Galway Light Rail Transit Feasibility Study Report

National Transport Authority

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Contents

Tables

Figures

1. Introduction

1.1. Background

The Galway Metropolitan Area Transport Strategy (GMATS) will provide a long-term strategic planning framework for the delivery of transport and the integrated development of transport infrastructure and services in the Galway Metropolitan Area (GMA). The GMATS will be developed in line with the existing national, regional and local policy and guidance.

The GMA has a dynamic economy, with a fast-growing population and high levels of mobility. This has resulted in high levels of congestion and delays on the road network.

Many stakeholders in the Galway area aspire for a step-change in public transport for Galway, which includes the development of light rail in the city. In response, the NTA has identified the requirement for a Light Rail Feasibility Study as one of the key components of the GMATS.

The findings from this study will be used to inform the development of the GMATS, alongside recommendations for active travel, bus services, rail, roads and demand management measures.

This report does not identify a preferred alignment of a light rail corridor in the city. This report is only intended to explore key issues and potential feasibility. Route options would need to be explored in more detail during any subsequent process of options assessment and development.

1.2. GMATS Draft Objectives

The GMATS draft strategic objectives are as follows:

- SO1 - Align with the Climate Action Plan requirements for 2030;
- SO2 - Provide sustainable mobility for people & goods with regard to the hierarchy of road users as set out in National Sustainable Mobility Policy
- SO3 - Develop a safe, efficient, resilient and integrated transport network for all users;
- SO4 - Maximise utility of existing transport assets to meet current and future travel needs, and protect the strategic function of key transport assets with regard to the modal and intervention hierarchy as set out in the National Investment Framework for Transport in Ireland ;
- SO5 - Support compact land use development and integration between transport investment and future growth as provided for in the National Planning Framework;
- SO6 - Support the role of the GMA as a regional centre for population, employment, education, tourism, health care, goods distribution and port access;
- SO7 - Support the concept of 10-minute neighbourhoods, providing access for local needs;
- SO8 - To enhance the natural and built environment, including public realm, for the benefit, health and wellbeing of those living in, working in and visiting the GMA;
- SO9 - To facilitate the effective phased delivery of appropriate transport measures throughout the strategy period; and
- SO10 - To deliver a fully accessible, equitable and socially inclusive transport system for all.

These objectives are fully aligned with national policies including the National Planning Framework, Northern and Western Regional Spatial and Economic Strategy, Climate Action Plan, National Investment Framework for Transport in Ireland, and Transport Appraisal Framework. The objectives are also important in helping to define and assess measures for potential consideration in the GMATS, including potential light rail options for the city and its environs.

1.3. Report Structure

This report describes the work undertaken for the LRT Feasibility Study and it contains the following chapters:

- Chapter 2 provides an overview of the methodology applied;
- Chapter 3 describes the process of identifying potential candidate corridors for consideration;
- Chapter 4 describes the process of identifying and assessment of potential network options, drawing on transport modelling to identify the strongest performing option(s);

- Chapter 5 explores the key parameters for light rail, including technology options and system requirements, which have informed technical assessment of the proposed corridors;
- Chapter 6 sets out the process of assessment of the proposed corridor, taking account of the technical parameters, to identify key technical constraints, potential operating model, infrastructure requirements, and factors that will drive capital and operating costs;
- Chapter 7 draws together the evidence to assess the benefits and costs of light rail, together with a preliminary financial appraisal to assess the potential viability of light rail in the city; and
- Chapter 8 presents the study conclusions.

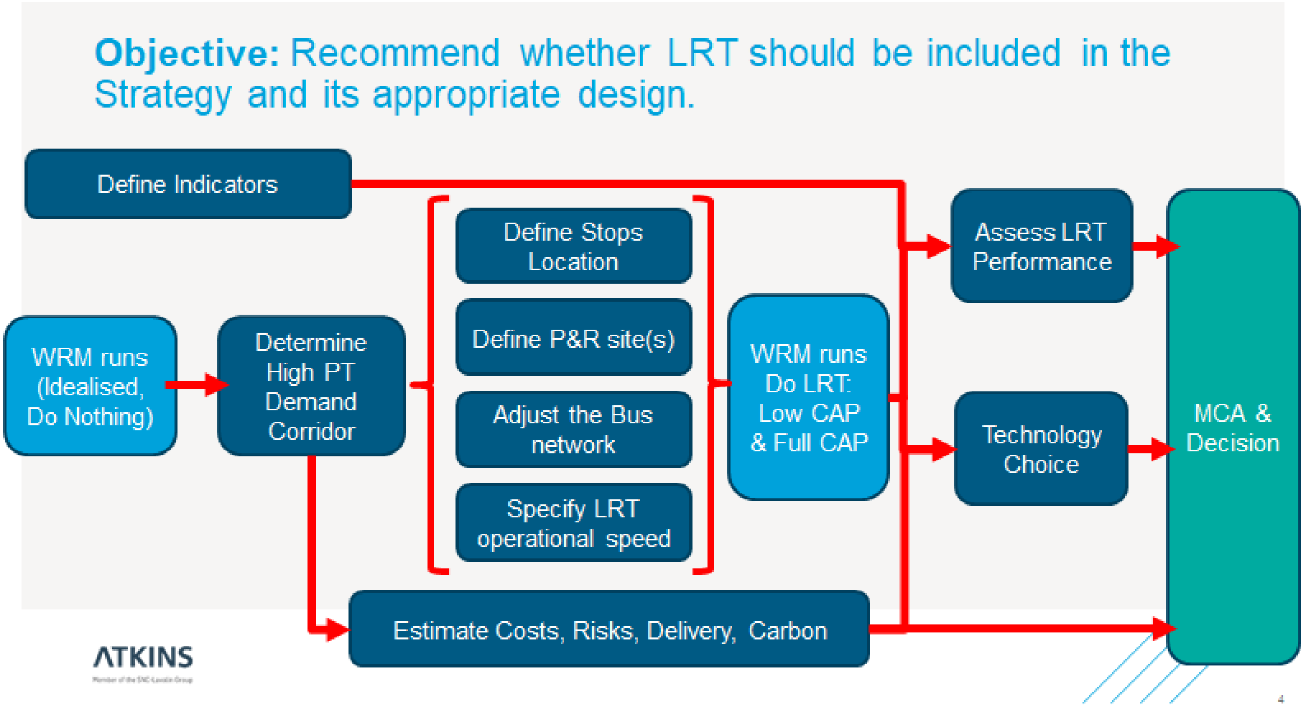
As highlighted above, this report does not identify a preferred alignment for light rail in the study area, as it does not cover Phase 1 & Phase 2 of the Project Appraisal Guidelines. This Feasibility Study is only intended to explore key issues and technical feasibility. Route options would need to be explored further, in line with the appropriate transport scheme development and appraisal guidance, following any decision to further progress light rail for the city.

2. Methodology

2.1. Overview

The purpose of the LRT Feasibility Study is to undertake technical assessments to provide robust evidence on whether light rail should form part of the GMATS. Figure 2-1 summarises the overall methodology.

Figure 2-1 – Methodology for LRT Feasibility Study



This provides a structured approach to the development of evidence to inform potential network concepts, operational parameters, assessment of performance, review of technology choices and recommendations.

Inputs to the study included the future BusConnects network, forecast travel demand, and a defined Do Minimum scenario. These inputs were then used in an optioneering process to identify the corridor(s) with the highest demand in the GMA, scoping of options within the corridor, technical assessments, demand forecasting, and performance assessment. The key steps are set out below.

2.2. Define indicators

The starting point was to identify the parameters to develop and assess light rail as a potential solution to address the mobility challenges faced in Galway. It is critical that the GMATS is based on addressing clearly defined problems and meeting outcome-based objectives, rather than immediately looking to 'solutions to a problem'.

The GMATS objectives (defined in Chapter 1) are fully aligned with national and regional policy objectives and inform the development of potential GMATS measures, including potential light rail options. In addition, the following parameters were identified to assess the performance of light rail options:

- Total demand (daily and annual patronage, maximum peak hour demand, vehicle occupancy);
- Journey times (including competitiveness of journey times compared with other modes);
- Sustainability impacts (including mode shift from car, and reductions in car vehicle-km travelled);
- Parameters informing technical feasibility, including width requirements, swept paths and gradients, to inform analyses of potential technical constraints and operating requirements; and
- Economic and financial performance (CAPEX, OPEX, estimated annual passenger revenues, wider social and economic benefits).

These are all key factors that will underpin the success of potential solutions for the GMA.

2.3. Identification of potential corridors

The starting point in this process was the identification of corridors with the greatest potential for light rail in the GMA. The approach used a 2043 Idealised Sustainable Modes Scenario, modelled using the Western Regional Model (WRM). The Idealised Sustainable Modes Scenario represents a theoretical future situation with very high-quality (fast and frequent) public transport services, aiming at identifying where there is a potential demand for public transport. Opportunities were then identified for potential Park & Ride sites along the corridor to intercept car trips from outside the city. Future development was also identified, in terms of new strategic growth locations on the edge of the city, to support future patronage. Options were also explored to reconfigure bus services, to avoid competition from buses, and to channel demand to light rail.

By applying these principles, it was possible to identify an east-west corridor through the city, which would be likely to have the strongest potential for light rail. **Chapter 3** explains the approach to identification of corridors.

2.4. Development of network options

Initial network options and service specifications were then developed, based on the principles defined above. Initial estimates of running speeds were developed, drawing on Luas in Dublin and other light rail systems in the UK and Europe. Stop spacings were considered, to maximise catchment areas within walking distance, whilst considering impacts of dwell time at stops on overall journey times along the route. Service headways were also specified, initially assuming 5-minute peak headways on core routes and 10 minute headways on branches. Further testing was also undertaken with longer (8-minute) headways as options were developed further.

Through this process, we developed a series of different options to cater for demand in the east-west corridor through the city. **Chapter 4** explains our approach to the development of the network options.

2.5. Demand assessment

The NTA Western Regional Model (WRM) was used to forecast potential demand for the different options. The initial phase of modelling has focused on the 'idealised sustainable modes' scenario, in which there is strong policy support for a shift to active travel and public transport. Further modelling will be undertaken, as part of the strategy integration process, to explore the potential impacts of wider demand management measures on mode shift in the study area.

The modelling has included detailed forecasting of demand along the route, during different time periods, to understand both peak and off-peak demand. **Chapter 4** sets out the findings.

2.6. Technical parameters

It is important to understand the technical parameters of light rail, in terms of the capacity of different types of vehicles, typical dimensions, and infrastructure requirements. There are also emerging developments in the sector, including more innovative forms of very light rail, which could be considered in the Galway setting. It is important to set this in context in Galway, in terms of forecast demand and implications for system specification. **Chapter 5** sets out the conclusions from this assessment.

2.7. Route concept development and operating model

Based on the identified light rail technical parameters, a review of the potential route options was undertaken, in terms of ability to accommodate light rail vehicles and infrastructure. This was a high-level assessment, identifying potential issues with corridor widths, turning movements for trams, and frontages, from which key technical risks were identified and can inform development of infrastructure options. Drawing on evidence from other light rail systems, and specific issues to be addressed along the route, the potential scale of capital costs was identified.

It is also important to consider the potential operating model for light rail services in Galway. This used service headways, vehicle speeds and end-to-end journey times to estimate peak vehicle requirements. Evidence from other light rail systems was also used to consider requirements for depots, maintenance, back-office support and management overheads to estimate potential operating costs. **Chapter 6** sets out the findings.

2.8. LRT impacts and performance

The evidence from the previous chapters was then drawn together, to assess the potential viability of light rail in Galway, with conclusions drawn in **Chapters 7 and 8**. As previously noted, this report does not identify a preferred alignment for light rail and is only intended to explore key issues and potential feasibility. Options would need to be explored further, at a later date, following any decision to further progress light rail for the city.

3. Identification of potential corridors

3.1. Introduction

This chapter sets out the approach to the identification of potential corridors for consideration in the LRT feasibility study. The starting point was to identify the critical success factors for light rail, in terms of the conditions needed for light rail to succeed. The next step was to review the proposals for the most frequent bus routes – BusConnects – which are most likely to form the basis of a viable future light rail corridor. Transport modelling was then undertaken to identify the corridors with the highest public transport demand, and conclusions drawn about potential corridors for further consideration.

3.2. Critical success factors for light rail

Drawing on the lessons learned from light rail systems across Europe, it is possible to identify a number of **critical success factors** that influence the success of light rail. These include:

- Strong travel demand within defined corridors, using current public transport services, or with the potential to shift from car to new transit services (both existing and future potential demand);
- Potential to channel a large 'upstream catchment', for example from more car-dependent rural areas, onto transit services at Park & Ride sites on the edge of the urban area;
- Potential to influence transit demand through 'transit-oriented development', including higher-density mixed uses oriented around transit corridors;
- Exploring wider transport policy measures to encourage transit use, including first mile / last mile solutions for active travel to and from stops, integration with the bus network, and demand management tools to encourage car users to shift mode; and
- The importance of addressing technical constraints, including cross-sectional requirements, swept paths of vehicles, and accommodating the route in different settings, including dense city centre environments with multiple competing activities.

In order to attract people from cars, light rail must provide:

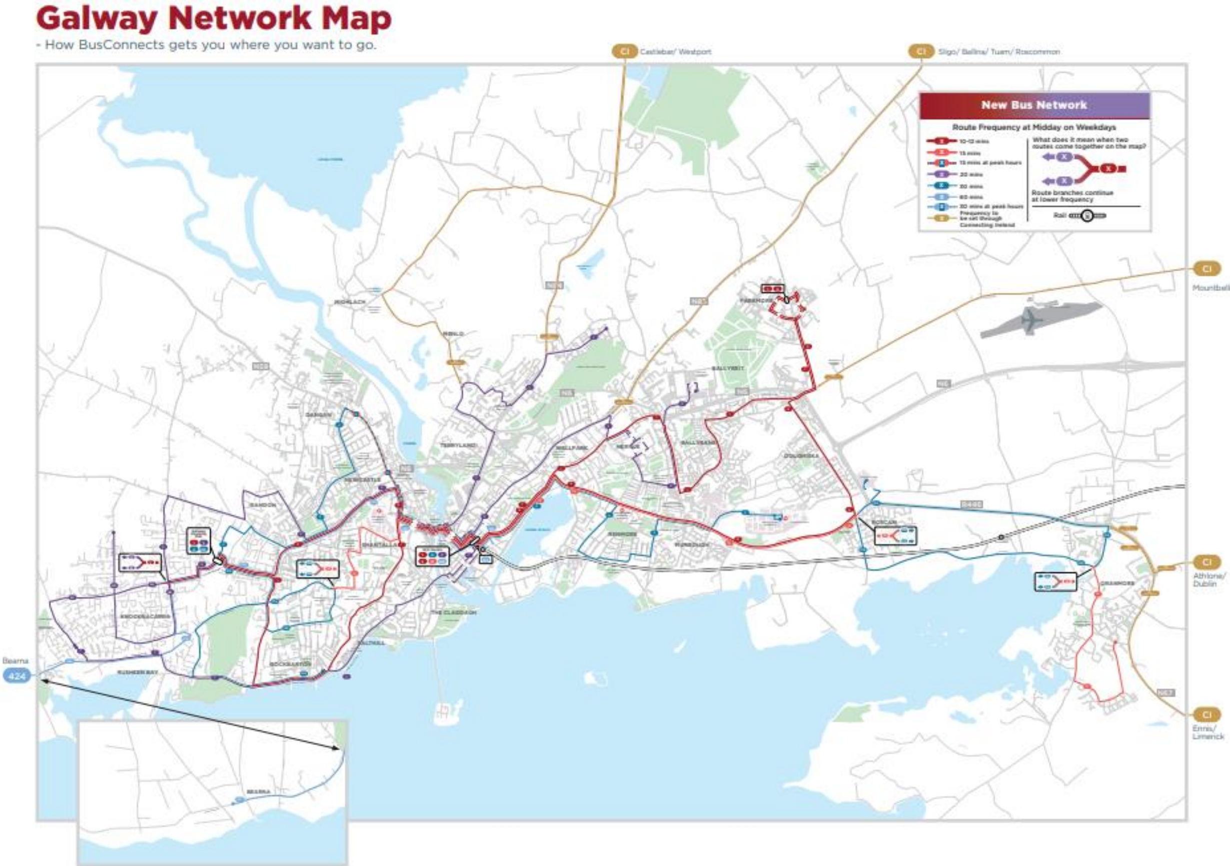
- A competitive offer, in terms of ease of access to the destination, overall journey time and cost;
- A highly visible, well-marketed solution to meet people's mobility needs;
- High quality information to enable easy journey planning;
- Easy access to stops, with good wayfinding and walking (and cycling) routes;
- Good quality facilities at stops, including seating, shelters, real-time information and easy-to-use ticketing;
- Short waiting times, with turn-up-and-go services;
- Fast and reliable journeys, with trams benefiting from segregation, and visibly faster than journeys by car;
- Direct access to destinations, or high-quality direct interchange with other public transport for onward journeys.

These principles will all be important in developing the specification of the system.

3.3. Existing policy focus

It will be important for a future LRT system to build on existing corridors of high demand and existing commitments to improve the public transport system. Figure 3-1 shows the current proposals for the new bus network in Galway.

Figure 3-1 –Bus Network in Galway - BusConnects –



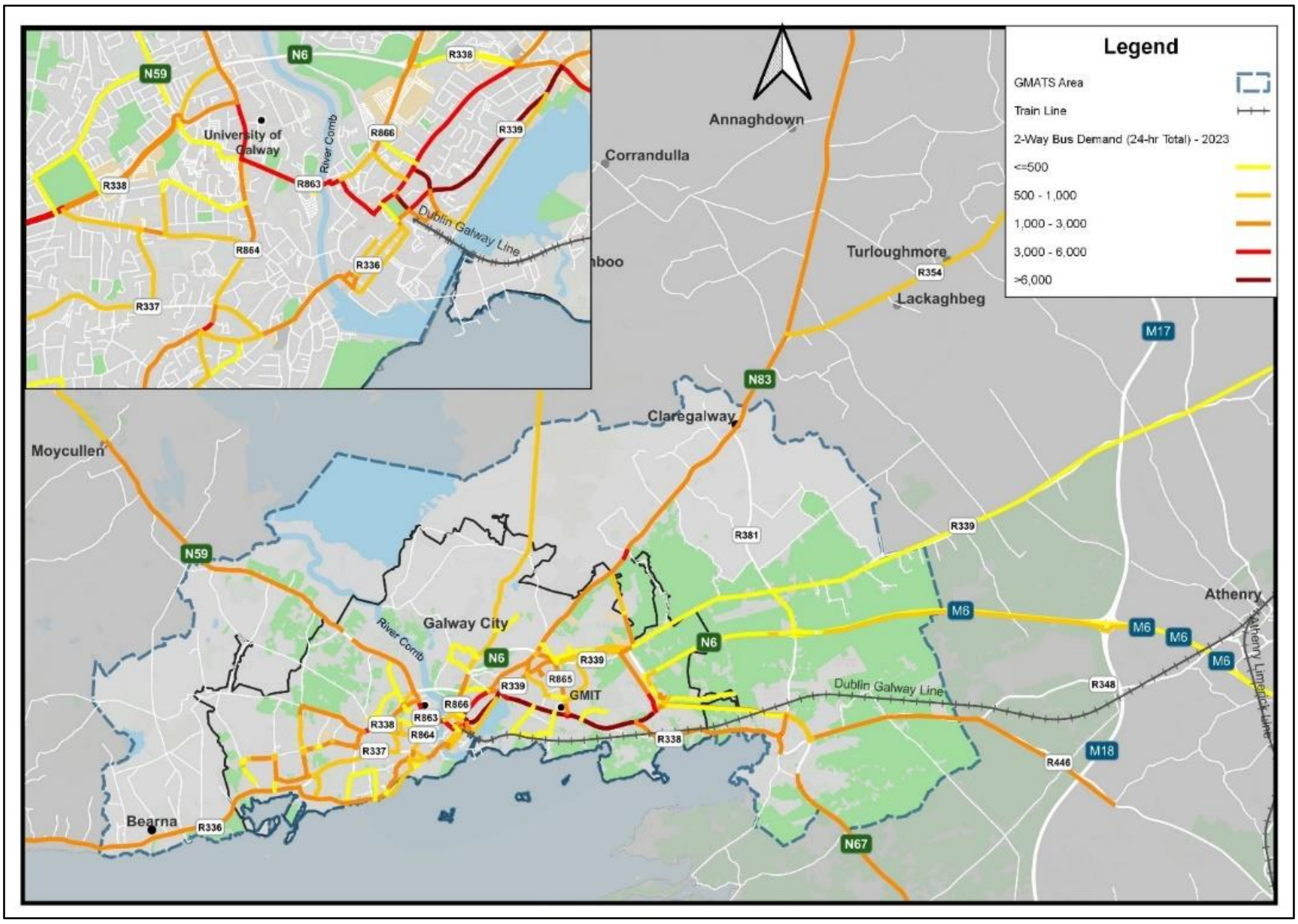
This network shows a clear east-west spine of high frequency services, from Parkmore and Doughiska, along the Dublin Road, and turning south along College Road towards the city centre. Eyre Square is the primary point of interchange for bus services in the city, which also benefits from close proximity to Ceannt train station. High-frequency services will then head west along Eglinton Street, over the Salmon Weir Bridge, along University Road towards the Hospital and University. Frequent services will then operate along Seamus Quirke Road, and Bishop O'Donnell Road, before heading along the Western Distributor Road towards Galway Shopping Park.

There is also a commitment to the Cross-City Link, which will restrict vehicular traffic movement on the city centre part of this corridor, significantly improving the level of priority given to sustainable modes.

3.4. Analysis of existing and future demand

Figure 3-2 shows existing 2023 bus patronage, expressed as two-way demand over 24 hours, extracted from the NTA Western Regional Model.

Figure 3-2 – Existing 2023 Two-Way 24-hour Bus Demand



This map shows that bus passenger flows are aligned with the current bus network, gradually increasing and converging towards the public transport hub around Eyre Square. The corridor between Roscam and the University of Galway via Dublin Road, College Road and University Road is the busiest public transport route, carrying more than 6,000 daily passengers (both directions combined).

Forecasting has also been undertaken, within GMATS, of potential future travel demand, across the GMA. This has used the NTA's Western Regional Model (WRM), using planned housing and employment growth, to forecast travel demand by all modes, including active modes, bus, rail and car. Forecasting has extended to 2043, to capture the significant planned growth over the next two decades.

A 2043 scenario was developed, in which conditions are maximised to encourage a shift to sustainable travel: walking, cycling and bus, to identify the corridor(s) with the highest levels of public transport demand: the Idealised Sustainable Modes scenario. Figure 3-3 shows a map of 24-hour bus demand for this scenario.

Figure 3-3 – Two-Way 24-hour Bus Demand, 2043 Idealised Sustainable Modes Scenario

This confirms that the strongest flows would be along the east-west axis through the city. Heading east from Eyre Square, the highest demand would follow College Road and Bohermore to Dublin Road, then following east along the Dublin Road to Roscam, with high demand then continuing along the Coast Road to Oranmore. There would also be high levels of demand generated by the new developments east of the city, including Ardaun, Garraun, and around Parkmore and Ballybrit.

Heading west from Eyre Square, the highest demand would follow the corridor over Salmon Weir Bridge and University Road, towards the Hospital and University, before then extending down Seamus Quirke Road, Bishop O'Donnell Road, and along the Western Distributor Road to Galway Shopping Park and Knocknacarra.

There would also be a corridor of high demand heading north-east, towards Mervue and Ballybane. Heading south-west out of the city centre, demand would be lower crossing the Wolfe Tone Bridge, following Father Griffin Road towards the Claddagh. Demand would also be lower on the corridor heading into the city from the north-west through Dangan, Greenfields and Newcastle.

This analysis shows that there could be significant growth in the public transport market to 2043, ***if*** the right conditions are in place. There will be a large increase in the number of people living and working in the GMA, which will significantly increase overall travel demand. However, significant improvements to active modes (through CycleConnects) and public transport (through BusConnects), together with measures to manage parking and control access to the city centre, will be required to deliver significant mode shift.

These different sources of evidence clearly demonstrate that the east-west spine has the greatest potential for high-capacity, high-quality public transport. This spine, with Eyre Square at its heart, extends east along the Dublin Road towards Roscam, and west towards the University, Hospital and towards Knocknacarra. This is supported, in policy terms, through the current commitments to BusConnects and Cross-City Link, and from modelling of forecast demand. In addition, there is the potential for strong demand in the north-east part of the city, driven by rapid economic and population growth around the Ardaun and Parkmore areas, which could follow the Transit Orientated Development (TOD) principles. TOD aims at designing urban areas around the public transport system, to reduce the reliance on private motorised vehicles by providing good quality transport alternatives, such as a Light Rail Transit system.

3.5. Proposed corridors for further assessment

This evidence was used to inform the corridors for further assessment. Figure 3-4 shows the corridors that formed the basis for initial assessment.

Figure 3-4 – Corridors for initial assessment

To the west of the city centre (in green), there is a strong case for exploring a corridor that serves the hospital, University of Galway, and corridor through Rahoon and Knocknacarra. This could also be served by a Park & Ride site west of Knocknacarra, which could intercept trips from west of the city, including Bearna and An Spidéal. This route would also pass through Eyre Square and along College Road through the east side of the city centre. This route would extend over 7.5km from Knocknacarra to Dublin Road.

To the east of College Road, two corridors were identified, and they are shown as separate branches in different colours.

The route shown in blue, following Dublin Road, is an obvious candidate. It is a high-frequency bus route in the BusConnects strategy, existing bus demand is already high, and it would have the highest demand in 2043. The 2043 modelling also indicates that there could also be consistently high demand along the corridor, extending beyond Roscam towards Oranmore. Park & Ride could also be provided along the route, to intercept trips from a wider catchment, including the N67 (at Oranmore) and from the N6/M6 (around Roscam). This route would extend over 9km from the junction with the green route at Wellpark to the terminus shown at Oranmore.

The route in red, would follow the Wellpark Road through Mervue, then past Ballybane, before continuing to Ballybrit and Parkmore. This would appear to be less immediately obvious than the Dublin Road, but there are a number of proposed BusConnects routes in the north-east of the city, and high demand is forecast from Ballybrit and Parkmore with future employment growth. However, this demand is spread along different corridors, and it might be more difficult to channel demand for future LRT services along a single corridor. Park & Ride could also be explored in the Parkmore area, to intercept a wider catchment from the N83 corridor to the north-east. This route would extend over 5.5km from the junction with the green route to the terminus at Parkmore.

These routes formed the basis for initial modelling of demand and development of network options.

4. Development of network options

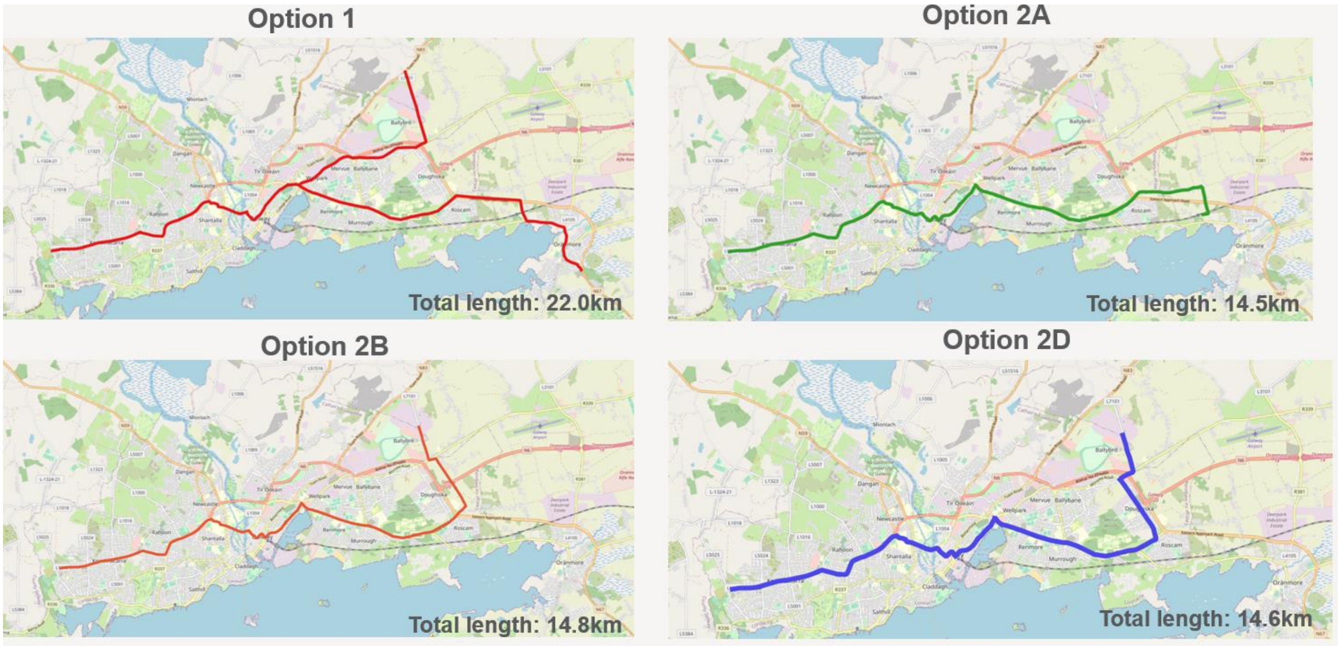
4.1. Introduction

This chapter explains the approach to the development of potential network options, drawing on the potential corridors described in the previous chapter. This process was informed by forecasting of demand, using the Western Regional Model (WRM). An iterative approach was taken, using demand modelling and assessment of performance, to select a corridor for more detailed assessment.

4.2. Route options

A series of route options were developed, tested, and assessed, as shown in Figure 4-1.

Figure 4-1 – Route options



All of the options were designed to address the critical success factors described in Section 3.2:

- Focused on corridors with strong public transport demand, enabled by a strong focus on sustainable travel, supported by complementary parking management measures in the city;
- Connecting major locations of travel demand in the city, including the city centre, hospital and university;
- Capturing of large potential upstream markets through Park & Ride on key corridors heading towards the city, from the west, east and northeast; and
- Routing of corridors to support large-scale development on the east side of the city; and
- Taking account of technical constraints, including cross-sectional requirements, turning radii and swept paths, frontage access issues, and potential traffic impacts along the route.

It was assumed that the LRT system would have different speeds on its sections, based on the level of segregation. These average speeds were extracted from the running speed of Luas in Dublin and include time spent at stops. Three section types were defined: Urban with mixed traffic (8kph), Suburban with partial segregation (16kph) and Full segregation (24kph).

It was also assumed that the spacing between stops would be approximately **700 metres**, based on a balance of maximising local catchment and ensuring an efficient operating model. Shorter distances in the city centre and longer distances in the suburbs between stops have been modelled. The modelled average distance between stops is consistent with the Dublin Luas system (625m average distance between stops).

This section describes the key parameters of each of the options that were tested. It provides an overview of the service headways, locations of Park & Ride sites, and briefly describes the key technical constraints. These issues are then explored in more detail in subsequent chapters.

The options described below are only intended to inform initial assessment of potential factors influencing potential demand. In particular, the service frequencies described below were initial tests, to inform understanding of the potential scale of patronage and mode shift under each option. Further tests, described later in this chapter, were also undertaken to explore implications of lower service frequencies.

Option 1 was the first option tested, and it includes the three route components from Figure 3.4. The total route length of this option would be approximately 22.0km. For the purposes of this early stage in options testing, it was assumed that the service headway would be five minutes on the section from Knocknacarra to Dublin Road, equivalent to 12 trams/hour in each direction. Services would then split onto two branch lines: a route to Oranmore, with 6 trams/hour, and a route to Parkmore, with 6 trams/hour.

Park & Ride sites would be located west of Knocknacarra, north of Roscam, at the terminus of the Oranmore branch, and at the terminus of the Parkmore branch. The Park & Ride site at Knocknacarra would be intended to intercept trips from the west. The sites at Oranmore and Roscam would be intended to intercept trips on the N67 and N6 corridors from the east. The site at Parkmore would be intended to intercept trips on the N83 corridor from the northeast.

The main technical constraints for this option would be associated with routing through or around the hospital area (northwest of the city centre), crossing the river, and through the city centre. The route would be characterised by limited roadspace through the city centre and the need to accommodate tight turning radii at junctions. It would also be necessary to identify a suitable route extending east from the city centre, towards the R338 Old Dublin Road and R339 Wellpark Road. Potential options could include the R336 Bohermore and R338 College Road. This option assumed routing via Bohermore, to capture a larger potential market, although there are width constraints and extensive on-street parking.

To the west, bus lanes are already provided on the R338 Bishop O’Donnell Road and Seamus Quirke Road, and there is space for widening on the verges of the Western Distributor Road. To the east, the R338 Old Dublin benefits from existing bus lanes, with further bus priority planned as part of the Bus Connects programme. It would be necessary to consider how light rail could be successfully integrated into the main street running through Oranmore (with extensive shop frontages, deliveries, and general traffic). To the northeast, the R339 Wellpark Road has space constraints, which would limit the scope for segregation, impacting on potential reliability of services.

Strategic modelling indicated that this would be unlikely to deliver the level of service needed to support substantial mode shift in the east of the city, so alternative options were explored for the two branches on the east side of the city.

The analyses indicate that it would be difficult to justify the long section of LRT between Oranmore and Roscam due to the lack of demand along the Coast Road. **Option 2A** therefore considered a shortened version, with a terminus at Oranmore railway station, which would form a multi-modal transport hub on the east side of the city. This would form a mobility hub for trips from the N67 corridor, and it would run through the future Garraun development on the north side of the N67. Park & Ride would also be provided north of Roscam and at Knocknacarra, as per Option 1. This total route length of this option would be approximately 14.5km, and services would operate on a five-minute headway between the Park & Ride sites at Knocknacarra and Oranmore station.

This option would face the same technical constraints as Option 1 in the central section through the city centre between the hospital and Old Dublin Road. For the purposes of this option, it was assumed that the routing east of the city centre would be via College Road, which is proposed as the priority public transport corridor in BusConnects. College Road also has width constraints and on-street parking, but Bus Connects proposes reallocation of roadspace to enable more reliable bus services. Option 2A would follow the same route as Option 1 towards Knocknacarra, and along the Old Dublin Road towards Roscam. It would then follow through the southern part of Ardaun and Garraun, which would require effective masterplanning oriented towards the light rail corridor, and then run towards the upgraded transport interchange at Oranmore station.

Option 2A would not address the demand generated by the northern parts of the future Ardaun development or the major employment hub at Parkmore. **Option 2B** was therefore designed to address these needs, although it would not serve Oranmore. This route would instead turn north, at the junction of the Old Dublin Road and N67, passing through the planned Ardaun development, crossing over the N6, and terminating in Parkmore East. Park & Ride would be provided at sites north of Roscam and at Knocknacarra, as per Options 1 and 2A. This total route length of this option would be approximately 14.8km, and services would operate on a five-minute headway between the Park & Ride site at Knocknacarra and terminus at Parkmore.

Option 2B would follow the same route as Options 1 and 2A towards Knocknacarra, and along the Old Dublin Road towards Roscam. This option would then route northwards, through the new development area at Ardaun, in this case crossing over the N6 on a new bridge, also serving the new development land north of the N6. This would again require effective masterplanning oriented towards the light rail corridor. The route would then follow the Parkmore Road (or on a new segregated route to the east) towards Galway Technology Park.

Further options were explored for the section of the route between Parkmore and Roscam, including routing through the existing community in Doughiska and edge of Ballybrit, before continuing to the Galway Technology Park and Parkmore. **Option 2D** would follow through Doughiska. Park & Ride would be provided at sites north of Roscam and at Knocknacarra, as per Options 1, 2A and 2B. This total route length of this option would be approximately 14.6km, and services would operate on a five-minute headway between the Park & Ride site at Knocknacarra and terminus at Parkmore.

It is recognised that five-minute headway services would be highly ambitious, and there could be potential viability issues in operating services at this frequency. However, the purpose of this testing was to explore the comparative performance of the options and potential impacts on overall mode split across the Metropolitan Area. Further testing, described later in this chapter, explored the impacts of increased service headways.

4.3. Comparison of performance

The initial assessment of options focused on impacts on 24-hour mode share and passenger boardings. Table 4-1 shows the impacts of the different options on mode share.

Table 4-1 – LRT Route Options: 24-hour Mode Share

		Galway Metropolitan Area 24H Mode Shares					Galway County 24H Mode Shares				
Year	Description	Car	PT	Walk	Cycle	TOTAL	Car	PT	Walk	Cycle	TOTAL
2023	Do Nothing	60.2%	7.3%	28.9%	3.5%	100%	70.9%	6.7%	19.7%	2.6%	100%
2043	Do Nothing	55.8%	8.0%	32.1%	4.1%	100%	67.2%	7.3%	22.5%	3.0%	100%
2043	Do Minimum (LRT)	50.8%	11.1%	31.6%	6.4%	100%	64.3%	8.9%	22.3%	4.5%	100%
2043	Do LRT v1	50.7%	12.3%	30.9%	6.1%	100%	64.2%	9.6%	21.9%	4.3%	100%
2043	Do LRT v2A	50.8%	12.0%	31.0%	6.1%	100%	64.3%	9.4%	22.0%	4.3%	100%
2043	Do LRT v2B	50.8%	12.2%	30.9%	6.1%	100%	64.3%	9.5%	21.9%	4.3%	100%
2043	Do LRT v2D	50.8%	12.2%	30.9%	6.1%	100%	64.3%	9.5%	21.9%	4.3%	100%

In the 2023 current year, car mode share is estimated to be 60.2% in the GMA, and 70.9% in Galway County. Public transport mode share is currently 7.3% in the GMA. In the 2043 Do Nothing scenario, car mode share is forecast to reduce to 55.8%, with a small increase in public transport mode share to 8.0%. The reduction in car mode share is primarily due to a significant increase in walking mode share (and a small increase in cycling).

The 2043 ‘Do Minimum’ scenario refers to the sustainable travel scenario used to define the forecast public transport demand shown in Figure 3-3. This includes CycleConnects, BusConnects, Cross-City Link, demand management in the city centre (parking management and increased charges), and Park & Ride. This is forecast to deliver a substantial reduction in car mode share, to 50.8%, and a significant increase in public transport mode share, to 11.1%. There would also be a large rise in cycling, to 6.4%, and small reduction in walking, to 31.6%.

The model tests for the different LRT options suggest that there would be a similar car mode split to the Do Minimum. The impacts are focused on changes between public transport and active travel mode split. The largest impact would be delivered by Option 1, due to having the largest network extent (22km route length, compared to approximately 15km for the other options).

Most of the increase in public transport mode share compared to the Do Minimum scenario would be due to reduced walking and cycling. The primary impact is due to some people, who would otherwise walk or cycle, instead shifting to light rail services. The short time intervals between services, and relatively low fares, would mean that many people choose to board a tram for short movements, rather than walking.

If we compare the 2043 LRT scenarios against the 2043 Do Nothing, we see a significant increase in cycling (6.1% mode split vs 4.1%) due to the CycleConnects proposals, slight reduction in walking (due to more people cycling and a shift to LRT for short journeys), and a large increase in public transport (12.0-12.3% mode split vs 8.0% in the Do Nothing, and a 5% reduction in car mode split, equivalent to a 10% reduction in car trips compared to the Do Nothing.

Table 4-2 shows forecast public transport boardings, both 24-hour totals and during the morning peak.

Table 4-2 – LRT Route Options: 24-hour and AM Peak Boardings

		24H Boardings PT Sub Mode						AM peak hour Boardings PT Sub Mode					
Year	**Scenario**	**Rail Commute**	**Rail**	**LRT**	**Urban Bus**	**Other Bus**	**TOTAL**	**Rail Commute**	**Rail**	**LRT**	**Urban Bus**	**Other Bus**	**TOTAL**
2023	Do Nothing	0	6,538	0	17,679	39,965	**64,181**	0	1,113	0	2,849	6,310	**10,272**
2043	Do Nothing	0	8,948	0	23,269	48,130	**80,347**	0	1,654	0	3,855	7,868	**13,376**
2043	Do Minimum (LRT)	0	8,616	0	48,351	29,777	**86,745**	0	1,428	0	9,115	5,063	**15,606**
2043	Do LRT v1	0	7,799	32,475	23,436	29,324	**93,033**	0	1,268	6,812	4,189	4,912	**17,182**
2043	Do LRT v2A	0	7,969	28,903	25,400	29,646	**91,917**	0	1,279	5,967	4,532	5,029	**16,806**
2043	Do LRT v2B	0	8,380	30,876	23,435	29,778	**92,469**	0	1,357	6,358	4,154	5,034	**16,903**
2043	Do LRT v2D	0	8,403	31,096	23,419	29,806	**92,724**	0	1,363	6,412	4,164	5,049	**16,987**

The 2043 'Do Minimum' scenario includes CycleConnects, BusConnects, Cross-City Link, Demand Management and Park & Ride. This shows large changes from the Do Nothing, particularly for buses, with a large shift from 'other bus' to 'urban bus' services. This is due to the very low modelled bus headways, designed to test the upper range of potential mode shift. Rail demand would also reduce slightly, due to the shift to high-frequency bus services along the Old Dublin Road (Oranmore route). Total public transport boardings would be 17% higher in the AM peak, and 8% across the whole day, when compared with the 2043 Do Nothing.

The LRT options would result in a significant increase in total public transport boardings, by up to 10% in the morning peak, and 7% across the whole day, compared to the Do Minimum scenario. Again, Option 1 would deliver the largest increase, due to having the largest network extent (22km route length, compared to 15km for the options).

The modelling forecasts a range of 6,000 - 6,800 boardings during the morning peak, and 28,900 – 32,500 boardings over a 24-hour period for the LRT. This is equivalent to 21% of daily LRT demand being generated during the AM peak. The demand for light rail is primarily due to a shift from urban bus services. The modelling assumed that bus services directly competing with the LRT would be withdrawn to avoid service duplication.

All of the LRT options were coded with 5-minute headways (12 trams per hour), to identify a likely maximum shift from other modes. As noted above, this is an ambitious assumption, and it is likely that service frequencies would be lower. Further testing, with 8-minute headways, will be explored later in this chapter.

The lowest forecast demand would be for Option 2A (to Oranmore station), whilst Options 2B and 2D (to Parkmore) would attract higher demand, by providing connectivity to the employment hub at Parkmore and strategic growth in the Ardaun area. There would be similar levels of demand for the routes via the new Ardaun growth area and via the existing Doughiska area.

It is also possible to undertake a preliminary comparison of the likely viability of the different options. The total length of the route options is a useful proxy for the operating costs and construction cost. A longer route costs more to operate because more trams are needed and will have a higher construction cost. By comparing daily demand with the total length of each option, the number of passengers per route-km metric is a useful measure of the relative viability of the options. Table 4-3 presents these metrics for the different options.

Table 4-3 – LRT Route Options viability metric: 24-hour passengers per km

Option	**24-hr passengers**	**Route length (km)**	**Passengers / km**
Option 1	32,475	22.0	1476
Option 2A	28,903	14.5	1993
Option 2B	30,876	14.8	2086
Option 2D	31,096	14.6	2130

Option 1 is likely to be the weakest of the options based on the passengers per km metric. The best-performing options are Options 2B and 2D (to Parkmore), whilst Option 2A (to Oranmore station) is weaker than the options heading to Parkmore.

Factors can also be applied to convert the modelled daily demand to estimate annual demand. Total LRT demand is estimated to be in the range of **8-10 million annual passengers** for the different options: ~10 million passengers for Option 1, ~8 million passengers for Option 2A, and ~9 million passengers for Options 2B and 2D. These forecasts are based on modelling of 5-minute headway services: longer service headways (e.g. 8 minutes headways) would result in reduced demand: this will be explored later in this chapter.

4.4. Park & Ride

All of the options include Park & Ride as a core component. Table 4-4 shows the forecast 24-hour demand at the Park & Ride sites for each route option.

Table 4-4 – LRT Route Options: 24-hour Park & Ride Demand

P&R Site	Option 1	Option 2A	Option 2B	Option 2D
Knocknacarra	420	420	430	420
Roscam	470	850	950	940
Parkmore	240	-	-	-
Oranmore Station	260	320	230	230
Oranmore East	710	-	-	-
Total	**2100**	**1590**	**1610**	**1590**

Note: Oranmore station includes rail demand.

As expected, the highest Park & Ride demand would be delivered through Option 1, with 2,100 users per day. Options 2A, 2B and 2D would have lower total demand, with around 1,600 users per day.

There would be consistent levels of demand for Park & Ride at **Knocknacarra**, with 420-430 users per day for all of the options. This shows that there is strong demand, irrespective of the LRT network configuration. There is a strong case for Park & Ride at this location, which would intercept trips west of the city.

There would be relatively low demand for Park & Ride at **Parkmore**. For trips heading towards Galway from the north-east, along the N83 from Tuam, relatively few people would choose to transfer to LRT. This is because driving into the city is likely to be faster than the journey via LRT, which would be significantly longer along the route via Ballybrit. Park & Ride at Parkmore was ***not***, therefore, included in any of the other network options.

In the case of **Oranmore station**, this was proposed as a Park & Ride interchange hub in Option 2A. In this case, total demand would be 320 users per day, including both tram and rail users. However, this is only slightly higher than the total daily demand (230-260 users per day) in Options 1, 2B, and 2D, in which it is only served by rail. The case for a strategic mobility hub at Oranmore station therefore appears to be comparatively weak.

Option 1 included a Park & Ride site at **Oranmore East**, to intercept demand from the N67 from the south-east. Total daily demand was forecast to be high, and tram services could provide an attractive option for people heading towards Galway from this direction. However, there is otherwise very low demand between Oranmore and Roscam along the Coast Road, and there is likely to be a relatively weak case for extending LRT to Oranmore, as noted above.

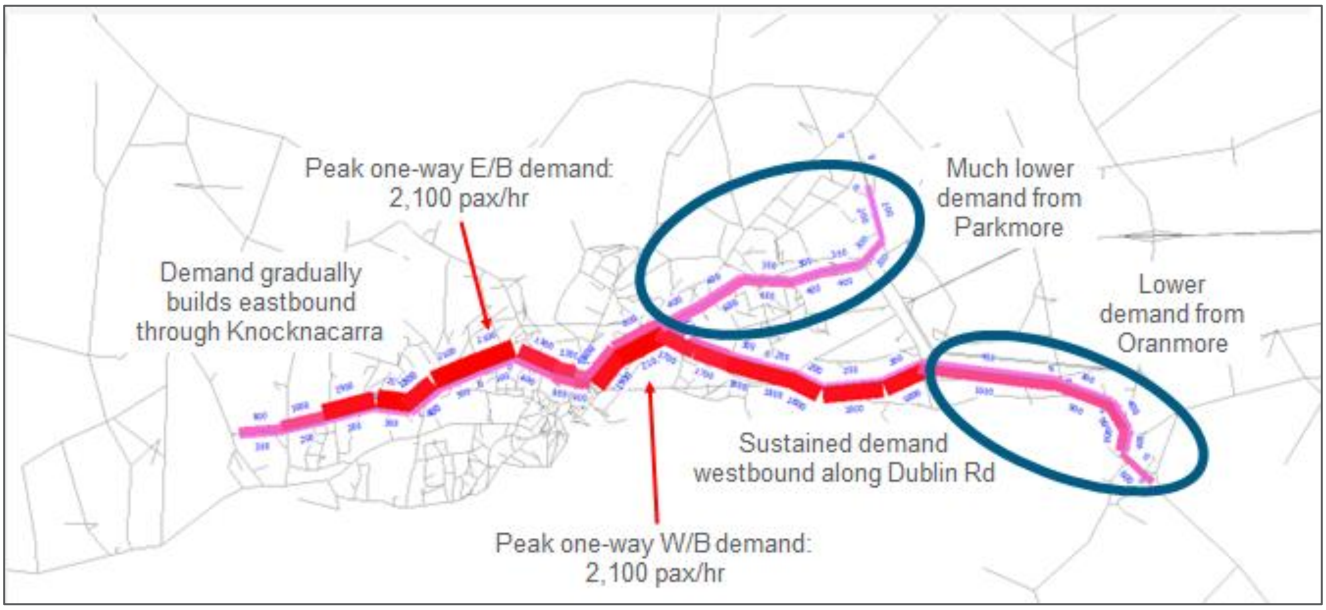
Roscam is an attractive location for Park & Ride on the east side of the city. This would intercept trips from both the N67 from the south-east, and N6/M6 from the east. The lowest demand would be in Option 1, because demand will also have been intercepted from Parkmore and Oranmore East. There would be much higher levels of demand in Options 2A, 2B and 2D. Options 2B and 2D would attract the highest demand, and demand would be slightly lower in Option 2A, due to a small amount of demand being intercepted at Oranmore station.

Based on this evidence, there is a strong case for further consideration of Park & Ride to serve LRT at **Knocknacarra**, to intercept trips into the city from the west, and near **Roscam**, to intercept trips from the east. There is not a strong case for Park & Ride at Parkmore: this is unlikely to be able to intercept significant trips from the north-east. There is also not a strong case for LRT-based Park & Ride at Oranmore, although Oranmore station should continue to serve rail trips into the city from the east.

4.5. Exploring route demand during the morning peak

It is also useful to explore patterns of demand along the route, for each option, during the morning peak. This highlights the locations with the highest demand, and potential operational issues to be addressed in each option. Figures 4-2-4.5 show the forecast 2043 AM peak passenger flows for the different options. All of the options include demand from Park & Ride and assume 5-minute service headways.

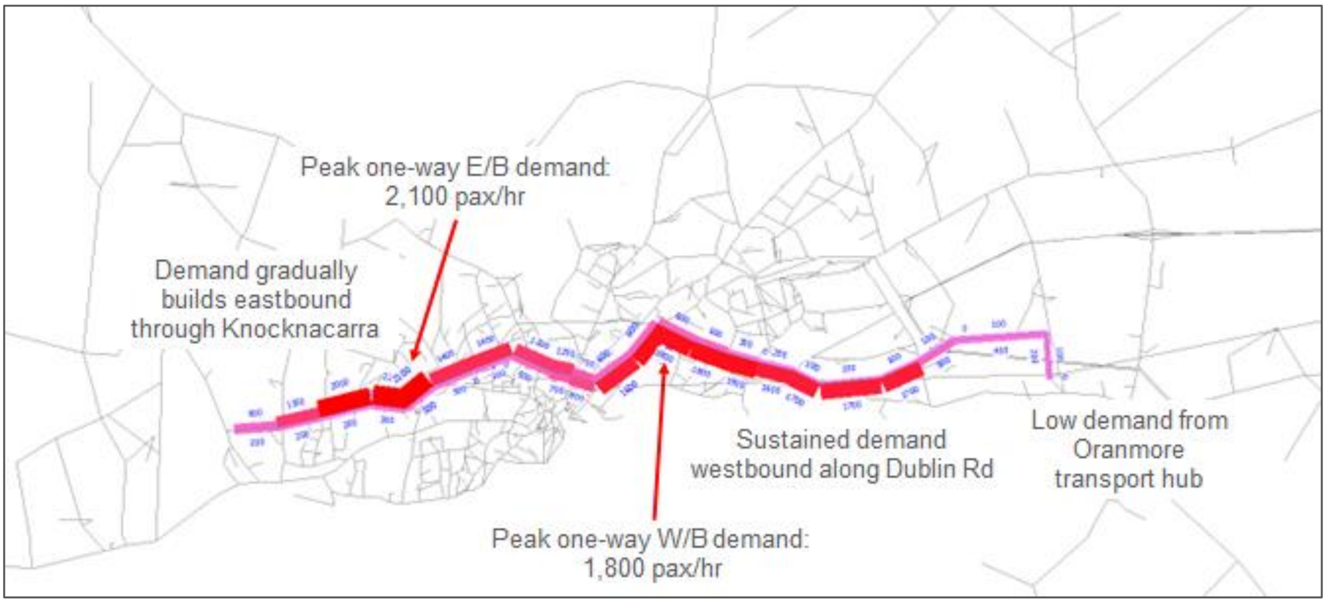
Figure 4-2 – Option 1: 2043 AM peak hour LRT passenger flows



In the case of **Option 1**, demand would build gradually through Knocknacarra (from the Park & Ride site at the western extent), reaching a maximum of 2,100 passengers per hour eastbound along Seamus Quirke Road heading towards the hospital. There would be strong westbound demand along Dublin Road towards the city centre, with demand reaching a maximum of 2,100 passengers per hour westbound along College Road, due to demand feeding in from the Parkmore route.

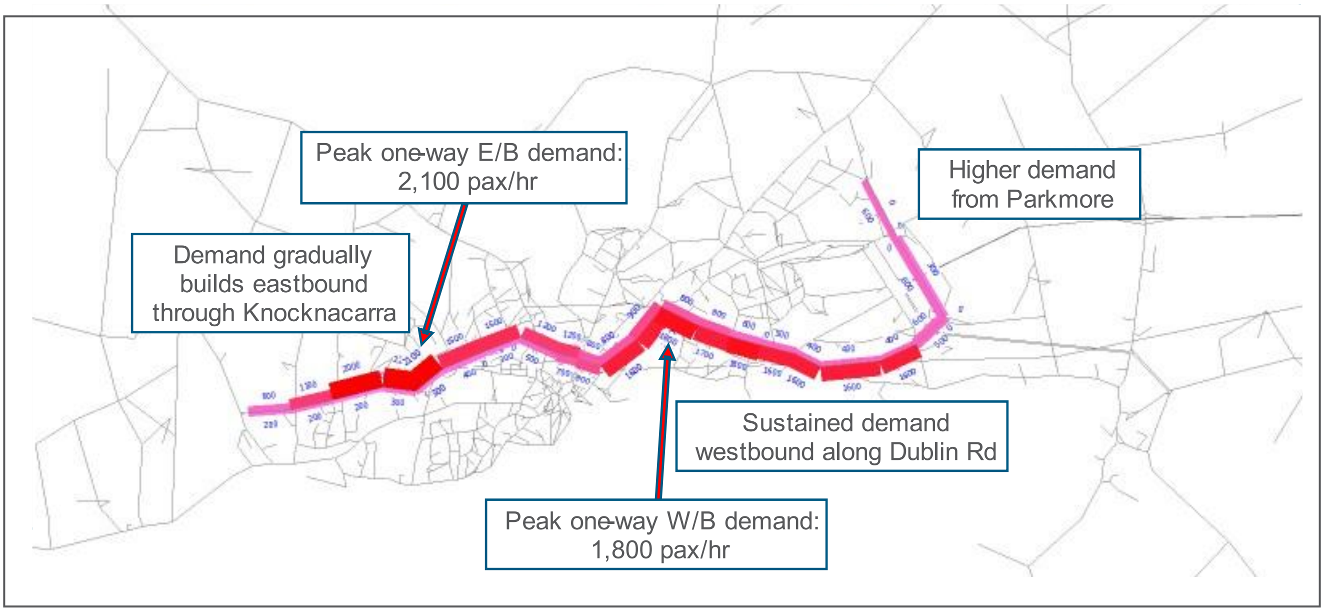
There would be lower demand between Oranmore and Roscam, and much lower demand from the Parkmore route. The low demand at these ends of the network is the root cause of the relatively poor viability metric for this option shown in Table 4-3.

Figure 4-3 – Option 2A: 2043 AM peak hour LRT passenger flows



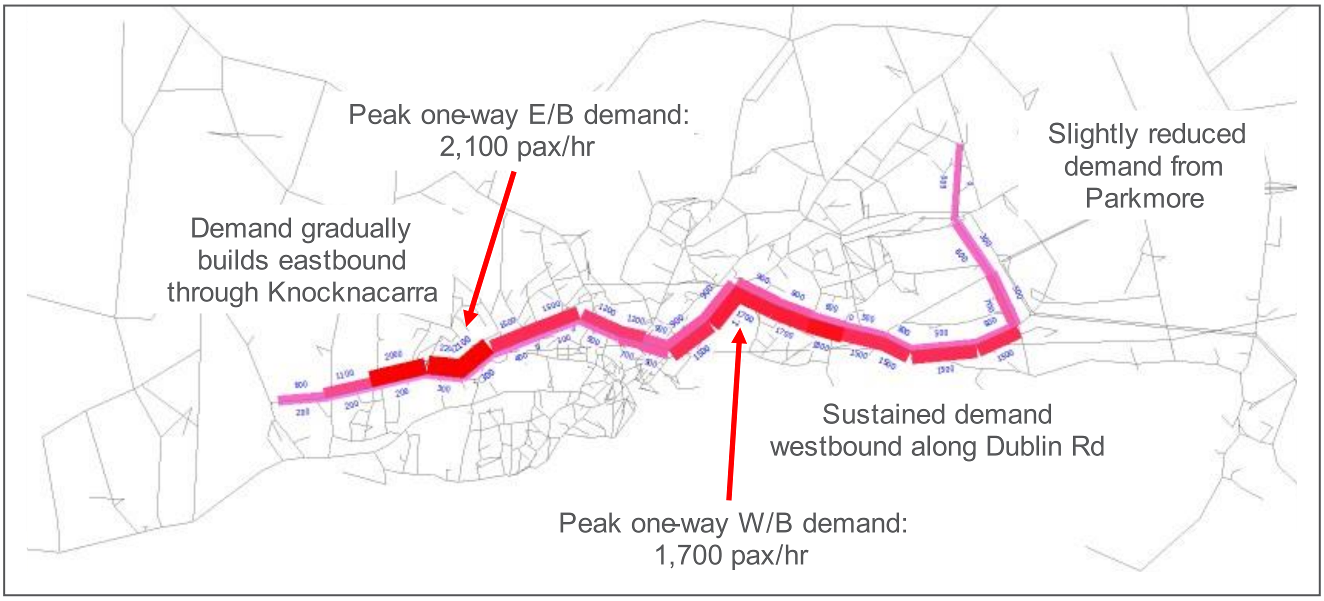
In the case of **Option 2A**, there would be similar pattern of demand on the route from Knocknacarra towards the city centre. There would again be sustained westbound demand along Dublin Road, but peak demand along College Road would be lower than Option 1. This is because there would be no demand feeding in from Parkmore. There would be very low demand feeding in from the Oranmore Park & Ride and transport hub.

Figure 4-4 – Option 2B: 2043 AM peak hour LRT passenger flows



In the case of **Option 2B**, there would be a similar pattern of demand heading eastbound from Knocknacarra. There would also be sustained westbound demand along the Dublin Road from the east, again reaching a maximum of 1,800 passengers per hour along College Road. There would be higher levels of demand from Parkmore, in this case, than from the Oranmore transport hub in Option 2A. This would be due to interception of demand from the large development area in Ardaun.

Figure 4-5 – Option 2D: 2043 AM peak hour LRT passenger flows



Option 2D is a variation of Option 2B, instead routing through the existing community of Doughiska. This shows a slight reduction in demand on the section between Parkmore and Roscam, and a slightly lower peak flow (1,700 passengers per hour) on College Road. However, there is limited overall difference in performance from Option 2B: Table 4-2 showed that total boardings during the AM peak would be similar (~6,400 boardings in both cases).

4.6. Proposed corridor for further assessment

Based on the evidence above, the strongest performing options are likely to be Options 2B and 2D. These have the strongest viability score (based on daily passengers per route-km, see Table 4-3), and have strong sustained demand along the route length.

There is a strong case for Park & Ride at Knocknacarra, which will intercept car trips from west of the city and generate a good base level of demand from the western terminus. Park & Ride near to Roscam will also generate high demand along the Dublin Road corridor, intercepting trips from both the N67 and N6 corridors.

Figures 4-6 to 4-9 show the 2043 forecast flows, for Option 2B, for different times of day. These are based on operating 5-minute headway services, see below for a commentary on implications of longer headways.

Figure 4-6 – Option 2B: 2043 AM peak hour LRT passenger flows

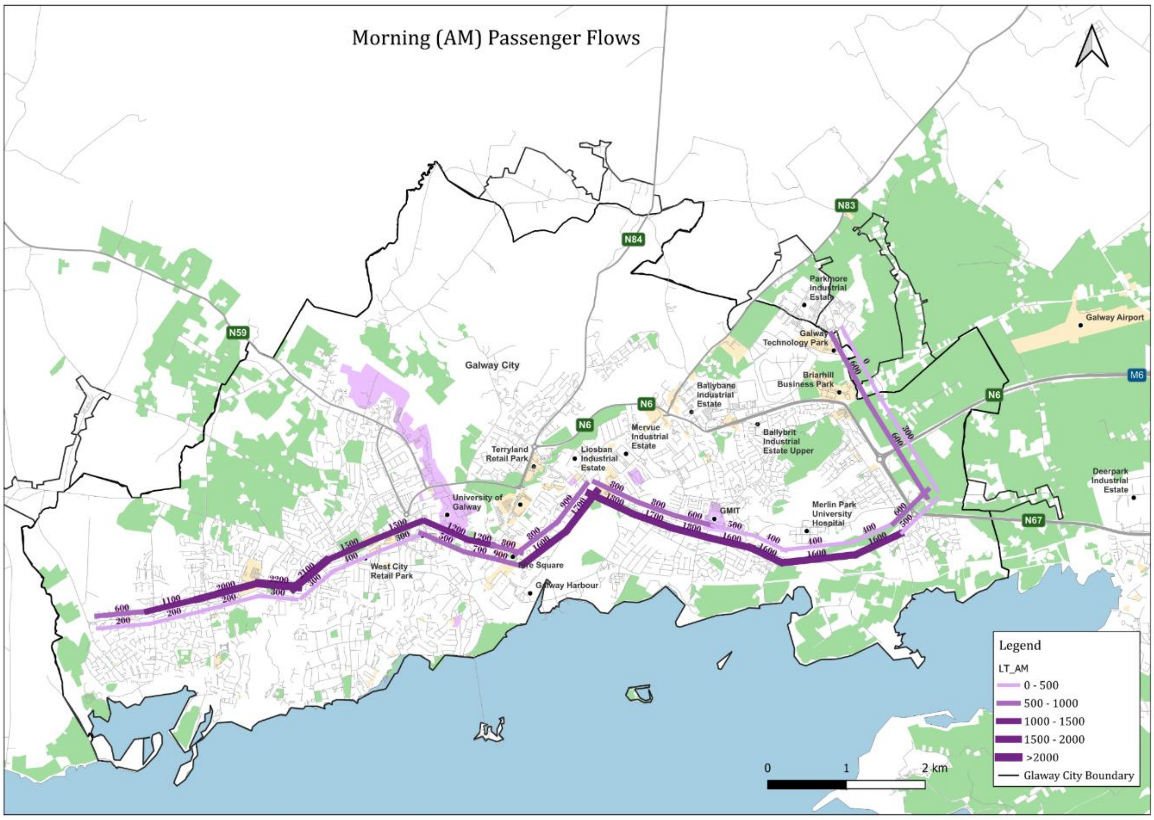


Figure 4-7 – Option 2B: 2043 lunchtime hour LRT passenger flows

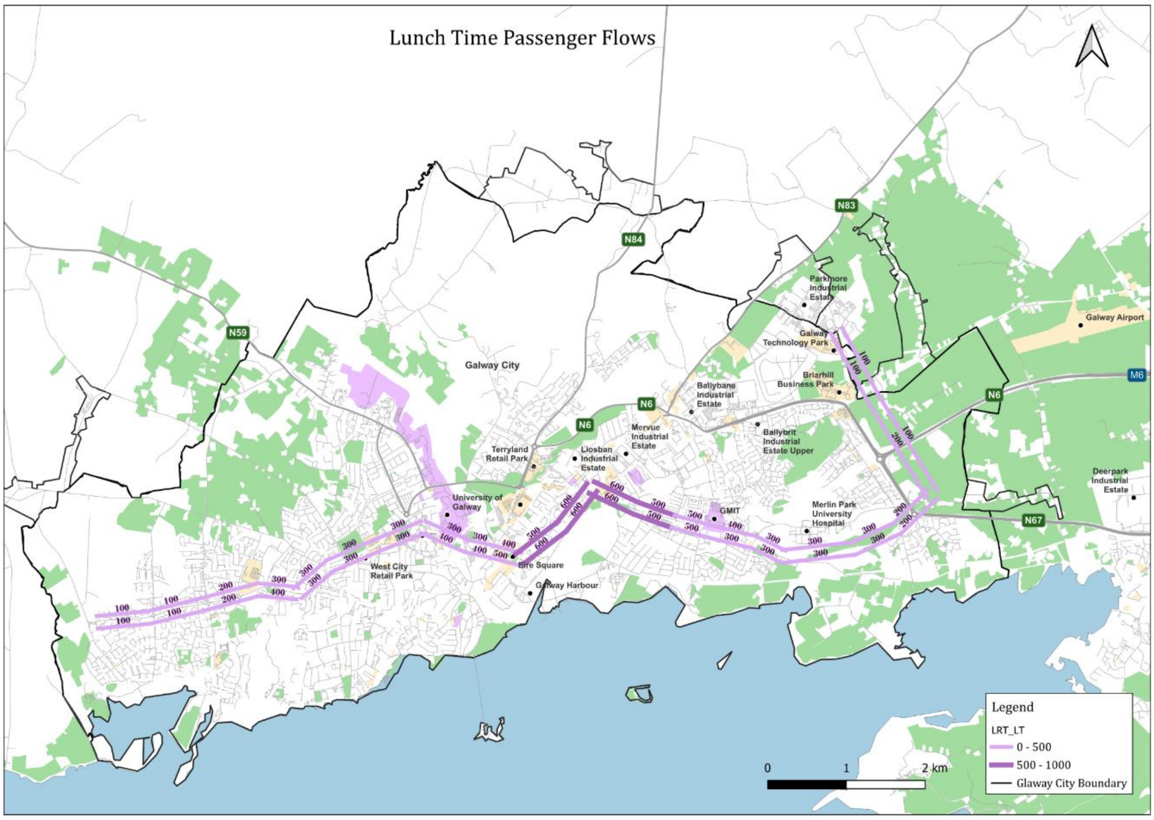


Figure 4-8 – Option 2B: 2043 school-run peak LRT passenger flows

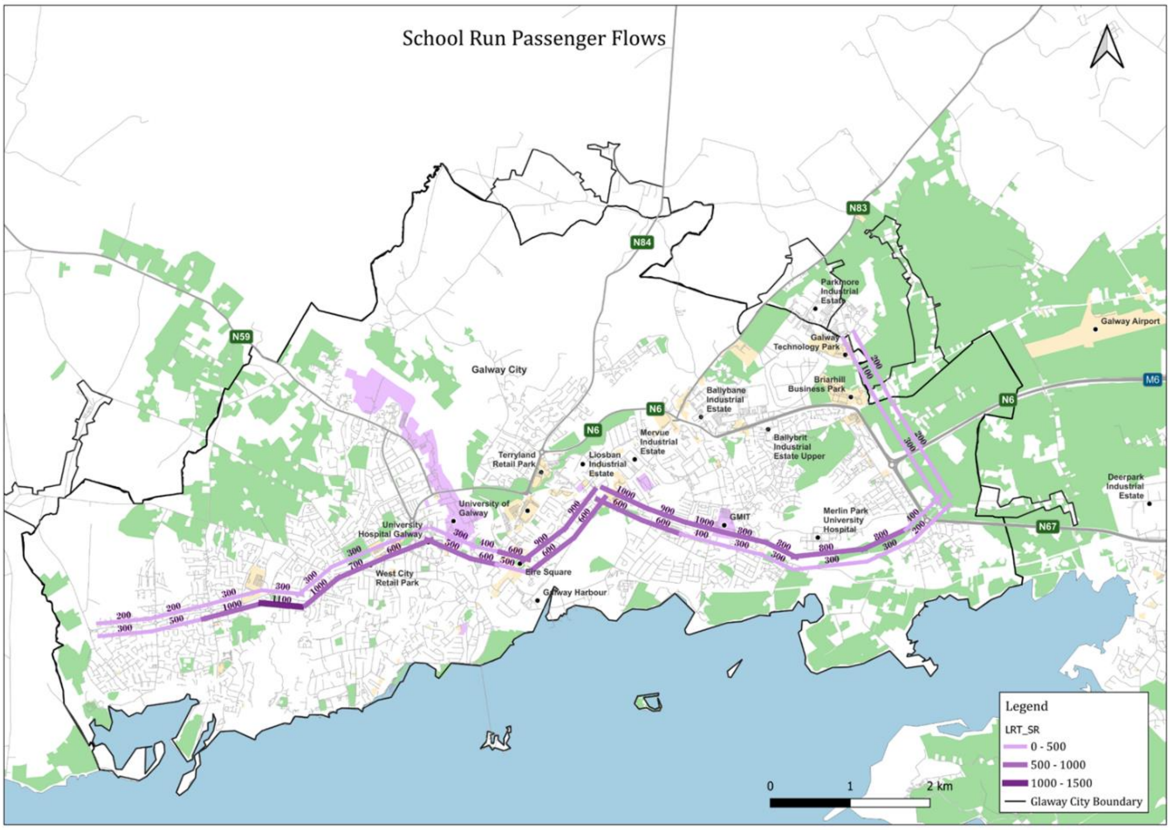


Figure 4-9 – Option 2B: 2043 evening peak LRT passenger flows

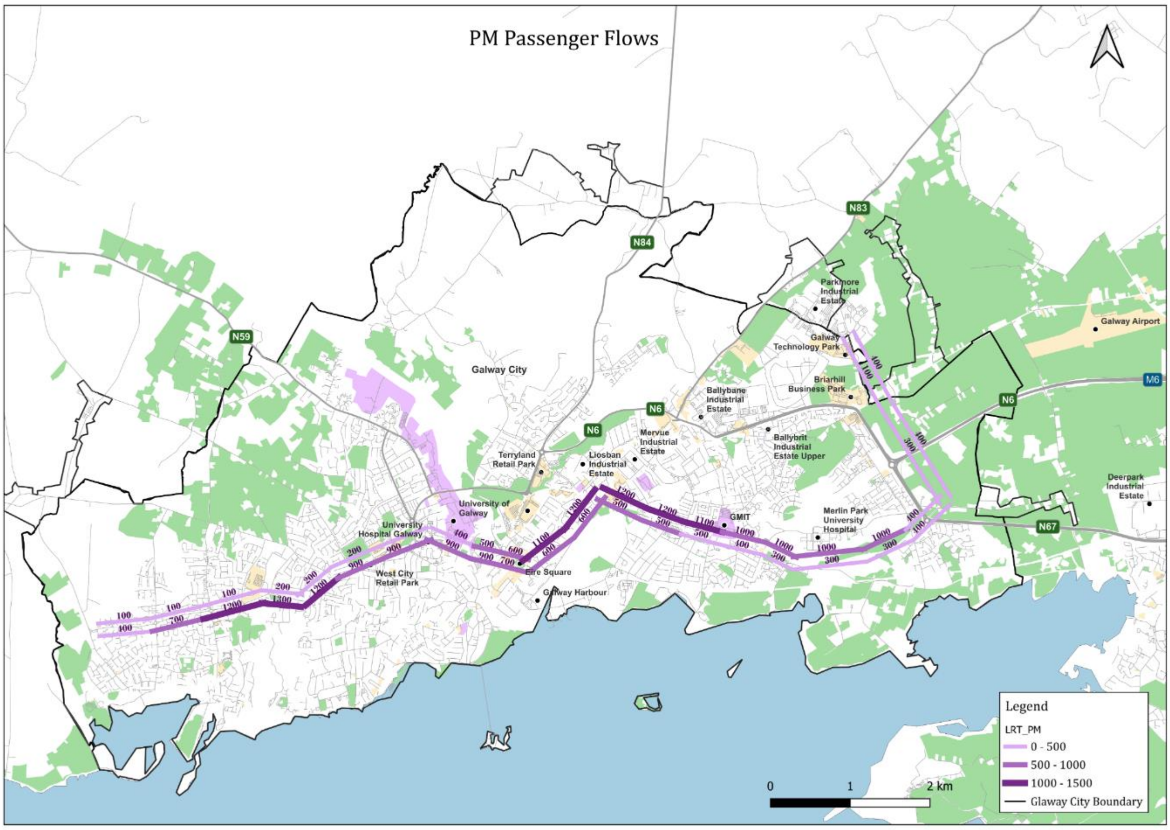


Table 4-2 showed that over 20% of daily demand would be generated during the morning peak, and Figure 4-6 clearly shows that flows will be highest during the morning peak. Flows would be much lower during the day, although there would be appreciable two-way flows between GMIT and the city centre. There would also be significant outbound flows from the city centre, both eastbound and westbound, during the school-run peak and evening peak.

Understanding the variations of flows throughout the day is important because these will inform key parameters for a future potential light rail system. The morning peak would generate the strongest peak flows: 2,200 passengers per hour eastbound at Bishop O'Donnell Road, and 1,700 passengers per hour westbound on College Road. Average flows would be much lower at other times of day: typically up to 300-600 passengers in each direction during lunchtime, 1,000-1,100 during the school-run, and 1,200-1,300 during the evening peak.

4.7. Further model testing

The analyses described above have, to date, been based on 5-minute headway services, to explore the potential maximum levels of demand using the LRT system. In practice, it is unlikely that vehicles would operate at such short headways, and further tests were therefore undertaken assuming 8-minute headways, equivalent to 7.5 trams per hour.

Table 4-5 shows the impacts on mode share of Option 2B, for the following scenarios:

- Five-minute headways (Scenario W_AAL001);
- Eight-minute headways (Scenario W_ABF001); and
- Eight-minute headways, with further demand management policies to support the Climate Action Plan (Scenario W_ABG001).

Table 4-5 – LRT Option 2B: 24-hour Mode Share

			Galway Metropolitan Area 24H Mode Shares					Galway County 24H Mode Shares				
Scenario	Year	Description	Car	PT	Walk	Cycle	TOTAL	Car	PT	Walk	Cycle	TOTAL
W_AAI001	2043	Do Minimum	50.8%	11.1%	31.6%	6.4%	100%	64.3%	8.9%	22.3%	4.5%	100%
W_AAL001	2043	Do LRT v2B	50.8%	12.2%	30.9%	6.1%	100%	64.3%	9.5%	21.9%	4.3%	100%
W_ABF001	2043	Do LRT v2B - 8min	50.9%	11.7%	31.3%	6.2%	100%	64.3%	9.2%	22.1%	4.3%	100%
W_ABG001	2043	Do LRT v2B - 8min - CAP	38.7%	19.3%	33.3%	8.7%	100%	54.3%	15.3%	24.3%	6.1%	100%

As noted in Table 4-1, the 'Do Minimum' scenario refers to the sustainable travel scenario, which includes CycleConnects, BusConnects, Cross-City Link, demand management in the city centre (parking management and increased charges), and Park & Ride. Under the five-minute LRT headway scenario, public transport mode split would increase from 11.1% to 12.2%, although this would be due to mode shift from walking and cycling, and no overall impact on car mode split.

The eight-minute headway scenario is forecast to achieve an 11.7% public transport mode split, higher than the Do Minimum (11.1%), but (as expected) lower than the five-minute scenario (12.2%).

The most notable results are for the scenario with policies to support the Climate Action Plan (CAP). In this case, there is a very large increase in public transport demand, rising to 19.3%, alongside increases in walking and cycling, and a large reduction in car mode split. This demonstrates the effectiveness of demand management policies in encouraging mode shift, which would also play a key role in enhancing the viability of new light rail services.

Table 4-6 shows forecast public transport boardings, both 24-hour totals and during the morning peak, for these same scenarios.

Table 4-6 – LRT Option 2B: 24-hour and AM Peak Boardings

			24H Boardings PT Sub Mode					AM peak hour Boardings PT Sub Mode				
Scenario	Year	Description	Rail	LRT	Urban Bus	Other Bus	TOTAL	Rail	LRT	Urban Bus	Other Bus	TOTAL
W_AAI001	2043	Do Minimum	8,616	0	48,351	29,777	**86,745**	1,428	0	9,115	5,063	**15,606**
W_AAL001	2043	Do LRT v2B	8,380	30,876	23,435	29,778	**92,469**	1,357	6,358	4,154	5,034	**16,903**
W_ABF001	2043	Do LRT v2B - 8min	8,461	25,506	25,641	29,882	**89,490**	1,376	5,249	4,572	5,061	**16,258**
W_ABG001	2043	Do LRT v2B - 8min - CAP	15,685	43,630	57,896	86,702	**203,914**	2,581	9,145	11,837	19,507	**43,070**

Under the five-minute headway scenario, around 31,000 daily boardings are forecast, equivalent to around 9 million passengers per annum. Under the eight-minute headway scenario, this is forecast to reduce by 17% to around 25,500 daily boardings, equivalent to around 7.5 million passengers per annum. This demonstrates the importance of optimising service headways: despite a 60% increase in headway (increasing from five to eight minutes), and reduction in peak tram requirements (from 25 to 16 vehicles), demand is forecast to reduce by only 17%.

The third scenario – including Climate Action Plan policies – is forecast to deliver a very large increase in public transport boardings (across all modes) across the Metropolitan Area. In the case of LRT, boardings are forecast to increase to almost 44,000 per day (from 25,500 without CAP policies), an increase of 70%. This would be equivalent to ~13 million passengers per annum.

The demand forecasting presented in this chapter can also be used to inform assessment of capacity issues and potential service specifications. For example, under the five-minute scenario, the maximum line loading was identified along Bishop O'Donnell Road, with ~2,200 passengers per hour inbound during the AM peak. Under the eight-minute scenario, it is estimated that this would be slightly lower, at around 1,800 passengers per hour. In the case of the scenario with CAP policies, demand could significantly increase, to over 3,000 passengers per hour. This will have important implications for the sizing and configurations of vehicles to accommodate demand. This is explored further in Chapter 5.

5. Technical parameters

5.1. Introduction

This chapter provides an overview of the characteristics of light rail, including the different technology options that are available. It then details the technical parameters that will need to be considered in developing potential options for Galway. This considers both vehicles and the supporting infrastructure to accommodate light rail vehicles. These parameters are then used to inform assessment of technical constraints and potential infrastructure requirements in the proposed corridor.

5.2. Technology options

The mass transit sector is rapidly evolving, driven by worldwide demand for solutions to accommodate mass movement of people into rapidly growing cities. Light rail sits within a spectrum of transit technologies, ranging from conventional bus services, through bus rapid transit, light rail, tram-train, and heavy rail. Figure 5-1 illustrates these technologies.

Figure 5-1 – Mass transit technologies

Bus Rapid Transit and the emerging concept of 'Trackless Tram' are based on rubber-tyred vehicles, operating at high frequencies, to deliver high-quality, high-capacity transit in urban corridors. Conventional Light Rail, which includes systems such as Luas in Dublin, Metrolink in Manchester, and Nottingham Express Transit, are based on modern tramway systems, which include on-street running and use of former rail corridors. Tram-train services have also been piloted in Sheffield, to enable mixed running of light rail both on-street and mixed running with heavy rail services. 'Very Light Rail' is a new concept, which is being pioneered in Coventry, to deliver the benefits of light rail at significantly reduced cost. This includes new lightweight vehicles (shown above) and lower-cost prefabricated trackforms.

The focus of this feasibility study is conventional light rail or very light rail. A full study of the suitability of the full range of potential mass transit options for Galway will need to be undertaken in due course, in accordance with the requirements of NIFTI and the Transport Appraisal Framework, to support future business case work. In the meantime, this study focuses on the potential feasibility of light rail options.

Conventional light rail

The first technology option to be considered is **conventional light rail**. The advantage of this technology is the large number of systems that have been delivered over the last two decades, resulting in strong worldwide knowledge of the critical success factors, risks and benefits of these systems. There is also a strong supplier market, with manufacturers including Alstom, Bombardier and Siemens all active in delivering trams to cities across the world. Table 5-1 provides a summary of the characteristics of some of the most common vehicles.

Table 5-1 – Technical parameters of common light rail vehicles

Supplier	Almstom Citadis	Bombardier Flexity	Skoda ForCity	Siemens Avenio	CAF Urbos	Stadler
Vehicle length	24 – 45 m	21 – 31 m	20 – 50 m	21 – 44 m	21 – 44 m	21 – 44 m
Vehicle width	2.4 - 2.6 m	2.65 m	2.3 – 2.65 m	2.3 – 2.65 m	2.3 – 2.65 m	2.3 – 2.65 m
Vehicle height	3,775 mm	3,680 mm	3,600 mm	3,550 mm	3,550 mm	3,680 mm
Low floor %	100%	100%	100%	100%	100%	100%
Max operating speed	80 kph	80 kph	80 kph	70 kph	70 kph	80 kph
Max design speed	88 kph	88 kph	88 kph	77 kph	77 kph	88 kph
Acceleration to base speed	1.34 m/s²	1.12 m/s²	1.72 m/s²	1.3 m/s²	1.3 m/s²	N/A
Examples	Nice, Paris	Brussels, Marseille, Berlin	Bratislava, Plzen	Testing world's first autonomous tram	Midland Metro	Tram-train in Sheffield

A number of different vehicle configurations are offered by the market, meeting the needs of varying demands and service specifications. For example, in Dublin, there was a recent order for 55m long trams with capacity for up to 408 passengers. This is in response to the success of Luas in attracting passengers, and there is a need for longer trams to accommodate peak loadings.

There is unlikely to be a need in Galway for such long trams, and manufacturers are also able to offer smaller configurations to meet the needs of smaller cities or less busy routes. For example, in Frankfurt, there was a recent new order for 31.5m long trams with capacity up to 190 passengers.

All tramways recently built in Ireland and the UK have been built to a standard 1,435mm track width. Guidance on the design of light rail systems has been provided by UKTram. This sets out minimum clearances between the swept envelopes (comprising the static envelope defined by the vehicle dimensions and the kinematic envelope taking account of movement and the vehicle) between vehicles and structures. It also notes that the width of lanes used by trams should normally be 3.65m in a two-way carriageway (a minimum lane width of 3.25m unless agreed by the highway authority). These dimensions are based on a 2.65m tram width, which is slightly wider than the Citadis tram described above. The trams operating in Dublin are 2.4m wide: if it is assumed that the maximum width of trams in Galway would also be 2.4m, the lane width would be 3.3m.

In terms of gradients, light rail vehicles can operate on gradients up to 10%. Manufacturers have developed options for powered bogies to enable vehicles to climb steeper gradients. Some other cities previously opted for systems where tyres are used, for example the Guided Light Transit in Nancy, where vehicles operated on tyres, with a single centre guide rail. However, this system faced multiple technical problems, and the vehicles were recently replaced with more conventional trolleybuses.

Trams can operate around relatively tight bends: the minimum curve radius for Citadis and Siemens Avenio trams are 25 metres. This means that it is possible to integrate light rail into city centres with constrained street networks. However, there could be locations in the centre of Galway where there could be significant geometric constraints. This will be explored in the following chapter.

Conventional light rail has traditionally operated under overhead electrification, which comprises around 99% of global systems. This reflects the historical development of tram systems, particularly in continental Europe. This is a well-established technology, however, there are visual impacts of overhead catenaries, and support structures and fittings become more complex in locations with more complex track layouts.

More diverse traction technologies are now becoming more common in many cities. For example, in Bordeaux, a groundfeed system enables trams to operate through the historic city centre without the need for overhead wiring. The power rail is only live when the tram passes over, improving safety for road users (pedestrians, cyclists). However, this requires additional works within the carriageway, introduces additional complexities for electricity supplies, and system maintenance can be difficult.

Hydrogen fuel cell vehicles have also been introduced, although not in Europe: these systems are limited to China, and the heritage tram in Aruba. Battery power is now becoming much more common. Birmingham introduced battery technology to enable catenary-free operation through the city centre. Short sections of catenary-free running are also being incorporated into future extensions to avoid unsightly overhead poles and wires, and to reduce construction costs in more constrained locations. However, the purchase costs of trams with battery capabilities are higher, there are higher maintenance costs, and greater issues on gradients, where acceleration is much slower under battery power.

One of the major challenges with light rail systems is the high construction cost. This is due to the major works required in the carriageway to accommodate light rail tracks and reconfigured traffic lanes, public realm improvements, overhead electrification, and utilities diversions. Utilities diversions often add significantly to the costs of light rail projects. For example, in the case of Edinburgh, uncharted utilities resulted in long delays and very high additional costs to the project. Some cities have explored options to deliver lower cost light rail schemes. For example, Besançon, in France, significantly reduced the scope of public realm improvements to deliver a lower-cost scheme. However, in France, the legal basis for engaging with utilities is different, meaning that the utilities are responsible for bearing the cost of works.

Very light rail

One of the options for addressing these issues is the emerging concept of **very light rail (VLR)**. Coventry is currently leading the way with this technology. This includes developing a solution that reduces excavation requirements and enables utilities to remain in-situ. Most utilities are located at least 450mm deep, and the promoters of VLR have developed a prefabricated 300mm-deep trackform, which enables reduced excavation in the road surface and avoids the requirement for relocation of utilities. Figure 5-2 illustrates this trackform.

Figure 5-2 – Very Light Rail trackform

Source: Coventry City Council

Some statutory undertakers may, however, wish to relocate access covers or inspection chambers, and the experience of implementing the Coventry system will provide new insights into addressing the utilities challenge.

Coventry has also led the development of lower-cost lightweight light rail vehicles (illustrated in Figure 5-1). These vehicles are 11m long and 2.65m wide, with capacity for 70 passengers: 20 seated and 50 standing. They are, therefore, much shorter (and lower-capacity) than the more conventional trams described above. The issue of passenger capacity will be a critical factor in the identification of appropriate technologies for Galway.

Very light rail systems will also need to comply with standard guidance on clearances and width requirements, as described above. These requirements are based on a 2.65m tram width, which is consistent with the vehicle design being promoted for Coventry. The vehicle designer has also stated that vehicles will be able to operate on gradients up to 5% and turn 15-metre radius curves (which is tighter than the 25m for conventional trams).

Other very light rail vehicle technologies have also been developed for other settings, which include conversion or reopening of branch lines to more frequent light rail operation.

The other major difference from conventional light rail is the expectation that vehicles will operate under battery power, with charging at depot and periodic en-route charging, removing the need for overhead catenaries along the route. However, this technology is still being trialled and live operations have not yet commenced. Furthermore, there is limited market competition, although this could increase as the technology matures.

For both conventional and very light rail, it will also be necessary to provide facilities for **maintenance of rolling stock and infrastructure**. In most cases, rolling stock, infrastructure and the Operations Control Centre are included on a single site. Infrastructure maintenance facilities would include space for storage of replacement rails and track equipment, overhead electrification equipment and spares, facilities for welding and site engineering, and track maintenance plant.

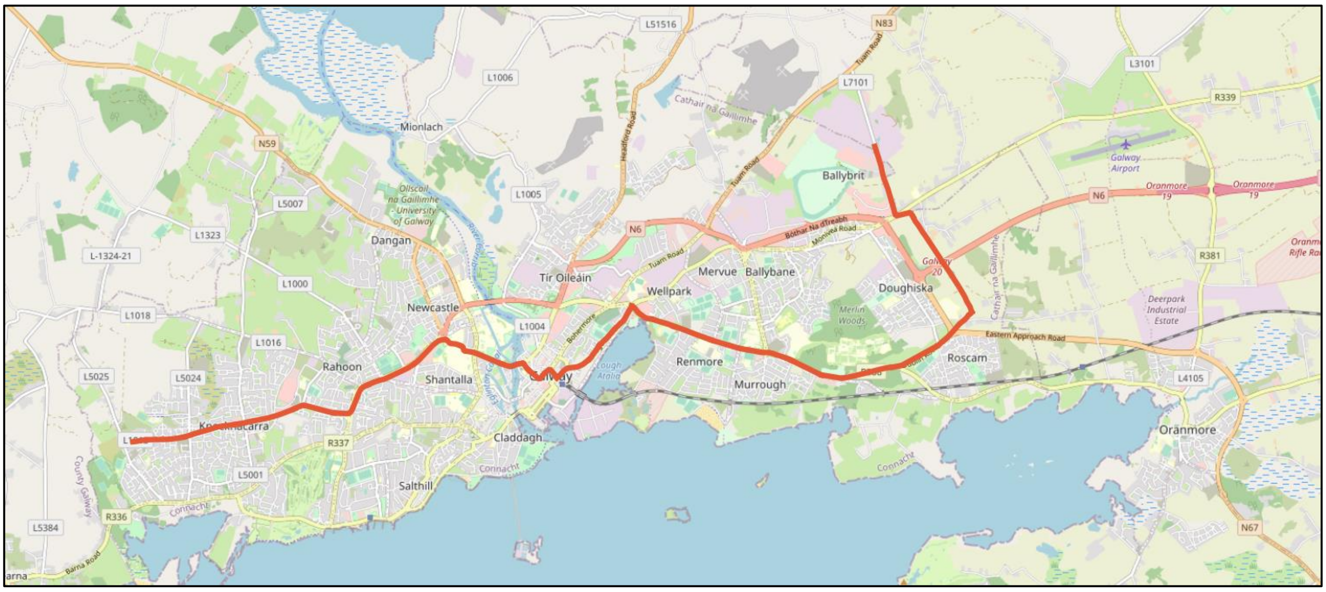
The site would provide a **depot** for vehicles, which will include stabling, external washing, internal cleaning, and maintenance facilities. The co-located **Operations Control Centre** (OCC), provides visualisation of trams on the network, with location information provided through an Automated Vehicle Location System. The OCC will also control passenger information displays and audio announcements at stops and will control CCTV and help-points for passengers.

A review has been undertaken of the configurations of depot and OCC buildings for existing systems in the UK and Ireland. The configurations depend on the available footprint across the wider site area. The Luas Red Cow depot building measures approximately 50m x 60m, the depot building in Nottingham is approximately 40m x 80m, and the building in Sheffield is approximately 30m x 90m. Building configurations will depend on the size and number of trams to be stabled and maintained. The wider site areas need to include space for movement of trams, and typically cover areas of around 150-200m width, and around 300m length, although this will depend on the constraints imposed by the site.

5.3. System parameters informing concept development

The proposed option for further development is based on Option 2B, as shown in Figure 5-3.

Figure 5-3 – Proposed option for further assessment



The system parameters are as follows:

- Service headway = 8 minutes in each direction, during AM and PM peaks;
- Route length (Knocknacarra – Parkmore) = 14.8 km;
- Average route speed = 17kph;
- End-to-end journey time = 52 minutes;
- Round trip journey time = 124 minutes (including 10 minute layover at each end of the route);
- Peak vehicle requirement = 16 trams (required to deliver 8 minute headway);
- Total fleet requirement = 20 trams (including 20% allowance of spare vehicles during maintenance);
- 2 Park & Ride sites: Knocknacarra & Roscam
- Total daily demand = 26,000 passengers per day (eight-minute headway scenario); and
- Maximum peak demand = 1,800 passengers per hour (Bishop O'Donnell Road inbound, AM peak).

These parameters will be used to inform development of the operating model and estimation of potential operating costs of the system.

Maximum demand loading and vehicle specification

The modelling indicates that there could be a maximum link loading of up to 1,800 passengers per hour in one direction, heading inbound on Bishop O'Donnell Road in the morning peak. However, this is a localised demand location, with slightly lower demand on other parts of the network during the same period. For example, 1,500 passengers per hour are estimated to be travelling on College Road inbound. Flows would be significantly lower during other times of day. For example, in the evening peak, maximum flows would be ~1,000 passengers per hour in each direction and ~900 passengers per hour during the evening school-run. Flows would be significantly lower at other times of day, for example ~500 passengers per hour in each direction at lunchtime.

The maximum loadings will be important in the specification of vehicle requirements. If the 1,800 maximum hourly loading were used, this would imply an average of 240 people on each tram at the busiest point in the network in the morning peak. If it is assumed that sufficient capacity is provided to address this peak loading, it would mean that vehicle occupancy would be much lower along other sections of the route and at other times of day. For example, during the evening peak, the trams would be around 50% full, and only around 25% full during the off-peak period.

If the LRT project progresses further, it is recommended that more detailed demand analysis is undertaken along the route, to determine the peak flows. In the meantime, it is considered appropriate to assume a design capacity of approximately 1,500 passengers per hour in each direction. Assuming an eight-minute headway, this would be equivalent to 200 passengers per tram.

In contrast, the very light vehicles described above only have capacity for 70 people. If operating at an eight-minute headway, this would only deliver a maximum capacity of 525 passengers per hour in each direction. This would fail to meet capacity needs during the morning peak (by a large margin), the school-run and evening peak. It would therefore require the operation of higher-frequency services, running up to 25 services per hour in the morning peak (equivalent to every 2½ minutes).

This would require a significant increase in the total fleet to meet these requirements. The conventional light rail solution would require up to 16 trams to meet peak vehicle requirements. However, it is likely that over 40 very light rail vehicles would be needed to deliver the equivalent level of capacity. If more very light rail vehicles are not provided, capacity will be significantly constrained, which would also constrain the maximum demand that can be accommodated. It is, therefore, recommended that more conventional light rail vehicles are provided to meet future demand.

Park and Ride

Two Park & Ride sites have been identified: west of Knocknacarra and north of Roscam. Forecast 24-hour demand is 430 users at Knocknacarra, and 950 users at Roscam, based on 5-minute headway services. Under the 8-minute headway scenario, it is estimated that this would reduce to around 360 at Knocknacarra and 800 at Roscam. The following assumptions have been made to identify the maximum parking demand (hence required capacity) and overall size at each site:

- Average car occupancy: 1.1 passengers per car;
- Average daily turnover of parking spaces: 1.2 (assuming that most demand is from commuting, hence spaces will be occupied for most of the day); and
- Average 30sqm per space, including circulation space within the car park, space for LRT corridor, waiting facilities and welcome building, and landscaping.

We therefore estimate that there would be a requirement for approximately 300 spaces at Knocknacarra and 600 spaces at Roscam. This would translate into ~0.9 hectare (90m x 100m) at Knocknacarra and 1.8 hectares (130m x 140m) at Roscam. We have assumed that the site at Knocknacarra would be accessed from Cappagh Road, and the site at Roscam would be accessed from Old Dublin Road or direct from the N67.

In practice, the siting of the Park & Ride sites will be dependent on the availability of suitable land and the need to minimise environmental impacts. This will, in turn, influence the LRT route.

Vehicle depot, maintenance and control centre

It is also necessary to consider potential locations for the vehicle depot, maintenance, and control centre. As discussed in Section 5.2, these facilities are normally co-located at a single site. Based on the dimensions of existing facilities, it would be appropriate to plan for an indicative site area of around 150m width x 300m length.

This will need to include extensive infrastructure, including stabling facilities, washing and maintenance, and Operational Control Centre. It needs to be located at some point along the route, at a location that is easily accessible from the road network and accessible to staff. It is also important to recognise the visual impacts of the extensive infrastructure.

Phasing and future expansion

It is important to consider how a light rail system could be phased and potentially expanded in future. The evidence in this report is indicating that a route from Knocknacarra to Parkmore would be the initial priority corridor, extending over approximately 15km. The strongest demand is between Knocknacarra and Roscam, due to the existing major destinations generating high levels of demand, including the city centre, hospital, University, and GMIT. The section between Roscam and Parkmore would either pass through Doughiska or the new development areas in Ardaun and is characterised by lower demand.

The initial focus for delivery would, therefore, be along the core section between Knocknacarra and Roscam, with potential phased delivery along the route. This could include one or both of the Park & Ride sites, which would be important in enabling mode shift from the wider catchments and generating strong demand from each end of the route. The depot would need to be planned as part of the initial phase, which will influence both choice of depot location and the phasing strategy. The section from Roscam to Parkmore could then be considered for delivery at a later stage. This issue is considered further in Section 6.5.

One issue that should also be considered is progressive evolution from bus to LRT. The Do-Minimum option is based on the Sustainable Travel Modes scenario, which includes the BusConnects programme, with a strong emphasis on encouraging mode shift through parking management in the city centre. The proposed corridor will be upgraded through the BusConnects programme, including the Cross-City Link through the city centre, together with further investment in bus priority on the Dublin Road. If a decision is made to progress LRT in Galway, consideration should be given to future-proofing of new bus infrastructure for future conversion to LRT.

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6. Route concept development

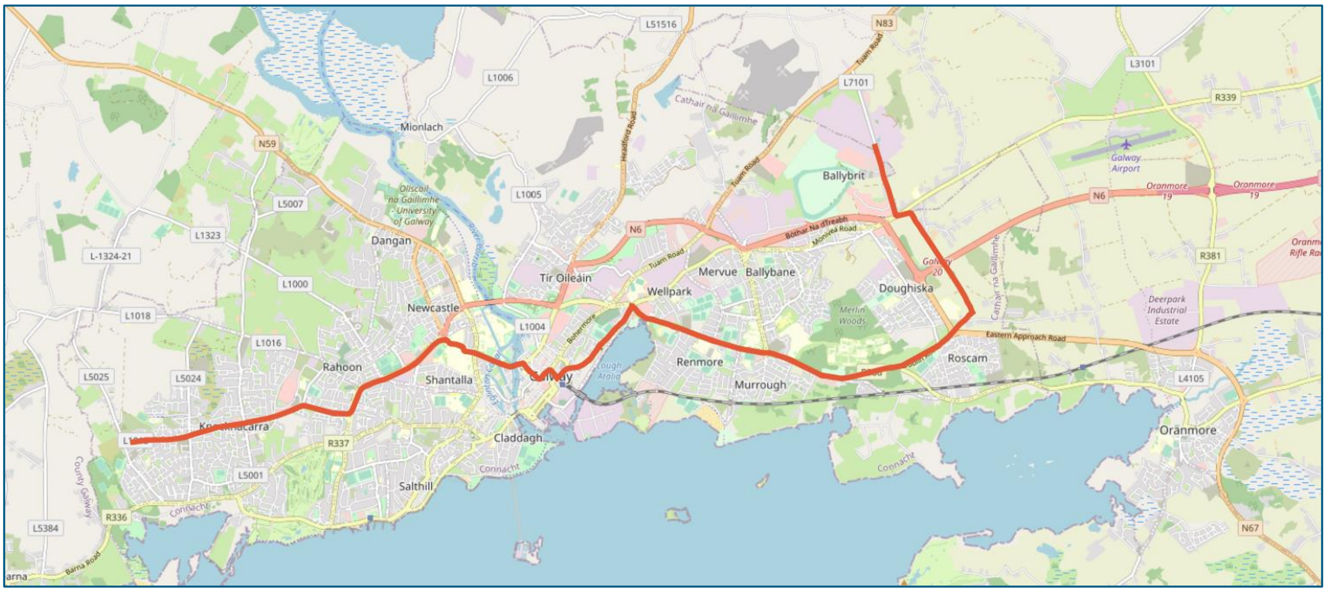
6.1. Introduction

This chapter describes the approach to development of the LRT concept for the route. The starting point has been to apply the technical parameters (from Chapter 5) and assess technical constraints along the route. The key technical factors are corridor width, gradients, turning radii, potential traffic impacts and frontage access. These have been used to identify potential infrastructure requirements along the route. Technical issues associated with the Park & Ride sites and depot have also been considered. This evidence has been used to inform assessment of potential capital costs. Evidence has also been used from other LRT systems to develop estimates of annual operating costs.

6.2. Route assessment

The proposed route is shown in Figure 6-1. This route has been identified based on the analysis presented in the previous chapters and **it is not a definitive preferred alignment for light rail in Galway**. This has been developed for the purposes of exploring key issues to inform this feasibility study and provide evidence relating to costs, benefits, and risks to feed into discussion about the potential role of light rail in the city.

Figure 6-1 – Proposed LRT route for assessment in the feasibility study



An initial assessment has been undertaken of each section of the route, taking account of the following parameters:

- Traffic impacts: it will be critical to provide reliable services, which will require appropriate levels of segregation from congested traffic. This could mean dedicated lanes (see below) or significant traffic controls, which could impact on general traffic;
- Corridor width: would LRT services run in dedicated lanes, in mixed traffic, or in LRT-only streets? The assumed minimum lane width for LRT is 3.25m, and there are parts of the road network with width constraints;
- Gradient: most of the route is relatively flat, although topography rises more steeply in the Parkmore area;
- Turning radii: the minimum turning radius of trams varies between 15m and 25m, depending on the vehicle type. There are tight radius turns along parts of the route, particularly through the city centre; and
- Frontage access: the route passes through the city centre, where deliveries will need to be made to retailers, and some sections of the route pass through residential streets, with on-street parking.

These assessments have highlighted the following issues:

- Gradient is unlikely to be a significant challenge along most of the route. There could be a localised issue with levels in the area around the **R338 roundabout** between the Western Distributor Road and Bishop O'Donnell Road. This is likely to require significant works to reconfigure the road layout in this area.

- The section of the route past or through the **hospital** would face multiple challenges of routing through a busy hospital environment, including Accident and Emergency, other busy hospital departments, and extensive parking areas. There are also tight radius turns on the roads through the hospital site.
- One option could be to explore an elevated structure through the site, although this would itself bring significant challenges during construction, and it would be necessary to design ramps to a suitable gradient for trams. Assuming a maximum 10% gradient and a 10m high structure, ramps of approximately 200m would be required on the north-west and eastern sides of the hospital site, which would be difficult to accommodate within the site footprint.
- An alternative option would be to take a different route north of the hospital, via Seamus Quirke Road, before turning south into Lower Newcastle. This would not directly serve the hospital site, but would instead provide more direct access to the University of Galway.
- There are likely to be significant technical constraints at **Salmon Weir Bridge** on the western side of the city centre, including width constraints and potential loading issues. A parallel active travel bridge has recently been built on the south side, and Salmon Weir Bridge could be dedicated to tram (and bus) operation. However, it is possible that significant bridge strengthening works would be required to accommodate trams.
- There are significant streetspace constraints along **Eglinton Street**, which will also require careful consideration of the need for deliveries to retailers and other businesses on the street. There is also a very tight radius turn at the junction with William Street, which appears to be close to the minimum achievable 25m radius for some trams and might require single-line running.
- There is a width constraint on **Forster Street** between The Elms and the Galway City Council offices. The Cross-City Link scheme proposes a single lane width for buses, to allow footway widening. It is assumed that this would also require a single track for trams, with signal-controlled shuttle working.

Appendix A contains a more detailed analysis of the technical constraints along the route.

Overall, the analysis indicates that the route can be characterised as follows:

- **Knocknacarra Park & Ride** (west side of Cappagh Road): access for cars to/from Cappagh Road, and tramway crossing over Cappagh Road onto the Western Distributor Road;
- **Western Distributor Road** (Knocknacarra – R338 Roundabout): realignment of existing Western Distributor Road and construction of a new segregated tramway;
- **Bishop O'Donnell Road / Seamus Quirke Road** (R338 Roundabout – Browne Roundabout): re-purposing of existing bus lanes or reallocation of one carriageway for a segregated tramway;
- **Hospital area** (Browne Roundabout – UHG Main Gate): running through the hospital grounds at-grade, on an elevated structure, or an alternative route via Seamus Quirke Road and Lower Newcastle;
- **Central section** (from University Road through the city centre, to the College Road / Wellpark Road junction): building on the proposals for the Cross-City Link, repurposing streetspace for tram operations;
- **Old Dublin Road** (College Road / Wellpark Road junction – Ballybane Road): widening to provide dedicated eastbound and westbound bus and tram lanes;
- **Old Dublin Road** (Ballybane Road – Doughiska Road): widening to provide dedicated eastbound and westbound bus and tram lanes, or alternatively creating a new tramway adjacent to the carriageway;
- **Roscam Park & Ride** (between Doughiska Road and N67 junction: tramway running off-line to serve Park & Ride site;
- **Ardaun** (east of N67 junction, through new development area, to R339 north of Coolagh): new segregated alignment, with the potential to run through the development area, which will require integrated masterplanning; and
- **Parkmore Road** (R339 to Galway Technology Park): on-street running, or segregated tramway on east side of Parkmore Road.

Overall, the analyses indicate that there are no critical technical constraints to the future development of a light rail corridor through the city.

Potential options for depot location

Chapter 5 discussed the requirements for a depot, to include stabling facilities, maintenance and control centre, with an indicative site area of 150m x 300m. The depot needs to be located close to the main LRT route, with good access from the road network. There are no suitable locations within the urban core, and it would be preferable to avoid locating the depot in open countryside.

Potential locations could include the area of land north-west of the hospital, south of Browne Roundabout, or a location on the south side of the Western Distributor Road in the west of the city. However, the site footprints within the urban area are constrained, so options may need to be considered outside the existing urban area, with potential locations near to Park & Ride sites. It will also be necessary to take account of phasing of delivery of the light rail system: the depot will be required to serve the first phase of the system, which will also influence the choice of depot location, which is discussed in Section 6.5.

6.3. CAPEX

At this stage, it is not appropriate to undertake a detailed bottom-up estimate of capital costs, because this would require a more detailed assessment of potential design options. However, based on the experiences of LRT systems across Europe, the following factors will be critical influences on the overall cost:

- Purchase of light rail vehicles;
- Track works: within the highway carriageway, or a separate alignment (with rails on ballast);
- Changes to the highway carriageway to accommodate the tramway, including widening of carriageway to provide space for tram tracks, or moving the carriageway to accommodate a segregated alignment;
- Site clearance and earthworks to accommodate carriageway widening or a segregated alignment;
- Changes to road junctions to accommodate LRT, including signalisation to provide separate stages for trams;
- Overhead electrification equipment (catenaries) to power the trams;
- Utilities diversions, to avoid disruption to tram services during future utility works (this is frequently a major cost component, and a major cost and programme risk – see below);
- Structures, for example new bridges or viaducts where grade-separation is deemed appropriate (this was identified as potential option in the hospital area and would bear additional costs);
- Construction of stops along the route (including shelters, seating, ticketing, and Real Time Information);
- Park & Ride sites;
- Signalling, communications and control systems, including SCADA systems, CCTV and help-points;
- Depot, maintenance facilities and control centre;
- Construction risk allowances; and
- Costs of planning, design and development of the project.

Section 6.2 set out the technical issues and potential options for each section of the route, and it is clear that there are a number of uncertainties that could influence future capital costs. However, existing evidence can be used to identify the main parameters that will influence future costs.

Capital costs in the sections that follow are expressed as current (2023) prices. The costs of the project will inevitably rise with future construction price inflation. At this early stage, it is not considered appropriate to attempt to forecast the future costs, due to uncertainties about when the project would be delivered, and uncertainties about future construction price inflation.

Purchase of trams

A review was undertaken of recent purchases of trams from manufacturers. Based on this evidence, it is assumed that a suitable indicative allowance of €3.5 million per tram should be made.

Section 5.3 identified the need for a total of 20 trams, including spares, which would imply an indicative budget of ~€70 million (in current prices) for the purchase of the trams.

Trackwork, highway works and stops

This is usually the largest single cost item in LRT schemes, and it is frequently the most significant construction cost risk. The cost depends on the track configuration, scale of required highway works, and changes to junctions. Our initial benchmarking indicates typical unit costs of around €6m/km for trackwork, €2-15m/km for highway works (depending on scale of change required), and €0.5-10m for changes to junctions (depending on the scale of work needed). In addition, allowance would be made for approximately €0.8 million for an island tram stop (with tracks either side) or €1.0 million for a pair of stops.

In addition, substantial allowances must be made for utilities diversions. These have been a major source of cost for many recent LRT schemes, with significant programme delays and cost overruns due to uncharted utilities. It is recommended that a further 20% allowance should be made at this early stage.

On some parts of the route, there would be relatively modest changes to road layout. For example, the route through the city centre is already planned for significant public transport prioritisation through BusConnects and the Cross-City Link. However, further modifications would be required to accommodate tram operations.

On other parts of the route, for example along the Western Distributor Road and Old Dublin Road, major works would be required to reconfigure the road layout to accommodate tram operations.

Overhead electrification and communications systems

Overhead electrification infrastructure is also a significant component of cost, due to the requirement for masts and power equipment. The requirements become more complex in dense urban areas and where tracks make tight turns within city streets. One option could be to explore catenary-free running through the city centre, through the use of hybrid battery-powered vehicles, as discussed in Section 5.2. An indicative allowance of €4.0m per km has been made. Allowance should also be made for signalling and communications systems. An indicative allowance of €2.5m per km has been made.

Park & Ride and Depot

The Park & Ride sites at Knocknacarra and Roscam will also be major cost items. The costs will depend on the configuration of the site, access arrangements, and waiting facilities. Provision should also be made for extensive EV charging and renewable energy generation. There will also be a requirement for high-quality landscaping to mitigate visual impacts. Recent schemes include a new site in Leeds (1,200 spaces, £38 million, which includes extensive local highway works), and west of Oxford (850 spaces, £51 million, including extensive reconfiguration of the local road network, including bus lanes). Provisional allowances have been made of €20 million for the site at Knocknacarra (300 spaces) and €40 million at Roscam (600 spaces).

The depot will be a major capital cost component, to include stabling facilities, maintenance, and control centre building. An initial cost allowance of €50 million has been made.

Risk allowance

There are significant risks in the construction of LRT projects. These include (but are not limited to):

- Uncharted utilities (as discussed above);
- Other unforeseen ground conditions, including geotechnical challenges;
- Environmental risks, including landscape and biodiversity impacts, particularly in the rural edges, including the Park & Ride sites at Knocknacarra and Roscam;
- Issues raised by stakeholders during the planning and consenting process, which require significant changes to scheme designs and increased mitigation measures;
- Challenges with traffic management, particularly in a congested urban environment;
- Other issues to be addressed in managing construction operations, particularly in maintaining access to homes and businesses along the route; and
- Impacts of noise and emissions during construction, which could significantly impact on working hours and construction methodology.

It is therefore appropriate to add a significant risk allowance. The NTA Contingency calculator states that 'Standard' project contingency for Phase 1 should be within the [30-44%] range. Calculations with both values were made to give a cost range.

Land costs

It is appropriate to make allowance for potential land purchase to accommodate the light rail corridor. A nominal 10% allowance has been made at this stage.

Planning, design and preparation costs

This would be a major project, which requires extensive planning, design, and assessment. A nominal 10% allowance has been made at this stage.

Initial benchmark CAPEX estimate

Table 6-1 uses these benchmark values to develop an initial benchmark CAPEX estimate. The total estimate is approximately **€1.23 billion to €1.34 billion**, in 2023 prices, including a 30 to 44% risk allowance and further

10% allowance for land costs and 10% for preparation costs. The total route length is approximately 14.8km, so the cost is equivalent to approximately **€80 million to €90 million per km** (including the costs of the depot, purchase of trams, indicative allowance for land costs, and 30% to 44% risk allowance).

It is recognised that this appears to be a very high cost. However, this is based on the expectation of major highway works, particularly outside the city centre, to provide sufficient levels of segregation to ensure reliability of services in a highly congested network.

This also shows that trackwork itself is a small component of the overall costs: supporting highway works could also be a major component, together with structures, utilities, depot and Park & Ride sites.

Table 6-1 – Initial benchmark CAPEX estimate (€ million, 2023 prices)

Cost component	Rate	Metric	Quantity	Units	Sub-Total
Trackwork	€6.0	m/km	0.0	km	€88.8
Highway works	Varies	m/km	0.0	km	€109.8
Junctions - major	Varies	m/ea	0	no	€108.0
Junctions - minor	Varies	m/ea	0	no	€33.5
Structures	Varies	m/ea	0	no	€90.0
Stops	€1.0	m/ea	0	no	€22.0
Utilities	20%	uplift			€90.4
Overhead electrification	€4.0	m/km	0.0	km	€59.2
Communications systems	€2.5	m/km	0.0	km	€37.0
Park & Ride sites	Varies	m/ea	2	no	€60.0
Depot	€50.0	m/ea	1	no	€50.0
Tram purchase costs	€3.5	m/ea	20	no	€70.0
Total estimated CAPEX (excl risk, land, preparation costs) (million Euro)					**€818.7**
Risk allowance	[30% - 44%]	uplift			[€245.6 - €360.2]
Land purchase costs	10%	uplift			€81.9
Planning and Design	10%	uplift			€81.9
Total estimated CAPEX (incl risk, land, preparation costs) (million Euro)					**[€1,228.1 - €1,342.7]**

Benchmarking costs

It is also useful to compare these CAPEX estimates with other recent systems: benchmarking shows that:

- Many systems delivered during the 1990s followed converted railway lines (or a combination with on-street running). The unit costs (per route-km) of these systems were much lower because there were reduced works to build the track. Systems with higher levels of on-street running incurred significantly higher route costs.
- The unit costs of more recent systems were much higher. This was due to much more significant levels of on-street running, which resulted in much greater highway works, utility diversions and public realm costs.
- The Midland Metro extension to Birmingham city centre, extended just over 1km, with a construction cost of £40 million in 2015 prices. This included major works to route the tram through the city centre, including public realm improvements. Applying construction price indices derives a unit cost of £50m per km in 2022 prices, equivalent to approximately €60m/km.
- Phase 2 of Nottingham Express Transit extended the city's tram system by 18km and cost £570 million in 2015 prices. This included major works to the road network and large new structures to carry the tram over Nottingham station and over the city's ring road and main hospital. Applying construction price indices derives a unit cost of £39m/km in 2022 prices, equivalent to approximately €45m/km.
- The proposed LRT line in Cork will extend over 17km and was estimated in the Cork Metropolitan Area Transport Strategy (CMATS) to cost ~€1 billion in 2018 prices. This was equivalent to €59m/km in 2018 prices.

In comparison, we have derived a unit rate of approximately €80m-€90m/km in current prices, which includes the costs of purchasing trams, an allowance for construction risks and planning and design costs. This includes a significant risk allowance (30-44%), reflecting the very early stage of development of the concept for the city. We consider that this is an appropriate indicative allowance at this early stage of concept development.

As noted above, these costs are expressed as current (2023) prices. The costs of the project will inevitably rise with future construction price inflation. At this early stage, it is not considered appropriate to attempt to forecast the future costs, due to uncertainties about when the project would be delivered, and uncertainties about future construction price inflation.

Exploring lower-cost options

There is currently extensive discussion about potential options for reducing the high capital costs in building light rail schemes. One of the pioneers of low-cost tramway construction is the city of Besançon in France. It is reported that the city opened (in 2014) a 31-station 14.5km line for €254 million, or €17.5m per km, significantly lower than the average (at that time) of €25-30m for light rail construction in France. This was achieved through simplified stations, structures and light rail equipment, simplified vehicle specification, and reduced public realm works.

However, it is critical to recognise the very different context in France, where there is a large and competitive market for light rail and different cost drivers. For example, light rail promoters are not required to pay for the costs of utilities diversions. If these costs were to be included, and costs uplifted to a current price base, unit costs for typical French systems would be greater than €50m per km.

In the UK, there is increasing interest in the concept of Very Light Rail, as discussed in Section 5.2. One of the most significant potential benefits is the development of the pre-fabricated trackform, with the promoters claiming that this could result in dramatic reductions in unit costs. One of the key principles of this approach would be the ability to leave utilities in place, and avoiding costly utilities diversions, due to the shallow track depth. However, this principle is still untested, and there could be significant challenges if utilities need to undertake works to their plant, potentially disrupting LRT services. Furthermore, this still takes no account of wider highway works to segregate tram services, which is a major cost component.

6.4. OPEX

An initial assessment of potential operating costs has also been undertaken, taking account of the following:

- Peak vehicle requirements to meet the eight-minute headway, derived from the average operating speed (17km/hr) over the 14.8km length, layover time at each end of the route (16 trams, as defined in Section 5.3);
- Overall fleet size = 20 trams, assuming 20% spares;
- Estimated total annual service mileage = 1.3 million km;
- Estimated total annual operational hours = 94,000 hours;
- Vehicle operating costs based on benchmark rates for power consumption and electricity costs, together with indicative estimate for vehicle maintenance, from which we derive an estimated annual cost of €4.2 million per annum;
- Vehicle parts and refurbishment, including replacement of mechanical components, battery replacement every five years, and mid-life refurbishment, estimated to be ~€2.7 million per annum;
- Total number of employed drivers (assuming 1,840 working hours per year) = 51 drivers;
- Driver wages estimated based on benchmarking Dublin Luas salaries, with allowances for pensions, training and other salary costs;
- Using these assumptions, we derive an estimated annual driver cost of ~€3.7 million per annum;
- We estimate annual costs of depot staff, including manager and engineers, of around ~€1 million per annum;
- We have identified a total staff requirement based on benchmarking from other tram systems in Ireland and the UK, which includes back-office and management team. In addition to driver costs, we estimate other staff costs of ~€5.5 million per annum;
- There will be significant IT costs to support operations, including signalling, communications and passenger information and assistance. We estimate a nominal annual IT cost of ~€1 million per annum;
- Marketing and communications will also be important, to provide maps and timetables, and to encourage passengers to use the system. We estimate a nominal annual cost of ~€0.5 million per annum; and
- The LRT operator will also need to make a profit. A 9% profit margin on operations has been assumed.

Based on these components, we estimate that the annual operating costs would be around **€20 million per annum**, in 2023 prices, or ~€1.39 million per route-km.

These costs have been benchmarked against the operating costs of other LRT systems in Ireland and the UK:

- Dublin: estimated annual OPEX of €70m per annum, total system length of 44.5km, equivalent cost per route-km = €1.56m per km;
- Edinburgh: estimated annual OPEX of £25m per annum, total system length of 19km, equivalent cost per route-km = £1.34m per km (equivalent to ~€1.6m per km);
- Nottingham: estimated annual OPEX of £24m per annum, total system length of 32km, equivalent cost per route-km = £0.75m per km (equivalent to ~€0.9m per km); and
- West Midlands: estimated annual OPEX of £16m per annum, total system length of 23km, equivalent cost per route-km = £0.69m per km (equivalent to ~€0.8m per km).

This shows a wide range of operating costs for LRT systems, both in terms of absolute totals and unit operating costs per route-km. One of the key drivers of this range is due to staff salary costs, which are estimated to be lower in Nottingham and the West Midlands, and higher in Edinburgh and Dublin. The indicative operating costs for the Galway system are at the upper end of the range, which is consistent with higher salary costs in Ireland.

6.5. Route length and phasing

As highlighted in Section 5.3, one approach to managing future capital and operating costs could be the phasing and progressive expansion of the route. The initial focus for delivery could be for one of the legs (west or east) to the city centre, with completion of the other leg at a later date. It is also worth noting that the route between Roscam and Parkmore would be dependent on development in the Ardaun area, which would be expected at a later date.

The initial phase could focus on Knocknacarra to the city centre, terminating at or near to Ceannt station, providing effecting multi-modal interchange with rail services. Enhanced rail services, and expansion of Park & Ride at Oranmore station, together with enhanced high-frequency bus services along Old Dublin Road, could support connectivity needs from the east of the city.

The initial phase, from Knocknacarra to Ceannt station, would be around 6.3km long, just under half the length of the full LRT system. It would be necessary to plan the depot location to serve this initial phase, which means that the depot would need to be located at a point along, or near to, the route towards Knocknacarra. As discussed in Section 6.2, potential options could include land north-west of the hospital or on the south side of the Western Distributor Road. If a larger site footprint is required, consideration could also be given to an area adjacent to the Park & Ride site, west of the Cappagh Road. If it is not possible to identify a suitable depot location on the route towards Knocknacarra, the phasing strategy would need to be reviewed.

The total estimated cost of this first phase is approximately €650 million in 2023 prices, including 44% risk allowance and indicative 10% allowances for land purchase and preparation costs. The operating costs for this first phase are estimated to be just over €11 million per annum. This would be slightly more than 50% of the estimated costs of operating the whole system: this is because some costs are fixed, and there will be economies of scale with future system expansion.

Consideration should also be given to planning of future BusConnects works on the corridor to future-proof for light rail operations. A very significant component of the forecast capital cost is due to highway works to provide adequate segregation for trams. The Cross-City Link will provide a strong foundation for subsequent future upgrading to light rail operation through the central core. However, outside the central core, major works will be required on the Western Distributor Road and Old Dublin Road.

The planning of future improvements on these routes should give active consideration to future-proofing for future conversion to tram operations. This should include active consideration to whether trams would operate in nearside bus/tram lanes as part of the main carriageway, or within a segregated alignment adjacent to the carriageway.

7. LRT impacts and performance

7.1. Introduction

This chapter draws together the evidence from previous chapters to provide an overall narrative on the potential impacts, benefits, and costs of a future LRT system in Galway. It draws on evidence on forecast demand (daily and peak demand), journey times, sustainability issues (mode shift and impacts on car demand), and economic and financial performance. The role that an LRT system could have in GMATS will be reviewed as part of the Strategy development, considering all the other transport modes and complementary measures to encourage mode shift across the Galway Metropolitan Area.

7.2. Demand and revenue

Chapter 4 demonstrated that the emerging preferred option would attract ~26,000 passengers per day, equivalent to ~7.5 million passengers per year (based on 2043 demand). This is equivalent to 0.51m passengers per km over the 14.8km route length. Table 7-1 benchmarks this forecast demand with other light rail systems in the Ireland and the UK (based on 2018 or 2019 demand, before the COVID-19 pandemic).

Table 7-1 – Benchmarking demand for LRT systems

City	Annual passengers (mn)	System length (km)	Passengers (mn) per route-km
Galway	7.5	14.8	0.51
Dublin	48	44.5	1.08
Edinburgh	7.5	14	0.54
Nottingham	18.8	32	0.59
West Midlands	8.3	22	0.38
Sheffield	11.9	34.6	0.34

The table shows that Dublin attracts very high demand, due to its role as a capital city and the relative attractiveness of Luas in meeting mobility needs across the capital. Forecast demand in the GMA would be lower, due to the relative size of the city. However, the passengers per route-km metric (0.51m) is forecast to be similar to Edinburgh and Nottingham, where the conditions are highly favourable to light rail. The route in Edinburgh connects the airport to the city centre, passing through areas that have high propensity to use public transport.

The routes in Nottingham pass through dense built-up areas, with high propensity to use public transport, supported by integration with the bus network. Over the last two decades, the city has also promoted policies to encourage mode shift, including Park & Ride and a Workplace Parking Levy. The systems in Sheffield and the West Midlands attract lower demand because they serve areas of lower population density, and there are fewer complementary measures to encourage mode shift.

This demonstrates that the demand forecasts developed for this study are consistent with other comparable light rail systems where comparable conditions are in place.

The introduction of policies to encourage further mode shift, to support the Climate Action Plan, would further enhance demand for light rail in the city, potentially increasing demand to around 13 million passengers per annum, or around 0.88m passengers per route-km.

Forecast passenger revenues

The estimated passenger revenue can be calculated by assuming an average fare yield per passenger. There are high numbers of students in the city, and numbers of concessionary users, which has the effect of reducing average fare yield.

The average fare yield has been assumed to be €1.50 per passenger, based on €8.5m revenue for 5.7m passengers on Galway Urban Bus network in 2019 (sourced from the NTA PSO Statistics Bulletin). This would result in estimated annual revenue of ~€11 million per annum (based on 2043 demand, fares in current prices). Total revenues will increase if higher fare yields can be increased, and also if passenger demand can be increased. Further demand management measures in the city, for example further increases in parking charges, and a Workplace Parking Levy, would help to encourage further mode shift towards LRT services.

This has been one of the key success factors in Nottingham, where the introduction of the city-wide Workplace Parking Levy has both created a new source of revenue to support public transport operations ***and*** encourage mode shift for businesses across the city.

The introduction of CAP policies in Galway could increase demand to around 13 million per annum (from 7.5 million with no CAP policies), which could increase annual revenues to almost ~€20 million per annum.

7.3. Financial sustainability

It is important to assess the overall financial sustainability of light rail in Galway. This assessment focuses on future passenger revenues, compared with annual operating costs, and potential subsidy requirements.

In Section 6.4, we estimated annual operating costs of approximately €20 million per annum (in current prices). Annual passenger revenues are forecast to be approximately €11 million per annum (in current prices). This means that there is likely to be a significant ongoing subsidy requirement.

This is common in many light rail systems across Europe, with an expectation that annual subsidies to operate tram services are important in improving accessibility, reducing car dependency, and creating a high-quality urban environment. However, there are three potential ways to reduce the annual subsidy requirement:

- **Increase fare yield**, through charging higher fares and reducing concessionary benefits, however this could pose the risk of reducing demand, so this would require further testing during business case development;
- **Encourage more people to shift to tram services**, through further demand management measures across the city and further improving multi-modal integration; and
- **Explore how to reduce operating costs**, through development of a more detailed operating model, particularly in terms of required staffing structure.

The introduction of CAP policies would have the potential to increase annual passenger revenues to almost €20 million per annum, which would be much closer to the €20 million annual operating costs and would therefore make a significant contribution to reducing the annual subsidy requirement.

These options should be explored further through any future development of the business case.

7.4. Economic case

The introduction of light rail in the GMA has the potential to deliver significant benefits. These could include:

- Significantly improved connectivity benefits, with shorter journey times, more reliable journeys, and better quality journeys;
- Wider economic benefits, including improved labour market mobility and agglomeration benefits, driving increased productivity through increased business clustering and proximity;
- Mode shift benefits, due to car drivers shifting to light rail, reducing congestion, improving air quality, enabling reallocation of road space, and reducing carbon emissions from transport;
- Placemaking benefits through the presence of light rail in the urban environment, together with wider public realm improvements; and
- Unlocking new growth, including urban regeneration in the city centre (e.g. the land around Ceannt station) and the strategic growth allocation in the Ardaun area.

This LRT Feasibility Study has not undertaken a detailed economic assessment, which would be needed to inform a business case. However, it is possible to draw a series of findings from this work.

First, in terms of connectivity benefits, the proposals would result in a high level of service reliability. One of the key challenges is the scale of journey time and reliability improvements compared to future BusConnects improvements. However, LRT has the potential to significantly improve passenger experience, and deliver significant benefits to existing passengers.

LRT also has the potential to attract more car drivers than bus. The evidence in this report indicates that LRT could play a central role in helping to deliver mode shift in the GMA, as part of a multi-modal mobility strategy. Section 4.3 provided evidence on potential passenger boardings and mode shift, in a future 2043 Do Nothing, 2043 idealised sustainable travel scenario, and 2043 with LRT in place. The idealised sustainable travel scenario was an interim step to build an initial understanding of the scale of mode shift that could be achieved with very high-quality active travel and public transport.

In practice, the modelling shows that LRT could support a significant mode shift from car. With BusConnects and LRT in place, public transport mode split could increase to over 12% (from 8% in the Do Nothing), and car mode share could reduce from 55.8% in the Do Nothing to 50.8%, equivalent to a 10% reduction in car trips. This reduction would not be due exclusively to LRT: this would be due to a comprehensive programme to significantly improve sustainable travel through CycleConnects, BusConnects, Park & Ride, and demand management, alongside the LRT scheme. Nevertheless, LRT could play a significant role as a major component of this programme.

This reduction in car trips will have multiple benefits. It will significantly reduce congestion, although this would be offset in part by road space reallocation to support CycleConnects, BusConnects and the LRT route. This will bring significant economic benefits to the GMA, by reducing traffic delays and improving journey reliability, which will, in turn, support labour market mobility, reduce business costs, and improve the attractiveness of the area for inward investment. Reduced congestion will also improve air quality and lower traffic flows will reduce collisions on the road network.

It is recognised that light rail can help to enable higher-value transit-oriented development in cities, particularly for businesses in the knowledge economy, which value good connectivity to deep skilled labour markets. The improved connectivity on the east-west axis through the city would significantly improve multi-modal connectivity to the regeneration area near Ceannt station, potentially enabling higher-density and higher-value development.

Good connectivity through Ardaun could also enable higher-density, mixed-use development in this strategic growth area for the GMA. It is strongly recommended that the teams developing the masterplans for this area consider future-proofing for transit services through the area. This is likely to start with conventional bus services, as the area is built, with light rail services being delivered at a later date after demand has progressively grown.

As previously noted, this report does not identify a preferred alignment for light rail in the study area and is only intended to explore key issues and potential feasibility. Route options would need to be explored further, following any decision to further progress light rail for the city.

8. Conclusions

8.1. Preliminary Findings

This study has shown that there could, under the right conditions, be a case for developing an LRT system in Galway. There is a strong axis of east-west travel demand with the potential to shift to public transport. The assessments have shown that the focus should be on the corridor from Knocknacarra to Roscam, with potential longer-term onward connection to Parkmore via Ardaun.

The modelling indicates that annual demand of ~7.5 million passengers per annum could be achieved on this corridor in 2043. This is likely to be driven by growth in travel demand in the GMA over the next two decades, meaning that the case for intervention will become stronger later in the strategy period. The LRT patronage could be higher if more future land development and growth is located in areas close to the LRT alignment. Our benchmarking of demand on other LRT systems in Ireland and the UK indicates that the demand forecast for Galway is consistent with other cities where conditions have been particularly favourable for LRT.

The introduction of policies to support the Climate Action Plan, for example demand management measures in Galway, have the potential to support further mode shift, potentially up to ~13 million passengers per annum. This would increase revenues from fare-paying passengers and enhance the financial sustainability of the future public transport system in the city.

Park & Ride will play an important role in enabling car drivers from outside the urban area to shift to enhanced public transport at each end of the route, supporting the mode shift agenda, and generating strong base demand from each end of the route.

Whilst this study has focused on an initial assessment of the potential feasibility of light rail in Galway, it will be important to objectively assess the full range of options to deliver enhanced public transport across the city. This study has shown that, under the right conditions, there is strong potential for significant mode shift to public transport in the city.

The delivery of further improvements to public transport, linked to compact development growth / Transport Orientated Development, has the potential to deliver multiple economic, social and environmental benefits to the GMA, including improved connectivity, improved labour market mobility, and agglomeration effects to support future competitiveness of the region’s economy. This would also support modal shift, which will deliver reduced congestion, improved air quality, reduced collisions, and significant reductions in transport user carbon emissions across the region.

8.2. Next Steps

This report has demonstrated that LRT, in time, could be considered as a viable transport option for Galway City, with a potential capacity requirement towards the end of the strategy timeline. In the intermediate period, consideration should be given to progressive public transport upgrades, with active consideration of future-proofing of new bus infrastructure to enable future conversion to LRT operations.

There may be potential to justify a Light Rail Transit system in the shorter term, notably if land use development follows the Compact Development / Transit Orientated Development (TOD) approach. By concentrating higher density development along public transport corridors and, ensuring that large scale development sites fully consider the potential to consolidate around a future LRT alignment, there could be a requirement to expediate the delivery of LRT in Galway.

This report does not identify a preferred alignment for light rail in the study area and is only intended to explore key issues and potential feasibility. Route options would need to be explored further, following any decision to further progress light rail for the city. This report will form part of the evidence base to inform the development of the multi-modal Galway Metropolitan Area Transport Strategy.

Appendix A. Route Assessment

A.1. Overview of the approach taken

Tables A-1 and A-2 provide a narrative of the existing road layout and potential illustrative measures that could be introduced, together with a Red-Amber-Green (RAG) assessment, using these criteria, for each section of the route. Table A-1 shows the section of route from Knocknacarra to the Wellpark Road junction, and Table A-2 extends from the Wellpark Road junction to the terminus at Parkmore.

The notes in these tables are ***purely illustrative*** options of what might be achieved: consideration would need to be given to a wide range of options to inform a future business case.

Table A-1 – RAG assessment of technical constraints along the route (Part 1 of 2)

Route section	Start	Finish	Approx length (m)	Existing characteristics of route section	Potential *illustrative* measures to accommodate LRT	Traffic impacts	Width constraints	Gradient	Turning radii	Frontage access
Western Distributor Road	Clappagh Road	Ballymoneen Road	810	Single carriageway + green verges.	Segregated tramway + realign road carriageway	1	1	1	1	1
Western Distributor Road	Ballymoneen Road	Clybaun Road	720	Single carriageway + green verges.	Segregated tramway + realign road carriageway	1	1	1	1	1
Western Distributor Road	Clybaun Road	Gort Na Bro / Gort Siar	400	Single carriageway + green verges.	Segregated tramway + realign road carriageway	1	1	1	1	1
Western Distributor Road	Gort Na Bro / Gort Siar	Gort Na Bro / An Logan	380	Single carriageway + green verges.	Segregated tramway + realign road carriageway	1	1	1	1	1
Western Distributor Road	Gort Na Bro / An Logan	R338 Roundabout	590	Single carriageway + green verges.	Segregated tramway + realign road carriageway	1	1	1	1	1
R338 Roundabout	Western Distributor Road	Bishop O'Donnell Road	20	Roundabout.	Reconfigure junction to traffic signals, with segregated alignment for LRT.	2	1	2	1	1
Bishop O'Donnell Road	R338 Roundabout	Rahoon Road	710	Dual carriageway with bus lanes.	Convert bus lanes to dedicated tram / bus lanes (or dedicate one carriageway to trams and buses)	1	1	1	1	1
Seamus Quirke Road	Rahoon Road	Browne Roundabout	900	Dual carriageway with bus lanes.	Convert bus lanes to dedicated tram / bus lanes (or dedicate one carriageway to trams and buses)	1	1	1	1	1
Hospital complex	Browne Roundabout	UHG Main Gate	490	Busy access route through hospital grounds.	Major works required to reconfigure road layout (elevated structure could be one option to segregate trams from general traffic, but major works required to create ramps)	3	3	1	2	3
University Road	UHG Main Gate	Gaol Road (west) (west side of cathedral)	370	Single carriageway + on-street parking.	Running in mixed traffic (existing proposals to reconfigure streetspace as part of Cross-City Link).	2	2	1	1	2
University Road	Gaol Road (west) (west side of cathedral)	Gaol Road (east) (east side of cathedral)	120	Single carriageway.	Cross-City Link proposal is for bus-only route. Potential to adjust road layout to accommodate trams.	1	1	1	1	1
Salmon Weir Bridge	Gaol Road (east) (east side of cathedral)	Newtownsmith	110	Narrow single carriageway with narrow footways on bridge.	Cross-City Link proposal is for bus-only route. Potential requirement to remove footways, bridge to operate as tram (and bus) only. Pedestrians to use parallel footbridge.	1	2	1	2	1
St Vincent's Avenue	Newtownsmith	Courthouse Square / St Francis Street	70	Single carriageway with tight turning radii at Newtownsmith junction and at Courthouse Square junction.	Cross-City Link includes proposal for westbound bus lane. Extensive reconfiguration required to accommodate turning radii of trams at junction.	2	2	1	2	2
St Francis Street / Eglinton Street	Courthouse Square	William Street	290	Single carriageway with extensive retail frontages.	Cross-City Link includes proposal for southbound bus lane. Will need to accommodate deliveries to retailers. Very tight radius turn at William Street junction: might require one-way working to accommodate tram turning movements.	2	2	1	3	3
Eyre Square (north side)	William Street	Prospect Hill	190	Single carriageway, with diverse traffic movements and public realm.	Cross-City Link includes proposal for eastbound bus lane. Tight radius turn at junction with Prospect Hill: reconfiguration required to accommodate tram turning movements.	2	1	1	2	2
Eyre Square (east side)	Prospect Hill	Station Road	130	Single carriageway, with diverse traffic movements and public realm.	Cross-City Link includes two-way bus gate at north end by Prospect Hill. Very tight radius turn at junction with Station Road by Ceannt station: reconfiguration of junction required to accommodate tram turning movements.	2	1	1	2	2
Forster Street	Station Road	Fairgreen Road	180	Narrow single carriageway with commercial frontages.	Cross-City Link includes two-way bus lanes + reconfiguration of Fairgreen Road junction. Could be converted to mixed tram and bus operation.	2	2	1	1	2
Forster Street	Fairgreen Road	Galway City Council offices	260	Narrow single carriageway with range of commercial and residential frontages. Significant width pinchpoint east of The Elms.	Cross-City Link includes bus gate (one lane width, with shuttle running) between The Elms and Galway City Council offices. Could be converted to mixed tram and bus operation.	2	3	1	1	2
College Road	Galway City Council offices	Lough Atalia Road	650	Single carriageway with residential frontages and on-street parking.	Cross-City Link includes proposals to reconfigure on-street parking. Assume running of trams in mixed traffic. Further access controls likely to be required.	2	2	1	1	2
College Road	Lough Atalia Road	R339 / Wellpark Road	250	Single carriageway with three narrow traffic lanes and residential frontages.	Cross-City Link includes major reconfiguration of carriageway, including northbound bus lane. Tram route will require revision of junction with Lough Atalia Road and major reconfiguration of junction with R338 / R339 / Wellpark Road.	2	2	1	2	2

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Table A-2 – RAG assessment of technical constraints along the route (Part 2 of 2)

Route section	Start	Finish	Approx length (m)	Existing characteristics of route section	Potential *illustrative* measures to accommodate LRT	Traffic impacts	Width constraints	Gradient	Turning radii	Frontage access
Old Dublin Road	R339 / Wellpark Road	Sailin	340	Single carriageway with eastbound bus lane and verges in places.	Cross-City Link proposes carriageway widening to accommodate two-way offside bus lanes, to just east of Wellpark Shopping Centre. Potential to convert bus lanes in each direction to shared bus / tram operation.	2	1	1	1	1
Old Dublin Road	Sailin	Michael Collins Road	770	Single carriageway with eastbound bus lane and verges in places.	Widen carriageway to provide westbound bus/tram lane and convert existing eastbound bus lane to combined bus/tram operation.	2	2	1	1	1
Old Dublin Road	Michael Collins Road	Ballybane Road (GMIT)	670	Single carriageway with westbound bus lane and verges.	Widen carriageway to provide eastbound bus/tram lane and convert existing westbound bus lane to combined bus/tram operation. Reconfiguration of Skerritt Roundabout will be required to provide segregation of trams from other traffic.	2	2	1	1	1
Old Dublin Road	Ballybane Road (GMIT)	Merlin Park Entrance	350	Single carriageway with westbound bus lane and hard strip on north side of carriageway.	Widen carriageway to provide eastbound bus/tram lane and convert existing westbound bus lane to combined bus/tram operation. Alternative option for segregated off-line tram line. Signalisation of junction with Merlin Park access required.	2	2	1	1	1
Old Dublin Road	Merlin Park Entrance	Murrough Drive	320	Single carriageway with westbound bus lane and hard strip on north side of carriageway.	Widen carriageway to provide eastbound bus/tram lane and convert existing westbound bus lane to combined bus/tram operation. Alternative option for segregated off-line tram line. Reconfiguration of signals at Murrough Drive required.	2	2	1	1	1
Old Dublin Road	Murrough Drive	R338 Coast Road	1090	Single carriageway with westbound bus lane and hard strip on north side of carriageway.	Widen carriageway to provide eastbound bus/tram lane and convert existing westbound bus lane to combined bus/tram operation. Alternative option for segregated off-line tram line. Reconfiguration of signals at Coast Road junction required.	2	2	1	1	1
Old Dublin Road	R338 Coast Road	Doughiska Road	560	Single carriageway with westbound bus lane and hard strip on north side of carriageway.	Widen carriageway to provide eastbound bus/tram lane and convert existing westbound bus lane to combined bus/tram operation. Alternative option for segregated off-line tram line. Reconfiguration of signals at Doughiska Road junction required. This could include access to/from Park & Ride site.	2	2	1	1	1
Old Dublin Road	Doughiska Road	N67 Roundabout	240	Wide single carriageway, with additional lanes at Doughiska Road junction. Dedicated left turn towards N67 northbound.	Route to divert through Park & Ride site, potentially in area north of Roscam. Need to address access to/from Park & Ride site for traffic. Reconfiguration of N67 roundabout required.	2	2	1	1	1
East of N67	N67 Roundabout	Access to Blackrock Health Clinic	200	Rural single carriageway.	Potential to provide separate tram route parallel to existing road.	1	1	1	1	1
Ardaun	Access to Blackrock Health Clinic	Ardaun South	520	Currently greenfield. Emerging plans for Ardaun Development Area. South area to be developed as first phase.	Opportunity to future-proof masterplan for future tram routing through development area.	1	1	1	1	1
Ardaun	Ardaun South	Ardaun North	640	Currently greenfield. Emerging plans for Ardaun Development Area. North area to be developed as second phase.	Opportunity to future-proof masterplan for future tram routing through development area. Bridge will be required for tram to cross over N6 dual carriageway.	1	1	1	1	1
Ardaun	Ardaun North	R339	440	Currently greenfield. Emerging plans for Ardaun Development Area. North area to be developed as second phase.	Opportunity to future-proof masterplan for future tram routing through development area.	1	1	1	1	1
R339	R339	R339 / Parkmore Road junction	150	Single carriageway + green space to south.	Dedicated tram alignment on south side of road.	2	2	1	2	1
Parkmore Road	R339 / Parkmore Road junction	Merit Medical	880	Single carriageway.	Option for mixed running on existing carriageway or new dedicated tram alignment on east side of road.	2	2	1	1	2

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