questions remain about transport automation but what is certain is that the next decade will be pivotal. If we do nothing we risk:

- The chance of playing an expensive game of catch-up, it has been estimated that by 2030 new forms of transport that don't currently exist, could account for 40 percent of today's transportation-revenue pool.
- A loss of ridership will further impact viability of providing public transport services
- Private sector dominance and ownership of connectivity and service Apps could utilise the commons, influence urban form and travel behaviour for commercial benefit over best for community outcomes.

In dealing with uncertainty and there are four steps can help cities, planners and transport providers work with their communities to deliver a cleaner, cheaper and more effective transport and achieve the promise of MaaS - that of seamless mobility.

These four steps include:

1. Collaborate to set the goals and vision and the transition process. Engaging and taking a system transition approach can manage the uncertainty through shared learning, re-evaluation, redefinition of interests, and other processes.
2. Develop a systems integrated transport masterplan that includes micro-mobility, active transit, land use, development potential and energy systems.
3. Choose the technologies to suit the place and people and design in adaptability to accommodate new technologies and growth. Infrastructure and operational risks can be shared through various contract models including procurement that requires flexibility to include latest technologies, build own operate and transfer or design, build, operate and maintain agreements can all assist to mitigate risk of the uncertain future and pace of transition.
4. Be strategic, work collaboratively sharing knowledge to help understand the evolving transport model. Important are the land developers, micro-mobility and on-demand service providers

as the integration of services through an App or single users interface has the potential to shape both mobility and urban form.

Multiple changes in transport technology are happening at once. These are transforming urban transport and creating new opportunities as well as risks. At the same time, significant events, demographic, economic, and behavioural trends are changing how and why we travel. Together, these technology-and demand-led changes will be accompanied by new business models that could if not regulated or managed will impact urban form and have unwanted effects.

The integration of these technologies and trends in personal deliveries parcels, communications, energy and transport can provide a viable and sustainable solution for our future mobility needs.

5 MID-TIER TRANSIT FOR PERTH

While previous sections have focused on the urban planning and transport considerations and presented a case for change, this section focuses on presenting the core findings of the engagement and study process related to the opportunities for mid-tier transit in Perth, what we need to do in establishing a world-first trial of Trackless Trams in Perth, and a proposal for what we suggest is needed to set up a Perth Trackless Tram system as part of the Recovery process (as set out in the Overview).

5.1 Stakeholder Perspectives

Throughout the project a range of processes were used to identify stakeholder perspectives around notion of mid-tier transit (using the Trackless Tram as the example being tested). This section seeks to summarise the perspectives drawn from a range of processes including:

- the Consortium and Stakeholder Risk Workshop in January 2019
- the Consortium and Stakeholder Workshop October 2020 – On Scarborough to Cannington Activated Corridor
- a range dialogues and meetings with consortium members and stakeholders

Outlined below in Table 5.1 is a summary of these perspectives that range from topics associated with land development, governance to high level implementation issues. It is not meant to be a broad-based assessment – but rather an overview of the higher level perspectives around the challenges and opportunities presented by seeking to introduce a mid-tier transit system.

Table 5.1 Challenges and Opportunities – Urban Regeneration through Activated Corridors

Stakeholder	Key perceived barriers	Key perceived opportunities
Development WA	• Dynamics of the urban property market - the cost of construction of single dwellings versus costs of apartment construction. • Fragmentation of and ownership means – renewal needs to focus on key sites. • Market viability for apartments is restricted to CBD/Inner City and high amenity locations such coast and river.	• Have access to some key sites (old Dept of Agriculture site and Technology Park) and have planning powers that could be utilised. • If accessibility and amenity building goes hand in a focussed way along corridors there is some potential.
Property Council	• Based on the Creating Great Australian Cities project – the evidence is Australian cities generally have poor coordination leading to insufficient investment in key infrastructure to realise potential. • Other jurisdictions have developed systems of governance can be learned from.	• See potential for new forms of political leadership to emerge through a 'team' approach which brings civic minded business leaders and engaged citizens working alongside all tiers of government – the City Deal Model. • Has identified the 'value' creation potential of the MAX LRT project – so sees potential in TTS.
Dept of Communities	• Question if land value uplift will provide sufficient funds implement TTS.	• See value in framing the value of this form of investment in

		activated corridors within framework of 'Wellbeing Uplift'.
General Local Authority sentiment	• Variable levels of planning readiness. • Variable levels of engagement with businesses and community.	• See the value proposition of exploring the potential for the introduction of mid-tier systems. • Keen to be part of the solution – and work in coordinated way .
Curtin University (as a key activity centre)	• Acknowledges the challenges of introducing new type of vehicle into the 'system'.	• Identified the benefit of creating PT link between the Bentley Campus and Perth City Centre as priority. • Wider campus (Greater Curtin) development benefits and have allocated space for Depot.
Dept of Transport	• Understand the challenges of 'system' change associated with introducing a mid-tier transit systems. • Acknowledge the changing PT environment as On-Demand transport emerges as bigger player.	• Significant opportunities to align with concepts and policy development in the area of movement and place. • See value in developing a 'model' for shifting to MaaS .
Public Transport Authority	• Concerned about existing contracts with bus operators. • Concerns about transfer penalties with the introduction of additional mode.	• Acknowledge that if a mid-tier systems was introduced then bus operators contacts could be re-assigned / re- negotiated.
Western Power	• Have not historically seen themselves just as energy provider.	• Identified the potential to of electric mobility to be part of the emerging business model.
Exiting Transperth Bus operators	• Are implementing corridor transit systems elsewhere and have knowledge from early adoption of issues and advantages of transitioning the network. • Road pavement not suited to vehicles running in same place resulting in rutting and bunching of pavement at stops. • One of the barriers to providing high quality bus service is lack of priority. • Prepared to partner and support innovation.	• More efficient service due to priority. • More legible. • Drivers like the separation with the ticketless entry. • Ticketless entry and multiple doors improve journey times. • Have improved operational costs elsewhere. • Integrated with on demand and micro mobility as part of whole of service offering.

The following statement (Box 4) captures a key aspirations of a consortium partner, highlighting the city shaping opportunities that the group has been working towards.

Box 4 - Perth a True Green Transport Smart City

Currently, there are several City development projects around the world embracing autonomous transportation and these technologies are fast becoming mainstream. I've personally been involved in 3 mega projects that have embedded autonomous transport systems (trackless trams, community buses and shared e-vehicle nodes) as integral Masterplan components.

Perth has the opportunity to be a true Green Transport Smart City by embracing autonomous and e-transport technologies to support its sustainable growth. The long term use of the metro buses within the City is not sustainable as the current service is adding to traffic congestion, impeding the development of the City's integrated pedestrian and cycle networks, doesn't support TOD development and is contributing to the City's raised air pollution levels.

The pending Perth Central Vision Plan should incorporate the provision for a Perth centric mass transport network (trackless trams) linked to the 3 potential TOD nodes around West Perth, Perth Central and Claisebrook train stations. The City of Perth is keen to take the lead role in investigating/designing Perth's trackless tram route and TOD master plans around the 3 train station sites, through a joint working group approach with PTA, DOT and DPLH.

Jayson Miragliotta, General Manager Planning & Economic Development City of Perth.

5.2 Accessibility Assessment – SNAMUTS

This section of the report summaries an Accessibility Assessment undertaken using the SNAMUTS tool. The assessment focuses on assessing improvements in accessibility in the context of urban intensification opportunities created by the proposed mid-tier transit system and the associated transit activated corridor of development opportunities it would help create. The full report on the SNAMUTS assessment and the route Options discussed below can be seen in that report which is available at https://sbenrc.com.au/research-programs/1-62/. The key findings of this assessment are summarised below.

Perth's public transport system is characterised by a widening performance and capacity gap between the two principal modes currently in use: rail and buses.

The starting point of this assessment is that at present there are a plethora of radial bus lines enter the CBD area along a small number of trunk routes, in a pattern that originated at a time when the metropolitan population was far smaller than today. As Perth has begun to attract its third million of residents, this pattern has reached its performance and capacity limit particularly along the St Georges Terrace, Adelaide Terrace and Causeway corridor.

Urban growth increases pressure for the decentralisation of knowledge-based employment and associated residential and service functions into higher-density growth hubs in inner and middle suburbs and around universities, such as Stirling, Cannington and Bentley. Linking these growth hubs to each other and to the heavy rail network requires a second-tier transport system with greater performance and capacity than conventional buses.

This analysis has been biased on initially on the stakeholder workshop in October 2019 that resulted in three proposals for route variations of a 30-km diametrical Trackless Tram line linking Scarborough Beach and Cannington via central Perth and Curtin University (Options 1, 2 and 3). A fourth route variation (Option X) along the same corridor was added by the project team after the first three options

had been assessed, in order to further optimise its performance. After further consultations with key decision makers, it was decided to also assess two route options for a shorter (16 km) radial Trackless Tram corridor connecting Burswood and central Perth with the Morley-Embleton area (Options 4 and 5).

Using the Spatial Network Analysis for Multimodal Urban Transport Systems (SNAMUTS) tool for a comprehensive accessibility assessment, it is shown that each of the six options improves public transport movement options across inner Perth and addresses mounting capacity problems on the bus system, if to varying extent.

A Trackless Tram CBD alignment along St Georges and Adelaide Terrace in conjunction with the transformation of some or most south-eastern radial bus routes into rail and Trackless Tram feeders at Burswood and Victoria Park (Options 1, 2, 4, 5 and X) will improve the efficiency and legibility of the CBD network and free up buses to be redeployed for better service frequencies and additional orbital bus lines elsewhere in inner Perth.

Continuing the Trackless Tram CBD alignment west along St Georges Terrace through West Perth and Leederville (Option X) has a more beneficial overall network effect and frees up more buses for other services than alternative alignments through Northbridge and North Perth (Options 1, 2 and 3). However, since the first Trackless Tram route would bypass Perth Central station in this scenario, two contrasting effects can be expected: Trains on the CBD approaches will experience some relief from mounting congestion, while congestion on buses particularly along Wellington Street may further deteriorate.

In a further step, proposals for targeted residential and employment growth in selected hubs along the Trackless Tram alignment were included in the analysis which highlights urban redevelopment opportunities along the corridor based on estimates provided by the Consortium Partners – see Figure 5.1 below) . It is shown that the viability of a medium-capacity public transport system is already established along its CBD section and Swan River crossing into Victoria Park without additional land use intensification. In the Glendalough-Stirling, Bentley-Curtin University and Carousel-Cannington areas, significant residential and employment growth over and beyond the 2031 trend is required to justify the added capacity and required infrastructure investment of a Trackless Tram. A further branch line between Curtin University and Canning Bridge station can further add to this rationale and greatly improve network connectivity in the inner south.

A second workshop in December 2019 motivated participants to think a step further and identify how the previous scenarios' shortfalls can be resolved by a longer-term network vision. Two further scenarios were constructed from this process. A combination of Options 4 and X generates a five-line network (Option Y) that maintains and extends the efficiency benefit of an east-west through route along the CBD Terraces while adding a link into and beyond Perth Central station to Morley. In a final scenario, an additional CBD Trackless Tram corridor along Wellington Street and a branch from West

Perth to UWA were included (Option Z), creating a six-line network and allowing for the removal and redeployment of all Causeway bus routes. This scenario is the best performer on all SNAMUTS indicators including resilience (congestion relief), and can be considered as the basis for a medium-term Trackless Tram target network in inner Perth.

Figures 5.2 and 5.3 show the composite index maps for Trackless Tram Options Z, as well as the incremental change of composite accessibility performance compared to the 2031 network and land use development potential. These Figures highlight the accessibility and development opportunities created by introduction of the mid-tier transit system.

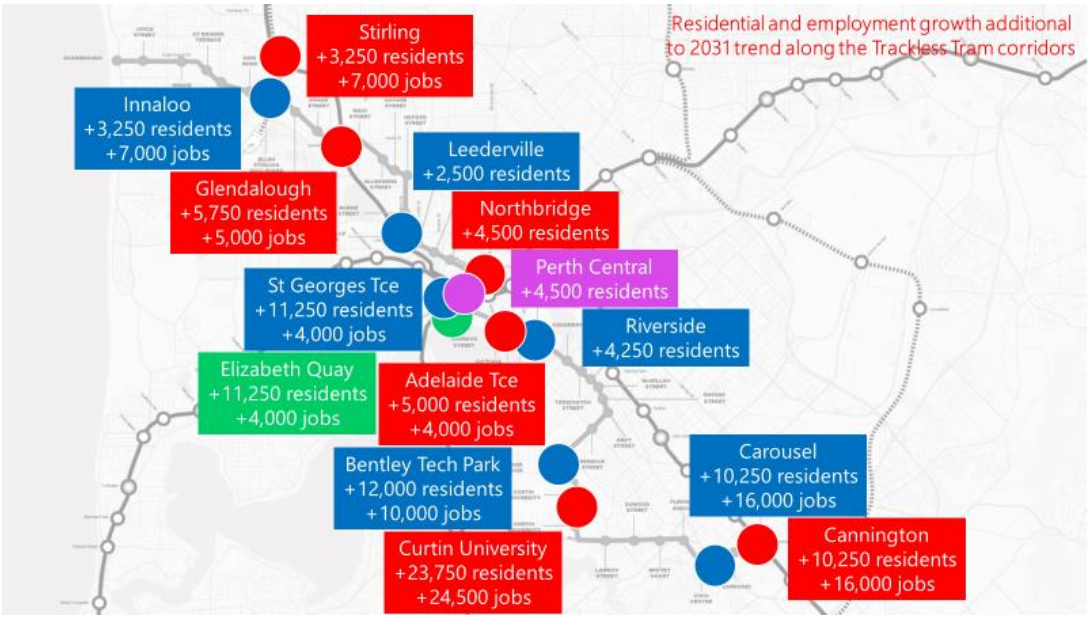


Figure 5.1: Residential and employment growth in the catchments of activity nodes along Trackless Tram routes over and beyond 2031 projections (provided by Consortium Partners)

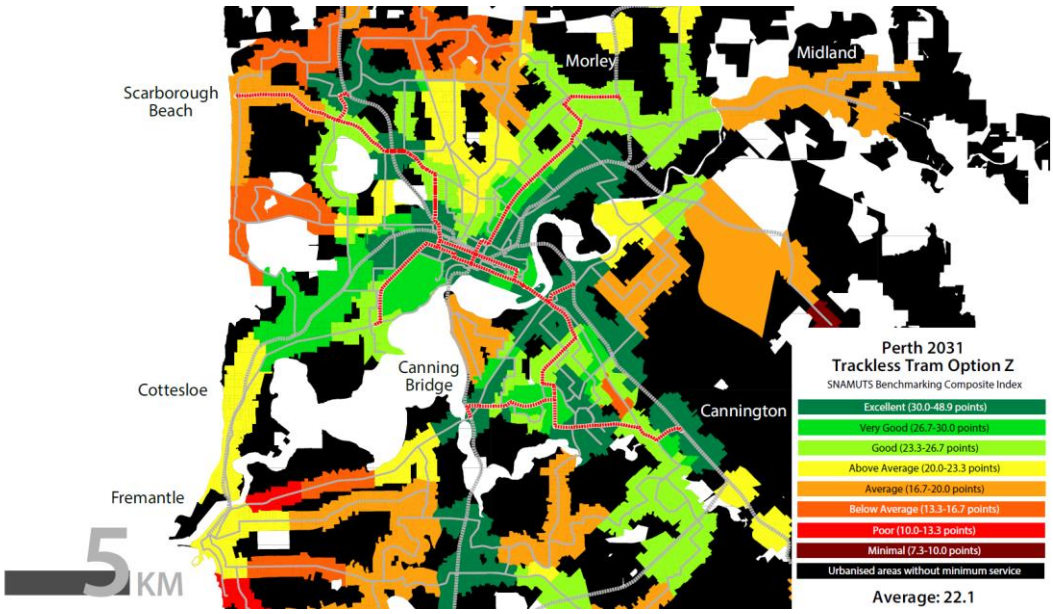


Figure 5.2: SNAMUTS Composite Index for Trackless Tram Options Z with additional land use intensification

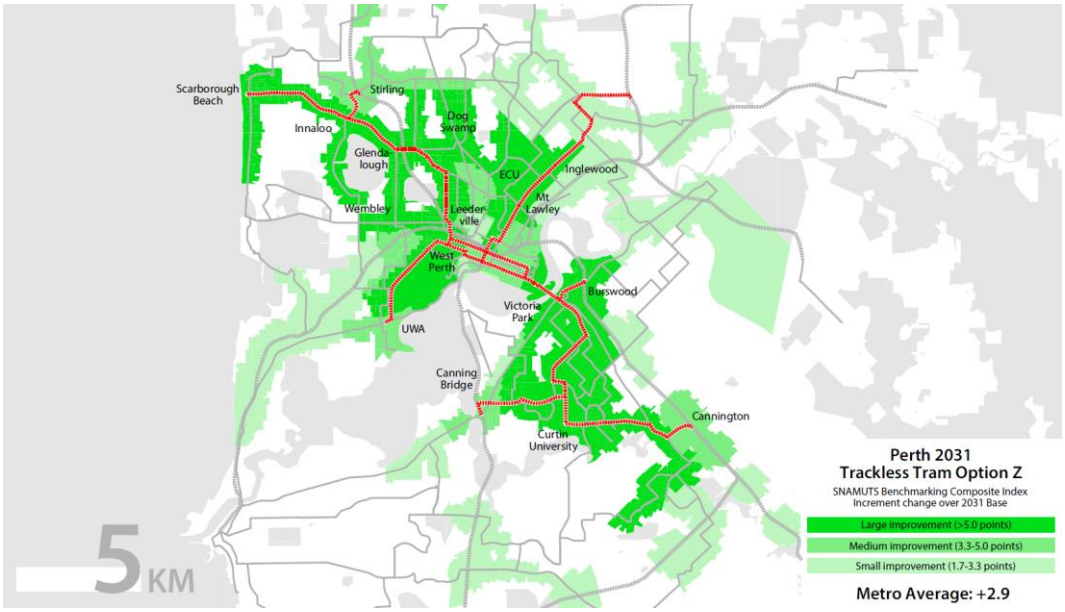


Figure 5.3: SNAMUTS Composite Increment Change for Trackless Tram Options Z with additional land use intensification

5.3 Implementation Challenges and Opportunities Framework

This section summaries the findings of a high level assessment of Implementation Challenges and Opportunities of the Transit Activated Corridor Route options discussed in Section 5.2. This process involved development and testing of assessment framework which highlights challenges and opportunities within the various segments of the route within each of the Consortium Partner local authorities – drawing on the local knowledge of the partners.

The process involved, initially development and testing of the criteria (involving the research team and local authority representatives). This was followed up with meeting with representatives of each of the 5 Consortium Partner local authorities to document their assessment of the various implementation challenges and opportunities along the proposed Transit Activated Corridor – derived from the Workshop in October 2019 and the subsequent analysis.

The Implementation Challenges and Opportunities Assessment Criteria framework is presented in Table 5.2. The full data bases of the assessments undertaken with each local authority has been provided to each of the consortium partners. The key findings form each local authority in terms of sections of the Activated Corridor Route through their municipality is summaries in Table 5.3. The value of this assessment is that it provides high level evaluation of the status of planning that has been undertaken across the route. This can be used to help clarify the scope for more detailed investigations to follow.

The key finding from this assessment is that City of Stirling, City of Canning Curtin University and to some extent Town of Victoria have significant amount of planning to identify the opportunities for transit corridors for mid-tier transit. There is much less clarity on preferred routes and alignments within the Perth CBD area and through the City of Vincent.

This assessment also highlights there is significant development potential along the route and clear recognition that the introduction of a transit corridor link will unlock significant inner urban renewal opportunities.

There are of course significant detail planning, design and implementation challenges that need to be worked through. As part of this process moving forward detailed engagement with stakeholders and communities will be need to be an important part of the processes moving forward.

Criteria	Measures	Score 1-10	Explanatory Notes
1. DEPOT The ease of providing Servicing and maintenance facilities	• Agreed sites • Ability to use exiting depots • Potential locations • No planned sites	10	No need for depot inner city Sites available Curtin and Stirling and existing bus depots suitable
2. LAND OPPORTUNITIES Potential development uplift	• Large under-utilised sites (potential to leverage private sector funding) • Potential to develop public sector sites • Medium density strata • Low density that could be uplifted	7.8	Apart from CBD most route sections have good opportunities due to under-utilised light industrial and commercial uses on large lots
3. VALUE CAPTURE / PLANNING ENABLED Planning enabled development uplift	• statutory uplift in place • strategic in place • in process • nothing	7.9	City already well served by PT zoned for development so little value uplift. TT will unlock development in the city at key nodes
4. ROAD RESPONSIBILITY Ease of delivery due to road classification and governance	• red road • blue road • local road)	7.3	Manning Road currently blue slated to become red. Constraint mainly on Albany Highway and Causeway. Issues could be intersections
5. PLANNING READINESS Alignment with state and local 'planning'	• local strategy in place • only identified in broad MRS terms • local govt strategies begun	8.5	Mostly planning in place
6. ROAD READINESS Ease of delivering transit priority	• Bus lane already in place • Can you easily take out a lane of traffic • Do you need road widening • Do you own the land	6.1	Most of Scarborough Beach Road Glendalough to Beach is procured or identified. Vincent sections of SBR, Oxford and Vincent difficult, William and Barrack intersections with St

	• Is it reserved		Georges Terrace need addressing Albany Highway has difficult sections Manning Road has level changes that may be better suited to kerb side running.
7. STATION READINESS Ease of delivering stations	• Stations sites identified • Existing Verge width • Road reserve width fits station • Gaps in the built form in the right space for the station	5.9	Pinch points may mean land procurement for some station sites. The height of the platform may be problematic in the Terrace.
8. ENGAGEMENT Has the transit planning been agreed by community/ business	• Certainty of agreement with community and business. • (statutory plans endorsed 10 • Strategic agreement 5 • No engagement 0)	6.3	Engagement differs across local authorities Canning and Stirling have progressed the planning but still areas unresolved.
9. LANDSCAPE OPPORTUNITIES/ PUBLIC REALM Impact and potential for tree-lined boulevard or Impact on Public Realm	• Trees already there, planned or possible. • Impact on or potential for tree-lined boulevard / Impact on or potential for Public Realm improvements	7.2	The opportunities for public realm improvements are influenced by corridor width and the ability or willingness to take out lanes of traffic or parking or purchase land.
10. SOCIAL HOUSING Enabling low cost housing opportunities	• Public / social / affordable housing plans for route	5.2	Opportunities at key sites but not along the whole corridor
11. CIVIC ASSETS Opportunities to enhance civic assets	• Enhanced accessibility to public services; Enhancement of civic identity; Improved social interaction	7.3	Opportunities along the corridor less in the city and inner areas where good accessibility and high level of service currently exists
12. ECONOMIC ASSETS	• Enhanced accessibility to	8.6	Opportunities along the corridor less in the city and

Opportunities to enhance economic assets	employment, shops and other services.		inner areas where good accessibility and high level of service currently exists

Table 5.2 High Level - Implementation Challenges and Opportunities Assessment Criteria

Consortium Partner	Key Challenges	Key Opportunities
City of Canning	From Cannington Station, along Cecil Avenue, along Albany Hwy to Manning Rd and along Manning Rd to Curtin University - Modest level of challenges	
	• Significant challenge in accommodating a transit corridor along Albany Hwy between Cecil Ave and Manning Rd – as this is Regional Road – (Red Road) regional through traffic the existing priority • Manning Rd has been identified as potential Regional Road – Red Road) • Some land acquisition required along small sections of Manning Rd Western portion of Manning Rd near Curtin University within South Perth and Victoria Park – so limited details there.	• Significant Transit preliminary planning has been undertaken within the Canning City Centre and along Manning Road • The planning framework – within City Centre area and along Manning Rd have allowed for Transit • Significant land development potential and potential for social housing because of site owned by Department of Communities • Canning have developed a City Centre urban regeneration financing model using a 'rate quarantining' approach that might have wider applicability (See section below on funding mechanisms).
Curtin University	A route the university has been identified and allocated within the master planning undertaken for the Greater Curtin master plan	
	• Only detailed design and implementation challenges	• Significant land development and activation potential identified
Victoria Park	Three distinct sections identified – Kent St from Curtin University to Jarrah Rd -Kent St from Jarrah Rd to Albany Hwy and Albany Hwy to Causeway, plus a potential link from the Causeway onto the Burwood Peninsular and the Perth Stadium - Modest to significant challenges	
	• Significant engagement required within built up area – along Kent St and along Albany Hwy. • Detailed design and implementation challenges with route down Albany Hwy – ideally require shared running environment and slow	• Southern part of Kent St has wide road reserve – so relatively easy. • Significant development opportunities along Albany Hwy. • Significant value in creating a link to the Burswood Peninsular to Perth Stadium (initial discussions held with Burswood Park board –

	movement through this built up area.	and potential link identified in park master plan)
City of Perth	Preferred route would be City Centre circuit – Along Wellington St and St Georges Tce / Adelaide Tce – Significant challenges to overcome	
	• Requires agreement to reduce Bus Route into the City. • Due to complexity of issues in the city centre – particularly in the area between Barrick St and King St lots of competing design / space challenges. • North south roads like William and Barracks St – relatively narrow. • Station platform heights and exiting street scape redesign required / need to avoid basement flooding from raised platforms.	• Significant value in creating the circuit route which would replace the parts of Cat Bus system • Planning in place to allow development. • Significant benefits from a circuit route which would help link the areas around the edge of the CBD to core activities.
Vincent	With Vincent there was no final agreed route – as all options undertaken within the SNAMUTS assessment require more detailed assessment. Significant challenges in terms of clarifying most viable route	
	• Detailed planning, design and engagement processes required • Significant challenges if route. along Oxford St and Scarborough Beach Rd through Mt Hawthorn - significant changes to streetscapes required. • Question the value of linking into Leederville as access already good.	• Significant redevelopment potential along most routes (such as along Newcastle St) • All routes provide benefits to inner ring. • Option Z aligns best with the Integrated Transport Plan under development. • The Beaufort St proposal – potential to adapt from bus lanes • The Charles St proposal OK as road reserve width provides more potential.
Stirling	Scarborough Beach Road – Very high level of readiness	
	• Some land acquisitions identified to widen parts of the Scarborough Beach Rd. • Further detailed design.	• Stirling have undertaken significant preparation work for transit along Scarborough Beach Rd. • Some develop proposal already occurring along the route. • High level cost estimates undertake for various types of road treatment and public realm condition – This provides order of magnitude costs.

Table 5.3 Consortium Partners Challenges and Opportunities Summaries

5.4 Cross Sections, Indicative Costs and Funding Opportunities

There were three other important insights that came out the engagement with the Consortium Partners. These are discussed briefly below

5.4.1 Cross Sections

One of the things that came out of the meetings was the need to consider cost and construction impacts of various running ways. A number of road cross sections were drawn up to provide an understanding of corridor impacts and requirements and to assist in discussions of the implications of the various running ways – either centre running or curb side and how these may impact property access, service relocations and land requirements of route sections. Appendix 5 provides a suite of possible cross sections that can be used as the basis of for further consideration and assessment.

5.4.2 Implementation Indicative Cost Estimates

One of the uncertainties associated with this high-level investigation is establishing a level of cost estimate for implementation – even if only at a 'ball park' level. The main unknown relates to civil works, services relocations and amenity upgrades that will be required to realise the value creation potential of a second-tier transit system (in this case a Trackless Tram system).

The qualitative assessment of implementation challenges and opportunities documented above – (see Section 5.3) has highlighted that there will be very different implication and therefore costs depending upon the existing conditions and type of built environment within any section of the route.

To help establish a 'ball park' level of cost 'guestimation' we are able to use estimates that City of Stirling have provided of some typical road section cost estimates based on a clear set of assumptions and professional cost estimations – for works undertaken to implement bus ways and basis for estimates of works for Scarborough Beach Road.. Further, these where cross compared against the implementation cost of the Cecil Ave civil works being undertaken by the City of Canning – where high end amenity treatments are being delivered to provide for a bus way.

Outlined in Appendix 6 are a set of assumptions and calculations which suggest that:

- Cost of rolling stock and stations would be in the order $4.87 million per km (based of supplier costs and our own estimates)
- The cost of civil works, landscaping and power and service relocations and minor land assembly requirements across the whole route would be $19.2 million per km
- This leads to a 'ball park' estimate that the Trackless Tram – may have an average capital cost in the order of $25 m per km
- Thus this guestimate suggests the project cost for a 30 km route is in the order of $750m.

Even if this estimate is out by 50% - and the cost come in at between $37.5 per km or $1,125m - it still represents a substantive saving over an equivalent light rail systems at $80 million per km for the proposed Max Light Rail or $2.4b or at Sydney Light Rail costs of $175m per km or $5.2b.

5.4.3 Possible Funding Mechanisms – an example of local government funding

A key challenge in taking a city infrastructure project from concept to implementation is identifying the appropriate funding mechanism. This Study is building on the model set out in the report – 'Delivering Integrated Transit, Land Development and Finance: a Guide and Manual with application to Trackless Trams' (see https://sbenrc.com.au/research-programs/1-55/). That report evaluated the

range of funding opportunities from fully private to fully government. Further, it proposed the need for partnership models established under a City Deal framework. At its core these processes aim to bring together the 3 levels of government, with business and community to develop strategies for delivering positive urban change – in this case the implementation of Trackless Tram Systems.

The Overview document sets out a funding model based on Recovery funding from government (Federal and State paying for vehicles and developers paying for station precincts as part of their development of the whole sites around the station entrances which sometimes maybe inside buildings or even on both sides of a road). The concept set out below shows how the projects could be funded by local governments themselves – also in partnership with developers.

This proposal has been developed from one of the Consortium Partners are primarily local – the City of Canning – who have readied themselves for the Trackless Tram and the associated urban regeneration as part of the Canning City Centre Regeneration Program.

The City of Canning has commenced a ten year - $76 million public realm and infrastructure works program (see Figure 5.4). The Program aims to build the amenity and liveability required to attract further private and public support and investment needed to fully realise the urban regeneration vision. The first phase of the Regeneration Program is the upgrading of the main street of the Canning City Centre – Cecil Avenue with high quality public realm and widening it to accommodate priority bus lanes, which can ultimately provide space for the implementation of a Trackless Tram Systems.

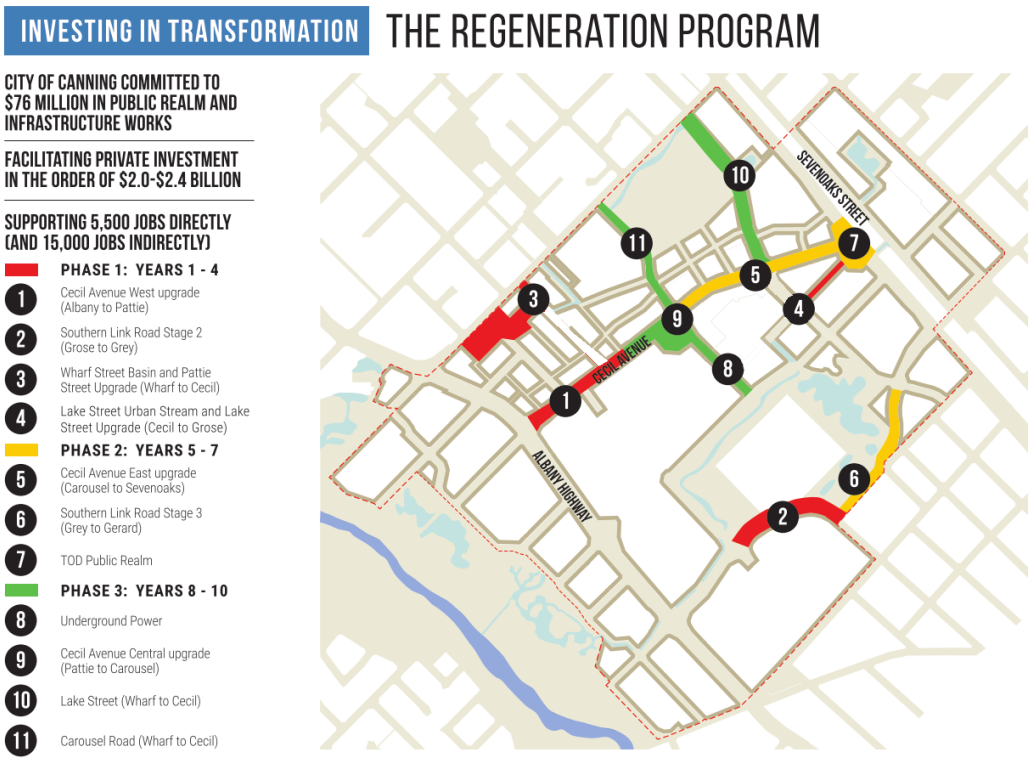


Figure 5.4 Canning City Centre Urban Regeneration

The key mechanism in this funding model has been the establishment of a rates guarantee model (similar to the tax increment models used in the United States[31]). The model is based on the following key elements:

- The program is funded without using any of the existing rate base. Only additional rates income generated through new development within the city centre zone from a specified date (1 July 2017) is being used to fund the regeneration program.
- The City has also shifted to a differential rating model which leverages additional rates from commercial property as compared to residential land.
- Income from the sale of any City owned land within the Canning City Centre is used to support the program.
- External contributions and grants are utilised to reduce the cost to the City (which are attracted because of the 'shovel ready' nature of the program of forward works program).
- Where required debt is used fund the major program of works and rates from the new developments within the city centre are used to pay the debt. Further, to minimise the interest payments a 'liquidity facility' has been established which helps provide the flexibility required to manage the ups and downs of delivering a capital works program of this scale. This effectively means that interests on loans is only paid on the exact amount of loans needed as each year of the capital works program as it is delivered.
- The timing of the cash inflows and outflows is matched, such that the capital program does not affect the City's existing budget allocations that are used for the remainder of the Council works programs across the rest of the municipality.

This model of rate quarantining represents an important example of how to contribute local funding to the civil works and amenity building that will go alongside the delivery of Trackless Tram systems.

5.5 Trial of Trackless Trams in Perth

Since the inception of the Trackless Tram project there has been an obvious need to independently evaluate the range of technologies and the associated land-use that could be combined to constitute a holistic mobility ecosystem. From a technical perspective some vehicle configurations and combinations, energy and guidance systems are well tested in commercial operations, whilst others are currently operational in only a limited environment, for example on a relatively short and level route or without network integration. In most of our discussions in Perth and in the 20 or so cities where our team has been asked to present, there is widespread interest and many questions, but always we end with the need for some on the ground testing.

The focus of our research work has been to identify and evaluate emerging technologies and to provide independent advice and support to those planning, developing and servicing our cities. Our work has resulted in other jurisdictions being interested in participating in a trial of emerging transit technologies and vehicle types and this could be coordinated through Perth. An investment and commitment to a trial of approximately $2m will assist to position Australia as a leader in this field whilst also providing 18 direct and 74 indirect jobs immediately.

As made clear at our Perth Consortium inception meeting and in communications regarding the SBEnrc 1.62 project, the trial is a discrete project that is not funded through the SBEnrc nor the Consortium contributions. The project has been being collaborating with Curtin, Department of Transport, vehicle manufacturers, network operators and private sector engineering firms and working closely with the RAC to scope the trial. To date there has been approximately $0.5m invested to bring the trial to

[31] See: 'Delivering Integrated Transit, Land Development and Finance: A Guide and Manual with application to Trackless Trams' Project webpage: http://sbenrc.com.au/research-programs/1-55/

fruition. This has delivered the preparatory stage that includes the project scoping and cost estimation, industry and government engagement and a study tour conducted to assess technology availability and maturity and system design and urban integration. These inputs have assisted in the development of a trial site plan, trial scoping and cost estimation, and a systems requirements and technical specifications framework that is required to approach the market.

With the trial readiness phase nearing completion, we need to formalize the project partnerships needed for implementation including project governance and funding. Several manufacturers of Trackless Trams have agreed to provide their vehicles for testing in Perth but they need to be brought here at our cost, by ship. The RAC are keen to participate as part of their on-going commitment to better understand the next phase of electro-mobility and autonomous vehicles. They would be part of the team and if some funding can be found they help with the testing at their facility on the airport grounds where it is possible to test vehicles not yet approved to run on public roads.

There are three additional drivers that will help the planning of a systems trial:

1. Discussions with manufacturers and industry have identified the opportunities for mutually beneficial relationships that would enable access to vehicles for evaluation purposes. The evaluation process would provide:
    a. Compliance testing and assist with certification
    b. Community and client vehicle familiarization
    c. Vehicle specifications and performance data
    d. Infrastructure requirements - inclusive of ITS, energy, pavement, stations and depots.

    There is an opportunity through upcoming international conferences to raise the profile of the initiative and enable suppliers to leverage additional benefits from Australian based trials.

    Building upon the world-leading work of the RAC and within the context of the broader electro mobility ecosystem feeder vehicles and the integration of micro mobility and last mile freight, these matters can be evaluated in tandem to assess their potential to provide first and last mile connectivity and a functional mobility service.
2. New Zealand has several cities assessing options for high priority transit routes. Following presentation and meetings with the New Zealand government there is an opportunity and potential for collaboration and an expressed interest to contribute to the technology trial in Perth.
3. There is a suite of complementary research and funding initiatives underway and proposed, including CRC Future Battery Industries, CRC RACE and iMove. All State agencies have some initiatives in the renewable energy and electro mobility field. Our engagement with them has identified the need for a coordinated leadership.

The provision of electro-mobility services are undergoing significant change and this brings with it opportunity, risk and complexity. To assist government, the private sector and society as a whole to identify, assess and plan for transition requires integration across 5 inter-related areas:

1. Place creation, route design and sense of permanence
2. Vehicle, pavement and systems technology.
3. Policy and regulatory frameworks
4. Funding mechanisms
5. Transition and systems change management.

For us, this means we need to rapidly conduct a trial that can set out the core objectives and answer questions needed to progress development proposals. A detailed set of technical questions has been developed.

The broader issues of how to establish electro-mobility in Perth and beyond into regions will be pursued in a cross-departmental stakeholder workshop on July 2nd run by Department of Transport.

5.6 Proposal for Trackless Trams in Perth

The project sets out the following options that could be adopted to bring a Trackless Tram system into Perth. The first option is a small step that could begin immediately in Central Perth with a leg to Morley. The second option is the Perth consortium concept over 30 km which has very detailed planning and costing. The third option is 112km across Perth taking a number of East-West routes to complement METRONET. The details are not complete as in Option 2 but are around three times the costs and jobs created.

5.6.1 Option 1 - Perth Central to Morley

Figure 5.5 shows how a Trackless Tram route could be part of a project that removes central city buses on a number of routes and provides a much faster and higher capacity system linking the three main central interchange points of the Vic Park Interchange, the Elizabeth Quay busport and the Central busport. It then goes out to Morley so that a major missing link in mid-tier transit can be filled and joins Morley Shopping Centre to the new Ellenbrook Rail line.

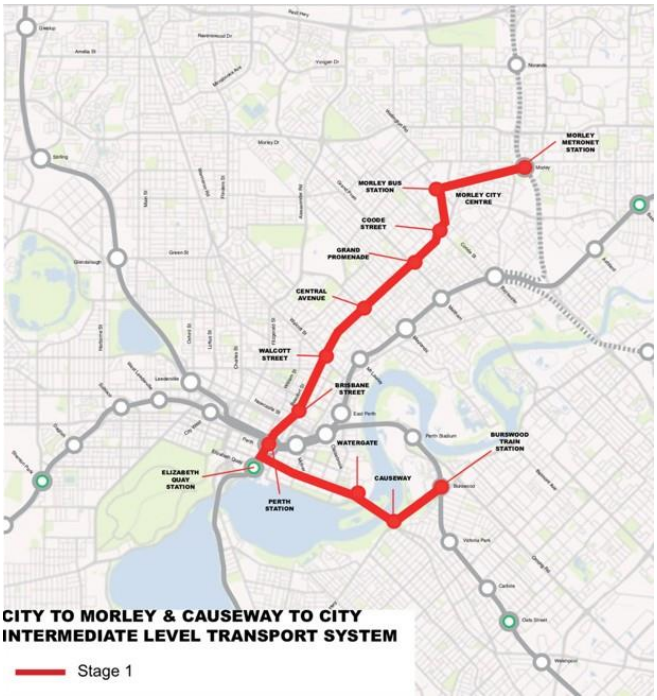


Figure 5.5. Option 1 Central Perth and Morley

This would require 25 Trackless Trams at a cost of $108m ($4.33m per 3 car set). The cost of establishing a trial here in Perth would add another $2m (more detail in Core Document). Total $110m. This would not include any work needed on the road surface or traffic lights which will require a detailed Master Plan. Savings of around $33m per year are anticipated from the rationalization of 28 buses in the city, 17 are fully saved (drivers transferred to TT's) and 11 can be redeployed. Thus the project would pay for itself in three years.

5.6.2 Option 2 - Cannington-Scarborough

Figure 5.6 sets out the route that has been determined by the Perth consortium through a series of detailed workshops and research over the past three years. It shows the potential urban development that is likely to happen in the period to 2031 along the Transit Activated Corridor.

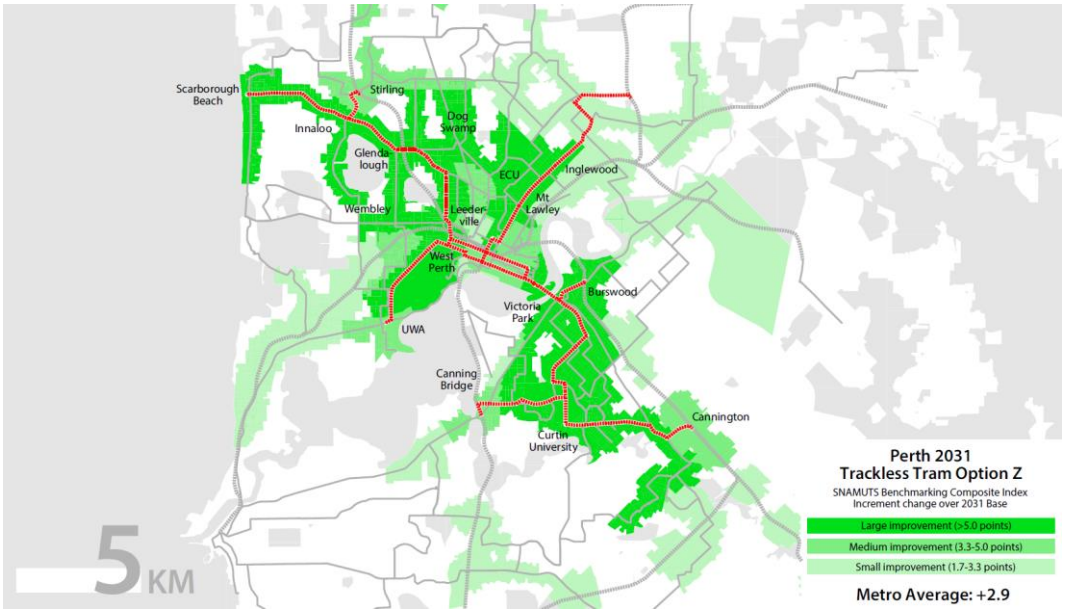


Figure 5.6 Trackless Tram from Cannington to Scarborough. This corridor route includes the Morley route as well as extensions to Canning Bridge, Burswood (for events) and Stirling City.

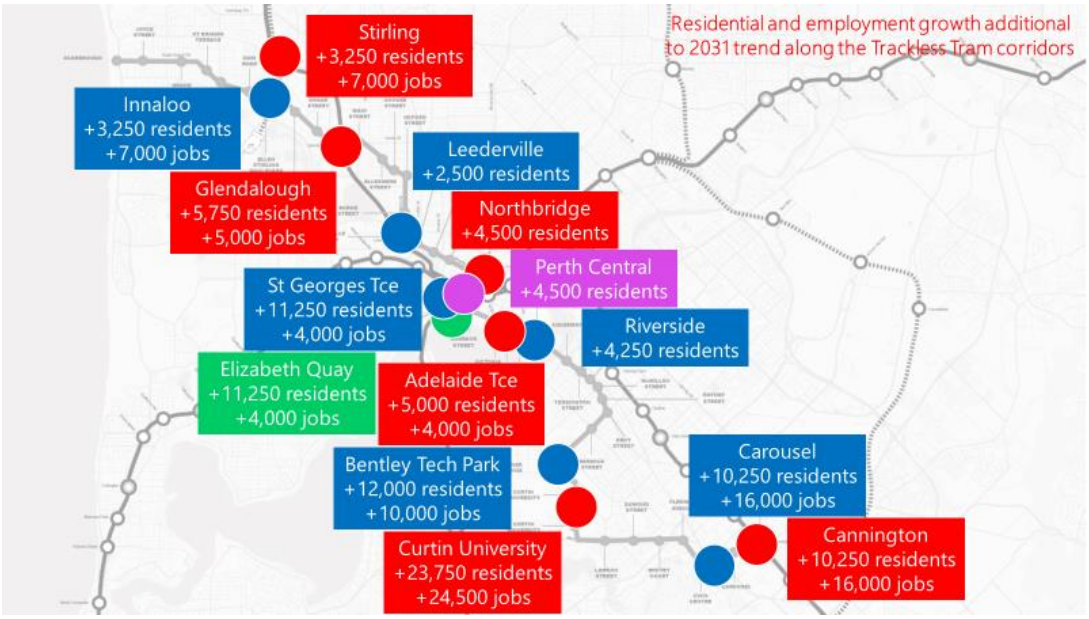


Figure 5.7 Redevelopment potential along Scarborough to Cannington corridor.

Redevelopment along this corridor has been assessed with the local governments, developers and communities. Thus estimates of the development potential and how much more can be unlocked through the Trackless Tram have been estimated.

Urban development is the fastest way to create new jobs with each new housing unit creating 7 jobs immediately, 3 direct and 4 indirect in the broader economy. Another way to see the economic value is that for every $1 million spent on construction there are 9 jobs created directly and 37 jobs created in the broader community (Kemp, 2020).

The magic of a Trackless Tram system along a corridor like this is that it will increase urban land value by 20% for residential and 50% for commercial properties (Mcintosh et al, 2015). This can be shown to increase land values along the TAC from around $19.8b to around $33.4b. This increase of $13.6b enables the city to gain development where it is critically needed and can have a substantial proportion of affordable and social housing as well so that the city progresses equitably and with a balanced workforce enabled to live within the area. The costs of development have been estimated based on the value of land in the station precincts before the value increase.

	Public Investment In Vehicles, Recharge and Depot facilities ($4.33m/km)[32] Roadworks ($19.2m/km)[33]	**Private Investment** Station precincts with 200m of road around it ($6m each precinct)[34]	**Private Investment in Land and Jobs Created** From land development, (est value of land; with 9/37 jobs per $1m)[35]
Cannington to Scarborough TTS (including Option 1) 30 kms	Stage 1: Vehicles $130m Stage 2: Roadworks $576m	30 station precincts $180m	$19.8b with 178,000 jobs directly and 732,600 jobs indirectly over 10 years, 10% per year so 17,800 direct and 73,260 indirect.
Whole of Perth Metro TTS (including Option 1 and 2) 112 kms	Stage 1: Vehicles $485m Stage 2: Roadworks $2.150b	112 station precincts $672m	Not researched but likely to be three times above.

This project has focussed on the Cannington to Scarborough corridor but as public discussions have happened over the past three years other projects have been proposed with similar goals. Together these projects suggest a bigger picture emerging for Perth's mid-tier transit and urban regeneration potential.

5.6.3 Option 3

The biggest change has been to take the same concept of going largely East-West to enable the North-South METRONET corridors to work better:

[32] See Core Report for details of vehicle costs and extra costs of fitting out recharge elements at stations and in Depots.

[33] See Core Report for estimate of roadworks for TransitWay

[34] Based on 100m either side of station precinct with estimated roadworks costs of $19.2m per km (see Core Report for details of this)

[35] Jobs estimated at 9 direct and 37 indirect by Kemp (2020) and same as those used by Property Council, UDIA and Master Builders. Land value before Trackless Tram improved value has been used to estimate investment.

1. KARRINYUP-MORLEY: From North Beach to Karrinyup Shopping Centre to Karrinyup Station then linking the new Morley station on the Ellenbrook line to Morley Shopping Centre and then down Beaufort Street to Perth as in Figure 5.5.
2. HILLARYS-GREENWOOD-KINGSWAY: From the Hillarys Marina to Greenwood station then to Wanneroo Road Kingsway Shopping Centre.
3. CANNINGTON-SCARBOROUGH: as in Figure 5.6
4. FREMANTLE-ARMADALE: South Street to Murdoch Station then on to Randford Road and Armadale Road to Armadale.
5. ROCKINGHAM: From the station to Read Street Shopping centre to the Rockingham Beach Area.
6. MANDURAH: Station to Mandurah Waterfront.

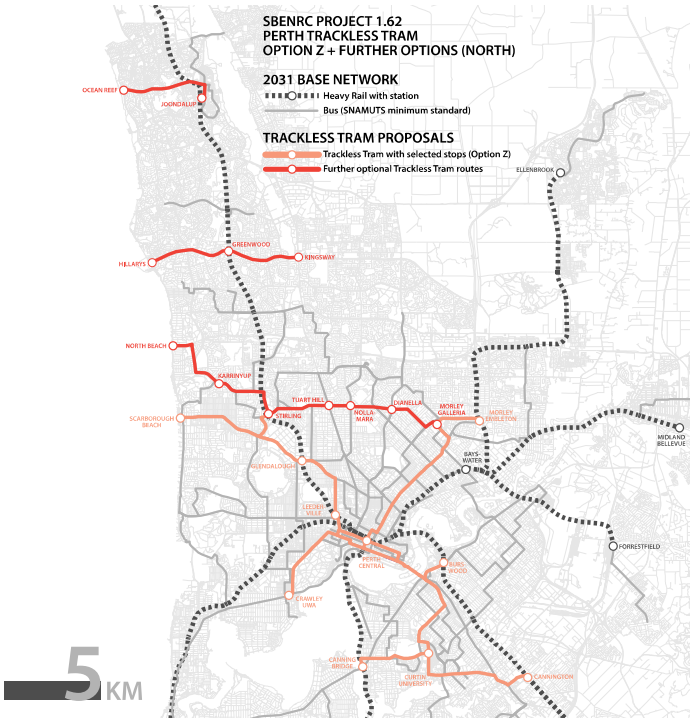


Figure 5.8a Potential Trackless Tram routes and Transit Activated Corridors across Perth

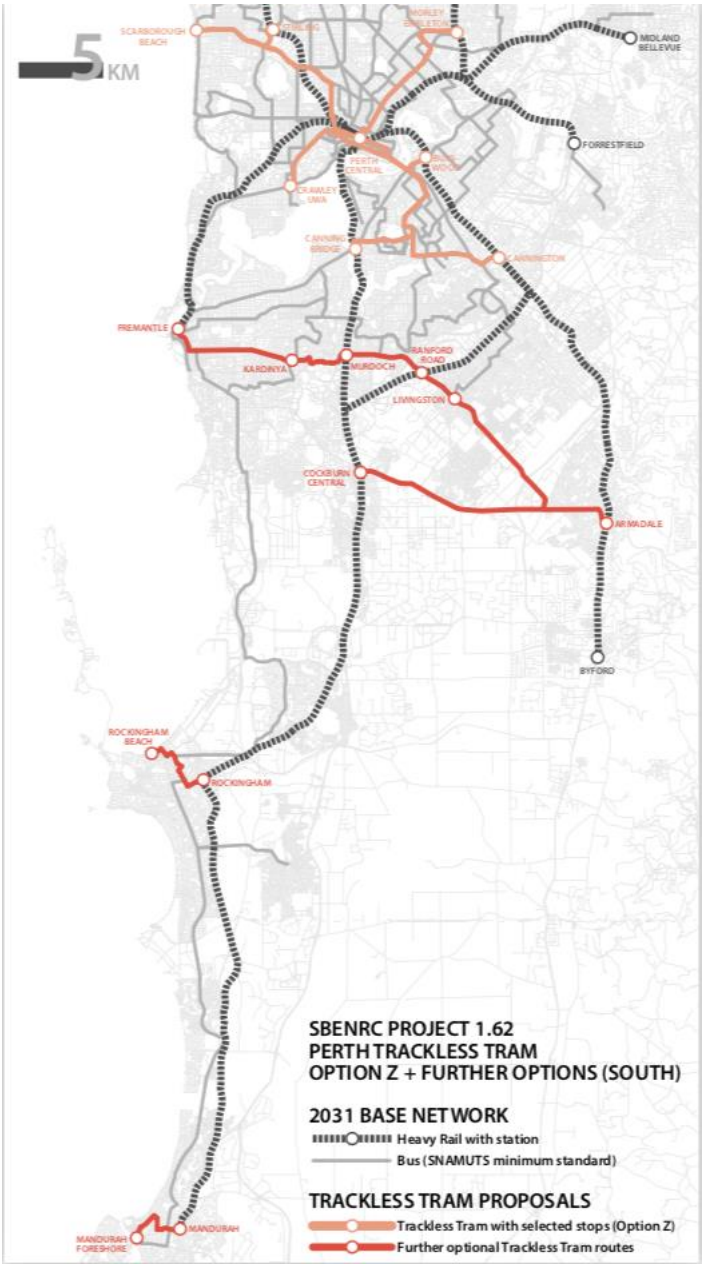


Figure 5.8b Potential Trackless Tram routes and Transit Activated Corridors across Perth

Figure 5.8 a & b shows the East-West links across the North-South corridors linking into MetroNet at various key points and with major urban development opportunities along each route. The urban development potential yield will be less the further out that the projects go. The total package enables a much more significant ability to create a better transit system and a more consolidated city with effective local town centres that can become the core of 21st century home and office development in Perth.

The key point about this project's applicability to any city, but especially to Perth, in a time of economic rebuilding, is that it lends itself to a full set of partnerships and can be delivered quickly and in stages.

Details of the project in terms of its economic value, community and environmental value, its alignment with government policy and stakeholder support, its deliverability, feasibility and risk, are set out below. Details can be pursued in the accompanying Core Report document.

5.7 The Project Benefits

5.7.1 Economics –

Economic Benefits Including Jobs, Capital Value, Innovation

The economic benefits of the Cannington to Scarborough TTS and the whole Perth TTS project are set out in Table 1. These show the immediate benefits in terms of investment and jobs from the land development associated with the Trackless Tram, and then over a ten-year period.

The innovation is that:

- It can fit into the present system quite simply (for example its relatively straight forward to fix the roads in preparation for a TTS, but even more easy to follow the TTS on the Main Roads Command Centre to monitor the services, and also Depots where buses will be stored at night, though a recharge point will be needed for each vehicle);
- It will bring smart city sensors into transit systems in a way that will need to be applied to all aspects of transport into the future;
- It will enable Perth to be a demonstration of how the very high take-up of roof top solar can be applied to new station precincts and depot roof tops, and enable the grid to be stabilized through battery-based Recharge Hubs earning money for the operator.
- By being the first western city to adopt this new transit technology (after a trial conducted with the RAC – see below and in a section in Core Document) cities around the world will be coming to Perth to view the new system and professional jobs in the area will be created to service other cities.
- Perth can manufacture the TTS here and thus create further jobs and enable us to extend the innovations as we learn how best to make the system work here.

5.7.2 Community and Environment –

Net Community Benefit Including For Example Social and Affordable Housing and Environmental Sustainability

The community and environmental benefits will include:

- The provision of *Localised Centres* in each Station Precinct with local shops, local services, local place features, that enable the surrounding areas from each station catchment to have a place to walk to, to take micro-mobility (bikes, scooters, skateboards) and provides a meeting place for community activities.
- A local *Recharge Hub* for any electric vehicle, large and small, and perhaps a local *Delivery Hub* for on-line shopping parcels – see section in Core Paper.
- *Affordable and Social Housing* in partnership between the developer and the Housing Authority which will vary with the location (eg some stations have substantial government land).
- *Consolidated Housing* benefits compared to fringe housing developments, with around $100,000 savings per residential housing unit from infrastructure, $50,000 savings per housing unit in travel times per year, and $80,000 per housing unit in health benefits due to making more active lifestyles in walkable urban environments (Trubka et al, 2015).
- *Climate change emissions reductions* of around 2 Tonnes per capita per year as the more urban/inner city quality of housing and transport is 33% less in greenhouse gases. These can be reduced to net zero emissions if the developer chooses to make net zero housing and all

the transport becomes electric with solar recharge (Thomson and Newman, 2018). This is expanded in the Core Document.

5.7.3 Government –

Aligns To Government Policy Objectives

The State Government's METRONET policy is to build a modern electric train system with associated METRONET Hubs around stations. This is a $7b project with seven new rail lines and a large number of Hubs. The Perth TTS project is a complementary project to METRONET, it builds on the North-South alignments of most of the seven new rail lines by connecting to key stations and drawing in key centres. For example:

- Along the Cannington to Scarborough TTS line Curtin University and Osbourne Park, two of the largest employment and activity centres in Perth, are linked into the city centre and to several METRONET stations as well as a major beach resort area.
- Along the Morley to North Beach TTS line two major shopping and employment centres of Karrinyup and Morley are linked in to the Northern Suburbs line and the Ellenbrook line.
- Along from Hillarys (a major tourist destination) to Greenwood station and then to Kingsway shopping centre.
- Along the Fremantle to Armadale TTS line the major activity centres of Fremantle, Murdoch and Armadale are joined to four METRONET lines at Fremantle, Murdoch, Ranford Road (new Thornlie-Cockburn station) and Armadale.
- Along the Rockingham TTS line the Southern Rail line is linked through Rockingham Shopping Centre to the Rockingham foreshore activity area.
- Along the Mandurah TTS line the Southern Railway is linked to the Mandurah foreshore activity area.

As outlined in section 3 on Strategic Planning for Perth, the Perth and Peel Plan, the Perth Transport Strategy and Movement and Place Strategy are all consistent with this Perth TTS project.

Most of the local governments associated with these lines have been lobbying for this kind of connection and development-unlocking mid-tier transit opportunity. They have all expressed strong support in seminars and meetings.

The Federal Government have been spoken to through several meetings with Ministers and Departments under the various City Deals being developed in Townsville, Sydney, Melbourne, Hobart, Adelaide and Perth – all of which have Trackless Trams at one level of commitment or another. The meetings all expressed considerable interest and confirmed that the work in Perth (through Curtin) was the most advanced. Brisbane's new electric-bus Metro is a mid-tier transit system with most of the character we have outlined above, but has not been as closely linked to urban development. This proposal follows the City Deal approach of developing partnerships with innovation, sustainability and affordable housing outcomes.

5.7.4 Stakeholders –

Stakeholder Support, Views Are Known Or Can Be Ascertained In An Expedited Manner

Stakeholder meetings have been regularly held over the past three years with the Perth Consortium group at Curtin University, led by Ian Callahan, Deputy Vice Chancellor Resources.

Throughout the project a range of processes were used to identify stakeholder perspectives around the notion of mid-tier transit (using the Trackless Tram as the example being tested). Table 2 summarises the perspectives drawn from a range of processes including:

- the Consortium and Stakeholder Risk Workshop in January 2019
- the Consortium and Stakeholder Workshop October 2020 – On Scarborough to Cannington Activated Corridor
- a range of dialogues and meetings with consortium members and stakeholders.

Stakeholder perspectives are outlined on a range of topics associated with land development, governance to high level implementation issues. These are set out in section 5.1.

5.7.5 Deliverability –

Project Complexity and Speed of Delivery E.G. Benefits Will Be Realised In the Short to Medium Term with Appropriate Management of Risk and Opportunities

It is imagined that the following stages could be used in its delivery.

- Step 1. Immediate road works can begin to enable the TTS to be fitted into the main roads at designated station precincts for a peak time TransitWay along the Cannington to Scarborough route; some of these roadworks have been planned for a number of years, eg in Stirling. Trial of Trackless Trams can begin immediately with RAC as set out in the Core Document. Procurement of the TTS and of the urban developments associated with the TAC can be conducted in parallel along with community engagement to ensure detailed local place issues are part of the final plan.
- Step 2. Within 18 months the TTS can be running and the urban developments will have begun to be built along Cannington to Scarborough.
- Step 3. Bids should be conducted within the first year for which of the other stages in the overall plan should be done next. The partnerships will be able to build on the experience of the first project.
- Step 4. Full city TTS system with urban regeneration along six TACs completed within 3 years.

5.7.6 Feasibility –

Feasible Proposal Eg Demand Is Evidenced, Supply Factors Mitigated, Proof Of Funding and Shovel Ready

The project is feasible as it builds on:

- The experience of Main Roads and the Public Transport Authority on how to make a main road service both cars and buses (but adds an extra dimension of an electric service with much bigger potential for fulfilling the Movement and Place Strategy due to the urban regeneration around stations).
- It builds on the PTA Depots and MRWA Command Control Centre.
- It builds on the strong support of UDIA, Property Council and Master Builders Association who in co-ordinating the response of developers can see the need for such a TTS project in the Recovery, and believe that investors are ready to work on the various urban development sites along such routes.

The project can deliver shovel ready roadworks and urban development projects along the routes.

5.7.7 Risk –

Probity can be assured – addressed in assessment process.

The major risk in the project is the need to test the Trackless Tram before it is allowed on public roads. The TTS contains various innovations that have not been design standards in Australia but they are simple to demonstrate as being safe, like having a driver's seat in the middle at both ends like a train, so that they are bi-directional, when the ADR says they must be on the right side alone. A number of companies have agreed to provide for free a test vehicle to be trialled. Thus Curtin has established with the RAC and the State Government Department of Transport, a process to test the TTS at the RAC test facility on airport land in Bentley, and enable all regulations to be cleared. A similar exercise was done with the RAC and Curtin's autonomous buses that were very popular with the public in recent years but were in fact on trial. This trial needs $2m to bring the Trackless Trams to Perth and to establish and run the trials. This would need to be part of the funding considerations from government but could also be sought from NAB or Macquarie Bank who have both expressed interest and could perhaps provide the funds for the trial in exchange for advertising rights on the sides of the vehicles. The government would be given first rights to this as part of the trial.

5.8 THE PROJECT OPPORTUNITY

The Perth Trackless Tram System project is a remarkable opportunity to provide a Recovery project which can begin immediately and with great public excitement. The arrival of several Trackless Trams in Perth for the Trial (in a matter of weeks) that can be made available for public viewing and riding, will be a chance to show that WA is:

- Up and running in its new economy,
- Looking to the future rather than the past,
- Taking a role as a global leader in innovation.

Within 6 months signs of road works and bid processes will be underway and people being employed on both the transit preparations and the new construction projects.

After 3 years a new transit system that helps make METRONET work better, provides hundreds of new houses and jobs in well located urban centres, and which has enabled thousands of jobs to be created, will be substantially completed.

6 WHAT HAVE WE LEARNT AND NEXT STEPS

This study has built on earlier work with the aim of illustrating that Perth could get significant value from a mid-tier transit system – particularly in the context of revitalising the central sub-region of Perth. The following points summarise the learnings, before a number high priority next steps are outlined.

Urban Planning and Transport Context - The review of planning and transport policy documents and insights gained from the engagement process undertaken as part of this project has highlighted that the density targets within the central subregion cannot be realised without significant changes in urban mobility. A mode shift to a mid-tier transit system is considered an imperative to enable urban regeneration where it is most needed within the inner ring of Perth.

A Solution for the Missing Middle - At present we have a North-South corridor-based city centric heavy rail that serves Perth well and suburban buses that meets the local needs of lower density suburbs, particularly in the East-West corridors that link to the main METRONET lines. The investment in providing 7 new lines in METRONET will make a world-class suburban rail network along the major North-South corridors. However, a Mid-tier transit is needed to link across the East-West corridors and connect to METRONET stations, connect centres and destinations, and most importantly it will help support and attract medium density development. This is especially so within the so-called - missing middle, helping to create vibrant places with excellent mobility – preferably along transit activated corridors. This project builds on a wide range of earlier work which has recognised the need for a mid-tier transit system in Perth – such as Light rail – but implementation cost and disturbance has made this difficult to achieve. The case is put in this report that there is a coalescence of new technologies, such as the TTS, that have the potential to meet this need in a more cost effective and less disruptive way than existing light rail technology.

Breakthrough Technologies - Advances in battery electric vehicle and communications technologies have resulted in new innovation in transport and more cost effective alternatives for the provision of public transport including mid-tier and last mile options. This shift in technology toward electric mobility is part of a bigger journey towards low or zero carbon transport solutions. The study tour attended by a number of partner representatives from the wider project – reported separately[36] – has highlighted that TTS can provide an effective, reliable, implementable mid-tier transit system suited to the Perth central sub region. Such a system could be supported by the uptake in micro mobility and active transit for last mile travel. The integration of electro mobility solutions into the urban fabric are an opportunity moving forward and there a range of implications related to energy grid management.

Transit Activated Corridors, Nodes and Places - The wider project of which this is a part, also developed and presented the case for Transit Activated Corridors, Nodes and Places and developed a set of principles and practices[37] to explore how these could be designed. This work has the potential to be now integrated with the work being undertaken on the development of Movement and Place policies and strategies presently being developed.

SNAMUTS Assessment – A detailed assessment of a range of mid-tier transit routes – using the TTS as the potential vehicle – was undertaken using the SNAMUTS model. This assessment has highlighted the potential of integrating such a system into the urban fabric of Perth – demonstrating a range of accessibility improvements across the region. Importantly, it highlighted the significant urban

[36] (See SBEnrc 1.62 - Public Transport Technical Tour – Summary Report https://sbenrc.com.au/research-programs/1-62/).

[37] See SBEnrc 1.62 –Sustainable Centres of Tomorrow: A Precinct Design Framework of Principles and Practices - Report https://sbenrc.com.au/research-programs/1-62/.

development benefits that could arise from such an investment. It also highlighted how bus services could be adjusted to integrate into a new system of this type.

Stakeholder Engagement – A broad process of stakeholder engagements was undertaken as part of the project. This process has highlighted the level of interest in introducing a new mid-tier transit system, as well as highlighting a range of challenges that need to be overcome to introduce a new transit system. None of these challenges are insurmountable and the learning from the engagement process has been around identifying any risks and challenges and identifying ways to move forward.

Implementation Challenges and Opportunities Framework – As the first step in clarifying on-ground challenges of implementation, the project developed a framework to begin that investigation process. This assessment highlighted, at this high level, the parts of the identified route that are easier or more difficult for implementation to occur. The process has also developed a number of potential road cross sections, to illustrate how the system could be accommodated in a number of road environments. The assessment also highlighted the planning readiness and significant development opportunities that could be realised through the implementation of the scheme.

Funding and Preliminary Costs – An example of how local government could contribute to funding is explored and some very high level cost estimates are provided that illustrate the value proposition of this form of transport – providing a very strong argument for more detailed investigations.

6.1 Next Steps

Three new steps will be taken as a result of this work.

6.1.1 Delivering Transit Activated Corridors

The next SBEnrc project in this field aims to help *deliver* the new concept of Transit Activated Corridors (TAC's). Best practice tools and case studies will be identified and integrated into multimedia digital communication package that will be interactive and accessible to industry and government, addressing decision-makers and practitioner needs.

This research will focus on the *delivery of projects* for new TAC's featuring innovations in corridor transit technology and integrated designs for station-precinct urban regeneration and affordable housing, through new tools and new approaches for each stage of the planning, assessment, procurement, engagement and governance these type of projects. To do this it will:

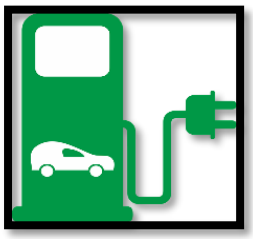
- **Evaluate TAC Case Studies in Different Urban and Regional contexts.** It will show how new TAC's can be delivered to provide greater housing choice and transit opportunities using new assumptions, models and assessment frameworks, in different parts of Australian cities and regional towns.
- **Consider the Best Enabling Frameworks for a TAC Business Case.** It will evaluate how emerging technologies in transit, electric micro-mobility and precinct design fit into new approaches to corridor refurbishment that integrate housing and transit, such as the mobility as service paradigm (MaaS), place and movement (P&M) strategies, and Sustainable Urban Mobility Plans (SUMPS). Assess new planning tools like SNAMUTS, and value uplift modelling, as well as factors such as health and well-being assessments in Cost Benefit Ratios. It will include how new tele-commuting technologies can reduce the need for travel post-Covid.
- **Develop a TAC Tool Box for Professional Development.** New multimedia tools (especially post-Covid) will be used to create communications opportunities for the new corridor and precinct technology assessments, new approaches to corridors, new models, new assessment processes and their detailed elaboration in case studies. They will be made available showing how to deliver better urban outcomes, particularly related to delivering urban regeneration (including how to deliver diverse affordable housing options) and innovative transport technologies.

6.1.2 EMUS -Electro Mobility and Urban Systems

The transformational change associated with the coalescence of technological advancement in energy, transport and communications requires a coordinated approach to adoption of new technology. The next step in the process is the concept of establishing an 'EMUS collaboration' which will provide research and advice to assist governments' transition to new urban mobility.

The proposed EMUS research centre will provide a systems approach to urban mobility and city planning combining new technology, people and place, and governance for the transition.

Technology



This area of research includes vehicle, energy and communications technology. Research will encompass the range of technologies including TT evaluating performance and suitability for varied urban applications and provide a pathway for certification and implementation. Energy systems research will include batteries, charging and storage. It will investigate the integration of micro grids with urban node development to service transport and city requirements and provide network resilience. Vehicle energy systems will also be evaluated including battery types, range and configuration and recharge options. Areas of communications research relevant to the emergent transport ecosystem include mobility as a service MaaS Apps that enable journey and network planning as well as the infrastructure required for vehicle autonomy to support V2V, V2G, signalling, ITS and network management.

People and Place

The potential people and place benefits of the new mobility ecosystem will be demonstrated through a number of case study examples. It will involve the testing and application of alternative partnered delivery models and urban fabrics frameworks. It will utilise models for evaluating route and node configuration and performance to provide guidance on the integration of place and movement and identify development opportunities. These guidelines will be written to provide direction for those procurement urban development projects.

Governance and Transition

A coordinated transition process is required in parallel that supports the delivery and operation of the new mobility ecosystem. Options will be examined with all the stakeholders.

Potential partnerships for future work would also be explored with other states, New Zealand, the private sector and other countries including the US.

The Value Proposition of EMUS

Through a clear and collaborative approach to emerging transport and energy technologies and services, we can enable innovation to flourish and harness this once-in-a-century opportunity to positively transform mobility and urban living.

The proposed EMUS research hub will deliver the following benefits:

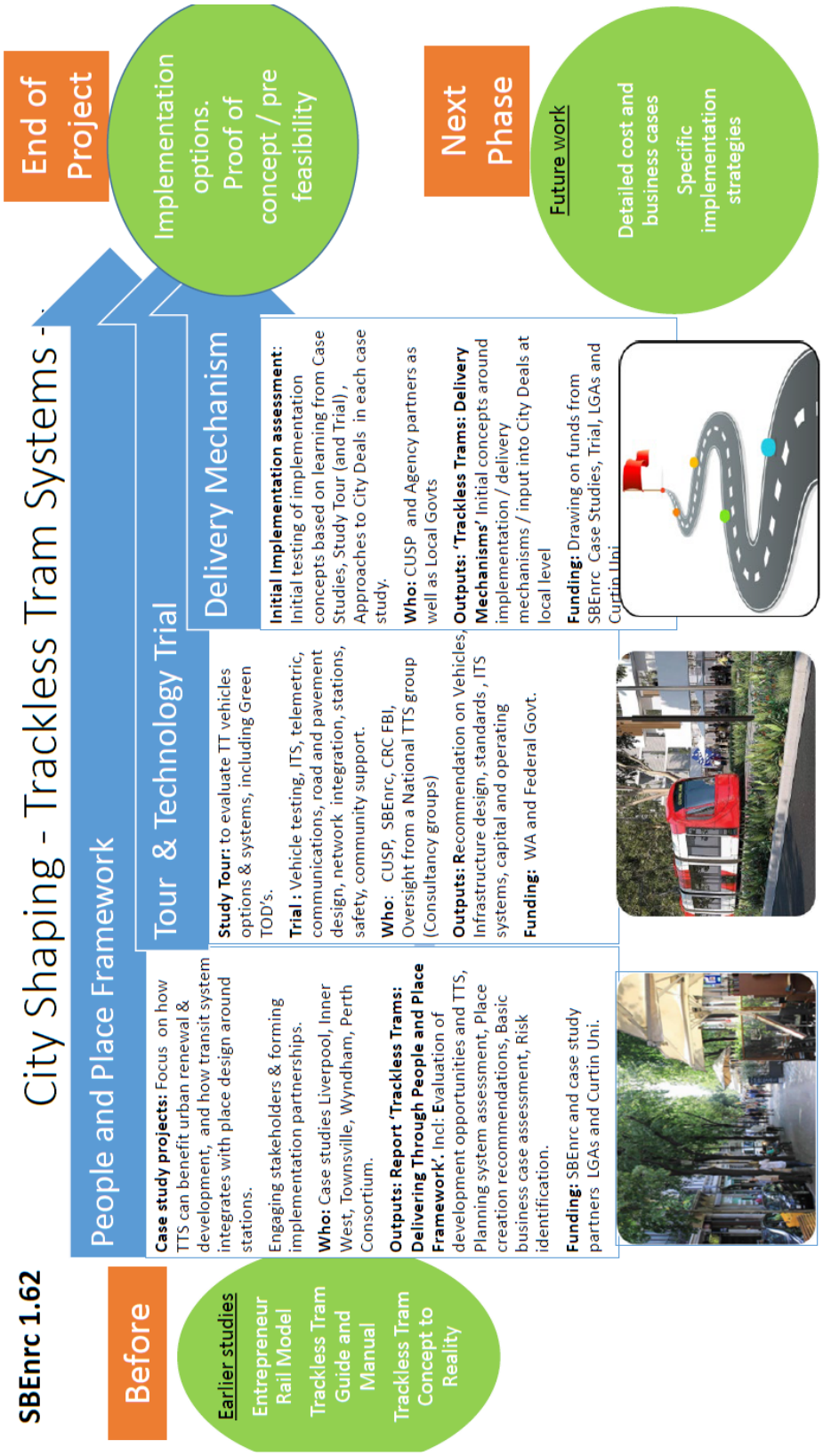
- Assist in the delivery of the demonstration project Canning to Scarborough through government and private sector investment

- Further Australia's knowledge, skills and international presence in research and innovation of sustainable and affordable energy and mobility systems
- Support opportunities for local manufacture and export of vehicles, energy infrastructure and IT systems
- Provide the community-wide knowledge and partnerships required to transition to a more affordable and efficient shared electric mobility ecosystem
- Increase affordable living through the delivery of alternative transport and energy systems
- Demonstrate the viability of private sector investment to support the provision of transport and energy infrastructure
- Build tourism opportunities through trials and via visiting academics, private and government officials who come to see Perth's global innovations in urban development.

6.1.3 Perth Metropolitan Region Trackless Tram System Proposal

In the Overview Report a simple outline of how the TTS across Perth could be adopted has been provided. It found the best six routes requiring East-West connection as well as the Core Report's detailed analysis of the Cannington-Scarborough project. This will be taken to another level and given detailed master planning and assessment analysis. Such work will depend on further funding of the concept.

APPENDIX 1: CITY SHAPING POTENTIAL OF THE TRACKLESS TRAMS



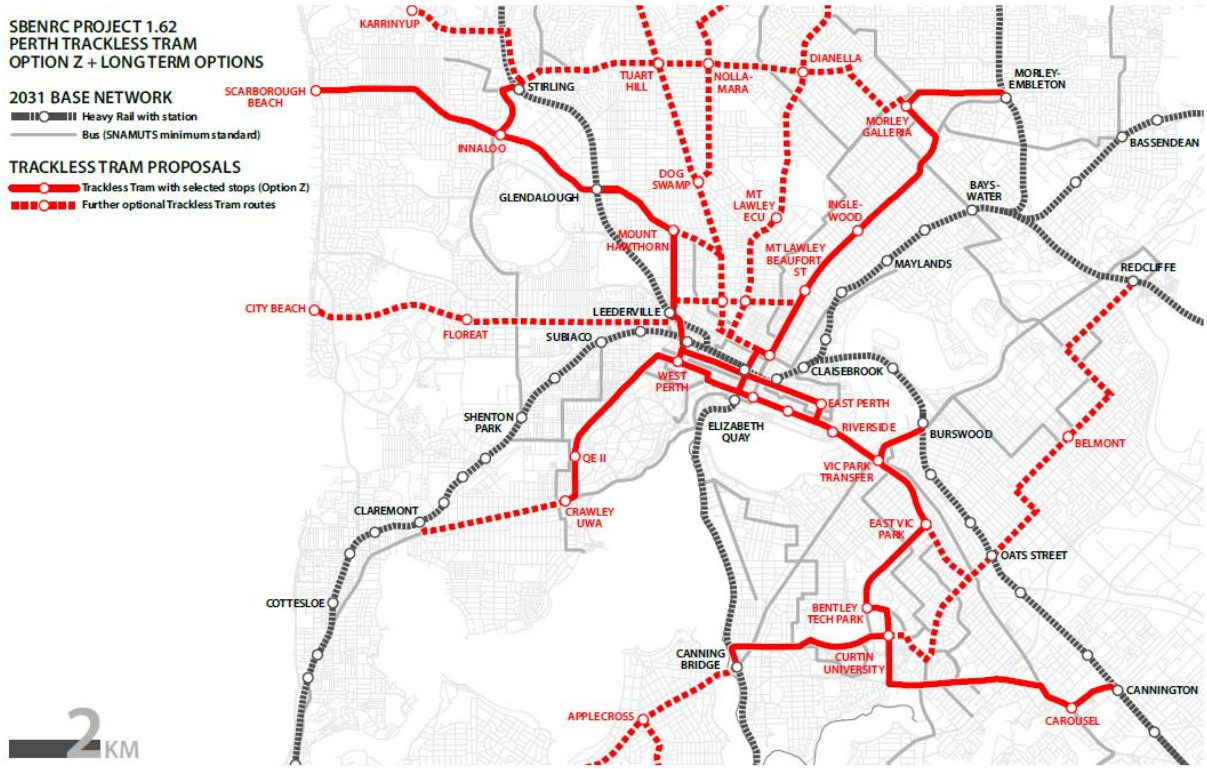
APPENDIX 2: CORE PRACTICES INFORMING THE FRAMEWORK FOR DESIGNING AND IMPLEMENTING CENTRES OF TOMORROW

(Source: See Sbenrc 1.62 – Report 1 … Sustainable Centres Of Tomorrow: A Precinct Design Framework Of Principles And Practices - Report Https://Sbenrc.Com.Au/Research-Programs/1-62/).

Practices informing the principles	Key literature references	References and resources for good practice
1. Precinct safety and accessibility		
• Human centered design	(Gudowsky, Sotoudeh et al., 2017; Russo, Lanzilotti et al., 2018)	Design Kit (IDEO.org)
• Walkable urban design	(Forsyth, 2015; Badland, Mavoa et al., 2017; Litman, 2017)	Pedestrians First (ITDP.org)
• Place and movement design	(Carmona, 2014; Wunderlich, 2017)	Movement and Place Framework (Transport Victoria)
2. Carbon neutral - positive approach		
• Solar passive design	(Horvat and Dubois, 2012; Futcher, Mills et al., 2017)	A focus on Greening our Precincts (Aurecon)
• Solar active design	(Kanters, Wall et al., 2014; Mohajeri, Gudmundsson et al., 2019)	Solar Energy (International Energy Agency)
• Carbon neutral analysis	(Liu, Zhou et al., 2014; Tozer, Klenk et al., 2018)	Carbon Value Analysis Tool (World Resources Institute)
3. Local shared mobility		
• Local mobility design	(Hüging, Glensor et al., 2014; Lyons and Practice., 2018)	Pedestrian Access and Mobility Plan (NSW RTA)
• Feeder transport design	(Cole, Burke et al., 2010; Venter, Jennings et al., 2018)	Principles of Network Planning (Griffith University)
• Mobility as a service	(Hietanen 2014; Jittrapirom, Caiati et al., 2017)	Rise of Mobility as a Service (Deloitte)
4. Property diversity		
• Community engaged planning	(Bose, Horrigan et al., 2014; Konsti-Laakso and Rantala, 2018)	Resources (Internat. Assoc. for Public Participation)
• Agglomeration economy analysis	(Duranton and Kerr 2015; Jin; Gong et al., 2018; Thisse, 2019)	Spatiotemporal Analysis Framework (Jin et al 2018)
• Financial modelling	(Evans, Foord et al., 2007; Mulley, Ma et al., 2016)	Toolkit for rapid economic assessment of cities (ADB)
5. Property affordability		
• Social housing analysis	(Kraatz, Mitchell et al., 2015; Flanagan, Martin et al., 2019)	Conceptual Analysis (AHURI)
• Life cycle assessment	(Lee, Ellingwood et al., 2017; Petit-Boix, Llorach-Massana et al., 2017; Trigaux, Wijnants et al., 2017; Mirabella and Allacker, 2018)	Applied to Urban Fabric Planning (Gabbarell et al, 2015)
• Sustainability operational analysis	(Gunasekaran and Irani, 2014; Yigitcanlar and Kamruzzaman, 2015; Nesticò, Sica et al., 2017; Nijkamp and Perrels, 2018)	Sustainable affordable housing (Wiesel et al, 2012)
6. Nature-loving and biodiverse spaces		
• Biophilic design	(Cabanek, Newman et al., 2017; el-Baghdadi, Desha et al., 2017)	Biophilic Design Initiative (Living-Future.org)
• Water sensitive design	(Seminal: Wong, 2006; Furlong, Dobbie et al., 2019)	Scenario Tool (CRC Water Sensitive Cities)
• Landscape oriented design	(Choi and Seo, 2018; Dennis, Barlow et al., 2018)	Foreground Forum (Inst. of Landscape Architects)
7. Inclusive, integrated, place-based planning		
• Joined up governance analysis	(Keast, 2011; van der Jagt, Elands et al., 2017; Rode, 2019)	A Joined Up Policy Guide (South Aust. Government)
• Partnership analysis	(McAllister, Taylor et al., 2015; Farhat, 2018)	Partnerships Analysis Tool (Vic Health)
• Procurement option analysis	(Grimsey and Lewis, 2017; Hueskes, Verhoest et al., 2017)	National Guideline (Australian Government)

APPENDIX 3: WORKSHOP IDENTIFIED SECONDARY ROUTES

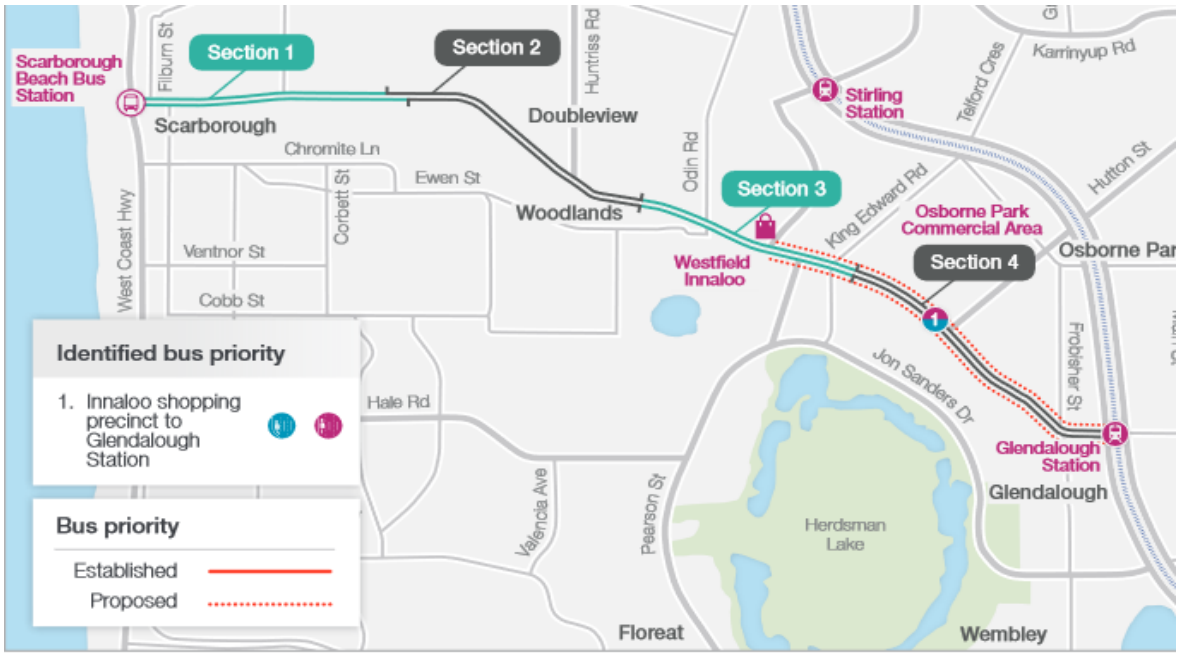
Possible secondary routes identified at Stakeholder Workshop October 2019



APPENDIX 4: PTA CORRIDOR TRANSIT REPORT - STUDY SECTIONS

The following information has been taken from the Public Transport: Major Road Corridor Review 2018 Report prepared by the Public Transport Authority and Transperth.

Scarborough Beach Road



Corridor performance*		Off-peak average journey time	Morning peak average journey time	Afternoon peak average journey time	Daily travel time varability	Daily average bus speed (km/hr)
WEST	Section 1	4:02	4:27	5:02	1:17	23.94
	Section 2	3:09	3:02	3:32	0:41	34.83
	Section 3	4:24	4:47	4:39	1:07	20.12
	Section 4	4:14	4:46	4:40	1:09	29.56
EAST	Section 1	3:35	4:14	3:16	1:03	29.56
	Section 2	2:48	3:39	2:38	0:49	35.43
	Section 3	4:40	4:15	4:46	1:09	20.57
	Section 4	4:35	4:26	5:23	1:11	27.42

Performance indicators*

Commentary

Scarborough Beach Road Corridor is a major arterial road which would greatly benefit from the introduction of bus priority infrastructure. The corridor supports the movement of people and goods to the Innaloo shopping precinct, commercial workplaces, and tourist hub, Scarborough Beach. The corridor experiences heavily congested intersections between the Innaloo shopping precinct and Glendalough Station. This congestion is expected to worsen as density in the area continues to increase. There is an opportunity to implement significant bus priority treatments within the corridor, due to the potential for road widening. A range of options are currently being explored to capitalise on this opportunity.

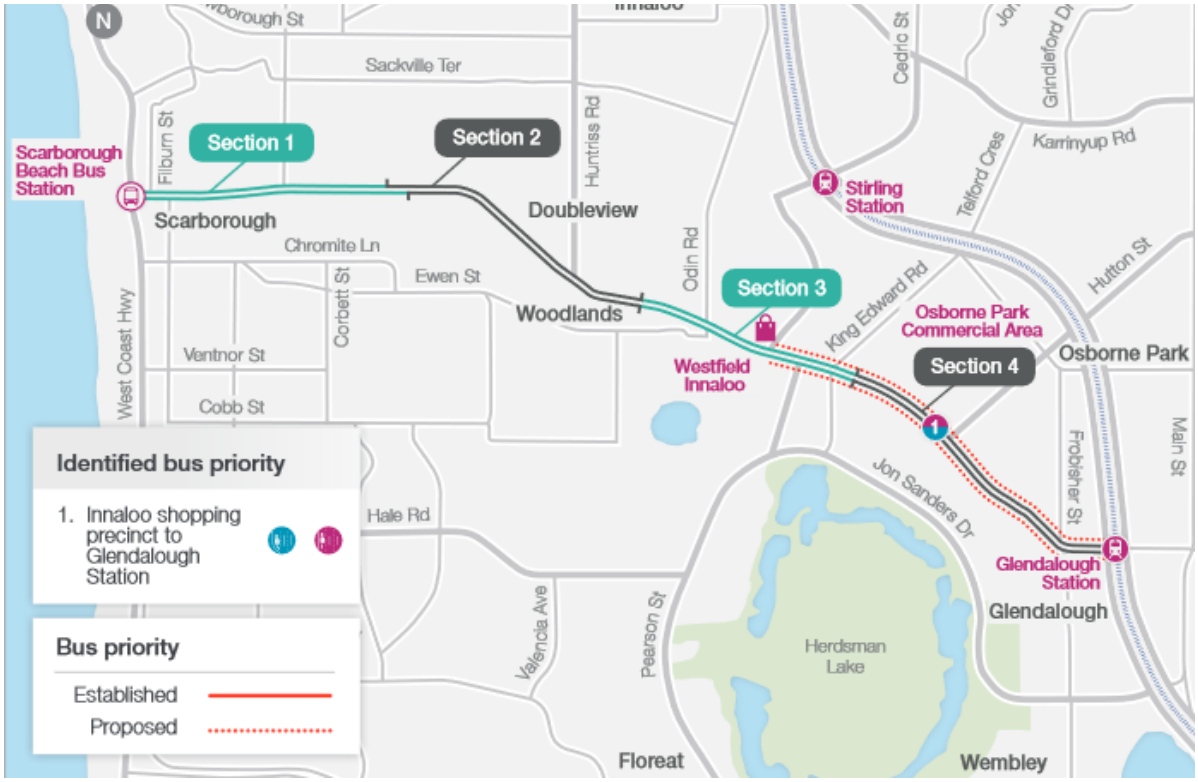
Issues

Bus journey times are negatively affected by a lack of priority at intersections and heavy congestion between Innaloo shopping precinct and Glendalough Station.

Actions

No established bus priority exists within the corridor. However, concepts have been developed for bus priority improvement opportunities across the length of the corrido

Cedric Street



Corridor performance*

		Off-peak average journey time	Morning peak average journey time	Afternoon peak average journey time	Daily travel time varability	Daily average bus speed (km/hr)
WEST	Section 1	4:02	4:27	5:02	1:17	23.94
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	Section 3	4:24	4:47	4:39	1:07	20.12
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EAST	Section 1	3:35	4:14	3:16	1:03	29.56
	Section 2	2:48	3:39	2:38	0:49	35.43
	Section 3	4:40	4:15	4:46	1:09	20.57
	Section 4	4:35	4:26	5:23	1:11	27.42

Performance indicators*

Commentary

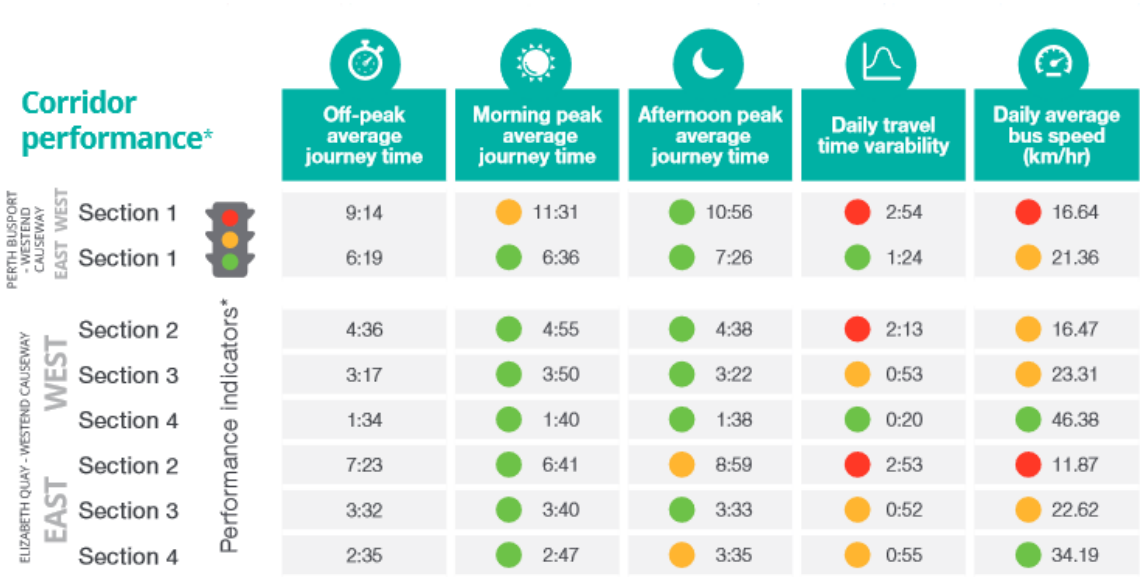
The Karrinyup Road and Cedric Street Corridor is a major transit arterial connecting residential, commercial and industrial areas. The corridor supports the movement of people and goods to the Karrinyup and Innaloo Shopping Centre precincts, and the Mitchell Freeway. A single westbound queue

jump exists on Cedric Street on the approach to Stirling Station. All corridor users would benefit from the introduction of further bus priority infrastructure. However, future bus priority projects must also take into consideration the planned connection of Stephenson Avenue and the Mitchell Freeway.

Issues
Bus journey times are negatively affected by congestion and a lack of signal priority at intersections. Density of the surrounding areas is also increasing, putting further pressure on the corridor.

Actions
No established bus priority exists within the corridor. However, concepts have been developed for bus priority improvement opportunities across the length of the corridor.

Perth CBD South-East Corridor



Commentary

The CBD South-East Corridor is the major arterial corridor connecting eastern suburbs and the civic centres to Perth CBD. The Causeway supports every bus service from the East to access the Perth City, with a small number of buses laying-over at Perth Busport with the majority laying-over at Elizabeth Quay Bus Station via St Georges Terrace. Buses are supported by exclusive bus lanes in both directions on St Georges Terrace between William Street and Barrack Street and then from the West End of the Causeway through to Victoria Park Transfer Station. Bus routes along St Georges Terrace experience the same delays in journey time as general traffic due to intersections being at capacity and the off-peak street side parking. Without additional bus priority measures, buses will continue to experience longer journey times for such a short distance.

Issues

Bus journey times are negatively impacted by a lack of bus lane on St Georges Terrace and Adelaide Terrace, between Barrack Street and Causeway. On-street parking and intersections without signal priority for buses also contribute to increased journey times through this section. Although the area is a clearway during peak periods, congestion from general traffic mitigates any improvement to bus journey times.

Actions

Established busway between Victoria Park Transfer Station and the western end of Causeway. Full-time bus lanes in both directions on St Georges Terrace between William and Barrack streets.

Perth CBD North-East Road Corridor

Corridor performance*		Off-peak average journey time	Morning peak average journey time	Afternoon peak average journey time	Daily travel time varability	Daily average bus speed (km/hr)
NORTH	Section 1	4:52	6:05	5:30	1:54	12.82
	Section 2	2:04	2:12	2:00	0:45	7.12
SOUTH	Section 1	4:47	4:34	6:21	1:37	13.00
	Section 2	2:19	2:30	3:43	1:11	8.30

Performance indicators*

Commentary

The CBD North-East Road Corridor connects vital civic centres and supports bus through-routes from the Beaufort Street Corridor. The majority of buses operate between Wellington and William Streets, and Elizabeth Quay Bus Station. The 950 bus service, a high-frequency 'super' bus route, is then through-routed to the CBD Western Corridor via Mounts Bay Road. Buses are supported by a northbound bus-only right turn from William Street onto Wellington Street, and a southbound bus-only right turn from William Street onto Mounts Bay Road. However, bus journeys are negatively affected by heavy congestion, low average speeds and intersections without signal priority. Without further bus priority treatments in this corridor, buses will continue to experience lengthy journey times over what is a relatively short distance.

Issues

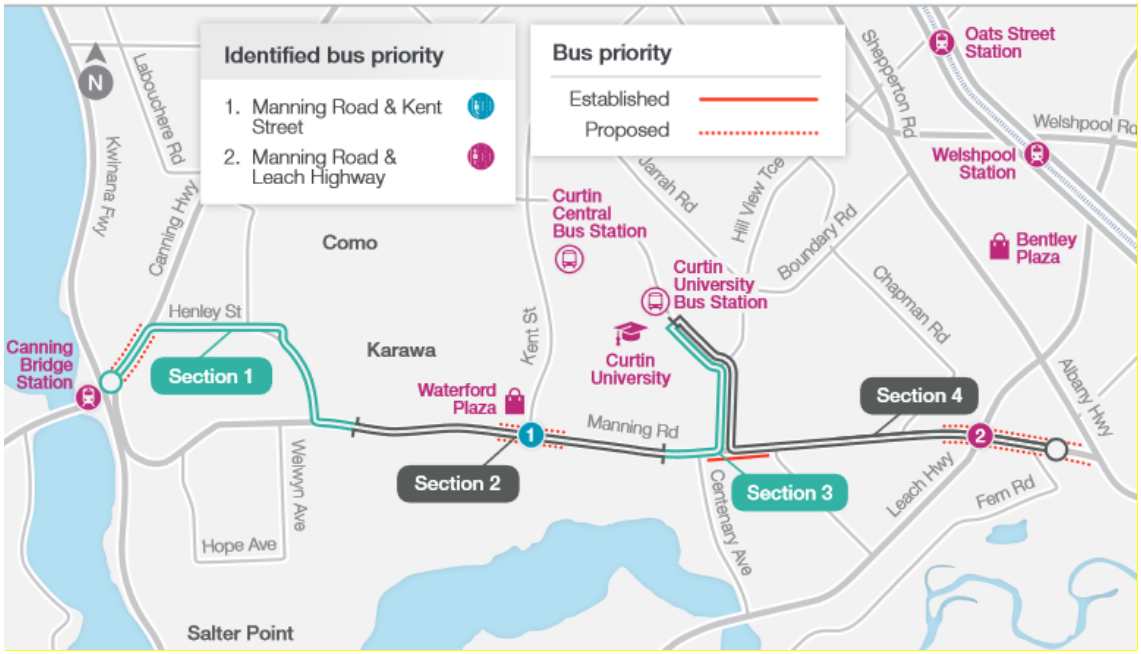
Buses experience heavy congestion in this corridor, resulting in low average speeds and high levels of travel time variability.

Actions

- Northbound bus-only right turn from William Street onto Wellington Street.
- Southbound bus-only right turn from William Street onto Mounts Bay Road.

There is a proposal to turn William Street, between Murray and Hay streets into a public-transport-only transit mall. This will prioritise pedestrian crossings and access to the city centre.

Manning Road



Corridor performance*

		Off-peak average journey time	Morning peak average journey time	Afternoon peak average journey time	Daily travel time varability	Daily average bus speed (km/hr)
WEST	Section 1	5:28	6:15	5:35	1:04	26.59
	Section 2	3:24	3:15	3:56	0:48	35.94
	Section 3	3:36	4:03	4:14	0:53	23.20
	Section 4	7:59	8:50	8:10	1:15	25.03
EAST	Section 1	5:54	6:14	5:47	0:51	25.17
	Section 2	4:25	4:48	4:27	1:19	28.86
	Section 3	2:37	2:52	2:39	0:44	29.58
	Section 4	8:51	9:39	9:19	2:01	25.04

Performance indicators*

Commentary

Manning Road Corridor is a major arterial connection which would greatly benefit from the introduction of bus priority infrastructure. The corridor supports the movement of people and goods to Curtin University, Canning Bridge Station, Carousel shopping centre and local residential areas. Congestion 'hot spots' are evident at many of the intersections along Manning Road. These are expected to worsen as density continues to increase; however, opportunity exists to widen the road corridor.

Issues

Bus journey times are negatively affected by no priority at intersections and heavy congestion on approach to Curtin University.

Actions

Bus-only right-hand turn from Manning Road onto Lawson Street.

Albany Highway

Corridor performance*

		Off-peak average journey time	Morning peak average journey time	Afternoon peak average journey time	Daily travel time varability	Daily average bus speed (km/hr)
WEST	Section 1	8:44	9:57	8:59	1:40	27.17
	Section 2	15:23	13:16	15:33	3:16	21.23
	Section 3	6:45	7:07	7:31	1:31	27.45
	Section 4	3:40	3:17	3:35	0:52	24.96
EAST	Section 1	8:28	8:02	9:58	1:33	28.08
	Section 2	14:24	11:20	14:39	2:17	17.35
	Section 3	7:26	7:02	8:08	1:38	25.18
	Section 4	2:52	2:09	3:05	1:01	21.34

Performance indicators*

Commentary

The Albany Highway and Shepperton Road Corridor is a vital arterial connection providing access (via the Causeway) to Perth CBD. The corridor would greatly benefit from introduction of further bus priority treatments. The corridor supports the movement of daily commuters into the CBD, as well as providing connections to the Victoria Park and Carousel Shopping Centre precincts. A southbound bus lane adjacent to Carousel shopping centre, and a northbound Queue Jump on Shepperton Road on the approach to Victoria Park Transfer Station support bus journey times. While these treatments generate benefits buses are generally slow-moving throughout the corridor and further priority measures are needed.

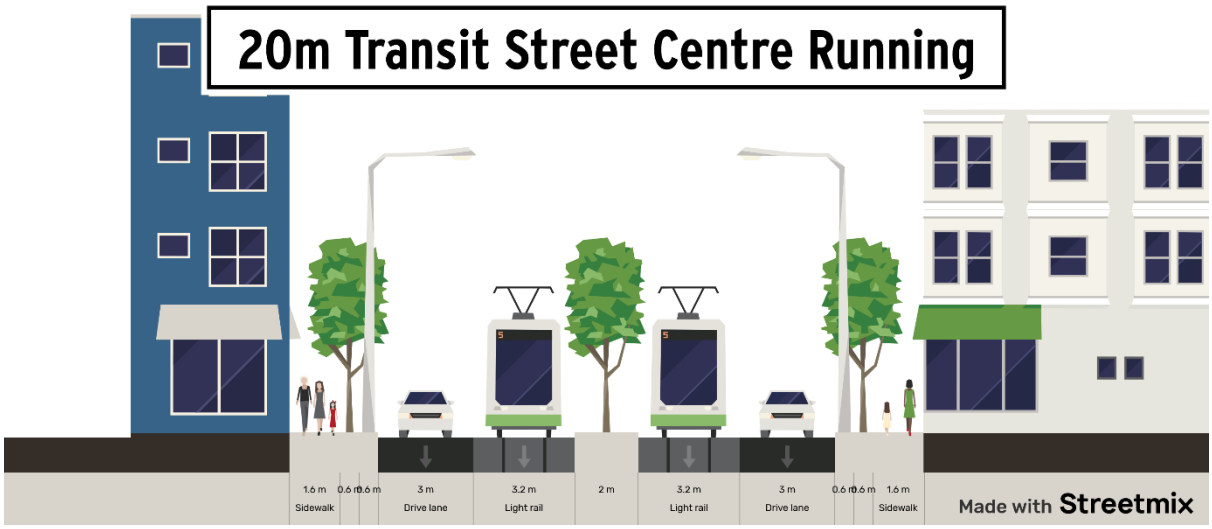
Issues

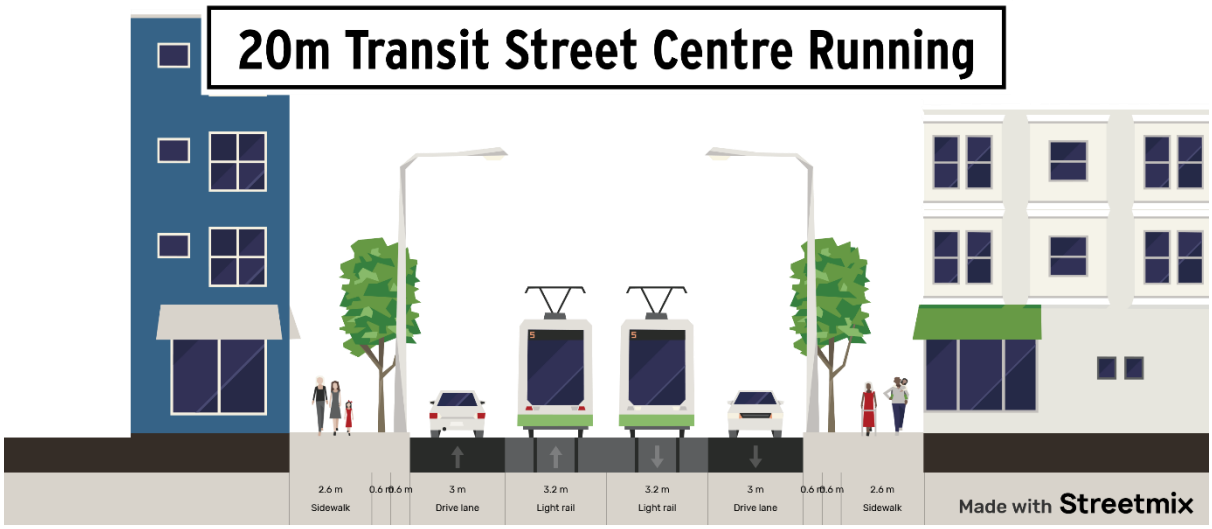
Bus journey times are negatively affected by heavy congestion along the corridor, no signal priority at intersections, and insufficient enforcement of established bus lanes. Use of the multipurpose corridor is continuing to increase, and on-road public transport needs to be prioritised to create additional capacity.

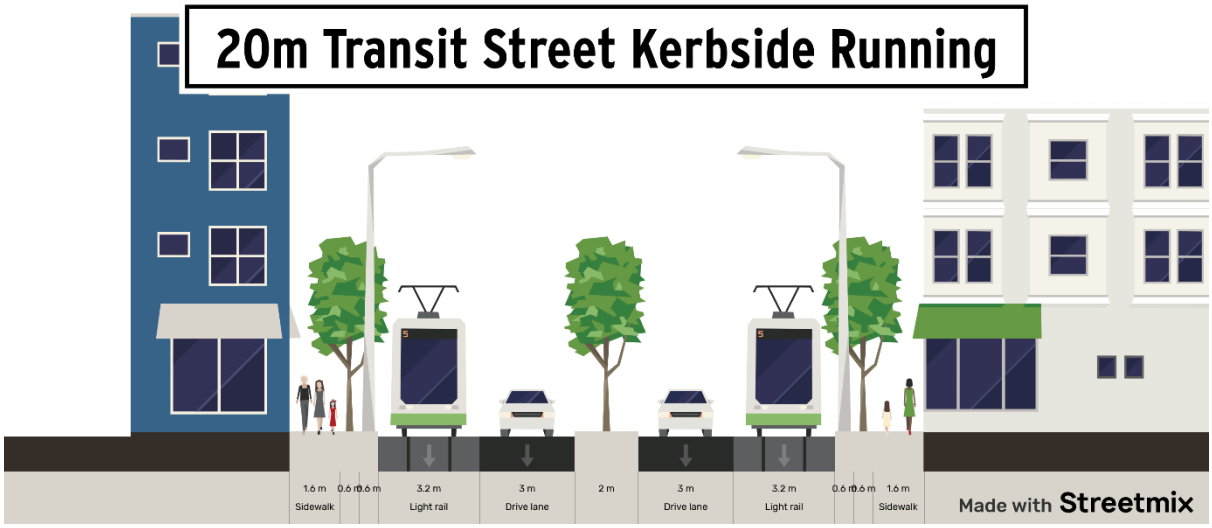
Actions

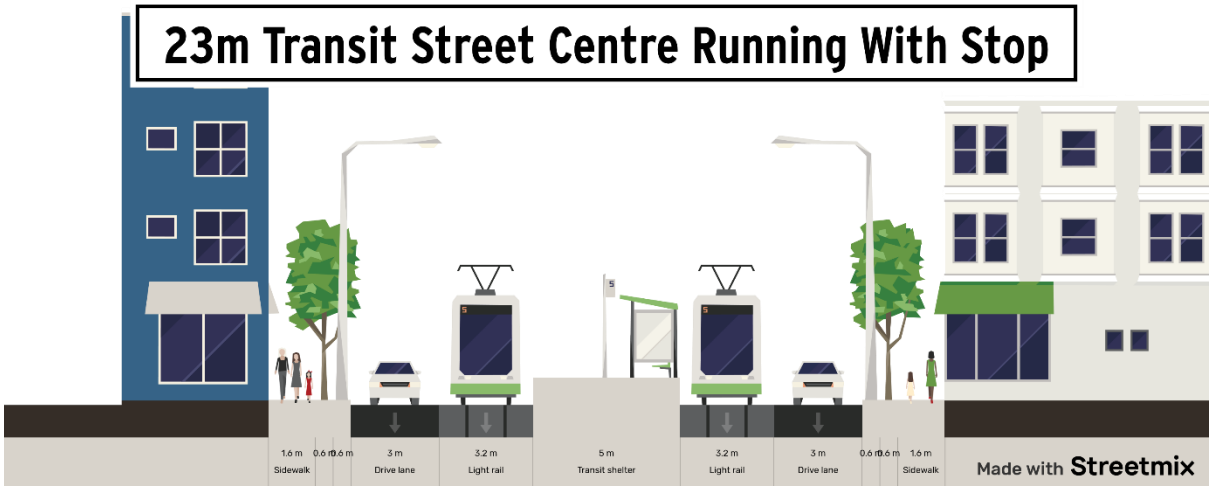
- Southbound bus lane adjacent to Carousel shopping centre.
- Northbound queue jump on Shepperton Road on the approach to the Victoria Park Transfer Station

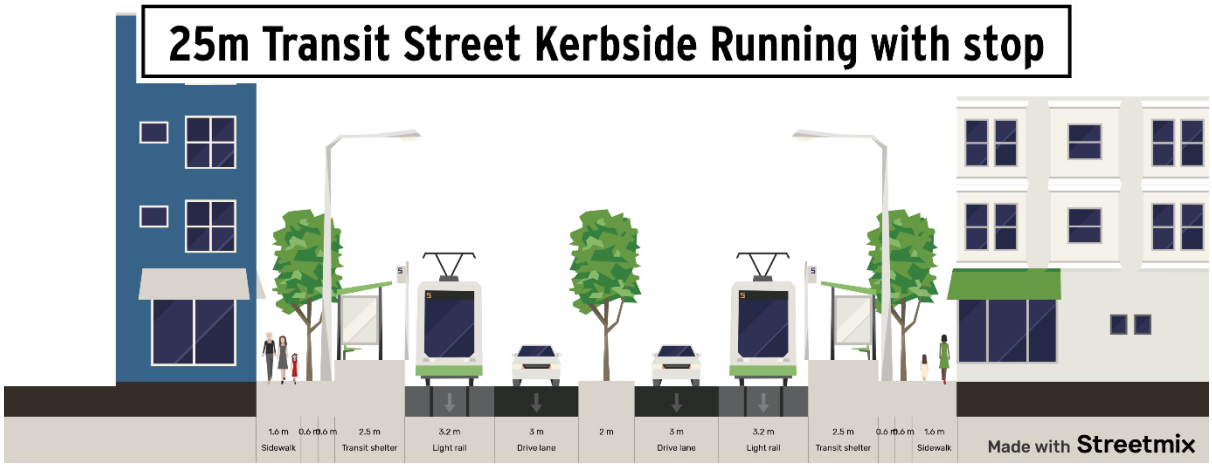
APPENDIX 5: ROAD CROSS SECTIONS

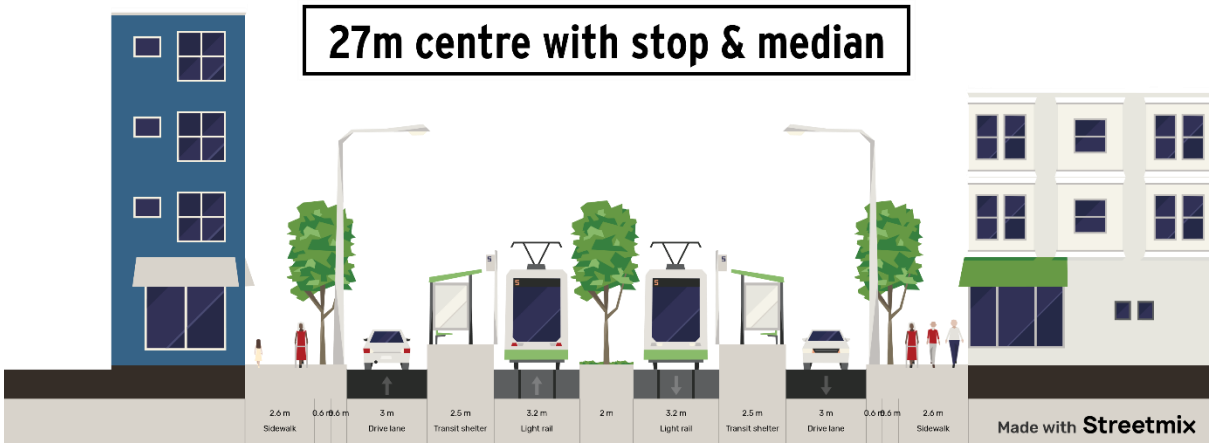




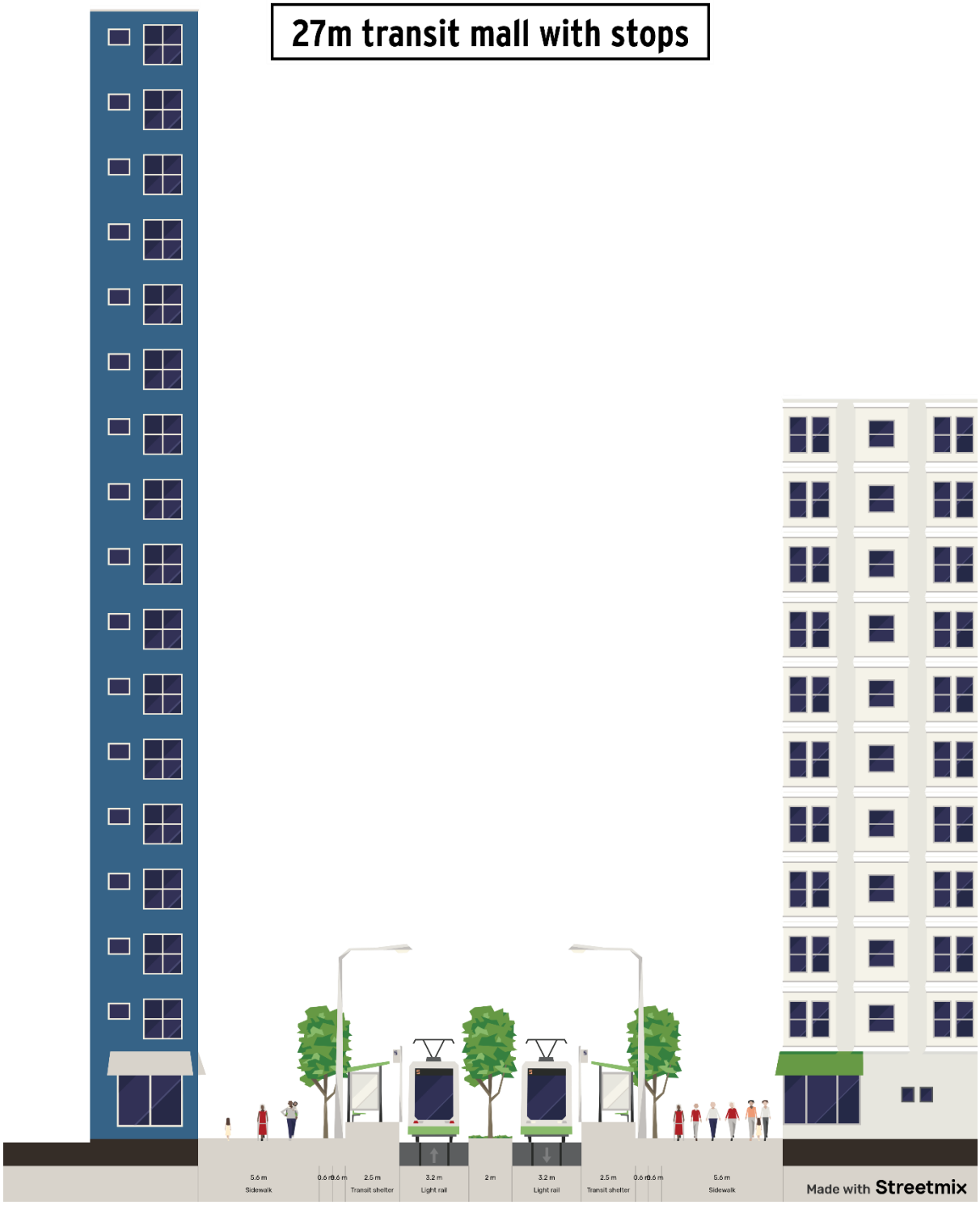



23m Transit Street Centre Running With Stop
1.6 m
Sidewalk
0.6 m
0.6 m
3 m
Drive lane
3.2 m
Light rail
5 m
Transit shelter
3.2 m
Light rail
3 m
Drive lane
0.6 m
0.6 m
1.6 m
Sidewalk
Made with Streetmix

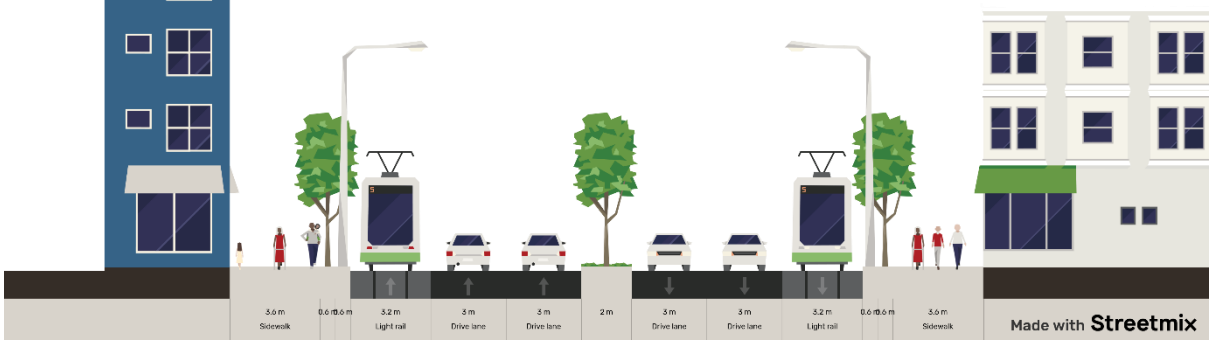

25m Transit Street Kerbside Running with stop
1.6 m
Sidewalk
0.6 m
0.6 m
2.5 m
Transit shelter
3.2 m
Light rail
3 m
Drive lane
2 m
3 m
Drive lane
3.2 m
Light rail
2.5 m
Transit shelter
0.6 m
0.6 m
1.6 m
Sidewalk
Made with Streetmix


27m centre with stop & median
2.6 m
Sidewalk
0.6 m
0.6 m
3 m
Drive lane
2.5 m
Transit shelter
3.2 m
Light rail
2 m
3.2 m
Light rail
2.5 m
Transit shelter
3 m
Drive lane
0.6 m
0.6 m
2.6 m
Sidewalk
Made with Streetmix

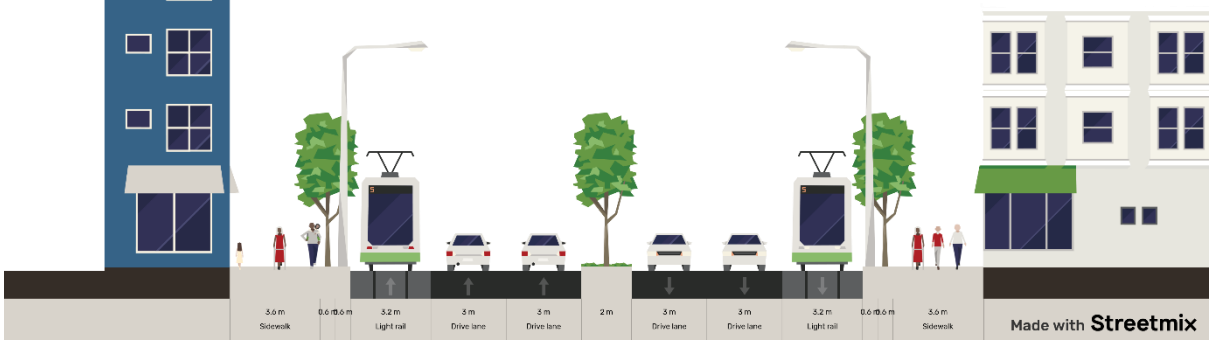
27m transit mall with stops



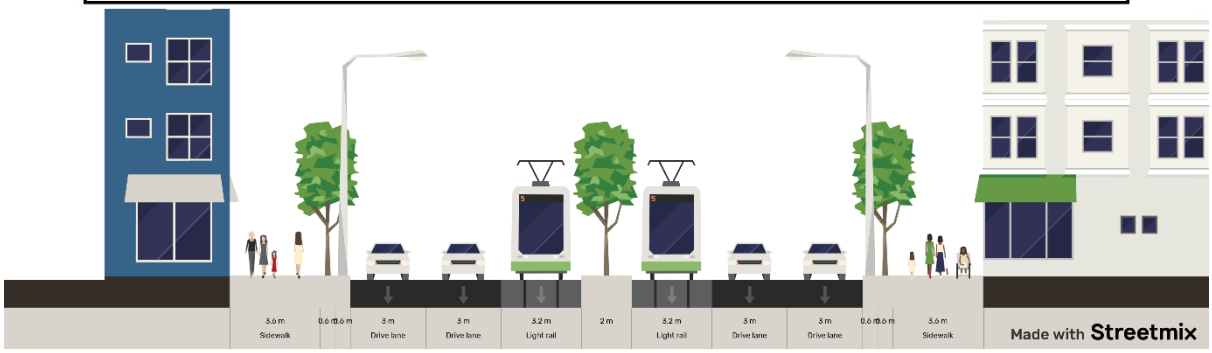
30m transit St with kerbside running & 2 Lanes



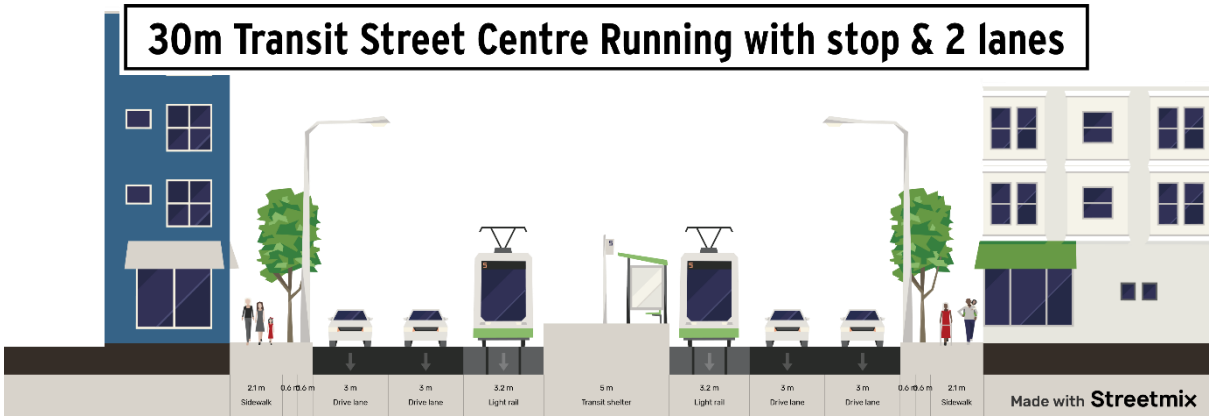
30m transit St with kerbside running & 2 Lanes



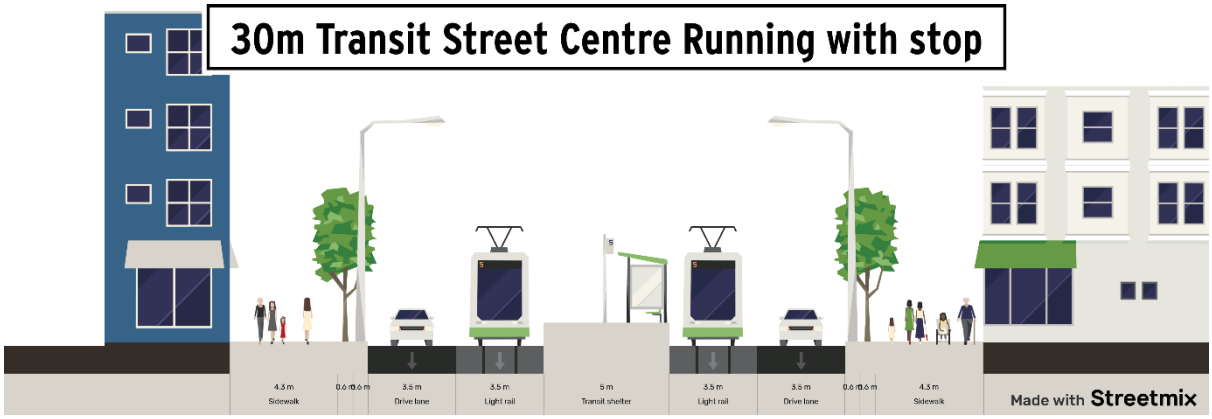
30m Transit Street Centre Running with two lanes of traffic



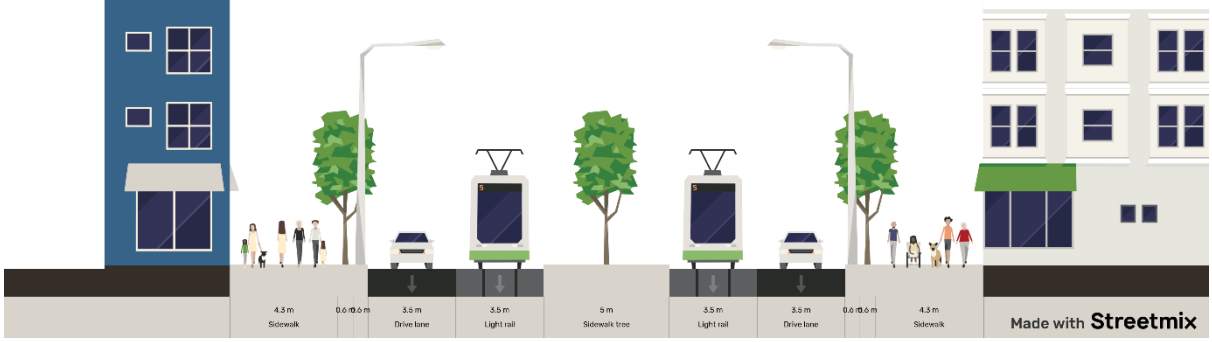
30m Transit Street Centre Running with stop & 2 lanes



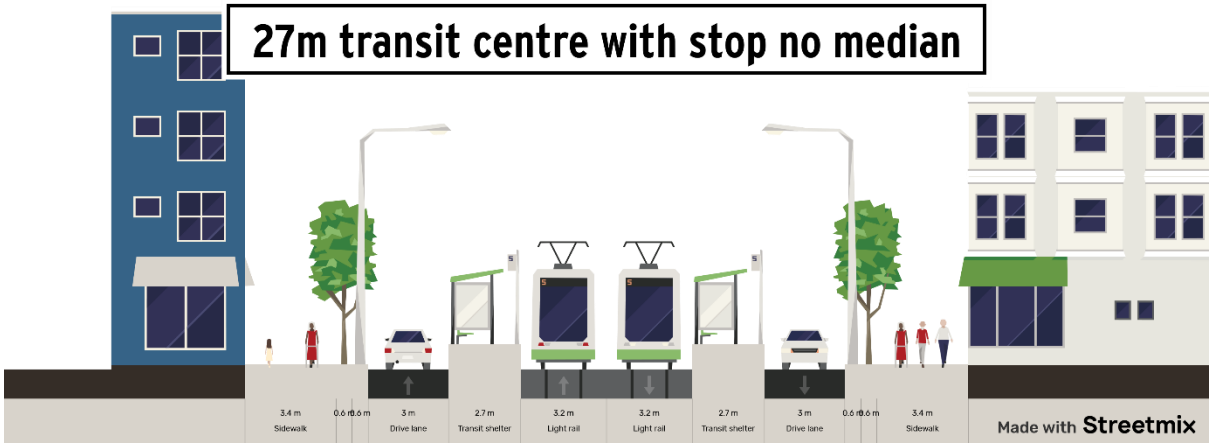
30m Transit Street Centre Running with stop



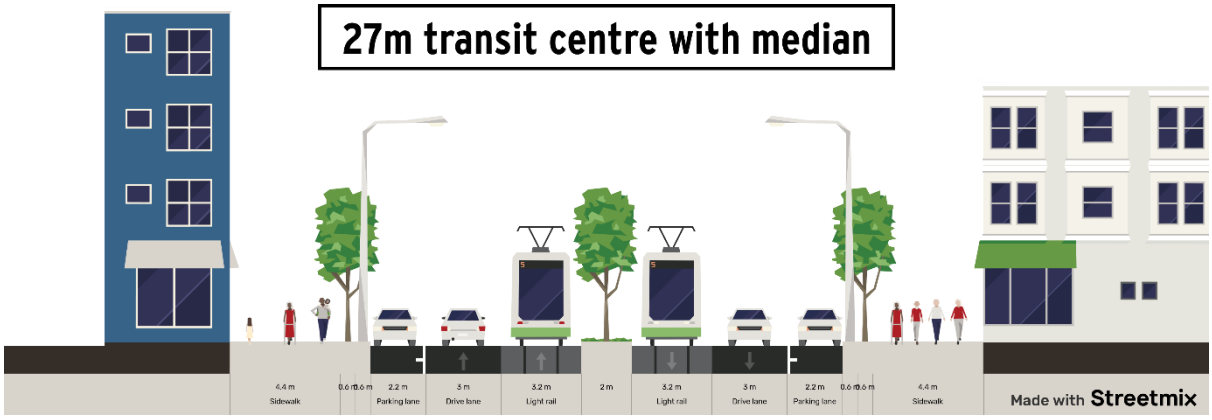
30m Transit Street Centre Running



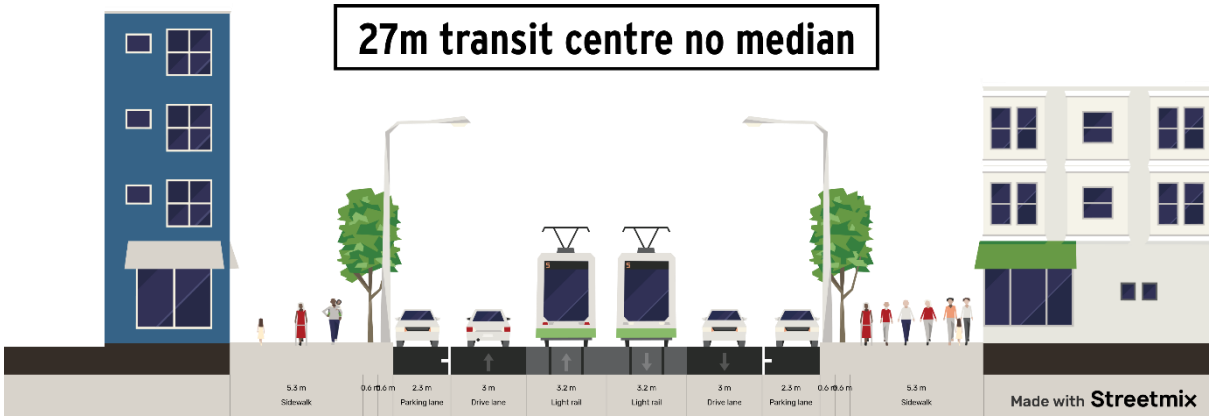
27m transit centre with stop no median



27m transit centre with median



27m transit centre no median



APPENDIX 6: COST IMPLICATION ESTIMATES

Implementation Indicative Costs associated with Civil Works and Vehicle and stations cost in implementing TTS in Perth

COSTING RATIONALE

Scenario Scarborough to Cannington via CBD and Curtin - 30km route

The cost estimates are based on following operations assumptions

Vehicle Frequency	Operation
Vehicle frequency: of 6 minutes	10 vph
Trip duration: 30 km route @40kph	45 mins
Station Duration: 30 stops @30sec	15 mins
Total journey time	**60 mins**
Each opportunity charge	10 mins

The cost below are based on cost provided by CRRC

Costs	No	Cost/ item	System Total
Number of vehicles required – round trip 60km	22	$3.6m	$79.2m
Interval Stops – both sides of road, (*median bi-directional stops would reduce this infrastructure cost) (see table below)*	30	$1.54 m	$46.2m
End stops with charging stations end of route	2	$2.24	$4.48m
Total Vehicles and Stops			$129.88m
Cost per kilometre (30 km route) Vehicles and stops both directions x2			$4.33m
Depot modifications and control room facilities** (can service a wider network)	1	$16.21m	$16.21m
Total vehicle and station cost	30km	$4.87m per km	$146.1 m
Civil costs (see rationale below)	30km	$19.2m per km	$576m
Estimated Total Cost			**$722.1 m**

**Assumes use of existing depots and control rooms – but provides for modifications

	Item	Unit Price (AUD)	Description
1	ART Rolling Stock	$3.6 m	3-module car
2	Station facilities		
2.1	First/Last Station (including charging facilities)	$2.24 m	Including ART fast charging system, signalling system, communication system, passenger information systems (PIS), ticket validators (AFC), security cameras (CCTV), Platform doors and other necessary electrical and mechanical system. Need at least one every 20 kms of route

2.2	Normal stations	$1.54 m	Including signalling system, communication system, PIS, AFC, CCTV, Platform doors and other necessary electrical and mechanical system. Can be single or double direction.
3	Rolling stock Depot (including command centre)	$16.21 m	ART Command centre standard facilities, special repair and maintenance equipment and comprehensive monitoring system, etc.

Civil Costs

One of the uncertainties associated with this high level investigation is establishing a level of cost estimate for implementation – even if only at a 'ball park' level. The main unknown relates to civil works, services relocations and amenity upgrades that will be required to realise the value creation potential of the Trackless Tram system.

The qualitative assessment – the implementation challenges and opportunities has highlighted that there will be very different implication challenges (and therefore costs) depending upon the existing conditions and type of built environment within any section of the route.

To help establish a 'ball park' level of cost estimation we are able to use estimates that City of Stirling have provided of some typical road section cost estimates developed based on a clear set of assumptions and professional cost estimations.

These estimates, along with an estimate of how these figures might be applied to the various sections route assessed in this study - leads to a 'ball park' estimate that the Trackless Tram – may have an average capital cost in the order of $19.2 m per km for Civil works (or $576m) plus vehicles and stations is $4.87 per km - $146.1 m. = $722.1m (or $24.1m per km)

Even if this estimate is out by 50% - and the cost come in at between $36 and 40M per km - it still represents a substantive saving over an equivalent light rail systems at $80 million per km for the proposed Max Light Rail or $2.4b or at Sydney Light Rail costs of $175m per km or $5.2b

See below for rational below.

Level of Costing	Cost Estimate per km	Key Assumptions	Length of similar configuration in proposed corridor Estimated length of corridor 30 Km
Very Low	< $500,000 per Km	Involves removal of one lane of traffic (as with a bus lane Fitzgerald Street) Remove black bitumen and replace with coloured bitumen Line marking Power lines already underground	Zero

		Minor streetscape improvements already undertaken No cost for stops included	
Low	$1m per km	Involves removal of one lane of traffic (as per 2 km of Scarborough Beach Road – between Selby St and Odin Road) Involves turning 3rd lane into TTS lane Remove black bitumen and replace with coloured bitumen Line marking Minor Intersection upgrades Power lines already underground No streetscape improvements No cost for stops included	6km = $6 M
Low / Medium	$5m per km	Involves removal of one lane of traffic (as per section 3 km of Scarborough Beach Road – between West Coast Hwy and St Bridges Tce) Involves turning 2nd lane into TTS lane Remove black bitumen and replace with coloured bitumen Line marking Minor kerb widening Introduce median Minor drainage improvements No power lines undergrounded Higher level upgrade of streetscape No cost for stops included	6 Km = $30M
Medium	$10m per km	Involves removal of one lane of traffic (as per section 3 km of Scarborough Beach Road	6 Km = $60 M

		– between West Coast Hwy and St Bridges Tce) Involves turning 2nd lane into TTS lane Remove black bitumen and replace with coloured bitumen Line marking Minor kerb widening Introduce median Drainage modifications Intersection modifications Power lines undergrounded Modest upgrade of streetscape No cost for stops included	
Medium /High	$35M per Km	As above – with station stops in centre lanes at intersections Land acquisitions Service relocations	6 km = $210M
High	$45m per km	Adding extra 2 lanes Power undergrounding All service New median New drainage New landscaping	6km = $270M
			$576 M (or $19.2 per Km)