LINE BXD

CITY/BROOMBRIDGE

OUTLINE BUSINESS CASE

June 2009

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Important Notice

This Luas Line BXD – City/Broombridge Outline Business Case (OBC) has been prepared by RPA for the confidential consideration and use of Government.

Because of the sensitive nature of the information contained in the OBC, the OBC should not be disclosed outside RPA or Government departments. RPA considers the OBC to be an exempt record and therefore not able to be released under the Freedom of Information Act 1997. Premature release of the OBC would, in the opinion of RPA, be contrary to the public interest. It contains:

- commercially sensitive information
- information that was provided in confidence
- advice for consideration by Government
- information relating to the deliberative processes of a public body, and
- information relating to the financial and economic interests of the State.

RPA must be notified upon a request being made for access to the OBC under the Freedom of Information Act 1997, or any other legislation.

1. Executive Summary

1.1Introduction

Development of an extensive Luas network for the Greater Dublin Area is a key element of the strategy for tackling congestion in Dublin, enhancing economic competitiveness and ensuring a sustainable, attractive city.

RPA has successfully delivered the first two lines of this network and is currently constructing three extensions: the extensions of the Red Line to the Point Village in the east and to Saggart in the west, and the extension of the Green Line to Cherrywood.

Although the Luas extensions currently being built will extend Luas to a wider catchment, light rail in Dublin in the absence of Line BXD will remain essentially two discrete lines, rather than a network. There is considerable demand for cross city trips on both the Red and Green Lines. Line BXD will fulfil this need and form the backbone of the future light rail network for the city.

This Outline Business Case (OBC) for Line BXD draws together the many aspects of work undertaken to date on the project including its costs and benefits, demand and capacity, risks and choice of procurement strategy.

The OBC demonstrates that there is a robust economic case for the implementation of Line BXD under a range of different scenarios.

Even with the most pessimistic of economic outlooks where there is no growth in employment or population in the region for decades to come, the benefit to cost ratio (BCR) at 1.26:1 still reveals that the project is worthwhile to society.

Growth in the current employment and population base would improve this BCR further to an impressive 2.46:1 and were Transport 21 to be implemented in full a BCR of 3.02:1 is achieved.

1.2 Background

In late 2004, and based on the early success of the Luas Red and Green lines which had been brought into service that year, RPA prepared a transport case setting out the merits of linking the two lines. This study concluded that the proposal to link the Luas Red and Green lines would be wholly in keeping with the transport and land use policies of the DTO, Dublin City Council and other relevant agencies and bodies for the following reasons:

- the creation of a Luas network;
- the enhanced integration and interchange opportunities;
- the wider trip penetration commensurate with the developing city centre; and
- the changing city centre traffic environment.

In 2005 the Government's 10-year investment strategy for transport to 2015, *Transport 21*, was announced and this incorporated plans to implement seven new Luas lines for Dublin along with two new Metro lines.

The plan included the proposal to extend the Luas Green Line further into the city centre, termed Line BX, and to continue this line to Liffey Junction (Broombridge) where it would interchange with Maynooth railway line services. This latter segment is referred to as Luas Line D.

The importance of integrated public transport in facilitating more concentrated patterns of development, in order to reduce reliance on the car and to achieve more sustainable forms of development, is now firmly reflected in land use planning policies. For example, the Regional Planning Guidelines and the National Spatial Strategy seek to achieve sustainable development and recognise the benefit of linking transport provision with land use development. In addition the plans of the Grangegorman Development Agency to develop a unified DIT campus facility at Grangegorman, which would be served directly by BXD, represent a best practice example of integrated transport and land use planning.

Line BXD represents the 'missing link' in the creation of a Luas network for Dublin with trips between the Luas Red and Green Lines (and their extensions) now made possible through intersecting lines in the city centre.

If Line BXD were postponed the result would be a disconnected terminus in the City centre for the Green Line and also Line F and, rather than a tram network, the city would be left with a series of spurs and branches off the discrete Red and Green Lines.

This would be a fundamental error with significant consequences for the strategic vision for the city's public transport.

Line BXD is also an opportunity to radically enhance the urban realm of Dublin city centre through attractive and sympathetic integration into the streetscape and revised traffic management with greater emphasis on sustainable modes. Luas is ideally suited to such a city centre environment and is very accessible to customers.

RPA is preparing to submit a Railway Order Application to An Bord Pleanála in late 2009. Construction is currently scheduled to commence in 2014 following completion of major Metro North works in the city centre. Having an enforceable Railway Order for Line BXD in advance of the contract award for the main Metro North works is necessary to ensure that elements of Line BXD infrastructure works can be incorporated into that contract.

1.3 Project Definition

The preferred route of Line BXD was selected following detailed assessment including multi-criteria analysis and the consideration of the views of the public and interested parties during the public consultation process.

The proposed route crosses the city centre from the current terminus of the Green line at St. Stephen's Green and provides an interchange link between the Luas Red and Green lines before extending north via Broadstone and Grangegorman to

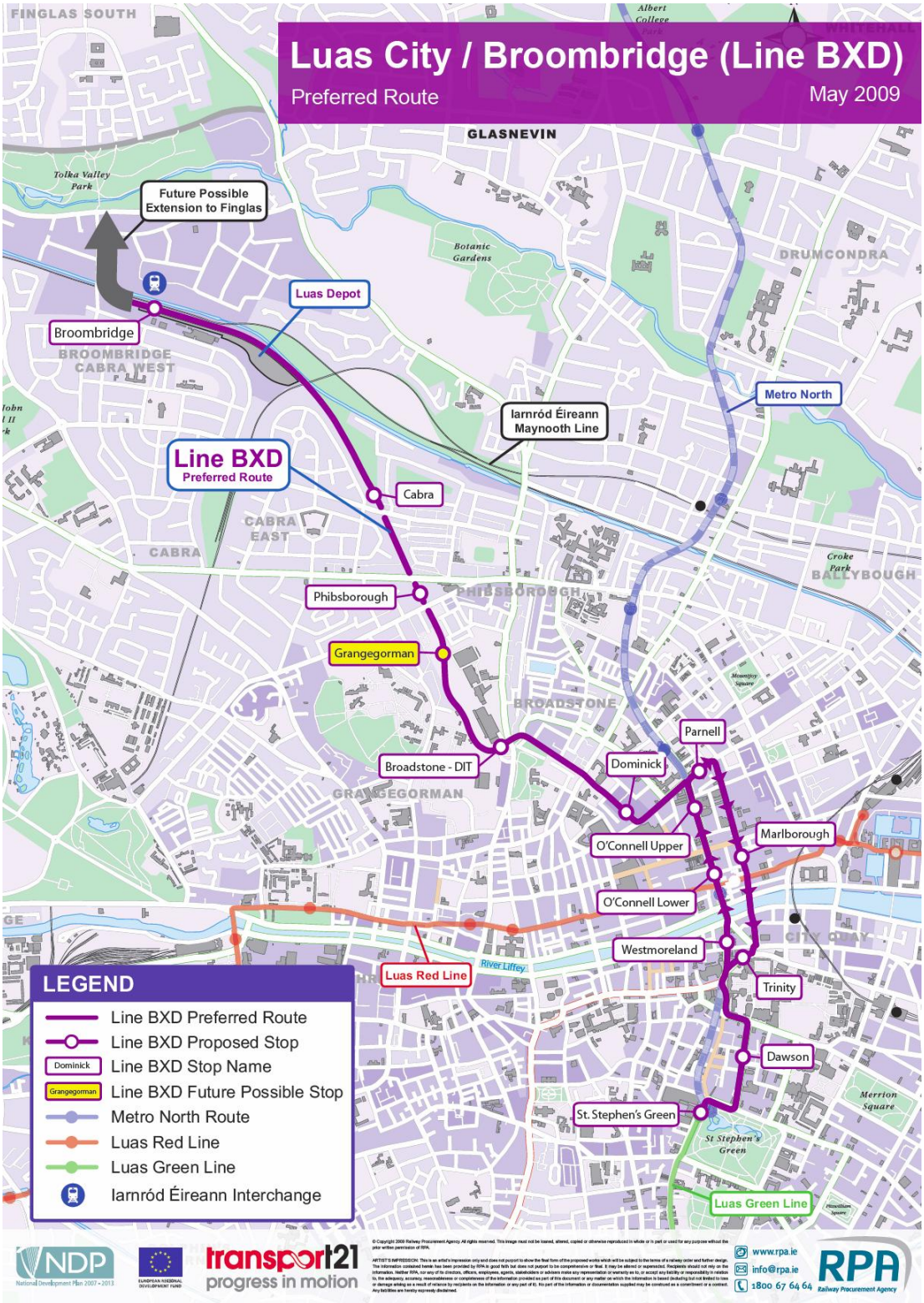
interchange with the suburban rail services at Broombridge station on the Maynooth railway line.

The proposed route of 5.6 km will comprise the essential link that creates a Luas network and will offer interchange opportunities with the planned Metro North scheme at a number of locations.

The proposed route reinstates a transport corridor in the northwest of the city centre along the former Broadstone railway cutting and provides increased access to the communities of Phibsborough and Cabra as well as the planned unified DIT campus facility at Grangegorman. Figure 1.1 overleaf illustrates the preferred route.

The system concept will be similar to the existing Luas system with Line BXD designed to operate as a seamless continuation of the Green Line into the city centre and onwards to Broombridge. There are 13 stops proposed and there will be 3 substations along the line.

Figure 1.1 Line BXD Preferred Route



1.4 Transport Planning

Luas Line BXD is designed to achieve greater penetration of the city area than exists with the present Luas system, with frequent stop spacing, platforms integrated into the streetscape, and high permeability of the city centre. The provision of Luas Line BXD should be considered a critical element in reducing traffic congestion in Dublin city centre.

Within the Luas Line BXD catchment, forecast employment is expected to grow considerably by 2016 to over 200,000 jobs, from the existing base of 135,000.

The demand forecasts indicate that the introduction of Luas Line BXD will add 10 million passenger boardings to the Luas network.

Part of these new Luas passenger boardings come from other public transport modes.

Previously, where a passenger had to transfer between modes to complete his/her journey there is now a direct service available as a consequence of the implementation of BXD.

This generates significant benefits for passengers who are travelling further into the city centre when Luas Line BXD is in place and results in more journeys being made on public transport.

Improved penetration of the city centre impacts on public transport demand. In the case of Luas Line BXD, it generates increased demand over the entire Luas Green Line.

Luas Line BXD's initial capacity, based on 40m long trams at 3 minute headways, will be in the order of 5,000 passengers per direction per hour (ppdph). The ultimate capacity based on 30 no. 53m long trams per hour will be in the order of 8,700 ppdph. When BXD is added, the maximum forecast line flow past any point on the Green Line is 4,229 ppdph, between Dundrum and Balally stops, which is well within the ultimate capacity and allows for considerable future growth in demand.

1.5 Capital Costing

The direct capital cost of Luas Line BXD is estimated to be €204m ex-VAT in 2009 prices.

When direct and indirect costs together with escalation are included the total capital costs amount to €386m ex-VAT.

Construction costs have been escalated at realistic levels over the early years which reflect the current economic climate. This represents a rate varying from 0% to 1.5% for the first 3 years with a 5% per annum rate adopted thereafter.

Escalation accounts for a significant portion of the total costs at €92.61m.

The capital cost estimate includes costs from the date of submission of the application for the Railway Order up to commencement of operations.

The cost of acquisition of CIE lands is not included within the total capital costs of the project as it is assumed that these lands will be made available free of charge to the project.

1.6 Risk

RPA is applying its standard Risk and Value Management Methodology to the BXD project. An initial quantitative cost risk analysis (QCRA) has been carried out to identify and quantify significant project risks and to support the estimate for risk provision in the capital costings. The top project risks are identified under technical, commercial, third party, project management and residual risk categories. They include the complex issues associated with construction of utility diversions in a dense city centre environment; the risks associated with the basements; CIÉ interfaces; and the delays that can ensue; agreements with Dublin City Council; and the risk of delays arising in the course of the statutory consent phase with An Bord Pleanála.

As the project scope is further clarified through the design development phase many of these risk estimates will be replaced by more detailed estimates. The latter will be used in further QCRAs whereby potential out-turn costs and project durations can be estimated with a higher degree of confidence.

1.7 Cost Benefit Analysis

The Luas Line BXD scheme displays strong economic benefits substantially in excess of the costs. The majority of these benefits are enjoyed by the scheme users although there are also benefits to non users of the scheme, i.e. car users benefitting from reduced congestion. The results of the cost benefit analysis (prepared in accordance with Department of Transport guidelines), shown in Table 1.1.1, demonstrate a strong economic case for the project.

Table 1.2 Luas Line BXD Economic Appraisal Results – Discounted to 2002

	Present Value (€m)
Total Benefits	862
Total Costs	350
Net Present Value (€m)	512
Benefit Cost Ratio	2.46:1
Internal Rate of Return	15.2%

The scheme displays an economic benefit to cost ratio of 2.46:1, an internal rate of return of 15.2% and an economic net present value of €512 million in 2002 prices. The scheme therefore represents very good value for money. Scenario testing indicates that the economic worth of the scheme is not particularly sensitive to assumptions regarding related projects going ahead or future employment growth.

There are likely to be significant wider economic benefits associated with the scheme which have not been quantified at this point.

1.8 Project Finance and Cashflows

The projected level of Exchequer grant funding required in nominal terms is €383 million over the period 2009 to 2020, which amounts to 100% of the capital cost of the project.

There is a possibility that a Section 49 Development Levy scheme, if introduced by Dublin City Council, could generate in the order of €5m which would be used to assist the funding of the scheme.

The results also show that Line BXD has an operating surplus in present value terms of €53 million when measured over a 30 year time frame (Table 1.3). Current projections indicate that renewal costs can be covered in full out of operational surpluses and, assuming modest growth, it is unlikely that Exchequer funding in the form of an operating subvention would be required.

Table 1.3 Operating Cash-flows (Present Values)

Cash-flow	€ millions
Total Operating Revenue	244
Total Operating Costs	text deleted
Renewals Costs	text deleted
Total Operating Surplus	**53**

1.9 Procurement Strategy

RPA has reviewed the option of procuring the project on a PPP basis and concluded that this model is not appropriate for Line BXD. The procurement option that best suits RPA's requirements is based on the Luas Line C1 model (Option B, *Client Design-Contractor Build*) adapted for the particular constraints facing the Luas Line BXD project.

This model can incorporate a number of the lessons learned from Luas and allows succession from the original Luas projects in building on the project management pool now in existence. It provides a flexible and balanced approach to risk and may provide marginal savings in the procurement time. It also provides flexibility in dealing with third parties, in particular the utility companies.

Option B is compliant with all procurement rules, can maintain competitive tension and is sufficiently flexible to accommodate legacy infrastructure and systems. It scores less well on private sector innovation, whole life approach, risk transfer and guaranteed delivery in respect of budget. However, because of the constraints and complexities of Luas Line BXD there is little opportunity for private sector innovation and efficiencies.

1.10 Programme and Way Forward

Construction is expected to commence in 2014 and is dependent on the following:

- Receipt of an enforceable Railway Order by end 2010 to allow inclusion of Line BXD works in the Metro North enabling works contract award
- Approval from the Department of Transport to proceed with the project
- Completion of major Metro North construction works in city centre and removal of associated traffic management measures by 2014

Based on a 2014 construction start date for the project, the construction will be completed at end 2017 with operations commencing by mid-2018.

The implementation of an effective and coherent communications strategy will play an essential part in maintaining the support of key stakeholders during the construction phase of Metro North, Line BXD and other projects in the city centre.

2. Background

2.1 Chapter Summary

- The development of an extensive Luas network throughout Dublin has been Government policy for over a decade.
- The first phase of this Luas system has now been delivered and has proven to be very successful with 27.5m passengers using the system in 2008.
- The construction of Luas Lines B1 to Cherrywood and C1 to the Point are well under way and works have commenced on the Luas Line A1 extension of the Red Line from Belgard to Saggart.
- The attractiveness of Light Rail is now clearly demonstrated given the established patronage levels experienced and the rate of development of areas adjacent to existing and proposed alignments.
- Transport 21 proposes extending the Luas Green Line through the city centre and onwards to Broombridge (Liffey Junction) to interchange with suburban rail line services. This new line will for the first time establish a Luas network in Dublin with trips between the Luas Red and Green lines (and their extensions) now made possible through intersecting lines in the city centre.
- Dublin City Council fully supports the realisation of an extended Luas system for Dublin. Other land use plans and policies endorse the implementation of a sustainable rail based mode of transport in the city underpinning the city's economic vitality.
- The Grangegorman Development Agency is a statutory agency tasked with planning and implementing a new education campus for the 22,000 DIT students and associated staff at St. Brendan's Hospital, Grangegorman, together with community health facilities for the Health Services Executive. The Grangegorman Development Agency fully supports the implementation of Line BXD.

2.1 Light Rail in Dublin

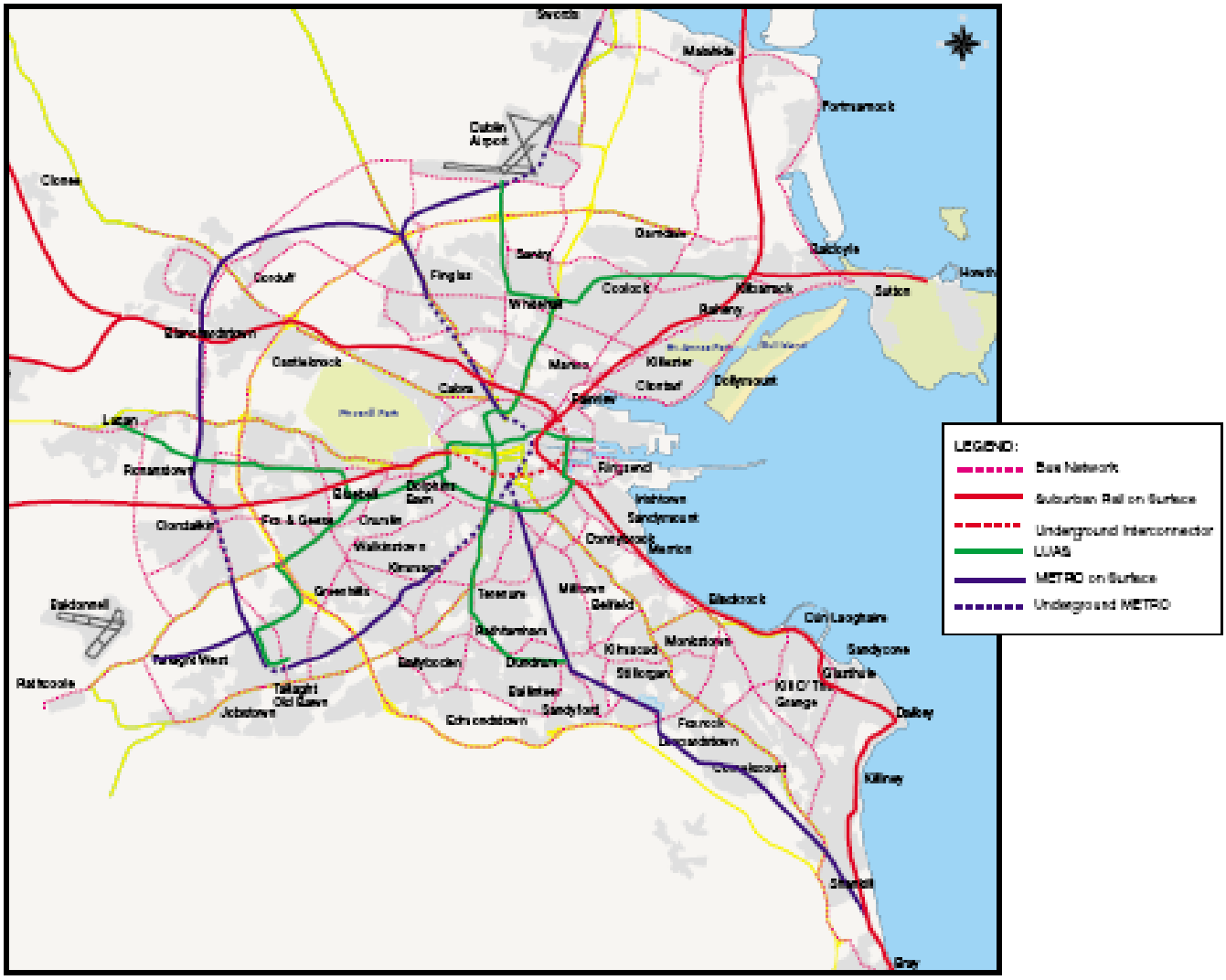
In 2001 construction of phase 1 of the Luas network began and the Luas Green Line between the City Centre and Sandyford opened to passengers on 30 June 2004. The Red Line, which runs from Tallaght to Connolly Station in the City Centre, began carrying passengers in September 2004. Since its introduction Luas has proven itself an attractive and popular means of transport for Dublin and has met and surpassed its projected patronage and financial performance targets since then.

In November 2001 the Dublin Transportation Office (DTO) published *A Platform for Change – Outline of an Integrated Transportation Strategy for the Greater Dublin Area – 2000 to 2016*. This report was an update of the Dublin Transportation Initiative report of 1994 and was developed as a consequence of the unprecedented economic growth and associated traffic congestion experienced in Dublin in the late 1990s. The DTO recognised that the DTI strategy of 1994 had significantly underestimated the growth in population and employment in the city and thus the

transport and land use strategy of the DTI would not now achieve its original objectives.

The DTO strategy recognised the large reliance on private car transport in Dublin and developed a strategy to deliver a viable public transport alternative with the objective of reducing car transport and associated congestion. The DTO strategy identified the need for a Luas network founded on the already planned system and much more extensive than that proposed in the DTI report.

Figure 2.1 A Platform for Change – Rail Proposals



A Platform for Change did not contain a proposal to extend the Green Line through the city centre by means of an on-street light railway. The document instead envisaged a wider on-street Luas network and also a Metro link from Dublin City Centre to Dublin Airport via the disused Broadstone rail alignment. The document envisaged "a new North – South Luas Line from Ballymun via Whitehall, city centre, Harold's Cross, Terenure and Rathfarnham to Dundrum."

However Line BXD is compatible with the principles of *A Platform for Change* and in particular by reducing the need for commuting by car; improving accessibility to the

city centre; promoting sustainable land use and travel; and optimising the use of existing infrastructure.

The 1998 application for a Railway Order by the Light Rail Project Office of CIÉ for a continuous Luas Line from Tallaght to Balally through the city centre had been withdrawn on the grounds of perceived congestion effects that Luas trams would have on other road traffic.

Since that time however environmental traffic cells have been piloted and implemented; banned turns have been introduced to discourage private car movements at George's Street and at Dawson Street; O'Connell Street has been reduced in width by one lane of traffic along its length northbound and southbound; and a HGV ban has been introduced into the city. Other enabling measures implemented by Dublin City Council include the Dublin Port Tunnel from which private cars have largely been discouraged through a high user charge for that class of vehicle, and the Macken Street Bridge which is due to open in early 2010.

Thus the background traffic context since 1998 has changed radically.

In late 2004, and based on the early success of the Luas Red and Green lines which had been brought into service that year, RPA prepared a transport case setting out the merits of linking the two lines. This study concluded that the proposal to link the Luas Red and Green lines would be wholly in keeping with the transport and land use policies of the DTO, Dublin City Council and other relevant agencies and bodies for the following reasons:

- the creation of a Luas network
- the enhanced integration and interchange opportunities
- the wider trip penetration to the city centre and
- the changing city centre traffic environment

In January 2005, RPA conducted a survey of Luas Red and Green line passengers which revealed overwhelming support for the cross city extension of Luas with:

- 35% of respondents stating they would use both lines for their trip purpose
- 30% stating that they would use an extended line
- 31% would use the link to access Heuston and Connolly stations

The attitudinal survey also demonstrated that:

- There is a considerable number of cross city trips being made from the Red Line to/from the South East Inner City (Trinity and St Stephens Green). Recent analysis by the DTO supports this outcome in revealing that the south-east quadrant of the city centre remains the predominant destination
- There is a considerable number of cross city trips being made from the Green Line to/from the Trinity/Grafton and Westmoreland areas
- there is a considerable number of cross city trips being made from the Green Line to/from the North Inner City (O' Connell/Abbey/Jervis and IFSC)

In 2005 the Government's 10-year investment strategy for transport to 2015, *Transport 21*, was announced and this incorporated plans to implement seven new Luas lines for Dublin along with two new Metro lines.

The plan included the proposal to extend the Luas Green Line further into the city centre, termed Line BX, and to continue this line to Liffey Junction (Broombridge) where it would interchange with Maynooth railway line services. This latter segment is referred to as Luas Line D.

2.2 Land Use and Transport Policy

Land use and transport policy at a national level is captured in the *National Development Plan 2007 – 2013 (2006), Transport 21 (2005)* and the *National Spatial Strategy, (2002)*. The *Regional Planning Guidelines Greater Dublin Area 2004-2016 (RPG)*, the *Dublin City Development Plan 2005 – 2011* and other local policies form the framework for development at local level.

National Development Plan 2007 – 2013

The National Development Plan covers the seven year period to 2013 and includes amongst its key themes: the elimination of major infrastructure deficits to improve the quality of life for all; the protection, preservation and improvement of the natural environment with long term sustainable development; commitments on social inclusion; reinforcement of the Regional Planning Guidelines; and adherence to value for money in the implementation of the plan.

Investment in transport infrastructure over the period of the Plan totals nearly €33 billion nationwide, of which €12.9 billion is earmarked for public transport, particularly in the Greater Dublin Area, where the delivery of a radically upgraded and more integrated public transport system in line with *Transport 21* (below) is identified.

Specifically with regard to the urban areas, the Plan notes that it is not sustainable to promote road and car transport as the major long-term mode of passenger transport. The growth in population and employment, together with the environmental imperative to reduce carbon emissions, demands a major modal shift from car to public transport. It is vital, the Plan states, that the workforce has access to reliable and efficient means of transport which is environmentally sustainable.

The Plan reinforces the commitments advanced in *Transport 21* for Luas projects in the Dublin area.

Transport 21 (2006 – 2016)

Transport 21 sets out the Government's 10 year plan for transport infrastructure across the nation amounting to €34 billion of capital investment in roads, public transport and regional airports.

The strategy seeks the provision of an efficient, reliable and sustainable national transport network which would underpin Ireland's economic growth and competitiveness. Environmental and economic sustainability; increased accessibility; increased use of public transport; increases in capacity; and enhanced quality comprise the main aims of the strategy.

Seven new Luas projects are included in Transport 21 along with two Metro projects – Metro North and Metro West.

The seven Luas projects are:

- Extension of the Red Line from Connolly to Docklands
- A spur from the Red Line to Saggart
- Extension of the Green Line initially to Cherrywood and thereafter to Bray
- A cross city Luas link (Line BX) which would subsequently be extended north to Liffey Junction via Broadstone / Grangegorman (Line D)
- A new Luas Line from Lucan to the city centre

Importantly the Transport 21 strategy aims to deliver an integrated, sustainable public transport plan, with a bus network fully coordinated with and complementing the rail network.

Line BXD is an integral part of this strategy and together with the planned implementation of other rail elements of Transport 21 (including the DART Interconnector), offers the opportunity for a radical reconfiguration of the bus network in the city centre.

National Spatial Strategy (NSS) for Ireland 2002 – 2020

The National Spatial Strategy is a 20 year planning framework for Ireland. While not an infrastructural investment plan, the future development of a spatial strategy will be underpinned by a national transport framework to facilitate planning for an improved network of roads and public transport services.

The NSS endorses the principle of increased use of public transport in major urban areas and notes that for balanced development the performance of the Greater Dublin Area be built upon and physically consolidated and that the Greater Dublin Area's vital national role is secured in terms of improved mobility, urban design quality, social mix, international and regional connections.

In particular, the Strategy promotes:

- the continued development of infrastructure connecting Dublin to the regions through an improved network of roads and rail

- the expansion of the transport network to enable interchange facilities between the national transport network and the international airports and sea ports; and

- an increase in public transport and so-called slow (cycling and walking) mode share.

The Regional Planning Guidelines Greater Dublin Area 2004-2016

The Regional Planning Guidelines (RPGs) develop the national policy and strategy outlined in the NSS at a regional and area specific level. The RPG identifies the critical relationship between land use development and infrastructure provision with a key infrastructure element being public transport. The RPG has identified the marrying of development with high quality public transport provision and has taken the principle of the transportation strategy for the Dublin metropolitan region set out by the DTO in 2001 as the basis for regional development and consolidation of the metropolitan region:

…'Development within the Metropolitan Area will be consolidated, with a much-enhanced multi-modal transport system…

The document also states that:

…In the Metropolitan Area, public transportation and other sustainable modes should be given precedence over the requirements of the private car in all relevant policy and decision-making…

Dublin City Development Plan 2005 to 2011

The Dublin City Development Plan 2005–2011 was adopted by Dublin City Council and came into effect in March 2005. The overall vision for the city as outlined in the Plan is to enhance the quality of life and experience of the city for the residents, workers, commuters and visitors and to consolidate the urban form of the city. The Plan looks at the need "to integrate an economic, cultural and social vision, while achieving necessary and sustainable densities within co-ordinating development frameworks". This is to be done in conjunction with improvements to the public transport network.

Chapter 7 of the Development Plan addresses transportation issues within the plan area. Policy T1 states that it is the "*policy of Dublin City Council to support the sustainability principles set out in the National Spatial Strategy, Dublin Transportation Office's 'A Platform For Change' and the Regional Planning Guidelines for the Greater Dublin Area*" and that "*Dublin City Council commits itself to the objective of identifying the specific lands required or likely to be required for the transportation and related infrastructure needs of the city (including but not limited to lands required or likely to be required for new or modified bus routes, cycle lanes, paths, roads, bridges, parking facilities, Park & Ride infrastructure, light rail, rail and metro links) during the period of the next Development Plan from 2011–2017*".

Policy T2 supports a shift from private car usage towards increased use of public transport, non-motorised means of transport and car-sharing and pooling.

Paragraph 7.4.0 states *"Dublin City Council support the measures currently being implemented or proposed by the Rail Procurement Agency, Iarnród Éireann, Dublin Transportation Office and other agencies to enhance capacity on existing lines/services and provide new infrastructure including the extension of Luas to the Point Depot and further extensions to Luas"*.

In addition to the policies that are directly related to Luas Line BXD, a number of general traffic and transport policies are important and have been taken into consideration:

- The traffic management policy recognises the varying needs of the city through the day such as commuter peaks, shopping and business, service and delivery etc.

- In assessing priority, account will be taken of the number of people movements and not exclusively the number of vehicle movements

- It is the policy of Dublin City Council to improve the management and control of traffic in the city to increase accessibility, and to tackle the adverse road safety and environmental impacts of the transport system

- The imposition of increased restrictions on the use of road space, for road works or general construction, [should be undertaken] in accordance with the "Directions for the Control and Management of Road Works"

Dublin City Council also has current plans for the regeneration of the Dominick Street area. Luas Line BXD on Lower Dominick Street will facilitate and encourage this development.

The proposed scheme therefore complies with and supports the policies detailed in Dublin City Council's Development Plan 2005–2011 and is itself endorsed within the Plan.

Dublin – A City of Possibilities; Economic, Social and Cultural Strategy 2002–2012 (2000)

This strategy for economic, social and cultural development was prepared by Dublin City Development Board. It is a ten year strategy and provides a framework for guiding all public services and development activities within the administrative area of Dublin City Council. Its vision is that Dublin city is accessible to all by transport systems that are efficient, safe, affordable, accessible, integrated and that maximise sustainable social and economic development and minimise negative environmental impacts. The Strategy fully supports the implementation of the DTO *Platform for Change* Strategy.

Grangegorman Development Agency

The Grangegorman Development Agency is a statutory body established in 2005 to develop the Grangegorman site for education and health facilities. Over time it will oversee the implementation of a single DIT campus facility catering for 22,000 staff and students currently dispersed throughout the myriad DIT facilities in the city.

The Masterplan for the Grangegorman site is currently being finalised and access to the city centre and the wider region is fundamental to its success. In this respect the Grangegorman Development Agency fully supports the provision of Luas to Grangegorman and the linkages that will flow from an integrated network providing access to large areas of the city and suburbs including connections to the Maynooth railway line services at Broombridge.

2.3 Conclusions

The implementation of the Luas Red and Green lines has proven to be a financial and economic success with passenger demand exceeding forecasts. The construction of further extensions and spurs to Cherrywood, the Point Village, and Saggart, that are currently underway, will extend Luas services to a wider catchment area.

The Regional Planning Guidelines and the National Spatial Strategy all seek to deliver sustainable development and recognise the benefit of linking transport provision with land use development.

Transport 21 builds on the delivery of the Luas Red and Green Lines and seeks to develop a transportation network over the next ten years comprising Luas, Metro, heavy rail and bus. Luas Line BXD is a key part of this network.

Dublin City Council supports Luas BXD and is currently cooperating with the Railway Procurement Agency to deliver this scheme.

The plans of the Grangegorman Development Agency to deliver a unified DIT campus facility will alter in a dramatic manner the northwest inner city area. Dublin City Council plans for the regeneration of Dominick Street will be supported by the implementation of Luas Line BXD on Dominick Street Lower. Strong transport links to these key locations and the rest of the transport system will be important in ensuring their viability. Luas Line BXD will provide this link.

3. Project Definition

3.1 Chapter Summary

- The preferred route of Line BXD was selected following detailed assessment including multi-criteria analysis and the consideration of views expressed by members of the public and interested parties during the public consultation process.
- The proposed route crosses the city centre from the current terminus of the Green line at St. Stephen's Green and provides an interchange link between the Luas Red and Green lines before extending north via Broadstone and Grangegorman to interchange with the suburban rail services at Broombridge station on the Maynooth railway line.
- The proposed route of 5.6km will comprise the essential link that creates a Luas network and will offer interchange opportunities with the planned Metro North scheme.
- The proposed route reinstates a transport corridor at the northwest of the city centre along the former Broadstone railway cutting and provides increased access to the communities of Phibsborough and Cabra as well as the planned unified DIT campus facility at Grangegorman
- The system concept will be similar to the existing Luas system with Line BXD designed to operate as a seamless continuation of the Green Line into the city centre and onwards to Broombridge.
- There are 13 stops proposed and there will be 3 substations along the line.

3.2 Background

The process of identifying the preferred route corridor for the Line BXD project was undertaken in two distinct phases. Public consultation on the Line BX segment of the project between St. Stephen's Green and the city centre commenced in December 2005 after the announcement of Transport 21 and concluded in March 2007 after an extensive period of public and stakeholder input, with the selection of the preferred corridor.

For the remaining length between O'Connell Street and Broombridge, Line D, the public consultation process commenced in September 2008 and a preferred corridor was selected in December 2008.

The assessment of the route options, of which there were six in the case of Line BX and two in the case of Line D, was conducted using multi-criteria assessment with the criteria and sub-criteria framed around the impacts on the environment and quality of life, economy, accessibility, policy and transport integration, and safety.

The potential impact of the scheme on the environment involved assessing the direct and indirect impacts of both users and non-users.

The economy objective is focussed on assessing the degree to which the economic efficiency of transport can be improved through implementation.

Accessibility is related to the ability with which people can reach different locations and facilities by different modes and whether or not this would be impacted upon through implementation.

Integration aims to ensure that all decisions are taken in the context of the Government's integrated transport policy, Transport 21, the City Development Plan and other regional and local plans. The degree to which public and stakeholder support for the various options was forthcoming was also considered.

The safety criterion is concerned with assessing the potential reduction in loss of life and injuries resulting from transport incidents through implementation of the scheme.

The resulting preferred corridors for Line BX and for Line D were those that achieved the highest rating when set against these criteria.

The RPA has concluded that in its consideration of all route options identified, there is no environmental, transport strategy, or economic reasons why the development of the preferred corridor for Line BXD to Railway Order application should not proceed.

3.3 Description of the Chosen Alignment

For ease of reference the geographic setting of the alignment is described in two areas. The first area represents that section of the alignment resting between St. Stephen's Green and the northern extents of the current Broadstone Bus Éireann depot. It is predominantly urban in nature, with the road traffic and pedestrian interfaces typical of an on-street running environment. There is also shared running with road vehicles at some locations. The second area comprises the remainder of the alignment from the bus depot to Broombridge railway station on the Maynooth suburban railway line and runs broadly along the length of the former Broadstone railway. It is a completely segregated track alignment with no road traffic or pedestrian interfaces.

The description of the alignment that follows is set out as one proceeds from the current terminus of the Luas Green line at St. Stephen's Green north to Broombridge, the exception to this being the description of the return loop via Parnell Street – Marlborough Street which follows the opposite direction (i.e. from Parnell Street south to St. Stephen's Green).

Area 1

Line BXD commences at the current St. Stephen's Green stop terminus of the Luas Green Line at St. Stephen's Green West. The existing stop platform will be extended in length to 53m to facilitate the possible future provision of longer trams as demand dictates over time. This extended length is in keeping with the design of all platforms for Line BXD.

From St. Stephen's Green West, the line turns east on to St. Stephen's Green North where a connection will be provided into a single track shunt area east of the Dawson Street junction and on the south side of St. Stephen's Green North. This shunt area will permit operational flexibility in offering the ability, as circumstances may dictate, to turn back trams from the extended Green Line.

The existing westbound road traffic movement on St. Stephen's Green North is to be discontinued under proposals for Metro North. Local access traffic will be permitted

to enter St. Stephen's Green North from Grafton Street and to exit on to Dawson Street at the Dawson Street / St. Stephen's Green North junction. The overhead catenary system on St. Stephen's Green North and St. Stephen's Green West will be supported through a combination of building fixings and lateral poles.

From St. Stephen's Green North the twin track alignment proceeds through the St. Stephen's Green North / Dawson Street junction and enters Dawson Street. Between St. Stephen's Green North and Nassau Street, the northbound (Broombridge direction) track is a shared running surface with road vehicles on Dawson Street. The southbound (Sandyford) track will be shared running with road vehicles between Duke Street and Molesworth Street only.

Dawson Stop is a staggered platform arrangement with the inbound platform located between South Anne Street and Duke Street, and the outbound stop platform sited on the east side of the street between Nassau Street and Dawson Lane.

Facilities for servicing of premises along with provision for bus stops will be retained on the west side of Dawson Street between St. Stephen's Green North and South Anne Street and also between Duke Street and Nassau Street.

The existing taxi ranks on the west side of the street will require to be relocated.
Traffic management arrangements to support the implementation of Line BXD along Dawson Street will be such as to limit road vehicle movements on the street largely to buses, taxis and local access.

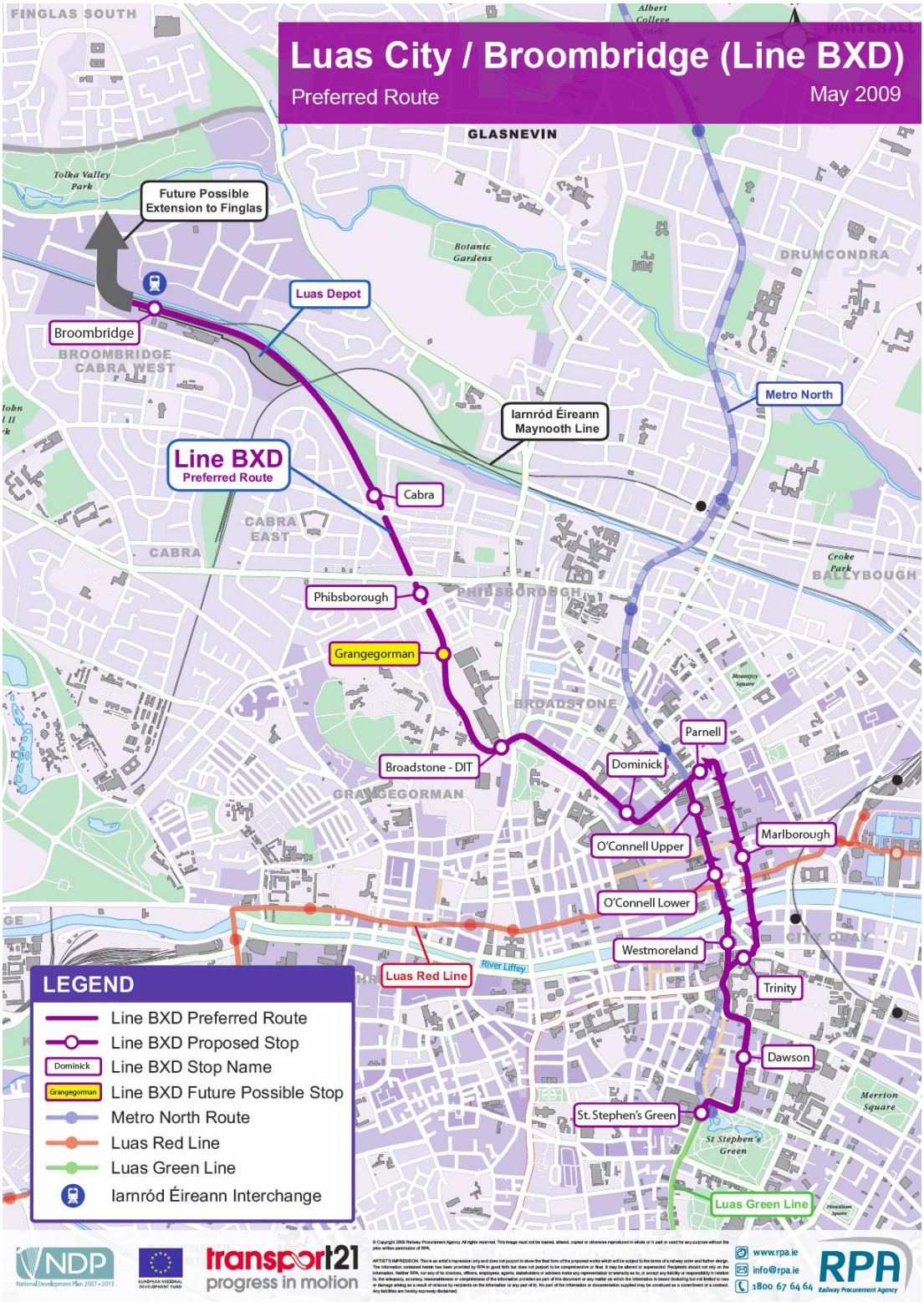
The overhead catenary support system in Dawson Street will mostly comprise building fixings save for the junctions with St. Stephen's Green North and Nassau Street where lateral pole supports will also be provided.

At the northern end of Dawson Street the twin track alignment turns westbound into Nassau Street where there will be shared running in both directions with road vehicles. Pole supports for the overhead catenary will be sited on the south side of Nassau Street with a single pole proposed to be located within the grounds of Trinity College.

At the junction with Grafton Street and Suffolk Street the alignment turns north into the lower part of Grafton Street with other southbound public transport and local access vehicles only sharing the track. The existing inset on the west side of the street accommodating a taxi rank and loading bay will be reduced in length. The bus stops located on the east side of the street will require to be relocated. Pole supports to the overhead catenary will be located on both sides of Grafton Street.

The route then crosses College Green with the northbound track sharing with inbound road vehicles on College Green and the southbound track emerging from College Street and sharing with road vehicles (public transport and local access only).

Figure 3.1 Line BXD Preferred Route



At College Green the twin track splits to form a single track loop arrangement around Westmoreland Street, O'Connell Street Lower, O'Connell Street Upper, Parnell Street, Marlborough Street, Hawkins Street, across the proposed new bridge over the Liffey (being developed by Dublin City Council) and on to College Street back to the twin track at College Green. The route of this single track loop is now described in this manner.

The northbound track crosses College Green and enters Westmoreland Street across the mouth of the junction with College Street. The track will encroach into the traffic island separating College Street, College Green and Westmoreland Street. This traffic island will require to be reconfigured to accommodate the proposed alignment.

On Westmoreland Street the single track occupies a position on the east side of the street passing in front of the Westin Hotel from where the existing taxi rank will require to be relocated in agreement with the statutory authorities. Passing across the Fleet Street junction where a new set of traffic signals will be installed to control traffic and tram movements, the route continues along the east side of Westmoreland Street where the single platform for the Westmoreland Stop will be located. The entrance to the proposed Metro North O'Connell Stop will be conveniently located on the west side of the street. Cantilever poles will support the overhead catenary along Westmoreland Street.

The alignment then crosses Burgh Quay, where measures under the proposed Metro North scheme will involve closure of the right turn into D'Olier Street. The alignment crosses O'Connell Bridge where the centre median will be widened to facilitate pedestrian movements. There will be shared running with road vehicles across O'Connell Bridge. The temporary right turn ban into Eden Quay off O'Connell Bridge to be implemented during Metro North works will be made permanent for BXD.

The alignment then crosses Bachelor's Walk and enters O'Connell Street Lower with the track bed running adjacent to the centre median. There will be shared running with road vehicles on this single northbound track between Burgh Quay and the Spire. The route crosses Middle Abbey Street and the Luas Red Line, where a turnout westbound onto the Red Line will be provided to enable movement of trams from the extended Green Line onto the Red Line for engineering purposes.

It should be noted that this turnout on to the Red Line will not be used for tramway services. Thus it will be a requirement that passengers on a Green Line tram with a destination on the Red Line will be required to interchange between Lines at O'Connell Street / Abbey Street.

A mixture of cantilever poles and building fixings will support the overhead catenary for the single track along O'Connell Street.

The proposed relocation under Metro North of the Luas and ESB underground substations will also incorporate the power requirements of BXD.

O'Connell Lower Stop will be located within the centre median north of Middle Abbey Street and will be conveniently located to provide interchange with the Luas Red Line at Abbey Street Stop and the proposed Metro North O'Connell Stop entrances. The location of this stop will require the removal of two bus stops in this area.

The route continues along O'Connell Street Lower and along the west side of the centre median before entering into the centre median north of the Spire and runs in a

segregated manner removed from the influence of road vehicles. O'Connell Upper Stop will be located close to the Cathal Brugha Street junction. The current right turn into Cathal Brugha Street off O'Connell Street Upper will be prohibited and the centre median widened at this location. The existing taxi ranks on both sides of the centre median will require to be relocated along with some bus stops on the west side of O'Connell Street Upper.

At the north end of O'Connell Street Upper the single track loop continues east into Parnell Street. A junction will be provided here to enable services to move west into Parnell Street and bound for Broombridge and for returning services from Broombridge to enter the single track on Parnell Street and bound for the extended Green Line.

The return single track to the extended Green Line is now described.

On Parnell Street the alignment abuts the northside kerbline and Parnell Stop is located between Parnell Square East and Parnell Place. The existing bus stops along this length will require to be relocated. Building fixings for the most part support the overhead catenary system along Parnell Street.

A new signalised junction will be provided at the junction of Parnell Street and Marlborough Street. The existing right turn movement into Marlborough Street will be prohibited.

The alignment is located on the east side of Marlborough Street and crosses the existing signalised junction at Cathal Brugha Street. It continues along the east side of Marlborough Street for its entire length with bus and car parking requiring removal at locations. A single lane of traffic is provided alongside to facilitate access and bus movements. A new signalised junction will be provided at Marlborough Street / Talbot Street and a one-way only entry into North Earl Street will be implemented. Marlborough Street will be southbound only along its length.

South of Talbot Street, the alignment continues along the east side of the street with Marlborough Stop located adjacent to the junction with Sackville Place and close to the Lower Abbey Street junction. The Marlborough stop will be conveniently located to provide interchange with the Luas Red Line stop at Abbey Street Stop. The bus layover and set down located in this area will require to be removed.

The alignment crosses the Luas Red Line at Lower Abbey Street and then runs along the west side of Marlborough Street as far as Eden Quay. A track turnout from the Red Line is provided to enable movement of trams from the Red Line on to the extended Green Line for engineering purposes.

Building fixings will be the predominant method of support for the overhead catenary along Marlborough Street.

The route crosses Eden Quay and on to the new public transport bridge across the river Liffey being progressed by Dublin City Council. The alignment will run along the centre of the structure segregated from other road traffic with a lane of traffic on either side for southbound bus or taxi movements. It is anticipated that the statutory consents for this bridge will be confirmed by An Bord Pleanála shortly.

The overhead catenary system will be supported by poles suitably placed at either end of the bridge structure.

The alignment then crosses Burgh Quay where a signalised junction will be provided in association with the public transport bridge. It enters Hawkins Street where it runs segregated and along the west side of the street as far as Townsend Street and crosses through the median to enter the south side of College Street where Trinity Stop is located, close to the junction with College Green. The track is segregated on College Street. Existing bus stops on College Street between D'Olier Street and College Green will require to be relocated. The route then meets up with the twin track section at College Green and this completes the description of the looped single track section within the city centre.

The twin track from O'Connell Street Upper to Broombridge is now described.

After leaving O'Connell Street Upper, the twin track alignment runs adjacent to the north side footpath on Parnell Street as far as Dominick Street Lower. Between Parnell Square West and Dominick Street Lower, the alignment occupies the full width of the current eastbound carriageway of the Parnell Street dual carriageway. The remaining westbound carriageway will alter to provide for a single lane of traffic in each direction. Supports for the overhead catenary system on Parnell Street are mostly building fixings with occasional poles as required.

The alignment then turns north into Dominick Street Lower where Dominick Stop is located. An emergency crossover is provided on the north side of the Dominick Stop to permit operational flexibility. The alignment is fully segregated along the length of Dominick Street Lower with an adjacent parallel lane of southbound road traffic provided with some associated parking provision.

The alignment continues along the west side of Dominick Street Lower and crosses Dorset Street into Dominick Street Upper where shared running in both directions is provided as far as Mountjoy Street. The alignment in this area occupies the width of the street.

From Mountjoy Street to Palmerston Place, shared running is maintained in the southbound direction only.

Support for the catenary system on Dominick Street Upper is provided by means of both building fixings and lateral poles.

The alignment then crosses Constitution Hill at-grade. No entry for road vehicles is permitted from Western Way onto Dominick Street Upper or to / from Temple Villas via Dominick Street Upper. A new alternative access road will be provided between Constitution Hill and Temple Villas.

Entering in front of Broadstone the trackbed is in open cut section with Broadstone Stop at road level and accessed off Constitution Hill. A future access to the planned Grangegorman development is provided adjacent to the Luas trackbed in a cut-and-cover section. This will be the access point into the planned DIT campus from the Luas stop pending development of the wider area incorporating a major access to DIT. The BXD proposals for this area are entirely compatible with this longer term vision.

The existing bus access road into the Broadstone Bus Éireann depot is relocated further west to enable passage over the overhead wires.

Beyond Broadstone Stop the alignment then begins to rise and meet with existing ground level within the confines of the existing bus depot and along its western

perimeter. A substation is sited on the west side of the alignment with access provided off the Upper Grangegorman Road.

A possible future Grangegorman Stop will be developed as demand from the future DIT facility materialises. Pedestrian access to this stop will be provided off Upper Grangegorman Road.

The alignment of the proposed scheme now enters Area 30.

Area 2

Between Constitution Hill and the terminus at Broombridge the alignment is completely segregated from road traffic.

From the possible future Grangegorman Stop the alignment proceeds into the railway cutting of the former Midland and Great Western Railway.

It crosses under the North Circular Road and Cabra Roads by means of the existing masonry arch overbridges which are protected structures. Phibsborough Stop comprising two lateral platforms is located between North Circular Road and Cabra Road with stair and lift access into the stop from both streets.

The alignment then continues along the railway cutting and crosses under Fassaugh Road Bridge before coming to Cabra Stop located immediately north of Fassaugh Road. A pedestrian ramp and stairs is provided from Fassaugh Road into the lateral platforms of Cabra Stop.

The alignment proceeds north from Cabra Stop along the old railway alignment to the terminus stop of Line BXD at Broombridge Stop. This terminus stop is located adjacent to the existing Broombridge stop on the Irish Rail Maynooth suburban railway line offering convenient interchange facilities.

A depot is located at Broombridge south of the running lines and provides stabling for a fleet of 20 trams. Facilities include a sand plant, sand silo and tram wash. A substation will also be located in this area as well as a radio mast for communications.

Two pit lanes and a slab lane are provided within the depot shed to enable light maintenance along with associated workshops, stores and offices. It is intended that heavy maintenance activities be undertaken at the existing Sandyford depot.

Staff car parking, a ‘Kiss and Ride’ facility, bus stop / turnaround and taxi set down complete the arrangements.

Support for the overhead line system along the railway cutting and formation is generally provided by means of centre poles between the inbound and outbound tracks north of Cabra Stop and in the depot area. South of Cabra Stop a mixture of centre poles and lateral poles are proposed.

The terminus stop is located in such a position as to allow a future crossing of the Maynooth railway line and Royal Canal to enable an onward extension to Finglas.

This completes the description of the alignment.

3.4 System concept

Line BXD will be designed to operate as a continuation of the Luas Green Line into the city centre and onwards to Broombridge. Some of the critical design considerations for Line BXD include:

- The structures gauge can accommodate vehicles up to 2.4 metres wide. This is similar to what is used on the Luas Red and Green Lines.
- The lateral clearances to the poles and other fixed obstacles are generally consistent with that shown on the Railway Safety Commissions "Guidelines for the Design of Railway Infrastructure and Rolling Stock," with some departures required in the vicinity of the Phibsborough Stop.
- The vehicles will be 100% low floor. The existing Luas Red Line vehicles are 70% low floor.
- A minimum radius of 25 metres is proposed, which is consistent with the minimum radius used to date on the Luas Red and Green lines.
- All the platforms are designed to cater for future generation 53 metre long vehicles.
- The traction system is designed using an overhead contact system of 750 V DC using a tram wire arrangement.
- The substations will each have a capacity of 2MVa
- It is an open system with at-grade crossings on public roads which facilitates integration into the urban environment and local street network.
- Provision is made for ticket vending machines and smart card validators at stops. Respecting the integrity of the historic city centre streetscape, there may be a requirement to limit street furniture at some locations.

In addition provision will be made for control systems, including:

- An automatic vehicle location system. This will automatically monitor the location of trams in service and display their location in a control centre. This can be used as an input into other systems such as a passenger information system and line signalling system and as well as for the monitoring of the operation of the system as a whole.
- A passenger information display system. Such a system is designed to display relevant information for passengers in the trams and at stop locations
- A SCADA (Supervisory Control and Data Acquisition) system to monitor the power supply system and some of the fixed equipment.
- A radio system. This is to provide communication between the control centre and operational staff and also the passengers.
- A video monitoring system and an emergency telephone system at stops. This is to improve passenger security and reduce vandalism.

3.5 Conclusions

A number of route options were identified for Line BX and for Line D. These route options were evaluated against criteria and sub-criteria under the following headings:

- Impacts on the Environment and Quality of Life
- Economy
- Accessibility
- Policy and Transport Integration
- Safety

The preferred alignment for Luas Line BXD was confirmed as the preferred route following a multi-criteria analysis of all feasible routes and taking account of the views expressed by major shareholders and interested parties during the public consultation process.

The chosen route extends the existing Luas Green Line from the current terminus at St. Stephen's Green further into the city centre via Dawson Street, Nassau Street and College Green. At College Green the twin track splits with a single track proceeding north into O'Connell Street where a track turnout with the Red Line will be provided and where interchange with the Luas Red Line is facilitated. The single track continues north on O'Connell Street Upper past the Spire and turns east into Parnell Street before returning towards College Green via Marlborough Street, the proposed new bridge over the River Liffey, Hawkins Street and College Street.

North of O'Connell Street Upper, the twin track to Broombridge routes via Parnell Street, Dominick Street Lower and Dominick Street Upper to Broadstone, where the route crosses Constitution Hill at grade.

The route emerges from the lower level in front of the Broadstone building into the existing Bus Éireann depot and continues along the western perimeter to reach the former Broadstone railway cutting. From here, the route uses the old cutting to travel the remaining length to Broombridge stop terminus where a depot will also be sited.

Approximately half of the total 5.6 km length is on-street with the remainder being segregated from road traffic within the Broadstone site and the old railway cutting.

There are thirteen stops proposed along this alignment at the locations listed below:

- Dawson
- Westmoreland
- O'Connell Lower
- O'Connell Upper
- Parnell
- Marlborough
- Trinity
- Dominick
- Broadstone
- Grangegorman (possible future stop)
- Phibsborough
- Cabra
- Broombridge

Line BXD will extend the Green Line into the city centre providing a convenient, quality public transport service and offering increased accessibility to the city centre and beyond.

It will be the link that creates a Luas network whereby passengers can readily interchange between Luas lines and will provide much needed access opportunities for the planned development of a single campus facility at Grangegorman for DIT. It will re-use the former railway cutting at Broadstone and open up a new transport corridor to the benefit of citizens in Phibsborough and Cabra.

This line will be an attractive and efficient means of public transport for the area and will ensure its sustainable development in the future.

4. Transport Planning

4.1 Chapter Summary

- Luas Line BXD is designed to achieve greater penetration of the city area than exists with the present Luas system, with frequent stop spacing, platforms integrated into the streetscape, and high permeability of the city centre.
- Within the Luas Line BXD catchment, population is forecast to remain reasonably stable up to 2016
- Within the catchment area employment is forecast to grow considerably by 2016 to over 200,000 from the existing base of 135,000, based on current land use forecasts. However based on the current economic situation it is considered unlikely that these strong growth projections will materialise within this timeframe. This being the case, RPA has adopted a prudent approach and undertaken sensitivity tests assuming population and employment remain at 2006 levels to 2018, the year of opening.
- The demand forecasts indicate that the introduction of Luas Line BXD will add 10 million passenger boardings to the Luas network
- Even in the unlikely scenario whereby the 2006 population and employment levels were assumed to obtain up to year of opening in 2018, the introduction of Luas Line BXD will still add 7.5 million passenger boardings to the Luas network
- Part of these new Luas boardings come from other public transport modes where passengers have transferred
- Previously, where a passenger had to transfer between modes to complete their journey there is now a direct service available as a consequence of the implementation of Line BXD
- This generates significant benefits for passengers who are travelling further into the city centre when Luas Line BXD is in place and results in more journeys being made on public transport
- Luas Line BXD complements the Metro network as it performs separate functions
- The initial capacity provided on Luas Line BXD will be in the order of 5,000 passengers per direction per hour based on 40m long vehicles running at 3 minute headways along the busiest section of the route between Broombridge and Sandyford
- The maximum forecast demand generated past any point is 4,229 on southbound services during the AM peak. This peak demand occurs between Dundrum and Balally stops
- The maximum forecast demand on Luas Line BXD infrastructure is 2,324 in the southbound direction between Dawson and St Stephen's Green stops.
- Luas Line BXD will have a positive effect in reducing traffic congestion in the city centre and will result in a significant increase in public transport journeys

4.2 Introduction

In November 2005 the Government announced Transport 21, a ten year national investment programme for transport in the state. Transport 21 seeks to build on the success of Luas and proposes the delivery of extensions to the Luas network and the

delivery of a Metro system for Dublin. Luas Line BXD has been proposed as a northward extension of the Green Line to connect with the suburban rail services at Broombridge. This Luas extension will also provide easy interchange between the Red and Green Luas Lines.

This chapter examines the effect of Luas Line BXD on the demand for public transport and public transport accessibility in the city centre. In order to undertake this assessment, RPA has developed passenger demand forecasts for Luas Line BXD using the RPA multi-modal transport model. This model generates forecasts of future trips on Luas and Metro for a forecast year of 2016, which was the time horizon for the DTO's 'A Platform for Change'. The model takes as an input, forecast population and employment statistics to generate estimates for future trip demand by public transport. RPA has applied this forecast model to generate trips for Luas Line BXD for a base case service pattern as well as two sensitivity tests reflecting different Transport 21 project phasing and growth projections in which BXD may be implemented. The Base Case test forecasts patronage for the future forecast year of 2016.

The resulting forecasts of passenger demand can then be used by RPA to identify required capacity, forecast revenues and service patterns for the proposed scheme.

4.3 Population and Employment Projections

Land use data for the proposed scheme's catchment area (taken as 1km in all directions from the proposed alignment) is used by RPA to develop an understanding of the likely demand for light rail in that area. Population and employment data taken from the 2006 Census carried out by the Central Statistics Office was used in the catchment analysis. In addition to these current Census projections, land use forecasts have been supplied to RPA by the Dublin Transportation Office (DTO) and Dublin City Council (DCC), for the lands in the vicinity of the proposed Luas Line BXD alignment. This demographic data is also used as an input to the RPA forecast demand model.

The walk-in catchment of Luas Line BXD has been taken as a 1km radius from the proposed stops as this is considered an acceptable walking distance to a stop. This is in keeping with the suggested acceptable walking distances for people without mobility impairment as stated in the IHT's (The Institute of Highways and Transportation) "Guidelines for Providing for Journeys on Foot". This guidance document states that a desirable walking distance for commuting is 500m (6.25 minute walk), and the acceptable walking distance is 1km (12.5 minute walk), with the maximum being 2km (25 minute walk).

An assessment of the total number of people in terms of population and employment that fall within the catchment of Luas Line BXD has been developed using a zonal system in GIS. The zonal structure used is largely based on EDs (Electoral Divisions) with disaggregation of these zones around the Luas Line BXD alignment and other public transport. Population and employment densities for each zone are then calculated. Population and employment are assumed to be equally distributed throughout the zone and thus, for any particular area the catchment in terms of people who live or work in the area can be calculated. Based on the walk-in catchment of Luas Line BXD and the population and employment densities, it was possible to determine the total population and employment within the catchment. Figure 4.1 illustrates the resulting catchment area of Luas Line BXD.

Figure 4.1 Catchment area of Luas Line BXD

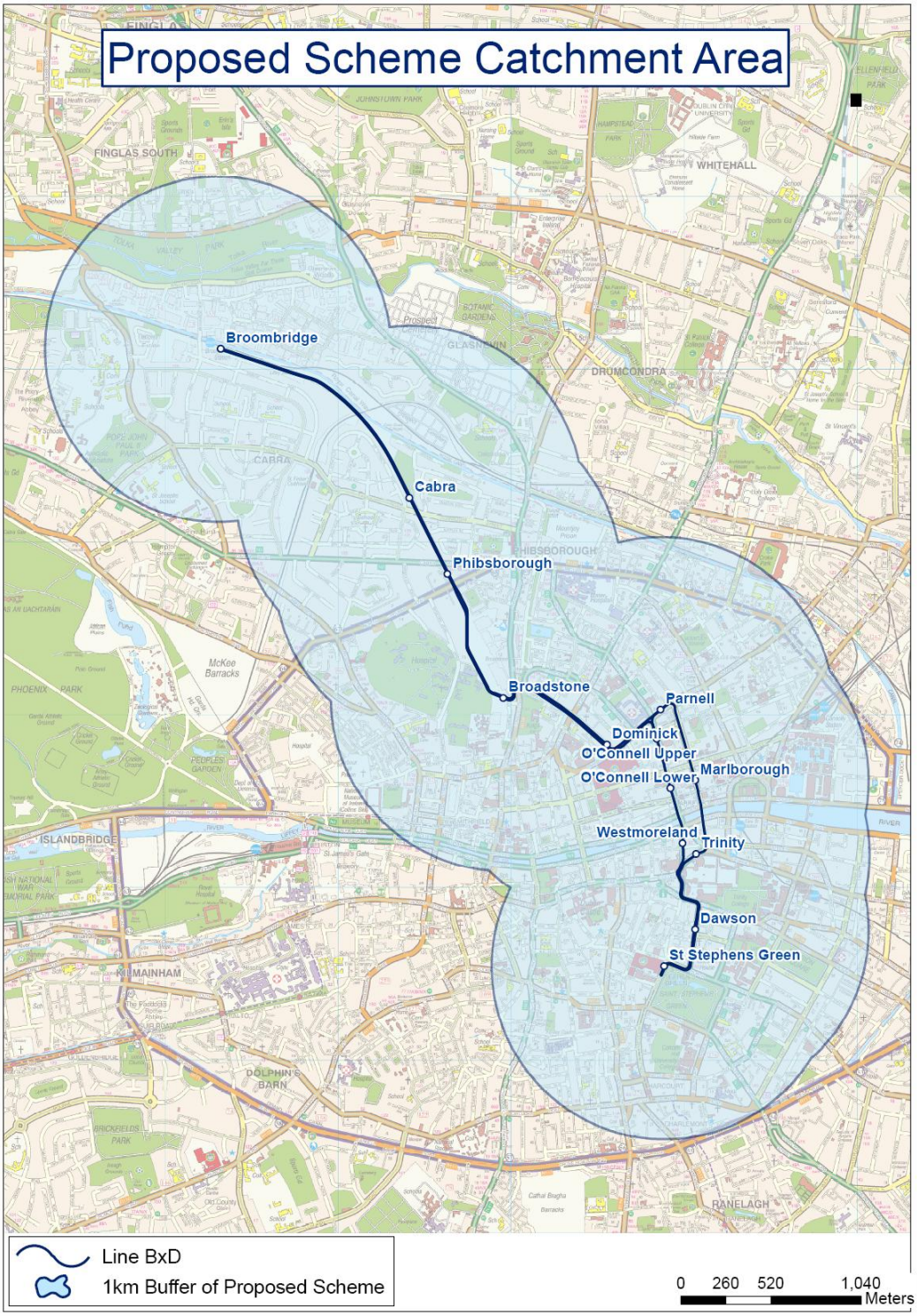


Table 4.1 illustrates population and employment for the catchment of Luas Line BXD. It gives the summarised forecast for both population and employment in the 1km catchment area of Luas Line BXD in 2016 compared to census data from 2002 and 2006.

Table 4.1 Population and Employment

Alignment	2002 Pop*	2006 Pop*	2006 Emp*	2016 Pop**	2016 Emp**
Line BXD	85,496	91,021	135,858	94,353	213,414

*Census figure

** Projected figure

Table 4.1 illustrates that currently (2006 figures), the proposed Luas Line BXD alignment has a catchment of approximately 136,000 jobs and 91,000 people. The future year projections show major growth in terms of employment in the Luas Line BXD catchment, growing to over 213,000 in 2016 compared to nearly 136,000 in 2006.

It is must be noted however that due to the current economic situation these projections are unlikely to be fully realised within the stated timeframe. It is for this reason that RPA has adopted an alternative approach to the demand forecasts which assumes that employment and population remain at 2006 levels throughout the period to commencement of services in 2018. These forecasts have been carried through to the economic assessment undertaken in Chapter 7.

Table 4.1 indicates a total population of 94,353 in 2016 compared to 91,021 in 2006. This shows that the population is forecast to stay reasonably stable in the short to medium term. There is no equivalent data available for employment in 2002.

4.4 Transport Provision and Network Integration

A key contributing factor to the demand for any new public transport service is the degree of integration with other transport infrastructure. 'Transport 21' proposes an integrated transport network which will help to reduce traffic congestion in the city centre and Luas Line BXD is a critical element of this network.

There are currently a number of other transport projects, as identified in 'Transport 21', in various planning and implementation phases, which through integration will have a direct influence on the potential patronage of Luas Line BXD. In addition to these projects there are both existing light and heavy rail lines in operation that will also have an influence on the potential patronage. The key transport projects in this regard are:

- Luas Line B1
- Luas Line B2
- Luas Red Line
- Luas Green Line
- Luas Line C1
- Luas Line A1
- Luas Line F
- Metro North
- Iarnród Éireann Rail Interconnector
- Iarnród Éireann Maynooth Line

- Quality Bus Network Expansion.

Luas Line BXD will provide and enable interchange with the Maynooth railway line and Interconnector rail services, Luas Red line, Luas Line F, Metro North and the Quality Bus Network being developed.

Interchange can be either the physical action of transferring between services or modes as part of the passenger's journey or it can be the physical location that provides access to the public transport system.

Why do people interchange? People interchange either because there is no direct through service or route from their origin to their destination, or they choose to change services or modes in order to take advantage of a more convenient, speedy, or cost effective mode of travel for part of their journey.

Interchange therefore can represent either an inconvenience imposed by the configuration of the public transport network or an opportunity for passengers to take advantage of reduced travel times and/or costs.

In either situation if the quality of the interchange experience is poor, fewer passengers would choose to make the journey by public transport if an alternative mode is available to them.

In the DTO Strategy *A Platform for Change* heavy emphasis is placed on the multiplicity of interchange points on Metro, heavy rail, Luas and bus networks, particularly in the city centre and the flexibility that this presents to the public transport customer. This Strategy envisaged it being possible to make almost all journeys on the public transport networks with no more than one interchange so that journeys on public transport are 'seamless'. If more than one interchange is required to complete a journey it will become significantly less attractive.

The function of Luas Line BXD is to extend the Luas Green Line beyond St Stephens Green and further into the commercial heart of the city centre, as well as to provide a link between the Luas Red and Green Lines. Additionally it will offer interchange with the Maynooth rail line services and provide greater accessibility to the Luas system for communities of the north west inner city and the proposed Grangegorman DIT campus. Luas Line BXD is also the platform for a future extension to Finglas and interchange with Metro West.

In the absence of Line BXD, Luas Green Line passengers seeking to extend their journey beyond St Stephens Green on Metro North would have to interchange and this interchange will not be attractive as it is not a seamless at-grade interchange. In addition Metro North would not provide a seamless link between the Luas Red and Green Lines. To use Metro North to complete a journey between the Red and Green lines is possible but with a requirement for 2 interchanges to travel from one to the other. Additionally, Metro North does not provide a platform for the northward extension of Luas to Grangegorman and Broombridge and beyond to Finglas.

Metro North does not provide the first phase of an expanded light rail network in the city and region. With Metro North delivered in the absence of Luas Line BXD, Dublin would then have:

- two independent Luas Lines (four if Lucan and Liffey junction are included and based on the preferred routes for these lines)
- a Metro Line

- and a separate heavy rail network with all cross city journeys requiring interchange (and generally more than one interchange).

Perhaps a more revealing analogy of the importance of Line BXD to a Luas network is the colloquial reference by Irish Rail / CIÉ to its Interconnector project as representing the 'missing link' in its suburban rail network for the Dublin area. This is because currently and due to the legacy of past independently built and operated railway companies in the country, the option of running suburban / mainline railway services from the Belfast line through the city centre to the Heuston station and the network to the west does not exist. Thus the two city centre mainline railway termini are not linked and flexibility in operation is sub-optimal. By providing the Interconnector linking Connolly with Heuston station, the Greater Dublin network for Irish Rail services is complete. This is no less the case with Line BXD – it represents the 'missing link' for the creation of a Luas network.

If Line BXD were postponed the result would be a disconnected terminus in the city centre for the Green Line and also for Line F and, rather than a tram network, the city would be left with a series of spurs and branches off the Red and Green Lines. This does not satisfy passenger demand nor realise the policy objectives for public transport integration and enhanced interchange policies.

It would be a fundamental error with significant consequences for the strategic vision of the city's public transport.

4.5 Forecast Demand

4.5.1 Inputs and Assumptions

To assess the effect of Line BXD the RPA multi-modal transport model has been applied to a number of specific tests. The first test is called the Base Case. In addition to the Base Case a number of different sensitivities were also tested to provide a rigorous and robust appraisal of Line BXD.

Two different scenarios are also tested - the 'Do Minimum' scenario and a 'Do Something' scenario. The 'Do-Minimum' scenario assumes that the projected land use forecasts are realised without Line BXD included whereas the 'Do Something' scenario includes Line BXD. The difference between one scenario and the other indicates the effect that Line BXD scheme implementation will have on trip making and mode choice.

It has been assumed in the RPA multi-modal transport model that bus speeds will decrease and journey times will increase on certain bus routes that parallel Luas Line BXD. The speeds of buses running along Luas Line BXD between O'Connell St and St Stephen's Green have been reduced to reflect the decrease in road space resulting from scheme implementation and increased congestion on these parallel routes.

Table 4.2 shows the transport inputs used for the base case.

Table 4.2 Transport Inputs for "Do Minimum" and "Do Something" scenarios

Inputs	"Do Minimum"	"Do Something"
Luas Tallaght to Connolly (Red Line)	Yes	Yes
Luas St Stephen's Green to Sandyford (Green Line)	Yes	Yes
Luas Connolly to The Point (Line C1)	Yes	Yes
Luas Sandyford to Bride's Glen (Line B1)	Yes	Yes
Luas Belgard to Saggart (Line A1)	Yes	Yes
Luas Bride's Glen to Bray/Fassaroe (Line B2)	No	No
Luas Stephen's Green to Broombridge (Line BXD)	**No**	**Yes**
Luas City-centre to Lucan (Line F)	No	No
Metro North	Yes	Yes
Metro West	Yes	Yes
Irish Rail Interconnector	Yes	Yes
Dublin Port Tunnel	Yes	Yes
Outer Ring Road	Yes	Yes
Luas P&R	Yes	Yes
DTO Quality Bus Network	Yes	Yes
Integrated Ticketing	Yes	Yes

For the purposes of forecast demand analysis and the economic and financial appraisal that follow for Luas Line BXD, a service pattern has been adopted and modeled that has all services emanating from Bride's Glen and Sandyford in the 'Do Minimum' scenario running to Broombridge in the 'Do Something' scenario. This results in a 3 minute headway in the city centre section.

Table 4.3 highlights the service pattern used in the do-something Base Case.

Table 4.3 Service Pattern for "Do Something" Base Case scenario

	Headway (mins)	
Service Pattern	Peak	Off peak
Interconnector	3.75	7.5
Luas: Tallaght – The Point	6	12
Luas: City West – Connolly	12	24
Luas: Heuston – Connolly	20	-
Luas: City West – Belgard	12	24
Luas: Broombridge – Bride's Glen	6	12
Luas: Broombridge – Sandyford	6	12
Metro North: Belinstown – St Stephens Green	4	8
Metro West: Belinstown – Tallaght	12	24
Metro West: St Stephens Green – Tallaght	12	24
Metro West: Dardistown – Tallaght	12	24

The implementation of a 3 min headway in the city centre between St. Stephen's Green and Parnell Street is a shorter headway than is currently operated on the existing Luas Red and Green Lines. This headway can be operated in a reliable fashion within the current traffic management context. Over time it is expected that further increases in priority will be given to public transport over the private car and we are seeing some positive developments on this front with the planned provision of the Public Transportation Gate at College Green. This will offer the flexibility to reduce the headway further as demand increases.

As the delivery of Transport 21 progresses and the light rail network expands, to ensure efficient operation and flexibility to meet demand requirements alternative service patterns can be introduced which would see some trams turning back at St. Stephen's Green rather than enter the city centre section referred to above. This would provide the operational flexibility to meet demand requirements over time.

4.5.3 Model Results

The demand forecasts for the service pattern described above are presented in Table 4.4. The demand forecasts indicate that the introduction of Luas Line BXD will add 10 million passenger boardings to the Luas network.

A considerable proportion of the new boardings on the system comes from the highway network. This will have a positive effect in terms of traffic decongestion in the city centre, i.e. taking cars off from the highway. The implementation of Luas Line BXD is forecast to reduce the number of car trips by 3 million per annum. The data also demonstrates that part of these new Luas boardings come from other public transport modes where passengers have transferred due to the implementation of Luas Line BXD.

Table 4.4 Model Results Base Case 2016 All Demand (per annum)

	Do Minimum	Do Something	Change from Do Min
Heavy Rail			
Boardings millions	114.6	112.8	-1.8
Bus			
Boardings millions	235.7	232.9	-2.8
Luas			
Boardings millions	76.8	86.8	**10.0**
Metro			
Boardings millions	80.2	74.9	-5.3
Total PT boardings (millions)	**507.3**	**507.4**	**0.1**

The results show a decrease in boardings made on the heavy rail network when Luas Line BXD is introduced. The decrease in boardings is in the order of 1.8 million and is due to some train users transferring to Luas at Broombridge because of the increased permeability of the city centre offered through Line BXD.

The results also show a decrease in boardings made on the bus network when Line BXD is introduced. This decrease in boardings of approximately 2.8 million can be

attributed to bus users transferring over to Luas as some bus routes run parallel to Line BXD. As the proposed Line BXD has a faster journey time and is significantly more frequent than these bus services, there will be a significant amount of bus transfers to Luas. It would seem reasonable that such bus services would be rearranged following the introduction of Line BXD and suggests the need for a re-configuration of the bus network within the city centre area.

As expected there is a decrease in boardings made on the Metro network when Luas Line BXD is introduced. This decrease reflects the fact that some journeys that would previously have been undertaken in the absence of Luas Line BXD by means of a combined Luas and Metro journey would now be replaced by a direct journey on Luas only. This is demonstrated in Table 17 of the appendix.

As outlined in Table 4.5, the more complete public transport network shows a decrease in the number of interchanges required to complete a journey when Luas Line BXD is introduced. As detailed in Appendix Table 4, this table shows a strong decrease in total public transport interchange boardings; where previously two or more boardings were required to complete the journey there is now a requirement for only one boarding.

Table 4.5 Model Results Base Case 2016 Total PT Interchange Journeys (per annum)

	Do Min	Service Pattern 1	Change from Do Min
Total PT interchange journeys	121.2	118.5	-2.7

The overall effect of the introduction of Line BXD reveals a small increase in total public transport boardings. The number of interchanges required to make a journey decreases when Luas Line BXD is in operation as outlined in Table 4.5.

Most importantly there is a significant increase in public transport journeys when Luas Line BXD is included, as outlined in Table 4.6 below. The implementation of Luas Line BXD generates benefits for passengers who are travelling further into the city centre when Luas Line BXD is in place and also due to the further opportunities provided by completion of the light rail network.

Table 4.6 Model Results Base Case 2016 Total PT Journeys (per annum)

	Do Min	Service Pattern 1	Change from Do Min
Total PT journeys	373.7	380.5	6.8

In conclusion, better penetration of the city centre impacts on public transport demand. In the case of Luas Line BXD, it generates increased demand over the entire Luas Green Line and reveals a strong demand for the continuation of journeys on the line further into the city centre than is presently possible.

4.5.4 Comparison of Public Transport Accessibility between Luas Line BXD and Metro North

Within the city centre, the preferred route corridor for Metro North has station locations at St. Stephen's Green, O'Connell Street and at Parnell Square East. In responding to concerns that the chosen corridor for Line BXD through the city centre duplicated that for Metro North, RPA undertook analysis on the effects of such a scenario.

This work concluded that whilst the delivery of Metro North would fulfil some of the functions of Luas Line BX – were Line BX not pursued – it cannot on its own fulfil many of these key functions. The corollary is also true. Indeed this emerges as a result of Metro North and Luas Line BX sharing very few if any common markets.

Luas is being delivered to act as a distributor system with frequent stops integrated into the streetscape, low speed, and high permeability of the city centre. Metro on the other hand is intended more to bring people from the suburbs to fewer stations in the city centre at greater speed and capacity. Luas Line BX will offer great accessibility to mass transit through the city centre. Metro North could act in this role if additional stations were added but this would be at significant cost and in any event is likely to be impractical.

It is also apparent that the delivery of both Luas Line BX and Metro North means that Metro North does not need to deliver this high level of city centre accessibility - this is achieved by Luas.

The analysis suggests that the combined effect of Luas Line BX and Metro North is considerably greater than the achievement of the delivery of one of these projects in isolation. This is in terms of both meeting passenger demand and the performance of specific roles. Whilst the preferred routes might mirror each other in geographic terms over a short common section, there is limited duplication of transport service. Indeed under the emerging route options the only duplication that occurs is the common location of 2 stops, St Stephens Green and O'Connell Street. There are strong merits in serving these locations by both modes in terms of transport interchange and network legibility.

It is also the case that the concentration of interchange at a single 'super' interchange point is not always ideal and the provision of interchange choice through the duplication of stops or routes is common practice on many if not the majority of the world's most successful integrated transport networks. Examples of such systems are London Underground, Paris Metro and Prague tram/metro network. Prague is indeed a suitable example as it is a city similar to Dublin in many respects, not least its population and European capital status.

In the longer term, an extensive network of Luas and Metro is envisioned for Dublin under Transport 21. Line BXD is the essential component for the expansion of the tramway system, in the first instance to Broombridge and Lucan and thereafter to other areas of the city. The provision of Metro North without the delivery of Luas Line BXD would be a fundamental omission in the aspiration towards a Luas network for the city. Thus the provision of Luas Line BXD and Metro North has to be assessed with this longer-term vision in mind.

It is true that in many other cities, metro and light rail lines on the same general route have not been constructed at the same time. However there are examples of many cities which continue to expand their tramway system and metro systems in parallel.

In Dublin this issue has emerged as a result of under-investment in infrastructure over many generations and the city is now seeking to deliver a metro and tram network in parallel.

It is also the case that such an approach could lead to significant issues of construction disruption, traffic management etc. RPA has addressed this through a phased implementation approach to Line BXD with city centre main works commencing only upon removal of traffic management interventions associated with Metro North station works.

A review of the projected numbers of boarders and alighters at the Abbey Stop on the Red Line reveals the effect that implementation of Line BXD has:

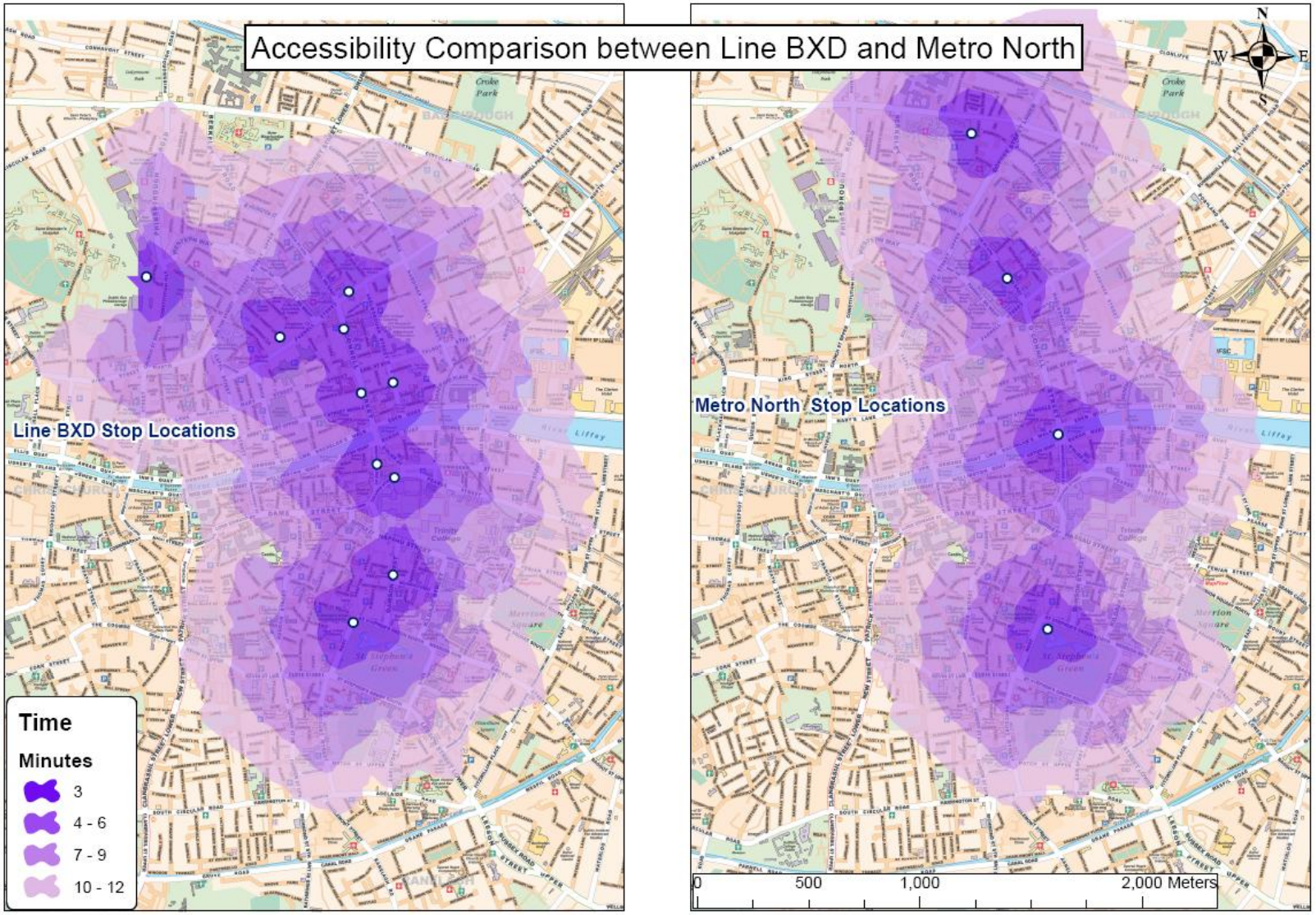
- 1,656 passengers per hour (pph) board at Abbey Stop during the am peak when Line BXD is in place, as against 1,437 pph when Line BXD is not included;
- 1,843 pph alight at Abbey Stop at during the am peak when Line BXD is in place, against 1,683 pph when it is not.

Better city centre penetration increases public transport demand. In the case of Luas Line BXD, it generates increased demand over the entire Luas Green Line.

It can be seen from Figure 4.2 that Luas Line BXD offers much better accessibility to mass transit in the city centre than Metro North alone. With Luas Line BXD the majority of the city centre area from Parnell Street to St Stephens Green would now be within 3 minutes walk of a Luas stop.

Luas Line BXD will provide a high quality and reliable transport service for short and local trips within the city centre area whilst Metro North will cater for longer distance trips associated with more strategic or commuter type travel.

Figure 4.2 Luas Line BXD and Metro North Accessibilities in the City Centre Area



4.5.5 Comparison with existing Luas Patronage

Under the proposed service pattern set out in 4.5.2 above, the results of the modelling analysis show that Line BXD is expected to perform extremely well in attracting passenger numbers similar to or in excess of those currently experienced on the existing Luas lines (Table 4.7 below).

Table 4.7 Line BXD Patronage Comparison with Current Luas

	Patronage (mpa)	Length (km)	Patronage (mpa/km)
Red Line (2008)	14.9	15.1	0.99
Green Line (2008)	12.5	8.9	1.40
Line BXD Patronage (2016)	10.0	5.6	1.78

On a per kilometre basis Luas Line BXD is forecast to be more heavily used than either the existing Red or Green lines (note boardings per route kilometre on BXD are not *directly* comparable to boardings on the Green or Red lines as some of the BXD trips will also use existing Green Line infrastructure).

4.5.7 Revenue

The output of the RPA model also forecasts revenues from fares for the proposed scheme. Table 4.8 shows the additional likely revenue generated on the Luas network as a result of Luas Line BXD implementation. It is assumed that the existing Luas zonal fare system will be adjusted to reflect the greater journey opportunities presented by Line BXD.

Table 4.8 Forecast Revenue per annum Base Case (2000 prices)

	Do Something (2016)
Revenue (2000 prices)	€11.75m

The additional revenue is based on an average yield per customer of €1.25 in 2000 prices. The incremental revenue is higher than what is currently being achieved on the existing Luas system.

It should be noted that the forecast higher yield on Luas Line BXD is due to forecast longer distance trips than on the existing Luas system and the assumption that a distance based fare system (similar to the existing Luas) is used on Line BXD. This means that the longer the trip the higher the fare. The maximum length of trip possible on Luas will be 22km as against 15km currently.

The forecasts presented above for demand and revenue in 2016 have not been adjusted in Table 4.8 by a demand ramp up. A demand ramp up in the early years for the purpose of financial and economic modelling has been included.

4.6 Capacity of Luas Line BXD

Appendix 1 of this document shows the expected 2016 line flows on Luas Line BXD as output by the RPA transport model. It should be noted that the base case assumes that Luas Line B1 is in place and that trams operate between Broombridge and Bride's Glen and between Broombridge and Sandyford. The maximum expected passenger carryings past any point is 4,229 in the southbound direction during the am peak. This peak occurs between Dundrum and Balally stops. The maximum forecast line flow on the Luas Line BXD infrastructure is 2,324 in the southbound direction between Dawson St and St Stephen's Green stops.

The system must therefore be capable of meeting this demand with flexibility for future growth. The initial capacity planned is 20 no. 40m long trams per hour along the busiest section between Broombridge and Sandyford. Based on a capacity of 250 persons per tram this gives an initial capacity of 5,000 passengers per direction per hour. The ultimate capacity is for 30 no. 53m long trams per hour along the busiest section. Based on a capacity of 290 persons per tram this gives an ultimate capacity of 8,700 passengers per direction per hour.

4.7 Sensitivity Testing

To test the robustness of the transport case for Luas Line BXD and give rigour to the appraisal, sensitivity tests were conducted and are as depicted in Table 4.9.

Table 4.9 Transport Inputs for Sensitivity Tests

Inputs	Do Min	Do Som
Luas Tallaght to Connolly (Red Line)	Yes	Yes
Luas St Stephen's Green to Sandyford (Green Line)	Yes	Yes
Luas Connolly to The Point (Line C1)	Yes	Yes
Luas Sandyford to Bride's Glen (Line B1)	Yes	Yes
Luas Belgard to Saggart (Line A1)	Yes	Yes
Luas Bride's Glen to Bray/Fassaroe (Line B2)	No	No
Luas Stephen's Green to Broombridge (Line BXD)	**No**	**Yes**
Luas City-centre to Lucan (Line F)	No	No
Metro North	Yes	Yes
Metro West	Yes	Yes
Irish Rail Interconnector	Yes	Yes
Dublin Port Tunnel	Yes	Yes
Outer Ring Road	Yes	Yes
Luas P&R	Yes	Yes
DTO Quality Bus Network	Yes	Yes
Integrated Ticketing	Yes	Yes

The first sensitivity test examines the impact of Line BXD when it is introduced after all of the public transport projects in the GDA in *Transport 21* have been implemented. This is called the 'Transport 21' scenario. In this scenario the service pattern used results in a 2.5 minute headway in the city centre section due to the increase of tram arrivals at St. Stephen's Green after the implementation of Line B2. The results are depicted in Table 4.10.

The addition of Line BXD in the 'Do Something' scenario adds 12.7 million passenger boardings to the Luas network. This highlights the fact that when more of the projects of Transport 21 are in place prior to Line BXD the impact of Luas Line BXD is greater as the public transport network deficit is bigger prior to its implementation. As the public transport network expands the importance of Luas Line BXD will continue to grow.

Table 4.10 Model Results 2016 - Full Transport 21 Sensitivity Test (per annum)

	Do Min	Do Something	Change from Do Min
Heavy Rail			
Boardings millions	110.1	108.5	-1.6
Bus			
Boardings millions	224.9	222.6	-2.3
Luas			
Boardings millions	116.7	129.4	12.7
Metro			
Boardings millions	81.5	75.9	-5.6
Total Public Transport Boardings	**533.2**	**536.4**	**3.2**

The second sensitivity test is based on the same public transport network and service patterns as the Base Case scenario but with patronage forecast based on the 2006 census population and employment data rather than that projected for 2016. This assesses the effect of there being no growth in population or employment up to year of opening in 2018. The results depicted in Table 4.11 imply that there would still be strong demand for Luas Line BXD in this scenario with boardings on the Luas network increasing by 7.5 million.

Table 4.11 Model Results 2006 – Base Case Sensitivity Test (per annum)

	Do Min	Do Something	Change from Do Min
Heavy Rail			
Boardings millions	81.3	80.4	-0.9
Bus			
Boardings millions	181.8	180.1	-1.7
Luas			
Boardings millions	40.9	48.4	7.5
Metro			
Boardings millions	62.3	58.9	-3.4
Total Public Transport Boardings	**366.3**	**367.7**	**1.4**

4.8 Conclusions

Luas Line BXD is designed to achieve greater penetration of the city area with frequent stop spacing, platforms integrated into the streetscape, and high permeability of the city centre. The provision of Luas Line BXD should be considered a critical element in reducing traffic congestion in Dublin city centre. Within the Luas Line BXD catchment area the population is forecast to remain reasonably stable up to 2016 and beyond; however employment is forecast to grow considerably.

With the Base Case transport inputs, the demand forecasts indicate that the introduction of Luas Line BXD will add 10 million boardings to the Luas network, a decrease in the number of interchange journeys and a significant increase in public transport journeys.

With the full build-out of 'Transport 21' in place prior to the introduction of Line BXD 12.7 million passenger boardings is added to the Luas network when Luas Line BXD is implemented. This highlights the fact that when more of the projects of Transport 21 are in place prior to Line BXD the impact of Luas Line BXD is greater as the public transport network deficit is bigger prior to its implementation. As the public transport network expands the importance of Luas Line BXD will continue to grow.

A further sensitivity test highlights that Luas Line BXD adds 7.5 million passenger boardings to the Luas network assuming 2006 population and employment figures. This highlights that there is still a strong demand for Luas Line BXD in the case where there is no growth in population or employment up to 2018, the year of opening..

The results show in all cases that there is a significant increase in boardings made on the Luas network when Luas Line BXD is introduced. Part of these new Luas boardings come from the other public transport modes.

The number of required interchanges to make a journey decreases when Line BXD is in operation. When Line BXD is introduced there is a significant decrease in total public transport interchange journeys - previously, where a passenger had to transfer between modes to complete their journey there is now a direct service available as a consequence of the implementation of Line BXD.

Most importantly there is a significant increase in public transport journeys when Luas Line BXD is included. The implementation of Luas Line BXD generates benefits for passengers who are travelling further into the city centre and also presents further opportunities for travel afforded by completion of the light rail network.

Line BXD's initial capacity, based on 40m long trams at 3 minute headways, will be in the order of 5,000 ppdph. The ultimate capacity based on 30 no. 53m long trams per hour will be in the order of 8,700 ppdph. The maximum forecast line flow past any point is 4,229 ppdph, which is well below the ultimate capacity provision and allows for considerable future growth in demand.

5. Capital Costing

5.1 Chapter Summary

- The capital cost estimates reflect the current preliminary stage of project definition and development
- Wherever possible the estimates were prepared using cost information available from current projects and existing operations and equipment contracts reflecting the anticipated demand, capacity and works required for Line BXD
- The total capital cost of Line BXD is estimated to be €386 million (including direct and indirect capital costs and excluding VAT). This figure includes escalation.

The capital cost estimates prepared for the purposes of this OBC reflect the current stage of project definition and development and the design information available for Line BXD.

The current cost estimate is based on the project scope as defined in Chapter 3 *Project Description.*

In the preparation of the capital cost estimates the following factors have been considered:

- International market conditions;
- Irish growth and labour rates;
- Industry norms and requirements;
- Historical cost data, cost information from current projects and existing operations and equipment contracts.

5.2 Methodology

5.2.1 Overview

The capital cost estimates were prepared by RPA's internal estimating department. A series of estimate peer reviews has been conducted to ensure consistency of approach, rates and estimating methodology, gap identification and other inputs to compilation of cost estimate.

5.2.2 Basis of Capital Cost Estimate

The capital cost estimates presented in Table 5.1 are based on the current project definition as set out in Chapter 3 *Project Definition*. The unit costs have been derived from historical cost information and from RPA projects currently under construction. Existing contracts have been utilised for pricing rolling stock, ticketing and mobilisation costs. Land and property acquisition costs have been advised by external property valuation consultants. In general, cost information from current projects has not been inflated to arrive at Q1 2009 prices (reflective of the current economic environment) except in instances where there is a specific contractual requirement.

The general assumptions and parameters are summarised below:

- Capital cost estimates have been prepared at Q1 2009 prices and escalated to reflect the current programme
- Capital costs are based on traditional methods of procurement i.e. planning and design by employer followed by issuance of tender following EU Procurement Directives (see Chapter 9 *Procurement Strategy*)
- The construction cost estimate has been incorporated into the financial model with appropriate uplifts for risk/contingency and escalation
- The estimate is based on the preferred route alignment, tram stop locations, structures, depot size and location and interfaces with Luas / Metro North
- The project schedule referenced is Line BXD Railway Order Programme (see Appendix 3)
- The risk allowance is based on a preliminary quantitative cost risk assessment

As the project develops it is anticipated that the estimates will be refined to reflect the evolving design, procurement strategy and contract conditions through a series of estimate reviews and risk, value engineering and value management workshops. Currently the estimates include allowances for the following capital costs:

- The design of Line BXD infrastructure
- The construction of Line BXD infrastructure
- Design, manufacture, shipping to site and installation of all equipment
- Relocation of existing equipment and services
- Testing, commissioning and trial running
- Reasonable stage works
- Rolling stock
- Property and land acquisition (CIÉ land acquisition costs assumed nil)
- Risk and contingency
- Fees
- Project management
- Escalation

The current estimating tolerance is approximately +/- 20-30% based on the level of design information and the knowledge of costs for projects of a similar nature. As the project evolves it is expected that the level of design development will reduce the estimating tolerance at Statutory Approval (FBC) stage to +/-10% to 20%. If the design is sufficiently developed at FBC stage then it is expected that the level of uncertainty will reflect an estimating tolerance at the lower end of this range.

5.3 Results

5.3.1 Total Direct Capital Costs

The direct capital cost estimate for the project is €204.44m (excl. VAT) and is presented in Table 5.1. It is based on the current preliminary project design as discussed earlier in this document.

Table 5.1 Direct Capital Cost Estimates (Q1 2009 €millions)

Cost Categories	Cost
Enabling Works	text deleted
Statutory and Utility Diversions	text deleted
Structures	text deleted
Ticketing	text deleted
Infrastructure – (Civils and Trackworks)	text deleted
Infrastructure – (Mechanical and Electrical)	text deleted
Rolling Stock	text deleted
Depot	text deleted
Land and Property Acquisition	text deleted
Total Direct Capital Cost (Excluding VAT)	**204.44**

Enabling Works

The enabling works consist mainly of direct works utility diversions which must be carried out as part of the project. Direct works utility diversions refer to civil works associated with protecting or diverting utilities away from the swept path of the line. The rates used to price the direct works utility diversions are reflective of the location of the services being protected or diverted (i.e. city centre and suburban). Utility schedules, where available, were utilised when pricing the direct works utility diversions.

Statutory and Utility Diversions

These costs relate to the utility companies' direct costs associated with utility diversions. Utility schedules, where available, were utilised when pricing the utility diversion works.

Structures

The allowances for structures include significant works associated with access to Broadstone. Structures also include works to existing bridges affected by the route alignment and works to existing structures and access requirements in the cutting. The cost estimates do not include allowance for the proposed new public transport bridge across the Liffey at Marlborough Street which is being progressed by Dublin City Council and separately funded.

Ticketing

These costs relate to the purchase, installation and commissioning of ticket vending machines (TVM) and smartcard validators. The estimate is based on costs extracted from the current TVM and Platform Validator Contract.

Infrastructure – Civils and Trackworks

Civil and trackworks include bulk earthworks, boundary works, landscaping, road and footpath works, public lighting, works to existing monuments/statues, modifications to street furniture and protection of existing structures. Allowance has also been made for the supply and installation of track works along the route together with the necessary crossovers and turnouts, spare parts and foundations for the overhead conductor system (OCS). The costs also include the construction of 53m long tram stops and supply/installation of tram stop furniture, construction of substation

structures and remedial/infill works to existing basements. Miscellaneous works such as art provision and power connections to sub-stations and tram stops by the ESB have also been included.

Infrastructure – Mechanical and Electrical

The scope of mechanical and electrical works includes the provision of the OCS system including poles and overhead line equipment (OHLE), power supply including substation fit-out, communications and SCADA systems.

Rolling Stock

Allowance for 19 no. Citadis 402 vehicles has been included in the estimate. Costs per vehicle have been extrapolated from recent contracts for the supply of these 43m long vehicles. The costs also include spares, special tools and training.

Depot

Allowances have been included for the proposed light maintenance depot facility at Broombridge. The scope includes the depot buildings (including mechanical and electrical installations), external works including car parking, wash tank/slab and depot equipment.

Land and Property Acquisition

The assessment of land and property acquisition costs has been undertaken by an external valuation consultant. Land and property take areas have been identified and priced. The potential costs associated with CIÉ lands are excluded from the estimate as it is assumed that these lands will be made available free of charge.

Due to the nature of the project and the current Railway Order programme which envisages construction commencing in 2014, the proposed Railway Order must remain valid over a longer number of years than is normal. However, there is little likelihood of this resulting in any significant degree of planning blight on account of the small amount of private property acquisition necessary for the scheme.

The estimated costs of basement acquisition were based on an assessment of the costs of basement acquisition for the Green and Red lines.

5.3.2 Total Direct plus Indirect Capital Costs

The total capital cost (escalated and exclusive of VAT) amounts to €386.06m.

The total capital cost represents the direct capital cost set out in Table 5.1 above plus the additional estimated indirect capital costs as presented in Table 5.2 below. The indirect costs include the following;

Risk/Contingency

The risk allowance for Line BXD is based on a preliminary quantitative cost risk analysis (QCRA). Experience from other Luas projects, and Line BXD project specific risks identified at a risk management workshop, form the basis for the risks register. A contingency allowance for unidentified risks has also been included in the estimate. For further details, refer to Chapter 6 *Risk*.

Client Costs

Allowances have been included in the estimate for an appropriate level of client cost associated with the various stages of the project lifecycle i.e. Project Definition, RO Preparation, Statutory Approval, Design and Procurement, Implementation and Start-Up. The costs reflect a strategy of in-house design and traditional methods of

procurement (i.e. planning and design by employer followed by issue of tender) following EU Procurement Directives. The costs allow for works to define, approve, design, procure and manage the project from project definition to commencement of operations. Client costs also include insurance, public relations, project management and legal costs during project implementation.

Start Up Costs

These costs include the operator's start up costs, the vehicle maintainer's costs, the infrastructure maintainer's costs and costs associated with the maintenance of ticketing equipment and public relations costs up to the commencement of operations. RPA's client costs associated with supporting the start-up are also included. The estimate for start up costs is extracted from the current operations contract.

Escalation

Allowances for escalation have been included to recognise the impact of inflation on construction and other costs over the construction period. The programme for project implementation foresees construction commencement in 2014. This delay is necessitated by the Metro North stations work in the city centre which will require significant traffic management interventions and which will preclude the commencement of BXD main works until these measures are removed. This has a significant effect on the overall escalation costs of €92.61m.

Reflecting the current economic climate, a realistic assessment of the rate of inflation at 0%, 0% and 1.5% for 2009, 2010 and 2011 respectively has been adopted for each of the cost categories. A figure of 5% per annum thereafter has been applied. The exception to this is in the case of rolling stock, for which a lower inflation rate representing 50% of the above figures has been assumed.

Were a rate of escalation of 5% per annum applied throughout from 2009 (with the exception of rolling stock), the total capital cost would increase to €435.17m (excl. VAT) from €386.06m (excl. VAT).

Table 5.2 Capital Cost Estimates [Total Project Direct and Indirect Capital Costs] including risk/contingency, client costs, start up costs and escalation (excluding VAT) (€ millions)

Cost Item	Cost €m
Total Direct Capital Cost	**204.44**
Risk/Contingency	text deleted
Client Costs	text deleted
Start Up Costs	text deleted
Total Capital Costs (Q1 2009 prices)	**293.45**
Escalation	92.61
Total Capital Costs (Escalated, Excl VAT)	**386.06**

5.4 Variance Analysis (Transport 21 and the OBC Capital Cost Estimate)

A number of changes have occurred to the BXD project scope since it was announced as part of Transport 21 in 2005, leading to a difference in the original T21 cost envelope of €336m (VAT inclusive, equivalent to €295m excluding VAT) and the costs as estimated in this OBC. The significant changes are identified below.

Programme

Timescale for the implementation of the combined Line BX and Line D in Transport 21 was envisaged as being 7 years to delivery in 2012. The current timescale for Line BXD to commencement of operations is 13 years. This extended period to implementation, which is due to a requirement to delay commencement of construction until Metro North construction works in the city centre are complete, has a significant impact on escalation costs.

Route Length

There has been an increase in route length and the track arrangement. The route assumed in Transport 21 was a twin track from St Stephen's Green through O'Connell Street terminating at Liffey Junction. The current preferred route is a combination of a twin and single track arrangement of greater length running from St Stephen's Green through O'Connell Street to Broombridge.

Property Acquisition

No property acquisition was included in the Transport 21 costs for Line BXD. That is not the case in the current capital cost estimate.

Depot

No depot was included in the Transport 21 costs for Line BXD. That is not the case in the current capital cost estimate. A maintenance depot facility is required at Broombridge which will include sand and wash plants.

Structures

No works to structures were included in the Transport 21 costs for Line BXD. That is not the case in the current capital cost estimate – there are significant structures works required at Broadstone and through the cutting.

Tram Stabling

No tram stabling was included in the Transport 21 costs for Line BXD. Stabling for 20 trams has been included in the current capital cost estimate.

5.5 Conclusions

Capital costs are preliminary and consistent with conceptual design and project definition at this stage of project development. Wherever possible the estimates were prepared using cost information available from current projects and existing operations and equipment contracts and reflect the anticipated demand, capacity and works required for Line BXD.

The capital cost of Luas Line BXD is estimated by RPA to be €386.06 million (escalated, excl. VAT).

It is anticipated that value engineering studies and further design development may result in cost savings which at this point in time cannot be quantified due to the preliminary status of the project definition.

6. Risk

6.1 Chapter Summary

- RPA is applying a formal Risk and Value Management Methodology in line with current DOF guidelines and other sources of best practice
- This OBC is supported by RPA's standard risk analysis covering both operational risks and contractual risks including opportunities
- RPA is preparing project costs and schedules on a risk adjusted basis for capital and operating expenditure using quantitative cost risk analysis (QCRA)
- The main project risks are identified under technical, commercial, third party, project management and residual risk categories
- In accordance with the traditional procurement approach recommended (Chapter 9), design risks are owned by RPA and construction/implementation risks are owned by the main contractor, unless otherwise defined

6.2 Background

The successful implementation of any major project requires formal risk and value management. Key commercial decisions should be supported by a comprehensive risk analysis covering both operational risks and contractual risks. This analysis should be clear about what the significant project risks are; what the potential impact of these risks could be on project objectives; who is best able to manage each category of risk; and what procurement strategy and risk mitigation strategy will deliver best value for money.

Risk assessment is therefore a key component of project appraisal. Project costs are being prepared on a risk adjusted basis, both for capital and operating expenditure. The project programme is also being prepared on a risk adjusted basis using lessons learned from similar RPA projects. RPA uses risk identification workshops and quantitative risk analysis to help identify the top project risks and to quantify their likely impacts.

This chapter outlines the work done to date on risk assessment. As the project progresses through design development phases additional data will become available which will help RPA to quantify the impact of these risks on project objectives with greater confidence.

6.3 Work completed to date

6.3.1 Risk Identification

RPA has carried out a review of risk registers from similar projects at the OBC phase to help ensure that no risks are overlooked and that the potential cost impacts are justifiable. RPA has also held a number of risk workshops and risk quantification meetings on the Line BXD Project to identify and evaluate project specific risks. A formal Value Management procedure is also being applied to help clarify the potential impact of risks and key stakeholder issues on project objectives.

The identified risks can broadly be categorised and summarised into the following five categories in order of potential cost impact:

- Technical risks:

    a) Design or scope development risks. As the project evolves through the design phase and detailed surveys are undertaken, further clarity is brought to the project scope. This can result in some changes such as amended trackwork, increased road reconstruction, enhanced paving treatments, additional basement acquisitions or protection works, etc.

    b) Utility diversions in the city centre are very complex. Advance non-invasive radar mapping of underground services assists in providing a fuller understanding of their extent. However, at implementation stage it is generally the case that the difficulties of working in a confined street space combined with the density of services results in further works that cannot be foreseen at this early stage of project development.

    c) Fassaugh Road Bridge, although of a more recent vintage than the bridges at Cabra Road and at North Circular Road, which are Protected Structures, is in poor condition and may, depending upon the outcome of detailed structural assessments, require significant remedial works.

    d) Systems, including testing and commissioning. The traditional procurement approach (client design / contractor build) recommended in Chapter 9 of this OBC does not extend to the systems works which would be under a design-build arrangement. Interfaces with the existing systems and the works of the infrastructure contractor are complex.

    e) Ground conditions particularly in the area of Broadstone (a bus depot) and close to the Maxol service station on Constitution Hill, where the risk of contaminated land is high.

    f) Enabling works. There are a significant number of basements along the BXD corridor, many of them associated with Protected Structures. The extent of acquisition, filling or protection is as yet unknown.

    g) Rolling stock risks associated with new vehicles and operational disruption

- Commercial Risks

    a) Funding

    b) Market appetite

    c) Property acquisition – including basements

    d) Contractual risks

    e) Insurance risks

- Risks relating to third parties

    a) CIÉ – in particular the issues around Broadstone which is a Bus Éireann and Dublin Bus depot setting; along the railway cutting where acquisition costs of CIÉ land are not included in the capital cost (but are accounted for in the CBA); and at Broombridge where there are interfaces with the Maynooth Railway Line.

    b) Maxol Service Station potential acquisition. The at-grade solution adopted for the crossing of Constitution Hill from Dominick Street Upper into the Broadstone environs may require acquisition of the Maxol service station.

    c) Dublin City Council – e.g. lane closure charges; parking bay removals; delayed approvals etc. The process of seeking approvals and consents from Dublin City Council at all stages of project development and implementation has generally led to delays in project progression.

    d) An Bord Pleanála (ABP) – planning uncertainty, potential for scope change. Recent communications with An Bord Pleanála on the BXD project have revealed an onerous requirement for significant additional studies as part of the statutory consents phase. The delays with the Metro North oral hearing are also of concern.

    e) Demand - the risk that fewer people will want to travel on Luas than forecast, or that the revenue from those people will be lower

    f) Betterment gains (opportunity)

    g) Other (e.g. environmental impacts, legal etc)

- Project Management risks

    a) Programme delays

    b) Metro North construction delays would directly lead to delays in BXD project implementation.

    c) Railway Order (RO) – delays or errors and omissions in formal documentation

    d) Quality – inadequacies in systems or documentation; control failures; non-compliances; levels of finishes etc.

    e) Safety – Operator delay in completing Safety Case leading to delay to testing and trial running; uncertainty relating to new works assessment; co-ordination risks between project supervisors design process (PSDP) and construction stage (PSCS).

    f) Construction – access restrictions; shared access risks; contractor performance / default; working hours restrictions etc.

- Residual risks

    a) Operator risks

b) Lifecycle risks (including residual contractual risks) - over the life of the project the risk that equipment may need replacing earlier than expected, or may be more expensive to replace

c) Operations and maintenance - risks that operating costs may be greater than estimated or operating performance may be below employer requirements.

RPA has a dedicated health and safety team to manage health and safety risks in parallel with the commercial and contractual risks discussed above. Designer risk assessments are carried out at each design phase to ensure that the formal risk management methodology is applied. A senior Health and Safety Manager has also been appointed to oversee this element of the project.

As part of its Enterprise Risk Management (ERM) process, RPA maintains a formal Corporate Risk Register to help manage non-project specific risks such as demand and funding risks.

Other risks which cannot be readily estimated include effects of the new mandatory GCCC form of contract; health and safety hazard risks; and inherent uncertainty of cost estimates at this initial stage of the project. These are included in the contingency estimate.

6.3.2 Risk Evaluation

RPA has used the data from previous similar risk registers and relevant lessons learned to test the Project Risk Register for adequacy and completeness. The risk provision in each risk category is evaluated using three point estimates of potential cost impacts. These data were used in risk simulations to run the QCRA. This QCRA has identified the expected value (probability times cost impact) of the top project risks as listed above.

The early assessment of risk has been taken into account in the OBC in the following manner:

- The capital cost estimates in Chapter 5 Capital Costing include a risk allowance for all identified and quantified risks
- The capital cost estimates in Chapter 5 also include a contingency allowance
- Insurance costs have been included in the capital cost and operations costs estimates for insurable risks

6.3.3 Risk Control

Typical mitigation actions for each of the categories are summarised below from the project risk register. Initial risk response plans are being prepared for each of the identified risks. Many of these actions are integrating lessons learned from previous projects.

- **Technical risks**

  a) Implement a rigorous change management procedure
  b) Implement design freeze

c) Secure timely agreements with approvals agencies
d) Agree and clarify design levels and standards
e) Carry out formal value engineering
f) Carry out regular design risk reviews
g) Specify minimum design and approvals periods
h) Agree deliverables lists
i) Conduct thorough site investigations

- **Commercial Risks**

a) Enforce standard Procurement and Contract Management procedures
b) Pre-qualify contractors
c) Include contingency plans in contracts e.g. early access provisions

- **Risks relating to third parties**

a) Manage relationships with third parties
b) Ensure CPO land requirements are adequate
c) Negotiate early agreements with land owners
d) Negotiate early agreements on betterment credits with utility owners
e) Ensure compliance with current regulations

- **Project Management risks**

a) Issue Project Execution Plan to all staff
b) Manage interfaces
c) Apply formal Risk and Value Management procedure
d) Use stage-gate reviews to verify progress on plan
e) Use Earned Value to indicate cost and schedule performance

- **Residual risks**

a) Early agreement of roles and responsibilities with operator
b) Consider contractual agreement between operator and contractor
c) Carry out whole life cost evaluations of tenders
d) Review demand forecast and include sensitivity analysis

6.3.4 Risk Review

Risks will continue to be reviewed, monitored and controlled by the RPA using regular management meetings and workshops in accordance with the Project Risk Management plan. The purpose of these reviews is to assess and validate progress on mitigation actions and identify any new or increasing risk trends. RPA uses standard project dashboards and trend reports to alert management to areas of increasing risk and record progress on mitigating actions. These reports also include a list of the top risks that are most likely to affect both the project end date and the out-turn cost so that management can make informed decisions to mitigate the likelihood of delays and cost over-runs and to justify draw-down of contingency funds if required.

6.4 Risk Allocation

As this project is recommended to be let under the traditional procurement approach (Chapter 9), the project design is being carried out by RPA, and therefore all design risks are carried by RPA unless otherwise defined. Construction and other implementation risks are to be carried by main contractor. Risk ownership is defined for each identified risk on the risk register.

6.5 Conclusions

RPA is applying its standard Risk and Value Management Methodology. An initial quantitative cost risk analysis (QCRA) has been carried out to identify and quantify the top project risks and to support the estimate for risk provision in the capital costings.

As the project scope is further clarified through the design development phase these risk estimates will be replaced by more detailed estimates. The latter will be used in further QCRAs whereby potential out-turn costs and project durations can be estimated with a higher degree of confidence.

7. Cost-Benefit Analysis

7.1 Chapter Summary

- Line BXD project displays a very strong economic case
- The economic benefit of the scheme is substantially greater than the costs, with the project displaying a benefit to cost ratio (BCR) of 2.46:1. The value-for-money case for the project is not significantly altered by the inclusion of Dublin Bus estimates of operating cost and revenue dilution impacts during the construction phase. Including such impacts reduces the BCR to 2.15:1
- Scenario testing demonstrates that the economic case for the project is resilient and it retains its value-for-money even assuming the most pessimistic demographic scenario of no growth in population or employment over 2006 levels.
- Scenario testing also indicates that the benefits of the scheme will be significantly enhanced following extension of the Luas network as planned under Transport 21.
- The majority of these benefits are enjoyed by the scheme users, and in particular cross-city Luas travellers achieving quicker and more convenient journeys without the need for multi-interchange
- Non-users of the scheme also experience benefits through a reduction in the number of car trips
- Traditional cost-benefit analysis does not take account of wider economic benefits (WEBs) which are now known to exist and are likely to be particularly significant for Line BXD due to the project's location serving Dublin city centre

7.2 Approach

The RPA multi-modal transport model has been applied to develop forecasts of patronage, user and non-user time benefits and revenue for 2016 as a result of Luas Line BXD. These outputs were then monetised, discounted and summarised according to the economic appraisal methodology and compared with the full discounted costs of the scheme over a thirty year appraisal period to give an indication of the economic worth of the project.

The 2016 forecasts of additional Luas patronage and revenue are outlined in Chapter 4. The transport and modelling assumptions which have a bearing on the economic outcome of the project are summarised below in Table 7.1.

Table 7.1Transport and Modelling Inputs

Input	Do minimum	Do Something
Luas Tallaght to Connolly (Red Line)	Yes	Yes
Luas St Stephen's Green to Sandyford (Green Line)	Yes	Yes
Luas Connolly to The Point (Line C1)	Yes	Yes
Luas Sandyford to Bride's Glen (Line B1)	Yes	Yes
Luas Belgard to Saggart (Line A1)	Yes	Yes
Luas Bride's Glen to Bray/Fassaroe (Line B2)	No	No
Luas Stephen's Green to Broombridge (Line BXD)	**No**	**Yes**
Luas City-centre to Lucan (Line F)	No	No
Metro North	Yes	Yes
Metro West	Yes	Yes
Irish Rail Interconnector	Yes	Yes
Dublin Port Tunnel	Yes	Yes
Outer Ring Road	Yes	Yes
Luas P&R	Yes	Yes
DTO Quality Bus Network	Yes	Yes
Integrated Ticketing	Yes	Yes

In keeping with the RPA approach to project appraisal, only projects that are committed or highly likely to proceed are included in the assumptions for the project. Generally a scheme that performs well under such conservative assumptions is likely to do at least as well in reality.

The Common Appraisal Framework requires that an assessment of the disbenefits arising during the construction phase be carried out. In previous discussions Dublin Bus provided RPA with their estimate of the impact on their operations during the construction phase. This is given below:

- Revenue dilution: text deleted
- Increased operating text deleted

Dublin Bus assumes that an additional text deleted will be required to produce the same level of bus service currently existing in the Dublin CBD due to the construction of BXD, at a cost of text deleted

Although RPA agrees with the principle of including impacts during the construction phase in cost-benefit analysis, there is no independent analysis of how Dublin Bus services will be affected and indeed how they should be adjusted in response to and during the construction of BXD. It is also unclear whether both revenue impacts and operating cost impacts should be included, given that the impact on operating costs that has been provided by Dublin Bus assumes that services are maintained in the area during construction, suggesting any revenue loss would be minimised.

In addition it should be pointed out that there is no accepted mechanism for incorporating the impacts on other public transport operators either, such as private bus operators and taxis. In the absence of any independently validated data or guidance on dealing with this issue, RPA has decided to include these estimates as provided by Dublin Bus as a sensitivity test, although in the opinion of RPA they overstate the likely impact on the bus operator.

The revenue dilution figure and the increased operating cost figure together amount to text deleted. RPA has assumed that Dublin Bus operations will be impeded in the city centre area for a period of two years, and on this basis has increased the operating cost impact by text deleted for each of these years in the cost-benefit analysis. In addition we have included a cost impact of text deleted for each of two years during the construction ramp-up period during which there may be some impact on Dublin Bus operations.

7.3 Economic Appraisal

RPA carried out an economic appraisal of Luas Line BXD based on the results of the model scenarios and the estimates of capital and operating costs of the scheme. For the economic appraisal it has been assumed that:

- The scheme opens on 1st June 2018
- The evaluation period is 30 years
- The discount rate is 4%

Arising from a recommendation made in an audit of a previous RPA business case, RPA now adopts a more conservative approach to the treatment of demand over the appraisal period. Model run results for 2016 were used to give the patronage and benefit levels for the duration of the appraisal period, i.e. there was no growth in demand beyond 2016 assumed. This is a conservative assumption as in reality it is likely that general economic growth over the appraisal period will lead to an increase in demand for trips to and within the city centre, which is the market served by Line BXD.

The capital, operating, maintenance and renewal costs of the project over the appraisal period have been calculated by RPA and are summarised below. These costs are expressed in 2002 prices and are in present value terms. The figures below exclude VAT. A provision for risk and contingency is included in the costs.

- Total Capital Cost = €184m[1]
- Total Operating and Maintenance Costs = text deleted
- Total Renewals Costs = text deleted

The parameters and assumptions used to develop the economic evaluation are presented in Appendix 2. All parameters and the methodology applied are consistent with the Department of Transport guidelines on parameter values for use in the appraisal of transport projects. All costs and benefits in the evaluation have been discounted to 2002 prices for analysis purposes (financial and funding projections take account of escalation in values over time).

[1] Economic cost-benefit analysis methodology requires that the market value of property is used in the capital cost rather than the actual cost to RPA.

The 2016 forecasts of additional patronage and revenue are outlined in Chapter 4. The transport assumptions and service pattern are also outlined in Chapter 4. The results of the economic appraisal for the base case are presented in Table 7.2. In this table the public transport revenue impact is disaggregated between Luas/Metro and Rail/Bus.

All property costs are included in the economic appraisal at their market value as required by the Common Appraisal Framework. This includes text deleted (Q1 09 prices) for CIÉ property which RPA assumes will be transferred at zero cost.

Table 7.2 Luas Line BXD Economic Appraisal Results (€2002m, PV)

	Discounted to 2002 (€m)		
	All Modes	**Luas/Metro**	**Rail/Bus**
User Time Savings	505		
Non User Time Savings	305		
Revenues	text deleted	text deleted	text deleted
Vehicle Operating Cost Savings	4		
Accident Savings	1		
Air emissions Savings	2		
Total Benefits	862		
Operating Costs	text deleted	text deleted	
Renewals Costs	text deleted		
Capital Costs	219		
Total Costs	350		
Economic Net Present Value (NPV)	512		
Benefit to Cost Ratio (BCR)	2.46:1		
Internal Rate of Return (IRR)	15.2%		

Table 7.3 below reports the summary economic results for the base case sensitivity which includes Dublin Bus's assessment of operating costs impact and revenue dilution during the construction phase.

Table 7.3 Luas Line BXD Economic Appraisal Results – Sensitivity with Dublin Bus Estimate of Cost Impacts Arising from Construction (€2002m, PV)

	Discounted to 2002 (€m)		
	All Modes	**Luas/Metro**	**Rail/Bus**
User Time Savings	505		
Non User Time Savings	305		
Revenues	text deleted	text deleted	text deleted
Vehicle Operating Cost Savings	4		
Accident Savings	1		
Air emissions Savings	2		
Total Benefits	862		
Operating Costs	text deleted	text deleted	text deleted
Renewals Costs	text deleted		
Capital Costs	219		
Total Costs	400		
Economic Net Present Value (NPV)	462		
Benefit to Cost Ratio (BCR)	2.15:1		
Internal Rate of Return (IRR)	12.6%		

As the results demonstrate, the economic case for the scheme remains strong even with the addition of Dublin Bus estimates of bus operating cost impacts and revenue dilution during the construction phase. The disbenefits to Dublin Bus users arising from longer journey times on some bus routes affected by BXD have been included in the calculation of user benefits in the base case.

The scheme generates significant user benefits as well as benefits for highway users arising from reduced congestion levels. The user benefits are generated by quicker in-vehicle times as well as reduced time and inconvenience associated with interchanging.

7.4 Scenario Testing

In order to test the robustness of the results of the economic appraisal the performance of the scheme has been examined under two additional scenarios, which have been designed to reflect the main risks to the demand and economic benefits forecast for the scheme. The economic appraisal results are summarised Table 7.4.

7.4.1 Transport 21 Network

In this scenario it was assumed that the entire public transport element for the Greater Dublin Area of the Transport 21 programme, excluding Line BXD, was in place in the do-minimum, and then Line BXD services were added for the do-

something. This increases the benefits of the project relative to the base case, as Line B2 in particular would generate significant additional demand on Line BXD. The BCR in this scenario is 3.02:1.

7.4.2 2006 Land Use

In this scenario it was assumed that the population and employment levels in the Line BXD catchment remain at 2006 levels. This is to test the sensitivity of the economic case for the line to future growth in population and employment. In this scenario, the economic case for the project is weakened considerably, with a BCR of 1.26:1. However, the assumption of no growth in population and employment levels within the catchment between 2006 and the scheme opening year of 2018 is highly conservative and considered to be unrealistic.

Table 7.4 Luas Line BXD Economic Appraisal Results – Scenario Testing (€2002m, PV)

	T21	2006 Land Use
User Time Savings	632	248
Non User Time Savings	385	150
Revenues	127	40
Vehicle Operating Cost Savings	8	3
Accident Savings	2	1
Air emissions Savings	3	1
Total Benefits	**1,158**	**442**
Operating Costs	text deleted	text deleted
Renewals Costs	text deleted	text deleted
Capital Costs	219	219
Total Costs	**384**	**350**
Economic Net Present Value (NPV)	774	92
Benefit to Cost Ratio (BCR)	**3.02:1**	**1.26:1**
Internal Rate of Return (IRR)	**19.1%**	**6.6%**

7.5 Wider Benefits

A failing of traditional cost-benefit analysis of transport schemes is its inability to include economic benefits of projects that are known to exist but which are not easily quantified and monetised.

Examples of additional benefits which Luas Line BXD will bring are:

- Increased employment and commercial opportunity in the area
- Improved quality of life
- Increased attractiveness of the area it serves and thus possible increased prosperity

- Increased integration though transport interchange
- Greater access for people with mobility impairment
- Improved social inclusion by serving areas of less advantage
- Improved local, regional and national attractiveness

Such benefits are known to exist and anecdotal evidence from commercial groups and businesses suggest Luas Red and Green Lines have enhanced property prices, improved footfall in commercial areas and improved business productivity through improved mobility in the areas through which it runs. The experience to date is that Luas is a major catalyst in the regeneration and development of communities along the various routes already served (e.g. Smithfield, Tallaght, Ballaly).

The catchment encompasses the traditional Dublin Central Business District (CBD), where there is a high density of employment and businesses. This area is also the traditional tourist core of Dublin. In addition to serving the Dublin city centre commuter market, Line BXD will also serve the important retail market in the city centre, through facilitating shopping trips for people wishing to move between the traditional city centre retail areas of Jervis Street/Mary Street/O'Connell Street north of the river and the Grafton Street area south of the river. In addition, BXD will also facilitate short tourist trips around the city centre.

Traditional transport cost benefit analysis fails to include some important economic benefits of new or improved transport services. These impacts typically derive from the presence of imperfect competition and economies of scale in production, and have become known as Wider Economic Benefits (WEBs). These benefits are:

- Agglomeration economies (increased productivity through agglomeration and the facilitation of jobs moving to more productive areas)
- Labour market effects (increased labour supply)
- Increased output in imperfectly competitive markets (relates to business travel)

Since 2005 emerging methodology developed by the UK DfT has been used to quantify and value these effects. The evidence there has demonstrated that WEBs can increase conventionally measured benefits by between 10%-40% depending on the scheme. Experience in the UK and elsewhere is also that WEBs are proportionately more important for schemes which:

- are in urban areas and increase accessibility
- serve areas of high productivity and
- serve areas with high levels of employment in financial and business services sectors[2]

Although these impacts have not been estimated in Irish transport appraisals to date and are not required to be considered quantitatively by the Common Appraisal Framework (CAF), it is likely that Line BXD will generate substantial Wider Economic Benefits because of its geographic location and the markets it serves.

RPA has estimated the employment impacts of BXD during the design and construction phase, based on observed resource use during the construction of the Green and Red lines and also the extensions currently under construction. Design and construction of BXD is estimated to generate 1,800 job years directly. This

[2] The Eddington Transport Study, 2006, HM Treasury
http://www.dft.gov.uk/adobepdf/187604/206711/executivesummary.pdf

number rises to 2,700 job years when indirect and induced employment generated by supply-chain linkages and salary expenditure is included. The majority of this employment will be generated during the construction phase 2014-2018. During this period it is estimated there will be on average 400 people employed directly in the construction of BXD, rising to 600 people in total including indirect and induced employment.

7.6 Project Appraisal Balance Sheet

The Common Appraisal Framework (CAF) requires that a Project Appraisal Balance Sheet (PABS) be drawn up summarising the principle results of the project appraisal. The PABS reports the scoring of the project against the five criteria of Economy, Safety, Environment, Accessibility and Social Inclusion and Integration. A seven point scaling system is used. Table 7.5 reports the Project Appraisal Balance Sheet for Line BXD.

Table 7.5 Line BXD Project Appraisal Budget Sheet (PABS)

Criteria	Line BXD		
	Qualitative Statement	**Quantitative Statement**	**Scaling Statement**
Economy			
Transport efficiency and effectiveness	Improves public transport generalised journey times through reduced need for interchange and quicker and more reliable journeys	BCR: 2.46:1 NPV: €512m PV	
Other economic impacts	Significant urban realm improvements; wider economic benefits likely to be generated through increased accessibility of city centre		Moderately positive
Safety			
	Slight reduction in road traffic accidents as a result of mode switching	Reduction in accidents: €1m PV	
Environment			
Air quality	Increased energy consumption by trams; reduced car emissions from modal shift.	Reduction in air emissions: €2m PV	
Noise and vibration	Reduction in highway trips	Removal of 3m car trips per annum	
Landscape & visual quality	Not assessable pending EIS		
Biodiversity	Not assessable pending EIS		
Cultural, archaeological and architectural heritage	Not assessable pending EIS		
Land use, soils and geology	Not assessable pending EIS		
Water resources	Not assessable pending EIS		
Accessibility & Social Inclusion			
Vulnerable groups	The benefits of Luas enjoyed by existing vulnerable groups, and in particular those without access to a car, will be enhanced through higher frequencies		Slight positive
Deprived geographic areas	Serves RAPID area as well as deprived Marborough St. area		Slight positive

Table 7.5 Line BXD Project Appraisal Budget Sheet (PABS) (continued)

Criteria	Line BXD		
	Qualitative Statement	Quantitative Statement	Scaling Statement
Integration			
Transport integration	Creates light rail network; creates interchange opportunities between Luas and heavy rail at Broombridge and Metro at O'Connell Street.		Highly positive
Land use integration	Fully compatible with RPGs, and City Development Plan. Fully supportive of policy of integrating land-use with transport planning; will facilitate Grangegorman DIT development		Highly positive
Geographical integration	No impact		Neutral
Other Govt. policy integration	No impact on enhancing regional income. However, the NSS recognises the importance of Dublin to the overall Irish economy, and commits to protecting the international competitiveness of the Dublin region, which will be facilitated by fast, frequent and high-capacity public transport networks.		Slight positive

7.7 Conclusions

The scheme displays an economic benefit-to-cost ratio of 2.46:1 with a net present value of €512m 2002 prices. Incorporating Dublin Bus estimates of bus operating cost and revenue dilution impacts during the construction phase does not significantly alter the value-for-money of the scheme. Under this scenario, the scheme retains a BCR of 2.15:1 and a net present value of €462m. The scheme is therefore of substantial societal worth. These economic appraisal results include the disbenefits associated with reduced bus journey times on some Dublin Bus routes that would arise assuming no re-configuration of the Dublin Bus network post implementation of Line BXD. The results also incorporate the market value of CIÉ property at Broadstone and along the railway cutting.

Scenario testing demonstrates that the economic case for the scheme is resilient and retains its value-for-money even assuming the most pessimistic demographic scenario of no growth in population and employment beyond 2006. Scenario testing also indicates that the benefits of the scheme will be significantly enhanced following extension of the Luas network as planned under Transport 21.

The strong economic outcome is a result of the high user benefits of the scheme which derive from the removal of the need for public transport passengers to interchange to complete their journey as well as quicker journey times. There are also strong non-user benefits, which reflect the reduction in highway congestion as a result of the scheme.

The traditional cost benefit analysis fails to include many additional benefits which are known to exist as a result of investment in transport projects such as Luas. It is likely that the Wider Economic Benefits generated by Line BXD will be significant, and because these are not yet included in the CBA the true economic return of the project is underestimated.

8. Project Finance and Cash Flows

8.1 Chapter Summary

- The total funding requirement from the Exchequer for Luas Line BXD is estimated to be €382.8 million (year of expenditure) over the period 2009 to 2020. In net present value and cash terms this amounts to 100% of the capital costs of the project.
- It is not expected that developer contributions will be available for this project. There exists the possibility that a Section 49 Development Levy scheme could raise in the order of €5m to assist in minimising the Exchequer funding requirement.
- Projections on operations show that incremental patronage as a result of this project will generate sufficient revenues to cover incremental operating costs. Current indications are that this will be the position from the first year of operations. Therefore it is unlikely that an Exchequer subvention will be required.
- Projections also show that operating surpluses should be sufficient to cover the renewal costs of the infrastructure over a 30 year operating timescale. Demand would be required to fall 22% below forecast over the lifetime of the project to eliminate the operating surplus.

8.2 Background

The financing structure for Luas Line BXD reflects its status as a traditionally procured project. Chapter 9 *Procurement Strategy* discusses the various procurement options available to RPA and concludes that a model funded through exchequer grants would best meet the objectives of the Luas Line BXD project. The use of PPP finance has therefore not being considered in the chapter.

This chapter considers the cash-flows and likely cost to Exchequer over a 30 year operating period starting in 2018.

8.3 Financial Model Assumptions

A number of assumptions have been made in the financial model:

Project Timing

Commencement of construction is projected to occur in 2014 assuming the Railway Order application is submitted in Q4 2009. Department of Transport approval to proceed with the project would be required at the date of the enforceable railway order. The programme is also critically highly dependent on Metro North phasing enabling on-street construction activities to commence in line with currently projected removal of Metro North temporary traffic management arrangements in 2014.

Inflation from 2009

The inflation rates assumed for public transport fares is informed by forecast changes in the consumer price index and takes account of issues such as the introduction of smartcards, more integrated journeys, the trend for increased take-up of period ticketing products and the effect of extensions to the Luas network over time.

On the cost side, allowances for escalation have been included to recognise the impact of inflation on construction and other costs over the construction period. An inflation rate of 0%, 0% and 1.5% for 2009, 2010 and 2011 respectively has been

adopted for each of the cost categories, moving to 5% per annum thereafter. The exception to this is rolling stock, for which a lower inflation rate representing 50% of the above figures has been assumed.

Discount Rate

Cash-flows have been discounted at a rate of 4.0%. This is a rate currently advised by the Department of Finance and corresponds to the cost of Government borrowing.

VAT

All VAT is excluded from the model. The model reflects the VAT status of RPA, which treats the Agency as an infrastructure provider. RPA is therefore able to recover all input VAT. The Revenue Commissioners have recently confirmed this status.

Capital Costs

The capital costs used in the financial model are set out in Table 8.1 and reflect the capital costs discussed in Chapter 5 *Capital Costing.*

Table 8.1 Total Capital Cost € million

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
Capital Costs - Q1 2009 prices	€3.38	€1.00	€1.00	€1.92	€3.19	€6.83	€28.47	€52.25	€81.22	€79.41	€20.22	€11.34	**€290.24**
Capital Costs - Cash Cost in year of expenditure[3]	€3.38	€1.00	€1.01	€2.04	€3.57	€8.03	€35.13	€67.68	€107.05	€105.77	€30.32	€17.86	**€382.85**
Discounted to 2009 @ 4.00%[4]	€3.38	€ 0.96	€ 0.93	€ 1.82	€ 3.05	€ 6.60	€27.76	€51.43	€78.22	€74.31	€ 20.49	€ 11.60	**€280.56**

[3] Excludes €3.21m sunk costs up to Q1 2009

[4] The estimated capital cost of the project is €290.24 million in Quarter 1 2009 prices. Chapter 9 *Project Finance & Cash-flows* outlines the inflation rates being applied to work out the cost in the years in which the expenditure will be incurred. On average the discount rate exceeds the inflation rate which is why the discounted capital cost of €280.56 million is greater than the cost in 2009 prices.

Exchequer Grants

It has been assumed that sufficient exchequer grants are available to fund the capital costs which will be borne by RPA. The capital envelope available to RPA for Luas projects under Transport 21 includes €336 million (nominal-year of expenditure, VAT inclusive; equivalent to €295m excluding VAT) in respect of Luas Line BXD. The actual level of exchequer funding required is estimated at €382.8 million, VAT exclusive.

Section 49 Development Levies

There exists the possibility that the size of the exchequer grant required will be reduced by an amount in the order of €5m if a Section 49 Development Levy scheme is introduced by Dublin City Council and development is realised within the catchment. Due to the nature of the alignment, which is predominantly brownfield, there is limited scope for significant planning gain within the catchment of BXD which limits the scope for Section 49 levies or developer contributions. An initial assessment at this stage, which assumes a low level of build-out and S49 rates that are similar to other schemes already in place, is that a scheme could raise between €7m and €10m (discounted) over the lifetime of the scheme.

The forecast provided makes the assumption that granted planning permissions can be levied in respect of a number of contribution schemes. Approximately 80% of the levy scheme area has potential to overlap with other proposed projects. This may have an impact if it is deemed inequitable to impose more than one supplementary contribution scheme levy on the same development.

Direct Contributions from Developers

It is not anticipated that there will be significant opportunities for direct contributions from developers for this project. The project will carry some of the costs associated with the development of the Broadstone Gate concept which will open up access to the Grangegorman development site, and as a result there is a possibility that RPA will receive some pecuniary compensation from the Grangegorman Development Agency for these works.

Transfer of land interests

Negotiations are being held with CIÉ and the Department of Transport for the transfer of lands (from Broadstone north to Broombridge) at nil consideration.

8.4 Funding of Capital Expenditure

The nominal cash-flows are shown in Table 8.2 below. The total nominal cost of the project is estimated at €382.8 million. Exchequer funding of €382.8 million is required over the period 2009 to 2020.

Table 8.2 Sources and Uses of Funds – Projected Cash-flows - Year of Expenditure

Nominal Cash-flows € millions	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
Capital Cost	€3.38	€1.00	€1.01	€2.04	€3.57	€8.03	€35.13	€67.68	€107.05	€105.77	€30.32	€17.86	€382.85
TOTAL	**€3.38**	**€1.00**	**€1.01**	**€2.04**	**€3.57**	**€8.03**	**€35.13**	**€67.68**	**€107.05**	**€105.77**	**€30.32**	**€17.86**	**€382.85**
Exchequer Grants (non-repayable)	€3.38	€1.00	€1.01	€2.04	€3.57	€8.03	€35.13	€67.68	€107.05	€105.77	€30.32	€17.86	€382.85
Developer Contributions	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
TOTAL	€3.38	€1.00	€1.01	€2.04	€3.57	€8.03	€35.13	€67.68	€107.05	€105.77	€30.32	€17.86	€382.85
Exchequer Grants %	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Table 8.3 Sources and Uses of Funds – Discounted Cash-flows € million

Cash-flows discounted @ 4%	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
Capital Cost	**€3.38**	**€ 0.96**	**€ 0.93**	**€ 1.82**	**€ 3.05**	**€ 6.60**	**€27.76**	**€51.43**	**€78.22**	**€74.31**	**€ 20.49**	**€ 11.60**	**€280.56**
Exchequer Grants (non-repayable)	€3.38	€ 0.96	€ 0.93	€ 1.82	€ 3.05	€ 6.60	€27.76	€51.43	€78.22	€74.31	€ 20.49	€ 11.60	€280.56
Developer Contributions	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -	€ -
TOTAL	€3.38	€ 0.96	€ 0.93	€ 1.82	€ 3.05	€ 6.60	€27.76	€51.43	€78.22	€74.31	€ 20.49	€ 11.60	€280.56
Exchequer Grants %	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

8.5 Operating Cash-flows

8.5.1 Life Cycle, Operating and Maintenance Costs

Life cycle, operating and maintenance costs (including renewals) are an important component of the overall cost of the project. The life cycle and renewal costs that fall within the 30 year operating period have been included in the financial model. The costs set out in Table 8.4 below are exclusive of VAT and are nominal; that is they are expressed in the prices of the year in which they occur.

Table 8.4 Renewals, Operating and Maintenance Costs (€ millions, Nominal)

	Years 1 to 5	Years 6 to 10	Years 11 to 15	Years 16 to 20	Years 21 to 25	Years 26 to 30	TOTAL
Operating and Maintenance Cost	text deleted	text deleted	text deleted	text deleted	text deleted	text deleted	€572.3
Renewals	text deleted	text deleted	text deleted	text deleted	text deleted	text deleted	€105.6

8.5.2 Fare Revenue

Demand and revenue forecasts for Line BXD are based on RPA's transport model and average yield per boarding assumptions. Revenue is assumed to be equal to demand multiplied by the average yield. Average yield per boarding has been estimated using the actual average yield per boarding on Luas in 2008 of €1.56, which was grown based on assumptions regarding changes in fares, preferences for ticket products, average length of journeys etc. Table 8.5 sets out the anticipated revenues. The revenues are exclusive of VAT and are nominal.

Table 8.5 Projected Revenue from fares (€ millions, Nominal)

	Years 1 to 5	Years 6 to 10	Years 11 to 15	Years 16 to 20	Years 21 to 25	Years 26 to 30	TOTAL
Fare Revenue	€88.8	€115.6	€127.7	€140.9	€155.6	€189.3	€817.9
Advertising Revenue	€0.9	€1.2	€1.4	€1.5	€1.7	€2.0	€8.7

Table 8.6 sets out the net present value of the Line BXD operating cash-flows over a 30 year operating period. A discount rate of 4% has been used.

Table 8.6 Operating Cash-flows (Present Values, discounted to 2002)

Cash-flow	€ millions
Total Operating Revenue including advertising	244
Total Operating Costs	text deleted
Renewals Costs	text deleted
Total Operating Surplus	**53**

Table 8.6 demonstrates that Line BXD has an operating surplus in present value terms of €53 million and that the operating surpluses over a 30 year timescale should be more than sufficient to cover renewal costs over the same timescale. This holds true also for the Transport 21 scenario; however under the 2006 land use scenario where no growth in population or employment is envisaged beyond 2006, the project will incur an operating deficit over the 30 year appraisal period. Under this scenario revenues are forecast to be sufficient to cover operating and maintenance costs, but they will not be sufficient to cover renewal costs. However it is considered that this is a most pessimistic scenario and one which is highly unlikely to materialise.

8.6 Risks and Sensitivity Analysis

Chapter 6 *Risk* sets out the key risks facing the project. A sensitivity test on costs has been carried out and reported in Chapter 7 *Cost-Benefit Analysis*. Projected revenue, and in turn the forecasts for an operating surplus (or deficit) depends on the accuracy of RPA's demand forecasting, and although this has been proven robust on the Green and Red Lines there remains a degree of risk in this area. For this sensitivity RPA modelled the impact of reductions in overall patronage over the life of the project, highlighting the reduction required to eliminate the operating surplus. The results are set out in Table 8.7 and all numbers are discounted using a 4% discount rate. It was assumed that operating and lifecycle costs remain unchanged.

Table 8.7 Sensitivity of Operating Cash-flows to patronage reduction (Present Values)

Cash-flow - € millions	Base Case	10% Reduction (Patronage)	22% Reduction (Patronage)
Total Operating Revenue	244	220	191
Total Operating Costs	text deleted	text deleted	text deleted
Renewals Costs	text deleted	text deleted	text deleted
Total Operating Surplus/Deficit	**53**	**29**	**0**

The sensitivity shows that the operating surplus in the base case reduces to €29m over the life of the project if patronage falls 10% below forecast. A reduction in the order of 22% would be required to reduce the lifetime operating surplus to nil. If any of these scenarios were to occur there would be cash shortfalls in some years which might

require short term funding arrangements to be put in place. It is unlikely that Exchequer funding in the form of an operating surplus would be required.

8.7 Conclusions

The results of the financial modelling of project cash-flows for Line BXD indicate a total capital cost of €382.8 million (nominal) with 100% of this being funded by the Exchequer. There is a possibility that a Section 49 Development Levy scheme, if introduced by Dublin City Council, could generate in the order of €5m which could be used to assist the funding of the scheme.

The results also show that Line BXD has an operating surplus in present value terms of €53 million when measured over a 30 year time frame. Current projections indicate that renewal costs can be covered in full out of operational surpluses and it is unlikely that Exchequer funding in the form of an operating subvention would be required.

9. Procurement Strategy

9.1 Chapter Summary

- The procurement strategy for Luas Line BXD must accommodate the project constraints and stakeholder requirements, and build on lessons learned during the construction of the Luas Red, Green, B1 and C1 Lines and facilitate the achievement of RPA's objectives
- The procurement strategy for Luas Line BXD must accommodate sufficient flexibility to ensure that the design and construction of the systems for other Luas projects to be constructed under Transport 21 can be achieved without undue constraints on these projects
- RPA has carried out a PPP Procurement Assessment in accordance with the Capital Appraisal Guidelines and the project was deemed unsuitable for procurement as a PPP.
- The option that best suits RPA's requirements is based on the Luas Line C1 model (Client Design-Contractor Build) adapted for the particular constraints facing the Luas Line BXD project

9.2 Introduction

This chapter considers a range of procurement approaches available for the implementation of Luas Line BXD. The relative merits of each are assessed and an appropriate way forward is recommended.

The approach adopted to determine the best procurement strategy was as follows:

- The project constraints, stakeholder requirements and lessons learned from the previous Luas contracts were considered;
- Objectives were set for the procurement process;
- A range of different options for the procurement process was developed;
- The advantages and disadvantages of each option in terms of the objectives were evaluated, drawing on internal and international experience where applicable.

9.3 Project constraints, stakeholder requirements and lessons learned

9.3.1 Project constraints and stakeholder requirements

A number of constraints face the project, some of which are more relevant than others to the procurement strategy:

Metro North's envisaged construction sequence between 2010 and 2016 dictates that BXD cannot commence construction until substantial completion of Metro North works at the city centre locations of O'Connell Street, Westmoreland Street and St. Stephen's Green.

Successful traffic management and the minimisation of disruption during the construction phase are key to the overall success of the BXD project. The procurement strategy must be sufficiently flexible to ensure that changes in the enabling works; the timing of adjacent developments; other transport projects; and transport operator constraints can be accommodated without undue impact on the Luas Line BXD project.

Luas Line BXD is traversing a dense built-up city centre environment with congested traffic issues which leaves little scope for deviation and which requires detailed coordinated design.

A further constraint facing the project is in regard to the extent and complexity of the required utility diversions in a busy pedestrian and vehicular traffic environment and the provision of additional utilities by others. The procurement strategy must take account of these issues both in relation to project timing and cost.

As with any project of this nature and scale there are a number of interfaces that may impact on project delivery. Expectations of Dublin City Council (DCC) and existing businesses will need to be considered when finalising the procurement strategy. Interfaces with other key stakeholders such as CIÉ will also be a crucial requirement for a successful project.

The procurement strategy for this project must be cognisant of the other Luas projects included under Transport 21 and ensure that it does not place undue constraints on these projects. This is particularly relevant in regard to rolling stock, systems design, installation and integration.

A new form of contract Government Construction Contract Committee (GCCC), will govern the relationship between the contractors and the RPA. The GCCC contract is largely untested in the market at present.

9.3.2 Luas Lessons

There are a number of key lessons arising from the construction of previous Luas projects:

- The statutory processes were managed well and should continue to be managed by RPA. The market has shown no appetite for taking any planning risk;
- The relationship and the working arrangements built up with the utility companies through the Joint Utilities Group (JUG) worked well, and this approach should be maintained in so far as is practicable;
- The quality of the finished product is excellent and any future procurement strategy must ensure the same high levels of quality control are maintained; and
- The contractual framework was reasonably robust. However, the effectiveness of the FIDIC contract (or any recourse style contract) in achieving real risk transfer is questioned. Under the new GCCC

contracts, contractors will have to price risk transfer at tender phase rather than focus on processing claims during the construction phase.

These lessons together with the constraints outlined above inform the options analysis.

9.4 Objectives

The objectives for the procurement are:

- Technical compatibility with the Luas network
- High quality of finished product
- Value for money
- Time
- Flexibility
- Process risk minimisation and
- Systems integration with other Transport 21 Luas projects

9.4.1 Technical Compatibility

It is essential that Luas Line BXD is designed and constructed to achieve a high quality, dependable and reliable service. As Luas Line BXD is an extension to the Luas network it is imperative that the systems, certain architectural features and the fixed infrastructure are compatible with the existing specifications. Ensuring technical compatibility is therefore important in finalising the procurement strategy.

9.4.2 Value for Money

The procurement process should offer value for money and Luas Line BXD should be developed and built for the best value. The following factors influence value:

- Use of lessons learned from previous RPA projects
- Use of lessons learned from other International light rail projects
- Private sector innovation
- Competitive tension
- Good project management and planning
- Whole life approach to design and
- Optimum risk balance and transfer.

Most of these factors are about reducing the costs of the project, or improving its quality. Costs should be lower if the process is cognisant of the lessons learned from the current Luas projects and allows bidders scope to provide innovative designs. Given the size of the Luas Line BXD project, the extent of technical constraints due to the built-up nature of the environment, the quantum of existing utilities and the requirement to integrate with the existing system the opportunity for private sector innovation is considered to be low. Experience also shows that

maintaining competitive tension between bidders until close to contract award will reduce costs. In particular, processes which involve protracted negotiations with a single preferred bidder are likely to result in higher costs or a worsened risk allocation. Good management and planning of the project are also vitally important to adding value.

Ensuring minimal costs to the public sector over the life of the project is also an integral part of obtaining value for money. The public sector should be looking for the optimal allocation of risks and should put a value on risks that can be transferred to the private sector.

9.4.3 Flexibility

Luas Line BXD is just one phase in the creation of a light rail network for Dublin. Future phases, which will impact on Luas Line BXD, include a possible extension from Broombridge via Finglas to join up with Metro West. This is unlikely to be developed in the short to medium term and is not included in the Government's current 10 year transport plan Transport 21. The selected procurement strategy must allow for any future extension to be procured using a competitive process, and with minimum interference and cost to the existing operations.

At present, some uncertainty remains regarding the future regulatory environment for public transport in Dublin. The contract to deliver Luas Line BXD must be sufficiently flexible to accommodate future regulatory changes at minimum cost.

Experience of building the Luas Red Line, Luas Green Line, Luas to Cherrywood and Luas to the Point has demonstrated the significant risks associated with the diversion of utilities, particularly in relation to the discovery of uncharted utilities. While a thorough utilities investigation programme has been undertaken including the use of radar mapping techniques, the procurement strategy must allow for the possibility of significant variations during construction.

9.4.4 Process risk minimisation

Process risk is treated separately from other project delivery risks. It relates to the risks around stakeholder and market buy-in and the procurement process itself. There is a risk that the procurement process will fail or be delayed (for instance, a losing bidder might succeed in challenging the procurement outcome in the courts as being unfair). Minimising or at least containing that process risk is a key objective. Ensuring that market appetite exists and the process is compliant with legislation and guidance may mitigate this and these should be included in assessing the viability of any procurement strategy.

9.5 Procurement Options

The procurement options available for Luas Line BXD are varied. Before short-listing options for consideration, a number of assumptions have been made.

9.5.1 Assumptions

Railway Order and Land Acquisition

The responsibility for securing the Railway Order and acquiring land will be retained by RPA as this approach has proved highly successful in the past. The Railway Order process requires a substantial time and resource input to prepare the material, together with significant engagement to reach agreement with statutory stakeholders such as the local authorities. Importantly there does not appear to be sufficient private sector interest in taking this risk to run an effective competition. Experience elsewhere, borne out by RPA's market consultation for various projects, is that the private sector will look for mechanisms that effectively pass the statutory powers and acquisition risks back to the public sector. A private sector scheme promoter could also be criticised at the Oral Hearing for pursuing a choice of scheme that maximised profits rather than the public good.

Operations and Maintenance

The existing Luas operating contract will expire in 2014. A new competition for a system wide operator will include Luas Line BXD. Having two operators on the Luas network would result in significant practical difficulties and inefficiencies. The existing Luas maintenance contracts will also be renewed to include Luas Line BXD, though it may be possible to have a new maintenance contract for Luas Line BXD, as demonstrated successfully by Docklands Light Rail. However, in complying with procurement legislation and realising economies of scale, it is more likely that competitions for operators and maintainers will be run for the entire network.

Rolling Stock

A competition was concluded for light rail vehicles in 2007 "to meet the short to mid-term requirements for the Dublin Light Rail System".

A Call for Competition was issued in September 2005 in the Official Journal of the European Union (OJEU) stating that RPA required up to 50 light rail vehicles to meet the requirement of Transport 21. To date, orders for only 26 of the 50 trams have been placed. While the requirement for BXD would fall comfortably within the maximum quantity stated in the OJEU Notice, the period from OJEU to commencement of operations would be 13 years (2018). By 2018, possible new entrants and innovation in the market could lead to better competition and value for money. Therefore, it is assumed that a competition for Rolling Stock for BXD will commence in 2015 i.e. three years before commencement of operations.

Systems Integration

In 2007 a contract was awarded for the design, construction and commissioning of the infrastructure, power supply and control systems for Luas Line B1 (Cherrywood). As an option, a further approximately 30 km of additional light rail lines over the subsequent five years was also included. The right to exercise this option will expire in 2013 which based on the current programme will be too early for Line BXD. However, a derogation under the EU rules permits the procurement of additional works or services without a Call for

Competition where for technical reasons the contract may only be executed by one particular supplier or contractor.

9.5.2 Public Private Partnership Assessment

Under the Capital Appraisal Guidelines and *Assessment of Projects for Procurement as a Public Private Partnership*, RPA is required to carry out a formal PPP Procurement Assessment. The purpose of this assessment is to determine if a PPP arrangement has the potential to offer a value for money solution for procuring the project. This assessment has been carried out and has concluded that the project is not suitable for procurement using a PPP arrangement.

While the assessment indicated that the Line BXD project is of sufficient scale, has a significant service and operational requirement, has stable future demand and performance can be measured in output terms; the project fails the assessment in terms of risk transfer.

Most importantly, as BXD is a continuation of the Green Line there is insufficient opportunity for the transfer of risk in the areas of design interface, commissioning and maintenance of the line. In addition the operations control room which will determine the availability and running of the system on a day to day basis will be controlled by RPA or RPA's operator. As previously noted, it would not be possible to transfer planning risk due to the significant levels of engagement required with statutory stakeholders and the complete lack of market appetite. It will be difficult to transfer full construction risk due to the congested nature of the areas. As already noted, the utility diversion risk will be retained by RPA. It is also likely that RPA would have to retain archaeology risk, particularly as it relates to National Monuments. It would also be difficult to transfer any availability risk to a PPP company, as the availability of the line is highly dependent on interfaces with the existing system. Not being able to transfer construction and availability risks fully would mean that the project could not be considered to be off balance sheet for Government accounting purposes.

A PPP approach is thus not recommended.

9.5.3 Traditional Procurement Options

Table 9.1 below lists the traditional procurement options which are considered viable drawing on experience from other projects and taking account of a comprehensive market consultation carried out to date.

Table 9.1 Shortlisted procurement options

Option	Brief Description
A	Turnkey Design and Build contract let to a single consortium including all enabling works, infrastructure and rolling stock.
B	Initial contract(s) for advance works including utility diversions, key structures, and build-only civils and trackwork contracts. Design and Build contract(s) for E&M, signalling and rolling stock. Responsibility for systems integration remains with RPA.
C	RPA carry out 100% design and let a series of separate contracts covering; (1) enabling works, including utility diversions and key structures; (2) Civils and trackwork (3) E&M and signalling and (4) rolling stock. Responsibility for systems integration remains with RPA.
D	Early contractor involvement using Luas to benchmark the cost plan. Select a primary contractor, agree a series of cost and programme benchmarks and transfer responsibility for sub-letting all packages, including rolling stock and systems integration.
E	Initial contract(s) for enabling works including utility diversions and key structures. Design & Build contract(s) for civils, trackwork, E&M, signalling, rolling stock and systems integration.

9.6 Evaluation of procurement options

Option A - Turnkey Design and Build contract let to a single consortium including all enabling works, infrastructure and rolling stock.

Option A is arguably the least attractive of all the options. Appetite within the utility companies to engage with a contractor in the planning and design of utility diversions will remain low impacting on project timing. It is also likely the private sector will view this as a high risk and cost it accordingly. Option A also takes away control over the process from RPA and transfers all responsibility to the private sector irrespective of the consequences. Given the extremely sensitive nature of the utilities in the area of Line BXD this would be unacceptable.

Option A effectively transfers all responsibility to the contractor while not providing good protection to RPA in relation to time and cost overrun. The turnkey approach is being used less and less in exchequer funded projects where without the inclusion of private capital the contractor has little incentive to manage change efficiently. It fails to meet the objectives and when compared with other options scores poorly.

Option B - Initial contract(s) for advance works including utility diversions, key structures and build-only civils and trackwork contracts. Design and Build contract(s) for E&M, signalling and rolling stock. Responsibility for systems integration remains with RPA.

The main advantage of Option B is the balance of risk apportionment between RPA and the private sector. Risk transfer is theoretically lower than for Option A but the model recognises some of the key constraints facing the project. By retaining the advance works and in particular the utility diversion works within RPA's design control a number of key risks are mitigated. Option B also provides RPA with the opportunity to improve a tried and tested model and benefit from the lessons learned on other RPA projects. The primary difference is that the civil and track elements are traditional contracts as exercised in Luas Line C1 as opposed to Luas Line B1 where they are part of the main Design and Build contract. For a project of the scale of Luas Line BXD which is in a built up urban environment with extensive utility diversions it is considered that this approach will enable many of the difficult interfaces to be addressed as part of an overall coordinated design and agreements reached with the various stakeholders in advance of the construction.

Option B offers a high degree of flexibility, particularly as it does not constrain future extensions or other changes. Market appetite for the model is proven. Also, by dividing the enabling works from the main works there will be an opportunity to carry out a significant amount of work during the procurement of the main civils and trackwork contract. This may reduce third party interface risks (e.g. with local authorities and private developments) and site availability risk to the civils and trackwork contractor. Rolling stock will be procured as a separate contract to ensure integration across future and existing Luas lines.

The model however provides very little incentive for a whole life approach to design by the main infrastructure contractor (though this can be mitigated by careful specification of the Employer's Requirements by RPA and good design quality control at construction stage). There is a good level of certainty as regards outturn costs and time but upfront due diligence by the contractor, a feature of privately funded projects, will be less rigorous. Some of the risk transfer to the private sector will be lost as RPA take control of more interfaces.

A further consideration is one of scale; by splitting out the design, main E&M works and systems integration from other packages market appetite for this element of the project may be low thus not attracting a robust international field. However, other benefits can be also be achieved by splitting the civil and track from the E&M works and systems integration. RPA needs to achieve consistency in its approach to all future lines in regard to the systems and as such the possibility of procuring the systems from the existing systems supplier provides RPA with the needed consistency. However by procuring the track and civil works using a traditional contracting approach this may appeal to domestic contractors.

Equally, the challenging nature of the utilities and track construction and the confined areas of working within the congested city centre street environment also lends itself to RPA retaining a higher degree of control over the design process.

The mechanism for ensuring timeliness may not be as critical as in other types of procurement and the risk of delay to completion of design is very low due to the long lead time (main construction works commencement in 2014).

On balance Option B does provide RPA with the flexibility to manage the project and fits well with the current status of the design and Railway Order. The key constraints of utility design and construction, and third party interfaces are better managed using this model.

Option C - RPA carry out 100% design and let a series of separate contracts covering; (1) enabling works, including utility diversions and key structures; (2) civils and trackwork (3) E&M and signalling and (4) rolling stock. Responsibility for systems integration remains with RPA.

The Railway Order for BXD will be lodged in 2009 giving ample time for the design of the new proposed line that cannot commence construction until Metro North construction in the city centre is largely completed. This creates a significant window of opportunity for RPA to carry out 100% design.

A major drawback to this approach however is the risks inherent in separating out the design from the build element in the technically complex areas such as E&M and signalling. Most of these systems are usually proprietary where the manufacturers retain control over design and use. RPA has not tried this before and it is very rare in the market place. A very high risk of entertaining interface difficulties would be the main reason for ruling out this option.

Option C provides a lesser degree of scope for innovation in the construction than Option B and contractor innovation will be fairly poor. Low risk transfer will reduce the entry cost of the project and by retaining utility and certain third party relationships within RPA the life cost of the capital project may be reduced.

As RPA would be managing the complete design of the project, there would be opportunities to achieve a better whole life approach to the project.

As with Option B splitting out the main infrastructure/E&M works from other packages is likely to marginally reduce market appetite for the project thus not attracting a robust field.

In summary Option C scores poorly against the objectives and should not be considered for Luas Line BXD.

Option D - Early Contractor involvement using Luas to benchmark the cost plan. Select a primary contractor, agree a series of cost and programme benchmarks and transfer responsibility for sub-letting all packages, including rolling stock and systems integration.

Option D would be a radical departure from any procurement model delivered successfully in Ireland although this is an approach being used extensively in the UK. The National Roads Authority has piloted a partnering approach on some of their non-PPP schemes.

A benchmark now exists from Luas Red and Green Lines for agreeing a target cost or guaranteed maximum price with a preferred contractor. Under this model, contractor innovation will theoretically be high as the reimbursement mechanism under the contract encourages up front idea sharing and opportunities also exist for early contractor input into E&M design. The competition can be designed to encourage a good level of competition by procuring the contractors using a schedule of rates with agreed percentage uplifts for overheads and profit and a dummy bid which can be used as a future benchmark for agreeing a target cost. Competitive tension however is lost early in the process using this model.

In theory risks are apportioned to those best placed to manage them although this generally takes place in a non-competitive environment that can lead to ransom demands as the project timescales become critical. This can be mitigated however using maximum price thresholds which the contractor is given the incentive to meet in order to ensure the project gets approval to proceed. Option D provides RPA with a good level of control and a high degree of flexibility while retaining the benefit of private sector efficiencies in project management. However, because of the particular complexities of the Luas Line BXD project and the constraints imposed by the existing systems, the utilities and the stakeholders, there is little opportunity for private sector efficiencies. Early commencement of some enabling work may facilitate speedier delivery and there is a strong international market for partnering style contracting, especially from the UK.

Considerable monitoring is required on procurements of this nature and RPA would have to recruit additional resources to manage this effectively.

As with any options where maintenance is de-coupled from construction, Option D provides no incentive for the private sector to design and build a whole-life based railway and there may be less cost and time certainty for RPA than with Option A. While the model does encourage upfront analysis this can often be protracted and in a non-competitive environment may lead to excessive charges for risk transfer or refusal to accept certain risks. Some interface management is likely to be retained by RPA.

In summary Option D scores poorly against the objectives and should not be considered for Luas Line BXD.

Option E - Initial contract(s) for enabling works including utility diversions and key structures. Design & Build contract(s) for civils, trackwork, E&M, signalling, rolling stock and systems integration.

Option E is very similar to Option B in terms of its advantages and disadvantages. The key difference under Option E is that RPA transfer the design and interface risks associated with the civils and trackwork to the private sector. Option E is the approach adopted on the original Luas Red and Green lines and, more lately, on the Line B1 extension.

However, while Option E can work well in the type of environment in which the B1 extension is being built, it is relatively inflexible when it comes to dealing with

the complex and difficult interfaces in the city centre. In the case of Line BXD, these include interfaces with the enabling works contracts; with adjacent private sector developments such as Dublin Central; with other transport projects, particularly Metro North; with an operational bus depot at Broadstone; and with a busy operating city centre, which must remain open for business at all times. The cost of transferring the risk of managing these interfaces to the private sector is likely to be prohibitive, if they were willing to take the risk at all. In terms of lessons learned, while this approach in general worked well on the original Luas Red and Green lines, significant difficulties arose in relation to the city centre sections, particularly Harcourt Street and Abbey Street.

On balance, Option E provides RPA with less flexibility to manage the project than Option B.

9.7 Conclusions

RPA has carried out a PPP assessment test which concluded that a PPP type procurement for Luas Line BXD was not suitable.

The Option B model is currently being successfully used by RPA in the case of Line C1 and the key constraints of utility design and construction, and third party interfaces are adequately managed using this model. It can incorporate a number of the lessons learned from Luas and allows succession from the original Luas projects in building on the project management pool now in existence. It provides a flexible and balanced approach to risk and will provide flexibility in dealing with third parties, in particular the utility companies, other private developments and interfaces with other transport projects.

Option B is compliant with all procurement rules, can maintain competitive tension and is sufficiently flexible to accommodate legacy infrastructure and systems. It scores less well on private sector innovation, whole-life approach, risk transfer and guaranteed delivery in respect of time and budget. However, because of the constraints and complexities of Luas Line BXD there is little opportunity for private sector innovation and efficiencies.

Due to the long lead-in-time coupled with lessons learned from other RPA projects and in-house design expertise in particular which has been built up over these years, it is considered that Option B is the most attractive and best meets the objectives for the procurement of Luas Line BXD.

10. Programme and Way Forward

10.1 Chapter Summary

- This chapter looks at the activities following submission of Outline Business Case
- These activities are essential for the project to remain on target
- There are two core activities to be progressed prior to construction commencement in 2014 - the Railway Order and the procurement for the project
- A Railway Order application in 2009 is necessary to confirm elements of Line BXD works within the scope for Metro North main infrastructure contract, which is scheduled to be awarded in late 2010. In this way, the undoing of street reinstatement under the Metro North contract in order to construct BXD infrastructure at certain locations, will be avoided
- An effective and integrated communications plan will be implemented by RPA which will aim to build confidence in the delivery of the project, reduce the potential negative effects of the works and underscore the benefits of its provision.

10.2 Activities

The work involved by RPA following approval of the outline business case is as follows:

a) Environmental Impact Study - an Environmental Impact Statement will be completed for the project in accordance with S.39 of the Transport (Railway Infrastructure) Act, 2001.

b) Railway Order application - the Railway Order application incorporating the EIS, scheme drawings and schedules will be submitted in late 2009 to An Bord Pleanála in line with the requirements of the Planning and Development (Strategic Infrastructure) Act, 2006. RPA will manage the process through the Oral Hearing which it is expected will be convened in early 2010. This early application for Railway Order considering the time that will elapse between then and construction commencement in 2014, is driven by the need to ensure that the statutory consents and the certainty that this brings, are in place to enable confirmation of elements of BXD works within Metro North main infrastructure contract award at end 2010.

c) Procurement - RPA will commence the procurement process for the utility works, the structure works and the civil & track works following a call for competition in the Official Journal of the European Union (OJEU Notice). This will be followed by pre-qualification of suitable bidders and a formal tender process.

d) Design - Prior to issuing any tender documents a detailed design will be prepared for the scope of works identified for each contract. This design work will also help RPA to identify the interface requirements with other developers and authorities in advance of construction. Design will be carried out in-house with the exception of E&M, signalling and rolling stock which will be design-build contracts.

e) Construction - The city centre elements of this project will be largely driven by progress on the key Metro North construction areas at St. Stephen's Green, Westmoreland St. and O'Connell Street. Significant works on BXD cannot commence until such time as the major traffic management interventions associated with Metro North are removed. The sequence of construction of Line BXD will largely be dictated by the need to minimise impacts on traffic flow during the construction period. The utility diversions and track works in the vicinity of St. Stephen's Green, O'Connell Bridge and Westmoreland St. will be carried out as part of the Metro North works. The phasing of the remainder of the city centre works such as Dawson/Nassau St., Marlborough St., Hawkins and College St., and College Green/ Lr Grafton St. will follow the aforementioned in a sequence that will minimise traffic disruption. The works in the Broombridge to Broadstone and Broadstone to Marlborough St. areas will be sequenced to achieve maximum construction efficiency within the overall timeframe commencing in mid 2014. The works are planned in such a sequence that no works will be in progress in O'Connell Street in the first half of 2016.

f) Risk - Risk assessment and allocation will form an essential part of managing the project going forward. RPA will continue the risk assessment work discussed in Chapter 7.

10.3 Programme

The key programme dates are set out in Table 10.1 below.

Table 10.1 Key Dates in Luas Line BXD Programme

Activity Description	Duration (Months)					
Finalise R.O. Application	1	Oct 09				
Commence Formal Process for R.O. Application	1		Nov 09			
Enforceable Order	12		Nov 10			
OJEU	1			Q1 13		
Pre-qualification, tender, award	24			Q1' 13 – Q3' 13		
Commence Construction	1				Q1' 14	
Complete Construction	42				Q3' 17	
Line Operational	9					Q2'18

The dates set out in the above table are dependent on a number of factors including:

- Receipt of an enforceable Railway Order by November Oct 2010
- Incorporation of elements of Line BXD within the Metro North main infrastructure contract award scheduled for end 2010
- Approval from the Department of Transport to proceed with the project
- Completion of major Metro North construction works in city centre and removal of associated traffic management measures by Q2 2014

An effective and integrated communications plan will be implemented by RPA which will aim to build confidence in the delivery of the project, reduce the potential negative effects of the works and underscore the benefits of BXD. The strategy will build upon RPA's extensive communications efforts made to-date and will cover the period of construction from enabling works to commissioning.

RPA recognises that it is critical for all agencies to co-operate and display "joined up" thinking especially in this economic climate and will co-operate fully with the Office of the T21 Joint Communications Strategy Sub-Group led by Dublin City Council.

The key messages of the communications plan will focus on RPA delivering a new transport choice for Dublin and keeping the city centre open for business during period of construction.

APPENDIX 1 – 2016 Line Flows

Line Flows

The line flows show the numbers of passengers per am peak hour who board and alight the Luas Line BXD at each stop, and give the respective loading at each stop. The line flows for each of the Line BXD Base case and sensitivity scenarios are presented below.

Table 1 – Line Flows 2016 (per hour during AM peak) Base Case

Total (Southbound)	Board	Alight	Load
Broombridge	422	0	422
Cabra	189	69	542
Phibsborough	79	46	576
Broadstone	57	79	554
Dominick	709	37	1,226
Parnell	71	39	1,258
Marlborough	381	135	1,504
Trinity	700	27	2,177
Dawson	217	70	2,324
St Stephen's Green	1,335	57	3,602
Total (Northbound)	**Board**	**Alight**	**Load**
St Stephen's Green	123	1,377	1,877
Dawson	15	536	1,356
Westmoreland	29	459	927
O'Connell Lower	185	369	742
O'Connell Upper	27	184	584
Dominick	45	169	460
Broadstone	9	39	431
Phibsborough	2	64	369
Cabra	2	205	165
Broombridge	0	165	0

Table 2 – Line Flows 2016 (per hour during AM peak) Transport 21 Scenario

Total (Southbound)	Board	Alight	Load
Broombridge	453	0	453
Cabra	204	76	581
Phibsborough	88	52	617
Broadstone	81	84	613
Dominick	756	37	1,332
Parnell	94	44	1,382
Marlborough	401	136	1,647
Trinity	747	54	2,341
Dawson	372	46	2,667
St Stephen's Green	1,437	62	4,042
Total (Northbound)	**Board**	**Alight**	**Load**
St Stephen's Green	127	1,977	2,563
Dawson	10	789	1,784
Westmoreland	97	637	1,244
O'Connell Lower	176	548	872
O'Connell Upper	29	222	679
Dominick	48	203	524
Broadstone	10	49	485
Phibsborough	2	85	402
Cabra	2	230	174
Broombridge	0	174	0

Table 3 – Line Flows 2006 (per hour during AM peak) 2006 Land Use Scenario

Total (Southbound)	Board	Alight	Load
Broombridge	298	0	298
Cabra	160	61	398
Phibsborough	65	28	434
Broadstone	37	72	399
Dominick	243	41	601
Parnell	55	27	630
Marlborough	141	79	692
Trinity	189	24	857
Dawson	37	46	848
St Stephen's Green	706	59	1,495
Total (Northbound)	**Board**	**Alight**	**Load**
St Stephen's Green	100	657	1,332
Dawson	13	376	969
Westmoreland	37	288	718
O'Connell Lower	80	229	569
O'Connell Upper	16	163	422
Dominick	45	133	333
Broadstone	12	24	321
Phibsborough	3	53	271
Cabra	2	84	189
Broombridge	0	189	0

Public Transport Demand

Table 4 – Public Transport Demand Base Case 2016 (per annum)

	Do Min	Do Something	Change from Do Min
Heavy Rail			
Boardings millions	114.6	112.8	-1.8
Bus			
Boardings millions	235.7	232.9	-2.8
Luas			
Boardings millions	76.8	86.8	10.0
Metro			
Boardings millions	80.2	74.9	-5.3
Total PT boardings (millions)	**507.3**	**507.4**	**0.1**
Total PT journeys (millions)	**373.7**	**380.5**	**6.8**
Total PT interchange journeys (millions)	**121.2**	**118.5**	**-2.7**

APPENDIX 2 – CBA Parameters and Assumptions

Discount Rate	4.00%
Appraisal Period	30
Price Base	2002
Evaluation Base	2002
Opening Year	2018
Inflation (2009 onwards)	
Background inflation pa	2.00%
Construction inflation pa	variable
Land Inflation	variable
Machinery inflation pa	variable
O&M Inflation pa	3.36%

From-to	Real GNP Growth % pa
2000 to 2002	6.23%
2002 to 2010	2.70%
2011 to 2015	2.37%
2016+	2.29%

Car (Non User Benefits)		
Am Peak (2002)	€	10.92
Off Peak (2002)	€	12.24
PT (User Benefits)		
Am Peak (2002)	€	8.89
Off Peak (2002)	€	8.62

1.1.1.1.1 Car Occupancy

2000	
Am Peak	1.2
Inter Peak	1.4
2016	
Am Peak	1.2
Inter Peak	1.4

1.1.1.1.2 Accident Costs

Accident Rate (per m veh km)	0.054
Average cost per accident (2002)	€ 179,343

1.1.1.1.3 Vehicle Operating Costs

Fuel	Consumption

Parameters	
Resource cost of fuel	€ 0.33
Duty	€ 0.39
VAT	€ 0.15
L = a + bv + cv^2	
a	0.1587516
b	-0.0026590
c	0.0000181
Non Fuel Costs	
C=a1 +(b1/V)	
a1 work	6.18
b1work	31.58
a1 non work	6.18
b1non work	31.58

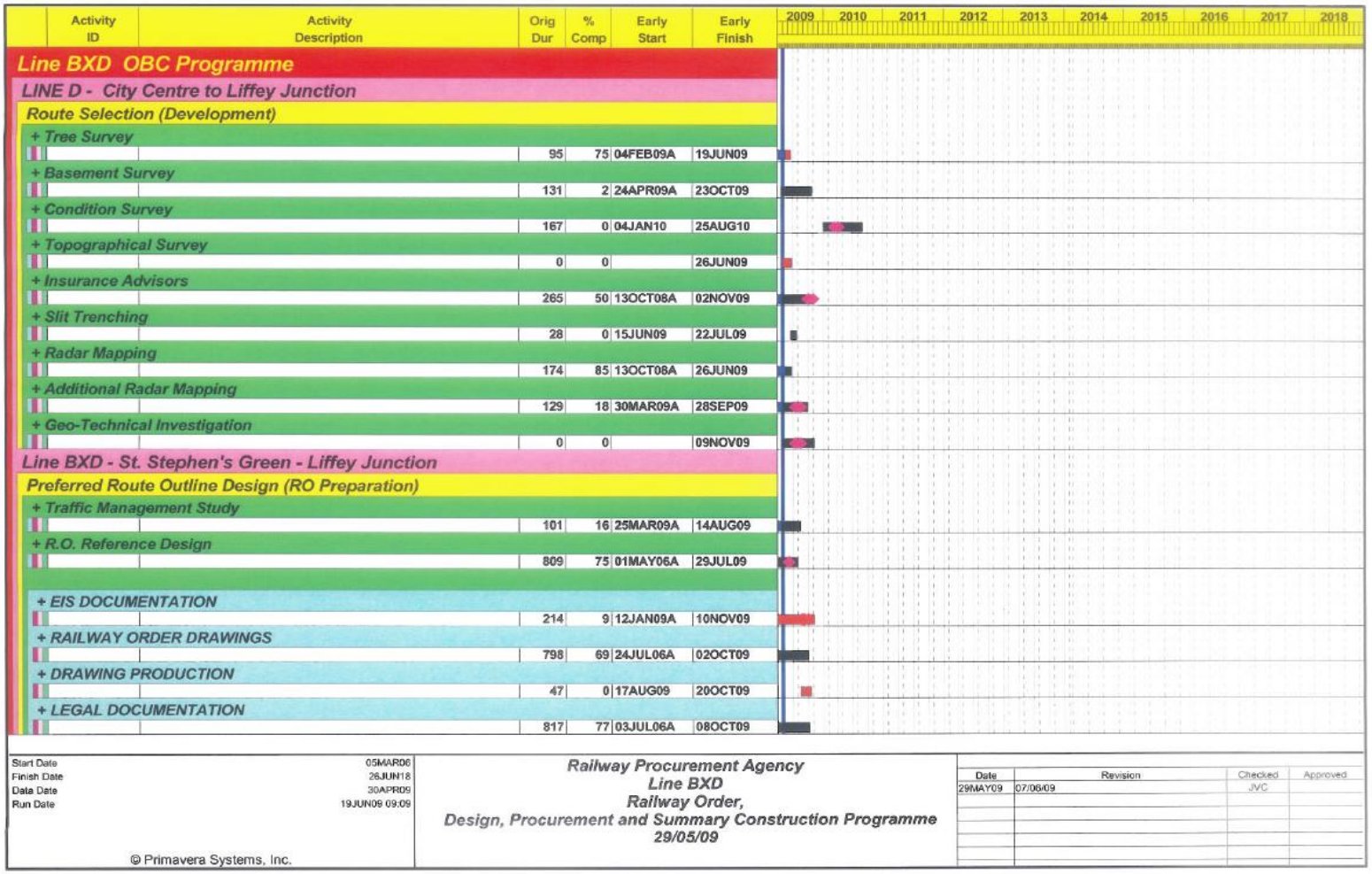
1.1.1.1.4 Operational Build Up	
Years from opening	
2018	100%
2019	100%
2020	100%
2021	100%
2022	100%
2023	100%

1.1.1.1.5 Demand Build Up	
Years from opening	
2018	80%
2019	85%
2020	90%
2021	100%
2022	100%
2023	100%

1.1.1.1.6 Annualisation	
Public Transport	
Peak	1040
Off Peak	3807
Highway	
Peak	1040
Off Peak	3965

1.1.1.1.7 Air Quality (Urban)	€ (2002) per vehicle km
CO2	0.007458
Non- CO2	0.008080

APPENDIX 3 – Line BXD Railway Order Programme



Activity ID	Activity Description	Orig Dur	% Comp	Early Start	Early Finish
	Line BXD OBC Programme				
	LINE D - City Centre to Liffey Junction				
	Route Selection (Development)				
	+ Tree Survey	95	75	04FEB09A	19JUN09
	+ Basement Survey	131	2	24APR09A	23OCT09
	+ Condition Survey	167	0	04JAN10	25AUG10
	+ Topographical Survey	0	0		26JUN09
	+ Insurance Advisors	265	50	13OCT08A	02NOV09
	+ Slit Trenching	28	0	15JUN09	22JUL09
	+ Radar Mapping	174	85	13OCT08A	26JUN09
	+ Additional Radar Mapping	129	18	30MAR09A	28SEP09
	+ Geo-Technical Investigation	0	0		09NOV09
	Line BXD - St. Stephen's Green - Liffey Junction				
	Preferred Route Outline Design (RO Preparation)				
	+ Traffic Management Study	101	16	25MAR09A	14AUG09
	+ R.O. Reference Design	809	75	01MAY06A	29JUL09
	+ EIS DOCUMENTATION	214	9	12JAN09A	10NOV09
	+ RAILWAY ORDER DRAWINGS	798	69	24JUL06A	02OCT09
	+ DRAWING PRODUCTION	47	0	17AUG09	20OCT09
	+ LEGAL DOCUMENTATION	817	77	03JUL06A	08OCT09

2009 2010 2011 2012 2013 2014 2015 2016 2017 2018

Start Date 05MAR06
Finish Date 26JUN18
Data Date 30APR09
Run Date 19JUN09 09:09

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Railway Procurement Agency
Line BXD
Railway Order,
Design, Procurement and Summary Construction Programme
29/05/09

Date	Revision	Checked	Approved
29MAY09	07/06/09	JVC	

Activity ID	Activity Description	Orig Dur	% Comp	Early Start	Early Finish
+ OUTLINE BUSINESS CASE					
		0	0		25JUN09
+ Preparation for Public Inquiry					
		43	0	29JAN10	31MAR10
+ Submission of Application (RO Preparation)					
		114	0	11NOV09	06MAR10
+ Statutory Approval					
		229	0	23DEC09	11NOV10
Design, Documentation and Procurement					
+ Main Infrastructure Works					
		300	0	21NOV13	23JAN15
Utility Diversion					
+ Detail Design					
		415	0	02JUN09	06JAN11
+ TENDERING / NEGOTIATIONS & AWARD					
		202	0	21JUL10	01MAY11
Construction Implementation					
+ Property Procurement					
		240	0	11NOV10	13OCT11
+ Utility Divrns under Metro North(UDI 160708)					
		189	0	11JAN10	01OCT10
+ Utility Diversions outside Metro North					
		1,504	0	02MAY11	24FEB17
+ Marlborough Street Liffey Bridge					
		385	0	05OCT09	31MAR11
+ Civil & Track under Metro North (UDI 160708)					
		319	0	04MAY15	26JUL16
+ Civil & Track Work outside Metro North					
		693	0	26JAN15	28SEP17
+ Depot Construction and Sidings					
		360	0	06NOV15	30MAR17
+ Rolling Stock Procurement, Manufacture, Delivery					
		560	0	05JAN16	06MAR18
Main Infrastructure Works					
+ Systems Installation					
		300	0	12OCT16	07DEC17
+ Testing and Commissioning					
		180	0	23JUN17	06MAR18
+ Trial Running					
		80	0	07MAR18	26JUN18