Údarás Náisiúnta Iompair
National Transport Authority

AECOM

FINGAL / NORTH DUBLIN TRANSPORT STUDY

STAGE TWO APPRAISAL REPORT

June 2015

Prepared by: .... Elaine Brick, Jonathan Hennessy
Associate Director, Senior Consultant

Checked by: .... John Finnegan, Joe Seymour, Shane Dunny
Regional Director, Director, Associate

Approved by: .... Bernard Feeney
Director

Fingal/North Dublin Transport Study:
Stage 2 Appraisal Report

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1 Introduction

The National Transport Authority (NTA) has commissioned the Fingal/North Dublin Transport Study to identify the optimum long term public transport solution to connect Dublin City Centre, Dublin Airport and Swords. Providing a high capacity public transport link along this corridor has been an objective of Government for some time but is also one that has suffered delay in recent years due to unfavourable economic conditions. Despite this, improved public transport provision along the corridor remains an important objective and the current study aims to provide clarity on the most feasible long term approach with a horizon year of 2033.

The study area is shown in Figure 1.1 and includes a north/south corridor from Swords and Dublin Airport to the city centre. Swords has a population of 43,000 (Census 2011) which is anticipated to grow to up to 100,000 in the long term. It has been identified as a "Metropolitan Consolidation Town[1]" in the Regional Planning Guidelines for the Greater Dublin Area and is a key driver for sustained regional economic development. In terms of industry and employment, Swords has established a combined 'activity cluster' with Dublin Airport, in the areas of aviation infrastructure, airport related services, and transport and logistics industries.

Dublin Airport is a key centre of future employment growth to 2033 which at present, handles 81% of Ireland's air passenger demand with passenger numbers of 21.7m in 2014. This passenger figure represented an increase of 1.5m passengers from 2013 and is expected to increase to 36m by 2033[2].

In addition to its importance as a transport hub, the Airport is also an important centre of employment with 15,300 people employed there in 2014.

While improvements have been made in recent years to the provision of bus services, travel within the study area is still heavily car dependent. Figure 1.2 illustrates the main mode of transport used within the study area for the commuting trip to work/education in 2011. North of the inner city, the private car is overwhelmingly the main mode of travel for commuting. The exception to this is seen only in small catchments close to the DART line.

Travel demand within the study is anticipated to grow by up to 40% by 2033. Although a certain proportion of this growth can be absorbed by the existing and planned public transport network, the road network is likely to experience the highest level of demand. Increased demand for car travel beyond that already experienced is likely to have adverse implications with average speeds decreasing by 19% and overall delay increasing by 72%[3].

Clearly the current and potential future levels of car dependency are not sustainable, particularly in the context of environmental impact and supporting anticipated future population and employment forecasts.

In light of these concerns, the following report recommends the optimum long term public transport solution for the study area.

[1] *Defined in the Regional Planning Guidelines for the Greater Dublin Area as 'strong active urban places with strong transport links'*
[2] *Source: Dublin Airport Masterplan 2015*

[3] *Results of '2033 Do Minimum Scenario' modelling using the NTA GDA Multimodal Model – see Section 2.3 for detail.*

Figure 1.1: Study area for the Fingal/North Dublin Transport Study

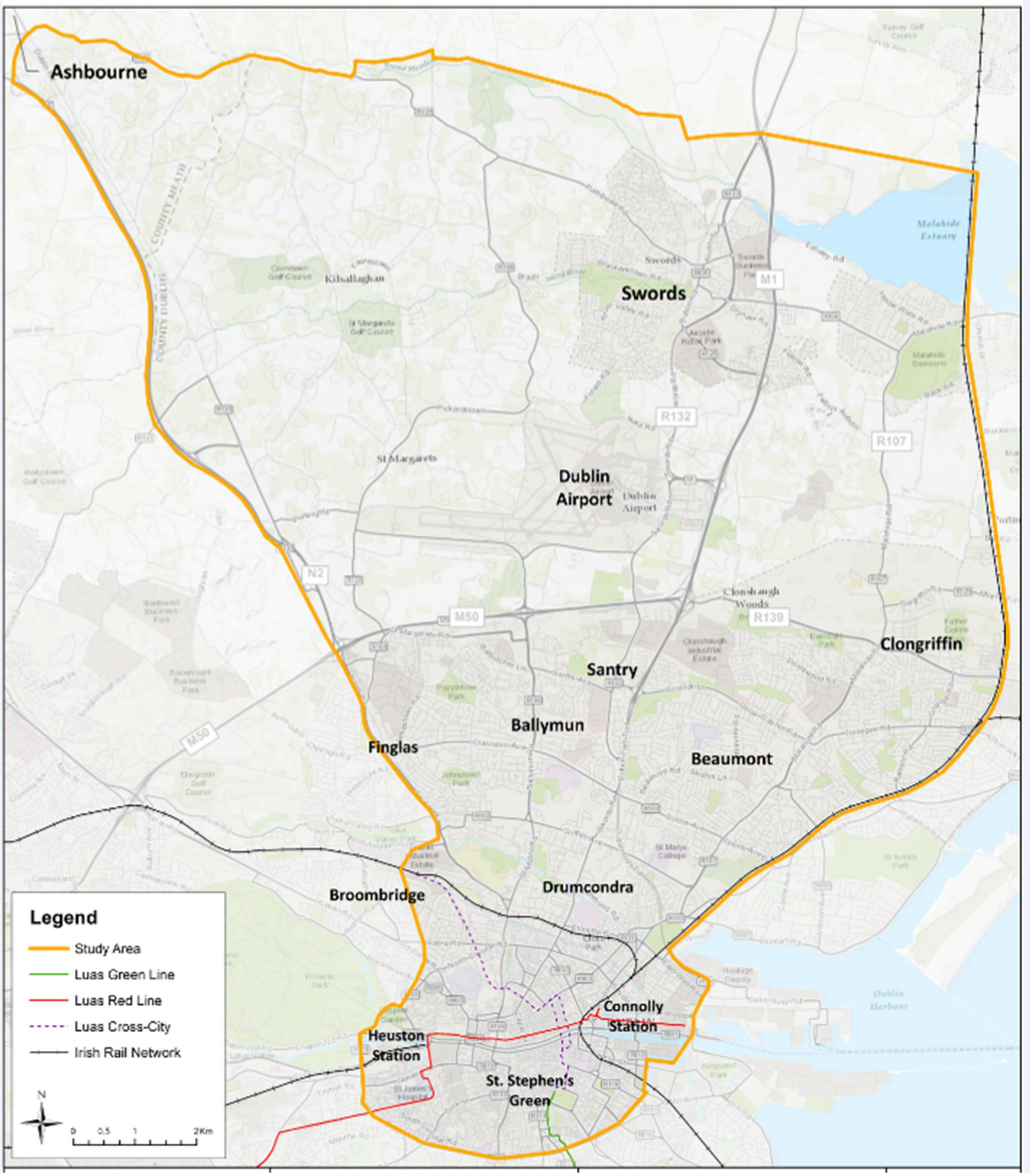
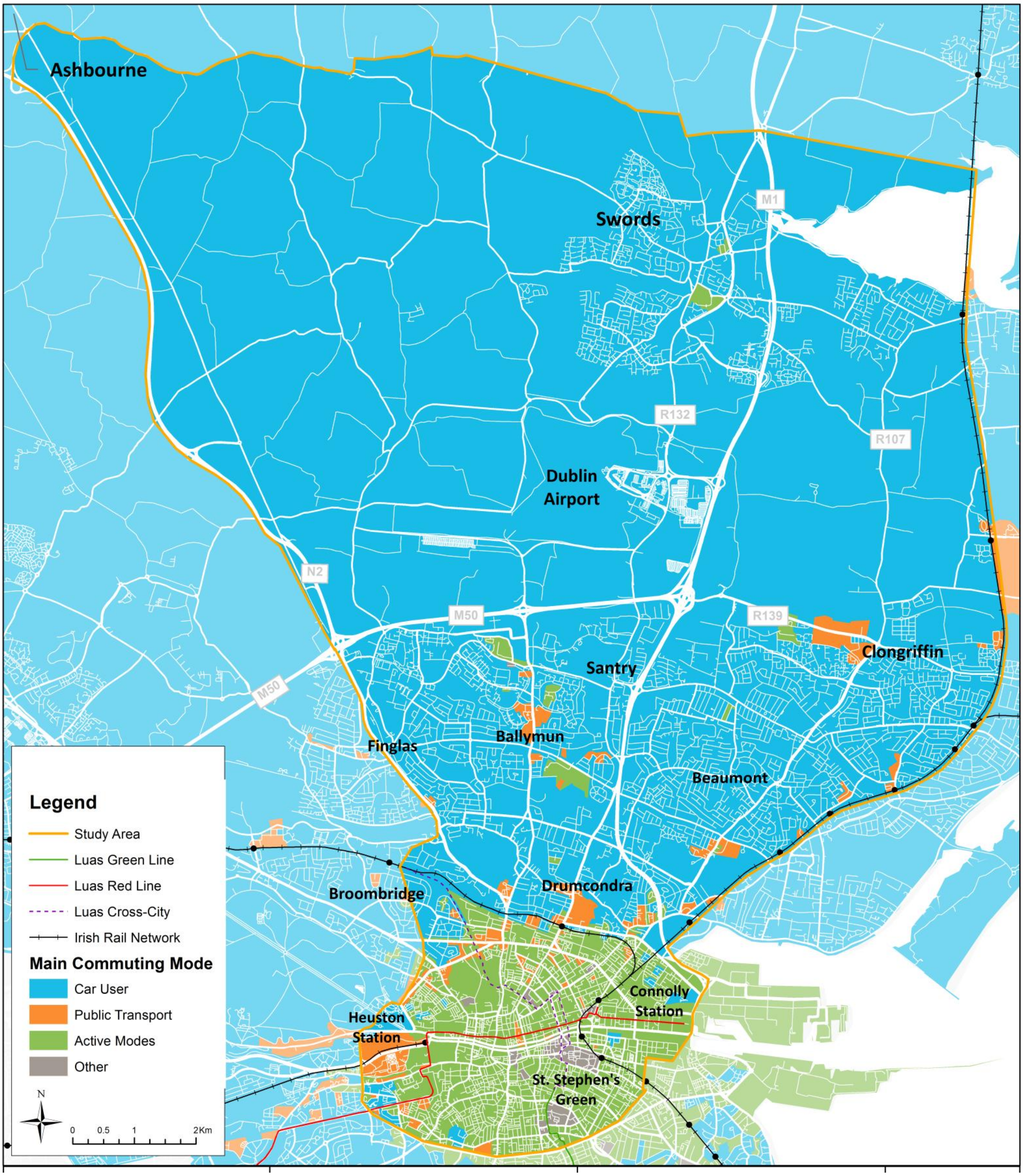


Figure 1.2: Main commuting mode within the Study area (POWSCAR, 2011)



This study has been undertaken on the basis of the following principles:

- All options previously proposed for this corridor, including Metro North, were revisited and their feasibility assessed in light of the current land use and transport context as well as the projected growth forecasts for the future;

- The study has been undertaken on an independent basis with no bias towards any schemes or transport modes. Recommendations are made on the basis of the scheme option which presents the best strategic fit for the study area;

- Land use planning, employment and population forecasts form the basis of identifying a strategic need for an expanded public transport network in the area. AECOM has liaised extensively with the National Transport Authority (NTA), Dublin Airport Authority (DAA), Fingal County Council (FCC) and Dublin City Council (DCC) to understand future forecasts for the area and plans for spatial development;

- The appraisal of the proposed schemes has been undertaken in compliance with Government guidelines for appraisal as outlined in the Public Spending Code[4] and the Common Appraisal Framework for Transport Projects and Programmes[5]; and

- Stakeholder engagement throughout the process has been a critical component of overall delivery with Irish Rail, the Railway Procurement Agency (RPA), DAA as well as DCC and FCC involved at key stages of project delivery. In addition, the Stage 1 Appraisal report was presented for public consultation with feedback reviewed and informed Stage 2 of project delivery, which short-listed 6 options.

The study has been delivered in two distinct phases as follows:

- Stage 1 was concerned with identifying the strategic context for future development within the study area. In response to this demand, a list of 25 potential public transport schemes was identified for the area. Each of these was developed to a conceptual level and appraised, with a shortlist of six potential schemes for future development recommended; and

- Stage 2 provided an opportunity for further development of each of the six shortlisted schemes to enable a more detailed appraisal. The technical and operational feasibility, environmental impact and cost of each scheme was developed, and detailed transport modelling was undertaken to understand how each scheme might respond to future travel demand within the study area. The outcome of Stage 2 is the identification of one preferred public transport scheme for future development within the study area.

A summary of Stage 1 and 2 subtasks is presented in Figure 1.3. More detail on the methodology of each of these stages is presented in Section 4, Section 6 and Section 11.

Although the following report is the main output of Stage 2, it also provides a summary of all project outcomes and deliverables to date.

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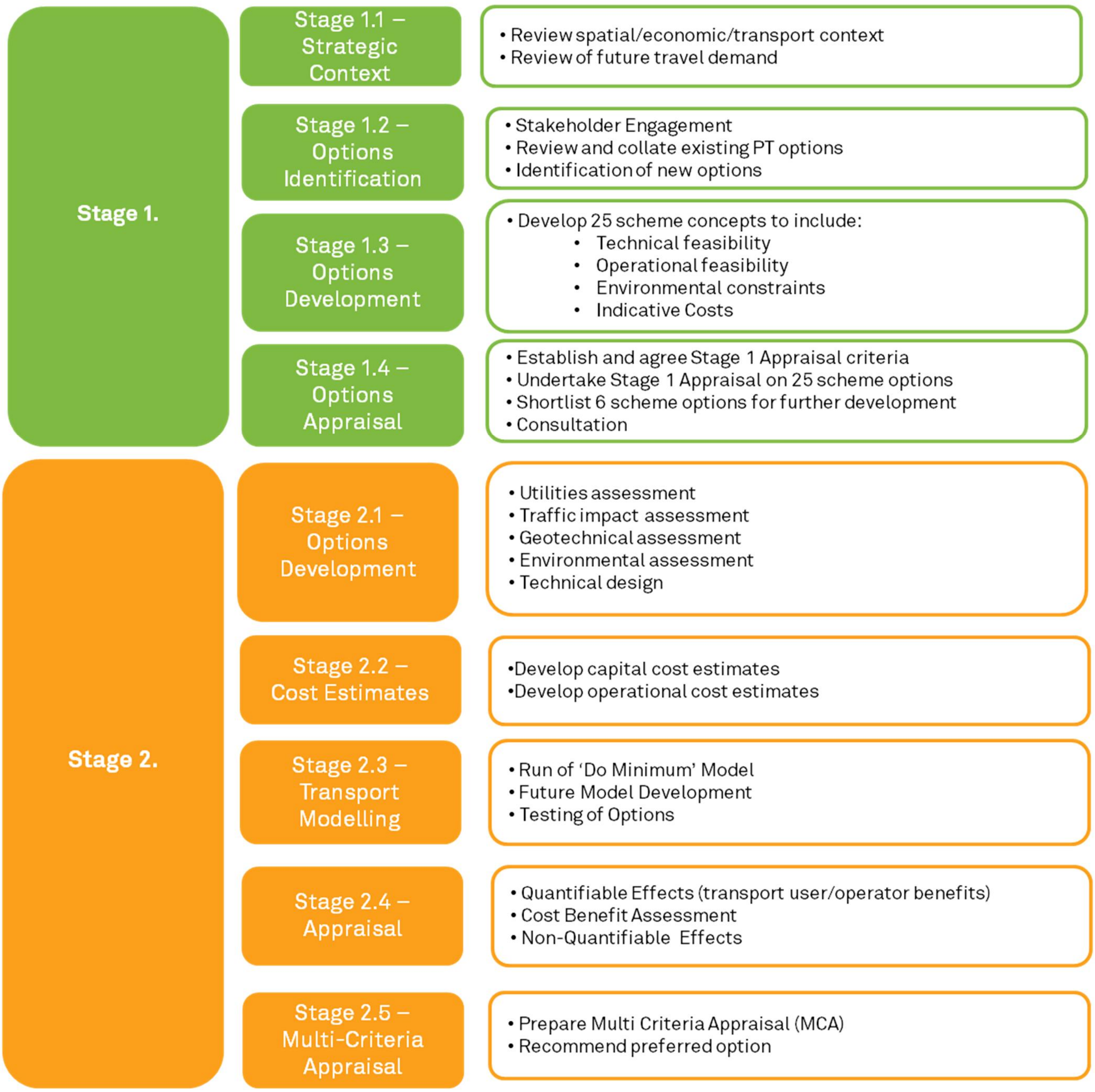
[4] *Central Expenditure Evaluation Unit, Department of Public Expenditure and Reform*

[5] *"Guidelines on a Common Appraisal Framework (CAF) for Transport Projects and Programmes" published by the Department of Transport (DoT, now DTTAS), June 2009*

Figure 1.3: Methodology used to undertake the Fingal/North Dublin Transport Study



2 Policy Context

2.1 Overview

The following section provides an overview of Government policies relevant to transport and land use development within the study area. While European and national policies focus on the need for greater sustainability of transport networks and a shift from private car travel to public transport, regional and local policies specifically set out priorities for public transport development and compatible land use development that is of direct relevance to the current study.

2.2 European Policy

The EU Transport White Paper[6] is focused on the reduction of emissions from transport and a series of target actions have been established for Member States, including supporting increasing demand for mobility whilst meeting the 60% emission reduction target. The White Paper sets out a specific objective that by 2050, all core network airports will be connected to the rail network.

The Trans-European Transport Network (TEN-T) (shown in Figure 2.1) is central to European transport policy which promotes coordinated improvements to roads, railways, ports, airports and a range of other transport infrastructure across a core network. In Ireland the Core Corridor for passenger traffic runs from Cork via Dublin City and the Airport to the border before continuing on to Belfast and Stranraer. Public transport proposals from the current study could therefore contribute to this important national connection.

[6] *Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system. COM(2011) 144 final. Brussels, 28.3.2011.*

Figure 2.1: TEN-T Network (Rail and Airport)

2.3 National Policy

2.3.1 National Spatial Strategy for Ireland 2002-2020

The National Spatial Strategy (NSS) sets out the strategic planning framework for the future development of Ireland. The Strategy favours the physical consolidation of the Metropolitan Area as an essential requirement for a competitive region. It seeks to sustain Dublin's role as the engine of the economy while strengthening the drawing power of other areas, bringing people, employment and services closer together to create a better quality of life – less congestion, less long distance commuting, more regard to the quality of the environment and increased access to services such as health, education and leisure.

2.3.2 Smarter Travel: A Sustainable Transport Future 2009-2020

Smarter Travel is a national government policy document aimed at addressing current unsustainable travel patterns. The document outlines a number of policies including encouraging a modal shift away from private car use and promoting public transport, walking and cycling. A high level objective of the policy is to achieve a transfer of work-related commuting trips from car to sustainable modes, i.e. walking, cycling and public transport. The policy seeks to reduce car commuting from a current mode share of 65% to 45% by 2020. To achieve this shift in travel behaviour, the Smarter Travel policy includes objectives to improve the level of service on public transport services by focusing on improving service quality, reliability, punctuality and efficiency. In addition, a significant focus of the policy is to encourage increased walking and cycling by offering incentives, improving facilities for slow modes and enhancing the quality of urban areas by prioritising pedestrians and cyclists.

2.4 Regional Policy

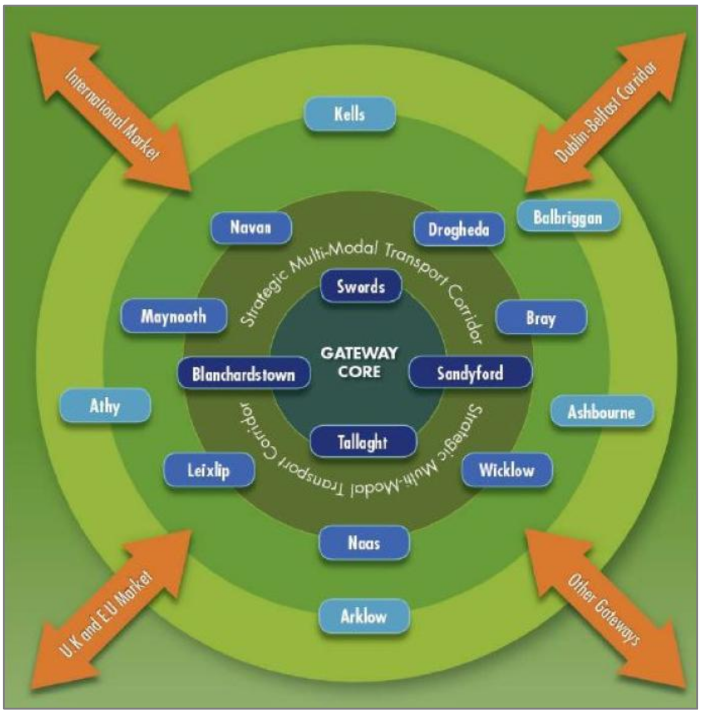
2.4.1 GDA Regional Planning Guidelines 2010-2022

The Regional Planning Guidelines (RPGs) for the GDA 2010-2022, establishes a vision for the Greater Dublin Area (GDA) to be an 'economically vibrant, active and sustainable international Gateway Region, with strong connectivity across the GDA, nationally and worldwide'. A Settlement Hierarchy has been proposed by the RPGs as a means of directing growth within the various local authorities. At the top of the hierarchy, a 'Gateway Core' of Dublin City Centre and its immediate suburbs is defined as the international business core with high density population, retail and cultural activities. Within Fingal, Swords is designated as a Metropolitan Consolidation Town. These towns function as part of a wider Gateway for the Dublin region and are encouraged to grow to a relatively large scale as part of the consolidation of the metropolitan area. These centres are supported as key destination points on public transport corridors and important locations for services, retail and economic activity.

The plan suggests that development within the GDA should be supported by investment in integrated high quality public transport services. Metro North is specifically referenced as having a role in '*providing opportunities to develop new integrated economic development areas or regenerate existing sites and to broaden sectoral business opportunities at strategic locations, taking advantage of fast access to the Airport and the City Centre'.*

Swords and Dublin Airport are identified as a combined cluster with activity in aviation infrastructure and airport related services, as well as transport and logistics. Future opportunities in the areas of high-tech manufacturing, high-value services, science and technology are encouraged within the cluster. A summary of the economic strategy is shown in Figure 2.2.

Figure 2.2: Spatial plan for economic growth



Source: GDA Regional Planning Guidelines 2010-2022

2.4.2 Draft Greater Dublin Area Transport Strategy 2011-2030 (2030 Vision)

The Draft GDA Transport Strategy 2011-2030 outlines a transport vision and objectives to achieve 'a competitive city-region with a good quality of life for all'. The strategy, which is due to be updated in 2015, identifies Swords as a 'Designated Town' which constitutes a major population and employment centre and provides a wider range of services to those living within its catchment. It is an objective of the strategy that trip intensive development is focused into Dublin City and Designated Towns or to locations served by stations on the existing and proposed rail network.

A key element of the Strategy is the delivery of a number of new rail schemes including Metro North, Metro West, the DART Interconnector and a number of new Luas lines. The Strategy includes objectives to improve the level of service on existing Quality Bus Corridors (QBCs) including the introduction of Bus Rapid Transit (BRT) as well as the development of orbital bus corridors to the north and south of the city.

2.5 Local Policy

2.5.1 Fingal Development Plan 2011-2017

A summary of the vision for delivery of the Fingal Development Plan is illustrated in Figure 2.3. As shown, the plan assumes delivery of the Metro North and Metro West corridors and proposed greater consolidation of future population and employment around them.

In response to population growth forecasts outlined in the RPGs, housing stock projections have been made and zoned within the Fingal Administrative Area. One third of the proposed residential zoning has been designated towards the Metro North Economic Corridor (MNEC) zoned lands in Swords and in the South Fringe (Santry/Ballymun). This zoning allows for mixed employment and residential use.

Malahide and the South Fringe (including Ballymun/Santry, Meakstown and Balgriffin) are also identifed as growth areas within the Gateway. The South Fringe is defined as nationally important given its location south of Dublin Airport and its proximity to the M50 and M1. Land between Dublin Airport and the M50 will not be released for development until the capacity of the transport system in the locality is increased.

The Development Plan proposes the use of 'clustering' to concentrate employment along the Metro Economic (ME) Corridor. The advantages of this policy are proposed as cost efficiencies and economies of scale, innovation, partnership opportunities, access to raw materials and availability of a skilled workforce. ME zoning has been applied to both the Metro North and Metro West corridors within the Development Plan. The zoning provides for an area of compact, high intensity/density and employment generating zoning within proximity to high capacity public transport corridors.

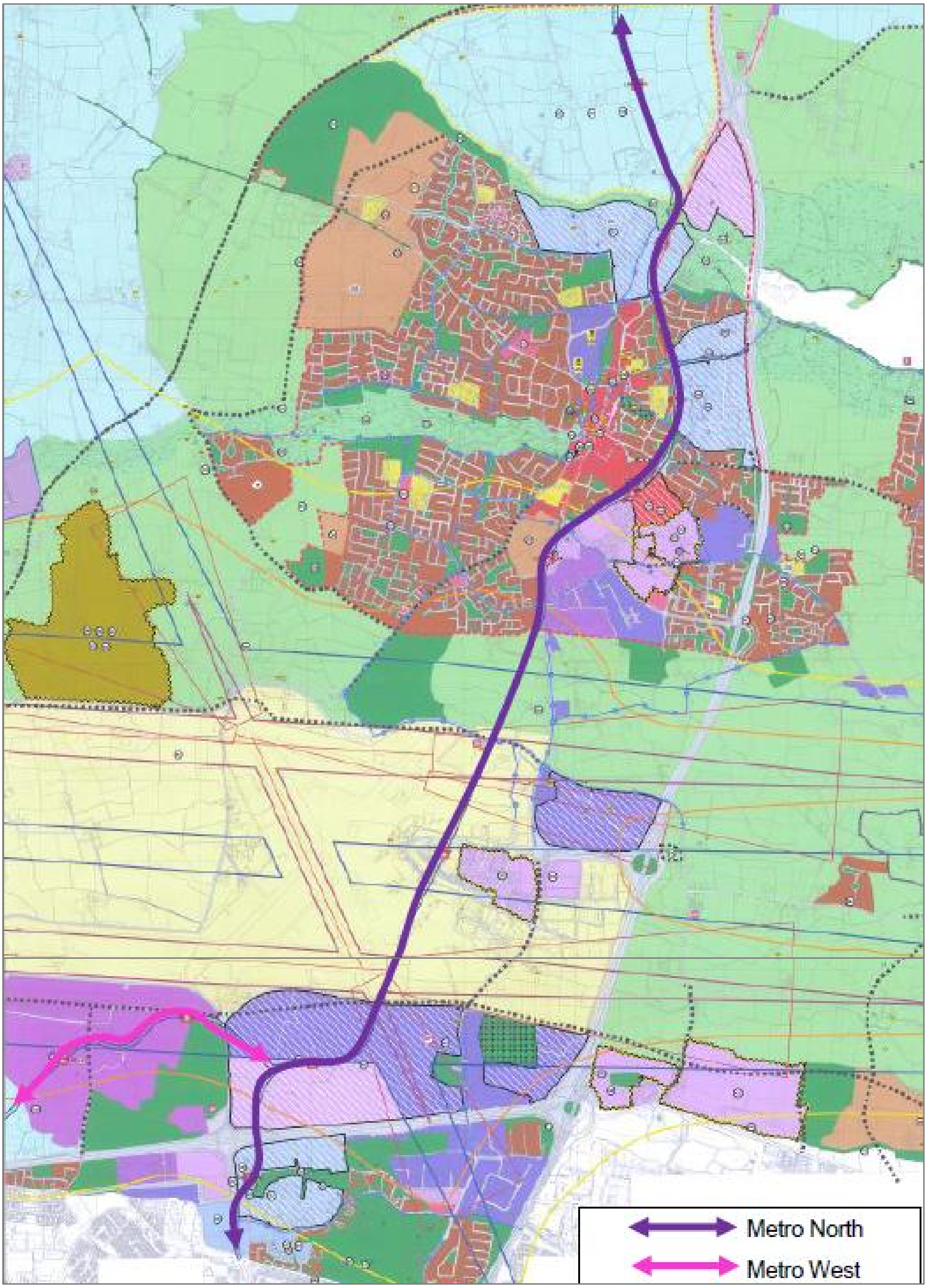
Local Area Plans have been developed for a number of areas running adjacent to the MNEC within Fingal, including: Dardistown, Barrysparks and Fosterstown. Focus within these plans is on supporting the development of high density residential and employment development around proposed stations.

Supporting the Fingal Development Plan, 'Swords Strategic Vision 2035' is a detailed plan for future spatial development of Swords in line with 'Consolidation Town' status. The Masterplan supports commitments for delivery of Metro North and sets out proposals for increased development densities within Swords and areas adjacent to proposed public transport nodes.

Figure 2.3: Summary of Fingal County Council Development Strategy

Source: Fingal Development Plan, Fingal County Council

Figure 2.4: Land use zoning map for Fingal Area (Source: Fingal County Development Plan 2011-2017)



2.5.2 Southwards from Trinity College *Dublin City Development Plan 2011-2017*

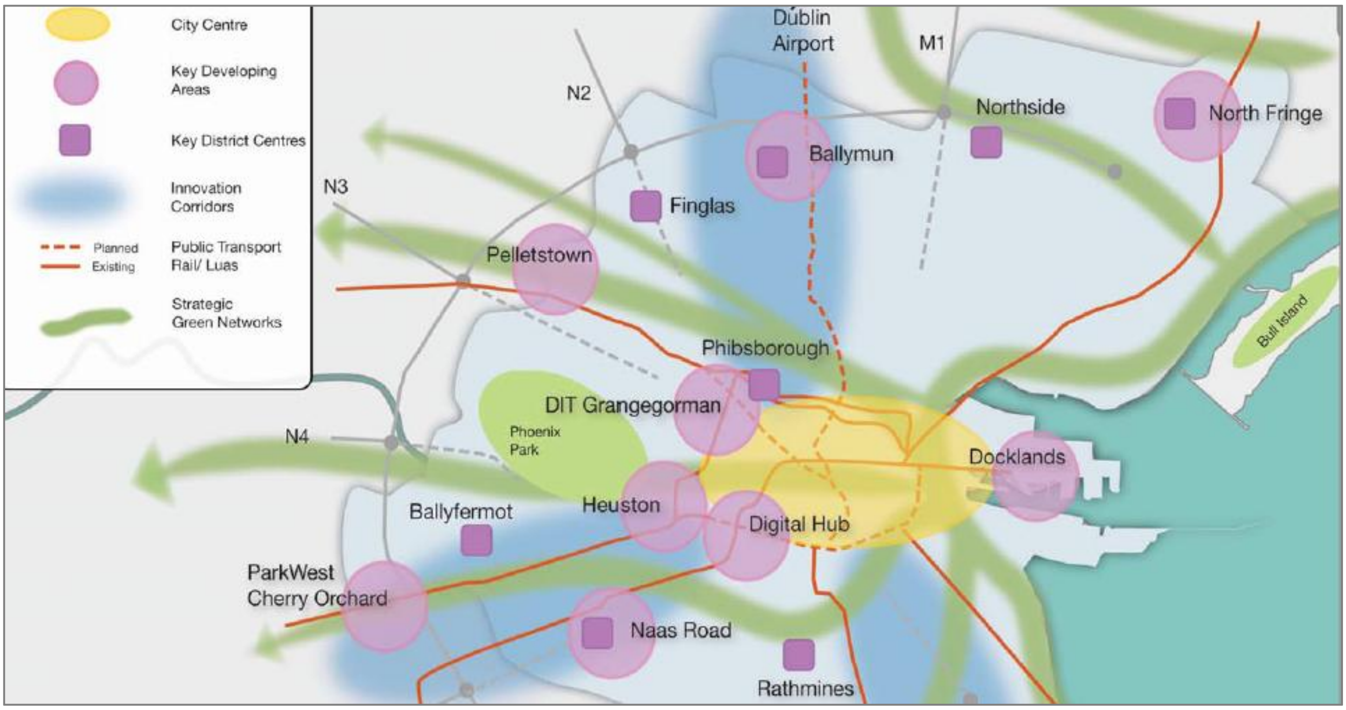
The Dublin City Development Plan aims to continue managing available zoned residential land in a sustainable manner to accommodate the regional housing allocations and provide for a quality compact city with an effective public transport system.

As shown in Figure 2.5, the plan proposes eight 'Key District Centres' outside the city centre to act as strong spatial hubs providing a comprehensive range of commercial and community services. These centres also closely align to public transport rail corridors, with the exception of two (Finglas and Northside) which perform an important regeneration role for local communities. Within the study area defined, this report, there are five designated district centres including: North Fringe East & West, Northside, Ballymun, Finglas and Phibsborough.

- In response to commitments made within the RPGs, the Development Plan identifies three 'economic corridors' for future development including: A northern corridor from the city to the airport including clusters, knowledge, research and growth centres such as Grangegorman, the Mater, DCU and Ballymun / Finglas;
- to UCD, primarily as a knowledge and innovation corridor including RTE as the national media centre and St. Vincent's Hospital; and
- Westwards from Heuston, including the Digital Hub, St. James Hospital, Park West, Cherry Orchard, the Naas Road development area and extending into the wider metropolitan area to incorporate new urban centres such as Adamstown.

The Plan fully supports the future development and expansion of public transport infrastructure within the city, namely Metro North, DART Underground, Luas, and Quality Bus Corridors, which it proposes will result in a fully integrated public transport system for the city.

Figure 2.5: Summary of proposed Dublin City Development Strategy 2011-2017



Source: Dublin City Development Plan, Dublin City Council

2.5.3 *Dublin Airport Central Masterplan (2015)*

In 2014, 21.7m passengers travelled through Dublin Airport. By 2033, this figure is forecast to increase to 33m[i]. To support this expected growth a future vision for Airport development is set out in the Dublin Airport Central Masterplan, which was finalised in 2015. It also establishes a framework for economic and spatial redevelopment of land within the defined Airport Zone.

The key focus of the Masterplan is the proposed development of a new 30 hectare business district and employment hub on existing non-operational lands. This will comprise 300,000sq.m of Grade A office accommodation (zoned as High Technology) and is proposed for development on a phased basis as three zones (see Figure 2.6). Initial development will be at Zone 1, located closest to the airport terminals and the Ground Transportation Centre (GTC), with Zone 3 proposed as a longer term development. Development density will be highest in Zone 1 as it is closest to the GTC and therefore is most accessible by public transport, with the permitted development density decreasing as distance from the GTC increases.

The GTC is centrally located within the Dublin Airport site and facilitates both local and regional bus and coach services, with close to 1,200 bus and coach movements per day. The GTC's position as a significant transport hub for the Airport and surrounding developments will be consolidated in the future, as DAA has outlined a preference for a future high capacity public transport scheme for the area to run via the GTC (as previously planned for Metro North), to provide increased accessibility and encourage a sustainable modal shift to public transport.

The proposed level of future parking provision is intended to encourage access by public transport and reduce the potential impact on the surrounding road network. As such, it is proposed that initial phases of development (up to approximately 26,000 sq. m.) will have parking provision of 1 space per 47 sq. m. Parking provision will then increase for subsequent phases of office development, which will be located further from the Ground Transportation Centre. The proposed rate of parking provision is predicated on further enhancements to the public transport facilities serving Dublin Airport.

Figure 2.6: Dublin Airport Masterplan Layout
(Source: Dublin Airport Authority)

2.6 Summary

The European and national planning policy context is heavily focused on the environmental, economic and social need for a shift to more sustainable modes of transport integrated with patterns of land use development to support it. At a regional and local level, policy commitments support this global need by facilitating more consolidated land use development and sustainable transport infrastructure.

The RPGs for the GDA set out growth strategies for population and employment which both have implications for the current study area. Dublin City Centre, Dublin Airport and Swords are all identified as core areas for future high density development supported by strong public transport connections.

The RPGs, like most of the other planning policies relevant to the study area, have been prepared on the basis that the future development of Metro North and Metro West, are focused on maximising the opportunities presented for more consolidated and high density development.

At a local level, various local area plans and vision documents have also been prepared which correspond with the future development of Metro North, and the development of many areas, such as the South Fringe in Fingal is almost wholly dependent on future provision of a high capacity public transport connection through the area.

3 Transport Context

3.1 Current Public Transport Provision

The current transport provision within the study area includes heavy rail commuter services on DART, the Northern Suburban Line and the Western Suburban Line as well as bus services which operate throughout the area.

The bus network currently provides the main response to travel demand within the study area. As shown in Figure 3.1, the network provides connectivity to the city centre from Swords, Finglas, Ballymun and the Airport via the north inner city, largely on a radial network.

Based on results of the 2011 Census, demand for the bus network is shown in Figure 3.2. South of the M50 the modal share of bus trips is relatively high in areas such as the north city, Ballymun, Finglas and Santry. North of the M50 the level of demand decreases with private car trips dominating in this area as previously outlined in Section 1.

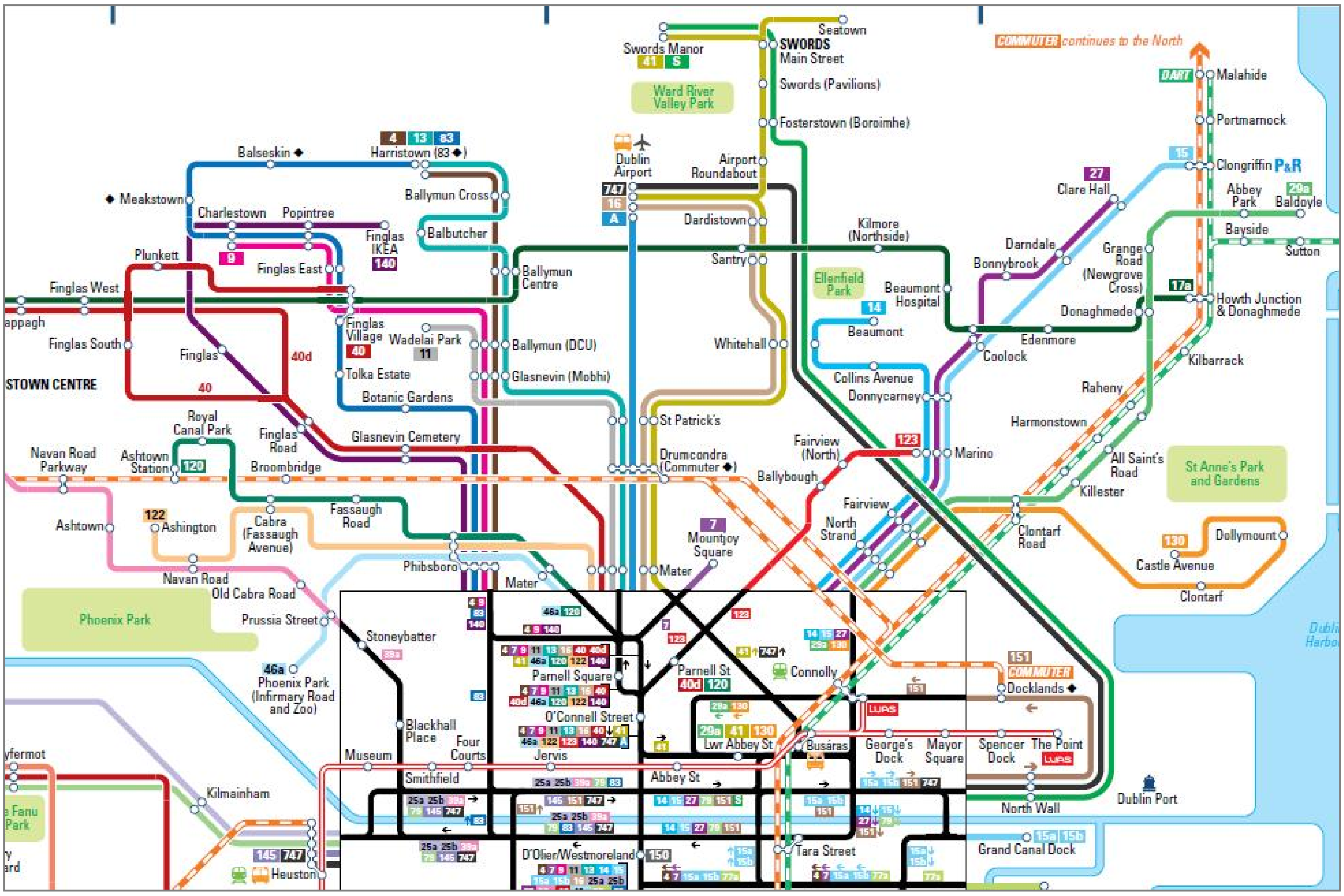
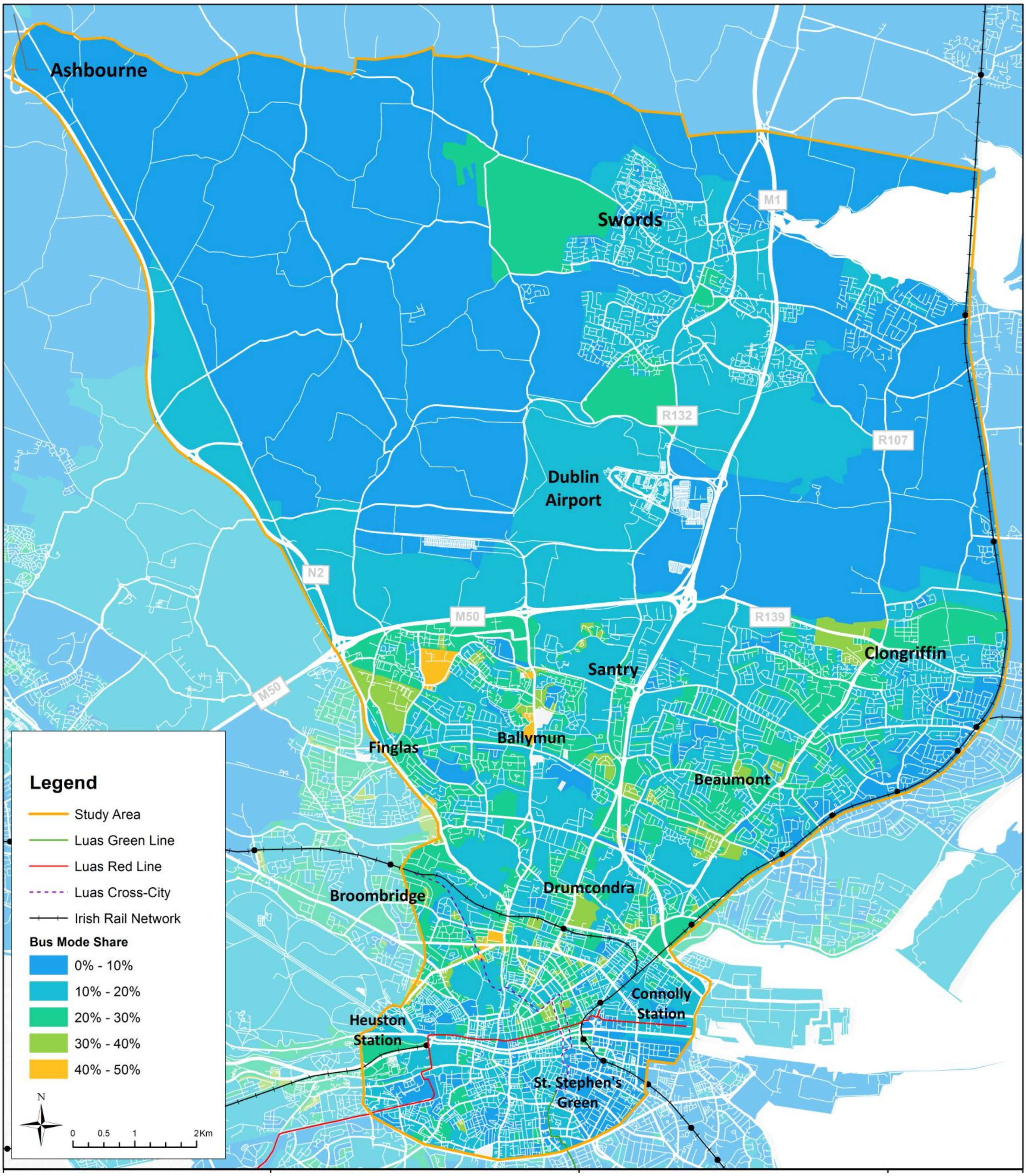


Figure 3.1: Dublin Bus network within the study area

(Source: www.transportforireland.ie)

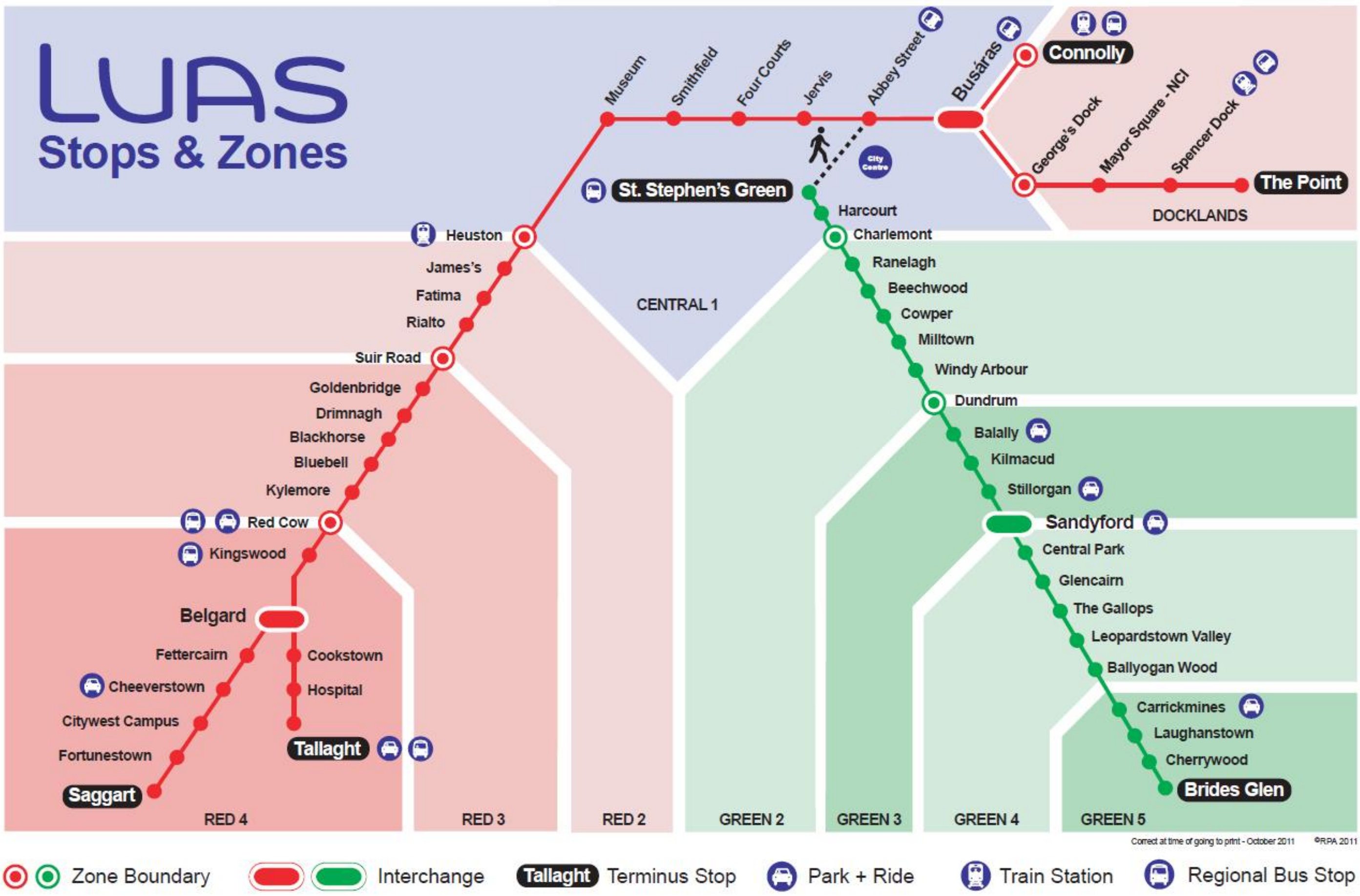
Figure 3.2: Bus trips for commute to work/education the study area, 2011 Census



In addition to services provided on the Dublin Bus network, there are a number of high frequency private bus services to the Airport and Swords which provide connection to the city centre and beyond such as the Air Coach and the Swords Express. The latter operates via the Dublin Port Tunnel and offers services to the city centre every 15 minutes in the AM peak with journey times of 25-40 minutes depending on the pick-up location within Swords.

The southern part of the study area is also served by the existing Luas light rail network. This network is currently comprised of Dublin currently consists two lines - the Green and Red Luas Lines which link Cherrywood and Tallaght respectively to the City Centre. The network started operation in 2004 and has been extended over the last decade to a length of approximately 37km. The two lines are currently being linked and extended through the city centre as part of the Luas Cross City project. The existing network zones and stops are illustrated in Figure 3.3.

Figure 3.3: Luas Network Stops and Zones

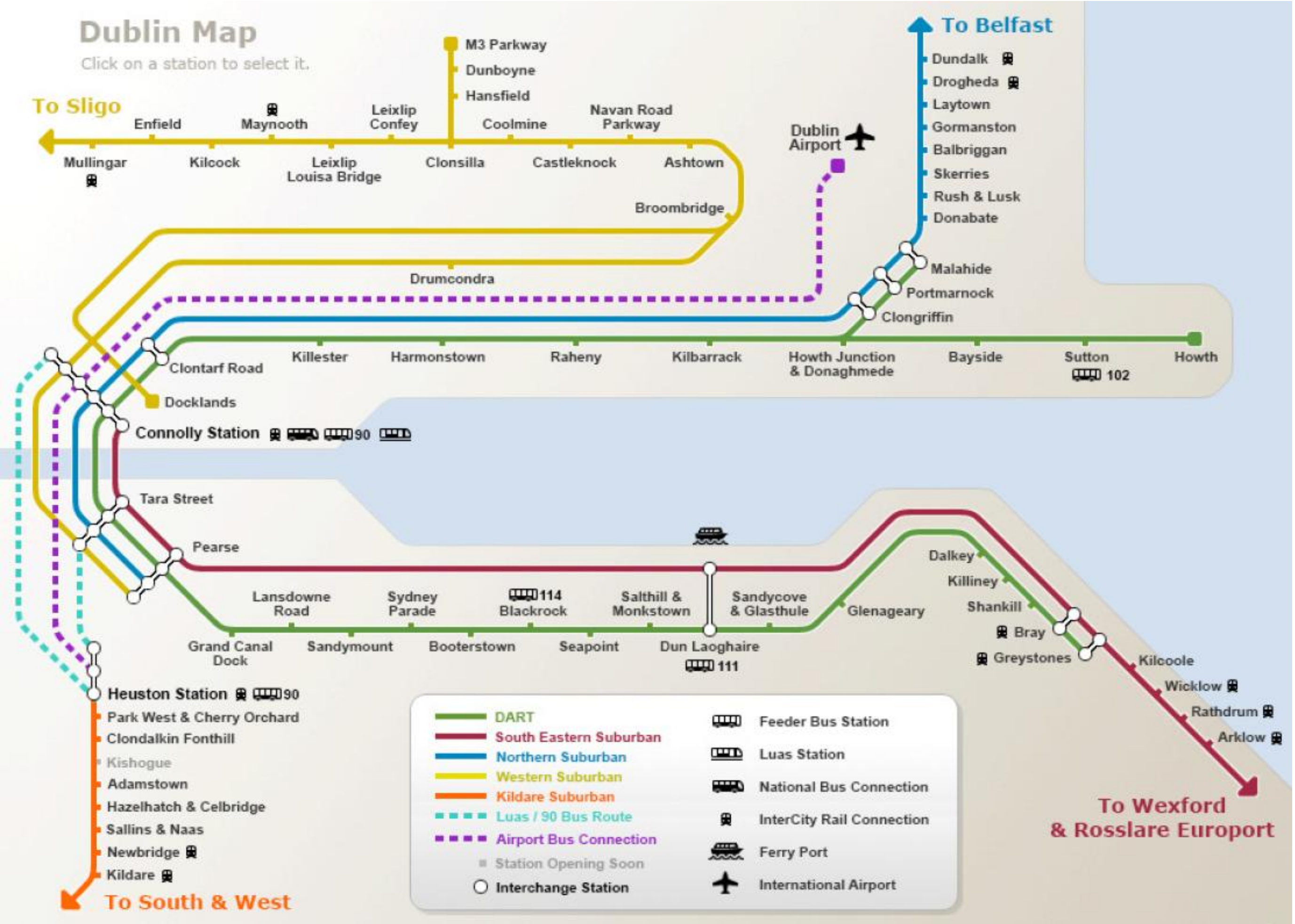


Source: www.luas.ie

The current heavy rail network within the Greater Dublin Area is shown in Figure 3.4. Within the study area, DART services run north/south to and from Malahide and there are also commuter rail services to stations on the Western Suburban Line at Drumcondra and Broombridge. Each of these services runs via Connolly Station.

Clongriffin Station is the most recent addition to the DART line and opened in 2010 to serve the adjacent developing residential areas, in the North Fringe. DART services currently run every 15 minutes between Howth Junction and Bray, with an extension to Greystones every half-hour. Trains north of Howth Junction serve either Malahide or Howth, with Malahide Station also supplemented by Northern Commuter trains.

Figure 3.4: Dublin rail network

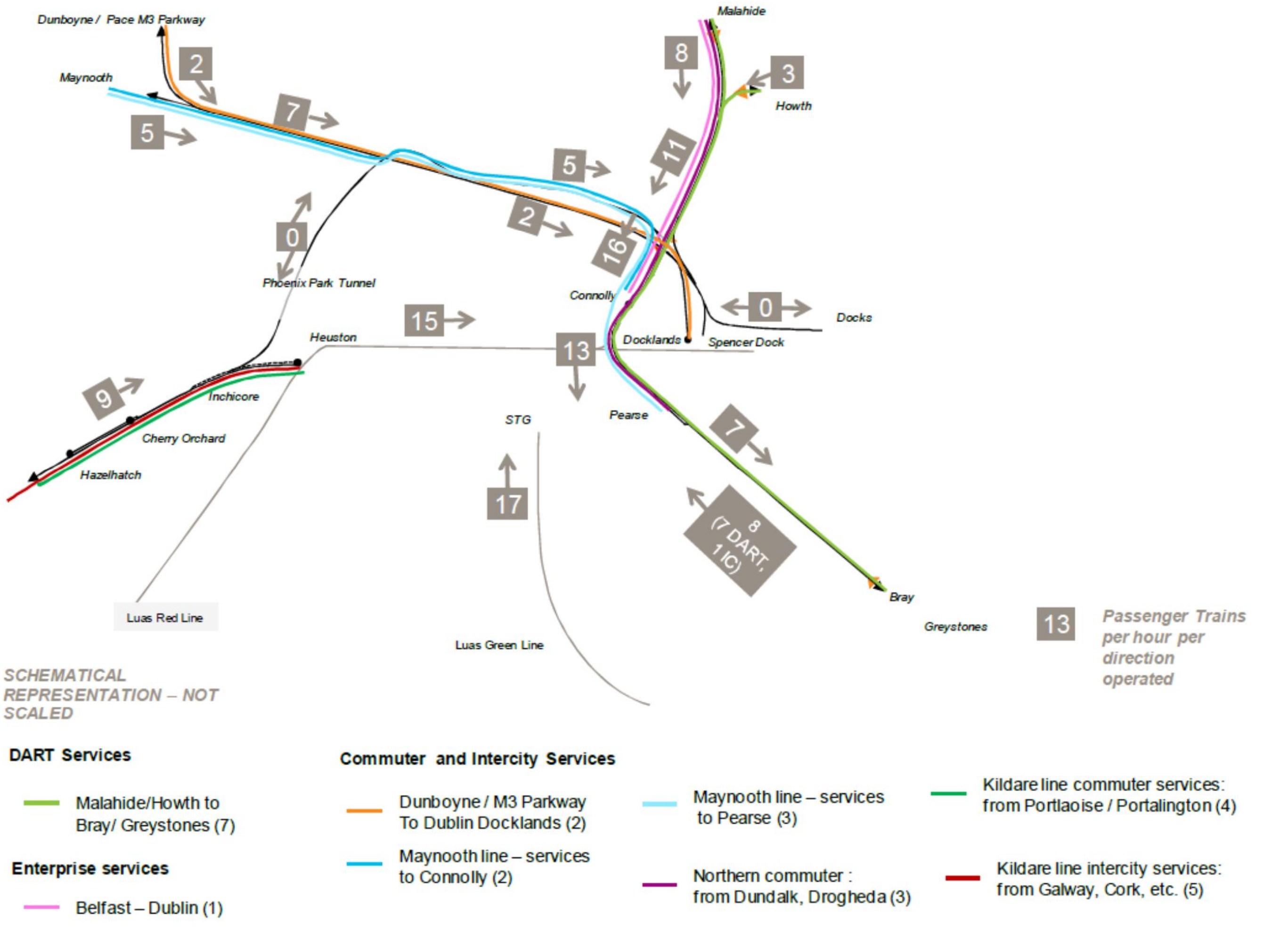


(Source: www.irishrail.ie)

The capacity of the DART system varies depending on the number of carriages on the service. While all DART platforms have been recently upgraded to allow eight carriage services, services normally run as six or eight carriage trains in peak periods, reducing to four or two carriage trains at other times. The overall capacity of the network is also largely dependent on the possible number of services per hour which is dependent on existing infrastructure, notably: the number of tracks, signalling, number of level crossing junctions and track profiles. Ultimately, the maximum capacity per hour is limited to 17 trains per hour which generates a maximum of 23,800pphpd (pphpd=passengers per hour per direction) on the network. The peak hour train paths are shown in Figure 3.5.

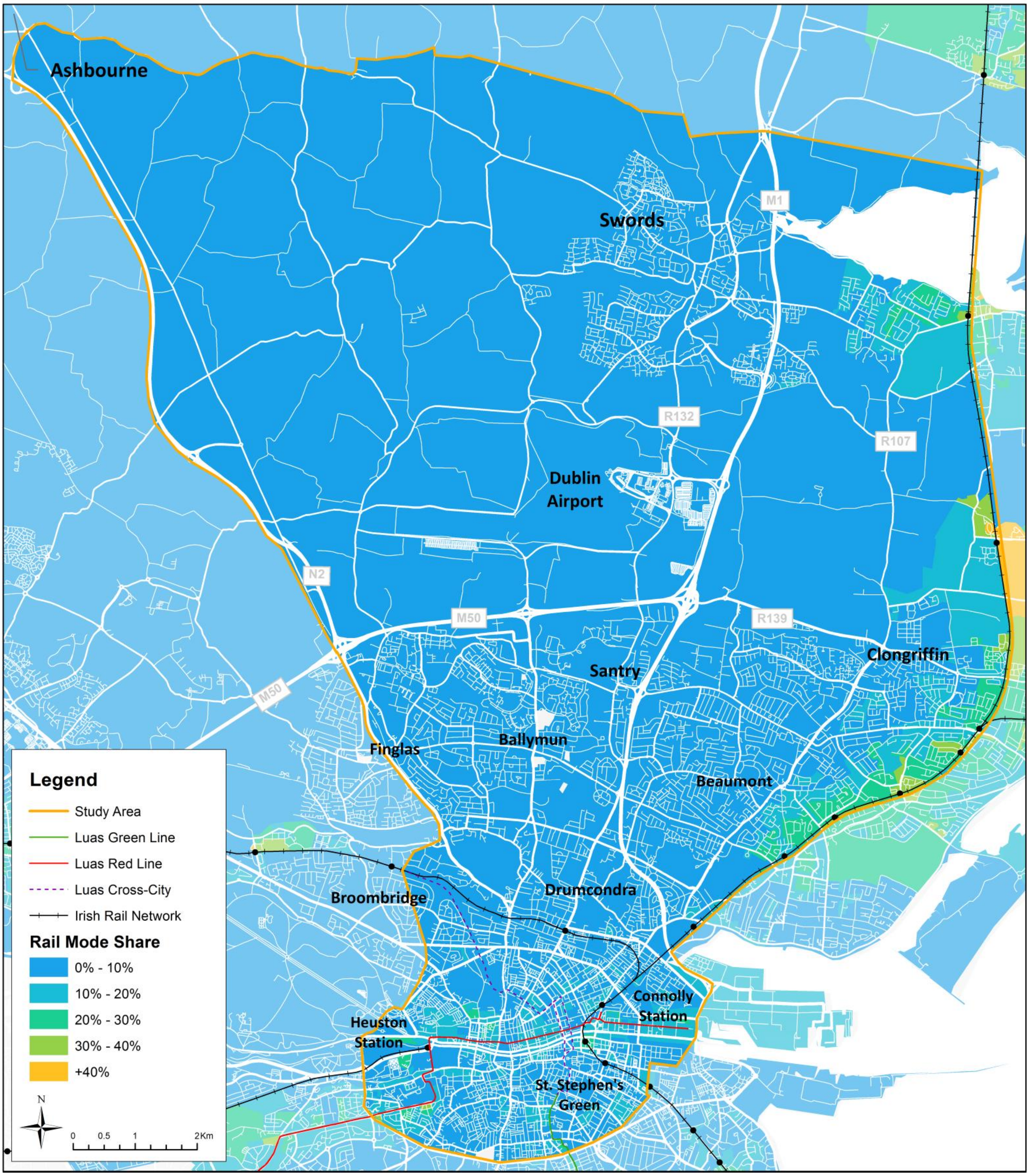
In 2013, 16.3m passengers used the DART service, carrying more than 55,000 passengers daily[7]. Naturally, demand for the service fluctuates through the day with the peak of demand from 07:00 to 09:00 resulting in high demand on central parts of the network. Current rail demand within the study area is shown in Figure 3.6. As shown, the modal share of rail trips to work/education within the area is quite restricted to the residential areas immediately adjacent to the existing heavy rail line. In areas like Malahide and Clongriffin the modal share of rail trips increases to 30% of all trips. Within the north city area where the Western Suburban Line provides service through Drumcondra, the modal share for rail trips is low. This is due to the fact that in these areas, walking, cycling and travel by bus is equally as convenient for city centre bound trips.

Figure 3.5: Current heavy rail operations, AM peak, inbound



[7] *Rail Census 2013, Table 5*

Figure 3.6: Rail trips for commute to work/education within the Study area, 2011 Census



3.2 Future Population and Employment Growth

Plots of the main growth areas in population and employment in the Fingal / North Dublin study area are presented in Figures 3.7 and 3.8 respectively. Both of these maps present the density of growth in population/employment (i.e. growth in people/jobs per sq. km) for each zone in the NTA model. In terms of population growth, some of the key areas of future growth across the GDA are within the Fingal/North Dublin area. These areas include: Clongriffin, Ballymun, Finglas, Swords, Drumcondra, the Docklands and Heuston South Quarter. Projections for employment growth indicate the city centre as the main growth area with some additional core areas outside of this, including the Airport, Ballymun and Clongriffin.

This pattern of future growth is likely to have a significant impact on travel demand, with population growth in the north of the study area generating increased travel demand for city centre and Airport bound employment trips. In light of the current high levels of car use in these areas, this additional travel demand will put the transport network under additional strain which will not be sustainable.

Based on the population and employment forecasts presented and the anticipated public transport network in 2033, a snapshot of future transport network operations has been developed to demonstrate potential implications of a “Do Minimum Scenario” in the following sections.

Figure 3.7: Population growth areas 2011 to 2031

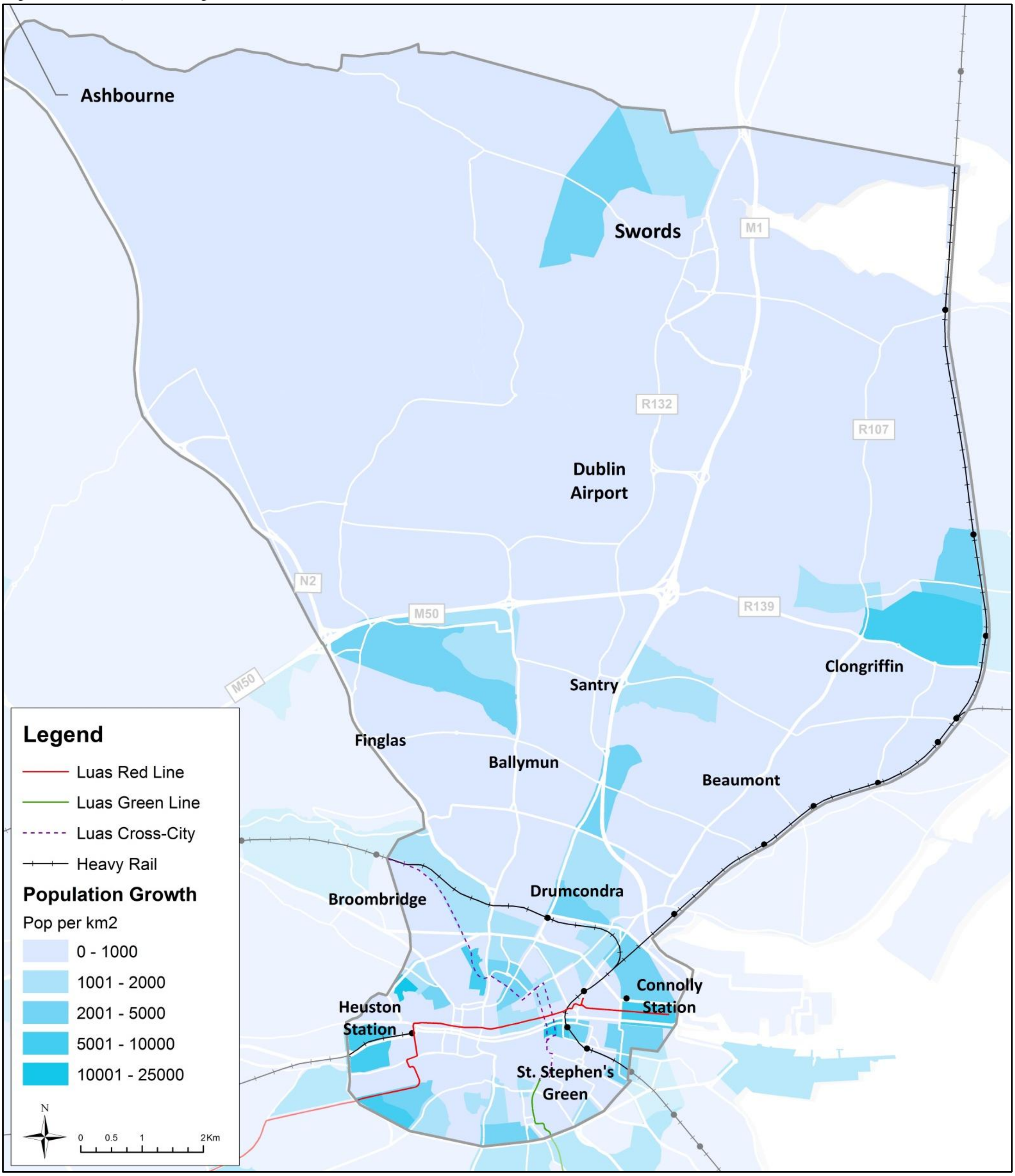
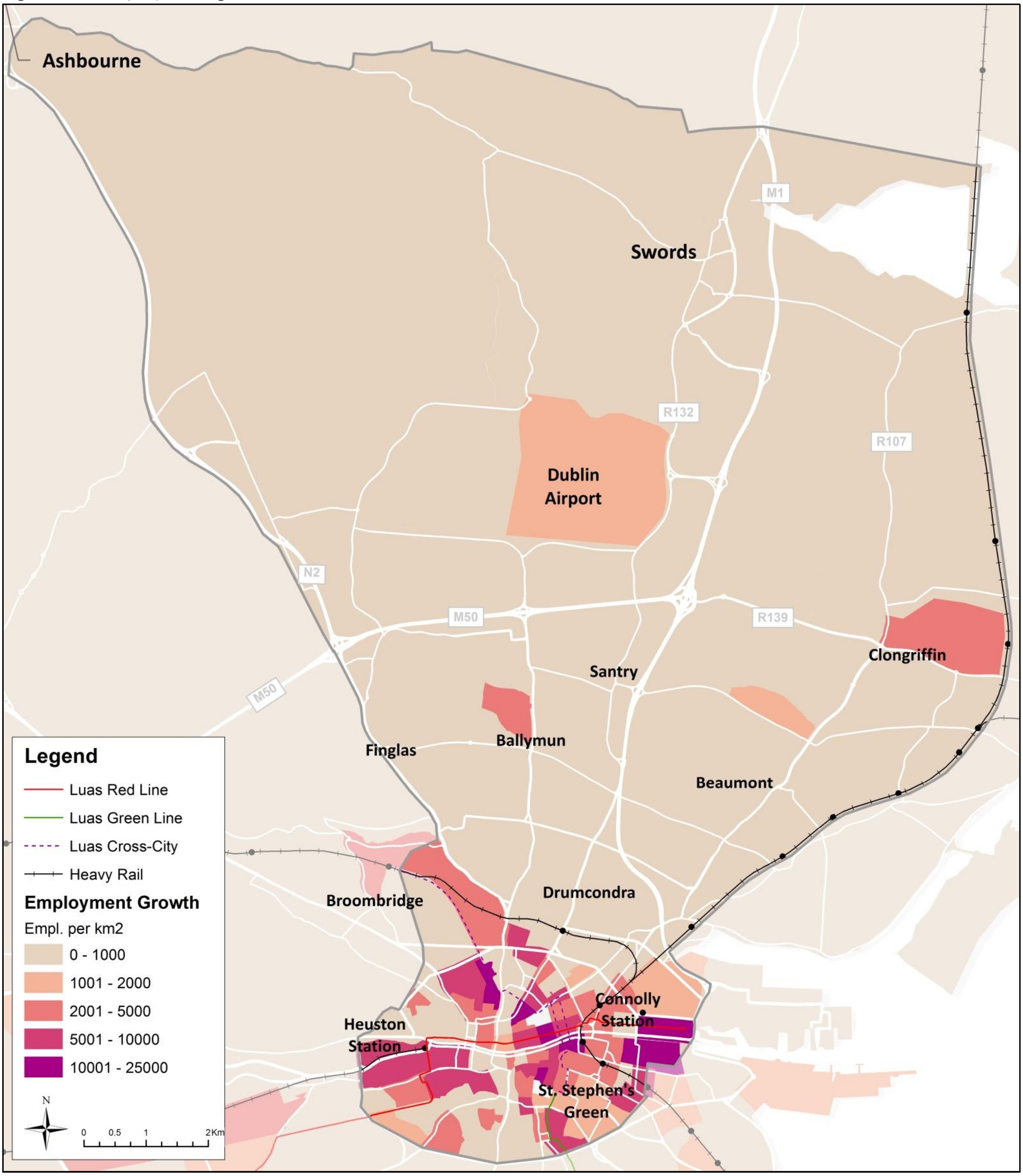


Figure 3.8: Employment growth areas 2011 to 2031



3.3 Change in Travel Demand

Total travel demand within the study area is expected to increase by 39% from 2011 to 2033. This increase in travel demand arises directly as a result of population and employment growth previously highlighted.

The NTA model forecasts trip demand matrices for AM peak hours (07:00 to 10:00) have been interrogated in order to determine the anticipated level of growth in trip demand that will occur between the key residential and employment areas in the study areas (Swords, Dublin Airport and the Ballymun Corridor) and the City Centre.

As shown in Figure 3.9, substantial growth in trip demand is predicted between all of the key residential and employment areas in the study area and the City Centre. Table 3.1 below summarises the increase in trip demand anticipated between Swords, Dublin Airport, the Ballymun Corridor and the City Centre.

Table 3.1: Trip Demand from key Residential / Employment Areas to the City Centre

Employment / Residential Area	Trip Demand		
	2011	2033	% Increase
Swords	4880	8396	72%
Airport	1884	3395	80%
Ballymun Corridor	15159	19369	28%
Total	*21923*	*31160*	*42%*

In total, an increase of 9,237 trips (42%) is predicted during the AM peak hours from Swords, Dublin Airport and the Ballymun Corridor to the City Centre. As the highway and existing public transport network are already experiencing capacity issues, it is anticipated that this additional trip demand will need to be absorbed by a new high capacity public transport solution.

3.3.1 Change in Demand for Car Travel

Between 2011 and 2033, it is assumed that no significant changes would be made to the road network. However, increases in travel demand which cannot be accommodated on a public transport network with limited capacity are likely to shift to car travel. Results from the 2033 Do Minimum Scenario suggest that demand for car travel in the area could rise by as much as 50% in the absence of further public transport provision.

3.3.2 Change in Road Network Journey Times 2011 to 2033

As outlined, increased demand for travel in 2033 will result in increased demand for the road network which will in turn have negative implications for journey times. A comparison of AM peak (08:00-09:00) network travel time, distance and average speeds between the 2006 base model and the 2033 forecasts is shown in Table 3.2. The results indicate that planned growth in the study area could result in increased travel time on the road network of 72% and reduce average travel speeds by 19%.

An indicative comparison of delay on the road network between the 2011 base year and 2033 forecast year is presented in Figure 3.10. Increased delay on the network is demonstrated by the thickness of lines/demand on the road network. Increased delays are experienced across the network but particularly in areas north of the M50. This is consistent with the assumed areas of highest population and employment growth presented in Section 6.4.

Table 3.2: SATURN Cordon Network Statistics 08:00-09:00

KPI	Unit	2011 Base	2033 DM	% Diff.
Travel Time	hrs	120,179	206,766	72%
Travel Dist	km	4,256,537	5,891,184	38%
Ave Speed	kph	35.4	28.5	-19%

Figure 3.9: Increase in Trip Demand to the City Centre within the study area 2011- 2033(all modes)

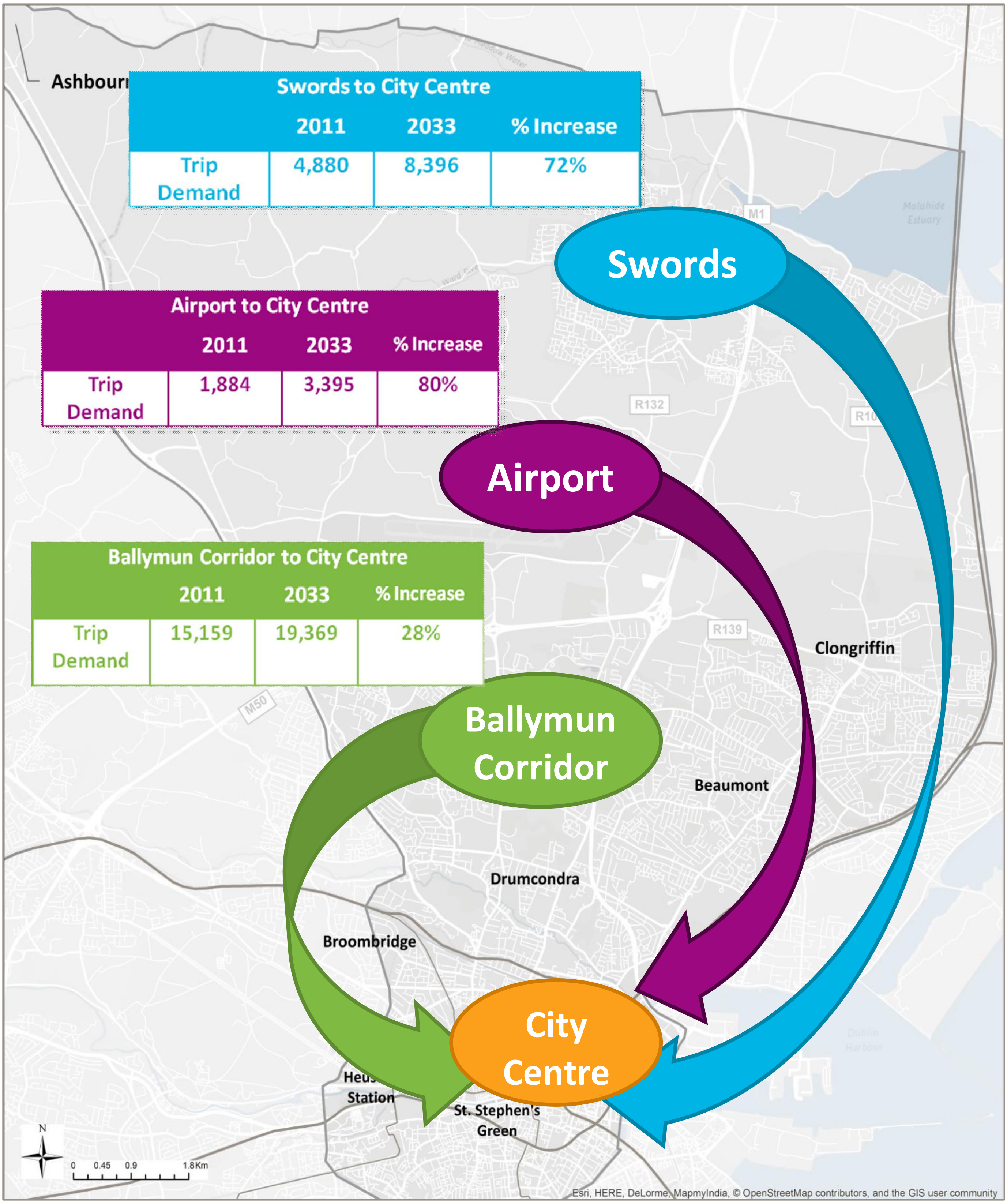
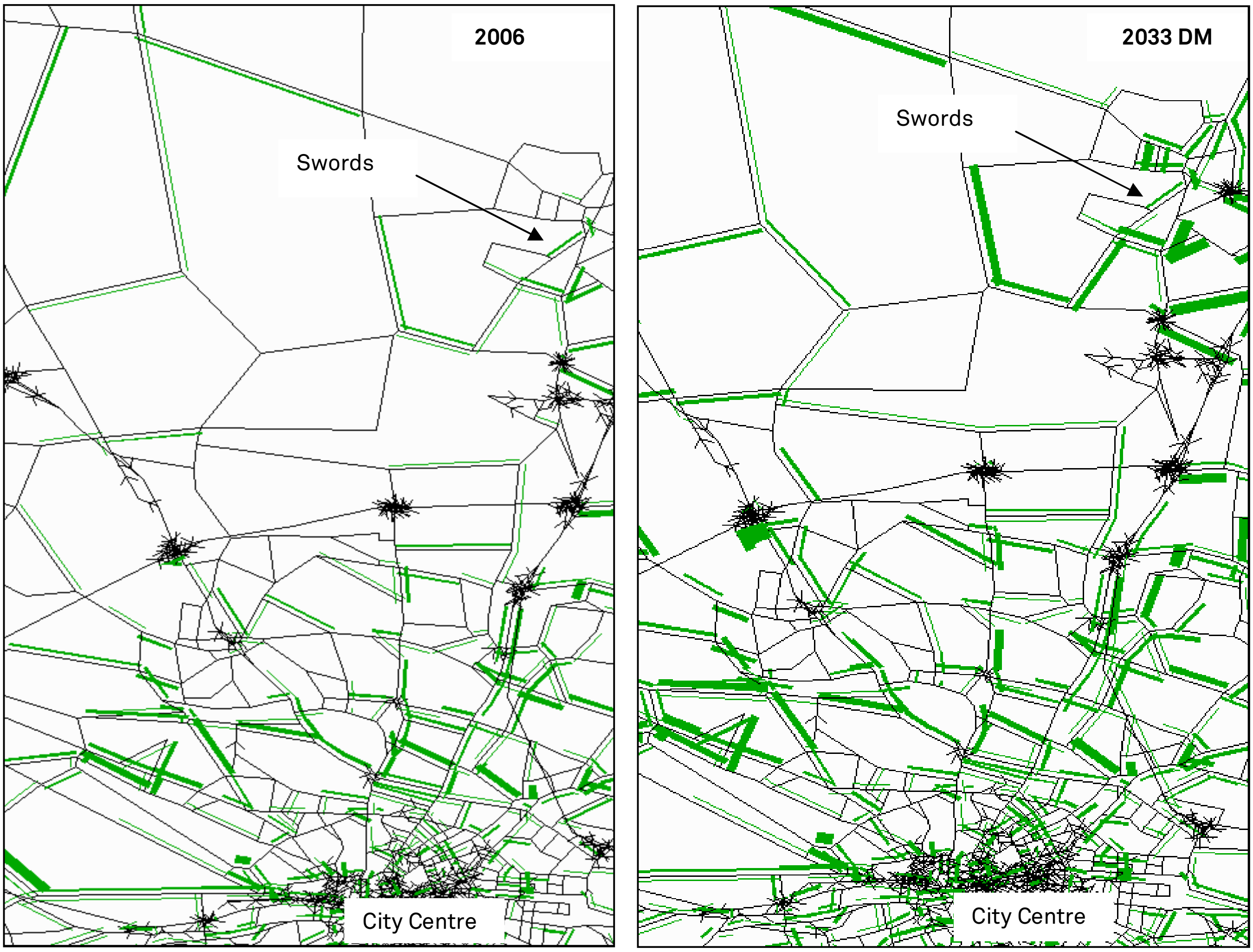


*Figure 3.10: Comparison of delay on modelled road network between base and forecast year**

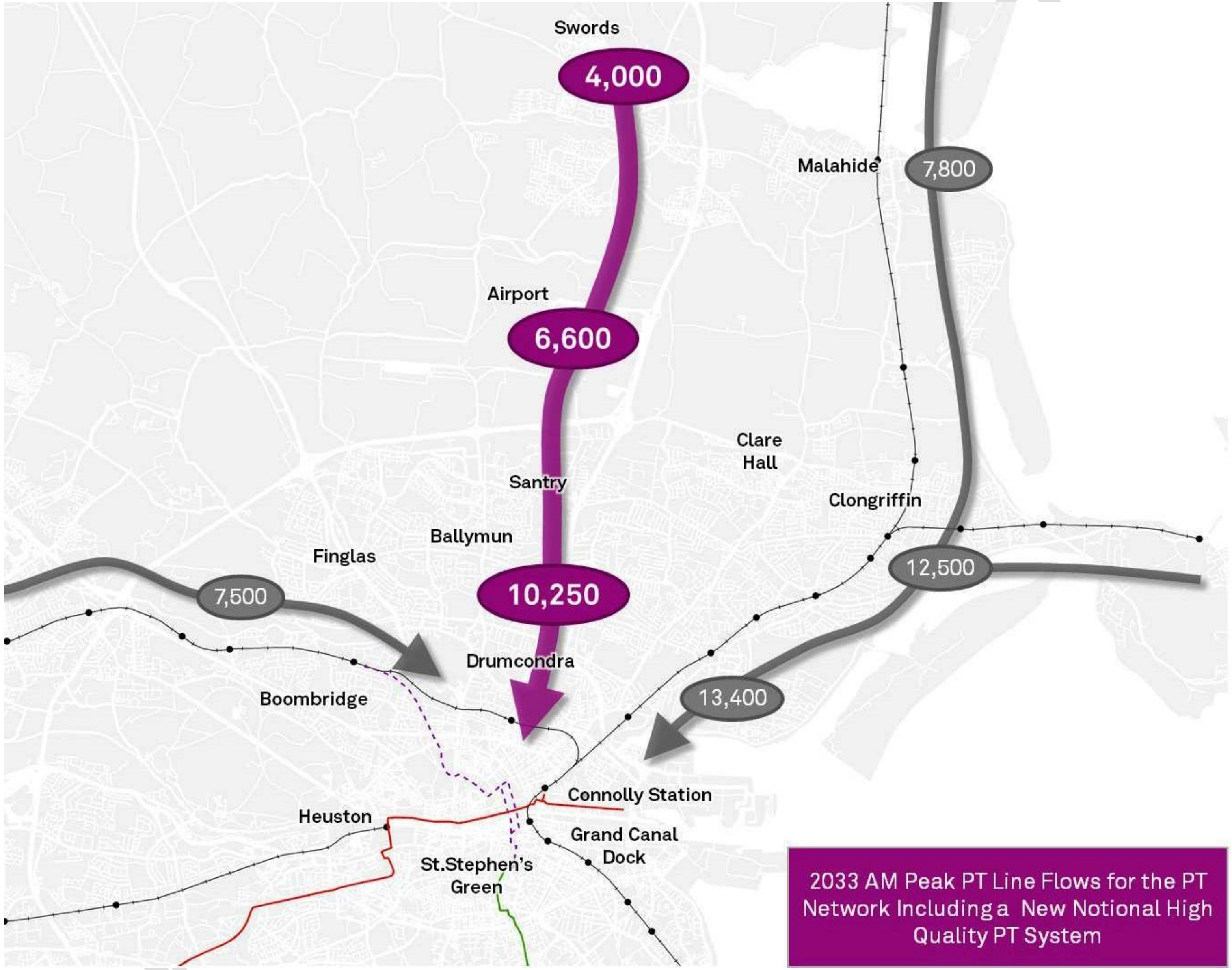


** The increased thickness of the green bands alongside the represented road links, indicate increased congestion on those road links*

In summary, anticipated population and employment growth to 2033 within the study area will have negative impacts on transport network operations. In particular, there is a need to reduce car dependency in the area through provision of improved public transport services. As the projected level of future growth in travel demand cannot be absorbed by the bus network, there is a need to look beyond services existing and planned to ensure there is adequate provision of sustainable mobility options.

The NTA's Strategic Transport Model has been used to establish the latent demand for a dedicated high capacity and high frequency public transport service in the study area. A test was carried out in which a notional high capacity public transport scheme was coded into the 2033 model. This test was used to establish indicative peak hour public transport flows in the vicinity of the Swords Road QBC. The test results reveal that a notional high quality public transport service in addition to the existing bus network could generate southbound passenger demands of up to 6,600 passengers south of Dublin Airport and 10,250 passengers in the vicinity of Dorset Street in 2033, see Figure 3.11.

Figure 3.11: Anticipated AM peak southbound public transport demand for notional new public transport service in 2033



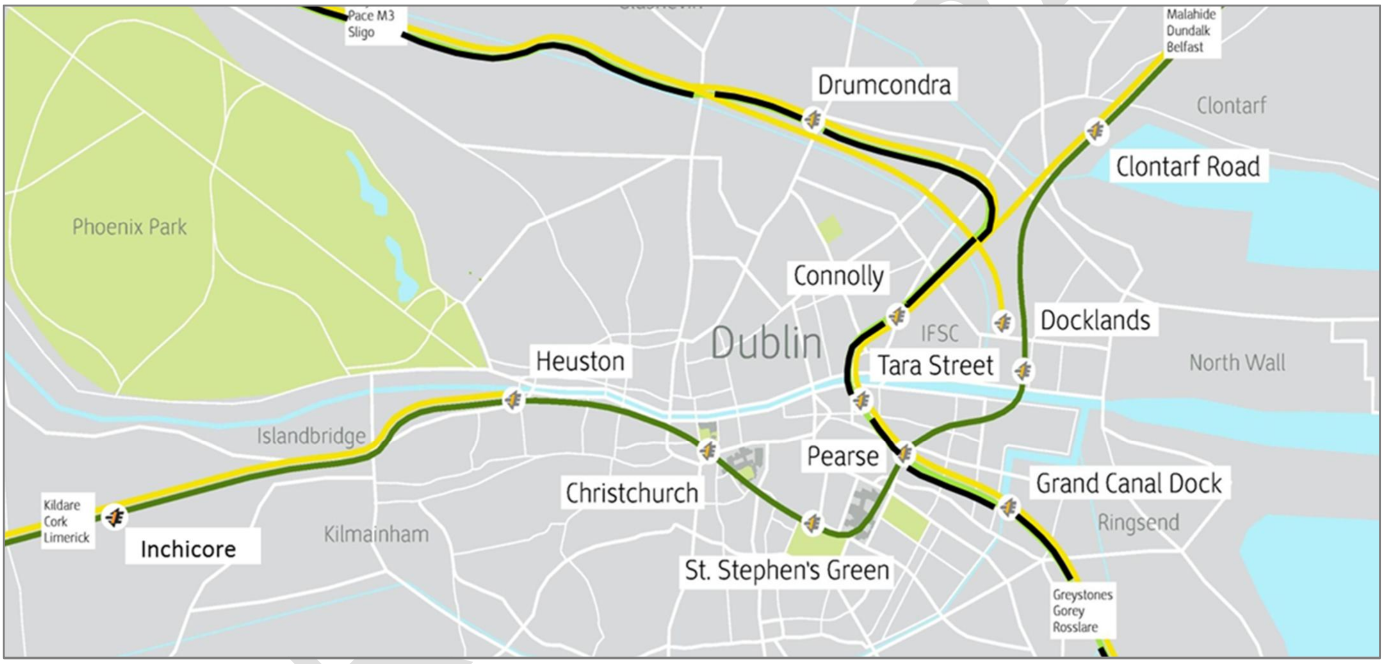
3.4 Future Transport Provision

Recognising the potential for increased travel demand within the study area, a number of public transport schemes are already underway. These schemes form part of the 2033 "Do Minimum" transport model as outlined in Section 6.4 and include the Luas Cross City, the City Centre resignalling project and reopening of the Phoenix Park Tunnel.

Additional schemes which have been proposed for the area but have not been confirmed for delivery in advance of 2033 include:

- **DART Underground:** This scheme, which will be approximately 7.6km in length, will connect the Northern and Kildare lines, with underground stations located strategically at Spencer Dock, Pearse Street, St Stephens Green, Christchurch and Heuston, as well as a new surface DART station at Inchicore. DART Underground would link all rail systems – DART, Commuter, Intercity and Luas – to form an accessible and integrated public transport network. The proposed route is shown in Figure 3.12.

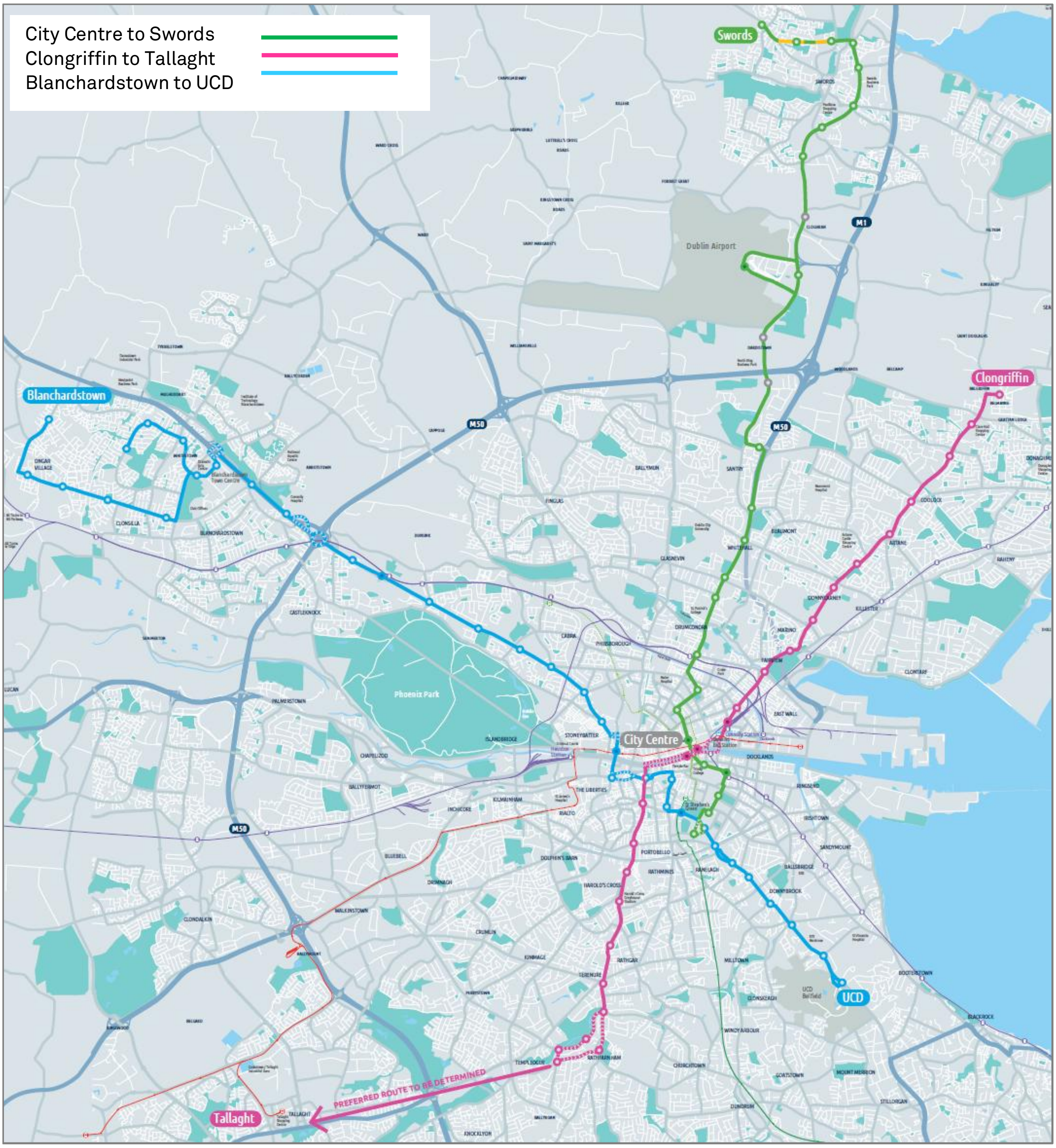
Figure 3.12: Proposed DART Underground Link



- **Swiftway BRT Network:** Swiftway is proposed as a high quality network which uses buses on roadways or in dedicated lanes to provide a higher level of segregation than regular bus services. Three Swiftway routes are proposed for the city including one serving the City Centre – Airport – Swords corridor. The Swiftway network offers the important advantage of being relatively quick to commission, cost-effective to install and less intrusive during the construction phase compared to light rail or underground alternatives.

A map of the proposed network is shown in Figure 3.13.

Figure 3.13: Proposed Swiftway BRT Network



(Source: www.nationaltransport.ie)

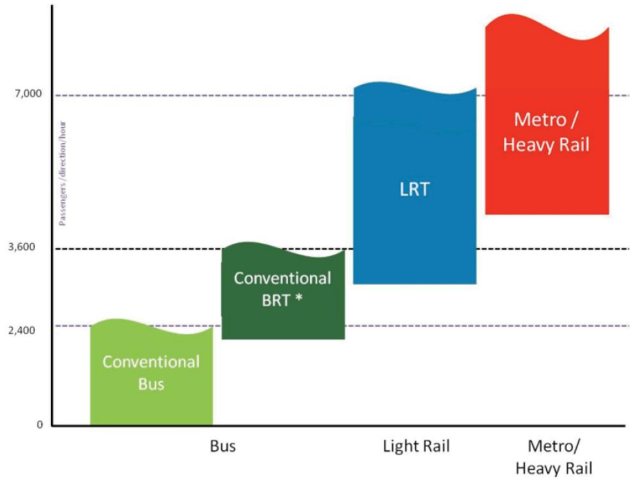
3.5 Public Transport Options and Capacities

The following section provides an overview of the various public transport options which could respond to the demand outlined in the previous section.

3.5.1 Bus Rapid Transit

Assessment of the potential capacity of various public transport modes is presented in Figure 3.14. As shown, conventional buses are limited in their potential to respond to high levels of transport demand. Providing greater segregation and priority to larger bus vehicles based on BRT design concepts can increase capacity substantially. Various BRT schemes around the world have capacities in excess of 10,000pphpd including Bogotá TransMilenio (Colombia) and Guangzhou BRT (China).

Figure 3.14: Comparison of Capacities of Public Transport Modes



* Higher Capacity BRT can be provided under specific conditions:
- dedicated bus lanes
- dual/overtaking BRT lanes
- longer vehicles
→ Not appropriate for Dublin.

Source (adapted): UITP Paper "Public Transport: making the right mobility choices", Vienna 2009

As shown, BRT schemes which can be delivered with a high operating capacity can compete favourably with light rail to an extent. The upper limits of BRT capacity are similar to what can be achieved on light rail and there are various pros and cons of each. In general, BRT is more flexible and is cheaper to construct. However, BRT vehicles have lower capacity so BRT generally needs to operate more frequent services to offer the same level of capacity as light rail. Therefore light rail has lower operating cost and can become more cost-effective than BRT at higher levels of patronage, and the ultimate carrying capacity of light rail exceeds that of BRT. It is possible to provide higher capacity BRT systems, which can compete with light rail capacities. However, this can only be achieved if full segregation, large stations, passing lanes and a full reorganisation of the existing bus system were considered. Typically, the design of these systems could consume extensive road capacity which in Dublin is already heavily constrained on many corridors. Cross sections of existing systems around the world are shown in Figure 3.15.

The Bus Rapid Transit (BRT) Core Dublin Network (NTA 2012) suggests that a lower capacity system is most likely in Dublin primarily due to our restricted City Centre environment. For demand over 7,000pphpd, greater segregation and bigger vehicles are required, pointing to Metro or heavy rail type services as demand increases.

Figure 3.15: Cross sections of high capacity BRT systems globally

Conventional buses are extremely limited in their ability to respond to the identified travel demand within the study area. At present, the maximum capacity potential of conventional buses with a minimum headway of 5 minutes is 1,200pphpd. As demonstrated through the Do Minimum 2033 scenario, the bus network is incapable of adequately responding to demand.

Achieving the upper range of bus capacity through delivery of BRT is highly dependent on having sufficient road capacity for conversion to dedicated BRT lanes. In Dublin, initial plans for the Swiftway scheme are proposed on the basis of partial segregation which would achieve a maximum of approximately 4,500pphpd[8]. However, achieving this is likely to result in reduced road network capacity and traffic restraints.

3.5.2 Light Rail

The application of light rail technology ranges from street running systems with relatively low speed and capacity (known as trams or streetcars) through to mainly or totally segregated tracks carrying large vehicles to cater for high passenger flows at high speeds (light metros). The current Luas system is in the middle of this spectrum. Sections on the Green Line south of Charlemont have similarities to a Light Metro concept while in the city centre its profile is more typical of urban streetcar than Metro. In a 'hybrid' network of this type, the street section normally constrains the length, width and frequency of vehicles and therefore limits the maximum capacity to less than that of an off street section. At present, the Luas Red and Green lines operate at a maximum capacity of 4,500pphpd, based on a 4

[8] This assumes 24m vehicles with a maximum capacity of 150 passengers.

minute frequency and 40m trams. However, future on-street running of Luas Cross City through the City Centre will limit operations to no more than 24TPH, pending delivery of the Dublin City Transport Strategy as well as a network wide signalling system. In the event that these measures are not implemented, 21TPH may be more realistic. With increasing segregation and priority, similar light rail technology could theoretically operate on a capacity of up to 20,000pphpd, as shown in Figure 3.16.

This upper limit of light rail capacity is based on a completely segregated network without operating constraints and with large vehicles and high service frequencies.

Figure 3.16: Existing and potential light rail capacity

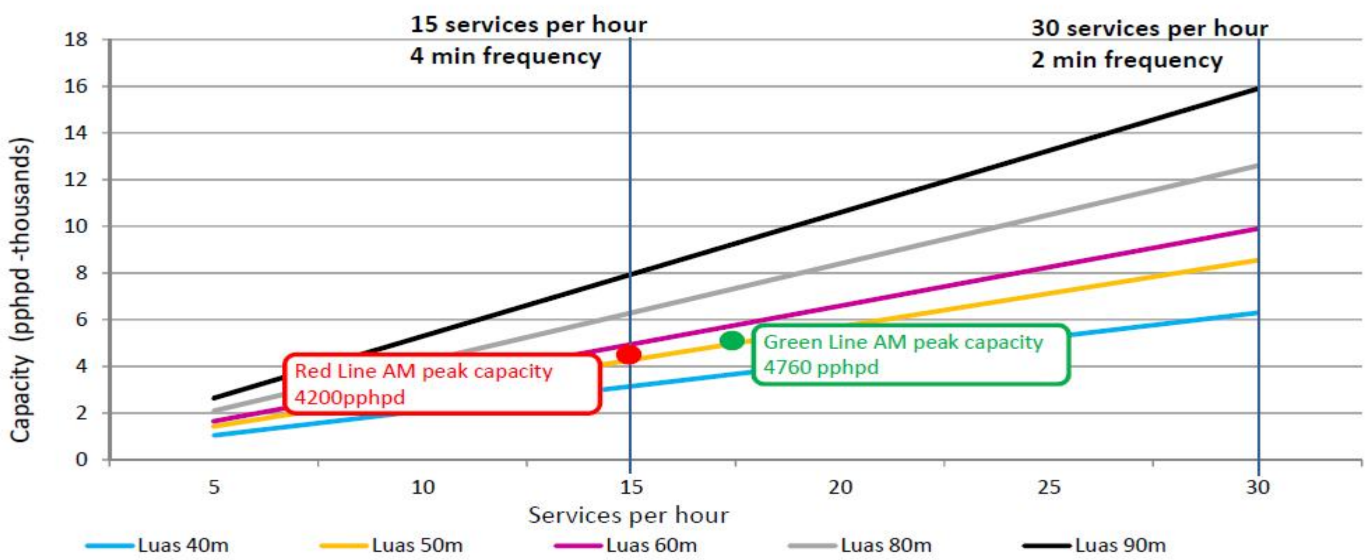
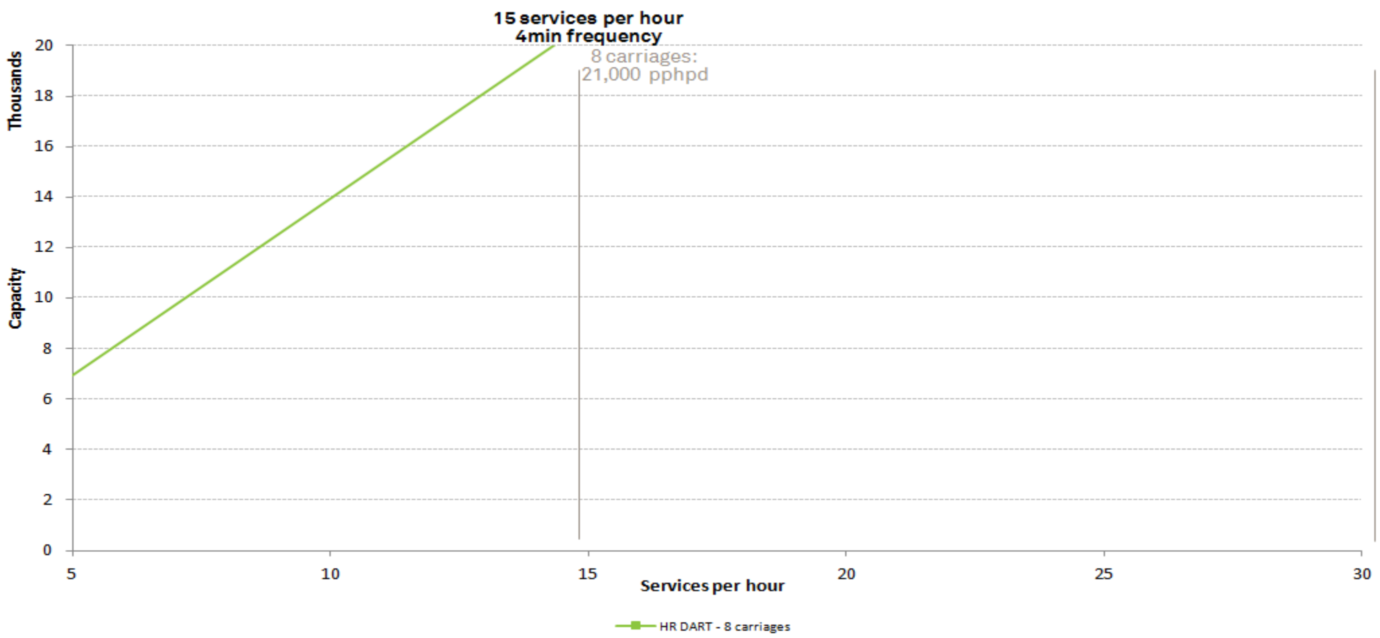


Figure 3.17: Potential heavy rail capacity



3.5.3 *Heavy Rail*

Heavy rail, with its benefit of maximum segregation and even larger vehicles has the potential to respond to a similar level of demand with a 4 minute frequency as outlined in Figure 3.17. However, the capacity of heavy rail services in the Dublin area is constrained by the number of possible train paths, flat junctions and infrastructure which must be shared with inter-city services. Level crossing closure times may also affect service frequency, for example as on the Bray line south of Grand Canal Dock.

3.6 Summary

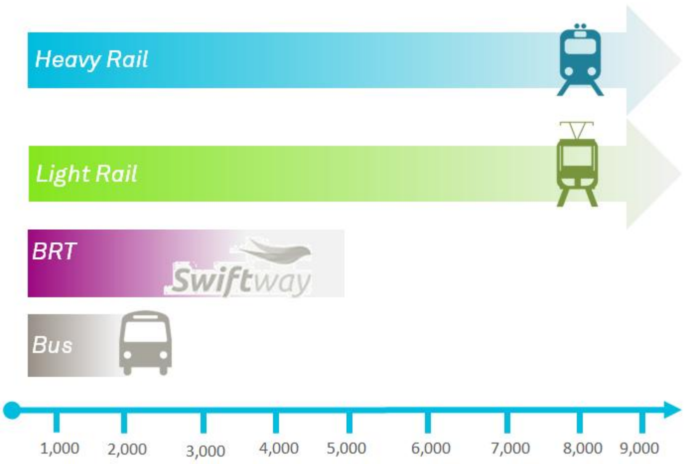
In terms of public transport provision, the bulk of the study area has bus services only with relatively small catchment areas served by the heavy rail line. A number of projects are under construction to address future transport demand within the study area – including Luas Cross City, City Centre Resignalling and the Phoenix Park Tunnel– however, none of these projects will serve future demand in the key nodes of Dublin Airport and Swords, key growth centres within the area.

Assessment of the expected future 2033 transport and land use scenario indicates that a large proportion of trips within the study area, in particular north of the M50, will be car based in 2033. Without improved public transport provision, the road network will struggle to cope with increased travel demand in 2033. Outputs from the NTA's Greater Dublin Area Strategic Transport Model indicate significant delay, with travel times increasing by 72% and average speeds decreasing by 19%. Similarly, the bus network will experience overcrowding as demand increases.

There are a number of potential transport options which could respond to this future demand, each with varying capacities and costs. A new public transport service will be required within the study area which is supported by the bus network and provides a minimum capacity of 6,000pphpd in the AM peak. This level of demand in likely to continue to increase in the longer term. BRT systems have a wide range of potential capacities and a high capacity BRT system could, in theory, meet this expected demand. However high capacity BRT systems require a number of essential conditions to function, including dedicated bus lanes, dual / overtaking BRT lanes, high levels of signal priority and longer vehicles. It is unlikely that these conditions could be implemented within the study area, particularly the City Centre, due to constrained road widths, impacts on the historical core, and significant impacts on traffic management and travel times. A lower capacity BRT system could be achieved with partial segregation and lower levels of signal priority; however the capacity of this type of system would be more limited.

Light rail systems also vary in terms of capacity and running speeds, with the level of service dependent on the degree of segregated running, vehicle size, frequency, signal priority etc. The flexibility of LRT systems in terms of capacity presents better opportunities to meet the estimated level of demand. However, it should be noted that the level of demand expected within the study area is likely to be higher than current demand on the Luas Green and Red lines which currently cater for up to 4,800pphpd in the AM peak. Therefore, the requirement for a more segregated, higher frequency and capacity scheme is likely.

Figure 3.18: Summary of potential mode capacities (pphpd)



Heavy rail systems benefit from fully segregated running and larger vehicles and therefore have the highest possible capacity. However it must be noted that in Dublin, a new heavy rail system may be constrained by the number of available train paths and other shared infrastructure.

The following sections present the development and appraisal of various public transport schemes to meet this demand.

4 Stage 1: Summary of Options Appraisal

4.1 Overview

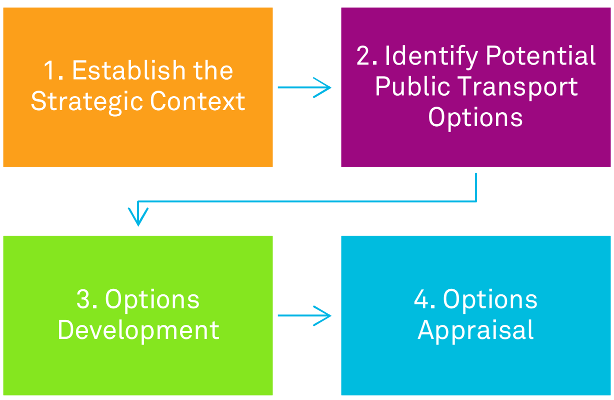
During Stage 1 of project development a comprehensive list of potential project options were identified, developed and appraised to generate a shortlist of preferred options for further development. Understanding the outcome of Stage 1 is directly relevant to Stage 2 and is therefore summarised in this section for convenience. A full copy of the report can be found on the NTA website.

A summary of the delivery approach taken in Stage 1 is also summarised prior to presenting the outcomes of Stage 1 Appraisal.

4.2 Stage 1 Approach and Methodology

There were four distinct phases of project development during Stage 1, summarised in Figure 4.1 and outlined in further detail below. Ultimately, the objective of this stage was to capture the existing and future land use and transport context within the study area and to identify and shortlist potential public transport options for future development.

Figure 4.1: Summary of Stage 1 Options Appraisal



4.2.1 Stage 1.1: Strategic Context

Establishing a firm understanding of the 2033 context for transport and land use within the study area was critical to ensuring the public transport options developed were feasible. The objective of this stage was to determine the existing and future travel needs within the study area and to provide a basis for identifying potential public transport infrastructure. The outputs of this task have been set out mainly in Section 3 of this report.

The identification of future growth areas within the study area required completion of a high level review of local, regional and national policy documents relevant to the study and the study area. This important task provides a focus on transport and land use priorities within the area.

To gauge the future levels of travel demand, an initial priority was to establish and agree population and employment growth projections for the Study area, which was undertaken in collaboration with the NTA Land Use Planning Team. This is outlined further in Section 6.

With the future population and employment projections for the study area established, it was necessary to identify the likely extent of the transport network in 2033. Each of the following schemes, combined with the existing transport network, are assumed to form part of the 2033 'Do Minimum'[9] transport network: Luas Cross City, City Centre resignalling and Phoenix Park Tunnel. Further information on these schemes can be found in Section 6.4 of this report.

4.2.2 Stage 1.2: Options Identification

This phase of the project commenced by collating and reviewing all previous proposals for public transport schemes within the study area. Table 4.1 below provides a summary of each of the schemes and the

[9] *It should be noted that following preparation of the Stage 1 report, DART Underground was omitted from the 'Do Minimum Scenario'*

scheme promoters with whom AECOM engaged to determine full details of the schemes proposed.

Once each of the six previously proposed existing schemes was reviewed, AECOM undertook a gap analysis to identify any further options which might feasibly be developed to respond to the travel demand identified within the corridor.

Ultimately, an additional 19 scheme options were identified. The identification of additional options was based on serving growth areas identified through the Strategic Context analysis and maximising the value of existing public transport infrastructure. The 25 scheme options identified for development and appraisal are outlined in Table 4.2.

Table 4.1: Public transport schemes initiated by stakeholders

Promoter	Scheme
Irish Rail	Northern line spur from Clongriffin to Dublin Airport Maynooth Line spur from Drumcondra to Swords
Railway Procurement Agency	Metro North Optimised Metro North Luas Line D1 from Broombridge to Finglas Luas Line D2 from Cabra to Swords
Metro Dublin	Metro Dublin Rail Network
“Drumcondra 2005”	City Access Transit (CAT)
Swiftway Bus Rapid Transit	National Transport Authority

Table 4.2: 25 Scheme Options Identified for Development and Appraisal

HEAVY RAIL	
HR1	Clongriffin to Airport
HR2	Extension of HR1 to Swords
HR3	Malahide to Airport via Swords
HR4	North Malahide Estuary to Airport via Swords West
HR5	Combination HR1 + HR3
HR6	Combination HR1 + Spur Malahide to Swords
HR7	Maynooth Line (Broombridge) to Swords via Airport
HR8	Maynooth Line (Drumcondra) to Airport-Swords, under Glasnevin
HR9	Heuston to Swords via Phoenix Park Tunnel, under Glasnevin
HR10	Metro Dublin (scheme as proposed from St James's Hospital to Malahide)
LIGHT RAIL	
LR1	Broombridge to Finglas (Luas D1)
LR2	Broombridge to Swords via Airport and Finglas
LR3	LCC to Swords via Airport, under Glasnevin (Luas D2)
LR4	LCC to Swords via Airport, via Phibsborough (Luas D2)
LR5	LCC to Swords via Airport, via Drumcondra (Luas D2)
LR6	Metro North
LR7	Optimised Metro North
LR8	Dublin CAT
BUS RAPID TRANSIT	
BRT1	Clongriffin to Airport via Malahide
BRT2	Clongriffin to Airport
BRT3	City Centre to Airport via Ballymun
BRT4	Docklands to Swords via Tunnel
BRT5	Combination of BRT2, BRT3, BRT4.
COMBINED OPTIONS	
C1	Combination of HR1 and LR3
C2	Combination of HR1 and high-capacity BRT Swords-Airport

4.2.3 Stage 1.3: Options Development

To ensure each of the 25 identified options could be appraised on a similar basis, each scheme was developed in the following areas:

- Technical feasibility;
- Operational feasibility;
- Environmental constraints; and
- Cost estimates.

Some of the proposed schemes identified, for example Metro North, were the subject of extensive study and development prior to this study. Others were at a concept stage and more comprehensive development was required to ensure sufficient information was available to ensure that they could be fairly appraised. Each of the 25 scheme options was presented to key stakeholders at a workshop in August 2014 and thereafter the Stage 1 Appraisal of each option commenced.

4.2.4 Stage 1.4: Options Appraisal

The first step of the Stage 1 Appraisal was a screening process to determine:

1. Is the scheme technically feasible?; and
2. Does the scheme meet the fundamental project objectives by serving the City Centre, Dublin Airport and Swords?

Options that did not receive a positive answer to both of these questions were eliminated and not considered further in the appraisal process.

For the options remaining, a more detailed appraisal of each scheme was undertaken in line with the 'Guidelines on a Common Appraisal Framework (CAF) for Transport Projects and Programmes' published by the Department of Transport (DoT, now DTTAS) in June 2009.

In lieu of preparing a full economic appraisal for each of the scheme options and to make the appraisal more tractable, the focus was on three of the criteria that are most relevant to strategy development, viz: Economy, Integration and Environment as outlined below:

Appraisal Criterion 1: Economy

The full appraisal of the economic impact of a transport investment is based on measuring the full economic benefits of the proposal for travellers and others, and the full costs of the proposal. For this preliminary appraisal, a number of variables were identified which could act as an appropriate proxy for potential benefits of the option. These indicators included:

- **Catchment per kilometre of additional route:** The effectiveness of any option is determined in large part, by the extent to which it can attract passengers and thus deliver economic benefits. Modelling of passenger demand was not appropriate at this preliminary appraisal stage. However, indicators of potential demand per kilometre of additional public transport route provided were used in order to assess the relative economic efficiency of the options. Potential demand was estimated using population and employment projections for the study area;
- **Journey times:** The efficiency of each option involves consideration of the level of service offered in terms of reduced journey times. Metro North journey times were based on information made available by the RPA. Heavy rail journey times were based on average speed on the existing system between Connolly and Clongriffin, according to the Irish Rail 2014 timetable. Light rail journey times were based on the RPA projections prepared for each option or the average speed of these services where specifics were not available. Although average journey speeds for BRT range from 20-25kph, the BRT journey times for the purpose of appraisal were based on the estimates from design work on the Swords Swiftway scheme; and
- **Capital Cost:** The overall indicative cost of implementing each scheme is used as a measure of economic efficiency in the appraisal. Costs generally comprise the capital costs of infrastructure and vehicles/rolling stock as well as operational and maintenance costs. However, for the Stage 1 Appraisal, it was decided to assess capital costs only for practical reasons and because all the other costs are dependent on the level of service that vary over the lifetime of the transport system. An "order of magnitude" level estimate of the cost of each option was calculated based on a common set of parameters of the cost per km and cost per station of each mode. This was developed based on an assessment of similar recent/planned schemes in the Irish context. The costs were then checked against current industry standards at present costs. The parameters used are not intended to give an estimate of the cost of actually implementing any of the options, merely to indicate the likely relative cost of options.

The purpose of the identified proxy measures for economic benefits was to allow an assessment of the relative amount of benefits that each option could be expected to deliver.

Appraisal Criterion 2: Integration

The appraisal of each proposed option in relation to integration was based on a qualitative assessment of the following criteria:

- **Compatibility with land use planning policies:** Further development of Swords and the Airport are key features of land use policy for the study area. While the initial screening process ensured each option connected with these areas, the appraisal also considered the extent to which the proposed options supported land use development objectives for the area;
- **Integration with public transport networks:** Public transport integration incorporates two aspects, as follows: The extent to which each of the options offers services that avoid the need to interchange with other public transport services to complete journeys within the Dublin City-Airport-Swords corridor, and the ease with which each of the options offers services that facilitates public transport based journeys to destinations off the Dublin City-Airport-Swords corridor; and
- **Integration with other modes**: This criterion investigates the level of connectivity with other modes including the road network as well as connectivity within Dublin Airport.

Appraisal Criterion 3: Environment

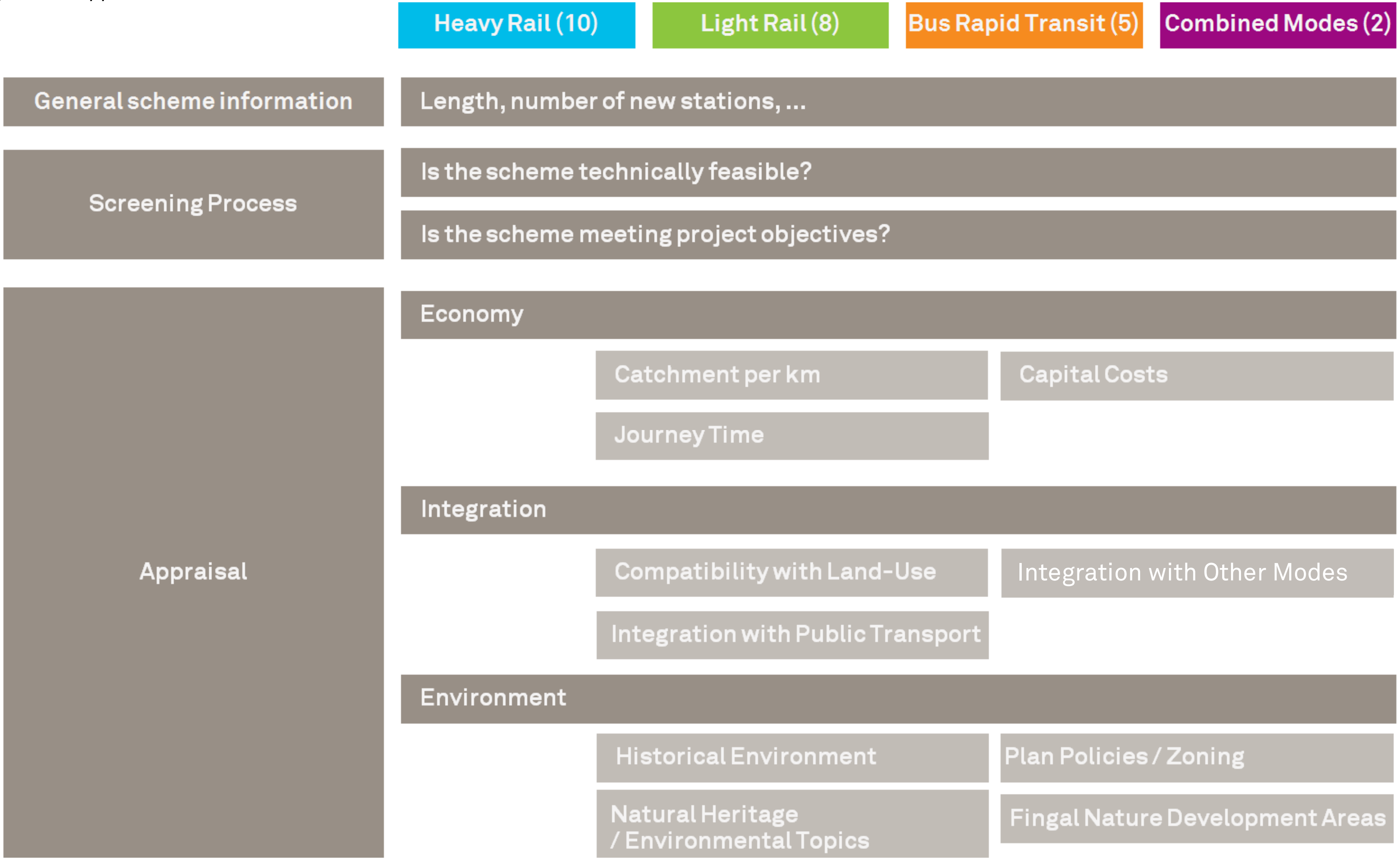
An environmental constraints assessment was undertaken for each of the proposed options using the following criteria:

- Historical Environment (Cultural Heritage);
- Natural Heritage/Environmental Topics;
- Plan Policies/Zoning; and
- Nature Development Areas within each local authority

Based on the analysis undertaken, a conclusion was drawn as to whether each option had negligible, moderate or significant (negative) environmental impacts.

Using the outputs of the analysis for each of the three criterion (economy, integration and environment), a representative set of options which cover all potential approaches to fulfilling the identified project need were brought forward to Stage 2 for further technical development and appraisal. The following sections provide a summary of each of the 25 Stage 1 options as well as the appraisal conclusion on each of them.

Figure 4.2: Appraisal structure



4.3 Heavy Rail Options

The heavy rail options proposed are effectively extensions of the existing DART network which was introduced to Dublin in 1984. It is assumed that, as with the DART, all options would be electric powered.

Irish Rail had previously considered two heavy rail options to potentially serve the Fingal/North Dublin area (the study area for this project), these are:

- **Clongriffin Spur to the Airport:** Irish Rail proposed this scheme as an elevated rail line from Clongriffin, across the M1 and terminating at a station close to the Airport terminals. A business case for the scheme was prepared in 2011 and concluded that the scheme would be relatively cheap to construct (in the region of €200m-€300m depending on the precise station location) and would deliver significant benefit by connecting the existing DART line to the city centre and wider rail network; and

- **Maynooth Line Spur from Drumcondra to Swords:** This scheme was previously proposed by Irish Rail in the 1990s (Irish Rail Air-Link Study 1998). The scheme was only suggested on a conceptual basis and the route followed an alignment towards the west of the M50 before connecting with the Airport.

Additional proposals for additional heavy rail scheme options were identified on the basis of developing spurs off the existing rail network to serve to existing city centre stations, the Airport and Swords. A summary of each of the schemes and the corresponding appraisal result is outlined in the following sections.

Figure 4.3: DART train at Connolly Station

HR1: Clongriffin to Airport

Alignment

This route would run from a junction north of Clongriffin Station to Dublin Airport across currently undeveloped agricultural land.

Infrastructure

The route would be elevated over the M1 and terminate at a station to be developed at the Airport Ground Transportation Centre (GTC).

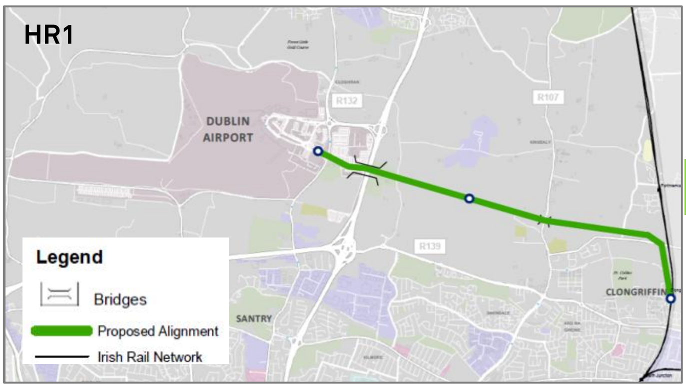
Stations

One new station is proposed on the route at the Airport (elevated) with potential for a park and ride station between Clongriffin and Airport in the future.

Stage 1 Indicative Comparison Cost: €200m - €300m (as suggested in the Irish Rail DART Airport Link Business Case).

Appraisal Result

HR1 does not meet the basic project objective of serving Swords and was therefore **eliminated at the Screening Process**. However, this route does form part of combined option C1.



HR2: Extension of HR1 to Swords via the Airport

Alignment

To serve the objective of the study, HR1 was extended to Swords via the Airport.

Infrastructure

HR2 could connect to Swords by continuing on an elevated alignment (over the R132) or by tunnelling.

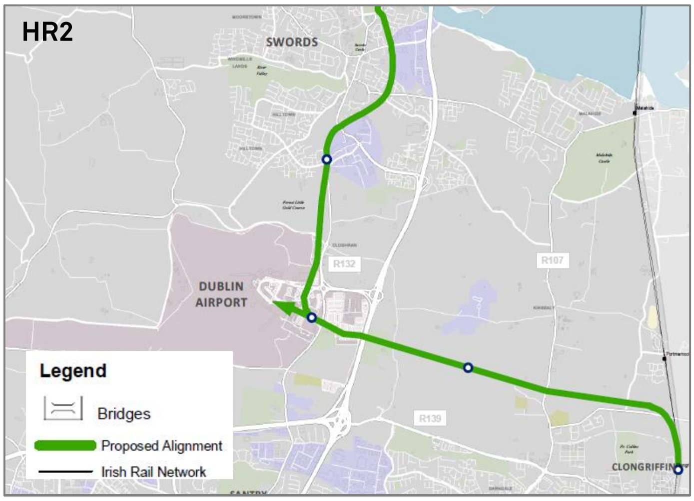
Stations

Stations are proposed at the Airport, Swords and Estuary. Estuary Station would be developed with a Park and Ride.

Stage 1 Indicative Comparison Cost: €600-790 million.

Appraisal Result

This scheme scored relatively well on economic criteria. The proposed spur serves a reasonable level of population per extra kilometre of track and integrates reasonably well with policy and existing public transport. **This scheme was brought forward to Stage 2. Further information on HR2 can be found in Section 7.**



HR3: Malahide to Airport via Swords

Alignment

This spur would run off the Northern Line at Malahide in a westerly direction to serve Swords before diverting southwards to serve the Airport.

Infrastructure

A tunnelled alignment would be required on this route due to the high density of existing development. Approximately 5km of tunnels would be required between Malahide and Swords. The section between Swords and the Airport could be tunnelled or elevated. The route would terminate at the Airport.

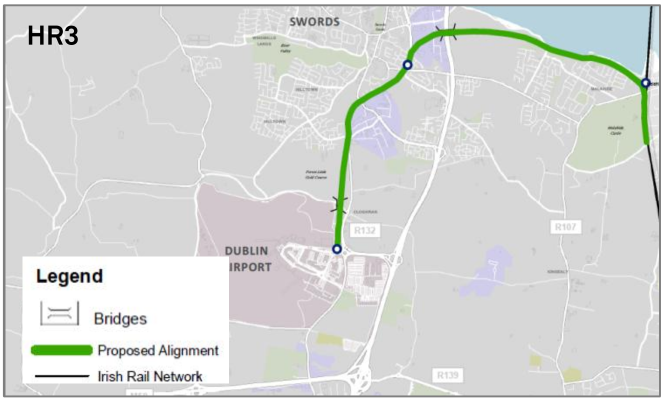
Stations

Stations are proposed at the Airport and Swords with an upgrade of Malahide Station required. One additional underground stop west of Malahide may also be possible.

Stage 1 Indicative Comparison Cost: €1240-1490 million.

Appraisal Result

This scheme performed relatively poorly on economic criteria. The route is shorter than HR2, however it serves a less dense catchment area leading to a lower catchment per kilometre and a higher cost than HR2. The proposed routing also integrates less well with land use policy as it does not serve the development areas of Swords as well as HR2. **This option was not brought forward to Stage 2.**



HR4: North Malahide Estuary to Airport

Alignment

The rail spur in this instance would commence further north of Malahide Estuary and run in a westerly direction to serve Swords before diverting southbound to the Airport.

Infrastructure

Between Malahide and the Airport, the route would be mostly at-grade. A number of level crossings or small bridge structures would be provided to cross local and regional roads. A long span bridge structure would be required to cross the M1 to the north east of Swords. To serve the Airport, elevated and tunnelled options would need to be looked at in more detail during Stage 2 if necessary.

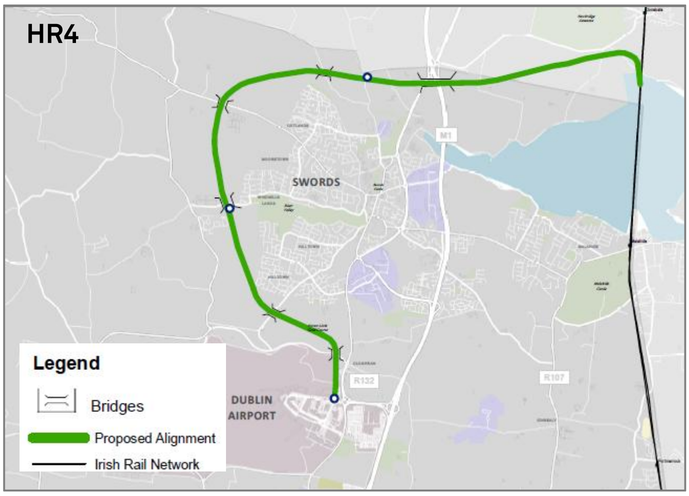
Stations

Three new stations are proposed on this route: one north of Swords, one to the west of Swords and one at the airport.

Stage 1 Indicative Comparison Cost: €310-460 million.

Appraisal Result

The appraisal results for this option are essentially the same as those for HR3 although potentially at lower cost. Despite this, journey times to the Airport would be excessive. **This option was not brought forward to Stage 2.**



HR5: Combination HR1 and HR3 –loop from Malahide to Clongriffin via Airport

Alignment

The scheme would combine HR1 and HR3 to create a loop from Clongriffin through the Airport, north to Swords and reconnect with the Northern Line at Malahide.

Infrastructure

The scheme would be elevated between Clongriffin and M1 and enter a tunnel through the Airport. The route would be elevated from the Airport to Swords with tunnelled sections through Swords and Malahide.

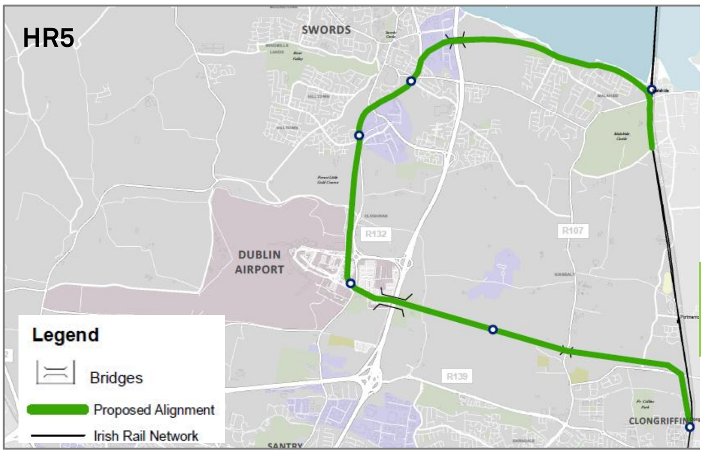
Stations

Stations are proposed at the Airport and Swords Pavilion, as well as an upgrade of Malahide Station and possible additional stops west of Malahide and a park and ride stop between Clongriffin and M1.

Stage 1 Indicative Comparison Cost: €960-1230 million.

Appraisal Result

Similar to HR3 and HR4, this option is longer than HR2 but has a lower catchment per kilometre, and relatively poor economic performance. **This option was not brought forward to Stage 2.**



HR6: HR1 with spur from Malahide to Swords

Alignment

Two spurs off the Northern Line are proposed in this instance, one from Clongriffin to the Airport and another from Malahide to Swords.

Infrastructure

HR1 would run on an elevated alignment to the Airport and the Malahide spur would require a tunnelled alignment.

Stations

Stations are proposed at the Airport and Swords, as well as an upgrade of Malahide Station and one possible additional stop for park and ride between the Airport and Clongriffin.

Stage 1 Indicative Comparison Cost: €870-1100m.

Appraisal Result

This option also performs poorly on the economic criterion as it involves constructing a relatively large length of track to serve a small catchment. In addition, it integrates poorly with land use polices as it does not enhance the planned Airport-Swords corridor. **This option was not brought forward to Stage 2.**

HR7: Maynooth Line (Broombridge) to Swords via the Airport

Alignment

This spur off the Western Line is 16km in length and runs from Ashtown to the west of the M50 before diverting northwards to serve the Airport and then Swords. The route is similar to that previously proposed by Irish Rail.

Infrastructure

At least 3km of the route would need to be tunnelled with the remainder at-grade or elevated.

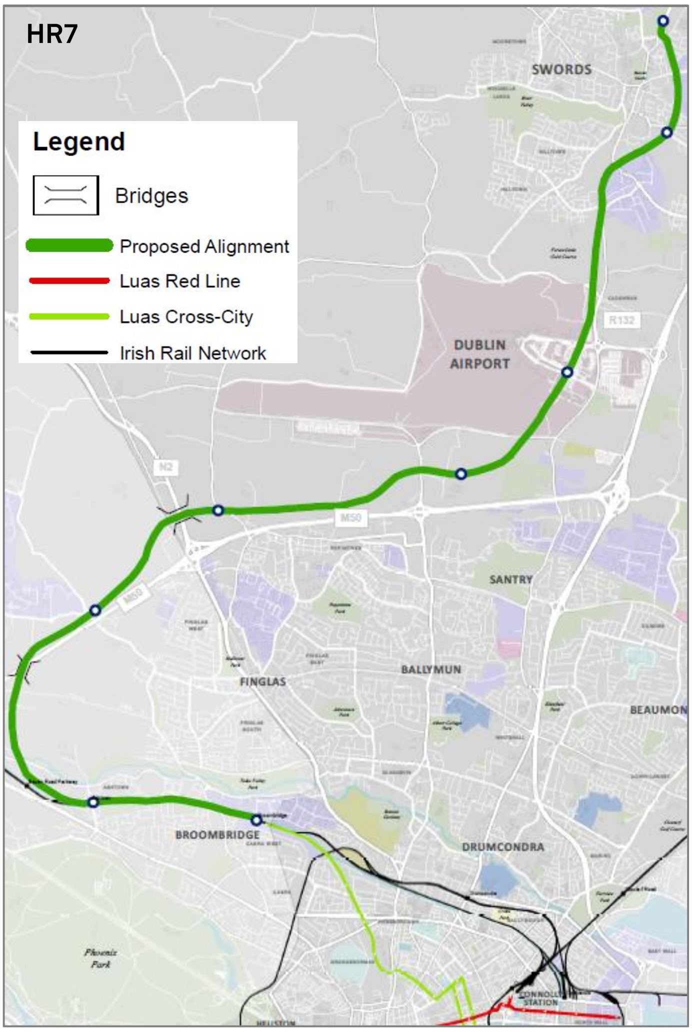
Stations

Seven new rail stations are proposed for this option: Ashtown, Dunsink, Finglas, Dardistown, Airport, Swords and Estuary.

Stage 1 Indicative Comparison Cost: €940-1210 million.

Appraisal Result

This is one of four options to build a new heavy rail link from the city centre northwards to Dublin Airport and Swords. (The others being HR8, HR9 and HR10). These routes all score well on the basis of the dense catchment areas they serve. HR7 is the longest of the three routes and has significantly higher journey times and therefore **was not brought forward to Stage 2.**



HR8: Maynooth Line (Drumcondra) to Airport and Swords

Alignment

This route is 12.6km in length and links the western line at Drumcondra Station to Dublin Airport and Swords.

Infrastructure

At least half of this alignment would need to run underground with a possibility of running elevated from the Airport to Swords.

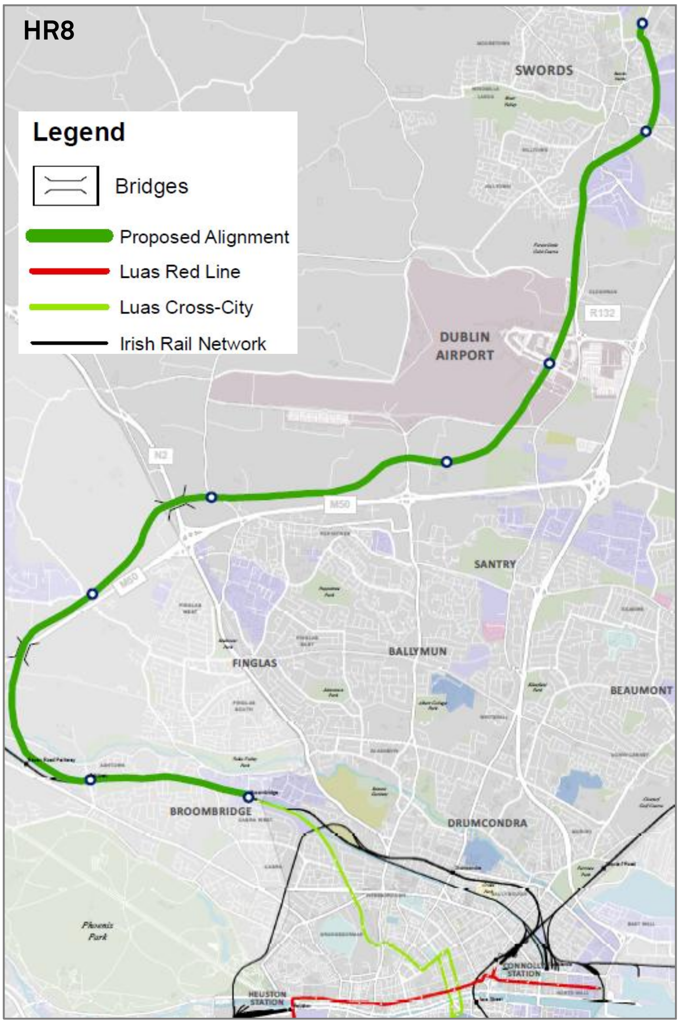
Stations

Eight new stations are proposed for this option: Glasnevin, DCU, Ballymun, Dardistown, Airport, Nevinstown, Swords, Estuary.

Stage 1 Indicative Comparison Cost: €1760-2130 million.

Appraisal Result

This proposal for a new rail line from the city to the Airport and Swords delivers the same relatively high scoring for catchment as HR7 and HR9. It also provides excellent journey times by taking a fast direct route via a tunnel. This option is highly compatible with land use polices and integrates very well with the existing public transport network. **This scheme was brought forward to Stage 2. Further information on this scheme can be found in Section 7.**



HR9: Heuston to Swords via Phoenix Park Tunnel

Alignment

This 13km route would run from Heuston Station northwards via the Phoenix Park Tunnel to serve the Ballymun corridor, the Airport and Swords.

Infrastructure

A large proportion of this route would need to be tunnelled, especially south of the Airport. Opportunities to keep the route at-grade/elevated north of the Airport need to be looked at.

Stations

Eight new stations are proposed for this option: Glasnevin, DCU, Ballymun, Dardistown, Airport, Nevinstown, Swords, Estuary.

Stage 1 Indicative Comparison Cost: €1760-2130 million.

Appraisal Result

This option scores similarly to HR8, however it is considered the weakest of the three proposals for a new rail link to the Airport and Swords as there are likely to be operational constraints associated with use of the Phoenix Park Tunnel. There are also likely to be issues in relation to interchange options at Heuston. In addition, its commencement at Heuston does not present a favourable city centre destination. **This option was not brought forward to Stage 2.**

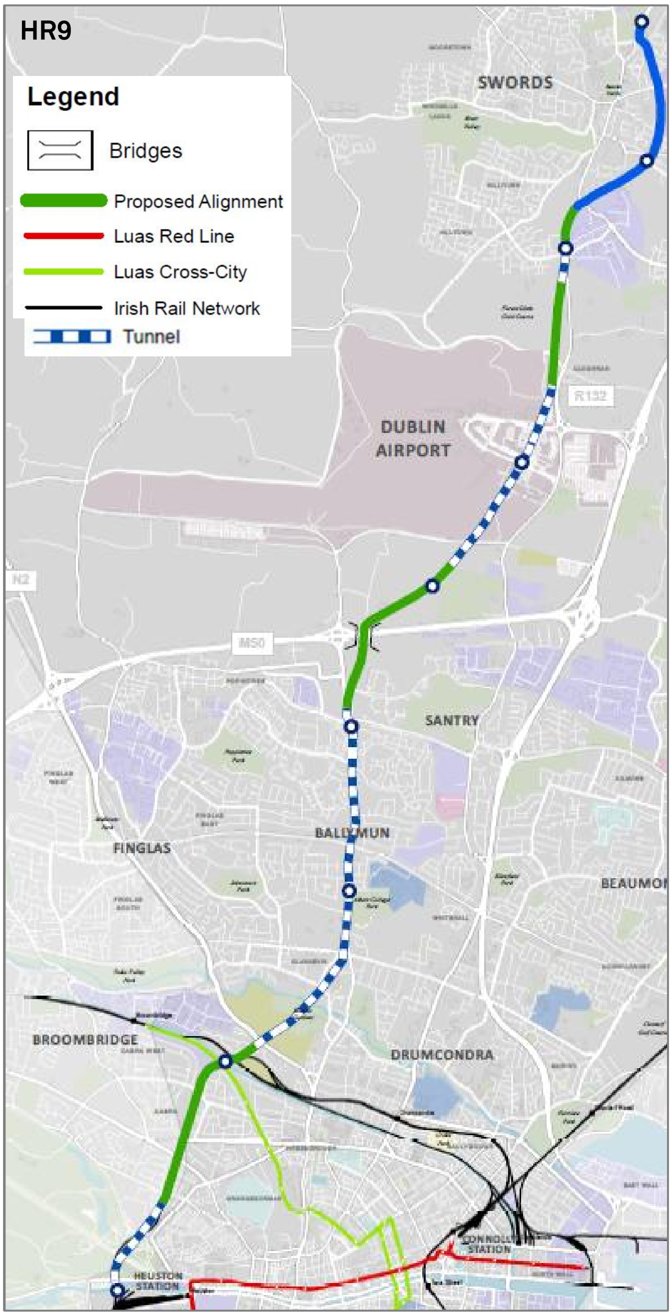
HR10: Metro Dublin (St. James's Hospital to Malahide)

Alignment

Metro Dublin includes a proposal for a new metro system that includes and extends the proposed DART Underground/Expansion. The system is 53 kilometres in length with 3 lines including one from Malahide to St Stephens Green via Heuston.

Infrastructure

11km of the 22km route to Swords would be tunnelled (from Glasnevin Cemetery to the M50, through Dublin Airport and through Swords) with the remaining section at grade.



Stations

Nine new stations would be developed including: Glasnevin, DCU, Ballymun, Dardistown, Airport, Nevinstown, Swords, Estuary and North Malahide.

Stage 1 Indicative Comparison Cost: €1.9 billion for full network build out.

Appraisal Result

This option was excluded at the screening process on the basis of technical feasibility, particularly in relation to measures required to integrate the scheme between St James' Hospital and Heuston Station. Concerns were also raised in relation to the use of Phoenix Park Tunnel. However, there are strengths to the proposed alignment and as such a similar alignment, HR8, is brought forward to the next stage of the study for further development and appraisal. **This option was eliminated at the Screening Process.**

4.3.1 Summary

Of the original 10 heavy rail schemes proposed, 2 were eliminated at the screening stage of appraisal (HR1 and HR10). Following this, a sketch appraisal was used to recommend two heavy rail schemes for development; one as a spur from the Northern Line (HR2) and another from Maynooth Line (HR8). A summary of the outcome of the Stage 1 Appraisal of heavy rail schemes is outlined in Table 4.3.

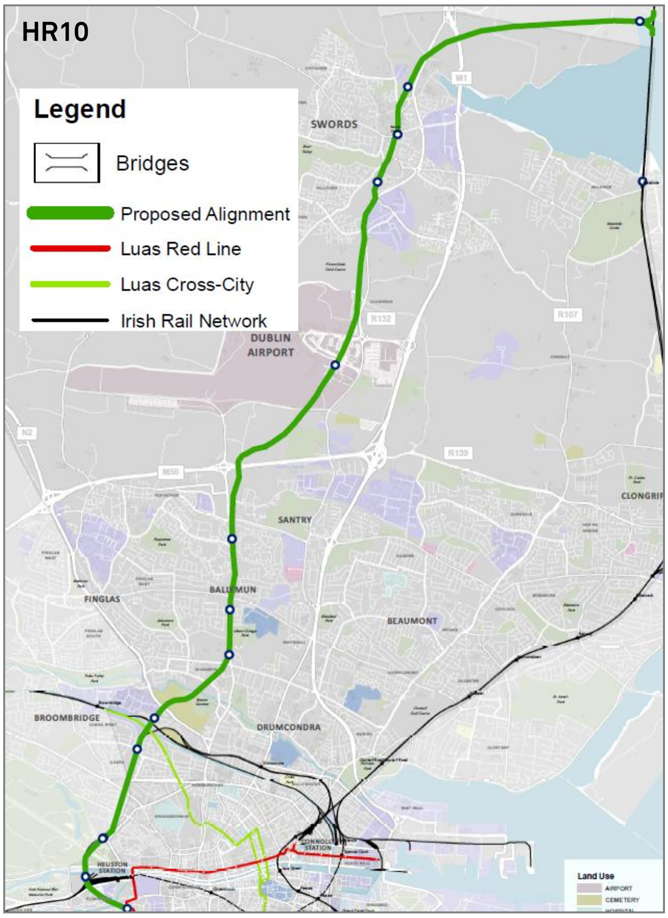


Table 4.3: Summary of Stage 1 Appraisal of heavy rail schemes

Code	Route	Stage 1 Appraisal Result
HR1	Clongriffin to Airport	Eliminated at the Screening Process
HR2	Extension of HR1 to Swords	Progress to Stage 2 on the basis of effectiveness, efficiency and integration
HR3	Malahide to Airport via Swords	Eliminated due to excessive journey times, capacity limitations and poor integration with land use policies
HR4	North Malahide Estuary to Airport via Swords West	Eliminated due to excessive journey times, capacity limitations and poor integration with land use policies
HR5	Combination HR1 + HR3	Eliminated due to relatively low catchment area, journey times, capacity limitations and poor integration with land use policies
HR6	Combination HR1 + Spur Malahide to Swords	Eliminated due to capacity issues on the Northern Line and poor land/public transport integration
HR7	Maynooth Line (Broombridge) to Swords via Airport	Eliminated due to relatively higher indicative cost per km
HR8	Maynooth Line (Drumcondra) to Airport-Swords, under Glasnevin	Progress to Stage 2 on the basis of catchment, journey times and integration
HR9	Heuston to Swords via Phoenix Park Tunnel, under Glasnevin	Eliminated due to relatively higher cost per km and poor connectivity with City Centre
HR10	Metro Dublin (scheme as proposed from St James's Hospital to Malahide)	Eliminated at Screening Process due to technical feasibility issues. However, a similar alignment, HR8, has been taken forward.

4.4 Light Rail Options

Light rail in Dublin currently consists of the Green and Red Luas Lines which link Cherrywood and Tallaght respectively to the City Centre. The network started operation in 2004 and has been extended over the last decade to a length of approximately 37km. The two lines are currently being linked and extended through the city centre as part of the Luas Cross City project. The services run on a combination of segregated and on-street running and, like the DART, are electric powered.

Figure 4.4: Luas operating on the Red Line

Proposals for Metro North, which is effectively a fully segregated light rail system, within the study area are well advanced and the scheme, which is entirely segregated from the road network, was granted a Railway Order in December 2010. However due to the economic conditions the project was put on hold. As outlined in Section 2, the planning context for much of the study area has been developed on the basis of Metro North proceeding. Since the Railway Order was granted in 2010, original forecasts for passenger demand on the line have declined resulting in a more difficult business case for the scheme which was originally estimated to cost within a range of €2.5billion-€3.0billion.

In light of concerns about the economic feasibility of Metro North, the RPA developed an alternative proposal based on an extension of the on-street Luas system called Luas Line D2. This scheme builds on the opportunity presented by Luas Cross City (LCC) to expand Luas services in the north of the city. Luas line D2 would extend services off the LCC to serve the Airport and Swords. North of Griffith Avenue the alignment would serve a similar corridor as Metro North but would provide a lower frequency and lower capacity service.

Opportunities to reduce the cost of the original Metro North project have also been investigated with a view to retaining the same alignment. Reduced demand for the scheme has given way to an opportunity for shorter trains and platforms resulting in cost savings. Additional savings have been proposed by running the light rail at surface level (as opposed to tunnel) through Ballymun and reducing the length of elevated viaduct at Swords. The introduction of the Luas Cross City also presents the opportunity to reduce the number of city centre Metro North stations by replacing the separate stations at O'Connell Bridge and Parnell Square with a single station at O'Connell Street. For the purpose of this study, this proposal is titled "Optimised Metro North".

Each of these schemes was put forward for Stage 1 Appraisal as well as five additional projects proposed by stakeholders and AECOM. Each of the light rail schemes put forward for Stage 1 Appraisal and the outcome of appraisal is summarised in the following section.

LR1: Broombridge to Finglas

Alignment

This 5km alignment was previously proposed by the RPA as Line D1 and runs as an extension of the Luas Cross City from Broombridge to Finglas.

Infrastructure

The full length of this Luas extension would be at-grade or elevated. The route crosses the Royal Canal and Western Suburban Line before entering Tolka Valley Park where a segregated route would be developed to connect to the residential areas of Finglas.

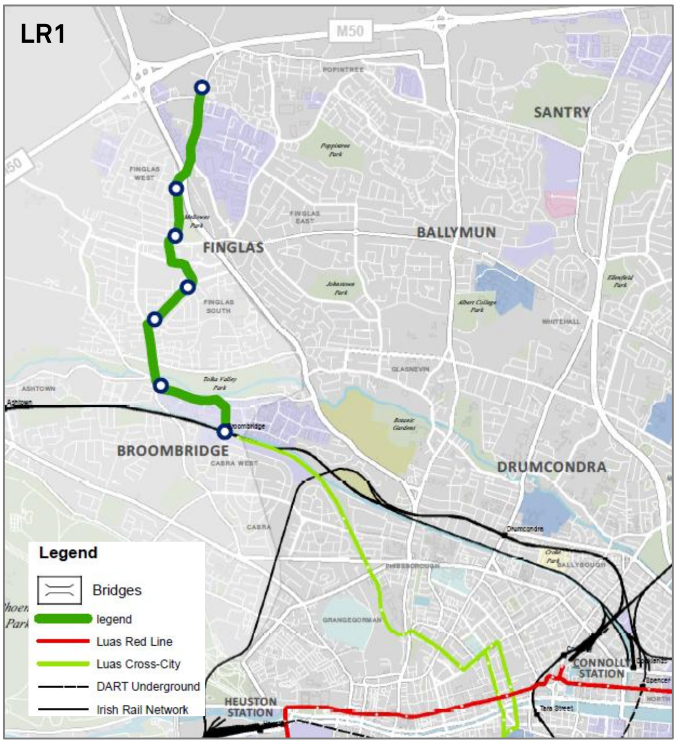
Stations

A total of six at-grade stops are proposed as part of this scheme between Broombridge and Finglas.

Stage 1 Indicative Comparison Cost: €250 million.

Appraisal Result

The route does not respond to the objective of this project in serving the Airport and Swords and was therefore **was eliminated at the Screening Process.**



LR2: Broombridge to Swords via Dublin Airport and Finglas

Alignment

This scheme proposes to extend LR1 to Swords and the Airport. The full route is at-grade and follows the same route as LR1 to Finglas before extending to the northside of the M50 at St. Margarets. The route then runs parallel with the M50 before turning north to the Airport and Swords Main Street.

Infrastructure

The full route is at-grade or elevated and requires a significant bridge structure over the M50.

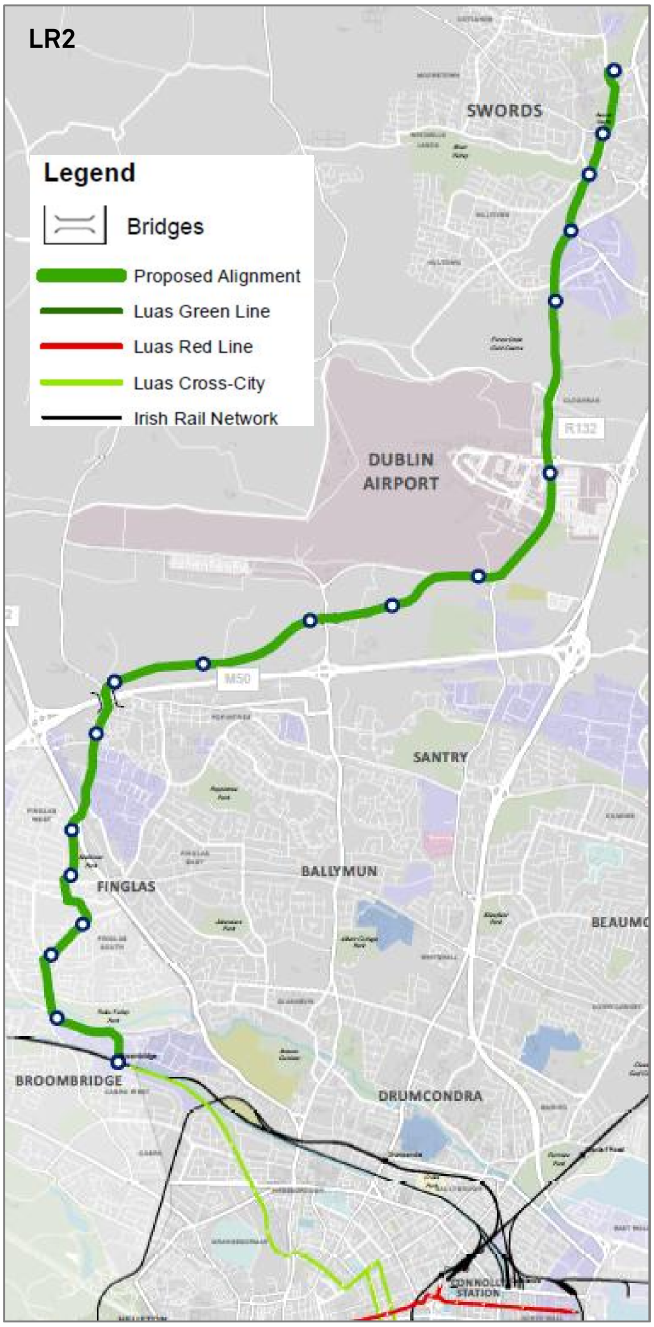
Stations

A total of seventeen new stops are proposed along the route, all at-grade.

Stage 1 Indicative Comparison Cost: €530-770 million.

Appraisal Summary

In common with most of the light rail options, LR2 ranks highly on cost and integration with other public transport services. LR2 scored neutrally on catchment per km, integration with land use policies and environmental considerations. The estimated journey times to the Airport and Swords is very high relative to other options and therefore this option **was not brought forward to Stage 2.**



LR3, LR4 and LR5: Cabra to Swords via Dublin Airport under Glasnevin Cemetery

Alignment

These three options are variations on Line D2 proposed by the RPA which would connect the Luas Cross City to the Airport and Swords. Although the alignment north of the Airport is the same, the southern sections differ as follows:

- LR3 - Cabra to Swords via Dublin Airport under Glasnevin Cemetery;
- LR4 - Cabra to Swords via Phibsborough and Dublin Airport; and
- LR5 - Cabra to Swords via Drumcondra and Dublin Airport.

Infrastructure

LR3 would require a tunnel under Glasnevin Cemetery and Cabra before following the Ballymun Road at-grade to the Airport. This would mitigate impacts of running at-grade on traffic and environment and is the preferred RPA approach.

LR4 would run at-grade through Phibsborough. As it is using existing roadways the traffic impact is much more significant than LR3 and the implementation of the infrastructure on some sections may be challenging, with significant detrimental impacts on Luas journey times and traffic.

LR5 follows an alternative alignment via Drumcondra and Santry to reach the airport. This route would make use of the Quality Bus Corridors (QBC) along the route to provide dedicated LRT infrastructure. As with LR4 traffic impact in this congested inner suburban location will be significant as a result of the at-grade running. Average Luas speeds on the route would also reduce due to traffic impacts.

Various options to serve the Airport were identified by RPA. Among these, an option along the R132 was preferred due to cost and on the basis that an Airport shuttle would be provided into the Airport.

Stations

Up to fourteen new stops are proposed depending on the preferred alignment.

Stage 1 Indicative Comparison Cost: €500-1050 million depending on tunnel requirements.

Appraisal Summary

It is recommended that each alignment is brought forward to Stage 2. The precise alignment should be identified based on more detailed examination of the routes and their technical feasibility. Further information on this scheme can be found in Section 8.

LR6: Metro North

Alignment

The original Metro North Scheme was developed by the RPA and approved by An Bord Pleanála in 2010. The route is 16.5km long and runs between St. Stephen's Green and Estuary.

Infrastructure

Almost 70% of the Metro North alignment is proposed to run underground from St Stephens Green to Northwood, just south of the M50. The route would be at-grade/elevated through Dardistown and further north of the Airport. A total of seven bridges, two viaducts, three footbridges and three underpasses are proposed as part of the alignment.

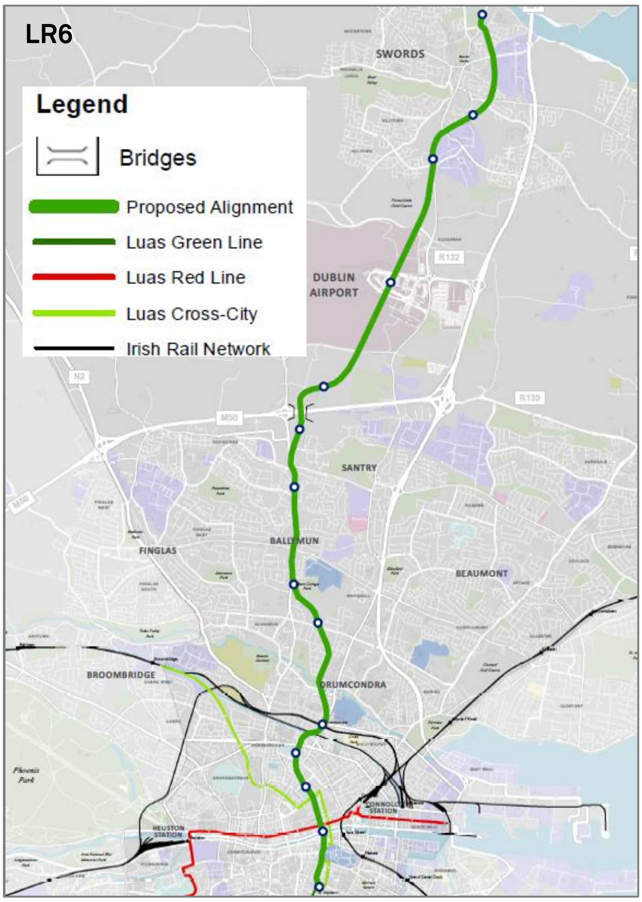
Stations

A total of fourteen new stations are proposed for this route, nine underground and five at-grade/elevated.

Stage 1 Indicative Comparison Cost: €2,500 million - €3,000 million.

Appraisal Summary

Metro North has already been subject to extensive development and appraisal. As expected, it scores highly in terms of potential benefits, but poorly on cost. It also integrates very well with land use and transport policy. **A more cost effective approach to delivering the scheme has been proposed as LR7, therefore this option was not brought forward to Stage 2.**



LR7: Optimised Metro North

Alignment

The Metro North scheme was reviewed with a view to reducing costs and downsizing the scale of system proposed.

Infrastructure

LR7 has smaller and fewer stations than Metro North. This alignment also includes a reduced amount of tunnelling with sections through Ballymun and Swords running at-grade.

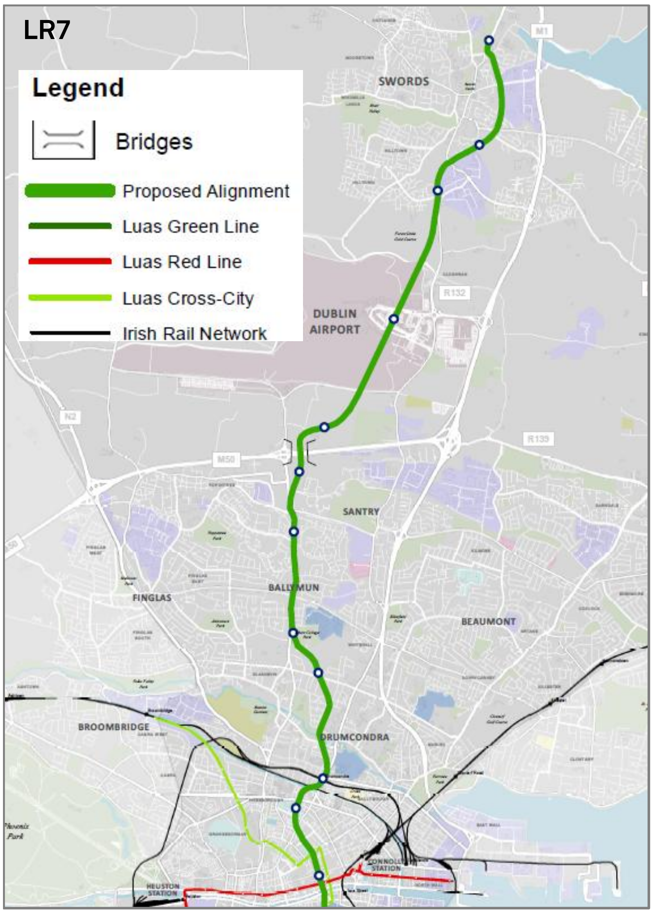
Stations

A total of fourteen new stations are proposed for this route with six underground and eight at-grade. O'Connell Bridge and Parnell Square stations were omitted from original scheme in favour of combined stop at O'Connell Street Upper.

Stage 1 Indicative Comparison Cost: €2,000 million

Appraisal Summary

LR7 is an optimised version of the original Metro North proposal. It proposes providing a similar service at reduced costs. It also produces the same preliminary appraisal results as Metro North. The scheme presents significant benefits and was **brought forward to Stage 2. Further information on this scheme can be found in Section 8.**



LR8: City Access Transit (CAT)

Alignment

City Access Transit (CAT) – Dorset Street and Drumcondra Road to Airport via Santry and Clonshaugh Industrial Estate terminating to the north of Swords.

Infrastructure

This proposed route is primarily at-grade and will require significant re-assignment of existing traffic lanes and impact on existing trees by overhead lines.

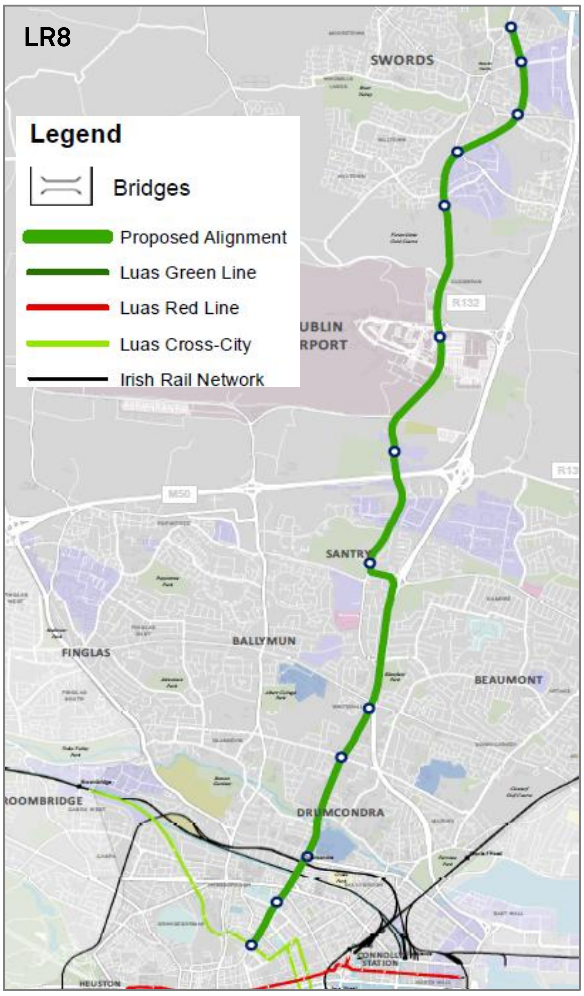
Stations

A total of fourteen new stations are proposed for this route, all at-grade

Stage 1 Indicative Comparison Cost: €590-850 million

Appraisal Summary

Very little information is available on this proposal. Its primary purpose is to improve public transport links in north Dublin City, rather than to provide a link to the Airport or Swords. In addition the LR5 route outlined above follows a similar routing. The route has relatively high journey times to the Airport and Swords and has significant traffic impact in Drumcondra, the main access route from the north to Dublin City Centre. **This option was not brought forward to Stage 2.**



4.4.1 Summary

Luas line extensions to the Airport and Swords via Finglas were eliminated during Stage 1 on the basis that journey times would be significantly longer. This was similarly the case for LR8 (the CAT), which proposes an indirect routing to the Airport and Swords. LR6 (Metro North) was superseded by a revised scheme - LR7, which has been brought forward for appraisal. Line D2 (LR3) has also been bought forward for further development and appraisal. A summary of the Stage 1 Appraisal of light rail options is provided in Table 4.4.

Table 4.4: Summary of Stage 1 Appraisal of light rail schemes

LIGHT RAIL APPRAISAL SUMMARY		
LR1	Broombridge to Finglas (Luas D1)	Eliminated at Screening Process
LR2	Broombridge to Swords via Airport and Fingal	Eliminated due to excessive journey times, and lower employment catchment served
LR3	Luas Cross City to Swords via Airport, under Glasnevin	Progress to Stage 2 on the basis of good journey times, cost and integration impacts.
LR4	Luas Cross City to Swords via Airport, via Phibsborough	
LR5	Luas Cross City to Swords via Airport, via Drumcondra	
LR6	Metro North	Pending outcomes of more detailed work in relation to technical and operational feasibility this scheme will be superseded by LR7 – Optimised Metro North.
LR7	Optimised Metro North	Progress to Stage 2 on the basis of adjusted demand requirements and lower costs.
LR8	Dublin City Access Transit (CAT)	Eliminated due to excessive journey times for key areas in the corridor. However, a light rail alignment through Drumcondra (LR5) is a possible sub-option for the next stage.

4.5 BRT Options

Bus Rapid Transit (BRT) has emerged as an effective, cost efficient and high quality bus network system. It offers fast, reliable, predictable and comfortable commuter journeys in modern, high quality vehicles.

BRT seeks to emulate the service, performance quality, and amenity characteristics of modern light rail-based transit systems at a reduced cost. Although BRT is a new concept for Dublin, the existing Quality Bus Corridors (QBC) within the city could be perceived as a form of BRT (albeit the level of segregation and priority is much lower). Some of the busiest QBCs in the city are within the study area for this project, namely: Malahide Road, Swords Road, Ballymun Road and Finglas Road.

BRT proposals made for the Stage 1 Appraisal included routes from:

1. Clongriffin to Airport via Malahide;
2. Clongriffin to the Airport;
3. City Centre to the Airport via Ballymun;
4. Docklands to Swords via Port Tunnel; and
5. Combined package of BRT routes 2, 3 and 4 above.

Figure 4.5: Proposed Swiftway BRT Service

These routes were proposed on the basis that the Swiftway BRT network (see Section 3) would be delivered by 2033. However, following feedback from stakeholders, the "2033 Do Minimum" future network was revised to omit the Swiftway BRT network as these schemes are not yet committed or under construction. On this basis a revised BRT proposal for the Stage 2 Appraisal process was developed to include development of the City Centre to Swords proposed Swiftway route as well as two additional supporting routes, one from Clongriffin Station to the Airport and another from the Airport to Heuston Station via Ballymun.

The proposed network of BRT routes was proposed to reflect the alignments of other heavy and light rail schemes albeit the services would be provided on a significantly lower capacity. Further information on the preferred BRT option can be found in Section 9.

4.6 Combined Options

In addition to setting out separate scheme options for each mode, combinations of schemes were proposed where they might present an advantage in responding to the project objectives. Two combined options were proposed as follows:

C1: HR1 + LR3

Alignment

The route proposed by the RPA for LR3 to the Airport was via the R132 with an elevated shuttle approximately 750m in length connecting to the Airport Ground Transportation Centre located to the north of the Terminal 1 car park. In the absence of a direct city centre connection to the Airport (i.e. not requiring an interchange) a combined option was proposed to deliver HR1 – the heavy rail spur from Clongriffin to the Airport – in addition to LR3.

Infrastructure

HR1 could be constructed on a mainly elevated alignment as previously proposed to the Airport. LR3 would connect with the heavy rail line on the R132 where an optional interchange could be delivered.

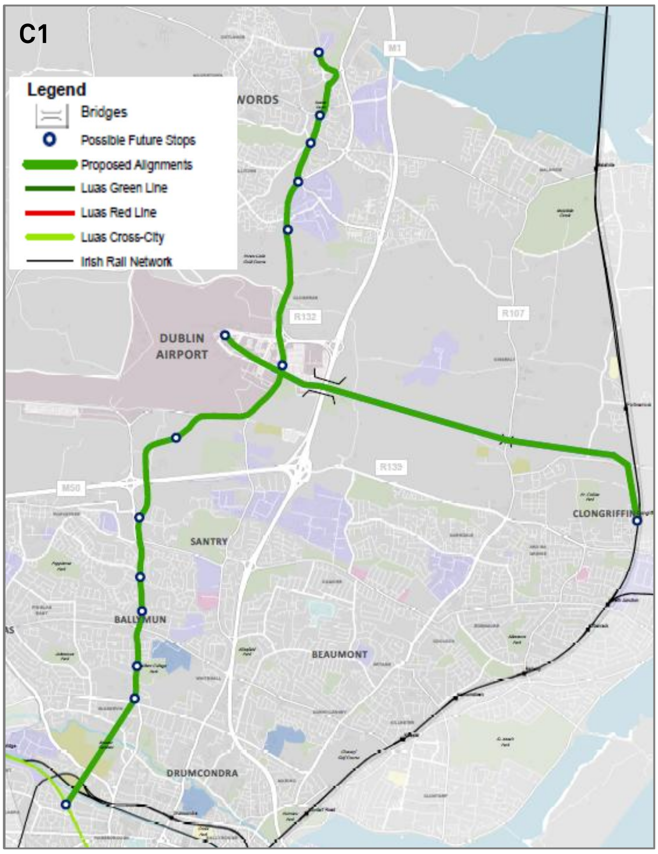
Stations

Fifteen stops as proposed on the LR3 with an additional heavy rail station at the Airport.

Stage 1 Indicative Comparison Cost: Up to €1,410 million

Appraisal Result

This option combines two schemes to meet the study objectives and therefore provides high capacity and low journey times. Additional work is required to understand if an interchange between the two routes close to the Airport would be required, and if so how this could be achieved. **The option was brought forward to Stage 2. Further information on this scheme can be found in Section 10.**



C2: HR1 + Swords – Airport BRT

Alignment

On the basis that C1 would potentially be expensive to deliver, an alternative option of delivering HR1 supported by a high capacity BRT route on the R132 was proposed.

Infrastructure

HR1 could be constructed on an elevated alignment as previously proposed to the Airport. The aim would be to fully segregate the BRT route from Swords to the Airport to secure higher journey times

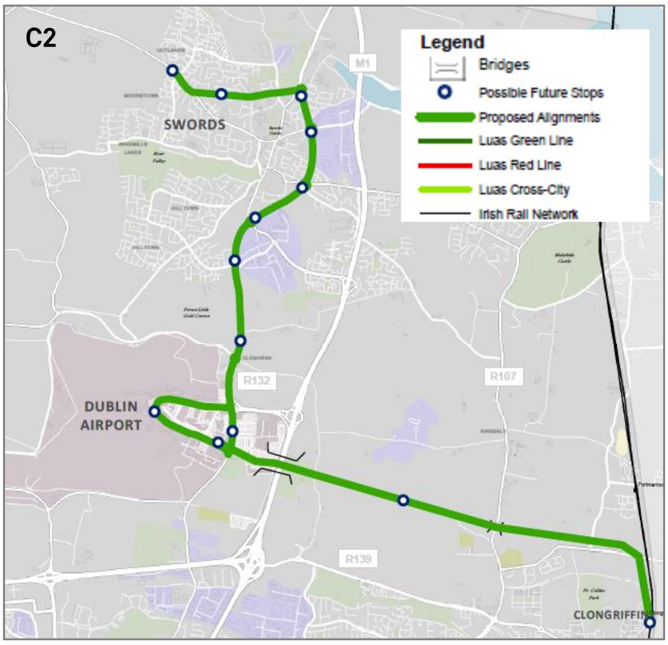
Stations

A total of twelve stops are proposed for this route, all at-grade.

Stage 1 Indicative Comparison Cost: €350 million

Appraisal Result

This option only provides a limited additional service to Swords and has limited capacity to cater for the future long-term corridor needs. This combined option also fails to provide a fixed rail commuting service to Swords. This option was not brought forward to Stage 2.



5.5.1 Summary

On the basis of relatively better service and capacity, it is proposed that C1 is brought forward for further development and full appraisal.

4.7 Summary

Twenty five public transport options were presented for Stage 1 Development and Appraisal. Each option was developed on the basis of stakeholder consultation, in the first instance, with schemes previously proposed for the study area by stakeholders a first point of reference. Further options were developed by AECOM to meet the study objectives. The scope and method of appraising the 25 options was undertaken on the basis of:

- A preliminary 'screening' to ensure the schemes meet the project objectives and are technically feasible. Through this process, 5 schemes were excluded from further appraisal; and
- A Stage 1 Appraisal based on the guidelines and criteria incorporated within the CAF. On the basis of this appraisal, just 6 of the remaining 20 options were suggested for further investigation. These schemes are summarised in Table 4.5 below.

Table 4.5: Summary of shortlisted schemes

HR2	This is a heavy rail spur from Clongriffin to the Airport and Swords. This option appears to provide a high quality, high capacity service to the Airport and Swords. However, further work is needed to ensure that it is technically and operationally feasible.
HR8	This is a new heavy rail spur from the Western Suburban Line to the Airport and Swords via a tunnel under Glasnevin. This option also offers a high quality, high capacity service and increases public transport provision in the city. Further design work is needed to determine the exact route, as well as technical and operational feasibility.
LR3	This is a light rail extension of LCC from Cabra to the Airport and Swords. Further design work is needed to determine the exact route, and demand forecasting will reveal whether this approach provides enough capacity and is cost effective.
LR7	This is a cost optimised approach to delivering Metro North. Demand forecasting is required to understand passenger demand and whether the reduced costs present a feasible option to serve the Airport and Swords.
BRT5	This option is a combination of a number of proposed BRT services. Demand modelling may indicate whether this relatively low capacity, low cost option is the most cost effective approach to providing enhanced links to the Airport and Swords.
C1	This option is a combination of HR1 and LR3, i.e. a heavy rail spur from Clongriffin to the Airport and light rail from Dublin to Swords via the Airport. The HR1 option could be an effective way to provide a high capacity link to the airport. Combining this with a light rail service may meet the needs of the corridor in a cost effective way.

5 Stage 1: Community and Stakeholder Feedback

5.1 Consultation Process

Full details of the 25 public transport options and the six shortlisted options were published on the 8th of December 2014 on the National Transport Authority website. Members of the public were invited to review the material and submit their views and opinions before the consultation period closed on January 19th, 2015. All of the consultation material was made available on the Authority's website and details of that website address were also included in the newspaper advertisements.

Presentations were given to local representatives of the relevant local authorities along the routes in advance of the public consultation. In addition, information packs were issued to all public representatives in Dublin - councillors, TDs and Senators.

5.2 Submissions Received

A total of 342 submissions were received. All submissions received were reviewed and the issues raised were categorised, summarised and analysed. Feedback on the 6 shortlisted options is as follows:

- 74 submissions (19.9%) were in favour of Optimised Metro North [LR7];
- 59 (15.9%) were in favour of Luas Cross City to Swords via the Airport (under Glasnevin) [LR3];
- 11 submissions (3%) favoured either HR8 or C1;
- 4 submissions were in favour of HR2; and
- 2 submissions were in favour of BRT.

A summary of the key points raised by stakeholders is outlined in Table 5.1.

Table 5.1: Public Consultation Submissions – Summary of Key Points

Public Consultation Submissions – Summary of Key Points:	
LR7:	- It was viewed as important that the system is "future-proof" in terms of potential to expand (route and capacity), and that whole of life cost is taken into consideration. - There was concern regarding construction impacts in the city centre in particular, the potential impacts from commuter parking in residential areas in Swords, and traffic impacts on the Ballymun Road. - It was noted that it is important that the system link to Luas Cross City, and suggested that some services run non-stop from Swords / the Airport and the city centre. - There were general supportive comments in relation to LR7, in particular noting that it provides a new high capacity public transport link, provides most of the benefits of Metro North and ability to expand the light rail network in the future.
LR3:	- There were general supportive comments in relation to LR3, in particular in terms of the areas served by the route, the cost-effectiveness as well as the connectivity and capacity provided. - There was concern regarding the proposed tunnel, in terms of the route proposed and the potential environmental impacts and the connectivity with other public transport systems. - It was suggested that this route be modified to also serve Finglas.
HR8	- There were supportive comments for HR8, in relation to its integration with other systems.
HR2	- There was concern that this option may be overly-reliant on the existing heavy rail line. - There was were general supportive comments for HR2 in relation to cost, the implementation time, and potential new markets for Dublin Airport from the connection to heavy rail line to Belfast.
BRT5	- There is concern regarding the viability of BRT5 especially as a long term solution, in terms of ability to meet demand, capacity, frequency etc. - There is also concern regarding the traffic impacts, the availability of road space, the impact of removal of parking in Swords, the enforcement of bus lanes and that this option does not meet the project objectives. - There was support for this option in relation to its affordability and lower construction impacts (in comparison to rail options).
C1	- There was general support for this option, in relation to cost-effectiveness, catchment and passenger types served, connectivity and potential for phased delivery.

6 Stage 2: Options Development Methodology

6.1 Overview

As discussed in Section 4, six schemes out of an original 25 proposed options were selected to progress to Stage 2 for more detailed development and comparative appraisal. These were:

- Heavy Rail 2 (HR2);
- Heavy Rail 8 (HR8);
- Light Rail 3 (LR3);
- Light Rail 7 (LR7);
- BRT Option 5; and
- Combination 1 (C1).

The following sections outline the approach taken to the development of options during Stage 2. A summary of each of the three development tasks is summarised in Figure 6.1 and presented in detail below.

Figure 6.1: Summary of Stage 2 Methodology

6.2 Stage 2.1: Options Development

The technical feasibility of each option was developed to further include:

- A detailed understanding of the potential alignment and development constraints/opportunities;
- Potential locations for stations / stops and construction feasibility;
- Structural and tunnelling requirements;
- The impact on existing utilities; and
- A summary of the technical risks associated with delivery of each option.

It should be noted that various sub-options of the six shortlisted options were assessed within the short listed options before a preferred alignment was identified. These sub-options are summarised within this report. Drawings at a scale ranging from 1:1,000 to 1:10,000 have been developed for each of the preferred options.

Parallel to developing the technical feasibility of each option, an assessment of the operating efficiency was undertaken. This assessment was largely dependent on the constraints/opportunities presented by the existing public transport network. The following indicators of operational feasibility were identified:

- **Journey times and frequency:** Journey times for each option were developed. Results of this exercise were cross correlated against experience of the current transport network and approved by project stakeholders prior to appraisal ; and
- **System capacity and fleet requirements:** The potential capacity of each transport option is an important indicator of the potential of each option to respond to transport demand. Two indicators of capacity were used to determine operational feasibility as outlined overleaf.

System Capacity and Fleet Requirements

To ensure accuracy in determining the potential carrying capacity of each public transport option, the ultimate capacity of each option has been developed based on international research as well as observed capacities in an Irish context.

Typically there are two different levels of system capacity, as follows:

- **Maximum capacity:** This is the theoretical maximum number of passengers that each vehicle can accommodate. This is a theoretical capacity based on a minimum of 5 passengers pm²; and
- **Design capacity:** When planning and designing for public transport, a 'design capacity' is a more appropriate measure of capacity used which facilitates safe movement within the system and mitigates overcrowding. This is lower than the maximum capacity and varies between modes. For example, in designing for heavy rail, a design capacity of 4 passengers pm² is optimal. Throughout this report, all scheme options are presented on the basis of design capacity.

The overall capacity, represented as PPHPD (passengers per hour per direction), for heavy rail and light rail is summarised in Table 6.1. As shown, the design capacity is proposed as 80%/75% of maximum vehicle capacity multiplied by the proposed number of services per hour.

The capacity of any system will also be heavily influenced by the network capacity. AECOM undertook analysis of existing heavy and light rail systems to understand the potential capacity for additional services. In all instances there are limitations on line capacity, thereby potentially limiting overall operation capacity. Line capacity for each option is presented in detail in the following sections.

Table 6.1: Summary of system capacity calculations

	Heavy Rail	**Light Rail**
Vehicle Type	8 Car DART (HR2 + HR8)	LR3 - 53m LR7 - 60m
Maximum Vehicle Capacity (MVC) *(based on maximum capacity of 5 pax pm²)*	1,400	53m - 380 60m - 440
Design Capacity - PPHPD *(Passengers Per Hour Per Direction Per Hour)*	80% x MVC x TPH	75% x MVC x TPH
Maximum Capacity - PPHPD	MVC x TPH	MVC x TPH
Reference:	Transit Capacity and Quality of Service Manual, 2nd Edition. Transportation Research Board, Washington. 2012.	

6.3 Stage 2.2: Costing

Once the preferred alignment for each option was identified as being technically and operationally feasible, and with environmental constraints that could be mitigated, cost estimates were prepared.

The cost estimates were developed by AECOM's Cost Consultancy Team using the preliminary scope and drawings for each shortlisted option. Unit rates used have been benchmarked against similar schemes in Ireland and the UK.

It should be noted that a prudent and conservative approach has been adopted in developing comparative assessment costs. At this stage of project development, only a limited level of design detail is available for most of the options, without the benefit of site specific surveys and ground investigations. Accordingly, a significant risk factor has been included in this cost estimation to address this high level of uncertainty.

This reflects recommended good practice in project development, where a high contingency allowance is included in the early phases of a project development, reducing as the project design matures and supporting site investigations are completed. International research has extensively documented a systematic tendency for project promoters and appraisers to be overly optimistic – this is referred to as "optimism bias" in project development. This is a worldwide phenomenon that affects both the private and public sectors. Many project parameters are affected by optimism – appraisers tend to overstate benefits, and understate timings and costs, both capital and operational.

In advice developed by the Highways Agency in the UK, which in return echoes advice provided by the UK Treasury, the recommended percentage addition to cost estimates (referred to as the Adjustment Factor for Optimism Bias) for standard highway schemes is 45% for projects at conceptual stage in respect of which a detailed risk assessment has not been undertaken. This factor reduces to 25% when the project reaches the "preferred solution" stage.

In the case of the comparative estimates used in relation to the six shortlisted options, a risk uncertainty factor of 30% to 35% has been used, reflecting the need for an appropriate factor to be included but acknowledging the more robust underlying cost rates that have been applied and the fact that a certain level of information is available for the options. In the case of LR7, this factor was reduced to 25% in light of the greater level of information available in respect of the previous Metro North proposal.

Assumptions used in the development of the cost estimated include:

- Costs have been developed using 2015 prices;
- The level of estimating uncertainty is +/-30%. This level of accuracy reflects the limited level of design available for each scheme;
- The level of risk proposed for each scheme varies depending on the level of design available. For LR7 detailed design drawings are available for a large proportion of the route, as such, a risk level of 25% has been used. This is the lowest proposed level of risk among all schemes. Similarly, for LR3, detailed level design drawings are available from the RPA. However, as amendments to these have been made by AECOM, a risk level of 30% has been used. For heavy rail alignments, only high level drawings are available at this stage, as such a risk level of 35% has been applied;
- Preliminary costs have been assumed at 30% of construction cost, following recommendations from project stakeholders;
- VAT of 13.5% was included for each scheme; and
- Costs include all property acquisition costs.

It should be noted however that VAT payable on the capital costs may be recoverable by the RPA. This is in line with a previous arrangement agreed with the Revenue Commissioners for Luas construction. However, for the purpose of the Stage 2 Appraisal, it has been assumed that VAT would be payable by RPA. This allows some contingency and allows comparison against other schemes.

6.4 Stage 2.3: Transport Modelling

Transport modelling is a key element of the options appraisal process. It has been used to assess the likely patronage of each option and their ability to respond to future transport demand.

The transport modelling undertaken for the Stage 2 Options Development process was undertaken using the NTA's Greater Dublin Area Strategic Transport Model.

6.4.1 Overview of the Model

The Greater Dublin Area (GDA) Strategic Transport Model is owned and operated by the National Transport Authority (NTA). The model covers the strategic road and public transport networks in the GDA. It is used by the NTA as a tool in the appraisal of potential transport schemes, land use and policy changes.

The NTA's model is made up of the following components:

- Trip Attraction and Generation Model based on Land Use Forecasts (TAGM);
- Car Ownership / Availability Model;
- Trip Distribution Model;
- Mode Choice;
- Hour of travel choice;
- Highway assignment (SATURN); and
- Public Transport assignment (TRIPS / CUBE).

<u>Time Periods</u>

The NTA model covers the following time periods:

- AM Peak Period (07:00 – 08:00, 08:00 – 09:00, 09:00 – 10:00); and
- Inter Peak Hour (14:00 – 15:00).

<u>Transport Modes</u>

The public transport element of the model includes the following modes:

- DART;
- Suburban rail;
- Luas;
- Dublin Bus; and
- Bus Eireann and other bus services.

The highway element of model includes the following user classes (UC):

- UC1: Heavy Vehicles (HV) – (OGV 1, OGV 2);
- UC2: Unused; and
- UC3: Light Vehicles (LV) – (Cars, LGV).

Bus services are coded on fixed routes in the SATURN model to incorporate the impacts of highway congestion on bus journey times. Detailed bus and rail routing, stops and timetabling is coded as part of the public transport assignment model in TRIPS/CUBE however the rail timetabling for the Do Minimum and Do Something was updated based on the latest Iarnród Éireann information as part of this project.

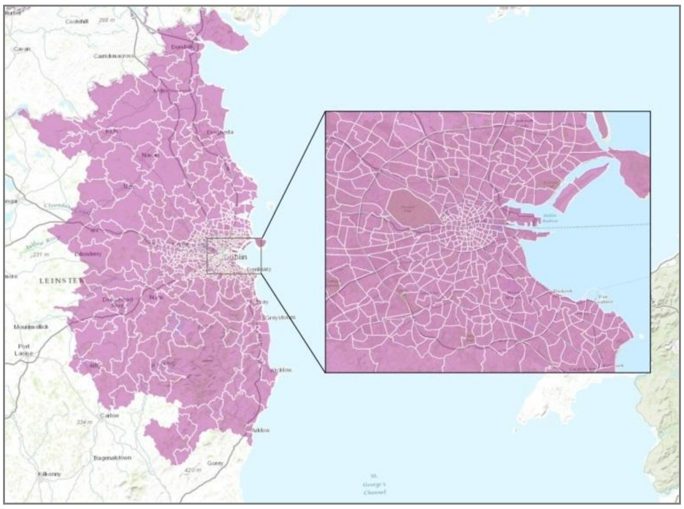
<u>Modelled Years</u>

The base year of the NTA model has been developed from the 2006 Census on the demand side of the model while the road and public transport networks on the supply side are based on the 2012 network layout. Forecast year models have been developed for the scheme opening year of 2033.

<u>Transport Zones & Network</u>

The model comprises 666 transport zones of which 657 zones are internal zones, based on Census Electoral Division (ED) boundaries. The remaining 9 zones are external zones which represent travel between the modelled area and the rest of Ireland at the boundary points of the model. In the urban area, the internal transport zones are subdivisions of Census EDs. In rural areas, the zones are larger and represent a combination of Census EDs. A plot of the transport zone system is shown in Figure 6.2.

Figure 6.2 - NTA Transport Zone System



Journey Purposes

Travel demand in the model is segregated into six main journey purposes:

- Work (Commuting);
- Education;
- Employer's Business;
- Shopping;
- Other; and
- Non-home based.

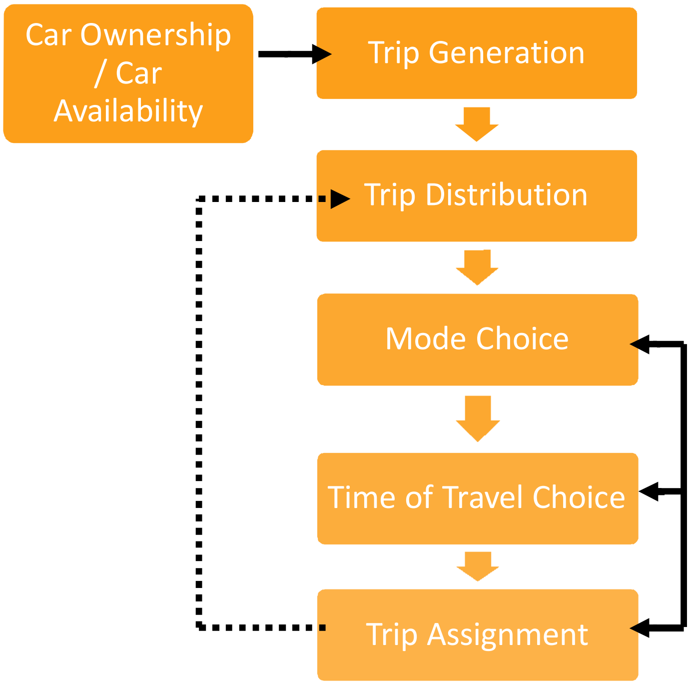
A further segregation is provided by person type, i.e. those with a car available for their trip and those without a car available for their trip.

Model Structure

The NTA model structure is based on a traditional 4 stage transport model with an additional component of time of day choice which models the impacts of congestion on people's decision re: time of departure, potentially avoiding congestion or public transport crowding.

Levels of highway congestion are based on formulae based on traffic flows at junctions etc., whilst public transport congestion is based on the diminishing attractiveness of a service as it exceeds capacity. The structure of the model is outlined in Figure 6.3.

Figure 6.3 - High level structure of the NTA model



Initially a car ownership and availability model is run to provide separate demand matrices for those who have access to a car and to those who do not. For each of these person types, there are a number of feedback loops capturing the impacts of various choices available for each trip. The model iterates between mode choice, time of travel choice and route choice (trip assignment) until an equilibrium is achieved for all modes. A further feedback loop is modelled between the travel costs calculated at trip assignment and the trip distribution stage to account for the impact of changes in travel costs on general travel patterns.

The travel demand forecasting aspect of the model works by predicting travel time and generalised costs[10] associated with utilising different modes of transport for trips between each zone of the model. When a new service offers improved travel times and reduced costs relative to existing services the model will reallocate demand from existing services to the new transport service as passengers derive benefit by switching.

[10] *Generalised cost refers to the sum of monetary(e.g. fares) and non-monetary costs of a journey(e.g. time)*

Model Calibration / Validation

The NTA model has been calibrated and validated to an extensive set of observed transport survey data. Full details are available from the *'DTO Model Calibration Report', July 2009*[11].

6.4.2 NTA Demand Forecasts

The NTA has prepared a set of demographic forecasts which form the basis of the 2033 models. The full detail of the development of these forecasts is documented in the 'Greater Dublin Area Interim Forecasting – Briefing Note 1', NTA (June 2014). A summary of the process is provided below.

The forecasts were initially developed for 2031, based on the CSO Regional Population Projections 2016-2031. The CSO population projections contain a number of forecasts based on alternative assumptions with regards to internal and external migration and fertility. The NTA forecasts were based on the CSO M2F2 'Traditional' scenario.

The population growth was spatially distributed according to a methodology developed by the NTA in collaboration with the relevant local authorities, and was based on available lands and land use zoning. The growth levels used were based on current projections, which are lower than were applied previously. For the current forecasts, the growth was capped at the CSO M2F2 'Traditional' levels.

To calculate and distribute employment within the GDA, the proportions in employment of the labour force in 2011 were used. The population to labour force ratio observed in 2006 was maintained at a regional level. The employment growth was then distributed based on a defined methodology. For education, it was assumed that the proportion of population of school going age would remain roughly the same, and that this proportion of the population will always require school places.

The above methodology was used to generate forecasts for 2033, based on a forward projection of the linear interpolation of growth between 2011 and 2031. Following consultation with local authorities and an initial generation of transport demand data from the NTA TAGM (Trip Attraction Generation Model), some local revisions were made to land use distribution assumptions. A summary of the growth assumptions at a county level, are provided in Table 6.2.

Table 6.2 - Summary of NTA Forecasts

Local Authority	2033	
	Pop.	Employ.
Central Business District	140,041	221,213
Rest of Dublin City	508,430	193,101
Dun Laoghaire/ Rathdown	251,713	96,429
Fingal	334,537	118,913
South Dublin	329,601	130,984
Mid-East	806,728	245,094
Total	**2,373,083**	**1,007,767**

6.4.3 Model Scenarios

In total seven scenarios were assessed through the model, the "2033 Do Minimum" scenario as well as six future "2033 Do Something" scenarios for the schemes shortlisted through Stage 1.

The "Do Minimum" scenario examines how the 2033 network might perform on the basis of no additional investment beyond what is already planned for delivery between now and 2033. These schemes include the following:

- **Luas Cross City:** Construction work is underway at present on the fourth Luas extension which will connect the Red and Green lines and extend further northwards to open up a new rail corridor in the north city. The line will connect the Green Line at St Stephens Green with the Red Line at Abbey Street before running further north to Parnell Street, DIT at Grangegorman, Cabra and Broombridge where it will connect with main line commuter heavy rail services. Luas Cross City is to be completed and operational in late 2017 and therefore forms part of the baseline network proposed for this study in 2033;
- **City centre signalling project:** This project, which is currently underway, involves an upgrade to signalling system and the provision of turn back

11 http://www.nationaltransport.ie/wpcontent/uploads/2011/12/HWPT_Calibration_AM.pdf

facilities on the city rail network to accommodate an additional eight train paths per direction per hour (up from 12 at present to a potential of 20); and

- **Phoenix Park Tunnel:** To maximise the benefit of investment in the signalling project, new service patterns will be developed through the Phoenix Park Tunnel, connecting Heuston and Connolly Stations. This project is expected to be operational during 2016.

It was assumed that in 2033 the Dublin bus network will be similar to its current configuration, although service capacity has been increased to avoid overcrowding on routes where demand has increased significantly, a likely scenario if no other infrastructure were put in place.

The transport modelling process focused on the AM Peak Period (07:00 to 10:00) as this is the key driver for daily patronage and was considered appropriate for the comparative analysis of the transport options.

Various model outputs, or indicators, for both public transport and highway were extracted from the models and analysed including: boardings, alightings and cumulative load, travel time savings, average network and total network delay. Using these indicators, an assessment of the feasibility of each public transport option to respond to 2033 travel demand was undertaken as follows:

- The generalised cost of travel in the "Do Something" scenario for each option was assessed against the "Do Minimum" scenario costs. Any reductions in generalised cost indicates areas where the scheme is having a beneficial impact i.e. reducing the cost of travel thereby making public transport options more attractive;
- Passenger demand for each scheme option was assessed by analysing the overall change in public transport boardings between the '2033 Do Minimum' and the '2033 Do Something Scenario'. This provides a comparable indicator of how effective each option would be in influencing a shift to public transport; and
- The number of boardings and alightings and the cumulative load on each scheme during its peak operational hour was assessed. The cumulative passenger loading for each option was plotted against the design and capacity as previously outlined. This enabled an assessment of the potential of each scheme to adequately cater for long term transport demand.

Shortlisted options which failed to cater for future travel demand in the opening year of 2033 were not brought forward for further detailed economic appraisal. These schemes were not deemed appropriate to meet the long term growth in transport demand beyond 2033.

7 Stage 2: Heavy Rail Options Development

7.1 Overview

Two heavy rail options were shortlisted for development and appraisal, as follows:

1. **HR2:** A heavy rail spur from the Northern Line at Clongriffin to the Airport and Swords; and
2. **HR8:** A heavy rail spur from the Western Suburban Line at Drumcondra to the Airport and Swords.

The feasibility of each of these options has been developed in further detail for appraisal as follows:

- Technical Feasibility, including: alignment, stations, tunnelling, structures, utilities and construction impact;
- Operational Feasibility;
- Environmental Assessment;
- Transport Assessment, including: generalised cost impact, passenger demand and network impacts; and
- Capital and Operating Cost Estimate.

7.2 Clongriffin to Swords (HR2)

This heavy rail option is based on an Irish Rail proposal for a DART Link spur from Clongriffin to the Airport. The route was previously proposed as route HR1 during Stage 1 of this study but was eliminated as it did not serve Swords, a key project objective. This option extends this previous route to serve Swords.

7.2.1 HR2: Technical Feasibility

Five potential alignments were previously shortlisted by Irish Rail for a heavy rail connection between Clongriffin and Swords, each of these was on an elevated alignment. As such, AECOM investigated various options to maintain an elevated alignment from Clongriffin to the Airport and to Swords.

While various options were identified, a number of common constraints arose in conceptual development of the elevated alignments, in particular, the impact on proposed development within Airport land (see Section 2) and the impact on existing residential areas north of the Airport.

As outlined in the Dublin Airport Masterplan, the Ground Transportation Centre (GTC) is identified as a key priority for future Airport development. However, achieving this on an elevated alignment is likely to have adverse implications for other development proposals as outlined in the recently published Airport Masterplan (see Section 2). In addition, retaining an elevated alignment north of the Airport would have significant negative implications for residential areas with extensive land acquisition likely to be required as well as subsequent visual and noise impacts.

In light of these constraints, AECOM concluded that in order to connect the DART spur to Swords, a tunnelled alignment is preferred. Despite being more expensive and more technically complex, tunnelling would have the following advantages:

- Minimise land acquisition and disturbance impacts;
- Limit noise and visual impacts;
- More flexible siting of stations;
- Facilitate development of larger, more modern stations;
- Limit road network impacts; and
- Limit at-grade structure requirements.

On the basis that a tunnelled alignment for the Airport to Swords section is most feasible, the opportunity to commence the tunnelled section east of the M1 was proposed with the aim of:

- Limiting impact on existing and future Airport development as outlined in the Airport Masterplan (see Section 2);
- Facilitating development of a station within the GTC and within the Station Box area previously reserved for Metro North; and
- Avoiding the requirement for a bridge structure over the M1 which could present technical risk and potential temporary impacts on the road network.

Alignment

Figure 7.1 shows the proposed alignment for HR2.

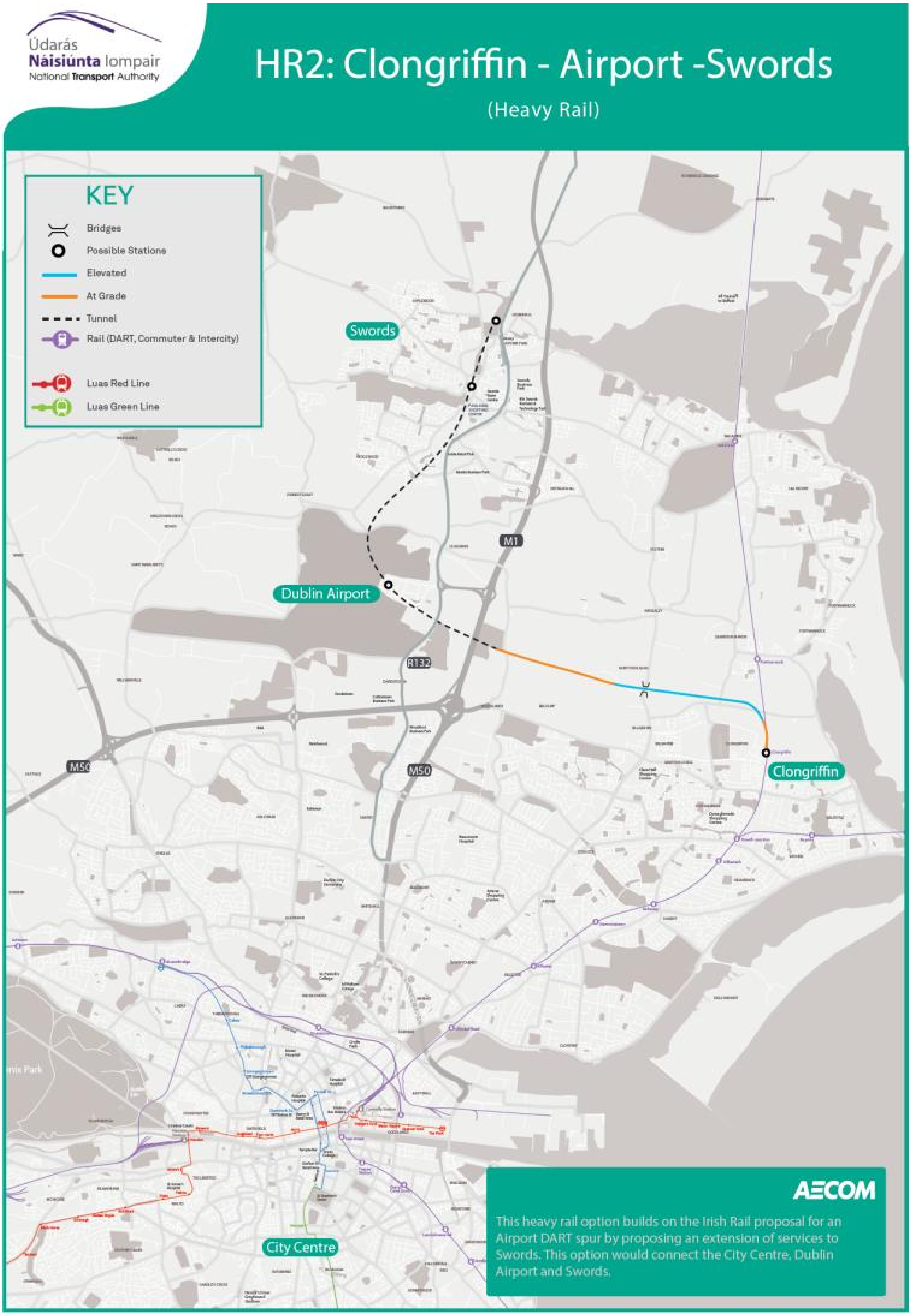
The route is approximately 13.2km in length and is composed of:

- 4.1km of at-grade/elevated alignment from Clongriffin to the tunnel portal; and
- 9.1km of tunnelled alignment from the east of the M1 to Estuary.

A grade separated junction would be constructed immediately north of Clongriffin Station to allow development of a westbound spur from the existing Northern Line. This spur would run on an elevated section of track across predominantly agricultural land before entering a twin bore tunnel east of the M1. The tunnel runs in a north-westerly direction to an underground station under the Airport. The tunnel then loops in a north-easterly direction west of the Airport Station and would run parallel to the Dublin Road to the centre of Swords and Estuary.

HR2 has been designed to accommodate electrified intercity trains in the future, as proposed in Irish Rail's "Rail Vision 2030, The Future of Rail Transport in Ireland", which would require lower gradients and higher curve radiuses than a DART only route. The use of tunnels will prevent the use of this route by diesel powered locomotives.

Figure 7.1: Proposed Alignment for HR2



Stations

Three stations are proposed on the HR2 alignment at the Airport, Swords and Estuary.

The Airport Station would be centred within the footprint of the safeguarded Metro Box area, within the GTC. While the original Metro North platform was proposed at 90m on a north/south alignment, the heavy rail platform would be 200m in length and on an east/west axis, as shown in Figure 7.2. Investigation of this alignment has demonstrated that it will be possible to construct the heavy rail station box entirely within the GTC using cut and cover techniques which would result in significant temporary disruption. Top down construction methods could be used to minimise the period of disruption to the GTC.

Swords Station would be established on Main Street (R836), immediately south of Swords Castle. In this part of Main Street there is at least 20m clear width between buildings which would allow construction of a station box using cut and cover techniques. The station box would occupy almost the entire road width and so there would be significant disruption to Main Street during construction. As with the Airport Station, top down construction could be used in this location to minimise the period of disruption to Main Street. It is also noted that the station could be incorporated into future development lands along Main Street if these were to become available during the planning process for this route.

A third station would be developed at Estuary, south of Lissenhall, to serve residential areas to the north of Swords. This stop would be the northern terminus of the route and occupies a similar location to the proposed Metro North station at Estuary. The station would be developed to the west of the R132 and the north of the R125 on land currently used as playing fields. The station could be supported by a large park and ride facility.

Figure 7.2: Proposed HR2 Airport Station Location

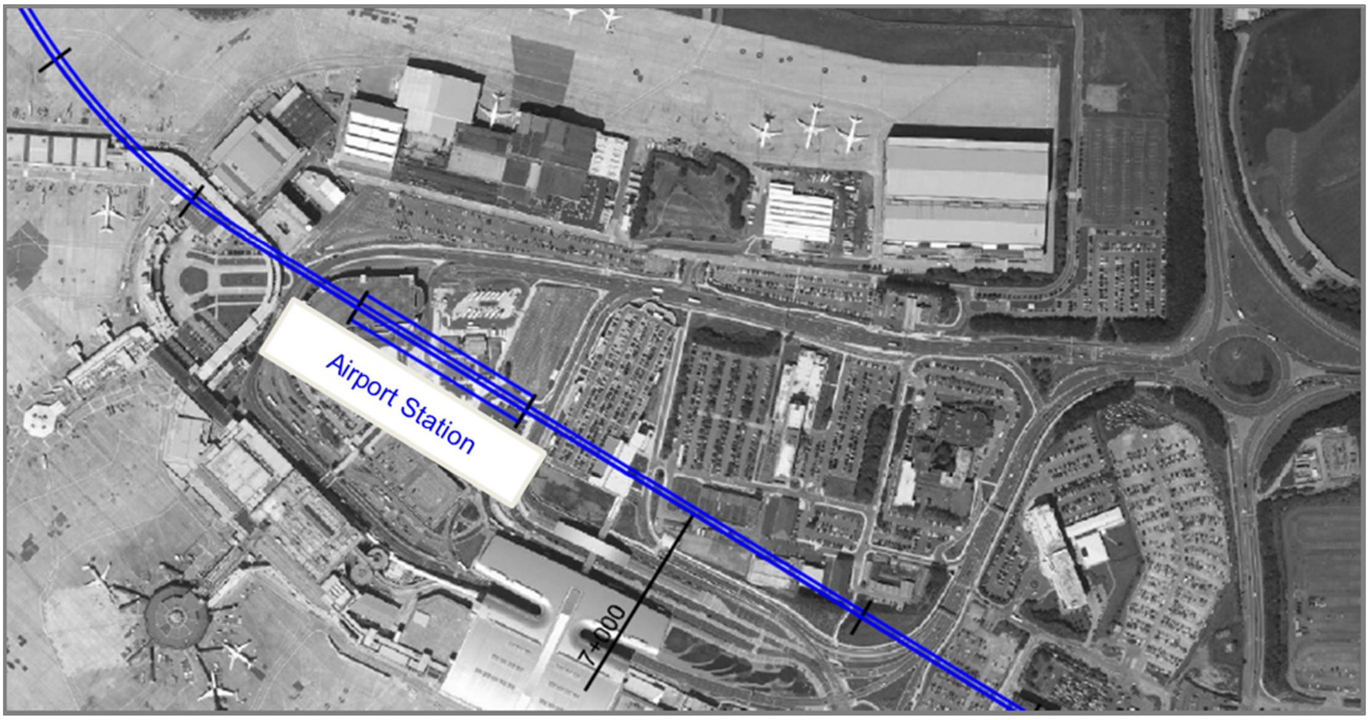


Figure 7.3: Proposed HR2 Swords Station Location

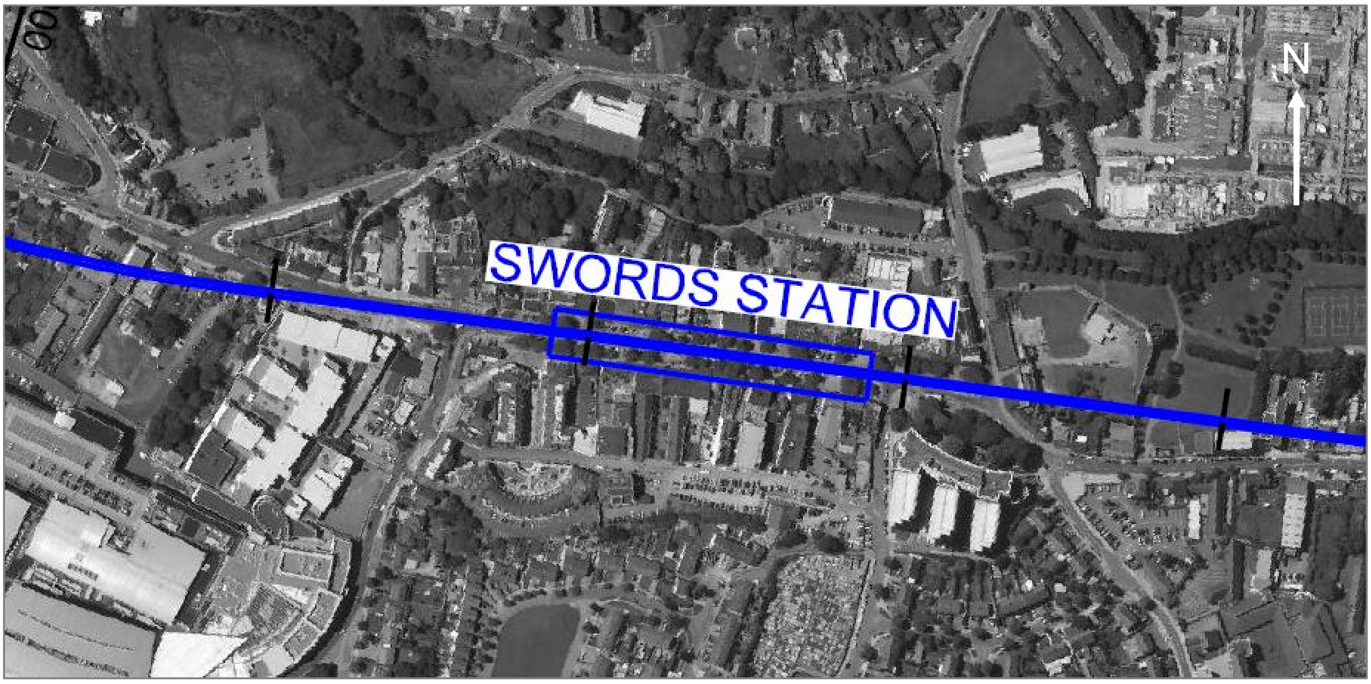
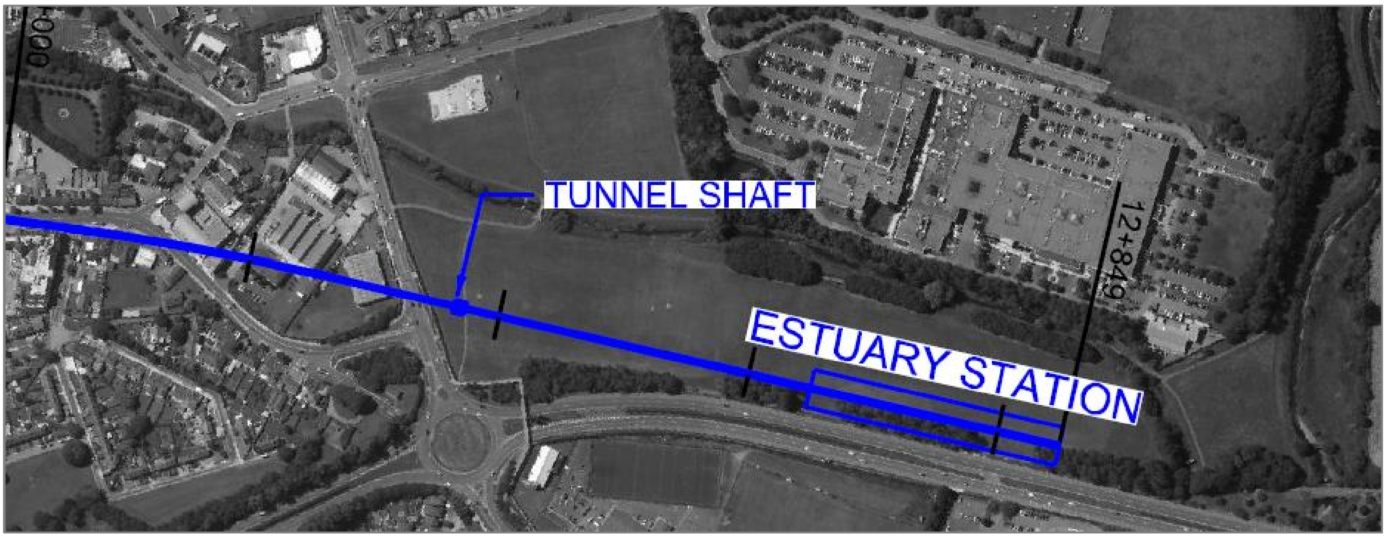


Figure 7.4: Proposed HR2 Estuary Station Location



Tunnels

The proposed HR2 tunnel starts immediately to the east of the M1 and extends for 9.1km to Estuary Station, this includes 7.5km of twin bore tunnel and 1.6km of cutting. The bored tunnels would be constructed with an internal diameter of 6.0m.

An indicative vertical alignment of the HR2 route is shown in Figure 7.5 below. The alignment depth exceeds 20m from the east portal through to Swords Station but within the last kilometre of tunnel (from Swords Station to Estuary Station) the cover drops below 20m to a minimum of 17.4m. The ground conditions will determine whether this low cover is problematic for a TBM driven tunnel. If so a regime of ground improvement works may be required in advance of tunnelling.

Individual tunnel section lengths are 2km, 4.2km and 1.3km in length. On the basis that a shaft is required every 1km, a minimum of three tunnel shafts are required. These could be placed as follows:

1: On the east side of the Airport in car-parks to the east of the terminal building;

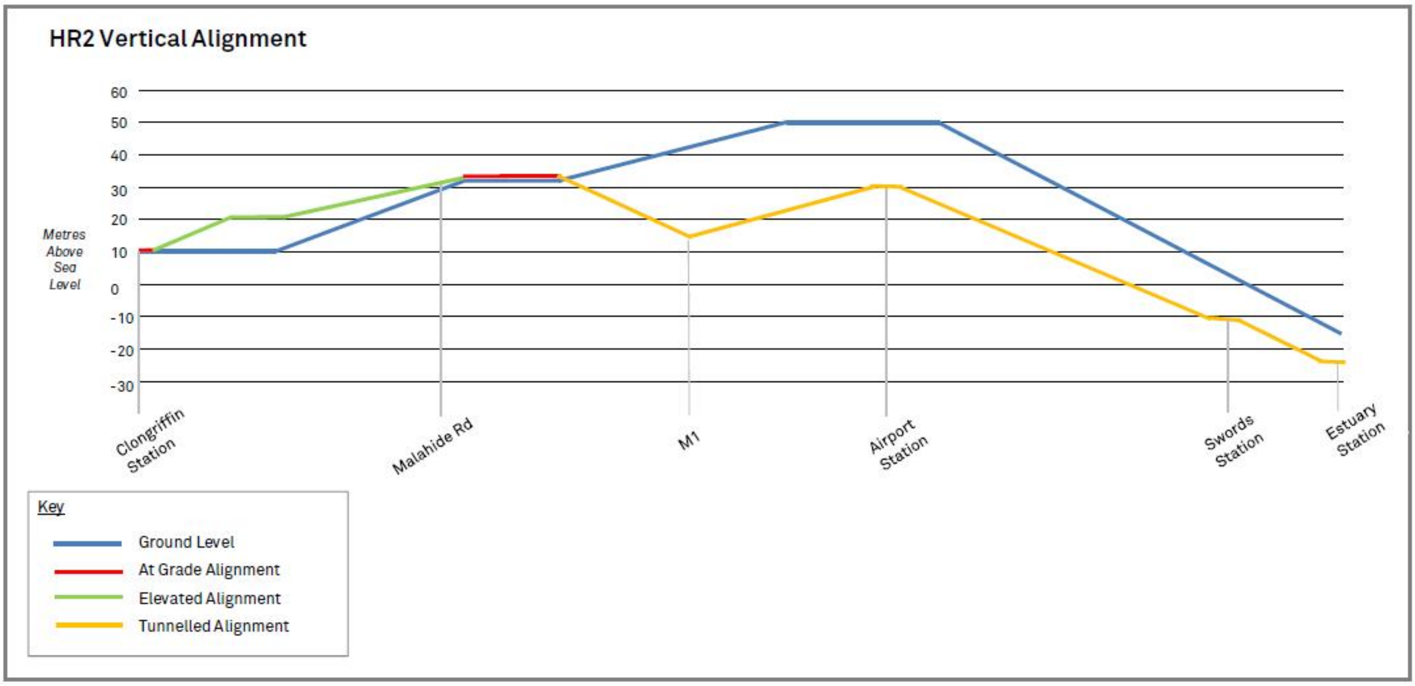
2: At the northern boundary of the Forrest Little Golf Club;

3: Within open space to the east of the roundabout where the R836 joins the R132.

Detailed ground investigations completed for Metro North shows a local high spot for the limestone bedrock level beneath the Airport. To the north and south, the bedrock drops away to broadly follow, at around 30m depth, the ground profile above. Beyond the Airport, at a depth of around 25m to 30m, the tunnel will potentially be close to top of bedrock for much of its length leading to "mixed face" conditions for the tunnel boring machine (TBM) to negotiate.

Either end of the tunnel could support the launch of a TBM for tunnel construction. At the northern end, there is a strip of open ground adjacent to the proposed Estuary Station which could be used on a temporary basis for tunnel construction. The southern portal is also close to the M1 in a large expanse of open land. Either end of the tunnel could thus support tunnel operations; however, as there is a period of learning with any TBM bore it may be better to drive from the south portal rather than from the north portal where the alignment is potentially more challenging.

Figure 7.5: Indicative vertical alignment for HR2



Structures

Apart from tunnelling, the main structures required on HR2 are on the elevated/at-grade section of the rail spur from Clongriffin to the tunnel portal as follows:

- **Track Flyover:** The most significant bridge structure is a new single track flyover which will carry the inbound HR2 track over the Dublin-Belfast mainline. This bridge span will have a high degree of skew resulting in increased construction depth; and
- **Drumnigh Road and Malahide Road:** Two new bridges will be required to carry the HR2 over these roads. The roads are single-carriageway and therefore the clear span should be easily achievable.

Utilities

A search of utilities records within the proposed heavy rail corridor has indicated the following implications for HR2 development:

- Buried services are densely located within Dublin Airport and Main Street (Swords). Construction of the station boxes in these locations will require extensive temporary support or permanent diversion of services;
- At Swords, most buried services are likely to be reinstated within the highway following completion of the station box;
- At Dublin Airport, it may be more appropriate to undertake advanced enabling works to permanently divert services away from the station box;
- To the west of Clongriffin Station, high voltage overhead transmission lines intersect the proposed heavy rail alignment. The railway will be elevated in this location and therefore the power lines will need to be either raised to a higher level or buried below the railway; and
- A proposed aviation fuel pipeline from Dublin Port to Dublin Airport will intersect the route of HR2 to the east of the M1 motorway. However, the depth of the bored tunnels in this location means the impact on the fuel pipeline would be minimal.

Construction Impact

The proposed alignment would require acquisition of approximately 13.5 acres of agricultural land as well as two residential properties and a market garden property. The alignment also runs close to two period properties which are not directly impacted but may experience adverse impacts due to proximity to the line. The estimated cost of property acquisition is approximately €8.3m which has been incorporated into the overall scheme cost.

Delivery of HR2 would result in additional disruption as follows:

- Construction of the three proposed stations will result in short term, but significant, disruption within the Airport, Swords and Estuary;
- Construction of the track flyover at Clongriffin is likely to have implications for operations on the Northern Line;
- Development of bridges across the Drumnigh Road and Malahide Road will result in temporary disruption to operations;
- Potential noise and vibration impacts from tunnelling; and
- Acquisition of agricultural land between the tunnel portal and Clongriffin will result in disruption to existing agronomy.

Summary of Technical Feasibility

The technical feasibility of HR2 has been developed beyond a conceptual level as proposed during Stage 1 of this study. Investigations into the structural and tunnelling requirements to support the proposed alignment and stations have been undertaken and determined that the route is technically feasible. Vertical and horizontal alignment drawings for HR2 have been developed.

Although the route is recommended as practically feasible, a summary of the main project risks is as follows:

- Detailed geotechnical surveys would be required to confirm the proposed tunnels are technically feasible;

- The three proposed stations are large and may be technically difficult to construct; and
- Construction of the Clongriffin flyover would be technically difficult so close to the active line.

7.2.2 HR2: Operational Assessment

The operational feasibility of HR2 is largely dependent on the line capacity available on the Northern Line. Proposals for 6TPH on the HR2 could be facilitated by diverting four existing Bray to Howth or Malahide services to Swords instead. In addition, two new services could be facilitated on the line to serve Swords. An indicative sketch of the proposed heavy rail service plan is shown in Figure 7.6 below.

The limit of 6TPH could potentially be increased in the longer term pending completion of the DART Underground.

HR2 would operate on the basis of 8 car DART trains, as currently used, with a design capacity of 1,120 passengers. This would offer a design capacity of 6,720pphpd based on 6TPH.

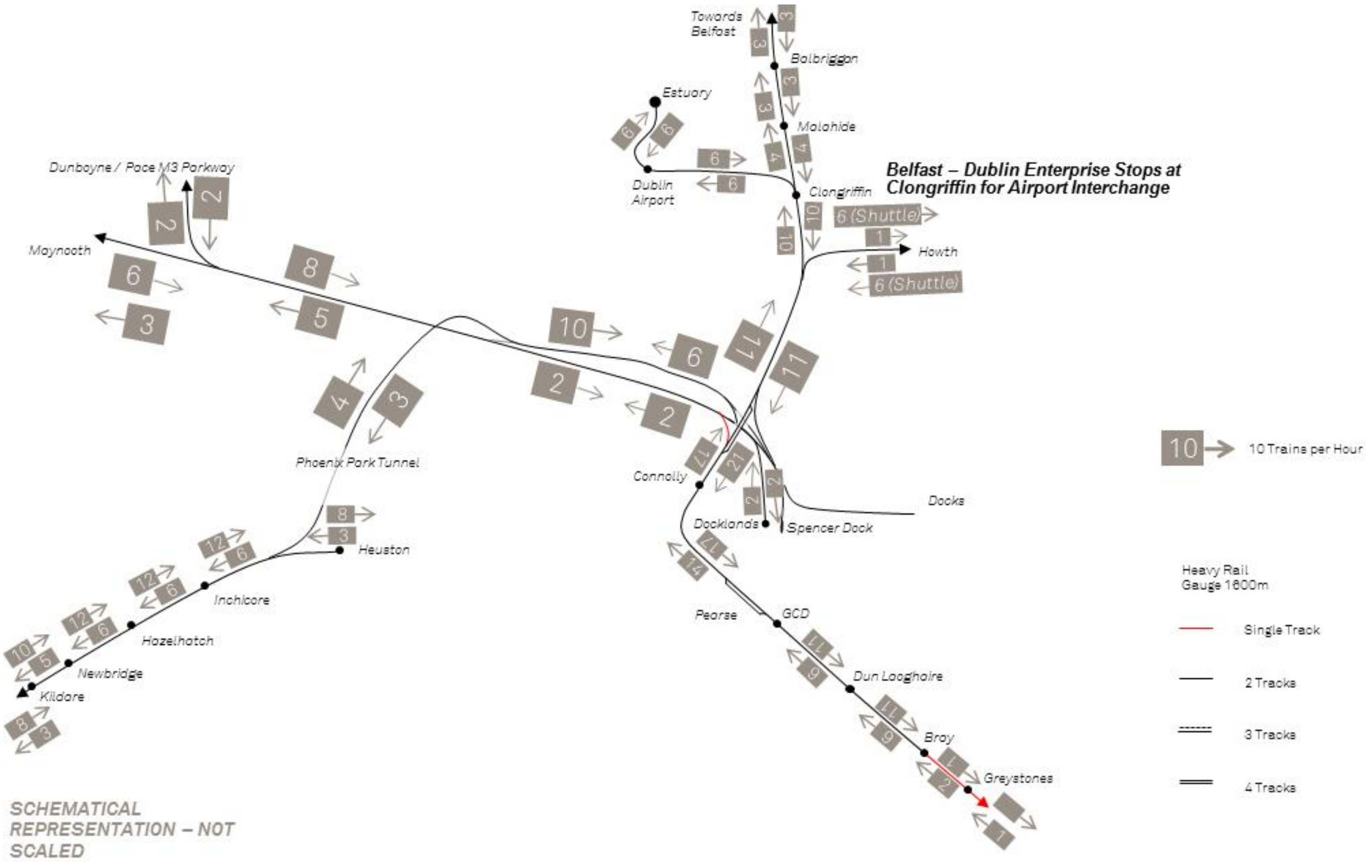
Journey time assumptions for HR2 are as follows:

- Connolly to the Airport: 23 minutes; and
- Connolly to Estuary: 30 minutes.

Table 7.1: Summary of HR2 operational feasibility

Vehicles	Capacity	Frequency	Journey Times
8 car DART	Design capacity: 6,720pphpd	6 trains per hour all day	Connolly to Airport: 23 min Connolly to Estuary: 30 min

Figure 7.6: HR2 Service Plan (08:00-09:00)

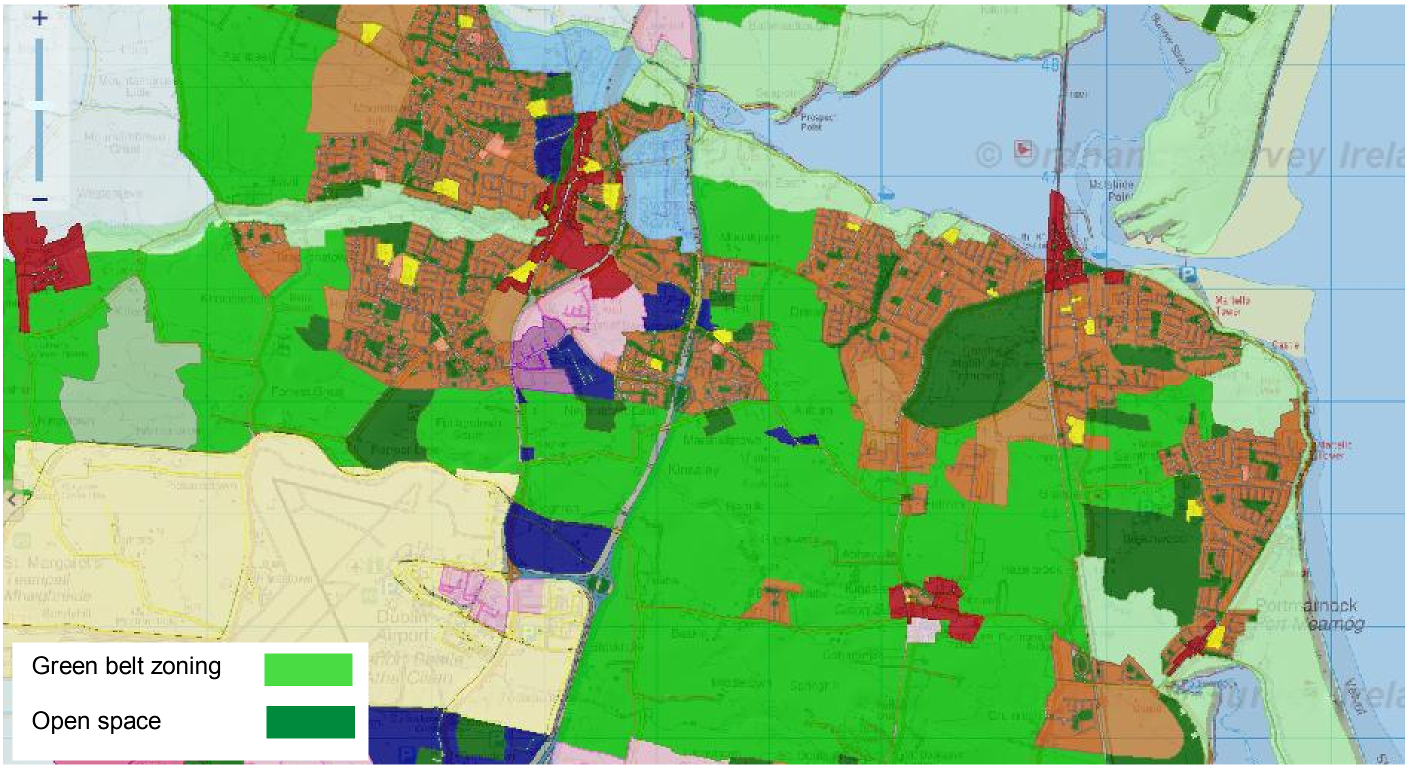


7.2.3 HR2: Environmental Assessment

A high level desktop assessment of the environmental impact of HR2 suggests the following impacts:

- **Air Quality:** Once operational, the proposed scheme would have limited impact on air quality. Any changes in local air quality would be associated with changes in traffic flows as a response to delivery of the scheme. These impacts are looked at in further detail through Section12, Economic appraisal;
- **Noise and Vibration:** Consideration needs to be given to the potential construction impact of tunnel boring under the Airport and Swords town centre as vibration may have an impact on sites and monuments or protected structures. Once operational, HR2 will generate noise impacts within the at-grade/elevated sections from Clongriffin to the tunnel portal. However, there is limited residential development within this area at present;
- **Landscape and Visual Quality:** The area from Clongriffin to the Airport is currently used mainly for arable farming and is flat in nature. The proposed elevated alignment would have a significant negative visual impact from Clongriffin to the tunnel portal;
- **Biodiversity – Flora and Fauna:** Appropriate Assessment (AA) Screening is required for the entire alignment to determine biodiversity impacts in detail. However, within the Airport to Clongriffin section there are likely impacts on biodiversity due to the removal of hedgerows. Watercourse crossings and possible connectivity to designated Natura sites also needs to be assessed in more detail. On the tunnelled section, any possible impacts on hydrological connections which may impact on designated sites or watercourses in the area would also need to be surveyed;
- **Land Use, Soils and Geology:** There are likely to be significant impacts arising from as a result of impacts on greenbelt zoning on land between Clongriffin and the Airport. Impacts on agronomy in this section are also likely. There are possible impacts on geology as a result of tunnelling which would require more detailed geotechnical investigation to determine;

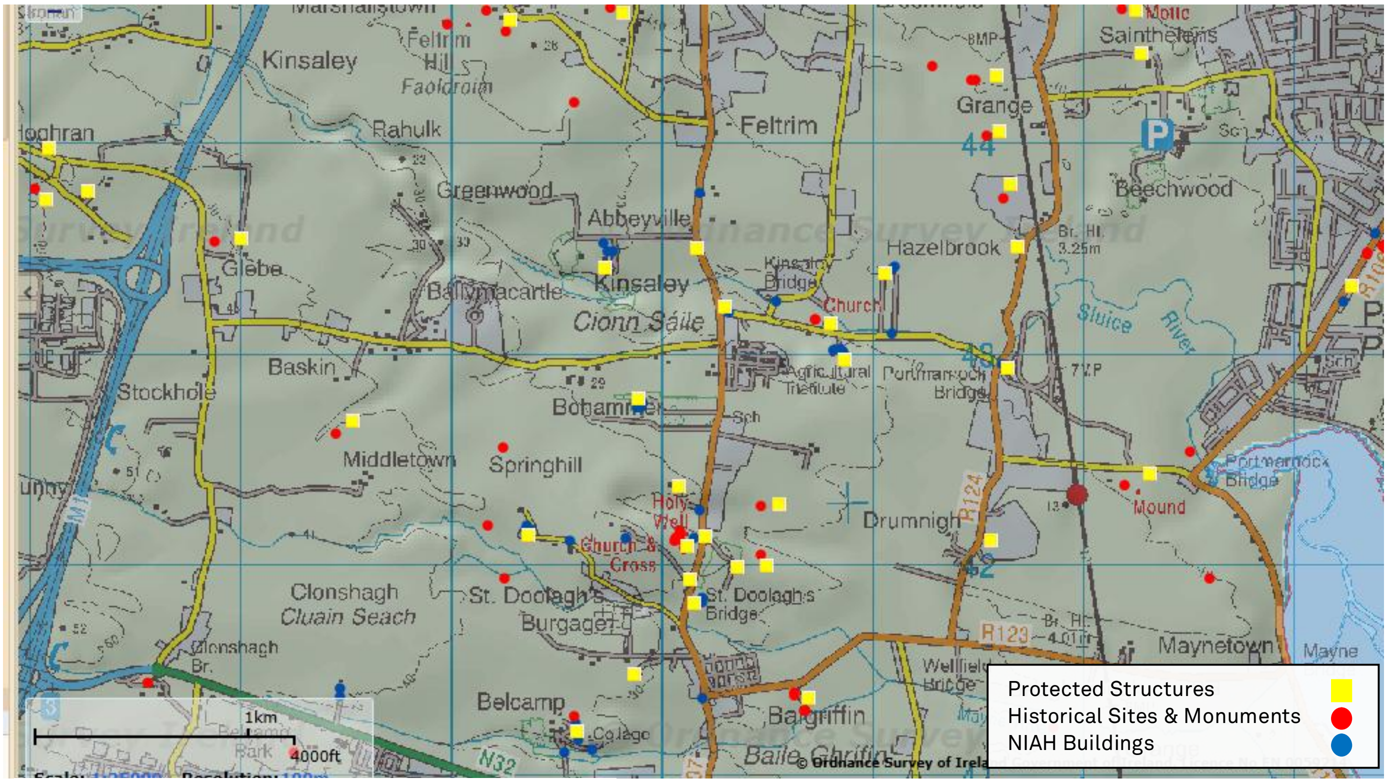
Figure 7.7 – Green belt zoning and Open Space outlined in Fingal County Development Plan 2011-2017



(Source: http://heritagemaps.biodiversityireland.ie/#/Map)

- **Cultural, Archaeological and Architectural Heritage:** There is a possible adverse impact on a high concentration of sites and monuments between Malahide Road and Clonshaugh Road. These include a variety of sites e.g. single ditched enclosures, wells, churches and graveyards etc. (see Figure 7.8). While the development of elevated route alignments through this section has been undertaken to mitigate negative impacts on these sites, the impact would need to be carefully examined to assess any impact on the zones of archaeological influence of recorded sites or monuments; and

Figure 7.8 - Sites of cultural, archaeological and architectural heritage



Source: *http://heritagemaps.biodiversityireland.ie/#/Map*)

7.2.4 HR2: Transport Assessment

A transport demand assessment for option HR2 was undertaken using the NTA's Greater Dublin Area Strategic Transport Model. In undertaking the analysis forecast opening year, 2033, demand matrices developed by the NTA were assigned to the Do Something network which included the HR2 scheme.

Passenger Demand

Table 7.2 presents an initial analysis of modelled boardings on all public transport services, after the implementation of HR2. The data is for the morning period of 07:00-10:00 in the forecast opening year of 2033. As shown in Table 7.1, the overall demand for DART services (which include HR2) in the "Do Something" model test increases by over 30% in the opening year. As expected, introduction of the new service would draw passengers from existing bus services with a cumulative 5.5% reduction in bus service boardings. The overall impact of the scheme is a 0.02% increase in public transport boardings.

Table 7.2: AM Period Public Transport Boardings

Mode	Do Min Boardings	Do HR2 Boardings	% Diff
DART	***40,795***	***53,807***	***31.90%***
Suburban Rail	62,812	62,457	-0.56%
Dublin/City Bus	241,111	232,519	-3.56%
Other Bus	57,179	53,048	-7.23%
Luas	49,171	49,329	0.32%
Total	***451,066***	***451,159***	**0.02%**

Total trip demand impacts for the Do Something HR2 scenario, compared to the Do Minimum scenario, are presented in Table 7.3. Total trip demand in this table is distinct from total boardings in Table 7.2 above. In Table 7.3 total demand represents trip demand from origin to destination rather than boardings on public transport services which can include interchanges between public transport options made in the course of a single origin to destination trip.

Transport Demand Impact

The overall performance of the modelled transport network for the Do Something HR2 scenario can be examined through an analysis of transport network demand.

As can be seen from Table 7.3, scheme option HR2 has a positive impact on public transport patronage in AM peak period with 964 new trips are forecast on public transport services during the AM peak hours 07:00 to 10:00. Of these new trips 580 come from private car trips with the remainder coming from slow modes (cycling and walking).

Table 7.3: AM Period Travel Demand Impact HR2

AM Demand Impacts	Unit	Do HR2
Public Transport	Trips	964
Highway	Trips	-580

The peak loads for scheme option HR2, southbound and northbound services are shown in Figures 7.9 and 7.10. Figure 7.9 shows that, on the southbound service, passenger demand is strongest at the Estuary, Dublin Airport and Clongriffin stops. The highest demand is seen at Estuary where a peak boarding of 1750 passengers is seen during the AM peak hour in the scheme opening year, 2033. It should be noted that the peak load (6,422) forecast on the service in opening year 2033 approaches the design capacity of 6,720, indicating limited room for growth in demand on the service.

Figure 7.10 shows that on the northbound service passenger demand is dominated by a peak loading of over 2,600 passengers at Bray in the AM peak hour. This peak loading is a reflection of the high population growth forecast for Bray, under the Regional Planning Guidelines (RPGs). The key destinations for the northbound passengers are Pearse Street, Tara Street, Connolly Station and Dublin Airport. No capacity issues are forecast in the scheme opening year 2033 on the northbound service.

Figure 7.9: AM Peak Hour Loading Southbound HR2 Estuary to Bray

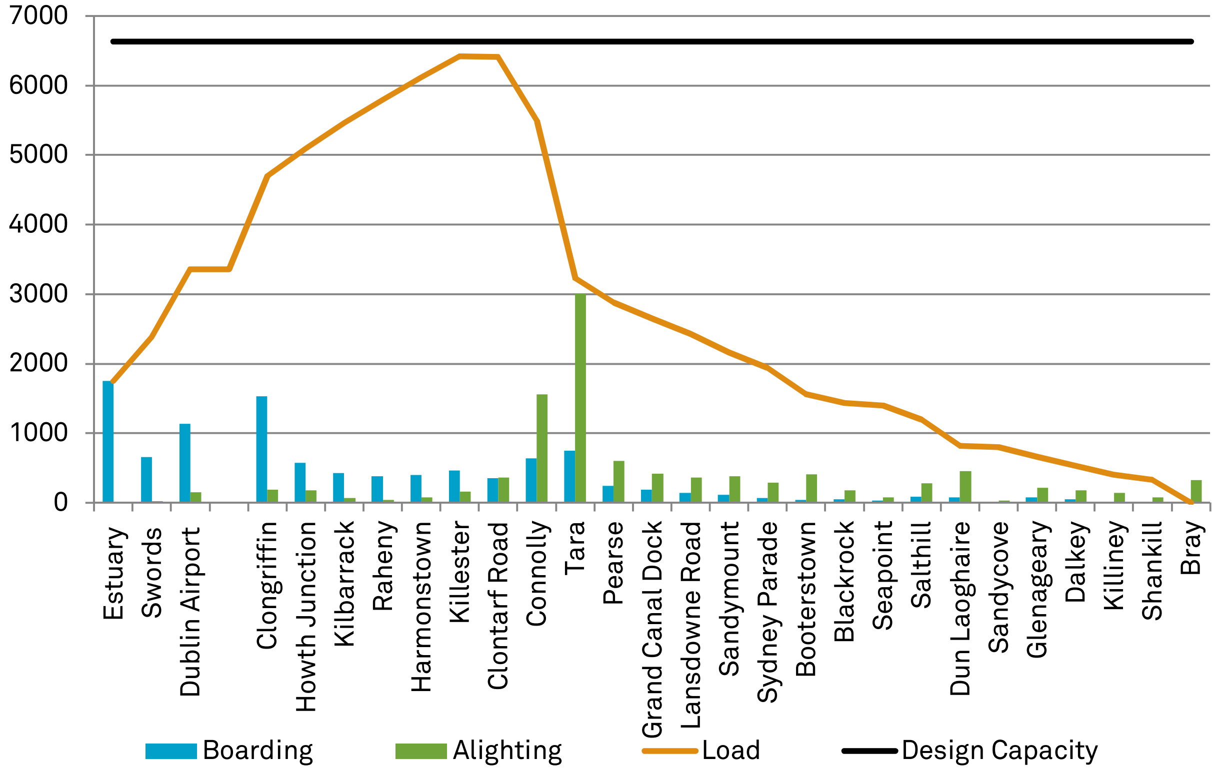
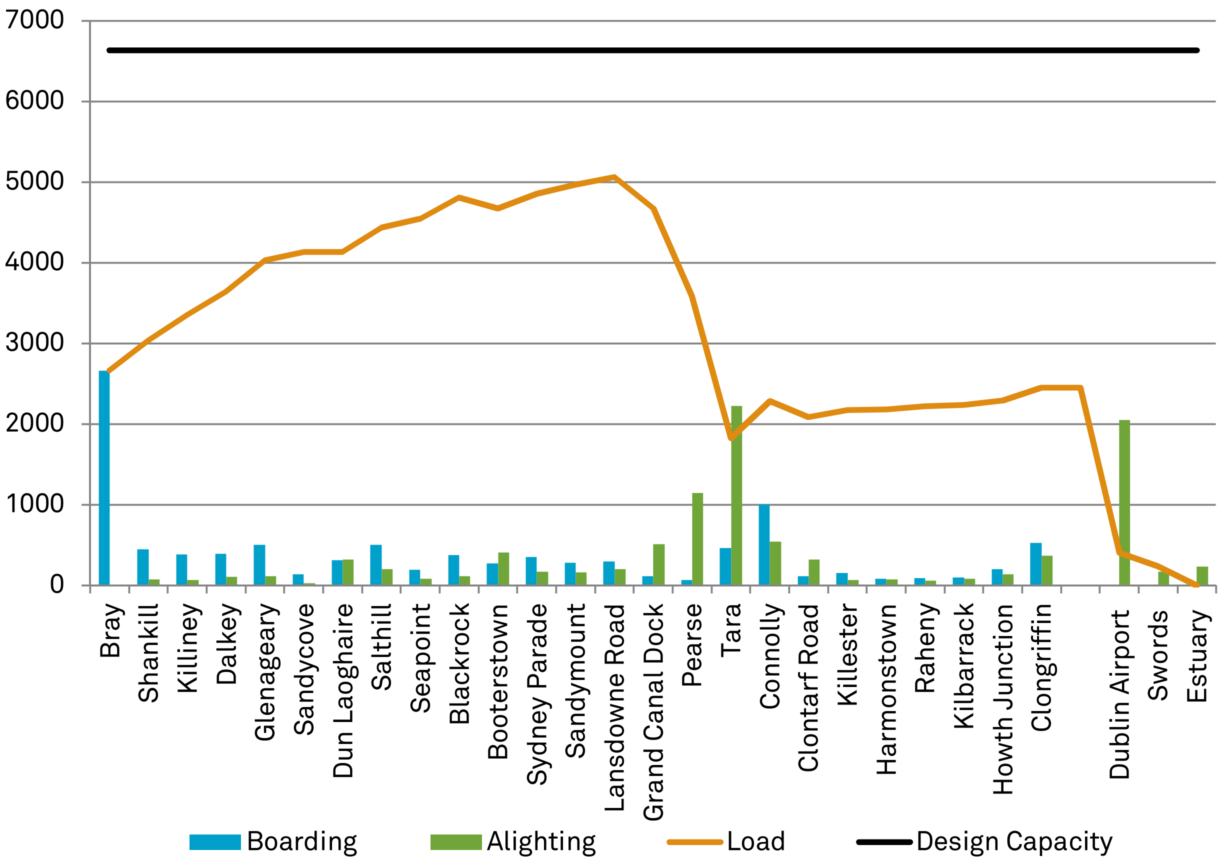


Figure 7.10: AM Peak Hour Loading HR2 Northbound Bray to Estuary



Generalised Cost Impact

As detailed in Section 6, the transport demand forecasting aspect of the NTA's Greater Dublin Area Strategic Transport Model works by predicting travel time and generalised costs of travel associated with utilising different modes of transport between each zone in the model. When a new service offers improved travel times and reduced costs relative to existing services, the model will reallocate demand from existing services to the new transport service as passengers will derive a benefit by switching.

The changes in the generalised cost of travel relative to the "Do Minimum Scenario" are presented in Figure 7.11. Any reductions in generalised costs indicate areas where the scheme is having a beneficial impact i.e. reducing the generalised cost of travel thereby making public transport more attractive. However, it should be noted that changes in aggregate generalised cost do not encompass the full benefits of the scheme, which are discussed in Section 12 Economic Appraisal.

As shown, HR2 generally has a positive impact on the generalised cost of travel along the Swords to City Centre corridor with reductions of 1% to 11% in the generalised cost of travel. There are also some benefits / reductions in the generalised cost of travel in zones to the south of the study area, such as at Bray and Dun Laoghaire, where there are reductions in the generalised cost of travel of up to 2%.

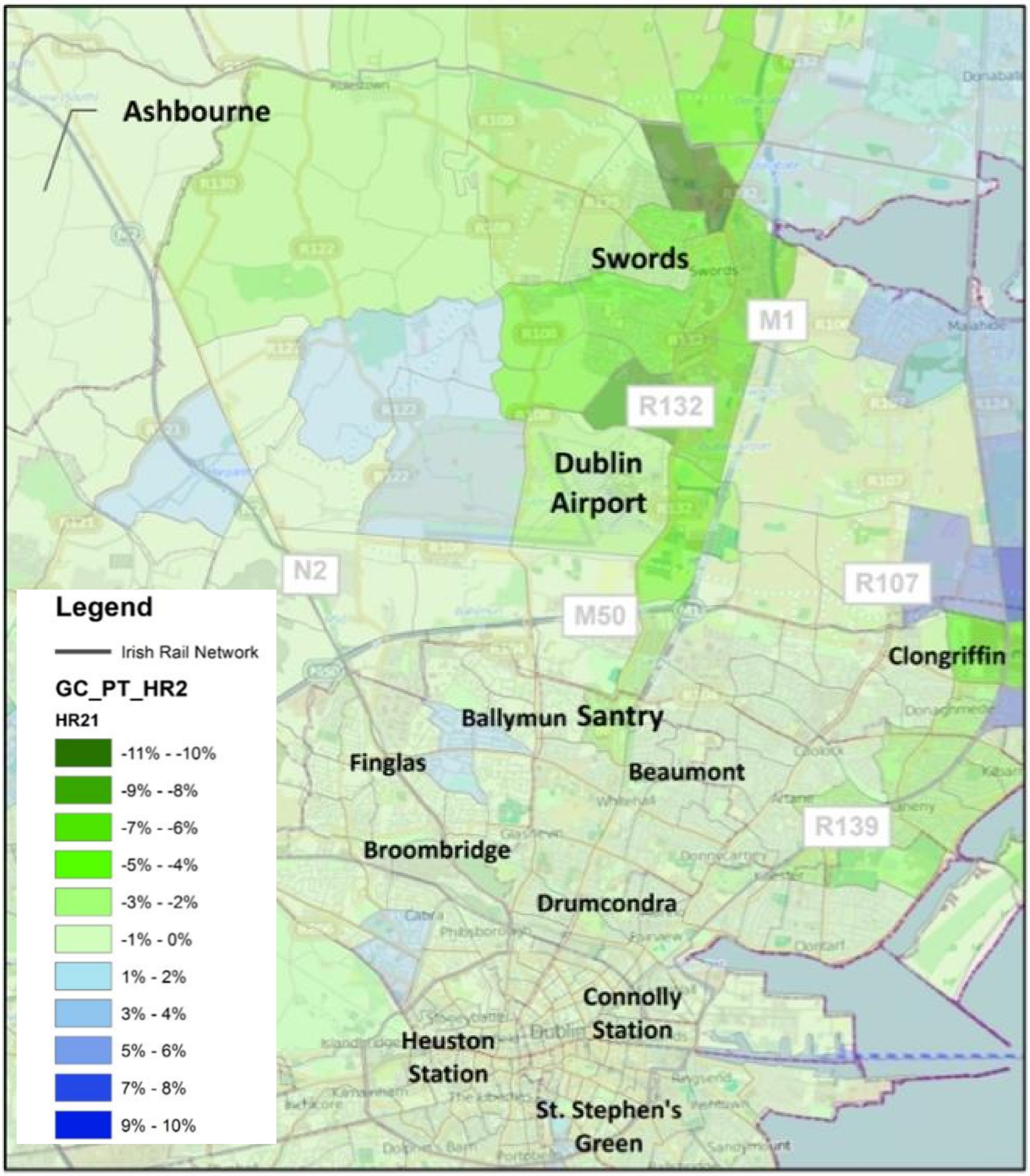
Despite these positive impacts, zones to the south of Bray experience increases of up to 2% in generalised cost of travel. This can be attributed to crowding on DART services arising from high demand for the new service. Larger increases in the generalised cost of travel can also be seen in zones to the north of Clongriffin where crowding impacts on the services will also take place. At Howth for example, an increase of 10% in the generalised cost of travel is expected. This is a result of the removal of direct DART services to Howth.

Summary of Transport Assessment

Based on a service pattern of 6 TPH, HR2 is estimated to generate high demand and operate with a peak loading of approximately 6,420 passengers in an opening year of 2033. This represents 95% of the design capacity. Therefore there is limited potential to accommodate future growth in demand without increasing service frequency.

The scheme also has some negative impacts on the generalised cost of travel for existing rail users on the rail line north and south of the Clongriffin and Bray stations. On the basis that there may be potential to further increase HR2 services on the Northern Line, this option is being brought forward for economic analysis.

Figure 7.11: 2033 Change in Generalised Cost Do Something Option HR2 relative to Do Minimum Option



7.2.5 Cost Estimate

A summary of the proposed cost estimate for HR2 is shown in Table 7.4. The scheme is estimated to cost €2.1bn. This estimate includes preliminary costs at a factor of 30%, a risk factor of 35% as well as VAT (13.5%). With regards rolling stock, it is assumed that eight new DART trains would be required at a cost of €16m each to operate 6TPH on the DART line. It should be noted that this a concept stage cost estimate therefore the degree of estimating uncertainty is set at +/- 30% of our estimate value.

*Table 7.4: Summary of HR2 capital cost estimates**

Description				Total amount (€)
i)	Construction Costs (incl. land acquisition)			1,049,880,000
ii)	Design costs			83,990,400
iii)	Client Costs			94,489,200
iv)	Rolling stock			128,000,000
			Sub total	**1,356,360,000**
v)	Miscellaneous client costs and project burdens		2.00%	27,127,000
vi)	Risk	1,383,487,200	35.00%	484,220,520
vii)	VAT	1,867,707,720	13.50%	252,140,542
			Total cost	**2,119,848,262**

** Note that the capital costs developed are for comparative purposes only*

Operating and maintenance (O/M) costs have also been developed for HR2, on the basis of current average costs, at a cost of €16.21m per annum. These costs are summarised in Table 7.5. These capital and O&M costs have been taken forward for the purpose of economic appraisal of HR2.

Table 7.5: Summary of HR2 operating and maintenance costs

Annual HR2 Operating and Maintenance Costs		
		2014 prices
Operations	Staff	€458,026
	Fuel	€2,338,269
	Insurance Staff	
	Other (Third Party Liability & Damage)	€1,139,600
Vehicles	Routine Maintenance	€4,198,091
	Additional Works	€419,809
	Depot	
Infrastructure	Station Maintenance	€150,000
	Routine Infrastructure Maintenance	€3,705,901
TVM	Routine Maintenance	€60,000
	Additional Maintenance	
	Subtotal	**€12,469,696**
	Contingency	€3,740,909
Total O&M		**€16,210,605**

7.2.6 HR2: Summary

HR2 is proposed as a 13.2km heavy rail spur from Clongriffin to Swords. The route would run at-grade/elevated from Clongriffin to east of the M1 where it would enter a tunnel portal that would connect to Swords via the Airport. Approximately 14 acres of agricultural land would need to be acquired between Clongriffin and the Airport to enable delivery of an at-grade alignment as well as two residential units. Three stations are proposed on the line at the Airport, Swords and Estuary. The route is technically feasible.

Delivery of HR2 is estimated to cost approximately €2.1bn with additional operating costs of €16m per annum.

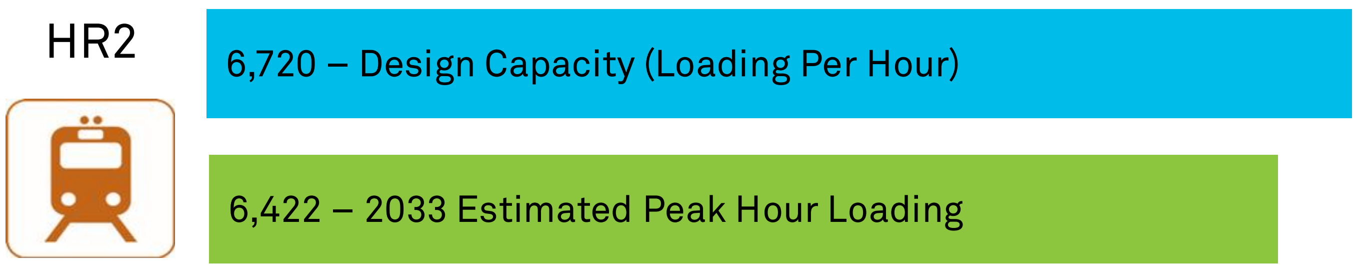
The route would operate 6TPH and offer journey times of 23 minutes from Connolly Station to the Airport and 30 minutes from Connolly Station to Estuary. Eight carriage DART trains would run on the line offering a design capacity of 6,720 pphpd, as summarised in Figure 7.12.

Assuming an opening year of 2033 for HR2, the estimated passenger loading on the route is 95% of the design capacity. Therefore, the scheme would be operating almost at capacity. However, there may be potential to further increase the number of services on the line, pending DART Underground completion.

Transport modelling of HR2 has demonstrated that development of the route would generate benefits for both the public transport and the highway network. However, a large proportion of the benefits generated are on the existing DART corridor. The scheme does not generate benefits south of the Airport within the study area.

On the basis that HR2 is a feasible option for future development within the study area, details of the scheme outlined above have been used as the basis for the economic appraisal and multi-criteria assessment in Sections 12 and 13 respectively.

Figure 7.12: Summary of HR2 design capacity and expected demand



7.3 Drumcondra to Swords (HR8)

While a concept for a northbound heavy rail route from the Maynooth Line was proposed during Stage 1 delivery, this was a very early concept and required significant further development for Stage 2 Appraisal. Details of the scheme are outlined in the following sections.

7.3.1 HR8: Technical Feasibility

HR8 is a 13km heavy rail spur from the Maynooth Line close to Drumcondra Station serving the Airport and Swords. Due to the density of development along the corridor, the route would need to be constructed entirely underground. This option would require the electrification of the western line from the proposed tunnel portal to the Northern Line at Connolly Station to allow DART trains to use this alignment. Figure 7.15 presents the route alignment.

<u>Alignment</u>

Due to the limited availability of land along the existing Maynooth rail corridor, the proposed HR8 rail corridor would need to diverge from the Maynooth Line at a flat double junction west of Drumcondra Station. Construction of the tunnel portal in this area would result in the acquisition and demolition of approximately 32 residential units.

The line would enter a cut and cover tunnel almost immediately and curve in a northerly direction below Glasnevin Cemetery. The line would continue in a twin bored tunnel running in a north easterly direction and pass below the Ballymun Road (R108), M50, Airport and Swords Town Centre.

<u>Stations</u>

Three stations are proposed along the route at Dublin Airport, Swords and Estuary. Each of these stations is proposed in the same location as previously outlined for HR2. At the Airport a north/south alignment for the station box can be facilitated within the safeguarded Metro North station box location.

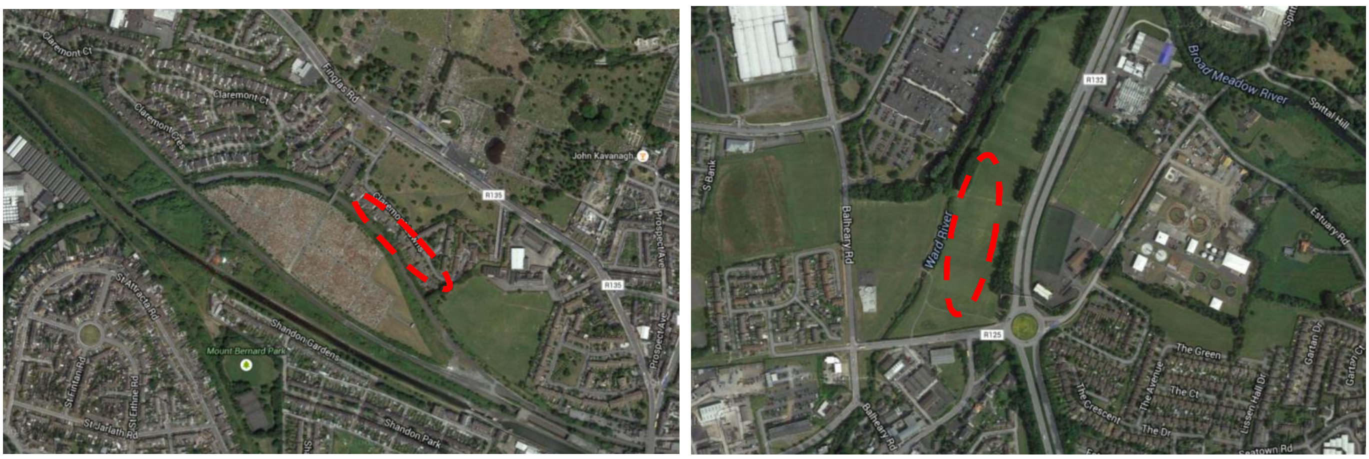
The depth of tunnelling in the vicinity of Ballymun would be in excess of 30m which would make the construction of a station here technically difficult and very expensive. For this reason, a station at Ballymun has not been included. It may be possible to facilitate development of a station at Dardistown in the future; however, tunnel depths in this area also mean construction would be difficult.

<u>Tunnelling</u>

The proposed Glasnevin to Swords Tunnel is approximately 12km long. This is the longest tunnel of those in the options considered. A twin bore heavy rail tunnel, similar to HR2 is proposed.

The proposed southern tunnel portal is located on the west side of the playing fields in the area of Claremont Lawns and the proposed north portal is located in open ground to the north-west of the Estuary Roundabout on the R132.

Figure 7.13: Potential location of HR8 tunnel portals



The tunnel is expected to run to depths of over 40m beneath the Ballymun Road. This depth is necessary due to the gradients required to facilitate usage by electric intercity trains in the future. As outlined above, the depth of tunnelling required in this area means that just three stations are proposed on the HR8 line.

The distance between the south portal and the Airport Station is approximately 7.5km meaning that six or seven shafts will be required based on a standard of a shaft each kilometre. Suggested sites are the open land between Glasnevin Cemetery and the Tolka River, (flood protection measures will probably be needed); the grounds of Scoil Chiaráin special school; the grassed area to the south of Ballymun Library (just to the north of the junction between Ballymun Road and Glasnevin Avenue; the open land bounded by Shangan Road, Balcurris Road and Ballymun Road; with two shafts located in the large expanses of open land between the M50 and the Airport south perimeter.

Between the Airport and Swords stations, two shafts will be required over this 3km tunnel section. These can be placed in the open land immediately to the north of the airport perimeter and to the north of Boroimhe Willows immediately to the west of the R132.

A 12km long bored tunnel will take a considerable time to construct and for this reason it may be preferable to drive the tunnel simultaneously from two separate locations. One tunnel could be driven southwards from Estuary Station which, at around 1.3km from the junction with the M1 motorway, has good access for deliveries and spoil removal. A second TBM could operate southwards from an enlarged shaft constructed close to the M50 motorway, which will also be convenient for deliveries and removal of spoil.

Figure 7.14: Vertical Alignment

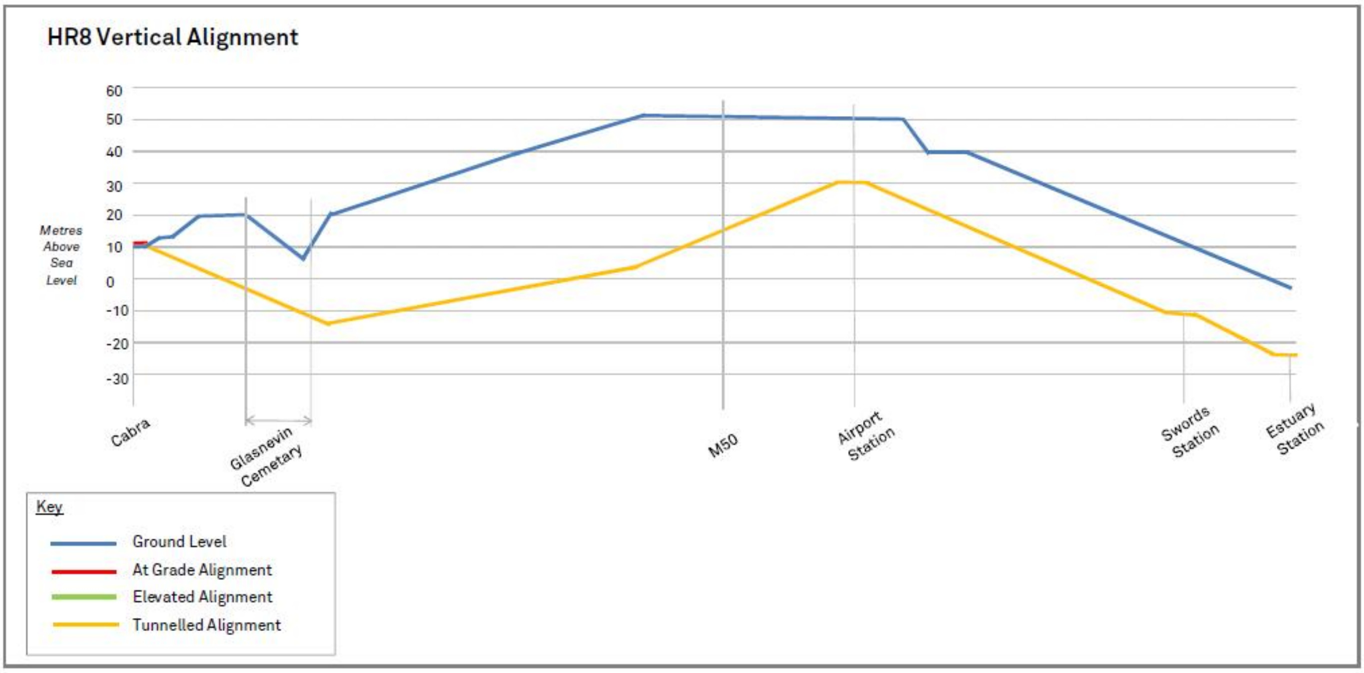


Figure 7.15: Proposed Alignment for HR

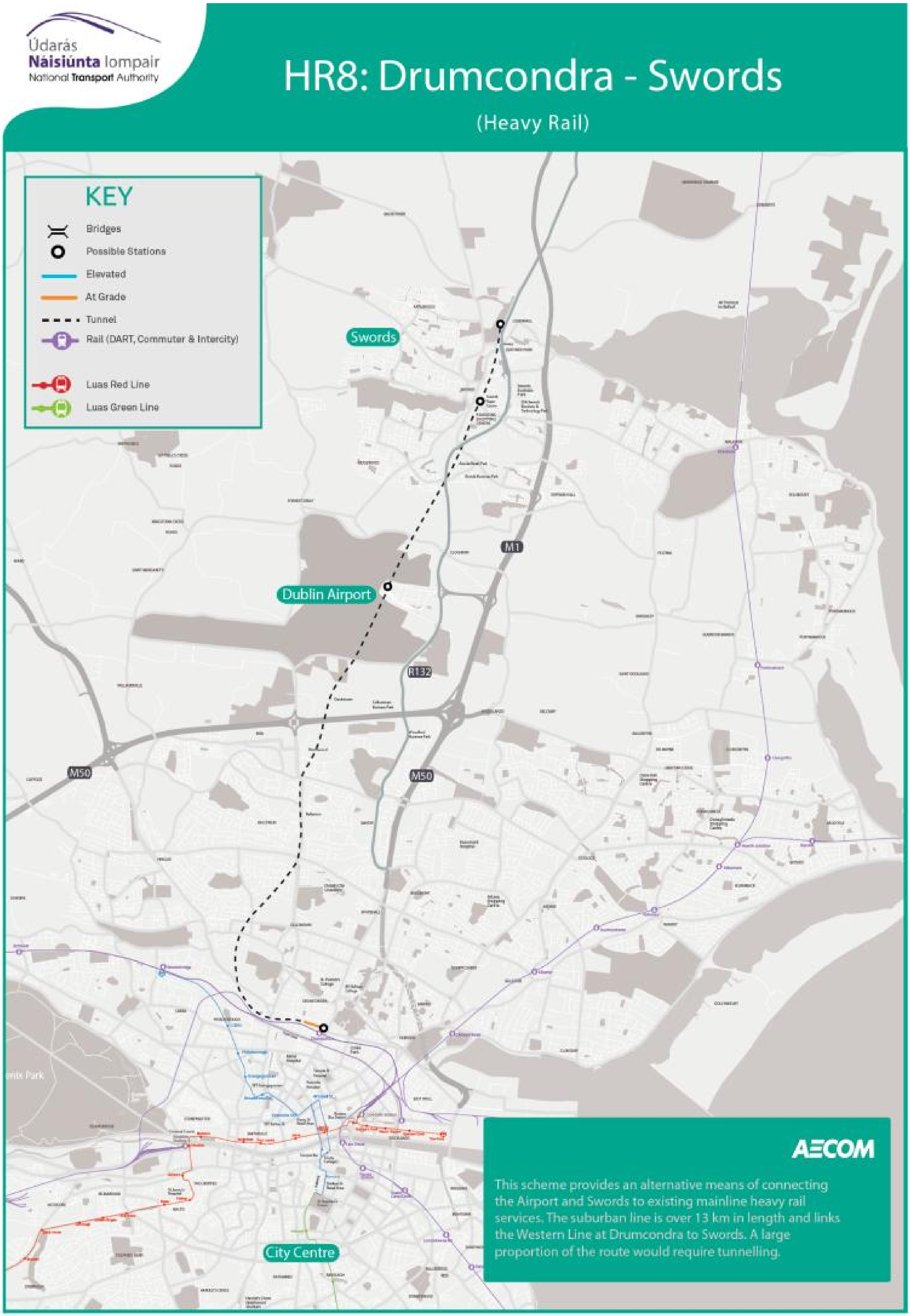


Figure 7.16: Proposed HR8 Alignment off the Western Suburban Line

Structures

The only significant above-ground structures will be located near the junction with the Western Suburban Line at Drumcondra. Here, there would be a requirement for a retained cutting adjacent to the Western Suburban Line as HR8 drops down towards the tunnel portal. This would probably require construction of a piled retaining wall immediately adjacent to the Western Suburban Line. The primary risk associated with this option is disturbance to the existing railway infrastructure. In addition, a new overbridge would be required to elevate the Phibsborough Road over HR8. This new span bridge would be located adjacent to an existing bridge carrying the road over the Western Suburban Line. Due to the proximity of the existing bridge, it may be necessary to install a new, longer bridge to cross both the Western Suburban Line and HR8.

Utilities

With 12.4km of the route in bored tunnels there will be few impacts on utilities other than at station box and shaft locations. Utility implications at Dublin Airport and Swords are the same as previously outlined for HR2.

Construction Impact

Because the majority of HR8 would run below ground, the main construction impacts are at the tunnel portals or stations. The main impacts arising from construction of HR8 include:

- Construction of the southern tunnel portal would require acquisition and demolition of 32 houses at Claremont Lawns, as shown in Figure 7.16. The cost of this acquisition is estimated to be in the order of €16m;
- Buried domestic utilities close to the proposed southern tunnel portal would need to be permanently relocated. However, reduced demand for these services as a result of property demolition may enable many of them to be decommissioned and removed;

- Elevating the Phibsborough Road would be technically difficult and will cause temporary disruption to this busy arterial route;
- Potential noise and vibration impacts from tunnelling; and
- Construction of the three proposed stations will result in short term disruption within the Airport, Swords and Estuary.

Summary of Technical Feasibility

The technical feasibility of HR8 has been developed beyond a conceptual level as proposed during Stage 1 of this study. Investigations into the structural and tunnelling requirements to support the proposed alignment and stations have been undertaken and determined that the route is technically feasible. Vertical and horizontal alignment drawings for HR8 have also been prepared.

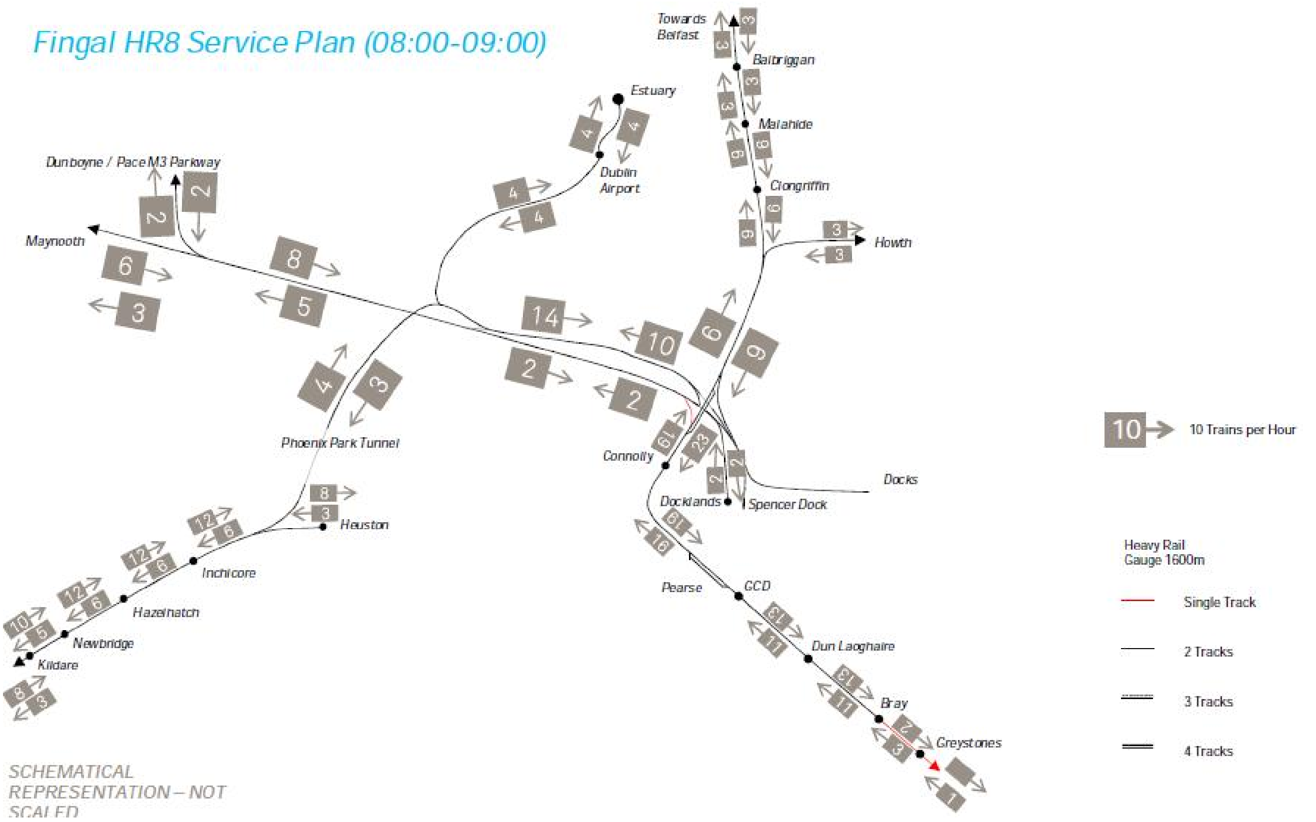
Although the route is recommended as practically feasible, a summary of the main project risks is as follows:

- Detailed geotechnical surveys will be required to confirm proposed tunnels are technically feasible;
- The three proposed stations are large and may be technically difficult to construct; and
- As no topographical survey was available for the area around Phibsborough Road, the accuracy of the drawings are lower, therefore additional land acquisition may be required to fit in the rail alignment as proposed.

7.3.2 *HR8: Operational Assessment*

The operational feasibility of HR8 is heavily dependent on capacities available on the Western Suburban Line. Unless service on the line is reduced in favour of a HR8 service to Swords, this option is limited in both the short and long term to 4 trains per hour. An indicative sketch of the proposed heavy rail service plan is shown in Figure 7.17 below.

Figure 7.17: HR8 Service Plan (08:00-09:00)



HR8 would operate on the basis of 8 car DART trains as currently used with a design capacity of 1,120 per train. This would offer a capacity of 4,480pphpd based on 4TPH.

Journey time assumptions for HR8 are as follows:

- Connolly Station to the Airport: 11 minutes; and
- Connolly Station to Estuary: 19 minutes

Table 7.6: Summary of HR8 operational feasibility

Vehicles	Capacity	Frequency	Journey Times
8 car DART as currently used	Design capacity: 4,480pphpd	4 trains per hour all day	Connolly – Airport 11 min Connolly – Estuary 19 min

7.3.3 HR8: Environmental Assessment

A high level assessment of the environmental impact of HR8 suggests the following impact:

- **Air Quality:** Once operational, the proposed scheme would have limited impact on air quality. Any changes in local air quality would be associated with changes in traffic flows as a response to delivery of the scheme. These impacts are looked at in further detail in Section 12, Economic Appraisal;
- **Noise and Vibration:** During construction, there are potential impacts in relation to tunnelling and impacts on underlying geology and hydrogeology. Vibration modelling would be required to be undertaken to understand at-grade impacts. This would be critical in determining the likely impacts on both archaeological and architectural heritage. Once the scheme is operational, impacts at-grade would be limited significantly depending on tunnel depths;
- **Landscape and Visual Quality:** These impacts would be limited to the southern section where development of the tunnel portal will result in the loss of 32 houses. In addition, proposals for a more elevated bridge structure over Phibsborough Road may also have a marginal negative impact.
- **Biodiversity**: Appropriate Assessment (AA) Screening is required to determine any likely significant impacts on nearby Natura 2000 sites, some of which are in close proximity e.g. Malahide Special Area of Conservation and Broadmeadow /Swords Special Protection Areas. Any impacts on hydrological connections or water quality would also be examined;
- **Cultural, Archaeological and Architectural Heritage:** There are possible adverse impacts on the Historic Environment as a result of tunnelling under the Glasnevin Cemetery area. In particular, concerns have arisen with regards to the depth of tunnelling and potential impacts of TBM vibration on the recorded monuments, graves, protected structures and Architectural Conservation Areas (see Figure 7.18). Detailed examination of potential impact would be required; and
- **Land Use, Soils and Geology**: There are potential impacts in relation to the geotechnical aspects and impacts on underlying geology and hydrogeology. Vibration modelling would be required to be undertaken as part of the project to determine likely impacts.

Figure 7.18 – Sites of cultural, archaeological and architectural heritage with the Glasnevin area

(Source: http://heritagemaps.biodiversityireland.ie/#/Map)

7.3.4 HR8: Transport Assessment

A transport demand assessment for the heavy rail option HR8 was conducted through the NTA's strategic multimodal model. In undertaking the analysis for the forecast opening year, 2033, demand matrices developed by the NTA were assigned to the Do Something network which included the HR8 scheme.

Passenger Demand

Table 7.5 summarises the total boardings on each public transport sub-mode, for the morning period of 07:00-10:00 in the forecast year of 2033 after the implementation of the scheme option HR8. As shown in Table 7.7, demand for DART services (which include HR8) increase by 53.14% in the "Do Something" scenario. Introduction of the new service would draw passengers from existing bus services with a cumulative 7% reduction on bus service boardings. Additionally, increased interchange with Luas is forecast with Luas boardings increasing by almost 1%. The overall impact of the scheme is a 1.23% increase in public transport boardings.

Table 7.7: AM Period Public Transport Boardings

Mode	Do Min Boardings	Do HR8 Boardings	% Diff
DART	***40,795***	***62,473***	***53.14%***
Suburban Rail	62,812	62,608	-0.32%
Dublin/City Bus	241,111	230,277	-4.49%
Other Bus	57,179	51,664	-9.65%
Luas	49,171	49,594	0.86%
Total	**451,066**	**456,615**	**1.23%**

Network Statistics

The overall performance of the modelled transport network for the Do Something HR8 scenario can be examined through an analysis of the transport network demand.

As can be seen from Table 7.8, scheme option HR8 has a positive impact on public transport patronage in AM peak hours with 1,624 new trips forecast on public transport services during the AM peak hours 07:00 to 10:00. Of these new trips 1,011 come from private car trips with the remainder coming from slow modes (cycling and walking).

Table 7.8: AM Period Travel Demand Impact

Travel Demand Impact	Unit	Do HR8
Public Transport	Trips	1,624
Highway	Trips	-1,011

Peak hour passenger loading for HR8 southbound and northbound services, are shown in Figures 7.19 and Figure 7.20. Figure 7.19 indicates that on the southbound service, passenger demand is again strong at the Estuary, Swords and Dublin Airport stops. The highest demand is seen at Estuary where peak passenger boarding of almost 1,950 is expected in the AM peak hour. This high demand reflects the rapid journey time, of just 19 minutes from Estuary to the City Centre that would be facilitated by HR8. The forecast key destinations are Drumcondra, Connolly Station and Tara Street.

While HR8 performs strongly in terms of passenger boarding numbers at the Estuary, Swords and Dublin Airport stops, boardings are minimal on existing stops south of Dublin Airport. This is most likely due to the fact that high boarding demand at Dublin Airport causes the service to become overcrowded with demand exceeding design capacity by up to 9%.

Figure 7.20 shows that on the northbound service, reasonably high passenger demand is generated at the Tara Street, Connolly and Drumcondra stops. Dublin Airport is a key destination followed to a lesser extent by Drumcondra and Swords. No overcrowding issues are evident on the northbound services.

Figure 7.19: AM Peak Hour Loading HR8 Southbound Estuary to Grand Canal Dock

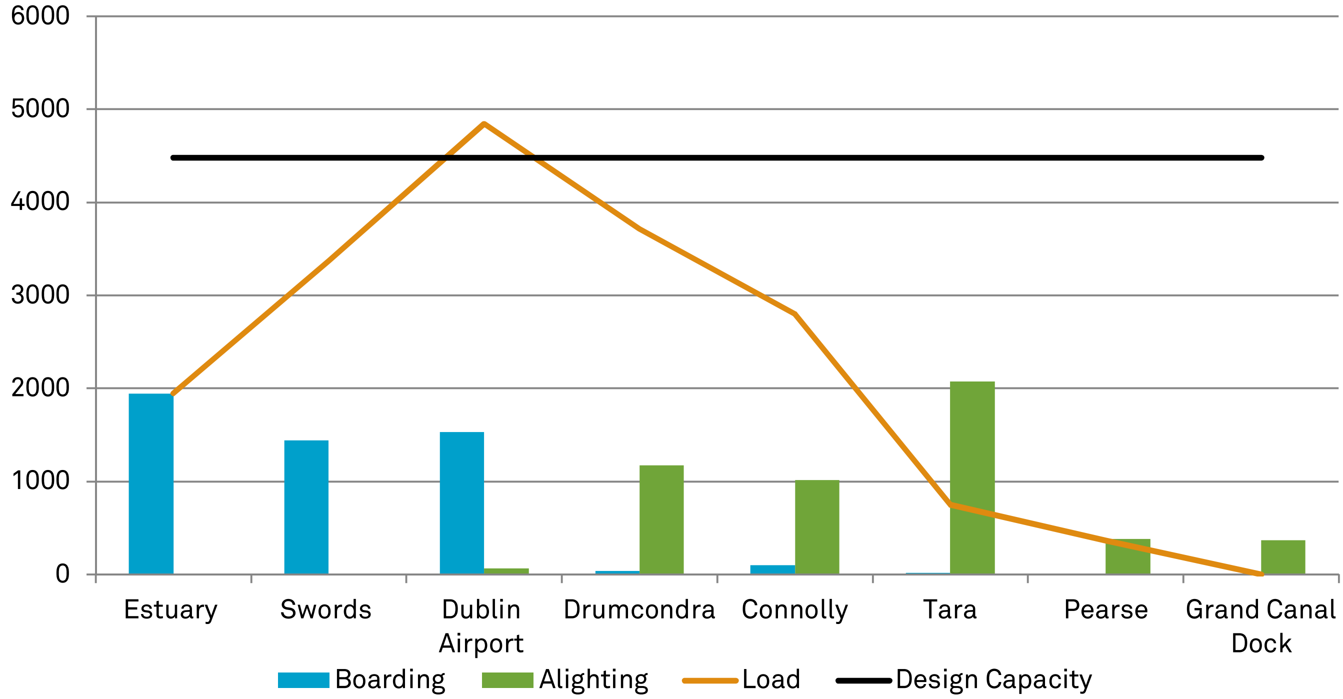
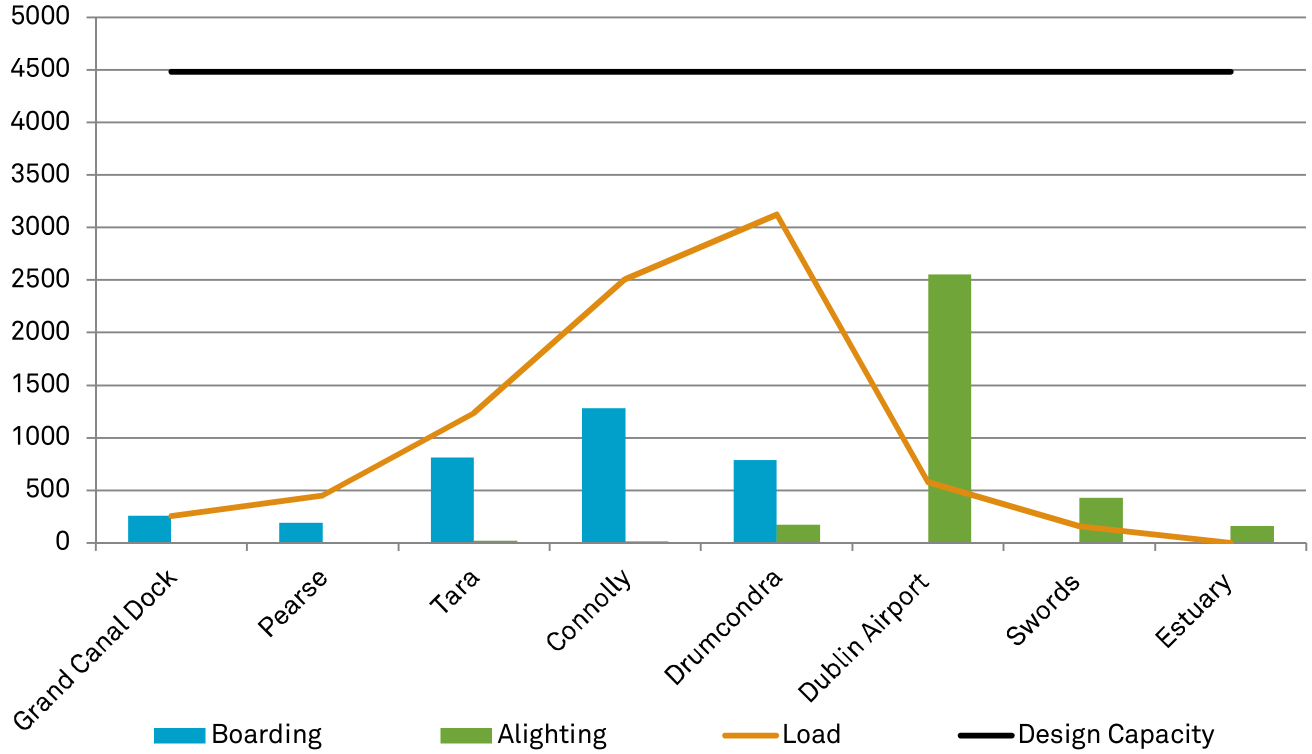


Figure 7.20: AM Peak Hour Loading HR8 Northbound Grand Canal Dock to Estuary



Generalised Cost Impact

Changes in the generalised cost of travel for HR8 relative to the "Do Minimum" scenario, as forecast by the NTA's Greater Dublin Area Strategic Transport Model, are presented in Figure 7.21. Any reductions in generalised costs indicate areas where the scheme is having a beneficial impact i.e. reducing the generalised cost of travel thereby making public transport options more attractive. However, it should be noted that changes in aggregate generalised cost do not encompass the full benefits of the scheme, which are discussed in Section12 Economic Appraisal.

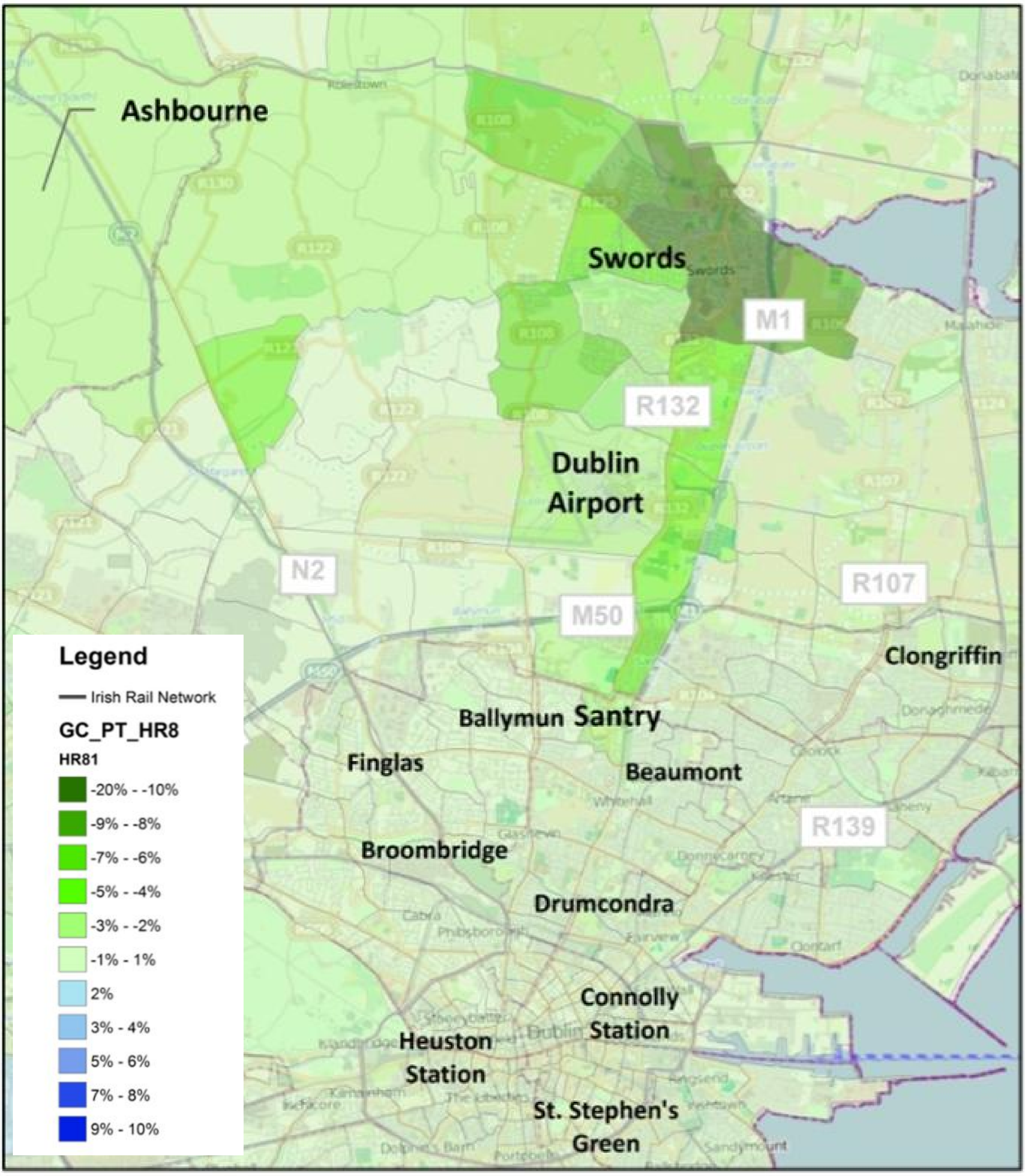
As shown, HR8 has a positive impact on the generalised cost of travel along the Swords to City corridor with reduction of 10% - 20% of the generalised cost of travel forecast at Swords with further, although diminishing reductions in the generalised cost of travel seen at zones to the south of Swords such as at Dublin Airport and Santry. As no new stations are proposed on the line further south of the Airport, no substantial changes in the generalised cost of travel in this area are forecast.

Summary of Transport Assessment

Based on service pattern of 4TPH scheme option HR8 will generate high demand at the Estuary, Swords and Dublin Airport. However in the scheme opening year, 2033, the demand generated at Dublin Airport stop is greater than available design capacity. A peak loading of approximately 4,840 passengers is forecast exceeds the optimal design capacity of 80% (4,480 passengers).

The only way to increase capacity is to schedule more frequent services. However as outlined in Section 7.3.2, the operational feasibility of HR8 is largely dependent on capacities available on the Western Suburban Line. Unless services are removed from this line the maximum frequency of the HR8 service is constrained to 4 trains per hour which as outlined graphically in Figure 7.17 is insufficient to meet demand and therefore does not meet the objectives of this study.

Figure 7.21: 2033 Change in Generalised Cost Do Something Option HR8 relative to Do Minimum Option



7.3.5 HR8: Cost Estimate

A summary of the proposed cost estimate for HR8 is shown in Table 7.9. The scheme is estimated to cost €2.5bn. This estimate includes preliminary costs at a factor of 30%, a risk factor of 35% as well as VAT (13.5%). With regard to rolling stock, it is assumed that six new DART trains would be required at a cost of €16m each to operate 4TPH on the DART line. It should be noted that this a concept stage cost estimate therefore the degree of estimating uncertainty is set at +/- 30% of our estimate value.

*Table 7.9: Summary of HR8 capital cost estimates**

Description				Total amount (€)
i)	Construction/Direct Costs (incl. land acquisition)			1,273,220,000
ii)	Design costs			101,857,600
iii)	Client Costs			114,589,800
iv)	Rolling stock			96,000,000
			Sub total	**1,585,670,000**
v)	Miscellaneous client costs and project burdens		2.00%	31,713,400
vi)	Risk	1,617,383,400	35.00%	566,084,190
vii)	VAT	2,183,467,590	13.50%	294,768,125
			Total cost	**2,478,235,715**

** Note that the capital costs developed are for comparative purposes only*

Operating and maintenance (O/M) costs have also been developed for HR8, on the basis of current average costs, at a cost of €10m per annum. These costs are summarised in Table 7.10.

Table 7.10: Summary of HR8 operating and maintenance costs

Annual HR 8 Operating and Maintenance Costs (2014 prices)		
Operations	Staff	€325,607
	Fuel	€655,589
	Insurance	
	Other (Third Party Liability & Damage)	€1,111,600
Vehicles	Routine Maintenance	€2,729,963
	Additional Works	€272,996
	Depot	
Infrastructure	Station Maintenance	€150,000
	Routine Infrastructure Maintenance	€2,409,898
TVM	Routine Maintenance	€60,000
	Additional Maintenance	
	Subtotal	**€7,715,654**
	Contingency	€2,314,696
Total O&M		**€10,030,350**

7.3.6 HR8: Summary

HR8 is proposed as a 13km heavy rail spur from Drumcondra Station to Swords. The route would run in a tunnel from Drumcondra to Estuary via stations at the Airport and Swords. Approximately thirty two residential units would need to be acquired in the vicinity of Claremont Lawns to facilitate development of the tunnel portal. Three stations are proposed on the line at the Airport, Swords and Estuary. The route is technically feasible.

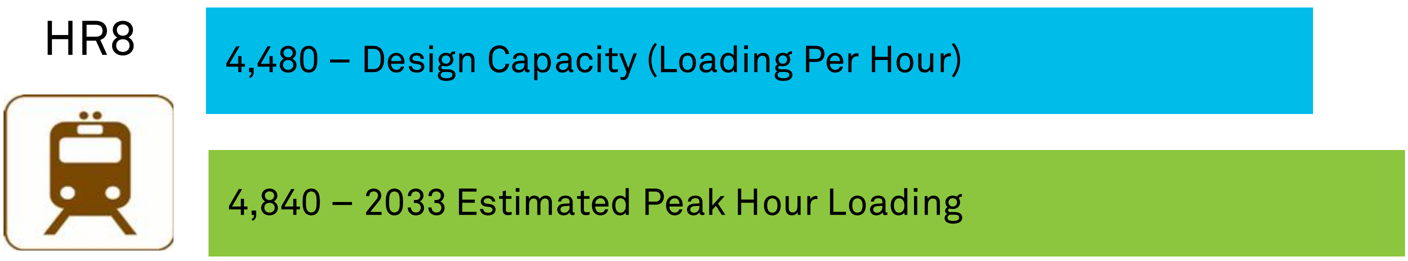
Delivery of HR8 is estimated to cost in €2.5bn with additional operating costs of €10m per annum.

The route would operate 4TPH and offer journey times of 11 minutes from Connolly Station to the Airport and 19 minutes from Connolly to Estuary. Eight carriage DART trains would run on the line offering a design capacity of 4,480pphpd.

It is expected that HR8 would exceed the design capacity in an opening year of 2033 with an estimated demand of 4,840pphpd. High demand for the line is generated because of the fast journey times it offers. However, despite this benefit, there is little potential to further increase capacity on the line.

On the basis that HR8 cannot respond to future travel demand on the corridor and there is very limited potential for further increases in capacity, the scheme is not being brought forward for economic appraisal or multi-criteria analysis.

Figure 7.22: Summary of HR8 design capacity and expected demand



7.4 Heavy Rail Recommendations

Of the two heavy rail schemes shortlisted during Stage 1 of this study, just one, HR2, is being brought forward for economic appraisal.

While both schemes were technically feasible, tunnelling requirements for HR8 meant that just three stations were feasible on the line. The low number of stations on the line, as well as the high level of segregation, resulted in fast journey times to the Airport (11 minutes) and Swords (19 minutes). However, these efficient journey times result in a high level of passenger demand on the HR8 line that cannot be accommodated on a limit of just 4TPH. There is limited potential to expand this level of service on the HR8 line in the future and as a result this option was been eliminated from further development.

HR2 also experiences high demand; however, as there may be greater potential to increase capacity on this line in the future it was brought forward for economic appraisal and multi-criteria analysis.

8 Stage 2: Light Rail Options Development

8.1 Overview

Two light rail schemes were shortlisted for further development following the Stage 1 Appraisal, namely: Luas Line LR3 and Optimised Metro North (LR7). Both of these schemes were developed as more cost effective variants of Metro North (previously discussed in Section 4.4).

Each scheme was looked at separately in the following sections using the same format as previously used for the heavy rail schemes as follows:

- Technical Feasibility, including: alignment, stations, tunnelling, structures, utilities and construction impact;
- Operational Feasibility;
- Environmental Assessment;
- Transport Assessment, including: generalised cost impact, passenger demand and network impacts; and
- Capital and Operating Cost Estimate.

8.2 LR3

LR3 was proposed by the RPA on the basis of extending the Luas Cross City (LCC) line to Dublin Airport and Swords. The proposed alignment north of the Airport would run at-grade via Swords Main Street. Three different alignments for the southern section were shortlisted, previously set out in Section 4.4, as follows:

1. **Glasnevin-Ballymun Corridor:** LCC to Cabra and then a new route with an underground section beneath the Glasnevin Cemetery and the Botanic Gardens and then at-grade along the Ballymun Road;
2. **Drumcondra Corridor:** LCC to Dominick Street and a new route along Dorset Street, Drumcondra Road and Swords Road; and
3. **Phibsborough-Ballymun Corridor:** LCC to Constitution Hill and then a new route along Phibsborough Road and Ballymun Road.

Each of the proposed southern options serves a distinctly different catchment area and presents varying technical difficulties in delivery. Based on a high level appraisal of each alignment, the RPA concluded on a preferred option of the Glasnevin-Ballymun Corridor for the following reasons:

- The route would serve most of the Metro North catchment area (with the exception of the Mater Hospital and Drumcondra) with a reduced tunnelling requirement and cost (see Figure 8.2);
- The route would make most use of the spare capacity identified on the LCC section between Parnell Square and Cabra upon opening of Luas Cross City;
- It provides the best journey times which could off-set the cost of tunnel construction;
- It provides a high level of segregation without affecting the capacity of already congested roads;
- It would not impact on central areas of the city during construction, taking full advantage of the newly built LCC; and
- It can be delivered in phases and built in parallel work fronts to minimise disruption.

8.2.1 LR3 Technical Feasibility

Technical proposals for LR3 were reviewed by AECOM to confirm the route alignment and understand the potential opportunities for further development. AECOM concluded that:

- The shortlist of potential alignments to extend LCC through the study area was thorough. There are limited alternative routings for the alignment which do not involve significant tunnelling;

- The introduction of light rail at-grade running through Phibsborough (option LR4) and Drumcondra (option LR5) would require significant traffic management including bans and restrictions which may have severe impacts for the local area and the Dublin region as a whole;
- The width of the existing streets through Phibsborough and Drumcondra would not easily facilitate construction of a light rail facility, as shown in Figure 8.1;
- At-grade construction of a Luas system through Phibsborough or Drumcondra would require shared use of tram lanes with buses and in some places with general traffic. This would inevitably lead to delays not just for trams but also for bus services from the wider region;
- At-grade routes are likely to require significant land acquisition in residential areas; and
- From an environmental perspective, the at-grade routes present issues for built heritage areas as well as visual and noise impacts.

While the environmental impact of Option 1 (Glasnevin Tunnel) needs to be determined in greater detail, it has been concluded for the purpose of appraisal that Options LR4 and LR5 can be eliminated on the basis of technical difficulty and adverse traffic impact. However, should LR3 be identified as the preferred scheme at the end of this study Options LR4 and LR5 would be considered as part of the detailed Route Options Selection Stage for the project.

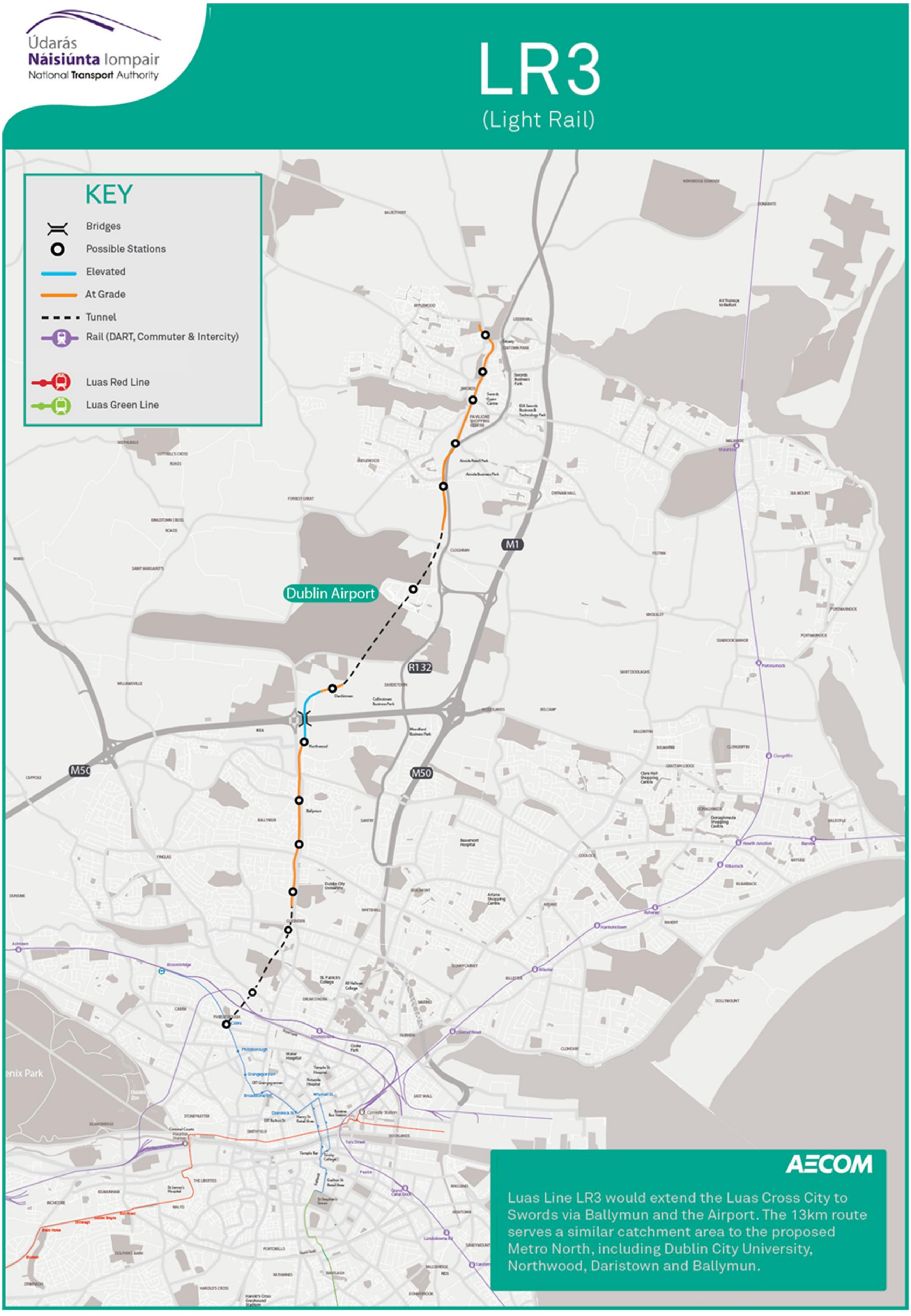
The following sections set out the preferred alignment in more detail.

Figure 8.1: Sample cross sections of Phibsborough Road and Drumcondra Road (source: Google Street View)

Phibsborough Road

Drumcondra Road

Figure 8.2: Proposed Alignment for LR3



Alignment

LR3 branches off the proposed LCC light rail line to the north west of the Cabra stop with a flat double junction. The alignment turns north and immediately enters a retained cutting followed by a 100m-long cut and cover tunnel. The alignment then enters a 2.0km-long twin bored tunnel and runs underneath Glasnevin Cemetery, the Botanical Gardens and the Tolka River. The alignment runs through a 300m-long cut and cover tunnel and calls at Griffith stop before emerging at-grade in the central reserve of Ballymun Road (R108).

LR3 runs along the central reservation of Ballymun Road, in a similar fashion to the Luas on the Naas Road, with stops at DCU, Glasnevin North and Ballymun. The route runs along the Ballymun Road at-grade and runs north east along a new segregated alignment to a stop at Northwood. Beyond Northwood, the alignment climbs up to an embankment and passes over the M50 motorway on a 100m-long bridge. Smaller bridge structures would carry the railway over minor local roads on either side of the motorway. The route continues to run at-grade through open land to the south of the Airport with stops proposed at Dardistown and Collinstown.

Various opportunities for connecting LR3 to the Airport terminals have been investigated by the RPA and AECOM, including:

- Tunnelled station under the Ground Transportation Centre between Terminals 1 and 2;
- A stop on the R132 with connecting Luas Shuttle to the Airport;
- A stop on the R132 with an Automated People Mover connecting passengers to the Airport;
- An at-grade Luas loop through the Airport from the R132; and
- Splitting Luas services between the Airport and Swords.

An assessment of each of the above options was undertaken on the basis of impacts of technical and operational feasibility. While the RPA proposal recommended a stop on the R132 with an Automated People Mover connection to the Airport, this assessment concluded that a tunnel beneath the Airport presents the best outcome for passengers to the Airport and Swords, particularly with regards journey time savings.

The Airport tunnel would be 2.2km in length with a station located within the GTC. The route comes up at-grade north of the Airport. Minor structures and earthworks carry the alignment on a slightly elevated alignment through fields and across minor roads and culverts before the line re-joins the R132 at Boroimhe. The route runs on a segregated alignment immediately to the west of the R132, where it serves the Pinnockhill stop. From Pinnockhill the alignment runs along Dublin Road (R836) to the Pavilions stop. The Pavilions stop is located slightly off alignment from Dublin Road (entering Swords Town Centre) and from here the alignment runs along the west side of the road on segregated alignment. LR3 then continues along a shared alignment on Dublin Road/ Swords Main Street to Swords Castle stop before terminating at Estuary.

It should be noted that more detailed assessment of the alignment in terms of traffic impact would be required to determine whether further grade separation of major junctions along the line is required, for example at the Collins Avenue junction. This would lead to additional costs and potentially more land take in and around these junctions.

Stations/Stops

Excluding Cabra Stop on the LCC line, thirteen stops are proposed at the following locations:

1. Glasnevin/Botanic - stop on N2 in front of Glasnevin Cemetery entrance and museum, in bored tunnel;
2. Griffith (at Griffith Avenue – Old Ballymun Road junction), in cut and cover;
3. DCU (same location as MN), at grade in road median;
4. Glasnevin North (Collins Avenue junction), at grade in road median;

5. Ballymun (same location as MN), at grade in road median;
6. Northwood (same location as MN), at grade off road east of Ballymun Road;
7. Dardistown (same location as MN), at grade off road;
8. Airport, underground in same location as Metro North;
9. Airside, at-grade off road;
10. Pinnockhill (on western side of roundabout), at-grade off road;
11. Pavillions, at-grade;
12. Swords Castle, at-grade; and
13. Estuary, at-grade.

The average distance between consecutive stops is 1,100m. Figure 8.2 illustrates the proposed alignment and stops.

LR3 would provide a connection between the DART and Airport-Swords via one interchange at Tara Street DART Station (approx. 400m walking distance from Tara to LCC stops O'Connell or Marlborough) or by using Luas Red Line between Connolly and Abbey Street. LR3 would also link Maynooth railway line to Airport-Swords via Broombridge Stop (with two changes at Broombridge and Cabra). Construction of DART Underground would create an interchange with LR3 at St Stephens Green.

<u>Tunnelling</u>

Two separate tunnelled sections are proposed on the LR3 route, as follows:

- Underneath Glasnevin Cemetery and Botanic Gardens – 2.0km; and
- Underneath Dublin Airport – 2.2km.

Twin bored tunnels would be constructed with an internal diameter of 5.8m, slightly narrower than the proposed heavy rail tunnels.

At the southern end of the Glasnevin Tunnel, the alignment branches off the LCC line after the Cabra stop within 150m drops into bored tunnel to pass beneath properties along Shandon Gardens.

At approximately 1km along the tunnel section, an access shaft will be required for the Glasnevin tunnel. Ideally this would be placed in the grounds of the Botanic Gardens but this is unlikely to be acceptable. Previous proposals placed a shaft in the grassed area of Claremont Lawns, however this divides the tunnel into lengths of approximately 450m and 1550m. An in-depth risk assessment, in conjunction with detailed discussions with the Emergency Services, may conclude that this 1550m length is acceptable.

Shafts associated with the Airport tunnel will be easier to position in this much less densely populated part of the proposed route.

Neither end of the proposed tunnel is ideal for the launching of a tunnel boring machine. Mount Bernard Park is surrounded on all sides by residential properties with no principal road in the vicinity. At the north end, the site availability is limited and lies adjacent to St Michael's School. Parents and teachers will be concerned about the disruption to pupils from noise and the distractions of construction activities. At the southern end launching from Mount Bernard Park looks to be the more favourable option but impacts to the local neighbourhood will have to be worked through in detail.

<u>Structures</u>

A major new bridge structure will be required for LR3 to cross the M50 motorway south of Dublin Airport. It is anticipated that the structure would comprise a steel or concrete bridge of one or two spans. The design and construction of this bridge would be a relatively straightforward but planning for the installation over the motorway may cause difficulties. However, comparable rail over motorway structures on other networks have been assembled adjacent to the road and moved into place during a single overnight closure of the motorway.

Otherwise, only relatively minor bridge structures will be required to carry LR3 over roads, waterways and other obstacles.

Utilities

It is anticipated that utility services will be located along the full length of this route with the possible exception of Glasnevin Cemetery where the LR3 would run deep underground. In particular, underground infrastructure for electricity, gas, water and telecommunications is expected to be heavily concentrated in the following areas:

- Ballymun Road (R108);
- Dublin Airport campus;
- Swords Road (R132);
- Dublin Road, Swords; and
- Swords Main Street.

Utility services located in these areas will probably need to be either diverted or strengthened in advance of the tramway construction, to accommodate the additional imposed loads and facilitate future maintenance of utilities.

Construction Impact

The main impacts of LR3 construction are as follows:

- Possible vibration impacts at-grade during tunnel construction;
- Disruption at the Airport during construction of the underground station;
- Permanent traffic diversions on Swords Main Street to facilitate on-street running, this includes the introduction of one-way systems in the town and the elimination of on-street parking;
- Disruption to traffic on Ballymun Road during construction of the on-street section;
- Disruption in the vicinity of Mount Bernard Park where it is proposed that the TBM would be launched from;
- Possible disruption to the operational LCC line at the Cabra junction with LR3; and
- Possible disruption during the placement of light rail bridge over the M50 at Ballymun.

LR3 Summary of Technical Feasibility

The technical feasibility of LR3 has been developed on the basis of work previously undertaken by RPA and reviewed and updated by AECOM. Investigations into the structural and tunnelling requirements to support the proposed alignment and stations has been undertaken and determined that the route is technically feasible. Vertical and horizontal alignment drawings for LR3 have been developed.

Although the route is recommended as technically feasible, a summary of the main project risks are as follows:

- Geotechnical assessments will be required to confirm the feasibility of proposed tunnels;
- Locating a tunnelling shaft in a confined residential area could be problematic;
- Construction of the Airport station within a confined area within the GTC;
- Construction of the alignment within live carriageways such as Ballymun Road; and
- Community support for at-grade running of LR3 through Ballymun (previously raised as an issue during Metro North planning).

8.2.2 LR3 Operational Assessment

The operational feasibility of LR3 is somewhat dependent on LCC operations. Within the City Centre long sections of the route are unsegregated, with the trams sharing with buses and other vehicles from St. Stephen's Green to Broadstone. Therefore, while the transport modelling carried out for this option has assumed a potential maximum service pattern of 24 trams per hour to forecast transport demand, in operation a maximum frequency of 21 trams per hour is more realistic. This reflects the level of co-running by other traffic along the tram lanes over this 2.5 to 3 kilometre city Centre section, and the fact that this line will cross the Luas Red line at Abbey Street where priority between the two lines would need to be shared.

While traffic management improvements have been proposed within the City Centre, which may assist the movement of trams through the central area, these proposals have not yet been adopted and, even if adopted, there will still be a significant level of co-running continuing along the tram lines, particularly with bus services.

Similar to the City Centre, within Swords there are significant areas of non-segregated operation, particularly on Swords Main Street, where the tram service shares the lane configuration with certain other traffic.

Given the above, a prudent approach to assessing likely operational capacity has been adopted in relation to this option, with a realistic frequency limit of 21 trams per hour considered in the capacity analysis.

Approximately 80% of the proposed corridor would run in a segregated corridor which ensures efficient run times. A design speed ranging from a minimum of 30kph (at road junction only) to 50-70kph on the majority of the route is expected with an overall journey time of 25 minutes from O'Connell Street to the Airport and 35 minutes to Estuary.

It is anticipated that 53m light rail vehicles, similar to style to the current Luas vehicles, would run on the line. The design capacity of these vehicles is 285 passengers. Therefore, based on 21TPH, this would provide a design capacity of 5,985pphpd for LR3.

Figure 8.3: LR3 theoretical operational scenario to forecast travel demand.

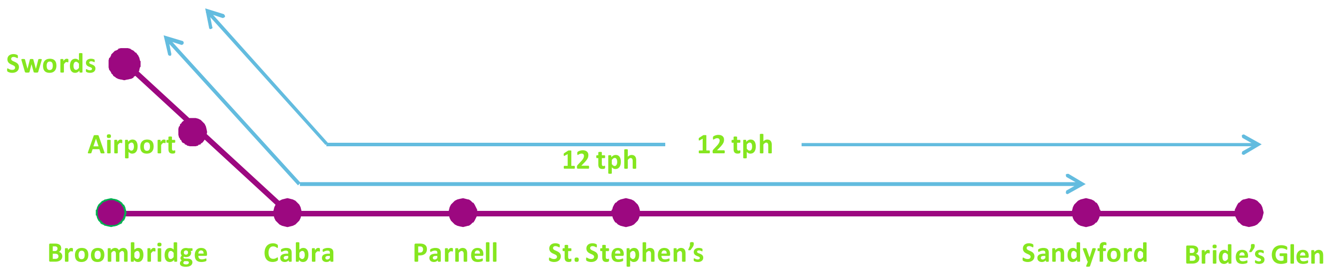


Table 8.1: Summary of LR3 operational capacity

Vehicles	Capacity	Frequency	Journey Times
53m Light Rail Vehicles	Design capacity – 5,985pphpd	21TPH (realistic estimate)	O' Connell St to Airport – 25 min O' Connell St to Estuary – 35 min

8.2.3 LR3 Environmental Assessment

The following environmental risks have been identified based on preliminary drawings for the LR3 alignment:

- **Air Quality:** Once operational, LR3 would have limited impact on air quality. Any changes in air quality would be associated with changes in traffic flows on the whole of Dublin's road network that are a direct result of delivery of the scheme. This is looked at in further detail in the Economic Appraisal section;
- **Noise and Vibration:** Vibration modelling would need to be undertaken to determine the likely impacts on both archaeological and architectural heritage at Glasnevin Cemetery as a result of proposed tunnelling;
- **Landscape and Visual Quality:** Potential impacts of LR3 development include the removal of trees, street furniture and paving to accommodate the alignment and stations, especially within Swords. Visual impacts of an at-grade line in less developed areas, such as Dardistown and south of Swords, will need to be considered as well as visual impacts from elevated sections close to the M50;
- **Biodiversity:** Appropriate Assessment (AA) screening of possible impacts of this route on the Natura 2000 sites would be required. It is also necessary to determine if there will be any impacts on designated sites as a result of the tunnelling and impacts on hydrological connections;
- **Cultural, Archaeological & Architectural Heritage:** The impact of tunnelling on a considerable density of Recorded Monuments and Protected Structures within the Glasnevin and Swords areas would need to be investigated. In particular, the potential for vibration impacts on Glasnevin Cemetery during construction need to be understood in greater detail. In addition, a programme of consultation is recommended so that potential religious or spiritual sensitivities can be considered and addressed during development of the programme. There is also a high concentration of important archaeological sites in Swords including Swords Castle which would need to be considered in the development of the project;
- **Land use, soils and geology:** Possible soil and geology impacts on historically contaminated lands would need to be investigated in greater detail, including: a quarry at Milestone, a smithy in Townparks, Swords and a gravel pit in Balheary; and
- **Surface Water** impacts on rivers which Line D2 would pass over including: Santry River, Mayne River tributary, Cuckoo Stream and Sluice River. In addition, it is noted that the line would pass under the Tolka River Basin.

The environmental impact of LR3 would need to be assessed in greater detail through completion of geotechnical surveys and vibration modelling to provide a full reflection of the scheme's impacts.

8.2.4 LR3 Transport Assessment

A transport demand assessment for the light rail option LR3 was conducted through the NTA's Greater Dublin Area Strategic Transport Model. In undertaking the analysis for the forecast year of 2033, demand matrices developed by the NTA were assigned to the Do Something network which included the LR3 scheme.

<u>LR3 Passenger Demand</u>

Table 8.2 summarises the total boardings on each public transport sub-mode, for the morning period of 07:00-10:00 in the forecast year of 2033. As shown in Table 8.2 demand for Luas services (which include LR3) increase by 45.23% in the "Do Something" scenario. Introduction of the new service would draw passengers from existing bus services with a cumulative 6% reduction on bus service boardings. Additionally some demand will be drawn from rail services with decreases of 1.08% and 1.49% respectively forecast on DART and suburban rail services. The overall impact of the scheme is a 0.19% increase in public transport boardings.

Table 8.2: AM Period Public Transport Boardings

Mode	Do Min Boardings	Do LR3 Boardings	% Diff
DART	40,795	40,353	-1.08%
Suburban Rail	62,812	61,878	-1.49%
Dublin/City Bus	241,111	226,790	-5.94%
Other Bus	57,179	51,485	-9.96%
Luas	***49,171***	***71,409***	***45.23%***
Total	451,066	451,914	0.19%

LR3 Network Statistics

The overall performance of the modelled transport network for the Do Something LR3 scenario can be examined through an analysis of the transport network demand.

As can be seen from Table 8.3 scheme option LR3 has a positive impact on public transport patronage in AM peak hours with 1,680 new trips forecast on public transport services during the AM peak hours 07:00 to 10:00. Of these new trips 1,032 come from private car trips with the remainder coming from slow modes (cycling and walking).

Table 8.3: AM Period Travel Demand Impact LR3

Demand Impacts	Unit	Do LR3
Public Transport	Trips	1,680
Highway	Trips	-1,032

The peak hour passenger loads for scheme option LR3, southbound and northbound services are shown in Figures 8.4 and 8.5. In the figures presented here the existing Luas Green Line services from Brides Glen and Sandyford to St. Stephens Green have been combined with the future LR3 services in order to outline the full Estuary to Brides Glen light rail public transport offering that would be available on the implementation of LR3 scheme option.

Figure 8.4 shows that on the southbound service in the AM peak hour, passenger demand is strong at Estuary, Swords Castle, Pavilions and Dublin Airport, as well as at Trinity in the city centre. The highest demand is forecast at Dublin Airport where a peak boarding of almost 1,380 passengers is estimated in the AM peak hour. This is lower than the forecasted Airport boarding's for HR8 because the journey times to the City Centre on LR3 are almost 15 minutes longer. Key destinations on LR3, and on the Green Line south of LR3, include Grangegorman, the City Centre stops (particularly Marlborough Street and Trinity) and Stillorgan. Peak loading on LR3 is estimated at approximately 5,540 passengers (occurring at Glasnevin/Botanic). This represents 93% of the available design capacity for a 21TPH service.

Figure 8.5 shows that on the northbound service high passenger demand is generated at the existing Luas Green Line stops including Balally, Cowper and Ranelagh. The key destinations are St. Stephens Green, Westmoreland and Dublin Airport. The northbound service is experiencing issues of overcrowding in the vicinity of Ranelagh, where it reaches peak loading of 7,055 passengers. This represents 118% of the available design capacity for a 21TPH service.

Figure 8.4: AM Peak Loadings LR3 Southbound Estuary to Brides Glen

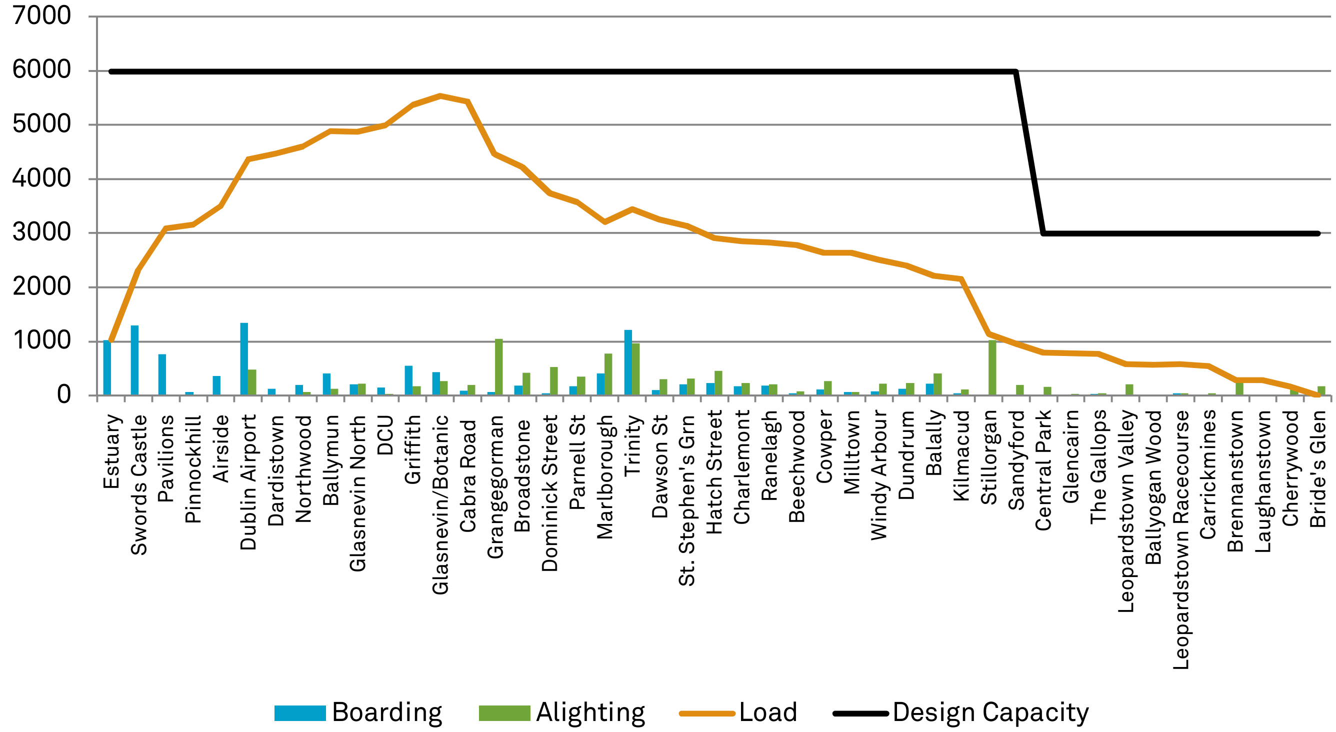
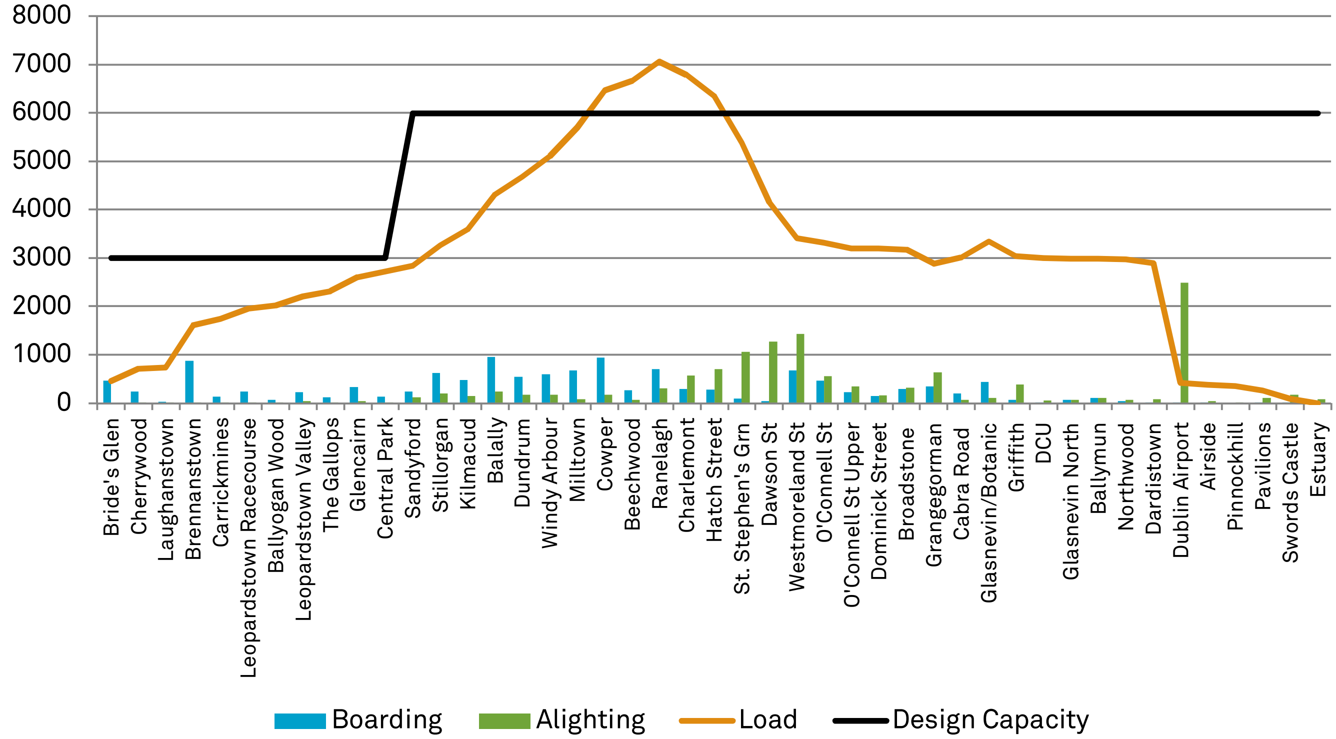


Figure 8.5: AM Peak Loadings LR3 Northbound Brides Glen to Estuary



Sensitivity Analysis

Based on the high levels of demand anticipated on LR3 and the risk of the scheme running overcapacity shortly after the opening year, additional sensitivity analysis has been undertaken using the GDA Strategic Transport Model. The sensitivity analysis assessed the impact on passenger numbers of the following scenarios:

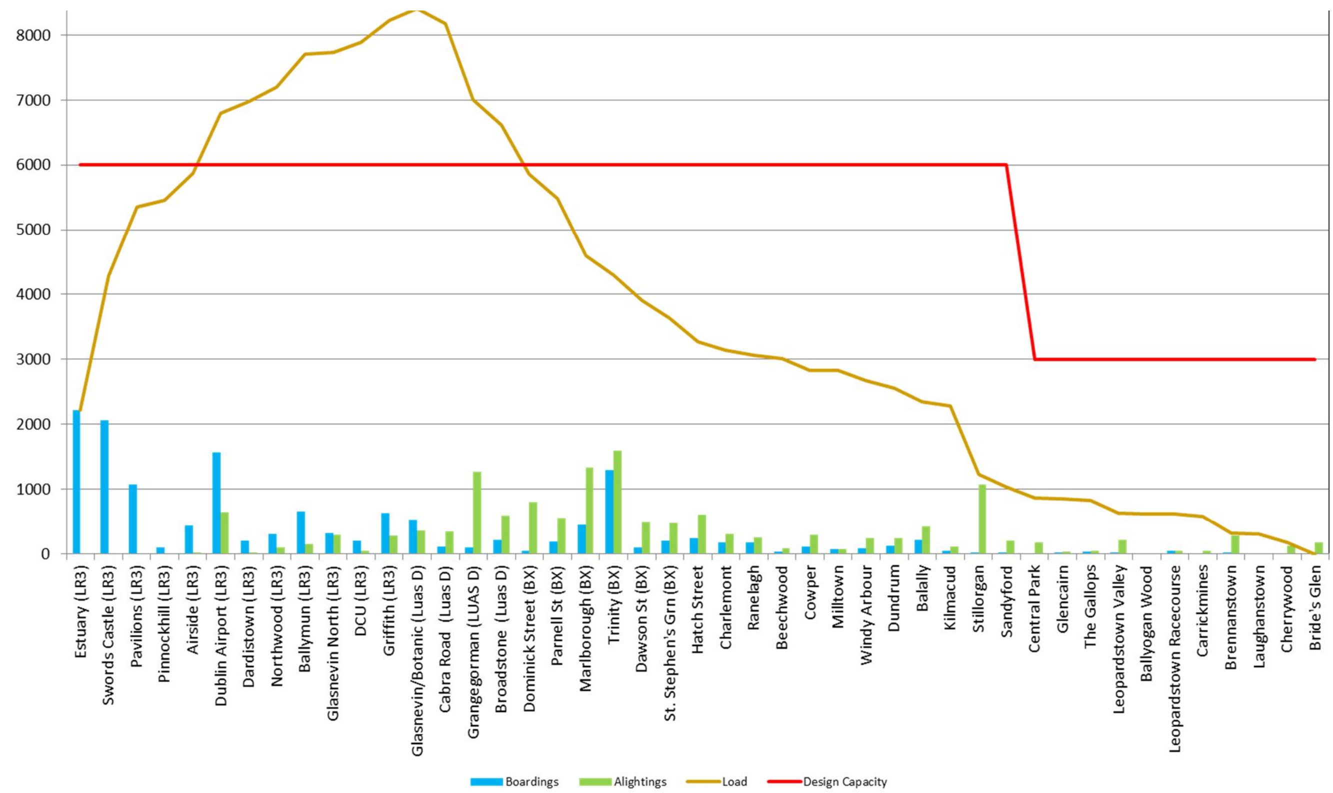
- Higher levels of population and employment growth at Swords;
- Higher levels of employment and passenger growth at the Airport;
- The inclusion of Park and Ride facilities at Swords; and
- The introduction of demand management measures on the M50.

Based on these assumptions, which are highly plausible, anticipated demand on LR3 would increase to peak flows of up to 8,300pphpd southbound in the AM peak. This level of demand is significantly higher than the design capacity of the proposed scheme at 138% of the design capacity (21TPH service). Even in the highly unlikely scenario that a frequency of 24TPH could be facilitated through the city centre, this level of demand would be still be 121% of the available design capacity of a 24TPH service pattern.

A further sensitivity assessment was also carried out, which included the addition of the Park and Ride facility plus the implementation of demand management measures on the M50 only. In this scenario, the peak southbound lineflow in the am peak hour was approximately 7,500 pphpd, exceeding the available design capacity of a 21TPH service by 25%.

On the basis of these sensitivity tests, it is unlikely that LR3 would have sufficient capacity to appropriately cater for future travel demand within the study area.

Figure 8.6: LR3 2033 AM peak southbound line flows – sensitivity analysis results



LR3 Generalised Cost Impact

Changes in generalised cost of travel relative to the Do Minimum scenario, as forecast by the NTA's strategic multimodal model, are presented in Figure 8.7 below. Any reductions in generalised costs indicate areas where the scheme is having a beneficial impact i.e. reducing the generalised cost of travel thereby making public transport options more attractive. However, it should be noted that changes in aggregate generalised cost do not encompass the full benefits of the scheme, which is estimated in Section 12 Economic Appraisal if the proposed scheme is brought forward for further appraisal.

As can be seen from Figure 8.7, scheme option LR3 has a positive impact on the generalised cost of travel along the Swords to City Centre corridor with reduction of 5% - 15% of the generalised cost of travel forecast from Swords as far as Santry. Closer to the City Centre, some lower reductions in the generalised cost of travel are seen in the Finglas, Ballymun and Cabra zones.

In spite of these reductions in generalised costs along the Swords to City Centre corridor, some disbenefits or increases in the generalised cost of travel are predicted in zones at Broombridge and westwards along the Western Suburban Line.

This occurs due to some of the Luas Cross City line services stopping at Cabra, when scheme option LR3 is implemented, rather than Broombridge as it does in the Do Minimum scenario.

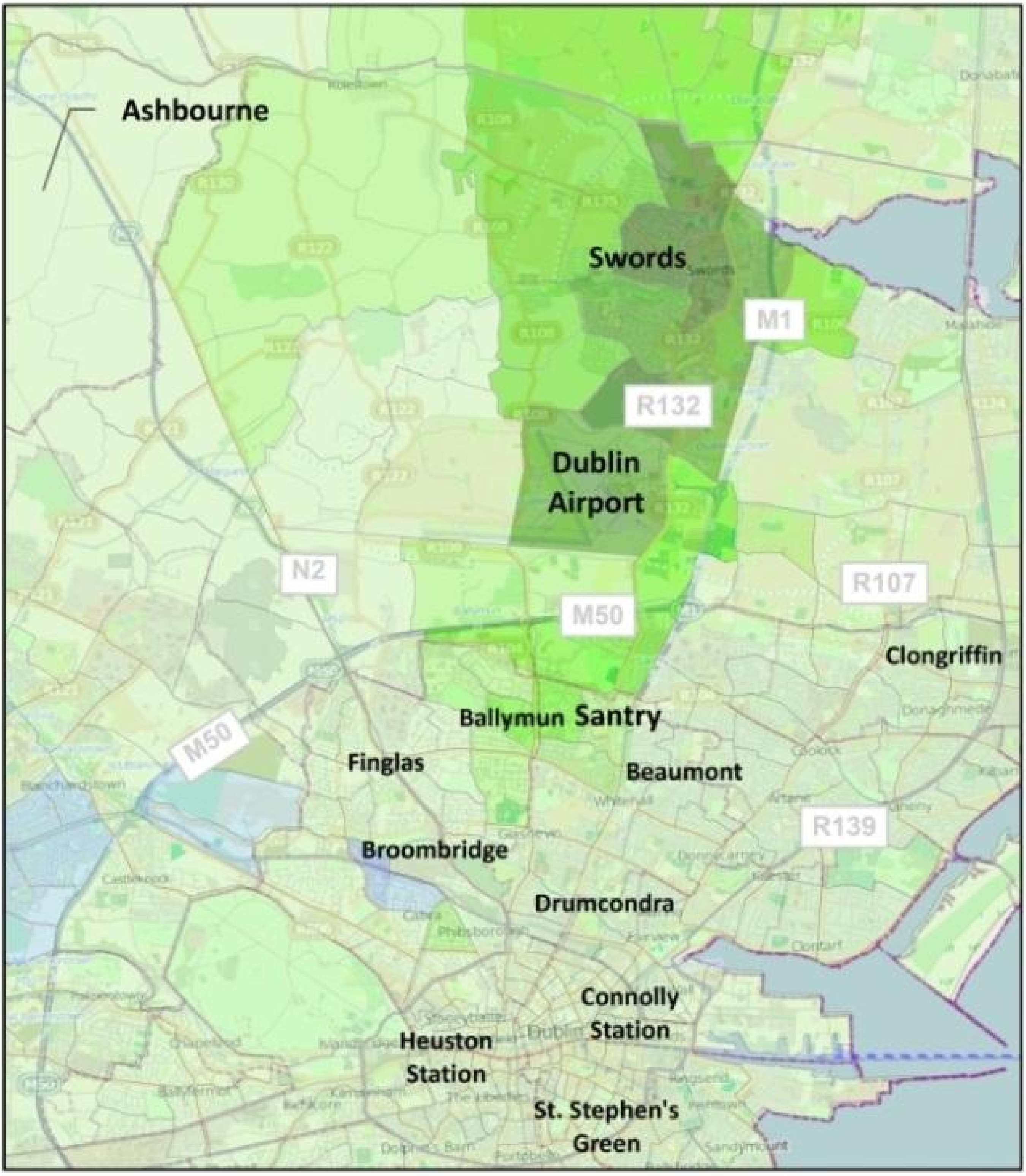
Summary of LR3 Transport Assessment

The transport assessment suggests that the proposed scheme option LR3 will generate high demand at Estuary, Swords Castle, Pavilions and Dublin Airport. In the scheme opening year, 2033, the demand generated on LR3 utilises 93% of the available design capacity on the south bound services, and 118% on the northbound services.

Sensitivity analysis of LR3 has been undertaken on the assumption of higher employment and population growth as well as the introduction of Park and Ride facilities and demand management measures on the M50. Results of this analysis indicate a much higher level of demand, in the order of 8,300pphpd southbound in the AM peak. This level of demand would represent 138% of the available design capacity of the scheme assuming 21TPH. Excluding the higher growth, but retaining the Park and Ride provision plus the M50 demand management measures, results in forecast passenger demand of 7,500pphpd, 25% above the available design capacity of a 21 TPH service.

Accordingly, it is considered that LR3 does not have sufficient capacity to appropriately cater for likely future travel demand along this corridor.

Figure 8.7: 2033 Change in Generalised Cost Do Something Option LR3 relative to Do Minimum Option



8.2.5 LR3 Cost Estimate

A summary of the proposed cost estimate for LR3 is shown in Table 8.4. The scheme is estimated to cost approximately €1.3bn to deliver. This estimate includes preliminary costs at a factor of 30%, a risk factor of 30% as well as VAT (13.5%). With regard to rolling stock, it is assumed that 24 new Luas vehicles would be required at a cost of €3m each to operate the service. It should be noted that this is a concept stage cost estimate and therefore the degree of estimating uncertainty is set at +/- 30% of our estimate value.

As noted previously further assessment of traffic impact may require additional grade separation at major junctions which would increase capital costs of this option.

*Table 8.4: Summary of LR3 capital cost estimates**

Total LR3 Capital Costs				
	Description			**Total Amount**
i)	Construction Costs (incl. land acquisition)			660,257,000
ii)	Client Costs			59,424,000
iii)	Rolling stock			72,000,000
			Sub total	**791,690,000**
iv)	Design costs			52,821,000
v)	Miscellaneous client costs and project burdens		2.00%	15,834,000
vi)	Risk	860,345,000	30.00%	258,104,000
vi)	VAT	1,118,449,000	13.50%	150,990,615
			Total Cost	**1,269,439,615**

** Note that the capital costs developed are for comparative purposes only*

Operating and maintenance (O/M) costs have also been developed for LR3, on the basis of current average costs, at a cost of €22.2m per annum. These costs are summarised in Table 8.5. These combined capital and O&M costs have been taken forward for the purpose of economic appraisal of LR3.

Table 8.5: Summary of LR3 operating and maintenance costs

LR 3 Light Rail Cabra to the Airport & Swords		
Operations	Staff	€4,903,227
	Fuel	€1,149,988
	Insurance	€919,493
	Other	€2,723,787
Vehicles	Routine Maintenance	€3,566,335
	Additional Works	€327,505
Infrastructure	Cleaning & Landscaping	€200,000
	Routine Highway Maintenance	€2,812,149
TVM	Routine Maintenance	€234,082
Subtotal		**€16,836,566**
Contingency		€5,050,970
Non-recoverable VAT		€286,153
Total O&M		**€22,173,689**

8.2.6 LR3 Summary

LR3 is proposed as a 13km light rail extension of the Luas Cross City from Cabra to Estuary via the Airport. The proposed route would include two tunnels, one under Glasnevin (2.0km) and another under the Airport (2.2km). The route would offer services to 13 new stations of which 11 would be at-grade and 2 underground.

Some of the main technical risks associated with delivery of LR3 include:

- The impact of tunnelling on sites of cultural heritage at Glasnevin Cemetery have yet to be determined through detailed geotechnical surveys;
- Long term disruption to Swords Main Street with traffic being diverted within the area to facilitate on-street tram running; and
- Development of underground stations, especially at the Airport, will result in temporary disruption and present some technical risk.

Delivery of LR3 is estimated to cost €1.3bn (or €1.1bn if VAT is not applicable) with additional operating costs of €22m per annum.

The route would offer journey times of 25 minutes from O'Connell Street to the Airport and 35 minutes from O'Connell Street to Estuary.

The service would operate with 53m light rail vehicles offering a design capacity of 5,985pphpd based on an assumption of 21TPH.

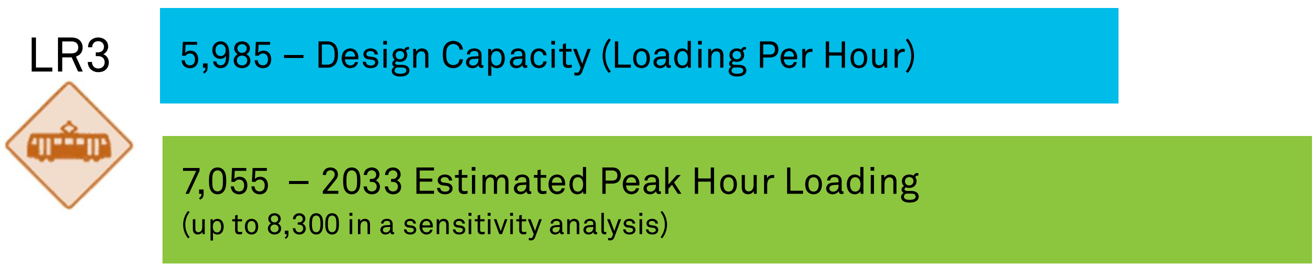
It is expected that southbound LR3 services would be running close to capacity in an opening year of 2033 with an estimated demand of 93% of available capacity. However, the northbound demand is significantly higher with AM peak demand at Ranelagh reaching 7,055, 118% of a 21TPH service. Even in the unlikely scenario that capacity could be increased to 24TPH, this level of demand would still be in excess of what the system could accommodate.

Results of sensitivity analysis emphasise capacity issues on LR3 and indicate that the scheme would not have the capacity to respond to future increases in travel demand. Higher population and employment forecasts, the introduction of demand management on the M50 as well as Park and Ride facilities at Swords, would push southbound AM peak demand to 8,300pphpd, 138% of the available capacity with 21TPH. Excluding the higher growth, but retaining the Park and Ride provision plus the M50 demand management measures, results in forecast passenger demand of 7,500 pphpd, 25% above the available design capacity of a 21 TPH service.

LR3 as proposed does not have sufficient capacity to meet the travel demand within the study area and has therefore been eliminated from further appraisal as it does not meet the project objectives.

Increasing the potential capacity of LR3 would require construction of a separate tunnel section through the City Centre to avoid the constraints caused by on-street running through the city centre. In addition to facilitating a higher frequency of service, a tunnel would also facilitate longer vehicles. The following section looks at opportunities to deliver LR3 with a tunnelled section through the city centre to increase operating capacity.

Figure 8.8: Summary of LR3 design capacity and expected demand



8.3 Tunnelled LR3

The previous section has highlighted LR3 capacity issues which are mainly related to the limitations of on-street running through the city centre. In order to increase capacity on the LR3 line, a proposal which provides a tunnel through the City Centre has been developed in consultation with the RPA. This could effectively follow on from the completion of LR3 outlined above. This section investigates the feasibility of this tunnelled extension from Broadstone to St Stephens Green via Jervis Street.

8.3.1 Tunnelled LR3: Technical Feasibility

Tunnelled LR3 is 16.5km in length (including the common LCC section at Cabra), 3.5km longer than LR3 with two additional underground stations at St Stephens Green and Jervis Street.

Alignment

There are two notable differences between the LR3 alignment and Tunnelled LR3 as follows:

- In order to facilitate longer trams (60m), faster journey time, higher frequencies and better reliability the route would run at-grade around the R132 on Swords, similar to LR7; and
- A tunnelled extension of the route would run from Broadstone to St Stephens Green via Jervis Street.

The full alignment is shown in Figure 8.12. As shown, the alignment would run on the LCC section between Cabra and Broadstone where the line would diverge from the LCC towards Jervis Street in a tunnel of approximately 2.5km in length.

The exact layout of the Tunnelled LR3 shared stop with LCC at Grangegorman will depend on the junction configuration. With a simple flat junction a two-platform layout could be retained. However, if a grade-separated junction was to be constructed then the stop at Grangegorman would need to be remodelled and enlarged. The larger stop would comprise two island platforms, providing four platform faces.

Stations

The full Tunnelled LR3 route would include 17 stations, incorporating four of the LCC planned stops. The proposed list of Tunnelled LR3 stations is as follows:

1. St Stephens Green – underground stop located under the Green;
2. Jervis Street – underground stop on Abbey Street adjacent to the current Luas Red Line;
3. Grangegorman – at-grade stop on the planned LCC;
4. Phibsborough – at-grade stop on the planned LCC;
5. Cabra – at-grade stop on the planned LCC;
6. Glasnevin/Botanic – stop on N2 in front of Glasnevin Cemetery entrance and museum, in bored tunnel;
7. Griffith (at Griffith Avenue – Old Ballymun Road junction) stop, in cut and cover;
8. DCU (same location as MN) – at-grade stop in road median;
9. Glasnevin North (Collins Avenue junction) – at grade stop in road median;
10. Ballymun (same location as MN) – at-grade stop in road median;
11. Northwood (same location as MN) – at-grade stop off road east of Ballymun Road;
12. Dardistown (same location as MN) – at-grade stop off road;
13. Airport – underground stop in same location as Metro North;
14. Fosterstown – at-grade stop adjacent to Airside Business Park;
15. Swords – at-grade stop on R132 close to Pavilions Shopping Centre;
16. Seatown – at-grade stop serving the IDA Business Park;
17. Estuary, at-grade stop.

Two city centre underground stops would be constructed at St Stephens Green and at Jervis Street. The proposed Jervis Station could be developed in a vacant site off Strand Street north of the current Luas Red Line Stop. The station could be constructed as an open-cut 'box' structure and the concourse could either be constructed at street level or, if the land was to be used for other purposes, below ground.

Figure 8.9 – Site at Abbey Street/ Strand Street, immediately adjacent Jervis Street Luas Stop.

The St Stephen's Green Station could be constructed as an open-cut box station in the same location as the previously proposed for Metro North. The deferred DART Underground line is also due to have an underground station at St Stephen's Green. It is recommended that the LR3 underground station should make provision for a future interchange with DART Underground.

Tunnels

The new tunnelled LR3 section from Broadstone to St Stephen's Green would comprise approximately 120m of cut and cover tunnel and 2.18km of twin tunnel bore tunnels.

At this stage of the project there is limited ground information available, however ground investigations carried out for the earlier planned Metro North project offer some details for this route option.

Approaching the City Centre the depth of bedrock is typically between 15 and 25m below ground level (bgl). This increases to between 23 and 32m bgl as a result of the combination of a rise in ground levels and the existence of a pre-glacial channel at the upper end of O'Connell Street. The levels rise to the River Liffey and continue on the south side of the river at levels between 7 and 12mbgl.

From an initial desktop study the depth of tunnel is known to be constrained by the River Liffey. From the Metro North geological section it appears that the river is approximately 7.5m deep, which would leave only 6.5m cover to the tunnel crown. This cover depth should not be reduced any further and, subject to detailed ground investigations, may need to be increased. This is likely to have an effect on the depth of the nearby Jervis station box.

Another likely alignment constraint is the presence of existing building foundations in Dublin City Centre. The horizontal alignment of the route is therefore likely to be required to run at significant depth to mitigate impact on large buildings. The resulting alignment may result in tighter curves (minimum radius 350m) with consequences for ride quality and increased track wear.

A Tunnel Boring Machine (TBM) would require a construction site area, both for launching as well as service operations. This site would accommodate, for example, site offices, welfare facilities, power supply for the TBMs, maintenance workshops, spoil storage / removal, lining segment storage/delivery, slurry spoil settlement tanks and plant movements. A space of 15,000m^2 (minimum desirable) should be allowed for a launch site and 6,000m^2 (minimum desirable) for a reception site.

Figure 8.10 – Bus Eireann Bus Depot Site at Broadstone.

It is noted that much of the Bus and Staff Parking area available at Broadstone Bus Depot would be required on a temporary basis for the TBM launch Site. While most of the area could be returned on completion of the works some would be lost permanently at this constrained site. For this reason it is assumed for the robust analysis of the proposed scheme that a new depot would be required for this option and this has been included in the cost estimates.

The TBM would be assembled and launched from the northern portal at Broadstone bus depot. Upon completion of tunnelling, the TBMs would be received, dismantled and removed from the station box at St Stephen's Green. While the station box in St Stephen's Green could potentially be used to launch a TBM, the likely disruption to the surrounding stakeholders, coupled with the difficultly of accessing the site will preclude this as a feasible option.

In the urban environment tunnelling settlements can damage the buildings above. Of the possible tunnelling techniques a TBM is best able to control these movements but a Sprayed Concrete Lined (SCL) tunnel could be considered for deeper tunnels.

Regulations require that the distance between emergency service access points should be approximately 1km. The length of the proposed tunnel is approximately 2km and therefore at least one intermediate access point should be provided between Broadstone and St Stephen's Green. Ideally, this should be combined with the proposed underground station at Jervis to minimise property acquisition and construction costs. The underground stations at Jervis Street and St Stephen's Green should also be equipped with tunnel ventilation equipment.

In the event of an emergency in twin bore tunnel systems, it is common to provide cross passages between the tunnels, thus using the non-event bore as a place of safety. The interval for such linkages can vary but the earlier planned Dublin Metro North project placed them every 250m.

Utilities

Utility services are located along the full length of the proposed Tunnelled Luas alignment. In particular, underground infrastructure for electricity, gas, water and telecommunications is expected to be heavily concentrated in the following areas:

- City centre;
- North inner city;
- Ballymun Road (R108);
- Dublin Airport campus;
- Swords Road (R132);
- Dublin Road, Swords; and
- Swords Main Street.

Utility services located in these areas will probably need to be either diverted or strengthened in advance of the tramway construction, to accommodate the additional imposed loads and facilitate future maintenance of utilities.

Figure 8.11: Proposed Tunnelled LR3 Alignment through Dublin City Centre

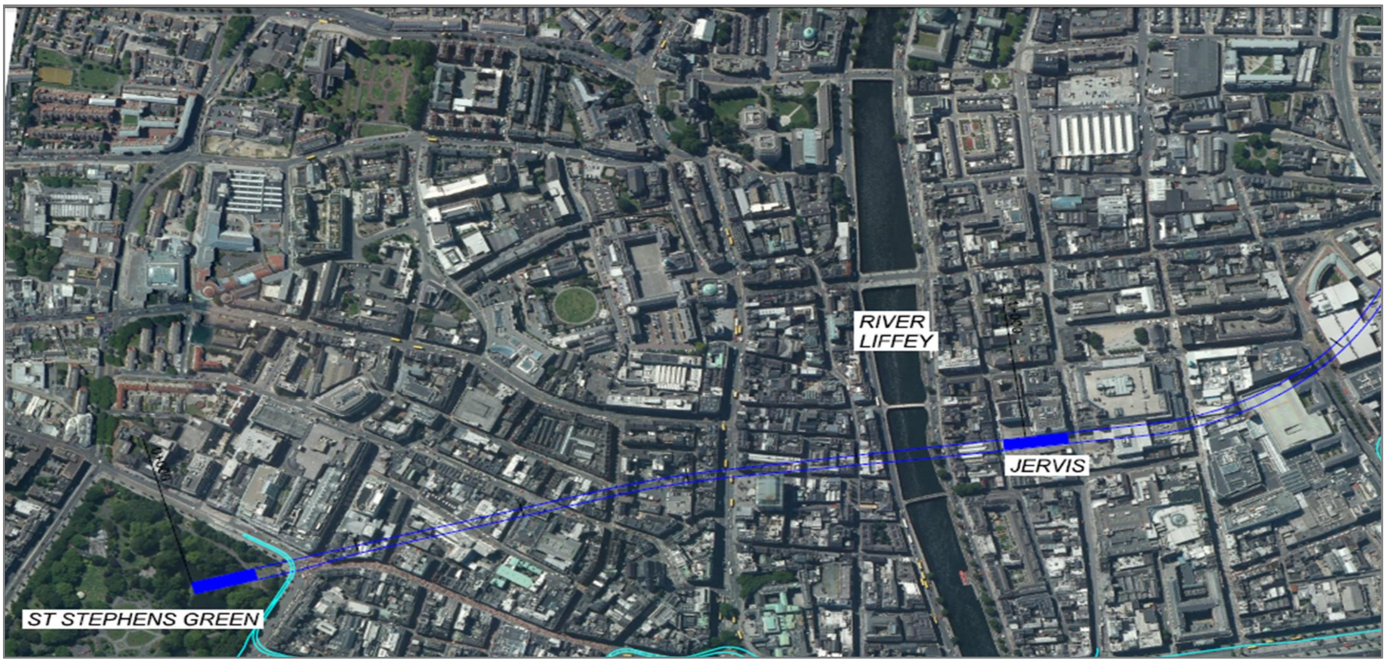
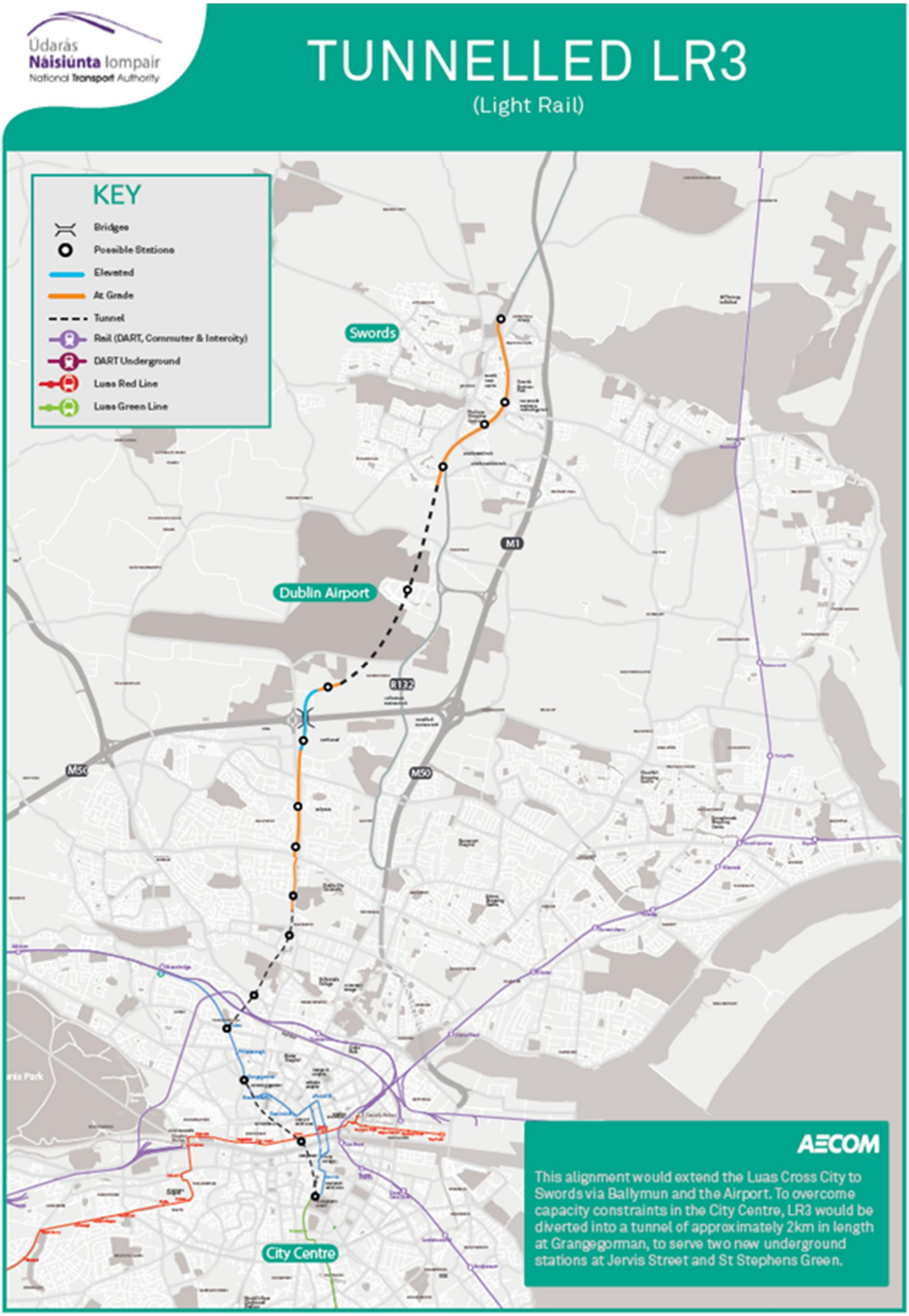


Figure 8.12: Tunnelled LR3 alignment



Construction Impact

The main impacts of Tunnelled LR3 construction are as follows:

- Significant disruption to Bus Eireann operations due to the use of the Broadstone Depot as a tunnel launch site and the permanent loss of about seventy bus parking spaces;
- Impacts on Dublin Bus operations due to tunnelling operations taking place in the vicinity of their Broadstone Depot;
- Impacts on LCC operations during construction of the tunnelled extension;
- Noise impacts in the city centre during TBM launch and operation;
- Possible vibration impacts at-grade during TBM operation;
- Disruption at the Airport during construction of the underground station;
- Disruption to traffic on the R132 around Swords during construction of the on-road sections;
- Disruption to traffic on Ballymun Road during construction of the on-street section;
- Disruption in the vicinity of Mount Bernard Park where it is proposed that the TBM would be launched from; and
- Possible disruption during the placement of light rail bridge over the M50 at Ballymun.

Summary of Technical Feasibility

At this early stage of the project the tunnelled LR3 route from Broadstone to St Stephen's Green is considered to be technically feasible. However, detailed ground investigations should be undertaken to confirm the assumptions made during preparation of this report.

Station box construction at Jervis and St Stephen's Green are also feasible but, due to their location in the centre of Dublin, will result in significant temporary disruption to their environs.

A grade-separated LCC/LR3 junction at Broadstone is expected to offer the greatest operational flexibility and capacity. However, a simple flat junction would require significantly less permanent land take. Both options are considered to be technically feasible but the selected junction type should be dictated by LUAS's operational requirements and the availability of land. For cost estimating purposes a grade-separated junction has been included.

8.3.2 *Tunnelled TLR3 Operational Assessment*

With a high degree of segregation and no shared running with other services, Tunnelled LR3 is capable of providing a high frequency service that is independent of other public transport network constraints.

However Tunnelled LR3 would share a section of twin track, running from Grangegorman to Cabra, with the Luas Cross City services linking Broombridge to the City Centre and further southwards along the existing Luas Green Line. This represents an operational constraint as this section of line will only be able to cater for a certain number of services.

Tunnelled LR3 would operate on the basis of 24TPH from Swords to St Stephens Green. This assumption is made on the prudent basis that a maximum of 30TPH could operate on the shared section between Grangegorman and Cabra. The operation of this 24 TPH service on LR3 would mean that the service to Cabra and Broombridge would be 6 TPH, which is lower than the service frequency planned at the opening of Luas Cross City.

While a higher capacity than 30 TPH along the common section may be achievable, it is unlikely to be significantly higher.

This limitation would also present issues for any potential light rail expansion to Finglas from Broombridge. An available service frequency of only 6 TPH is unlikely to provide sufficient capacity to meet the transport demand of the Finglas corridor. While a higher level of frequency along the common section may prove operationally feasible, it is unlikely to be sufficient to be able to address the tram frequency of both Tunnelled LR3 and an extended Luas line to Finglas. Accordingly, the implementation of Tunnelled LR3 would be likely to preclude the extension of Luas Cross City to the Finglas area.

Tunelled LR3 would operate using 60m light metro vehicles. This would offer a design capacity of 7,920pphpd based on 24TPH. The service would offer the following journey times:

- SSG to the Airport: 22 minutes; and
- SSG to Estuary: 34 minutes.

Table 8.6: Summary of TLR3 operational feasibility

Vehicles	Capacity	Frequency	Journey Times
60m Light Rail Vehicles	Design capacity: 7,920pphpd	24TPH	O'Connell Street* to Airport – 20 mins O'Connell Street* to Estuary – 32 mins

Jervis Street

8.3.3 Tunnelled LR3 Environmental Assessment

The environmental risks raised by Tunnelled LR3 are similar to those previously identified for LR3 as set out in Section 8.2.3. Additional risks arise in the vicinity of the R132 where the route would run at-grade and within the city centre where a 2.5km tunnel would be constructed. A summary of key risk areas, in addition to those previously highlighted for LR3, include:

- **Noise and Vibration:** Vibration modelling would need to be undertaken on the tunnelled alignments to determine the likely impacts on at-grade and underground structures;
- **Cultural, Archaeological & Architectural Heritage:** Temporary removal or relocation of monuments during construction, in particular the siting of TBM launch points;
- **Land use, soils and geology:** Detailed geotechnical surveys required to understand soil and geology mitigation measures. Temporary/permanent changes to land use likely, particularly at Broadstone;
- **Landscape and Visual Quality:** Potential impacts of LR3 development include the removal of trees, street furniture and paving to accommodate the alignment and stations, especially within Ballymun and on the R132 alignment; and
- **Water** impacts on and of rivers which Tunnelled Luas would under including the River Liffey need to be determined in greater detail using geotechnical surveys.

8.3.4 Tunnelled LR3 Transport Assessment

A transport demand assessment for Tunnelled LR3 was conducted through the NTA's Greater Dublin Area Strategic Transport Model. Demand matrices developed by the NTA were assigned to the Do Something network which included Tunnelled LR3.

<u>Tunnelled LR3 Passenger Demand</u>

Table 8.7 summarises the total boardings on each public transport sub-mode, for the morning period of 07:00-10:00 in the forecast year of 2033. As shown in Table 8.7 demand for Luas services (which include Tunnelled LR3) increase by 53.63% in the "Do Something" scenario. Introduction of the new service would draw passengers from existing bus services with a cumulative 6.27% reduction on bus service boardings. The overall impact of the scheme is a 0.93% increase in public transport boardings.

Table 8.7: Tunnelled LR3 AM Period Public Transport Boardings

Mode	Do Min Boardings	Do Tunnelled LR3 Boardings	% Diff
DART	40,795	40,784	-0.03%
Suburban Rail	62,812	61,243	-2.50%
Dublin/City Bus	241,111	226,003	-6.27%
Other Bus	57,179	51,677	-9.62%
Luas	***49,171***	***75,540***	***53.6%***
Total	451,066	455,248	0.93%

<u>Network Statistics</u>

The overall performance of the modelled transport network for the Do Something Tunnelled LR3 scenario can be examined through an analysis of transport network demand.

As can be seen from Table 8.8, Tunnelled LR3 has a very positive impact on public transport patronage in AM peak hours with 1,800 new trips forecast on public transport services during the AM peak hours 07:00 to 10:00. Of these new trips 1,080 come from private car trips with the remainder coming from slow modes (cycling and walking).

Table 8.8: AM Period Travel Demand Impacts LR7

Travel Demand Impact	Unit	Do LR7
Public Transport	Trips	1,800
Highway	Trips	-1,080

The peak hour passenger loads for Tunnelled LR3, southbound and northbound services, are shown in Figures 8.13 and 8.14. Figure 8.13 shows that on the southbound service, passenger demand is strong at Estuary, Pavillions, Airside and Dublin Airport. The highest demand is forecast at Estuary where a peak boarding of over 2,023 passengers is estimated in the AM peak hour. Peak hour boarding at Dublin Airport is estimated to be approximately 1,392 passengers. Key destinations on Tunnelled LR3 are Dublin Airport, Griffith Avenue, Grangegorman, Jervis Centre and St. Stephens Green. Peak loading on the southbound service occurs at Glasnevin/Botanic, with 5,804 passengers – approximately 73% of design capacity. No overcrowding issues are forecast on the southbound service in its opening year, 2033.

Figure 8.14 shows that the northbound service generates high passenger demand at the St. Stephens Green and Jervis Centre stops. Peak loading occurs at Glasnevin/Botanic, with approximately 3,721 passengers (47% of design capacity). No overcrowding issues are evident on the northbound services, with substantial reserve capacity being available.

Tunnelled LR3 Generalised Cost Impact

Changes in generalised cost of travel relative to the Do Minimum scenario, as forecast by the NTA's strategic transport model, are presented in Figure 8.15 below. Any reductions in generalised costs indicate areas where the scheme is having a beneficial impact i.e. reducing the generalised cost of travel thereby making public transport options more attractive. However, it should be noted that changes in aggregate generalised cost do not encompass the full benefits of the scheme, which are discussed in Section12 Economic Appraisal.

As shown, Tunnelled LR3 has a positive impact on the generalised cost of travel along the Swords to City corridor with reduction of 2%-19% of the generalised cost of travel forecast along the Swords corridor. These reductions in generalised cost feed into the Tunnelled LR3 patronage.

Tunnelled LR3 Demand Modelling Summary

Based on a service pattern of 24TPH, Tunnelled Luas will generate high demand at Estuary, Pavillions, Airside, Dublin Airport, Grangegorman, Jervis Centre and St. Stephens Green. Tunnelled Luas is expected to utilise 73% of available capacity on southbound AM peak services in 2033. Tunnelled LR3 has sufficient capacity to meet the forecast travel demand upon opening with spare capacity to accommodate further growth. Therefore this option should be brought forward for further appraisal.

Figure 8.13: AM Peak Hour Loading Tunnelled TLR3 Southbound Estuary to St. Stephens Green 2033

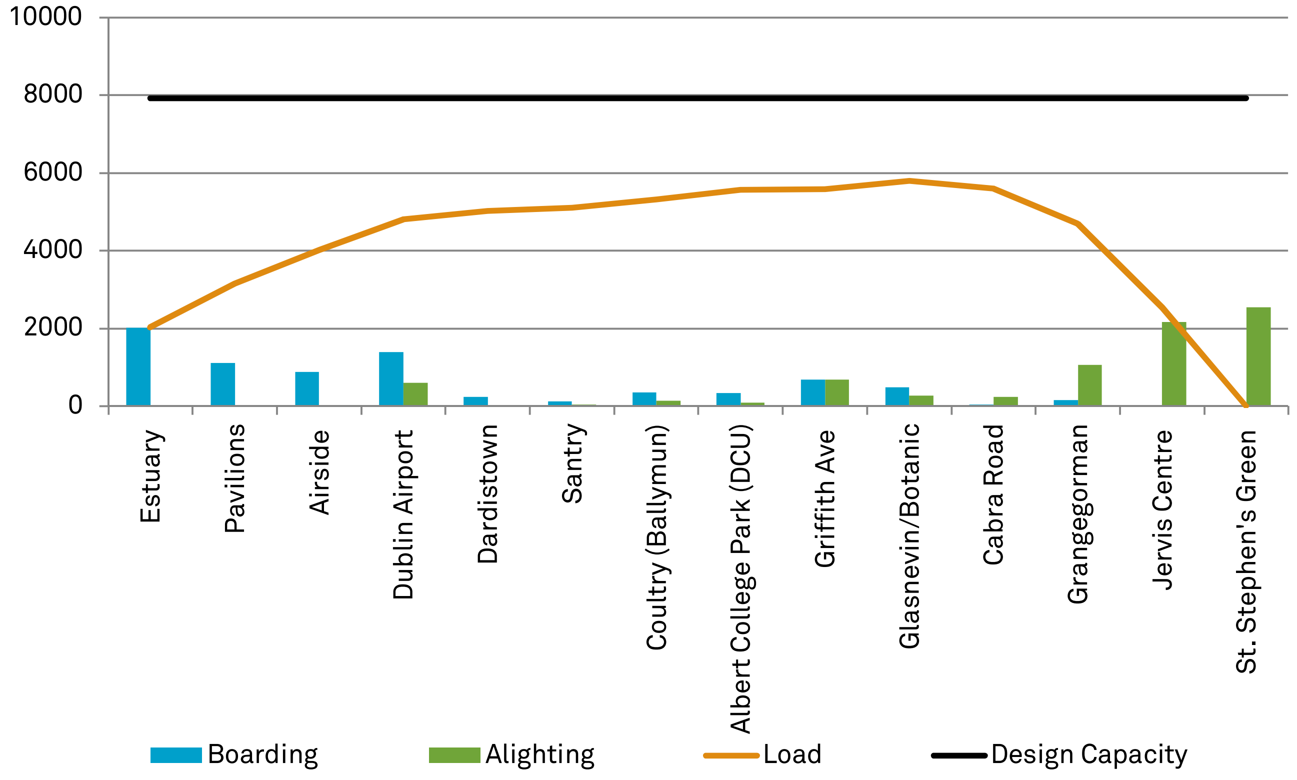


Figure 8.14: AM Peak Hour Loading Tunnelled TLR3 Northbound St. Stephens Green to Estuary 2033

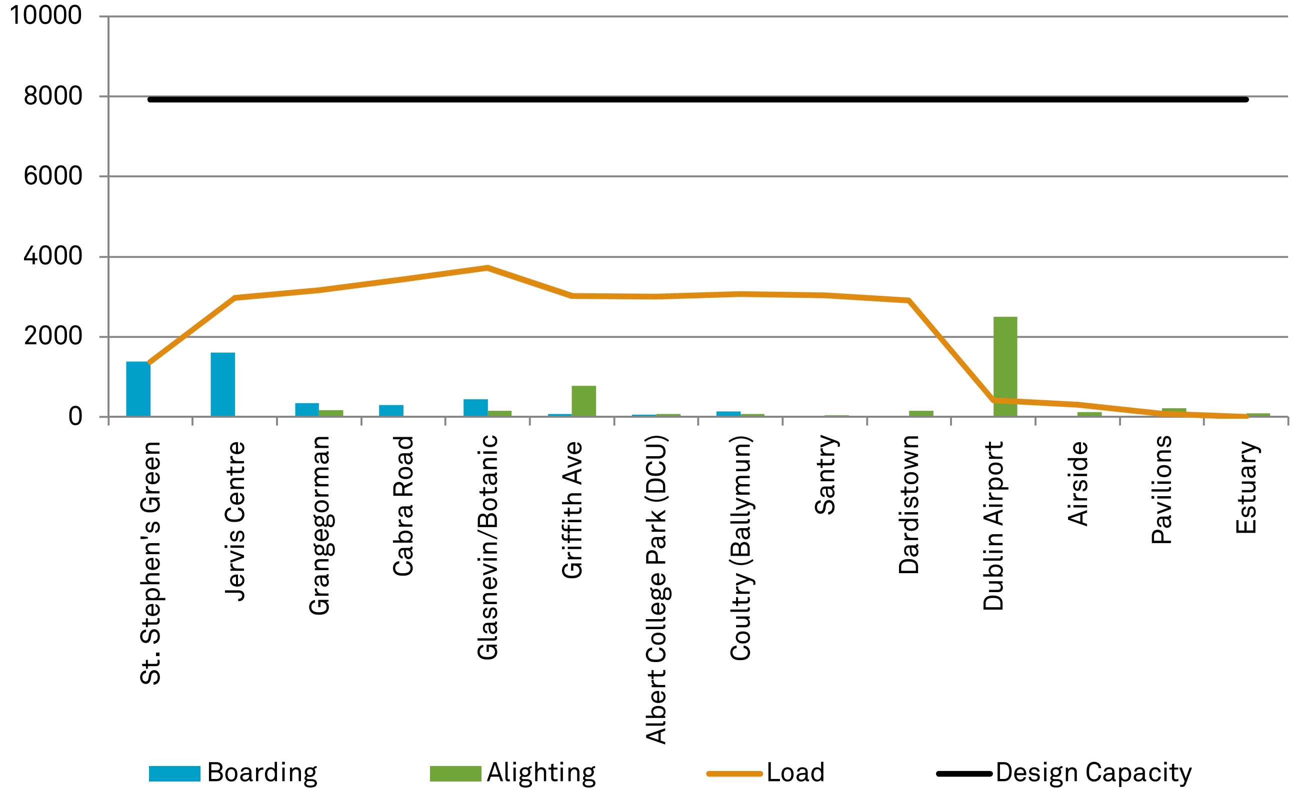
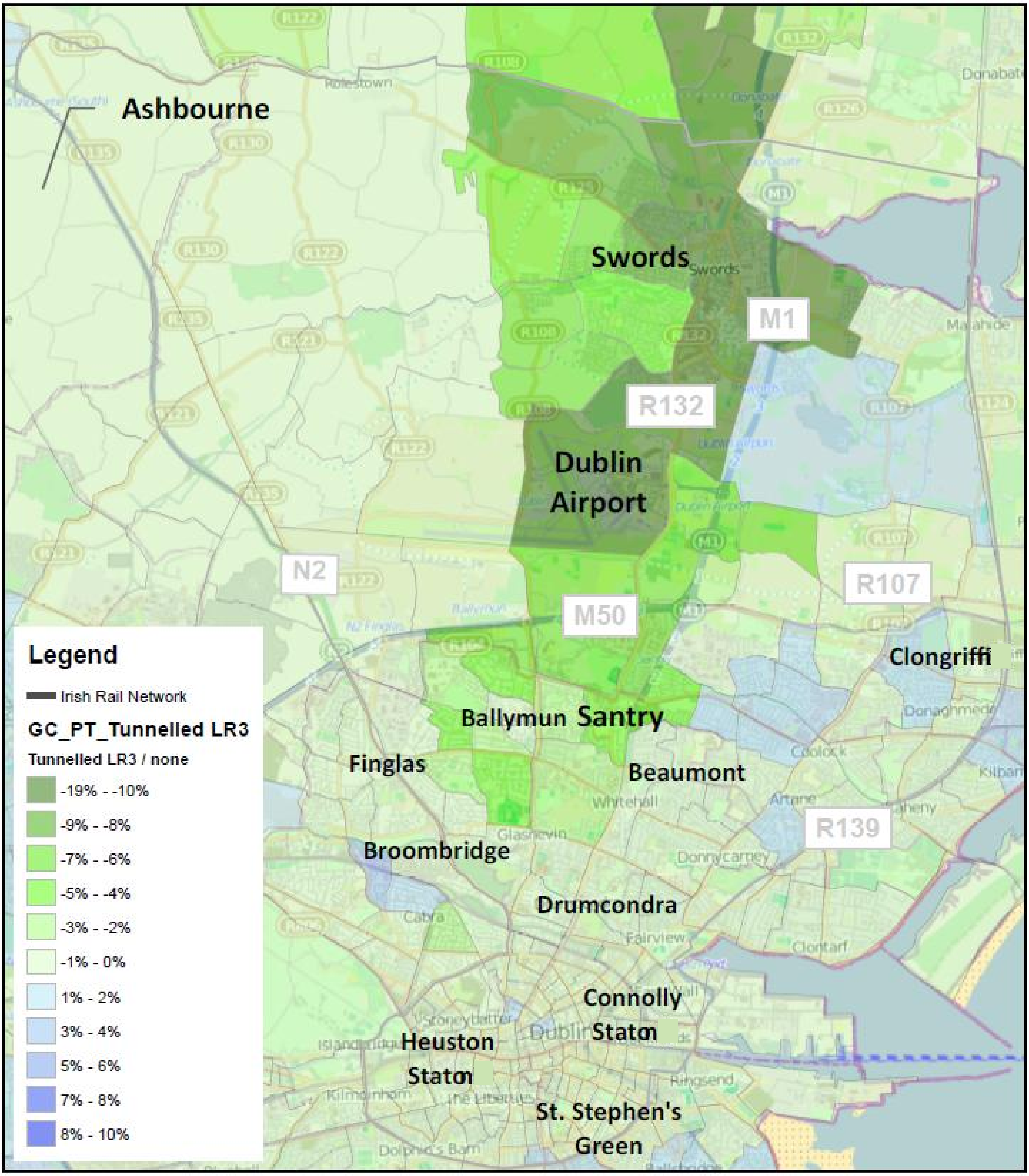


Figure 8.15: 2033 Change in Generalised Cost Do Something Tunnelled Option LR3 relative to Do Minimum Option



8.3.5 Tunnelled LR3 Cost Estimate

A summary of the proposed cost estimate for Tunnelled LR3 is shown in Table 8.9. The scheme is estimated to cost approx. €2.2bn to deliver (or €1.9bn if VAT is not applicable). This estimate includes preliminary costs at a factor of 30%, a risk factor of 25% as well as VAT (13.5%). With regard to rolling stock, it is assumed that 30 new light rail vehicles would be required. It should be noted that this is a concept stage cost estimate therefore the degree of estimating uncertainty is set at +/- 30% of our estimate value.

It should be noted that further assessment of traffic impact may require additional grade separation at major junctions which would increase capital costs for this option.

*Table 8.9: Summary of Tunnelled LR3 capital cost estimates**

Tunnelled LR3 Capital Costs				
Description				**Total amount**
i)	Construction/Direct Costs (incl. land acquisition)			1,222,260,000
ii)	Design costs			97,782,000
iii)	Client Costs			110,004,000
iv	Rolling stock			120,000,000
			Sub total	**1,550,046,000**
v)	Miscellaneous client costs and project burdens		2.00%	31,000,920
vi)	Risk	1,581,046,920	25.00%	395,261,730
vii)	VAT	1,976,308,650	13.50%	266,801,668
			Total cost	**2,243,110,318**

** Note that the capital costs developed are for comparative purposes only*

Operating and maintenance costs have also been developed for LR7, on the basis of current average costs, at a cost of approximately €25m per annum. These costs are summarised in Table 8.10. These capital and O/M costs have been taken forward for the purpose of economic appraisal of LR7.

Table 8.10: Summary of Tunnelled LR3 operating and maintenance costs

Annual LR7 Operating and Maintenance Costs		
Operations	Staff	€4,732,063
	Fuel	€1,349,948
	Insurance	€1,071,957
	Other	€3,721,624
Vehicles	Routine Maintenance	€4,186,447
	Additional Works	€327,505
	Depot	€112,842
Infrastructure	Cleaning & Landscaping	€233,333
	Routine Highway Maintenance	€3,301,124
TVM	Routine Maintenance	€273,096
Subtotal		**€21,380,071**
Contingency		€5,759,129
Non-recoverable VAT		€335,800
Total O&M		**€25,292,026**

8.3.6 Tunnelled LR3 Summary

Tunnelled LR3 is proposed as a 16.5km light metro route connecting St. Stephens Green to Estuary via Dublin Airport. Almost 7km of the route would run in a tunnel in three sections through the city centre, Glasnevin and the Airport. The route serves key destinations such as Henry Street, Grafton Street, Grangegorman and Ballymun in addition to the Airport and Swords.

Delivery of Tunnelled LR3 is estimated to cost €2.2bn (or €2.0bn if VAT is not applicable) with additional operating and maintenance costs of €25m per annum.

Tunnelled LR3 would offer journey times of 20 minutes from St Stephens Green to the Airport and 29 minutes to Estuary.

The service would operate with 60m light metro vehicles, which offers a design capacity of 7,920pphpd on the assumption of 24TPH.

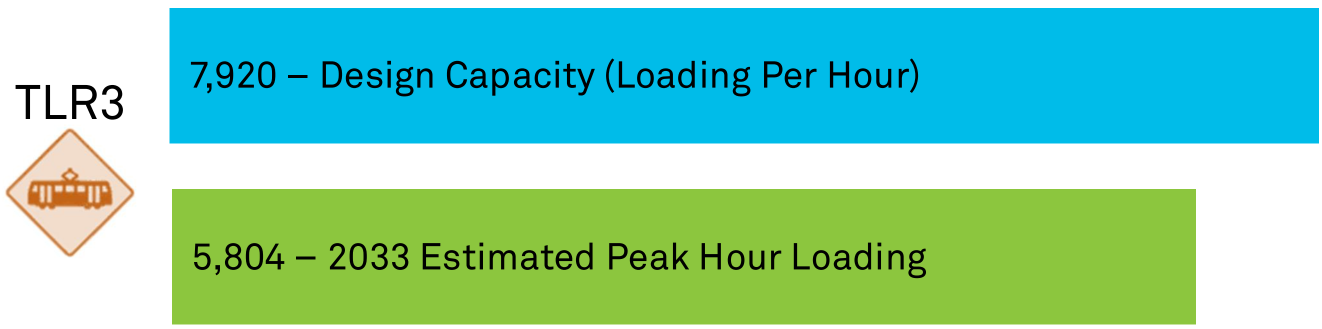
Tunnelled LR3 would share a section of twin track, running from Grangegorman to Cabra, with the Luas Cross City services This represents a significant operational constraint in the number of services on the two lines.

Assuming a prudent planning limitation of 30TPH on the shared section between Grangegorman and Cabra, a 24TPH frequency on Tunnelled LR3 would leave a residual 6TPH frequency available on the LCC line between Grangegorman and Cabra. In addition to this frequency being lower than the planned opening frequency of LCC, this also has implications for the potential extension of LCC to Finglas.

Arising from the constriant of the commin section, it is unlikely that there would be sufficient tram frequency capacity available to meet the transport demands of the Finglas corridor. While a higher level of frequency along the common section may prove operationally feasible, it is unlikely to be sufficient to be able to address the tram frequency of both Tunnelled LR3 and an extended Luas line to Finglas. Accordingly, the implementation of Tunnelled LR3 would be likely to preclude the extension of Luas Cross City to the Finglas area.

Tunnelled LR3 could potentially be delivered in two phases, with the initial development of a light rail extension from Cabra to Swords being the first phase, and a tunnelled city centre section being constructed as a second stage. As such, Tunnelled LR3 is being brought forward for further appraisal.

Figure 8.16: Summary of Tunnelled LR3 design capacity and expected demand



8.4 Optimised Metro North (LR7)

Opportunities to reduce the cost of Metro North were investigated on the basis of reduced passenger demand for the future transport network. Essentially, the original scheme was proposed on the assumption of a future demand of up to 20,000pphpd. However, this demand in unlikely to materialise within the design period, largely owing to the impact of the economic recession on population and employment forecasts. On this basis, the capacity requirement for Metro North was reduced with various opportunities for amendment to the scheme as follows[12];

- **Fewer stations:** The opening of Luas Cross City will provide greater accessibility around the city centre for public transport users. This offers an opportunity to review and rationalise the Metro North city centre stations. Metro North proposed stations at O'Connell Bridge and Parnell Square which presented technical difficulties due to construction constraints in the centre of the city. Now, it is proposed that the greater accessibility provided by Luas Cross City offers an opportunity to combine these two stations into a single station at O'Connell Street Upper;
- **Vertical alignment changes:** Underground stations and tunnels are expensive, thus running at grade where possible offers significant savings. Tunnelled stations through Ballymun were previously proposed but would involve signifcant financial cost due to the requirement for an undergound station that is in excess of 20m below ground. The potential to run the service at-grade through Ballymun was previously suggested but faced some local opposition. Now, it is recommended that the opportunity to revert the Ballymun section to a surface alignment be revisited. The elevated Metro North alignment on the R132 could also be changed to at-grade running with priority given to light rail running at junctions;
- **Smaller stations:** Based on a revised original sizing requirement of 12,000pphpd, it is possible to reduce tram lengths from 90m to 60m. Platform lengths within stations could therefore also be reduced; and
- **Rolling stock:** In addition to the construction savings outlined above, the revised capacity requirement reduces the quantity of rolling stock required by one third (two-car sets instead of three-car sets).

8.4.1 LR7 Technical Feasibility

For the purpose of Stage 2 Appraisal, AECOM has reviewed proposals for Optimised Metro North (LR7) as summarised in the following sections.

<u>LR7 Alignment</u>

The Optimised Metro North alignment is 16.5km long and runs between Estuary, to the north of Swords, and St. Stephen's Green, in the city centre. The at-grade alignment starts to the north of Swords and follows the R132, Swords Bypass, around the town running in the central median. The existing heavily congested roundabouts along this section would be converted to traffic signals with the alignment passing through the middle of the junctions providing a high level of priority over other traffic. To the south of the existing Malahide roundabout, the Swords stop is located adjacent to the Pavilions Shopping Centre and will be an integral part of a proposed extended Swords Main Street which will link the Pavilions Shopping Centre with the proposed Barrysparks development and existing Airside Development to the east of the R132.

South of the Swords stop, the alignment continues at-grade along the central median to the proposed Fosterstown stop located close to the Airside Retail Park on the R132. The alignment then continues at surface level through a greenfield area to a tunnel portal north of the Airport. The route runs under the Airport in a bored tunnel with an underground station located at the GTC providing access to Terminal 1 and 2.

South of the Airport, the alignment rises to surface level to cross agricultural lands between Dublin Airport

[12] *Source RPA Fingal/North Dublin Transport Study: Preliminary Appraisal Report August 2014*

and the M50 where the proposed Dardistown Stop is located. From this point, the route runs on surface along the R108 Ballymun Road, rising over busy signal controlled junctions at Santry and Collins Avenue. Stops will be located at Northwood, Ballymun and DCU.

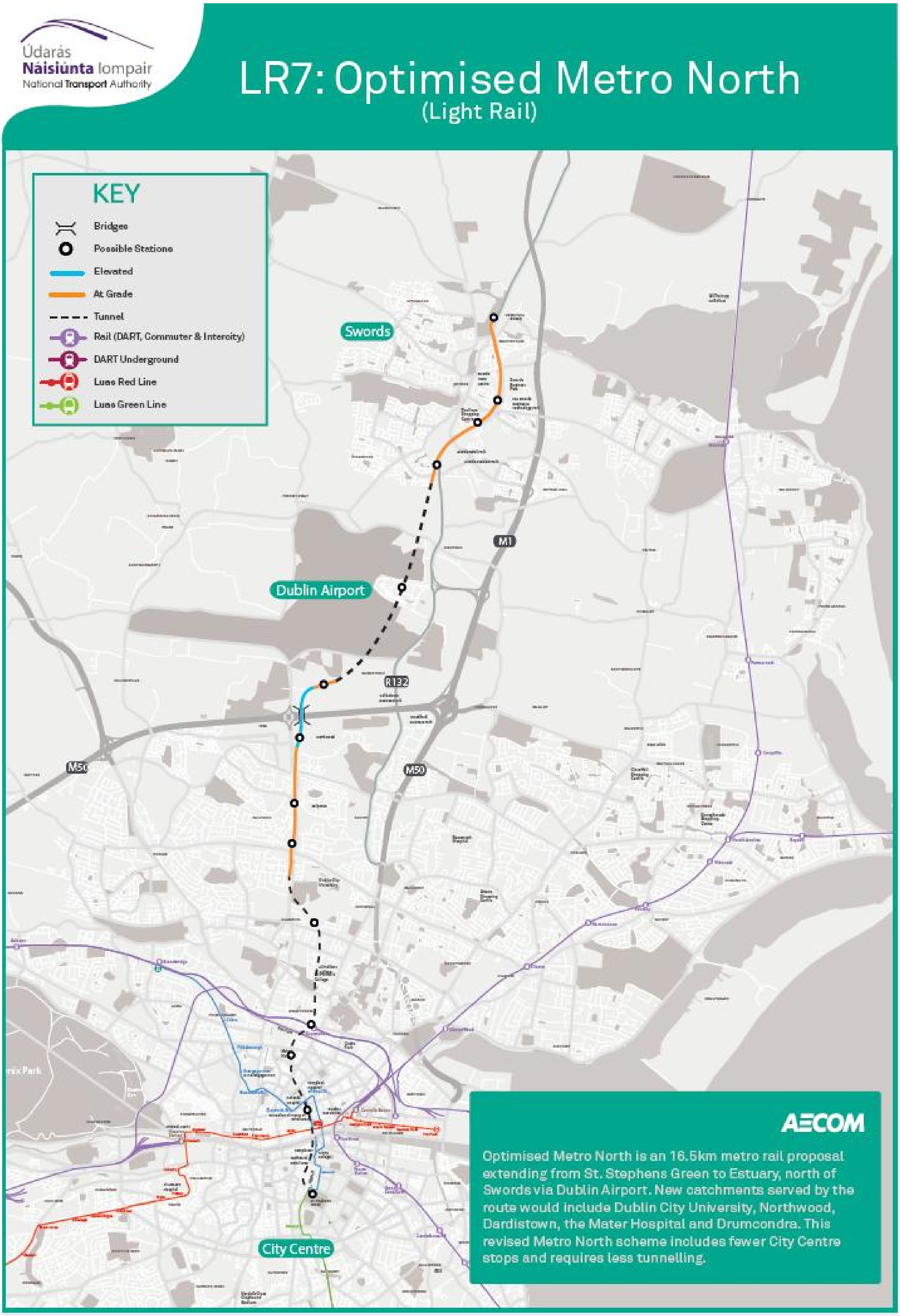
South of Collins Avenue, the alignment would enter cut and cover twin bored tunnels near the southern boundary of Hampstead Park. The alignment remains underground in a bored tunnel until the terminus at St. Stephen's Green.

From St Stephens Green there is potential to extend the tunnel further south to increase the current capacity of the Green Line, which is expected be exceeded in the intervening period.

It should be noted that more detailed assessment of the alignment in terms of traffic impact would be required to determine whether further grade separation of major junctions along the line is required. However, a contingency has been made within the cost estimate for the potential requirement for grade separation at Collins Avenue and Santry Avenue on the Ballymun Road.

The full LR7 alignment and stops are shown in Figure 8.17. More detailed drawings of the vertical and horizontal alignment have also been developed.

Figure 8.17: Proposed Alignment for LR7



LR7 Stops

There are fourteen stops along the route, 6 underground and 8 at-grade, as follows:

1. Estuary – at-grade stop;
2. Seatown – at-grade stop;
3. Swords – at-grade stop close to the Pavilion Shopping Centre ;
4. Fosterstown – at-grade stop close to Airside Retail Park;
5. Airport – underground stop at the Ground Transportation Centre in-between Terminals 1 and 2;
6. Dardistown – at-grade stop in-between the Airport and M50 and potentially serving future growth area;
7. Northwood – at-grade stop serving North Ballymun;
8. Ballymun – at-grade stop;
9. DCU – at-grade stop north of Collins Avenue;
10. Griffith Avenue – underground stop serving residential areas on St Mobhi Road and Home Farm Road;
11. Drumcondra – underground stop located to the west of Lower Drumcondra Road;
12. Mater – underground stop under the Mater Hospital;
13. O'Connell Street Upper – underground stop which replaces previously proposed O'Connell Bridge and Parnell Street stops; and
14. St. Stephen's Green – underground stop located on the northwest corner of St. Stephens Green.

LR7 Tunnelling

At the southern end of the alignment, the LR7 tunnel starts at a 21m deep station constructed at St Stephens Green and runs at depth until the alignment reaches the Ballymun Road to the north of Hampstead Avenue.

A total of five underground stations are proposed along the deep bored tunnel length from St Stephens Green to Ballymun. Shaft locations previously proposed for the original Metro North scheme within this section may need to be reviewed as tunnel lengths between stations have changed following the reduction in station numbers. Where no obvious sites are available in the City Centre to facilitate shafts, it is likely that an existing occupied site would need to be purchased.

The main tunnel alignment through the city lies between approximately 20m to 30m below ground level. At this depth the tunnel is largely in the limestone bedrock but between Parnell Square and Mater Hospital the top of bedrock lowers meaning the alignment will enter the superficial deposits composed of glacial till or glacial sands and gravels. The tunnel would ideally be driven from north to south. At the north end, a TBM could be launched from a site placed in the playing fields to the east of Ballymun Road to the north of Hampstead Avenue. The southern end of the alignment is at depth and in the City Centre. While the station box at St Stephens Green could potentially be used to drive the tunnel the likelihood is that this would cause too much disruption.

LR7 Structures

LR7 would require less structures than originally proposed for Metro North. Similar to Tunnelled LR3, LR7 would require a major new bridge structure across the M50. In addition, LR7 will run at-grade along the R132, Swords Bypass, instead of being elevated on viaducts.

All other structures along the route of LR7 will comprise bored tunnels and retained cuttings.

LR7 Utilities

It is anticipated that utility services will be located along the full length of the at-grade and elevated sections of LR7. In particular, services are likely to be heavily concentrated in the following areas:

- Ballymun Road (R108);
- Dublin Airport; and
- Swords Road (R132).

Utility services located in these areas will probably need to be either diverted or strengthened in advance of the Metro construction to accommodate the additional imposed loads and facilitate future maintenance of utilities. Services are less likely to be encountered at the depths required for the bored tunnels below Dublin city centre and Airport (typically 20m) and the likelihood of services requiring diversion or strengthening is considered to be relatively low.

LR7 Construction Impact

Of alll options shortlisted, LR7 will result in the most construction stage impacts within the City Centre, with extensive traffic, noise and dust impacts predicted for the following areas:

- St Stephens Green area;
- O'Connell Street (although confined to a smaller area then the original Metro North Scheme); and
- The Mater/ Drumcondra.

These areas will be impacted by large hoarded off works areas, increased traffic in the immediate vicinity of the works, localised dust and noise polution. For the original Metro North scheme An Bord Pleánala accepted that these temporary negative impacts could be mitigated to allow the project to proceed to construction. The Scheme Traffic Management Plan, which was developed for Metro North, will need to be updated to take into account the revised scheme and changes in traffic operations within the City Centre.

North of the Royal Canal the impacts of LR7 will be similar to Tunnelled LR3.

The construction stage impacts of LR7 are therefore likely to be severe and more wide ranging than the other options considered in this report, however, mitigation measures can be put in place to reduce impacts.

LR7 Technical Feasibility Summary

As LR7 is effectively a reduced scale Metro North, its technical feasibility has already been assessed to a much greater detail by the RPA with concept, preliminary and detailed design stages all completed, albeit requiring updating for the reduced scale scheme. In addition, the majority of the scheme designs have been assessed, and a Railway Order granted, by An Bord Pleánala. Therefore there is less risk with the design of this option as all required information was available and thoroughly reviewed by many parties associated with the project. However, the change of vertical alignment in the Ballymun area should be highlighted as a risk, as an at-grade proposal was rejected by the local community during the initial design stages of Metro North.

8.4.2 LR7 Operational Assessment

With a high degree of segregation and no shared running with other services, Optimised Metro North is capable of providing a high frequency, high capacity service that is independent of other public transport network constraints. This option will be designed to operate a maximum peak service frequency running at two minute headways (i.e. 30 trams per hour in each direction).

Optimised Metro North would operate using 60m light rail vehicles with a design capacity of 330 passengers per vehicle. This would offer a capacity of 9,900pphpd based on 30TPH. The service would offer the following journey times:

- O'Connell Street to the Airport: 19 minutes; and
- O'Connell Street to Estuary: 31 minutes.

Table 8.11: Summary of LR7 operational feasibility

Vehicles	Capacity	Freq.	Journey Times
60m Light Rail Vehicles	Design capacity: 9,900pphpd	30TPH	O'Connell Street to Airport - 19 mins O'Connell Street to Estuary - 31mins

8.4.3 LR7 Environmental Assessment

The RPA has undertaken a detailed Environmental Impact Assessment (EIA) of the original Metro North scheme. Results of this assessment have been revisited in the context of the proposed LR7 amendments. A summary of the main environmental issues highlighted are as follows:

- **Air Quality:** Once operational, the proposed scheme would have little or no negative impact on air quality along the alignment. Any changes in local air quality would be associated with changes in traffic flows on Dublin's road network as a result of the proposed scheme;
- **Noise and vibration:** Some residual noise impacts during construction and operations which will be minimised through design and mitigation measures. Vibration impacts during construction would need to be assessed in detail while no significant vibration impacts post-construction are likely due to tunnel depths;
- **Landscape & visual quality:** Some impacts from construction compounds, hoarding and removal of landscape features are expected. Mitigation measures can be applied. Some high or very high significance impacts during operation are possible where views are blocked. Mitigation measures can be implemented;
- **Biodiversity:** Some temporary loss of habitat of low nature conservation value during construction is expected. Some permanent loss of semi-natural habitat which is deemed insignificant due to the low species diversity it supports. When operational the proposed scheme will have no significant impact on habitats and surrounding wildlife;
- **Cultural, archaeological and architectural heritage:** Temporary removal or relocation of monuments during construction is possible. Removal of the curtilage of some buildings with architectural merit is possible. In addition, there are residual impacts from the visual impact of above ground structures on the existing environment;
- **Land use, soils and geology:** Residual impacts (construction and operations) are low or very low, as the majority of the scheme runs through areas already paved or which are of low sensitivity; and
- **Water resources:** Residual impacts (construction and operations) on groundwater are of low significance. Residual impacts (construction and operations) on surface water are of low magnitude with negligible to low significance.

8.4.4 LR7 Transport Assessment

A transport demand assessment for LR7 was conducted using the NTA's Greater Dublin Area Strategic Transport Model. In undertaking the demand forecasts for 2033, demand matrices developed by the NTA were assigned to the Do Something network which included the LR7 scheme.

<u>Passenger Demand</u>

Table 8.12 summarises the total boardings on each public transport sub-mode for the morning period of 07:00-10:00 in the forecast year of 2033 with LR7 in place. As shown in Table 8.12 demand for Luas services (which include LR7) increase by 64.85% in the "Do Something" scenario. Introduction of LR7 would draw passengers from existing bus services with a cumulative 8.05% reduction on bus service boardings. The overall impact of the scheme is a 1.54% increase in public transport boardings.

Table 8.12: LR7 AM Period Public Transport Boardings

Mode	Do Min Boardings	Do LR7 Boardings	% Diff
DART	40,795	40,978	0.45%
Suburban Rail	62,812	62,938	0.20%
Dublin/City Bus	241,111	221,699	-8.05%
Other Bus	57,179	51,317	-10.25%
Luas	***49,171***	***81,060***	***64.85%***
Total	451,066	457,992	1.54%

Network Statistics

The overall performance of the modelled transport network for the Do Something LR7 scenario can be examined through an analysis of transport network demand.

As shown in Table 8.13, LR7 has a very positive impact on public transport patronage in AM peak hours with 2,545 new trips forecast on public transport services during the AM peak hours 07:00 to 10:00. Of these new trips, 1,552 come from private car trips with the remainder coming from slow modes (cycling and walking).

Table 8.13 AM Period Travel Demand Impacts LR7

Travel Demand Impact	Unit	Do LR7
Public Transport	Trips	2,545
Highway	Trips	-1,552

The peak hour passenger loads for scheme option LR7, southbound and northbound services, are shown in Figures 8.18 and 8.19. Figure 8.18 shows that on the southbound service during the AM peak hour, passenger demand is strong at Estuary, Pavillions, Airside and Dublin Airport. The highest boarding demand is forecast at Estuary where a peak boarding of over 2,240 passengers is estimated in the AM peak hour. Peak hour boarding at Dublin Airport is estimated to be approximately 1,575 passengers. This is the highest predicted at Dublin Airport for any of the scheme options modelled and reflects the rapid journey times to the city centre offered by LR7 as well as the frequency of service. Key destinations on LR7 in terms of passenger demand are Dublin Airport, Drumcondra, Mater Hospital, O'Connell Street and St. Stephens Green. Peak loading on the southbound service occurs at Albert College Park (DCU stop), with 6245 passengers – approximately 63% of available design capacity. No overcrowding issues are forecast on the southbound service in the opening year of 2033.

The modelling work undertaken indicates that in the AM peak hour 3,220 passengers will alight at the O'Connell Street stop. This is the highest of all schemes illustrating the importance of O'Connell Street as a destination. This number is over 1,000 passengers higher in the peak AM hour than the Jervis stop on Tunnelled LR3.

Figure 8.19 shows that the northbound service generates high passenger demand at the St. Stephens Green, O'Connell St and Drumcondra stops. Key points of passenger demand are Griffith Avenue and Dublin Airport. Peak loading occurs at Drumcondra, with approximately 4,950 passengers (50% of design capacity). No overcrowding issues are evident on the northbound services, with substantial reserve capacity available.

A sensitivity analysis was carried out to assess likely line flows with higher population and employment forecasts, the introduction of demand management on the M50 as well as the provision of Park and Ride facilities at Swords. This indicated a potential maxuimum southbound AM peak demand in excess of 8,500 pphpd, still within the capacity of LR7.

Figure 8.18 AM Peak Hour Loading LR7 Southbound Estuary to St. Stephens Green 2033

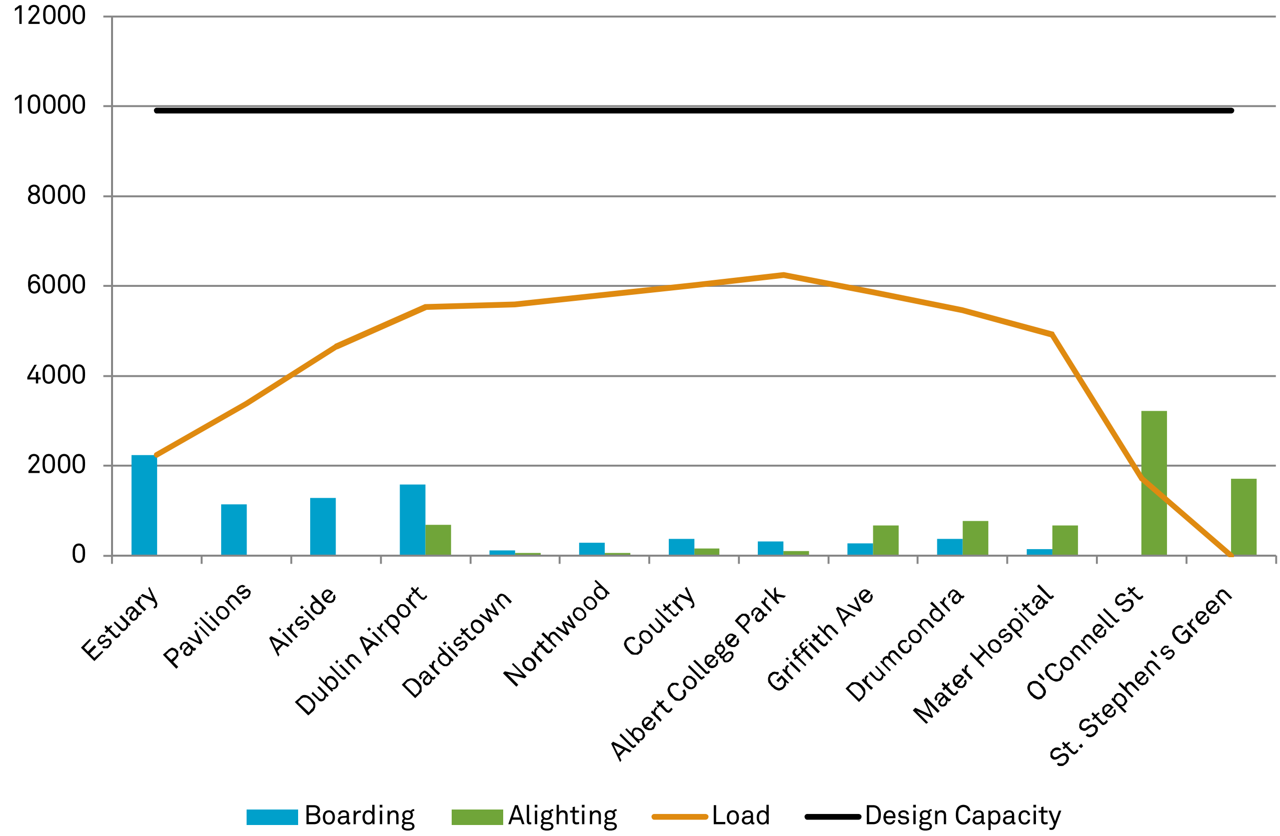
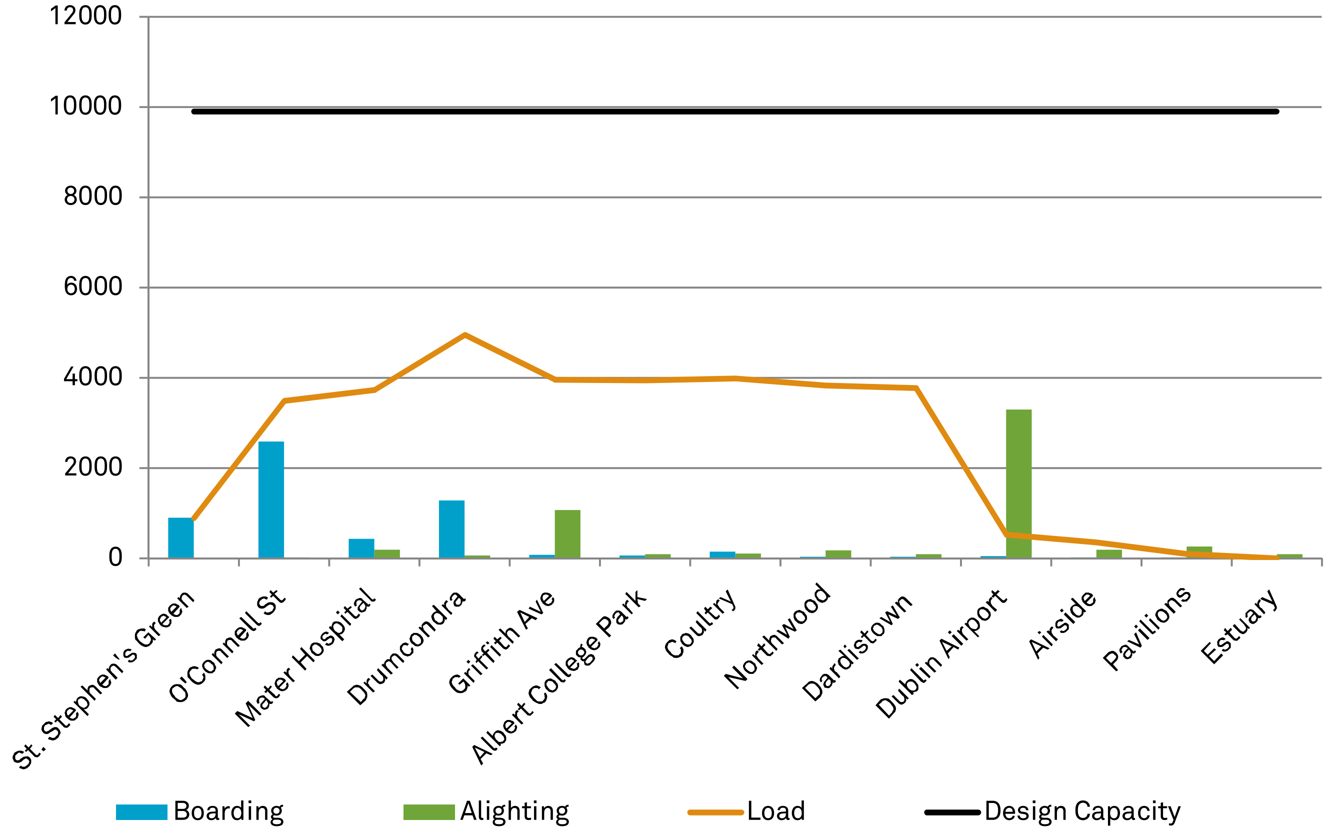


Figure 8.19: AM Peak Hour Loading LR7 Northbound St. Stephens Green to Estuary 2033



LR7 Generalised Cost Impact

Changes in generalised cost of travel relative to the Do Minimum scenario, as forecast by the NTA's strategic transport model, are presented in Figure 8.20. Any reductions in generalised costs indicate areas where the scheme is having a beneficial impact i.e. reducing the generalised cost of travel thereby making public transport options more attractive. However, it should be noted that changes in aggregate generalised cost do not encompass the full benefits of the scheme, which are discussed in Section12 Economic Appraisal.

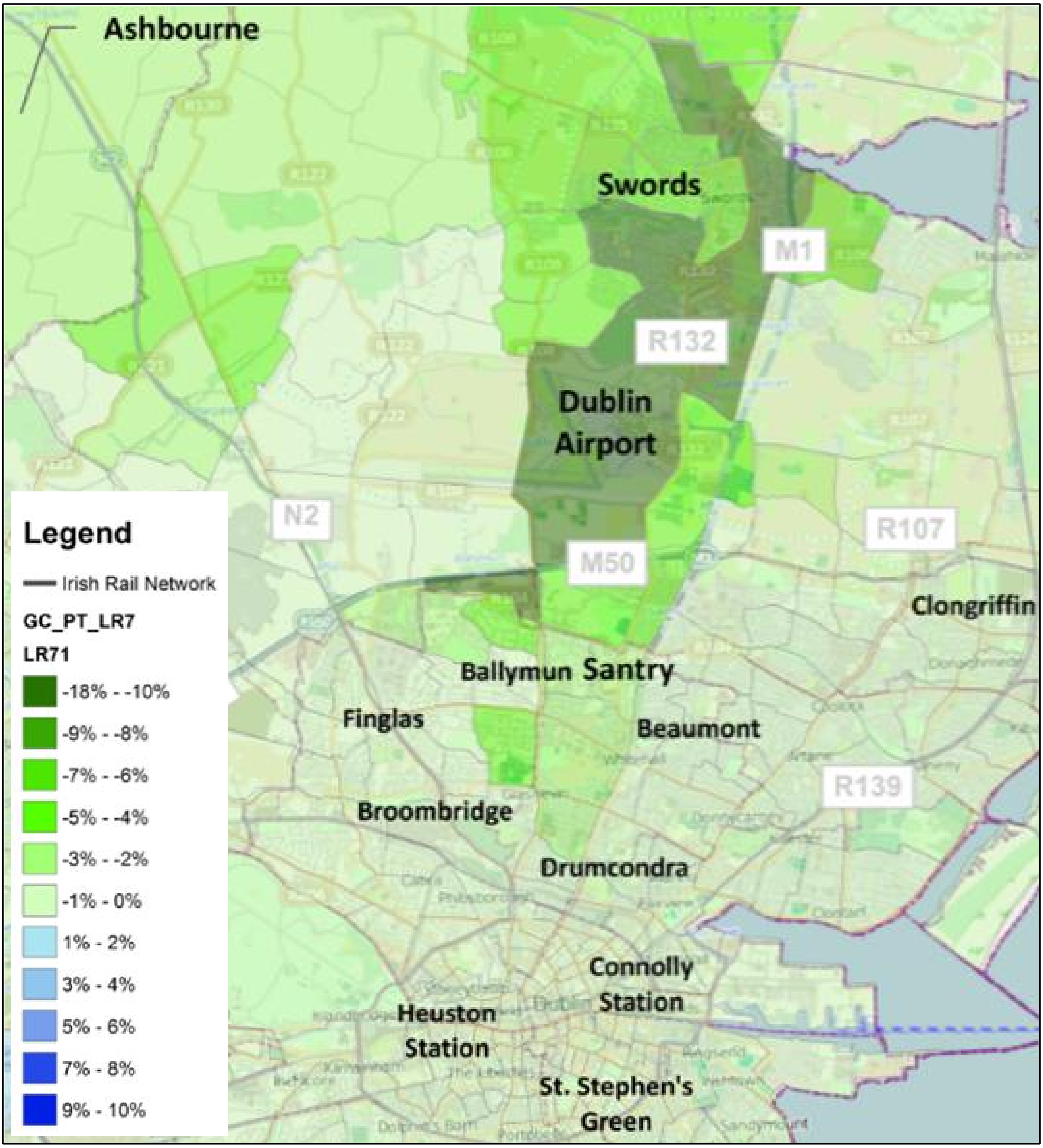
As shown, LR7 has a positive impact on the generalised cost of travel along the Swords to City corridor with reduction of 2% -18% of the generalised cost of travel forecast along the corridor.

LR7 Demand Modelling Summary

Based on a service pattern of 30TPH, LR7 will generate high demand at Estuary, Pavillions, Airside, Dublin Airport, Drumcondra. O'Connell Street and St. Stephen's Green. Overall,it has the highest number of additional public transport trips in the am peak travel period of all of the assessed options.

In the opening year, LR7 is expected to utilise 63% of available design capacity, therefore there is sufficient reserve capacity available to accommodate future growth. The level of service in the opening year could commence at 25TPH and be increased incrementally as required. This option generates the highest demand at Dublin Airport and the highest public transport travel time savings per trip.

Figure 8.20: 2033 Change in Generalised Cost Do Something Option LR7 relative to Do Minimum Option



8.4.5 LR7 Cost Estimate

A summary of the proposed cost estimate for LR7 is shown in Table 8.14. The scheme is estimated to cost approx. €2.3bn to deliver (or €2bn if VAT is not applicable). This estimate includes preliminary costs at a factor of 30%, a risk factor of 25% as well as VAT (13.5%). With regard to rolling stock, it is assumed that 30 new light rail vehicles would be required.

It should be noted that this is a concept stage cost estimate therefore the degree of estimating uncertainty is set at +/- 30% of our estimate value.

It should also be noted that this includes an allowance for grade-separaion of the alignment at major junctions along the Ballymun Road.

*Table 8.14: Summary of LR7 capital cost estimates**

Total LR7 Capital Costs				
Description				**Total amount**
i)	Construction/Direct Costs (incl. land acquisition)			1,274,351,000
ii)	Design costs			101,949,000
iii)	Client Costs			114,692,000
iv	Rolling stock			120,000,000
			Sub total	1,611,000,000
v)	Miscellaneous client costs and project burdens		2.00%	32,220,000
vi)	Risk	1,643,220,000	25.00%	410,805,000
vii)	VAT	2,054,025,000	13.50%	277,293,375
			Total cost	2,331,318,375

** Note that the capital costs developed are for comparative purposes only*

Operating and maintenance costs have also been developed for LR7, on the basis of current average costs, at a cost of approximately €28m per annum. These costs are summarised in Table 8.15. These capital and O/M costs have been taken forward for the purpose of economic appraisal of LR7.

Table 8.15: Summary of LR7 operating and maintenance costs

Annual LR7 Operating and Maintenance Costs		
Operations	Staff	€5,483,906
	Fuel	€1,478,810
	Insurance	€1,176,859
	Other	€4,009,527
Vehicles	Routine Maintenance	€4,586,075
	Additional Works	€409,381
	Depot	€112,842
Infrastructure	Cleaning & Landscaping	€233,333
	Routine Highway Maintenance	€3,616,241
TVM	Routine Maintenance	€273,096
Subtotal		**€21,380,071**
Contingency		€6,414,021
Non-recoverable VAT		€366,162
Total O&M		**€28,160,255**

8.4.6 LR7 Summary

LR7 is proposed as a 16.5km light rail route connecting St. Stephens Green to Estuary via Dublin Airport. Almost 8.5km of the route would run in a tunnel from St. Stephens Green to Griffith Avenue and under the Airport. Fourteen stops are proposed on the line, 8 at-grade and 6 underground. The route serves key destinations such as Drumcondra, the Mater Hospital, DCU and Ballymun in addition to Dublin Airport and Swords.

Significant work has already been undertaken in development of the technical specification for Metro North which is very similar to the proposed LR7 option. Work undertaken has demonstrated that technical risks can be mitigated, including environmental concerns.

Delivery of LR7 is estimated to cost €2.3bn (or €2bn if VAT is not applicable) with additional operating and maintenance costs of €28m per annum.

LR7 would offer journey times of 19 minutes from O'Connell Street to the Airport and 31 minutes from O'Connell Street to Estuary.

The service would operate with 60m light rail vehicles, which offer a design capacity of 9,900pphpd, although expandable in future if required.

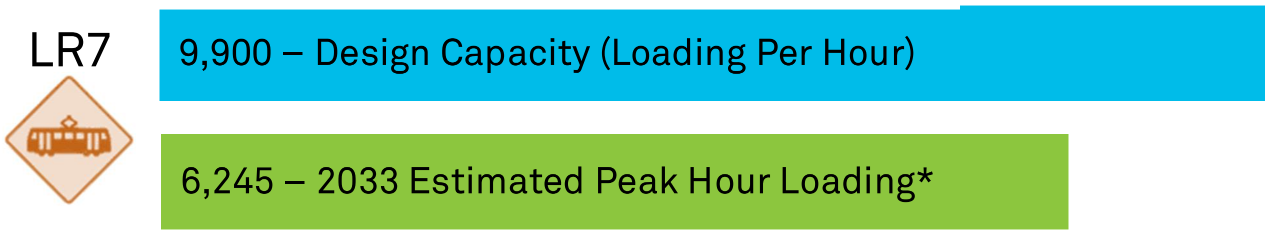
As there are no operating constraints on the line, 30TPH or more could operate on the line. This means the service would be flexible and responsive to increases in future demand.

LR7 generates the highest number of additional public transport trips in the AM peak travel period of all of the assessed options.

It is expected that the scheme would operate at 63% of its design capacity in an opening year of 2033 with potential to absorb significant further growth. Service frequencies on the line could commence at 25TPH, as opposed to the modelled 30TPH, and increase in response to demand over time.

On the basis that LR7 is a feasible option for future development within the study area, details of the scheme outlined above have been used as the basis for the economic appraisal and multi-criteria assessment in Sections 12 and 13 respectively.

Figure 8.21: Summary of LR7 design capacity and expected demand



* Excludes the impact of provision of a Park and Ride facility at Swords plus implementation of demand management measures on the M50.

8.5 Light Rail Recommendations

Two light rail options were brought forward from Stage 1 for further development and appraisal.

The first of these, LR3, is a light rail extension of Luas Cross City to the Airport and Swords. The route is expected to generate high passenger demand most likely owing to the high level of integration which the line offers, linking existing Luas Green Line catchment to the North City, Airport and Swords. LR3 is constrained due to on-street running in the city centre which could limit services on the line to 21TPH. However, modelling of passenger demand on the line demonstrates that even if 24TPH on the line were possible in the future, the service would still be running over its design capacity due to nortbound AM peak passenger demand of 7,055pphpd. In addition, sensitivity analysis indicates that with the addition of a Park and Ride facility at Swords, and the introduction of demand management measures on the M50, southbound line flows would significantly exceed the available design capacity. Accordingly, LR3 has not been brought forward for further appraisal on the basis that it does not have sufficient capacity to meet the future passenger demand anticipated in the study area.

An alternative alignment for LR3 was investigated to understand whether a tunnelled alignment through the city centre could provide a better response to travel demand. The proposed tunnel would run from Broadstone to St Stephens Green via Jervis Street at a length of 2.5km. While the tunnel would ensure 24TPH could run via the city centre, the route is also likely to experience capacity constraints on the section from Grangegorman to Cabra which would be shared with LCC services to Broombridge. On the basis of 24TPH, the service is expected to experience demand of up to 5,804pphpd, 73% of its design capacity. The tunnel therefore provides the guarantee of a higher capacity service with reliable journey times. The tunnelled option also presents the option of a phased approach to delivery. Based on these merits, a tunnelled version of LR3 has been brought forward for further appraisal.

Finally, LR7 has developed as a variant of the original Metro North scheme. The route has less stations, more at-grade running and shorter platforms but runs along the same alignment as Metro North. The scheme would run through the city centre in a tunnel. This high degree of segregation presents the benefit of being able to run a higher capacity service and journey times. The service is assumed to operate on a service frequency of 30TPH in an opening year of 2033. On this assumption, the service is expected to generate demand of 6,245pphpd, 63% of its design capacity. LR7 has been brought forward for further appraisal because of the expected high level of passenger demand as well as its potential to respond to future growth in travel demand witin the study area.

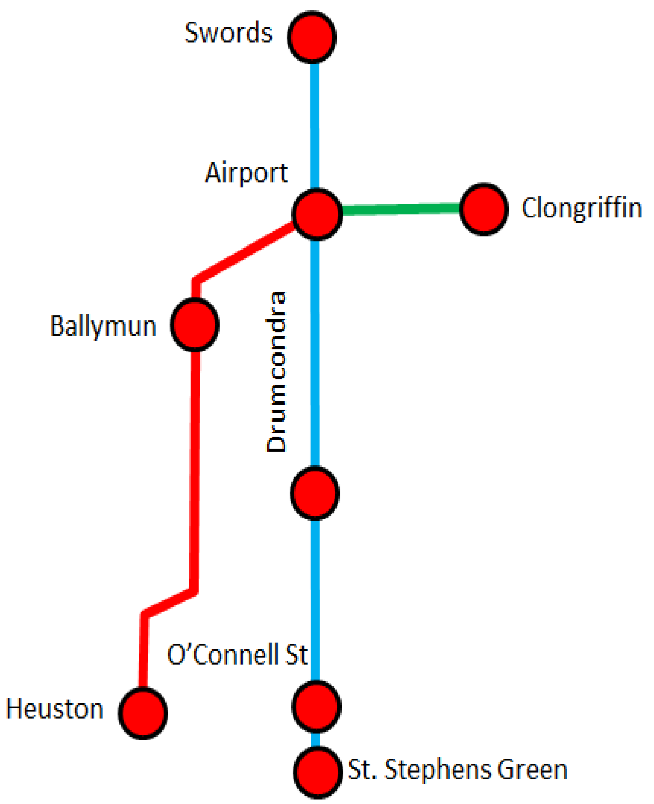
9 Stage 2: Bus Rapid Transit Options Development

9.1 Overview

Following consultation as part of the Stage 1 Appraisal process, the Swords/Airport to City Centre Swiftway BRT project was excluded from the "2033 Do Minimum Scenario" and a separate set of potential BRT routes for the study area was investigated. For this reason three alternative BRT routes have been combined to form a proposed network, as follows:

- Swords to City Centre, via Swords Road (R132) and Drumcondra Road (current Swiftway Alignment);
- Airport to Heuston Station, via Ballymun Road (R108) and Phibsborough Road; and
- Airport to Dart Station at Clongriffin, via Northern Cross (R139) (effectively an extension of the Clongriffin to Tallaght Swiftway corridor).

Figure 9.1: Proposed BRT Routes



BRT is a term that can be interpreted in different ways with schemes around the world carrying anywhere from less than 2,000pphpd (Nantes, France) to over 36,000pphpd (Bogota, Columbia) depending on the scale of infrastructure provided (as previously outlined in Section 3.5). Lower specification systems would run on similar infrastructure to the current Quality Bus Corridors (QBC) in Dublin, while the higher capacity systems would have continuous priority over their full length, and include capacity enhancements such as overtaking facilities at stations and maximum priority at traffic signals.

For the purposes of this study, it is assumed that a medium capacity system should be provided at a minimum. The primary reasons for limiting the capacity to the lower end of potential BRT system capacity is as follows:

- Many of the potential BRT routes are already carrying significant volume of buses and taxis, e.g. Swords Road and Ballymun Road. These public service vehicles would need to continue to use the BRT Lanes, a decision taken as part of the Swords Swiftway design development. This limits the carrying capacity of the new BRT system to approximately 4,500 pphpd, although the overall carrying capacity of the lanes, taking into account other bus routes, is likely to be at least double this figure;
- The roads on the approach to the City Centre and through the Centre have limited space available and there is limited potential for widening on the basis of potentially significant environmental and heritage constraints; and
- The design principles used for the preliminary design of the Swords/Airport to City Centre Swiftway project were taken as the basis for the

design of the expanded network for this study. Therefore the BRT lanes are typically located on kerbside of the road and involve an upgrade of the existing Quality Bus Corridor Lanes.

Each of the proposed BRT routes would require significant upgrade to existing bus priority facilities along their length in order to significantly increase priority. This is outlined in further detail in the following sections. The proposed BRT network is shown in Figure 9.5.

9.2 BRT Technical Feasibility

The engineering feasibility of each of the three proposed BRT lines is looked at separately in the following sections. Each element of the BRT project could easily be phased in over a number of years – however, for this assessment it is assumed that all would be in place by the design year. As with all bus-based projects, the proposed BRT network could be expanded quickly to serve other areas.

Route 1: Heuston to Airport, via Ballymun Road

This BRT route runs from the west of the City Centre at Heuston to the Airport, via Phibsborough and Ballymun. The route already has significant bus priority facilities along much of its length, including high quality facilities associated with the Ballymun QBC, between Phibsborough and Ballymun. In the city centre, the route will link to the existing North and South Quays bus lanes. However, the route will require the provision of significant additional bus priority between the Quays and Phibsborough, with increased priority requiring the replacement of existing traffic lanes with bus lanes. North of Phibsborough, the existing Ballymun QBC would require significant upgrade including the provision of segregated cycle facilities.

North of Ballymun, new bus lanes would be required along the R108 and the Old Airport Road which will require the widening of the relatively narrow roads.

Figure 9.2 Ballymun Road indicating existing bus lanes

Of note is that this route will serve the soon to be completed Dublin Institute of Technology (DIT) Campus at Grangegorman, and has high quality linkages to both the Luas Red Line and the Luas Cross-City route as well as many bus routes arriving from the west (Heuston Station and Quays) and north (Airport) of the City.

The scheme is likely to result in increased traffic congestion in the Smithfield, Phibsborough and Glasnevin areas as existing traffic lanes will be converted to bus lanes thus reducing capacity for other vehicles. This impact would need to be assessed in detail as this area includes some of the routes which are to be used to divert traffic around the City Centre as a result of the Luas Cross City project.

Route 2: St Stephens Green to Swords, via the Swords Road

This corridor is currently at Preliminary Design Stage, with an Environmental Impact Statement expected to be lodged with An Bord Pleanála later this year. Therefore, the design for the route has been developed to a higher level than the other two route options. The route runs from St Stephens Green to Swords, via the City Centre, Drumcondra, Santry and Dublin Airport. The route will include segregated bus lanes over much of its length apart from on O'Connell Street where the street currently acts predominently as a public transport corridor. The corridor will continue to be used by many other bus routes and taxis, therefore the additional capacity as a result of the BRT will be limited to approximately 4,500pphpd based on 24m double articulated buses (which is 75% of Maximum Capacity of 200 passengers for typical 24m vehicles).

North of the Airport, a long section of central running BRT Lane is to be provided along the median of the R132. This will provide a higher level of priority for BRT vehicles as other vehicles will only be permitted to enter it under licence.

This scheme will have a marginal negative traffic impact on much of the route, however it is likely to have a significant negative impact on the Drumcondra Road as a result of the loss of traffic capacity particularly at junctions.

Route 3: Clongriffin to Airport, linking to DART Services

This route will provide a direct linkage to the DART Line at Clongriffin from the Airport, and potentially with Northern Intercity services. Effectively this route would be a replacement to a bus route that previously ran from Howth Junction to the Airport, although it would offer a much more direct and faster alternative.

The route would initially follow the, yet to be completed, bus priority alignment from Clongriffin Station to the Malahide Road via the North Fringe Development Area.

On leaving the Development Area, the route would follow the reintroduced bus lanes on the R139 (Old N32). Drawings which have been developed for this route demonstrate that that the route could cross the M1 on a new bridge north of the M50/M1 interchange to provide direct access into the Airport via the Long-term Car Park.

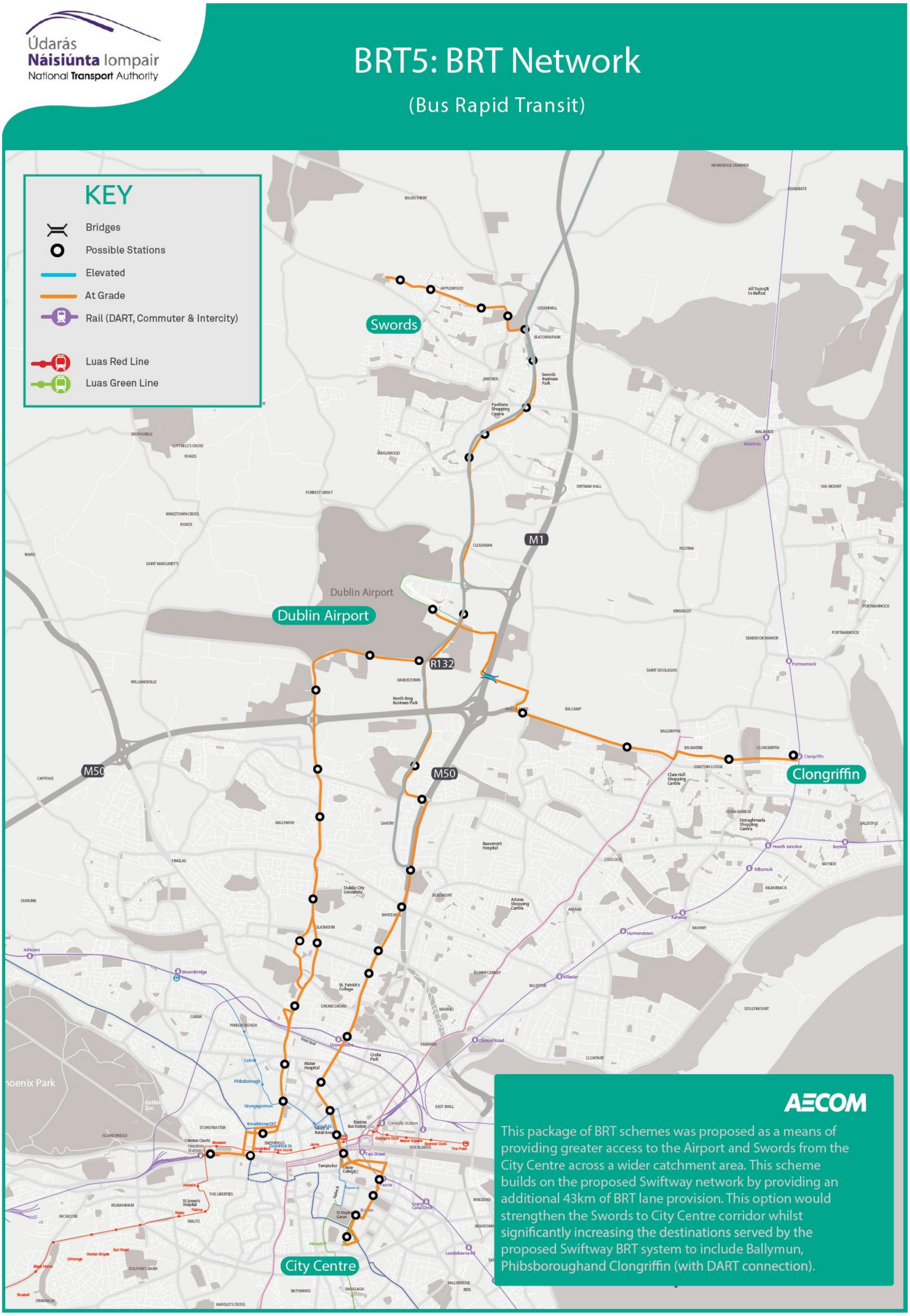
This route could potentially provide a rapid link of just 15 minutes from Clongriffin Station to the Airport.

Figure 9.3 Existing Bus Lanes passing through Clongriffin

(Source: Google Streetview)

Figure 9.4 Existing, but not operational, bus lanes on the R139

Figure 9.5: Proposed alignment for BRT5



9.3 BRT Operational Assessment

The operational feasibility of this option is dependent on the number and type of buses that will run along each corridor. For assessment purposes, it is assumed that each BRT route will be additional to the existing bus services operating on these corridors. It is assumed that high capacity vehicles with a maximum capacity of approximately 150 passengers will use most routes.

The operational potential of BRT is summarised in Table 9.1. The City Centre to Swords route would offer the highest level of service, operating on 2 minute headways and with design capacity of 3,375pphpd and a maximum capacity of 4,500pphpd. The other two BRT routes would operate on shorter headways and therefore offer lower capacities. Overall, it is expected that the combined BRT network would offer a design capacity of 5,400pphpd and a maximum capacity of 7,200pphpd.

BRT journey times are estimated at less than 45minutes for Swords to City Centre trips on the basis of an operating speed of approximately 26kph.

Table 9.1: Summary of operational feasibility of each BRT route

Route	Vehicles	Frequency (peak)	Journey Speed (KPH)	Maximum Capacity (pphpd)
Heuston to Airport	150 passenger capacity	5 minute headway	28	1,800
St Stephens Green to Swords	150 passenger capacity	2 minute headway	26	4,500
Clongriffin to Airport	150 passenger capacity	10 minute headway (to meet DART services)	35	900

9.4 BRT Environmental Assessment

Each BRT option has been assessed under the following environmental factors:

- **Air Quality:** The level of air quality generated by the BRT network will depend on the type of buses being used. Any changes in air quality would be associated with any changes in traffic flows on the whole of Dublin's road network that are a direct result of delivery of the scheme. This is looked at in further detail in Section 12, Economic Appraisal;
- **Noise and Vibration:** The proposed BRT is unlikely to have significant noise impacts, however, the impact of new service running through residential areas should be monitored;
- **Landscape & visual quality:** As the proposed routes are to be primarily located along existing roadways is it not expected that there will be any significant negitive impacts on landscape and visual quality. The possible new bridge north of the M50/M1 interchange is also not expected to cause any severe landscape or visual impacts as the majority of the surrounding area is within the Airport complex;
- **Biodiversity:** Localised impacts on biodiversity may be possible, however this is not expected to be significant. For the Airport to Heuston Station route north of Ballymun, new bus lanes would be required along the R108 and the Old Airport Road which will require the widening of the these relatively narrow roads. This may infringe on the hedgerows and agricultural lands along the route. Restrictions as to what time of the year the hedgerows may be removed will have to be adhered to if widening of the route involves their removal. Appropriate Assessment (AA) Screening of possible impacts of this route on the Natura 2000 sites e.g. Malahide Estuary SAC and Broadmeadow/Swords Estuary SPA will be needed;
- **Cultural, archaeological and architectural heritage:** No likely significant effects expected;
- **Land use, soils and geology:** Residual impacts from construction and operation are expected to

be low or very low as the majority of this scheme runs through areas that are already paved or are of low sensitivity or importance; and

- **Water resources:** Residual impacts from construction and operations on surface water are of low magnitude with negligible to low significance.

9.5 BRT Transport Assessment

A transport demand assessment for the BRT option was conducted using the NTA Strategic Transport Model. In undertaking the analysis forecast opening year, 2033, demand matrices developed by the NTA were assigned to the "2033 Do Something" network which included the BRT schemes.

Passenger Demand

In order to examine the impacts of the BRT scheme option, an initial analysis of modelled public transport boardings was undertaken. Table 9.2 summarises the total boardings on each public transport sub-mode, for the morning period of 07:00-10:00 in the forecast year of 2033. As shown in Table 9.2 demand for BRT services (which are a new mode) total 30,047 boarding in the "Do Something" scenario. Introduction of the new BRT service would draw passengers from existing bus services with a cumulative 9.0% reduction on bus service boardings. The overall impact of the scheme is a 0.88% increase in public transport boardings.

Table 9.2: AM Period Public Transport Boardings

Mode	Do Min Boardings	Do BRT Boardings	% Diff
DART	40,795	40,820	0.06%
Suburban Rail	62,812	62,583	-0.36%
Dublin/City Bus	241,111	220,928	-8.37%
Other Bus	57,179	51,798	-9.41%
Luas	49,171	48,874	-0.60%
BRT		***30,047***	***100.00%***
Total	451,066	455,050	0.88%

Network Statistics

As shown in Table 9.3, BRT has a positive impact on public transport patronage in AM peak hours with 2,270 new trips forecast on public transport services during the AM peak hours 07:00 to 10:00. Of these new trips, 1,313 come from private car trips with the remainder coming from slow modes (cycling and walking). It is important to note that unlike the other Options, which are single routes or corridors, the BRT is a network and impacts on a much wider area which results in more positive results which could be misleading. The following section outlines the line capacities for the busiest route, the Swords to City Centre BRT, which is more important barometer for the assessment of the BRT scheme option as a potential long term solution.

Table 9.3: AM Period Travel Demand Impact BRT

Travel Demand Impact	Unit	Do BRT
Public Transport	Trips	2,270
Highway	Trips	-1,313

The peak hour passenger loads for the BRT scheme option, southbound and northbound services, are shown in Figures 9.6 and 9.7. In the figures presented here the BRT Swords to City Centre and Airport to City Centre BRT line flows have been combined in order to outline the full Swords to City Centre BRT offering that would be available on the implementation of the BRT scheme option. Figure 9.6 outlines that on the southbound service passenger demand is strong at Applewood, Jugback Lane and Dublin Airport. The highest demand is seen at Dublin Airport where a peak loading of in excess of almost 2,000 passengers is seen in the AM peak hour. The key destinations are Drumcondra, Dorset Street and D'Olier Street.

As shown in Figure 9.6, the BRT southbound service becomes crowded from the Seatown stop. At Dublin Airport, the substantial increase in patronage causes the service to become more heavily overcrowded, with the service remaining overcrowded until after the Dorset Street stop. Figure 9.7 shows that on the northbound service high passenger demand is generated at St. Stephens Green, Westmoreland Street and St. Patricks. Key destinations are Griffith Avenue, Collins Avenue and Dublin Airport. No overcrowding issues are evident on the northbound services in the am peak period of the scheme opening year, 2033. However, a peak load of 3,740 passengers is forecast which is 83% of its design capacity.

Figure 9.6: AM Peak Hour Loading BRT Southbound Oldtown to Earlsfort Terrace 2033

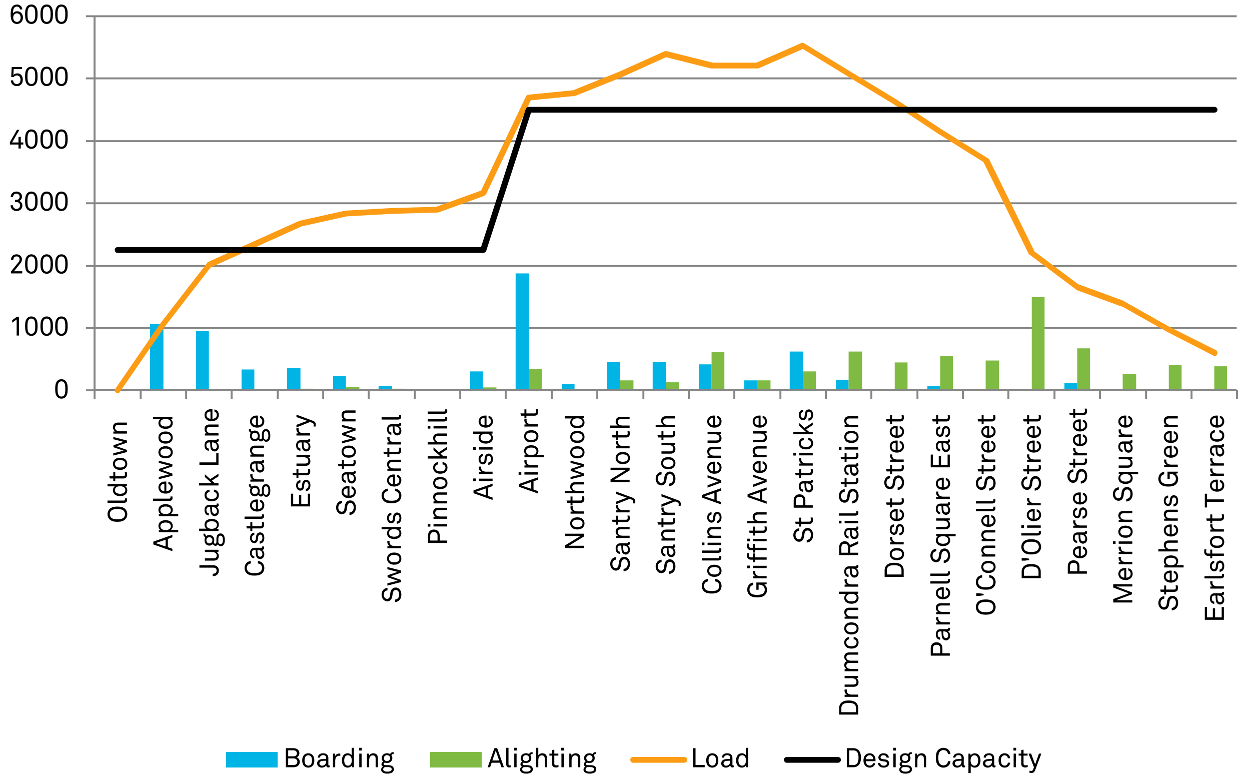
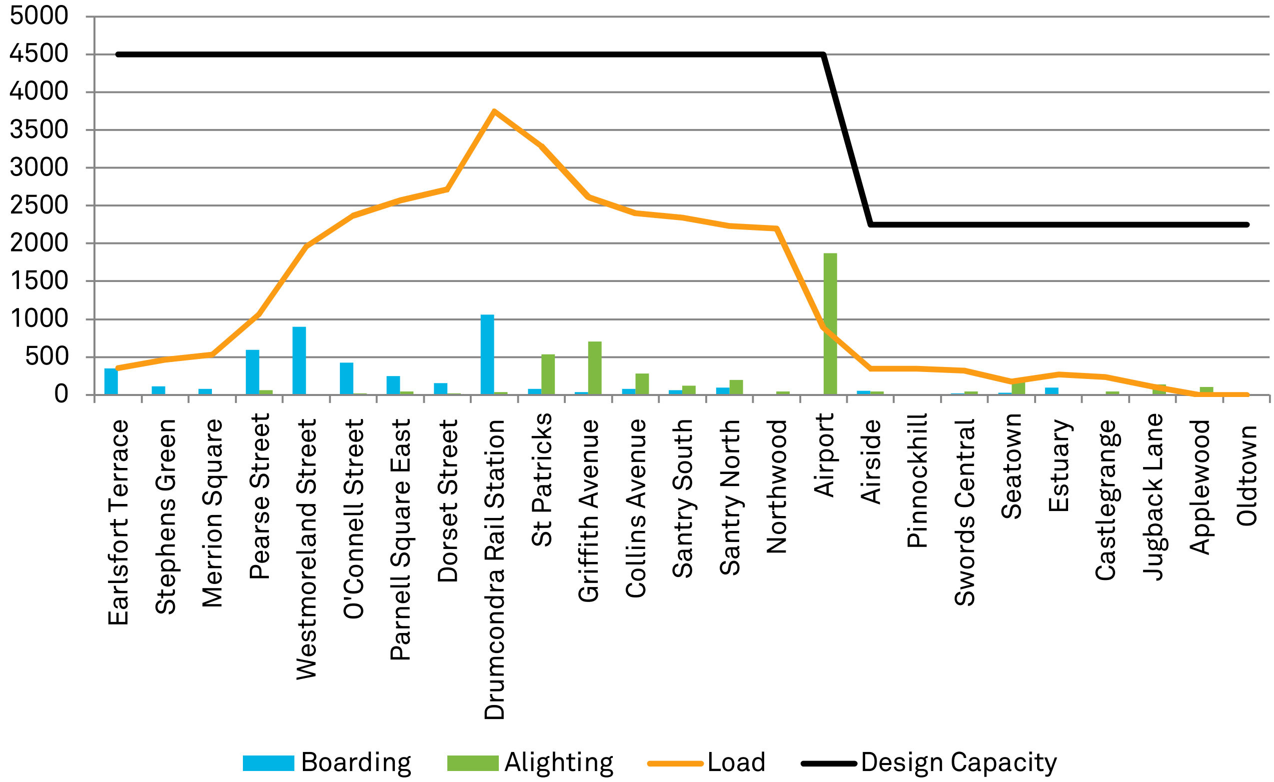


Figure 9.7: AM Peak Loading BRT Northbound Earlsfort Terrace to Oldtown 2033



BRT Generalised Cost Impact

Changes to the generalised cost of travel relative to the Do Minimum scenario are presented in Figure 9.8 below. Any reductions in generalised costs indicate areas where the scheme is having a beneficial impact i.e. reducing the generalised cost of travel thereby making public transport options more attractive. However, it should be noted that changes in aggregate generalised cost do not encompass the full benefits of the scheme.

As shown, BRT has a positive impact on the generalised cost of travel along the Swords to City corridor with reduction of 2% -15% of the generalised cost of travel forecast along the Swords corridor. These reductions in generalised cost feed into the BRT patronage as detailed in the following sections.

BRT Travel Demand Summary

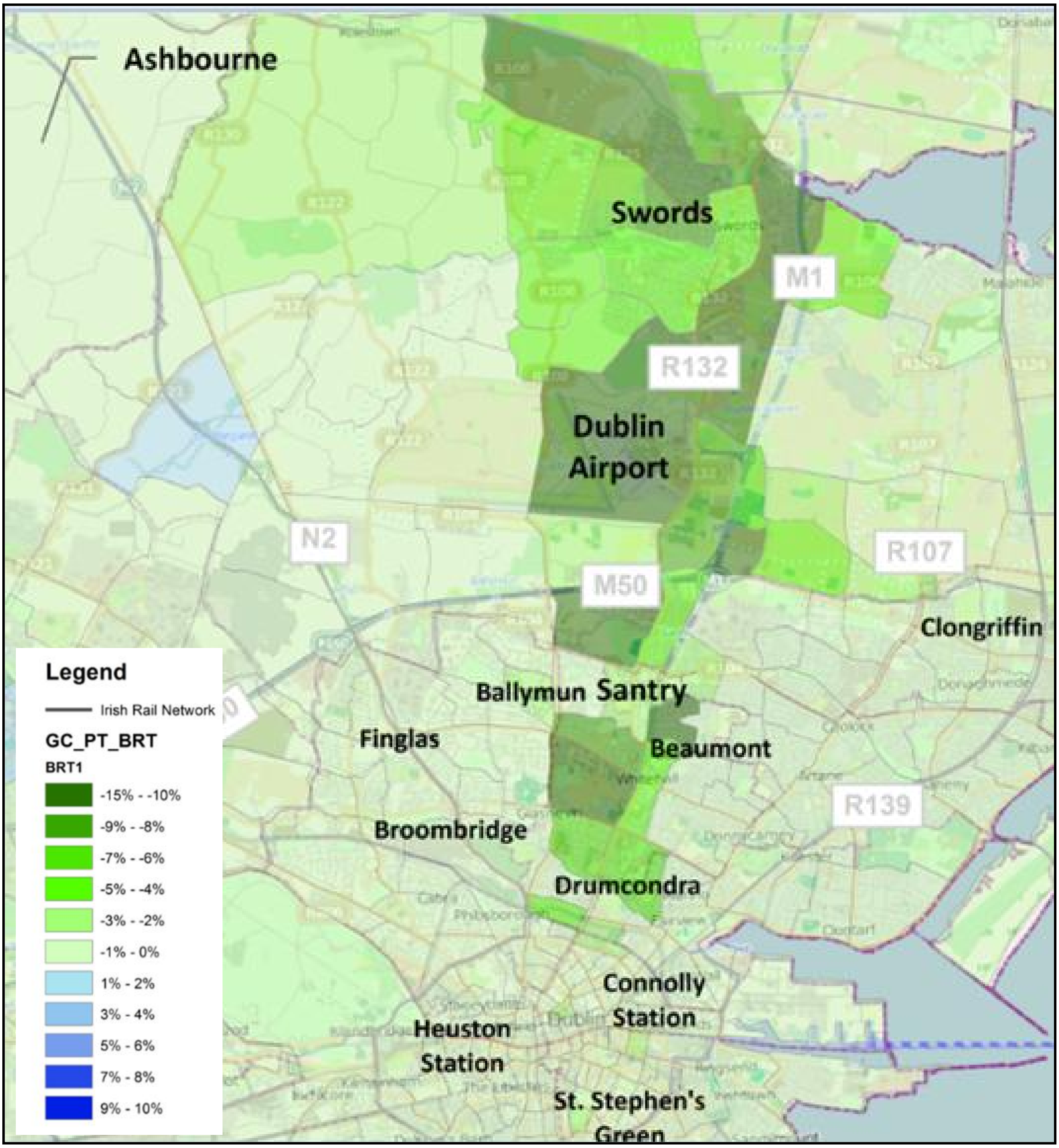
The BRT system generates high demand in the scheme opening year 2033, with a peak demand loading of 5,400 passengers generated. Additionally the system is forecast to generate travel time savings of 50 seconds per public transport trip during the AM peak hours 07:00 to 10:00.

These results however need to be treated with caution, as the system could not realistically cater for the level of demand forecast.

The NTA's Greater Dublin Area Strategic Transport Model, like all models, has certain limitations. One such limitation is that the model will continue to allocate demand to a service after its capacity is breached. In this instance, the BRT systems maximum design capacity is 4,500pphpd. However, a substantially higher peak loading of 5,400 is forecast. Given that the BRT system will be operating at 2 minute headways south of the Airport and that BRT infrastructure network will be shared with other Dublin Buses (and Bus Eireann and many other operators that use the Drumcondra corridor to access the City Centre) there is little or no potential to increase the frequency of service in order to cater for this level of demand.

The BRT system can therefore not cater for the level of demand forecast and the travel time savings forecast per trip are therefore unrealistic. On this basis, BRT is not able to provide sufficient capacity to meet the long term needs of the study area and has been omitted from further project appraisal.

Figure 9.8: 2033 Change in Generalised Cost Do Something BRT Option relative to Do Minimum Option



9.6 BRT Cost Estimate

A summary of the proposed cost estimate for the BRT option is shown in Table 9.4. The scheme is estimated to cost €816m to deliver. This estimate includes preliminary costs at a factor of 30%, a risk factor of 35% as well as VAT (13.5%). With regards rolling stock, it is assumed that 100 new BRT vehicles would be required at a cost of €700,000 each. It should be noted that this a concept stage cost estimate therefore the degree of estimating uncertainty is set at +/- 30% of our estimate value.

*Table 9.4: Summary of HR2 cost estimates**

Total BRT Capital Costs				
	Description			**Total amount (€)**
i)	Construction/Direct Costs			336,690,000
ii)	Design costs			26,935,200
iii)	Client Costs			30,302,100
iv)	Rolling stock (fleet and depot costs)			100,000,000
			Sub total	**493,930,000**
v)	Miscellaneous client costs and project burdens		2.00%	9,878,600
vi)	Risk	503,808,600	35.00%	176,333,010
vii)	VAT	1,007,617,200	13.50%	136,028,322
			Total cost	**816,169,932**

** Note that the capital costs developed are for comparative purposes only*

Operating and maintenance costs have also been developed for BRT at a cost of €35m per annum. BRT is the most expensive option to operate on the basis that higher frequency services are required to meet demand, thus requiring many more vehicles and drivers. These costs are summarised in Table 9.5.

Table 9.5: Summary of BRT operating and maintenance costs

Annual BRT Operating and Maintenance Costs		
Operations	Staff	€6,920,669
	Fuel	€3,500,643
	Insurance	€1,137,717
	Other	€3,913,175
Vehicles	Routine Maintenance	€10,473,007
	Additional Works	€327,505
	Depot	€0
Infrastructure	Cleaning & Landscaping	€750,000
	Routine Highway Maintenance	€3,464,115
TVM	Routine Maintenance	€877,808
	Additional Maintenance	€0
Subtotal		**€31,364,640**
Contingency		€3,136,464
Non-recoverable VAT		€852,686
Total O&M		**€35,353,791**

9.7 BRT Summary

A 43km BRT network is proposed consisting of three routes as follows:

- City Centre to Swords via Dublin Airport (21km);
- Clongriffin to Dublin Airport (8km); and
- Dublin Airport to Heuston Station (14km).

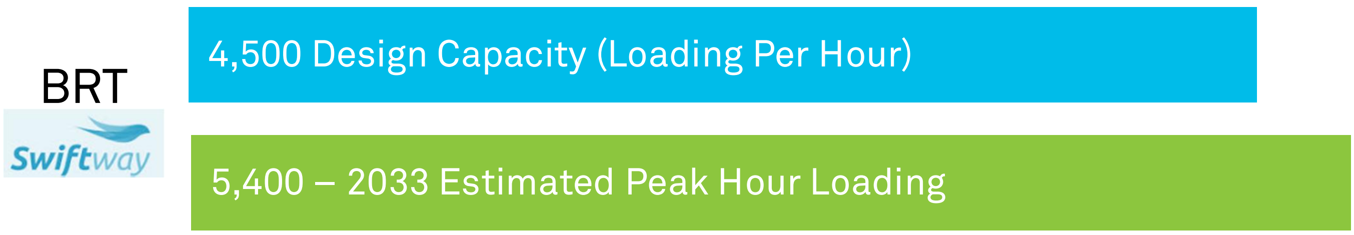
Stops are proposed on each route at a maximum of 1,000m distance from each other. The proposed network provides access to key destinations such as Heuston Station, Mater Hospital, Grangegorman, DCU and Ballymun as well as the City Centre, Airport and Swords.

The proposed service is expected to operate at speeds of 26-35km with forecast journey times to Swords of under 45 minutes from the City Centre. The City Centre to Swords route is proposed to operate on a 2 minute frequency while the Heuston and Clongriffin routes would run at a 10 minute frequency.

The design capacity of the BRT network is 4,500pphpd, assuming the larger 24m articulated BRT vehicles are used. However, assuming an opening year of 2033, the BRT network is expected to experience boardings of 5,400. To increase the potential capacity of the BRT network is likely to require significant infrastructure work which is likely to have significant impacts for the existing traffic and bus networks. On this basis, BRT does not present a feasible option for future delivery within the study area.

BRT does not provide sufficient capacity to meet the long term needs of the study area. Therefore, it has not been brought forward for economic appraisal or multi-criteria assessment.

Figure 9.9: Summary of BRT design capacity and expected demand



10 Stage 2: Combined Option

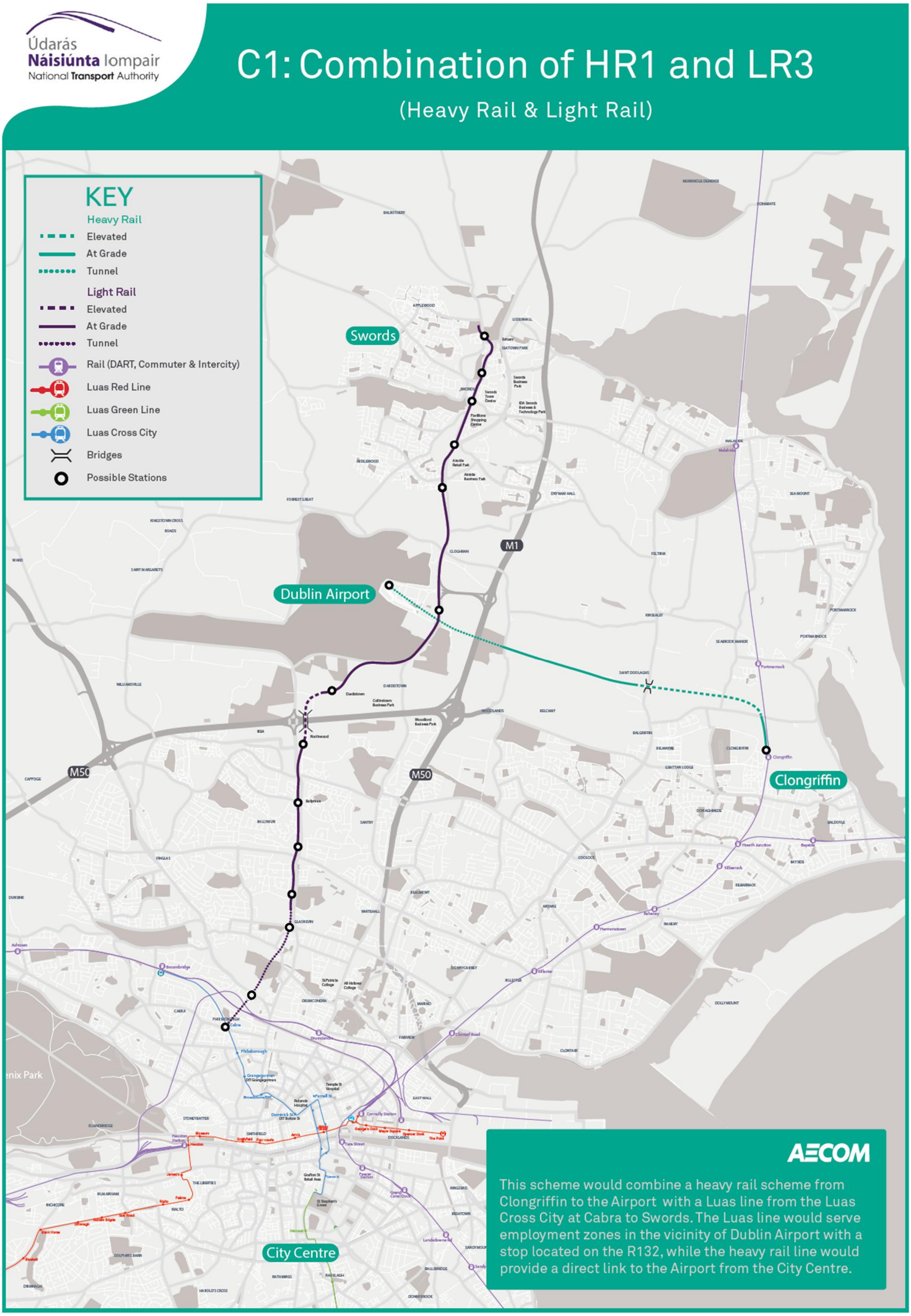
10.1 Overview

This potential scheme emerged during the stakeholder workshops held during the Stage 1 Appraisal process and would combine HR1 (a heavy rail scheme from the Northern Line to Dublin Airport) with LR3 (Luas Line D2 from the Luas Cross City at Cabra to Swords). Passengers from Swords would therefore benefit from direct access to the City Centre with Luas, while from the Airport, passengers could benefit from both heavy rail and light rail services to reach the City Centre. This option overcomes the issue with HR1 not serving Swords - a key requirement of the study. This option provides a high quality light rail corridor to the Airport and Swords, and links into the DART network via the heavy rail link.

It is important to note that while LR3 on its own meets the objectives of the study, HR1 does not. For this reason HR1 cannot be considered on its own as it does not fulfil the strategic objectives of the study.

Figure 10.1: DART train at Connolly Station

Figure 10.2: Proposed Alignment for Combined Option 1(C1)



10.3 C1 Technical Feasibility

The technical feasibility of routes LR3 and HR2 have previously been assessed in earlier sections of this report. The following sections outline the main differences between those alignments and the revised formats proposed for C1.

Alignment

Alignment for LR3 and HR1 are summarised separately below.

The LR3 alignment proposed for C1 is the same as previously proposed. The one exception is at the Airport where an at-grade alignment on the R132 is proposed instead of an underground tunnel. This alignment was originally proposed by the RPA for Luas Line D2 on the basis that an Automated People Mover would connect passengers from the R132 to the Airport terminals. However, in the combined option where the heavy rail link (HR1) would connect directly to the Airport, it was concluded that a light rail connection on the R132 would provide more convenient access to proposed employment development in the area. As such, HR1 would provide the primary Airport connection and LR3 would provide the primary Swords to City connection via Airport employment areas. On the R132, LR3 would share space with bus lanes running along the kerbside. This would require the existing bus stops to either be removed or indented between the cemetery and Airport entrances along the R132. In this instance, LR3 would be 13.4km in length.

HR1 would link to the Northern Line at Clongriffin Station in the same manner as outlined for HR2 in Section 7.1. The route would leave the Northern Line via a grade-separated junction, continuing westbound on an elevated alignment through agricultural land, returning to grade west of the Malahide Road before entering a tunnel portal immediately east of the M1, in the same location proposed for HR2. Similar to HR2, opportunities to maintain HR1 at-grade or elevated were investigated. However, it would be difficult to provide an elevated or at-grade connection to the Airport GTC that does not adversely impact on development proposals or the existing transport network serving the Airport. Therefore, a tunnelled connection was identified as the preferred approach. HR1 would be approximately 7.5km in length and composed of a 4.1km of at-grade/elevated alignment from Clongriffin to the tunnel portal and 3.4km of tunnelled alignment from the east of the M1 to Dublin Airport.

Stations

Overall, C1 would provide 14 new stations, 13 on LR3 and 1 on HR1. The only difference in stations proposed for LR3 is at the Airport which as outlined above would be located west of the R132, just south of the Airport roundabout. This station would directly serve proposed employment areas of the Airport Masterplan. While it is not intended that the light rail is promoted as the main access to the Airport, it could be connected in the future to the Airport terminals using an Automated People Mover. Alternatively, the walking distance to the Airport terminal 2 is approximately 10 minutes.

The proposed HR1 station would be located at the Airport GTC, as previously proposed for HR2, and would provide convenient access to both terminals 1 and 2.

Tunnels

LR3 includes tunnelling under Glasnevin Cemetery and its environs, which is described in Section 8.2. Likewise, HR1 includes 3.4km of tunnelling from east of the M1 motorway to the Airport, as described in Section 7.

Construction Impact

Option C1 is the longest of all the options, and is therefore likely to present the most significant construction impact in comparison to the other options. Most of the impacts have already been identified for LR3 and HR2 and include:

- Disruption to Swords Town Centre (including local residents and traders), with impacts on traffic flows, parking, noise and visual amenity;
- Disruption to residents in and around the Glasnevin tunnel portals and traffic disruption with the consutruction of LR3 along the median of Ballymun Road

- Disruption to farming and market gardening on arable land between Clongriffin and the Airport;
- Severe disruption at Dublin Airport during construction of a large underground station at the GTC;
- Disruption along at-grade and elevated sections (e.g. the R132 and Ballymun Road), with impacts on traffic flows, parking, noise and visual amenity;
- Significant disruption along the R132 during the construction of the shared running sections of LR3; and
- Potential delays during delivery and installation of bridge structures over Malahide Road, Drumnigh Road and Northern Rail Line.

Summary of Technical Feasibility

As part of the Stage 2 Appraisal, the vertical and horizontal alignment, proposed stations, tunnelling and construction impacts of C1 were investigated. Based on this, it was concluded that Option C1 is technically feasible, with acknowledgment of the following risks:

- The impact of tunnelling has yet to be determined through detailed geotechnical surveys;
- Long term disruption to Swords Main Street with traffic being diverted within the area to facilitate on-street tram running; and
- Development of underground stations, especially at the Airport, will result in temporary disruption and present some technical risk.

10.4 C1: Operational Assessment

Operational assumptions for LR3 outlined in Section 8.2 would remain unchanged for C1. It is noted that the operational feasibility is somewhat dependent on LCC operations, with a maximum potential frequency of 24TPH and a more realistic maximum frequency of 21TPH which would offer a design capacity of 5,985pphpd.

On HR1, 4TPH are proposed for Connolly Station to the Airport. These trains will be existing trains serving Howth or Malahide, diverted to the Airport. It is possible that a further 2 trains could be added to generate a 10 minute frequency with more substantial changes to train movements on the Northern Line.

10.5 C1: Environmental Assessment

A summary of the forecast environmental impacts on LR3 and HR1 are as follows:

- **Air Quality:** Once operational, C1 would have limited impact on air quality. Any changes in local air quality would be associated with changes in traffic flows as a response to delivery of the scheme. These impacts are looked at in further detail through Economic Appraisal in Section 12;
- **Noise and Vibration:** Consideration needs to be given to the potential construction impacts of tunnel boring at Glasnevin and under the Airport. Once operational, HR1 will generate noise impacts within the at-grade/elevated sections from Clongriffin to the tunnel portal. The noise impacts of LR3 are less significant as the route runs mainly on existing busy traffic routes;
- **Landscape and Visual Quality:** Elevated structures on LR3, such as over the M50, will result in visual impacts in addition to the area from Clongriffin to the Airport where HR1 would be elevated over arable land that is flat in nature;
- **Biodiversity – Flora and Fauna:** Appropriate Assessment (AA) Screening is required for the entire alignment to determine biodiversity impacts in detail. However, within the Airport to Clongriffin section there are likely impacts on biodiversity due to the removal of hedgerows. At-grade sections of LR3 north of the Airport may also have negative impacts on biodiversity;
- **Cultural, Archaeological & Architectural Heritage:** C1 would have potentially significant impacts on sites of archaeological and architectural heritage. HR1 runs through an area with a high concentration of sites and monuments between Malahide Road and Clonshaugh Road. These include a variety of sites e.g. single ditched enclosures, wells, churches and graveyards etc. (see Figure 7.8). In addition, the impact of tunnelling under Glasnevin for LR3 is to be determined; and
- **Land Use, Soils and Geology:** Both LR3 and HR1 include tunnelled sections, approximately 5km in

total. Geotechnical data for these areas is required for these corridors to fully understand the impact on soils and geology. As such, this remains a risk for C1.

10.6 C1: Transport Assessment

A transport demand assessment for the combined scheme, C1, which encompasses a heavy rail spur from Dublin Airport to Clongriffin connecting in the existing DART Line and a light rail option from Swords to Cabra connecting into the Luas Cross City light rail line at Broombridge, was conducted through the NTA's strategic multimodal model. In undertaking the analysis forecast opening year, 2033, demand matrices developed by the NTA were assigned to the Do Something network.

Passenger Demand

Table 10.1 summarises the total boardings on each public transport sub-mode, for the morning period of 07:00-10:00 in the forecast year of 2033. As shown in Table 10.1 demand for Luas services (which include the light rail element of scheme C1) and DART services (which include the heavy rail element of C1) are forecast to increase by 17.44% and 24.68% respectively in the "Do Something" scenario. Introduction of the new service would draw passengers from existing bus services with a cumulative 7% reduction on bus service boardings. Additionally some demand will be drawn from suburban rail services with decreases of 1.4% forecast on these rail services. The overall impact of the scheme is a marginal 0.21% decrease in public transport boardings.

Table 10.1: AM Period Public Transport Boardings

Mode	Do Min Boardings	Do C1 Boardings	% Diff
DART	***40,795***	***47,909***	***17.44%***
Suburban Rail	62,812	61,755	-1.68%
Dublin/City Bus	241,111	226,083	-6.23%
Other Bus	57,179	53,079	-7.17%
Luas	***49,171***	***61,307***	***24.68%***
Total	451,066	450,133	-0.21%

Network Statistics

The overall performance of the modelled transport network for the Do Something C1 scenario can be examined through an analysis of transport network demand.

As can be seen from Table 10.2 above scheme option C1 has a positive impact on public transport patronage in AM peak hours with 1,271 new trips forecast on public transport services during the AM peak hours 07:00 to 10:00. Of these new trips 706 come from private car trips with the remainder coming from slow modes (cycling and walking).

Table 10.2: AM Period Travel Demand Impact C1

Travel Demand Impact	Unit	Do C1
Public Transport	Trips	1,271
Highway	Trips	-706

The peak hour passenger loads for the C1 combined heavy and light rail scheme options, southbound and northbound services, are shown in Figures 10.3 to 10.6. The figures presented include the existing Luas Green Line services from Brides Glen and Sandyford to St. Stephens Green as well as the future C1 light rail services.

Figure 10.3 outlines that on the southbound light rail service passenger demand is significantly weaker than other options at the Swords stops and Dublin Airport. This is likely a result of the slower journey time from Swords to the City for this light rail option which runs along the R132 rather than under Dublin Airport. No overcrowding issues are forecast on the service.

Figure 10.4 shows that, on the southbound C1 heavy rail service passenger demand is strongest at the Dublin Airport and Clongriffin stops. The highest demand is seen at Clongriffin, where a peak loading in excess of 1,700 passengers is seen during the AM peak hour in the scheme opening year, 2033. No overcrowding issues are forecast on the service.

Figure 10.5 shows that on the northbound C1 light rail service high passenger demand is generated at the existing Luas Green Line stops including Balally, Dundrum and Cowper. The key destinations are the city centre (including St. Stephens Green, Dawson St, Westmoreland St and O'Connell St), Grangegorman and Dublin Airport. The scheme will breach its design capacity in the northbound direction in the opening year of 2033 with a peak load of just under 7,000pphpd.

Figure 10.6 shows that on the northbound C1 heavy rail service passenger demand again dominated by a peak loading of almost 2,700 passengers at Bray in the AM peak hour. The key destinations for the northbound passengers are the Pearse Street, Tara Street, Connolly and Dublin Airport stops. No overcrowding issues are forecast on the service.

Figure 10.3: AM Peak Loadings C1 Light Rail Southbound Estuary to Brides Glen

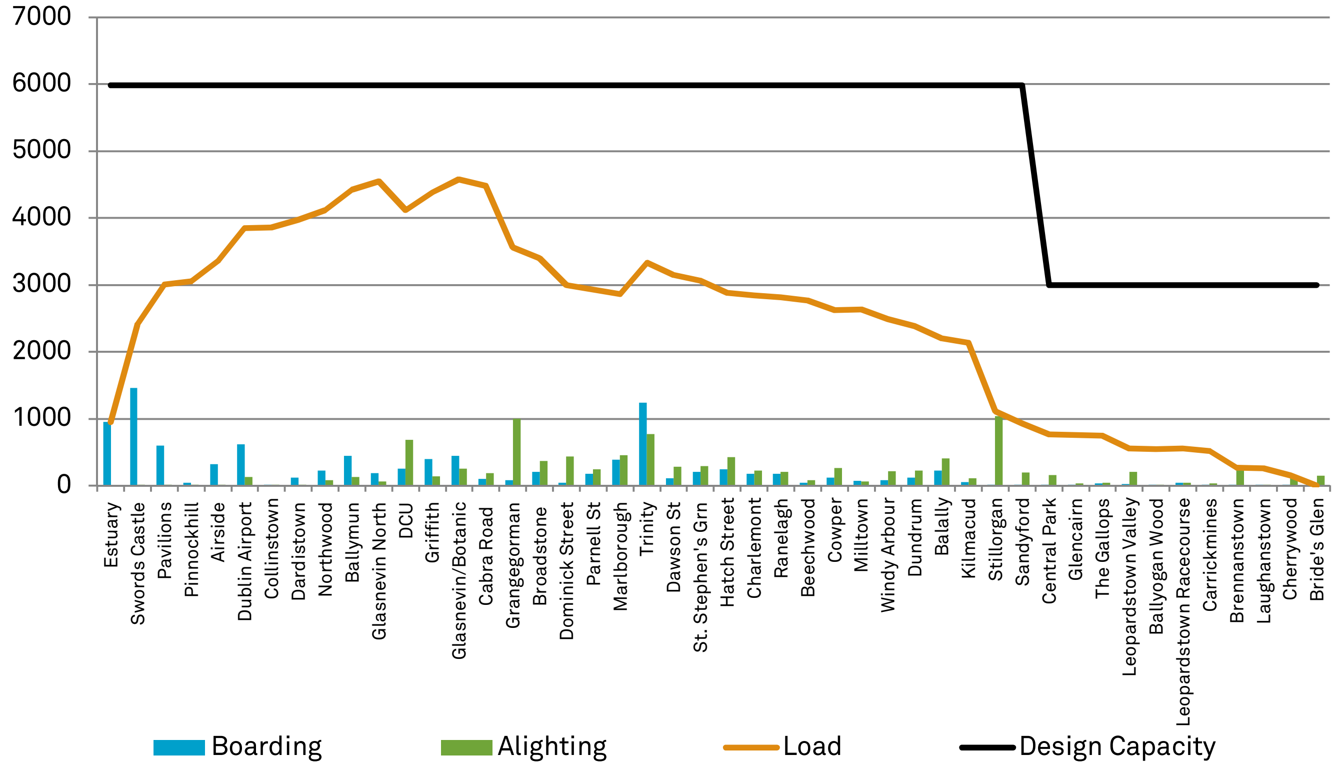


Figure 10.4: AM Peak Loadings C1 Heavy Rail Southbound Dublin Airport to Bray

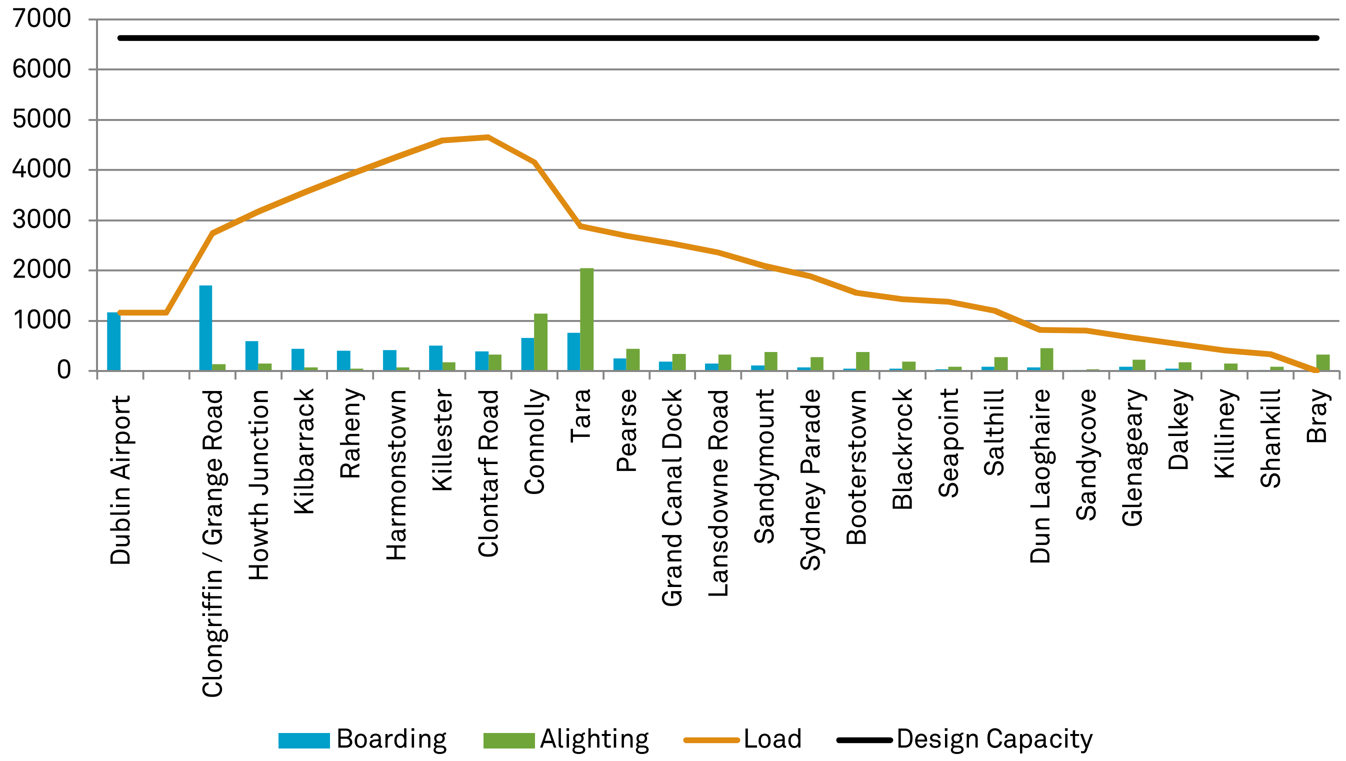


Figure 10.5: AM Peak Loadings C1 Light Rail Northbound Brides Glen to Estuary

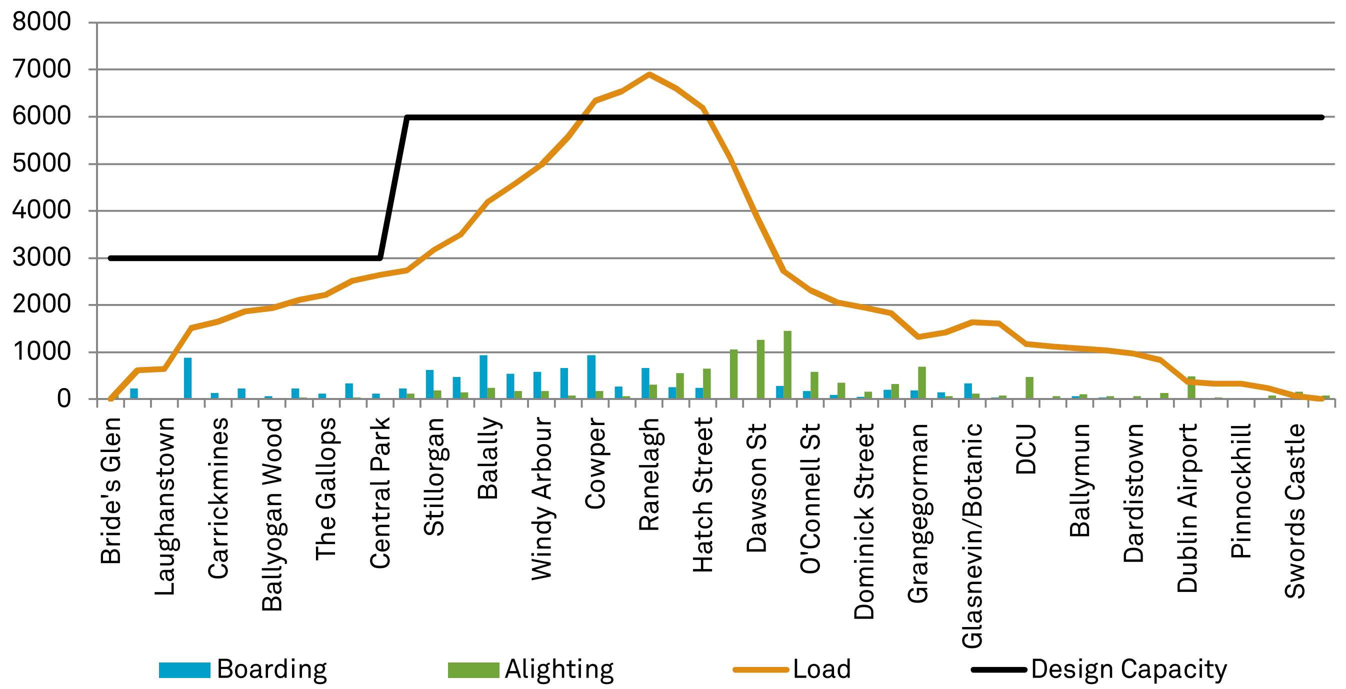
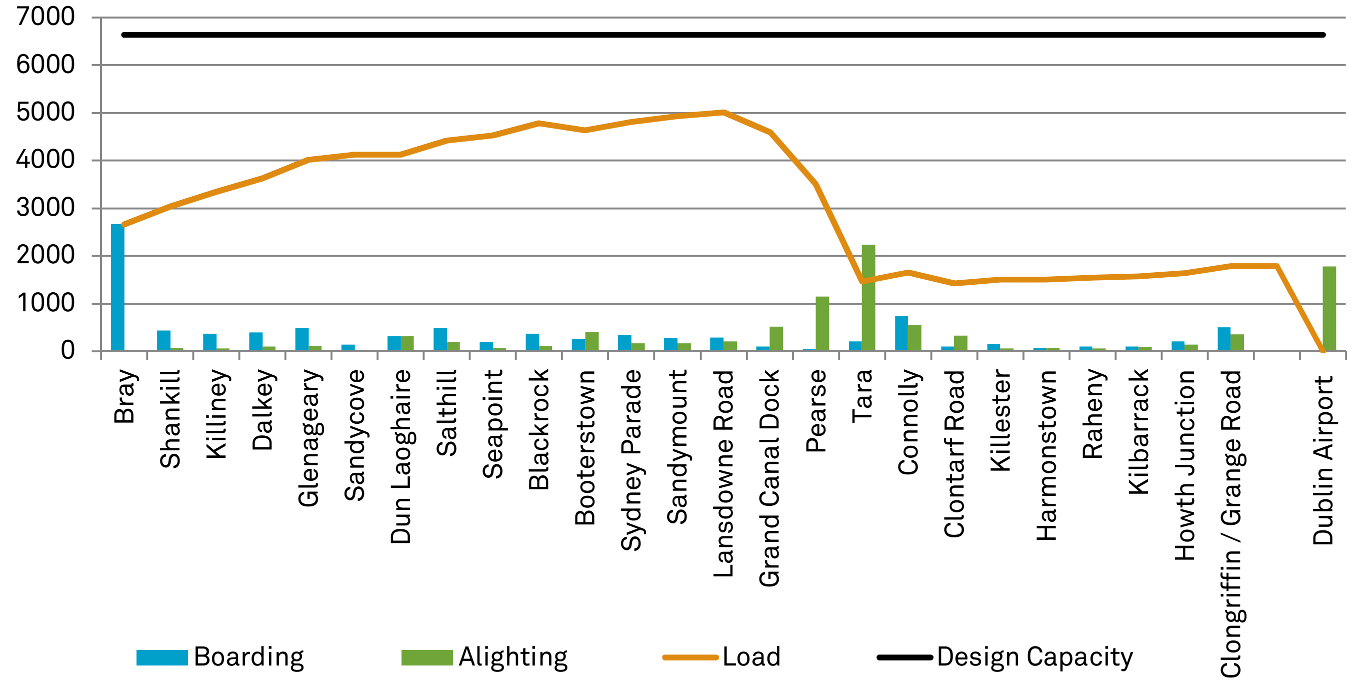


Figure 10.6: AM Peak Loadings C1 Heavy Rail Northbound Bray to Dublin Airport



<u>Generalised Cost Impact</u>

Changes in generalised cost of travel relative to the Do Minimum scenario, as forecast by the NTA's strategic multimodal model, are presented in Figure 10.7. Any reductions in generalised costs indicate areas where the scheme is having a beneficial impact i.e. reducing the cost of travel thereby making public transport options more attractive.

As shown, C1 generally has a positive impact on the generalised cost of travel along the Swords to City corridor with reductions of 1% to 14% of the generalised cost of travel forecast. Additionally, some benefits / reductions in the generalised cost of travel are forecast to the south of the study area, such as at Bray and Dun Laoghaire, where reductions in the generalised cost of travel of up to 3% are seen.

In addition to these positive impacts, zones north of Clongriffin experience an increase in the generalised cost of travel of 2% to 4% and at Howth an increase of 10% in the generalised cost of travel is forecast. This is as a result of the removal of direct Dart services to Howth and a reduction in services north of Clongriffin. Additionally some disbenefit is seen at Broombridge and zones west of Broombridge where the Luas will act as a shuttle to link with LR3 in future years.

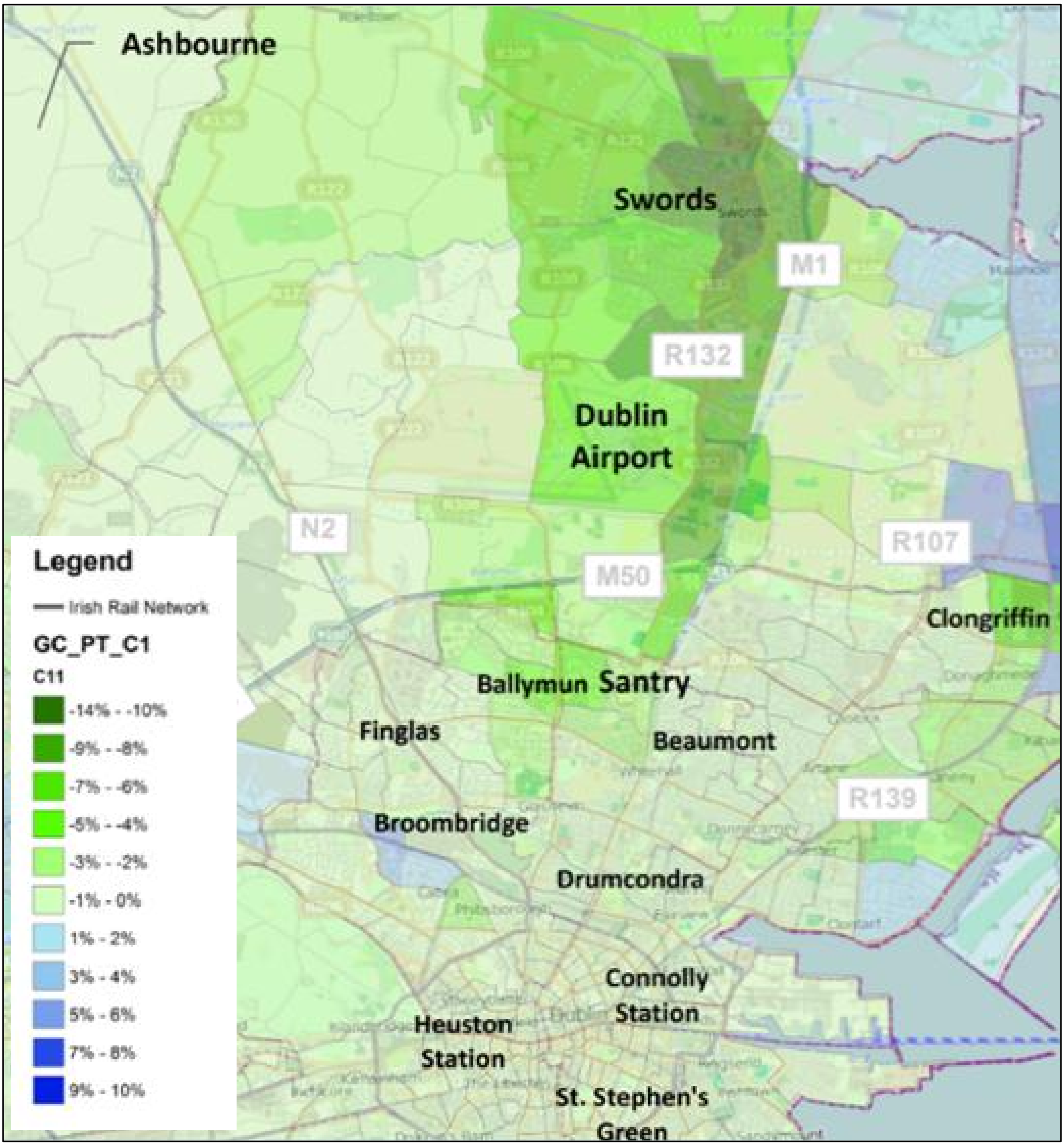
These impacts on the generalised cost of travel feed into the HR2 patronage as detailed in the following sections. Other fluctuation in generalised cost of travel at zones far removed from the study area can be attributed to model "noise" and do not have significant impact on the demand generated for the proposed schemes.

<u>Summary of C1 Travel Demand Assessment</u>

The light rail element of the combined scheme option C1 generates significantly lower southbound passenger demand than other options examined. This points to the service delivering less benefit in terms of journey time saving to Swords residents accessing the City Centre. On the northbound service some overcrowding issues are noted in the scheme opening year, with the peak load exceeding the design capacity.

Reasonable demand is generated on the heavy rail element; this is a result of heavy loading at the Airport and Clongriffin. However this results in dis-benefits to existing and future passenger numbers north of Clongriffin. No overcrowding issues are forecast on heavy rail services.

Figure 10.7: 2033 Change in Generalised Cost Do Something Option C1 relative to Do Minimum Option



10.8 C1: Cost Estimate

A summary of the proposed cost estimates for the LRT and heavy rail alignments for C1 are shown in Table 10.3 and Table 10.4 below. The revised scope of C1 has allowed some cost savings in comparison to the original proposal for LR3 tunnelled through airport. The overall scheme is estimated to cost €1.83bn to deliver.

*Table 10.3: Summary of C1 Light Rail (LR3 via R132) capital cost estimates**

Total LR3 Capital Costs				
Description				**Total amount**
i)	Construction/Direct Costs			354,120,000
ii)	Design costs			31,871,000
iii)	Client Costs			21,247,200
iv)	Rolling stock			72,000,000
			Sub total	**479,240,000**
v)	Miscellaneous client costs and project burdens		2.00%	9,585,000
vi)	Risk	504,809,000	30.00%	146,647,500
vii)	VAT	656,252,000	13.50%	85,788,855
			Total cost	**721,261,355**

** Note that the capital costs developed are for comparative purposes only*

*Table 10.4: Summary of C1 Heavy Rail (HR1) capital cost estimates**

Total HR1 Capital Costs				
Description				**Total amount**
i)	Construction/Direct Costs			553,150,000
ii)	Design costs			44,252,000
iii)	Client Costs			49,783,500
iv)	Rolling stock			0
			Sub total	**647,190,000**
v)	Miscellaneous client costs and project burdens		2.00%	12,943,800
vi)	Risk	660,133,800	30.00%	231,046,830
vii)	VAT	891,180,630	13.50%	120,309,385
			Total cost	**1,011,490,015**

** Note that the capital costs developed are for comparative purposes only*

Estimated operating and maintenance costs for C1 are €30.1m per annum, €22.2m for LR3 and €7.9m for HR1. These capital and O/M costs have been taken forward for the purpose of economic appraisal of C1.

10.9 C1: Summary

C1 is proposed as a combination of a heavy rail link between Clongriffin and Dublin Airport (HR1) with a light rail extension of Luas Cross City to Swords (LR3). In this instance, LR3 would run on the R132 and serve employment areas at the Airport while the heavy rail link would provide more direct access to the City Centre from the Airport.

The heavy rail component is 7.5km in length, of which 4.1km is at-grade/elevated and 3.4km is tunnelled (from east of the M1 to the Airport); while the light rail component is approximately 13km in length, including a 2km (approx.) tunnel under Glasnevin. One stop is proposed on the HR1 alignment at Dublin Airport, while the LR3 alignment has 13 stops, with the Airport stop located on the R132.

C1 has been found to be technically feasible. Some of the main technical risks associated with delivery of this option include:

- The impact of tunnelling on sites of cultural heritage at Glasnevin Cemetary have yet to be determined through detailed geotechnical surveys;
- Long term disruption to Swords Main Street with traffic being diverted within the area to facilitate on-street tram running;
- Development of the underground station at the Airport will result in temporary disruption and present some technical risk; and
- The proposed alignment presents possible adverse impacts to sites of archaeological significance between Clongriffin and the proposed tunnel portal. These include historic enclosures and wells. The proposed alignment has been developed to mitigate as many sites as possible.

Delivery of C1 is expected to cost €1.7bn with additional operating costs of €30m per annum.

LR3 journey times for Option C1 are 7 minutes longer to Estuary as the route operates on the R132, past the airport. This results in a journey time of 29 minutes between O'Connell Street and the Airport, and 42 minutes between O'Connell Street and Estuary. The journey time for HR1 between the Airport and Connolly Station is 24 minutes.

The HR1 route would operate 6TPH, with eight carriage DART trains offering a design capacity of 6,720pphpd. While theoretically, the LR3 route could operate to a maximum of 24TPH, a more realistic limit is 21TPH. This gives a design capacity of 5,985pphpd. This results in C1 offering the highest level of capacity of all options.

On the basis that C1 is a feasible option for future development within the study area, details of the scheme outlined above have been used as the basis for economic appraisal and multi-criteria assessment in Sections 12 and 13 respectively.

11 Stage 2 Appraisal Methodology

11.1 Overview

This section details the approach taken for the appraisal of the 4 schemes which were selected to progress for detailed appraisal and comparative evaluation. These were:

- Heavy Rail 2 (HR2);
- Tunnelled Light Rail 3 (TLR3);
- Light Rail 7 (LR7); and
- Combination 1 (C1).

The following sections outline the appraisal methodology for Stage 2. This process followed the Stage 2 Options development phase (previously outlined in Section 6).

11.2 Stage 2.4: Economic Appraisal

Economic appraisal of the public transport options which meet the identified 2033 travel demand within the study area was undertaken. The analysis was carried out in line with the Department of Transport, Tourism & Sport (DTTAS) 'Guidelines on a Common Appraisal Framework for Transport Projects and Programmes', 2009 and in accordance with Section D.03 "Guide to Economic Appraisal: Carrying out a Cost Benefit Analysis" of the Public Spending Code published by the Department of Public Expenditure and Reform.

Economic parameters used as part of the economic appraisal are based on the latest industry standard variables extracted from the NRA Project Appraisal Guidelines which are based on DTTAS guidance. In particular, the appraisal criteria defined in the Common Appraisal Framework (CAF), will guide the choice of the "optimum" solution.

In addition to the appraisal criteria considered during Stage 1 (economy, integration and environment), a more detailed assessment of each scheme in relation to the two remaining CAF criterion, Safety and Accessibility and Social Inclusion was undertaken.

The economic appraisal undertaken was used only for comparative assessment of each of the shortlisted scheme options. As the preferred option is further refined, additional analysis will be required based on more detailed cost information, design refinements, etc.

The economic appraisal was undertaken using the strategic transport model outputs from the "2033 Do Minimum" and "2033 Do Something" scenarios summarised in the Section 6.4. The results were used to develop network indicators for each option which would allow a comparison of each proposed options with reference to a baseline scenario. The options were tested using the model network indicators (model outputs) as shown in Table 11.1.

These model outputs were fed into bespoke software called TUBA (Transport User Benefit Appraisal) to compare the relative benefits and disbenefits of each of the scheme options. TUBA was developed on behalf of the UK Department for Transport as a tool to convert transport modelling and cost inputs into economic appraisal outputs and is a widely-used industry standard tool.

Table 11.1: Network Indicators to be used for testing of route options

Project Objective	Network Output
Environment	Vehicle Kilometres, PT Passenger Kilometres
Safety	Vehicle Kilometres, PT Passenger Kilometres
Economy	Total Vehicle Travel Time & Distance, Total PT Travel Time & Distance

TUBA calculates changes to user and non-user time benefits, operating cost impacts and fares as a result of the implementation of the defined scheme option. These impacts are monetised, discounted and summarised to allow a comparison with the full discounted costs of the scheme over a 60 year appraisal period. The results give an indication of the economic worth of the project.

The economic appraisal used a Discount Rate of 5% and a 60 year appraisal period (30 years appraisal plus 30 years residual value). All costs and benefits are represented in 2009 prices. A growth in benefits in line with projected population growth (1.0% per annum) has been assumed after the 2033 modelled year up to the end of the appraisal period.

Annualisation factors were used to convert the outputs from the modelled time periods to annual outputs. The annualisation factor used to convert highway benefits was 253 x 2 = 506 (based on 253 weekdays per annum and two peak periods). The highway benefits generated by the scheme are only expanded in line with the AM and PM peak traffic periods as these are the time when the congestion relieving benefit of these schemes would be realised on the highway network.

For public transport benefits, a separate annualisation factor was developed which accounted for full day benefits to public transport users generated by the each scheme option. To determine this factor, an analysis of the distribution of daily boarding data on DART services and Dublin Bus services on the Swords Road was undertaken. An expansion factor of 1057 was developed by summing the boardings on relevant PT services between the hours 07:00 to 10:00 and dividing the total daily boardings by the result to get a 07: 00 to 10:00 to daily expansion factor. The daily expansion factor was further multiplied by a yearly expansion factor.

Certain effects and features of each of the schemes selected for detailed appraisal are quantifiable and can be monetised. The economic appraisal identifies the costs and benefits for the following effects:

- **Economic Effects:** The economic appraisal estimates the welfare gain from the investment in each proposed scheme option, on the efficiency and effectiveness of the transport system. This included the following elements:
    - Net transport user benefits such as: Journey time (in-vehicle time, transfer time, walk and wait time etc.), charges (fares/tolls/parking etc.) and vehicle operating costs;
    - Net transport operator benefits such as: Investment costs, operating and maintenance costs, revenue and grant/subsidy payments;
- **Safety Effects:** Safety benefits were calculated using bespoke safety models, which relate the in-vehicle kilometre outputs from the transport model, to the number of accidents via the application of accident rates; and
- **Environmental Effects:** The TUBA appraisal software was used to quantify and value the effect of each of the options in relation to air quality.

A summary of the model outputs used for the economic appraisal can be found in Table 11.1. The full economic appraisal for each scheme option can be found in Section 12.

11.3 Stage 2.5: Multi-Criteria Analysis (MCA)

A multi-criteria analysis (MCA) was undertaken which aimed to capture how each of the shortlisted schemes responds to the objectives of each of the following CAF appraisal criteria.

A MCA for each scheme option was prepared which consolidates all information available in relation to expected scheme impacts under each appraisal criterion. On the basis of these individual appraisals, a ranking exercise was undertaken to determine which of the four options performed best against the objectives of each criterion using the following scale:

- Advantages over other options;
- Neutral compared to other options; and
- Disadvantages compared to other options.

So for example, for the 'Biodiversity' sub-criterion of Environment, a judgment was made by our Environmental Team, based on all information available, as to which option was Most/Least

Advantageous. The ranking for each criterion was done in this way and allowed and overall conclusion to be drawn in relation to the most advantageous option.

The MCA is presented in Section 12 and outlines each of the shortlisted options in detail as well as the recommended scheme.

12 Stage 2: Economic Appraisal

12.1 Overview

Stage 2 of this study has consisted of further examination of the options shortlisted in Stage 1 of this study. Sections 7 to 10 of this report describe how each of these options has been subject to further technical development and scrutiny. Amongst other things, the NTA's Greater Dublin Area Strategic Transport Model has been used to estimate the traveller response to each of the shortlisted options.

As a result of this further technical work it became apparent that a number of the options shortlisted in Stage 1 could be eliminated from further consideration. In particular it became clear that some of these alternatives would not have sufficient capacity to meet the strategic objectives of the study, i.e. they would not be able to meet future demand for travel between Dublin City Centre and each of Dublin Airport and Swords.

The remaining transport options were appraised in accordance with the requirements of the Common Appraisal Framework (Department of Transport, 2009) and Section D.03 *'Guide to Economic Appraisal'* of the Public Spending Code published by the Department of Public Expenditure and Reform.

As is required by these guidelines, this appraisal consisted of a full examination of the effects of each option under five headings:

- Environment;
- Economy;
- Safety;
- Accessibility and Social Inclusion; and,
- Integration.

Where these impacts can be valued in money terms, this has been done and the results have been used to prepare an economic appraisal of the remaining shortlisted options. This section describes this process and the resulting economic appraisal.

12.2 Approach

A detailed overview of the approach and methodology used in developing the Economic Appraisal is provided in Section 11. It is important that the key assumptions and parameters used are reviewed in advance of analysing the results presented in the following sections. For convenience, a summary of the key assumptions are as follows:

- **Opening year:** Each of the Options has been appraised assuming an opening year of 2033. While different opening years are possible for all of the options, utilising the same opening year provides a common comparative basis for evaluating the alternatives. The NTA strategic transport model has been used to forecast the response of travellers to each scheme option in this opening year;
- **Appraisal period:** The benefits and costs of each scheme option have been forecast over a thirty year appraisal period. The residual value of each option at the end of this thirty year appraisal period has been calculated by estimating the costs and benefits of the options over a further 30 year residual life. This approach is the standard methodology for major investments in transport infrastructure. Transport infrastructure has a particularly long useful life and this length of appraisal period is, for example, required by the DTTAS Common Appraisal Framework.

- **Discount rate:** The forecast costs and benefits of each Option have been discounted to a single present value using a discount rate of 5 per cent, as required by the DPER Public Spending Code.
- **Annualisation factor:** The NTA's Greater Dublin Area Strategic Transport Model produces a forecast of traveller response to each option in a single morning peak travel period. This allows the calculation of the transport benefits generated by each option during a single morning peak. These estimates have been converted into estimates of the benefits realised in a whole year by applying annualisation factors. The annualisation factor for public transport benefits is 1057. This factor was calculated based on the latest travel census data on public transport use, and the ratio between public transport use in the morning peak and public transport use in the whole year. Benefits to road users are assumed to only arise in morning and evening peaks when roads are particularly congested. On this basis a lower annualisation factor of 506 has been applied to benefits accruing to "highway" users during peak periods.

12.3 Economy

Major investments in transport infrastructure have significant impacts on the economy, and in particular on the economy of the areas that they serve. These impacts comprise:

- Benefits for the individuals and firms that make use of the additional or improved transport services that are now available. These are referred to as "Transport User Benefits";
- The cost of building, operating and maintaining the infrastructure in question represents a use of scarce resources and hence a cost to the economy as a whole; and
- The impacts of improved transport on the productivity of firms and workers the area that now enjoys better transport services. These are referred to as "Wider Economic Benefits".

In relation to the options under assessment, each of these economic impacts is described and, to the extent possible, valued in money terms in the following sub-sections.

12.4 Transport User Benefits

The key economic objectives of the schemes assessed for the Fingal/North Dublin Transport Study are:

- To deliver a high quality public transport service along the Swords/Airport to City Centre corridor;
- To provide journey-time reliability and consistency of speeds for a public transport system from Swords and the Airport to the City Centre;
- To provide a high frequency public transport service between the Airport and the City Centre;
- To respond to anticipated passenger demands and national transportation policy; and
- To improve the economy, integration and efficiency of transportation, by increasing the use of public transport.

Fulfilling these objectives will produce benefits for travellers, which can be measured and valued in money terms based on the transport modelling work carried out as part of this study.

As described above, the NTA's Strategic Model was used to develop forecasts of public transport and private transport demand. These demand forecasts were carried out for the Do Minimum and the four Do Something scenarios that were brought forward from the Stage 2 Options Development process as detailed earlier, namely:

- Do Something HR2;
- Do Something TLR3;
- Do Something LR7; and
- Do Something C1.

Passenger forecasts were generated for the assessment scheme opening year of 2033.

The transport user benefits of the 4 options relative to the Do-Minimum Scenario were calculated based on modelling outputs using TUBA.

The net transport user benefits associated with the schemes were forecast based on the difference between the Do Minimum and relevant Do Something scenario. The benefits evaluated include those accruing to public transport users, road users and the environment.

Disbenefits (i.e. negative benefits) may also occur. For example users of existing public transport services that now must interchange in order to travel between some stations (such as between Cabra and Broombridge and between Howth and Howth Junction). The economic appraisal accounts for such disbenefits by evaluating the net change in benefits.

The benefits (and costs, see next Section 12.4) are discounted back to a base year providing the net present value (NPV) of the project. These benefits are set out in Table 12.1 below. Option LR7 delivers by far the highest level of transport user benefits. These benefits of LR7 have a present value just over €1.2bn. This is expected and is consistent with the high passenger numbers and low journey times expected from this high capacity, high speed option. The next highest level of benefits is provided by Tunnelled LR3 - the lower capacity, slower Light Rail option. This is expected to deliver benefits with a present value of €749m. The remaining options deliver significantly lower levels of transport user benefit, consistent with the lower levels of passenger demand and/or lower levels of service.

12.5 Costs

The costs of the proposed projects comprise capital as well as operation and maintenance (O&M) costs. These costs are outlined in the Stage 2 Options Development sections of this report.

TUBA was used to calculate present values for the capital and O&M costs of each of the four options relative to the Do-Minimum Scenario. These calculations were carried out on the same basis as the calculations of the present values of transport user benefits.

Three of the four options have broadly similar levels of O&M costs. The present values of options HR2, TLR3 and LR7 range from €148m to €270m. The combined C1 option comprises a light rail scheme and a heavy rail spur and so has higher O&M costs. The present value of the O&M costs for C1 is €285m.

12.6 Appraisal Results

TLR3 and LR7 generate the highest Benefit to Cost Ratios (BCR's), which taking only transport user benefits into account give BCR's of 0.8 and 1.5 respectively. The low BCR generated by C1 of 0.4 is a reflection of the high cost to deliver the scheme and the low €378m benefits generated during to longer travel times on LR3 via the R132 at the Airport.

There are other benefits of the scheme options that can be assigned a monetary value, and the effect of these benefits on the overall appraisal of the options are detailed below.

Table 12.1: Costs and Transport User Benefits of the shortlisted options

	HR2	TLR3	LR7	C1
Present Value of Transport User Benefits	415,776	758,084	1,562,716	378,261
Present Value of Capital Costs	769,433	715,755	751,696	628,930
Present Value of Net Operating Costs	147,960	201,211	269,982	285,332
Present Value of Costs	917,393	916,966	1,021,678	914,262
Net Present Value of Monetised Benefits & Costs	-501,617	-158,882	541,038	-536,001
Benefit Cost Ratio of Monetised Benefits & Costs	0.45	0.84	1.56	0.43

** Values reported in € '000s*

12.7 Wider Economic Benefits

Improvements in transport infrastructure can have effects on the productivity of the economy as a whole in addition to the benefits for transport users described above. These "Wider Economic Benefits" are considered to be of four types:

- Agglomeration effects on productivity; and
- Labour Market Effects:
    - Encouraging people to enter the labour market;
    - Allowing people to move to more productive jobs; and
    - Expended output in imperfectly competitive markets.

Agglomeration benefits arise from the increase in productivity that comes with increases in the level of concentration of economic activity. These productivity benefits from greater concentrations of economic activity were first noticed in studies of the economic performance of cities. In general firms in larger cities - with greater concentrations of individuals and businesses - are more productive than firms in smaller towns and cities or in rural areas. These productivity benefits come from having access to:

- Larger labour markets providing access to a specialised labour force;
- Larger product markets providing a bigger potential market for products; and
- A broader range of other firms providing specialist inputs and services and acting as potential partners and sub-contractors.

The transport user benefits of the options reduce the effective distances between firms and individuals in the areas served by the options. These can give rise to the type of agglomeration effect described above. The potential for agglomeration effects from each of the options is, therefore, proportionate to the journey time savings it realises.

For the purposes of this appraisal the potential agglomeration benefits of each option have been ranked based on the total journey time savings associated with each option.

Equally the reduction in effective distance between firms and individuals may encourage additional people to enter the labour market, or could allow people to travel further to work and so take on more productive jobs. Both of these effects lead to net increases in economic output and welfare. For the purposes of this appraisal the potential of each option to give rise to these types of Labour Market Effects has been ranked based on the commuter time savings that each option produces.

Finally, the majority of markets for goods and services operate in conditions of less than perfect competition. As a result, the level of production in these markets will be lower than the socially optimal level that would be reached under conditions of perfect competition. Reducing the costs faced by firms in an imperfectly competitive market leads to them increasing their output and reducing prices, so producing economic benefits. Reductions in the travel costs of firms can produce this type of benefit in the economy as a whole. These benefits are usually estimated as being 10 per cent of the value of travel time savings for business travel. For the purposes of this appraisal process the potential Imperfect Competition benefits of each option have been ranked based on the total business travel time savings associated with each option.

The Wider Economic Benefits of each option based on the approach outlined here are set out in Table 12.2. As shown, LR7 generates the highest level of wider economic benefit. This is largely due to the fast journey times and high level of travel demand it generates. The inclusion of these Wider Economic Benefits would improve the attractiveness of LR7 relative to the other options.

Table 12.2: Wider Economic Benefits of Options

	HR2	TLR3	LR7	C1
Agglomeration	3	2	1	4
Labour Market	3	2	1	4
Imperfect Competition	17,634	9,066	30,756	13,163

Values reported in € '000s

12.8 Environment

Each scheme option will have a positive impact on quality of life through reduced journey times. It will also improve air quality by reducing greenhouse gas emissions caused by the movement of transport users from cars to public transport.

The reduction in greenhouse gas emissions arising from each of the scheme options has also been assessed and monetised through TUBA.

Results of the assessment, shown in Table 12.3 demonstrate that LR7 is likely to generate the highest level of CO2 reductions with a present value of benefits Present Value of Benefits (PVB) of €302,000. Again, taking this impact into account in the appraisal process, marginally increases the attractiveness of LR7 relative to the other options.

Table 12.3: Monetised environmental impact of shortlisted options

	HR2	TLR3	LR7	C1
PVB CO2 Reductions	266	199	302	210

Values reported in € '000s

12.9 Safety

The implementation of the scheme options has the potential to reduce the frequency and severity of road accidents by generating a shift from private car travel to public transport.

In order to assess the monetary impacts of the reduction in road accidents arising from the implementation of each scheme, reductions in Vehicle Kilometres Travelled (VKT) have been assessed. Standard accident rates and costs per VKT have been examined and the cost savings accruing from any reduction in VKT upon scheme implementation have been developed. The rankings of each option based on the approach outlined here are set out in Table 12.4.

Table 12.4: Monetised safety impact of shortlisted options

	HR2	TLR3	LR7	C1
Accident Reduction Value	€ 1,519	€ 2,330	€ 3,945	€1,516

Values reported in € '000s

LR7 delivers the highest level of safety benefits, consistent with the fact that it has by far the highest level of patronage of the shortlisted options.

12.10 Conclusion

The results described above can be brought together into an economic appraisal of each of the shortlisted options. This is a statement of the costs and benefits of each option that can be expressed in monetary terms. This is set out in Table 12.5 below.

As illustrated in this section, LR7 is a high capacity, high quality scheme which attracts by far the highest level of patronage. As a result, it produces much higher levels of monetary benefits than the other options, at over €1.5bn. Despite the fact that it is the highest cost option it delivers a much better ratio of benefits to cost than HR2 or C1 and higher ratio of benefits to costs than the marginally lower cost TLR3.

Table 12.5: Costs and Benefits of the shortlisted options

	HR2	TLR3	LR7	C1
Present Value of Transport User Benefits	415,776	758,084	1,562,716	378,261
Present Value of Imperfect Competition Benefits	17634	9066	30756.2	13163
Present Value of Emission Reductions	266	199	302	210
Present Value of Accident Reductions	1519	2330	3945	1516
Present Value of Monetised Benefits	435,195	769,679	1,597,719	393,150
Present Value of Capital Costs	769,433	715,755	751,696	628,930
Present Value of Net Operating Costs	147,960	201,211	269,982	285,332
Present Value of Costs	917,393	916,966	1,021,678	914,262
Net Present Value of Monetised Benefits & Costs	-482,198	-147,287	576,041	-521,112
Benefit Cost Ratio of Monetised Benefits & Costs	0.45	0.84	1.56	0.43

* Values reported in € '000s

13 Stage 2: Multi- Criteria Analysis

13.1 Overview

A multi-criteria analysis (MCA) was undertaken to consolidate the quantifiable and non-quantifiable impacts of each shortlisted public transport option. The MCA provides a valuable tool in prioritising schemes for investment and supporting decision making.

A summary of each of the options presented for MCA is provided in Table 13.1. As shown, four options have been brought forward for analysis as follows:

- **HR2:** Heavy rail connection from Clongriffin to Swords via a tunnelled station at the Airport;
- **TLR3:** Extension of the Luas Cross City to the Airport and Swords with tunnelled city centre connection via Jervis;
- **LR7:** Optimised Metro North includes fewer and smaller stations and more at-grade running instead of tunnels; and
- **C1:** This option combines a heavy rail connection from Clongriffin to the Airport with an extension of Luas Cross City to the Airport and Swords.

As shown in Table 13.1, the schemes present similar characteristics in terms of the levels of capacity they offer and demand they generate. The following sections present a more detailed comparison of each option in accordance with adopted appraisal guidelines.

Table 13.1: Summary of shortlisted public transport schemes for appraisal

	HR2	TLR3	LR7	C1	
				HR1	*LR3*
Technically Feasible	Y	Y	Y	Y	Y
Length of New Route	13.2km	16.5km	16.5km	7.5km	13km
Journey Times					
O'Connell to Airport	23 (from Connolly)	20 (from Jervis)	19	24	25
O'Connell to Estuary	30 (from Connolly)	29 (from Jervis)	31	N/A	35
TPH	6TPH	24TPH	30TPH	4TPH	24TPH
Design Capacity	6,720	7,920	9,900	4,480	6,840
New Stations Served	3	15	14	1	13
2033 AM Peak Loading*	6,420	5,804	6,245	5,000**	7,055**
Cost (2014) (incl. VAT)	€2.1bn	€2.2bn	€2.3bn	€1bn	€721m

* These loadings do not include the impact of Park and Ride provision and M50 demand management measures.

** These line flows occur on the existing DART line and on the existing Luas Green line – flows on the proposed new infrastructure are lower.

13.2 Approach

As outlined in Section 11, the MCA has been developed on the basis of the 'Guidelines on a Common Appraisal Framework (CAF) for Transport Projects and Programmes'. The MCA consolidates available information with regards all shortlisted options to enable a 'ranking' of each option against the following criteria:

- **Environment:** The objective of the environmental appraisal is to assess which scheme provides the highest level of protection of the environment. The appraisal is based on the high level assessment of environmental impacts previously undertaken and presented in this report. While a large proportion of the identified environmental impacts are qualitative in nature, TUBA software has been used to quantify and value the effect of each of the options on air quality;

- **Economy:** The economic criterion aims to establish which of the proposed options is likely to return the highest economic benefit and the relative potential of each scheme to act as a catalyst for economic activity. The outcomes are largely based on the outputs of the economic appraisal presented in Section 12. The economic appraisal is mainly quantitative and relates to the consumer and producer effects of each shortlisted scheme. Consumer effects are transport user costs/benefits such as journey time, charges (like fares and tolling) and vehicle operating costs. Producer effects are the transport operator costs/benefits and include capital and operating costs as well as revenue. The Cost Benefit Ratio of each scheme is presented as well as the Net Present Value;

- **Safety:** The safety appraisal aims to identify the shortlisted scheme which is most likely to result in the highest level of safety for road users. Outputs from the transport model are used to quantify the expected impact of each option on road accidents;

- **Accessibility and Social Inclusion:** This appraisal aims to identify the scheme which is likely to have the best impact in terms of improving access to areas of defined social deprivation. To ensure some level of quantity in this assessment, each scheme was ranked in terms of the number of defined areas of social deprivation served by each new scheme; and

- **Integration:** This appraisal aims to identify the scheme which is likely to provide the best integration with existing public transport networks, land use integration and geography. The appraisal is largely qualitative and is strongly based on the context previously presented in Section 2.

The MCA designates a ranking for each scheme option against the criteria outlined above, as follows:

Advantages over other options
Neutral compared to other options
Disadvantages compared to other options

The appraisal does not provide a numerical ranking to indicate the preferred option; however, it does indicate the most advantageous option across all those considered.

The following sections provide a summary of the appraisal against each of the CAF criterion as well as the most advantageous scheme option in each case.

13.4 Environment

The assessment of environmental impacts forms an important part of the multi-criteria appraisal, as significant adverse impacts which cannot be effectively mitigated can potentially render an infrastructure project unviable. The appraisal is based on the following criteria:

- Air quality;
- Noise and vibration;
- Landscape and visual quality;
- Biodiversity – flora and fauna;
- Cultural, archaeological and architectural heritage;
- Land use, soils and geology; and
- Water resources.

13.4.1 Air Quality

Air quality impacts are considered both in terms of the contribution towards reduced greenhouse gas emissions (in particular CO_2 emissions), as well as the impact on local air quality.

For each option, $C0_2$ emissions for that option were monetised in terms of Present Value of Benefits (PVB). This was calculated using outputs from the NTA model in relation to vehicle kilometres travelled for each option and adopted monetised parameters for air quality emissions. The scoring of each option is presented below. As shown, LR7 has the most positive impact on air quality. This is because LR7 is most likely to influence modal shift and reduce vehicle kilometres travelled by car.

Table 13.2: Summary of Air Quality Appraisal

Scheme	HR2	TLR3	LR7	C1
Air Quality (€000 of CO2 reductions)	199	266	302	210

13.4.2 Noise and vibration

Transport-related noise can affect quality of life (and in extreme circumstances can result in health impacts), while vibration impacts can potentially impact on properties and other structures during construction. For this appraisal, noise and vibration have been considered in relation to the construction and operational stage of each option.

Impacts during construction are too difficult to determine at this stage of project development. Therefore, a comparative assessment of noise impacts has been based on the overall route length of each option. On this basis, C1 is ranked as Most Disadvantageous at 21km in length. LR7 and TLR3 at 16.5km are both ranked as neutral while HR2 ranks positively at 13km in length.

Post construction, the noise impacts of heavy rail schemes are generally higher than light rail. However, in this instance HR2 is likely to have the least impact as it largely runs through either agricultural areas or tunnel. Therefore, this option is regarded as most advantageous during the operational phase.

Post construction noise impacts for TLR3 and LR7 are not expected to be significant, particularly as the at-grade alignment of these options is largely through existing roads with high traffic volumes.

Given that C1 is likely to have noise and vibration impacts associated with both its light rail and heavy rail components, it presents the least advantage in terms of this appraisal. All options present impacts during the construction phase; however HR2 performs best in terms of impacts during the operational phase given the limited residential development adjacent to its at-grade alignment.

Table 13.3: Summary of Noise and Vibration Appraisal

Noise and Vibration	**HR2**	**TLR3**	**LR7**	**C1**
Construction				
Operational				

13.4.3 Landscape and visual quality

Landscape and visual quality impacts are assessed in terms of impact on the intrinsic character of a landscape / townscape and the impact on the quality of views. These impacts can occur through the introduction, removal or alteration of infrastructure or natural landscape features, as well as from changes in numbers of traffic movements. Landscape and visual quality impacts are assessed through determining the number and type of properties / landscapes to be affected.

All options are considered to have potentially adverse landscape and visual quality impacts, as follows:

- TLR3 and LR7 are expected to have impacts around tunnel portal locations, as well as visual impacts due to the at-grade sections in rural areas south of Swords; and
- HR2 is expected to create a negative visual impact due to the proposed elevated section (west of Clongriffin Station), given the surrounding land is mainly used for arable farming and is flat in nature. A similar impact is expected for the heavy rail component of C1.

C1 is estimated to perform least well in terms of landscape and visual quality as it combines the visual impact of the heavy rail elevated section as well as the townscape impacts of TLR3. TLR3 and LR7 are recommended as the most advantageous options as their route and stations generally run at-grade and do not present significant impacts. On this basis, HR2 is ranked as neutral, largely on the basis of the elevated sections forming part of its alignment.

Table 13.4: Summary of Landscape and Visual Quality Appraisal

Environment	**HR2**	**TLR3**	**LR7**	**C1**
Landscape and Visual Quality				

13.4.4 Biodiversity – flora and fauna

Biodiversity impacts have been considered in terms of impacts on specific flora or fauna and / or defined habitats. The construction, presence and operation of transport infrastructure can impact on nature conservation resources through direct loss or damage to habitat or specific species, creation of barriers to population movement or indirect effects resulting from, for example, changes in water quality of levels, air quality or noise and light levels.

A summary of the appraisal is as follows:

- HR2 is likely to have significant impacts within the Airport to Clongriffin section of the alignment as it runs through agricultural land. Similar impacts are expected for the heavy rail component of C1;

- TLR3 will require detailed investigation of impacts in relation to tunnelling and impact on hydrological connections, as well an investigation to determine possible impacts of this alignment on Natura 2000 sites; and

- LR7 presents an advantage over the other options, as habitats and species along the alignment are generally of low to moderate local nature conservation value.

Noting that all options require further investigation, it is estimated that C1 presents the most disadvantage in terms of biodiversity impacts due to its alignment through both urban and rural areas. HR2 also presents potential significant disadvantages. TLR3 presents no major impacts at this high level appraisal, while LR7 presents an advantage as habitats and species along the alignment have previously been identified as low to moderate nature conservation value.

Table 13.5: Summary of Biodiversity Appraisal

HR2	TLR3	LR7	C1

13.4.5 Cultural, archaeological and architectural heritage

Cultural, archaeological and architectural heritage impacts are assessed in relation to the impacts on below ground archaeological remains, historic buildings (individual and areas), and historic landscapes and parks. This assessment was undertaken by identifying the number, location and type of sites potentially impacted by each option, and the significant of these impacts.

A summary of the appraisal is as follows:

- The heavy rail spur from Clongriffin to the Airport will result in potentially significant impacts (including impacting on a known enclosure), as a high concentration of sites and monuments exist in this area. This has affected the ranking of HR2 and C1;
- Vibration caused by tunnel boring under Glasnevin, the Botanic Gardens and Swords Town Centre may also have significant impact on Recorded Monuments and Protected Structures along TLR3, HR2 and C1; and
- Many impacts of LR7 have previously been designated as avoidable and revised at-grade sections do not have significant impacts.

Overall, LR7 is considered most advantageous and C1 is least advantageous.

Table 13.6: Summary of Cultural, Archaeological and Architectural Heritage Appraisal

Environment	HR2	TLR3	LR7	C1
Cultural, archaeological and architectural heritage				

13.4.6 Land use, soils and geology

This element considers the effects, both permanent and temporary, on:

- Land-use: Potential impacts through land- take severance or reduction of viability, which prevents or reduces its value for intended use; and

- Soil and geology: Potential impacts due to soil usage and degradation during construction, pollution from run-off, subsidence, contamination etc.

At this stage of project delivery, a preliminary conclusion can only be drawn with regards to land use as there is limited detailed information available in relation to soil and geology for HR2, TLR3 and C1. A land use assessment has concluded that TLR3 and LR7 are similar but have no particular advantage over each other and are thus rated neutral. HR2 and C1 are Least Advantageous in that it requires acquisition of agricultural land and disruption to existing agronomy.

Table 13.7: Summary of Land Use, Soils and Geology Appraisal

Environment	**HR2**	**TLR3**	**LR7**	**C1**
Land use, soils and geology				

13.5 Economy

13.5.1 Economic Appraisal

As outlined in Section 11, an economic appraisal was undertaken using the TUBA programme (v1.9). This analysis expressed the transport user benefits and the costs of the Options in monetary terms. In addition, a money value of one of the Wider Economic Benefits of the options - Imperfect Competition Effects - was calculated. A qualitative assessment of the other three Wider Economic Benefits was carried out.

These results on the economic impacts of the Options are summarised in Tables 13.8 and 13.9 below.

Options TLR3 and LR7 have the highest BCR values of 0.84 and 1.56 respectively, taking only economic impacts into account. This demonstrates that both schemes are economically viable and are therefore worthwhile projects to progress. These strong economic indicators tally with the estimated reduction in travel times.

As shown in Figure 13.8, LR7 has the highest Present Value of Benefits followed by TLR3. The qualitative assessment of the remaining Wider Economic Benefits reinforces this finding that LR7 delivers the highest level of economic benefits.

Table 13.8: Economic Costs and Transport User Benefits Results Summary

Present Values (€'000)	HR2	TLR3	LR7	C1
Present Value of Transport User Benefits	415,776	758,084	1,562,716	378,261
Present Value of Capital Costs	769,433	715,755	751,696	628,930
Present Value of Net Operating Costs	147,960	201,211	269,982	285,332
Present Value of Costs	917,393	916,966	1,021,678	914,262
Net Present Value of Monetised Transport User Benefits & Costs	-501,617	-158,882	541,038	-536,001
Benefit Cost Ratio of Monetised Transport User Benefits & Costs	0.45	0.84	1.56	0.43

** Note: All costs and values represented 2009 prices*

Table 13.9: Wider Economic Benefits of the Options

	HR2	TLR3	LR7	C1
Agglomeration Effects	3	2	1	4
Labour Market	3	2	1	4
Imperfect Competition Effects (€'000)	17634	9065.7	30756.2	13162.8

** Note: All costs and values represented 2009 prices*

Table 13.10: Cost Summary

	HR2	TLR3	LR7	C1
Present Value of Costs	917,393	916,966	1,021,678	914,262

** Note: All costs and values represented 2009 prices*

Table 13.11: Passenger Demand

	HR2	TLR3	LR7	C1
Total PT Demand in AM Peak Period	451,159	455,248	457,992	450,133

13.6 Safety

As outlined in Section 12, the TUBA programme does not calculate accident benefits, therefore the assessment of accident benefits is based on:

- Outputs from the traffic model in terms of the estimated reduction in vehicle kilometres travelled (VKT); and
- Data on accident incidence from the Road Safety Authority (RSA) personal injury accident database; and
- DTTAS accident parameters taken from the Common Appraisal Framework.

Analysis has shown that the construction of the scheme will reduce the frequency and severity of road accidents through a reduction of VKT for each option brought about through modal shift from private car to public transport. The analysis undertaken has indicated that scheme option LR7 will result in the greatest overall reduction in VKT followed by scheme option TLR3.

Table 13.12: Summary of Safety Impact Analysis

Present Values (€'000)	**HR2**	**TLR3**	**LR7**	**C1**
Safety (Accident Reduction)	1519	2330	3945	1516

13.7 Accessibility and Social Inclusion

The Accessibility and Social Inclusion criterion ensures that some priority is be given to benefits that accrue to those suffering from social deprivation, geographic isolation and mobility and sensory deprivation. Two elements - Deprived Geographical Areas and Vulnerable Groups - form the basis of appraisal.

13.7.1 Deprived Geographical Areas

Transport has a major role in improving accessibility to employment, education and essential services and amenities. It is important therefore that the impacts of the proposed scheme in improving access for socially excluded areas are accounted for. In this case, this is done through identification of RAPID Areas and socially deprived areas which would benefit through improved accessibility[13] to and within these communities.

RAPID is an investment programme targeting the most disadvantaged urban areas across the country. Overall, the programme aims to increase Government investment in these areas and improve the delivery of public services through integration and coordination. There are 7 RAPID Areas within the study area (Finglas; Ballymun; Northside; North East Inner City; North West Inner City; South East Inner City and South Inner City).

TLR3 has the greatest positive impact, providing new access to 4 of the 7 RAPID Areas (Ballymun; North East Inner City; North West Inner City and South East Inner City), while LR7 provides new access to 3 RAPID areas (Ballymun; North East Inner City; North West Inner City). C1 provides new access to 1 RAPID Area (Ballymun), while HR2 does not provide any benefit to RAPID Areas.

The appraisal process also identified the number of deprived[14] areas which will benefit from improved accessibility. LR7 provides the most benefit, due to the length of the route and number of stops. It provides new access to 12 deprived areas along the route. TLR3 and C1 provide improved accessibility to 8 deprived areas, while HR2 provides no benefit to deprived areas.

Table 13.13: Summary of Access and Social Inclusion Appraisal

Deprived Geographical Areas	HR2	TLR3	LR7	C1
RAPID Areas				
Deprived Small Areas				

[13] Improved Accessibility is defined as a RAPID Area / socially deprived Electoral District being located within a 1km radium of a proposed new stop / station.

[14] Deprived area has been defined as an Electoral Division which had a Relative Index Score of -10 or lower on the 2011 Pobal Haase-Pratschke Deprivation Index

13.7.2 Vulnerable Groups

It is important to identify the wider impacts of the project in delivering improved accessibility for communities, through increasing access to employment opportunities and other vital services and infrastructure. To assess these potential benefits, a quantified analysis was undertaken whereby key employment areas as well as education and healthcare facilities were identified and the most advantageous option is the one which provides new access[15] to most areas. The assessment is as follows:

- **Employment:** LR7 provides new access to 22 key employment sites within the study area including: Dublin City Centre (North & South), Dublin Airport, Airside Retail and Business Parks, Swords Town Centre and IDA Swords Business and Technology Park. TLR3 provides similar benefit, with new access to 21 employment sites, while C1 provides new access to 17 key employment zones including: Grangegorman, Dublin Airport, Park Airside Retail and Business Parks, Swords Town Centre and IDA Swords Business and Technology Park. HR2 does not provide significant benefit as new stations are only provided at the Airport and Swords, therefore there is limited opportunity to improve access to employment zones;

- **Education:** LR7 provides new access to 80 education facilities within the study area (including primary, post primary and special needs facilities), particularly in the vicinity of the proposed O'Connell Street, Griffith Avenue and DCU stops. It also provides new access to major third level education facilities such as St. Patricks College, DCU, DIT Bolton Street and Trinity College. TLR3 and C1 also provide new access to a number of third level education facilities (including Grangegorman DIT and DCU) as well as primary and post primary facilities. However these options do not provide access to as many education facilities as LR7, as there are many educational facilities as located in proximity to the proposed City Centre, Drumcondra and Griffith Avenue stops on the LR7 route. HR2 does not provide significant benefit as new stations are only provided at the Airport and Swords, therefore there is limited opportunity to improve access to education facilities; and

- **Healthcare:** LR7 provides new access to 35 important healthcare facilities, including the Mater Hospital, Rotunda Hospital and many smaller healthcare facilities including private hospitals, health centres and retirement homes along the route. TLR3 and C1 also provide new access to a number of healthcare facilities including private hospitals, health centres and retirement homes. However these options do not provide new access the Mater Hospital – a major healthcare facility within the study area. HR2 preforms poorly as new stations are only provided at the Airport and Swords, therefore there is limited opportunity to improve access to healthcare facilities.

Table 13.14: Summary of Access and Social Inclusion Appraisal

Vulnerable Groups	HR2	TLR3	LR7	C1
Access to Employment	6	21	22	17
Access to Education	16	40	80	39
Access to Healthcare	6	29	35	22

15 Access is defined as an employment zone or education / healthcare facility being located with a 1km radius of the proposed new stop / station.

- **Integration**

The integration element aims to ensure planning for transport infrastructure takes account of other elements of Government policy and infrastructure investment. Three types of transport integration are appraised to ensure that investment across the transportation portfolio is integrated towards achieving a common goal, these are:

- Transport integration;
- Land use integration; and
- Geographical integration.

13.7.3 Transport integration

This criterion addresses the promotion of integration of transport infrastructure and services by focusing on the development of missing links in the existing network and improving opportunities for interchange between modes. In this case, the options have been evaluated in relation to their integration with the heavy rail, light rail and bus networks (as per the 2033 “Do Minimum” scenario).

A summary of the assessment is as follows:

- C1 provides the most benefit, with advantages in terms of connectivity to heavy rail, light rail and the bus network. The heavy rail component provides a direct connection to the heavy rail network on the Northern Line, while the light rail component (i.e. LR3) provides an additional indirect connection to the heavy rail network (via the LUAS network / within walking distance of city centre stations). In addition, the light rail component provides an extension of the Luas Green Line and connects with the Red Line on O'Connell Street, while the heavy rail component also connects to the Luas Red Line at Connolly. The high number of stations on the C1 route means there are significant opportunities for it to integrate with the bus network;
- LR7 performs slightly better than TLR3, as LR7 provides a direct connection to the heavy rail network at Drumcondra, while both options provide an indirect connection to the heavy rail network (via the Luas network / within walking distance of city centre stations). Both options connect to the light rail network - TLR3 and LR7 connect to the Luas Red Line at Jervis and O’Connell Street respectively, and also connect to the Luas Green Line at St Stephen’s Green. Similar to C1, the high number of stations on the TLR3 and LR7 routes results in significant opportunities for integration with the bus network. One major disadvantage of TLR3 is that it may jeopardise future delivery of light rail services to Finglas due to limits on capacity of services through Cabra and also impacts on Bus Éireann and Dublin Bus Depots which will significantly impact on their operations; and
- HR2 provides the least benefit overall. It performs well in terms of heavy rail network integration, providing a direct connection to both the DART network and potentially connecting to wider national rail services. However, it connects only to the Red Luas Line (at Connolly Station), and has limited potential for bus network integration as there as just 3 new stations on the proposed route.

Table 13.15: Summary of Transport Integration Appraisal

Transport Integration	HR2	TLR3	LR7	C1
Heavy Rail				
Light Rail				
Bus Network				

13.7.4 Land use integration

The integration of transport and land use is the single most important element of the Integration section of the appraisal. Distribution of land uses plays an important part in determining travel demands and the viability of public transport systems. The integration of each option with the land use objectives for the study area has been evaluated in relation to its compatibility with the following development plans and planning guidelines:

- Greater Dublin Area Regional Planning Guidelines;
- Fingal County Development Plan; and
- Dublin City Development Plan.

A summary of the assessment is as follows:

- Options C1, LR7 and TLR3 all perform well in terms of land-use integration. This is due to the fact that the proposed Metro North alignment was adopted within the Regional Planning Guidelines, the Dublin City Development Plan and the Final County Development Plan. This alignment heavily influenced the adopted spatial and economic growth strategy for these areas, including the development of the proposed Metro North Economic Growth Corridor. The LR7 alignment is the same as Metro North, while the TLR3 alignment is also based on it (although it varies south of DCU where the alignments are tunnelled). Therefore these two options, as well as C1 (which has LR3 as its light rail component) all integrate well with the development plans and RPGs;
- As C1 alignment travels along Swords Main Street, it doesn't align as fully with the Fingal Development Plan policies as LR7 and TLR3; however it presents the additional advantage by supporting forecast increases in travel demand at the North Fringe growth area; and
- HR2 ranks poorly in relation to the RPGs and the Fingal Country Development Plan. While it supports the objectives of the RPGs by supporting future growth of Swords (a Consolidation Town) and serving Connolly Station, the level of improved accessibility it offers is limited to the Airport and Swords areas. In addition, while it supports population and employment growth within Swords, it does not support further intensification of development within Fingal in areas such as the South Fringe – therefore it does not integrate well with the objectives of the Fingal County Development Plan.

Table 13.16: Summary of Land Use Integration Appraisal

Integration	HR2	TLR3	LR7	C1
Regional Planning Guidelines				
Dublin City Development Plan				
Fingal County Development Plan				

13.7.5 Geographical integration

Improving connectivity within Ireland and to other parts of the world is a key objective of national transport policy, with two aspects of geographical integrations of particular importance:

- Internal transport links with Northern Ireland; and
- International transport links with Europe and the rest of the world

Improving cross-border connectivity through efficient and integrated transport services is essential to economic co-operation, access to employment opportunities and trade development, including tourism. HR2 and C1 both provide an advantage in this regard, as these options facilitate a stop for all trains on the Northern Line - providing access for Northern Ireland passengers to Dublin Airport. TLR3 and LR7 score poorly in this regard as they do not provide any direct connectivity for passengers to / from Northern Ireland.

This is also reflected in the appraisal of international connectivity – HR2 and C1 provide an advantage as they both provide a direct heavy rail link connection to the Airport for DART passengers and a potential direct link for passengers on the national rail network, (while the light rail component of C1 would provide an additional indirect connection to the Airport).

TLR3 and LR7 perform poorly in comparison, as although they provide a direct connection to Dublin Airport from the city centre, passengers travelling from outside the Dublin area would require an interchange to connect with the Airport.

Table 13.17: Summary of Geographical Integration Appraisal

Integration	**HR2**	**TLR3**	**LR7**	**C1**
Connectivity to N.I.				
International Connectivity				

13.8 Conclusion

A summary of the multi-criteria appraisal is shown in Table 13.18. A summary of the appraisal for each criterion is as follows:

- **Environment:** LR7 and TLR3 both rank highly against environmental criterion. However, most of the LR7 route has already undergone detailed Environmental Impact Assessment and therefore, there is more confidence that any negative impacts associated with this scheme can be mitigated;
- **Safety:** LR7 ranks highest in relation to the value of reduced vehicle kilometres travelled (VKT);
- **Economy:** In terms of BCR, TLR3 and LR7 have equal ranking. However, the Present Value of Benefits for LR7 is significantly higher than TLR3. In terms of wider economic impacts, LR7 is also most advantageous;
- **Accessibility and Social Exclusion:** TLR3 and LR7 both provide a good level of access to defined areas of social deprivation as well as employment, education and healthcare facilities. LR7, however, does provide access to a larger number of health, education and employment areas; and
- **Integration:** With the exception of Geographical Integration, LR7 and TLR3 are the most advantageous options for all Integration criteria. The scheme provides excellent compatibility with land use planning and integrates well with regional public transport networks.

Appraisal of the shortlisted scheme options has demonstrated that LR7 is the most advantageous option for delivery in the long term. However, the analysis undertaken above has not considered the benefits that might be presented by phasing the delivery of infrastructure. While LR7 is amenable to phasing, TRL3 presents specific advantages in this regard as an extension of the LCC could be constructed as an initial phase and the city centre tunnelled section could be delivered as a subsequent stage.

Accordingly, the next section of this report focuses on a comparative assessment of only these two options – LR7 and TLR3.

Table 13.18: Multi Criteria Analysis Summary

Multi-Criteria Appraisal Summary				
Criteria	**HR2**	**TLR3**	**LR7**	**C1**
Environment				
Safety				
Economy				
Accessibility and Social Inclusion				
Integration				

Advantages over other options
Neutral compared to other options
Disadvantages compared to other options

14 Stage 2: Light Rail Phasing

14.1 Overview

The results of the multi criteria and economic analysis identify the Tunnelled LR3 and LR7 as the two highest ranked options, albeit with LR7 ranking more highly. It was therefore decided to examine the potential options for implementing each of the schemes using a phased approach. The phased approach would allow the schemes to be developed in an incremental manner with a Phase 1 element of each of the schemes being delivered by 2025 and the last phase being delivered by 2033. This would:

- Allow costs to dispersed over a longer period; and
- Allow the benefits of implementing an initial Phase 1 to be realised at an earlier stage.

The scenarios proposed for the phasing of each of the Tunnelled LR3 and LR7 schemes were developed in consultation with stakeholders and are outlined in the following sections.

14.2 Tunnelled LR3 Phased

Tunnelled LR3 could be delivered in two distinct phases as follows:

- **Phase 1:** The scheme is developed from Swords as far as the existing Luas Cross City line. The service would link to the Luas Cross City line at Cabra and continue southwards along the alignment of the Luas Cross City and Luas Green lines. In this phase the full tunnelled service would then continue as far as the existing Green Line stops at Sandyford and Brides Glen in south Dublin; and
- **Phase 2:** In Phase 2 a new tunnel would be constructed from Grangegorman to link with new underground stops at Jervis Street and St. Stephens Green. The full Tunnelled LR3 service would then terminate at the new underground St. Stephens Green stop where passengers would be able to interchange with the Luas Green line.

The first phase of Tunnelled LR3 follows the same alignment as LR7 from Swords to Dublin City University before connecting to Luas Cross City at Cabra. The second phase of Tunnelled LR3 involves a tunnel constructed from Grangegorman via a station at Jervis to terminate at St. Stephen's Green.

In order to cater for potential future growth, the capacity of the Tunnelled LR3 scheme option has been developed based on 60 metre trams.

The first phase of Tunnelled LR3 includes approximately 13km new twin track of with over 4km is underground. There are 13 new stations or stops along the line.

The scheme then joins Luas Cross City at Cabra continuing to St. Stephen's Green and onwards to the Luas Green Line. All Luas Cross City trams to/from the city centre would operate via the new alignment. The journey times for the key sections of the route are outlined in Table 14.1 below.

Table 14.1: Tunnelled LR3 Phase 1 –Journey Time

Section	Time (mins)
O'Connell Street – Dublin Airport	25
O'Connell Street - Estuary (Swords)	35

The second phase of Tunnelled LR3 includes an additional 2.3 km of new twin track tunnel and two new underground stations at Jervis Street and St. Stephen's Green. The additional stations are:

- Jervis (underground); and
- St. Stephen's Green (underground).

Once complete, Luas Cross City services would operate to/from Grangegorman and to/from Broombridge. The Luas Cross City trams operating to/from Broombridge would run along the same track as Tunnelled LR3 from Grangegorman to Cabra. The journey times for the key sections of the route are outlined in Table 14.2 below.

Table 14.2: Tunnelled LR3 Phase 1 & 2 – Distance and Journey Time

Section	Time (mins)
O'Connell Street* – Airport	20
O'Connell Street* – Estuary	32

**Jervis Street*

14.3 LR7 Phased

Three options were proposed for Phase 1 of LR7, namely:

- **Phase 1A:** LR7 would be developed from the Airport to St. Stephens Green initially with an extension to Swords being delivered in Phase 2;
- **Phase 1B:** LR7 would be developed from Swords to St. Stephens Green with lower demand stops not constructed until a later Phase 2; and
- **Phase 2:** In Phase 2 the full scheme would be completed from Swords to St. Stephens Green with all stops in included.

The following sections evaluate the benefits of implementing the phased options for both Tunnelled LR3 and LR7. The implementation of both schemes is examined on a single-phase and two-phase basis.

The LR7 scheme operates on a north-south alignment from Swords via Dublin Airport to St. Stephen's Green. Full details of this scheme option are provided in Section 8.4 of this report.

The journey times for the key sections of the route are outlined in Table 14.3 below.

Table 14.3: LR7 –Journey Time

Section	Journey Time (mins)
O'Connell Street – Dublin Airport	19
O'Connell Street – Estuary	31

Three potential options for phasing of LR7 have been developed as outlined above. Under each of these options, the final scheme would be the full LR7. The first phases examined are as follows:

- **Phase 1A:** LR7 option developed from the Airport to St. Stephens Green. The journey times for the key sections of the route are outlined below.

Table 14.4: Phase 1A – Journey Time (minutes)

Section	Time (mins)
O'Connell Street – Dublin Airport	19

- **Phase 1B:** LR7 options would be developed from Swords to St. Stephens Green but with lower demand stops not being constructed initially, with all stops subsequently being implemented in Phase 2. The stops not included in Phase 1B are:
  - Dardistown
  - Northwood; and
  - Mater Hospital

The journey times for the key sections of the route are outlined below and are marginally faster than the full operational system as the trams stop less often.

Table 14.5: Phase 1B – Journey Time (minutes)

Section	Journey Time (mins)
O'Connell Street – Dublin Airport	17
O'Connell Street – Estuary	29

14.4 Capacity & Frequency

The key purpose of developing the Tunnelled LR3 Phase 2 scheme option is to increase capacity beyond the likely limit of 21TPH on LR3. The full Tunnelled LR3 scheme option provides additional capacity for up to 2,000pphpd due to the higher frequency possible and the use of longer vehicles. The segregated city centre alignment of TLR3 facilitates longer vehicles which at 60m would have a higher capacity. However, it should be noted that the frequency of service on this line may be limited to 24TPH to facilitate Luas Cross City services to Cabra and Broombridge.

LR7 would also operate with 60m vehicles with a design capacity of 330. However, because the alignment would not be shared with any other services it could operate up to 30TPH providing a much higher capacity than TLR3. The TLR3 service plan reflects the need to operate some Luas Cross City trams to/from Broombridge.

Table 14.6: Potential Capacity of phased light rail options

Section	Trams per Hour per Direction	Design Capacity	Max. Capacity per Direction per Hour
Tunnelled LR3 (Phase 1)	21	285	5,985
Tunnelled LR3 (Phase 1 & 2)	24	330	7,920
LR7 (including phased options)	30	330	9,900

14.5 Transport Modelling Results

Three types of scenarios for each light rail scheme were modelled using the GDA Strategic Transport Model, namely:

- Phase 1 scheme options only;
- Phased schemes involving developing an initial phase followed by a second phase at a later date; and
- Full Schemes developed in their entirety with a single opening year.

In total seven scenarios are examined between the two schemes as set out in Table 14.7. This level of analysis will allow the preferred phasing approach for each scheme to be determined but also provides conclusive evidence as to the scheme which presents the best economic return.

Table 14.7: Transport Scenarios Modelled for Cost Benefit Appraisal

Scenarios	Opening Year
Tunnelled LR3 – Phase 1	2025
Tunnelled LR3 – Phase 1/2	2025/2033
Tunnelled LR3 – Full Scheme	2033
LR7 – Phase 1A Terminating at O'Connell Street	2025
LR7 – Phase 1B Reduced Stations	2025
LR7 – Phased (Phase 1A/1B + Phase 2)	2025/2033
LR7 – Full Scheme	2025

The remainder of this section presents the transport modelling results based on 2033 Peak Period (7am to 10am). It includes line flow diagrams for each option which are based on 2033 Peak Hour (8am to 9am). The modelling results are presented relative to the 2033 Do Minimum scenario. Results are shown for Phase 1 and Full Scheme options. The Phased options correspond to these schemes based on the stage of development.

14.5.1 Passenger Demand

Table 14.8 summarises the total boardings on each public transport sub-mode, for the morning period of 07:00-10:00 in the forecast year of 2033 for the Tunnelled LR3 scenarios. As shown in Table 14.8, demand for Luas services increase by 47% in the Phase 1 scenario and 54% in Full Scheme scenario. Introduction of the new service would draw passengers from existing bus services with a cumulative 8% reduction on bus service boardings. Additionally some demand will be drawn from rail services with decreases of 2.10% and 2.50% respectively forecast on suburban rail services. The overall impact of the scheme is a 0.25% increase in public transport boardings in Phase 1 and a 0.93% increase in public transport boardings for the Full Scheme.

Table 14.8: Tunnelled LR3 – 2033 Peak Period Boardings

Mode	Do Minimum	Phase 1	% Diff	Full Scheme	% Diff
DART	40,795	40,537	-0.63%	40,784	-0.03%
Suburban Rail	62,812	61,491	-2.10%	61,243	-2.50%
Dublin/City Bus	241,111	226,098	-6.23%	226,003	-6.27%
Other Bus	57,179	51,678	-9.62%	51,677	-9.62%
Luas	***49,171***	***72,403***	**47.25%**	***75,540***	**53.63%**
Total	451,066	452,207	0.25%	455,248	0.93%

Tables 14.9 and 14.10 summarise the total boardings on each public transport sub-modes, for the morning period of 07:00-10:00 in the forecast year of 2033 for the LR7 scenarios. As shown, demand for Luas services increase by 50.3% in the Phase 1A scenario; in the Phase 1B scenario demand for Luas services increases by 60.7%; and in the full scheme scenario (including all stops) demand increases by 65.7%.

Introduction of the new service would draw passengers from existing bus services with some additional demand being drawn from rail services. The overall impact of the scheme is a 1.6% increase in public transport boardings when the in the full scheme is built. Interestingly, all of the LR7 phased scenarios proposed generate similar levels of additional public transport boardings overall.

These results indicate that despite different phasing approaches, LR7 is still most likely to generate the highest demand and increase the use of public transport. The scheme leads to an increase in Luas patronage of over 65% and an overall increase in public transport of 1.6%.

Table 14.9: LR7 Phase 1A and 1B – 2033 Peak Period Boardings

Mode	Do Minimum	Phase 1A	% Diff	Phase 1B	% Diff
DART	40,795	41,045	0.6%	41,033	0.6%
Suburban Rail	62,812	63,752	1.5%	63,050	0.4%
Dublin/City Bus	241,111	228,037	-5.4%	223,510	-7.3%
Other Bus	57,179	51,356	-10.2%	51,246	-10.4%
Luas	***49,171***	***73,889***	***50.3%***	***79,023***	***60.7%***
Total	451,066	458,078	1.6%	457,862	1.5%

Table 14.10: LR7 Full Scheme – 2033 Peak Period Boardings

Mode	Do Minimum	Full Scheme	% Diff
DART	40,795	40,861	0.2%
Suburban Rail	62,812	63,091	0.4%
Dublin/City Bus	241,111	221,397	-8.2%
Other Bus	57,179	51,330	-10.2%
Luas	***49,171***	***81,462***	***65.7%***
Total	451,066	458,141	1.6%

14.5.2 Network Statistics

Total trip demand impacts for the Tunnelled LR3 and LR7 scenarios, compared to the Do Minimum scenario, are presented in Tables 14.11 to 14.13. Total trip demand in these tables is distinct from total boardings in passengers demand table in the previous section. In Tables 14.11 and 14.12 total demand represents trip demand from origin to destination rather than boardings on public transport services which can include interchanges between public transport options made in the course of a single origin to destination trip.

The overall performance of the modelled transport network for the Do Something scenarios can therefore be better examined through an analysis of the transport network demand.

As can be seen from Table 14.11 below the Tunnelled LR3 scheme options have a positive impact on public transport patronage in AM peak hours with 1,780 new trips forecast on public transport services during the AM peak hours 07:00 to 10:00. Interestingly however the implementation of Phase 2 in the full scheme option does not result in additional public transport trip demand overall. Of the new public transport trips in Phase 1, 1,100 come from existing highway trips and a similar but slightly lower number of highway trips, 1,080, being attracted onto public transport when the full scheme is implemented. The remainder of the additional trips come from walking and cycling trips.

Table 14.11: Tunnelled LR3 – 2033 AM Period Transport Demand Impacts

AM Demand Impacts	Unit	Phase 1	Full Scheme
Public Transport	Trips	1,780	1,780
Highway	Trips	-1,100	-1,080

As can be seen from Table 14.12 below the LR7 scenario options again all have positive impacts on public transport patronage in AM peak hours. A maximum of 2,550 new trips are forecast on public transport services during the AM peak hours 07:00 to 10:00. Interestingly the implementation of Phase 1B and the Full Scheme have approximately the same levels of additional public transport trip demand overall. Of the new public transport trips in these scenarios 1,550 come from existing highway trips with the remainder coming from walking and cycling trips.

Table 14.12: LR7 – 2033 AM Period Transport Demand Impacts

Travel Demand Impact	Unit	Phase 1A	Phase 1B	Full Scheme
Public Transport	Trips	2200	2500	2550
Highway	Trips	-1350	-1530	-1550

14.5.3 Loading Profiles

Loading profiles on each of the proposed phased options are outlined in the following sections and summarised in Table 14.13 below. For TLR3, passenger loading is highest for Phase 1 of the scheme when it is directly connected to the Luas Green Line its wider catchment area.

For LR7, phased option 1B, the full alignment with reduced stations, generates a higher level of passenger loading than Phase 1A. Further details on each line are provided below.

Table 14.13: Summary of passenger capacity, loading and spare capacity on each phasing option

Section	Design Capacity	2033 Max Line Flow	2033 Spare Capacity
Tunnelled LR3 – Phase 1	5,985	7,050	-18%
Tunnelled LR3 – Full Scheme	7,920	5,800	27%
LR7 – Phase 1A	9,900	3,450	65%
LR7 – Phase 1B	9,900	5,750	42%
LR7 – Full Scheme	9,900	6,250	37%

Tunnelled LR3 Passenger Loading

The peak loads for the Tunnelled LR3 scenario options for the southbound services, which are generally the services with the highest patronage in the AM peak hours, are shown in Figures 14.1 to 14.3. For TLR3 LR3 Phase 1, the northbound service has the highest patronage numbers, reflecting the fact that the service extends to Sandyford and Bridges Glen catchment areas.

Figure 14.1 shows that, on the southbound service in Phase 1, passenger demand is strongest at the Estuary, Pavilions, Airside and Dublin Airport stops. The highest demand is seen at Estuary where a peak boarding of 1,950pphpd is seen during the AM peak hour in the assessment year, 2033. The peak load, 5,420, forecast on the service is seen at the Glasnevin / Botanic stop to the south of Griffith Avenue.

Figure 14.1: Tunnelled LR3 Phase 1 – 2033 Peak Hour Southbound Line Flows

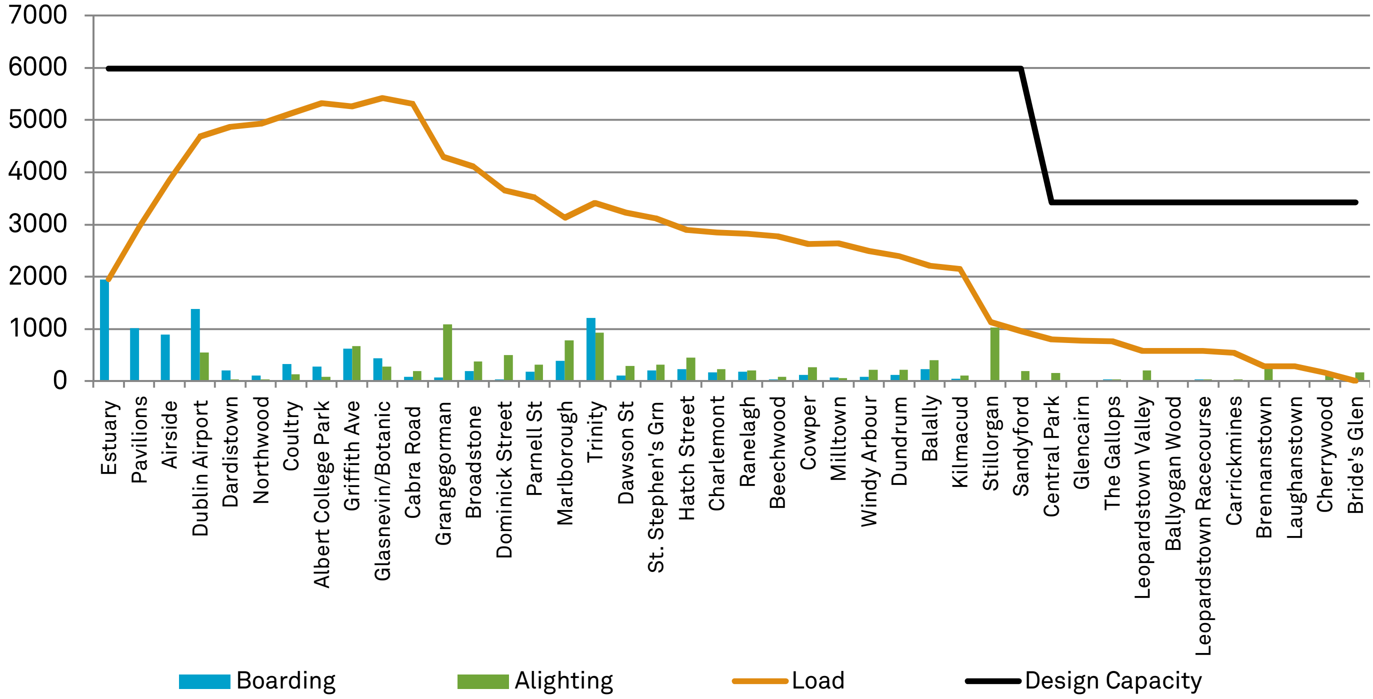


Figure 14.2 below shows that, on the northbound service in Phase 1, passenger demand is strongest at the existing Luas Green Line stops including Balally, Cowper and Ranelagh. The key destinations are St. Stephens Green, Westmoreland and Dublin Airport. In the modelled assessment year 2033, the northbound service would exceed the design capacity issue by 2033 in the vicinity of Ranelagh, where it reaches peak loading of 7,050 passengers. This represents 118% of the available design capacity for a likely 21 TPH service.

Figure 14.2: Tunnelled LR3 Phase 1 – 2033 Peak Hour Northbound Line Flows

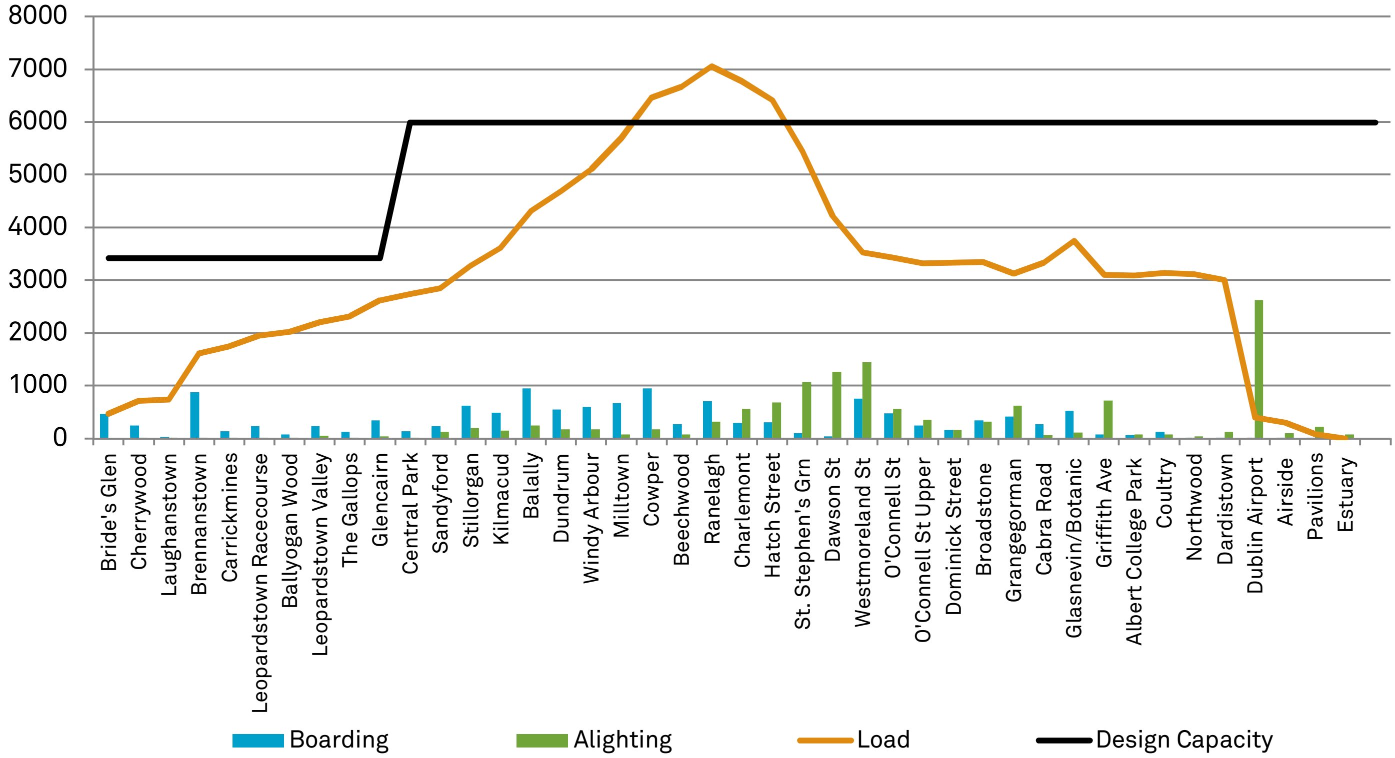
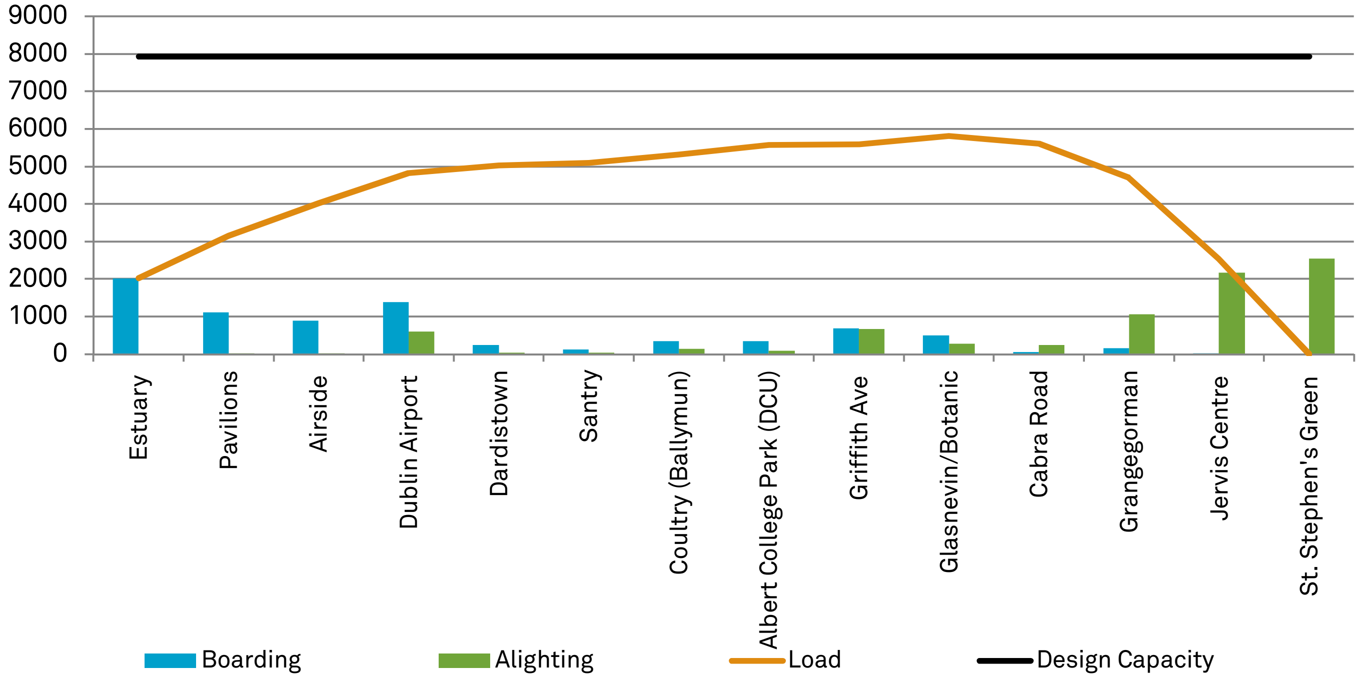


Figure 14.3 shows that, on the southbound service when the full scheme (Phase 1 & 2) is built out in 2033 passenger demand remains strongest at the Estuary, Dublin Airport stops. The peak boarding figure is 2,025 at the Estuary stop. The peak load, 5,800, forecast on the service is again seen at the Glasnevin / Botanic stop to the south of Griffith Avenue.

Figure 14.3: Tunnelled LR3 Full Scheme – 2033 Peak Hour Southbound Line Flows



LR7 Passenger Loading

The peak loads for the LR7 scenario options for the busiest services, the southbound services, are shown in Figures 14.4 to 14.6.

Figure 14.4 below shows that on the southbound service in Phase 1A demand is strongest at Dublin Airport with a peak demand in excess of 2,000 passengers forecast. The peak load, 3,450, forecast on the service is again seen at the Griffith Avenue stop.

Figure 14.4: LR7 Phase 1A – 2033 Peak Hour Southbound Line Flows

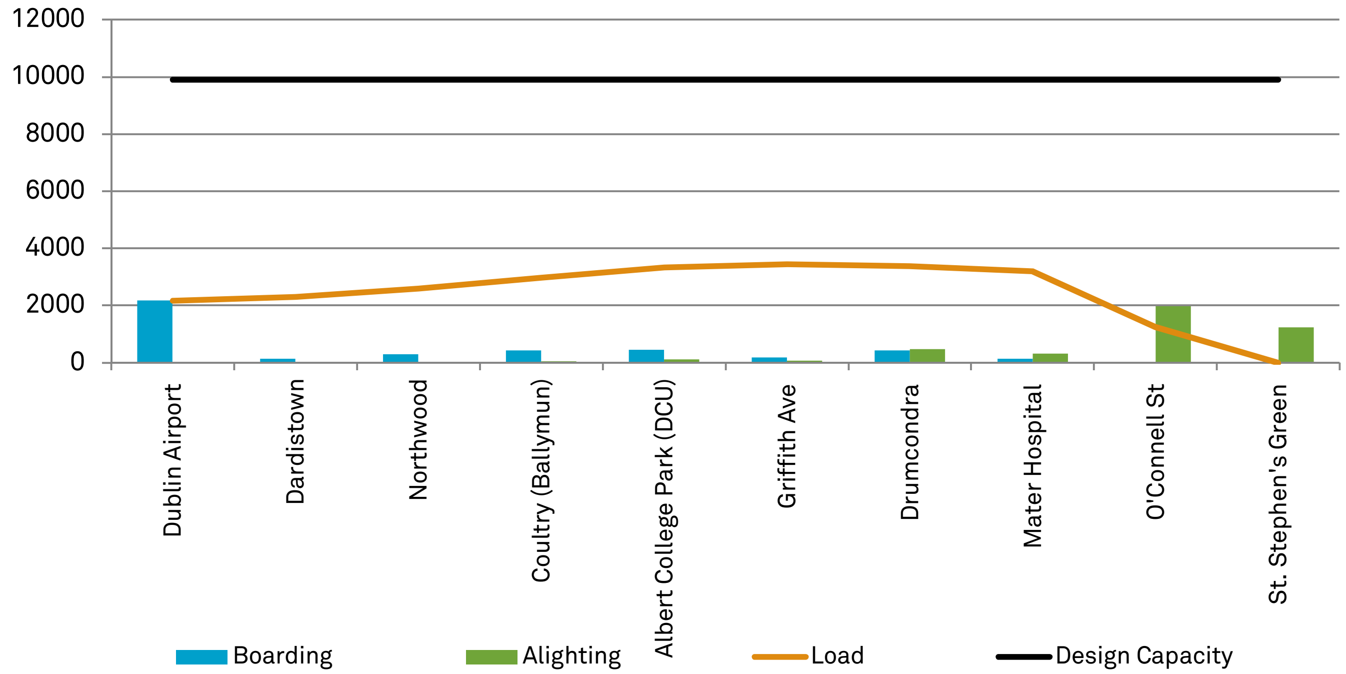


Figure 14.5 shows that on the southbound service in Phase 1B demand is strongest at the Estuary, Pavilions, Airside and Dublin Airport stops with a peak demand in excess of 2,100 passengers forecast at Estuary. The peak load, 5,950, forecast on the service is seen at the Coultry (Ballymun) stop.

Figure 14.5: LR7 Phase 1B – 2033 Peak Hour Southbound Line Flows

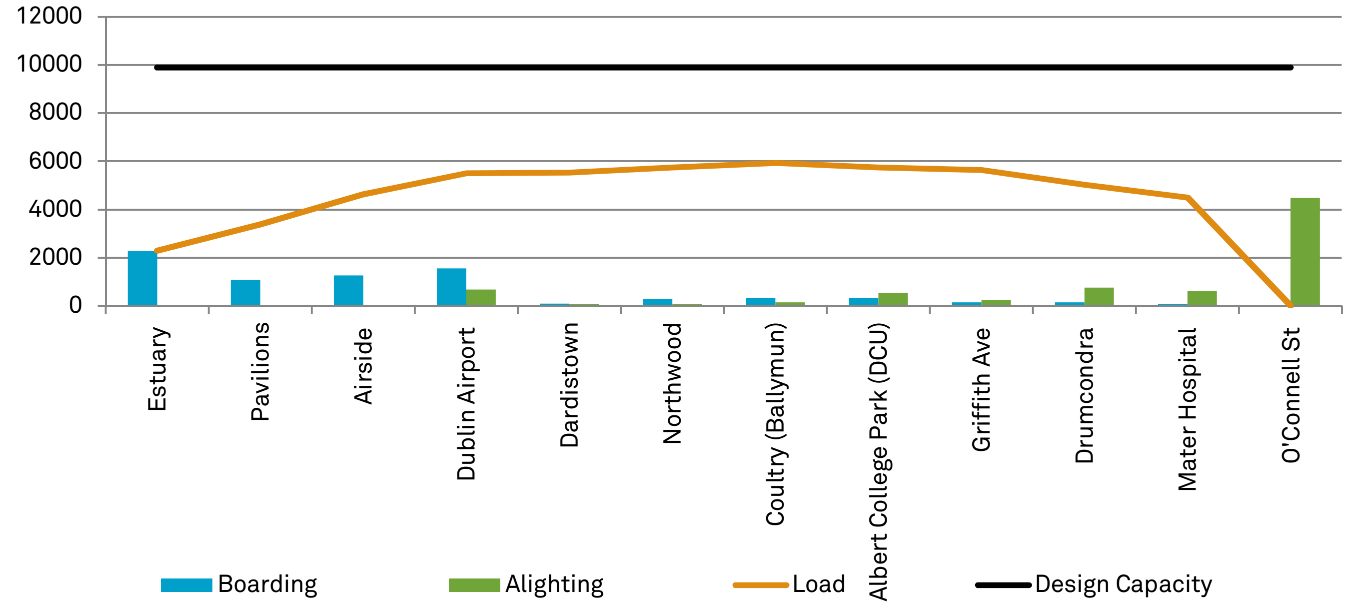
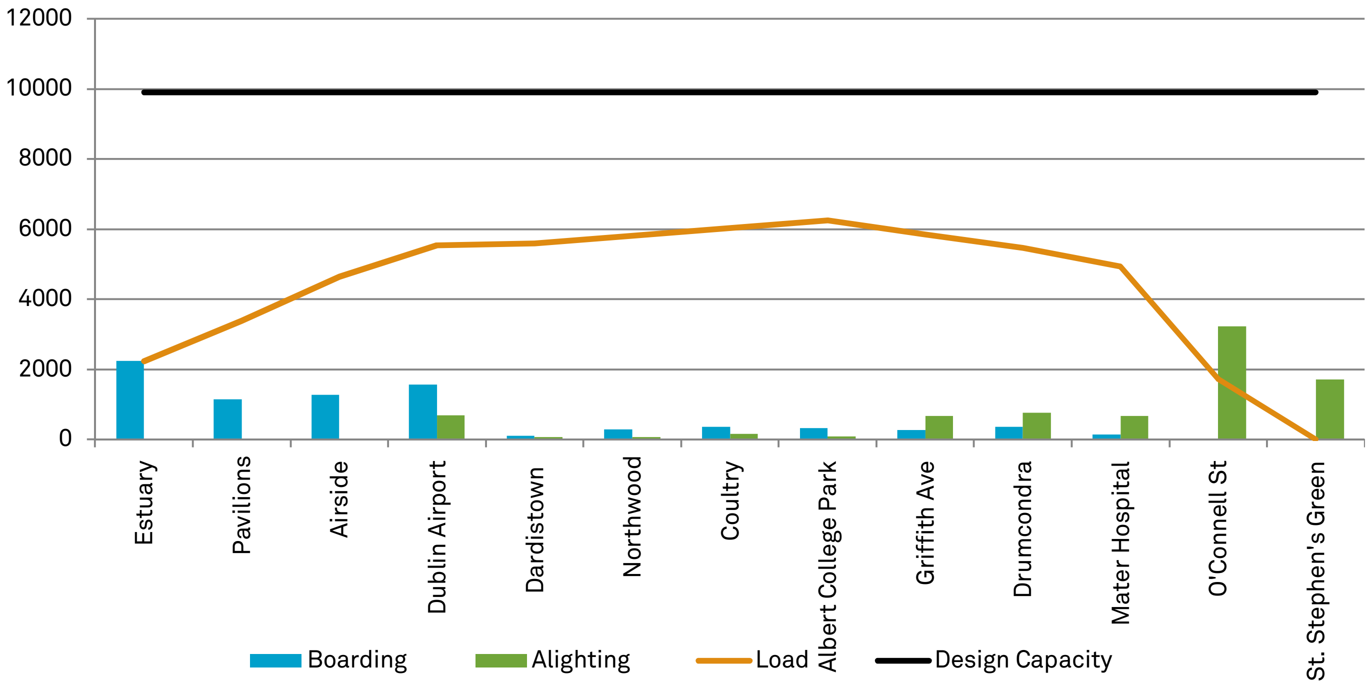


Figure 14.6 below shows that on the southbound service for the Full Scheme, demand remains strongest at the Estuary, Pavilions, Airside and Dublin Airport stops, with a peak demand in excess of 2,200 passengers forecast at Estuary. The peak load, 6,240, forecast on the service is seen at the Albert College Park (DCU) stop.

Figure14.6: LR7 Full Scheme – 2033 Peak Hour Southbound Line Flows



14.7 Costs

The following sections present the capital costs and operating and maintenance costs (O & M) costs for each option and phase of delivery. The costs provided are all in 2014 prices. The price escalations that have been used throughout this report will continue to be used, as follows:

- Capital costs are forecast to increase in line with general inflation i.e. 0% increase in real terms; and
- O&M costs are forecast to increase 1% in real terms per annum.

14.7.1 Tunnelled LR3

A summary of the capital cost estimate for Tunnelled LR3 options is shown in Table 14.14. Delivery of the LR3 Phase 2 tunnel is anticipated to cost almost €1bn which would be in addition to the €1.2bn for delivery of Phase 1. As shown in Table 14.15, there would be little variation in the O & M costs for Tunnelled LR3 between the first and second phases. Note: There are some cost savings when the full scheme is implemented due to the shorter running length and time.

Table 14.16 presents an indicative profile of spend for each approach to delivery of the scheme. For TLR3 Phase 1, spend would be accelerated in the short term for scheme opening in 2025. For Phase 2 it is assumed that investment would commence in 2024 for a 2033 opening year. These assumptions have been incorporated within the cost benefit analysis of each phase.

*Table 14.14: Summary of LR3 Capital Cost Estimates**

Description	Tunnelled LR3 Phase 1	Tunnelled LR3 Phase 2	Tunnelled LR3 Full Scheme
Construction (incl. Land Acquisition)	€ 690,417,000	€ 531,843,000	€1,222,260,000
Client Costs	€ 62,138,000	€ 42,548,000	€104,686,000
Rolling Stock	€ 45,000,000	€ 47,866,000	€92,866,000
Design Costs	€ 55,234,000	€ 60,000,000	€115,234,000
Misc Client Costs & Project Burdens	€ 15,952,000	€ 13,645,200	€29,597,200
Risk (30%)	€ 217,187,000	€ 173,976,500	€391,163,500
VAT	€ 146,600,955	€ 117,434,030	€264,034,985
Total (incl. VAT)	***€ 1,232,533,955***	***€ 987,315,730***	***€2,219,849,685***

**Note: Capital costs have been developed for comparative purposes only; Totals may not add due to rounding*

Table 14.15: Summary of LR3 Operating & Maintenance Costs

Description		Tunnelled LR3 Phase 1	Tunnelled LR3 Full Scheme
Operations	Staff	€5,181,575	€4,732,063
	Fuel	€1,149,988	€1,349,948
	Insurance	€921,446	€1,071,957
	Other	€3,604,829	€3,721,624
Vehicles	Routine	€3,566,335	€4,186,447
	Additional	€327,505	€327,505
Infrastructure	Cleaning	€200,000	€233,333
	Highway	€2,812,149	€3,301,124
TVM	Routine	€273,096	€273,096
Subtotal		€17,997,909	€19,197,097
Contingency		€5,399,373	€5,759,129
Non Recoverable VAT		€286,153	€335,800
Total O & M		***€23,683,435***	***€ 25,292,026***

Table 14.16: Tunnelled LR3 – Capital Cost Profile

Year	Tunnelled LR3 (Phase 1)	Tunnelled LR3 (Phase 2)	Tunnelled Luas Phase 1 & 2 Phased Approach)
2016	0.6%	0.0%	0.4%
2017	1.2%	0.0%	0.7%
2018	1.2%	0.0%	0.7%
2019	1.5%	0.0%	0.8%
2020	1.1%	0.0%	0.6%
2021	11.3%	0.0%	6.5%
2022	17.0%	0.0%	9.7%
2023	18.9%	0.0%	10.8%
2024	16.0%	0.8%	9.1%
2025	14.1%	1.4%	8.1%
2026	11.3%	1.4%	6.5%
2027	3.8%	1.7%	2.2%
2028	1.9%	1.3%	1.1%
2029	0.0%	11.2%	5.2%
2030	0.0%	16.8%	7.8%
2031	0.0%	18.7%	8.6%
2032	0.0%	15.9%	7.3%
2033	0.0%	14.0%	6.5%
2034	0.0%	11.2%	5.2%
2035	0.0%	3.7%	1.7%
2036	0.0%	1.9%	0.9%

14.7.2 LR7

Full delivery of LR7 is expected to cost €2.3bn. Of the two options for Phase 1 presented, there is little difference in the capital cost of delivery with both options estimated to cost in the region of €2.2bn.

Delivery of a Phase 2 at a later stage, constructing three new stations within the existing alignment, is expected to cost approximately €150m.

Table 14.17: LR7 Capital Costs – € million (2014 prices, excl. escalation)

Description	LR7 (LR7) Phase 1A – Dublin Airport	LR7 (LR7) Phase 1B – Delayed Stops	LR7 Phase 2 (Assuming Phase 1B)	Full Scheme
Construction (incl. Land Acquisition)	€1,219,192,000	€1,206,348,000	€68,003,000	€1,274,351,000
Client Costs	€97,536,000	€96,508,000	€5,441,000	€101,949,000
Rolling Stock	€109,728,000	€108,572,000	€6,120,000	€114,692,000
Design Costs	€96,000,000	€96,000,000	€24,000,000	€120,000,000
Misc Client Costs & Project Burdens	€30,449,200	€30,148,600	€2,071,400	€32,220,000
Risk (30%)	€388,227,500	€384,394,750	€26,410,250	€410,805,000
VAT	€262,053,455	€259,466,402	€17,826,973	€277,293,375
Total (incl. VAT)	***€2,203,190,155***	***€2,181,439,752***	***€149,878,623***	***€2,331,318,375***

**Notes: Capital costs have been developed for comparative purposes only; Totals may not add due to rounding*

Operation and maintenance costs for LR7 are summarised in Table 14.18 below. The lowest level of O&M costs would, unsurprisingly, arise from the Phase 1A option which would have a short alignment and fewer stations.

The cost profile developed for LR7 (see Table 14.19) makes similar assumptions to those made for TLR3. Investment for each Phase 1 approach would commence in the short term for a 2025 opening year with Phase 2 investment starting in that same year for a 2033 opening year. These assumptions have been incorporated within the cost benefit analysis of each phase.

Table 14.18: Summary of LR7 Operating & Maintenance Costs

Description		LR7 (LR7) Phase 1A – Dublin Airport	LR7 (LR7) Phase 1B – Delayed Stops	Full Scheme
Operations	Staff	€5,296,624	€5,651,331	€5,596,748
	Fuel	€1,067,339	€1,413,046	€1,478,810
	Insurance	€859,724	€1,127,523	€1,176,859
	Other	€3,186,732	€3,816,294	€4,009,527
Vehicles	Routine	€3,310,021	€4,382,127	€4,586,075
	Additional	€409,381	€409,381	€409,381
Infrastructure	Cleaning	€166,667	€166,667	€233,333
	Highway	€2,610,039	€3,455,423	€3,616,241
TVM	Routine	€195,068	€195,068	€273,096
Subtotal		€17,101,596	€20,616,861	€21,380,071
Contingency		€4,275,399	€5,154,215	€6,414,021
Non Recoverable VAT		€264,147	€345,602	€366,162
Total O & M		***€21,641,142***	***€26,116,678***	***€ 28,160,255***

Table 14.19: LR7 – Capital Cost Profile

	OMN (Phase 1A - Airport)	OMN (Phase 1B - Delayed Stops)	OMN (Phase 1 & 2 in Phased Approach)	LR7 (Full Scheme)
2016	0.4%	0.4%	0.3%	0.0%
2017	0.7%	0.7%	0.6%	0.0%
2018	0.7%	0.7%	0.6%	0.0%
2019	0.8%	0.8%	0.8%	0.0%
2020	0.6%	0.6%	0.6%	0.0%
2021	11.6%	11.6%	11.0%	0.0%
2022	17.4%	17.4%	16.5%	0.0%
2023	19.4%	19.4%	18.3%	0.0%
2024	16.5%	16.5%	15.6%	0.3%
2025	14.5%	14.5%	13.7%	0.6%
2026	11.6%	11.6%	11.0%	0.6%
2027	3.9%	3.9%	3.7%	0.7%
2028	1.9%	1.9%	1.8%	0.6%
2029	0.0%	0.0%	0.6%	11.7%
2030	0.0%	0.0%	1.0%	17.5%
2031	0.0%	0.0%	1.1%	19.4%
2032	0.0%	0.0%	0.9%	16.5%
2033	0.0%	0.0%	0.8%	14.6%
2034	0.0%	0.0%	0.6%	11.7%
2035	0.0%	0.0%	0.2%	3.9%
2036	0.0%	0.0%	0.1%	1.9%

14.8 Results of Cost Benefit Analysis

A cost benefit analysis has been undertaken to establish the economic merits of the phased approach for each option. As shown in Table 14.20, phased delivery of the full TLR3 scheme (Phase 1 in 2025 and Phase 2 in 2033) is likely to deliver the highest proportion of benefit across the three delivery approaches but the lowest BCR due to the high level of costs incurred across a longer delivery period.

Delivering the full scheme by 2033 generates the lowest level of benefit. This is due to the fact that benefits are realised at a later date with discount rates applied.

In relation to LR7, the most expensive approach to delivering the scheme would be in two separate phases. However, this would deliver the highest level of benefit as the travel time savings are realised at an earlier date and over a longer period. Overall, delivery of the full scheme by 2033 in one phase is likely to present the highest BCR.

Table 14.20: Tunnelled LR3 Capital Cost Benefit Analysis – € million (2009 prices, 2009 present value)

Description	Phase 1 2025	Phase 1 2025 Phase 2 2033	Full Scheme 2033
Total Costs	949,136	1,551,472	982,734
Total Benefits	869,024	925,101	758,084
Net Present Value (NPV)	-80,112	-626,371.0	-224,650
Benefit to Cost Ratio (BCR)	0.9	0.6	0.8

Table 14.21: Phased LR7 Cost Benefit Analysis – € million (2009 prices, 2009 present value)

Description	Phase 1A 2025	Phase1B 2025	Phase 1B 2025 Phase 2 2033	Full Scheme 2033
Total Costs	1,349,391	1,316,376	1,672,868	1,026,853
Total Benefits	1,475,258	1,529,054	1,770,855	1,562,716
Net Present Value (NPV)	125,867	212,678	97,987	535,863
Benefit to Cost Ratio (BCR)	1.1	1.16	1.1	1.5

14.9 Financial Analysis

In order to assess any potential variances in the financial performance of Tunnelled LR3 and LR7 a high level financial analysis was undertaken using outputs from the transport modelling exercise.

14.9.1 Assumptions

The change in fare revenue is evaluated by using the outputs from the transport modelling process (such as boardings or kilometres travelled) and multiplying by an estimated fare rate for each public transport mode. Using passenger kilometre data, as opposed to boardings, is considered a more accurate and preferred way of forecasting fare revenue. Unfortunately there is no reliable source of passenger kilometre data for the city bus (incl. Dublin Bus) and regional bus modes, therefore boardings must be used in each of these cases. Fares for the proposed Light Rail services are assumed to be in line with the Luas fare structure in terms of cost per km travelled.

The financial appraisal is evaluated for the overall exchequer which includes the changes in fares across all public transport modes. It is assumed that any changes in fare revenue collected will impact the exchequer. This is a conservative assumption as some of the reduction in fares (e.g. on regional buses that are run by private operators) will not impact upon the exchequer. It is also assumed that the same annualisation factor applies across all public transport modes. This is justified given any movement between modes during the modelled period should remain in the same proportion.

14.9.2 Operating Cash Flows

Table 14.22 below shows the changes in fare revenue across all public transport modes based on the introduction of the proposed schemes. The annual levels for 2033 and 2062 are shown as well as the present value (2014 values) of the 30-year appraisal period.

The results show a significant shift from both Regional and City buses to each of the proposed schemes with very limited impact on DART and Suburban Rail. It should be noted that this is not a comparison to the present day. As such the reduction in revenues for other modes is not from present day levels but from potential future levels. The fare changes are shown graphically in Figure 14.7 and 14.8 below.

Overall, an increase in net fares across all modes is forecast for both LR3 and LR7 however the net fare increase is significantly higher withLR7 in place.

Table 14.22 – Fare Revenue Changes (€ Millions)

	LR7			LR3		
€m (2014 prices)	**2033**	**2062**	**PV**	**2033**	**2062**	**PV**
DART	-0.2	-0.4	-2	-0.1	-0.2	-1
Suburban Rail	6	11	52	1	2	11
City Bus	-48	-80	-379	-41	-69	-327
Regional Bus	-27	-44	-211	-25	-42	-199
Light Rail	117	196	934	102	171	815
Net Fares	**50**	**83**	**394**	**38**	**63**	**299**

**2033/2062 columns represent values from that year, PV is presented in 2014 values*

Figure 14.7 – Fare Revenue Changes across all modes due to proposed LR7 scheme

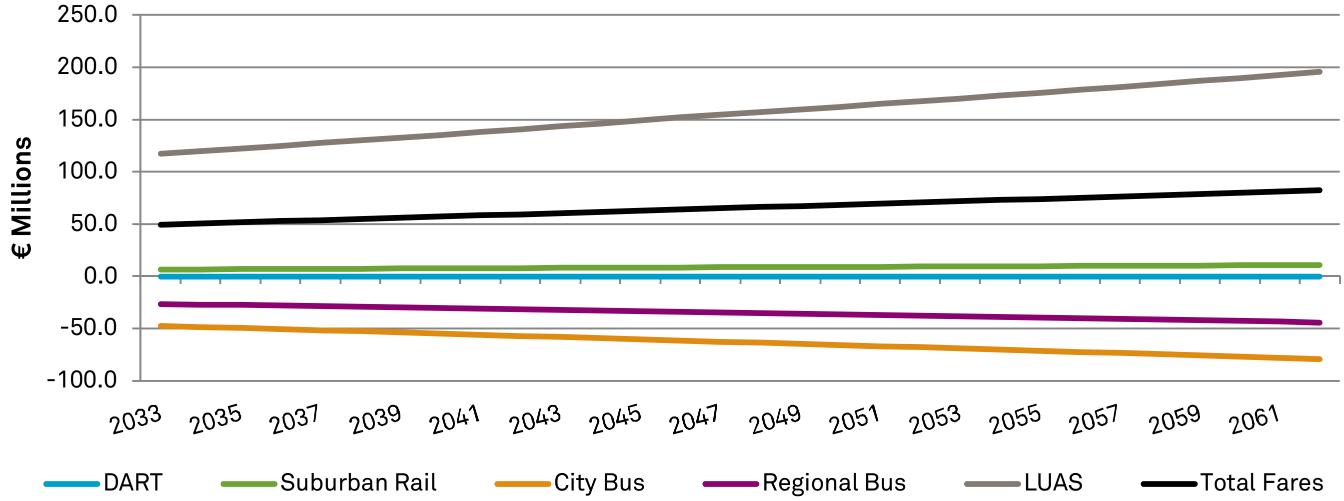
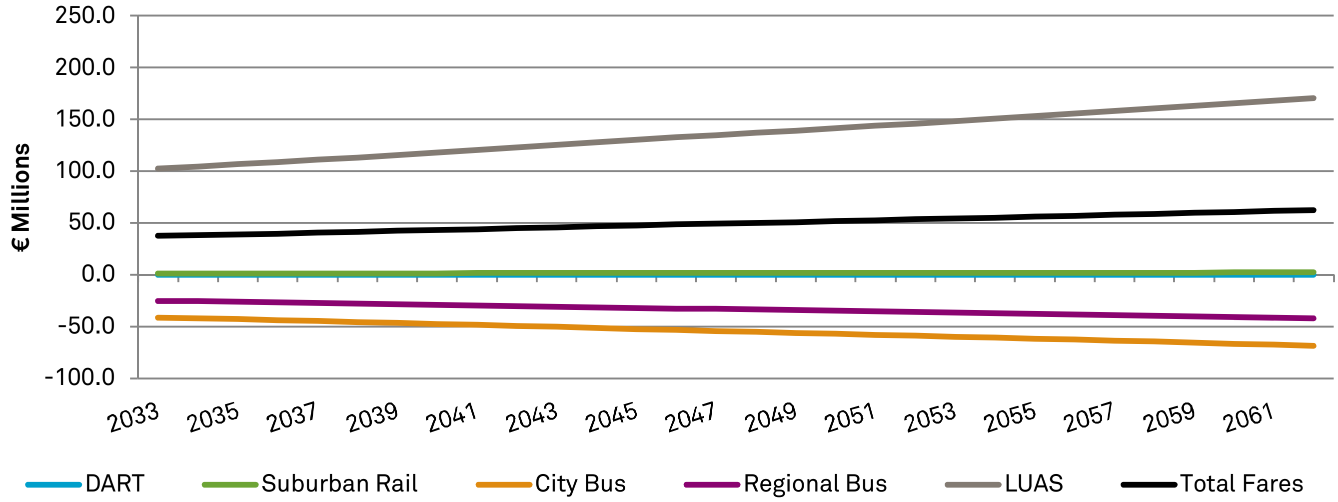


Figure 14.8 – Fare Revenue Changes across all modes due to proposed Tunnelled LR3 scheme



Light Rail Impact

The operational cash flow of each scheme (exclusive of other PT systems) is presented in Figures 14.9 and 14.10 below. The analysis shows that both LR3 and LR7 will operate with a significantly positive cash flow (does not account for capital costs).

Figure 14.9 – Net Revenue Impact of LR7 (exclusive of other PT transport systems)

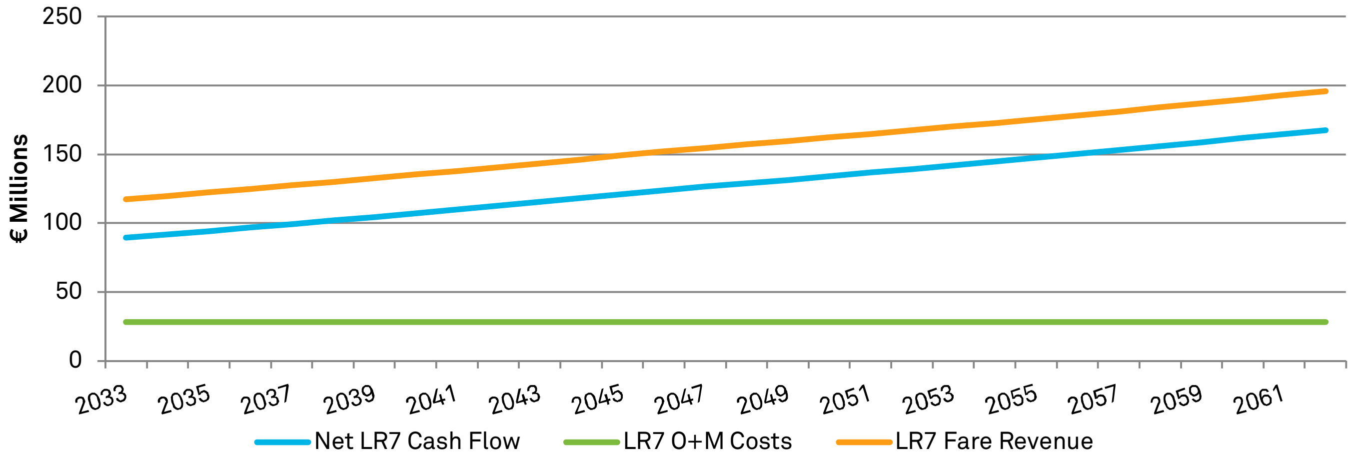
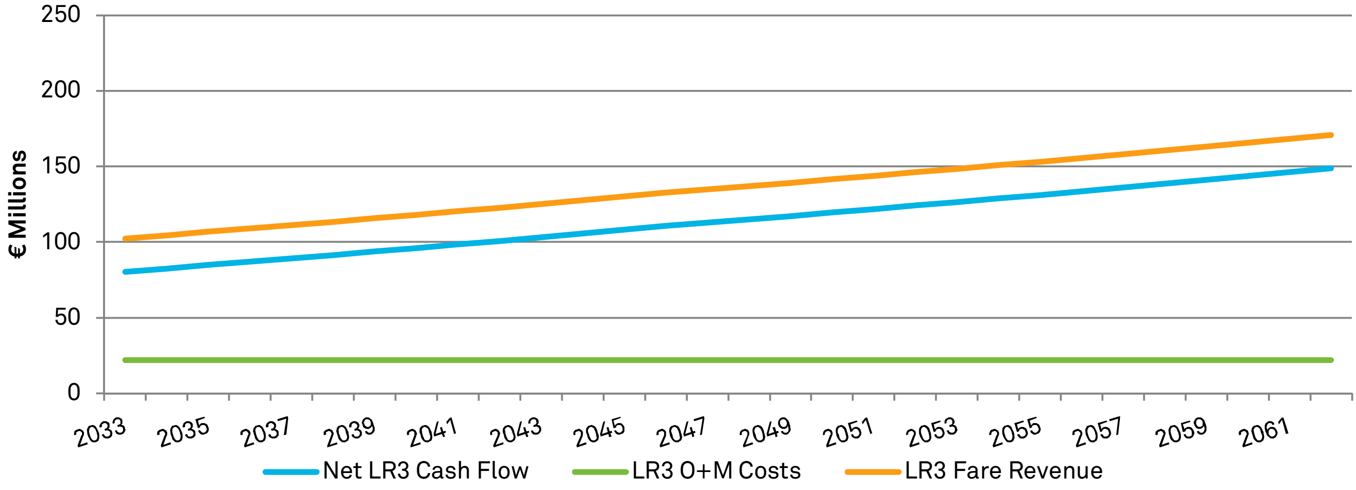


Figure 14.10 – Net Revenue Impact of Tunnelled LR3 (exclusive of other PT transport systems)



Exchequer Impact

Table 14.23 provides a summary of the overall exchequer impact taking account of O+M costs and fare revenues (from all PT systems) to the exchequer. Capital costs of each project are excluded from the analysis presented below.

Table 14.23 – Exchequer Impact (PV in 2014 values)

	LR7			LR3		
€m (2014 prices)	2033	2062	PV	2033	2062	PV
O&M Costs	-28	-28	-180	-22	-22	-140
Net PT Fares	50	83	394	38	63	299
Total	**21**	**54**	**214**	**16**	**41**	**158**

**2033/2062 columns represent values from that year, PV is presented in 2014 values*

LR7 will operate with a gain of €21 million in 2033 rising to €54 million in 2062. The present value of the exchequer impact over the 30-year appraisal period is in excess of €214 million. This excludes the capital cost and any potential fleet renewal costs during the appraisal period.

For LR3, the scheme will operate with a gain of €16 million in 2033 rising to €41 million in 2062. The present value of the exchequer impact over the 30-year appraisal period is in excess of €158 million. This excludes the capital cost and fleet renewal costs during the appraisal period.

Overall, when capital and fleet renewal costs are excluded the financial performance of LR7 is significantly stronger than LR3.

Figure 14.11 – Exchequer Impact of the LR7 Scheme

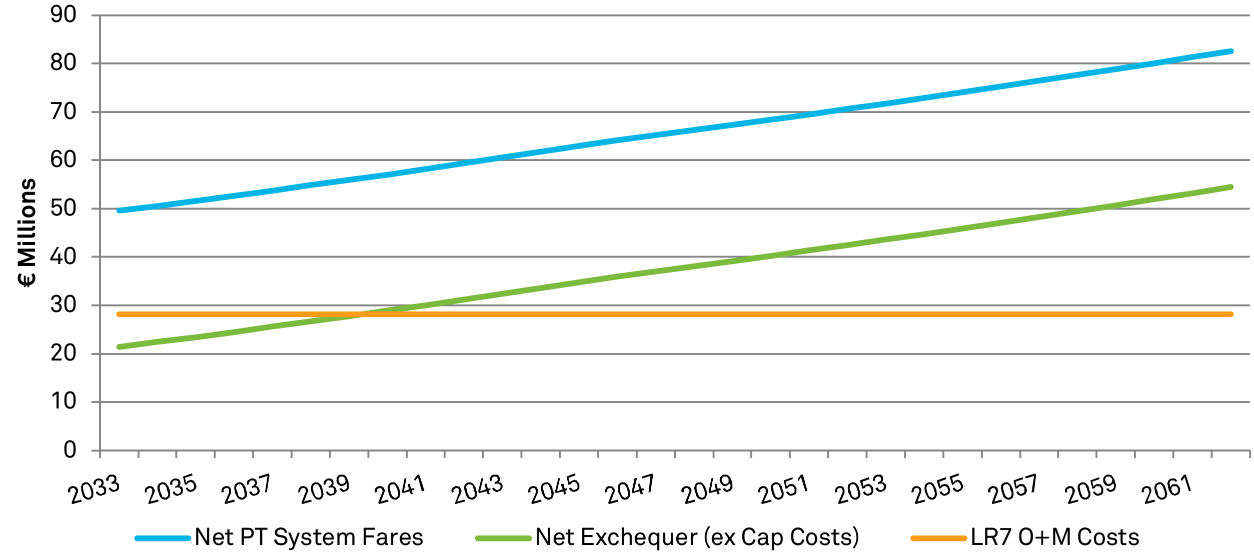
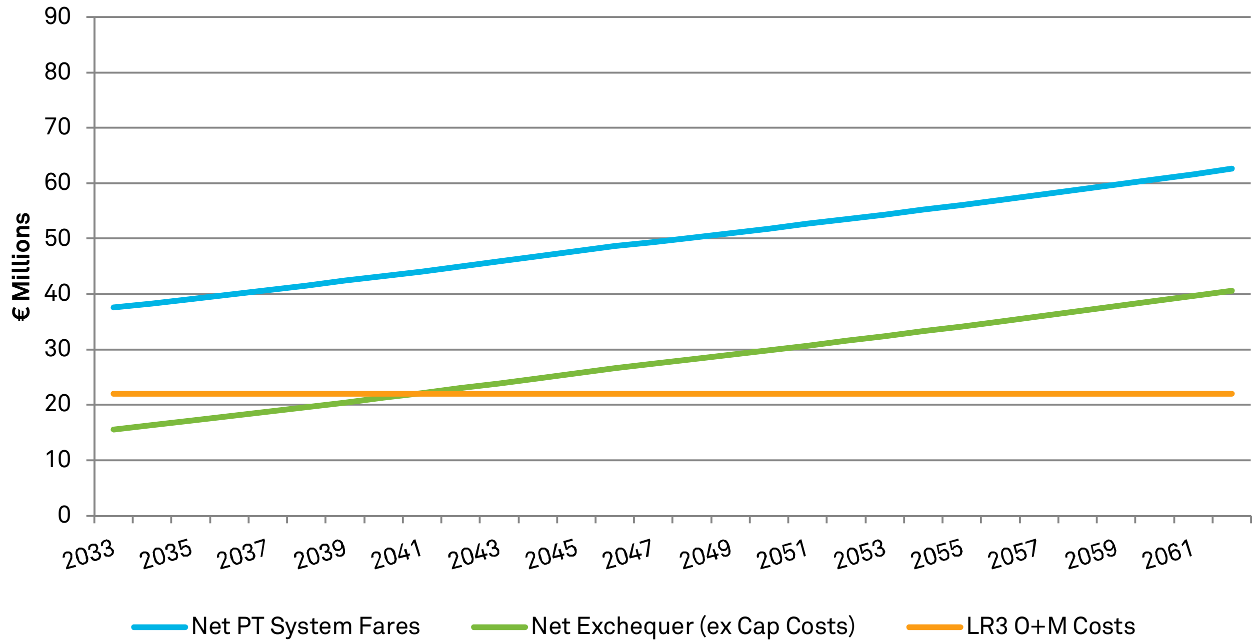


Figure 14.12 – Exchequer Impact of the Tunnelled LR3 Scheme



14.9.3 Summary of Financial Appraisal

In summary, the financial appraisal finds the following impacts (all in 2014 present value terms) for each of the scheme options:

- LR7 – Results in a significant increase in PT fares with majority of movements from Regional/City buses to Light Rail. A positive exchequer impact of circa €214 million during the 30-year operational phase excluding capital cost however when initial capital costs (€988 million, 2014 values and prices) are taken into account this results in a negative exchequer impact of circa €774 million over the 30 year appraisal period.
- TLR3– Results in a significant increase in PT fares with majority of movements from Regional/City buses to Light Rail. A positive exchequer impact of circa €158 million during the 30-year operational phase excluding capital cost however when initial capital costs (€538 million, 2014 values and prices) are taken into account this results in a negative

exchequer impact of circa €380 million over the 30 year appraisal period.

Overall the financial performance (excluding capital/fleet renewal costs) of LR7 is significantly stronger than LR3.

14.10 Conclusion

The analysis of phasing potential of LR7 and TLR3 has demonstrated that implementing the schemes in a phased approach would not result in improved BCRs for either of the schemes. The reason being that whilst implementing the schemes in a phased manner allows benefits be realised earlier, the upfront cost required to deliver the Phase 1 of the schemes, negates the earlier delivery of benefits. Overall, LR7 delivers substantially greater benefits than TLR3 at a similar cost.

15 Conclusion

This study has taken a fresh and comprehensive look at the long term public transport needs of the Fingal/North Dublin area. The study has considered a wide range of schemes previously proposed for the area and generated potential new schemes which might meet future travel demand.

Concluding the study and providing a recommendation for future infrastructure development has been based on a robust process, which included an assessment of the technical feasibility of the schemes considered and a detailed appraisal of the schemes following the guidelines set in the Public Spending Code and the Common Appraisal Framework for Transport Projects.

The study found that the key transport infrastructure priority for Fingal/North Dublin is the provision of new public transport capacity for the corridor from Dublin City Centre, through the north inner city and Ballymun to the Airport and Swords. Investments in this corridor provide the greatest community and economic benefit. This is due to density of residential development within the area and the high number of major trip generators along the corridor.

Heavy rail, light rail and BRT options for this corridor were developed and appraised. Heavy rail options for the corridor would prove technically difficult and are constrained by the need to share existing rail corridors. For example, without removing other services on the Maynooth Line, HR8 would be limited to no more than 4TPH, significantly limiting its potential capacity. The multi-criteria analysis has demonstrated that HR2 is not the best public transport solution to serve the study area and performs poorly in economic terms. The scheme is more expensive than initially considered due to the requirement to provide a tunnel at the Airport to avoid impacting upon development potential.

In relation to BRT, the assessment undertaken concludes that BRT services on this corridor would not provide sufficient capacity to meet the long-term identified passenger demand.

Light rail infrastructure presents the best opportunity to respond to travel demand in terms of operational and technical feasibility. The two shortlisted light rail schemes, LR7 (Optimised Metro North) and LR3 (Luas Line D2), are relatively similar in terms of alignment and the catchments they serve.

A capacity assessment was undertaken which indicated that LR3, as an extension to the planned Luas Cross-City scheme, would be running over capacity in the modelled year of 2033 in a base case scenario. Indeed, when a scenario was examined which included park and ride provision at Swords and demand management measures on the M50, predicted passenger numbers exceeded the design capacity by approximately 25%. A further scenario which considered a higher growth potential for Dublin Airport and the corridor, indicated that the capacity of the surface running LR3 would be exceeded by approximately 40% in 2033.

To overcome the capacity constraint on LR3, an option which introduced a tunnel from Broadstone to St Stephens Green was developed and appraised. The provision of a tunnel along this section removes the capacity restriction arising from the limitation on the number of trams that could run on surface through the city centre. This option presents the potential benefit of allowing LR3 to commence at an earlier stage with the tunnel delivered as a second phase before the capacity of the line is reached. However, the level of identified capacity shortfall by 2033 indicates that the tunnel provision is required much earlier, if LR3 was delivered in advance of this date.

While LR7 has more than adequate capacity to cater for the expected passenger demand, it is at a significantly higher cost then the surface running LR3. Similarly to the sequential approach for LR3, the phased introduction of LR7 was considered with options of delaying the introduction of some stations or stopping the line at the Airport for a period, before continuing to Swords.

Both schemes and phases have been assessed in detail to understand which option is most likely to effectively serve the corridor in the medium to long term. This analysis concluded that phased delivery of a tunnelled LR3 would not present the same scale of benefit as LR7 for the following reasons:

- A capacity assessment indicates there is a high potential of passenger demand exceeding, or being close to exceeding, the capacity of the surface running LR3 at its opening date, or close to its opening date, requiring the second phase (tunnelled section) to be completed concurrently, or close to concurrently, with the completion of the first phase if the line is to operate within capacity;
- The passenger numbers in the peak hour for LR7 are approximately 8% higher than the phased LR3;
- The stop location at Jervis on LR3 is less attractive to users than the O'Connell Street stop on LR7, which has approximately 1,000 more passengers alighting in the peak hour;
- The construction and operation of Tunnelled LR3 would have significant negative impacts for the Bus Eireann depot at Broadstone, with a large section of the depot unavailable during the construction period and the permanent loss of about seventy bus parking spaces;
- The tunnel section of LR3 introduces operational constraints on the Grangegorman to Cabra section, with a lower limitation on the number of services that can be accommodated on the link to Cabra and Broombridge;
- Due to the above operational constraint, the delivery of tunnelled LR3 would jeopardise the future potential to expand the light rail network to serve Finglas and a strategic park and ride site to be located at the M2/M50 junction; and
- The economic assessment indicated a significantly lower benefit to cost ratio for Tunnelled LR3 (BCR of 0.8) than for LR7 (BCR of 1.5).

It is concluded that delivery of LR7 as a full scheme is the preferred option for this corridor for the following reasons:

- It generates the highest level of transport benefits – over double the benefits of Tunnelled LR3;
- It has the highest number of additional public transport trips in the AM peak travel period of all of the assessed options;
- It has the highest BCR of all of the options assessed (BCR of LR7=1.5);
- It provides a new strategic public transport corridor, avoiding additional reliance on either the existing heavy rail lines or the Luas Cross City line which is under construction;
- It delivers a connection right into the heart of the city, serving O'Connell Street as well as St. Stephen's Green;
- It retains the opportunity to extend Luas Cross City to Finglas, which would be severely limited if Tunnelled LR3 were selected;
- Because of the high level of segregation on the line, there are no operational constraints thereby providing a high degree of flexibility in relation to service frequencies and capacity. The operational reliability of this option is therefore the highest;
- Equally due to the high level of segregation, it has significant capacity to allow for potential future growth in the future;
- It generates the highest level of highway and public transport benefits, demonstrating that it is the scheme most likely to encourage modal shift from car to public transport;
- Expected technical and environmental risks of the scheme can be mitigated based on preliminary designs and the previously approved Railway Order for Metro North;

- It provides a maximum level of accessibility to socially deprived areas within the study area and opens up connectivity to employment, health and education facilities;
- It integrates very well with spatial policies for the area and supports future growth areas within the study area;
- It integrates well with the existing and proposed public transport network of the City;
- Unlike Tunnelled LR3 it does not impact on existing constrained Bus Depots which could severely impact the operations of both Bus Éireann and Dublin Bus in the City; and
- It could potentially be extended southwards in the longer term to alleviate high travel demand on the Luas Green Line.

It should be noted that LR7 could be delivered on a phased basis and present a similar high level of benefits. Options include construction of the route only to the Airport as a first phase or delivery of the full scheme at the outset but with fewer stations. However, the economic analysis has indicated that such an approach would be likely to result in lower benefit to cost ratios when compared with the implementation of the full scheme in a single phase.

Optimised Metro North represents the best medium and long term public transport solution for the Greater Dublin Area.