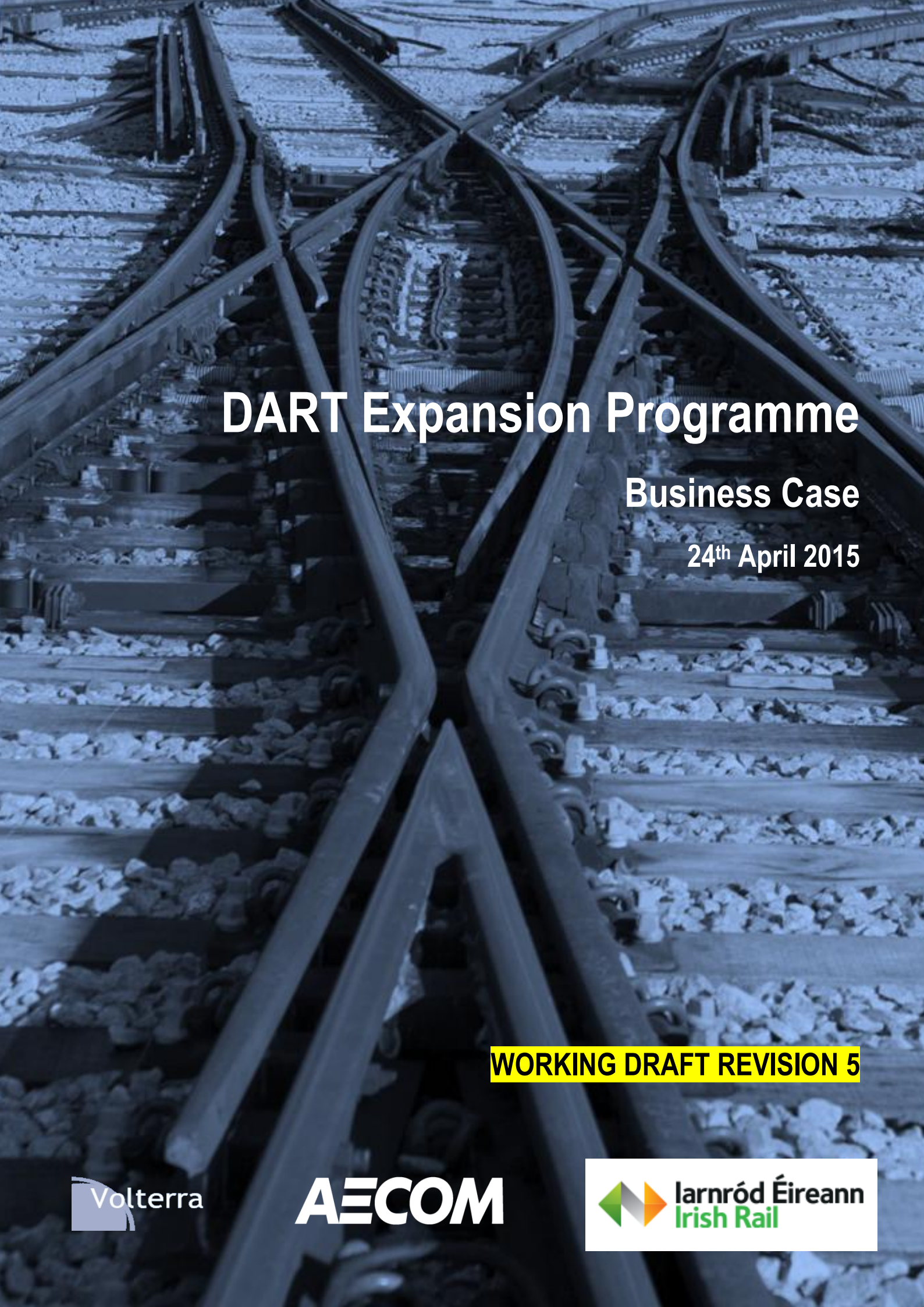

DART Expansion Programme

Business Case

24th April 2015

WORKING DRAFT REVISION 5

Volterra

AECOM

Iarnród Éireann
Irish Rail

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1 EXECUTIVE SUMMARY

1.1 Introduction

The DART Expansion Programme will be the single most important transport infrastructure investment in the State alleviating congestion in the Greater Dublin Area and enabling a modal shift from private to public transport.

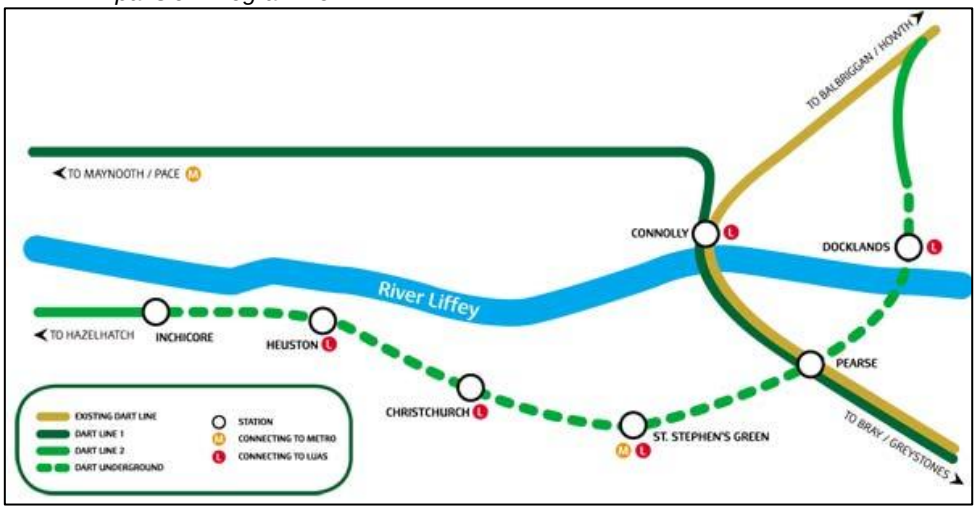
The purpose of the DART Expansion Programme is to provide a substantial improvement in public transport in the Greater Dublin Area by integrating the existing four heavy rail lines in Dublin city centre and thereby increasing passenger capacity, train frequency and interchange opportunities. The DART Expansion Programme will represent the cornerstone of the future transport system for the Greater Dublin Area through integration with other modes of transport.

The DART Expansion Programme is primarily enabled through the construction of a rail tunnel underneath Dublin city centre, linking the Cork Line west of Heuston station to the Northern Line north of Connolly station. Ancillary improvements to the existing network include electrification of the network to Drogheda, Maynooth and Hazelhatch (near Celbridge), removal of level crossings, purchase of additional rolling stock and provision of new depot facilities.

The tunnel section of the DART Expansion Programme (with stations at Inchicore, Heuston, Christchurch, Saint Stephens Green, Pearse and Docklands) is called the DART Underground Project. This is also evaluated on a standalone basis as part of this Business Case.

The DART Expansion Programme will provide a DART service from Drogheda to Hazelhatch via the city centre tunnel and a second segregated DART service operating from Maynooth to Greystones. The two segregated services will intersect at Pearse station, which will be the main passenger interchange.

Figure 1.1 - DART Expansion Programme



The DART Expansion Programme will also increase capacity at Connolly station and Heuston station, which will provide for additional growth in outer commuter and intercity services, as required by future demand.

This report provides the Business Case for the DART Expansion Programme. It has been prepared by AECOM and Volterra Partners on behalf of Iarnród Éireann and supersedes the previous Business Case prepared in 2010.

1.2 Background

The DART Expansion Programme has been considered as part of Dublin's transportation planning strategy since the Dublin Rapid Rail Transit Study was published in 1975. This study envisaged an east-west tunnel along the general corridor of the city centre section of the DART Expansion Programme (i.e. the DART Underground Project). Subsequent studies including the Dublin Suburban Rail Strategic Review (2000) and A Platform for Change (2001) further developed this proposal.

Iarnród Éireann commenced the planning and design of the city centre tunnel section (the DART Underground Project) in 2002. This process culminated in 2014 when a Railway Order for the DART Underground was made.

The Railway Order provides a 10 year planning consent for the construction of the DART Underground Project and sets September 2015 as a deadline for issuing 'Notices to Treat' for compulsory acquisitions in respect to the lands necessary for the construction and operation of DART Underground.

In the Government's Infrastructure and Capital Investment Programme 2012-2016 the DART Expansion Programme was deferred, with a view to progressing when funding permitted.

The DART Expansion Programme has strong policy support at European, national, regional and local level. It is a pre-identified project on the Core Network Corridors in the Connecting Europe Facility (CEF) and a Priority Project in the Trans-European Transport Network (TEN-T).

The NTA's regional transport plan for the Greater Dublin Area (Integrated Implementation Plan 2013-2018) includes specific provision to *"Protect or progress DART Underground in line with the Government's decision on the next national capital plan".*

In this context, this Business Case will inform the decision to include the DART Expansion Programme in future transport and capital spending plans.

1.3 Consideration of Options

The Dublin Suburban Rail Strategic Review carried out in 2000 on behalf of Iarnród Éireann examined a wide range of schemes for developing the heavy rail network to meet the future needs within the Greater Dublin Area.

The schemes considered included improvements on the existing lines and also the consequent issues arising from such improvements, including rail capacity constraints, the availability of railway land and adjacent neighbouring development. The study found that increasing city centre rail capacity is fundamental to the ability of Iarnród Éireann to expand heavy rail services from the suburban Greater Dublin Area commuter belt to the city centre. It was concluded that underground heavy rail through the city centre was the preferred means of improving city centre penetration and permitting integration between all suburban lines, whilst avoiding major city centre disruption to transport and the community.

Following publication of the recommended integrated transport strategy for the Greater Dublin Area (A Platform for Change, DTO 2001), Iarnród Éireann commissioned a study in 2002 to examine the alignment options for the city centre underground tunnel element, based on recommendations in the Dublin Suburban Rail Review.

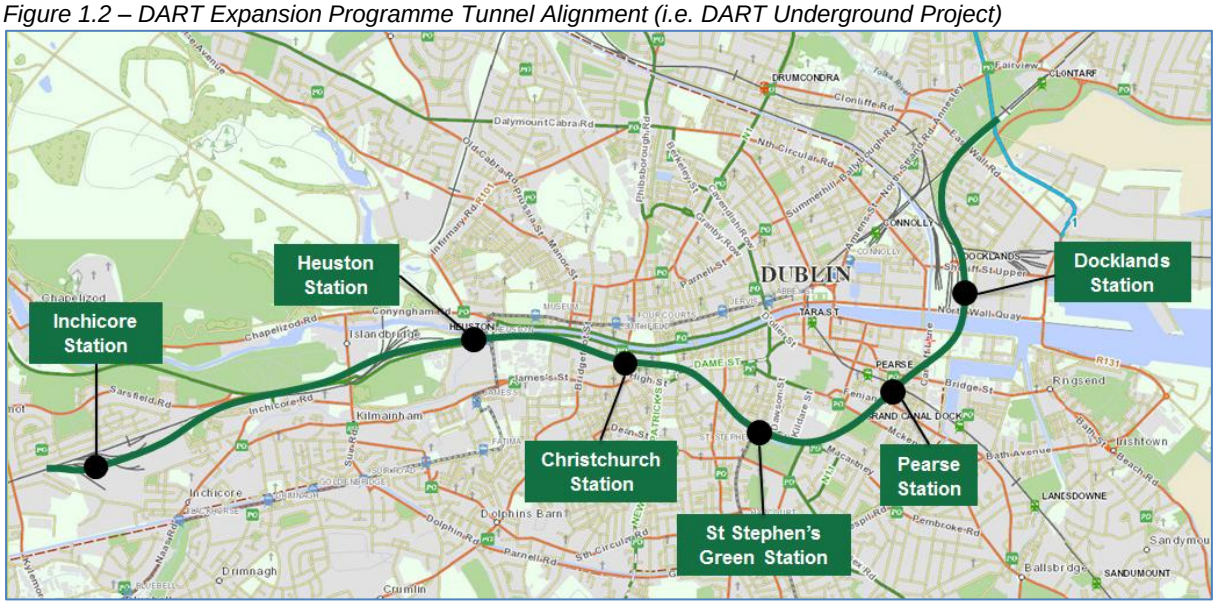
A range of route and station options between Heuston station and the north of Connolly station were examined. The alignment identification process phase found that the most favoured route connected to the Northern Line with stations at Docklands, Pearse, St Stephen's Green, Dublin Castle/Digital Hub and Heuston.

The preliminary design phase commenced in 2006. This included route verification, conceptual design, station design, a review of constraints, a review of the tunnel type (single versus twin bore) and construction methodologies.

The reference design and Railway Order Application phase commenced in 2008. The outcome of this phase was a number of key changes from the preferred alignment including the extension of the tunnel to Inchicore and the decision to locate the Dublin Castle/Digital Hub station at Christchurch. The culmination of this phase was the submission of a Railway Order Application in 2010, which was subsequently approved and made in 2014.

The final alignment of the city centre underground tunnel (DART Underground project) is shown in Figure 1.2 below.

Figure 1.2 – DART Expansion Programme Tunnel Alignment (i.e. DART Underground Project)



The detailed analysis of heavy rail options carried out during the planning and design phases of the city centre tunnel (DART Underground Project) have not been repeated in this Business Case. However, a range of alternative options based on other public transport modes have been examined.

Potential light rail, bus rapid transit (BRT) and bus alternatives were identified and assessed in comparison with the DART Expansion Programme using multi-criteria analysis. This process confirmed the DART Expansion Programme as the preferred option.

1.4 Transport Planning

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

AECOM used the NTA model to examine the Greater Dublin Area transport network both with and without the DART Expansion Programme and separately with the DART Underground Project only.

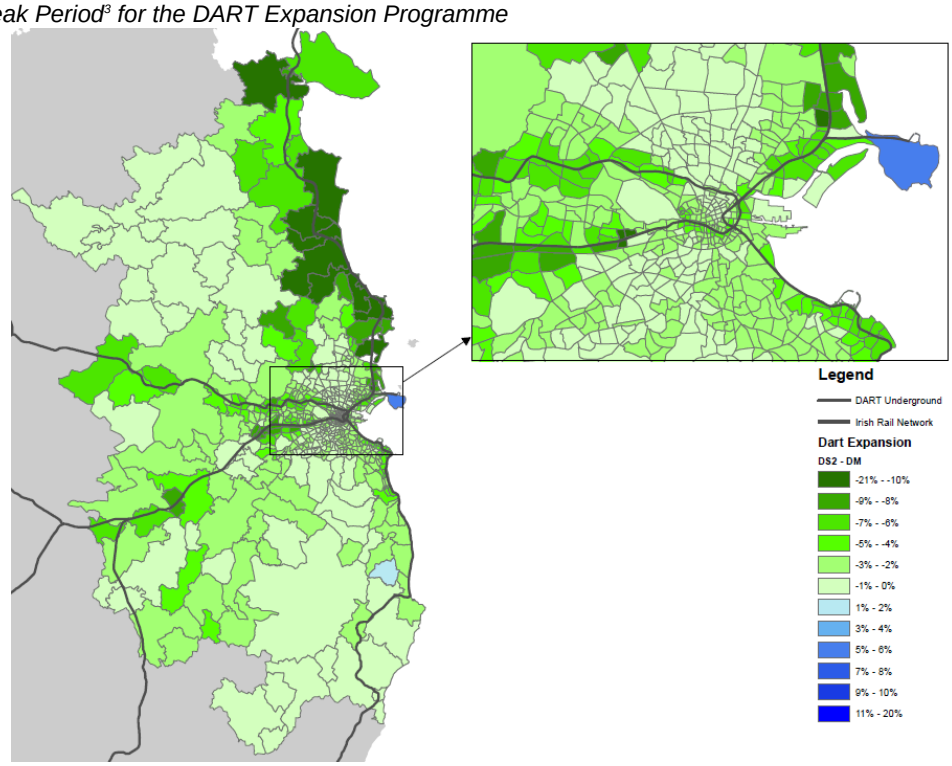
The results of this analysis indicates that the provision of the DART Expansion Programme will result in an increase in public transport trips of 1% and a reduction in car use of 0.3%.

It will also lead to a 46% increase in heavy rail boardings at the expense of city bus (10% reduction), regional bus (11% reduction) and Luas (6% reduction)[1].

Therefore the scheme overall is forecast to move people to public transport and within public transport to heavy rail.

The overall impact on public transport users in terms of generalised cost[2] is a significant reduction across the vast majority of zones in the Greater Dublin Area as shown in Figure 1.3.

Figure 1.3 – Percentage Difference in Average Generalised Cost by Zone for Public Transport Users in the Morning Peak Period[3] for the DART Expansion Programme



1.5 Scheme Costs

The costs associated with the DART Expansion Programme include capital costs and on-going annual operations and maintenance costs. These are shown below along with the costs of the DART Underground Project (tunnel section only).

Table 1.1 – Cost Summary

Costs – € million[4]	DART Expansion Programme	DART Underground Project
Capital Cost	4,007	2,994
Annual Operations & Maintenance Cost	111	69

It should be noted that the DART Underground Project costs are included in the DART Expansion Programme costs shown.

[1] *All figures relate to 2033*
[2] *Generalised cost include both monetary costs (such as fares) and non-monetary costs (such as time)*
[3] *Morning Peak Period is 7am to 10am*
[4] *2014 values; Including VAT; price escalation not included*

1.6 Scheme Appraisal

The scheme is appraised in accordance with the Common Appraisal Framework[5] against the standard multi-criteria appraisal headings of Economy, Safety, Environmental, Accessibility and Social Inclusion, and Integration.

The key element of the economic appraisal is the cost benefit analysis (CBA), the results of which show a strong economic case for the DART Expansion Programme. The case for the DART Underground Project without the other elements of the DART Expansion Programme is forecast to come at a net economic cost with the benefits generated being less than the overall cost. These are presented below.

Table 1.2 – Cost Benefit Analysis

€ billion, 2009 prices, 2009 present value	DART Expansion Programme	DART Underground Project
Total Costs	4.48	2.65
Total Benefits	6.12	2.17
Net Present Value (NPV)	1.64	-0.48
Benefit to Cost Ratio (BCR)	1.4	0.8

The Wider Economic Benefits associated with the schemes were also evaluated. The result of this analysis leads to an increase in the BCR for the DART Expansion Programme to 1.6 and for the DART Underground Project to 0.9.

A range of sensitivity tests has been carried out as part of the economic appraisal. The economic case for the scheme is found to be most sensitive to changes in future demand.

The DART Expansion Programme is also found to fulfil all of its key objectives which are as follows:

- Assist in the delivery of the national transportation strategy by increasing the passenger carrying capacity on (1) the Northern Line and Cork Line and (2) the Sligo Line and South Eastern Line;
- Improve the economy, integration and efficiency of transportation, by increasing the use of public transport;
- Support National spatial objectives by encouraging economic growth and improving quality of life and the environment;
- Support the Local Authorities in the GDA (especially Dublin City Council and Fingal County Council) sustainable development and regeneration objectives, including a better balance of development in the city centre by improving accessibility and transport integration;
- Provide for the integration of the National and Greater Dublin Area Rail Networks (including intercity, commuter, DART and Luas);
- Improve safety for transport users by increasing the use of public transport;
- Provide a segregated rail route that penetrates all the major areas of demand in the city centre; and
- Respond to anticipated passenger demands and the national transportation strategy.

[5] *Department of Transport (2009)*

1.7 Financial Appraisal

The financial appraisal examines the financial impact of the project. The primary components of this are the capital cost, operation & maintenance cost, change in fare revenue and other additional revenues generated by the scheme.

In addition to the capital cost of the project, there is a requirement for additional Iarnród Éireann subvention of €65 million (€65 million for the DART Underground Project) per annum in 2025 decreasing to €50 million (increasing to €80 million for the DART Underground Project) per annum in 2045.

There is likely to be a requirement to increase subvention to other public transport operators to compensate for lost fare revenue as public transport users move to heavy rail. However, this will be offset somewhat by reduced operating costs.

1.8 Risk, Procurement and Implementation

Iarnród Éireann has implemented a risk management process on the DART Expansion Programme which includes the identification and recording of all risks in a Project Risk Register on an ongoing basis.

The risk management processes and procedures are included in the Risk Management Plan for the DART Expansion Programme with risks categorised as technical, economic/financial, third party, project management, operation & maintenance and health & safety.

Iarnród Éireann has a well developed procurement process. However, given the scale of the DART Expansion Programme, it is likely that new processes and procedures will need to be agreed with the Department of Transport, Tourism and Sport and the Department of Public Expenditure and Reform in order to manage the procurement.

Funding this project is challenging given the capital cost is equal to the total estimated capital expenditure of the State for 2014 and is over three times the capital expenditure currently administered by the Department of Transport, Tourism and Sport. The source of funding for this project is beyond the scope of this Business Case.

The DART Underground Project, which is the principal component of the DART Expansion Programme, has been evaluated as a standalone project. This provides the basis for a decision to be made to develop the DART Expansion Programme in a phased manner by first implementing the DART Underground Project.

Finally, the timing of the development of the DART Expansion Programme (or DART Underground Project only) is assessed based on meeting the deadline imposed by the current Railway Order of completion by the end of 2024. This would require construction to start in 2017 and as such is an aggressive timeframe. It is therefore considered appropriate that changes in the timing for delivery of the scheme may be considered.

2 INTRODUCTION

2.1 General

AECOM has prepared this Business Case for the DART Expansion Programme which supersedes the 2010 Business Case.

This report documents transportation, economic and financial appraisals conducted by AECOM between October 2014 and April 2015.

2.2 Methodology

The methodology employed in developing this Business Case is based on the guidance provided in the Public Spending Code (Department of Public Expenditure and Reform, 2011). Where sector specific guidance is required and not covered in the Public Spending Code, the Common Appraisal Framework for transport projects (Department of Transport[6], 2009) is followed.

The **Programme Context** is examined in Section 3. This provides an overview of the current heavy rail network in Dublin and reviews the needs and objectives of the DART Expansion Programme.

Section 4 examines the **Policy Background** from a European, national, regional and local level to determine the policy support for the DART Expansion Programme.

The **Consideration of Options** in Section 5 reviews the heavy rail alternatives to the DART Expansion Programme. These alternatives have been examined in detail as part of the planning, design and statutory approval phases carried out to date. In addition, a number of alternative public transport modes are examined. The alternatives identified are evaluated against the DART Expansion Programme using multi-criteria analysis.

Section 6 provides details of the **Preferred Scheme** including details of how the final alignment was determined.

The National Transport Authority's Greater Dublin Area (GDA)[7] model was used to forecast the impact of the DART Expansion Programme. A 'Do Minimum' scenario consisting of existing and committed transport infrastructure was modelled which provides a baseline against which to measure the impact of changes in the transport network. A 'Do Something' scenario consisting of the addition of the DART Expansion Programme to the Do Minimum scenario was also modelled. The differences between the two scenarios are used as a forecast of the impact of the scheme. A further scenario consisting of the DART Underground Project only (the tunnel section of the DART Expansion Programme) was also modelled. The results and detailed methodology of the **Transport Planning** is included in Section 7.

A detailed review of the **Scheme Costs** was carried out, the results of which are included in Section 8.

A **Scheme Appraisal** is carried out to determine the impact of the scheme on society. The outputs from the modelling and cost review are used as inputs to the industry standard TUBA tool which evaluates the economic impact of the scheme through a Cost Benefit Analysis. The benefits primarily accrue as time savings for transport users whereas the costs consist of both capital and O&M costs. In addition, the sensitivity of results to changes in key inputs and assumptions are examined. Section 9 provides the results of the scheme appraisal.

[6] *Now the Department of Transport, Tourism and Sport*

[7] *In this Business Case, the term Greater Dublin Area refers to the area covered by the NTA model i.e. the local authority areas of Dublin City, South Dublin, Fingal, Dún Laoghaire-Rathdown, Wicklow, Kildare, Meath and Louth. In other documents, the Greater Dublin Area may not include Louth*

Given the scale of the DART Expansion Programme, there are likely to be **Wider Economic Benefits** associated with the scheme. These are evaluated using a bespoke method based on UK Department for Transport guidance. The results are presented in Section 10.

A **Financial Appraisal** is carried out to examine the impact of the DART Expansion Programme in terms of financial flows only. This appraisal is carried out using the outputs of the transport modelling process to estimate the additional fares that passengers will pay. This is then evaluated with the costs of the scheme to determine the financial impact on exchequer as a whole and on Iarnród Éireann. The results are presented in Section 11.

A **Risk Assessment** review is provided in Section 12, **Procurement** options are examined in Section 13 and **Proposals for Implementation** are discussed in Section 14. Finally, the key assumptions associated with the Business Case development process are included in the appendices including detailed service plans for heavy rail in the Greater Dublin Area which have been modelled using the NTA transportation model.

2.3 Project Overview

The heavy rail network operated by Iarnród Éireann is a critical component of the overall transport network owing to its ability to carry large numbers of people in a reliable and fast manner from origin station to destination station. Land use and planning policies and strategies aim to focus consolidation and intensification of development along the railway corridor.

The heavy railway network, developed from the mid to late 19th century, radiates from Dublin Metropolitan centre on four national main routes, namely:

- Northern Line (to Malahide, Drogheda, Dundalk, Belfast);
- Cork Line (to Hazelhatch, Sallins, Newbridge, Kildare, Portlaoise, Cork, Limerick, Waterford, Galway, Westport)[8];
- Sligo Line (to Clonsilla, Maynooth, Mullingar, Longford, Sligo)[9]; and
- South Eastern Line (to Bray, Greystones, Arklow, Wexford and Rosslare).

The Northern Line and Sligo Line converge north of Connolly Station, which imposes operational capacity constraints and hampers delivery of a high quality and high frequency service on both lines.

Services on the Cork Line, including those from Cork, Limerick, Galway, Kerry, Waterford, Portlaoise and Kildare, terminate at Heuston Station, approximately 2 km west of the city centre.

Iarnród Éireann operates three main types of rail services in the Greater Dublin Area to meet passenger needs. These services operate throughout daytime and evening periods, but are most heavily utilised during the morning and evening peak work commuting periods. The services operated are:

1. Intercity services into and out of Dublin from national towns and cities;
2. Commuter services into and out of Dublin from the Greater Dublin Area; and
3. DART Metropolitan service (DART), from Malahide/Howth to Greystones.

DART services have operated since the mid 1980s and have been an acknowledged public transportation success in terms of a frequent and reliable mass transport option. The DART network was significantly improved in 2000, with extension to Greystones and Malahide and in 2005 with increased platform length and train capacity.

[8] *The Cork Line as far as Kildare is commonly referred to as the Cork Line*
[9] *The Sligo Line as far as Maynooth is commonly referred to as the Maynooth Line*

Further improvements are planned which include city centre re-signalling, an improved turn-back facility at Grand Canal Dock station and an upgrade of the centralised traffic control system.

These improvements will reduce the capacity constraints allowing increased frequency of services including a 10-minute DART service throughout the day. However, significant further expansion of DART services will remain constrained by the Iarnród Éireann rail network.

Iarnród Éireann, with contributions from other transportation and land-use planning agencies and Local Authorities, has devised the DART Expansion Programme to provide a step change in heavy rail services in the Greater Dublin Area and also improve journeys for intercity passengers.

The ***DART Expansion Programme*** consists of a number of investment projects that will significantly expand the heavy rail capacity, frequency and connectivity in Dublin city centre and throughout the Greater Dublin Area (GDA). The projects include:

- The ***DART Underground Project***, consisting of a 7.6 km underground tunnel under the heart of Dublin City to link the Northern Line to the Cork Line;
- Electrification of the Cork Line to Hazelhatch and completion of 4 tracking from Park West to Inchicore;
- Electrification of the Northern Line to Drogheda;
- Electrification of the Sligo Line to Maynooth, together with removal of level crossings and re-signalling; and
- Expansion of fleet and depot facilities.

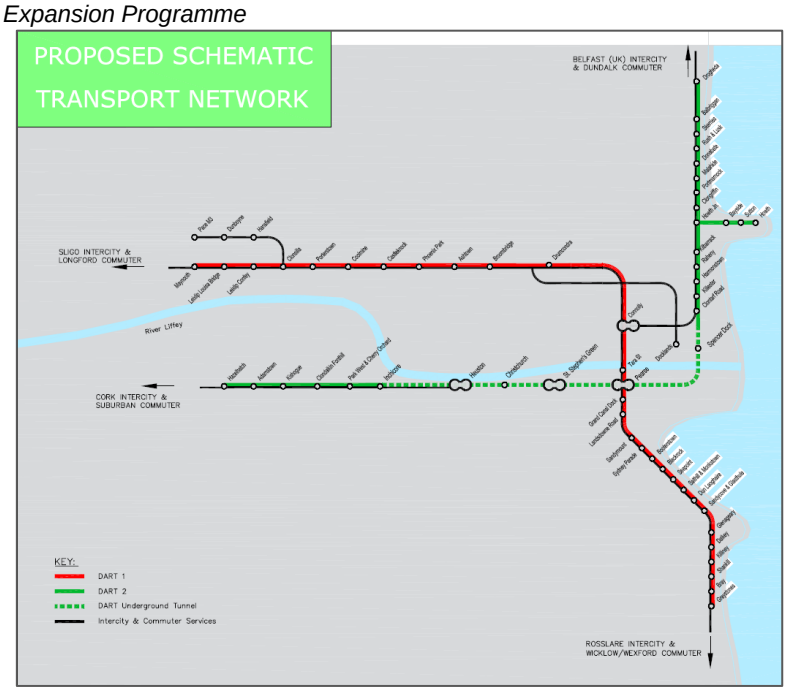
This report is strict in its use of the term DART Underground Project to describe the city centre heavy rail tunnel and the term DART Expansion Programme to describe the full scheme of which the DART Underground Project is a component.

The purpose of the DART Expansion Programme is to integrate the existing four rail lines in Dublin and to fill in the crucial final link to release the full potential of a significantly expanded and improved heavy rail network.

The DART Expansion Programme will allow for high capacity train services from Drogheda (Northern Line) to Hazelhatch (Cork Line) via an underground city centre tunnel and a second segregated high capacity train service running from Maynooth (Sligo Line) to Bray/Greystones (South Eastern Line). The two segregated services will intersect at Pearse Station, which will be the main passenger interchange between services. The DART Expansion Programme will increase capacity at Connolly station and Heuston station, which will enable growth on outer commuter and intercity services, as required by future demand.

The DART Expansion Programme will be the single most important transport infrastructure investment in the State alleviating congestion and enabling a modal shift from private to public transport in the Greater Dublin Area.

Figure 2.1 – DART Expansion Programme



The principal component of the DART Expansion Programme is a heavy rail tunnel linking the Cork Line to the west of Heuston station with the Northern Line to the north of Connolly station including six new stations in the city centre. This is termed the DART Underground Project and has obtained full planning consent and compulsory purchase powers for the lands necessary to construction and operation.

2.4 Background to the Programme

The DART Expansion Programme (variously described in previous reports as the *DART Underground* Programme *and Railway Interconnector*) has been considered as part of Dublin's transportation planning strategy for over forty years.

The key developments in the DART Expansion Programme include:

- The Dublin Transportation Study published by An Foras Forbartha Teoranta in 1972 identified key areas for growth in the Dublin area and recommended CIÉ review transportation options to facilitate such growth;
- The Dublin Rapid Rail Transit Study, published by CIÉ in 1975, set out a four phase implementation approach to modernisation and development of the heavy rail network. Financial backing to implement the recommendations of this study was provided to CIÉ, using which the current DART system was developed in the early 1980s. The second phase would have seen the development of an east-west tunnel linking Connolly and Heuston station. However, financial backing was not provided due to economic circumstances prevailing in the 1980s;
- The Dublin Suburban Rail Strategic Review published by CIÉ in 2000 concluded that more city centre heavy rail capacity was required and the preferred method of providing this capacity was an east-west tunnel linking the Cork Line with either the Northern Line or Sligo Line north of Connolly station;
- An integrated transportation strategy for the Greater Dublin Area, "A Platform for Change", was published in 2001 by the Dublin Transportation Office. This Strategy document set out a recommendation for improvements to public transportation to enable achievement of land-use and planning objectives. The recommended transportation

strategy included an east-west tunnel linking Heuston station and the north of Connolly station via the south city centre; and

- Iarnród Éireann commenced the planning and design of the city centre tunnel section of the DART Expansion Programme (the DART Underground Project) in 2002 with the following key steps:
    - Feasibility study (July 2002 to June 2003), consider alignment and station locations for an east-west tunnel to link Cork Line to either Northern Line or Sligo Line north of Connolly Station;
    - Preliminary design (November 2006 to May 2008), to develop the tunnel, railway system and station design, consider construction methodologies and verify the route alignment and land requirements;
    - Reference design (September 2008 – April 2011), to (including review and refinement of alignment and station locations);
    - A Railway Order Application for DART Underground was submitted to An Bord Pleanála in June 2010;
    - Oral hearing held from November 2010 to April 2011;
    - Railway Order made by An Bord Pleanála in December 2011; and
    - Railway Order perfected by High Court, following judicial review proceedings, in March 2014. The perfected Railway Order provides a 10 year planning consent for the construction of DART Underground Project and sets September 2015 as a deadline for issuing 'Notices to Treat' for compulsory acquisitions in respect to the lands necessary for the construction and operation of DART Underground.

Based on the September 2015 deadline for the issuing of 'Notices to Treat' for lands necessary for construction and operation of the DART Underground Project (and the resultant commitment of funding), the Department of Transport, Tourism and Sport, the National Transport Authority and Iarnród Éireann decided to prepare a fresh Business Case of the full DART Expansion Programme and the DART Underground Project as a standalone project based on most up to date guidance and data.

2.5 Business Case

This report sets out the Business Case for the DART Expansion Programme. The Business Case is the output of the detailed appraisal process and provides a key milestone in the evaluation of the DART Expansion Programme.

This report also examines the Business Case for the DART Underground Project in isolation, to determine if this project is advantageous on a standalone basis.

In the Government's Infrastructure and Capital Investment Programme 2012-2016 the DART Expansion Programme was deferred, with a view to progressing when funding permitted. This Business Case will assist in informing a decision on progressing the DART Expansion Programme, or the DART Underground Project as a standalone advanced phase, in the Government's next Infrastructure and Capital Investment Programme.

This Business Case will inform Iarnród Éireann, the National Transport Authority, the Department of Transport, Tourism and Sport and the Department of Public Expenditure and Reform in the planning of future transport investment in the Greater Dublin Area.

3 PROGRAMME CONTEXT

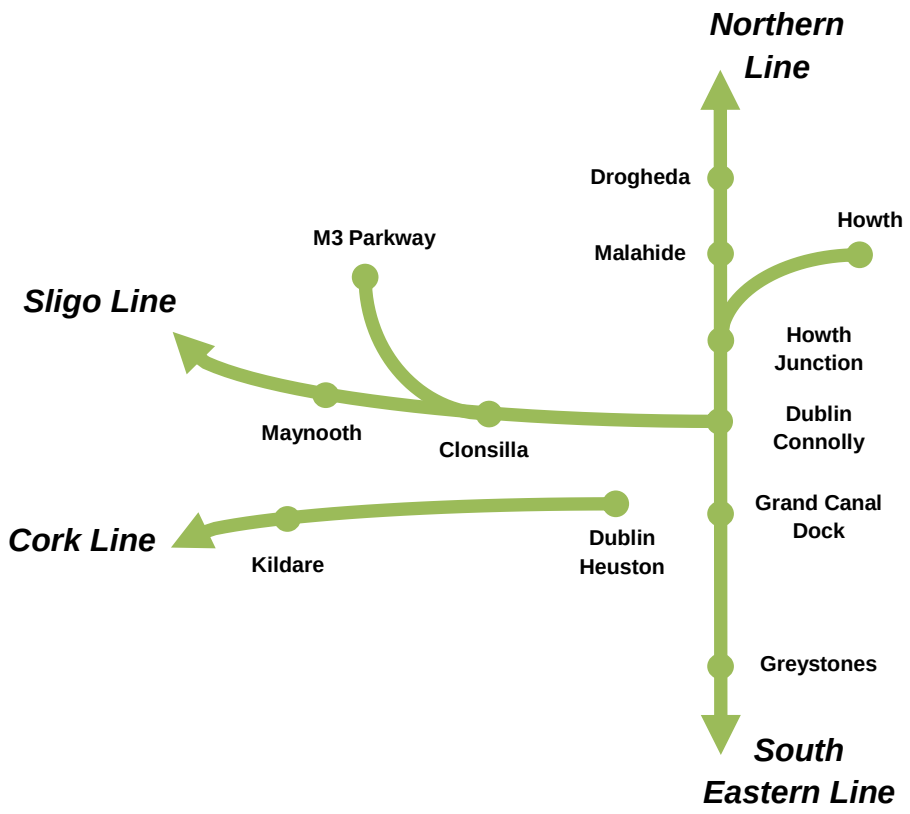
3.1 Dublin's Heavy Rail Network

Dublin's heavy rail network comprises four main routes radiating from the city, namely:

- The ***Northern Line*** – from Belfast via Drogheda to Connolly station;
- The ***Sligo Line*** – from Sligo via Maynooth to Connolly station;
- The ***South Eastern Line*** – from Rosslare Europort via Greystones to Connolly station; and
- The ***Cork Line*** – from Cork, Limerick, Tralee; from Ballina, Westport & Galway - converging with Cork line west of Portarlington, and from Waterford & Athy – converging with Cork line west of Kildare. All services terminate at Heuston station.

The Northern Line and the Sligo Line converge at Connolly Station before connecting to the South Eastern Line across the river Liffey on the Loop Line Bridge. The Cork Line terminates at Heuston Station[10] approximately 2 km to the west of the city centre.

Figure 3.1 – Current Heavy Rail Network



In recent years, there have been a number of improvements to the heavy rail network in the Greater Dublin Area. These improvements have included a new branch from the Sligo Line via Dunboyne to a park and ride facility adjacent to the M3, new stations, additional rolling stock and expanded depot facilities.

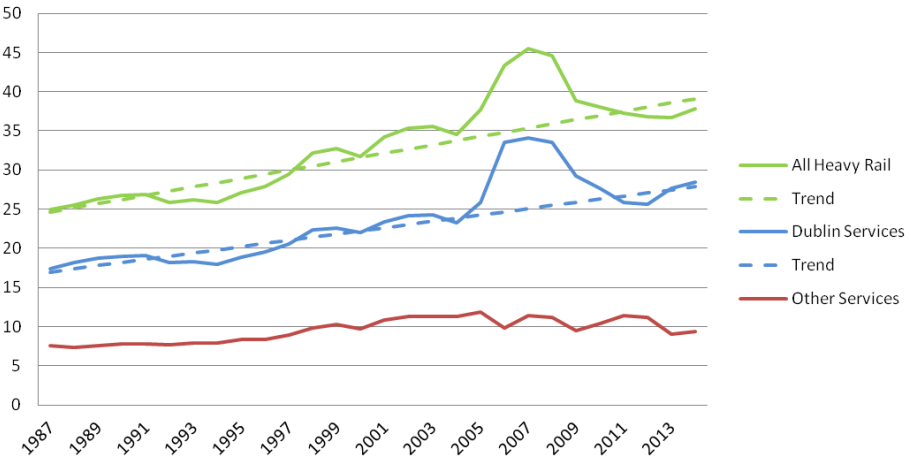
[10] *Connolly Station is also commonly referred to a Dublin Connolly and Heuston Station is commonly referred to a Dublin Heuston*

These works have led to an increase in the attractiveness and capacity of the heavy rail network. However, the ability for the heavy rail network in the Greater Dublin Area to support substantial future growth in passenger numbers is limited by a number of factors. The most notable issues are:

- Capacity constraints at Connolly station – limiting the number of potential services;
- The remoteness of Heuston station – impacting the attractiveness of commuter services on the Cork Line to passengers; and
- A lack of penetration for all heavy rail passenger journeys into central business districts – particularly the south east quadrant of the city.

An examination of the number of heavy rail passenger journeys shows a steady increase in demand since the late 1980s. This is shown in Figure 3.2.

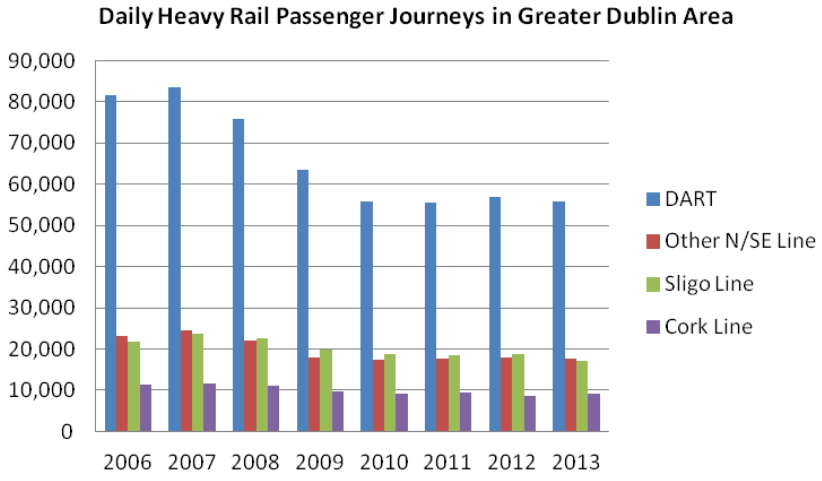
Figure 3.2 – Heavy Rail Passenger Journeys 1987 to 2014[11]



The period from 2005 to 2009 saw particularly high levels of patronage on Dublin services (DART and commuter) followed by a steep fall. The trend lines shown above disregard this period and indicate that current passenger numbers are broadly in line with the long-term trends.

The number of daily passenger journeys in the Greater Dublin Area for each of the lines from 2006 to 2014 is shown in Figure 3.3 below.

Figure 3.3 – Daily Heavy Rail Passenger Journeys in Greater Dublin Area[12]



[11] *Source: CSO (1987-2013); Iarnród Éireann (2014); Trend ignores 2005 to 2009 inclusive); Note some Other Services were reclassified as Dublin services from 2013 onwards*

[12] *Source: Table 5, Rail Census 2013, National Transport Authority & EY (2013)*

DART services between Howth/Malahide and Greystones carry over half of all passengers in the Greater Dublin Area. In 2013, DART carried over 55,000 daily passengers. Other services on the Northern and South Eastern lines carried almost 18,000 daily passengers while Sligo Line services (principally to/from Maynooth) carried over 17,000 daily passengers.

An examination of the 2013 Rail Census shows the daily, morning peak period (7am to 10am) and morning peak hour (8am to 9am) flows on the four key lines is shown in Table 3.1 below. This includes all traffic including passengers travelling to/from areas outside of the GDA.

Table 3.1 – Daily, Morning Peak Period and Morning Peak Hour Heavy Rail Flows

Line	Direction	Daily	7am to 10am	8am to 9am
Connolly – Northern Line	Inbound	17,900	11,600	6,700
	Outbound	16,900	1,000	400
Connolly – Sligo Line	Inbound	5,800	3,800	2,100
	Outbound	5,700	300	100
Pearse – South Eastern Line	Inbound	14,500	5,000	2,500
	Outbound	14,600	5,200	2,900
Heuston – Cork Line	Inbound	8,900	4,700	2,600
	Outbound	8,600	600	200

Source: Rail Census 2013; Data is based on flow into/out of station i.e. passengers on trains north of Connolly, west of Heuston and South of Pearse

It can be seen from the table above that the highest level of capacity in the morning peak is inbound (southbound) to Connolly station on the Northern (11,600) and Maynooth (3,800) lines which have a combined total of over 15,000 passengers between 7am and 10am. Of this total almost 9,000 (57%) arrive at Connolly between 8am and 9am. It should be noted that these passengers either alight, interchange or remain on trains at Connolly station.

It can also be seen that almost 5,000 heavy rail passengers arrive at Heuston station in the morning peak period (7am to 10am). These passengers must interchange to alternative forms of transport to access the city centre.

Under the National Transport Authority's Integrated Implementation Plan 2013-2018, a number of heavy rail projects will be completed in the coming years. Improvements to the signalling in the city centre and an improved turn-back facility at Grand Canal Dock station will increase the number of trains that can operate between Connolly and Grand Canal Dock stations. The re-opening of the Phoenix Park Tunnel will allow trains to operate between the Cork Line and Connolly station (and onwards to the South Eastern Line).

These works will have a positive effect on the frequency, capacity and connectivity of the heavy rail network. However, they do not provide a level of improvement that is comparable in scale to the DART Expansion Programme.

3.2 Project Needs & Objectives

Public transport is essential for the sustainability and consolidation of development in the Greater Dublin Area. The Iarnród Éireann heavy rail network provides the central arteries of the overall public transport network, providing a means of transporting large volumes of people to work, education and amenities throughout the day, but most especially during the peak AM and PM commuter periods. The Iarnród Éireann network is the only public transport network that is fully segregated from the road network and, therefore, the services and travel times are not influenced by road congestion.

The need for DART Expansion Programme remains, in that it will unlock the capacity potential of the heavy rail network and form a central element of an integrated public transport network for the Greater Dublin Area.

The DART Expansion Programme will involve a reorganisation of current services on the Iarnród Éireann network, for the improvement of passenger experience. The DART Expansion Programme will provide a second heavy rail crossing of the River Liffey. It will connect Heuston Station to the central business district and to the Docklands regeneration area. The reorganised network will provide high capacity service potential throughout the GDA, with two fully segregated lines.

The DART Expansion Programme is designed to:

- Support sustainable economic growth in the Greater Dublin Area through the provision of a high-quality, segregated, high-capacity mode of public transport which integrates with other road based public transport modes;
- Remove or reduce existing capacity constraints in the current heavy rail system – particularly at Connolly station;
- Provide greater city centre penetration and a high capacity public transport service from Heuston station to the south city centre and Docklands area; and
- Assist in supporting substantial future economic growth in the Greater Dublin Area and the Government's policy for sustainable development in the GDA.

In summary, the DART Expansion Programme will transform the current heavy rail network into the central pillar of a high-quality, cohesive, public transport network serving the Greater Dublin Area into the future.

The objectives of the DART Expansion Programme are defined as follows:

- Assist in the delivery of the national transportation strategy by increasing the passenger carrying capacity on (1) the Northern Line and Cork Line and (2) the Sligo Line and South Eastern Line;
- Improve the economy, integration and efficiency of transportation, by increasing the use of public transport;
- Support National spatial objectives by encouraging economic growth and improving quality of life and the environment;
- Support the Local Authorities in the GDA (especially Dublin City Council and Fingal County Council) sustainable development and regeneration objectives, including a better balance of development in the city centre by improving accessibility and transport integration;
- Provide for the integration of the National and Greater Dublin Area Rail Networks (including intercity, commuter, DART and Luas);
- Improve safety for transport users by increasing the use of public transport;
- Provide a segregated rail route that penetrates all the major areas of demand in the city centre; and
- Respond to anticipated passenger demands and the national transportation strategy.

The effectiveness of the DART Expansion Programme is assessed against each of these objectives below.

3.2.1 Increase Heavy Rail Capacity

The DART Expansion Programme aims to assist in the delivery of the national transportation strategy by increasing the passenger carrying capacity on the heavy rail network in general and, in particular, on the Northern Line and the Cork Line.

There are limits to the number of rail services that can be provided on the Iarnród Éireann network in the GDA, due to capacity constraints in the city centre. As a result, rail services are likely to become heavily congested in the future as the economy continues to grow and as passenger demand grows.

The remoteness of Heuston station and its lack of penetration into the city centre leads to a large level of passengers interchange to the Luas Red Line, thus increasing congestion on that service between Heuston and the city centre.

As transport demand grows, roads will also become progressively more congested, with increasing numbers of cars being used by commuters in the absence of an attractive public transport alternative. Modal shift to public transport will only be secured when potential users are confident that their journeys on the public transport network are comparable or more favourable to those undertaken by private car, in terms of journey time and journey completion security.

The DART Expansion Programme will lead to a significantly enhanced level of capacity on all four rails lines serving Dublin including the key growth corridors along the Northern Line and the Cork Line.

The increased capacity on the heavy rail system will lead to a more attractive public transport proposition further increasing the migration from cars and contributing to relieving congestion on roads.

3.2.2 Support Economic Growth and Integration

The DART Expansion Programme will support the economy and the integration and improved efficiency of the transport system, by increasing the use of public transport.

In order for the region to grow, it is critical to ensure the efficient movement of people between residential, business and employment areas.

The future of the Greater Dublin Area is reliant on its ability to attract and maintain residents, workers, businesses and tourists. This can only be achieved if the GDA is viewed positively in comparison with other international destinations.

A high-quality public transport system is an integral element in a region's attractiveness. The DART Expansion Programme provides the key public transport component that helps transform the current transport system into a fully 'joined up' network putting it on a par with comparable European regions.

The DART Expansion Programme provides a step-change in the capacity and potential for future growth of the public transport system leading to improvements in accessibility and transport integration.

3.2.3 Support National Spatial Objectives

The National Spatial Strategy aims to keep existing cities, towns and villages as physically compact and public transport friendly as possible thus minimising urban sprawl.

The provision of high quality public transport between key residential, business and retail areas is critical to support National spatial objectives.

The DART Expansion Programme provides the missing link in the Greater Dublin Area heavy rail network providing public transport links to key growth areas – effectively joining up the public transport network.

In addition, the scheme improves the quality of life and the environment by providing a high quality alternative to motor car transport.

3.2.4 Support Sustainability

The Greater Dublin Area needs to ensure long-term sustainable land use development. In order to achieve this, there is a need for higher-density residential and employment development.

To achieve these sustainable transport objectives and to cater for economic, employment and population growth into the future, a significant modal shift from the motor car to public transport is required.

The DART Expansion Programme will provide a high-capacity attractive alternative to travel by car. This scheme will ensure that high volumes of travellers can be moved directly (or with more integrated interchange) to their desired destination. This will support a significant modal shift to public transport.

The DART Expansion Programme also provides a high-capacity link between areas identified for high-density employment and high-density residential developments. The scheme provides the scope for new areas to develop along public transport corridors that can support growth into the future.

3.2.5 Provide an Integrated Rail Network

The current public transport system in the Greater Dublin Area provides a relatively high level of service for point to point journeys on many routes. However, the integration of the various services and modes is poor in many cases. The lack of interchange between rail services on the Heuston corridor with those on the Northern Line and South Eastern Line, especially in the Connolly to Grand Canal Dock sector, is particularly notable.

The DART Expansion Programme provides a significant increase in the level and quality of interchange opportunities between public transport modes and between what are currently four separate rail lines. Interchange opportunities include the Luas Red Line (Heuston Station and Docklands), Luas Green Line / Cross City (St Stephens Green) and existing DART services (Pearse).

The overall impact on the public transport system in the Greater Dublin Area is a shift from a system of individual modes to a much greater level of integration of services benefiting transport users throughout the Greater Dublin Area.

The DART Expansion Programme provides a key east-west public transport link across the city centre providing a high-capacity integration between Heuston station (and the suburbs served by lines to Heuston) with the remainder of the heavy rail network.

3.2.6 Provide City centre Rail Penetration

The centre of Dublin is a key centre of employment and retail activity for the Greater Dublin Area. Maintaining and improving the accessibility to this area is a key objective for the GDA as a whole.

The DART Expansion Programme provides a step-change in the level of city centre penetration with the new high-capacity rail link delivering passengers directly into the heart of the south city centre.

This will allow passengers boarding at all stations on the Northern Line from Howth and Malahide and on the Cork Line from Hazelhatch to directly access city centre locations such as St Stephen's Green and Christchurch without interchange.

3.2.7 Respond to Anticipated Demand

The rail transport system in the Greater Dublin Area is currently constrained from supporting future growth. This is most acute at Connolly station but as demand increases the volumes of travellers using Luas and bus services at Heuston station to access the city centre may also reach saturation levels.

There are projects underway to allow additional train services to be provided on the key Connolly station to Grand Canal Dock section. However, these improvements will only provide short-term relief from the constraints. The ability of the rail system to support further growth will remain limited.

The DART Expansion Programme will see a quantum change in the level of growth that the heavy rail system can handle by providing two non-conflicting through running DART lines through the city centre.

3.2.8 Outputs from the Project

The outputs expected from the DART Expansion Programme are:

- A significant increase in service frequency and capacity on all four rail lines serving the city;
- Shorter journey times for passengers;
- More direct access to the city centre;
- Improved accessibility to transport;
- Links between key business districts that are currently not well served by public transport;
- Improved public transport connectivity between suburbs;
- Increased interchange opportunities between public transport modes;
- Increased use of public transport;
- Increased efficiency of the public transport system;
- A reduction in emissions;
- An enhanced quality of life;
- Increased attractiveness for the region as a place to live and do business; and
- Capacity to support future passenger demand and economic growth.

4 POLICY BACKGROUND

There are a number of European, national, regional and local strategies and polices that govern the current land use and transportation policy in the Greater Dublin Area. The principal documents in relation to this Business Case are reviewed below.

4.1 European Policy

4.1.1 Trans-European Transport Networks (TEN-T)

The DART Expansion Programme is a pre-identified project on the Core Network Corridors in the Connecting Europe Facility (CEF) Regulation 1316/2013 (i.e. part of the North Sea – Mediterranean Alignment) and a Priority Project in the Trans-European Transport Network (TEN-T) (Priority Project 26 – Railway/Road axis Ireland/United Kingdom/Continental Europe).

The Connecting Europe Facility finances projects which fill the missing links in Europe's energy, transport and digital backbone and assists in making Europe's economy greener by promoting cleaner transport modes. By focussing on smart, sustainable and fully interconnected transport, energy and digital networks, the Connecting Europe Facility will help to complete the European single market.

The Trans-European Transport Network Programme and Priority Projects are chosen according to their European added-value and their contribution to the sustainable development of transport. TEN-T promotes coordinated improvements to roads, railways, ports, airports and a range of other transport infrastructure.

The DART Expansion Programme (specifically the link from the Northern Line to the Cork Line) forms part of this Core Corridor thus recognising the importance of the project in a national and international context.

4.2 National Policy

4.2.1 Programme for Government 2011-2016 (published in March 2011)

The Programme for Government contains the following commitment:

> *"A modern high speed transport system is essential to ensure our economic competitiveness. We will support the expansion in range and frequency of high capacity commuter services, which will be subject to cost benefit analysis."*

4.2.2 Statement of Government Priorities 2014-2016 (published in July 2014)

The Statement of Government Priorities emphasises the need to continue to develop the Greater Dublin Area as a priority:

> *"We will continue to support the development of Dublin as an international city region that will have positive economic benefits for the entire country."*

4.2.3 Infrastructure and Capital Investment 2012-2016: Medium Term Exchequer Framework (DPER)

The Medium Term Exchequer Framework sets out the results of a Government-wide review of infrastructure and capital investment policy in the context of the reduced resources then available.

The level of funding provided to public transport exceeds that provided for road schemes. Nonetheless the quantum of both is much reduced on previous periods.

The Framework finds that larger public transport projects (including the DART Expansion Programme) that require significant Exchequer contributions cannot proceed in the lifetime of the plan.

The overall need for the DART Expansion Programme and other high profile public transport projects is not questioned. The decision not to proceed in the timeframe of the strategy is purely based on the availability of funding.

4.2.4 Transport 21 (2006-2016) – National Transport Investment Strategy (2005)

Transport 21 set out the Government's 10-year capital investment strategy for transport infrastructure. In total €34 billion was to be invested in roads, public transport and regional airports. In total €16 billion was to be invested in public transport projects.

The strategy envisaged the provision of an efficient, reliable and sustainable national transport network which would:

- Underpin Ireland's economic growth;
- Improve Ireland's competitiveness;
- Contribute to environmental and economic sustainability;
- Provide increased accessibility;
- Lead to increased use of public transport;
- Provide increases in capacity; and
- Enhance transport quality.

The DART Expansion Programme was a key element of the public transport provision in the Greater Dublin Area. The Transport 21 strategy included the following objective:

> *"To construct the Suburban Rail Interconnector providing a tunnelled link between Heuston Station and the Docklands, via St. Stephen's Green and linking with the Northern line"*

Due to the economic situation in Ireland, Transport 21 was officially discontinued in 2011.

4.2.5 Strategic Framework for Investment in Land Transport Consultation (August 2014, DTTAS)

In August 2014, the Department of Transport, Tourism and Sport (DTTAS) launched a public consultation on a Strategic Framework for Investment in Land Transport.

The communication from the Minister for Transport, Tourism and Sport that accompanied the consultation stressed that the draft framework does not set policy. It does however outline the constraints within which policy decisions must be made.

The steering group that oversaw the development of the framework identified a number of objectives for transport investment including:

- Economic development;
- Societal benefits (including promoting inclusion);
- Environmental sustainability; and
- Balanced regional development.

However, given the current economic climate in Ireland and the key role that efficient transport has in economic development – particularly supporting economic growth, improving competitiveness, labour mobility, encouraging foreign direct investment and supporting sustainable job creation – this is considered the primary objective in prioritising transport investment.

Of particular note is the key link between transport investment and economic development:

> *"Failure to invest in our transport network to meet the needs of enterprise and society as a whole will lead to long-term costs through reduced competitiveness and productivity. An inadequate and inefficient transport system creates costs for society, and acts as a barrier to economic growth."*

The framework highlights the importance of strategic and longer-term planning. However, it does identify an issue funding major road and rail investments, including the DART Expansion Programme, in the medium term. The level of funding and operational subvention necessary to maintain and operate the heavy rail network is also highlighted. However, this is not unique to heavy rail with the long-run average annual transport investment of 1.13% of GDP equating to approximately €1.8 billion of which €1.6 billion is required for road and rail network maintenance[13].

A key positive aspect the framework highlights is the perception associated with Dublin due to recent investment in rail projects. The Luas investment is seen as improving the image of Dublin as a modern contemporary city with particular benefit to the tourism industry.

4.2.6 Smarter Travel, A Sustainable Transport Future, A New Transport Policy for Ireland 2009 – 2020 (DTTAS, 2009)

The Smarter Travel policy sets out a broad vision which aims to:

- Improve quality of life and accessibility to transport for all;
- Improve economic competitiveness through maximising transport system efficiencies and alleviating congestion;
- Reduce emissions and fossil fuel dependence; and
- Reduce car usage.

The aim is that by 2020 future population and economic growth will take place in a sustainable manner. The strategy foresees a considerable shift to public transport and a public transport system that will enhance Ireland's competitiveness.

The policy contains a target to increase the number of commuters travelling to work by alternative means by 500,000 leading to a drop in the total share of car commuting from 65% to 45%. Alternative means, such as public transport, cycling and walking, will therefore constitute a 55% share of commuter journeys.

In order to support such a sizeable shift to sustainable transport, the level of service and provided by public transport will need to improve significantly in order to offer a suitably attractive alternative to car transport.

4.2.7 National Spatial Strategy for Ireland 2002-2020 (DELG[14], 2002)

The National Spatial Strategy (NSS) is a twenty-year planning framework designed to deliver more balanced social, economic and physical development between regions. Although the strategy does

[13] *Based on 2013*

[14] *The Department of Environment and Local Government (now the Department of Environment, Community and Local Government)*

not include a plan for infrastructure investment, the spatial plan is supported by national transport policies.

The strategy proposes Ireland keeps existing cities, towns and villages as physically compact and public transport friendly as possible thus minimising urban sprawl.

The NSS supports increased use of public transport in the Greater Dublin Area. The spatial policy for a more efficient GDA proposes its vital national role is secured in terms of improved mobility, urban design quality, social mix, and international and regional connections.

In addition, the NSS promotes the continued development of infrastructure connecting Dublin to the regions including an improved heavy rail network.

In order to meet the goals of the NSS, high-quality public transportation that reduces congestion and improves the regions attractiveness and competitiveness is required.

In 2013, it was announced by the then Minister for Community, Environment and Local Government that the National Spatial Strategy would be replaced by a new policy. However, to date no such policy has been published.

4.3 Regional Policy

4.3.1 Regional Planning Guidelines for the Greater Dublin Area 2010-2022 (Dublin Regional Authority and Mid-East Regional Authority, June 2010)

The guidelines support the development of the DART Expansion Programme, noting that it will integrate the various rail infrastructures operating across the city and region. It includes the DART Expansion Programme as a strategic transport investment for the GDA.

The guidelines' vision for transport policy and development in the GDA is steered by the convergence of national policy towards greater consistency in transport planning, spatial planning and land use management.

The guidelines identify a need to implement land use policies that support and protect the investments made in public transport to ensure that the maximum benefit is gained economically, socially, environmentally and in relation to overall health.

Furthermore, the guidelines recognise the importance of building up a critical mass in suitable locations to support the capacity requirements that make particular public transport investments feasible, sustainable and cost effective.

The development of the DART Expansion Programme supports the objectives of the guidelines providing a vital element of the required public transport system.

4.3.2 Greater Dublin Area Draft Transport Strategy 2011-2030 (NTA, June 2011)

The NTA published this draft strategy to establish appropriate policies and transport measures that will support the GDA region in meeting its potential. The strategy has a vision for the GDA by 2030 to be *"a competitive, sustainable city-region with a good quality of life for all."*

In order to achieve this, the strategy sets out five overarching objectives, namely:

- Build and strengthen communities;
- Improve economic competitiveness;
- Improve the built environment;

- Respect and sustain the natural environment; and
- Reduce personal stress.

Each of these high-level objectives includes a number of transport specific sub-objectives of which the following are some of the key elements:

- Improve accessibility – to work, education, retail etc;
- Improve links between communities within the region;
- Reduce journey times;
- Improve ease of use of public transport system;
- Support business agglomeration;
- Minimise the physical intrusion of motor traffic; and
- Improve the environment – streetscapes, air, water etc.

The strategy found that the DART Expansion Programme met all of the strategy's objectives and therefore proposed it as a key measure to be delivered by 2030. The medium term period of the strategy (2017-2026) proposes to focus on the delivery of the two most significant public transport projects (DART Expansion Programme and Metro North).

The strategy declares that:

"DART Underground represents a cornerstone of the future transport system."

Although the strategy is still in draft form and yet to be finalised, it is clear the DART Expansion Programme is viewed as an integral part of Dublin's transport future.

4.3.3 Integrated Implementation Plan 2013-2018 (NTA, April 2014)

In April 2014, the NTA's published its plan for transport investment in the GDA up to 2018. This plan set a number of high-level economic, social and environmental objectives including:

- Improve travel time and reliability for the movement of people and goods;
- Enhance accessibility to jobs, schools, shops, local services, leisure facilities and other destinations;
- Improve internal connections between communities and external links to/from areas outside the GDA;
- Advance the user-friendliness of the public transport system including easy transfer across the various modes and operators; and
- Reduce transport related greenhouse gas emissions.

Specific objectives were set in relation to heavy rail including to *"Protect or progress DART Underground in line with the Government's decision on the next national capital plan".*

In addition, a number of other elements of the DART Expansion Programme are to be progressed including city centre re-signalling, level crossing closures and extension of the electrified DART services north of Malahide and westwards to Maynooth.

The plan also targets the development of the Phoenix Park Tunnel Project to bring commuter train services directly from the Cork Line into the city centre. Although this will provide a link from the Cork Line to Connolly station, it does not fulfil the same needs and objectives of the DART Expansion Programme. This is confirmed in the Business Case for the Phoenix Park Tunnel Project which stated:

"It should be noted The Phoenix Park Tunnel project does not fulfil the needs and objectives of the DART Expansion Programme, which has a substantially larger scale and impact".

4.4 Local Policy

4.4.1 Dublin City Development Plan 2011-2017

A large proportion of the DART Expansion Programme is located in the Dublin City Council local authority area. The vision for the city contained in the current development plan envisages a *"socially inclusive city of urban neighbourhoods, all connected by exemplary public transport"*.

The City Council identified six key themes integral to the development of Dublin City. The Movement theme targets building an integrated transport network and encouraging the provision of greater choice of transport. It aims to bring planning and zoning objectives together to increase the opportunities to live and work close to transport hubs and corridors.

The plan supports a modal shift from private modes of transport to alternative modes including public transport. It supports the development of the DART Expansion Programme to achieve a consolidated metropolitan area.

4.4.2 Fingal County Development Plan 2011-2017

The strategic policy contained in the Development Plan includes the aim to develop a high quality public transport system throughout and adjoining the County.

The extension of the DART rail service to Balbriggan (which would include all stations within Fingal on the Northern Line) is an objective in the development plan for Fingal. This is an integral component of the DART Expansion Programme.

4.4.3 South Dublin County Development Plan 2010-2016

The current South Dublin County Development Plan includes support for the DART Expansion Programme as a transport policy.

4.4.4 Dún Laoghaire-Rathdown County Development Plan 2010-2016

The Development Plan for Dún Laoghaire-Rathdown supports the implementation of sustainable transport mode to ensure land use and zoning are fully integrated with the provision and development of high quality transportation systems. Supporting a model shift from private car to more sustainable modes of transport is a key objective of the plan.

4.4.5 Meath County Development Plan 2013-2019

The Meath County Development Plan highlights the long-term need to provide a rail link to Navan. This provision of such a link would increase demand further on the capacity of the rail system in Dublin city centre. The DART Expansion Programme would enable projects such as the Navan rail link to be developed in the future.

4.4.6 Kildare County Development Plan 2013-2019

The Kildare County Development Plan supports the provision of a high-quality, integrated transport system in a manner which is consistent with sustainable development.

The plan includes strong support for the Transport 21 programme of investment including the extension of electrified rail services to Maynooth and Hazelhatch.

4.4.7 Wicklow County Development Plan 2010-2016

The Wicklow County Development Plan includes a commitment to work with the national transport bodies to delivery of a high quality, integrated transport system in the Greater Dublin Area.

4.5 Future Policy

It is acknowledged that the National Transport Authority (NTA) is formulating a new transport strategy for the Greater Dublin Area. Similarly, the Department of Transport, Tourism and Sport (DTTAS) is formulating a Strategic Framework for Investment in Land Transport.

It is expected that this Business Case will inform the NTA and DTTAS in their formulation of these future polices.

4.6 Policy Conclusions

The current rail network in the Greater Dublin Area provides a valued public transportation service. A number of projects due to be completed in the coming years will further improve the service provided.

However, the limitations of the rail network are recognised. In order to support a significant increase in the number of heavy rail passengers, the development of the DART Expansion Programme is proposed.

The DART Expansion Programme comprises the DART Underground Project (a city centre heavy rail tunnel linking the Northern Line and Cork Line) together with the expansion of electrification in the Greater Dublin Area and the segregation of fast and slow trains on the Cork Line.

The DART Expansion Programme is widely supported in European, National, regional and local transportation strategies.

The development of the DART Expansion Programme is not included in current capital plans due to the current economic conditions.

This Business Case provides an up-to-date assessment of the case for developing the DART Expansion Programme. This will allow policy makers to position the project appropriately in future capital plans.

5 CONSIDERATION OF OPTIONS

5.1 Options Overview

An important element of the development of a Business Case is the examination and assessment of potential alternatives to the scheme being assessed.

In this Business Case, the DART Underground Project (the city centre tunnel element of the DART Expansion Programme) is evaluated as a standalone scheme. This is in addition to the full DART Expansion Programme. Alternative heavy rail options and alternative mode options are also considered.

Alternative heavy rail options were considered in detail during the planning and design phases of the city centre tunnel (DART Underground Project). It is not proposed to repeat that analysis as part of this Business Case. However, a review of the work carried out to identify the DART Expansion Programme as the preferred heavy rail option is provided in Section 5.2. The process of selection of the route alignment and station locations is included in Section 6.2.

Alternative modes were examined in the various policies and strategies that led to the DART Expansion Programme (e.g. the Dublin Transportation Office's A Platform for Change). Nonetheless the potential for alternative modes that could provide a similar outcome is examined further in this Business Case.

The potential alternative modes generally comprise light rail, bus rapid transit (BRT) and bus. As shown in Table 5.1, the carrying capacity of the alternative modes is less, in some cases significantly less, than heavy rail.

Table 5.1 – Public Transport Modes and Potential Capacities[15]

Mode	Frequency (minutes)	Maximum Capacity (passengers per vehicle)	System Capacity (passengers per direction hour)
Standard Bus	2	80	2,400
BRT – non segregated on road	4	120	1,800
BRT – segregated on road	2	120	3,600
Light Rail – 40m[16]	4	300	4,500
Light Rail – 40m	3	300	6,000
Light Rail – 50m	3	350	7,000
Heavy Rail[17]	5	1,400	16,800
Heavy Rail	3	1,400	28,000

The carrying capacity of each of the alternatives and the availability of road space (for surface options) will be a key factor in their potential success or failure. Cost is also a key element that must be factored in to any assessment of alternatives with the higher capacity modes attracting a much higher cost.

The potential for light rail and bus/bus rapid transit alternatives to the DART Expansion Programme are examined in Sections 5.3 and 5.4. Finally, the alternative modes identified are assessed (via multi-criteria analysis) in Section 5.5.

[15] *Source: AECOM estimates*

[16] *Note: The current Luas Red Line operates circa 15 trams per hour per direction at peak providing a capacity of circa 4,500.*

[17] *Note: The current maximum frequency from Connolly station to Grand Canal Dock station is 12 trains per hour per direction (i.e. 5 min frequency). This will increase to 20 trains per hour per direction (i.e. 3 minute frequency) in the coming years under committed projects.*

5.2 Heavy Rail

5.2.1 Transport Strategy Background

The development of the DART Expansion Programme and the DART Underground Project (city centre tunnel section) originate from studies dating back to the 1970s. It is considered important to set out the context and evolution of these studies and how such studies are linked with national transport, land-use and planning strategy.

The modern planning for public transport for the Greater Dublin Area dates back to a 1967 masterplan for Greater Dublin (Wright Plan, 1967) which proposed the creation of four sub-urban "new towns" to be developed around the villages of Clondalkin, Lucan, Tallaght and Blanchardstown, where adjacent lands were capable of significant development. In response to this masterplan, in 1971, An Foras Forbartha Teoanta (the National Institute for Physical Planning and Construction Research Ltd.) published the "Dublin Transportation Study". This study recommended that CIÉ review public transportation options to facilitate growth in the Greater Dublin Area and specifically recommended that:

> *"an immediate investigation should be undertaken to examine the feasibility and costs of constructing a short underground in central Dublin that would more effectively connect the four existing rail lines in the city".*

In 1975 CIÉ prepared the "Dublin Rapid Rail Transit Study", which set out a progressive four phase approach to expanding the rail network to existing and proposed Dublin suburbs.

1. Phase 1 consisted of electrification of the Northern Line and Southeast Line from Howth to Bray;
2. Phase 2 consisted of underground rail tunnel from Heuston to Connolly and construction of a spur to Tallaght and construction of rapid transit tracks from Clondalkin to Heuston;
3. Phase 3 consisted development of spur from the Sligo Line to serve Blanchardstown; and
4. Phase 4 consisted of tunnel from Broadstone to Sandymount.

Government funding was provided to CIÉ to advance the recommendations of the Dublin Rapid Transit Study. Phase 1 was completed in 1984 with the delivery of DART services between Bray and Howth. Phase 2 was also partially advanced with the acquisition of necessary lands. However, due to the onset of economic decline in the 1980s, Government funding was not continued to allow CIÉ complete the study recommendations.

In 1995 the Department of Transport published the Dublin Transport Initiative (DTI) aimed at securing a shift towards public transport, cycling and walking in preference to private car trips. The DTI objectives were to:

- Provide improved public transport capacity and reliability across the GDA network; and
- Implement demand management tools to incentivise a modal shift from private car to public transport.

The DTI recommended an integrated transport strategy and investment and implementation programme for the Greater Dublin Area up to 2011 and a longer term planning framework for public transport. Substantial progress was achieved in implementing the recommended elements of the Strategy, albeit delivery of some major elements were significantly delayed (Dublin Port Tunnel, Luas, Quality Bus Corridors). The actual growth in demand for travel was far in excess of the forecasts provided in the DTI Strategy (for both private and public transport), resulting in significant road congestion and high fuel emissions.

The Dublin Transportation Office (DTO) was established in 1995, to prepare a revised transportation strategy for the Greater Dublin Area, taking account of the revised socio-economic forecasts for the GDA and which supported the development objectives of the Strategic Planning Guidelines. The revised transportation strategy needs to take account of the rapid growth in population and households in the GDA, the dispersed nature of development, the substantial increase in peak hour travel demands, increasing car ownership trends and economic growth projections.

In 1997, Iarnród Éireann produced a "Technical and Policy Review" which identified key structural opportunities and deficiencies in the existing suburban rail network, relating to train path capacity constraints, rolling stock deficiencies and lack of city centre penetration.

Further in 2000, Iarnród Éireann published the "Dublin Suburban Rail Strategic Review" (DSRSR) study to determine the optimal development strategy for the heavy rail network up to 2020. The development strategy was founded upon the demand requirements outlined in the Strategic Planning Guidelines and upon key Iarnród Éireann objectives of enhancing services on existing lines, strategically reopening closed lines, constructing new spurs for development clusters, providing strategic new stations and seeking to progress new city centre connections. A thorough evaluation process of various options was conducted by independent consultants, using multi-criteria analysis (i.e. each option was assessed against 14 assessment criteria). The DSRSR study concluded that with increased demand the Northern Line, the Cork Line and the Sligo Line would encounter severe capacity constraints. Six capacity alleviation options were explored for improving rail capacity and passenger services. The evaluation concluded that a tunnel connecting the Cork Line at Heuston Station to either the Northern Line or the Sligo Line north of Connolly Station emerged as the option with the highest ranking. Other complementary recommendations, for upgrades or improvements to other areas of the network, were also proposed. The DSRSR study was submitted the DTO in 2000.

In 2001, the DTO published the revised integrated transport strategy for the Greater Dublin Area, entitled "A Platform for Change" This included a recommended strategy for improving public transportation by multi modal means (i.e. by walking, cycling, bus, Luas and rail) in preference to private car. The Strategy also highlighted the need for demand management tools to encourage use of public transport in preference to private cars to reduce road congestion.

A Platform for Change concluded that there was a strategic and strong need for a rail interconnector from the Cork Line to the Northern Line or Sligo Line via the south city centre. The recommended strategy noted:

> *"The centrepiece of the DART/suburban rail strategy is an underground interconnector linking Heuston Station with East Wall junction north of Connolly Station, via the south inner city, Pearse Station and Docklands. This interconnector allows for through running from the Kildare line to the Maynooth line and/or the Dundalk line. It provides a by-pass of the existing severe bottleneck approaching Connolly Station; it serves areas of high demand, especially the south-east inner city and Docklands; and it allows for the maximum use of the Maynooth and Kildare lines. The tunnel will be too long and will have too many underground stations to allow diesel trains. Therefore, both the Maynooth and Kildare lines will be electrified so that these services can run via the tunnel. This, in effect, will be a major extension of the present DART system. The interconnector will transform the DART/suburban rail system from one with severe constraints in terms of capacity and accessibility to a system that has a well balanced high capacity, that is operationally very efficient and that penetrates all the major areas of demand in the city centre."*

Following publication of the DTO's A Platform for Change in 2001, Iarnród Éireann progressed with design and refinement of an east-west underground rail tunnel, which has culminated with the DART Expansion Programme. At periodic junctures in the design process, the objectives and rationale for the DART Expansion Programme have been reassessed. Iarnród Éireann, or their independent

consultants, have not identified any alternative scheme that can meet the aims of the DART Expansion Programme, in terms of increasing the capacity of the heavy rail network and improving city-centre penetration.

The DTO commenced a review of the "A Platform for Change" strategy in late 2007. The National Transport Authority took over this review on its establishment in December 2009. A draft of the revised integrated transport strategy for the GDA 2011-2030 (2030 Vision) was issued in 2011. DART Expansion was identified as a key pillar of the recommended GDA public transport strategy. The NTA has recently (2015) conducted public consultations on a review of the draft 2030 vision, with a view to preparing a new transport strategy for the GDA to cover the period 2015 to 2035. Iarnród Éireann has formally sought to have the DART Expansion Programme included in the updated transport strategy.

5.2.2 Alternative Heavy Rail Options

The Dublin Suburban Rail Strategic Review Study (Ove Arup, 2000) considered a wide range of schemes for developing the Iarnród Éireann network to meet the future needs within the Greater Dublin Area. The schemes considered included improvements on the radial lines entering Dublin Metropolitan Area and also the consequent issues arising from such improvements, including rail capacity constraints, the availability of railway land and adjacent neighbouring development.

The study found that increasing city centre rail capacity is fundamental to the ability of Iarnród Éireann expanding heavy rail services from the suburban Greater Dublin commuter belt to the metropolitan centre.

The study also concluded that, unless the railway network was expanded beyond the existing alignments in the city centre, there would be no increase in city centre penetration. On the basis of technical studies and consultations with statutory agencies, local authorities and interested parties, it was concluded that underground tunnels were the preferred means of improving city centre penetration and permitting integration between all suburban lines, while avoiding major city centre disruption to the transport and community.

The DSRSR study examined the feasibility and benefits of a number of underground options, including:

- Heuston – Pearse;
- Heuston – Pearse – Connolly tunnel;
- Heuston – Connolly – Pearse – Heuston Loop;
- Broadstone – Connolly – Pearse – Broadstone Loop; and
- Spencer Dock – Pearse.

Each of the underground options was examined in a series of forecast tests. The two emerging concepts that performed best in the forecasting tests were:

- An west-east tunnel to link the Cork Line and the Northern and/or the Sligo Line north of Connolly Station; or
- A city centre tunnel loop offering interchange at Connolly and Pearse which would be served by the Cork Line and/or the Sligo Line trains.

The Heuston-Pearse tunnel did not offer direct rail connectivity with the Northern Line and/or the Sligo Line and therefore the forecast service plan was constrained by this lack of integration.

The Broadstone-Connolly-Pearse-Broadstone Loop would require the reopening of the Broadstone line and would only be able to serve the Sligo Line. This option was found to be less effective in terms of service pattern and alleviating capacity constraints on other lines.

The Spencer Dock-Pearse option was found to be heavily constrained in construction due to the built environment and lack of vacant land. This option would allow for alleviation of Connolly constraints, but scored poorly in terms of integration with the remainder of the network.

When the two best performing concepts were subjected to demand forecast testing, the west to east tunnel from Cork Line to connect with either the Northern Line or the Sligo Line scored best. It provides direct cross city service opportunities and significantly widens the city centre rail catchment. It alleviates the capacity constraints at Connolly and allows Iarnród Éireann grow its services in line with passenger demand into the future.

The DSRSR study examined a suite of rail investment recommendations for growing and expanding the rail based public transport. These included schemes that were already identified for investment as an essential first step in the rail improvement programme and thereafter a follow on investment programme for completion of the rail improvement programme. The recommendations were as follows:

Previously identified investment:

- Procurement of diesel railcars;
- Procurement of DART cars;
- Platform lengthening of DART stations to accommodate 8-car trains;
- Four tracking of Cork Line from Hazelhatch (Kildare) to Cherry Orchard;
- City centre re-signalling from Howth to Grand Canal Dock; and
- Provision of strategic new stations (Lucan South, Leixlip Intel, Ashington).

Recommended investment:

- The East-West tunnel linking the Cork Line to the Northern and/or Sligo Line;
- Provision of terminal platform south of Loop Line Bridge;
- Upgrade of Northern Line to three or four tracks from Connolly North to Howth Junction and modification of DART terminal layout at Malahide;
- Removal of level crossing gates from Grand Canal Dock to Blackrock;
- Electrification of the Cork Line to Sallins/Kildare and the Sligo Line to Maynooth;
- Construction of a rail link to Dublin Airport;
- Construction and electrification of a line to City West;
- Construction and electrification of a branch line to Blanchardstown;
- Phased extension of this Blanchardstown line to Navan; and
- Acquisition of additional rolling stock and stabling/maintenance facilities.

The DSRSR study highlights that the recommendations are subject to refinement of the design for the Luas light rail.

The DSRSR study is the genesis for defining the DART Expansion Programme. Since its publication in 2000, there has been no other integrated heavy rail transport option advanced that utilises and integrates the existing Iarnród Éireann network in the Greater Dublin Area in such a comprehensive manner.

In 1999 Ove Arup and Partners assessed a number of rail transport options for Dublin to identify which schemes should be considered for development up to 2020. The outcome of this assessment

was published as the Dublin Suburban Rail Strategic Review (Arup, 2000). The report found that there were severe capacity constraints on the Northern Line, Sligo Line and Cork Line.

In total, six options were considered for increasing capacity and improving passenger service:

- Phoenix Park Line – use of the Phoenix Park Tunnel to divert Cork Line services to Connolly station;
- North-South Suburban Line Upgrade – upgrade of the Northern Line and the South Eastern Line to maximise capacity;
- Loop Line Quadrupling – increase the capacity from Connolly station to Grand Canal Dock station through the addition of extra tracks;
- Broadstone Tunnel Loop – Sligo Line loop via Broadstone and Connolly station back to the Sligo Line;
- Heuston Tunnel Loop – Cork Line loop from Heuston to Connolly and back; and
- East to West Tunnel – East-West tunnel from Cork Line to Northern Line or Sligo Line.

An evaluation of each of the options was carried out using fourteen criteria which included economic, environmental and cost measures. The three tunnel based options showed significantly higher scores than the other options. The East to West Tunnel had the highest score of all.

The report found that the preferred method of providing an increase in city centre heavy rail capacity was an East to West Tunnel linking the Cork Line and the Northern Line and/or the Sligo Line. A series of additional recommendations (such as extension of electrification to the Sligo Line and Cork Line) was included in the report.

In 2001, the Dublin Transportation Office launched A Platform for Change. This policy document developed an integrated transport plan for the Greater Dublin Area. The development of the plan included a baseline model which showed a demand for an extra 135,000 trips by car and associated congestion due to a major public transport infrastructure deficit by 2016.

In determining the public transport element of the plan, three different approaches were used:

- Bottom Up: incremental addition of public transport lines (heavy rail and light rail) to the baseline model;
- Middle Road: exploitation of existing networks to their maximum including addition of a major enhancement to the bus network including an array of orbital and radial bus corridors; and
- Top Down: assumption of high capacity (i.e. heavy rail or light rail) for the baseline network providing a viable alternative to car transport on all routes and therefore a forecast of potential demand.

The Bottom Up approach did not provide any viable transportation solution. The Middle Road approach concluded that buses alone could not provide a solution due to the bus capacity being unable to meet forecast demand. The Top Down approach provided an attractive alternative to travel by motor car but many of the routes could not support the high capacity network modelled.

Based on this analysis, a number of themes were developed based on heavy rail, metro and light rail. The heavy rail theme included the East to West Tunnel proposed in the Dublin Suburban Rail Strategic Review.

Following the assessment of the findings of the three theme tests described above, a new preferred strategy was developed (known as Strategy 4). This strategy concluded that the East to West Tunnel

is the best approach to meet the meet the east/west demand in the city centre and provide a link between the various rail lines in the city.

The possible use of the Phoenix Park Tunnel was examined. Although the Phoenix Park Tunnel's ability to bring Cork Line services closer to the city centre is acknowledged, the lack of service to the key southeast inner city business area, the continuation of the capacity constraints in the city centre and the possibility of reduced capacity on the Sligo Line were critical issues. As a result, use of the Phoenix Park Tunnel was excluded as a viable option.

The final strategy (termed Strategy A) included a combination of heavy rail, metro, light rail and bus measures. The East West Tunnel (or Interconnector as it was termed) was the centrepiece of the heavy rail strategy.

Transport 21, launched in November 2005, further confirmed the DART Underground Project as the crucial component needed to enhance the heavy rail network in the Greater Dublin Area.

The choice of a tunnel linking the Cork Line at Heuston to the Northern Line and/or Sligo Line near Connolly station is thus the preferred heavy rail measure.

The choice of rail alignment, station locations and detailed design of this link was the subject of a number of further studies. This process and the alternative options examined are detailed in Section 6.2.

5.2.3 Heavy Rail Developments and Improvements

CIÉ and Iarnród Éireann have sought to secure investment in the heavy rail network in order to provide a high quality, reliable and segregated (from road) mode of transport to passengers. All investments made to the network in the GDA have been aimed at increasing the capacity for services on the existing core network and new spurs to new development centres. The overall aim is to provide an integrated network which best suits passenger demands and in accordance with land-use and planning policy.

The delivery of the DART system in 1984 was a significant milestone for rapid rail transit in the Greater Dublin Area. However, the frequency of DART services is constrained because the DART system shares the track with outer commuter and intercity traffic in the city centre, leading to limitations on available train paths.

Since commissioning of the DART system in 1984, Iarnród Éireann has achieved further development of the network where funding was available. This has included:

- Extending the DART system to Malahide and Greystones;
- Extending platforms along the DART network to accommodate longer trainsets;
- Increasing tracks from 2 to 4 on the Cork Line from Cherry Orchard to Hazelhatch (Kildare) to allow for improved journey times and reduction in constraints;
- Re-signalling of the Northern Line and City centre to Grand Canal (scheduled for completion in 2016) to alleviate constraints, especially at Connolly and across the Loop Line Bridge;
- Increasing the DART fleet and refurbishing the existing rolling stock;
- Expanding and improving the Diesel fleet to meet the capacity on commuter lines;
- Improving station accessibility across the network;
- Improving ticketing; and
- Providing park and ride facilities at commuter stations.

Iarnród Éireann has been cognisant that the improvements to the network in the GDA were made with the long term objective of providing an integrated transportation system, including the provision of an east-west tunnel section. All infrastructural development since 2000 has been in accordance with the transportation strategy outlined in A Platform for Change and with Transport 21 funding framework.

5.3 Light Rail

The Luas light rail system has proved to be a success in Dublin with the original Red and Green lines extended and passenger numbers in excess of 30 million per annum. The Luas Cross City project is currently extending the Green Line north from St Stephen's Green to Broombridge with an interchange to the Sligo Line (Luas Cross City project). This will also allow interchange between the Green Line and Red Line at Abbey Street and serve the new Dublin Institute of Technology campus at Grangegorman.

The current Red Line provides the only city centre east-west rail link in Dublin with the line from Saggart and Tallaght linking Heuston station to Connolly station via the north city centre. This line provides an option for heavy rail passengers alighting trains at Heuston station to connect to rail services at Connolly station along with accessing city centre business locations.

Two light rail options have been identified as possible alternatives to the DART Expansion Programme. The first is based on enhancing the capacity and level of service provided by the Red Line. The second option is based on a light rail link from Heuston station via the south city centre.

5.3.1 Option 1: Light Rail – Red Line Enhancement

The current Luas Red Line runs from Tallaght and Saggart in south west Dublin to Connolly station and the south docklands with all services stopping at Heuston station. Passengers using heavy rail services to Heuston station can use the Red Line to connect to the Sligo Line, Northern Line and South Eastern Line services at Connolly. Once the Luas Green Line extension to Broombridge is complete, passengers will also be able to interchange with this line at Lower Abbey Street.

During peak hours, the Red Line runs approximately 15 times per hour giving a capacity of 4,500 passengers per hour per direction.

Although a theoretical maximum of 30 trams per hour could be achieved, the NTA have advised that even with enhanced signal priority at junctions, a maximum frequency of 24 trams per hour could be achieved. This would increase the capacity to 7,200 passengers per hour per direction.

The length of Red Line trams could be increased from the current 40 metres to 50 metres. This would increase the carrying capacity of each tram from 300 to 350. The current platforms lengths are not designed for 50 metre trams and therefore would need to be extended. Although there is no technical barrier to this work, there would be a cost impact of carrying out works at the 32 stations on the Red Line. If 50 metre trams running at a frequency of 24 per hour were used, a capacity of 8,400 passengers per direction per hour could be achieved. It should be noted that a detailed study would need to be completed in order to establish the exact capacity that could be delivered.

The option to run a shuttle service between Heuston station and Connolly station is available given the city facing terminus at Heuston station. This would allow higher frequency and/or higher capacity trams to be run on this section of the Red Line only. This could provide a low cost short-term solution with works being carried out on only the city centre section and 8 of the Red Line stations.

The enhancement of the Red Line Luas services provides a much lower cost alternative to the DART Expansion Programme. It also provides additional capacity to handle increased passenger numbers arriving at Heuston.

However, it fails to meet a number of the objectives of the DART Underground Project. The principal shortcomings are:

- By failing to resolve the identified capacity constraints, it does not increase the carrying capacity of the heavy rail network;
- It does not provide high capacity (i.e. rail) access to the south city centre;
- By continuing to require multiple interchanges to access many areas of the city, the attractiveness of the Cork Line to passengers may not be enough to achieve the desired mode shift from motor cars;
- Although an approximate doubling of the capacity on the Red Line may be possible, much of this capacity will be needed for future growth on the corridor to Tallaght and Saggart – as such this solution may not be considered a long-term solution; and
- The increased capacity on the Red Line will not provide for long-term substantial growth in population and employment.

Nonetheless, given the reasonably low cost (in comparison to the DART Expansion Programme) and the short timeframe in which it could be implemented, the enhancement of the Red Line is considered a potentially viable alternative option. It is therefore included in the assessment of alternatives carried out in Section 5.5.

5.3.2 Option 2: Light Rail – South City Line

The annual Rail Census carried out by Iarnród Éireann shows 4,700 passengers arrive at Heuston station between 7am and 10am on a weekday morning. Over half of these passengers arrive between 8am and 9am. The number of these passengers accessing the Luas Red Line services is estimated to be less than half of the total[18]. The remainder of the passengers use a combination of other modes (i.e. bus, taxi, cycle and walking) to get to their final destination.

This is not unexpected given that the Luas Red Line does not provide direct access to the key south city centre business district. An alternative option is to provide an equivalent light rail link from Heuston station to the south city centre.

There are three potential corridors for such a service namely:

- The south quays;
- Thomas Street and Dame Street; and
- Grand Canal / South Circular Road.

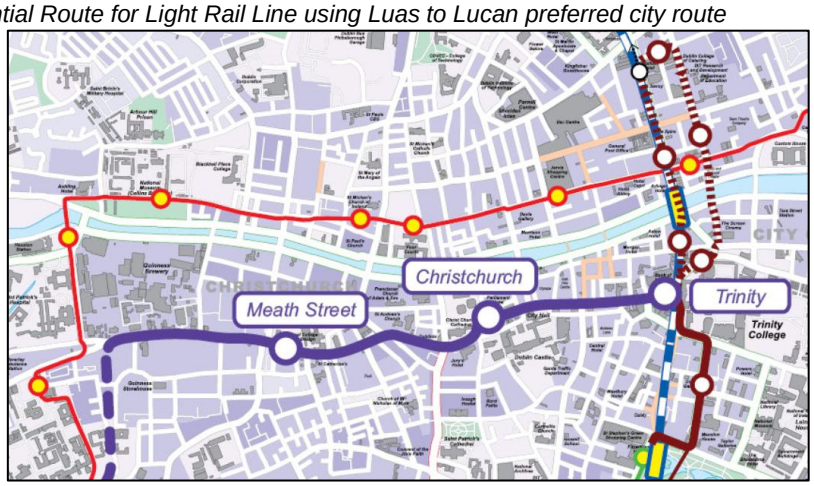
The provision of a segregated route on the south quays is unlikely given its importance for car and bus traffic. The Grand Canal and South Circular Road corridor skirts the city centre and does not provide the penetration to the key business districts required. As a result, the Thomas Street and Dame Street corridor is deemed the most viable.

An indicative route would see Luas services travelling south from Heuston station along the current Red Line tracks on Steeven's Lane to Thomas Street where new tracks would be installed bringing trams down Thomas Street, High Street and Dame Street. At Trinity College the trams could join the Luas Green Line (extended via the Luas Cross City project). Tara Street rail station would be a 600 metre walk away.

This is the corridor that was selected as the preferred option for the previously planned Luas line to Lucan with the city centre section shown in Figure 5.1.

[18] *Based on examination of the Nation Transport Authority's Greater Dublin Area model*

Figure 5.1 – Potential Route for Light Rail Line using Luas to Lucan preferred city route



This option would provide an additional east-west high capacity rail link from Heston station to the key south city business district.

The use of the Luas Red Line tracks from Heuston station along Steeven's Lane to Thomas Street would allow the Red Line services from the north city centre to loop back into south city centre along the new Thomas Street and Dame Street corridor. Depending on the configuration of tracks at Trinity College, connection to the Luas Green Line may also be possible.

However, these route options are unlikely to have much demand given it would be possible to walk from the Luas Red Line to the new south city centre line in approximately five minutes. In addition, using the existing tracks would limit the capacity on the existing Red and Green Lines.

In addition, the use of the Thomas Street and Dame Street corridor for a segregated light rail line would have a significant impact on bus services that use this route. The possibility of co-running with bus services would limit the capacity of the line.

The south city light rail line does provide a high capacity link into the city centre which provides Cork Line passengers to access the south city with a single interchange at Heuston.

This option does not resolve the identified capacity constraints in the heavy rail system and therefore does not increase the carrying capacity of the heavy rail network. In addition, it is unlikely that the system will allow direct interchange with the Northern, Maynooth and South Eastern Lines. This limits the connection possibilities for passengers on these lines.

In the long-term, the establishment of a second east-west light rail corridor in the city centre will enable further expansion westwards – possible the construction of Luas to Lucan in future years.

Overall, the south city light rail line is considered a potential viable alternative and included in the assessment.

5.4 Bus & BRT

Bus Rapid Transit (BRT) is generally considered a public transport solution that is located between bus and light rail in terms of cost and capacity, in particular along congested corridors where full segregation of BRT from general traffic and junctions is unfeasible. BRT uses many of the elements of traditional light rail including segregated road space, increased spacing between stations, ticket purchase at stations and multi-door vehicles for quick boarding and alighting. Although the capacity of a BRT line is not generally as high as a light rail system, the level of investment required is significantly reduced.

Bus services are the lowest capacity and lowest cost public transport service option. The passenger carrying capacity would be of the order of 10% that of the DART Expansion Programme. However, the cost of implementing additional bus services is a fraction of heavy rail.

5.4.1 Option 3: BRT – South City Line

For similar reasons to those examined above, a BRT link from Heuston station through the south city centre linking with the Luas Green Line and existing DART services is the most attractive.

The route planned uses the same alignment as the Light Rail – South City Line proposed above. It would depart from Heuston station, travel up Steeven's Lane (co-running with the Luas Red Line), and turn onto Thomas Street before travelling along High Street and Dame Street to Trinity College. From there it could travel along Nassau Street or Pearse Street connecting to the DART services at Pearse Station.

The BRT service would have similar drawbacks to a light rail line through the south city centre. These include the lack of a resolution to the capacity constraints in the heavy rail system thus not increasing the carrying capacity of the heavy rail network.

The use of the Thomas Street and Dame Street corridor for a BRT corridor would have a significant impact on bus services. A non-segregated service (co-running with buses) would limit the capacity that can be provided by BRT.

The potential integration of the proposed BRT service with one or more of the BRT lines currently being planned by the National Transport Authority is a possible future benefit of such a scheme.

5.4.2 Given the lower costs associated with developing a BRT line, the Bus Rapid Transit option is considered a potentially viable alternative and is included in the assessment. Option 4: Bus – Expanded City centre Bus Network

There are already a large number of bus services operating from Heuston to the south city centre and connecting with Luas Green Line and DART services. A direct bus service along the approximate route of the tunnel section of the DART Expansion Programme (similar to the light rail and BRT options proposed) would not offer the capacity to be a viable option. Instead a wider network of bus routes is considered.

An expansion of the city centre bus network would see a greater number of routes linking heavy rail and light rail stations. This would allow passengers arriving at the main heavy rail stations (primarily Heuston station and Connolly station) to have a single interchange option to most locations in the city centre.

In terms of the crucial west to east corridor from Heuston to the south city business district bus routes could be provided on corridors along the quays, along Thomas/Dame Street, through the Liberties and along South Circular Road/Grand Canal.

Bus services connecting to the north to south rail line from Connolly to Grand Canal Dock would concentrate on offering passengers a bus alternative to more favourable destinations. This could reduce the need for heavy rail penetration of the south city business areas.

In a similar manner to previous alternative options, the capacity constraints associated with the current heavy rail system would not be resolved. There is a reasonably good level of bus service already available and the availability of road space for significantly expanded level of services in the city centre is questionable.

Nonetheless, given the very low capital cost associated with providing bus services (when compared with heavy rail), this option is considered a potential viable alternative and will be assessed.

5.5 Assessment of Alternatives

As discussed in Section 5.2, the potential alternative heavy rail options were reviewed extensively as part of the planning and design of the DART Underground Project. It is not proposed to revisit these as part of this Business Case.

As the options assessed here are based around alternative modes, there are elements of the DART Expansion Programme that cannot be reproduced. For instance, relieving the capacity constraints on the current heavy rail network cannot be achieved without a heavy rail solution.

The alternative options are expected to provide a lower level of benefits than the DART Expansion Programme but at a reduced cost.

The DART Expansion Programme and the four alternative options identified are assessed using multi-criteria analysis under the following performance criteria:

- Economy;
- Safety;
- Environment;
- Accessibility and Social Inclusion; and
- Integration.

Each of these performance criteria is described in turn and the findings of the multi-criteria analysis summarised.

In order to assist this analysis, a workshop was held on 11th September 2014 with Iarnród Éireann, the National Transport Authority and AECOM in attendance.

5.5.1 Economy

Economy is the most important of the five performance criterion assessed. It includes the costs and a large proportion of the benefits associated with the scheme.

The cost elements of the options primarily consist of the capital, operations and maintenance costs. Other costs are considered including the impact of on-street public transport on other transport modes and congestion.

In general, capital and operating costs are highest for heavy rail. Light rail is the next most expensive followed by BRT and bus.

The DART Expansion Programme has a multi-billion euro capital cost and a substantial annual operation and maintenance cost. The location of the tunnel underground and the small footprint of the station entrances and exits in the city centre add little cost in terms of city centre congestion. Nonetheless, the overall high cost associated with the scheme leads the DART Expansion Programme to have the lowest economy cost score.

The next most expensive option, in terms of capital and operational cost, is the light rail line through the south city centre. The need for a segregated corridor for this option adds further cost in terms of impact on other modes and congestion.

The development of a BRT line through the south city centre will have a similar impact on other modes and congestion as the light rail line. However, the capital and operational costs associated with the providing the service will be lower.

The Red Line Enhancement requires additional vehicles and potentially station works. The capital and operational costs are assessed to be low given this is an existing service on a segregated corridor.

The expansion of bus services is expected to be the lowest cost of all options assessed with the low capital and operating costs offsetting the potential increased congestion over other options.

The benefits associated with public transport schemes generally include:

- Journey time savings (including congestion reduction);
- Reliability and quality improvements; and
- Wider economic impacts.

The journey time savings include savings for passengers on existing public transport services whose journey time is reduced, passengers who have changed transport mode in order to reduce journey time and general transport users who benefit from congestion relief associated with the scheme. The efficiency, level of integration and number of passengers attracted to each option is a key driver of the level of journey time savings.

Reliability and quality improvements are a measure of the utility changes transport users associate with a particular transport option. In general rail journeys are found to have a higher utility than BRT with bus being the lowest. The frequency of service must also be factored into the assessment of reliability and quality.

Wider economic impacts generally include the effects the scheme has on employment, productivity and efficiency. Examples include the agglomeration effects that arise from firms being closer to each other and benefits from increase competition derived from extending the geographical reach of firms.

The scale and scope of the DART Expansion Programme is unmatched in economic benefits with high levels of journey time reduction, quality and reliability improvements and wider economic benefits. Of most critical importance is the ability of the DART Expansion Programme to support substantial economic growth (through growth in passenger numbers).

Providing high capacity access to the south city centre by light rail and BRT has a significant impact on journey times – particularly for passengers arriving at Heuston station. These options could expand (e.g. westwards to areas such as Lucan) supporting future economic growth. However, the level of capacity and expected patronage of these options is not on the scale of the DART Expansion Programme due to the limited reach and interchange requirements.

The ability of the BRT option via the south city centre to support economic growth (through growth in passenger numbers) is more limited than the light rail equivalent. The BRT option is likely to have a capacity substantially lower than the DART Expansion Programme.

The enhancement of the Red Line has a positive impact on journey times. However, there are capacity limitations on this option. In addition, the wider economic benefits are significantly lower given that is an enhancement of an existing service.

The bus expansion option has the lowest economic benefit. Journey time improvements are expected to the small. Bus services are generally considered to have the lowest quality and reliability and would have a very low wider economic impact.

5.5.2 Safety

Transport investments can have a significant effect in improving safety and reducing accidents. In particular, the movement of transport users from motor cars to public transport can greatly reduce the

number of accidents. The patronage of the options being assessed will therefore have a large impact on the safety benefits.

In addition, the level of segregation of public transport has an effect with fully segregated being the safest, followed by on-street segregation and finally on-street modes.

The DART Expansion Programme has a large positive impact on safety by a combination of attracting the largest patronage and being a fully segregated system.

The Light Rail South City Line provides on-street segregation and reasonably large patronage. The BRT option on the same route has lower capacity and therefore is likely to attract less patronage.

The Red Line Enhancement option provides on-street segregation but will not result in high additional patronage. Finally, the Expanded City centre Bus Network will lead to the lowest safety benefits due to the lack of segregation and low patronage.

5.5.3 Environment

The assessment of the environmental impacts of the transport measures include:

- Air quality;
- Noise and vibration;
- Landscape and visual quality;
- Biodiversity;
- Cultural, archaeological and architectural heritage;
- Land use, soils and geology; and
- Water resources.

The vast majority of the DART Expansion Programme is below ground significantly reducing its overall environmental impact. The high level of patronage of the scheme will also see a reduction in motorists which will have a positive environmental impact.

The Red Line Enhancement will have a very low environmental impact given it is an existing service being expanded. The level of patronage may not be as high as other options and therefore the benefits from reduced traffic on other modes will be lower.

The light rail line through the south city will see high patronage but will involve an on-street service with associated works through an area of high historical and cultural significance. The BRT line through the area will have a lower impact but also a lower patronage (and therefore a lower reduction in other transport means).

The bus option will not provide a high capacity transport link into the south city centre and therefore the patronage is expected to be the lowest of the options examined. The environmental impacts of the additional services may not be significant but the net positive environmental impact is likely to be the lowest of all options given the low patronage.

5.5.4 Accessibility and Social Inclusion

Consideration of the socially excluded, vulnerable groups and deprived geographic areas is a critical component in the assessment of transport project – in particular public transport projects.

The DART Expansion Programme has a far reaching impact in the city centre and across the Greater Dublin Area. The project provides a step change in public transport capacity and ensures future economic growth can be supported. The contribution of the DART Expansion Programme to

developing a fully integrated public transport network in the region and particularly in the city centre will lead to a significant increase in accessibility and social inclusion.

The two options that provide a high-quality transport link through the south city centre will also lead to increases in public transport integration particularly in the city centre. These options are not seen to provide the same level of impact across the Greater Dublin Area as they do not resolve the capacity constraints on the heavy rail network.

Finally, the Red Line Enhancement and Expanded City centre Bus Network are seen to have the lowest positive impact on accessibility and social inclusion given their impacts are primarily capacity enhancement on existing services.

Overall, the contribution of all the DART Expansion Programme and the four alternative options are generally positive.

5.5.5 Integration

The assessment of transport infrastructure investment must take account of the overall transport system including other modes. The integration with public transport policies and other national and regional policies is important for any public transport project. The key elements considered in the assessment of the integration criterion are:

- Land Use Integration;
- Transport Integration;
- Geographical Integration; and
- Other Government Policy Integration.

The DART Underground Project is fully compliant with all land use and transport policies. It supports transport and geographical integration on a wide scale. It also supports other Government policies such as the National Spatial Strategy.

The other options do not have as wide a reach as the DART Expansion Programme. Nonetheless they are generally in compliance with land use policy and support both transport and geographical integration.

The level of integration provided by the two south city line options is the highest of the alternative options given they provide a new medium to high capacity public transport link via the key south city centre business district.

The Red Line and bus based options have significantly lower integration benefits given these are expansion of existing services.

5.5.6 Summary

The assessments, qualitatively described above, were scored on a scale of 1 to 10 for each of the performance criteria. For the economy criterion, the costs and benefits have been assessed separately. This doubles the weighting of the economy criterion relative to the other criteria.

The overall results of the multi-criteria analysis is shown in Table 5.2, with the DART Expansion Programme found to be strongly favoured over the alternative options.

Table 5.2 - Alternatives Assessment – Summary

	Economy Costs	Economy Benefits	Safety	Environment	Accessibility & Social Inclusion	Integration	Total
DART Expansion Programme	2	10	9	9	8	10	**48**
Option 1: Light Rail – Red Line Enhancement	8	4	6	8	6	5	**37**
Option 2: Light Rail – South City Line	4	7	8	7	7	7	**40**
Option 3: BRT – South City Line	6	5	6	7	7	7	**38**
Option 4: Bus – Expanded City centre Bus Network	10	2	5	6	6	4	**33**

The DART Expansion Programme is seen to rate very highly in all performance criteria with the exception of cost. The light rail option via the south city centre is seen as the next most favoured option. This option similarly scores highly in all criteria with the exception of cost.

Given the needs and objectives outlined previously, it is not surprising to find that high capacity (and therefore high cost) public transport solutions are preferred.

A Luas light rail line through the south city is identified as the best potential alternative. This alternative is further examined by use of transport modelling. The results, presented in Section 7.4.9, confirm the DART Expansion Programme as the preferred option.

5.6 Options Summary

The following options were examined as possible alternatives to the DART Expansion Programme:

- Light Rail – Red Line Enhancement;
- Light Rail – South City Line;
- BRT – South City Line; and
- Bus – Expanded City centre Bus Network.

The DART Expansion Programme is preferred to all of the alternative options based on an evaluation using multi-criteria analysis and confirmed by transport modelling of the best alternative option.

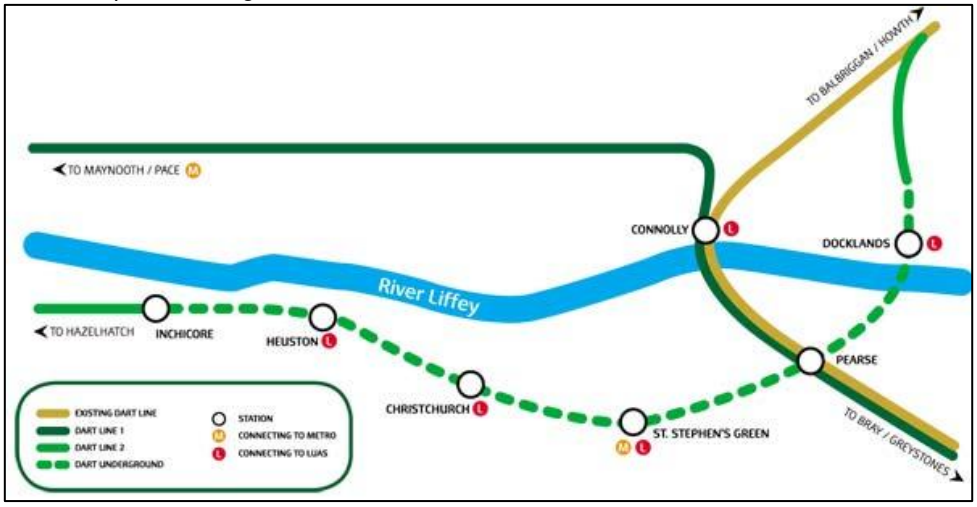
6 THE PREFERRED SCHEME

6.1 Overview of the Scheme

The ***DART Expansion Programme*** consists of a number of investments that will transform the Dublin's four heavy rail lines into two through running lines.

One DART line will run from Drogheda to Hazelhatch with the second running from Maynooth to Greystones intersecting at Pearse – a key interchange station – as shown in Figure 6.1.

Figure 6.1 - DART Expansion Programme



This reconfiguration of Dublin's heavy rail network provides significantly increased capacity, frequency and connectivity.

It will provide shorter journey times for passengers and more direct access to the city centre. In addition, the DART Expansion Programme will improve the accessibility and connectivity of the public transport system while increased in interchange opportunities for passengers.

Most importantly, the DART Expansion Programme will lead to increased public transport use and provide the capacity to support future passenger demand and economic growth in the Greater Dublin Area.

The DART Expansion Programme includes the following key investments:

- DART Underground Project – an east-west heavy rail tunnel under Dublin city centre, connecting the Cork Line with the Northern Line;
- Kildare Route Phase 2 Project – increased segregation of commuter and intercity services on the line from Heuston station;
- Expansion of Electrification – to Drogheda, Maynooth and Hazelhatch; and
- Expansion of Fleet – including depot facilities.

The city centre tunnel (DART Underground Project) is the principal element of the DART Expansion Programme constituting circa 75% of the capital cost – see Section 8 for further details. The development of the DART Underground Project included the identification of a preferred alignment, construction methodology and station locations.

The development of the remaining elements of the DART Expansion Programme was more straightforward given the works are essentially upgrades to existing rail lines.

6.2 Programme Development

The DART Expansion Programme is based on using the four existing heavy rail corridors into Dublin city centre. As such, the city centre section (i.e. the DART Underground Project) is the key development area.

The development of the DART Underground Project was carried out in three main phases, namely:

- Identification of Preferred Alignment;
- Preliminary Design; and
- Reference Design.

Following these three phases, a final design was concluded for the DART Underground Project (the city centre tunnel section of the DART Expansion Programme) for which a Railway Order has now been made.

6.2.1 Identification of Preferred Alignment of DART Underground

Following publication of the recommended integrated transport strategy for the Greater Dublin Area (A Platform for Change, DTO 2001), CIÉ commissioned Parsons Brinckerhoff in 2002 to examine the alignment options based on recommendations in the Dublin Suburban Rail Review.

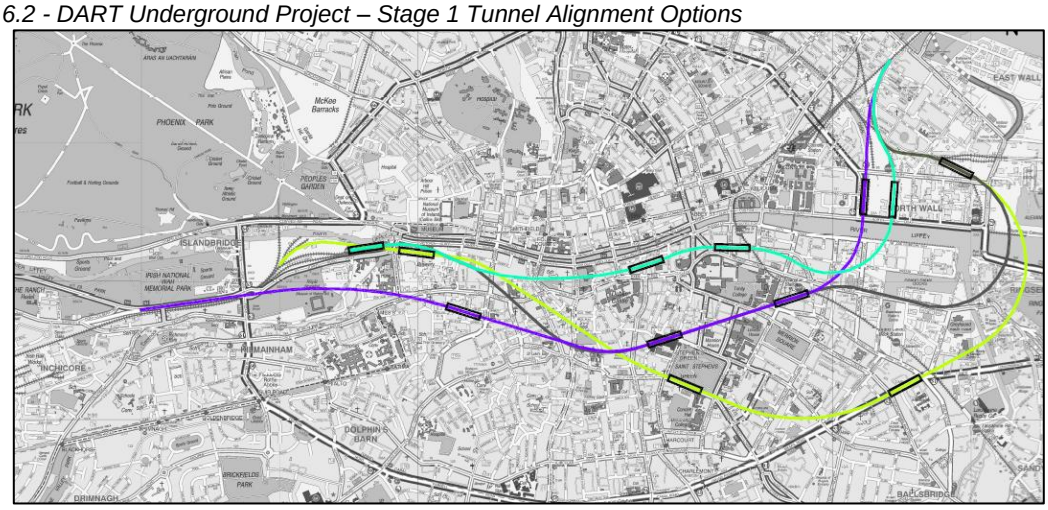
The preferred alignment was required to meet the following objectives:

- Connect into the Northern Line and Sligo Line near Church Road;
- Connect into the Cork Line in the vicinity of Heuston/Inchicore;
- Cross under the River Liffey;
- Serve the new development at Spencer Dock; and
- Facilitate interchange with other rail, bus, Dublin Metro North and Luas services.

In addition, the study examined if the route via Phoenix Park to North Wall would complement construction of the DART Expansion Programme.

Stage 1 of the process to identify the preferred alignment developed four main options based on the objectives above. These were termed 1, 2, 2A and 3 and are shown in Figure 6.2.

Figure 6.2 - DART Underground Project – Stage 1 Tunnel Alignment Options



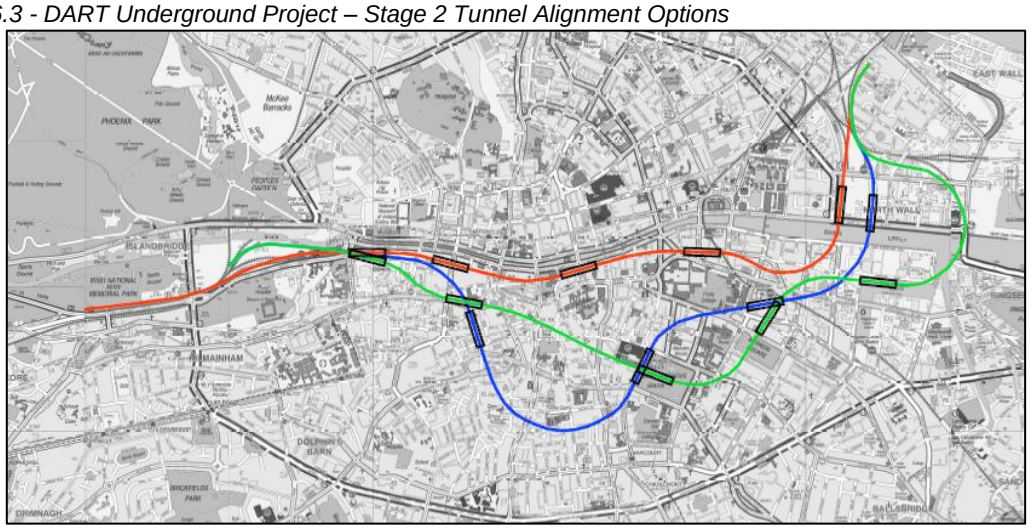
The location of stations was based on the need to connect with other transport nodes, interchange with existing stations and proximity to business, retail and tourist areas. In addition, the stations were located to be approximately 1 km apart and within 5-7 minutes walking time to the River Liffey.

The four alignments and station options were the focus of a workshop which included key planning and transportation stakeholders. The strengths and weaknesses of each of the options were assessed. Based on this assessment, three revised alignments were considered in the next stage of assessment. These were:

- Red Route: Docklands – Tara Street – Dublin Castle (via Temple Bar) – Heuston
- Blue Route: Docklands – Pearse – St Stephen's Green – St. Patrick's Cathedral – Digital Hub – Heuston
- Green Route: Docklands – Eastern Sweep to Pearse – St Stephen's Green – St. Patrick's Cathedral – Digital Hub – Heuston

These are shown in Figure 6.3 below.

Figure 6.3 - DART Underground Project – Stage 2 Tunnel Alignment Options



In a similar manner to the Stage 1 assessment, the Stage 2 assessment developed the strengths and weaknesses of each option. Based on this assessment, the Blue route was determined to be the most environmentally acceptable route followed by Green with Red having the highest impacts.

Overall, the Red alignment was found to have many weaknesses and did not meet the objectives of the study. The Blue alignment had greater strengths than weaknesses. However, the weaknesses did include a southern sweep. The Green alignment also had the weakness of the eastern sweep.

With the agreement of key stakeholders, a hybrid of the Blue and Green alignments was brought forward to Stage 3.

Stage 2 also included a detailed review of station locations. This led to the selection of locations at the Docklands, Pearse, St Stephen's Green, Digital Hub and Heuston.

Stage 3 developed the selected alignment to a much higher level of detail which included assessing issues around the feasibility, cost effect and performance of the project. This included testing of the alignment using the DTO and RPA models and an economic evaluation.

Although it was preferable for the alignment to connect to both the Northern Line and the Sligo Line, it was found that this was not practicable. Three potential timetables were developed with the strengths and weaknesses of each assessed. The outcome was a decision to connect to the Northern Line.

This final stage of the alignment identification examined the potential for the Phoenix Park to North Wall route would complement the DART Expansion Programme. The assessment found that the Phoenix Park Line could provide some benefits to the Cork Line. However, the route would not provide the integration and capacity of the DART Expansion Programme. The route was found to a by-pass of the city and would not provide a significant part of a regional/suburban electrified network.

In summary, the alignment identification process phase found that the most favoured route connected to the Northern Line with stations at Docklands, Pearse, St Stephen's Green, Dublin Castle/Digital Hub and Heuston.

6.2.2 Preliminary Design

The preliminary design phase commenced in 2006. The objective of this phase was to prepare a preliminary design of the Expansion Programme based on the tunnel alignment identified in the first phase. This included route verification, conceptual design, station design, a review of constraints, a review of the tunnel type (single versus twin bore) and construction methodologies.

A similar methodology of developing alternative options and assessing the strengths and weaknesses of each was used.

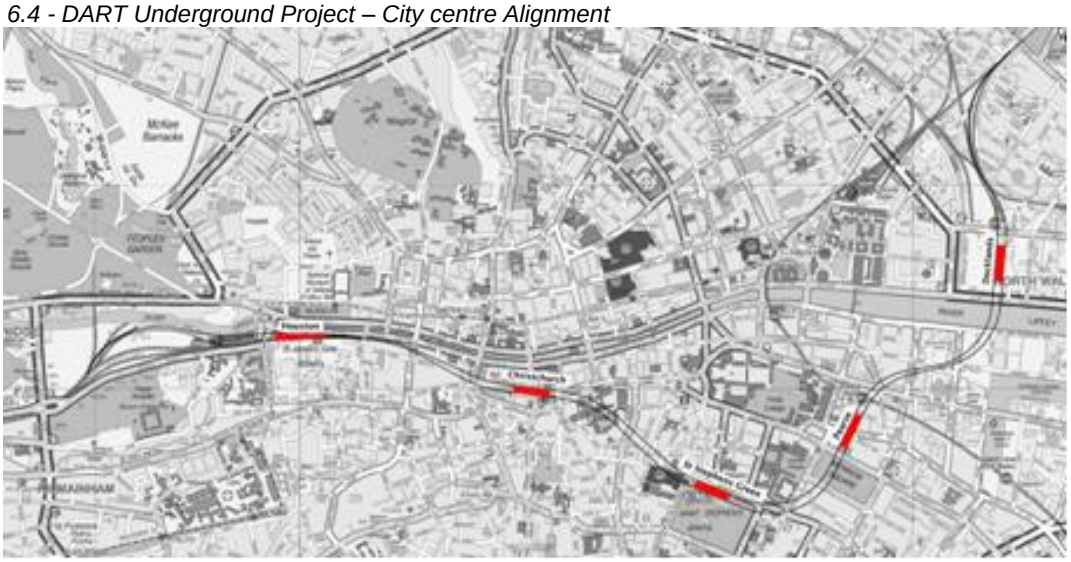
The outcome of this phase was a number of key changes from the preferred alignment including:

- The development of two options for the location of the Heuston station;
- The Dublin Castle/Digital Hub station to be located at Christchurch;
- St Stephen's Green station to located beneath the northern section of the park with multiple entrances;
- Pearse station to located beneath the existing station; and
- Docklands station to be relocated to Spencer Dock.

In addition the construction methodology for each station was identified.

Finally, the assessment of single bore and twin bore tunnels found a twin bore arrangement would provide the best value and cost assurance.

Figure 6.4 - DART Underground Project – City centre Alignment



6.2.3 Reference Design

The Arup and Halcrow Joint Venture (AHJV) was commissioned in 2008 to carry out the reference design for the DART Expansion Programme.

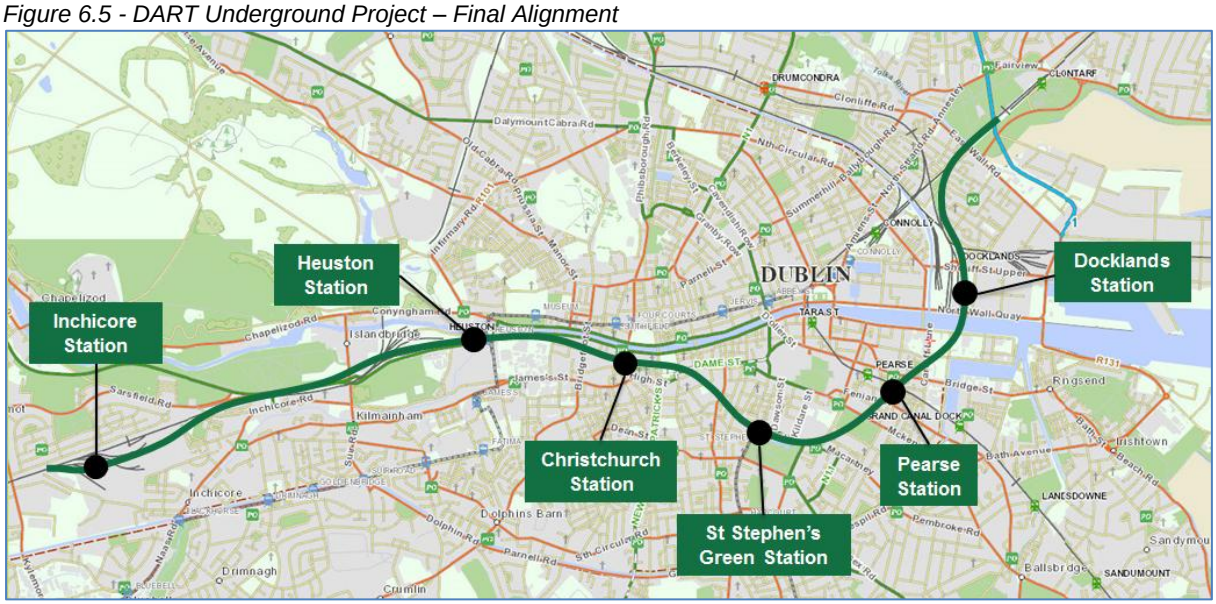
As part of their scope, AHJV were required to complete a complete design review of the route alignment and station location options, to ensure all justifications, assumptions and limitations were understood and the design progressed during the reference design process was compliant with all statutory requirement and industry good practices.

During the design review, and in consultation with Iarnród Éireann, AHJV highlighted the technical difficulties in achieving a rail tie-in from the Cork Line to the DART Underground at Heuston. The construction impacts on the existing track and station at Heuston were foreseen as significant and technically challenging. AHJV indicated that during construction of the DART Underground/Cork Line tie-in, rail services on the Cork Line would likely be disrupted and impacts on the national N4 road network between Concolbert Road and Islandbridge and at Diageo's St. James Gate Brewery could also be felt at Victoria Quay. On the basis of the issues raised by AHJV during the design review, Iarnród Éireann commissioned a feasibility study for extending DART Underground to terminate within CIÉ lands at Inchicore as opposed to Heuston Station. The feasibility study indicated that the socio-economic and environmental impact of extending DART Underground to Inchicore were significantly lower than seeking a tie-in to the Cork Line at Heuston.

Phase 3 culminated in the completion of the DART Underground Reference Design and the preparation of all documentation statutorily required for the lodgement of a Railway Order Application to An Bord Pleanála.

The output from this phase was the finalised design for the DART Underground Project. This design was subsequently the subject of a Railway Order application and now has full planning authorisation.

Figure 6.5 - DART Underground Project – Final Alignment



6.3 DART Expansion Ancillary Elements

The DART Expansion Programme has been developed to meet the following objectives:

- Assist in the delivery of the national transportation strategy by increasing the passenger carrying capacity on (1) the Northern Line and Cork Line and (2) the Sligo Line and South Eastern Line;

- Improve the economy, integration and efficiency of transportation, by increasing the use of public transport;
- Support national spatial objectives by encouraging economic growth and improving quality of life and the environment;
- Support the Local Authorities in the GDA (especially Dublin City Council and Fingal County Council) sustainable development and regeneration objectives, including a better balance of development in the city centre by improving accessibility and transport integration;
- Provide for the integration of the National and Greater Dublin Area Rail Networks (including intercity, commuter, DART and Luas);
- Improve safety for transport users by increasing the use of public transport;
- Provide a segregated rail route that penetrates all the major areas of demand in the city centre; and
- Respond to anticipated passenger demands and the national transportation strategy.

7 TRANSPORT PLANNING

7.1 Overview

This section outlines the transport modelling work undertaken as part of the Business Case for the proposed DART Expansion Programme and the DART Underground Project.

7.2 The NTA Transport Model

This sub-section provides an overview of the NTA Greater Dublin Area Transport Model which was used in order to test the impacts of the proposed scheme[19].

7.2.1 Overview of Model

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

The NTA model is made of up 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).

7.2.2 Time Periods

The NTA model covers the three key AM Peak Periods of

- 07:00 – 08:00;
- 08:00 – 09:00; and
- 09:00 – 10:00.

7.2.3 Transport Modes

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

- DART;
- Suburban rail;
- Luas;
- Dublin/City Bus; and
- Bus Éireann and other regional bus services.

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

[19] *The model used in this study was issued by the NTA to AECOM in January 2015*

- 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.

7.2.4 Modelled Years

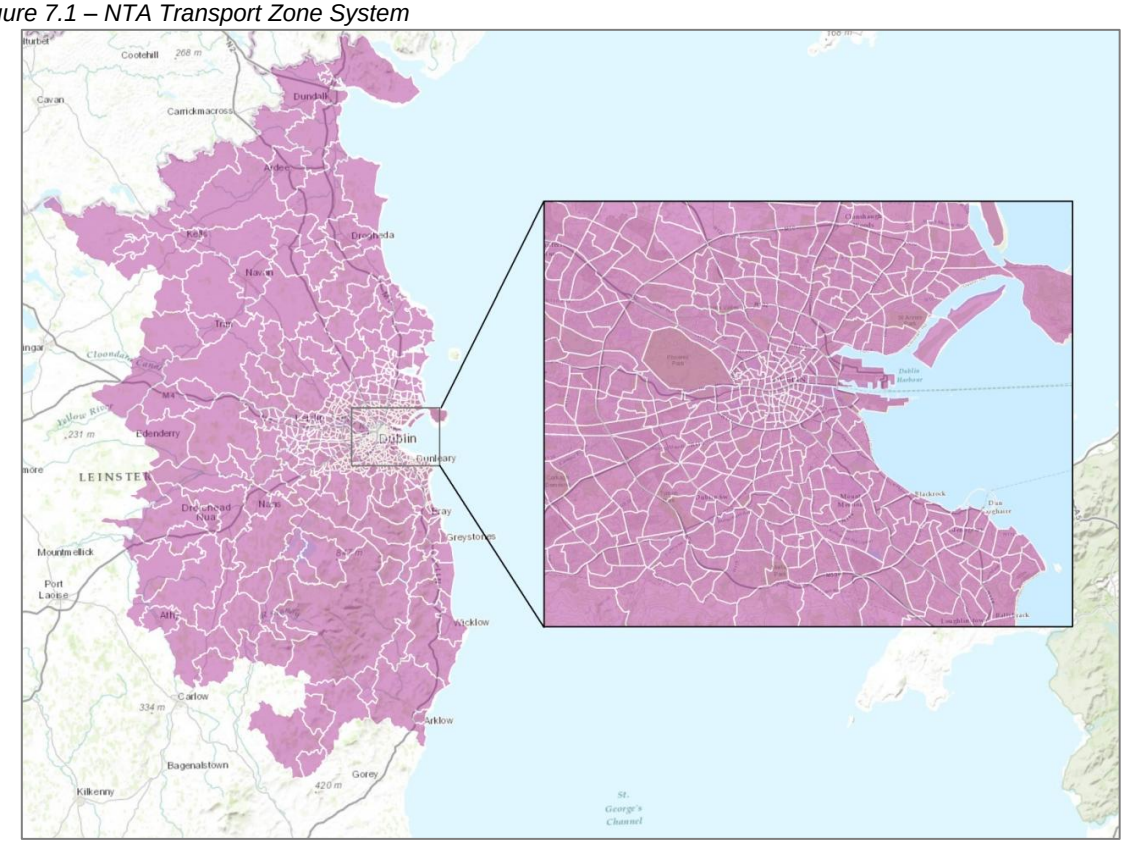
The base year of the NTA model has been developed from the 2006 Census on the demand side of the model and the 2011 road and public transport networks on the supply side. Forecast year models have been developed for the scheme opening year of 2025 based on a linear interpolation between the NTA's 2011 base and 2031 future model population/employment forecasts.

The transport network used in the models includes key developments such as the Newlands Cross upgrade.

7.2.5 Transport Zones

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 7.1.

Figure 7.1 – NTA Transport Zone System



7.2.6 Journey Purposes

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

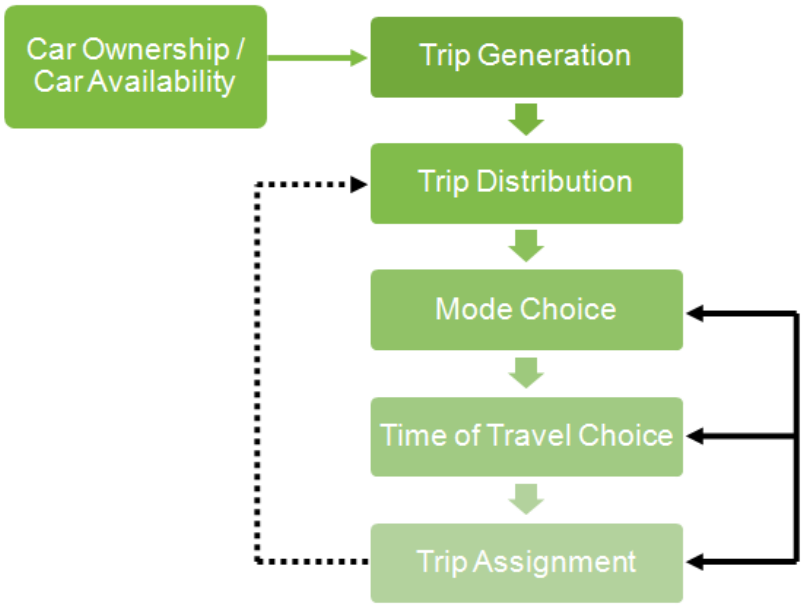
- Work (Commuting);
- Education;
- Employer's Business;
- Shopping;
- Other; and
- Non-home based.

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.

7.2.7 Model Structure

The NTA model structure is based on the classic 4 stage transport model with an additional component of time of choice which models the impacts of congestion on people's decision on when to depart, potentially to avoid 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 lessening attractiveness of a service as it exceeds capacity. The structure of the model is outlined in Figure 7.2.

Figure 7.2 – 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.

7.2.8 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*[20].

The NTA model has also been used in the evaluation of a number of other projects in the Greater Dublin Area such as the potential Bus Rapid Transit system from Swords (via Dublin Airport) to the city centre and the evaluation of potential long-term public transport projects for north Dublin.

7.3 Model Scenarios

7.3.1 NTA Demand Forecasts

The NTA has prepared a set of demographic forecasts which form the basis for the future demand matrices for the 2025 and 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 the 'Scenario A' methodology developed by the NTA for the Draft 2030 Vision. This was developed by the NTA and the relevant local authorities and was based on available lands and land use zoning. The overall population growth forecast used in this study is based on the CSO M2F2 'Traditional' levels with a population of 2.37 million in the Grater Dublin Area (including Louth).

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 the 'Scenario A' analysis. 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 2025 and 2033, based on 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, some local revisions were made to land use distribution assumptions. A summary of the growth assumptions at a county level, are provided in Table 7.1.

Table 7.1 – Summary of NTA Forecasts

Local Authority	2033	
	Population	Employment
Central Business District	140,041	221,213
Rest of Dublin City	508,430	193,101
Dún Laoghaire Rathdown	251,713	96,429
Fingal	334,537	118,913
South Dublin	329,601	130,984
Mid East	806,728	245,094
Total	***2,371,050***	***1,005,734***

[20] http://www.nationaltransport.ie/wp-content/uploads/2011/12/HWPT_Calibration_AM.pdf

7.3.2 Do Minimum Network

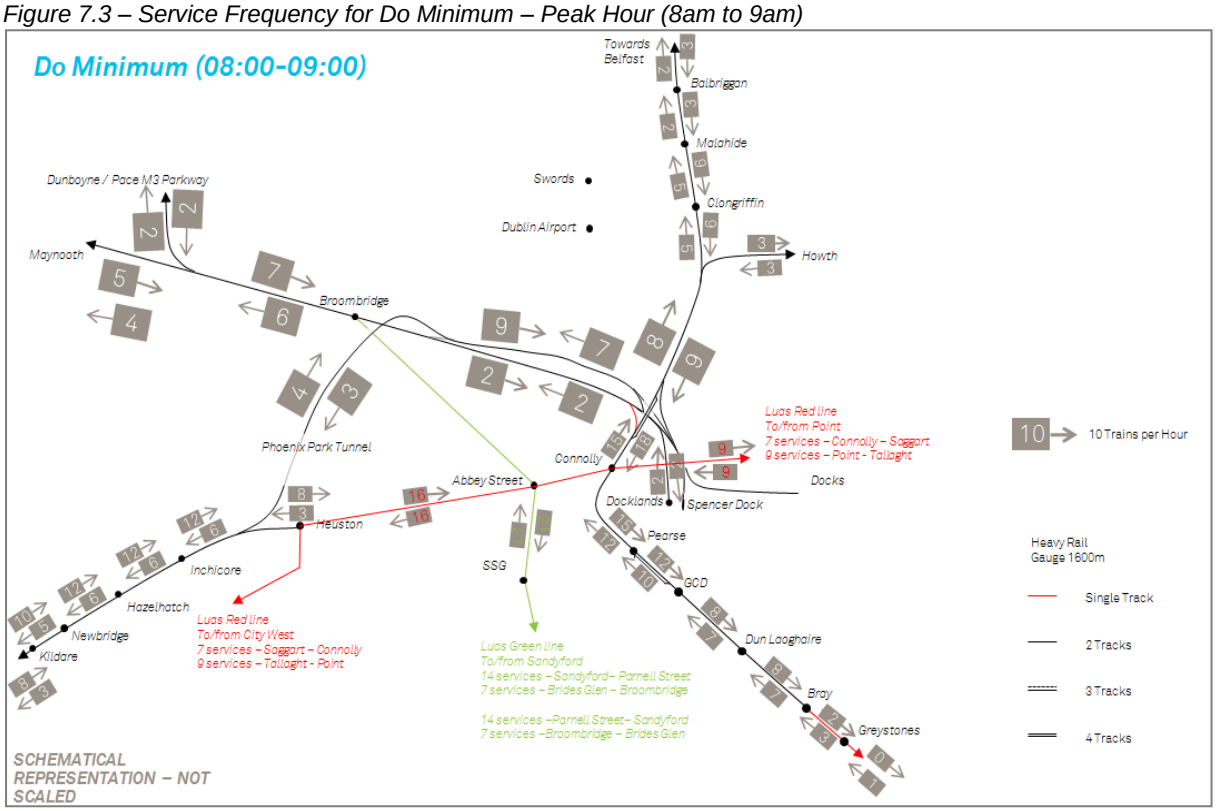
The 'Do Minimum' network scenario is a representation of the future transport network with the existing infrastructure retained and only committed infrastructure improvements included. Therefore the 'Do Minimum' scenario is comprised of the base year road and public transport networks and the inclusion of the following schemes:

- City-centre re-signalling project;
- Grand Canal Dock turn-back;
- Use of Phoenix Park tunnel;
- LUAS Cross City; and
- Centralised Traffic Control (CTC) upgrade.

In addition, an increased frequency of DART services running every 10 minutes throughout the day is being introduced by Iarnród Éireann.

AECOM updated the rail service plans for the Do Minimum scenario based on information received from Iarnród Éireann as presented in Figure 7.3, detailed service plans are contained in the Appendices and should be referred to in the first instance.

Figure 7.3 – Service Frequency for Do Minimum – Peak Hour (8am to 9am)



7.3.3 Planned Heavy Rail Infrastructure Improvements (2015/2016)

Centralised Traffic Control (CTC)

The upgrade of the Heavy Rail CTC will not result in changes to service patterns. However, the development of a modern CTC, with best train control technology, will allow for better train control functions across the GDA and the entire Iarnród Éireann network.

City-centre Re-signalling

The re-signalling of the city-centre section of the heavy rail network (specifically from Connolly station to Grand Canal Dock) will provide the ability to run up to 20 trains per hour per direction (tphpd). This is an increase from the current limit of 12-13 tphpd to 20 tphpd. It is noted that the level of 20 tphpd is unlikely to be realised given the constraints south of Grand Canal Dock (level crossings) and the limitation on the number of trains that can be 'turned back' at Grand Canal Dock. A flow of 16-17 tphpd is expected.

Grand Canal Dock Turn-back

The Grand Canal Dock turn-back is new railway infrastructure that is currently being constructed at Grand Canal Station. At present there are two through roads for north and south bound rail traffic and a southbound terminating siding. It is proposed to conduct permanent way improvements to reconfigure the track to provide two through roads and a centre-road turn-back. Together with the city centre re-signalling project, the Grand Canal Dock turn back and the CTC upgrade, the capacity of the services between Connolly and Grand Canal Dock will be increased from 12-13 trains per hour per direction to 16-17 trains per hour per direction.

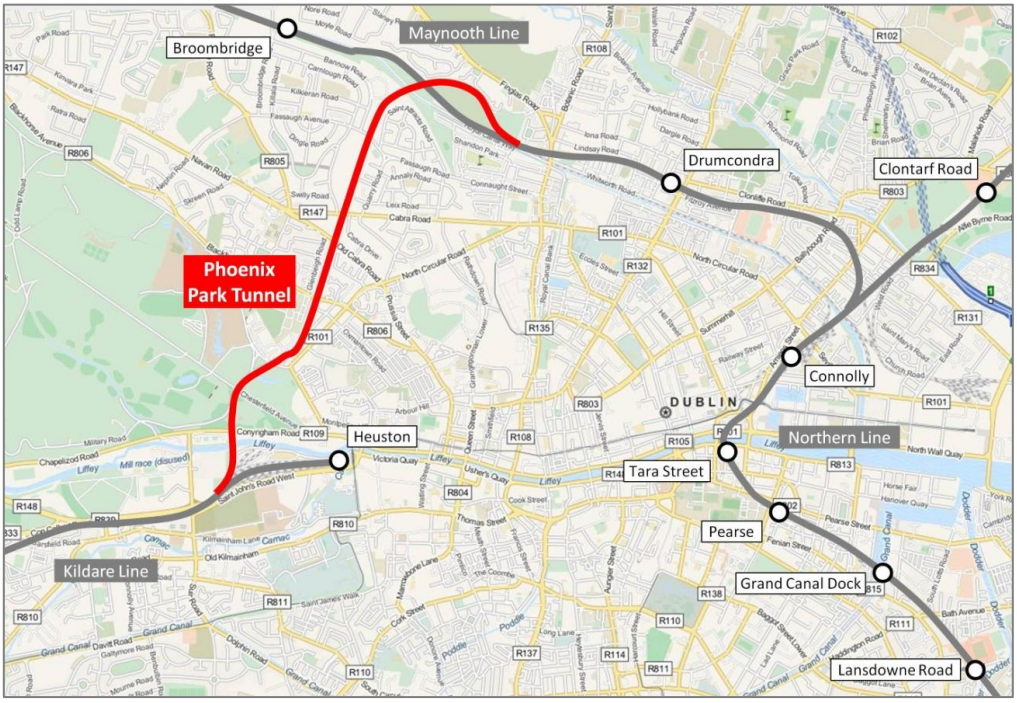
This is in accordance with the recommendations set out as part of the NTA Integrated Implementation Plan 2013-2018.

Phoenix Park Tunnel

The Phoenix Park Tunnel section is existing railway that runs from Platform 10 in Heuston Station (some 1km west of the main Heuston Station concourse) to converge with the Sligo Line at Glasnevin Junction (approximately 3.8km in length). This railway section is predominantly in deep cutting between Heuston and Glasnevin, however approximately 720m is tunnelled beneath Phoenix Park (from Cunningham Road to North Circular Road/Infirmary Road, and hence the railway section is commonly referred to as "the Phoenix Park Tunnel" section.

The Phoenix Park Tunnel railway section provides linkage between the Cork Line and the Sligo Line and further into Connolly Station. A schematic of the tunnel is shown in Figure 7.4.

Figure 7.4 – Schematic of Phoenix Park Tunnel line



Light Rail Infrastructure - Luas Cross City

The Luas Cross City project is currently under construction and when complete will link the existing red and green lines from St. Stephens Green to Connolly Street and continue to Broombridge, in Cabra. An interchange point to the Sligo Line will be provided in Broombridge.

Increased DART Frequency

By 2016, Iarnród Éireann plan to introduce an 10-minute frequency on DART services throughout the day.

7.3.4 Do Something Network

The 'Do Something' scenarios represent the future transport network with either the full DART Expansion Programme or the DART Underground Project in place, in addition to the infrastructure provided in the 'Do Minimum' scenario. A 'Do Something' network scenario has been developed for each scheme option as follows:

- DART Expansion Programme; and
- DART Underground Project as a standalone development.

DART Expansion Programme

The DART Expansion programme consists of:

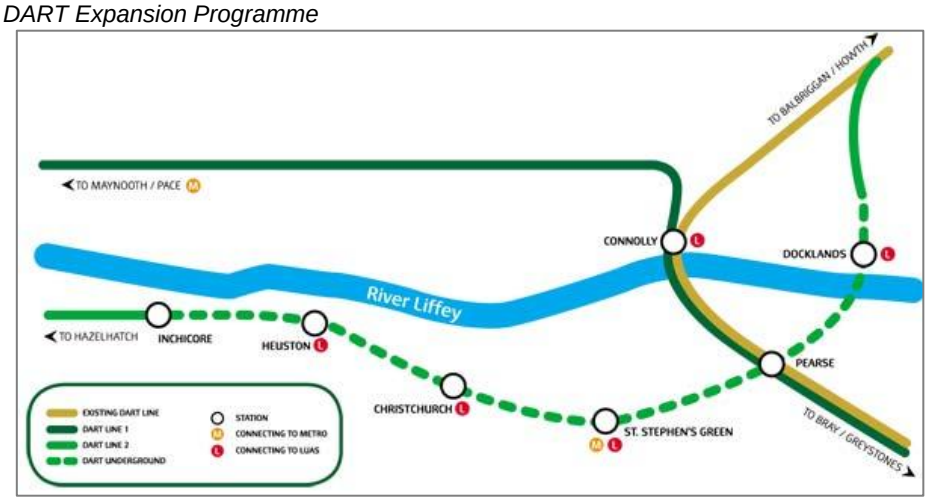
- A 7.6 km east-west heavy rail tunnel under Dublin city-centre including one over-ground and five underground stations with a total project length of 8.6 km (this is the DART Underground Project);
- Expansion of electrification to Drogheda, Maynooth and Hazelhatch;
- Segregation of inner-commuter services from outer-commuter and intercity services from Hazelhatch (Kildare) to north of Connolly Station; and
- Expansion of fleet and depot facilities.

The new DART Underground stations will provide new interchange opportunities, including:

- Docklands station: connects with the Luas Red Line;
- Pearse station: interchange with the Northern Line and Sligo Line commuter services;
- St Stephen's Green station: connects with the Luas Green Line; and
- Heuston station: links with Luas Red Line and Iarnród Éireann's intercity and outer-commuter services.

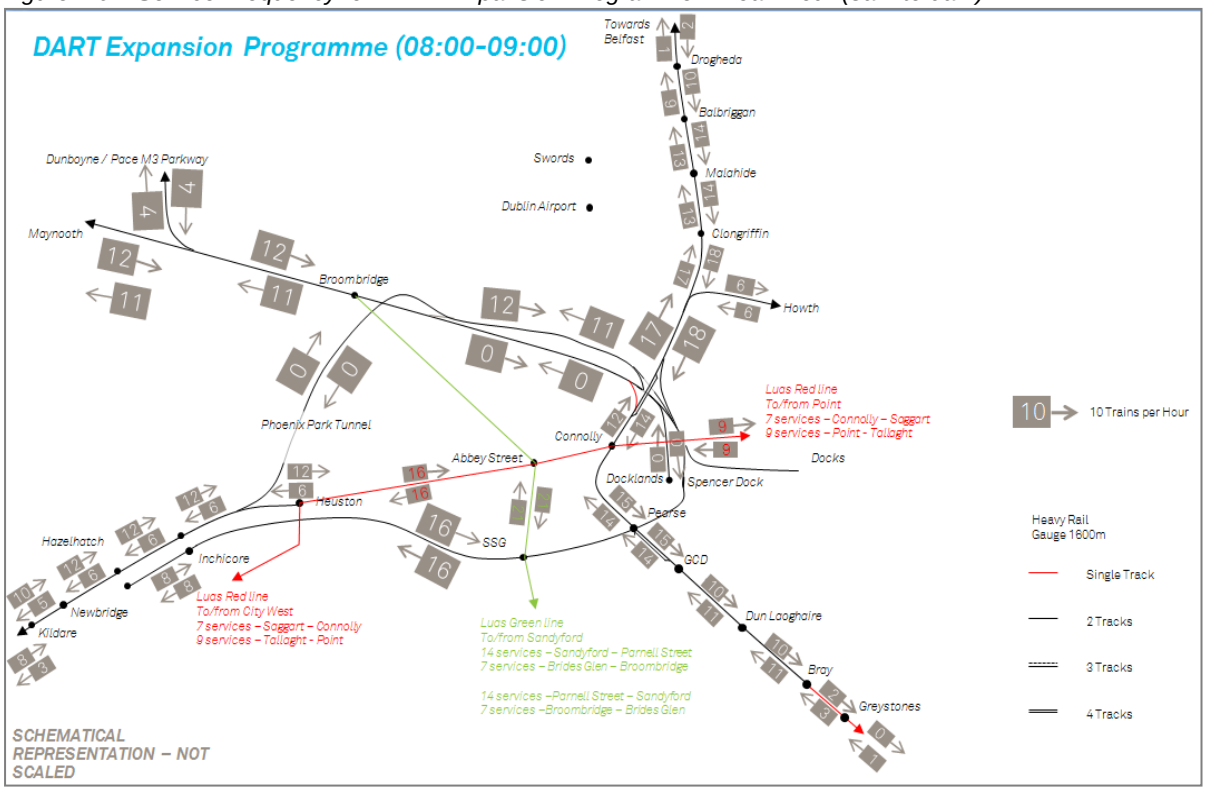
The full DART Expansion programme will provide two fully segregated DART lines, (1) Maynooth to Greystones and (2) Drogheda to Hazelhatch, as presented in Figure 7.5.

Figure 7.5 – DART Expansion Programme



The proposed service frequency on each section of the rail network under the DART Expansion programme is shown in Figure 7.6 below.

Figure 7.6 – Service Frequency for DART Expansion Programme – Peak Hour (8am to 9am)

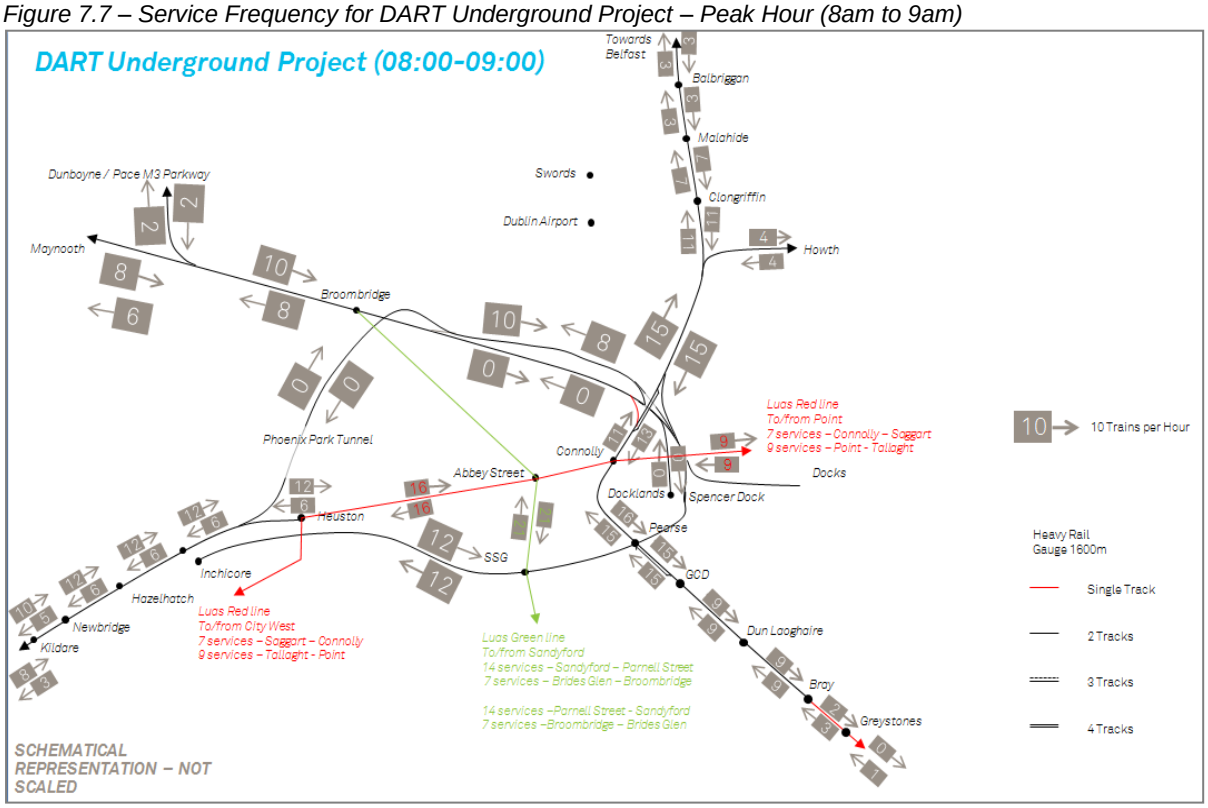


DART Underground Project

The DART Underground Project consists only of the 7.6 km of tunnel, one over-ground and five underground stations, electrification of the proposed tunnel and connection to the Northern Line.

The proposed service frequency on each section of the rail network under this scenario is shown in Figure 7.7 below.

Figure 7.7 – Service Frequency for DART Underground Project – Peak Hour (8am to 9am)



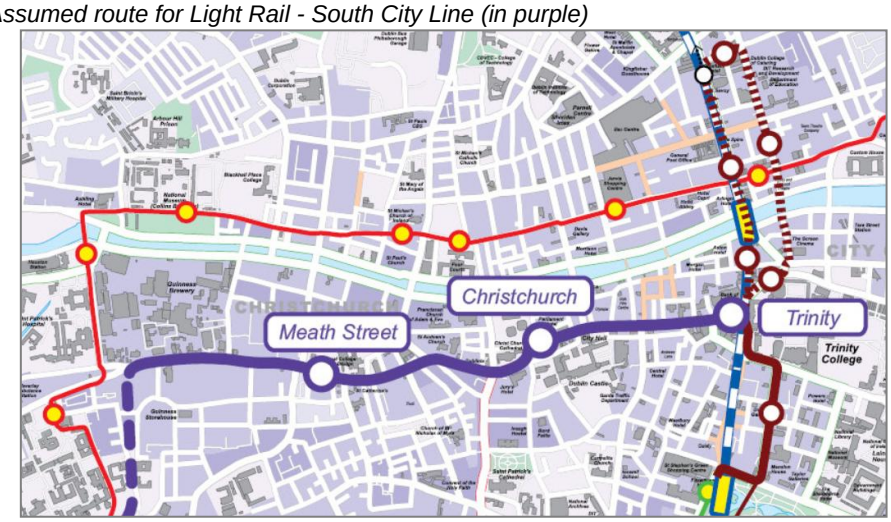
7.3.5 Alternative Network

A Luas light rail line through the south city is identified as the best potential alternative (see Section 5.5). This alternative is further examined by use of transport modelling.

The potential route of Luas services would travel south from Heuston station along the current Red Line tracks on Steven's Lane to Thomas Street where new tracks would be installed bringing trams down Thomas Street, High Street and Dame Street. At Trinity College the trams could join the Luas Green Line (extended via the Luas Cross City project). Tara Street station would be a 600 metre walk away.

This is the corridor that was selected as the preferred option for the previously planned Luas line to Lucan with the city-centre section shown in Figure 7.8. The results are provided in Section 7.4.9.

Figure 7.8 – Assumed route for Light Rail - South City Line (in purple)



7.3.6 Model Runs

Table 7.2 summarises the modelled scenarios outlined above in terms of the major public transport infrastructure upgrades assumed. It shows that the Luas Cross City project is assumed in all scenarios. Use of the Phoenix Park Tunnel is only included in the Do Minimum scenario. It is also of note that although the DART Expansion Programme includes the DART Underground Project, both of these are shown to apply to the DART Expansion Programme scenario to avoid any misunderstanding.

Table 7.2 – Modelled Scenarios

Scenario	Planned Heavy Rail Improvements & Luas Cross City	Phoenix Park Tunnel Use	DART Underground Project	DART Expansion Programme
Do Minimum	✓	✓		
Do Alternative	✓	✓		
DART Underground Project	✓		✓	
DART Expansion Programme	✓		✓	✓

The assumptions regarding the service plans for each scenario are included in Appendix A.

7.4 Model Results

7.4.1 Public Transport Boarding Figures

In order to examine the impacts of the scheme options, an initial analysis of modelled public transport boardings was undertaken. Table 7.3 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.

Table 7.3 –2033 Total Public Transport Boardings (07:00-10:00)

Mode	Do Minimum	DART Expansion Programme		DART Underground Project	
	Boardings	Boardings	% Diff	Boardings	% Diff
DART	42,993	125,069	191%	72,224	68%
Suburban Rail	66,138	33,826	-49%	68,113	3%
Total Heavy Rail	***109,131***	***158,895***	**46%**	***140,337***	**29%**
Luas	45,649	42,791	-6%	44,629	-2%
Dublin/City Bus	232,422	208,646	-10%	217,931	-6%
Other Bus	51,386	45,980	-11%	50,335	-2%
Total	***438,588***	***456,312***	**4%**	***453,232***	**3%**

Table 7.4 –2033 Total Public Transport Passenger Distance (07:00-10:00)

Mode	Do Minimum	DART Expansion Programme		DART Underground Project	
	Km	Km	% Diff	Km	% Diff
DART	505,092	1,781,789	253%	654,862	30%
Suburban Rail	1,685,000	971,061	-42%	1,638,338	-3%
Total Heavy Rail	***2,190,092***	***2,752,850***	**26%**	***2,293,200***	**5%**
Luas	341,980	324,544	-5%	331,723	-3%
Dublin/City Bus	1,649,108	1,442,943	-13%	1,565,390	-5%
Other Bus	1,631,480	1,419,234	-13%	1,594,268	-2%
Total	***5,812,660***	***5,939,571***	**2%**	***5,784,581***	**0%**

The full DART Expansion Programme will result in a 46% increase in heavy rail boardings, with reductions of 6% on Luas and 10-11% on bus boardings.

In the DART Expansion Programme, the increase in DART boarding is substantial at 191% which is accompanied by a 49% reduction in suburban rail boarding. This is due to a consolidation of commuter services and the conversion of existing services such as the Cork Line and Sligo Line services to DART.

The analysis indicates that the provision of the DART Underground Project will result in a 29% increase in heavy rail boardings. There are principal impact on other modes is a reduction in city bus boardings of 6%.

7.4.2 Rail Line Passenger Flows

The model outputs have been used to generate forecast daily passenger flows on the city-centre rail network. Morning peak period line flows have been factored to daily flows using expansion factors developed from an analysis of daily profiles of rail demand from the Irish Rail Census database. Figure 7.9 to Figure 7.11 show schematic plots of the forecast daily passenger flows in 2033 for the Do Minimum, DART Expansion Programme and DART Underground Project scenarios respectively. A tabular summary is provided in Table 7.5.

Figure 7.9 – 2033 Daily Forecast Passenger Flows – Do Minimum Scenario

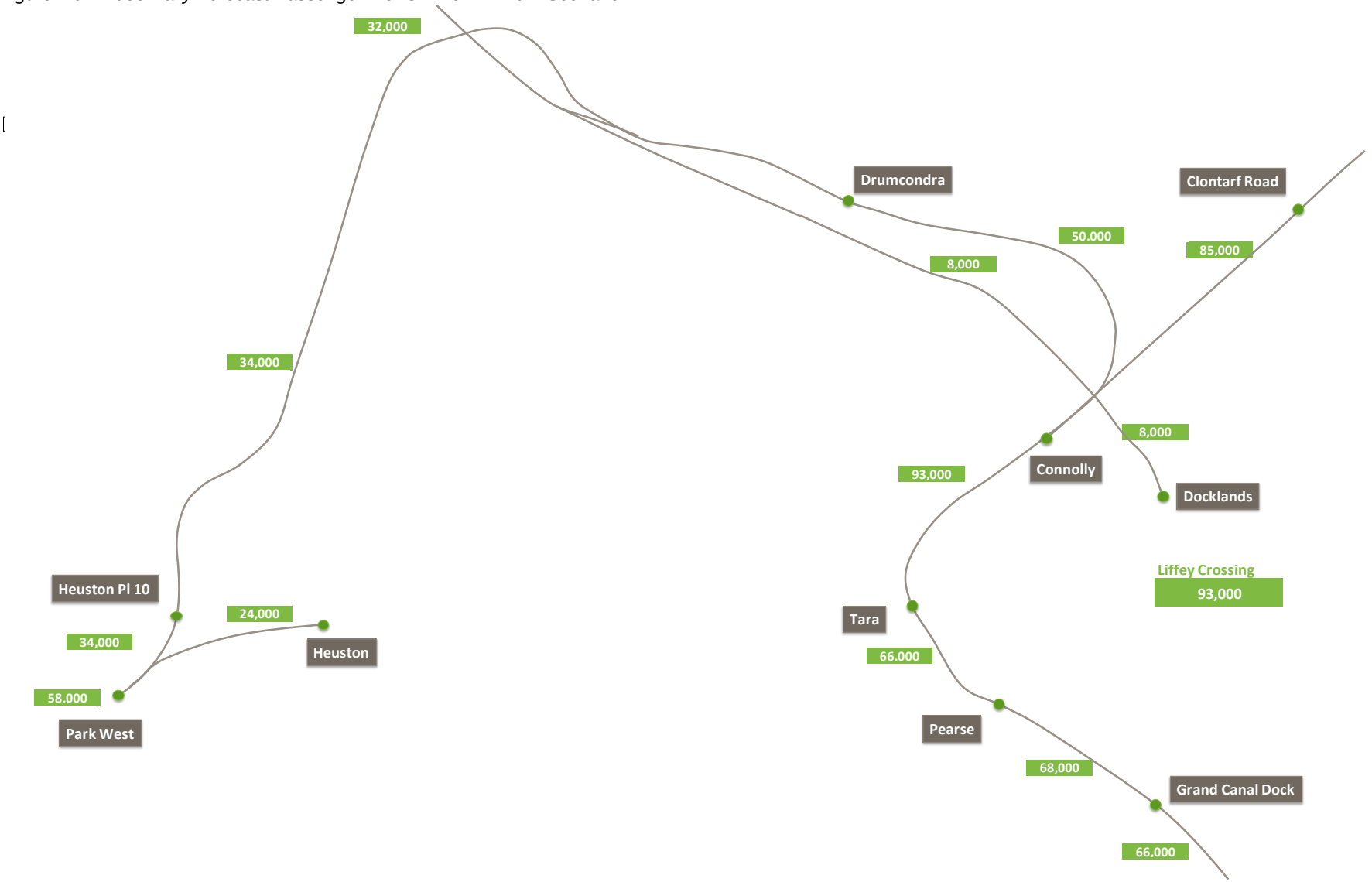


Figure 7.10 – 2033 Daily Forecast Passenger Flows – DART Expansion Programme

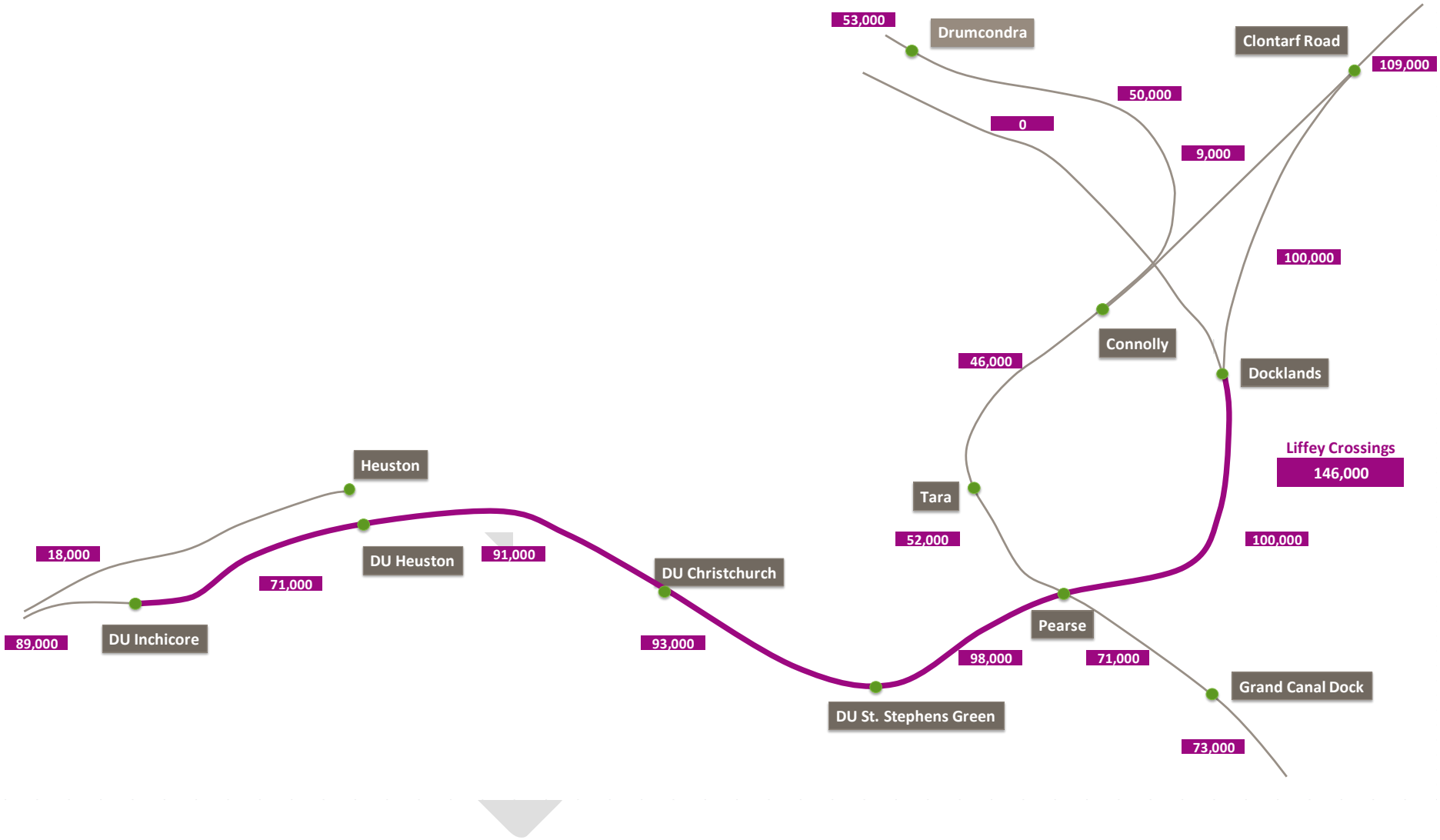


Figure 7.11 – 2033 Daily Forecast Passenger Flows – DART Underground Project Scenario

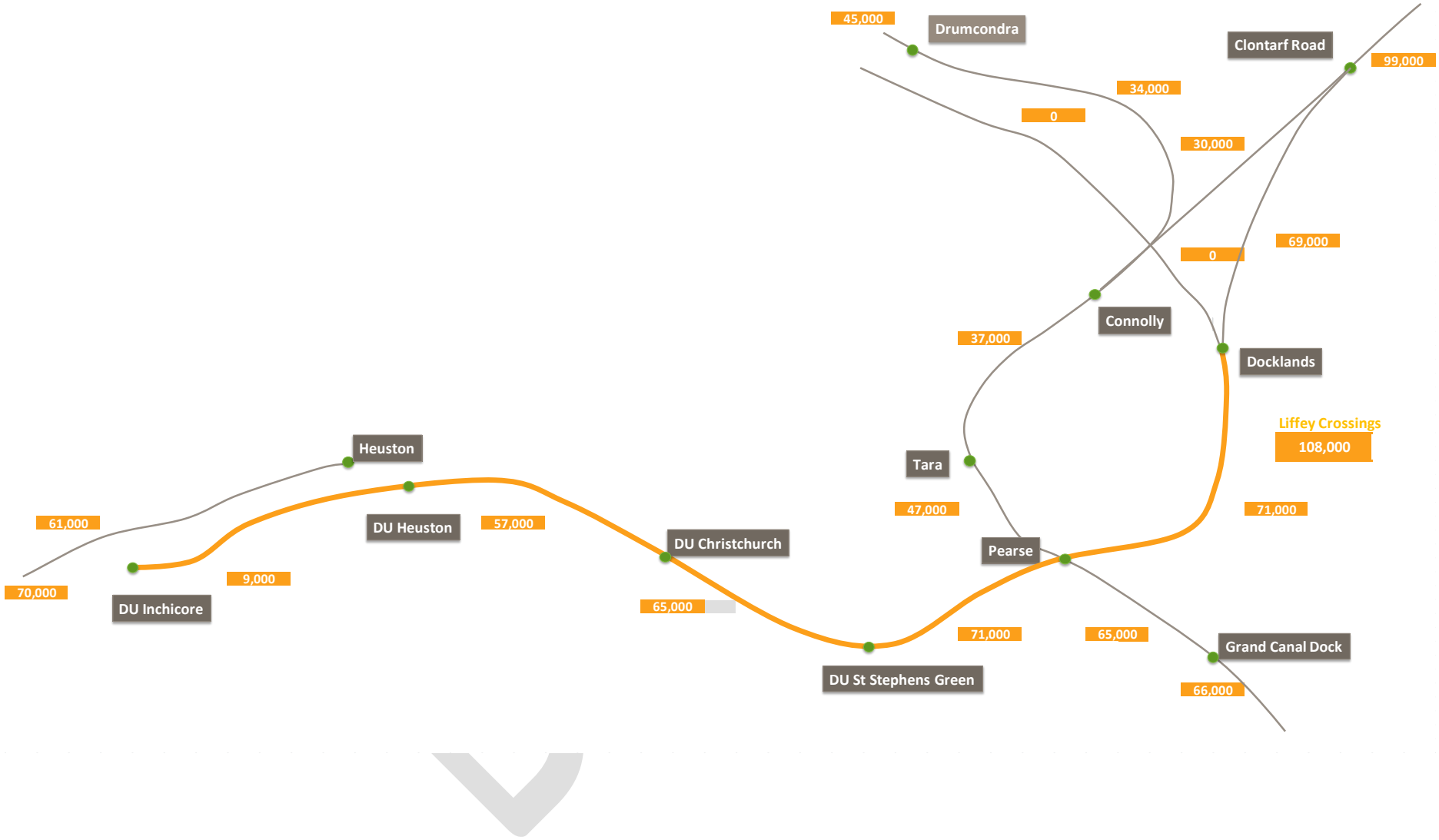


Table 7.5 – 2033 Daily Forecast Passenger Flows

Between Stations		Do Minimum	DART Expansion Programme	DART Underground Project
Broombridge	Drumcondra	40,000	53,000	45,000
Docklands (Maynooth)	Broombridge	8,000	0	0
Clontarf Road	Connolly	85,000	9,000	30,000
Tara	Connolly	93,000	46,000	37,000
Tara	Pearse	66,000	52,000	47,000
Pearse	Grand Canal Dock	68,000	71,000	65,000
Grand Canal Dock	Lansdowne Road	66,000	73,000	66,000
Park West/Cherry Orchard	Heuston	24,000	-	-
Park West/Cherry Orchard	Heuston West (Plt10)	34,000	-	-
Heuston West (Plt10)	Cabra Road	34,000	-	-
DU Docklands	East Wall Rd No stop	-	100,000	69,000
DU Pearse	DU Docklands	-	100,000	71,000
DU St. Stephen's Green	DU Pearse	-	98,000	71,000
DU Christchurch	DU St. Stephen's Green	-	93,000	65,000
DU Heuston	DU Christchurch	-	91,000	57,000
DU Inchicore	DU Heuston	-	71,000	9,000
DU Inchicore	Heuston	-	18,000	61,000

The following impacts on city-centre daily flows for the DART Expansion Programme scenario are forecast:

- A maximum daily flow of 100,000 passengers in the new DART Underground tunnel;
- An increase in daily passengers crossing Liffey from 93,000 (on Northern Line only) to 146,000 (Northern Line and DART Underground);
- An increase in daily passengers on the Northern Line from 85,000 (south of Clontarf Road) to 109,000 (including the new line between Clontarf Road and Docklands);
- An increase in daily passengers on the South Eastern line from 66,000 (south of Grand Canal Dock) to 73,000;
- An increase in daily passengers on the Cork Line from 58,000 to 89,000 (including the new line between Inchicore and Heuston); and
- An increase in daily passengers on the Sligo Line from 40,000 (excluding Phoenix Park Tunnel) to 53,000.

The following impacts on city-centre daily flows for the DART Underground Project scenario are forecast:

- A maximum daily flow of 71,000 passengers in the new DART Underground tunnel;
- An increase in daily passengers crossing Liffey from 93,000 (on Northern Line only) to 108,000 (Northern Line and DART Underground);
- An increase in daily passengers on the Northern Line from 85,000 (south of Clontarf Road) to 99,000 (including the new line between Clontarf Road and Docklands);
- No change in daily passengers on the South Eastern line 66,000 (south of Grand Canal Dock);

- An increase in daily passengers on the Cork Line from 58,000 to 70,000 (including the new line between Inchicore and Heuston); and
- An increase in daily passengers on the Sligo Line from 40,000 (excluding Phoenix Park Tunnel) to 45,000.

7.4.3 Line Flow Analysis

Table 7.6 shows the forecast daily passenger flows at key points on the four major lines into Dublin. In addition, the number of passengers crossing the Liffey in the city-centre is also shown. The equivalent figures from Rail Census 2013 are also shown for comparison purposes.

Table 7.6 – 2033 Forecast Daily Passenger Flows and 2013 Actual Flows

Corridor	Rail Census 2013	Do Minimum 2033	DART Expansion Programme 2033	DART Underground Project 2033
Sligo Line *to/from Connolly/Docklands*	13,000	40,000	53,000	45,000
Northern Line *to/from Connolly/DART Tunnel*	35,000	85,000	109,000	99,000
South Eastern Line *to/from Grand Canal dock*	28,000	66,000	73,000	66,000
Cork Line *to/from Heuston/Phoenix Park/DART Tunnel*	22,000	58,000	89,000	70,000
Liffey Crossings *Tara to/from Connolly and DART Tunnel*	34,000	93,000	146,000	108,000

There are two key factors evident from the figures provided above:

- Substantial growth in heavy rail passenger numbers up to 2033 as evidenced by the difference between the Rail Census 2013 and Do Minimum 2033 figures; and
- A significant increase in numbers using heavy rail as a result of the DART Expansion Programme and, to a lesser extent the DART Underground Project.

The first of these impacts is examined in detail in Table 7.7 which shows the annual average growth between the 2013 Rail Census and the forecast Do Minimum in 2033.

Table 7.7 – Daily Passenger Flow Growth from 2013 Rail Census to 2033 Do Minimum Forecast

Corridor	Annual Average Growth	Total Growth
Sligo Line *to/from Connolly/Docklands*	5.8%	208%
Northern Line *to/from Connolly/DART Tunnel*	4.5%	143%
South Eastern Line *to/from Grand Canal dock*	4.4%	136%
Cork Line *to/from Heuston/Phoenix Park/DART Tunnel*	5.0%	164%
Liffey Crossings *Tara to/from Connolly and DART Tunnel*	5.2%	174%

The level of annual average growth from the 2013 Rail Census to the 2033 Do Minimum is circa 5% for most lines and for Liffey Crossings. This level of growth is considered significant and is driven by the underlying assumptions in the NTA model.

The other factor is the impact the two schemes have on the passenger numbers which is shown in Table 7.8 below.

Table 7.8 – Daily Passenger Flow Growth from 2033 Do Minimum forecast to Dart Expansion Programme 2033 and Dart Underground Project 2033

Corridor	DART Expansion Programme	DART Underground Project
Sligo Line *to/from Connolly/Docklands*	+33%	+13%
Northern Line *to/from Connolly/DART Tunnel*	+28%	+16%
South Eastern Line *to/from Grand Canal dock*	+11%	+0%
Cork Line *to/from Heuston/Phoenix Park/DART Tunnel*	+53%	+21%
Liffey Crossings *Tara to/from Connolly and DART Tunnel*	+57%	+16%

As can be seen above, in 2033 the DART Expansion Programme is forecast to increase the passenger numbers travelling significantly, whereas the DART Underground Project on its own leads to a lower level of increase.

7.4.4 Do Minimum Boarding & Alighting

The passenger flows on the existing rail lines are presented below for the forecast year of 2033. The boarding/alighting profiles are for all rail services stopping at each station during the AM peak hour. **The 'Load' presented below is for both DART and Suburban Rail services** and represents total load on the specific corridor rather than any specific service. Corridor flows have been shown to provide station boarding/alighting for services in the DART Expansion Programme and DART Underground Project scenarios that extend to stations such as Balbriggan which are not currently serviced by DART.

Figure 7.12 – 2033 Total Southbound Boarding & Alighting at Stops between Drogheda and Grand Canal Dock in Do Minimum (08:00-09:00)

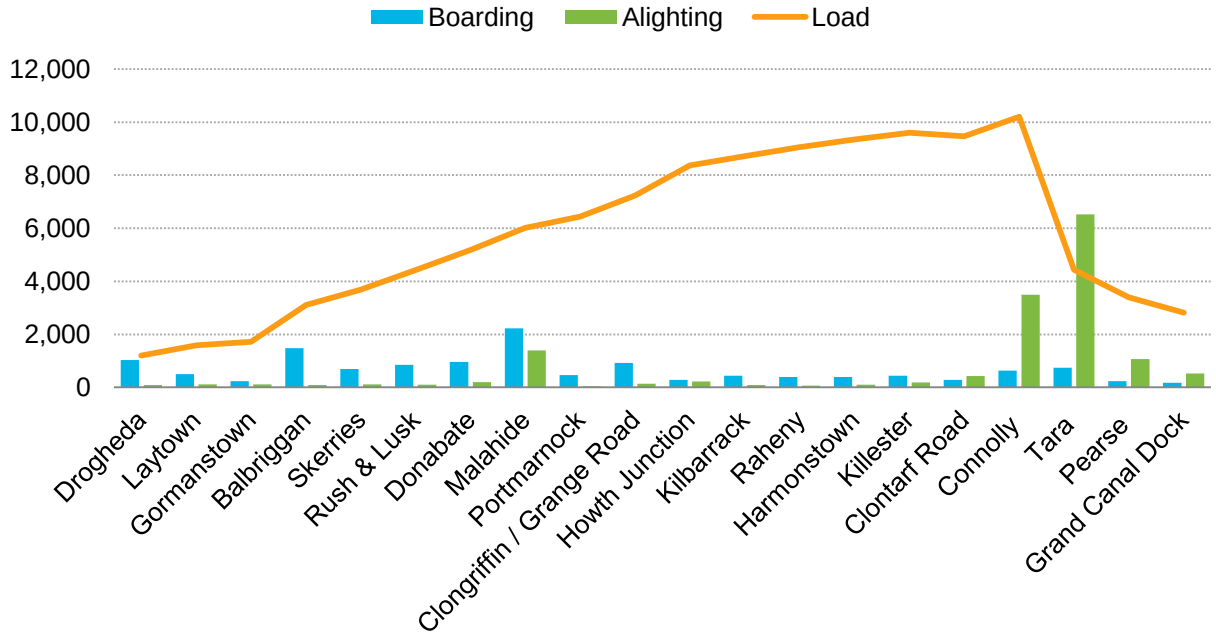
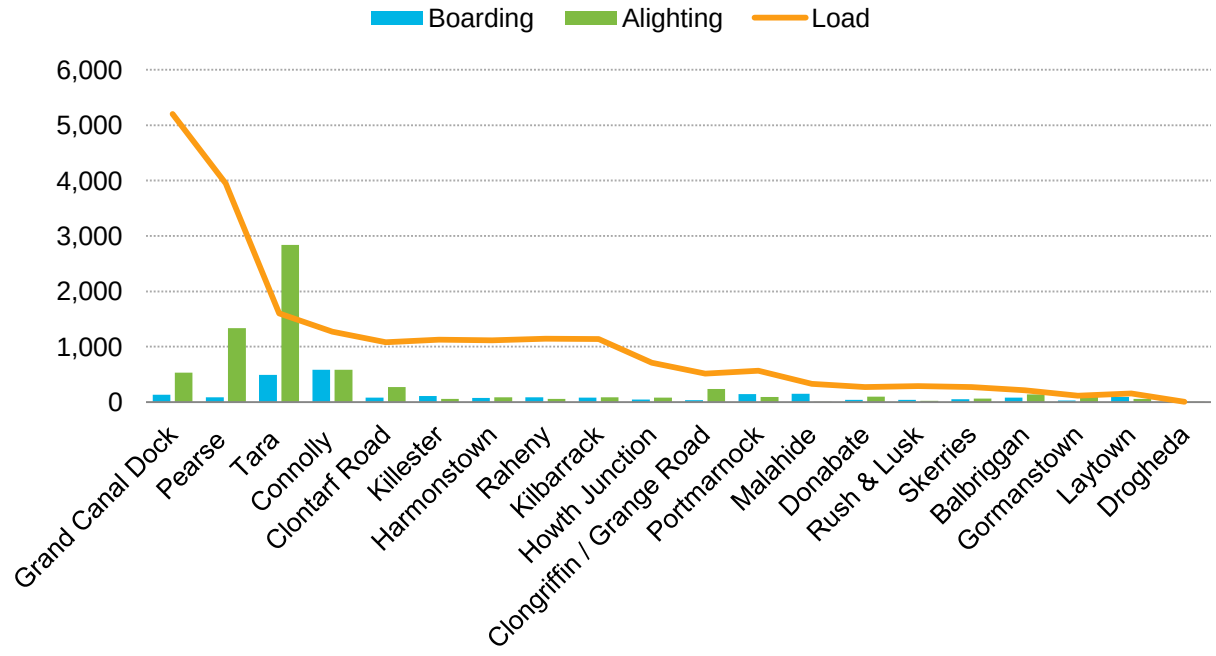


Figure 7.13 – 2033 Total Northbound Boarding & Alighting at Stops between Grand Canal Dock and Drogheda in Do Minimum (08:00-09:00)



The converse situation is expected during the PM Peak with commuters exiting the city-centre, thereby creating a load north and south of the city-centre.

7.4.5 DART Expansion Programme Boarding & Alighting

In the DART Expansion scenario, maximum passenger loadings are forecast to be higher due to the running of full DART services to Hazelhatch and Balbriggan. In the southbound/westbound direction the maximum peak hour (08:00-09:00) loading of approximately 12,000 passengers is forecast to

occur at Killester. In the eastbound/northbound direction the maximum peak hour loading of approximately 9,100 passengers is forecast to occur at Parkwest.

Forecast boardings are highest at Drogheda and Clongriffin in the southbound/westbound direction, with the highest alighting occurring at Pearse and St. Stephen's Green with less at Christchurch and Heuston. In the eastbound/northbound direction, the highest boarding is forecast at Hazelhatch with alighting highest at St. Stephen's Green, Pearse and Christchurch in the city-centre.

A plot of forecast 2033 boarding, alighting and passenger load data on the Maynooth to Bray/Greystones service under the DART Expansion Programme scenario is presented in Figure 7.14 and Figure 7.15 and for the Balbriggan-Hazelhatch line in Figure 7.16 and Figure 7.17.

Figure 7.14 – 2033 Boarding & Alighting on DART Expansion Programme (08:00-09:00) – Maynooth to Bray/Greystones

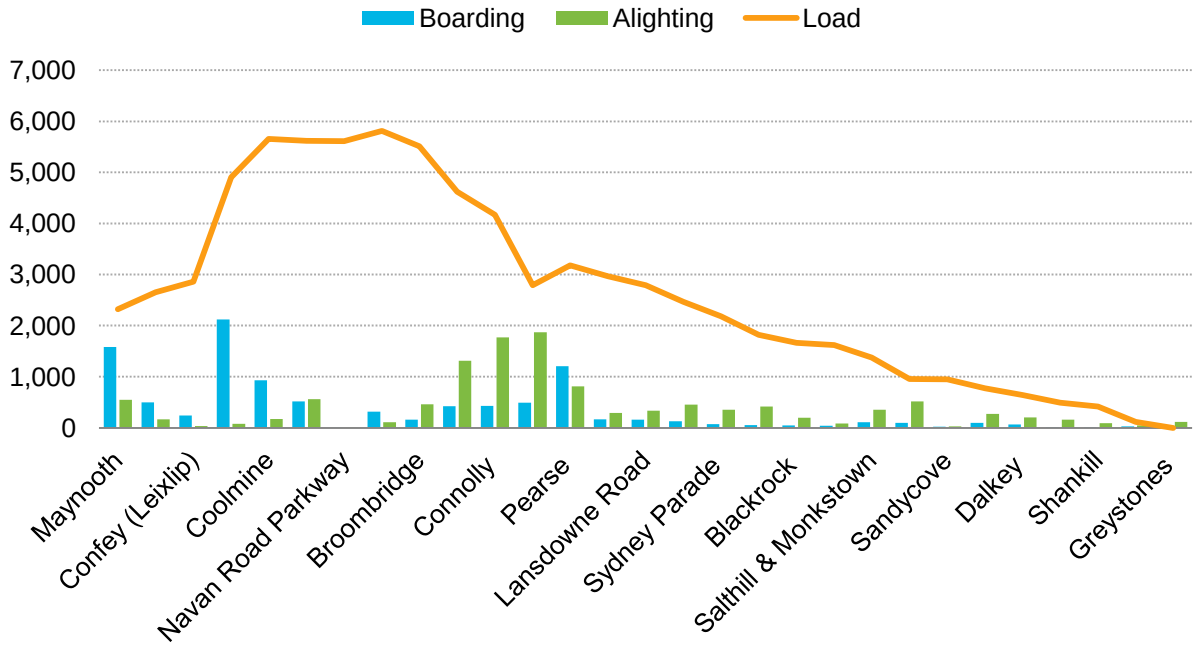


Figure 7.15 – 2033 Boarding & Alighting on DART Expansion Programme (08:00-09:00) – Bray/Greystones to Maynooth

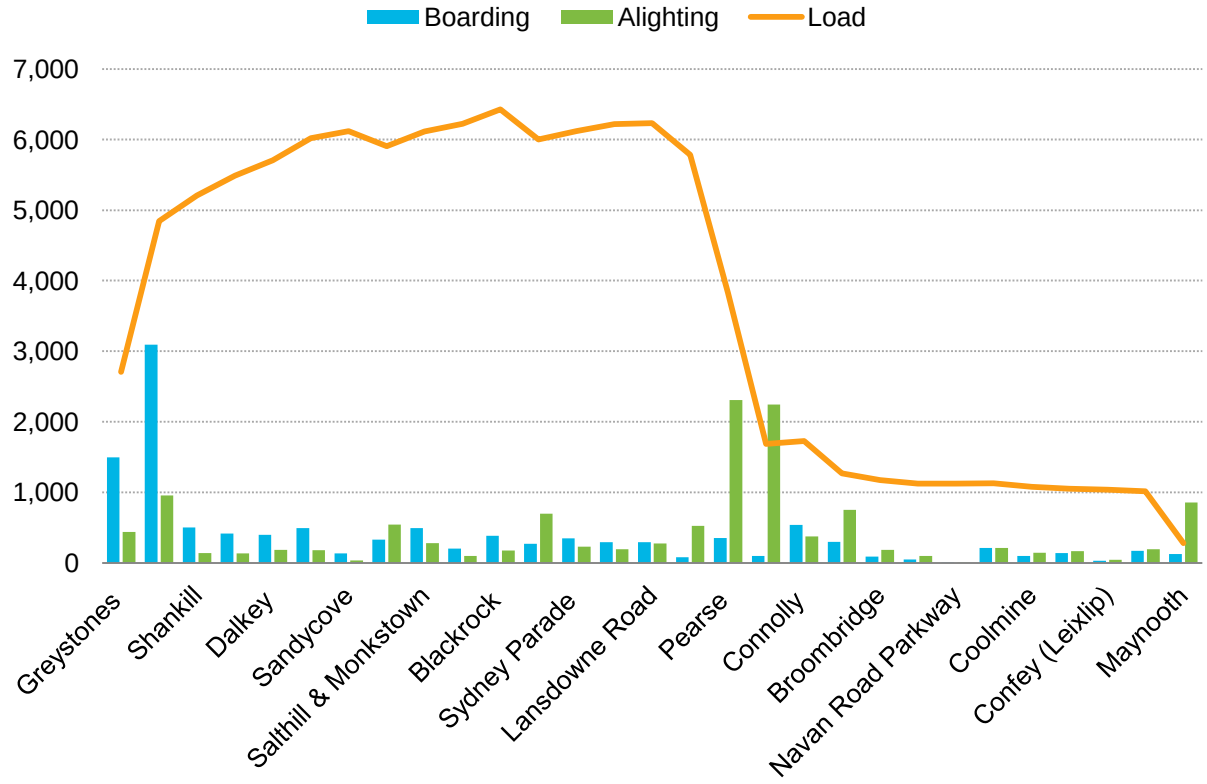


Figure 7.16 – 2033 Boarding & Alighting on DART Expansion Programme (08:00-09:00) – Hazelhatch to Drogheda

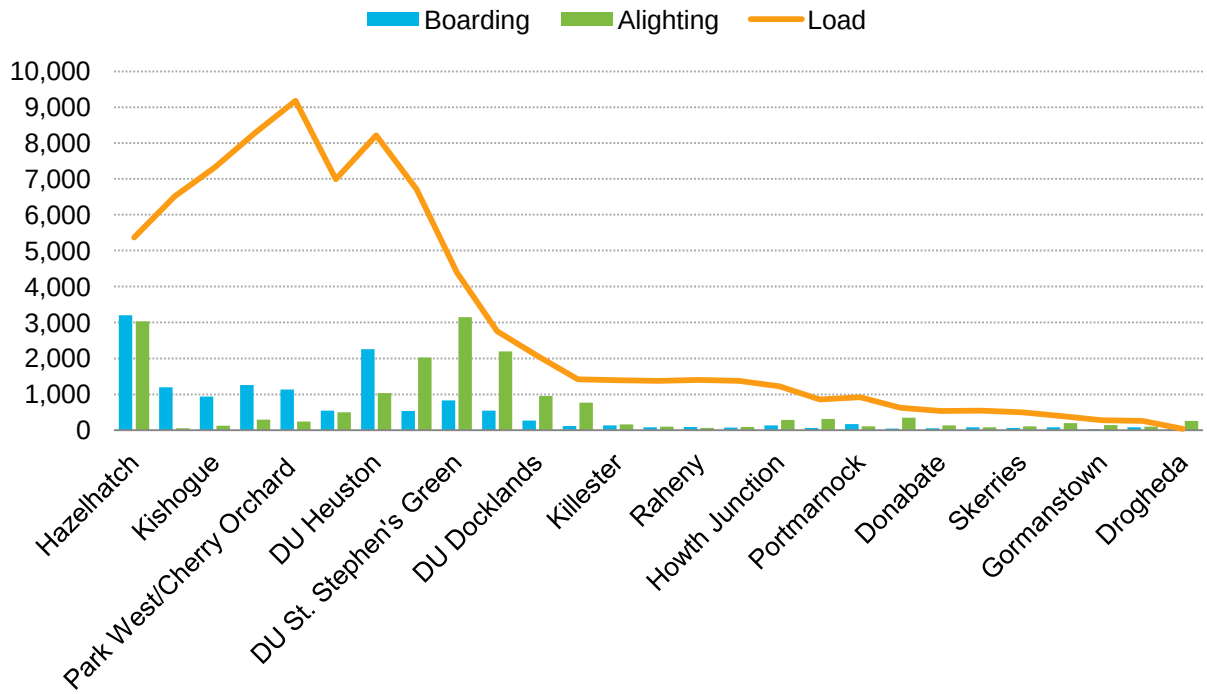
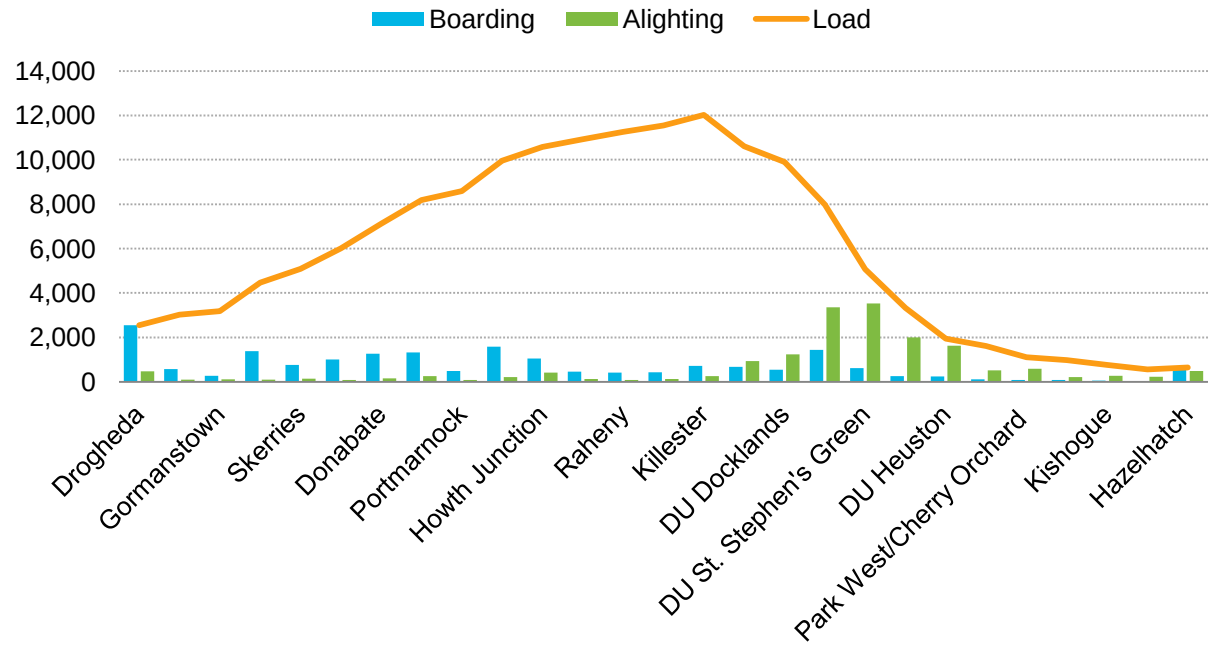


Figure 7.17 – 2033 Boarding & Alighting on DART Expansion Programme (08:00-09:00) – Drogheda to Hazelhatch



7.4.6 DART Underground Project Boarding & Alighting

A plot of forecast 2033 boarding, alighting and passenger load data on the Malahide to Inchicore service under the DART Underground Project scenario is presented in Figure 7.18 and Figure 7.19. The '**Load' presented below is for all rail services** and represents total load on the specific corridor.

Figure 7.18 – 2033 Boarding & Alighting on DART Underground Project (08:00-09:00) – Drogheda to Inchicore

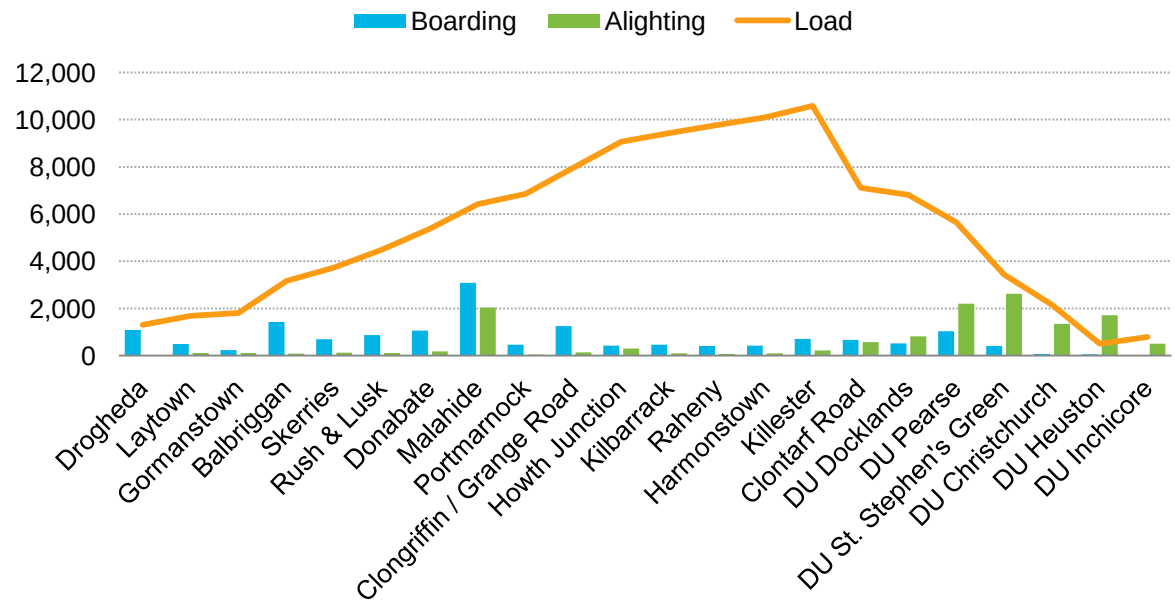
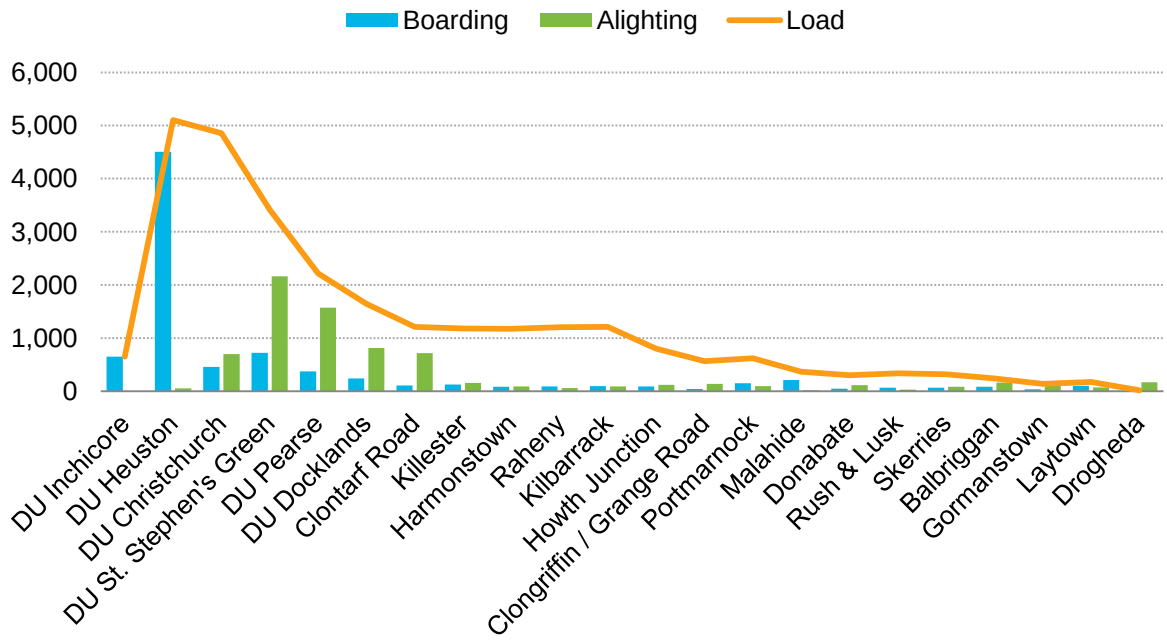


Figure 7.19 – 2033 Boarding & Alighting on DART Underground Project (08:00-09:00) – Inchicore to Drogheda



In the DART Underground Project scenario, maximum peak hour (08:00 – 09:00) passenger loading of approximately 10,500 passengers is forecast to occur at Killester in the southbound/westbound direction. In the eastbound/northbound direction the maximum loading of approximately 5,100 passengers is forecast to occur between Heuston and Christchurch.

Modelled boardings are highest at Malahide, Balbriggan, Clongriffin and Drogheda in the southbound/westbound direction, with the highest alighting occurring at Pearse and St. Stephen's Green with slightly less at Christchurch and Heuston. In the eastbound/northbound direction, the highest boarding is forecast at Heuston with some alighting at St. Stephen's Green, Pearse and Docklands in the City-centre.

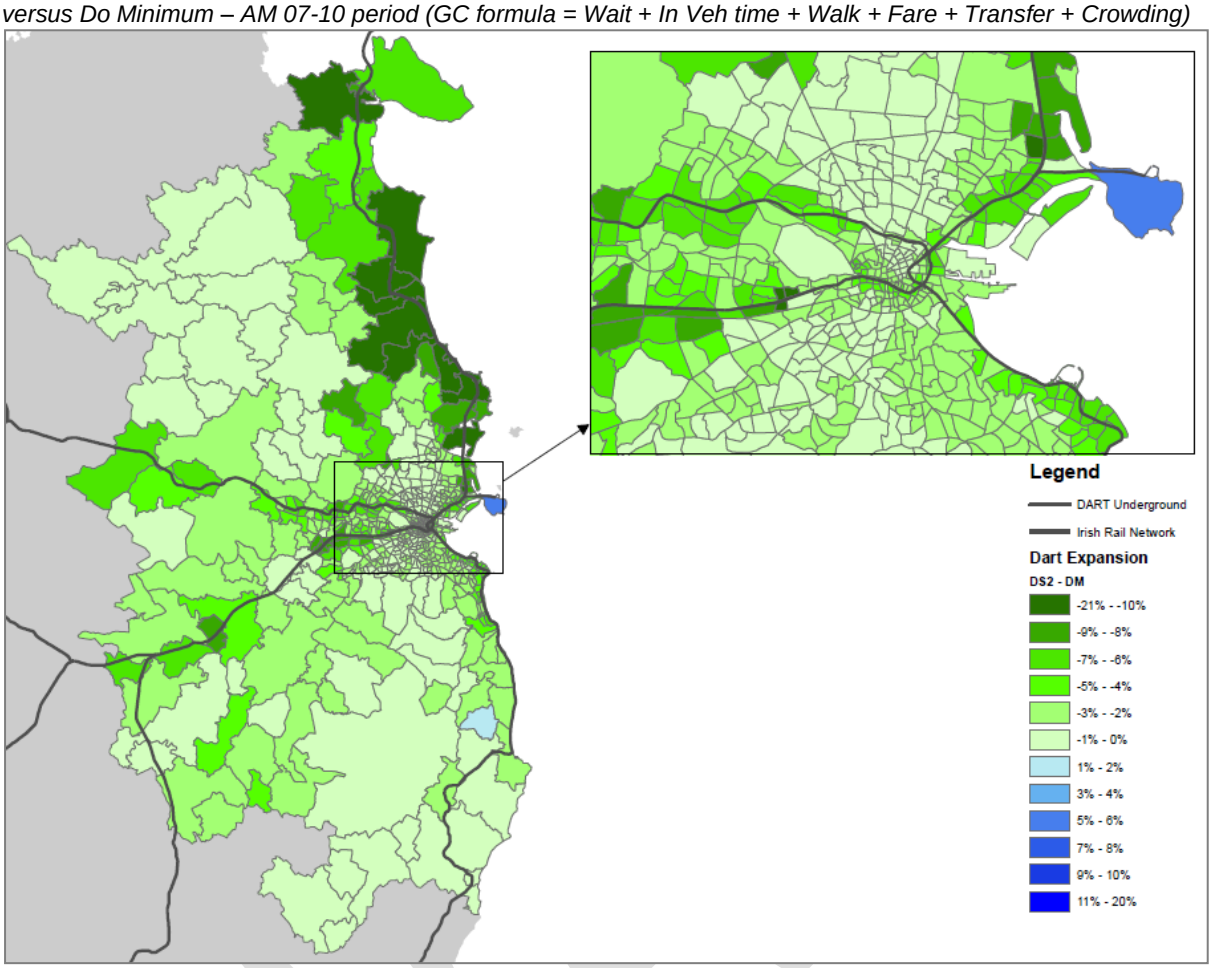
7.4.7 Travel Time Impacts

The impact of each of the proposed scheme scenarios are shown graphically in Figure 7.20 below.

DART Expansion Programme

As can be seen from Figure 7.20 there are significant public transport generalised cost (travel cost including Wait + In Vehicle time + Walk + Fare + Transfer + Crowding) savings along the Northern Line, South Eastern Line, Cork Line and Sligo Line as a result of the inclusion of the DART Expansion as shown by darker green zones below. As expected the impacts are generally focused along the existing rail lines with the improved accessibility, reduced need for interchange and improved frequency resulting in significant travel cost savings.

Figure 7.20 – % Difference in average zonal generalised cost - Public Transport – DART Expansion Programme versus Do Minimum – AM 07-10 period (GC formula = Wait + In Veh time + Walk + Fare + Transfer + Crowding)



Network Statistics

The overall performance of the modelled transport network for each scenario can be examined through an analysis of network statistics. Table 7.9 presents the network statistics for each scenario for the public transport and highway networks. Time savings for each Do Something scenario, compared to the Do Minimum scenario, are presented in Table 7.10.

Table 7.9 - 2033 AM Period Network Statistics

Statistic	Unit	Do Minimum	DART Expansion Programme	DART Underground Project
Public Transport				
Travel Time	hours	597,758	589,484	589,258
Total Demand	trips	409,605	413,553	410,452
Highway				
Travel Time	hours	465,653	459,922	465,457
Total Demand	trips	764,316	761,884	763,888

Table 7.10 – 2033 AM Period Time Savings (hours)

AM Time Savings	DART Expansion Programme	DART Underground Project
Public Transport	8,274	8,500
Highway	5,731	196
Total	**14,005**	**8,696**

The results of the model indicate that the full DART Expansion Programme will result in public transport time savings of the order of 8,274 hours in the morning peak period of a typical day along with highway travel time savings of approximately 5,731 hours. With the DART Underground Tunnel alone, public transport time savings of the order of 8,500 hours in the morning peak period of a typical day could potentially be achieved. The model forecasts minor highway travel time increases in this scenario.

In summary, this indicates that the provision of the DART Expansion Programme will result in an increase in public transport trips of 1% and a reduction in highway trips (i.e. car use) of 0.3%.

7.4.8 Annualisation of Results

Factors were developed to allow AM peak period passenger flows to be converted to daily and annual flows. All information regarding passengers numbers per service were converted to train arrival times rather than departure times in line with the NTA model which is based on arrivals. The factors were developed based on data from the Iarnród Éireann 2013 Census data for DART in addition to annual patronage figures for 2013 as set out below.

Table 7.11 – Annualisation

Period	DART Boardings/Alightings	Factor	
Weekday 07:00 – 10:00	17,085		
Weekday 24 hr	55,921	AM Period to Daily	3.273
Annual	15,985,000	AM Period to Annual	936

7.4.9 Best Alternative Option

A range of heavy rail options and alternatives have been assessed as part of the planning and design of the DART Expansion Programme (see Section 5.2). In addition, a number of alternative public transport modes have been examined. The best alternative mode option has been identified as a Luas light rail line through the south city.

This has been modelled as a light rail line running from Heuston station to Trinity College with stops at Meath Street and Christchurch. A high frequency of 20 services per hour per direction is assumed.

The results of the modelling are shown in Table 7.12 and Table 7.13. Although the introduction of the best alternative option results in an increase in Luas use, it does not lead to an increase in public transport use overall as is the case for the DART Expansion Programme. In particular, it does not unlock the capacity potential of the heavy rail network and therefore does not provide the step change in public transport that is provided by the DART Expansion Programme.

Table 7.12 –2033 Total Public Transport Boardings (07:00-10:00) – Best Alternative Option

Mode	Do Minimum	DART Expansion Programme		Best Alternative Option	
	Boardings	Boardings	% Diff	Boardings	% Diff
DART	42,993	125,069	191%	42,984	0%
Suburban Rail	66,138	33,826	-49%	66,214	0%
Total Heavy Rail	***109,131***	***158,895***	**46%**	***109,198***	**0%**
Luas	45,649	42,791	-6%	46,067	1%
Dublin/City Bus	232,422	208,646	-10%	232,297	0%
Other Bus	51,386	45,980	-11%	51,347	0%
Total	***438,588***	***456,312***	**4%**	***438,909***	**0%**

Table 7.13 –2033 Total Public Transport Passenger Distance (07:00-10:00) – Best Alternative Option

Mode	Do Minimum	DART Expansion Programme		Best Alternative Option	
	Km	Km	% Diff	Km	% Diff
DART	505,092	1,781,789	253%	504,671	0%
Suburban Rail	1,685,000	971,061	-42%	1,688,239	0%
Total Heavy Rail	***2,190,092***	***2,752,850***	**26%**	***2,192,910***	**0%**
Luas	341,980	324,544	-5%	342,137	0%
Dublin/City Bus	1,649,108	1,442,943	-13%	1,651,428	0%
Other Bus	1,631,480	1,419,234	-13%	1,631,717	0%
Total	***5,812,660***	***5,939,571***	**2%**	***5,818,192***	**0%**

7.5 Differences from Previous Business Case

The difference in the transport modelling between the current Business Case (2033) and the previous Business Case (2030) have been examined. The key difference between the two modelling results is the level of public transport use present in the 'Do Minimum' scenarios. This is presented in Table 7.14.

Table 7.14 – Do Minimum Total Public Transport Boardings (07:00-10:00)

Public Transport Mode	Current Business Case Year = 2033	Previous Business Case Year = 2030	Difference between Previous (2030) and Current (2033)
DART	42,993	94,321	-54%
Suburban Rail	66,138	117,592	-44%
Luas	45,649	142,276	-68%
Dublin Bus	232,422	192,378	21%
Other Bus	51,386	25,492	102%
Total	***438,588***	***572,058***	***-23%***

It is clear there is a substantial decrease in the numbers of public transport boardings from the previous Business Case to the current. Although some of this is likely to be explained by the inclusion of a number of light rail projects in the previous Business Case, the heavy rail figures are significantly reduced and cannot easily be explained. The difference in these results is of such a magnitude to explain a large proportion (if not the majority) of the difference in BCRs between the two studies.

The underlying population and employment assumptions are examined in Table 7.15 below as a possible source of the difference. It is again noted that 2033 and 2030 forecasts are being compared.

Table 7.15 – Population and Employment Assumptions

	Current Business Case Year = 2033		Previous Business Case Year = 2030		Change from Previous (2030) to Current (2033)	
	Pop	Emp	Pop	Emp	Pop	Emp
Central Business District	140,041	221,213	147,017	243,023	-5%	-9%
Rest of Dublin City	508,430	193,101	422,804	192,649	20%	0%
Dún Laoghaire Rathdown	251,713	96,429	228,986	102,143	10%	-6%
Fingal	334,537	118,913	260,262	121,889	29%	-2%
South Dublin	329,601	130,984	319,934	138,860	3%	-6%
Mid East	806,728	245,094	697,398	190,978	16%	28%
Total	***2,371,050***	***1,005,734***	***2,076,401***	***989,542***	***14%***	***2%***

The figures above show that the population in the Greater Dublin Area is much larger in the current Business Case with all areas increasing showing an increase with the exception of the central business district (an area roughly bounded by the canals).

There is a small increase in employment along with a significant shift from the Dublin counties to the rest of the GDA.

The differences between the current Business Case and previous Business Case are examined in more detail in Section 9.2.9.

8 SCHEME COSTS

8.1 Cost Overview

Iarnród Éireann has prepared cost estimates of the capital, operation and maintenance costs associated with the DART Expansion Programme. The costs are summarised in Table 8.1 below.

Table 8.1 – DART Expansion Programme Cost Summary (2014 Prices)

	Cost € million[21]
Capital Cost	4,007
Annual Operations & Maintenance Cost	111

The present value of these costs over the 30-year appraisal period are summarised in Table 8.2 below[22].

Table 8.2 – DART Expansion Programme Present Value of Costs (2014 Prices and Year)[23]

	Present Value of Cost € million[24]
Capital Cost	3,100
Operations & Maintenance Cost	1,310
Total	4,410

8.2 Capital Cost

The capital cost of the DART Expansion Programme includes:

- Construction and commissioning of the tunnel section of the project – included in a review of costs by AECOM;
- Electrification of the Sligo Line as far as Maynooth station and level crossing removal;
- The Kildare Route Phase 2 project – including completion of four tracking and electrification from Inchicore to Hazelhatch;
- Electrification of the Northern Line as far as Drogheda;
- Additional rolling stock;
- Stabling and depot facilities;
- Luas diversion works at Saint Stephens Green; and
- Other minor capital works.

The capital costs are summarised in Table 8.3 below. The figures presented above do not include price escalation (see Section 8.4).

[21] *2014 values; Including VAT; price escalation not included*

[22] *Note: In addition to a 30 year appraisal period, the residual value of the scheme at the end of this period is evaluated in the economic appraisal based on a further 30 years of operation*

[23] *It should be noted that a present value year and a price year of 2009 is used in the economic appraisal in order to provide consistency with other Business Cases being prepared for transport projects and being assessed by the NTA and DTTAS. As such the economic appraisal will show present value costs of different values to those shown in this table.*

[24] *2014 prices and present value year; Including VAT; price escalation is included*

Table 8.3 – DART Expansion Programme Capital Costs (2014 Prices)

	Cost € million[25]
Tunnel Construction & Commissioning	2,595
Sligo Line Electrification and Level Crossing Removal	357
Kildare Route Phase 2	190
Northern Line	173
Additional Rolling Stock	548
Stabling and Depot Facilities	120
Luas Diversion	17
Other Minor Capital Works	7
Total	**4,007**

Note: Totals may not add due to rounding

The capital cost of the tunnel shown above constitutes 65% of the cost of the DART Expansion Programme. The DART Underground Project includes the tunnel and a portion of other costs (such as additional rolling stock) and constitutes 75% of the cost of the DART Expansion Programme.

A detailed analysis of the costs associated with the capital cost of the tunnel section of the project was carried out as part of the detailed design of the DART Underground Project. These costs have been reviewed and updated to 2014 prices as part of the preparation of this Business Case[26]. The remainder of the capital cost estimates have been provided by Iarnród Éireann for this Business Case.

The cost of extending electrification on the Cork Line to Hazelhatch, on the Sligo Line to Maynooth and on the Northern Line to Drogheda is detailed separately for each line. The cost associated with the Sligo Line works is increased due to the need to remove level crossings. This is necessary in order to operate trains at the planned frequencies.

Additional rolling stock in the form of Electric Multiple Units (EMUs) is required. This is an expansion of the DART fleet from the current level of 144 EMU carriages in order to provide the planned services. The DART Expansion Programme is forecast to require a total of 440 EMU carriages.

In addition to new rolling stock, depot and stabling facilities are required to house and repair the expanded fleet.

There is a cost associated with diverting the Luas Green Line during the construction of the Saint Stephens Green station. This diversion would ensure the Luas Green Line (including the Luas Cross City extension) continues to operate during the construction period.

The present value of the capital costs are calculated by profiling the expenditure over the years 2017 to 2024 and escalating in line with expected price inflation (see Section 8.4). A summary of the capital costs are provided in Table 8.4 below.

Table 8.4 – DART Expansion Programme Capital Cost Summary (2014 Prices and Year)

	Cost € million
Capital Cost[27]	4,007
Present Value (2014) of Capital Cost[28] [29]	3,100

[25] *2014 values; Including VAT; escalation not included*
[26] *DART Underground Project, Capital Cost Estimate 3Q14 Update Report (AECOM, December 2014)*
[27] *2014 values; Including VAT; price escalation not included*
[28] *2014 prices and present value year; Including VAT; price escalation is included*

8.3 Operation & Maintenance Cost

The cost of operation and maintenance (O&M) for the DART Expansion Programme includes:

- Operation & maintenance of the tunnel section of the project – including staffing of stations, management, utilities, insurances, maintenance and renewals;
- Operation of additional rolling stock – including maintenance;
- Operation of additional services – including train crews, traction cost (fuel/electricity); and
- Infrastructure maintenance – including non-tunnel railroad maintenance.

A detailed analysis of the costs associated with the O&M of the tunnel section of the project was carried out in as part of the detailed design of the DART Underground Project[30]. These costs have been updated to 2014 prices as part of the preparation of this Business Case. The remainder of the O&M cost estimates have been forecast by Iarnród Éireann for this Business Case.

The O&M costs are summarised in Table 8.5 below.

Table 8.5 – DART Expansion Programme Annual O&M Costs (2014 Prices)

	Annual Cost € million[31]
Tunnel O&M	52
Train Maintenance	31
Personnel (Train Drivers)	7
Traction (Fuel/Electricity)	15
Overhead Line Maintenance	5
Infrastructure Maintenance	0.5
Additional Retail & Advertising Revenue	(0.5)
Total	**111**

Note: Totals may not add due to rounding

It can be seen that the costs associated with the operation and maintenance of the tunnel (including staffing of stations) constitutes approximately half of the DART Expansion Programme O&M costs.

The next largest element of the O&M cost is associated with rolling stock maintenance. It should be noted that all new rolling stock is electrically powered which has a lower operating and maintenance cost that diesel powered trains. In many cases (for instance on the Sligo Line), electrically powered trains will be replacing diesel powered. Therefore, although there is a significant increase in rolling stock, the annual O&M cost increase is tempered by the efficiency gains.

In line with the additional rolling stock and services provided, train crew and traction costs increase. Iarnród Éireann estimate the number of drivers will increase from 106 (in the Do Minimum scenario) to 364 for the DART Expansion Programme respectively.

The increase in traction costs is predominantly due to increased use of electrical energy to power the additional services provided.

The DART Expansion Programme has extra cost associated maintenance of the electrified of lines to Drogheda, Maynooth and Hazelhatch.

[29] *It should be noted that a present value year and a price year of 2009 is used in the economic appraisal in order to provide consistency with other Business Cases being prepared for transport projects and being assessed by the NTA and DTTAS. As such the economic appraisal will show present value costs of different values to those shown.*

[30] *DART Underground Project, Reference Design Submission, Operations, Maintenance and Renewal Strategy (Arup Halcrow Joint Venture, August 2010)*

[31] *2014 values; Including VAT; escalation not included*

Finally, there are some small additional O&M costs associated with the maintenance and renewal of the rail infrastructure.

The O&M costs are assumed to run for the full 30-year appraisal period. A summary of the O&M costs are provided in Table 8.6 below.

Table 8.6 – DART Expansion Programme O&M Cost Summary (2014 Prices and Year)

	Cost € million
Annual O&M Cost[32]	111
Present Value (2014) of O&M Cost[33] [34]	1,310

8.4 Cost Profile & Escalation

The capital costs for the DART Expansion Programme are forecast to be payable from 2017 to 2024 while the O&M costs will be payable from 2025.

In order to calculate the present value of the DART Expansion Programme costs, the capital costs have been profiled as per Table 8.7 below.

Table 8.7 – DART Expansion Programme Capital Cost Profiles

Year	Profile
2017	1.5%
2018	6.9%
2019	19.5%
2020	23.6%
2021	14.2%
2022	15.9%
2023	13.3%
2024	5.0%

The design of the DART Underground Project developed a series of cost profiles for capital costs including the tunnel section of the project, other infrastructure works and rolling stock purchases. Adjustments have been made to these profiles to reflect the planned 2017 to 2024 time frame of construction.

As the capital and O&M costs have been estimated in 2014 prices they need to be escalated in line with price inflation to the years in which they are payable.

Guidance from the Department of Public Expenditure and Reform[35] recommends that:

- For services with a labour component below 50%, the Harmonised Index of Consumer Prices (HICP) should be applied;
- The medium to long term HICP rate is 2%;
- For services with a labour component in excess of 50%, HICP + 1% is to be applied; and

[32] *2014 values; Including VAT; price escalation not included*

[33] *2014 prices and present value year; Including VAT; price escalation is included*

[34] *It should be noted that a present value year and a price year of 2009 is used in the economic appraisal in order to provide consistency with other Business Cases being prepared for transport projects and being assessed by the NTA and DTTAS. As such the economic appraisal will show present value costs of different values to those shown.*

[35] *See: http://www.per.gov.ie/project-discount-inflation-rates/*

- For construction and construction related services, the relevant technical advisor will advise on a project specific basis the inflation rates to be used.

A review of the estimated O&M cost indicates an overall labour content of over 50%. As per the guidance above, an annual nominal price escalation rate of 3% (1% in real terms) is used for O&M costs.

Based on an examination of tender price indices and industry outlook, an annual nominal price escalation rate of 3% (1% in real terms) is also used for capital costs.

8.5 DART Underground Project

The DART Underground Project (the tunnel section of the DART Expansion Programme) is evaluated as a standalone project in this Business Case.

The capital costs associated with the DART Underground Project are shown in Table 8.8 below.

Table 8.8 – DART Underground Project Capital Costs (2014 Prices)

	Cost € million[36]
Tunnel Construction & Commissioning	2,595
Additional Rolling Stock	255
Stabling and Depot Facilities	120
Luas Diversion	17
Other Minor Capital Works	7
Total	**2,994**

Note: Totals may not add due to rounding

The full tunnel construction and commissioning costs associated with the DART Expansion Programme are induced in the DART Underground Project. Similarly the costs associated with stabling and depot facilities, Luas diversion and other minor capital works.

The rolling stock cost is reduced due to the lower level of trains required while the costs associated with extension of electrification is not included.

The profile for the DART Underground Project capital costs varies from that of the DART Expansion Programme due to the different constituent costs and is shown in Table 8.9.

Table 8.9 – DART Underground Project Capital Cost Profiles

Year	Profile
2017	1.7%
2018	8.0%
2019	21.9%
2020	24.3%
2021	13.6%
2022	13.8%
2023	12.0%
2024	4.7%

[36] *2014 values; Including VAT; escalation not included*

The O&M costs for the DART Underground Project shown in Table 8.10 are the same level for the tunnel section but reduced for all other elements due to the lower level of services proposed.

Table 8.10 – DART Underground Project Annual O&M Costs (2014 Prices)

	Annual Cost € million[37]
Tunnel O&M	52
Train Maintenance	10
Personnel (Train Drivers)	2
Traction (Fuel/Electricity)	5
Overhead Line Maintenance	0.3
Infrastructure Maintenance	0.1
Additional Retail & Advertising Revenue	(0.5)
Total	**69**

Note: Total may not add due to rounding

The DART Underground Project costs are shown in Table 8.11 below in present value terms

Table 8.11 – DART Underground Project Present Value of Costs (2014 Prices and Year)[38]

	Present Value of Cost € million[39]
Capital Cost	2,330
Operations & Maintenance Cost	820
Total	3,150

8.6 Cost Summary

The costs associated with the DART Expansion Programme and DART Underground Project are shown in Table 8.12 below.

Table 8.12 – Summary of Costs (2014 Prices and Year)

Cost – € million[40]	DART Expansion Programme	DART Underground Project
Capital Cost	4,007	2,994
Annual Operations & Maintenance Cost	111	69
Present Value (2014) of Capital Cost	3,100	2,330
Present Value (2014) of O&M Cost	1,310	820
Present Value (2014) of Total Cost	4,410	3,150

[37] *2014 values; Including VAT; escalation not included*

[38] *It should be noted that a present value year and a price year of 2009 is used in the economic appraisal in order to provide consistency with other Business Cases being prepared for transport projects and being assessed by the NTA and DTTAS. As such the economic appraisal will show present value costs of different values to those shown in this table.*

[39] *2014 prices and present value year; Including VAT; price escalation is included*

[40] *2014 values; Including VAT; price escalation is included only in present value costs*

9 SCHEME APPRAISAL

9.1 Overview

The scheme is appraised in accordance with the Common Appraisal Framework (Department of Transport, 2009) against the standard multi-criteria appraisal headings:

- Economy;
- Safety;
- Environmental;
- Accessibility and Social Inclusion; and
- Integration.

Each of these categories is examined in the following sub-sections with a project appraisal balance sheet also provided.

9.2 Economy

The key economic objectives of the DART Expansion Programme are:

- Assist in the delivery of the national transportation strategy by increasing the passenger carrying capacity on (1) the Northern Line and Cork Line and (2) the Sligo Line and South Eastern Line;
- Improve the economy, integration and efficiency of transportation, by increasing the use of public transport; and
- Respond to anticipated passenger demands and the national transportation strategy.

In order to evaluate the economic impact of the DART Expansion Programme, a Cost Benefit Analysis (CBA) has been developed. A CBA was also developed for the DART Underground Project.

The NTA Greater Dublin Area Transport Model was used to develop forecasts of public transport and private transport demand. These demand forecasts were carried out for the Do Minimum, DART Expansion Programme and DART Underground Project scenarios. Forecasts were generated for both 2025 and 2033 as detailed in Section 7.

The costs of the project comprise capital and operation and maintenance (O&M) costs. The costs are reviewed in Section 8.

The output of the transport modelling and cost review processes provides the inputs for the economic appraisal of the project. The Transport User Benefit Appraisal (TUBA) tool has been developed on behalf of the UK Department for Transport. TUBA is used to convert the transport modelling and cost inputs into economic appraisal outputs. TUBA is a widely-used industry standard tool.

A number of important assumptions must also be included in the TUBA economic appraisal. These include the Value of Time, Appraisal Period and Discount Rate.

The Public Spending Code[41] and guidelines from the Department of Transport, Tourism and Sport (DTTAS)[42] provide the source of many assumptions used. A full list of the assumptions used and sources of each is included in Appendix A.

[41] *Public Spending Code (Department of Public Expenditure and Reform)*
[42] *Guidelines on a Common Appraisal Framework for Transport Projects and Programmes (Department of Transport now DTTAS, 2009)*

The increase in overall economic benefits associated with the schemes is forecast based on the difference between the Do Minimum and relevant Do Something scenarios. The benefits evaluated include those accruing to public transport users, road users and the environment.

Disbenefits (i.e. negative benefits) may occur such as users of existing DART services that now must interchange in order to travel between some stations (such as Howth and Grand Canal Dock). The economic appraisal accounts for such disbenefits by evaluating the net change in benefits.

The benefits and costs are discounted back to a base year providing the net present value (NPV) of the project.

A 30-year appraisal period is used. It is assumed there will be a residual value of the scheme at the end of the appraisal period. This is evaluated by forecasting the net economic benefit of the scheme over the following 30 years. Therefore the Cost Benefit Analysis is evaluated over an effective 60-year appraisal period. A sensitivity of no residual value is evaluated in the sensitivity analysis.

A growth in benefits in line with projected population growth (0.6% per annum) is assumed after the 2033 modelled year up to the end of the 30-year appraisal period.

A discount rate of 5% is used on the recommendation of the Department of Transport Tourism and Sport.

It should be noted that a present value year and a price year of 2009 is used in order to provide consistency with other Business Cases being prepared for transport projects and being assessed by the NTA and DTTAS.

The results of the cost benefits analysis are shown in Table 9.1.

Table 9.1 – Cost Benefit Analysis

€ billion, 2009 prices, 2009 PV	DART Expansion Programme	DART Underground Project
Total Costs	4.48	2.65
Total Benefits	6.12	2.17
Net Present Value (NPV)	1.64	-0.48
Benefit to Cost Ratio (BCR)	1.4	0.8

It is seen that the DART Expansion Programme generates a positive economic return with benefit to cost ratio (BCR) of 1.4.

Given the scale and cost of the DART Expansion Programme, this level of return is significant as evidenced by the high NPV of €1.6 billion (2009 prices and year).

The DART Underground Project is forecast to generate a negative economic return with the benefits being less than the costs of the scheme. The NPV is a negative €0.5 billion (2009 prices and year) and the BCR is 0.8.

In order to test the robustness of the economic case to changes in the underlying assumptions, a series of sensitivity tests were carried out. These are detailed below.

9.2.1 Discount Rate

The central discount rate used is 5%. A sensitivity analysis is carried out at 4% and 6% levels.

Table 9.2 – Discount Rate Sensitivity Analysis – DART Expansion Programme

€ billion, 2009 prices, 2009 PV	4%	Central Case (5%)	6%
Total Costs	5.63	4.48	3.65
Total Benefits	9.00	6.12	4.27
Net Present Value (NPV)	3.37	1.64	0.62
Benefit to Cost Ratio (BCR)	1.6	1.4	1.2

The use of a 4% discount rate leads to an increase in both the costs and benefits. Given the high level of capital costs at the start of the assessment and the large benefits later in the assessment, the use of a lower discount rate leads to proportionately greater increase in the benefits. As a result the BCR increases from 1.4 to 1.6.

Conversely use of a 6% discount rate leads to a lower BCR due to the higher discounting of benefits later in the schemes lifetime.

Table 9.3 – Discount Rate Sensitivity Analysis – DART Underground Project

€ billion, 2009 prices, 2009 PV	4%	Central Case (5%)	6%
Total Costs	3.22	2.65	2.23
Total Benefits	3.21	2.17	1.50
Net Present Value (NPV)	-0.01	-0.48	-0.73
Benefit to Cost Ratio (BCR)	1.0	0.8	0.7

The discount rate sensitivities lead to a similar impact on the DART Underground Project with a change in the discount rate from 5% to 4% leading to the BCR increasing from 0.8 to 1.0. The use of a 6% discount rate leads to a forecast BCR of 0.7.

9.2.2 Demand

Sensitivities are examined at low and high levels of passenger demand growth. This is to examine the robustness of the economic case to changes in future demand. An overall reduction in public transport demand of 5%, 10% and 20% is examined for low growth scenarios and the same levels of increase for high growth scenarios.

Table 9.4 – Demand Growth Sensitivity Analysis – DART Expansion Programme

€m, 2009 prices, 2009 PV	Low Growth (-20%)	Low Growth (-10%)	Low Growth (-5%)	Central Case	High Growth (+5%)	High Growth (+10%)	High Growth (+20%)
Total Costs	4.32	4.40	4.44	4.48	4.52	4.56	4.64
Total Benefits	4.90	5.51	5.82	6.12	6.43	6.73	7.35
Net Present Value (NPV)	0.58	1.11	1.38	1.64	1.91	2.17	2.71
Benefit to Cost Ratio (BCR)	1.1	1.3	1.3	1.4	1.4	1.5	1.6

The economic basis for the DART Expansion Scheme is seen to be very sensitive to demand change. For instance, a 20% decrease in public transport demand leads to the NPV of the scheme reducing to less than half the level in the central case and the BCR dropping to 1.1.

Higher demand assumptions lead an increasing in the net economic value of the scheme. A 20% increase in public transport demand leads to a BCR of 1.6.

This demonstrates the high level of sensitivity of the scheme appraisal to changes in demand.

A similar pattern is seen for the DART Underground Project as shown below.

Table 9.5 – Demand Growth Sensitivity Analysis – DART Underground Programme

€m, 2009 prices, 2009 PV	Low Growth (-20%)	Low Growth (-10%)	Low Growth (-5%)	Central Case	High Growth (+5%)	High Growth (+10%)	High Growth (+20%)
Total Costs	2.64	2.65	2.65	2.65	2.65	2.66	2.66
Total Benefits	1.73	1.95	2.06	2.17	2.28	2.38	2.60
Net Present Value (NPV)	-0.91	-0.70	-0.59	-0.48	-0.37	-0.28	-0.06
Benefit to Cost Ratio (BCR)	0.7	0.7	0.8	0.8	0.9	0.9	1.0

In general, economic appraisals carried out on transport projects in Ireland assume there is no growth after the future modelled year. In the case of this scheme, that year is 2033. However, the scheme is not due to open until 2025. If no growth in benefits is assumed post 2033, there would be 21 years of the appraisal period with no growth assumed. As a result a growth of benefits of 0.6% (in line with forecast population growth) is used.

The impact of assuming no growth in benefits after the future modelled year (2033) is evaluated below.

Table 9.6 – No Growth in Benefits Post Model Year (2033) – DART Expansion Programme

€m, 2009 prices, 2009 PV	0%	Central Case (0.6%)
Total Costs	4.44	4.48
Total Benefits	5.71	6.12
Net Present Value (NPV)	1.27	1.64
Benefit to Cost Ratio (BCR)	1.3	1.4

It is seen that the impact of assuming no growth in benefits post 2033 has a small impact on the scheme appraisal. This is reflective of the conservative level of growth assumed in the central case.

A similar level of impact is seen for the DART Underground Project below.

Table 9.7 – No Growth in Benefits Post Model Year (2033) – DART Underground Programme

€m, 2009 prices, 2009 PV	0%	Central Case (0.6%)
Total Costs	2.65	2.65
Total Benefits	2.02	2.17
Net Present Value (NPV)	-0.63	-0.48
Benefit to Cost Ratio (BCR)	0.8	0.8

9.2.3 Appraisal Period

The Business Case uses an assumption of a 30-year project life and a residual value which is assessed over a further 30-year period. A sensitivity analysis is carried out using a 30-year appraisal period which assumes no residual value.

It is seen that assuming no residual value for the schemes at the end of a 30-year period leads to a significant deterioration in the economic benefits generated. This is not unexpected given the scale of investment and the expected life of the scheme being well in excess of 30 years.

Table 9.8 – Appraisal Period Sensitivity Analysis – DART Expansion Programme

€m, 2009 prices, 2009 PV	30-Year	Central Case (60-Year)
Total Costs	5.26	4.48
Total Benefits	4.10	6.12
Net Present Value (NPV)	-1.16	1.64
Benefit to Cost Ratio (BCR)	0.8	1.4

Table 9.9 – Appraisal Period Sensitivity Analysis – DART Underground Project

€m, 2009 prices, 2009 PV	30-Year	Central Case (60-Year)
Total Costs	3.24	2.65
Total Benefits	1.41	2.17
Net Present Value (NPV)	-1.83	-0.48
Benefit to Cost Ratio (BCR)	0.4	0.8

9.2.4 Shadow Prices

The Public Spending Code recommends the application of 'shadow prices' to both public funds and labour.

The central case does not include the use of shadow prices which is in keeping with other transportation project evaluations. A sensitivity analysis is carried out applying shadow prices.

A shadow price of public funds (SPPF) of 130% is assumed and a shadow price of labour (SPL) of 80% is assumed. It is also assumed that 50% of the project cost is labour.

The results of the sensitivity analysis are shown in the tables below.

Table 9.10– Shadow Prices Sensitivity Analysis – DART Expansion Programme

€m, 2009 prices, 2009 PV	Shadow Prices	Central Case
Total Costs	5.11	4.48
Total Benefits	6.12	6.12
Net Present Value (NPV)	1.01	1.64
Benefit to Cost Ratio (BCR)	1.2	1.4

Table 9.11– Shadow Prices Sensitivity Analysis – DART Underground Project

€m, 2009 prices, 2009 PV	Shadow Prices	Central Case
Total Costs	3.09	2.65
Total Benefits	2.17	2.17
Net Present Value (NPV)	-0.92	-0.48
Benefit to Cost Ratio (BCR)	0.7	0.8

9.2.5 Cost

The costs associated with the DART Expansion Programme have undergone significant review. Large fluctuations in the cost of the scheme are therefore not expected.

Nonetheless it is considered worthwhile to examine what impact a large increase or decrease in overall costs would have of the project. Sensitivities of plus/minus 20% are examined.

This level of sensitivity is high and therefore generates a significant impact on the appraisal results as shown below.

Table 9.12 – Cost Sensitivity Analysis – DART Expansion Programme

€m, 2009 prices, 2009 PV	Lower Cost (-20%)	Central Case	Higher Cost (+20%)
Total Costs	3.74	4.48	5.22
Total Benefits	6.12	6.12	6.12
Net Present Value (NPV)	2.38	1.64	0.90
Benefit to Cost Ratio (BCR)	1.6	1.4	1.2

Table 9.13 – Cost Sensitivity Analysis – DART Expansion Programme

€m, 2009 prices, 2009 PV	Lower Cost (-20%)	Central Case	Higher Cost (+20%)
Total Costs	2.13	2.65	3.17
Total Benefits	2.17	2.17	2.17
Net Present Value (NPV)	0.04	-0.48	-1.00
Benefit to Cost Ratio (BCR)	1.0	0.8	0.7

9.2.6 Public Transport Network

It was seen (Section 7.5) that the number of passengers travelling on public transport in the Do Minimum scenario (i.e. before the implementation of the DART Expansion Programme) was significantly higher in the previous Business Case.

One potential reason for this is the public transport network that is assumed to be in place prior to the implementation of scheme. For example the assumption that Metro North would be in place prior to the DART Expansion Programme provides the potential for large numbers of passengers to interchange at the Saint Stephens Green station. In the absence of Metro North, this potential interchange is not available and therefore the benefits of the scheme may be reduced.

In order to understand the potential impact of a larger public transport network in the GDA on the economic case for the DART Expansion Programme, a sensitivity analysis has been carried out. For the purposes of this sensitivity, four key rail developments that were included in the previous Business Case have been assumed to be in the Do Minimum, namely:

- Metro North;
- Metro West;
- Luas from Lucan to the city centre; and
- Luas Green Line extension to Bray.

It must be stressed that this sensitivity does not attempt to capture either the costs or benefits of these projects. Instead it seeks to quantify the additional benefits generated by the DART Expansion Programme if these projects are already in place. The results are provided in Table 9.14.

Table 9.14 – Enhanced Public Transport Network – DART Expansion Programme

€m, 2009 prices, 2009 PV	Central Case	Extra Public Transport Network
Total Costs	4.48	4.42
Total Benefits	6.12	5.82
Net Present Value (NPV)	1.64	1.40
Benefit to Cost Ratio (BCR)	1.4	1.3

It is seen that there is a relatively small reduction in the overall benefits associated with the DART Expansion Programme when a greater level of public transport infrastructure is included in the Do Minimum scenario.

There is likely to be an increase in benefits due to the extra public transport network operating in combination with the DART Expansion Programme. However, this appears to be more than offset by the other public transport services reducing the benefits delivered directly by the DART Expansion Programme.

The current Business Case assumes that the Phoenix Park Tunnel route is used for scheduled services in the Do Minimum scenario. However, this was not assumed by the previous Business Case.

Currently all Cork Line services terminate at Heuston station and passengers must interchange in order to access the city centre. The Phoenix Park Tunnel project provides an alternative route to the city centre from the Cork Line. The benefits that the Phoenix Park Tunnel project would realise include reduced journey times for new and existing passengers on the Cork Line. These benefits may also be provided by the DART Expansion Programme.

A sensitivity analysis has therefore been carried out to examine the additional benefits realised by the DART Expansion Programme if the Phoenix Park Tunnel project is not developed in advance.

This is done by assuming that no trains use the Phoenix Park Tunnel in the Do Minimum service plan. Instead services on the Cork line terminate at Heuston station. The results are shown in Table 9.15 below.

Table 9.15 – No Phoenix Park Tunnel Project – DART Expansion Programme

€m, 2009 prices, 2009 PV	Central Case	No Phoenix Park Tunnel in Do Minimum
Total Costs	4.48	4.41
Total Benefits	6.12	6.39
Net Present Value (NPV)	1.64	1.98
Benefit to Cost Ratio (BCR)	1.4	1.4

The omission of use of the Phoenix Park Tunnel from the Do Minimum scenario improves the economic case for the DART Expansion Programme. However, this improvement is relatively small.

It should be noted that the Business Case for the Phoenix Park Tunnel Project is based on realising benefits from late 2016 onwards. As such, the benefits associated with that Business Case are in excess of the difference shown above.

9.2.7 Land Use

The analysis carried out to date has used the land use assumptions provided by the NTA and incorporated in the Greater Dublin Area transport model.

The differences between the current assumptions and those used in the previous Business Case have been reviewed in Section 7.5.

Given the scale of the DART Expansion Programme, it is quite likely to lead to a change of land use. The principal impact could be an increase in the population growth around heavy rail stations which would provide much improved capacity and journey times.

In order to test the impact of such a change, 86 'High Growth Zones' were identified as being both in close proximity to heavy rail stations and enhanced by the DART Expansion Programme (based on transport modelling results). These zones are considered as having potential for changed population growth assumptions.

The annual average growth across the 86 zones identified is 1.4% from 2011 to 2033 which is higher than the level for the entire GDA (0.9%). Although these 86 zones only constitute 22% of the population of the total GDA in 2011, they are forecast to constitute a 35% share of the population increase from 2011 to 2033 in the current model assumptions.

This shows there is already a high level of population growth assumed in zones positively impacted by the DART Expansion Programme. For this sensitivity, a further increase in the level of growth is examined by assuming these 86 zones grow to the level of population identified in the NTA's 'Strategy B' forecast which provided for high population growth near heavy rail corridors. In order to keep the overall population growth in the GDA constant, the populations in all other zones were reduced by the same proportion.

The result was the proportion of growth in the 86 zones increased from 35% to 55% of the total GDA growth from 2011 to 2033.

The results of the DART Expansion Programme CBA using this level of population growth are shown in Table 9.16. The combination of this concentrated growth and the extra public transport network are also examined.

Table 9.16 – Changed Population Distribution – DART Expansion Programme

€m, 2009 prices, 2009 PV	Central Case	Concentrated Land Use Around Rail	Concentrated Land Use Around Rail & Extra Public Transport Network
Total Costs	4.48	4.55	4.40
Total Benefits	6.12	5.93	5.94
Net Present Value (NPV)	1.64	1.38	1.54
Benefit to Cost Ratio (BCR)	1.4	1.3	1.3

The impact of a greater level of concentration of population around heavy rail is a small reduction in the benefits associated with the DART Expansion Programme. This is not unexpected given the high level of concentration around heavy rail already assumed in the base case.

The combination of concentration of population around heavy rail and additional public transport has a relatively similar impact.

9.2.8 Public Transport Policy

It widely accepted that road congestion will continue to worsen and the Greater Dublin Area will require a significant increase in public transport capacity and quality in order to provide a viable alternative to private car usage.

The DART Expansion Programme provides a step change increase in public transport capacity that could accommodate a significant future shift from car to public transport use. As such, the DART Expansion Scheme is viewed a key enabler for the potential future implementation of policies to further encourage public transport use.

For instance, should demand management measures be implemented on roads, the DART Expansion Scheme would provide a suitable alternative for transport users. It could be argued that demand management measures could not be implemented in the absence of a scheme such as the DART Expansion Programme.

A sensitivity is examined which assumes the implementation of a policy of road user charging that incentivises car users to shift to public transport use. It must be stressed that the cost of such a policy has not been evaluated and it is not considered appropriate to assume this would be put in place prior to the DART Expansion Programme (as was done in terms of the public transport network). Therefore the only the additional benefits are evaluated and not a full CBA.

Table 9.17 – Public Transport Policy – DART Expansion Programme

€m, 2009 prices, 2009 PV	Central Case	Policy Change
Total Benefits	6.12	6.45

An increase in benefits of 4% is seen when demand management measures are in place prior to the implementation of the DART expansion Programme. This sensitivity demonstrates the potential for the DART Expansion Programme to provide additional benefits in a scenario where demand management measures are deemed necessary.

9.2.9 Comparison to Previous Business Case

The results of the current Business Case are different from those developed in the previous Business Case (published in 2010).

Table 9.18 provides the central outputs from the two studies.

Table 9.18 – Scheme Appraisal Results for Current and Previous Business Case

(€ bn 2009 prices)	Current Business Case	Previous Business Case
Total Costs	4.48	6.23
Total Benefits	6.12	14.92
Net Present Value (NPV)	1.64	8.69
Benefit to Cost Ratio (BCR)	***1.4***	***2.4***

There are a number of potential reasons for the differences between the two sets of results including:

- Public transport networks which were not included in the Do Minimum scenario for the original Business Case but are included in the new Business Case – e.g.:

- Phoenix Park Tunnel services
- City centre re-signalling & Grand Canal Dock turn-back (providing increased train paths through the city centre)
- Replacement centralised traffic control centre
- 10-minute DART services

- Public transport networks which were included in all scenarios in the original Business Case but are not included in the new Business Case – e.g.:
  - Metro North
  - Metro West
  - Luas Extension to Bray
  - Luas Line from Lucan to the city centre.
- Socio-economic changes;
- Updated costs;
- The timing of the projects – with the current assumption of a 2025 opening year versus 2019 previously; and
- Changes to the public spending code, appraisal parameters and methodology – e.g. the use of a 5% discount rate versus 4% previously.

The timing difference between the previous Business Case (scheme operational in 2019) and current Business Case (2025) impacts the level of discounting applied. As both the current and previous Business Cases discount to 2009, there is an extra six years of discounting in the current study.

This extra six years of discounting does not change the BCR as costs and benefits are impacted to the same degree. In order to compare the previous and current results on the same basis, an additional six years of discounting at 4% have been applied to the previous Business Case results. No adjustment has been made for price changes. The result is presented in comparison to the current Business Case using the 4% discount rate sensitivity below. This shows that when the timing and discount rate change are accounted for the difference between the previous and current Business Case is reduced.

Table 9.19 – Previous Business Case – Adjusted Timing

(€ bn 2009 prices)	Previous Business Case Adjusted Timing	Current Business Case 4% Discount Rate
Total Costs	4.92	5.63
Total Benefits	11.79	9.00
Net Present Value (NPV)	6.87	3.37
Benefit to Cost Ratio (BCR)	***2.4***	***1.6***

The potential impact of various assumptions on the remaining difference in the BCRs between the previous and current Business Case has been examined in a number of the sensitivity analyses above.

No single element has been identified as explaining a large proportion of the difference. It is more likely a combination of factors such as the benefits already realised in the Do Minimum scenario through improvements to the heavy rail network that were previously in the DART Expansion Programme. A prime example of this is the increased frequency of services through the city centre.

9.3 Safety

The following objective relates to safety:

- Improve safety for transport users by increasing the use of public transport

The construction of the scheme has the potential to reduce the frequency and severity of road accidents through effecting a shift from in road traffic to public transport use.

9.4 Environmental

The following objective relates to the environment:

- Support National spatial objectives by encouraging economic growth and improving quality of life and the environment

The scheme will have a positive impact on quality of life through reduced journey times. It will also improve air quality by reducing green house gas emissions caused by the movement of transport users from cars to public transport.

9.5 Accessibility and Social Inclusion

The following objective relates to the accessibility and social inclusion:

- Support the Local Authorities in the GDA (especially Dublin City Council and Fingal County Council) sustainable development and regeneration objectives, including a better balance of development in the city centre by improving accessibility and transport integration

The DART Expansion Programme provides a step-change in the level of public transport access to the city centre and integrates the heavy rail, light rail and major transport hubs. It provides increased levels of accessibility and therefore social inclusion to a widespread area. In addition, it provides significant additional capacity to cater for additional growth and development.

9.6 Integration

Two of the DART Expansion Scheme's objectives relate to integration, namely:

- Provide for the integration of the National and Greater Dublin Area Rail Networks (including intercity, commuter, DART and Luas); and
- Provide a segregated rail route that penetrates all the major areas of demand in the city centre

The DART Expansion Programme integrates the heavy rail, light rail and major transport hubs in Dublin city centre. It provides an east-west heavy rail corridor through the south-city centre. It caters for current demand and has capacity to meet future demand growth.

9.7 Project Appraisal Balance Sheet

The Common Appraisal Framework (CAF) requires that a Project Appraisal Balance Sheet (PABS) be developed. The PABS provides a summary of the appraisal of the project against its key objectives under the criteria of Economy, Safety, Environment, Accessibility and Social Inclusion and Integration.

The Project Appraisal Balance Sheet (PABS) is shown in Table 9.20 below.

Table 9.20– Project Appraisal Balance Sheet

Economy	
Objective: Assist in the delivery of the national transportation strategy by increasing the passenger carrying capacity on (1) the Northern Line and Cork Line and (2) the Sligo Line and South Eastern Line	
The DART Expansion Programme provides significant carrying capacity on the Northern and Heuston mail lines.	
Quantitative: Annual Northern Line passenger flow (measured to/from Connolly station) increases from 35,000 (2013 Rail Census) to 109,000 (2033 Forecast) Annual Cork Line passenger flow (measured to/from Connolly station) increases from 22,000 (2013 Rail Census) to 89,000 (2033 Forecast)	Qualitative: **Strong Positive**
Objective: Improve the economy, integration and efficiency of transportation, by increasing the use of public transport	
The DART Expansion Programme leads to a small increase in public transport use in the Greater Dublin Area.	
Quantitative: The DART Expansion Programme leads to a 1% increase in public transport trips and a 2% increase in public transport kilometres travelled.	Qualitative: **Positive**
Objective: Respond to anticipated passenger demands and the national transportation strategy	
The DART Expansion Programme provides a significant increase in the public transport carrying capacity in the Greater Dublin Area.	
Quantitative: Annual city centre Liffey Crossings increases from 34,000 (2013 Rail Census) to 146,000 (2033 Forecast)	Qualitative: **Strong Positive**
Safety	
Objective: Improve safety for transport users by increasing the use of public transport	
The DART Expansion Programme leads to an increase in public transport use in the Greater Dublin Area.	
Quantitative: The DART Expansion Programme leads to a 1% increase in public transport trips and a 2% increase in public transport kilometres travelled.	Qualitative: **Positive**

Environment	
Objective: Support National spatial objectives by encouraging economic growth and improving quality of life and the environment	
The scheme will have a positive impact on quality of life through reduced journey times.	
Quantitative: The DART Expansion Programme leads to a 1% reduction in total travel time in the Greater Dublin Area	Qualitative: **Strong Positive**
Accessibility and Social Inclusion	
Objective: Support the Local Authorities in the GDA (especially Dublin City Council and Fingal County Council) sustainable development and regeneration objectives, including a better balance of development in the city centre by improving accessibility and transport integration	
The DART Expansion Programme provides a step-change in the level of public transport access to the city centre and integrates the heavy rail, light rail and major transport hubs. It provides increased levels of accessibility and therefore social inclusion to a widespread area. In addition, it provides significant additional capacity to cater for additional growth and development.	
Quantitative: N/A	Qualitative: **Positive**
Integration	
Objective: Provide for the integration of the National and Greater Dublin Area Rail Networks (including intercity, commuter, DART and Luas)	
The DART Expansion Programme integrates the heavy rail, light rail and major transport hubs in Dublin city centre. It provides an east-west heavy rail corridor through the south-city centre. It caters for current demand and has capacity to meet future demand growth.	
Quantitative: N/A	Qualitative: **Strongly Positive**
Objective: Provide a segregated rail route that penetrates all the major areas of demand in the city centre	
The DART Expansion Programme provides an east-west heavy rail corridor through the south-city centre with stations in new locations at Inchicore, Christchurch and Stephen's Green and existing locations at Heuston, Pearse and Docklands.	
Quantitative: N/A	Qualitative: **Positive**

9.8 Appraisal Summary

The scheme appraisal for the DART Expansion Programme is summarised as follows:

- There is a strong economic case for the DART Expansion Programme with a BCR of 1.4 and NPV of €1.6 billion (2009 prices and present value);
- The DART Expansion Programme is found to fulfil all of its key objectives; and
- The DART Expansion Programme provides a significant increase in capacity that will allow future shift from road transport to public transport.

When evaluated as a standalone project, the DART Underground Project is forecast not to generate net economic benefits. It is forecast to have a BCR of 0.8 and a negative NPV of €0.5 billion (2009 prices and present value).

It is therefore concluded that the economic case for the DART Expansion Programme is strong whilst the option of developing the DART Underground Project in isolation from the other elements of the DART Expansion Programme is not considered appropriate.

10 WIDER ECONOMIC BENEFITS

10.1 Overview

Traditional transport appraisal concentrates on user benefits derived from transport investment. It says that there is a value for saving travel time which is dependent on the purpose of the journey.

This method misses out the economic impacts that urban railways, in particular, deliver. These impacts – known as Wider Economic Benefits (WEBs) – can happen when transport changes the accessibility of firms to workers, thereby increasing employment density. This densification of employment is shown to increase productivity through the process of agglomeration.

At present, there is no Irish guidance on WEBs. The principles within the UK Department for Transport (DfT) guidance on WEBs have therefore been applied in order to estimate the value of the benefits.

The DfT guidance applies the concept of "effective density" (ED) rather than using absolute employment density. ED is a gravity model style calculation of accessibility, combining the number of jobs and the generalised cost of reaching them. This means that a transport investment can increase ED (and therefore productivity) without changing the distribution of employment – an improvement to accessibility can itself make an area effectively denser.

This chapter estimates the benefits from two elements of WEBs, as summarised in Table 10.1.

Table 10.1 – Summary of WEBs Elements

WEBs	Description	Rationale
Agglomeration	External productivity gains from increases in effective density.	Increasing accessibility between businesses raises the productivity of workers within those businesses. The extent of the productivity increase varies by sector of the economy.
Move to More Productive Jobs (M2MPJ)	Overcoming capacity constraints on central area employment growth.	Relieving transport capacity restraints on employment distribution can enable significant changes in output by enabling more workers to access jobs in the central area, where density and productivity is generally highest.

10.2 Application of WEBs

A number of issues need to be accounted for in order to estimate WEBs for the DART Expansion Programme and separately for the DART Underground Project. This section describes these issues and the assumptions used in the analysis to account for them.

10.2.1 Sectoral split

The value of the agglomeration benefit is determined by estimating the change to effective density between the Do Minimum and Do Something scenarios, and then applying an agglomeration elasticity to determine the increase in productivity. For instance, if effective density increases by 10% and the agglomeration elasticity is 0.05, this suggests that productivity will increase by 10% x 0.05 = 0.5%.

The propensity to benefit from agglomeration differs by sector; the DfT reflects this by assigning a different agglomeration elasticity to each of four sectors (Table 10.2).

Businesses in the producer services sector have the highest agglomeration elasticity because they are shown to benefit more from clustering effects. This is part of the reason why these businesses are more likely to be found in city centres than, for instance, manufacturing.

This analysis uses these elasticities and weights them by the employment split in Dublin. Some sectors fall outside of the DfT's four categories so the productivity uplift from agglomeration impacts is assumed to only apply to a proportion of Dublin employment.

Table 10.2 – Agglomeration Elasticities by Industrial Sector

Industrial sector	Agglomeration Elasticity[43]
Manufacturing	0.021
Construction	0.034
Consumer services	0.024
Producer services	0.083
Weighted average for Dublin	0.046

10.2.2 Productivity

The value of the WEBs is sensitive to future productivity growth. The estimates in this chapter assume that real productivity growth is at an annual rate of 0.68%, which is based on the level of real growth between 2000 and 2012. This is a historically low rate of growth and includes a period of recession. It could therefore be argued that this is a conservative assumption.

Another issue is the lack of detailed productivity and earnings data available for different areas of Dublin. To estimate productivity at the level of geography required to estimate WEBs, we disaggregated productivity relative to sectoral split and employment density in Dublin. This uses 'absolute' measures of employment density instead of ED, but provides a reasonable estimate of productivity differentials. The differentials estimated reflect the impact of economic geography on productivity, the basis of WEBs.

10.3 Move to More Productive Jobs

The agglomeration benefit outlined above assumes fixed land use, thus the pattern of employment is the same in the Do Minimum and Do Something scenarios. However, to the extent that services during the peak period are overcrowded, the DART Expansion Programme/DART Underground Project will relieve the capacity constraint and enable more workers to access jobs in the central business district (CBD). Productivity in the CBD is higher than elsewhere, so this change to the distribution of employment brings about a further increase to total output. A proportion of the increase in output represents a welfare benefit that is additional to the conventional transport benefits.

For the purposes of this study, it has been assumed that DART Expansion Programme and DART Underground Project enable an additional 2,000 jobs in central Dublin around each of the five central stations – thus an additional 10,000 central Dublin jobs in total. Overall employment in Dublin is assumed to remain fixed, thus the increased in jobs in the centre is balanced by a reduction in employment in the rest of the city.

The DfT guidance suggests that the M2MPJ benefit should only be included as a sensitivity test.

10.4 Results

The value of the agglomeration benefit is presented in Table 10.3. This shows that for the DART Expansion Programme, the benefit is €875 million as a Present Value over 60 years. The total increase in output as a result of the DART Underground Project is worth over €300 million. The DART Expansion Programme is expected to facilitate a greater increase in ED and therefore higher productivity increases in Dublin than in the DART Underground Project.

[43] *Source: WebTAG Unit A2.1: Wider Impacts*

Table 10.3 – Value of Agglomeration Benefits[44]

€m, 2009 prices and values (PV)	DART Expansion Programme	DART Underground Project
Agglomeration	875	310
BCR Prior to WEBs	1.4	0.8
BCR Including WEBs	***1.6***	***0.9***

10.5 Sensitivity Test

As outlined above, the DfT generally recommends that the M2MPJ benefit is only included as a sensitivity test, unless a land use-transport interaction model is used to determine the changes to employment distribution.

The table below shows the value of the WEBs if the M2MPJ benefit is included in addition to the agglomeration impact. The value of the agglomeration benefit differs slightly from that shown in Table 3. This is because the change in employment distribution associated with the M2MPJ benefit impacts on effective density, which has a knock-on effect on the agglomeration benefit.

Table 10.4 – Value of agglomeration and M2MPJ benefits (€m PV, 2009 prices and values)

Benefit €m, 2009 prices and values (PV)	DART Expansion Programme	DART Underground Project
Agglomeration	875	310
M2MPJ	215	215
Total	***1,090***	***525***

The M2MPJ benefit would therefore add circa €215 million to the total value of the WEBs.

10.6 Summary

The DART Expansion Programme will contribute towards wider economic benefits by improving accessibility between areas of employment in Dublin. This will increase effective density, in turn providing a boost to productivity and output.

Applying the guidance and parameters used by the UK Department of Transport suggests that this will lead to a benefit of €875 million for the full DART Expansion Programme or over €300 million for the DART Underground Project.

If the scheme also boosts total employment in central Dublin by enabling more workers to access jobs there, the total value of the WEBs could be as much as €1.1 billion for the DART Expansion Programme or €525 million for the DART Underground Project.

[44] *Source: Volterra calculations*

11 FINANCIAL APPRAISAL

11.1 Overview

The economic appraisal of the DART Expansion Programme and DART Underground Project examines the impact of the project on society as a whole (see Section 9). This includes non-monetary elements such as the value of time for transport users.

The financial appraisal examines the financial impact of the project only. The primary components of this are:

- Capital cost;
- Operation & maintenance cost;
- Change in fare revenue; and
- Other additional revenues generated by the scheme.

The capital cost and O&M cost have been detailed in Section 8. The capital cost is presented in Table 11.1 below.

Table 11.1 – Present Value of Capital Costs

€bn (2014 prices)	Present Value (2014)
DART Expansion Programme	3.10
DART Underground Project	2.33

The following sub-sections include the O&M costs only as these are the only costs that apply during the operational phase of the scheme.

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 rate for each public transport mode. Using passenger kilometre data is considered a more accurate way of forecasting fare revenue and so is preferred. Unfortunately there is no reliable source of passenger kilometre data for the city bus and regional bus modes and so boardings must be used in each of these cases. Full details of the rates used are included in Appendix A.

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 the exchequer.

An evaluation is also carried out for Iarnród Éireann which provides a guide on the additional subvention that is likely to be required.

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.

11.2 Fare Revenue

Table 11.2 below shows the changes in fare revenue across all public transport modes based on the introduction of the DART Expansion Programme. The annual levels for 2025 and 2045 are shown as is the present value (2014) of the 30-year appraisal period.

Table 11.2 – Fare Revenue Changes due to DART Expansion Programme

€m (2014 prices)	2025	2045	Present Value (2014)
DART	130	225	1,790
Suburban Rail	-70	-125	-995
Regional Bus	-15	-30	-230
LUAS	-5	-10	-60
City Bus	-35	-55	-440
Net Fares	***5***	***5***	***65***

There is a clear reduction in the fares collected by all modes with the exception of DART. Given the replacement of many suburban rail services with DART services (on the Sligo, Cork and Northern Lines) the reduction in suburban rail fares in favour of DART fares is not surprising.

The decrease in boardings and passenger kilometres for the two bus modes and Luas leads to a decrease in fares.

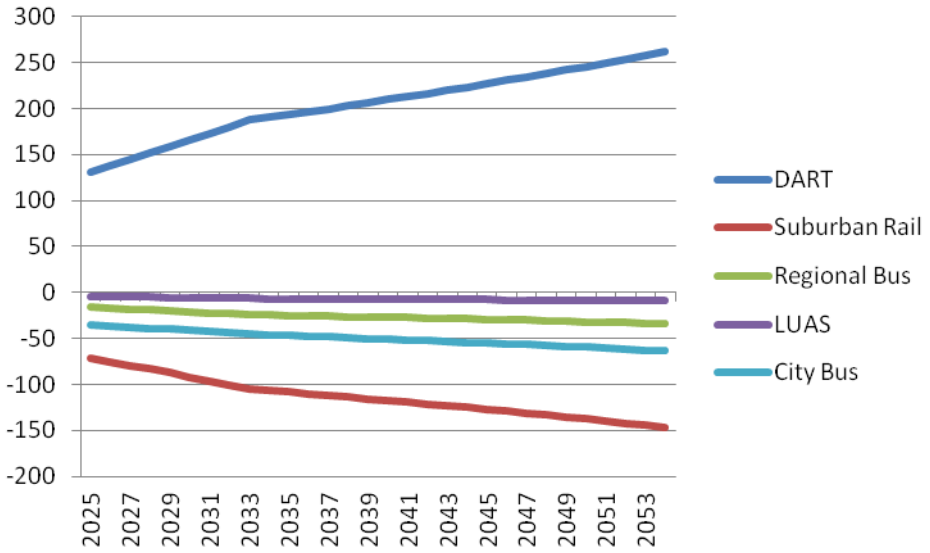
The values presented above are the difference between the Do Minimum scenario and the DART Expansion Programme. This is not a comparison to the present day. As such the reduction in revenues for other modes is not from present day levels but from potential future levels.

It must be noted that the scenarios modelled in this Business Case do not include any reconfiguration of bus services assumptions. It is likely that should the DART Expansion Programme proceed, there would be a significant change in the level and type of bus services offered. For instance, some bus services may alter to become feeder services to heavy rail stations whilst others would not require as much capacity. The potential cost savings associated with such savings would be an additional benefit of the DART Expansion Programme.

Overall, a small increase in net fares across all modes is forecast. A level of circa €5 million (2014 prices) in 2025 is forecast to remain relatively stable over the appraisal period. The present value of the overall increase in fare revenue is circa €65 million.

The fare changes are shown graphically in Figure 11.1 below.

Figure 11.1 – Fare Revenue Changes due to DART Expansion Programme (€m 2014 prices)



11.3 Exchequer Impact

Given the relatively small change in of net fares, there are little additional public transport fare revenues to offset the large costs associated with the DART Expansion Programme.

The additional revenue that will accrue to Iarnród Éireann associated with the retail and advertising opportunities in the new stations is included.

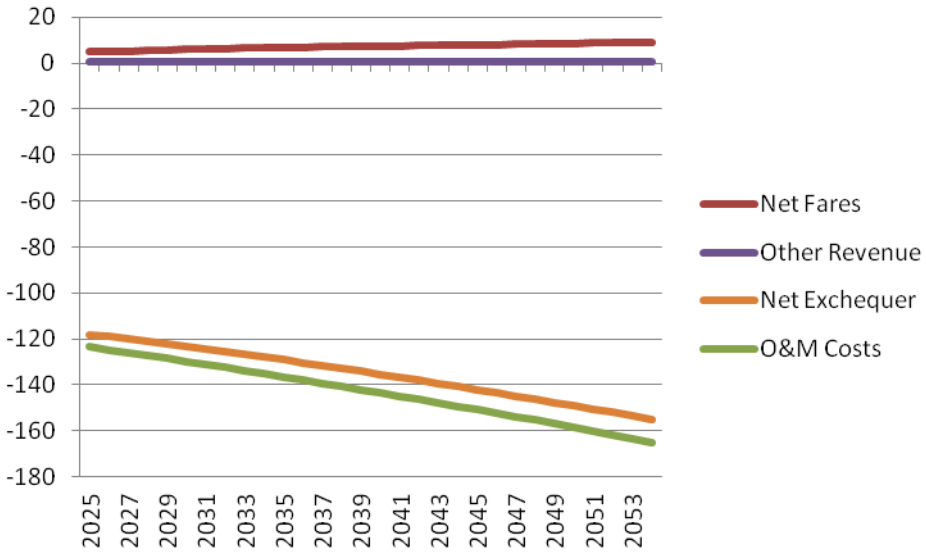
Table 11.3 provides a summary of the overall exchequer impact.

Table 11.3 – Exchequer Impact of the DART Expansion Programme

€m (2014 prices)	2025	2045	Present Value (2014)
O&M Costs	-125	-150	-1,305
Net Fares	5	5	65
Other Revenue	0	0	5
Total	***-120***	***-145***	***-1,235***

It can be seen that the DART Expansion Programme will have a negative annual exchequer impact of circa €120 million in 2025 increasing to circa €145 million in 2045. The present value of the exchequer impact over the 30-year appraisal period is in excess of €1.2 billion. This is in addition to the €3.1 billion capital cost.

Figure 11.2– Exchequer Impact of the DART Expansion Programme (€m 2014 prices)



11.4 Iarnród Éireann Financial Appraisal

The impact of the DART Expansion Programme on Iarnród Éireann is examined in Table 5.4 below. This examines the difference between additional O&M costs and the additional revenue generated from fares and other sources.

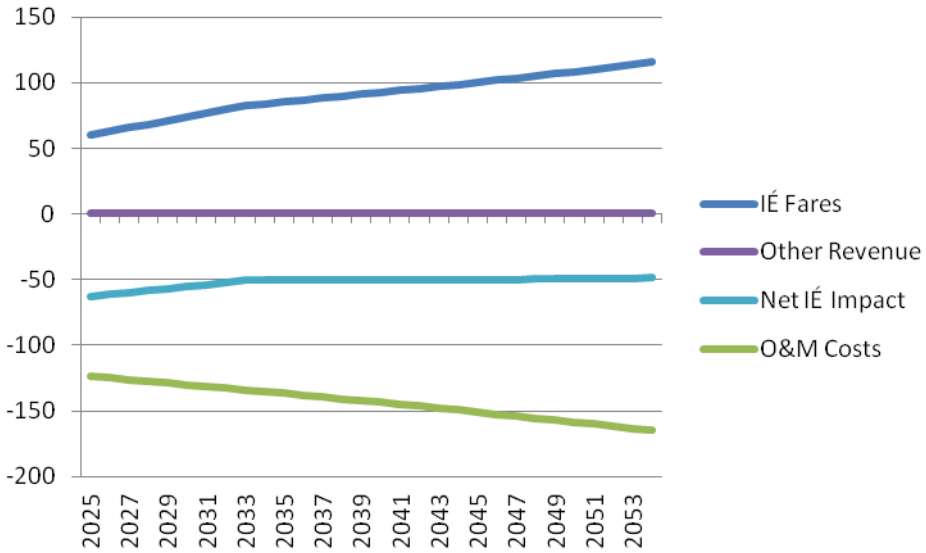
Table 11.4 – Financial Impact of Iarnród Éireann the DART Expansion Programme

€m (2014 prices)	2025	2045	Present Value (2014)
O&M Costs	-125	-150	-1,305
IR Fares	60	100	795
Other Revenue	0	0	5
Total	***-65***	***-50***	***-505***

It can be seen that the increased fare revenue significantly offsets the O&M costs. However, there does remain a need for additional funding – most likely in the form of increased subvention.

This is shown is graphical terms in Figure 11.3 below.

Figure 11.3 – Financial Impact of Iarnród Éireann the DART Expansion Programme (€m 2014 prices)



11.5 DART Underground Project

The following tables show the same information for the DART Underground Project. In general the fare revenue is lower. However, this is somewhat offset by the lower level of O&M cost.

Table 11.5 – Fare Revenue Changes due to DART Underground Project

€m (2014 prices)	2025	2045	Present Value (2014)
DART	15	25	215
Suburban Rail	-5	-10	-65
Regional Bus	0	-5	-40
LUAS	0	-5	-35
City Bus	-20	-35	-270
Net Fares	***-10***	***-30***	***-195***

Table 11.6 – Exchequer Impact of the DART Underground Project

€m (2014 prices)	2025	2045	Present Value (2014)
Costs	-75	-95	-815
Net Fares	-10	-30	-195
Other Revenue	0	0	5
Total	***-85***	***-125***	***-1,005***

Table 11.7 – Financial Impact of the DART Underground Project on Iarnród Éireann

€m (2014 prices)	2025	2045	Present Value 2014
Costs	-75	-95	-815
IR Fares	10	15	150
Other Revenue	0	0	5
Total	***-65***	***-80***	***-660***

11.6 Financial Appraisal Summary

It is forecast that the DART Expansion Programme will lead to a requirement for additional subvention of €65 million per annum in 2025 decreasing to €50 million per annum in 2045 (both figures at 2014 prices). This reduction is due to increasing demand growth from 2025 to 2045 with resultant increasing revenue.

If progressed as a standalone project, the DART Underground Project is forecast to lead to a requirement for additional subvention of €65 million per annum in 2025 increasing to €80 million per annum in 2045 (both figures at 2014 prices).

In summary, the financial appraisal finds the following impacts (all in 2014 present value terms) for the DART Expansion Programme:

- A negative exchequer impact of circa €3.1 billion due to the capital cost;
- A negative exchequer impact of circa €1.2 billion during the 30-year operational phase; and
- A negative impact of circa €505 million on Iarnród Éireann.

The equivalent levels for the DART Underground Project (all in 2014 present value terms) are:

- A negative exchequer impact of circa €2.3 billion due to the capital cost;
- A negative exchequer impact of circa €1.0 billion during the 30-year operational phase; and
- A negative impact of circa €660 million on Iarnród Éireann.

12 RISK ASSESSMENT

The principal risks associated with the DART Expansion Programme are outlined in this section.

Iarnród Éireann has implemented a risk management process on the DART Expansion Programme which includes the identification and recording of all risks in a Project Risk Register on an ongoing basis.

Further details of the risk management processes and procedures are included in the Risk Management Plan for the DART Expansion Programme.

Programme risks are categorised as follows:

- Technical;
- Economic / Financial;
- Third Parties;
- Project Management;
- Operation & Maintenance; and
- Health & Safety.

Individual risks are evaluated based on the likelihood of the risk occurring and the impact should the risk occur. Contingency elements have been included in planning either as additional programme time or cost allocations.

The six risks are discussed in more detail in the following sub-sections.

12.1 Technical

There are a number of technical risks associated with the DART Expansion Programme. These include:

- The design of works;
- Ground conditions;
- Tunnel conditions;
- Flooding – particularly in tunnel operations;
- Coordination and management of work;
- Interfaces with existing systems; and
- Scope of work.

The design work undertaken to date has allowed these risks to be better understood and assessed by the Iarnród Éireann project team.

12.2 Economic

The economic and financial risks are primarily associated with the accuracy of the assumptions and evaluations in this Business Case. These risks include:

- Accuracy of cost estimates;
- Accuracy of demand forecasting;

- Scale and distribution of future population growth;
- Accuracy of evaluation parameters used (e.g. Appraisal period, Value of Time, Discount rate, etc.); and
- Future passenger behaviour.

The impact of changes in assumptions used in the economic appraisal was evaluated using a sensitivity analysis. See Section 9 for more detail.

12.3 Third Party

The risks associated with Third Party include:

- The need for additional approvals (for the elements contained in the DART Expansion Programme and not in the DART Underground Project);
- Railway Safety Commission – potential for additional requirements or design modifications;
- Traffic management and site access;
- Public relations issues;
- Sub-surface land ownership issues; and
- Potential legal challenges.

Although these risks have been minimised through detailed planning and consultation, they remain as risks to the delivery of the project in a timely manner.

12.4 Project Management

Risks that are classified as project management related include:

- Construction delays;
- Quality;
- Safety; and
- Interface issues.
- These risks can be minimised, but not eliminated, through detailed planning and management.

12.5 Operation & Maintenance

The operation and maintenance risks include:

- Accuracy of cost estimates; and
- Accuracy of fare estimates.

12.6 Health & Safety

This report does not attempt to identify or classify the Health and Safety risks associated with the project. The Iarnród Éireann project team will ensure that adequate risk assessments are carried out at each stage of the design and implementation.

The operational phase of the project will be encompassed by the overall Iarnród Éireann health and safety processes overseen by the Health and Safety Manager.

13 PROCUREMENT

13.1 Procurement Overview

The DART Expansion Programme consists of a number of elements including the DART Underground Project (construction and commissioning of the city centre tunnel), Kildare Route Phase 2 project, extension of electrification, additional rolling stock and new stabling and depot facilities.

The scale of the DART Expansion Programme will provide a significant funding challenge which will impact the procurement methods employed.

The high-level issues are reviewed below. However, the detailed funding and procurement options are beyond the scope of this Business Case.

13.2 Funding

The capital cost required for the DART Expansion Programme is estimated to be €3.1 billion in 2014 present value terms. This cost equates to circa 2% of the State's GDP and is without parallel in terms of scale.

There are a number of funding options that are likely to be explored including:

- Direct exchequer funding;
- Private equity (in the form of a Public Private Partnership); and
- Development / business levy.

Funding this project from annual exchequer revenues would be challenging given the capital cost is equal to the total estimated capital expenditure of the State for 2014 and is over three times the capital expenditure currently administered by the Department of Transport, Tourism and Sport[45].

Given the annual revenues associated with the scheme are estimated to be less than the additional O&M cost of the scheme, the opportunity for using future revenues as a source of funding the capital costs may not be straightforward.

The introduction of a development or business levy is likely to meet resistance and require substantial political and business backing. It would also be necessary to consider the possible scale of levy that could be applied.

The funding of the DART Expansion Programme is therefore likely to be a significant undertaking and, as such, is considered beyond the scope of this report.

13.3 Procurement Options

The DART Underground Project element of the project is the most complex and highest cost (circa 75% of the total capital cost) component of the DART Expansion Programme.

The following are likely to be considered as part of the procurement process:

- Number of size of contracts;
- Size and scale of companies that can provide the services required;
- Apportionment of risk;

[45] *Comprehensive Expenditure Report 2015-2017 (Department of Public Expenditure and Reform)*

- Funding requirement during construction;
- Value for money; and
- Governance.

Given the scale of DART Expansion Programme, it is likely that new processes and procedures will need to be agreed with the Department of Transport, Tourism and Sport and the Department of Public Expenditure and Reform in order to manage the procurement.

The other elements of the scheme include the extension of electrification, purchase of new rolling stock and addition of new depot facilities. These are all areas that Iarnród Éireann has detailed experience with many similar investments in the past. As such, these projects may be developed through traditional design and build contracts managed by the existing Iarnród Éireann procurement processes.

13.4 Procurement Summary

The funding of the DART Expansion Programme is likely to be a significant undertaking and funding will have a strong bearing on the method of procurement employed.

The identification and evaluation of potential sources of funds and funding mechanisms is considered beyond the scope of this report.

14 PROPOSALS FOR IMPLEMENTATION

14.1 Implementation

The DART Expansion Programme is of a scale and cost that does not compare with any previous infrastructure project. The implementation of such an investment is therefore, by its nature, bespoke.

The DART Underground Project, which is the principal component of the DART Expansion Programme, has been evaluated as a standalone project. This provides the basis for a decision to be made to develop the DART Expansion Programme in a phased manner by first implementing the DART Underground Project.

Other phasing options could include developing some of the other components of the DART Expansion Programme first. For instance, the electrification and level-crossing removal on the Sligo Line could be progressed along with the purchase of some rolling stock. This could be followed by electrification of the Northern Line to Drogheda and Cork Line to Hazelhatch along with the development of depot facilities and the purchase of further rolling stock. In this scenario, the DART Underground Project could be the final element of the DART Expansion Programme put in place.

This Business Case does not examine the phased implementation options other than the evaluation of the DART Underground Project on a standalone basis.

Ultimately the implementation plan for the DART Expansion Programme will be heavily influenced by the availability and structure of funding that is put in place.

14.2 Timing

The timing of the DART Expansion Programme used in this Business Case is based on delivery in line with the current Railway Order for the DART Underground Project (i.e. the city centre tunnel) which requires the scheme to be constructed by 2024. As such the scheme is assumed to operate from 2025 onwards.

In order for the scheme to be operational by 2025, construction must commence in 2017. This must be preceded by a number of other elements of work such as finalisation of design work, obtaining the remaining necessary statutory approvals (e.g. for works associated with electrification of lines) and procurement. As such, the timeframe for commencement of construction assumed in this Business Case is aggressive. In addition, given the cost of this scheme, the availability of funding provides a further challenge.

It is therefore considered appropriate that changes in the timing for delivery of the scheme may be considered. As the current Railway Order does not provide for a delay beyond 2024, this would need to be included in any such consideration.

14.3 Monitoring and Evaluation

With all investment programmes, it is necessary to map out a monitoring and evaluation programme for the programme.

As detailed in the Public Spending Code[46], the four stages in the life-cycle of a project or programme are:

- Appraisal;

[46] *Section A01 Public Spending Code (Department of Public Expenditure and Reform)*

- Planning/Design;
- Implementation; and
- Post-Project / Post-Implementation Review.

These are discussed in some detail below.

14.3.1 Appraisal

The appraisal stage normally consists of two steps – a Preliminary Appraisal and a Detailed Appraisal.

The preliminary appraisal aims to establish whether, at face value, a sufficient case exists for considering a proposal in more depth. It leads to a recommendation on whether or not to proceed to the detailed appraisal stage.

A preliminary appraisal of a project includes the background, initial specification of the needs and objectives, identification of potential options and a preliminary assessment of the costs and benefits.

The detailed appraisal stage aims to provide a basis for a decision on whether to proceed with a project in principle or not. It includes the finalisation of the needs and objectives, evaluation of potential options and a detailed assessment of the costs and benefits of the project.

The level of economic appraisal carried out should be reflective of the scale of the project. A full Cost Benefit Analysis (CBA) is required for projects where the capital cost is in excess of €20 million which is the case for the DART Expansion Programme.

It should be noted that the Public Spending Code specifies that if the value of the capital project exceeds €20 million then the Cost Benefit Analysis should be submitted to the CEEU in the Department of Public Expenditure and Reform for their views, prior to the Sanctioning Authority granting the Approval in Principle.

In the case of the DART Expansion Programme, a detailed Business Case was completed in 2010[47] which provided a strong economic case for the scheme. Given this report was completed circa five years ago, it is necessary to carry out an updated detailed appraisal – in particular due to the scale of the scheme.

This Business Case is the output of the detailed appraisal process and provides a key milestone in the evaluation of the project. This report will be used by Iarnród Éireann, the National Transport Authority, the Department of Transport, Tourism and Sport and the Department of Public Expenditure and Reform as a basis for evaluating the scheme.

14.3.2 Planning / Design

The planning and design stage starts with the project receiving approval in principle from the appraisal stage. This stage involves detailed planning and costing of the project.

No commitment to finance a project should be made until this stage is completed and a decision taken on whether to proceed is made.

A large portion of the elements of this stage have been completed (particularly in the case of the DART Underground Project) in order to inform the detailed appraisal.

The procurement process (including tender evaluation) will be a key element of this stage.

[47] *DART Underground Business Case (Colin Buchanan on behalf of Iarnród Éireann, April 2010)*

When a tender price and other relevant information become available, the case for proceeding with the scheme should again be reviewed. The analysis contained in this Business Case should be reviewed to ensure it is still relevant.

If there are changes to the costs or outputs such that there are substantive changes to costs and benefits evaluated herein, then the approval in principle may need to be reviewed.

If there are no substantive changes to the costs and benefits in this Business Case, a decision to proceed can be made.

14.3.3 Implementation

This stage is likely to commence with contract placement. This stage generally includes management, monitoring, supervision and control of the implementation of the project.

For the capital elements of the project, the implementation stage will be at least eight years in duration. The current expenditure element (i.e. operation and maintenance cost) will extend over the operational lifetime of the project.

14.3.4 Post Project / Post Implementation Review

A post-project review aims to confirm whether project objectives have been met, the project has been delivered to the required standard, on time and within budget and to ensure that experience gained can be used on other projects. It may also help to inform managers on the continued best use of a new asset.

This Business Case will form a key starting point for the post-project review. It is proposed that an interim post-project review is carried out after one full year of operational services on the Phoenix Park Tunnel route. A detailed post-project review should be carried out approximately three years after operation commences with further reviews at intervals defined in the post-project review.

Given the scale of the DART Expansion Programme, a detailed monitoring and evaluation plan should be developed prior to the decision to proceed with the scheme is made.

APPENDIX A – ASSUMPTION LOG

General

- The DART Expansion Programme consists includes:
    - a 7.6 km tunnel, one over-ground and five underground stations, electrification of tunnel and connection to Northern Line;
    - Kildare Route Phase II Project;
    - Extension of electrification to Maynooth, Drogheda and Hazelhatch;
    - Fleet expansion (including depots); and
    - Sligo Line re-signalling and level crossing removal.
- The DART Underground Project consists includes:
    - a 7.6 km tunnel, one over-ground and five underground stations, electrification of tunnel and connection to Northern Line; and
    - Fleet expansion (including depots).
- The DART Expansion Programme and DART Underground Project are both evaluated individually in comparison to a Do Minimum scenario.
- The Do Minimum scenario includes the current transport infrastructure in the Greater Dublin Area. In addition, all committed infrastructure is included.
    - City centre re-signalling project;
    - Grand Canal Dock turn-back;
    - Use of Phoenix Park Tunnel[48];
    - Luas Cross City; and
    - Centralised Traffic Control (CTC) upgrade.
- The Phoenix Park Tunnel will be available for use in the Do Minimum, DART Expansion Programme and DART Underground Project scenarios. The service plans for each of these scenarios determines the level of use of the Phoenix Park Tunnel.
- Scheme opening: 2025
- Scheme construction begins: 2017
- Scheme costs:
    - DART Expansion Programme Capital Cost: €4,007 million (2014 prices, inc VAT, without escalation)
    - DART Expansion Programme O&M Cost: €105 million (2014 prices, inc VAT, without escalation)
    - DART Underground Project Capital Cost: €2,994 million (2014 prices, inc VAT, without escalation)
    - DART Underground Project O&M Cost: €76 million (2014 prices, inc VAT, without escalation)
- Profiling of capital costs:

[48] *The Phoenix Park Tunnel is viewed as committed infrastructure*

Year	DART Expansion Programme	DART Underground Project
2017	1.5%	1.7%
2018	6.9%	8.0%
2019	19.5%	21.9%
2020	23.6%	24.3%
2021	14.2%	13.6%
2022	15.9%	13.8%
2023	13.3%	12.0%
2024	5.0%	4.7%

Note: Totals may not add to 100% due to rounding

Transport Modelling

- NTA Greater Dublin Area model used – further details included in Section 7
- Service plans: Provided by Iarnród Éireann – see Appendix C
- Annualisation factor: AM Peak Period (7am to 10am) to Annual 936 (based on Rail Census data)

Economic Appraisal

- Present Value Year: 2009
- Price Year: 2009
- A present value year and a price year of 2009 is used in order to provide consistency with other Business Cases being prepared for transport projects and being assessed by the NTA and DTTAS.
- Appraisal Period: 30 years
- The Public Spending Code recommends a default 20 year period. However, the Common Appraisal Framework for transport projects recommends a 30 years appraisal period.
- Residual Value: Evaluated over 30 years
- Benefit Ramp-up: All benefits are assumed to accrue from 2025
- The economic appraisal is carried out using prices inclusive of VAT
- Discount Rate: 5%
- General Price Inflation: 2%
- Tender Price Inflation: 1% (real) during the planning and construction phase (i.e. up to and including 2024).
- Operations & Maintenance Price Inflation: 1% (real) as per the Public Spending Code where O&M costs are assumed to have a labour content of over 50%.
- Shadow Price of Public Funds: Not included in base case – sensitivity at 130%
- Shadow Price of Labour: Not included in base case – sensitivity at 80%
- Value of Time (2002 market prices) – based on Common Appraisal Framework
    - Working: €26.50 per hour
    - Commuting: €8.10 per hour

- Non-commuting: €7.30 per hour

- VOT Growth per Annum – based on Common Appraisal Framework
  - 2002 to 2010: 2.70%
  - 2011 to 2015: 2.37%
  - 2016 onwards: 2.29%
- Demand Growth:
  - Demand projects up to 2033 are provided by the NTA model outputs
  - Growth post 2033: 0.6% (in line with long term population growth rates)
- Fare Revenue: Not included in the evaluation of the Net Present Value (NPV) of the schemes in the economic appraisal

Financial Appraisal

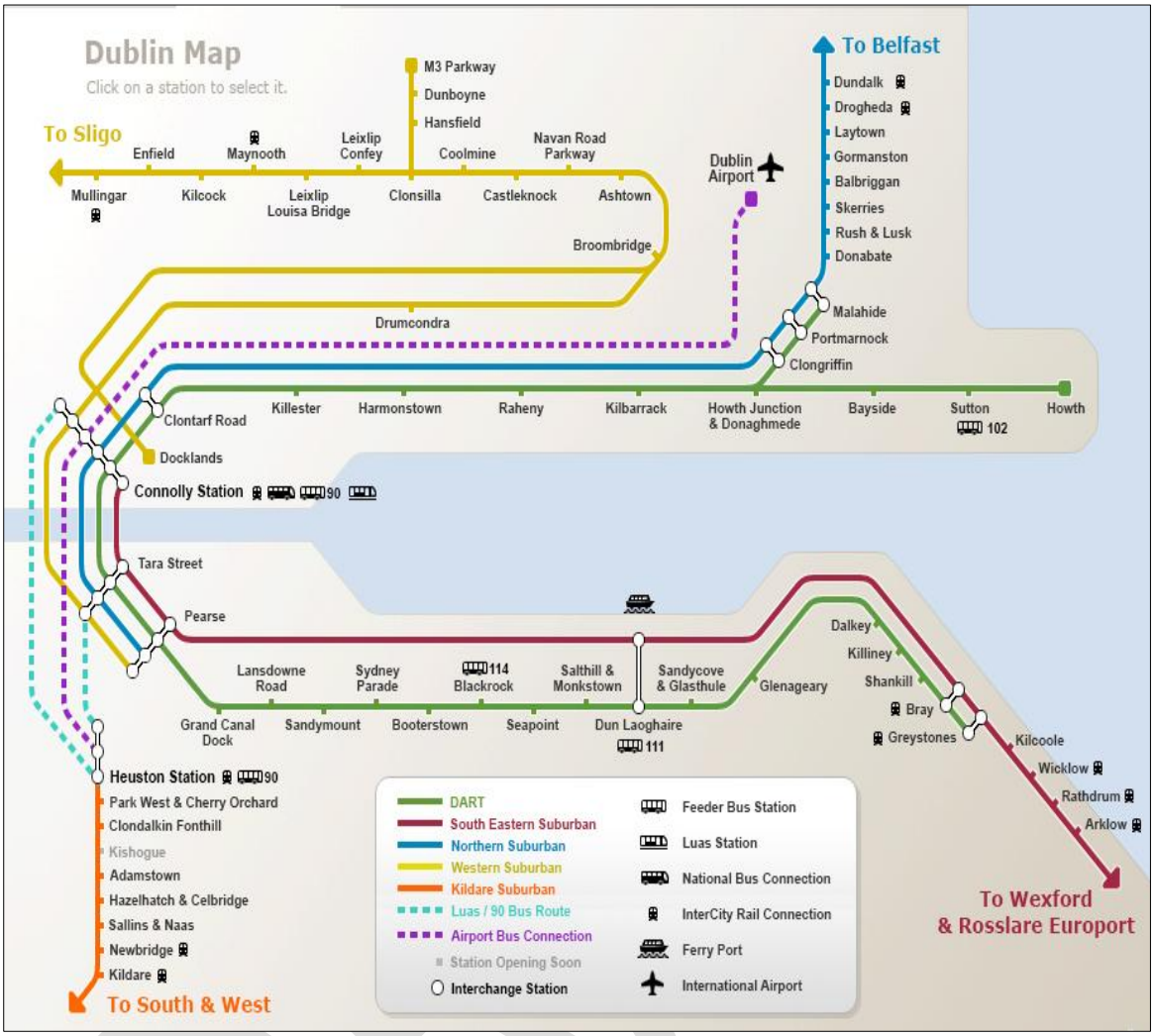
- 30 year time frame
- Costs as per Economic Appraisal
- Additional Fare Revenue (based on fare per kilometre or fare per passenger boarding)
  - DART & Suburban Rail: 13 cents/km (2014 prices)
  - LUAS: 32 cents/km (2013 prices)
  - City Bus: €1.64 per passenger boarding (2013 prices)
  - Regional Bus: €3.84 per passenger boarding (2013 prices)
- Fare revenue growth: 1% (real terms)
- Annual Retail & Advertising Revenue: €500,000 (2014 prices) for both scenarios
- Annual Retail & Advertising Revenue Growth: 1% (real terms)

APPENDIX B – RAIL NETWORK

Current Rail Network in Ireland[49]

[49] *Source: www.irishrail.ie*

Current Rail Network in Dublin[50]



[50] *Source: www.irishrail.ie*

APPENDIX C – SERVICE PLANS

Do Minimum Service Plan

Do Minimum Service Plan	Peak Period Train Type	Number of Services			
		7am-8am	8am-9am	9am-10am	2pm-3pm
DART					
Malahide to Bray – all stops	8-car DART	2	2	2	2
Malahide to Greystones – all stops	8-car DART	1	1	1	1
Howth to Bray – all stops	8-car DART	2	2	2	2
Howth to Greystones – all stops	8-car DART	1	1	1	1
Greystones to Malahide – all stops	8-car DART	1	1	1	1
Greystones to Howth – all stops	8-car DART	1	1	1	1
Bray to Malahide – all stops	8-car DART	2	2	2	2
Bray to Howth – all stops	8-car DART	2	2	2	2
Commuter – Northern Line					
Dundalk to Connolly – all stops to Malahide then non-stop to Connolly	2 x 3ICR		1		
Dundalk to Pearse – all stops to Malahide then Connolly, Tara, Pearse	8 x DMU	1			
Dundalk to Pearse – all stops to Malahide then Connolly, Tara, Pearse	4 x DMU				1

Do Minimum Service Plan	Peak Period Train Type	Number of Services			
		7am-8am	8am-9am	9am-10am	2pm-3pm
Dundalk to Bray – all stops to Malahide, then Connolly, Tara, Pearse, GCD, Lansdowne, Sydney Parade, Blackrock, Dun Laoghaire, Bray	8 x DMU		1	1	
Drogheda to Pearse – all stops to Malahide, then Connolly, Tara, Pearse	4 x DMU				1
Drogheda to Pearse – all stops to Malahide, then Connolly, Tara, Pearse	8 x DMU	1		1	
Drogheda to Pearse – all stops to Malahide, then Connolly, Tara, Pearse	2 x 3ICR	1			
Drogheda to Bray – all stops to Malahide, then Connolly, Tara, Pearse, GCD, Lansdowne, Sydney Par, Blackrock, Dun Laoghaire, Bray	8 x DMU		1	1	
Pearse to Drogheda – Pearse, Tara, Connolly, non-stop to Malahide then all stops	8 x DMU		1		1
Pearse to Dundalk – Pearse, Tara, Connolly, non-stop to Malahide then all stops	4 x DMU			1	
Commuter – Sligo Line					
Longford to Pearse – all stops to Pearse	1 x 6HCR	1			
Longford to Pearse – all stops to Pearse	1 x 8HCR		1		
Maynooth to Connolly – all stops	4 x DMU	2	1	1	
Maynooth to Connolly – all stops	8 x DMU	1			
Maynooth to Pearse – all stops	8 x DMU	1	1	2	1

Do Minimum Service Plan	Peak Period Train Type	Number of Services			
		7am-8am	8am-9am	9am-10am	2pm-3pm
Maynooth to Bray – all stops	8 x DMU		1		
Connolly to Maynooth – all stops	8 x DMU	1	1		
Connolly to Maynooth – all stops	4 x DMU	1	2		
Connolly to Maynooth –non-stop	4 x DMU	1			
Pearse to Maynooth – all stops	1 x 6HCR			1	
Pearse to Maynooth – all stops	8 x DMU		1		1
M3 Parkway to Docklands – all stops	8 x DMU	2	2	2	
Docklands to M3 Parkway – all stops	8 x DMU		2	1	
M3 Parkway to Clonsilla – all stops (Shuttle)	4 x DMU				1
Clonsilla to M3 Parkway – all stops (Shuttle)	4 x DMU				1
Commuter – Cork Line (via Phoenix Park Tunnel)					
Portlaoise to GCD – all stops	8 x DMU		1		
GCD to Portlaoise – all stops	8 x DMU			1	
Kildare to GCD – all stops	8 x DMU	2	2	2	1
GCD to Kildare – all stops	8 x DMU	2	2	2	1
Newbridge to GCD – all stops	8 x DMU		1		
GCD to Newbridge – all stops	8 x DMU		1		
Commuter – Cork Line (to Heuston Terminus)					
Portlaoise to Heuston – all stops	6 x ICR	1	1	1	1

Do Minimum Service Plan	Peak Period Train Type	Number of Services			
		7am-8am	8am-9am	9am-10am	2pm-3pm
Heuston to Portlaoise – all stops	1 x 6ICR	1	1	1	1
Kildare to Heuston – all stops	1 x 3ICR	1			
Newbridge to Heuston – all stops	8 x DMU		1		
Heuston to Newbridge – all stops	8 x DMU	1			
Commuter – South Eastern Line					
Gorey to Connolly – Arklow, Rathdrum, Wicklow, Kilcoole, Greystones, Bray, Dun Laoghaire, Blackrock, Lansdowne, Pearse, Tara, Connolly	8 x DMU	1			
Rosslare to Connolly – Arklow, Rathdrum, Wicklow, Kilcoole, Greystones, Bray, Dun Laoghaire, Blackrock, Lansdowne, Pearse, Tara, Connolly	8 x DMU		1		
Rosslare to Connolly – all stops to Arklow, Greystones, Bray, Dun Laoghaire, Pearse, Tara, Connolly	1 x 3ICR				1
Connolly to Rosslare– Tara, Pearse, Dun Laoghaire, Bray, Greystones, Wicklow, Rathdrum, Arklow all stops to Rosslare	1 x 3ICR			1	
Intercity					
Belfast to Connolly – stopping at Dundalk & Drogheda	7 x DD			1	1
Connolly to Belfast – stopping Dundalk & Drogheda	7 x DD		1		1
Sligo to Connolly – all stops to Maynooth then Connolly	8 x DMU		1	1	1
Connolly to Sligo – Maynooth then all stops to Sligo	1 x 3ICR			1	1
Heuston to Cork – non-stop to Portlaoise	Mk IV	1			

Do Minimum Service Plan	Peak Period Train Type	Number of Services			
		7am-8am	8am-9am	9am-10am	2pm-3pm
Heuston to Cork – non-stop to Portlaoise	Mk 4			1	
Cork to Heuston – No stops in GDA	1 x 3ICR		1	1	1
Heuston to Galway/Westport – Kildare, Portarlington	1 x 6ICR		1	1	1
Galway to Heuston – Monasterevin, Kildare, Newbridge, Sallins	1 x 6ICR		1		
Galway to Heuston – Non-Stop	1 x 3ICR		1		
Galway to Heuston – Portarlington, Sallins	1 x 6ICR			1	
Heuston to Waterford – Newbridge, Kildare	1 x 6ICR		1		
Waterford to Heuston – stopping in Athy, Kildare	1 x 6ICR			1	
Waterford to Heuston – stopping in Athy, Kildare and Newbridge	8 x DMU		1		
Athlone to Heuston – Kildare, Newbridge, Sallins, Hazelhatch	1 x 3ICR	1			
Carlow to Heuston – Athy, Kildare, Newbridge, Sallins, Hazelhatch, Adamstown	1 x 6ICR	1			
Limerick/Tralee to Heuston – stopping in Portlaoise only	1 x 6ICR	1	1	1	
Westport to Heuston – Portarlington, Monasterevin, Kildare, Newbridge	1 x 3ICR		1		

DART Expansion Programme Service Plan

DART Expansion Programme Service Plan	Peak Period Train Type	Number of Services			
		7am-8am	8am-9am	9am-10am	2pm-3pm
DART					
Inchicore to Drogheda – all stops	8-car DART	8	8	8	4
Hazelhatch to Clongriffin – all stops	8-car DART	4	4	4	2
Hazelhatch to Balbriggan – all stops	8-car DART	4	4	4	2
Drogheda to Inchicore – all stops	8-car DART	8	8	8	4
Balbriggan to Hazelhatch – all stops	8-car DART	4	4	4	4
Clongriffin to Hazelhatch – all stops	8-car DART	4	4	4	2
Howth to Howth Junction (Shuttle) – all stops	4-car DART	6	6	6	3
Howth Junction to Howth (Shuttle) – all stops	4-car DART	6	6	6	3
Maynooth to Bray – all stops	8-car DART	6	6	6	3
Connolly to Bray – all stops	8-car DART	2	2	2	1
Maynooth to Greystones – all stops	8-car DART	2	2	2	1
Greystones to Maynooth – all stops	8-car DART	2	2	2	1
Bray to Maynooth – all stops	8-car DART	6	6	6	3
Bray to Connolly – all stops	8-car DART	2	2	2	1
M3 Parkway to Clonsilla (Shuttle) – all stops	4-car DMU	4	4	4	2
Clonsilla to M3 Parkway (Shuttle) – all stops	4-car DMU	4	4	4	2
Commuter – Northern Line					
Dundalk to GCD – all stops to Malahide then Connolly, Tara, Pearse, GCD	8 x DMU	2	2	2	2

DART Expansion Programme Service Plan	Peak Period Train Type	Number of Services			
		7am-8am	8am-9am	9am-10am	2pm-3pm
GCD to Dundalk – GCD, Tara, Pearse, Connolly then non-stop to Malahide then all stops to Dundalk	8 x DMU			2	2
Commuter – Sligo Line					
Maynooth to GCD – all stops	8 x DMU	2	2	2	0
GCD to Maynooth – all stops	8 x DMU	2	2	2	0
Longford to GCD – all stops	8 x DMU	1	1	1	1
GCD to Longford – all stops	8 x DMU	1	1	1	1
Commuter – Cork Line					
Portlaoise to Heuston – all stops to Hazelhatch then Heuston	8 x DMU	1	2	1	1
Heuston to Portlaoise – non-stop to Hazelhatch then all stops to Portlaoise	8 x DMU	1	1	2	1
Kildare to Heuston – all stops to Hazelhatch then Heuston	8 x DMU	3	2	2	1
Heuston to Kildare – non-stop to Hazelhatch then all stops then non-stop to Kildare	8 x DMU	2	2	2	1
Newbridge to Heuston – all stops to Hazelhatch then Heuston	2 x 3ICR		2		
Heuston to Newbridge - non-stop to Hazelhatch then all stops then non-stop to Newbridge	2 x 3ICR	1	1		
Commuter – South Eastern Line					
- *Same as Do Minimum*					
Intercity					
- *Same as Do Minimum*					

DART Underground Project Service Plan

DART Underground Project Service Plan	Peak Period Train Type	Number of Services			
		7am-8am	8am-9am	9am-10am	2pm-3pm
DART					
Inchicore to Clongriffin	8-car DART	4	4	4	2
Inchicore to Malahide	8-car DART	4	4	4	2
Inchicore to Howth	8-car DART	4	4	4	2
Clongriffin to Inchicore	8-car DART	4	4	4	2
Malahide to Inchicore	8-car DART	4	4	4	2
Howth to Inchicore	8-car DART	4	4	4	2
Greystones to Connolly	8-car DART	2	2	2	1
Bray to Connolly	8-car DART	6	6	6	3
Connolly to Bray	8-car DART	6	6	6	3
Connolly to Greystones	8-car DART	2	2	2	1
Commuter – Northern Line					
Dundalk to Connolly – all stops to Malahide then non-stop to Connolly	8 x DMU	1	1	1	1
Connolly to Dundalk – non-stop to Malahide then all stops	8 x DMU		1	1	1
Dundalk to Bray – all stops to Malahide then non-stop to Connolly then Tara, Pearse, GCD, Lansdowne, Sydney Parade, Blackrock, Dun Laoghaire, Bray	8 x DMU		1	1	
Drogheda to Connolly – all stops to Malahide then non-stop to Connolly	8 x DMU	2	1	2	1
Connolly to Drogheda – non-stop to Malahide then all stops	8 x DMU		1	1	1

DART Underground Project Service Plan	Peak Period Train Type	Number of Services			
		7am-8am	8am-9am	9am-10am	2pm-3pm
Commuter – Sligo Line					
Maynooth to GCD – all stops	4 x DMU	6	6	6	3
GCD to Maynooth – all stops	4 x DMU	6	6	6	3
Longford to Pearse – all stops	1 x 6HCR	1			
Longford to Pearse – all stops	1 x 8HCR		1		
M3 Parkway to Connolly – all stops	8 x DMU	2	2	2	
Connolly to M3 Parkway – all stops	8 x DMU	2	2	2	
M3 Parkway to Clonsilla – all stops (Shuttle)	4 x DMU				1
Clonsilla to M3 Parkway – all stops (Shuttle)	4 x DMU				1
Commuter – Cork Line					
Portlaoise to Heuston – all stops	2 x 3ICR	1	2	1	1
Heuston to Portlaoise – all stops	2 x 3ICR	1	1	2	1
Kildare to Heuston – all stops	8 x DMU	3	2	2	1
Heuston to Kildare – all stops	8 x DMU	2	2	2	1
Newbridge to Heuston – all stops	2 x 3ICR		2		
Heuston to Newbridge – all stops	2 x 3ICR	1	1		
Commuter – South Eastern Line					
- *Same as Do Minimum*					
Intercity					
- *Same as Do Minimum*					

Light Rail Service Plans – All Scenarios

All Scenarios	Number of Services in both Directions		
	7am-8am	8am-9am	9am-10am
Red Line			
Red Cow – Connolly	3	-	-
Tallaght – The Point	6	9	6
Saggart – Connolly	3	7	6
Green Line			
Sandyford – Parnell Street	8	14	8
Bride's Glen – Broombridge	6	7	6

Capacities

	Seated Capacity	Total Crush Capacity
Heavy Rail		
DART (8-car)	512	1,382
DMU (8-car)	370	1,321
ICR (3-car)	190	340
HCR (4-car)	262	464
Intercity (DD & Mk IV)	417	747
Light Rail		
Red Line	80	310
Green Line	90	350

All other train sizes are calculated pro rata based on number of cars (carriages)