Údarás
Náisiúnta Iompair
National Transport Authority

Bus Rapid Transit

(BRT)

Core Dublin Network

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1 INTRODUCTION

Bus Rapid Transit (BRT) has emerged in recent years as an effective, cost efficient and high quality public transport system. As BRT is a relatively new mode of transport, there are various definitions and interpretations as to what BRT represents and there are many different forms of BRT systems in operation worldwide. Definitions of BRT range from a Quality Bus Corridor (QBC) to being a fully guided, fully segregated bus system.

BRT systems are generally of a higher standard than conventional QBCs in that they offer increased reliability in relation to punctuality, journey times and also provide higher passenger capacity, which requires additional investment and improvement in infrastructure, vehicles and systems.

BRT should be viewed as a new, separate system with its own specific field of application. When BRT has a suitable operating environment it can attract car users and stimulate economic development. BRT should be seen as an appropriate mode of public transport on corridors where there is a significant public transport deficit, but which are unlikely to have the required passenger demand to justify major investment in rail based systems.

The draft National Transport Authority (NTA) transport strategy for the Greater Dublin Area for the period up to 2030 includes various measures in relation to BRT.

This report describes and defines a system concept for BRT in the Dublin context. The system concept was defined based on an examination and assessment of the typical components and features that make up a BRT system.

The report also describes the feasibility study that was carried out on the proposed core BRT network for Dublin. The purpose of this feasibility study was not to identify the preferred route for a BRT system on a particular corridor nor was it to suggest the preferred design on any section of alignment considered. Instead, it was to investigate the technical, environmental, demand and economic feasibility of a proposed core BRT network. Should the proposed BRT network be considered feasible and worthy of advancement, a further route selection and design process will be required to advance specific proposals.

2 SYSTEM CONCEPT

2.1 Background

Bus is an essential transport mode in providing mobility within the Greater Dublin Area. Bus currently carries the largest share of public transport users and will continue to carry a major share in the foreseeable future. The potential of bus is currently constrained because without full segregation from other road traffic, buses get delayed in general traffic congestion and are, therefore, subject to unreliability of services. As additional buses are added to routes to cater for growing demand, buses start delaying one another which can also affect their attractiveness and reliability.

There are various forms of BRT systems in operation worldwide. As stated earlier, they are generally of a higher standard than a conventional QBC. Some BRT systems remove the buses fully from other traffic, for example, running parallel to a congested motorway, while others are much less segregated.

In circumstances where Exchequer constraints do not permit investment in higher capacity rail based systems, BRT can also prove to be a more affordable means of achieving many of the transport objectives, while recognising that BRT cannot generate the full benefits of higher efficiency systems such as Light Rail Transit (Luas), Metro or heavy rail.

BRT systems can operate as an end-to-end system in the style of Light Rail Transit (LRT) ("closed system") or other bus services and routes can join the BRT system as tributaries ("open system") or as a combination of both as a "semi-open" system.

Early implementers of BRT systems typically were cities in Latin America such as Curitiba and Bogota. More recently BRT systems have been implemented and planned in China and South East Asia. Recently, BRT systems have also been developed in cities across North America. Figure 1 illustrates the Bogotá TransMilenio BRT System.

There are fewer BRT systems in Europe and this is in part because rail based systems already provide the mass transit function in many European cities. It may also be due to the perception that until the emergence of a high quality BRT system, bus based public transport would not achieve significant modal shift from private car. A major difference between successful BRT systems in developing countries and those in Western Europe and North America is that in developing countries, public transport users typically do not have a car available and the road networks are operating in excess of capacity. In Western Europe, BRT needs to be of a standard that offers an attractive alternative to other options available to transport users.

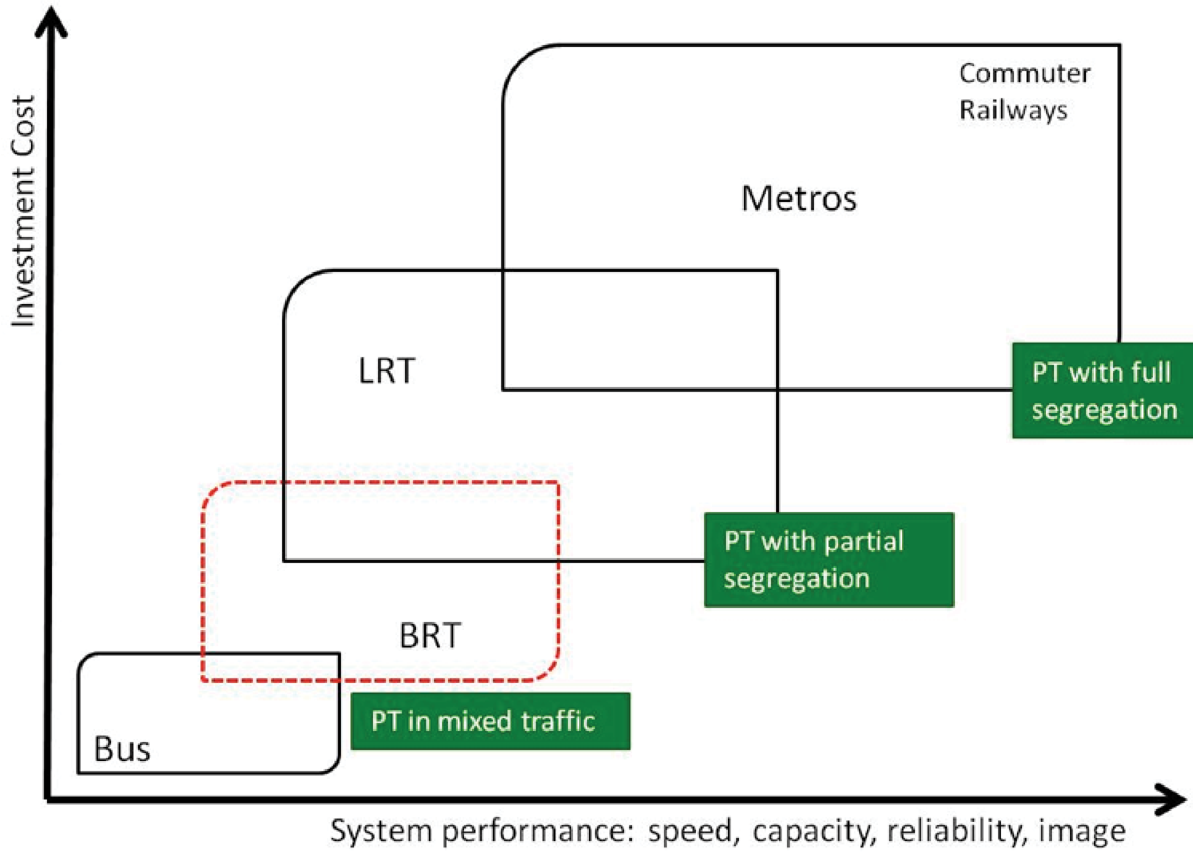
Source: Institute for Transportation & Development Policy (ITDP) BRT Planning Guide 2007, p10

Figure 1 Bogotá TransMilenio BRT System

2.2 Capacity

The key issue relating to any public transport system including BRT is its ability to have sufficient carrying capacity to meet existing demand and reserve capacity to meet future demand and to fulfil its transportation needs and objectives.

The traditional view is that BRT systems typically have capacity ranging between 2,000 and 6,000 ppdph (passengers per direction per hour) depending on the level of segregation from other road users. A modern BRT vehicle would have a capacity for 120 passengers. BRT is sometimes considered as an intermediate mode providing a service between conventional buses and Light Rail Transit (LRT) in terms of both performance and investment cost. It should be viewed as a new, separate system with its own specific field of application but there can be an overlap zone between the higher end of BRT capacity and the lower end of LRT capacity. This is illustrated in Figure 2 below.



Source: Vukan R. Vuchic – "Urban transit systems and Technology 2007"

Figure 2 Traditional view of BRT

BRT systems can be broadly grouped into three categories:

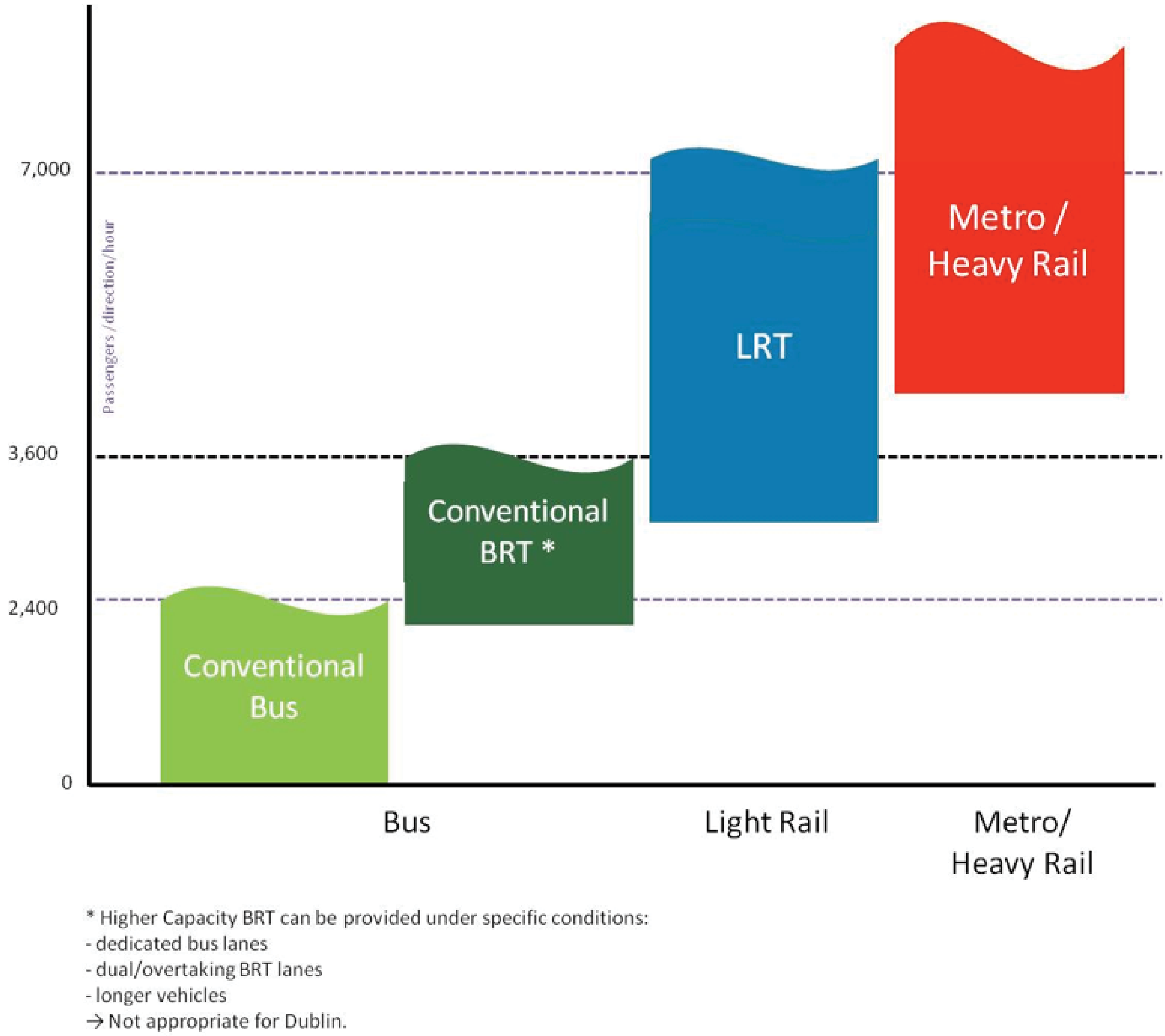
- High Capacity;
- Moderate Capacity; and
- Partial or Low Capacity.

High capacity BRT has typically been implemented in South America, South East Asia and Africa. These systems have capacities exceeding LRT and sometimes matching Metro. These typically operate on dedicated bus roads with overtaking facilities.

Moderate capacity BRT systems, such as the French concept 'Bus with a High Level of Service' (BHLS) have capacities typically less than LRT but in some instances matching or exceeding LRT, for example Nantes. Moderate capacity BRT systems have also been implemented in North America, other parts of Europe and Australia.

Partial or Low Capacity BRT – This is typically a European approach where conventional bus systems are upgraded with the focus on quality, reliability and image.

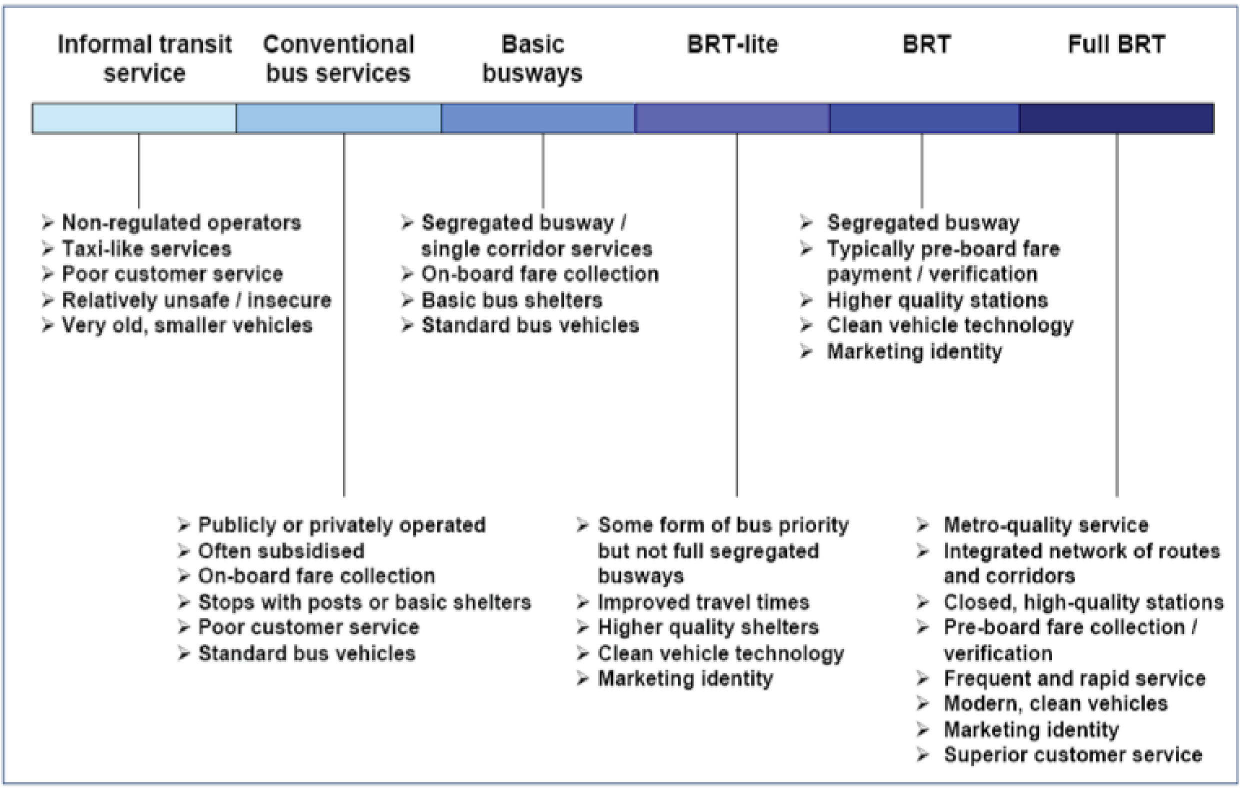
Figure 3 below illustrates the capacity that can be achieved by these different types of BRT systems and how they can compare with LRT and Metro systems.



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

Figure 3 Public Transport Mode Capacities

Figure 4 below illustrates the typical features and characteristics that are in place for the different Bus based systems.



Source: Institute for Transportation & Development Policy (ITDP) BRT Planning Guide 2007, p12

Figure 4 Typical Features of Bus Based Systems

2.2.1 Capacity – Irish context

Based on the experience to date on Luas, the key factors of success are the predictability in terms of frequency and journey times as well as reliability and consistent performance. These factors are critical to determining capacity. If these factors are reduced, the performance and correspondingly, the quality of the system will be reduced and result in a system unattractive to passengers and which will not achieve the desired modal shift from private car. This implies a need for low dwell times at stops, priority at traffic lights, and is highly dependent on the level of segregation achieved.

With regards to establishing an appropriate capacity threshold for a BRT system on a particular corridor, the decision depends primarily on the size of the vehicle and the frequency of service. Typically, capacity is measured by the number of passengers past a point per direction per hour. Based on a maximum reliable frequency of 30 vehicles per hour using a typical BRT vehicle of approximately 18m long with a capacity of 120 passengers will give an ultimate capacity of 3,600 passengers per direction per hour (ppdph). There is the possibility of extending these single articulated vehicles from 18m to approximately 25m long vehicles through adding in a second articulation. This would increase the ultimate capacity to 4,500 ppdph.

To achieve the thresholds outlined above will require a significant change to the current philosophy regarding junction priority. Bus frequencies operating in excess of the thresholds above would result in reduced reliability and performance particularly at road junctions because, in effect, there would be a bus crossing each junction on average every 60 seconds which is less than the average signal cycle time in Dublin (typically 120 seconds).

At these frequencies, removal of priority would lead to bunching of services and a deterioration of reliability and quality.

The experience of public transport from other cities where a large proportion of the population have "access to a car" confirms that a modal shift from private car can only be achieved if the public transport offering is reliable, frequent and provides competitive journey times.

Table 1 shows typical capacities in terms of both rolling stock and systems based on a 2 minute operating frequency.

Rolling Stock	Capacity of Rolling stock in terms of number of maximum passengers	Capacity of the system in terms of number of maximum passengers per direction per hour (based on a frequency of 2 min.)
Standard bus (12 m)	80	2,400
BRT Single Articulated Vehicle (18.5 m)	120	3,600
BRT Bi-articulated Vehicle (24.5 m)	150	4,500
Light Rail Vehicle (40m long/ 2.40 m wide)	250	7,500

Table 1 Capacities of different Vehicles and Systems

2.2.2 Commercial speed

BRT systems represent a significant upgrading over conventional bus operation. They operate on corridors where there is sufficiently high passenger demand to justify investment in these systems. As outlined above, experience shows that for a public transport system to be successful it needs to be reliable, frequent and have competitive journey times with the private car. If these ingredients are not in place a modal shift from private car will not be achieved. Based on experience from other cities that operate these systems, for BRT systems to be successful in terms of modal shift they need to achieve average commercial speeds between 15 and 25 km/h. Currently in Dublin, average speeds on some Quality Bus Corridors are above 15km/h. As the BRT system would represent an upgrade over the conventional bus operation the average commercial speed for a BRT system should be between 20 km/hr and 25km/h.

Average journey speeds of this order are already achieved on the Priority 1 QBCs; however they are not achieved consistently. For example, the Stillorgan QBC has an average journey speed of 17.9km/h during the AM period however bus journey times range widely between 25.00 and 40.49 minutes.

Unreliability in journey time can act as a disincentive to travel. Whilst the commercial speed needs to be competitive with private car, the reliability and consistency in journey time is of equal importance.

2.2.3 Recommendation

As noted above, High Capacity BRT systems can have capacities exceeding LRT and sometimes matching Metro. These typically operate on dedicated bus roads with overtaking facilities provided at stops. The types of cities that operate these BRT systems are not directly comparable to Dublin. The demand on the bus corridors examined as part of the technical work undertaken in the preparation of the NTA draft transport strategy does not justify this type of BRT system.

It would also be difficult to physically accommodate this type of BRT system into the existing streetscape particularly in the city centre with its narrow roads network. To maintain an end

[1] A very substantial amount of transport modelling work was undertaken by the NTA on corridor demand in the period 2009 to 2010 while drawing up its draft strategy document.

to end journey time with very high frequencies, a totally segregated route (busway) would be required and road junctions would have to be grade separated. This would significantly increase the capital cost. Such a BRT system would also require more physical space than a LRT system due to increased alignment clearances and overtaking facilities at stops to accommodate the high bus frequencies. This additional infrastructure also increases very significantly the capital cost.

Taking into account the capacity thresholds, likely demand levels and commercial speeds required, the BRT system for Dublin should be based on a moderate capacity BRT system (2,400 to 3,600 ppdph with some expansion possibilities) as outlined above.

2.3 Strategic Context

As noted earlier, the NTA has already examined the potential for BRT in Dublin in terms of demand along key transport corridors. In the draft National Transport Authority (NTA) transport strategy for the Greater Dublin Area for the period up to 2030, the NTA identified the potential for the upgrade of some or all of four current, and strongly performing, QBCs to BRT type operations, taking into account passenger demand, proximity of rail alternatives, the level of bus priority that is feasible along the corridor and the suitability of the corridor for BRT type vehicle operation.

Figure 5 illustrates the quality bus corridors that were identified in the draft Transport Strategy.

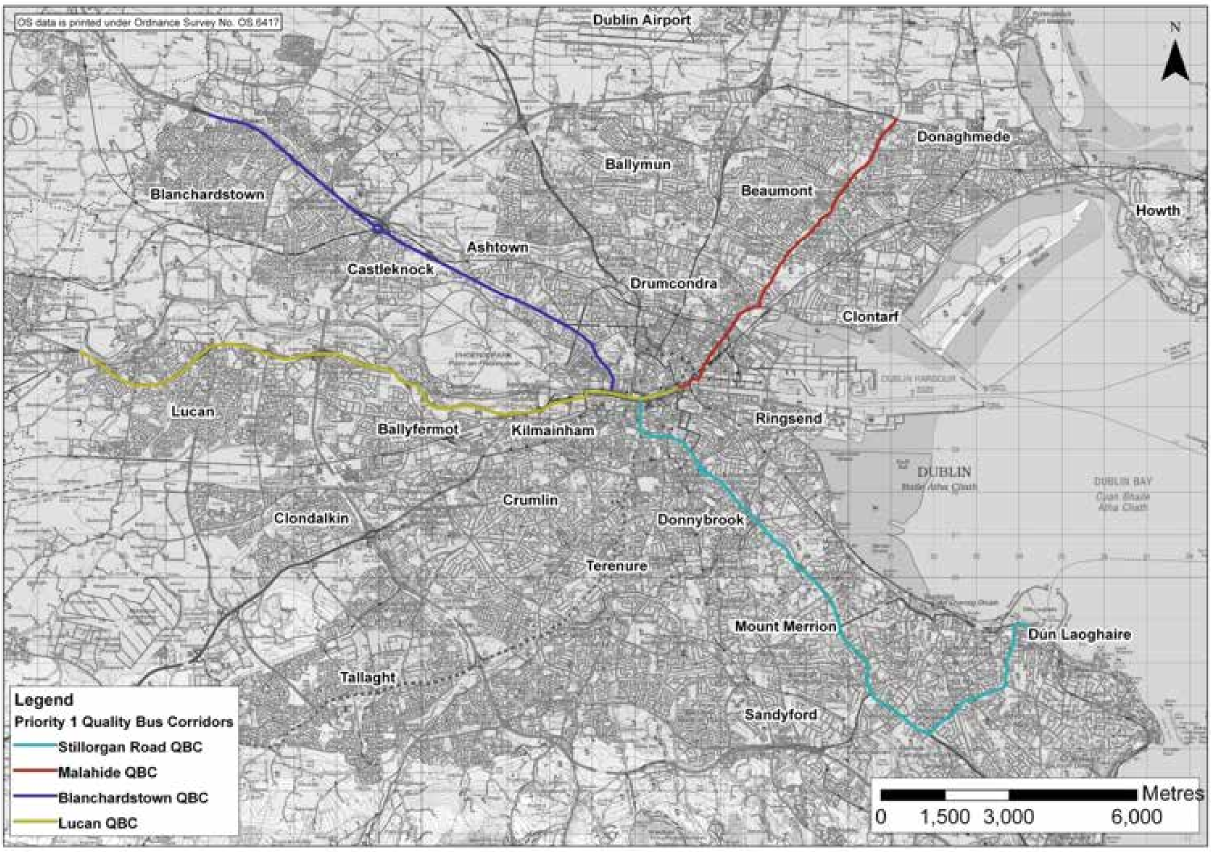


Figure 5 NTA draft Transport Strategy - Priority 1 Quality Bus Corridors

In addition, the NTA identified the need for either a BRT or LRT system to serve the southwest sector of Dublin and connecting to the south city centre via the Kimmage area.

2.4 Characteristics of BRT

As discussed previously there are a wide variety of BRT systems in operation worldwide, but they can all be described in terms of the following key elements:

- Running Ways;
- Stops;
- Vehicles;
- Operating Philosophy/Service Provision;
- Support Systems; and
- Attractiveness.

2.4.1 Running Ways

The running way (BRT lane) is the most important aspect of the BRT system. This is what enables the BRT services to operate reliably and at high speed. For a BRT system, the primary requirement is to have very high levels of, if not full, segregation from all other traffic. Physical separation from general traffic will prevent encroachment. Running ways normally fall into three categories:

- Dedicated bus road;
- Median dedicated lanes in the centre of the road; and
- Lateral dedicated lanes located at the edge of the road.

A dedicated bus road category is typically associated with high capacity BRT systems while the median and lateral dedicated lanes categories are associated with moderate capacity BRT systems on which the proposed Dublin BRT system concept should be based. Local conditions and constraints on particular corridors will determine the exact location of the dedicated lanes. Typically it is not possible to have dedicated bus roads that penetrate a city centre, such as Dublin, due to space constraints.

Figure 6 and Figure 7 illustrate typical configurations for median and lateral running.

Source: http://www.nantes.fr/bd-du-gal-de-gaulle

Figure 6 Typical configuration for median running

Source: Bus with a High Level of Service (BHLS) report, Certu, p183

Figure 7 Typical configuration for lateral running

The running surface should be of high quality, smooth, durable, with clear delineation markings or using distinctively-coloured surfacing materials.

Figure 8 illustrates such an example.

Source: http://joelcayford.blogspot.ie/2010/08/auckland-bus-lane-enforcement.html

Figure 8 Running Way with distinctively - coloured materials

Opening these lanes to other categories of vehicle (e.g. bicycles, taxis, and conventional bus services) is an option that may be envisaged, particularly where the frequency of the BRT line allows it and where the impact on BRT safety and service levels (i.e. reliability, speed) is low. There is a trade off however between achieving a target end to end commercial speed and allowing access to non-BRT modes. For certain critical sections, it may be preferable that such sections can only be used by BRT vehicles and for other buses that do not stop in that section.

As with LRT, choices regarding protection levels depend on the urban context and on the risk of dedicated lanes being compromised. To be effective, dedicated lanes must above all be respected by other road users.

Table 2 below summarises the advantages and disadvantages of types of dedicated lanes.

Lane Type	Advantages	Disadvantages
Bilateral lanes	- Pavements can be encroached upon to make room for stops - Easier and safer for cyclists using these lanes on the approach to junctions - Improved passenger safety at stops	- Potential conflicts with the surrounding environment (parking, deliveries, adjacent general traffic lanes, residential access) - Potential conflicts caused by turning traffic needing to cross the dedicated lane
Two-way median lanes	- Easier access for services (refuse collection, deliveries, parking) in direct contact with businesses and housing - Conflicts with residential access reduced - Dedicated lanes respected - Easier to negotiate junctions - In practice, possible to obtain higher speeds on the approach to junctions (less risk of side collisions)	- Takes up more space, especially around stops - Pedestrians have to cross the road to access stations
Two-way lanes on the same side	- Useful in cases of urban asymmetry (residential access, junctions, businesses) - Cars run in the opposite direction to the nearest buses (improved safety, dedicated lanes respectively)	- Operational problems at signal-controlled junctions (3 phases necessary) - Less safe for cyclists using these lanes - Potential problems associated with traffic turning at junctions and residential access

Source Bus with a High Level of Service (BHLS) report, Certu, p82

Table 2 Advantages and Disadvantages of different types of dedicated lanes

BRT systems require more physical space than LRT systems due, for example, to alignment clearances and overtaking facilities at stops if and when the system is being run at high frequencies to ensure reliability of journey time.

2.4.2 Stops

BRT systems and stops represent a significant upgrading over regular buses and QBCs. In that sense a specific image with a brand name is appropriate to help distinguish it and set it apart from regular bus services. BRT stops should, therefore, also represent a significant upgrade from regular bus stops or QBC stops. The passenger waiting experience should be a comfortable one with shelters and other facilities to be provided as standard. Passengers should be provided with information both on the vehicle and at stops. This should include real-time passenger information relating to the BRT service. Figure 9 shows a city centre stop in Nantes, France.

Source: http://www.transportphoto.net/cmtbrt

Figure 9 City Centre Stop - Nantes

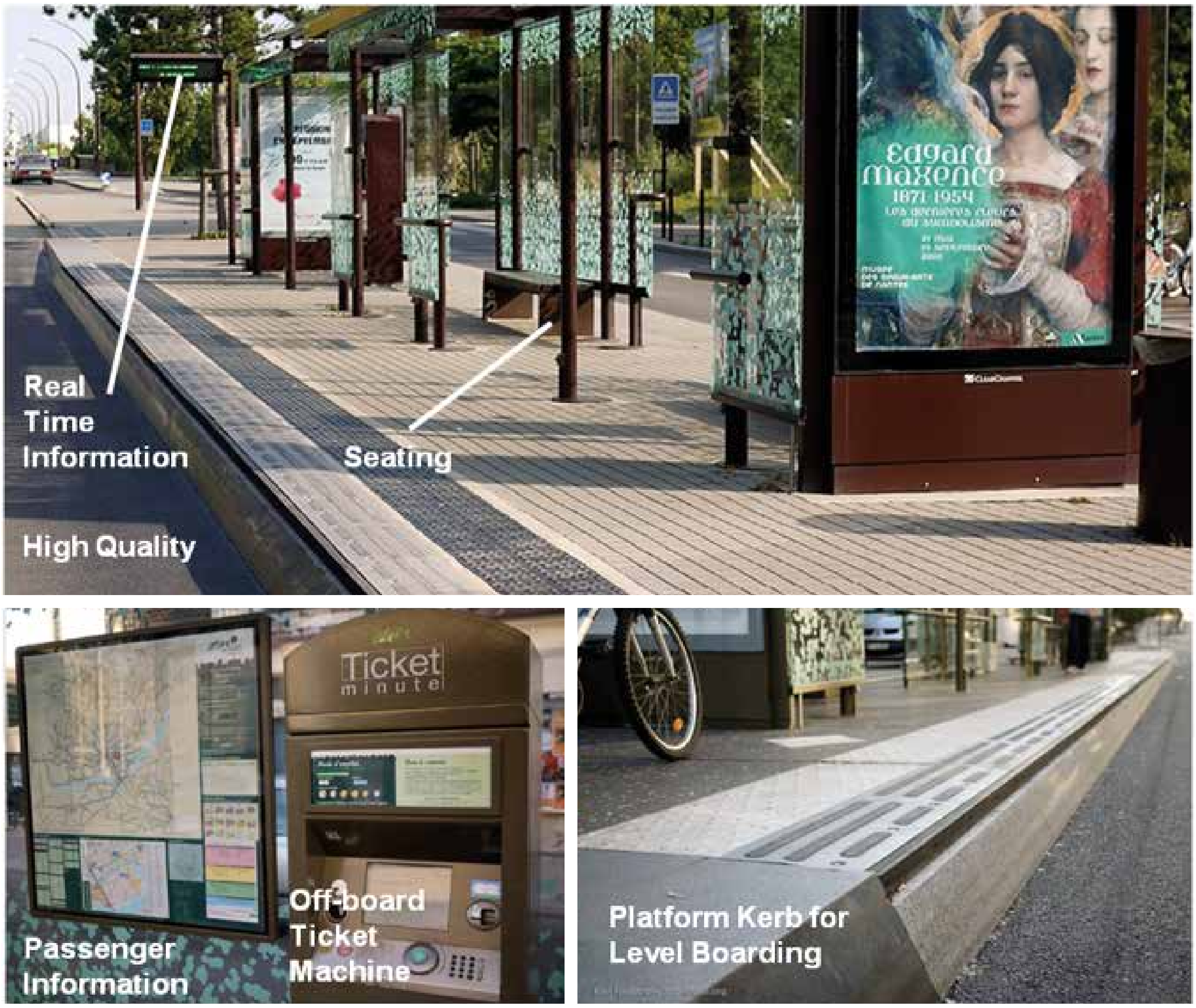
Stops should be identifiable by name and should be clearly displayed at each stop. All stops should be pleasing environments for the passenger, utilising designs, materials and components of a high quality. BRT stops should come as standard with high quality features, such as surfacing, shelters, automatic ticket vending machines and passenger information displays, CCTV systems, and audio systems.

Shelters should be aesthetically pleasing and, whilst being constructed of high quality materials, should be robust and low maintenance. Surfacing should be of high quality, appropriate for its function, relate to its receiving environment and clearly designate the stop environ. Stops should offer good accessibility from local neighbourhoods.

These design features, as well as being attractive, would also help maintain the reliability and commercial speed on the system.

The design should make provision of off-bus fare collection and off-vehicle ticket validation in order to allow passengers to board through all doors, thereby reducing the boarding times. Buses with guidance wheels/systems should be considered to allow for more precise docking at platforms. Platforms and approaches to ramps should incorporate tactile warnings. These facilities will decrease passenger boarding times and enhance accessibility for all.

Figure 10 below shows a typical layout of a BRT stop.



Source: http://www.transportphoto.net/

Figure 10 Typical design and layout for a BRT stop

2.4.3 Vehicles

The types of bus vehicles utilised on BRT systems can vary widely as illustrated in Figure 11. The main determinants in choice are the demand, frequency, operational, concept, and image of the BRT system. The main categories of bus vehicles are:

- Rigid single deck vehicle;
- Articulated single deck vehicles for moderate to high capacity;
- Bi-articulated single deck vehicles, where very high capacity is required; and
- Rigid double deck.

The characteristics of these vehicle categories in terms of, for example, accessibility, capacity, manoeuvrability, cost, reliability, etc, will determine the vehicle that meets the requirements of the BRT system.

Source: Top Left http://www.transbus.org/construc/man_lionscity.html, Top Right http://www.mercedes-benz.fi/content/finland/mpc/mpc_finland_website/fi/home_mpc/bus/home/consulting/brt/systems_brt/nantes.0003.html, Bottom Left http://www.dvb.de/de/Aktuelles/DVB-Kampagnen/95-Jahre-Bus/Dresdner-Bushistorie/#van_hool, Bottom Right http://www.busworld.org/articles/detail/1560

Figure 11 Vehicle Types: MAN Lion's City rigid single deck (top left); Mercedes-Benz Citaro G CNG articulated single deck (top right); VanHool AGG300 bi-articulated single deck (bottom left); and biofuel-powered ADL/Scania double decker (bottom right).

In order to select the appropriate vehicle type for a Dublin BRT, it is important to consider a number of basic design requirements. It is assumed that the Dublin BRT vehicle will:

- be capable of operating on all public roadways in Ireland;
- match the accessibility of Dublin's Luas Light Rail Vehicles;
- minimise dwell times at BRT stops;
- be capable of transporting a minimum of 120 passengers under peak loading conditions; and
- maintain a seating provision appropriate to the average duration of passengers' journeys.

2.4.3.1 Public Roadways

In order to retain maximum flexibility in the event of disruption to their normal routing and service (and to maximise their residual value and utility), it is assumed that Dublin BRT vehicles will be capable of operating on all public roadways in Ireland. Irish Statutory Instrument No. 99/2004 mandates that the Dublin BRT vehicle must therefore be one of the following; a twin-axle rigid bus with a maximum length of 13.50 metres; a tri-axle rigid bus with a maximum length of 15.00 metres; or an articulated bus with a maximum length of 18.75 metres (operation of a bus greater than 18.75 metres in length on public roadways in Ireland would currently necessitate amendment of these regulations and possible upgrade works to the road network).

It is further assumed that Dublin BRT vehicles will not be required to operate within tunnels or confined spaces other than road tunnels equipped with ventilation systems designed to extract road traffic emissions, such as the Dublin Port Tunnel. It will not, therefore, be necessary for Dublin BRT vehicles to be equipped with a fully-electric propulsion system or enhanced emissions control equipment, or indeed to be equipped with fire suppression or safety equipment superior to the existing mandatory requirements for urban buses operating in Ireland.

2.4.3.2 Accessibility

One of the successes of the Luas Light Rail system is the accessibility of the vehicle in that people of all ages and mobility are able to easily board and alight from it. It is therefore considered essential that the BRT system aspires to match the accessibility of Luas insofar as is possible.

Figure 12 illustrates the accessibility that the BRT should try to match.

Source: Bus with a High Level of Service (BHLS) report, Certu, p99

Figure 12 Accessibility for all

Dublin BRT vehicles will be low-floor, with a door threshold height of circa 300mm-340mm from the top of the running surface. The platform heights at Dublin BRT stops will be circa 300mm from the top of the running surface in order to minimise the vertical gap between the platform surface and the door thresholds.

In addition, it is likely that a guidance system will be deployed at, and on the approaches to, Dublin BRT stops so as to minimise the horizontal gap between the door thresholds on Dublin BRT vehicles and the platform edge and thereby match the accessibility of Luas light rail system. It is also possible that such a system could be deployed on sections of Dublin BRT running ways where limited horizontal clearances exist. It will be necessary for each Dublin BRT vehicle to be equipped with onboard equipment designed to interact with the guidance system in the event that such a system is adopted on Dublin BRT.

The various measures proposed will facilitate level access and will, therefore, make boarding and alighting easier for passengers, which will assist in the minimisation of dwell times at BRT stops.

The vehicle must also be compatible with the infrastructure in other ways as well, for example, Automatic Vehicle Location System (AVLS) and traffic loops.

2.4.3.3 Dwell Times

The measures described above will facilitate level access and will make boarding and alighting easier for passengers, which will assist in the minimisation of dwell times at BRT stops. In order to further reduce dwell times, it is assumed that the Dublin BRT vehicle will be equipped with multiple door positions (potentially with up to 4 or 5 double-leaf doors on the nearside or both sides of the vehicle) so as to facilitate rapid boarding and alighting of passengers. Of these door positions, it is assumed that all doors will be capable of being accessed by a wheelchair or pushchair, with at least one of the door positions leading directly into a spacious multi-functional area inside the Dublin BRT vehicle.

It is assumed that Dublin BRT stops will typically consist of one or more platforms, with each platform face being circa 25 metres in length with a 6 metre long ramp at each end. Each platform will, therefore, comfortably accommodate one Dublin BRT vehicle and allow it to load/unload using all doors, even in the event that the vehicle exceeds the current maximum permitted length of 18.75 metres.

Should the alignment of a Dublin BRT running way incorporate one or more BRT stops equipped with island or offside platforms, it will be necessary for the Dublin BRT vehicle to be equipped with multiple door positions on both sides of the vehicle, which may also necessitate the inclusion of a centrally-positioned driver’s cab. Installing doors on both sides will reduce the seating capacity of the vehicle and reduce the amount of floor space available for use as a multi-functional area, but will increase the standing capacity and, therefore, the overall capacity of the vehicle.

However, depending on the chassis design and propulsion system arrangement, it may not be possible to equip certain manufacturers’ vehicles with door positions on the offside in similar locations and quantities to those on the nearside without a substantial redesign of the chassis or an acceptance that not all of these door positions will offer level access. Furthermore, an increase in the number of door positions will introduce a greater reliability risk as the doors on public transport vehicles are typically the components that require the most maintenance and the most likely source of faults whilst the vehicle is in service.

In the event that the BRT system operates in a semi-open manner it would not be possible for regular buses to utilise island or off-side platforms as their doors are positioned on the near side only.

On balance it is proposed that, unless alignment requirements dictate otherwise, the BRT system design should be based on a system with lateral stop platforms and vehicles incorporating multiple doors on the near side only.

2.4.3.4 Capacity & Seating Provision

It is assumed that a minimum capacity of 120 passengers per vehicle is sufficient to cater for expected passenger demand on any of the initial corridors considered within the GDA where it is proposed that the initial rollout of Dublin BRT will take place.

It is important to note that, unlike some modern light rail vehicles (trams), it will not be possible to extend the Dublin BRT vehicle to cater for increases in demand as, although some vehicle manufacturers have alluded to the possibility, none have yet brought to market a proven solution that would overcome the difficulties associated with the absence of distributed traction power equipment (which facilitates the extension of modern light rail vehicles) and guidance. In the event that demand does exceed capacity and service frequencies cannot be increased, the acquisition of larger-capacity and longer replacement vehicles is currently the only feasible solution.

2.4.3.5 Conclusions

A rigid single deck vehicle is incapable of meeting the Dublin BRT vehicle requirements as regards capacity and seating provision (typical capacity of 80 only). Moreover, a rigid single deck vehicle designed to maximise passenger capacity by exploiting the maximum permitted lengths for this vehicle type is also likely to encounter severe difficulties in attempting to access existing bus infrastructure and minimise the horizontal gaps between door thresholds and platform surfaces at Dublin BRT stops.

A bi-articulated single deck vehicle represents the optimum solution where passenger demand is expected to grow significantly within the service life of the vehicle, as it is the highest capacity vehicle type that is currently available for use on BRT systems. However, given that it is assumed that the Dublin BRT vehicle will be capable of operating on all existing public roadways in Ireland, it is not currently feasible to opt for a bi-articulated single deck vehicle as its length (24-plus metres) will exceed the maximum vehicle length of 18.75 metres imposed by current regulations. Furthermore, a vehicle of such length will be unable to access existing bus infrastructure.

Rigid double deck vehicles have been used extensively throughout Ireland for at least 70 years and are valued for possessing a minimal road and garage footprint while offering a high passenger capacity and plentiful seating. Most models are accessible to Persons with Reduced Mobility (PRMs), typically possessing a low floor along a substantial proportion of their lower deck, while others are equipped with up to three door positions and two stairwells to speed the boarding and alighting of passengers. Nonetheless, given that the minimisation of dwell times at Dublin BRT stops and achieving a high degree of accessibility for all passengers are key requirements, the fact that for more than half of the usable floor space of the Dublin BRT vehicle would be positioned on an upper deck accessible only by one or two narrow stairwells does not provide an optimal solution. The rigid double deck vehicle is, therefore, not proposed for adoption as the Dublin BRT vehicle.

2.4.3.6 Proposed Vehicle Type

Based on the assumptions contained within the basic design requirements, the Dublin BRT vehicle should be an articulated single deck vehicle with a maximum length of 18.75 metres and a maximum width of 2.55 metres. This type of vehicle is capable of fulfilling all of the basic design requirements as it will be capable of: operating on all public roadways in Ireland; utilising all relevant existing public transport infrastructure (to an acceptable extent); emulating the accessibility of Luas; minimising dwell times at Dublin BRT stops; transporting a minimum of 120 passengers per vehicle under peak loading conditions; and maintaining a seating provision appropriate to the average journey time. Should demand assessment indicate that a longer vehicle will be required, the potential for amending the existing regulatory restrictions on vehicle length will be examined.

2.4.3.7 Potential Vehicles

Aside from the basic design requirements outlined above, the vehicle selected to be the Dublin BRT vehicle should also be attractive, distinctive and possess an interior ambience superior to the existing bus fleet operating in the GDA. As such, the vehicle should aspire to match or even eclipse the high standards (both in terms of aesthetics, passenger facilities and passenger comfort) that have been achieved on vehicles for recent BRT/BHLS projects in France, the U.S.A. and Britain. Aside from enhanced exterior styling, expansive glazing, translucent bellows and distinctive colour schemes, the vehicle is also likely to incorporate: air conditioning in the driver's cab; extensive soundproofing and vibration damping; onboard Wi-Fi; induction loops for the hard-of-hearing; and dynamic passenger information displays. Figure 13 and Figure 14 illustrate the exterior and interiors of some modern high quality BRT vehicles.

It is also desirable that the Dublin BRT vehicle should consider the latest developments in propulsion technologies so as to minimise the vehicle's carbon footprint. Based on contemporary experiences and the rate of progress in the development of energy conversion and storage technologies, consideration will be given to whether the Dublin BRT vehicle should incorporate proven diesel-hybrid technology, although there is, as yet, no clear preference regarding which of the diesel-hybrid formats (i.e. series, parallel or combined) or energy storage media (i.e. batteries, capacitors, flywheel, other) the Dublin BRT vehicle may utilise.

Source: Top Left http://allaboutbuses.wordpress.com/category/wrightbus/, Top Right http://en.wikipedia.org/wiki/File:Ftr_bus_in_University_Road,_York_University_campus,_19004_(B7_FTR),_7_April_2007.jpg, Bottom Left http://www.lineoz.net/forum/viewtopic.php?f=1&t=16019&start=250, Bottom Right http://www.lineoz.net/forum/view-topic.php?f=1&t=13874&start=250

Figure 13 Potential Vehicles: WrightBus StreetCar RTV and StreetCar BRT, for Las Vegas and York, respectively (top left and top right); VDL Group/APTS Phileas for "évéole" system in Douai (bottom left); and Irisbus/Iveco Crealis Neo for Dunkerque (bottom right).

Source: Top Left http://www.lineoz.net/forum/viewtopic.php?f=1&p=290872, Bottom Left Nimes – Certu BHLS Séminaire Productivité dans les transports publics TRANSDATA, October 2010, Top and Bottom Right FTR York – Presentation Alan Brett ATKINS (International Mass Transport Fair 2007 "Bus Rapid Transit in the UK: Experience and Plans"

Figure 14 General views of the passenger saloon onboard IrisbusCrealis Neo articulated single deck vehicles for Dunkerque (top left), Swansea (top right), Nimes (bottom left) and Swansea (bottom right) showing dynamic passenger information displays, bespoke high-quality interior finishes

2.4.4 Guidance Systems

Guidance is often used on BRT systems to increase operational efficiency. For certain route corridors due to space constraints and lateral clearances it can be extremely difficult to penetrate the existing street networks particularly in the city centre. On these corridors it would be nearly impossible for a BRT system driver to maintain a constant clearance from parallel traffic lanes or buildings etc in the absence of a guided system.

Guidance systems are also used extensively at stops in BRT systems. These provide the ability to dock the vehicle precisely at stops thereby improving accessibility and reducing dwell times.

2.4.4.1 Dublin BRT – Potential Application #1: Accessibility

As mentioned one of the successes of the Luas light rail system is the accessibility of the vehicle in that people of all ages and mobility are able to easily board and alight from it. It is therefore considered essential that the Dublin BRT system aspires to match the accessibility of Luas insofar as is possible. On Luas, the vertical gap is minimised by providing platforms that are of a comparable height (280mm) to the door threshold of the trams. Dublin BRT stop platforms will be 300mm in height from the top of the running way surface so as to minimise the vertical gap to the door thresholds of the Dublin BRT vehicles, which will be 300mm-340mm from the top of the running way surface.

However, Luas light rail vehicles achieve a minimal horizontal gap between the door threshold and the platform edge because they run on fixed rails that ensure that the lateral positioning of the tram door threshold relative to the platform is extremely consistent.

Achieving consistent lateral positioning between the door threshold(s) on Dublin BRT vehicles and the platform edge(s) at Dublin BRT stops is essential in emulating the accessibility of Luas. The application of a guidance system at stops is key to meeting these requirements of accessibility and should be included as part of the BRT system concept for Dublin.

2.4.4.2 Dublin BRT – Potential Application #2: Locations with Restricted Lateral Clearances

Another potential application of the guidance system technologies is in locations where there is a desire to construct dedicated BRT running ways in locations where there are insufficient lateral clearances to accommodate regular-width bus lanes and where there is a requirement or preference to maintain existing traffic flows and avoid the demolition of structures along the route.

It should be noted that guidance systems however, are not essential to the success of BRT systems. BRT/BHLS systems such as Zuidtangent (Amsterdam, The Netherlands) and BusWay (Nantes, France) have been hugely successful in spite of the absence of any guidance system. In those cases the lateral movement of each vehicle is solely the responsibility of the driver of the vehicle on each system, albeit that running ways in the vicinity of, and through, stops are designed to be very straight in order to aid positioning of the vehicle. Nonetheless, it has been demonstrated on other systems such as TEOR (Rouen, France) that guidance systems can assist in improving the accessibility, comfort and safety of BRT, as well as having the potential to reduce the land-take required for BRT running ways. Dublin BRT may exploit the advantages offered by guidance systems in these two aspects of system operation and design. Examples of lateral gaps achieved with and without guidance are shown in Figure 15.

Source: Left Photo Bus with a High Level of Service (BHLS) report, Certu, p87, Middle and Right Photo Source ITDP www.transportphoto.net

Figure 15 (Left and middle) Nantes' BusWay system does not employ a guidance system but still achieves minimal lateral gaps at stops; (Right) View of a bus on Amsterdam's Zuidtangent, showing the minimal lateral gap that can be achieved at stops

The extent of provision and the sophistication of guidance systems utilised on BRT systems can vary and depend on the aims of the promoter of the system on which guidance system is being implemented. Typically, the guidance system will assume control of the steering of the vehicle along those sections where it is installed while the driver remains in control of acceleration and braking.

2.4.4.3 Dublin BRT – Potential Applications: Conclusions

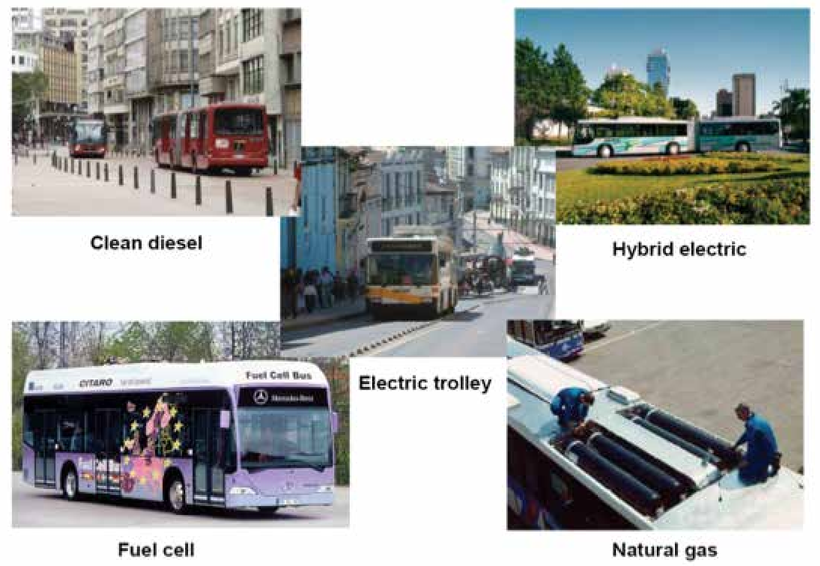
Optically guided busway technology would appear to be the most appropriate of the guidance system technologies currently available to help minimise the horizontal gap between the door thresholds of the Dublin BRT vehicles and the Dublin BRT stop platforms.

Should it also prove necessary for the Dublin BRT system running ways to traverse locations with restricted lateral clearances by using a guidance system, the optical system may not be suitable. It would be undesirable to have two separate guidance systems on a vehicle.

The decision as to which guidance system technology to adopt for the BRT system will reflect both the ability of the technology to facilitate one or both of the potential applications, and the feasibility of the technology in terms of reliability, cost, complexity, safety, maintenance requirements and ease of integration into the urban landscape.

2.4.5 Propulsion

Worldwide, the predominant fuel source for BRT vehicles is diesel, as is the case for conventional buses. In recent years, restrictions on emissions, increases in the price of oil and a growing realisation that the world's supply of oil is being exhausted, have led vehicle manufacturers to explore ways of reducing diesel consumption and to pursue alternative fuel sources. Figure 16 illustrates some examples of propulsion systems.



Source: Institute for Transportation & Development Policy (ITDP) BRT Planning Guide 2007, p423

Figure 16 Types of Propulsion systems

In addition to refinements being made to the exhaust after-treatment of emissions from traditional diesel engines, a small proportion of vehicles now either utilise, or are capable of using, bio-diesel or similar fuels derived from organic matter, while a growing number of vehicle manufacturers now offer engines that run on Compressed Natural Gas (CNG) or Liquid Petroleum Gas (LPG), which are less polluting than diesel.

A more popular, and more recent, development has been the advent of hybrid vehicles that reduce reliance on fossil fuels by recovering energy usually lost as heat during braking and then storing this energy so that it can be used to supplement diesel, petrol, CNG or LPG engines, which, as a consequence, can be smaller than the engines on non-hybrid vehicles and, therefore, consume less fuel and emit less pollution. Vehicles powered entirely by batteries are less common owing to the restricted range between charges (although this has improved greatly in recent years) while vehicles equipped with fuel cells are currently only being trialled on a limited basis in major cities worldwide, owing to their extremely high capital cost, the ongoing challenges involved in supplying and storing hydrogen economically, and the scarcity of the necessary support infrastructure, including refuelling facilities.

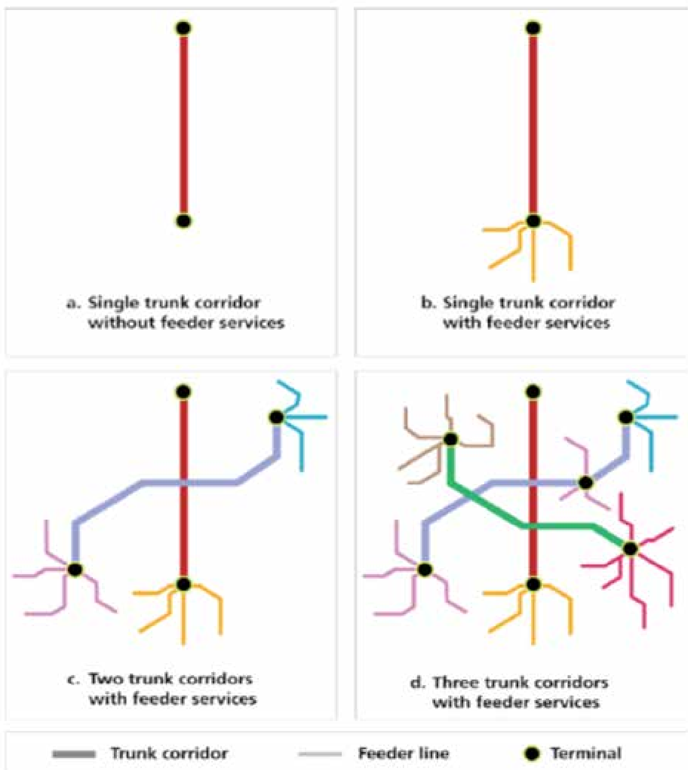
Electrically-powered trolleybuses are also employed on some BRT systems but these require significant investment in fixed power supply infrastructure to enable them to run (albeit some trolleybuses now incorporate energy storage devices or auxiliary diesel engines in an attempt to reduce the expenditure required on power supply infrastructure).

Some of the propulsion systems outlined above are currently at the development stage and testing stage. Also, some of the technologies are currently not available for all vehicle categories. At this stage it is too early to rule out any of the approaches as a possibility, however, it is noted the proven technology is diesel based.

It is intended that further research will be conducted to ensure that up to date information on the available alternative propulsion systems is maintained, but the design will be progressed based on a diesel or a diesel based hybrid vehicle.

2.4.6 Service Provision Operational Plan

The operational plans for BRT systems vary widely. Figure 17 illustrates different operating plans.



Source: Institute for Transportation & Development Policy (ITDP) BRT Planning Guide 2007, p182

Figure 17 Different Operating Plans

These different operating plans can however be grouped into the following categories:

- Closed systems whereby a single service operates end to end similar to a Metro or Luas type system. No other bus services, i.e. conventional buses or other QBCs services are permitted to operate on the running way;
- Semi Open systems where multiple authorised services use the BRT running way, either along its entire length or can join and leave at certain points along the running way; and
- Open systems where all buses may use the BRT system.

The operations side of the system concept for a BRT system in Dublin is complex as currently the bus corridors identified are used for multiple bus services. There is a need to address the impact of BRT operation on non-BRT services.

The increased bus priority at junctions along the BRT route also has implications for other modes of transport. This will require careful management by local authorities of the limited road and footpath space along the route.

The "closed system", takes its inspiration from Line 4 in Nantes and this configuration is relatively close to that of a typical LRT system. The philosophy is that the dedicated lanes are for the exclusive use of the BRT services in order to guarantee a higher level of service. More than one BRT line can operate on certain trunk sections, but these are limited by service frequency. Interchange and transfers are organised around certain key stops.

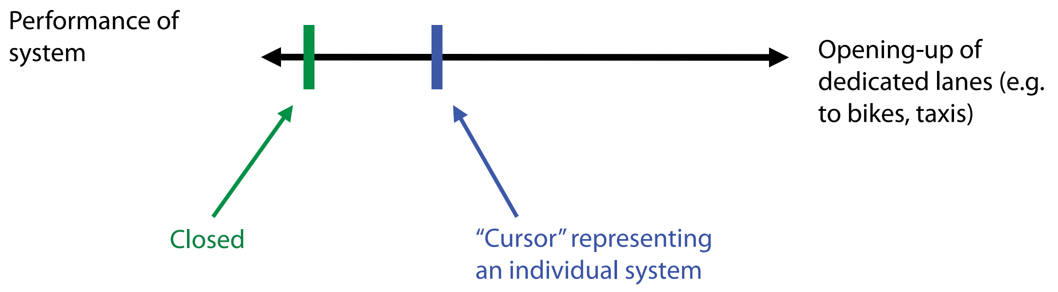
Very occasionally, these dedicated lanes may be shared with other bus traffic – as is the case with certain sections of tramway – in order to ensure the continuity of a particular bus route. The amount of shared running is limited in each direction otherwise priority at traffic lights cannot be guaranteed at every junction. This "closed system" configuration can be found in Nantes, Rouen, Caen and Nancy.

As an intermediate option between the closed and fully open system, and in order to make the most of the available space and/or optimise the performance of a public transport network, certain urban transport authorities opt for a "mixed" (semi-open) configuration. Under this arrangement the BRT corridor is designed to share the BRT lane with a limited number of other vehicles, frequently conventional buses. Provision for cyclists along the corridor is generally provided on adjacent cycle lanes.

Overall, the challenge rests in achieving the optimum balance between performance objectives for the system and making best use of the reserved space. This balance must be established as early as possible in the planning process.

Figure 18 illustrates the performance of the system and striking the right balance. This shows that the more open the BRT system is the lower the potential of performance of the system. This is extremely important along critical sections of the routes.

At the opposite end of the spectrum from the 'closed system' is the 'open system'. In this arrangement the BRT lane can be used, typically, by all other users of standard bus lanes – conventional buses, taxis and cyclists. However, the extensive mixing of these differing traffic streams means that the key benefits of BRT are reduced. Accordingly a fully open system is only suitable in certain cases, where the required service level is low, or where the number of other users in the corridor is limited.



Source: Bus with a High Level of Service (BHLS) report, Certu, p40

Figure 18 Performance of the System

In principle, taking into account the evidence of similar BRT systems in operation internationally, it is proposed that the operating plan for the proposed Dublin system concept would be based on a semi-open system. The exact quantum of conventional buses and other vehicles that should be permitted to use the BRT lane will be determined on a case by case basis. By operating appropriately with this philosophy in conjunction with a high specification vehicle and infrastructure facilities (including interchange at appropriate locations) the BRT system will be of high quality, reliable and fast, thereby achieving the mode shift from private car.

In conclusion, the type of operating system chosen plays a key role in determining the overall attractiveness of the BRT network. While the performance of the BRT system would be optimised by operating as a closed system, this is not considered practical for the full proposed network in the Dublin context. Instead, it is proposed to proceed with a 'semi-open' system, but with the possibility of segments of the routes being fully reserved for BRT vehicles where appropriate.

2.4.7 Support Systems

Most BRT systems will invest in advanced support systems technology in terms of customer/passenger information, operations management. For any proposed BRT system in Dublin it is essential that these type of systems are in place. Figure 19 and Figure 20 show typical support systems that are utilised in practice. Such systems include but are not limited to:

- Automatic Vehicle location system, headway control, operations management;
- Radio system for voice and data communication;
- Interface with traffic control signals to ensure preferential treatment of the buses at junctions and also involve the extension of green time or actuation of the green light at signalised junctions upon detection of an approaching bus;
- Real time passenger information at stops and in the vehicles;
- Ticket vending machines, smart cards and integrated ticketing;
- CCTV for security and stop management;
- Emergency Help Points at stops;
- A SCADA (Supervisory Control and Data Acquisition) system to monitor and control all devices installed at stops and along the network;
- A telecommunication trunk system to relay back to the Central Control Room all information from vehicles and the network; and
- In vehicle intelligent systems to assist the driver of the buses.

Source: Left Photo Institute for Transportation & Development Policy (ITDP) BRT Planning Guide 2007, p313, Right Photo http://www.railforthevalley.com/latest-news/zweisystem/what-the-hell-is-guided-bus-is-it-b-line-brt/

Figure 19 Typical Support Systems

Source: https://leapcard.ie

Figure 20 Integrated Ticketing as Standard

It is essential for the smooth/efficient operation of the BRT system, particularly on lateral running lanes, that there is no parking, loading/unloading or unauthorised vehicle usage of the bus lanes. The main methods of enforcement are:

- On-vehicle cameras;
- Static cameras;
- Gardaí; and
- Self enforcement.

2.4.8 Attractiveness

Attractiveness is of key importance to any public transport system that is trying to achieve a modal shift from the private car. Branding and marketing is a fundamental aspect of most successful BRT systems. This can be easily overlooked. A number of common strategies are:

- Establishing a system name and strong public presence;
- Designing strong brand identity and visual presence;
- Develop and maintain high quality throughout the system; and
- Engage with stakeholders and public to gain approval.

2.4.8.1 The Bus Rapid Transit Brand for Dublin

To ensure support and adoption of the BRT concept by stakeholders and, in time and more specifically, by customers, it is critically important that the unique features of the BRT system concept are communicated effectively.

To allow simple and effective communication of the unique features of the BRT system concept it is essential that steps be taken to develop a brand initially starting with a brand name, logo and tagline.

Members of the public will quickly associate a properly developed and well managed brand with the unique features of the bus rapid transit concept and so the brand will become a key communications tool during the planning and establishment and following the commissioning of the system.

As a starting point the branding process should take the system concept statement as an initial brand definition, as it describes what is to be provided, why it is needed, what is unique or better about BRT and what it promises to future customers. Following its conception, best practice brand development processes should be followed. This will involve linking the unique benefits of the concept to possible brands and then engaging with potential customers to explore what these potential brands actually communicate to them and more specifically the extent to which they communicate the unique features of the BRT concept.

This brand development process should provide a solid platform for creating the BRT name, logo and tagline, and supporting communication items.

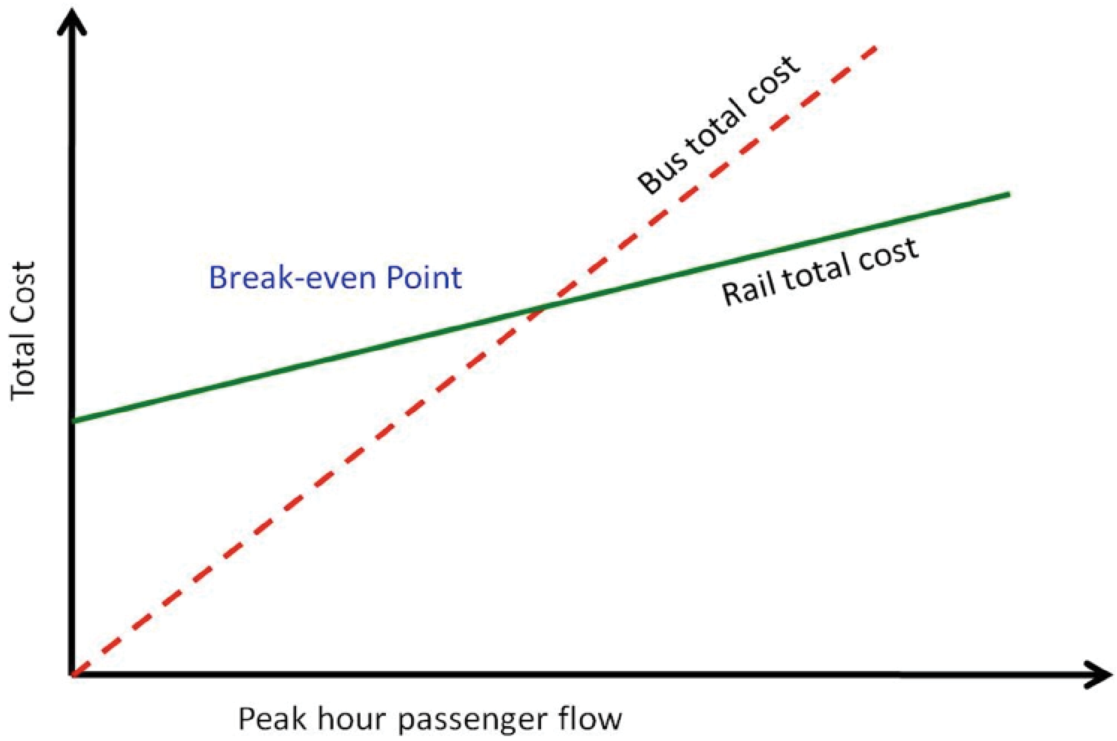
2.4.9 Cost

BRT systems are generally cheaper to build than LRT systems, although the cost savings are less in systems that involve the construction of a segregated bus road and incorporate high quality systems and vehicles. The total cost of the BRT system can be broken down into Capital Costs and Operating Costs (including renewals). Depending on the type of BRT system defined, both categories of costs can vary. A detailed cost estimate based on the system concept is detailed in Chapter 5 of this report.

Rail based systems usually require heavier investments than bus based systems. Traditional views consider underground Metro systems as being five times more costly than light rail systems, with BRT being considered to be 3-4 times cheaper than light rail. The actual quantum of investment depends however on the desired quality and level of segregation of the BRT system. A BRT system with high quality features and significant investment in segregation can approach the typical cost range of LRT.

In general it can be said that higher investment costs in LRT are offset by lower operation costs. When choosing the appropriate mode for particular corridors efficient ratios of passengers per driver result in lower operation costs. The driver numbers are dictated by the number of vehicles required to operate the system, and this is directly proportional to the capacity of the vehicles proposed. For example, to carry 10,000 ppdph in the order of 90 bus drivers would be required against 30 tram drivers for LRT versus 10 metro drivers.

Figure 21 illustrates that if demand justifies it, higher investment costs will be offset by lower operating costs over the full life cycle.



Source (adapted): Source: Peter White "Public Transport: Its Planning, Management and Operation", 4th Edition p93

Figure 21 Demand versus Cost

In general terms the costs of enabling works and utility diversions are less than that required for an LRT system. The infrastructure costs in terms of civil works and running ways will be less than a LRT system. The cost per vehicle is cheaper than for a Light Rail Vehicle (LRV). The construction period for a BRT system is often shorter than for light rail, which means that the benefits can be accrued sooner.

Depending on the particular corridor, there may be reduced costs for a BRT system in relation to land and property costs, as the system may operate on the existing road network. However, due to pinch points and areas of constrained space, there may be a requirement to acquire some land and property, particularly to ensure an adequate level of segregation.

The operating and maintenance costs of the system including life cycle and renewals are an important component of the overall cost of the system. Typically the maintenance cost of a bus is less than that of a LRV, but generally they have a reduced life compared to a light rail vehicle.

2.5 Conclusion

Experience elsewhere has demonstrated that for a public transport system to be successful it needs to be reliable, frequent and have jouney times which are competitive with the private car. If these components are not in place, a modal shift from the private car will not be realised.

The BRT system concept will seek segregation wherever practicable and, where it is not practicable, will seek to achieve the appropriate balance between competing demands such that the BRT offering is not unduly compromised in any way.

The BRT system will need to have high priority at traffic lights to maintain its commercial speed, reliability and to offer a realistic alternative to private car. All of these components will ensure operational efficiency, reliability, attractiveness and quality of the BRT system.

It is considered that if demand does not exceed in the region of 3,600 passengers per direction/ hour (ppdph), the corridor is appropriate for a Dublin BRT. This is based on 30 vehicles with 120 passenger capacity. It may be possible in the future, should demand dictate it, to increase the capacity to 4,500 ppdph.

Taking into account the capacity thresholds and commercial speeds required, the BRT system concept for Dublin should be based on a moderate capacity BRT system as outlined above.

The BRT system concept includes:

- High quality running ways with significant segregation;
- High quality stop design with off board ticketing and fare collection;
- Real time passenger information;
- High specification vehicles with multiple door openings to reduce dwell and increase reliability; and
- High performance operating regime.

The infrastructure side is just one component of the overall BRT system. The operations side of the BRT system is complex and will have to be examined in greater detail on a case by case basis, as it is dependent on the existing and planned future public transport provision along the proposed corridors. However, in general it is intended that the BRT system for Dublin will be developed, predominately, as a semi-open system.

The main features of the proposed system concept for BRT in Dublin can be summarised as shown in Figure 22 below.

<table>
<tr><th></th><th>Capacity</th><th>Running Way</th><th>Stops</th><th>Vehicles</th><th>Propulsion</th><th>Support Systems</th><th>Attractiveness</th></tr>
<tr><td rowspan="8">Dublin Concept BRT</td><td rowspan="8">Approximately 3600 ppdph</td><td rowspan="8">Median or Lateral lanes</td><td>High Quality Features</td><td>High Quality</td><td>Diesel</td><td>AVLS</td><td rowspan="8">Branding</td></tr>
<tr><td>TVMs</td><td>Nearside Multiple doors</td><td>Clean Diesel</td><td>RTPI</td></tr>
<tr><td>PIDs</td><td>Guidance System</td><td rowspan="6">Hybrid</td><td>ITS</td></tr>
<tr><td>Shelters</td><td rowspan="5">Single deck articulated vehicle</td><td rowspan="5">CCTV</td></tr>
<tr><td>25m long Platforms</td></tr>
<tr><td>6m long Access Ramps</td></tr>
<tr><td>typically 3m platform width</td></tr>
<tr><td>max grade at stops 4%</td></tr>
</table>

Figure 22 Summary of System Concept

3 FEASIBILITY STUDY

The purpose of this feasibility study is not to identify the preferred route for a BRT system on a corridor, nor is it to suggest the preferred design on any section of alignment considered. Instead, it is to investigate the technical, environmental, demand, and economic feasibility of a proposed core BRT network for Dublin. Should the proposed BRT network be considered feasible and worthy of advancement, a further route selection and design process will be required to advance specific proposals.

A feasibility study is the first step in a process of assessing as to whether a BRT line should be pursued further. This step precedes the identification of preferred route options from a set of feasible route options, as part of a route selection process.

A transport feasibility study normally involves the identification of a workable corridor within a defined study area, identifying constraints and impacts, carrying out demand and revenue forecasting projections, and assessing the overall likely high level costs and benefits of the schemes. It is unlikely at this stage that a detailed financial or economic appraisal would be carried out given the degrees of uncertainty of the route corridors and potential impacts.

A feasibility study generally culminates in identifying the study area, corridor(s) for further study, the project constraints, the scoping of costs and benefits, the high level impacts, and highlighting the difficult issues to be resolved, which can include engineering, property, construction, traffic and environmental issues.

3.1 Core BRT Network

As identified earlier, BRT, in terms of its carrying capacity, occupies one section of the public transport spectrum. Based on the European style of moderate capacity, BRT using single articulated vehicles up to 18.5 metres is most suited to corridors with passengers per direction per hour (ppdph) demand in the approximate range of 1,500/2,000 to 3,600 ppdph. While BRT may be feasible in some circumstances either below or exceeding this range, conventional buses would generally be most applicable below 1,500 to 2,000 ppdph. Above, 3,600 ppdph, light rail or metro/heavy rail solutions are generally required, although longer BRT vehicles may be sufficient for smaller increases in some specific cases.

In developing the recent draft transport strategy for the Greater Dublin Area (GDA), the NTA examined transport demand levels on various corridors around the region. Many of the corridors required rail based solutions – light rail, metro, heavy rail - to cater for the future public transport demand along the particular route. Other corridors were identified to have passenger demand that aligned best with standard bus carrying capacity and did not justify higher capacity modes.

However, a number of corridors were identified that were likely to exceed, over time, the carrying capacity of conventional bus provision, even operating on a QBC network. These were identified in the NTA's draft transport strategy as "Priority 1" corridors which included:

- Stillorgan Road QBC;
- Malahide Road QBC;
- Lucan Road QBC; and
- Blanchardstown/Navan Road QBC.

Measure *BUS 7* in the NTA's draft transport strategy for the GDA provides for these corridors to transition *"to Bus Rapid Transit (BRT) type operations, taking into account passenger demand, proximity of rail alternatives, and the level of bus priority that is feasible along the corridor and the suitability of the corridor for BRT type vehicle operation".*

Additionally, measure *RAIL 11* of the draft transport strategy states that "the Authority will seek the provision of a light rail line serving the southwest sector and connecting to Dublin south city centre, via the Kimmage area, subject to assessment of feasibility and value for money and the consideration of a BRT option". Further work carried out on demand modelling along this corridor indicates the passenger demand level along this corridor is well within the capacity of a BRT system. Accordingly, this south western corridor, titled for convenience 'Tallaght to City Centre', is being added to the list of Priority 1 corridors referred to above. It should be noted that there are a considerable number of potential route options to serve this overall corridor and the indicative route used later for assessment purposes represents only one of the potential options that would be examined should it be decided to proceed with further development work on this scheme. Routes both to the north and south of the indicative assessment route would be examined as part of a detailed route option analysis.

In relation to the Lucan Road QBC corridor, further work carried out on this route indicates that there would not be sufficient demand to justify a BRT provision in this sector in the event of Luas Line F (Luas Lucan) proceeding as currently planned.

In the light of the postponement of Metro North, the Swords Road corridor was included in the BRT assessment to establish possible demand levels for such a system on this route, potentially as an interim transport solution in advance of Metro North. Accordingly, Swords to the City Centre has been included with the Priority 1 corridors for assessment.

Amalgamating all of the above gives the following core BRT network, which is based upon the transport analysis carried out for the NTA's draft transport strategy for the GDA, together with further subsequent demand modelling.

The Core Dublin BRT Network comprising of four radial routes:

- Stillorgan Road corridor;
- Malahide Road corridor;
- Blanchardstown/Navan Road corridor; and
- Tallaght to City Centre (via Kimmage area) corridor.

The above core network derives from transport demand analysis and represents corridors that are likely to fit within the carrying capacity envelope of the BRT system concept proposed for Dublin.

Since the Swords to City Centre route is intended to be served by a metro solution, it does not form part of the core BRT network. However, for the purposes of exploring whether BRT can perform a role on this corridor on an interim basis, it has been included for initial analysis in this feasibility study.

3.2 Methodology

As part of the feasibility study for each of these cross city corridors a single route was selected for high level appraisal, based predominantly (where plausible) on the existing QBC network. Alternatives to the route alignments chosen for these high level comparative assessments exist and these would be examined in further detail should a decision to proceed with further work be made, during the route option phase of a project. It is important to note that these route alignments chosen for this assessment do not reflect what a final route might be for a BRT line along these corridors.

The initial evaluation was concentrated on forecast demand modelling on the proposed BRT corridors to determine forecast demand and to provide inputs into the cost benefit analysis.

Demand forecasting was carried out under different scenarios using different combinations of infrastructure and landuse. The scenarios being tested include the following:

- 2006 landuse and current/existing infrastructure;
- Future landuse (2030) and current/existing infrastructure; and
- Future landuse (2030) and draft NTA transport strategy public transport network.

By running these different scenarios it is possible to determine which corridors would have sufficient capacity to cater for both current demand and future demand based on growth in population and an investment in public transport infrastructure. The demand forecasting analysis will play a key role in determining the feasibility of the BRT network.

In parallel, an environmental desktop feasibility study was carried out on a very narrow corridor directly adjacent to the proposed cross city alignments with a view to identifying significant environmental impacts.

Further to the outputs of the demand forecasting analysis, the feasible route options were assessed at a high level from an engineering and constructability point of view, to identify any potential design related obstacles or areas where expensive intervention in terms of property take or structures may be required. Any additional cost elements will be added to the cost per km rate as defined in the Chapter 5 of this report.

3.2.1 Study Area

In order to identify possible feasible cross city BRT alignments to enable the appraisal and evaluation of the proposed core BRT network, a study area for each cross city corridor was defined. Figure 23 illustrates the proposed BRT network study area. It should be noted that the study areas for the Swords and Clongriffin radial corridors overlap due to their geographic proximity and convergence of possible alignments as they approach the city centre.

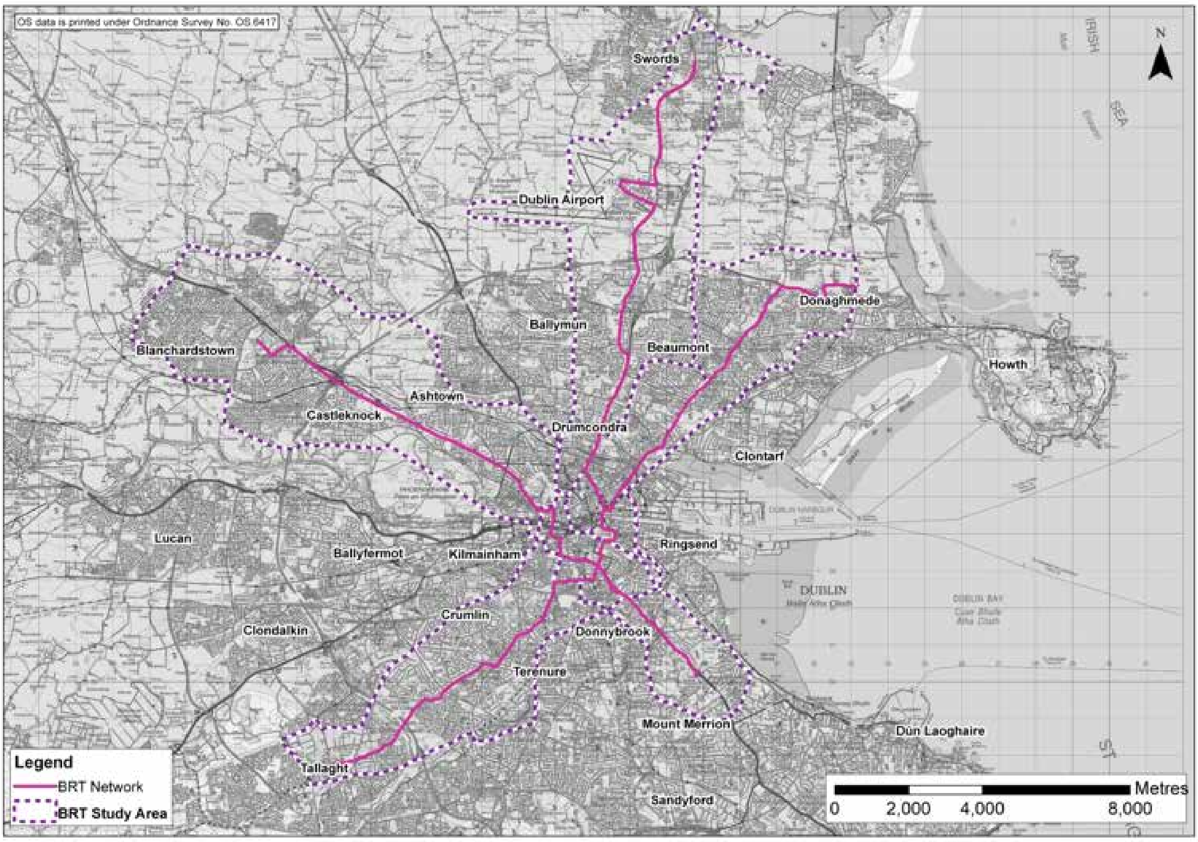


Figure 23 BRT Network Study Area

Blanchardstown to City Centre

The extent of the Blanchardstown to city centre study area is defined by the County boundary with Meath to the west, Tyrrellstown and Ballycoolin Road to the north. The study area boundary to the south is defined by the Maynooth Railway Line.

As the corridor approaches the city centre, the width narrows and is bounded to the north by the Ratoath Road and the Tolka River, and to the South by Chesterfield Avenue in the Phoenix Park.

Swords to City Centre

The extent of the Swords to city centre study area is defined by Estuary Road to the north and east and is defined by Watery Lane and Church Road to the west. As the corridor moves southwards towards the city it is bounded to the east by Clonshaugh Road and the Naul Road which acts as a perimeter to the airport.

South of the M50 the boundary of the study area is defined by Ballymun Road / Main Street to the west and Clonshaugh Road to the east.

As the corridor continues further south, it is defined by St. Mobhi Road and Botanic Road and Prospect Road to the west. The study area is further defined by Kilmore Road and Malahide Road to the east

Clongriffin to City Centre

The extent of the Clongriffin to city centre study area is bounded by Balgriffin Road, Moyne Road and the N32 to the north, and the Northern Railway line to the east. The study area is defined by the Clonshaugh Road to the west, south of the N32. As the corridor moves southwards towards the city the study area boundary is defined to the east initially by Grange Road, and then Raheny Road, and as it continues into the city centre, the boundary is further defined by the Northern railway line south of Harmonstown Station.

The study area boundary to the west is defined by Kilmore Road initially and then follows Skelly's Lane, Beaumont Road, and Grace Park Road and onto Drumcondra Road Lower as it continues into the city centre.

<u>UCD to City Centre</u>

The extent of the UCD to city centre study area is bounded to the west by the Luas Green Line, to the north by the River Liffey and to the east by the DART and the River Dodder. The Study Area boundary to the south is defined by a combination of Roebuck Road, Greenfield Road, and Booterstown Avenue to the south and south-east of UCD. The indicative southern terminal point of this radial corridor has been identified as UCD reflecting the fact that it represents a particularly large nucleus point. Should any further work proceed on this corridor it is suggested that the implications of extending the terminal point southwards to either Sandyford Business Estate of further southwards along the N11 be considered before a final decision is made on the southern terminal point.

3.2.2 Indicative Corridor Alignment

Within each of the corridor study areas defined earlier, preliminary analysis work was undertaken to identify a possible route alignment that would then be used for evaluation and assessment of a particular BRT corridor. Accordingly, the alignment identified is simply a representative route for the particular corridor for the purposes of this feasibility study. A full option analysis would be required to be undertaken in order to identify and select the optimal route. This is outside the scope of this feasibility report and would, instead, be the next stage of progression if a particular corridor were to be developed.

The various indicative BRT cross city corridors identified in Figure 23, comprise of five separate radial routes into the city centre. A representative alignment for each corridor has been identified, and frequently based on an existing QBC route where appropriate. These proposed indicative alignments are illustrated in Figure 24 to Figure 28.

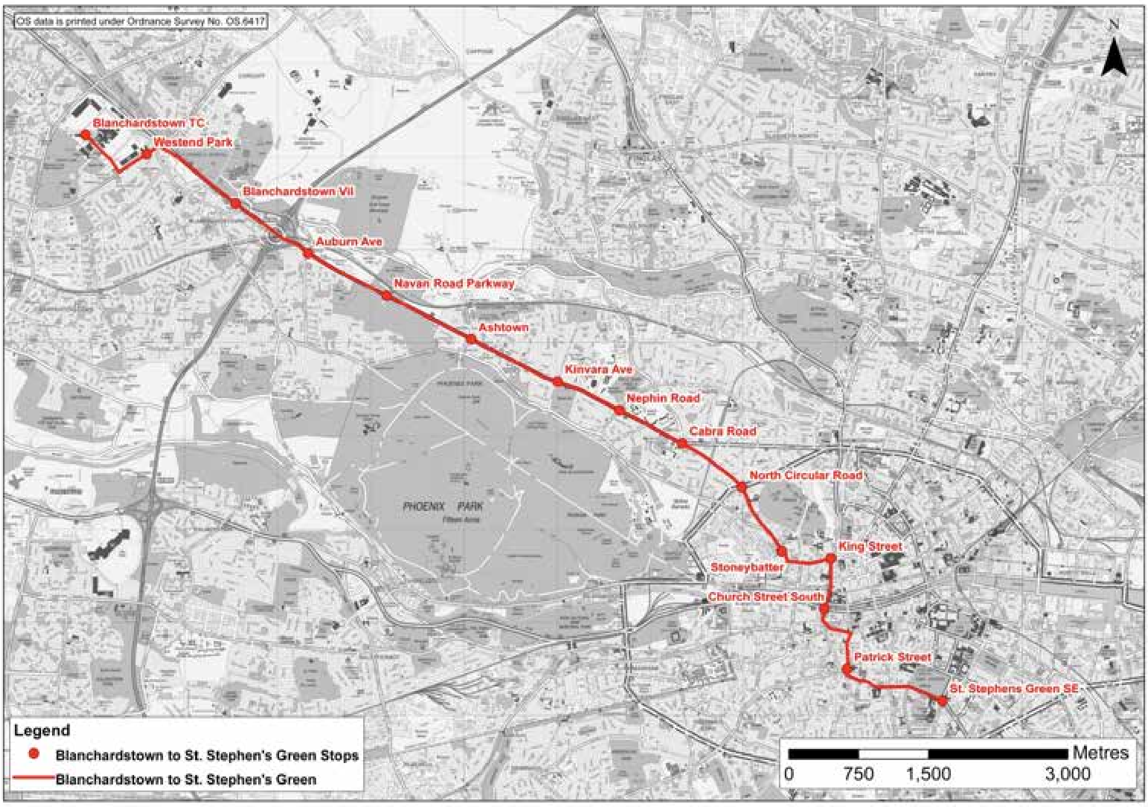


Figure 24 Blanchardstown to City Centre

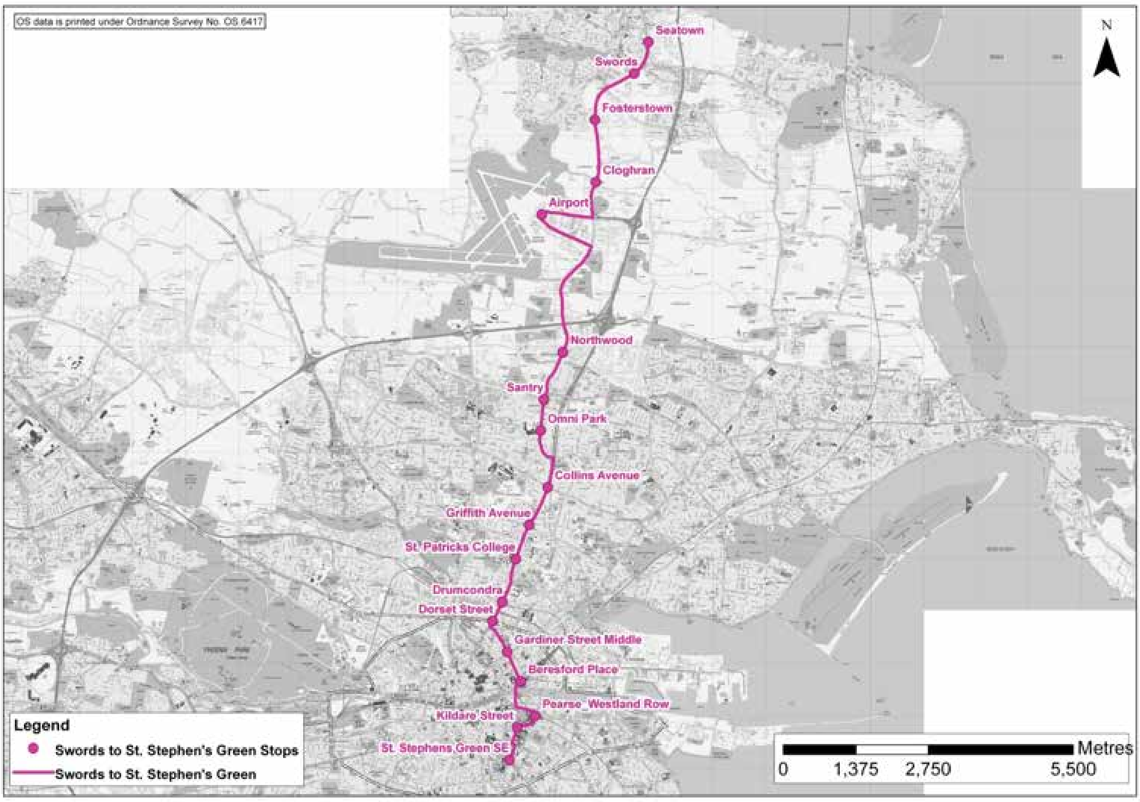


Figure 25 Swords to City Centre

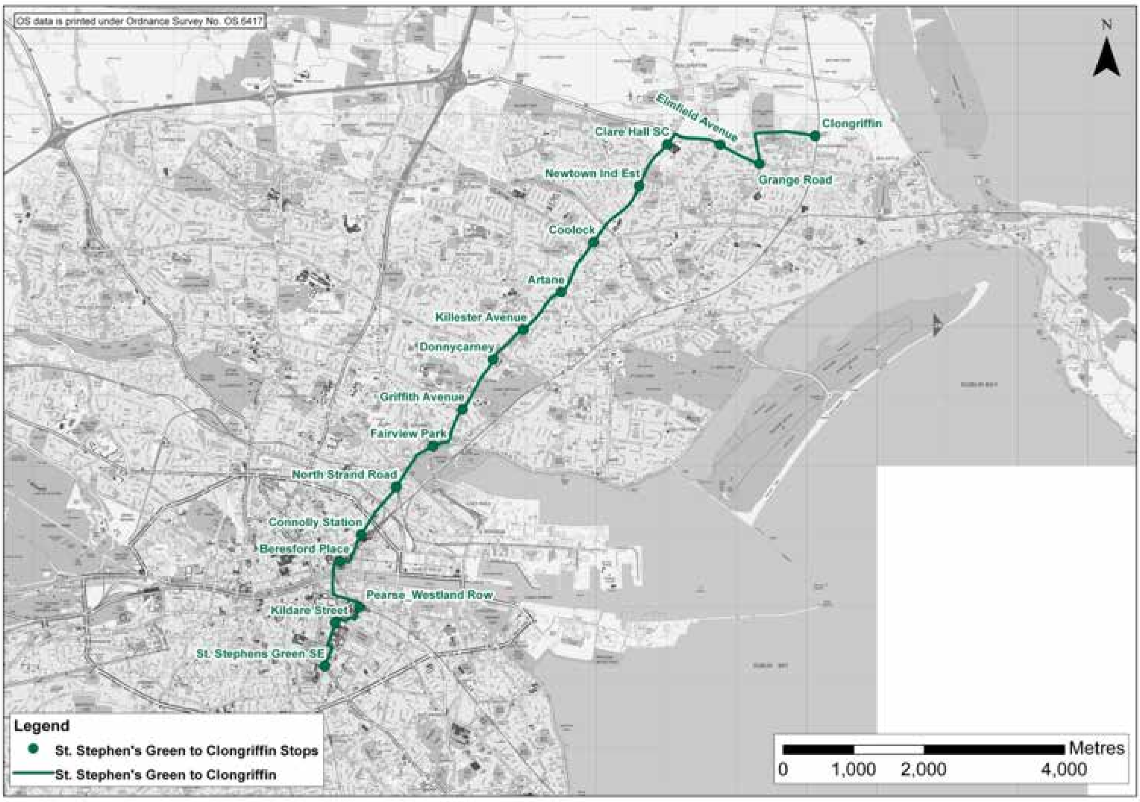


Figure 26 Clongriffin to City Centre

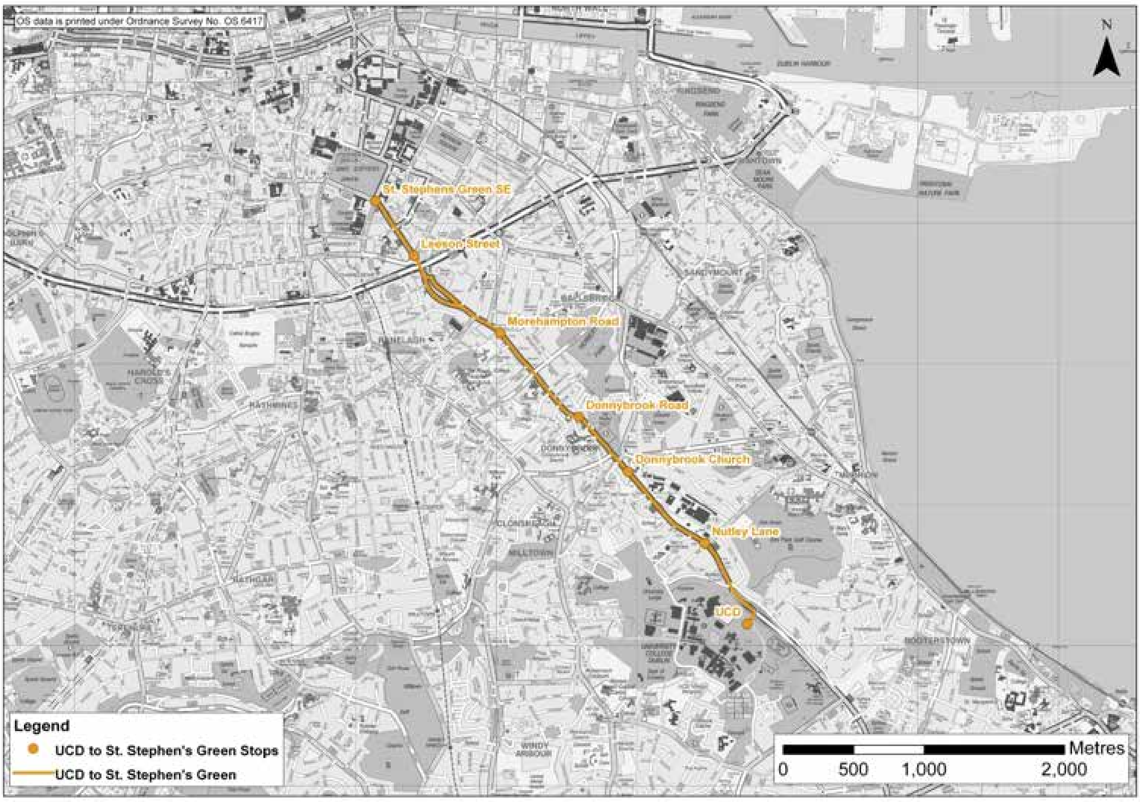


Figure 27 UCD to City Centre

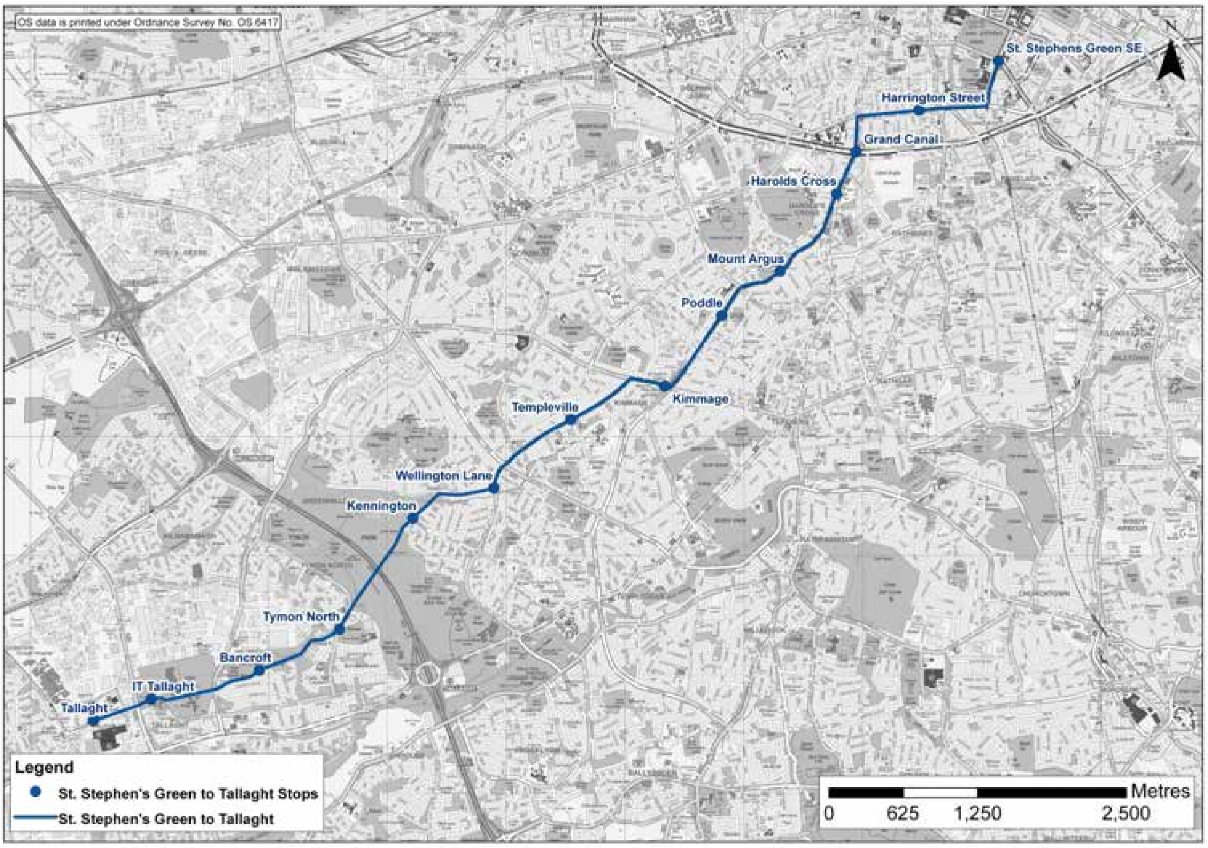


Figure 28 Tallaght to City Centre

3.3 Description of Indicative Routes

3.3.1 Blanchardstown to N11 (UCD)

The proposed cross-city BRT route commences at Blanchardstown Town Centre and terminates at University College Dublin (UCD). The description below presents an indicative route for assessment purposes.

From Blanchardstown Town Centre, the route extends southeast along the N3 onto the Old Cabra Road as far as Stoneybatter, where it turns east along King Street and then south to cross the River Liffey at Church Street South. From there the route turns east along High Street, south along Patrick Street and then east along Kevin Street and Cuffe Street to St. Stephen's Green. From St. Stephen's Green, the route travels south along Leeson Street and onto the Stillorgan Road via Donnybrook Village to terminate in UCD campus.

3.3.2 Malahide Road (starting at Clongriffin) to Tallaght

The proposed cross-city BRT route commences at Clongriffin and terminates at a stop to the north of the Square shopping centre in Tallaght. The description below presents an indicative route for assessment purposes.

From Clongriffin, the route extends west onto The Hole in the Wall Road and then south onto Grange Road before turning west as far as the junction with the Malahide Road, onto which it travels south as far as Fairview.

From Fairview, the route passes along the North Strand Road before turning west at Beresford Place to cross the River Liffey at Tara Street. The route then turns east along Pearse Street and then south from Westland Row to Kildare Street via Lincoln Place and Leinster Street South.

From Kildare Street, the route passes south along the east side of St. Stephen's Green onto Earlsfort Terrace before turning west along Harrington Street as far as the junction with Clanbrassil Street. From Clanbrassil Street, the route travels south across the Grand Canal through Harold's Cross and onto Kimmage via Kimmage Road Lower. From Kimmage, the route will pass from Whitehall Road onto Limekiln Road and then pass across Tymon Park and west through Bancroft Park along the River Dodder and then through the grounds of the Institute of Technology Tallaght before terminating at the Square Shopping Centre in Tallaght.

3.3.3 Swords to Tallaght (via Kimmage)

The proposed cross-city BRT route commences at Seatown and passes through the village of Swords and terminates at a stop to the north of the Square shopping centre in Tallaght. The description below presents an indicative route for assessment purposes.

From Seatown, the route extends south along the Swords Road via the main street of Swords as far as the airport roundabout where the route loops west to take in a stop at Dublin Airport before rejoining the Swords Road. The route then travels south on this road to pass through Drumcondra via Drumcondra Road and onto Dorset Street. Just south of the junction of Dorset Street with North Circular Road, the route travels southeast along Gardiner Street before turning west at Beresford Place to crosses the River Liffey at Tara Street. The route then turns east along Pearse Street and then south from Westland Row to Kildare Street via Lincoln Place and Leinster Street South.

From Kildare Street, the route passes south along the east side of St. Stephen's Green onto Earlsfort Terrace before turning west along Harrington Street as far as the junction with Clanbrassil Street. From Clanbrassil Street, the route travels south across the Grand Canal through Harold's Cross and onto Kimmage via Kimmage Road Lower. From Kimmage, the route will pass from Whitehall Road onto Limekiln Road and then pass across Tymon Park and west through Bancroft Park along the River Dodder and then through the grounds of the Institute of Technology Tallaght before terminating at the Square Shopping Centre in Tallaght.

4 DEMAND FORECASTING ANALYSIS

4.1 Introduction

A catchment analysis was undertaken to identify the population and employment trends over the 3 selected timeframes of 2006, 2011 and 2030 and was used to develop an understanding of the likely demand for BRT in that area. This type of analysis also illustrates catchment differences between the possible cross city corridors.

In order to assess the effect of the proposed BRT system passenger demand forecasts have been developed using the NTA Multimodal Transport Model (2006 Base Year). Travel demand models are used to represent the key elements of the travel demand process using mathematical equations. The model was used to examine the effect that a BRT system will have on trip making and mode choice and the change in public transport accessibility as result of its implementation.

The model takes population and employment statistics as inputs to generate estimates for present and future trip demand by public transport.

In order to assess the effect of the proposed BRT Scheme, the transport model is run with two different scenarios. The first scenario is called the Do-Minimum senario. This scenario assumes that the projected land use forecasts are met without the BRT system included. A second scenario is then run where the BRT system is included. This is called the Do-Something scenario and this scenario includes all the assumptions of the Do-Minimum scenario plus the BRT system. The difference between one scenario and the other gives us an indication of the effect of the BRT system.

4.2 Catchment Analysis

4.2.1 Introduction

A Catchment Analysis was carried out for the three cross city routes using a Geographical Information System (GIS) assessment. This analysis and evaluation was carried out using Census data and An Post's geodirectory of addresses from Quarter 3 2011 as inputs.

Two catchment areas chosen for this assessment were a 500m and 1km radius from each stop. 500m is the suggested desirable walking distance and 1km is the maximum acceptable walking distance for commuting in the IHT's (Institute of Highways and Transportation) "Guidelines for Providing for Journeys on Foot".

4.2.2 Method and Results – Census Data

The inputs required to carry out this method are BRT stop location data and Electoral Divisions (EDs) data. The EDs data included population and employment data from the 2006 Census of the population, preliminary population from the 2011 Census and population and employment for 2030 based on NTA projections. The NTA projections are based on an NTA land use forecast for the NTA Transport Strategy Scenario B. In this scenario new development is consolidated around existing and proposed rail corridors.

The population and employment density of each of the EDs within the catchment is used to estimate the population and employment along the catchment area. This is an approximate method as the density of the ED may not be uniform.

A sample of the EDs for the Clongriffin to Tallaght 500m catchment is presented in Figure 29 below and the output results of the catchment analysis are presented in Table 3 and Table 4.

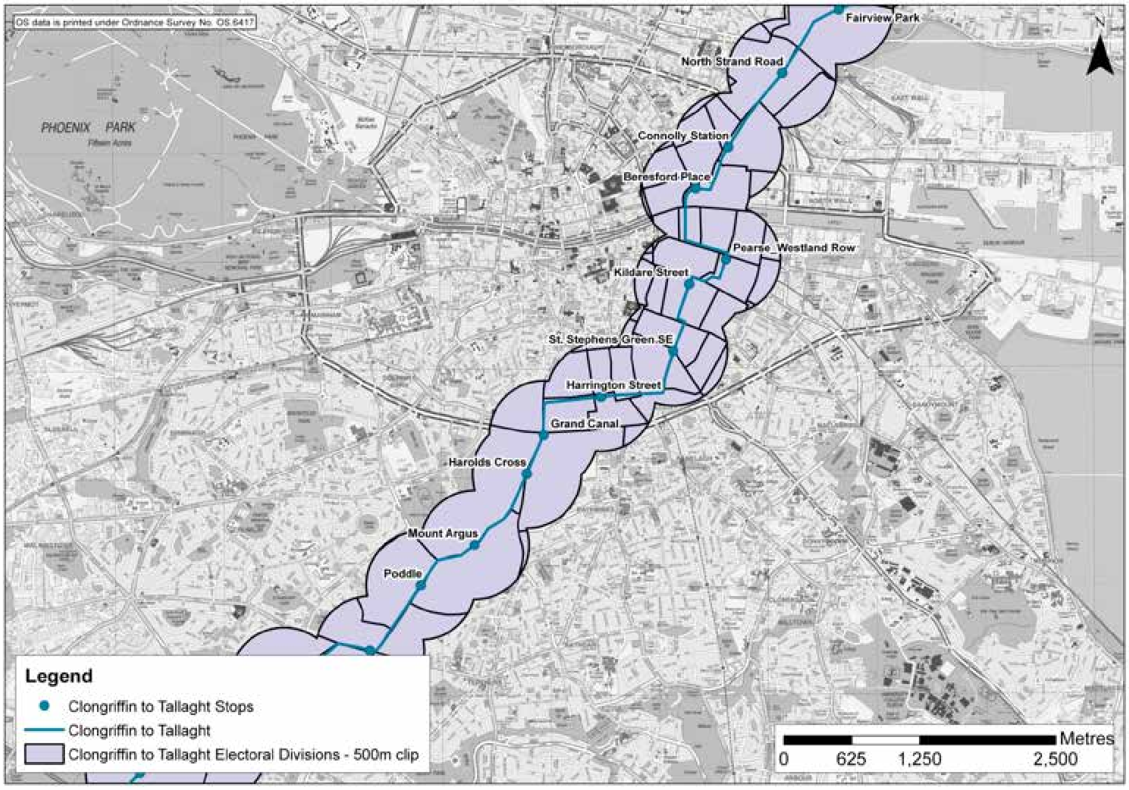


Figure 29 Electoral Divisions for Clongriffin to Tallaght

500m Buffer	Length (km)	2006 Population	2006 Employment	2011 Population	2030 Population	2030 Employment
Swords Tallaght	27.787	88,039	124,798	91,188	114,218	157,375
Blanchards-town UCD	16.531	64,322	75,200	67,690	84,700	92,254
Clongriffin Tallaght	23.254	93,421	110,247	98,535	118,051	139,368

Table 3 Catchment Analysis of Electoral Divisions for 500m radius from stops

1km Buffer	Length (km)	2006 Population	2006 Employment	2011 Population	2030 Population	2030 Employment
Swords Tallaght	27.787	202,704	227,886	211,303	267,691	307,398
Blanchards-town UCD	16.531	141,822	173,139	148,704	192,874	223,995
Clongriffin Tallaght	23.254	211,229	206,899	222,140	272,243	278,038

Table 4 Catchment Analysis of Electoral Divisions for 1km radius from stops

4.2.3 Method and Results – Geodirectory

This method is carried out to cross check the information that is contained in the Census data as per the method above. The inputs required to carry out this method are BRT stop location data and Geodirectory data. This data included the exact number of address points for residential and commercial premises as at Quarter 3 in 2011. These can then be counted to ascertain the number of commercial and residential premises within the catchment. A sample of the Geodirectory point data for the Blanchardstown to UCD 1km catchment is shown in Figure 30 below and the output results of the catchment analysis are presented in Table 5 and Table 6.

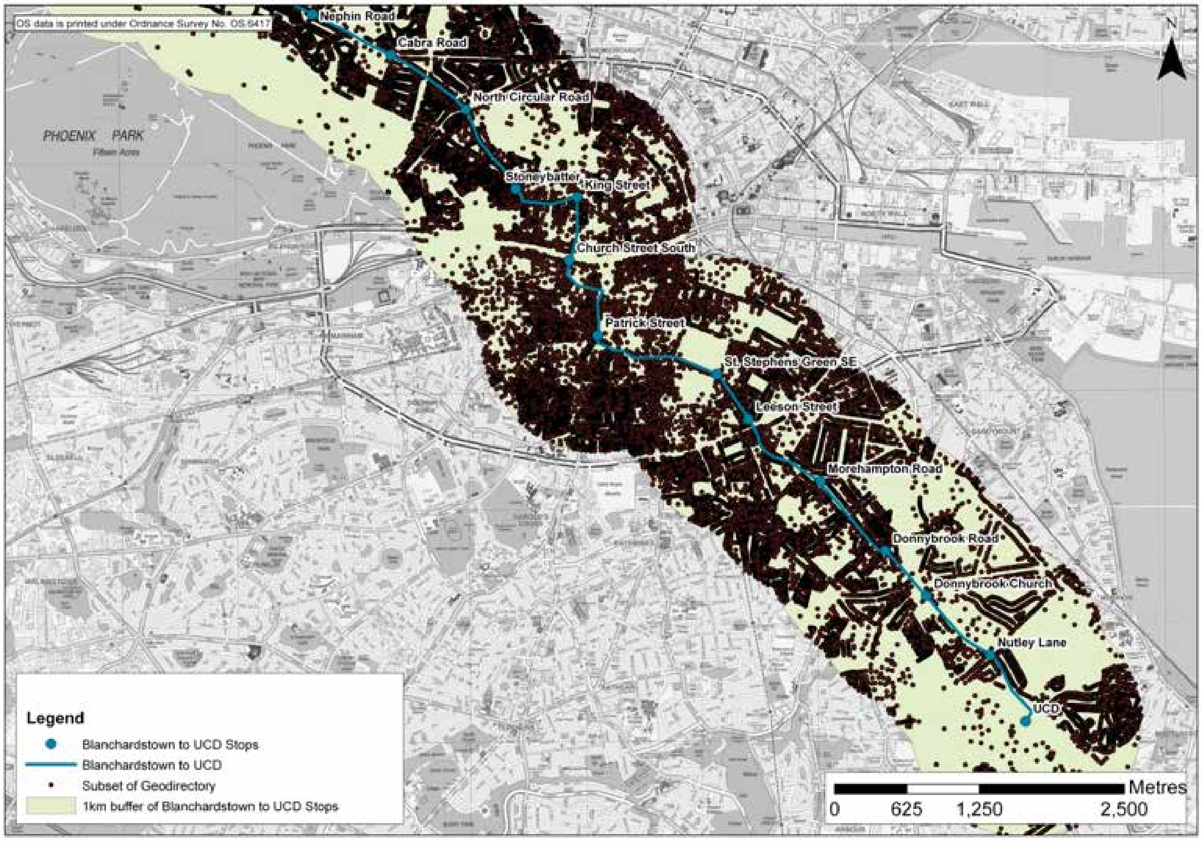


Figure 30 Geodirectory data for Blanchardstown to UCD

500m Buffer	Length (km)	Residential	Commercial
Swords Tallaght	27.787	38,258	7,652
Blanchardstown UCD	16.531	28,527	4,574
Clongriffin Tallaght	23.254	41,985	6,818

Table 5 Catchment Analysis of Geodirectory for 500m radius from stops

1km Buffer	Length (km)	Residential/km	Commercial/km
Swords Tallaght	27.787	89,882	14,379
Blanchardstown UCD	16.531	66,008	11,113
Clongriffin Tallaght	23.254	92,477	13,215

Table 6 Catchment Analysis of Geodirectory for 1km radius from stops

4.2.4 Comparative Analysis

In order to provide a comparison between the cross city routes the data has been analysed to show the catchment per kilometre. This is shown below in Table 7 to Table 10 for both the 500m and 1km buffer.

500m Buffer	2006 Population/km	2006 Employment/km	2011 Population/km	2030 Population/km	2030 Employment/km
Swords Tallaght	3,168	4,491	3,282	4,110	5,664
Blanchardstown UCD	3,891	4,549	4,095	5,124	5,581
Clongriffin Tallaght	4,017	4,741	4,237	5,077	5,993

Table 7 Catchment Analysis of Electoral Divisions for 500m radius from stops per kilometre

1km Buffer	2006 Population/km	2006 Employment/km	2011 Population/km	2030 Population/km	2030 Employment/km
Swords Tallaght	7,295	8,201	7,604	9,634	11,063
Blanchardstown UCD	8,579	10,474	8,995	11,667	13,550
Clongriffin Tallaght	9,084	8,897	9,553	11,707	11,957

Table 8 Catchment Analysis of Electoral Divisions for 1km radius from stops per kilometre

500m Buffer	Length (km)	Residential/km	Commercial/km
Swords Tallaght	27.787	1,377	275
Blanchardstown UCD	16.531	1,726	277
Clongriffin Tallaght	23.254	1,805	293

Table 9 Catchment Analysis of Geodirectory for 500m radius from stops per kilometre

1km Buffer	Length (km)	Residential/km	Commercial/km
Swords Tallaght	27.787	3,235	517
Blanchardstown UCD	16.531	3,993	672
Clongriffin Tallaght	23.254	3,977	568

Table 10 Catchment Analysis of Geodirectory for 1km radius from stops per kilometre

4.2.5 Discussion

In terms of the total area served, the Clongriffin to Tallaght route has the highest population within the catchment in 2006 and 2011 for both the 500m and 1km catchment areas. It also has the highest number of residential premises. The Blanchardstown to UCD route had the lowest overall population according to Census data and also the lowest number of residential premises, arising largely from its shorter length.

Reflecting its longer length, the Swords to Tallaght route had the highest overall employment in 2006 for both the 500m and 1km catchment; it also had the highest number of commercial premises. Conversely, the Blanchardstown to UCD route had the lowest employment in 2006 and the lowest number of commercial premises.

As each cross city route was a different length, the catchment area was also analysed in terms of population and employment per kilometre. Again, the Clongriffin to Tallaght route had the highest population per kilometre for 2006 and 2011, and it also had the highest number of residential premises per kilometre within 500m. The Blanchardstown to UCD route had the highest number of residential premises per kilometre within 1km.

The Blanchardstown to UCD route had the highest employment in 2006 and the highest number of commercial premises within 1km of the route when assessed on a per kilometre basis. The Clongriffin to Tallaght route has the highest number of commercial premises per kilometre and the highest employment level within 500m.

The Swords to Tallaght route had the lowest employment level per kilometre in 2006 and the lowest number of commercial premises within 500m and 1km of the route.

In the 2030 Scenario, the Blanchardstown to UCD and Clongriffin to Tallaght routes have similar population and employment levels per kilometre and are higher than the Swords to Tallaght route.

4.3 Trip Attractors/Places of Interest

This section of the report highlights the major trip attractors and generators for each of the three cross city routes outside of the City Centre. These are illustrated in Figure 31 to Figure 33.

- The Blanchardstown to UCD Corridor serves, amongst others, Blanchardstown Town Centre, the RDS and University College Dublin.
- The Swords to Tallaght Corridor serves Swords Main Street, the Pavilions Shopping Centre, Dublin Airport, North Ring Business Park, Dublin City University, St. Patrick's College, Harolds Cross Greyhound Stadium, Greenhills Industrial Park, Cookstown/Tallaght Industrial Estates and Tallaght Town Centre.
- The Clongriffin to Tallaght Corridor serves Clare Hall, Donaghmede and Artane Shopping Centres, Croke Park, the International Financial Services Centre (IFSC), Harolds Cross Greyhound Stadium, Greenhills Industrial Park, Cookstown/Tallaght Industrial Estates and Tallaght Town Centre.

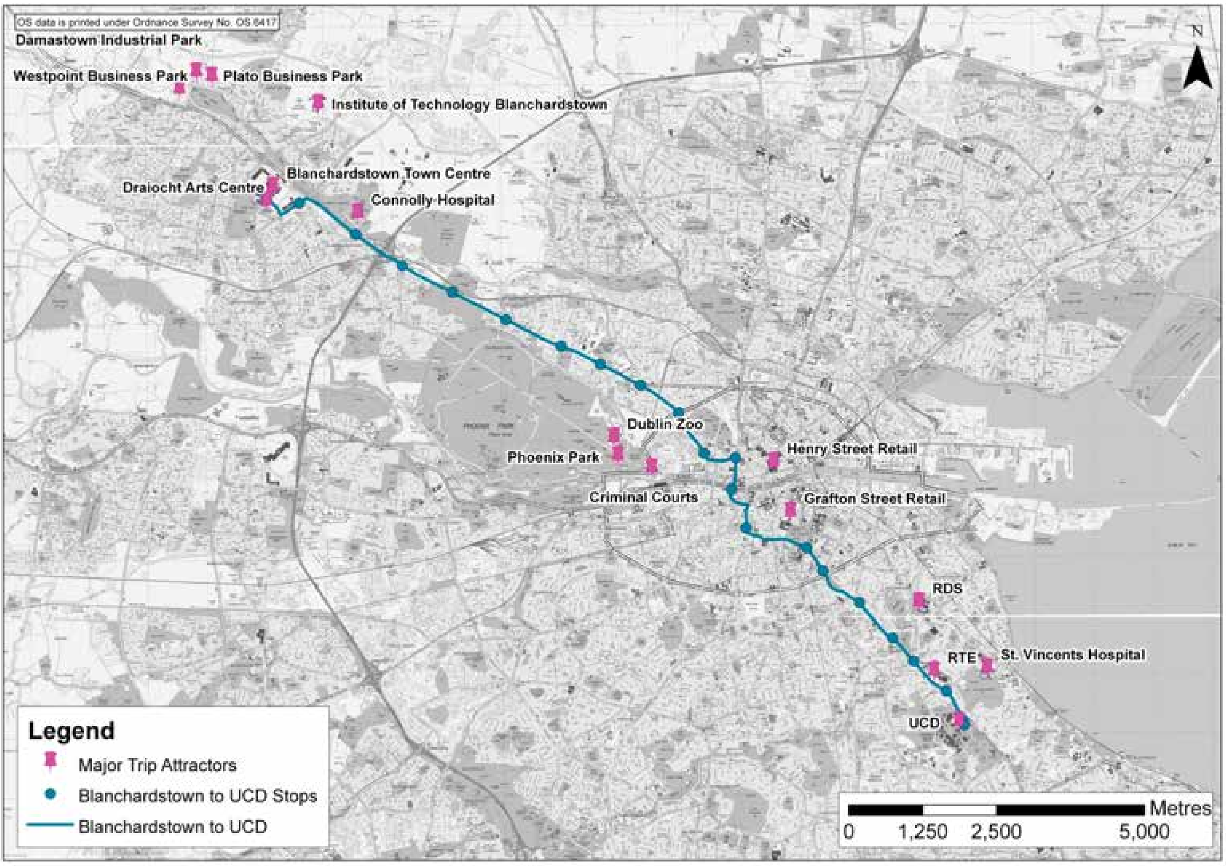


Figure 31 Blanchardstown to UCD Trip Attractors

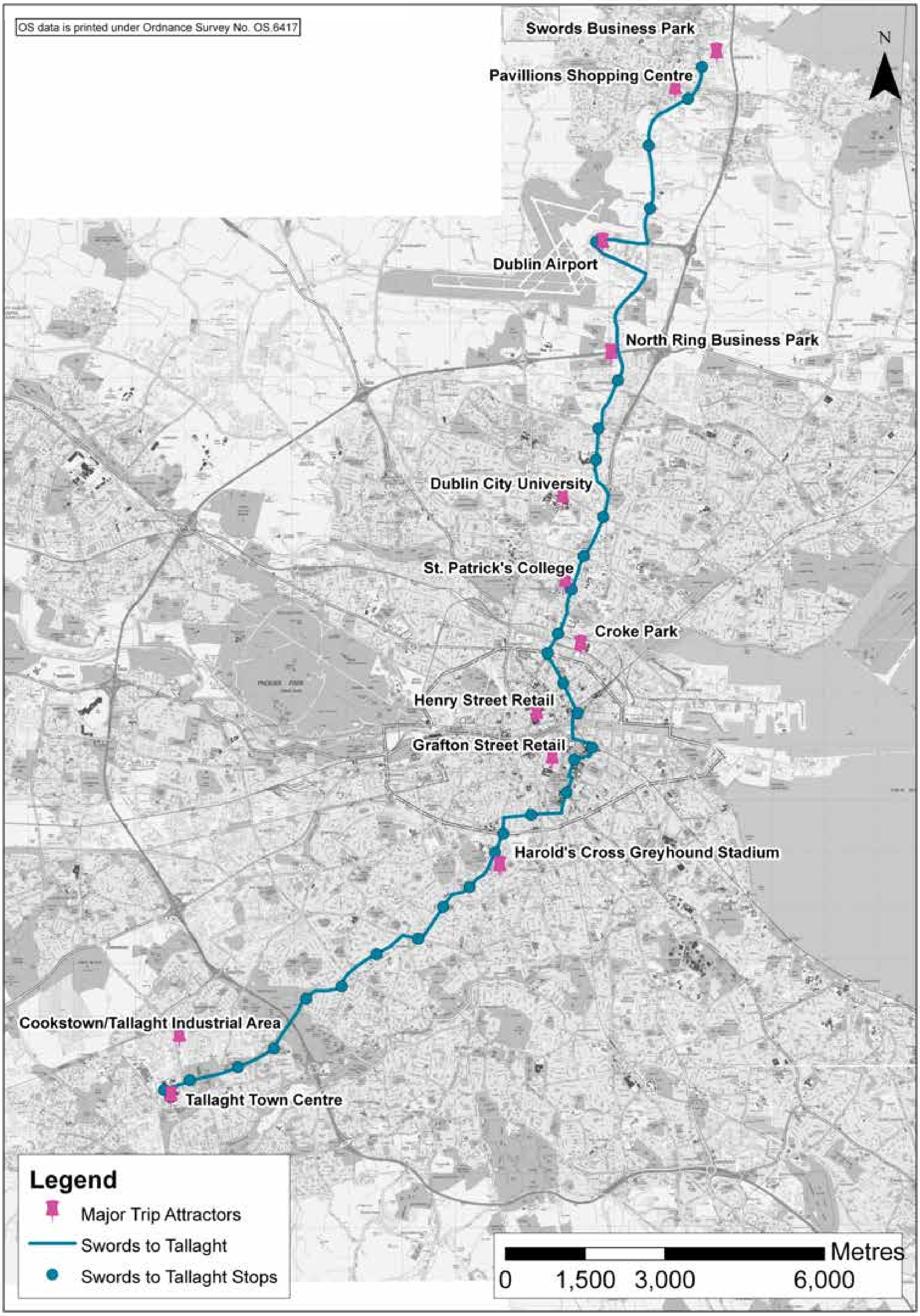


Figure 32 Swords to Tallaght Trip Attractors

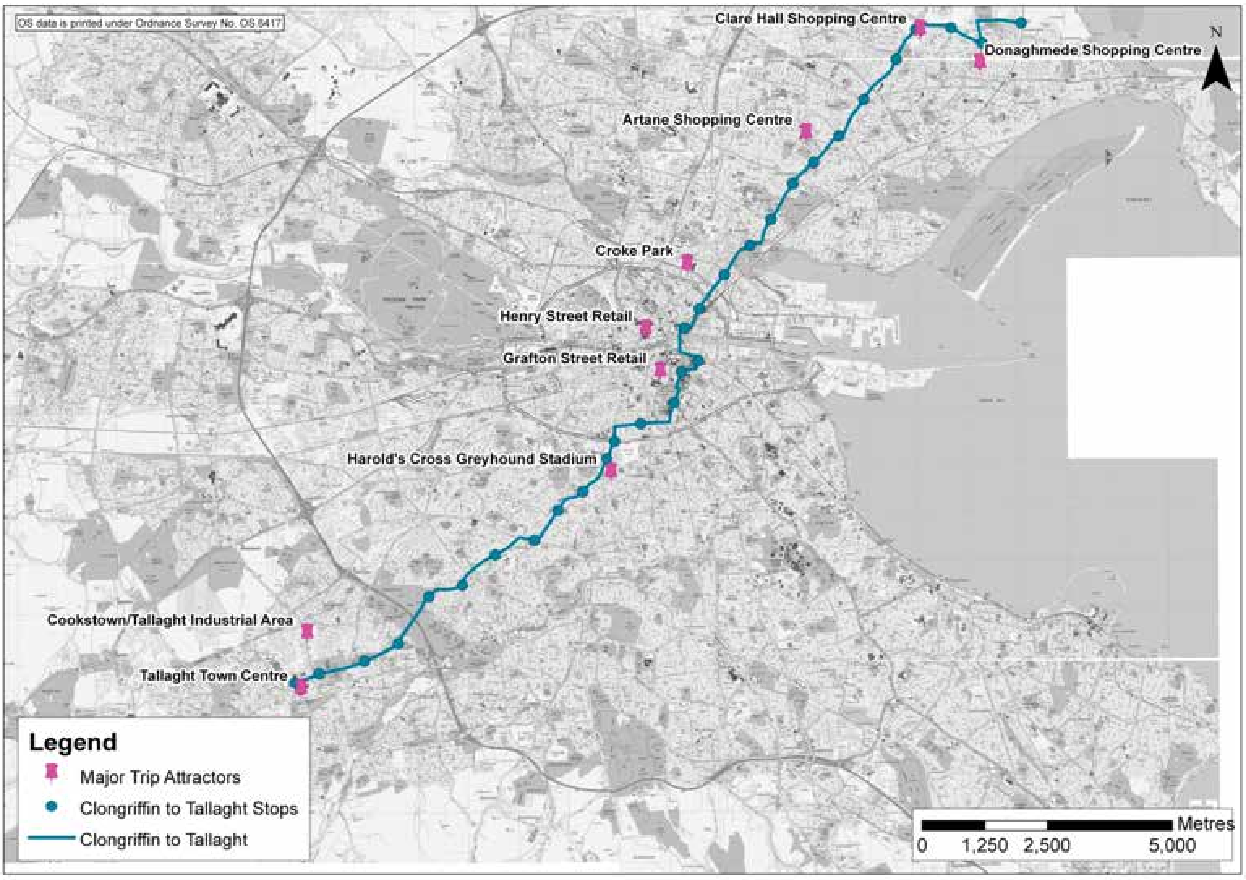


Figure 33 Clongriffin to Tallaght Trip Attractors

4.4 Demand Analysis

4.4.1 Overview

A series of scenarios were tested using the NTA multimodal transport model (2006 Base Year) in order to assess the future demand on three potential cross city BRT alignments from the proposed core BRT network. The potential BRT alignments are:

- Blanchardstown to UCD;
- Swords to Tallaght; and
- Clongriffin to Tallaght.

The core BRT network is shown in Figure 34.

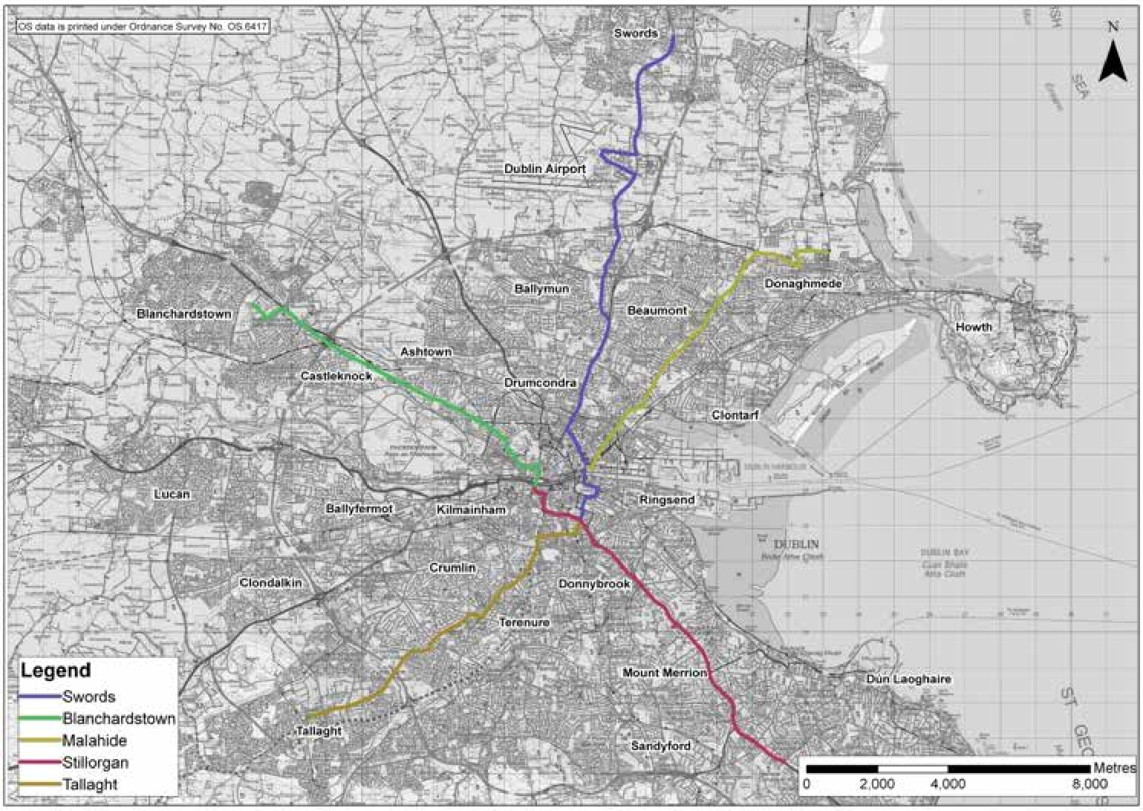


Figure 34 Proposed BRT Core Network

4.4.2 Methodology

The demand analysis was conducted using the NTA Multimodal Transport Model (2006 base year). This model forecasts demand for a given BRT option by assessing the travel time and costs associated with its introduction and allocating demand from existing modes when the BRT service offers an improvement or benefit. Demand for AM Peak period (7am to 10am) and an off peak hour (2pm-3pm) is calculated as part of the model run. This demand is then factored up to produce an annual demand estimate for the proposed BRT option.

The assumption used in this modelling analysis is that the proposed BRT system will be a high quality service as outlined in the system concept, with characteristics more in line with a Luas service than the existing bus service. As a result, the modelling parameters used to define the BRT service (i.e. crowding curves, and transfer penalties) are more comparable to rail based modes than bus. In this way, potential demand for a high quality BRT service can be established. If the system concept is not fully implemented, it will result in reduced patronage and act as a disincentive to potential passengers transferring to public transport.

4.4.3 Landuse and Infrastructure Assumptions

In order to assess demand, three specific landuse/infrastructure scenarios were investigated for each BRT alignment.

- Base Year (2006) Current Infrastructure;
- Future Year (2030) Current Infrastructure; and
- Future Year (2030) Proposed draft NTA Transport Strategy public transport network.

The Base Year scenario uses 2006 population and employment levels as inputs as this is currently the most up-to-date census data available. The 2030 scenarios use population and employment forecasts defined in the NTA's Scenario B 2030 landuse forecasts .

For the Current Infrastructure scenarios, it is assumed that the current public transport network will be maintained and no additional public transport infrastructure will be present in the future year scenario. For example, Luas Broombridge, Metro North and Dart Underground are not included in these scenarios. The Proposed Strategy Infrastructure scenario includes the proposed infrastructure set out in the NTA's draft Transport Strategy.

4.4.4 Mode and Service Characteristics

For each cross city alignment, demand was estimated for the AM peak period (7am-10am); and a representative off peak hour during (2pm-3pm)

For all model runs, a service headway of 4 minutes (equivalent to 15 BRT vehicles per hour) was assumed in the AM and PM peak periods. A headway of 8 minutes (equivalent to 7.5 BRT vehicles per hour) was assumed in the inter-peak period.

The capacity of each BRT vehicle was assumed to be 120 passengers (60 seated). The resulting hourly service capacities are given in Table 11.

	Frequency	
Capacity	15vph	7.5vph
	1,800	900

Table 11 Hourly Service Capacities (Passengers per direction per hour (ppdph))

A distance-based fares structure, based on the Dublin Bus fares table was assumed for this analysis.

Prior to conducting a detailed run-time modelling exercise, the average speed (including stopping/dwell times at stops and junctions) for all BRT alignments was assumed to be 20kph outside the canal cordon and 15kph within the canal cordon.

Further to these operational speeds, an additional assumption was made regarding how passengers perceive the journey time on BRT vehicles relative to conventional bus services. An in-vehicle time speed factor of 1.3 was applied to all BRT services, which reflects the assumption that time spend travelling on a BRT service will be preferred to time spent travelling on a conventional bus service.

Within the modelling exercise all existing Dublin Bus services travelling along the proposed BRT corridors were retained for the purposes of this analysis. In reality, existing bus services are likely to be adjusted wherever a BRT service is introduced. However, the nature of these adjustments is not part of the scope of this analysis and has, therefore, not been included in the modelling assumptions. A previous demand analysis of the Lucan (N4) corridor demonstrated, as expected, that adjustments to the bus network can lead to a significant increase in BRT patronage.

[2] Scenario B assumes a consolidation of landuse development around heavy rail/metro corridors.

4.5 Results

The results of the demand analysis are outlined in this section. Lineflows are presented for the AM peak hour (8am-9am) together with a summary of demand for the proposed cross city corridors at the end of the section.

4.5.1 Blanchardstown to UCD

The AM peak passenger loads on the Blanchardstown to UCD BRT service are given in Figure 35 and Figure 36.

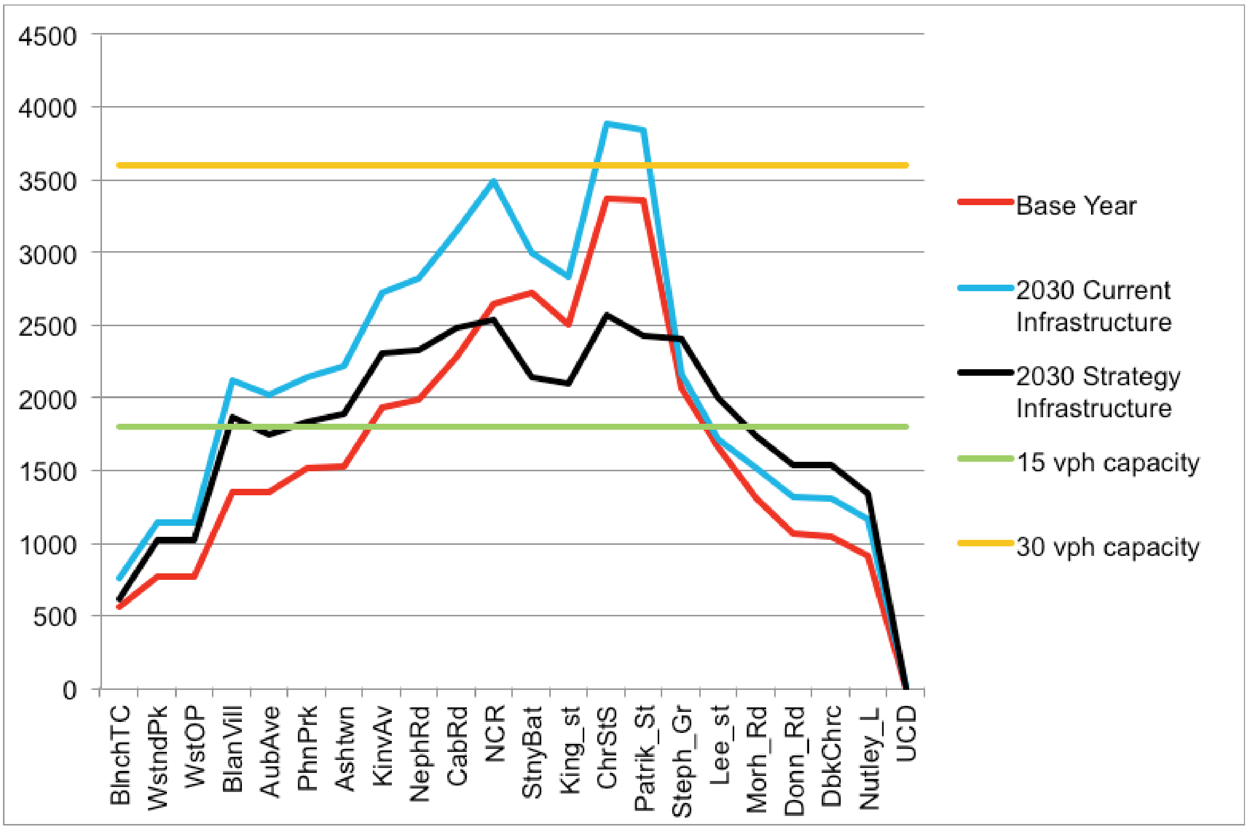


Figure 35 AM Peak Blanchardstown to UCD Load

Figure 35 shows that the Base Year AM peak lineflow is approximately 3,370 passengers at Church Street South. This would exceed the capacity of a 15vph service, and also a 20vph service (2,400 ppdph). The 2030 results show a marked difference, depending on whether additional transport infrastructure is in place or not. In this case, the DART Underground project likely has the biggest effect on differences observed in the city centre. The 2030 Current Infrastructure scenario shows that, in the absence of additional infrastructure, the peak lineflow is nearly 3,900. This exceeds the ultimate capacity of 3,600 ppdph. The 2030 draft Strategy scenario shows a peak lineflow of just over 2,500. This is lower than the peak lineflow estimated in the base year 2006 scenario.

Figure 36 shows that demand will likely be lower in the UCD to Blanchardstown direction, with an AM peak lineflow in 2006 of approximately 1,350 passengers. The 2030 Current Infrastructure and 2030 Strategy scenarios show a peak lineflow of approximately 3,600 and 2,500 respectively.

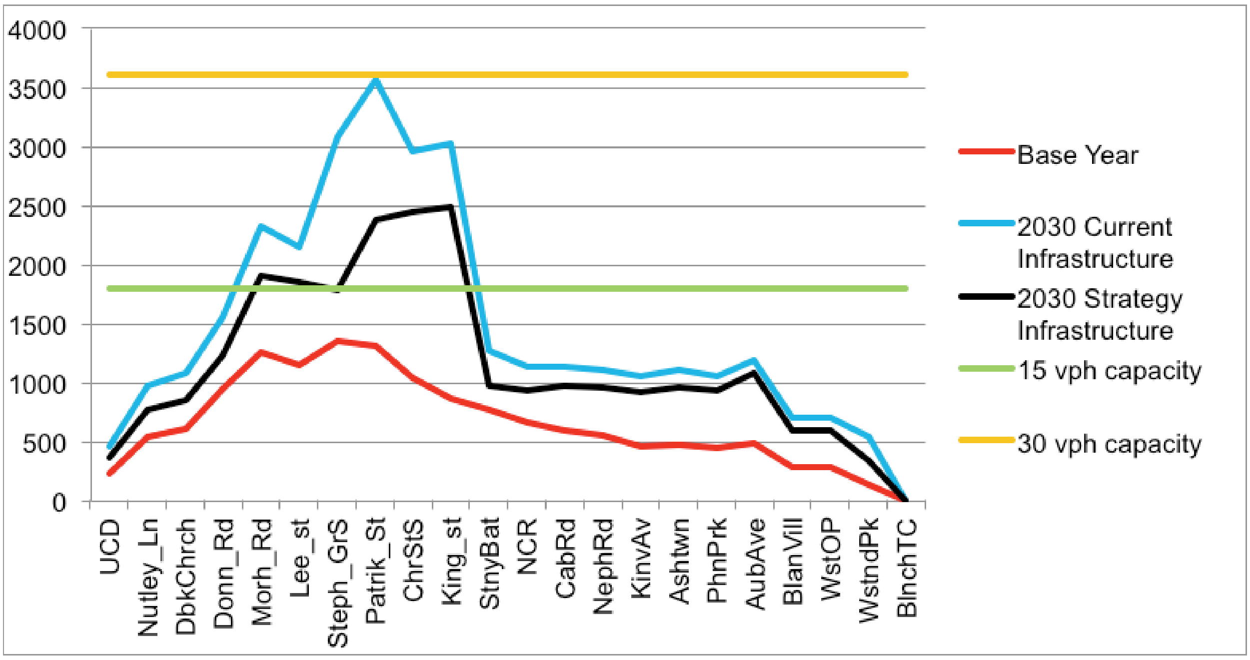


Figure 36 AM Peak UCD to Blanchardstown Load

4.5.2 Swords to Tallaght

The AM peak passenger loads on the Swords to Tallaght BRT service are given in Figure 37 and Figure 38.

From Figure 37, it can be seen that demand in the Base Year AM peak will likely be strong in this direction, with a peak lineflow of approximately 3,500 passengers at Drumcondra. This far exceeds the capacity of a 15vph service and is also very close to the ultimate capacity of 3,600 ppdph. In the absence of Metro North, the 2030 Current Infrastructure scenario shows a peak lineflow of approximately 5,900 at St. Patricks College. This far exceeds the ultimate capacity of 3,600ppdph.

The 2030 draft NTA Strategy scenario shows a lower level of demand for the service, which is due primarily to the presence of Metro North in this scenario. In this case the peak lineflow is approximately 4,000, again at St. Patricks College. This also exceeds the ultimate capacity of 3,600ppdph.

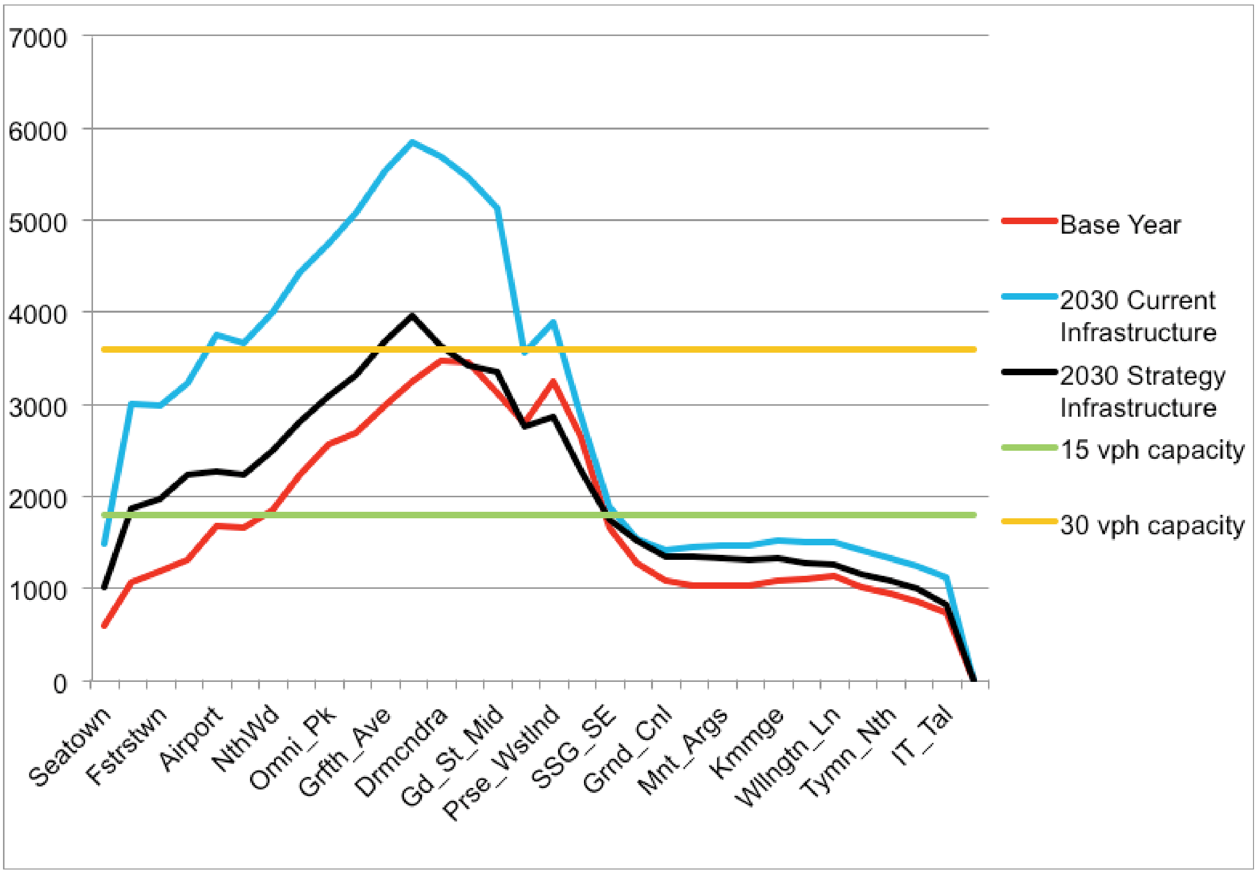


Figure 37 AM Peak Swords to Tallaght Load

In the opposite direction (Figure 38), all scenarios show a demand for BRT that will again exceed the service capacity of 15 vph and 20 vph. In both the Base Year and 2030 NTA Strategy scenarios the peak lineflow exceeds 3,000 ppdph at approximately 3,100ppdph and 3,300ppdph respectively but are below the ultimate capacity of the BRT system, while the 2030 Current Infrastructure scenario has a peak lineflow of approximately 4,200 at St. Stephen's Green.

It is on the northern section of this corridor – between Swords and the City Centre – that the high levels of demand arise. The southern section – Tallaght to City Centre – is within BRT capacity. This section of the corridor is common to the Clongriffin to Tallaght proposal which is dealt with in subsequent paragraphs. Overall, the link between the city centre and Swords has demand levels that exceed the capacity of a moderate capacity BRT system, in the longer term. While BRT may provide an interim partial transport solution in the shorter term, a higher capacity rail solution, such as a metro system, will ultimately be required on this corridor. In light of this, the Swords to City Centre BRT section has not been progressed to the later costing and appraisal sections of this feasibility study report.

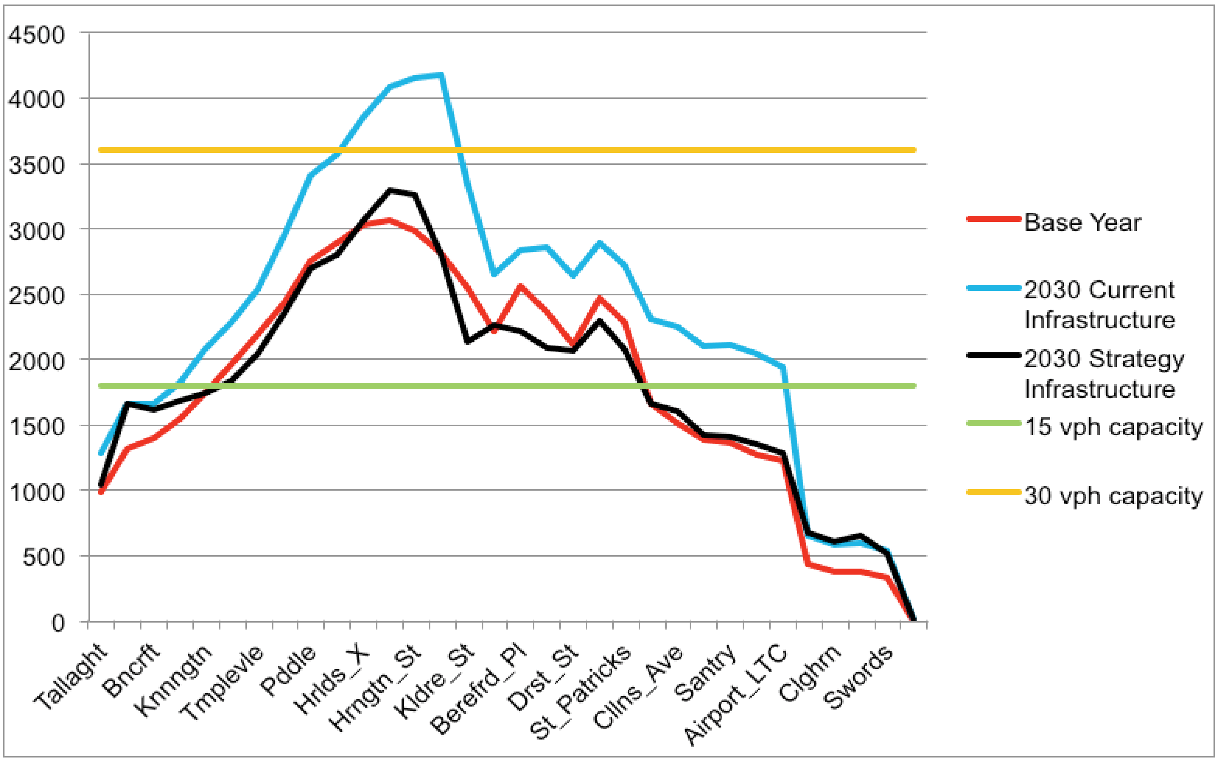


Figure 38 AM Peak Tallaght to Swords Load

4.5.3 Clongriffin to Tallaght

The AM peak passenger loads on the Clongriffin to Tallaght BRT service are given in Figure 39 and Figure 40.

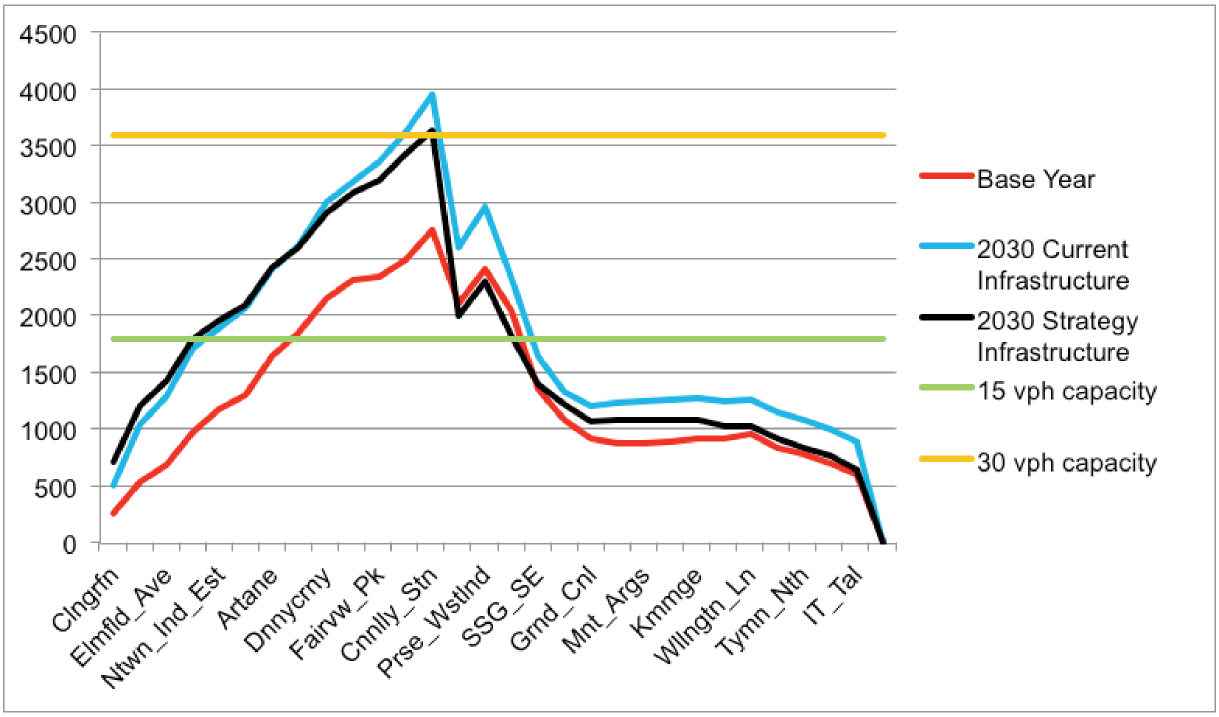


Figure 39 AM Peak Clongriffin to Tallaght Load

The results in the southbound direction from Clongriffin to Tallaght (Figure 39) show that demand for a BRT service along this alignment will be in line with the ultimate capacity of the BRT service in both future year scenarios and lower in the Base case. The AM peak lineflow in the Base Year is forecast to be almost 2,800 at Connolly Station. The peak lineflows for the 2030 Strategy and Current Infrastructure scenarios occur along the same segment and are approximately 3,600 and 4,000 respectively.

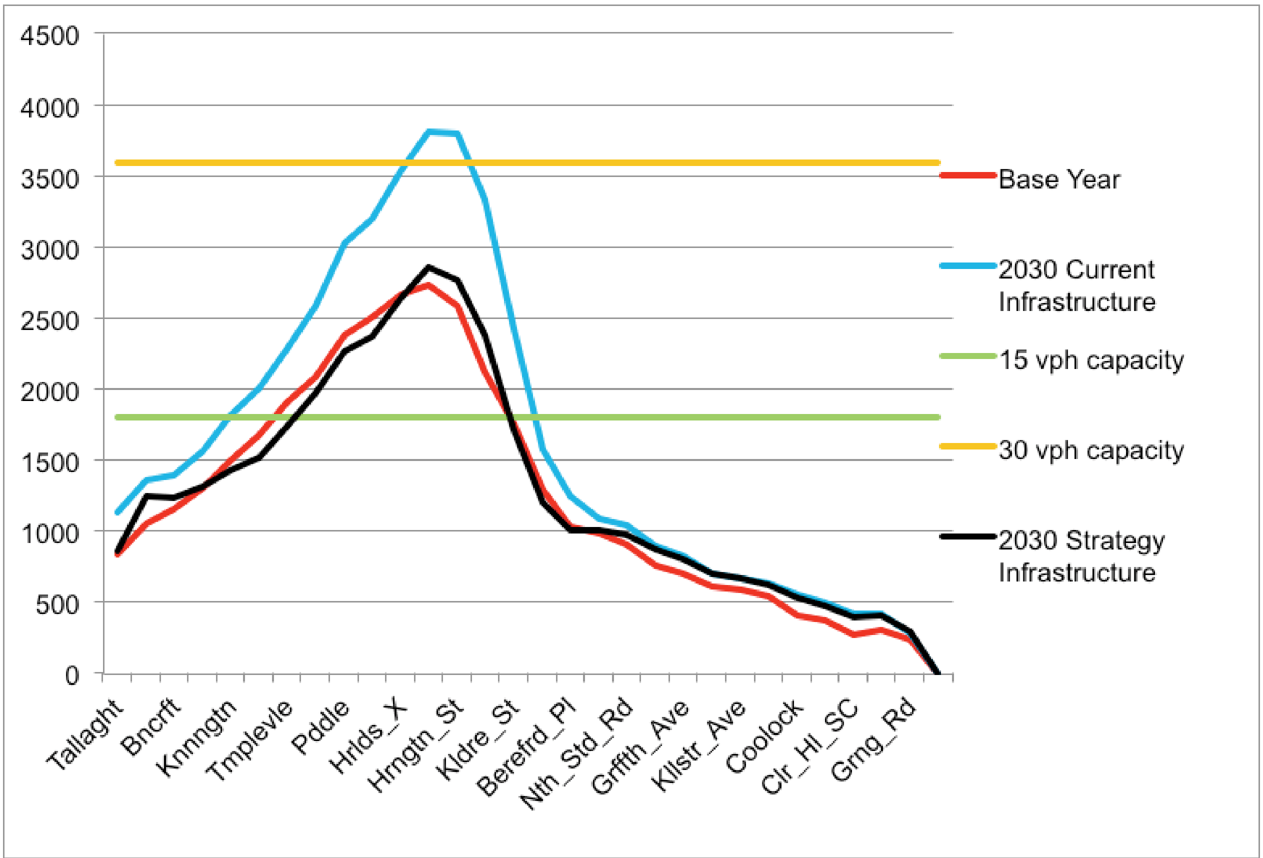


Figure 40 AM Peak Tallaght to Clongriffin Load

In the opposite direction from Tallaght to Clongriffin (Figure 40) both the Base Year and 2030 Strategy scenarios have a peak lineflow of less than 3,000 ppdph crossing the Grand Canal at approximately 2,700 ppdph and 2,900 ppdph respectively, while the peak lineflow in the 2030 Current Infrastructure scenario is over 3,800 passengers.

4.6 Summary of Results

Figure 41 presents a summary of the results of the demand analysis. These results include the AM peak hour demand presented in the previous section together with a summary of the % above or below different capacities. The AM peak period boardings are also included.

Alignment	Scenario	Peak Lineflow	% above 15vph Capacity (1,800)	% above 20vph Capacity (2,400)	% above 30vph Capacity (3,600)	AM Peak Boardings
Blanchardstown to UCD	Base Year	3,369	87%	40%	-6%	9,482
	2030 Curr Inf	3,877	115%	62%	8%	14,577
	2030 Strategy Inf	2,564	42%	7%	-29%	11,838
Swords to Tallaght	Base Year	3,482	93%	45%	-3%	17,224
	2030 Curr Inf	5,845	225%	144%	62%	22,120
	2030 Strategy Inf	3,963	120%	65%	10%	17,828
Clongriffin to Tallaght	Base Year	2,754	53%	15%	-24%	11,899
	2030 Curr Inf	3,954	120%	65%	10%	14,618
	2030 Strategy Inf	3,638	102%	52%	1%	12,792

Figure 41 Summary of Results

The results show that the Swords to Tallaght cross city alignment has the highest overall forecast demand, particularly in the 2030 Current Infrastructure scenarios. Demand to/from the Swords area and the Airport is high in these scenarios, resulting in a peak demand of nearly 6,000 ppdph, which far exceeds the capacity of the proposed BRT service. Forecast demand on the Clongriffin to Tallaght and the Blanchardstown to UCD service also exceeds capacity in the 2030 Current Infrastructure scenario by 8% and 10% respectively. The Blanchardstown to UCD service has the lowest demand of the alignments tested.

4.7 Conclusion

While the capacity of all cross city alignments is exceeded in some scenarios, demand on the Blanchardstown to UCD alignment and the Clongriffin to Tallaght alignment are closest to the proposed BRT service capacity of 3,600 ppdph. The Blanchardstown to UCD cross city corridor only exceeds the BRT service capacity in the 2030 Current infrastructure scenario where the peak line flow is forecast to be 3,877ppdph. Similarly the Clongriffin to Tallaght corridor only exceeds the BRT service capacity in the 2030 current infrastructure scenarios where the peak line flow is forecast to be 3,954 ppdph.

These peak line flow demands could however be catered for should the option of running longer (circa 25m) double articulated vehicles become a viable option. The results of the demand forecasting suggest that both of these cross city corridors would be a feasible corridor for BRT.

The Swords to Tallaght corridor has a forecast demand that greatly exceeds the capacity of BRT in the current 2030 current infrastructure scenario and also exceed the 3,600 ppdph in the 2030 scenario.

The demand forecasts suggest that the introduction of Metro North on this corridor has a significant effect on demand on the BRT service, particularly as it serves both Swords and the Airport. The demand forecasting suggests that BRT is not a feasible proposal on this cross city corridor in the absence of other public transport provision such as Metro North.

It is on the northern section of this corridor – between Swords and the City Centre – that the high levels of demand arise. The southern section – Tallaght to City Centre – is within BRT capacity. This section of the corridor is common to the Clongriffin to Tallaght proposal which is has been discussed in previous paragraphs. Overall, the link between the city centre and Swords has demand levels that exceed the capacity of a moderate capacity BRT system, in the longer term. While BRT may provide an interim partial transport solution in the shorter term, a higher capacity rail solution, such as a metro, will ultimately be required on this corridor. In light of this, the Swords to City Centre BRT section has not been brought forward to the later costing and appraisal sections of this feasibility study report.

In relation to the cross city corridor from Clongriffin to Tallaght there is significant potential to further optimise transport services in the northern section of the corridor to rebalance usage between rail, BRT and conventional buses. For instance, the demand forecasting suggests that in both of the future year scenarios there is significant demand at the proposed interchange at Clongriffin Station. If this demand should occur in practice, further consideration could be given to adjusting the frequency of rail services to Clongriffin and providing a feeder bus service to the rail station for example. This, in turn, would allow an adjustment to the terminal point of the BRT service, which might not require the route to extend fully to Clongriffin Rail station, which is the location selected for the demand modelling exercise. These adjustments could be augmented by modification to the bus service patterns, providing for a rebalancing of passenger distribution between BRT and conventional buses. Overall, given the nature of this particular corridor, there is considerable scope for further optimisation of the BRT proposal such that demand and capacity be more closely aligned.

In summary, the cross city corridors from Blanchardstown to UCD and Clongriffin to Tallaght have been included in both the economic appraisal and engineering evaluation.

5 COST ESTIMATES

5.1 Introduction

The purpose of this cost estimate section is to produce approximate capital and whole life costs for BRT on a per kilometre basis that can be used for comparative assessments of possible route options. The estimate covers the running BRT line only. The total cost of the BRT system can be broken down into Capital Costs and Operating Costs (including renewals). Depending on the type of BRT system defined, both categories of costs can vary. As the project develops, the estimates will be refined to reflect the evolving design, procurement strategy and contract conditions, and a series of estimate reviews and risk workshops.

5.2 Basis of Estimate

The Dublin BRT system concept is at a very early stage of development, and preferred route corridors have not been selected or designed and service patterns have not been determined.

In the absence of this detailed design information, it was necessary to make a series of assumptions and exclusions to be used as the basis of an estimate for capital and life cycle costs for the proposed system concept. The high level assumptions include the following:

- Existing bus corridors will be used where possible by the BRT system;
- The BRT system will be open (no physical segregation from other traffic);
- The civil works for the 1km section comprise of 500m lateral running and 500m of median running (as per typical cross sections); and
- All stops are assumed to utilise lateral platforms (as per typical cross sections).

Specific exclusions include:

- VAT;
- Inflation;
- Provision of a depot; and
- Provision of a control room and control room systems.

5.3 Estimate Methodology

The following sections detail further the scope and approach used to compile the capital cost estimate. For clarity they have been grouped using the characteristics of the BRT systems. The cost estimate was prepared using historical cost data, cost information from current projects and existing operations and equipment contracts. This estimate reflects 2011 prices. The current estimating tolerance is approximately +/- 25% based on level of design information and the knowledge of costs for projects of a similar nature.

5.3.1 Running Way

The civil works along the running way for either dedicated lateral or median lanes is as follows:

- A notional allowance has been made for general demolitions;
- Plane the road surface in the proposed BRT lanes only (Approx. 100mm deep);
- Install new asphalt surface to the proposed BRT lanes only;
- A notional allowance for removal and relocation/re-profiling approx 100m of footpath per km; and
- A notional allowance has been made for street signage.

5.3.2 Stops

- Stops are to be similar in design to current Luas stops but smaller; platforms to be 25 long including two 6 metre ramps and 3m wide overall;
- Stops will be approx 800m apart;
- Utility diversions at stop locations to run for approximately 100m and includes both diversion and decommissioning of the utilities;
- One ticket vending machine per platform (2 per stop);
- One ticket validator per platform (2 per stop); and
- Platform fit out as per a current Luas stop which includes for: litter bin, signage, shelter (including seating), rail mounted sign, handrails, advertising drum, and notice board.

5.3.3 Vehicles

- The proposed vehicles (1.4 per km) will be a single deck articulated bus, approximately 18.5m long, with multiple doors along the sides, and utilising a diesel or diesel hybrid propulsion system.

5.3.4 Systems

- The BRT system will utilise an optical guidance system (at stops only); and
- Support systems shall be as per the current Luas arrangement but utilising wireless technology instead of cables where possible.

5.3.5 Property

- An allowance of €1m per km has been allowed for property acquisition.

5.4 Operation and Maintenance Cost Estimate

To estimate the operating and maintenance (O&M) costs of a Dublin BRT system the existing RPA Luas O&M cost model was adapted to reflect BRT standards. The RPA Luas O&M model is based on models deployed by TfL (Transport for London), and has been developed over time to incorporate the Luas system operating contracts. It is used by the RPA to test the impact of timetable changes and new lines, extensions etc. For this exercise, the O&M model was updated to reflect the latest available outturn budgets for the Luas system for 2010.

Reflecting the system concept for BRT in Dublin, certain elements of the operational costs of BRT will be of a similar level to the costs incurred on Luas. This is to achieve a similar level of quality and passenger experience. Therefore, costs such as driver salaries etc. are assumed to equate to current light rail equivalents. In addition, the methodology for estimating driver numbers and associated staff, such as Revenue Protection Officers (RPOs), is based on current light rail standards.

Support and administrative functions, such as management, HR, traffic control and planning, contract management, secretariat etc. are assumed to reflect light rail standards also.

Fuel costs are based on fuel consumption levels of 5 mpg assuming a diesel hybrid vehicle. This was conservatively estimated based on analysis of fuel consumption levels observed on similar hybrid vehicles elsewhere. The costs of replacing onboard traction battery packs approximately every 5 years are also included (assuming a vehicle with a hybrid propulsion system is used).

Vehicle maintenance costs are assumed to be significantly different from light rail costs and are, therefore, based on vehicle maintenance costs for the Dublin Bus fleet in 2010. An allowance has been made for the higher specification of vehicle required for a BRT system. BRT stops will be equipped with similar passenger facilities as a light rail service, and associated maintenance costs for TVMs, PIDs etc., are assumed to be equivalent to light rail costs.

BRT incurs significantly lower infrastructure maintenance costs than light rail, as there are no costs associated with OCS, substations, track maintenance etc. However, costs associated with vandalism, stop cleaning, landscaping etc. are assumed to be similar to the existing light rail system in Dublin, and an allowance is also made for costs associated with routine maintenance of the busway.

Other overhead costs such as rates, insurance, advertising and marketing, passenger surveys etc. are assumed to be at a level similar to a light rail service.

For the system as a whole, O&M costs are lower than the costs associated with running an equivalent light rail system. Once BRT frequencies are required to increase to provide more capacity, BRT O&M costs tend towards light rail operating costs at similar levels of capacity, and typically are in excess of light rail costs beyond a certain capacity.

5.5 Conclusion

The capital cost estimate is preliminary and consistent with the level of 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 contract.

The capital cost of a BRT system on a per kilometre basis is €9,520,000.

Table 12 below summaries the cost of each route option appraised in terms of capital cost and annual operation and maintenance cost using the service pattern modelled to estimate demand as set out in section 4.4.4 of the report.

Route Option	Capex (excld Vehicles) €m	Capex (incld. Vehicle Costs) €m	Capex for 3 fleet renewals up to 2044 €m	Annual O&M €m
Blanchardstown to UCD	139	188	100	18.8
Clongriffin to Tallaght	195	264	140	25.8

Note: Above costs exclude VAT, inflation, depot and control room

Table 12 Capital Cost and Annual O&M Costs (2011€)

6 ECONOMIC APPRAISAL

6.1 Methodology

The overall approach and methodology applied to conducting the economic appraisal of the BRT system is in line with standard approaches to preparing a business case and economic appraisal work for Transport Projects.

The approach to economic appraisal is grounded in, and consistent with, the Department of Transport, Tourism & Sport's guidance in the area, Guidelines on a Common Appraisal Framework for Transport Projects and Programmes (the 'CAF'). This guidance is in turn set within the Department of Finance's guidance for the appraisal of all publicly-funded capital projects, Guidelines for the Appraisal and Management of Capital Expenditure Proposals in the Public Sector .

The Department of Public Expenditure and Reform (DPER) recently published a new Public Spending Code code. The Public Spending Code was produced with the intention to introduce best practice in the appraisal, implementation and evaluation of projects and programmes across sectors including transport. This new guidance will be used as the project progresses.

A high level economic appraisal of the BRT alignments has been carried out using the results of the model outputs and the TUBA economic appraisal programme. The parameters used in the economic evaluation and the methodology 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 and presented in 2002 prices for analysis purposes (2002 is the year for which mandated parameter values have been provided).

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 2030 forecasts of additional BRT patronage are outlined in section 4.6 above. The transport and modelling assumptions which have a bearing on the economic outcome of the project are summarised below in Table 13.

[3] Guidelines on a Common Appraisal Framework for Transport Projects and Programme, 2009, Department of Transport. Available at [http://www.transport.ie/upload/general/11801-DOT_COMMON_APPRAISAL_FRAMEWORK1-0.PDF]

[4] Guidelines for the Appraisal and Management of Capital Expenditure Proposals in the Public Sector, 2005, Department of Finance. Available at: [http://www.finance.gov.ie/documents/publications/other/capappguide05.pdf]

[5] Available at: http://publicspendingcode.per.gov.ie/

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)	Yes	Yes
Luas Stephen's Green to Broombridge (Line BXD)	Yes	Yes
Luas City-centre to Lucan (Line F)	Yes	Yes
BRT	**No**	**Yes**
Metro North	Yes	Yes
Metro West	Yes	Yes
DART Underground	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

Table 13 Modelling Assumptions for Future Year 2030 Strategy Network

An economic appraisal of BRT was carried out based on the results of the demand forecasting and the estimates of capital and operating costs of the scheme. For the economic appraisal it has been assumed that:

- The BRT system opens on 1st January 2017;
- The evaluation period is 30 years; and
- The discount rate is 4%.

Model run results for 2006 and 2030 were used to give the patronage and benefit levels for the opening year of 2017, through interpolation. The benefits calculated for 2030 were assumed to hold for the duration of the appraisal period, i.e. there was no growth in demand beyond 2030 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 the BRT system.

Financial and funding projections take account of escalation in values over time. The capital cost estimates are the outputs of the costing exercise described in Section 5 above. A three-year construction programme from 2014-2016 inclusive was assumed. Escalation of 1.5% in 2011 followed by 3% in subsequent years was applied to the capital cost estimates. BRT vehicles are assumed to have a useful economic life of 8-10 years and, therefore, provision is made in the cost estimates for three vehicle fleet renewals over the 30 year operational period. No residual value is included in the CBA.

6.2 Results

Each alignment was appraised under two scenarios – assuming current infrastructure provision obtained in the future year of 2030, and also assumed that the 2030 Strategy infrastructure (as discussed above) was in place in 2030. For each alignment the economic performance is maximised under the current infrastructure scenario, as the addition of public transport capacity in future (Metro North, Dart Underground etc.) in the 2030 Strategy scenario reduces demand on the BRT service.

The two alignments perform very similarly in cost benefit terms, with benefit-cost ratios (BCRs) of 4.9:1 in the current infrastructure scenario and 4.2:1-4.5:1 in the 2030 Strategy scenario as shown in Table 14 below (30vph). The difference in BCRs between these two routes is within the margins of error for this stage of the economic appraisal, given the margin of error attached to the capital cost estimates.

Alignment	Scenario	Estimated Capex (€2011m) incld. Vehicles	BCR	NPV (€2002m) PV
Blanchardstown to UCD	2030 Curr Inf	288	4.9	526
	2030 Strategy	288	4.2	478
Clongriffin to Tallaght	2030 Curr Inf	404	4.9	733
	2030 Strategy	404	4.5	687

Table 14 Summary of Economic Appraisal (30vph)

The Clongriffin-Tallaght alignment has a higher net present value (NPV) over 30 years however, (€733m compared to €526m in the current infrastructure scenario), indicating the overall benefit to society of the project is greater.

This indicates both schemes warrant further analysis on the basis of this initial economic appraisal test.

This analysis is at the feasibility stage, and therefore there is some uncertainty associated with both the costs and demand and benefits presented in this analysis. However, there would have to be considerable negative movements in levels of costs and benefits presented here to alter the conclusion that BRT in both alignments perform well in economic terms.

7 ENVIRONMENTAL APPRAISAL

7.1 Methodology

In order to inform the feasibility of the BRT network, an environmental scoping exercise was undertaken to determine the environmental topics for consideration in the environmental feasibility report. The environmental feasibility report considered the environmental constraints in relation to the following:

- Landuse;
- Flora and Fauna, in particular in relation to protected natural heritage sites;
- Soil and Geology in relation to soil contamination;
- Surface Water, in particular in relation to flooding events;
- Landscape and Visual; and
- Material Assets: Archaeological, Architectural and Cultural Heritage in relation to Recorded Monuments and Protected Structures.

The environmental feasibility report also identified the locations of sensitive receptors such as childcare facilities, education facilities, health/medical centres, hospitals, community centres, cinemas, theatres, churches and graveyards along each route. All three BRT options – Blanchardstown UCD; Swords Tallaght; and Clongriffin Tallaght – were included in the environmental feasibility review.

7.1.1 Landuse

From a landuse perspective, all three BRT options will predominantly utilise existing roads along the routes. However, the Clongriffin and Swords options both require the construction of new bus lanes through Tymon Park and Bancroft Park. Tymon Park is zoned GB (to provide a Green Belt between development areas) and Bancroft Park is zoned G (to protect and improved high amenity areas). The Blanchardstown to UCD option is considered feasible from a landuse perspective. The Clongriffin to Tallaght and the Swords to Tallaght options have the potential to result in negative environmental impacts on landuse based on the indicative alignment assessed. However, these options would also be considered feasible though the identification of appropriate mitigation, for example if an alternative route alignment which didn’t impact on the Green Belt amenity in Tymon and Bancroft Park was identified, or if the current zoning was modified through variations to the development plan to permit a BRT alignment.

7.1.2 Flora and Fauna

In relation to Flora and Fauna, potential impacts on the Royal Canal, Grand Canal, Santry Demesne pNHA (proposed National Heritage Area) and on rivers at river crossings will need to be managed in the development of feasible BRT options. All three options pass on existing structures over the Royal and Grand Canal pNHAs. The Swords to Tallaght option also passes on the road adjacent to the Santry Demesne pNHA. The Blanchardstown to UCD option is considered feasible from a flora and fauna perspective. The Clongriffin to Tallaght and the Swords to Tallaght options have the potential to result in negative environmental impacts on flora and fauna based on the alignments assessed. However these options would also be considered feasible though appropriate mitigation, such as for example if an alternative route alignment which didn’t impact on the flora and fauna amenity in Tymon and Bancroft Park was identified.

7.1.3 Soil and Geology

Soil and geology was considered predominantly in order to identify potential areas of historic contaminated land within the vicinity of each feasible BRT route option. The routes under review generally pass through areas that are built-up and urban in nature. It is expected that the quality of existing soil/subsoil across each feasible BRT option will be somewhat degraded throughout. Two of the feasible BRT options require new bus lanes to be constructed through Tymon and Bancroft Parks and these options would, as a result, negatively impact on the soil and geology in these areas. However, the land in the park has been considerably modified for use as parkland and for sports pitches and the soils present at these sites are predominantly classified as Made Ground. It is, therfore, considered that the feasibility of the three BRT options does not differ significantly in terms of soil and geology aspects.

Significant potential constraints in relation to contaminated land have been identified in order to inform the route evaluation report. A review of historical OS maps for each BRT option revealed that a number of industrial enterprises were located in the vicinity of the routes over the course of the past 200 years (Figure 42). The environmental functions and/or socio-economic value of both soil and subsoil can be significantly diminished if they have been contaminated by historical or present day activity, most notably at industrial sites and/or along transport corridors.

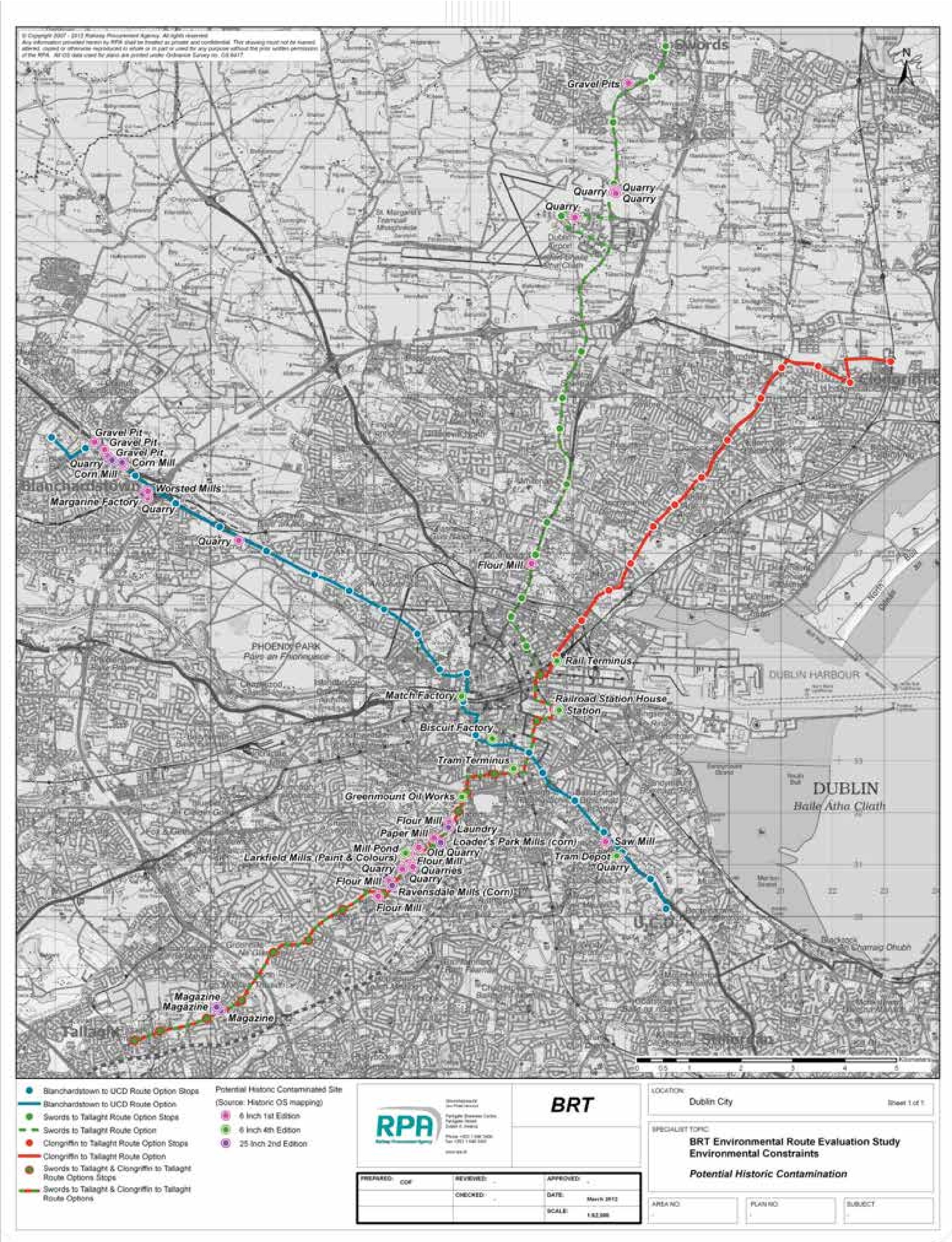


Figure 42 Environmental Constraints Potential Historic Contamination

The soil and geology evaluation identified the area from the city centre to Tallaght as an area of intense historical industrial activity. This activity is largely associated with milling and quarrying associated with the River Poddle. Another area of historical industrial activity was identified in the vicinity of the Tolka River at Blanchardstown. Other than this area, the northern section of all three routes was primarily Greenfield interspersed with small towns and villages until relatively recently so there is little historical industrial activity in these areas.

In light of the previous information, all three BRT options are considered feasible in relation to soil and geology. However, the feasibility study has identified areas of intense historical activity along the River Poddle for both the Clongriffin to Tallaght and the Swords to Tallaght options, which has the potential to generate contaminated material. This issue will require careful consideration during the subsequent development of a BRT route in these areas.

7.1.4 Surface Water

Surface water bodies in the vicinity of each BRT option comprise of rivers, canals and ponds. Impacts on surface water will be further evaluated in the subsequent route evaluation phase of the assessment. However, flooding events have occurred in the vicinity of each of the BRT options and these are considered in order to inform the route evaluation (Figure 43). Potential impacts on surface water bodies in the vicinity of each feasible BRT option will be minimised during the development of the emerging preferred route.

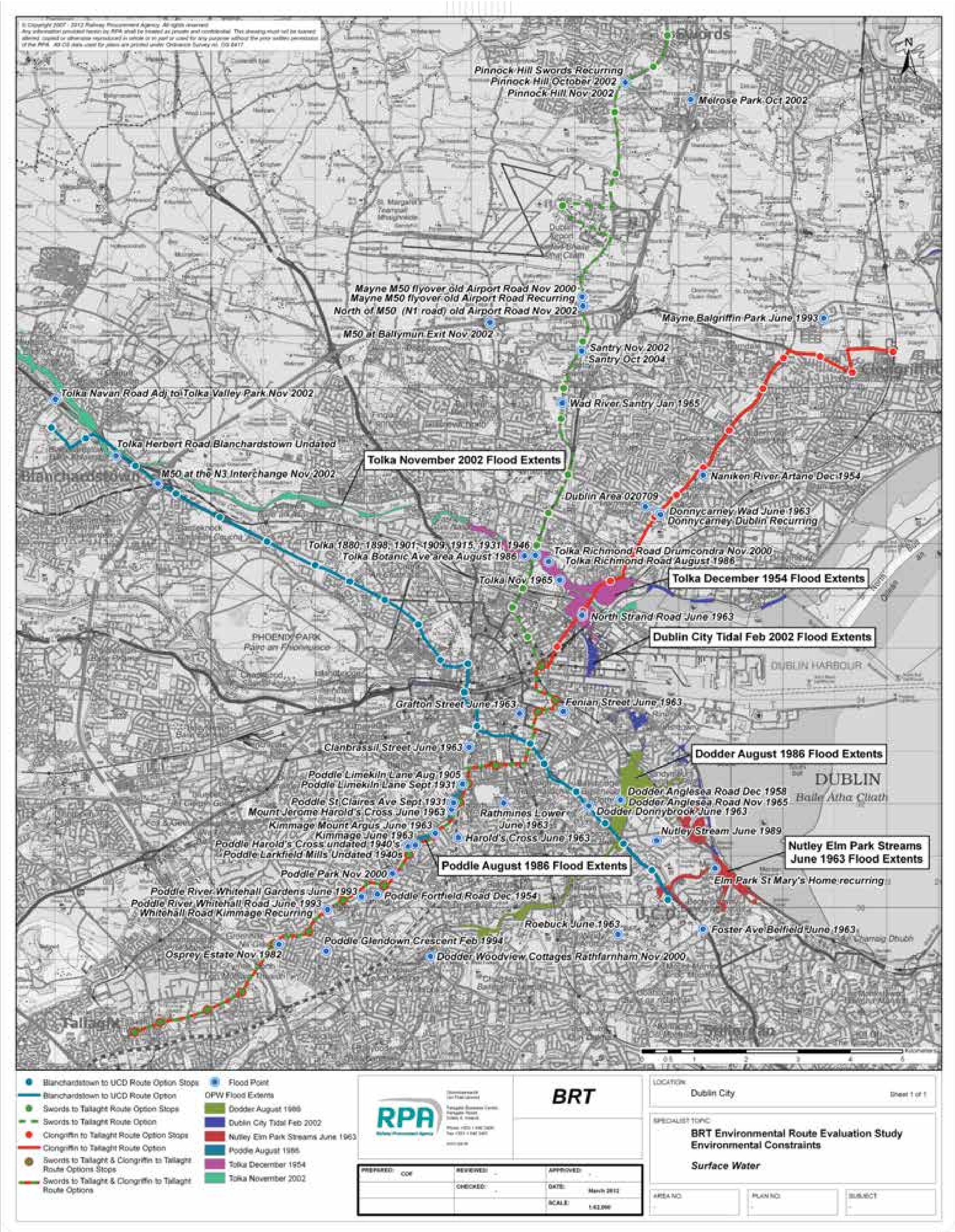


Figure 43 Environmental Constraints Surface Water

All of the indicative BRT options are considered feasible although flood points and events associated with the Tolka and Dodder Rivers and the Nutley stream along the N11, south of Donnybrook Village, are recorded along the Blanchardstown to UCD route. In relation to the Clongriffin to Tallaght option, flood points and events associated with the Naniken River, the

Donnycarney Wad, Tolka River, the Dublin City Tidal Flood and the River Poddle were identified. The Swords to Tallaght option has recorded flood events and points at Pinnockhill Roundabout, the Mayne River, the Santry River, and the Wad River at Santry, the Tolka River at Drumcondra and at various points along the River Poddle. The development of the BRT network will need to give careful consideration to the areas identified as flood points.

7.1.5 Landscape and Visual

From a landscape and visual perspective, the Clongriffin and Swords options have the greatest potential for impact as the indicative alignment would require the construction and operation of new bus lanes through Tymon and Bancroft Parks. Additionally, both of these options have protected views and prospects in the vicinity of the route. There are a number of views associated with the Custom House on Beresford Place and, as a result, these are common to the Clongriffin and Swords options. The Swords option impacts on the urban parks and passes in the vicinity of five protected views and prospects. The Clongriffin option passes in the vicinity of four protected views and prospects. The Blanchardstown option does not impact significantly on parks and there are only three recorded views and prospects in the vicinity of the route.

All three options are considered feasible but the development of a feasible BRT route option will need to ensure that any impacts on trees, street furniture, street lighting and paving and on parks and key views and prospects in the vicinity of the selected route are minimised.

7.1.6 Archaeology, Architectural and Cultural Heritage

The feasibility study confirmed that the area in the vicinity of all of the indicative BRT options has been intensely occupied, in particular in the post-medieval period, and as a result there is a considerable density of Recorded Monuments and Protected Structures in the vicinity of each route. Accordingly, the study focused on the streets/roads through which the indicative BRT routes under consideration may pass. All these sites are afforded legal protection and will need to be considered, particularly in the subsequent route evaluation phases and in the selection of the locations for BRT stops. Of particular significance in the study area is the cemetery at Donnybrook and the St. Stephen's Green Park which is of archaeological, architectural and cultural heritage significance. Impacts on these areas may occur if additional requirements for land arise in congested areas. These constraints need to be fully considered in the development of feasible options for BRT.

The evaluation for archaeology, architectural and cultural heritage focused on Recorded Monuments and Protected Structures for this stage of the assessment (Figure 44). All Recorded Monuments are afforded legal protection and will require consideration during the development of a feasible BRT system. The archaeology, architectural and cultural heritage evaluation identified that each proposed route option was located in a rich archaeological and architectural heritage environment. The most significant concentrations of both archaeological and architectural heritage constraints for each feasible route option was noted to the south of the River Liffey where Dublin's medieval core acted as an impetus for later habitation and development.

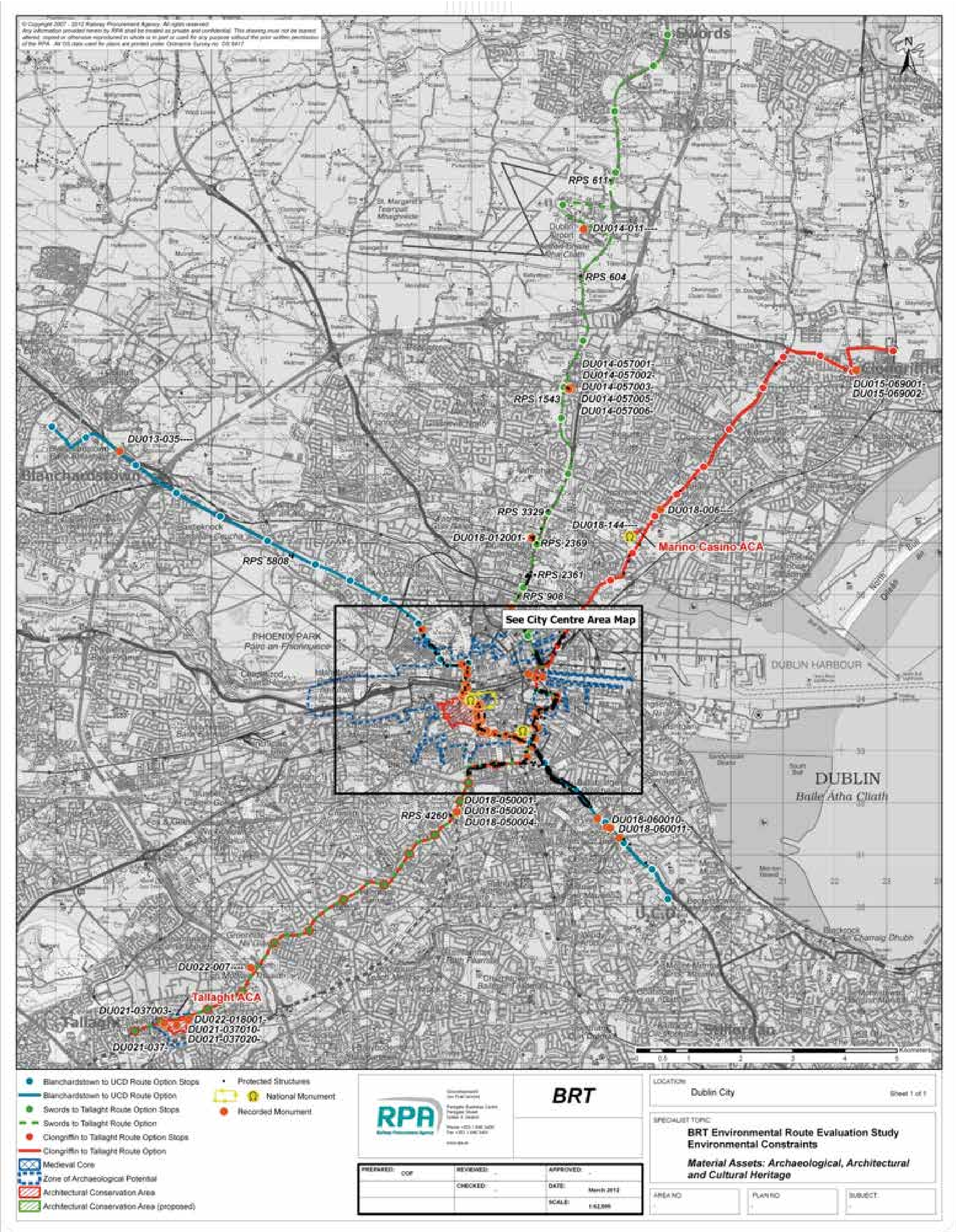


Figure 44 Environmental Constraints Material Assets: Archaeological, Architectural and Cultural Heritage

From an archaeological perspective, the representative Blanchardstown to UCD route option has the greatest potential for impact as it traverses the city's medieval core with 111 Recorded Monuments on its alignment (Figure 45). Significantly, this route option will impact on the subsurface remains of the city's town wall, which is a national monument, at 3 locations including St. Nicholas' Gate on Nicholas Street. This option will impact on a further 2 national monuments and on a significant ecclesiastical site in Donnybrook believed to house at least 7,000 human burials. The development of the route option at this location will require careful consideration in order to avoid and/or minimise impacts.

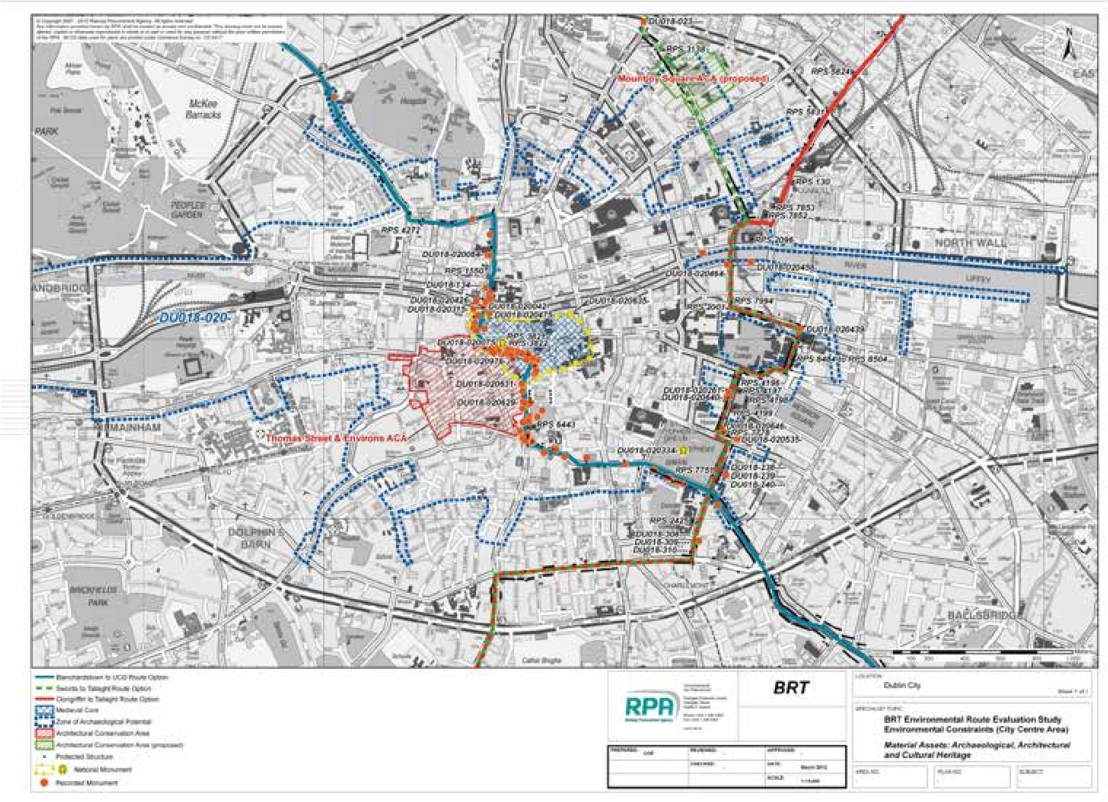


Figure 45 City Centre Area Environmental Constraints Material Assets: Archaeological, Architectural and Cultural Heritage

The Clongriffin to Tallaght and the Swords to Tallaght options will potentially impact on 35 and 40 subsurface Recorded Monuments respectively, with both options impacting on the perimeter area of St. Stephen's Green Park National Monument, and significantly on the ecclesiastical enclosure of St. Maelruain's in Tallaght. In light of the previous information, all three options are considered feasible but careful consideration of potential impacts on national and recorded monuments will be required in the subsequent development of the routes, particularly in areas that are susceptible to ground disturbance for utility diversions at BRT stop locations and in areas where additional land may be required to facilitate the installation of the system.

In relation to architectural heritage, it is considered unlikely that any of the proposed BRT options will impact directly on Protected Structures, so all three route options are considered feasible. There are 414 Protected Structures on the Blanchardstown to UCD route, 390 Protected Structures on the Swords to Tallaght route and 312 along the Clongriffin to Tallaght route. The evaluation has indicated that all three indicative BRT options have the potential to generate visual impacts on Protected Structures including buildings identified as Landmark buildings. Consequently, potential visual impacts on Protected Structures will need to be considered in relation to the selection and design of BRT stop locations in the subsequent development phases of a BRT system.

7.1.7 Conclusions

In conclusion, this evaluation has identified potential environmental impacts in relation to Landuse, Flora and Fauna, Soil and Geology, Surface Water, Landscape and Visual, and Material Assets: Archaeological, Architectural and Cultural Heritage. Potential impacts from BRT on the constraints identified in this feasibility study can be avoided and/or minimised during the subsequent development of feasible route options. Additionally, environmental topics which were scoped out of the constraint study can be scoped back in as appropriate in subsequent stages of the assessment. The Clongriffin to Tallaght Option and the Swords to Tallaght Option were considered to have some potential for significant impacts in relation to landuse and flora and fauna as a result of the impacts on both Tymon and Bancroft Parks. Both of these options would be considered feasible from an environmental perspective through the identification of appropriate mitigation measures.

8 ENGINEERING EVALUATION

8.1 Methodology / High level assumptions

This section of the report details the high level engineering analysis of the constraints and opportunities along the 2 feasible cross city corridors. Based on the results of the demand analysis the Swords to Tallaght corridor has not been evaluated. This assessment is high level and will be subject to more detailed analysis and design, including a traffic impact assessment, should the project progress.

The working assumption for this engineering evaluation and space proofing exercise is that the BRT system will operate in a segregated manner on a dedicated running way as per the system concept.

While the space proofing exercise identifies some pinch points along the cross city alignments, the critical space constraint in many cases will occur at junctions where there is a necessity to provide dedicated left or right turning lanes. This and other constraints would be examined in further detail, should a decision to proceed with further work be made, during the route option analysis phase of a project. It is important to note that the indicative route alignments chosen for this assessment do not reflect what a final route might be for a BRT line along these corridors.

8.2 General Proposed Measures:

In order to provide for fully segregated BRT lanes the following measures have been used for this engineering evaluation:

a. Use existing bus lanes wherever available;

b. Use existing hard shoulders along national primary routes or widening the same with possible new retaining structures if in cutting, where no existing bus lanes are available;

c. Extend existing bus lanes to stop lines at junctions. To do so, either the left turn for general traffic is brought across the BRT lane on the left side in advance to the junction, or the BRT lane is kept on the left side and full provision for turning lanes is proposed. If existing junction is constrained by buildings, then in most cases traffic capacity reduction is considered where approaching lanes are combined into one. At some junctions, banning the turning movements could be implemented;

d. On-street parking is removed where present;

e. Footpaths are narrowed down to a minimum of 2.0m and trees are removed where necessary, subject to survey and assessment (If mature trees are present decisions must be taken on a case by case basis);

f. Cycle lanes are relocated. If the relocation of cycle lanes is necessary an assessment of alternative cycle route options will be carried out. Lower speed limits coupled with reduced lanes widths will also be assessed prior to decisions being made;

g. General traffic is banned in one direction (one way system is implemented) where lateral land take would be required over long sections. Other traffic management measures including the relocation of general traffic completely to accommodate the BRT running lanes or providing local access would also be considered. Along these sections an assessment on whether it is viable to operate a single land loop type arrangement based on the existing adjoining road network; and

h. The need for property acquisition will be assessed on a case by case basis. Property take is considered in a hierarchical manner starting with gardens and only in very extreme cases at local bottlenecks, acquiring and removing buildings. This also will have to be looked at in detail in the next design stage.

8.3 Engineering Evaluation Conclusions

Overall, there are a number of technical constraints identified along the cross city corridors with an almost corrisponding number of technical solutions to mitigate these constraints. To accommodate BRT lanes running on some of the existing roads may require significant property take, reductions in road capacity and changes to the existing traffic management, particularly along sections with pinch points.

There may be the possibility to use a guidance system to reduce the space required along certain sections. A detailed survey of these areas would be undertaken to examine this possibility. Using the results of the detailed survey, combined with the narrower width from the use of guided lanes could lessen some of the technical impacts.

These potential solutions will need to be fully considered in any further development and design of BRT along these corridors.

Based on the engineering evaluation and space proofing exercise the proposed BRT network is technically feasible.

9 CONCLUSIONS AND RECOMMENDATIONS

The purpose of this study was not to identify the preferred route for a BRT system on a particular corridor nor was it to suggest the preferred design on any section of alignment considered. Its purpose is to investigate the technical, environmental, demand and economic feasibility of the proposed BRT network. Should the proposed BRT network be considered feasible and worthy of advancement, a further route selection and design process will be required to advance proposals.

For each of these cross city corridors a single representative route was selected based predominantly, where plausible, on the existing QBC network. Alternatives to the route alignments chosen for this high level comparative assessments exist and these would be examined in further detail during the route option phase of the project should a decision to proceed with further work be made. It is important to note that these route alignments chosen for this assessment do not reflect what a final route might be for a BRT line along these corridors.

The initial evaluation work concentrated on forecast demand modelling on the proposed BRT cross city corridors to determine forecast demand and to provide inputs into the cost benefit analysis. By running these different scenarios it was possible to determine which corridors would have sufficient capacity to cater for both current demand and future demand based on growth in population and an investment in public transport infrastructure. The demand forecasting analysis will play a key role in determining the feasibility of the BRT network.

The demand forecasting analysis and evaluation has shown that if a BRT system is introduced on these cross city corridors they have the potential for significant levels of demand and the potential to draw a significant portion of demand from the private car. In economic terms, due to the level of demand forecast coupled with the relatively low cost, the proposed BRT system performs well.

This economic analysis is at the feasibility stage and, therefore, there is some uncertainty associated with both the costs and demand and benefits presented in this analysis. However, there would have to be considerable negative movements in levels of costs and benefits presented here to alter the conclusion that BRT in both alignments perform well in economic terms.

The feasibility study has demonstrated the existence of a significant public transport deficit on each of the cross city corridors with the highest demand occurring on the Swords to Tallaght corridor. The demand on the Swords to City section greatly exceeds the capacity that can be provided by a BRT system. Based on this level of demand a BRT solution does not cater for the public transport needs of the northern section of this corridor over the longer term. Accordingly, the Swords to City Centre section was not progressed further within this report. The two feasible cross city corridors based on the analysis are:

- Blanchardstown to N11 (UCD); and
- Malahide Road (starting at Clongriffin) to Tallaght.

It should be noted that the assumptions used in the demand analysis were for a high quality BRT system, with service and vehicle characteristics similar to the current Luas system. Any changes to these assumed characteristics would likely result in lower demand on the proposed BRT system.

The environmental feasibility study has identified sensitive environmental constraints along the cross city corridors for the environmental topics that were scoped in. Potential impacts on these key constraints must be either avoided or minimised when developing these corridors further through the consideration of alternatives in accordance with the prescribed statutory process for environmental assessment.

The engineering evaluation and space proofing study has identified a number of potential technical constraints, traffic impacts and property costs along the cross city corridors. There are a number of possible technical solutions to mitigate these constraints. These will need to be fully considered in any further development and design of BRT along any of these corridors.

Based on the conclusions of the feasibility study, it is recommended that further and more detailed work should proceed on the two feasible cross city corridors identified, namely the Blanchardstown to the N11 corridor and the Malahide Road to Tallaght corridor. This further work should include route option identification and analysis, selection of a preferred route for each corridor, the development of a design for each of the preferred routes, an environmental assessment of the routes, and also the preparation of a business case for each proposal.